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STANDARDIZATION SECTOR
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Z.100
Annex F2
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SERIES Z: LANGUAGES AND GENERAL SOFTWARE ASPECTS FOR TELECOMMUNICATION SYSTEMS

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Specification and Description Language – Overview of SDL-2010

Annex F2: SDL-2010 formal definition: Static semantics

Recommendation ITU-T Z.100 – Annex F2

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Recommendation ITU-T Z.100

Specification and Description Language – Overview of SDL-2010

Annex F2

SDL-2010 formal definition: Static semantics

Summary

Annex F2 describes the static semantic constraints of SDL-2010, the mapping to the abstract grammar and the transformations identified by the 'Model' clauses of Recommendations ITU-T Z.101, Z.102, Z.103, Z.104, Z.105 and Z.107, that are included by reference in Recommendation ITU-T Z.100.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Z.100	1984-10-19		11.1002/1000/2222
1.1	ITU-T Z.100 Annex A	1984-10-19		11.1002/1000/6664
1.2	ITU-T Z.100 Annex B	1984-10-19		11.1002/1000/6665
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3.2	ITU-T Z.100 Annex D	1993-03-12	X	11.1002/1000/3156
3.3	ITU-T Z.100 Annex F1	1993-03-12	X	11.1002/1000/3157

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

3.4	ITU-T Z.100 Annex F2	1993-03-12	X	11.1002/1000/3158
3.5	ITU-T Z.100 Annex F3	1993-03-12	X	11.1002/1000/3159
3.6	ITU-T Z.100 App. I	1993-03-12	X	11.1002/1000/3160
3.7	ITU-T Z.100 App. II	1993-03-12	X	11.1002/1000/3161
4.0	ITU-T Z.100	1993-03-12	X	11.1002/1000/3154
4.1	ITU-T Z.100 (1993) Add. 1	1996-10-18	10	11.1002/1000/3917
5.0	ITU-T Z.100	1999-11-19	10	11.1002/1000/4764
5.1	ITU-T Z.100 (1999) Cor. 1	2001-10-29	17	11.1002/1000/5567
6.0	ITU-T Z.100	2002-08-06	17	11.1002/1000/6029
6.1	ITU-T Z.100 (2002) Amd. 1	2003-10-29	17	11.1002/1000/7091
6.2	ITU-T Z.100 (2002) Cor. 1	2004-08-29	17	11.1002/1000/356
7.0	ITU-T Z.100	2007-11-13	17	11.1002/1000/9262
8.0	ITU-T Z.100	2011-12-22	17	11.1002/1000/11387
8.1	ITU-T Z.100 Annex F1	2000-11-24	10	11.1002/1000/5239
8.2	ITU-T Z.100 Annex F2	2000-11-24	10	11.1002/1000/5576
8.3	ITU-T Z.100 Annex F3	2000-11-24	10	11.1002/1000/5577
8.4	ITU-T Z.100 Annex F1	2015-01-13	17	11.1002/1000/12354
8.5	ITU-T Z.100 Annex F2	2015-01-13	17	11.1002/1000/12355
8.6	ITU-T Z.100 Annex F3	2015-01-13	17	11.1002/1000/12356
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Specification and Description Language, SDL-2010, formal definition, Static semantics, shorthand transformations.

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SDL-2010 formal definition: Static semantics

F2.1 General information for the static semantics

An overview of the static semantics is described in clauses F1.2.1, F1.2.2 and F1.2.3 of Annex F1.

F2.1.1 Definitions used from Annex F1

The following definitions for the syntax and semantics of abstract state machines (ASM) are used within this annex (Annex F2). They are defined in Annex F1. They are introduced here for cross-referencing reasons together with the keyword **provided** that is used in transformation rules (see clause F2.2.1.4 Transformation rules).

> The keywords **case**, **choose**, **controlled**, **else**, **elseif**, **endcase**, **endchoose**, **endif**, **endlet**, **if**, **initially**, **let**, **monitored**, **of**, **otherwise**, **provided**, **then**.
>
> The domains *X*, *BOOLEAN*, *NAT*, *TOKEN*, *DefinitionAS1* and *DefinitionAS0*.
>
> The functions *chr*, *empty*, *false*, *head*, *isAncestorAS0*, *isAncestorAS1*, *isSameNode0*, *isSameNode1*, *last*, *length*, *num*, *parentAS0*, *parentAS0ofKind*, *parentAS1*, *parentAS1ofKind*, *replaceInSyntaxTree0*, *replaceOnceInSyntaxTree0*, *substring*, *tail*, *take*, *toSet*, *true* and *undefined*.
>
> The operation symbols *, +, **-set**, **-seq**, =, ≠, ∧, ∨, ⇒, ⇔, ¬, ∃, ∀, >, ≥, <, ≤, +, -, *, /, **in**, ×, ⌒, ∪, ∩, \, ∈, ∉, ⊆, ⊂, | |, **U**, ∅, **mk-**, **s-**, **s1-**, **s2-**.

For more information about the syntax of ASM see Annex F1.

The domain *TOKEN* is used in the definition of the AS0 constructors for <name>, <quoted operation name>, <character string>, <hex string>, <bit string> and the AS1 constructor *Name*. In the formal definition it is assumed the unique *TOKEN* element values can be represented by character strings such as "Predefined", so that the <name> for the predefined package is **mk-**<name>("Predefined") and the *Name* for the predefined package is **mk-***Name*("Predefined"). In most cases, the *TOKEN* element value is the same for the <name> and the corresponding *Name*. The construct <name>(*x*) is a <name> where <name>.**s-***TOKEN* is represented by the sequence of characters for the actual name *x*: letters or digits or underlines for <name> in clause 6.1 of [ITU-T Z.101]; decimal digits for <integer name> in clause 6.1 of [ITU-T Z.101]; decimal digits or <full stop> or e or E or <hyphen> or <plus sign> for <real name> in clause 6.1 of [ITU-T Z.101]; and for a <string name> (<character string>, <hex string> and <bit string> in clause 6.1 of [ITU-T Z.101]) the sequence of characters specified including enclosing and enclosed apostrophes. One case where the *TOKEN* value is not the same for the <name> and the corresponding *Name* is for operator names (including literal and quoted operation names) where the *TOKEN* value for the *Name* depends on the signature of the operation and data type in which it is defined (see clause F2.2.9.5 Operations below).

F2.1.3 Status of Annex F2 (this annex)

There have been a significant number of changes since the (10/2016) edition, but there remains some issues to be resolved for full alignment with the text of SDL-2010 in the main body of [ITU-T Z.100], [ITU-T Z.101], [ITU-T Z.102], [ITU-T Z.103], [ITU-T Z.104], [ITU-T Z.105], [ITU-T Z.106], and [ITU-T Z.107]. These issues are identified by the phrase "Further study needed …" in the text.

F2.2 Static semantics

In this annex, the static semantics of SDL-2010 is formalized. This entails defining static well-formedness rules for the concrete and abstract syntax, transformations of the concrete syntax and mappings from concrete to abstract syntax. The concrete syntax is expressed using Abstract Syntax Notation level 0 (AS0), an abstraction of the SDL text-only phrase representation (SDL-PR) grammar (see [ITU-T Z.106]). The well-formedness rules are expressed in terms of first order predicate calculus. The transformations are represented as rewrite rules, comprising patterns, conditions (expressed using first order predicate calculus) and substitutions. The mappings are expressed using the abstract state machine formalism defined in Annex F1.

For the static semantics, the presentation of the grammar as described in Annex F1 is again used.

Context conditions (well-formedness rules) are reflected in the abstract syntax tree as relations from nodes to nodes. First order predicate calculus is used to express the relations as follows: The nodes of the AST are the objects of reasoning. Some functions are defined to retrieve nodes, e.g., the function *n.parentAS1* returns the parent node of *n*. This is explained in detail in Annex F1. Syntax structures are described on sets of nodes by quantifying over them. Predicates are defined over nodes showing the context-dependent rules of these nodes.

For example, in order to define that all the entities of the same type in a scope unit obey the rules of no duplicate appearance, the following static semantic rule is defined:

$$\forall d, d1 \in \mathit{ENTITYDEFINITION1}: d.\mathit{entityKind1} = d1.\mathit{entityKind1} \wedge d \neq d1 \Rightarrow d.\mathit{identifier1} \neq d1.\mathit{identifier1}$$

where:

d and *d1* represent any two abstract syntax tree nodes belonging to the set *ENTITYDEFINITION1*.

d.entityKind1 and *d1.entityKind1* get the entity kinds of the corresponding syntax constructs.

d.identifier1 and *d1.identifier1* get the full identifiers of the corresponding syntax constructs.

F2.2.1 General definitions

F2.2.1.1 Division of text

The static semantics is presented with the following division of text. Please find below the headings used and for each of the headings a short description of the contents.

Abstract syntax

This part is used to describe the abstract grammar as already defined within Recommendation ITU-T Z.100. There will be usually no comments in this section as it is copied as is from the language definition.

Conditions on abstract syntax

This part reflects the conditions that can be formulated on the abstract syntax level. The conditions are usually commented by the corresponding part of the language definition.

Concrete syntax

This part shows the concrete syntax. In fact, an abstraction of the concrete syntax, namely the AS0 as defined below, is used. There will be usually no comments in this section as it is copied from the language definition.

Conditions on concrete syntax

This part reflects the conditions that must be true for the concrete syntax (AS0 here). The conditions are usually commented by the corresponding part of the language definition.

Transformations

This part shows the transformations within the AS0. Please see below for the format of the rules. The transformations are usually commented by the corresponding part of the language definition.

Mapping to abstract syntax

This part shows how the transformed AS0 is mapped to AS1. If the mapping is straightforward, no comments are given.

Auxiliary functions

This part introduces auxiliary functions that are used later on to define the conditions on AS0 and the transformations. The aim and the definition of the functions are explained.

F2.2.1.2 Abstraction of the concrete grammar (AS0)

For the sake of the definition of the static semantics rules, a special format of the concrete grammar is used. This special format is called abstract syntax level 0 (AS0). It is an abstraction of the concrete grammar of the text-only phrase representation (SDL-PR), where all the unnecessary grammar items such as separators and terminal keywords are omitted. Any concrete graphical representation (SDL-GR) graphical constructs in a description are converted to the equivalent SDL-PR: in the conversion annotation (comments, notes and other items such as <create line area> and <gate property area>) and underlines followed by spaces are removed; each text extension is made part of the text it extends; and each multiple page diagram is reduced to one page. Formal rewrite rules for this conversion of SDL-GR graphical constructs to SDL-PR is an issue for further study, but most of the syntax rules of SDL-GR are textual rules that are also part of SDL-PR and therefore require no conversion.

AS0 is in principle generated by a simple parsing algorithm from the concrete grammar of SDL-PR, and the SDL-PR syntax rule names are preserved in AS0. As this algorithm is an item for further study not specified here, the assertion that AS0 is a valid abstraction of SDL-PR is true has been checked by comparing the SDL-PR concrete syntax and AS0.

The AS0 does not only represent the original syntactical structure, but it also forms a tree. To achieve this, the syntax constructors "::=" of Recommendation ITU-T Z.100 are replaced by an alias construct ("=") and a tree node constructor ("::"). Both these constructs are already defined in Z.100 in the scope of the abstract syntax, which is called AS1 here.

The metalanguage for the concrete grammar is defined in [ITU-T Z.111]. However, the notation used in this document to represent semantic subcategories differs from the definition in [ITU-T Z.111]. For example, instead of writing

<data type name>

the following sections will use

<data type<name>

This convention facilitates automatic extraction of the grammar from this document.

F2.2.1.3 Static conditions on the concrete syntax (AS0)

Usually, the AS0 conditions are checked before the transformations start. However, some conditions are only valid after some transformation steps. This is indicated by preceding the corresponding condition with a numbering sign (e.g., "=4=>"), where the number in the arrow indicates the next transformation step. This means, a condition with the prefix "=4=>" is checked between the transformation steps 3 and 4. By default, conditions are preceded with "=2=>", i.e., they are checked before any transformations except macro expansion and conversion to AS0.

F2.2.1.4 Transformation rules

Transformations and redefinition of functions on AS0 are represented by rewrite rules. The syntax for rewrite rules is:

<rewrite rule> ::=
<pattern> [<provision>] "=" [<integer>] "=>" <expression> { and <dependent transformation> }*

<dependent transformation> ::=
<pattern> [<provision>] { "=>" } <expression>

<provision> ::=
provided <Boolean<expression>

The pattern (as well as the expression) is written using the syntax for ASM transition rules defined in Part 1 of Annex F.

The pattern can be a sequence, such as " < *a* = <textual typebased agent definition> >" in which case the expression is a replacement sequence. The non-terminal constructor names shall all match a non-terminal in the AS0 syntax. A variable is not allowed to appear more than once on the left hand side. Free variable names that appear on the right hand side shall also appear on the left hand side. Furthermore, the pattern and expression patterns shall be correctly typed and be of the same type.

The pattern can be a function, such as "*implicitName*" in which case the expression is a replacement function.

A rule *Pattern* =i=> *Expression* is equivalent to an ASM rule of the form

```
choose v:DefinitionAS0
    case v
        | Pattern then
            let e = CreateExpr(Expression) in
                replaceInSyntaxTree0(v, e, v.parentAS0)
            endlet
    endcase
endchoose
```

In the definition above, *CreateExpr* means for every constructor of *Expression* an extend of the corresponding domain and the setting of the contents function to a corresponding **mk-** for the following sub pattern. The placeholder *replaceInSyntaxTree0* means to replace *v* by e in the parent node of *v*. This does not cause problems as the syntax tree is a tree and it is always possible to find the parent and to replace one of its children.

A transformation rule can be enclosed in an ASM **let** constructor.

A rule **let** *e* = *expression* **in** *Pattern* =i=> *Replacement* **endlet** is equivalent to an ASM rule of the form

```
let e = expression in
    choose v:DefinitionAS0 in
        case v
            | Pattern then
                let e = CreateExpr(Replacement) in
                    replaceInSyntaxTree0(v, e, v.parentAS0)
                endlet
        endcase
    endchoose
endlet
```

Dependent transformation rules have a similar semantics. They are interpreted together with their main rule for each matching dependent pattern while the provisions of both the main rule and the dependent transformation are met.

A rule **let** *e = expression* **in** *Pattern* =i=> *Replacement* **and** *Pattern1 => Replacement1* **endlet** is equivalent to an ASM rule of the form

```
let e = expression
    do in-parallel
        choose v:DefinitionAS0 in
            case v
                | Pattern then
                    let e = CreateExpr(Replacement) in
                        replaceInSyntaxTree0(v, e, v.parentAS0)
                    endlet
            endcase
        endchoose,
        choose v:DefinitionAS0 in
            case v
                | Pattern1 then
                    let e = CreateExpr(Replacement1) in
                        replaceInSyntaxTree0(v, e, v.parentAS0)
                    endlet
            endcase
        endchoose
    enddo
endlet
```

The integer in a rewrite rule means the transformation step this rule belongs to. The steps are described in clause F2.3. In the case of the integer being omitted, the rewrite rule can be applied in any transformation step.

The optional <provisions> of <rewrite rule> are Boolean expressions the <pattern> needs to satisfy for the rule to be applied.

We use one auxiliary function *newName* to construct new names during the transformation.

monitored *newName*: <name>→ <name>

The constraint on this function is that it always returns a new unique name. However, the result is the same when the argument is the same unless the argument is *undefined*. For an *undefined* parameter a new unique name that is not already used within the syntax tree is provided.

NOTE – *newName* is usually used without an argument, which has the same meaning as *newName*(*undefined*).

F2.2.1.5 Mapping rules

The mapping rules introduce a function.

Mapping: *DefinitionAS0* → *DefinitionAS1*

The definition of the function *Mapping* is formed by the concatenation of all the cases contained in all **Mapping** sections. This is preceded with the following header part and followed by an **endcase**.

Mapping(*a*: *DefinitionAS0*): *DefinitionAS1* $=_{def}$
case *a* **of**

This way the mapping function is defined step by step in the appropriate places in the **Mapping** sections. Each alternative of the mapping will thus be preceded by a bar ("|"), because it is one alternative of the *Mapping* function description. The bar ("|") is followed by a case selector terminated by the keyword **then** followed by the mapping for that case. Sometimes the *Mapping* function is called with a *DefinitionAS0* parameter that is *undefined*, in which case the result is also *undefined*.

Consider the following as AS0 syntax:

<definition x> :: <y> <zlist>

Typically this would have a *Mapping* starting with the case selector, such as:

| <definition x> (*yvalue, zl*) **then**

If this *Mapping* were a list of the component mappings, this would be:

| <definition x> (*yvalue, zl*) **then**
< *Mapping*(*yvalue*), *Mapping*(*zl*) >

Where the zlist value is not used in the mapping, this would be

| <definition x>(*yvalue*, *) **then**
< *Mapping*(*yvalue*) >

Or alternatively (with the same meaning)

| *dx* = <definition x> **then**
< *Mapping*(*dx*.**s-**<y>) >

If the result of mapping has only one component, the list brackets "<" and ">" are optional, so that the mapping of *dx* above could also be defined by:

| *dx* = <definition x> **then**
Mapping(*dx*.**s-**<y>)

Where a syntax item is a list, for example in:

<zlist> :: <z>*

If the result of mapping needs to be a list, this could be (without outermost list brackets):

| <zlist> (*zitems*) **then**
< *Mapping*(*zitems*[*i*]) | i ∈ 1.. *zitems.length* >

If the result of the mapping needs to be a set, this could be:

| <zlist> (*zitems*) **then**
{ *Mapping*(*zitems*[*i*]) | i ∈ 1.. *zitems.length* }

There is no general rule for the mapping of a list component (such as *zitems*) of a selector (such as <zlist>), so that the mapping has to be given explicitly in each case.

F2.2.1.6 Predefinition

The following domains and functions are used throughout the static conditions for AS1 and concrete syntax.

F2.2.1.6.1 General functions

The function *bigSeq* is used to concatenate a sequence of sequences into one sequence.

bigSeq(*s*: (*X**)*): *X** =$_{def}$
if *s* = *empty* **then** *empty* **else** *s.head* ⌒ *bigSeq*(*s.tail*) **endif**

F2.2.1.6.2 Domain definitions for AS1

AGENTKIND1: the set of agent kinds in AS1.

AGENTKIND1=$_{def}$ {**system**, **block**, **process**}

ENTITYDEFINITION1: the union of all the entity definitions in AS1.

ENTITYDEFINITION1=$_{def}$ *Package-definition*

∪ *Agent-definition*
∪ *Agent-type-definition*
∪ *Procedure-definition*
∪ *Composite-state-type-definition*
∪ *Channel-definition*
∪ *Gate-definition*
∪ *Signal-definition*
∪ *Timer-definition*
∪ *Variable-definition*
∪ *Data-type-definition*
∪ *State-node*
∪ *Syntype-definition*
∪ *Literal-signature*
∪ *Operation-signature*

ENTITYKIND1: the set of all the entity kinds in AS1.

ENTITYKIND1 $=_{def}$ { **agent**, **agent type**, **channel**, **exception**, **gate**, **literal**, **operation**, **package**, **procedure**, **signal**, **sort**, **state**, **state type**, **timer**, **variable** }

SCOPEUNIT1: the union of all the scope units in AS1.

SCOPEUNIT1 $=_{def}$ *Package-definition*
∪ *Agent-definition*
∪ *Agent-type-definition*
∪ *Procedure-definition*
∪ *Signal-definition*
∪ *Composite-state-type-definition*
∪ *Data-type-definition*
∪ *State-node*
∪ *Compound-node*

SIGNAL1 $=_{def}$ {*id*∈*Identifier*: *id.idKind1*∈{**signal**, **timer**}}

TYPEDEFINITION1 $=_{def}$ *Agent-type-definition*∪*Procedure-definition*∪*Composite-state-type-definition*∪ *Data-type-definition*

VALUE1 $=_{def}$ *Literal-signature*

F2.2.1.6.3 Domain definitions for AS0

BINDING0 $=_{def}$ <name> × *ENTITYDEFINITION0*

BINDINGLIST0 $=_{def}$ *BINDING0**

CONTEXT0 $=_{def}$ <assignment> ∪ <decision> ∪ <expression>

ENTITYDEFINITION0 $=_{def}$
<block definition> ∪
<channel definition> ∪
<composite state definition> ∪
<literal signature> ∪
<operation definition> ∪
<operation signature> ∪
<package definition> ∪
<parameters of sort> ∪
<process definition> ∪
<remote variables of sort> ∪
<signal list definition> ∪
<synonym definition> ∪
<syntype definition> ∪

<system definition> ∪
<textual gate definition> ∪
<textual typebased agent definition> ∪
<textual typebased state partition def> ∪
<timer definition item> ∪
<variables of sort> ∪
FORMALCONTEXTPARAMETER0 ∪
PREDEFINEDDEFINITION0 ∪
TYPEDEFINITION0

ENTITYKIND0 =$_{def}$ {**agent**, **agent type**, **block**, **block type**, **channel**, **exception**, **gate**, **interface**, **literal**, **method**, **operator**, **package**, **procedure**, **process**, **process type**, **remote procedure**, **remote variable**, **signal**, **signallist**, **sort**, **state**, **state type**, **synonym**, **system**, **system type**, **timer**, **type**, **variable**}

The domain *EXPRESSION0* is the union of constructor rule alternatives of <expression0>

EXPRESSION0 =$_{def}$
<binary expression> ∪
<operand5> ∪
<equality expression> ∪
<create body> ∪
<procedure call body> ∪
<remote procedure call body> ∪
<decoding expression> ∪
<encoding expression>

FORMALCONTEXTPARAMETER0 =$_{def}$
<agent context parameter> ∪
<agent type context parameter> ∪
<compositestate type context parameter> ∪
<gate context parameter> ∪
<interface context parameter name> ∪
<procedure context parameter> ∪
<remote procedure context parameter> ∪
<remotevariable contextparameter names> ∪
<signal context parameter name> ∪
<sort context parameter> ∪
<synonym context parameter name> ∪
<timer context parameter name> ∪
<variable context parameter names>

INTTOKEN0=$_{def}$ (*SINGLEDIGIT0* ∪ { *it* + *d* | *it* ∈ *INTTOKEN0* : *d* ∈ *SINGLEDIGIT0* }) ⊂ *TOKEN*

In order to deal with the predefined data, the following four domains are introduced.

PREDEFINEDDEFINITION0=$_{def}$*PREDEFINEDLITERAL0*∪*PREDEFINEDOPERATION0*∪*PREDEFINEDSORT0*

PREDEFINEDLITERAL0=$_{def}$ represents all the literals defined within the package Predefined.

PREDEFINEDOPERATION0=$_{def}$ represents all the operations defined within the package Predefined.

PREDEFINEDSORT0=$_{def}$ represents all the sorts defined within the package Predefined.

REFERENCE0 =$_{def}$ <package reference> ∪ <block reference> ∪ <process reference> ∪
<composite state reference> ∪ <operation reference> ∪ *TYPEREFERENCE0*

SCOPEUNIT0 =$_{def}$
<agent definition> ∪

<composite state definition> ∪
<compound statement> ∪
<operation definition> ∪
<package definition> ∪
<signal context parameter name> ∪
<sort context parameter> ∪
TYPEDEFINITION0

SIGNAL0=$_{def}$ {*id*∈<identifier>: *id.idKind0*∈{**remote procedure**, **remote variable, signal**, **timer**}}

SINGLEDIGIT0=$_{def}$ {"0", "1", "2", "3", "4", "5", "6", "7", "8", "9"} ⊂ *TOKEN*

STATEPART0 =$_{def}$
<connect part> ∪
<continuous signal> ∪
<input part> ∪
<priority input> ∪
<save part> ∪
<spontaneous transition> ∪
<state timer part>

The domain *SYMBOL0* is used in the function *isDefinedSym0* to determine if the given symbol is defined for the range condition of a specified syntype.

SYMBOL0=$_{def}$ {"<",">","<=",">=","length"}

TYPEDEFINITION0 =$_{def}$
<block type definition> ∪
<composite state type definition> ∪
<data type definition> ∪
<interface definition> ∪
<procedure definition> ∪
<process type definition> ∪
<signal definition> ∪
<system type definition>

TYPEREFERENCE0 =$_{def}$ <agent type reference> ∪ <composite state type reference> ∪
<procedure reference>

F2.2.1.6.4 Function definitions on AS1

The function *agentInstanceId1* returns the fully qualified *Agent-identifier* of an agent instance set from an *Agent-instance* list.

agentInstanceId1(*ail*: *Agent-instance**, *pl*: *Path-item**): *Agent-identifier* =$_{def}$
let *sys*=*take*({*s* ∈ *Sdl-specification*}) **in**
if *ail* = *empty* **then**
mk-*Identifier*(**mk-***Qualifier*(*empty*), *sys*.**s-***Agent-definition*.**s-***Agent-name*)
elseif *pl* = *empty* **then**
agentInstanceId1(*ail*, **mk-***Agent-type-qualifier*(*sys*.**s-***Agent-definition*.**s-***Agent-name*))
elseif *ail*.*length* = 1
mk-*Identifier*(**mk-***Qualifier*(*pl*), *ail*[1].**s-***Agent-name*)
else
agentInstanceId1(*ail.tail*, *pl* ⌒ **mk-***Agent-type-qualifier*(*ail.head*.**s-***Agent-name*))
endif
endlet

The function *agentInstanceSort1* returns the pid sort of the interface defined in the context of the agent that has the same name as the agent. Note that no conversion is needed between the *Agent-identifier* returned by *agentInstanceId1* for the *Sort-reference-identifier* because both these are equivalent to *Identifier*.

```
agentInstanceSort1(aiv: Agent-instance-pid-value): Sort-reference-identifier =def
    agentInstanceId1(aiv.s-Agent-instance-seq, empty)
```

The function *agentKind1* is used to get the agent kind for an *Agent-definition* or *Agent-type-definition*.

```
agentKind1(d: Agent-definition∪Agent-type-definition):AGENTKIND1=def
    if d∈Agent-type-definition then d.s-Agent-kind
    else
        let td=getEntityDefinition1(d.s-Agent-type-identifier, agent type) in
            td.s-Agent-kind
        endlet
    endif
```

The function *decodeResult1* returns the static sort of decoding an expression according to the identified encoding rules. Each of the three elements of *Encoding-rules* is equivalent to *Identifier*; therefore **s3**-*Identifier* is used to select the *Decode-procedure-identifier* of *er*.

```
decodeResult1(de: Decoding-expression): Sort-reference-identifier =def
    let ep = de.s-Encoding-path in
    let er  =
        if ep.s-Encoding-rules = undefined
        then getEntityDefinition1(ep.s-Gate-identifier, gate).s-Encoding-rules
        else ep.s-Encoding-rules
        endif
    in
        getEntityDefinition1(er.s3-Identifier, procedure).s-Result.s-Sort-reference-identifier
    endlet
    endlet
```

The function *derivedDataType1* is used to get the data type definition for a given *Syntype-definition*.

```
derivedDataType1(d: Syntype-definition∪Data-type-definition): Data-type-definition =def
    if d∈Data-type-definition then d
    else getEntityDefinition1(d.s-Parent-sort-identifier, sort).derivedDataType1
```

The function *encodeResult1* returns the static sort of encoding an expression according to the identified encoding rules. Each of the three elements of *Encoding-rules* is equivalent to *Identifier*, therefore **s1**-*Identifier* is used to select the *Rules-identifier* of *er* and **s2**-*Identifier* is used to select the *Encode-procedure-identifier* of *er*.

```
encodeResult1(ee: Encoding-expression): Sort-reference-identifier =def
    let ep = ee.s-Encoding-path in
    let er  =
        if ep.s-Encoding-rules = undefined
        then getEntityDefinition1(ep.s-Gate-identifier, gate).s-Encoding-rules
        else ep.s-Encoding-rules
        endif
    in
        let nm = getEntityDefinition1(er.s1-Identifier, literal).s-Identifier.s-Name.s-TOKEN in
        case nm of
        |   "text" then predefinedId1("Charstring")
        |   "BER" then predefinedId1("Octetstring")
        |   "CER" then predefinedId1("Octetstring")
        |   "DER" then predefinedId1("Octetstring")
        |   "APER" then predefinedId1("Octetstring")
        |   "UPER" then predefinedId1("Bitstring")
        |   "CAPER" then predefinedId1("Octetstring")
```

```
        |   "CUPER" then predefinedId1("Bitstring")
        |   "BXER" then predefinedId1("Charstring")
        |   "CXER" then predefinedId1("Charstring")
        |   "EXER" then predefinedId1("Charstring;
        |   "OER" then predefinedId1("Octetstring")
        otherwise
            getEntityDefinition1(er.s2-Identifier, procedure).s-Result.s-Sort-reference-identifier
        endcase
        endlet
    endlet
    endlet
```

The function *entityKind1* is used to get the entity kind for an entity definition on AS1.

```
entityKind1(d: ENTITYDEFINITION1): ENTITYKIND1 =def
    case d of
    | Package-definition then package
    | Agent-definition then agent
    | Agent-type-definition then agent type
    | Procedure-definition then procedure
    | State-node then state
    | Composite-state-type-definition then state type
    | Channel-definition then channel
    | Gate-definition then gate
    | Signal-definition then signal
    | Timer-definition then timer
    | Variable-definition then variable
    | Data-type-definition then sort
    | Syntype-definition then sort
    | Interface-definition then sort
    | Literal-signature then literal
    | Operation-signature then operation
    otherwise undefined
    endcase
```

The function *entityName1* is used to get the entity name for an entity definition in AS1.

```
entityName1(d: ENTITYDEFINITION1): Name =def
    case d of
    | Package-definition then d.s-Package-name
    | Agent-definition then d.s-Agent-name
    | Agent-type-definition then d.s-Agent-type-name
    | Procedure-definition then d.s-Procedure-name
    | State-node then d.s-State-name
    | Composite-state-type-definition then d.s-State-type-name
    | Channel-definition then d.s-Channel-name
    | Gate-definition then d.s-Gate-name
    | Signal-definition then d.s-Signal-name
    | Timer-definition then d.s-Timer-name
    | Variable-definition then d.s-Variable-name
    | Value-data-type-definition then d.s-Sort
    | Syntype-definition then d.s-Syntype-name
    | Interface-definition then d.s-Sort
    | Literal-signature then d.s-Literal-name
    | Operation-signature then d.s-Operation-name
    otherwise undefined
    endcase
```

The function *fullQualifier1* is used to get the full qualifier for an entity definition in AS1.

```
fullQualifier1(d: ENTITYDEFINITION1): Qualifier =def
    let su= parentAS1ofKind(d, SCOPEUNIT1) in
        if su = undefined then empty
```

```
        elseif d.entityKind1∈{operation, literal}∧su ∈ Data-type-definition then su.fullQualifier1
        else su.fullQualifier1⌒mk-Qualifier(su.entityKind1, su.entityName1)
        endif
    endlet
```

The function *getEntityDefinition1* gets the entity definition for an identifier and entity kind.

```
getEntityDefinition1(id: Identifier, k: ENTITYKIND1): ENTITYDEFINITION1=def
    take({d∈ENTITYDEFINITION1: d.identifier1 = id ∧ d.entityKind1 = k∧
        (d.entityKind1 = operation ⇒
            isActualAndFormalParameterMatched1(id.actualParameterListOfOpId1,
                                                d.formalParameterSortList1))})
```

The function *identifier1* is used to get the identifier with full qualifier for an entity definition in AS1.

```
identifier1(d: ENTITYDEFINITION1):Identifier =def
    mk-Identifier(d. fullQualifier1, d.entityName1)
```

The function *idKind1* is used to return the entity kind for an identifier in AS1 based on syntactic context.

```
idKind1(id:Identifier):ENTITYKIND1=def
        case id.parentAS1 of
        | Create-request-node∪Signal-destination then agent
        | Agent-type-definition∪Agent-definition then agent type
        | Procedure-definition∪Call-node∪Value-returning-call-node then procedure
        | Gate-definition∪Output-node∪Save-signalset then signal
        | Channel-path then
            if id in id.parentAS1.s-Identifier-seq then signal
            else gate
            endif
        | Data-type-definition∪Parameter∪Result∪Signal-definition∪Timer-definition∪
            Formal-argument∪Variable-definition∪Any-expression then sort
        | Set-node∪Reset-node∪Timer-active-expression then timer
        | Originating-gate∪Destination-gate then gate
        | Composite-state-type-definition∪State-machine∪State-node∪State-partition then  state type
        | Literal then literal
        | Open-range∪Operation-application then operation
        | Input-node then
            if id in id.parentAS1.s-Variable-identifier-seq then variable
            else signal
            endif
        | Variable-access ∪ Assignment then variable
        | Direct-via then
            if getEntityDefinition1(id, channel) ≠ undefined then channel
            else gate
            endif
        endcase
```

The function *isCompatibleTo1* determines if one *Sort-reference-identifier* is compatible to the other.

```
isCompatibleTo1(id1: Sort-reference-identifier, id2: Sort-reference-identifier): BOOLEAN=def
    let d1 = getEntityDefinition1(id1, sort) in
        let d2 = getEntityDefinition1(id2, sort) in
        d1=d2 ∨ isSuperType1(d2, d1)
        endlet
    endlet
```

The predicate *isDirectSuperType1* is used to determine if the first entity definition is the direct super type of the second one.

```
isDirectSuperType1(d: ENTITYDEFINITION1, d1: ENTITYDEFINITION1): BOOLEAN=def
```

case *d1* **of**
| *Agent-type-definition* **then**
d ∈*Agent-type-definition* ∧ *d* = *getEntityDefinition1*(*d1*.**s**-*Agent-type-identifier*, **agent type**)
| *Procedure-definition* **then**
d∈*Procedure-definition* ∧ *d* = *getEntityDefinition1*(*d1*.**s**-*Procedure-identifier*, **procedure**)
| *Composite-state-type-definition* **then**
d∈*Composite-state-type-definition* ∧
d = *getEntityDefinition1*(*d1*.**s**-*Composite-state-type-identifier*, **state type**)
| *Value-data-type-definition* **then**
d∈*Value-data-type-definition* ∧ *d* = *getEntityDefinition1*(*d1*.**s**-*Data-type-identifier*, **sort**)
| *Interface-definition* **then**
d∈*Interface-definition* ∧
(∃*dataId*∈*Data-type-identifier*: *dataId .parentAS1= d1* ∧ *d* = *getEntityDefinition1*(*dataId*, **sort**))
| *Syntype-definition* **then**
isDirectSuperType1(*d*,*d1*.*derivedDataType1*)
otherwise *false*
endcase

The function *isInOpenRange1* determines if the given value is in the given open range.

isInOpenRange1(*v1*: *VALUE1*, *r*: *Open-range*): *BOOLEAN* =def
let *operator* = *r*.**s**-*Operation-identifier*.**s**-*Name* **in**
let *vrc* = *r*.**s**-*Constant-expression*.*value1* **in**
let *v*= *v1*.*value1* **in**
case *operator* **of**
| "=" **then** *v* = *vrc*
| "/=" **then** ¬ (*v* = *vrc*)
| "<=" **then** *v* ≤ *vrc*
| ">=" **then** *v* ≥ *vrc*
| ">" **then** *v* > *vrc*
| "<" **then** *v* < *vrc*
endcase
endlet
endlet
endlet

The predicate *isSuperType1* is used to determine if the first entity definition is the super type of the second one.

isSuperType1(*d1*: *ENTITYDEFINITION1*, *d2*: *ENTITYDEFINITION1*): *BOOLEAN* =def
isDirectSuperType1(*d1 d2*)∨∃ *d3*∈*ENTITYDEFINITION1*: *isSuperType1* (*d1 d3*)∧*isSuperType1* (*d3*, *d2*)

The function *predefinedId1* produces the *Identifier* of package Predefined with a specified *Name* given as a character string (to represent a *TOKEN*), for example *predefinedId1*("Boolean").

predefinedId1(*nm*: *TOKEN*): *Identifier* =def
qualifiedId1(**mk**-*Qualifier*(<**mk**-*Package-qualifier*(**mk**-*Name*("Predefined"))>), *nm*)

The function *qualifiedId1* produces the *Identifier* with the specified *Qualifier* and a specified *Name* given as a character string (to represent a *TOKEN*).

qualifiedId1(*ql*: *Qualifier*, *nm*: *TOKEN*): *Identifier* =def
mk-*Identifier*(*ql*, **mk**-*Name*(*nm*))

range1 returns the set of elements that satisfy the condition.

range1 (*r*: *Range-condition*): *VALUE1*-**set** =def
{ *v*∈*VALUE1*:
∃*ci* ∈ *r*.**s**-*Condition-item*:
((*ci* ∈ *Open-range*) ∧ *isInOpenRange1*(*v*, *ci*)) ∨
((*ci*∈*Closed-range*) ∧
(∃*s1*, *s2*∈ *ci*.**s**-*Open-range*: (*s1* ≠ *s2*) ∧ *isInOpenRange1*(*v*, *s1*)∧ *isInOpenRange1*(*v*, *s2*)))}

The function *staticSort1* returns the static sort of *e*.

```
staticSort1(e: Expression ): Sort-reference-identifier =def
    case e of
    |   Active-agents-expression then predefinedId1("Natural")
    |   Agent-instance-pid-value then agentInstanceSort1(e)
    |   Any-expression then e.s-Sort-reference-identifier
    |   Conditional-expression then staticSort1(e.s-Consequence-expression)
    |   Decoding-expression then decodeResult1(e)
    |   Encoding-expression then encodeResult1(e)
    |   Equality-expression then predefinedId1("Boolean")
    |   Literal then getEntityDefinition1(e.s-Literal-identifier, literal).s-Result
    |   Now-expression then predefinedId1("Time")
    |   Offspring-expression then predefinedId1("Pid")
    |   Operation-application then getEntityDefinition1(e.s-Operation-identifier, operation).s-Result
    |   Parent-expression then predefinedId1("Pid")
    |   Range-check-expression then predefinedId1("Boolean")
    |   Sender-expression then predefinedId1("Pid")
    |   Self-expression then
            let at = parentAS1ofKind(e, Agent-type-definition) in
                qualifiedId1(at.s-Qualifier, at.s-Agent-type-name.s-TOKEN)
                // Interface
            endlet
    |   State-expression then predefinedId1("Charstring")
    |   Timer-active-expression then predefinedId1("Boolean")
    |   Timer-remaining-duration then predefinedId1("Duration")
    |   Type-check-expression then predefinedId1("Boolean")
    |   Type-coercion then e.s-Sort-reference-identifier
    |   Value-returning-call-node then getEntityDefinition1(e.s-Procedure-identifier, procedure).s-Result
    |   Variable-identifier then getEntityDefinition1(e, variable).s-Sort-reference-identifier
        // Variable-access
    endcase
```

F2.2.1.6.5 Function definitions on AS0

The function *binaryOpName0* gets the name of an operation used in a <binary expression>.

```
binaryOpName0(be: <binary expression> ): <name> =def
mk-<name>(
    case be.s-<infix operation name>.s-implicit of
    | <implies sign> then "=>"
    | or then "or"
    | xor then "xor"
    | and then "and"
    | <greater than sign> then ">"
    | <greater than or equals sign> then ">="
    | <less than sign> then "<"
    | <less than or equals sign> then "<="
    | in then "in"
    | <plus sign> then "+"
    | <hyphen> then "-"
    | <concatenation sign> then "//"
    | <asterisk> then "*"
    | <solidus> then "/"
    | mod then "mod"
    | rem then "rem"
    endcase
)
```

The function *contextQualifier0* gets the actual <qualifier> specified in an entity definition or a reference. In most cases for an entity definition the <qualifier> in the heading is optional, because the qualifier of the entity identifier is determined by the nearest enclosing scope unit in which the entity definition occurs. The <qualifier> is needed for any <referenced definition> (except outermost

packages) if the entity kind with the entity name is ambiguous. It is only allowed to have a <qualifier> in the heading of an entity definition that is a <referenced definition>.

contextQualifier0(*d*: *ENTITYDEFINITION0* ∪ *REFERENCE0*): <qualifier> =$_{def}$
case *d* **of**
| <block definition> **then** *d*.**s-**<block heading>.**s-**<qualifier>
| <block type definition> **then** *d*.**s-**<block type heading>.**s-**<qualifier>
| <block type reference> **then** *d*.**s-**<identifier>.**s-**<qualifier>
| <composite state definition> **then** *d*.**s-**<composite state heading>.**s-**<qualifier>
| <composite state type definition> **then**
if *d*.**s-implicit** ∈ <composite state type graph>
then *d*.**s-implicit**.**s-**<composite state type heading>.**s-**<qualifier>
else *d*.**s-implicit**.**s-**<state aggregation type heading>.**s-**<qualifier>
endif
| <composite state type reference> **then** *d*.**s-**<identifier>.**s-**<qualifier>
| <internal procedure definition> **then** *d*.**s-**<procedure heading>.**s-**<qualifier>
| <operation definition> **then** *d*.**s-**<operation heading>.**s-**<qualifier>
| <package definition> **then** *d*.**s-**<package heading>.**s-**<qualifier>
| <package reference> **then** *d*.**s-**<identifier>.**s-**<qualifier>
| <procedure reference> **then** *d*.**s-**<procedure reference heading>.**s-**<qualifier>
| <process definition> **then** *d*.**s-**<process heading>.**s-**<qualifier>
| <process type definition> **then** *d*.**s-**<process type heading>.**s-**<qualifier>
| <process type reference> **then** *d*.**s-**<identifier>.**s-**<qualifier>
| <system type definition> **then** *d*.**s-**<system type heading>.**s-**<qualifier>
| <system type reference> **then** *d*.**s-**<identifier>.**s-**<qualifier>
otherwise *undefined*
endcase

The function *entityKind0* gets the kind of a given entity definition.

entityKind0(*ed*: *ENTITYDEFINITION0*): *ENTITYKIND0* =$_{def}$
case *ed* **of**
| <agent context parameter> **then** *ed*.**s-**<agent kind>
| <agent type context parameter> **then**
if *ed*.**s-**<agent kind> = **block then block type else process type endif**
| <block definition> **then block**
| <block type definition> **then block type**
| <channel definition> **then channel**
| <composite state type definition> **then state type**
| <composite state definition> **then state**
| <compositestate type context parameter> **then state type**
| <data type definition> **then type**
| <external synonym definition item> **then synonym**
| <gate context parameter> **then gate**
| <interface context parameter name> **then interface**
| <interface definition> **then interface**
| <internal synonym definition item> **then synonym**
| <literal signature> **then literal**
| <operation definition> **then** *ed*.**s-**<operation heading>.**s-**<operation kind>
| <operation signature> **then if** *ed.parentAS0* ∈<operator list> **then operator else method endif**
| <package definition> **then package**
| <procedure context parameter> **then procedure**
| <procedure definition> **then procedure**
| <process definition> **then process**
| <process type definition> **then process type**
| <remote procedure context parameter> **then remote procedure**
| <remote procedure definition> **then remote procedure**
| <remote variables of sort> **then remote variable**
| <remotevariable contextparameter names> **then remote variable**
| <signal context parameter name> **then signal**
| <signal definition> **then signal**
| <signal list definition> **then signallist**

| <sort context parameter> **then type**
| <synonym context parameter name> **then synonym**
| <syntype definition> **then type**
| <system definition> **then system**
| <system type definition> **then system type**
| <textual gate definition> **then gate**
| <textual typebased block definition> **then block**
| <textual typebased process definition> **then process**
| <textual typebased state partition def> **then state**
| <textual typebased system definition> **then system**
| <timer context parameter name> **then timer**
| <timer definition item> **then timer**
| <variable context parameter names> **then variable**
| <variables of sort> **then variable**
otherwise *undefined*
endcase

The function *entityName0* gets the name of a given entity definition.

entityName0(*ed*: *ENTITYDEFINITION0*): <name> =$_{def}$
case *ed* **of**
| <block definition> **then** *ed*.**s-**<block heading>.**s-**<name>
| <block type definition> **then** *ed*.**s-**<block type heading>.**s-**<name>
| <composite state type definition> **then** *ed*.**s-**<composite state type heading>.**s-**<name>
| <composite state definition> **then** *ed*.**s-**<composite state heading>.**s-**<name>
| <data type definition> **then** *ed*.**s-**<data type heading>.**s-**<name>
| <external procedure definition> **then** *ed*.**s-**<procedure heading>.**s-**<name>
| <interface definition> **then** *ed*.**s-**<interface heading>.**s-**<name>
| <internal procedure definition> **then** *ed*.**s-**<procedure heading>.**s-**<name>
| <literal signature> **then**
  if *ed*∈<literal name> **then** *ed*
  elseif *ed*∈<named number> **then** *ed*.**s-**<literal name>
  else *undefined*
  endif
| <operation definition> **then** *ed*.**s-**<operation heading>.**s-**<name>
| <operation signature> **then**
  if *ed*.**s-**<operation name> ∈ <operation<name> **then** *ed*.**s-**<operation name>
  else mk-<name>(*ed*.**s-**<quoted operation name>)
  endif
| <package definition> **then** *ed*.**s-**<package heading>.**s-**<name>
| <process definition> **then** *ed*.**s-**<process heading>.**s-**<name>
| <process type definition> **then** *ed*.**s-**<process type heading>.**s-**<name>
| <signal definition> **then** *ed*.**s-**<name>
| <signal list definition> **then** *ed*.**s-**<name>
| <system definition> **then** *ed*.**s-**<system heading>.**s-**<name>
| <system type definition> **then** *ed*.**s-**<system type heading>.**s-**<name>
| <syntype definition> **then**
  let *s*=*ed*.**s-implicit in**
    if *s*∈<syntype definition syntype> **then** *s*.**s-**<syntype<name>
    else *s*.**s-**<data type heading>.**s-**<data type<name>
    endif
  endlet
| <textual gate definition> **then** *ed*.**s-**<name>
| <textual typebased block definition> **then** *ed*.**s-**<name>
| <textual typebased process definition> **then** *ed*.**s-**<name>
| <textual typebased state partition def> **then** *ed*.**s-**<name>
| <textual typebased system definition> **then** *ed*.**s-**<name>
| <timer definition item> **then** *ed*.**s-**<name>
| <variables of sort> **then** *ed*.**s-**<name>.*head*
| *FORMALCONTEXTPARAMETER0* **then** *ed*.**s-**<name>
endcase

The function *getEntities0* is used to get the entity definitions of the enclosing scope unit.

getEntities0(*n*: *DefinitionAS0*): *ENTITYDEFINITION0** =$_{def}$
if *n* = *undefined* **then** *undefined* **else**
case *n* **of**
| <system type definition> ∪ <block type definition> ∪ <process type definition>
then *n*.**s-**<agent structure>.**s-**<entity in agent>**-seq**
| <agent definition> **then** *n*.**s-**<agent structure>.**s-**<entity in agent>**-seq**
| <composite state definition>(<composite state graph>(*,*,<composite state structure>(*, *entities*,*)))
then *entities*
| <composite state definition>(<state aggregation>(*,*,<aggregation structure>(*entities*,*)))
then *entities*
| <composite state type definition>(
<composite state type graph>(*,*,<composite state structure>(*, *entities*,*),*))
then *entities*
| <composite state type definition>(
<state aggregation type>(*,*,<aggregation structure>(*entities*,*),*))
then *entities*
| <data type definition>(*, *, *,*, <data type definition body>(*entities*, *, *,*)) **then** *entities*
| <internal procedure definition>(*, *, *entities*, *) **then** *entities*
| <package definition>(*, *, *entities*) **then** *entities*
otherwise *n.parentAS0.getEntities0*
endcase
endif

The function *isConstantExpression0* is true if and only if the given expression does not contain an <active primary> or a <value returning procedure call>.

isConstantExpression0 (*expr*: *EXPRESSION0*): *BOOLEAN* =$_{def}$
¬(∃ *subexpr* ∈ <variable access> ∪ <value returning procedure call> : *isAncestorAS0*(*expr*,*subexpr*)

The function *kind0* gets the name of a given entity definition or reference.

kind0(*d*: *ENTITYDEFINITION0*∪ *REFERENCE0*): *ENTITYKIND0* =$_{def}$
case *ed* **of**
| *REFERENCE0* **then** *d.referenceKind0*
| *ENTITYDEFINITION0* **then** *d*. *entityKind0*
endcase

The function *name0* gets the name of a given entity or reference.

name0(*d*: *ENTITYDEFINITION0*∪ *REFERENCE0*): <name> =$_{def}$
case *d* **of**
| *REFERENCE0* **then** *d.referenceName0*
| *ENTITYDEFINITION0* **then** *d.entityName0*
otherwise *undefined*
endcase

The function *natToIntToken* produces a *TOKEN* corresponding to the given Natural number.

natToIntToken(*n*: *NAT*): *INTTOKEN0* =$_{def}$
case *n* **of**
| 0 **then** "0"
| 1 **then** "1"
| 2 **then** "2"
| 3 **then** "3"
| 4 **then** "4"
| 5 **then** "5"
| 6 **then** "6"
| 7 **then** "7"
| 8 **then** "8"
| 9 **then** "9"
otherwise

```
    take({t ∈ TOKEN :
            tens ∈ NAT ∧ tens > 0
        ∧   units ∈ NAT ∧ units < 10
        ∧   n = tens * 10 + units
        ∧   t = if tens=0 then "" else natToIntToken(tens) endif ⌒ natToIntToken(units)
    })
endcase
```

The function *intTokenToNat* produces a *NAT* corresponding to the given *INTTOKEN0*.

```
intTokenToNat(t: INTTOKEN0): NAT =def
    take({n ∈ NAT : natToIntToken(n) = t})
```

The function *predefinedId0* produces the <identifier> of **package** `Predefined` with a specified name given as a character string, for example *predefinedId0*("Charstring").

```
predefinedId0(cs: TOKEN ): <identifier> =def
mk-<identifier>( < mk-<path item>(package, mk-<name>("Predefined"))>, mk-<name>(cs))
```

The function *predefinedItem0* produces an <identifier> for an item defined in a data type of **package** `Predefined` with the specified data type name given as a character string, and the specified item name given as a character string, for example *predefinedItem0*("Boolean","true").

```
predefinedItem0(q: TOKEN, n: TOKEN): <qualifier> =def
mk-<identifier>( predefinedQual0(q), mk-<name>(n))
```

The function *predefinedQual0* produces a <qualifier> for the context of data type defined in **package** `Predefined` with a specified data type name given as a character string, for example *predefinedQual0*("Integer").

```
predefinedQual0(cs: TOKEN ): <qualifier> =def
<  mk-<path item>(package, mk-<name>("Predefined")), mk-<path item>(sort, mk-<name>(cs)) >
```

The function *predefinedSort0* produces a predefined <sort> of **package** `Predefined` with a specified name given as a character string, for example *predefinedSort0* ("Integer").

```
predefinedSort0(cs: TOKEN ): <sort> =def
mk-<sort>(mk-<type expressin>(predefinedId0(cs)))
```

The function *referenceKind0* gets the entity kind of a specified reference.

```
referenceKind0(ref: REFERENCE0 ): ENTITYKIND0=def
case ref of
| <block reference> then block
| <block type reference> then block type
| <composite state reference> then state
| <composite state type reference> then state type
| <operation reference> then ref.s-<operation kind>
| <package reference> then package
| <procedure reference> then procedure
| <process reference> then process
| <process type reference> then process type
| <system type reference> then system type
otherwise undefined
endcase
```

The function *referenceName0* gets the name of a given reference.

```
referenceName0(ref: REFERENCE0 ): <name> =def
case ref of
| TYPEREFERENCE0 then ref.s-<identifier>.s-<name>
| <operation reference> then ref.s-<operation heading>.s-<operation name>
```

otherwise *ref*.**s-**<name>
endcase

The function *surroundingQualifier0* gets the qualifier to use for entities defined in the surrounding scope unit of a node in AS0.

NOTE – The function *surroundingQualifier0* has the same body as the function *fullQualifier0* but accepts any *DefinitionAS0* item as a parameter, whereas *fullQualifier0* requires an *ENTITYDEFINITION0*.

surroundingQualifier0(*d*: *DefinitionAS0*): <qualifier> $=_{def}$
let *su* = *d*.*surroundingScopeUnit0* **in**
if *su* = *undefined* **then** *empty*
else *su*.*fullQualifier0*⌒ **mk-**<path item>(*su*.*entityKind0*, *su*.*entityName0*)
endlet

The function *surroundingScopeUnit0* gets the surrounding scope unit for a node in AS0.

surroundingScopeUnit0(*d*: *DefinitionAS0*): *SCOPEUNIT0* $=_{def}$
if *d* ∈ <referenced definition> ∧ *d*.*parentAS0* ∈ <sdl specification> **then**
parentAS0ofKind(*d*.*referencedBy0*, *SCOPEUNIT0*)
else
parentAS0ofKind(*d*, *SCOPEUNIT0*)
endif

F2.2.1.6.6 Lexis

The following lexical items are used here:

Keywords ... (implicitly as <keyword> :: ())

<asterisk> :: ()

<concatenation sign> :: ()

<equals sign> :: ()

<greater than or equals sign> :: ()

<greater than sign> :: ()

<hyphen> :: ()

<implies sign> :: ()

<infix operation name> ::
<implies sign> | **or** | **xor** | **and**
| <greater than sign> | <greater than or equals sign>
| <less than sign> | <less than or equals sign> | **in**
| <plus sign> | <hyphen> | <concatenation sign> | <asterisk> | <solidus> | **mod** | **rem**

<less than or equals sign> :: ()

<less than sign> :: ()

<not equals sign> :: ()

<plus sign> :: ()

<solidus> :: ()

F2.2.2 Visibility rules, names and identifiers

F2.2.2.1 Name

Abstract syntax

Name	::	*TOKEN*
Agent-name	=	*Name*
Agent-type-name	=	*Name*

Channel-name	=	*Name*
Compound-node-name	=	*Name*
Connector-name	=	*Name*
Data-type-name	=	*Name*
Exception-name	=	*Name*
Gate-name	=	*Name*
Interface-name	=	*Name*
Literal-name	=	*Name*
Operation-name	=	*Name*
Package-name	=	*Name*
Procedure-name	=	*Name*
Signal-name	=	*Name*
State-entry-point-name	=	*Name*
State-exit-point-name	=	*Name*
State-name	=	*Name*
State-type-name	=	*Name*
Syntype-name	=	*Name*
Timer-name	=	*Name*
Variable-name	=	*Name*

NOTE – There are no concrete constructs in SDL-2010 for the use of exceptions, but the concept of an *Exception-name* and *Exception-identifier* is retained for descriptions of when an exception is raised. Therefore, an implementation that handles exceptions can extend the formal semantics. Similarly, for the user of the language there is no syntax for an exception name, but <exception name> is defined for the description of predefined data types [ITU-T Z.104] and the exception names are listed as part of **package** `Predefined`.

Concrete syntax

<name>	:: *TOKEN*
<quoted operation name>	:: *TOKEN*
<character string>	:: *TOKEN*
<hex string>	:: *TOKEN*
<bit string>	:: *TOKEN*
<operation name>	= <operator><name> | <quoted operation name>
<literal name>	= <literal><name> | <string name>
<string name>	= <character string> | <bit string> | <hex string>

NOTE – A lexical distinction is made (in clause 6.1 of [ITU-T Z.101]) between a <name>, an <integer name> and a <real name> to avoid some lexical ambiguities, whereas in the static formal semantics these are (currently) all treated as <name>.

Mapping to abstract syntax

```
| <name>(x) then mk-Name(x)
| <quoted operation name>(x) then mk-Name(x)
| <hex string>(x) then mk-Name(x)
| <bit string>(x) then mk-Name(x)
| <character string>(x) then
    let cscontext = x.parentAS0 in
        case cscontext of
            | <transition option> ∪ <task> ∪ <decision>
```

```
            then mk-Informal-text()
        | <textual answer part>
            then
            let q = cscontext.parentAS0.parentAS0.s-<question> in
                if q.s-<operand5>.s-<primary>.s-<literal identifier> ∈ <character string>
                then mk-Informal-text() // after interpretation how the system behaves is undefined
                else
                    if   (isSubSort0(predefinedId0("Charstring")), q.staticSort0)) ∨
                         (length(x) =1) ∧ (isSubSort0(predefinedId0("Char")) q.staticSort0)) ∨
                         (isSubSort0(predefinedId0("NumericString")), q.staticSort0)) ∨
                         (isSubSort0(predefinedId0("PrintableString")), q.staticSort0)) ∨
                         (isSubSort0(predefinedId0("TeletexString")), q.staticSort0)) ∨
                         (isSubSort0(predefinedId0("VideotexString")), q.staticSort0)) ∨
                         (isSubSort0(predefinedId0("VisibleString")), q.staticSort0))
                    then mk-Name(x)
                    else mk-Informal-text() // after interpretation how the system behaves is undefined
                    endif
                endif
            endlet
        otherwise mk-Name(x)
    endcase
endlet
```

A <character string> in a <textual answer part> is a special case. If the <question> is informal, all the answers have to be <character string> answers and are informal. If the question is an expression (but not a <character string>) of a sort with values that have a <character string> representation (as detailed above), a <character string> represents a value of the sort. If the sort of the question expression is not one of these sorts, the <character string> answer is informal.

F2.2.2.2 Identifier

Abstract syntax

Identifier	::	*Qualifier Name*
Qualifier	=	*Path-item**
Agent-identifier	=	*Identifier*
State-identifier	=	*Identifier*
Agent-type-identifier	=	*Identifier*
Procedure-identifier	=	*Identifier*
Signal-identifier	=	*Identifier*
Data-type-identifier	=	*Identifier*
Sort-reference-identifier	=	*Sort-identifier*
	|	*Syntype-identifier*
Sort-identifier	=	*Identifier*
Syntype-identifier	=	*Identifier*
Timer-identifier	=	*Identifier*
Gate-identifier	=	*Identifier*
Exception-identifier	=	*Identifier*
Composite-state-type-identifier	=	*Identifier*
Literal-identifier	=	*Identifier*
Operation-identifier	=	*Identifier*
Variable-identifier	=	*Identifier*

Conditions on abstract syntax

$\forall d, d1 \in$ *EntityDefinition1*: *d.entityKind1 = d1.entityKind1* $\wedge$ *d* $\neq$ *d1* $\Rightarrow$ *d.identifier1* $\neq$ *d1.identifier1*

Each entity of a kind shall have an *Identifier* different from any other entity of the same kind.

NOTE - Consequently, no two definitions in the same scope unit and belonging to the same entity kind are allowed to have the same <name>, except operations defined in the same <data type definition> that differ in at least one argument <sort> or the result <sort> (in which case they have different *Operation-name* values).

Concrete syntax

<identifier> :: <qualifier> <name>

<qualifier> = <path item>*

Transformations

i=<identifier> **provided** *i* $\neq$ *fullIdentifier0*(*i*) =14=> *fullIdentifier0*(*i*)

It is allowed to omit some of the leftmost <path item>s, or the whole <qualifier> of an <identifier> if it is possible to uniquely expand the remaining <path item>s to a full <qualifier>. See clause 6.6 of [ITU-T Z.101].

Mapping to abstract syntax

| <identifier>(*q*, *name*) => **mk-***Identifier*(*Mapping*(*q*), *Mapping*(*name*))

Auxiliary functions

For any given identifier, return its full identifier.

fullIdentifier0(*i*:<identifier>): <identifier> =$_{\text{def}}$ *i.refersto0.identifier0*

For any given identifier, return the definition it refers to.

refersto0(*i*:<identifier>): *EntityDefinition0* =$_{\text{def}}$ *getEntityDefinition0*(*i*, *idKind0*(*i*))

For any given entity definition in AS0, the function *identifier0* returns its identifier with full qualifier.

identifier0(*def*: *EntityDefinition0*): <identifier> =$_{\text{def}}$
mk-<identifier>(*def.fullQualifier0*, *def.entityName0*)

The function *fullQualifier0* is used to get the full qualifier for an entity definition.

fullQualifier0(*d*: *EntityDefinition0*): <qualifier> =$_{\text{def}}$
let *su* = *d.surroundingScopeUnit0* **in**
if *su* = *undefined* **then** *empty*
else *su.fullQualifier0*$^\frown$ **mk-**<path item>(*su.entityKind0*, *su.entityName0*)
endlet

The function *fullQualifierWithin0* is used to get the full qualifier for items defined directly within the entity definition *d*.

fullQualifierWithin0(*d*: *EntityDefinition0*): <qualifier> =$_{\text{def}}$
d.fullQualifier0 $^\frown$ **mk-**<path item>(*d.entityKind0*, *d.entityName0*)

The function *getEntityDefinition0* is used to get the definition that the given identifier refers to.

getEntityDefinition0(*id*:<identifier>, *ek*: *EntityKind0*): *EntityDefinition0* =$_{\text{def}}$
if *ek*$\in${**operator**, **literal**, **method**} **then**
resolveByContext0(*id*)
else
let *su* = *getStartingScopeUnit0*(*id*, *id.surroundingScopeUnit0*) **in**
if *su* = *undefined* **then** *undefined*

```
            else resolveByContainer0(su, id, ek)
            endif
        endlet
    endif
```

The function *resolveByContainer0* binds an <identifier> to a definition through resolution by container.

```
resolveByContainer0(su: SCOPEUNIT0, id:<identifier>, ek:ENTITYKIND0): ENTITYDEFINITION0 =def
    let d1=bindInLocalDefinition0(su, id, ek) in
        if d1≠ undefined then d1
        else let d2=bindInBaseType0(su, id, ek) in
            if d2≠ undefined then d2
            else let d3=bindInUsedPackage0(su.s-<package use clause>-seq, id, ek) in
                if d3≠ undefined then d3
                else let d4=bindInLocalInterface0(su.localInterfaceDefinitionSet0, id, ek) in
                    if d4≠ undefined then d4
                    else let su1=su.surroundingScopeUnit0 in
                        if su1 ≠ undefined
                        then resolveByContainer0(su1, id, ek)
                        elseif ek= system ∧ (∃ sd ∈ <system definition>: sd.s-<name> = id.s-<name> ) then
                            take({sd ∈ <system definition>: sd.s-<name> = id.s-<name>})
                        elseif ek= package ∧ id.s-<qualifier> = undefined
                            ( ∃ pd ∈ <package definition>: pd.s-<name> = id.s-<name>
                                ∧ pd.s-<qualifier> = undefined)
                        then
                            take({pd ∈ <package definition>: pd.s-<name> = id.s-<name>
                                ∧ pd.s-<qualifier> = undefined})
                        else undefined
                        endif endlet
                    endif endlet
                endif endlet
            endif endlet
        endif
    endlet
```

The function *bindInLocalDefinition0* is used to search in the given scope unit to determine if there exists a local entity definition for the specified identifier.

```
bindInLocalDefinition0(su: SCOPEUNIT0, id: <identifier>, ek: ENTITYKIND0): ENTITYDEFINITION0=def
    let d = take({d∈ ENTITYDEFINITION0:
            d.surroundingScopeUnit0 = su ∧ isSameEntityName0(id.s-<name>, d )∧
            isConsistentKindTo0(d.entityKind0, ek)∧isVisibleIn0(d, id.surroundingScopeUnit0)}) in
        if d ≠ undefined then d
        else let rd = take({rd ∈REFERENCE0 : rd.surroundingScopeUnit0 = su ∧
                rd. referencedDefinition0.entityName0= id.s-<name>∧
                isConsistentKindTo0(rd.referencedDefinition0.entityKind0, ek) ∧
                isVisibleIn0(rd, id.surroundingScopeUnit0))}) in
            if rd ≠ undefined then rd.referencedDefinition0
            else undefined
            endif endlet
        endif
    endlet
```

The function *bindInBaseType0* finds the entity definition corresponding to the given <identifier> in the base type of the scope unit if there is a specialization and the <identifier> is not within the specialization.

```
bindInBaseType0(su: SCOPEUNIT0, id: <identifier>, ek: ENTITYKIND0): ENTITYDEFINITION0=def
    let spec = su.specialization0 in
        if (spec = undefined) ∨ isAncestorAS0(spec, id) then undefined
```

```
        else resolveByContainer0(spec.s-<type expression>.baseType0, id, ek)
        endif
    endlet
```

The function *bindInUsedPackage0* finds the entity definition corresponding to the given <identifier> in the used packages of the scope unit.

```
bindInUsedPackage0(ucl:<package use clause>*, id: <identifier>, ek: ENTITYKIND0):
    ENTITYDEFINITION0=def
    if ucl = empty then undefined
    elseif ucl.head = id.parentAS0 then
        bindInUsedPackage0(ucl.tail, id, ek)
    else
        let d = bindInLocalDefinition0(ucl.head.usedPackage0, id, ek) in
            if d ≠ undefined then d
            else bindInUsedPackage0(ucl.tail, id,ek)
            endif
        endlet
    endif
```

The function *bindInLocalInterface0* finds the entity definition corresponding to the given <identifier> in the interfaces of the scope unit.

```
bindInLocalInterface0(is:<interface definition>-set, id: <identifier>, ek: ENTITYKIND0):
    ENTITYDEFINITION0 =def
    if is = ∅ then undefined
    else let d = is.take in
            let ed = bindInLocalDefinition0(d, id, ek) in
        if ed ≠ undefined then ed
        else bindInLocalInterface0(is \ {d})
        endif
        endlet
    endif
```

The function *isSameEntityName0* is used to determine if the given name has the same name as the entity definition.

```
isSameEntityName0(n: <name>, d: ENTITYDEFINITION0 ): BOOLEAN=def
    (n = d.entityName0)
```

For a given identifier (left most path item may be omitted), the function *getStartingScopeUnit0* gets the starting scope unit denoted by the partial qualifier.

```
getStartingScopeUnit0(id: <identifier>, su: SCOPEUNIT0): SCOPEUNIT0=def
    if su= undefined then undefined
    elseif isQualifierMatched0(id.s-<qualifier>, su) then su
    else let su1= getStartingSuInUsedPackage0(id, su.usedPackageDefinitionList0) in
        if su1≠ undefined then su1
        else let su2= getStartingSuInInterface0(id, su.localInterfaceDefinitionSet0) in
            if su2≠ undefined then su2
            else getStartingScopeUnit0(id, su.surroundingScopeUnit0)
            endif
            endlet
        endif endlet
    endif
```

The function *getStartingSuInUsedPackage0* finds the starting scope unit in the packages list.

```
getStartingSuInUsedPackage0(id: <identifier>, pdl:<package definition>*): SCOPEUNIT0=def
    if pdl =empty then undefined
    elseif isQualifierMatched0(id.s-<qualifier>, pdl.head) then pdl.head
    else getStartingSuInUsedPackage0(id, pdl.tail)
    endif
```

The function *getStartingSuInInterface0* finds the starting scope unit in the interface list.

```
getStartingSuInInterface0(id: <identifier>, ifds:<interface definition>-set): ScopeUnit0=def
    if ifds = ∅ then undefined
    else let d = ifds.take in
        if isQualifierMatched0(id.s-<qualifier>, d) then d
        else getStartingSuInInterface0(id, ifds \ {d})
        endif endlet
    endif
```

The function *isDefinedIn0* determines if an entity definition is defined in a given scope unit.

```
isDefinedIn0(ed: EntityDefinition0, su: ScopeUnit0): Boolean=def
    if (su = undefined ∨ ed =undefined)then false
    else
            su = ed.surroundingScopeUnit0 ∨
            isVisibleInInterface0(ed, su) ∨
            isVisibleInDataType0(ed, su) ∨
            isVisibleThroughBaseType0(ed, su)
    endif
```

The function *isVisibleIn0* determines if an entity definition is visible in a given scope unit.

```
isVisibleIn0(ed: EntityDefinition0, su: ScopeUnit0): Boolean=def
    isDefinedIn0(ed, su) ∨
    isVisibleThroughUsedPackage0(ed, su) ∨
    isVisibleIn0(ed, su.surroundingScopeUnit0)
```

The function *isVisibleInInterface0* determines if the scope unit contains an <interface definition> that is the defining context of the entity.

```
isVisibleInInterface0(ed: EntityDefinition0, su: ScopeUnit0): Boolean=def
    ( ed.surroundingScopeUnit0∈ su.localInterfaceDefinitionSet0 )
```

The function *isVisibleInDataType0* determines if the scope unit contains a <data type definition> which is the defining context of the entity.

```
isVisibleInDataType0(ed: EntityDefinition0, su: ScopeUnit0): Boolean=def
    (ed.surroundingScopeUnit0∈ su.localDataTypeDefinitionSet0) ∧
    (ed∈<literal signature> ∪ <operation signature> ⇒ ed.isPublic0)
```

The function *isVisibleThroughBaseType0* determines if the entity is visible through the base type of the scope unit. The entity is visible if the type is a direct sub type of the base type in which the entity is visible, and the entity is either a literal/operation (that is not private/renamed) or is a formal context parameter of the base type not bound to an actual context parameter.

```
isVisibleThroughBaseType0(ed: EntityDefinition0, su: ScopeUnit0): Boolean=def
    let spec = su.specialization0 in
        if spec = undefined then false
        else (∃btd∈TypeDefinition0 : isDirectSubType0(su, btd) ∧ isVisibleIn0(ed, btd) ∧
            (ed ∈ <literal signature>∪<operation signature> ⇒
                ¬isPrivate0(ed)∧¬ isRenamedBySpec0(ed, spec))∨
            ed∈ FormalContextParameter0⇒¬isBoundToActualContextPara0(ed, spec))
        endif
    endlet
```

The function *isVisibleThroughUsedPackage0* determines if an entity definition is visible through used packages.

```
isVisibleThroughUsedPackage0(ed: EntityDefinition0, su: ScopeUnit0): Boolean =def
    let ucs = su.s-<package use clause>-seq.toSet in
        if ucs = ∅ then false
```

```
        else (∃uc∈ucs: ed.surroundingScopeUnit0= uc.usedPackage0∧
                isVisibleThroughUseClause0(ed, uc))
        endif
    endlet
```

The function *isBoundToActualContextPara0* determines if a <formal context parameter> is bound to an <actual context parameter> in a <specification>.

```
isBoundToActualContextPara0 (fcp: FORMALCONTEXTPARAMETER0, spec: <specialization>):
    BOOLEAN =def
    (∃acp∈<actual context parameter>:
        acp.parentAS0.parentAS0 = spec∧isContextParameterCorresponded0(fcp, acp))
```

The function *isVisibleThroughUseClause0* determines if an entity definition is visible through the <package public> and <package use clause>.

```
isVisibleThroughUseClause0(ed: ENTITYDEFINITION0, uc:<package use clause>): BOOLEAN =def
    let pd=uc.usedPackage0 in
    let pp = pd.s-<package heading>.s-<package public> in
        (pp = undefined∨
            ∃ds∈ <definition selection>: ds.parentAS0= pp∧
                isMentionedInDefSelection0(ed, ds, pd)) ∧
        (uc.s-<definition selection>-seq = empty ∨
            ∃ds∈<definition selection>: ds.parentAS0 = uc ∧
                isMentionedInDefSelection0(ed, ds, pd))
    endlet
```

The function *isMentionedInDefSelection0* determines if an entity is mentioned in a <definition selection>.

```
isMentionedInDefSelection0
    (ed: ENTITYDEFINITION0, ds:<definition selection>, pd:<package definition>):
        BOOLEAN =def
    (ds.s-<name> = ed. entityName0 ∧
        (ds.s-<selected entity kind> ≠undefined⇒ ds.s-<selected entity kind> = ed. entityKind0))∨
    (ed.entityKind0= signal ∧ ds.s-<selected entity kind> = signallist ∧
        (∃sld∈<signal list definition>: sld.surroundingScopeUnit0= pd∧
            sld. entityName0= ds.s-<name> ∧
            (∃sigId∈ sld.signalSet0: getEntityDefinition0(sigId, signal) = ed)))
```

The function *isConsistentKindTo0* is used to determine if the first entity kind is consistent to the second one.

```
isConsistentKindTo0(t1: ENTITYKIND0, t2: ENTITYKIND0): BOOLEAN =def
    t1 = t2 ∨
    (t2= agent) ∧ ((t1 = system)∨(t1 = block)∨(t1 = process)) ∨
    (t2= agent type) ∧ ((t1 = system type)∨(t1 = block type)∨(t1 = process type)) ∨
    (t2 = sort)∧(( t1=interface)∨( t1= type))
```

The function *isQualifierMatched0* is used to determine if the given <qualifier> is the same as the rightmost part of the full <qualifier> denoting the given scope unit.

```
isQualifierMatched0(q1: <qualifier>, su: SCOPEUNIT0): BOOLEAN =def
if q1 = undefined then true
elseif su∈<compound statement> then false
else
    let q2 = su.fullQualifier0 ⁀< mk-<path item>(su.entityKind0, su.entityName0) > in
        (q1.length≤ q2. length∧
            (∀i∈1.. q1.length:∀j∈NAT: j = q2.length - q1. length+ i ⇒
                (q1[i].s-<name> = q2[j].s-<name> ∧
                    (q1[i].s-<scope unit kind> ≠ undefined ⇒
```

```
                    q1[i].s-<scope unit kind> = q2[j].s-<scope unit kind>))))
    endlet
endif
```

The function *resolveByContext0* is used to bind all <name>s of entity kind **operator**, **method** and **literal** in an <expression> in an <assignment> or <decision> or <expression> to their corresponding entity definitions. The function *resolveByContext0* is called only from *getEntityDefinition0* with the identifier of an **operator**, **method** and **literal**.

```
resolveByContext0(id:<identifier>):ENTITYDEFINITION0=def
    let bl = take(getBindingListSet0(id.contextOfIdentifier0)) in
        getDefinitionInBindingList0 (id.s-<name>, bl)
    endlet
```

The function *contextOfIdentifier0* gets the context for resolving the identifier.

```
contextOfIdentifier0(id:<identifier>):CONTEXT0=def
    if (∃exp∈<expression>: isAncestorAS0(exp, id))
    then contextOfExp0(parentAS0ofKind(id, <expression>))
    else undefined
    endif
```

The function *getBindingListSet0* is used to bind all <name>s of entity kind **operator**, **method** and **literal** in the context to their corresponding entity definitions.

```
getBindingListSet0(c: CONTEXT0): BINDINGLIST0-set =def
    let nameList = c.nameList0 in
    let possibleBindingListSet = nameList.possibleBindingListSet0 in
    let possibleResultSet = {pbl∈ possibleBindingListSet: isSatisfyStaticCondition0(pbl, c)} in
    let resultSet = {r∈ possibleResultSet: ∀r1∈ possibleResultSet: r ≠ r1 ⇒
                        mismatchNumber0(r, c)≤ mismatchNumber0(r1, c)} in
        if |resultSet| = 1 then resultSet
        else ∅
        endif
    endlet
```

The function *nameList0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in the context.

```
nameList0(c: CONTEXT0): <name>*=def
    case c of
    |<assignment> then c.s-<variable>.nameListInVariable0⌒c.s-<expression>.nameListInExpression0
    |<decision> then c.nameListInDecision0
    |<expression> then c.nameListInExpression0
    otherwise empty
    endcase
```

The function *nameListInExpression0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in the <expression>.

```
nameListInExpression0(exp: <expression>):<name>*=def
case exp of
| <binary expression> then
    let mk-<binary expression>(e1, op, e2)= exp in
        exp.s1-<expression>.nameListInExpression0⌒
        binaryOpName0(exp) ⌒
        exp.s2-<expression>.nameListInExpression0
    endlet
| <create expression> then
    exp.actualParameterList0.nameListInActualParameterList0
| <equality expression> then
```

exp.**s1-**<expression>.*nameListInExpression0* ⌒
case *exp*.**s-implicit of**
| <equals sign> **then** < **mk-**<name>("=") >
| <not equals sign> **then** < **mk-**<name>("/=") >
endcase ⌒
exp.**s2-**<expression>.*nameListInExpression0*
| <range check expression> **then** *exp*.**s-**<expression>.*nameListInExpression0*
| <operand5> **then**
case *exp*.**s-implicit of**
| <hyphen> **then** < **mk-**<name>("-") >
| **not then** < **mk-**<name>("not") >
otherwise *empty*
endcase ⌒ *exp*.**s-**<primary>.*nameListInPrimary0*
| <value returning procedure call> **then**
exp.actualParameterList0.nameListInActualParameterList0
endcase

The function *nameListInPrimary0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in the <primary>.

nameListInPrimary0(*p*: <primary>):<name>*=$_{def}$
case *p* **of**
| <conditional expression> **then**
p.**s-**<expression>.*nameListInExpression0*⌒
p.**s-**<consequence expression>.*nameListInExpression0*⌒
p.**s-**<alternative expression>.*nameListInExpression0*
| <expression> **then** *p.nameListInExpression0*
| <extended primary> **then** *p.nameListInExtendedPrimary0*
| <literal> **then** <*p*.**s-**<literal identifier>.**s-**<literal name>>
| <operator application> **then** *p.nameListInOperationApplication0*
otherwise: *empty*
endcase

The function *nameListInOperationApplication0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in the <operation application>.

nameListInOperationApplication0(*oa*: <operator application>):<name>*=$_{def}$
case *oa* **of**
| <method application> **then**
oa.**s-**<primary>.*nameListInPrimary0*⌒<*oa*.**s-**<operation identifier>.**s-**<operation name>>⌒
oa.actualParameterList0.nameListInActualParameterList0
| <operator application> **then**
<*oa*.**s-**<operation identifier>>⌒*oa.actualParameterList0.nameListInActualParameterList0*
endcase

The function *nameListInExtendedPrimary0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in the <extended primary>.

nameListInExtendedPrimary0(*ep*:<extended primary>):<name>*=$_{def}$
case *ep* **of**
| <composite primary> **then** *ep*.**s-**<actual parameter>**-seq**.*nameListInActualParameterList0*
| <field primary> **then** *ep*.**s-**<primary>.*nameListInPrimary0*
| <indexed primary> **then**
ep.**s-**<primary>.*nameListInPrimary0*⌒
ep.**s-**<actual parameter>**-seq**.*nameListInActualParameterList0*
endcase

The function *nameListInActualParameterList0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in the actual parameter list.

```
nameListInActualParameterList0(el: <expression>*): <name>*=def
    if el = empty then empty
    else
        el.head.nameListInExpression0⌒el.tail.nameListInActualParameterList0
    endif
```

The function *nameListInVariable0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in <variable>.

```
nameListInVariable0(v:<variable>):<name>*=def
    if v∈<indexed variable> then
        v.s-<variable>.nameListInVariable0⌒
            v.s-<actual parameter>-seq.nameListInActualParameterList0
    elseif v∈<field variable> then
        v.s-<variable>.nameListInVariable0
    else empty
    endif
```

The function *nameListInDecision0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in the <decision>.

```
nameListInDecision0 (d: <decision>): <name>*= def
    d.s-<question>.nameListInExpression0⌒ d.rangeConditionList0.nameListInRangeConditions0
```

The function *nameListInRangeConditions0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in the <range condition> list.

```
nameListInRangeConditions0 (rcl: <range condition>*): <name>*= def
    if rcl = empty then empty
    else rcl.head.nameListInRangeList0⌒rcl.tail.nameListInRangeConditions0
```

The function *nameListInRangeList0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in the <range> list.

```
nameListInRangeList0 (rl: <range>*): <name>*= def
    if rl = empty then empty
    else rl.head.nameListInRange0⌒rl.tail.nameListInRangeList0
```

The function *nameListInRange0* gets all the <name>s of entity kind **operator**, **method** and **literal** appearing in the <range>.

```
nameListInRange0(r: <range>): <name>*= def
    case r of
    | <closed range> then
        let r = mk-<closed range> (c1, c2) in
            c1.nameListInExpression0⌒c2.nameListInExpression0
        endlet
    | <open range> then
        let r = mk-<open range>(c1, n, c2) in
            c1.nameListInExpression0⌒ <n> ⌒c2.nameListInExpression0
        endlet
    endcase
```

Each element in the *possibleBindingListSet0* represents a possible resolution for the given name list.

```
possibleBindingListSet0(n: <name>*):BINDINGLIST0-set =def
    {b∈BINDINGLIST0: b.length = n.length∧
    ∀i∈1..b.length:b[i].s-<name>= n[i]∧ b[i].s-ENTITYDEFINITION0∈n[i].possibleDefinitionSet0}
```

The function *isSatisfyStaticCondition0* determines if the binding violates any static sort constraints in the context.

```
isSatisfyStaticCondition0(bl:BINDINGLIST0, c:CONTEXT0): BOOLEAN=def
    case c of
    | <assignment> then isSatisfyAssignmentCondition0(bl, c)
    | <decision> then isSatisfyDecisionCondition0(bl, c)
    | <expression> then isSatisfyExpressionCondition0(bl, c)
    otherwise false
    endcase
```

The function *isSatisfyAssignmentCondition0* determines if the binding violates any static sort constraints in the <assignment>.

```
isSatisfyAssignmentCondition0(bl:BINDINGLIST0, ass: <assignment>): BOOLEAN=def
    let varSort= getVariableSort0(ass.s-<variable>) in
    let expSort= getStaticSort0(ass.s-<expression>, bl) in
        (isSortCompatible0(varSort, expSort) ∨ isSortCompatible0(expSort, varSort))∧
        (ass.s-<variable>∈<indexed variable>⇒
            isSatisfyIndexVariableCondition0(bl, ass.s-<variable>)
    endlet
```

The function *isSatisfyIndexVariableCondition0* determines if the binding violates any static sort constraints in the <indexed variable>.

```
isSatisfyIndexVariableCondition0(bl:BINDINGLIST0, var:<indexed variable>): BOOLEAN=def
    let apl=var.s-<actual parameter>-seq in
        isSortCompatible0(getStaticSort0(apl[1],bl), getIndexSort0(getVariableSort0(var)))∧
        (var.s-<variable>∈<indexed variable>⇒
            isSatisfyIndexVariableCondition0(bl, var.s-<variable>))
    endlet
```

Get the static sort of a <variable>.

```
getVariableSort0(var:<variable>):<sort>=def
    case var of
    | <identifier> then getEntityDefinition0(var, variable).parentAS1.s-<sort>
    | <indexed variable> then getItemSort0(getVariableSort0(var.s-<variable>))
    | <field variable> then getFieldSort0(getVariableSort0(var.s-<variable>), var.s-<field name>)
    endcase
```

The function *getItemSort0* gets the item sort of a <sort> that is a subtype of the predefined sort String or Vector or Array.

```
getItemSort0(s: <sort>):<sort>=def
    let d=getEntityDefinition0(s, sort).derivedDataType0 in
        if d.specialization0 = undefined then undefined
        else
        let btn= d.specialization0.s-<base type>.s-<name> in
            if btn = "String" ∨ btn = "Vector"
            then d.actualContextParameterList0[1]
            elseif btn = "Array"
            then d.actualContextParameterList0[2]
            else undefined
            endif
        endlet
        endif
    endlet
```

The function *getIndexSort0* gets the index sort of a <sort> that is a subtype of the predefined sort String or Vector or Array.

```
getIndexSort0(s: <sort>):<sort>=def
    let d=getEntityDefinition0(s, sort).derivedDataType0 in
        if d.specialization0 = undefined then undefined
        else
        let btn= d.specialization0.s-<base type>.s-<name> in
            if btn = "String" ∨ btn = "Vector"
            then predefinedId0("Integer"))
            elseif btn = "Array"
            then d.actualContextParameterList0[1]
            else undefined
            endif
        endlet
        endif
    endlet
```

The function *getFieldSort0* gets the field sort of a field name in the <data type definition> referred by the given <sort>.

```
getFieldSort0(s: <sort>, n:<name>):<sort>=def
    let d=getEntityDefinition0(s, sort).derivedDataType0 in
    let cons= d.s-<data type definition body>.s-<data type constructor> in
        if cons ∈ <structure definition> then
            take({fos.s-<sort> : fos∈<fields of sort>∧
                    (∃name∈<name>: name.parentAS0=fos∧name=n)})
        else undefined
        endif
    endlet
```

The function *isSatisfyStaticCondition0* determines if the binding violates any static sort constraints in the <decision>.

```
isSatisfyDecisionCondition0(bl:BINDINGLIST0, d: <decision>): BOOLEAN=def
    let q=d.s-<question>, rcs=d.rangeConditionList0.toSet in
        isSatisfyExpressionCondition0(bl, q)∧
        (∀rc1∈rcs:∀ce1∈<constant expression>:isAncestorAS1(rc1, ce1)⇒
            isSatisfyExpressionCondition0(bl, ce1)∧
            isSortCompatible0(getStaticSort0(ce1, bl), getStaticSort0(q, bl)∧
            (∀rc2∈rcs: ∀ce2∈<constant expression>:isAncestorAS1(rc2, ce2)⇒
                (isSortCompatible0(getStaticSort0(ce1, bl), getStaticSort0(ce2, bl))∨
                    isSortCompatible0(getStaticSort0(ce2, bl), getStaticSort0(ce1, bl))))
    endlet
```

The function *isSatisfyExpressionCondition0* determines if the binding violates any static sort constraints in the <expression>.

```
isSatisfyExpressionCondition0(bl:BINDINGLIST0, exp: <expression>): BOOLEAN=def
case exp of
| <binary expression> then
    let opDef = getDefinitionInBindingList0(binaryOpName0(exp), bl) in
    let fpl = opDef.operationParameterSortList0 in
        fpl.length = 2∧
        isSortCompatible0(getStaticSort0(exp.s-<expression>, bl), fpl[1])∧
        isSortCompatible0(getStaticSort0(exp.s2-<expression>, bl), fpl[2])∧
        isSatisfyExpressionCondition0 (bl, exp.s-<expression>)∧
        isSatisfyExpressionCondition0 (bl, exp.s2-<expression>)
    endlet
    endlet
| <create expression> then isSatisfyCreateCondition0(bl, exp)
| <equality expression> then isSatisfyEqualityExpCondition0(bl, exp)
| <operand5> then
    let pr = exp.s-<primary> in
    case exp.s-implicit of
```

```
    | <hyphen> then
        let fpl = getDefinitionInBindingList0(mk-<name>("-"),bl).operationParameterSortList0 in
            fpl.length = 1∧
            isSortCompatible0(getStaticSort0(pr, bl), fpl[1])∧
            isSatisfyPrimaryCondition0(bl, pr)
        endlet
    | not then
        let fpl = getDefinitionInBindingList0(mk-<name>("not"),bl).operationParameterSortList0 in
            fpl.length = 1∧
            isSortCompatible0(getStaticSort0(pr, bl), fpl[1])∧
            isSatisfyPrimaryCondition0(bl, pr)
        endlet
    otherwise isSatisfyPrimaryCondition0(bl, pr)
    endcase
    endlet // pr
| <range check expression> then isSatisfyRangeCheckCondition0(bl, exp)
| <value returning procedure call> then
    if exp∈<procedure call body> then isSatisfyProcedureCallBodyCondition0(bl, exp)
    else isSatisfyRemoteProcCallBodyCondition0(bl, exp)
    endif
endcase
```

The function *isSatisfyCreateCondition0* determines if the binding violates any static sort constraints in the <expression>.

```
isSatisfyCreateCondition0(bl: BINDINGLIST0, ce: <create expression>):BOOLEAN =def
    let def = ce.getCreatedAgentDefinition0 in
    if def =undefined then false
    else
        let fpl = def.agentFormalParameterList0 in
        let apl = ce.actualParameterList0 in
            fpl.length=apl.length ∧
            (∀i∈1..fpl.length: isSortCompatible0(getStaticSort0(apl[i], bl), fpl[i].parentAS1.s-<sort>)∧
            isSatisfyExpressionCondition0(bl, apl[i]))
        endlet
        endlet
    endif endlet
```

The function *getCreateExpSort0* gets the static sort of <create expression>.

```
getCreateExpSort0 (ce: <create expression>): <sort>=def
    let def = ce.getCreatedAgentDefinition0 in
    if def =undefined then Pid
    else def.identifier0
    endif endlet
```

The function *isSatisfyProcedureCallBodyCondition0* determines if the binding violates any static sort constraints in the <procedure call body>.

```
isSatisfyProcedureCallBodyCondition0(bl: BINDINGLIST0, body: <procedure call body>):BOOLEAN=def
    let apl = body.actualParameterList0 in
    let fpsl=body.calledProcedure0.formalParameterSortList0 in
        fpsl.length=apl.length ∧
        (∀i∈1..fpsl.length: isSortCompatible0(getStaticSort0(apl[i], bl), fpsl[i)∧
        isSatisfyExpressionCondition0(bl, apl[i]))
    endlet
    endlet
```

The function *getProcCallBodySort0* gets the static sort of <procedure call body>.

```
getProcCallBodySort0 (body: <procedure call body>): <sort>=def
    case body.s-implicit of
    | id  = <identifier> then getEntityDefinition0(id, procedure).procedureResult0
```

```
    | te  = <type expression> then te.baseType0.procedureResult0
    endcase
```

The function *procedureResult0* gets the result sort of a <procedure definition>.

```
procedureResult0(pd: <procedure definition>):<sort>=def
    if pd.s-<procedure heading>.s-<procedure result>≠undefined then
        pd.s-<procedure heading>.s-<procedure result>
    elseif pd.specialization0 ≠ undefined then
            pd.baseType0.procedureResult0
    else undefined
    endif
```

The function *getRemoteProcCallBodySort0* gets the static sort of <remote procedure call body>.

```
getRemoteProcCallBodySort0 (body: <remote procedure call body>, bl: BINDINGLIST0): <sort>=def
    getEntityDefinition0(body.s-<remote procedure<identifier>,remote procedure).procedureResult0
```

The function *isSatisfyRemoteProcCallBodyCondition0* determines if the binding violates any static sort constraints in the <remote procedure call body>.

```
isSatisfyRemoteProcCallBodyCondition0(bl: BINDINGLIST0, body: <remote procedure call body>):
    BOOLEAN =def
    let rpd = getEntityDefinition0(body.s-<remote procedure<identifier>,remote procedure) in
    let fpsl= rpd.formalParameterSortList0 in
    let apl = body.actualParameterList0 in
        fpsl.length=apl.length ∧
        (∀i∈1..fpsl.length: isSortCompatible0(getStaticSort0(apl[i], bl), fpsl[i])∧
        isSatisfyExpressionCondition0(bl, apl[i]))
    endlet
    endlet
    endlet
```

The function *operationResultSort0* gets the result sort of an <operation signature>.

```
operationResultSort0(os:<operation signature>):<sort>=def
    if os∈PREDEFINEDOPERATION0 then os. getPredefinedOpResult0
    else os.s-<result>.s-<sort>
    endif
```

The function *isSatisfyRangeCheckCondition0* determines if the binding violates any static sort constraints in the <range check expression>.

```
isSatisfyRangeCheckCondition0(bl: BINDINGLIST0, rce: <range check expression>): BOOLEAN=def
if rce.s-implicit ∈ <range check constrained sort> then
    isSatisfyExpressionCondition0(bl, rce.s-<expression>)∧
    isSameSort0(getStaticSort0(rce.s-<expression>, bl), rcesort.s-<sort<identifier>)
elseif rce.s-implicit ∈ <identifier> ∧ getEntityDefinition0(rce.s-implicit,sort) ∈ <syntype definition>
then // syntype
    isSatisfyRangeCheckCondition0(bl,
        mk-<range check expression>(rce.s-<expression>,
            mk-<range check constrained sort>( rce.s-implicit,
                getEntityDefinition0(rce.s-implicit,sort).s-implicit.s-<constraint>)))
elseif rce.s-implicit ∈ <identifier> ∧ isPidSort0(mk-<sort>( (rce.s-implicit))
then // pid sort
    isPidSort0(getStaticSort0(rce.s-<expression>, bl)) // expression has to be pid sort
else true // <datatype<type expression> any expression valid. Type check in F3
endif
```

The function *isSatisfyEqualityExpCondition0* determines if the binding violates any static sort constraints in the <equality expression>.

```
isSatisfyEqualityExpCondition0(bl: BINDINGLIST0, eq: <equality expression>): BOOLEAN=def
```

isSatisfyExpressionCondition0(*bl*, *eq*.**s-**<expression>)∧
isSatisfyExpressionCondition0(*bl*, *eq*.**s2-**<expression>)∧
(*isSortCompatible0*(*getStaticSort0*(*eq*.**s-**<expression>, *bl*), *getStaticSort0*(*eq*.**s2-**<expression>, *bl*))∨
isSortCompatible0(*getStaticSort0*(*eq*.**s2-**<expression>, *bl*),
getStaticSort0(*eq*.**s-**<expression>, *bl*)))

The function *isSatisfyPrimaryCondition0* determines if the binding violates any static sort constraints in the <primary>.

isSatisfyPrimaryCondition0(*bl*: *BINDINGLIST0*, *pr*: <primary>):*BOOLEAN*=$_{\text{def}}$
case *pr* **of**
| <operator application> **then** *isSatisfyOpAppCondition0*(*bl*, *pr*)
| <method application> **then** *isSatisfyMethodAppCondition0*(*bl*, *pr*)
| <expression> **then** *isSatisfyExpressionCondition0*(*bl*, *pr*)
| <conditional expression> **then**
isSatisfyExpressionCondition0(*bl*, *pr*.**s-**<expression>)∧
isSatisfyExpressionCondition0(*bl*, *pr*.**s-**<consequence expression>)∧
isSatisfyExpressionCondition0(*bl*, *pr*.**s-**<alternative expression>)
| <extended primary> **then** *isSatisfyExtendedPrimaryCond0*(*bl*, *pr*)
otherwise *true*
endcase

The function *isSatisfyExtendedPrimaryCond0* determines if the binding violates any static sort constraints in the <extended primary>.

isSatisfyExtendedPrimaryCond0(*bl*: *BINDINGLIST0*, *epr*: <extended primary>):*BOOLEAN*=$_{\text{def}}$
case *epr* **of**
| <indexed primary> **then**
isSatisfyPrimaryCondition0(*epr*.**s-**<primary>, *bl*)∧
(∀*i*∈1..*epr*.**s-**<actual parameter>-**seq**.*length*:
isSatisfyExpressionCondition0(*bl*,*epr*.**s-**<actual parameter>-**seq**[*i*]))∧
isSortCompatible0(*getStaticSort0*(*epr*.**s-**<actual parameter>-**seq**[1], *bl*),
getIndexSort0(*getPrimarySort0*(*epr*.**s-**<primary>, *bl*)))
| <field primary> **then**
(*epr*.**s-**<primary> ≠ *undefined*)⇒
(*isSatisfyPrimaryCondition0*(*epr*.**s-**<primary>, *bl*)∧
getFieldSort0(*getPrimarySort0*(*epr*.**s-**<primary>, *bl*), *epr*.**s-**<field name>) ≠ *undefined*)
| <composite primary> **then**
let *sl* = <*getStaticSort0*(*para*, *bl*)| *para* **in** *epr*.**s-**<actual parameter>-**seq**> **in**
epr.**s-**<actual parameter>-**seq**≠*empty*⇒
(*getCompositeSort0*(*sl*)≠ *undefined* ∧
(∀*i*∈1..*epr*.**s-**<actual parameter>-**seq**.*length*: *epr*.**s-**<actual parameter>-**seq**[*i*]= *undefined*∨
isSatisfyExpressionCondition0(*bl*,*epr*.**s-**<actual parameter>-**seq**[*i*])))
endlet
endcase

The function *getCompositeSort0* gets the sort that refers to a structure data type whose field sort list is the same as the specified parameters.

getCompositeSort0(*sl*:[<sort>]*):<sort>= $_{\text{def}}$
let *def* = *take*({ *d*∈<data type definition>∪<syntype definition>:
∃*cons*∈<structure definition>:
let *fsl* = *cons*.*fieldSortList0* **in**
fsl.*length*=*sl*.*length*∧
(∀*i*∈1..*fsl*.*length*: *sl*[*i*]=*undefined*∨*isSortCompatible0*(*sl*[*i*], *fsl*[*i*]))
endlet // fsl
}) **in**
def.*derivedDataType0*.*identifier0*
endlet // def

The function *getPrimarySort0* gets the static sort of a <primary>.

```
getPrimarySort0(pr: <primary>, bl: BINDINGLIST0): <sort>= def
    case pr of
    | <operation application> then getOpAppSort0(pr, bl)
    | <literal> then
        getDefinitionInBindingList0 (pr, bl).surroundingScopeUnit0.identifier0
    | <expression> then getStaticSort0(pr, bl)
    | <conditional expression> then getStaticSort0(pr.s-<consequence expression>, bl)
    | <indexed primary> then getItemSort0(getPrimarySort0(pr.s-<primary>, bl))
    | <field primary> then getFieldSort0(getPrimarySort0(pr.s-<primary>, bl), pr.s-<field name>)
    | <composite primary> then
            getCompositeSort0(<getStaticSort0(para, bl)| para in pr.s-<actual parameter>-seq>)
    | <variable access> then getVarAccessSort0(pr)
    | <imperative expression> then getImperativeExpSort0(pr)
    otherwise getSynonymSort0(pr) // <synonym>
    endcase
```

The function *getVarAccessSort0* gets the static sort of a <variable access>.

```
getVarAccessSort0(va: <variable access>): <sort>= def
    if va∈ <identifier> then
        getEntityDefinition0(va, variable).s-<sort>
    else
        let od = parentAS0ofKind(va, <operation definition>) in
            od.operationFormalparameterList0[1].parentAS1.s-<sort>
        endlet
    endif
```

The function *getImperativeExpSort0* gets the static sort of an <imperative expression>.

```
getImperativeExpSort0(ie: <imperative expression>): <sort>= def
    case ie of
    | <now expression> then predefinedId0("Time")
    | <pid expression> then
        if ie ≠ self then
            predefinedId0("Pid"))
        else
            let def = parentAS0ofKind(ie, <agent definition>∪<agent type definition>) in
                if def = undefined then predefinedId0("Pid"))
                else def.identifier0
                endif
            endlet
        endif
    | <any expression> then ie.s-<sort>
    | <state expression> then  predefinedId0("Charstring"))
endcase
```

The function *getSynonymSort0* gets the static sort of a <synonym>. For a valid model the <constant expression> has only one possible static sort, which is returned. If there is more than one possible sort, *undefined* is returned.

```
getSynonymSort0(s: <synonym>): <sort>= def
    let sd = getEntityDefinition0(s, synonym) in //sd is an external or internal synonym definition item
    if sd.s-<sort> ≠ undefined then sd.s-<sort> //sd is an external item or internal item with sort
    else sd.s-<constant expression>.staticSort0 // sort of <constant expression> of internal synonym definition
    endif endlet
```

The function *isSatisfyOpAppCondition0* determines if the binding violates any static sort constraints in the <operator application>.

```
isSatisfyOpAppCondition0(bl:BINDINGLIST0, oa:<operation application>): BOOLEAN=def
    let opDef = getDefinitionInBindingList0(oa.s-<operation identifier>.s-<name>, bl) in
    let fpl = opDef.operationParameterSortList0 in
    let apl =oa.actualParameterList0 in
```

fpl.*length* = *apl*.*length* ∧
(∀*i*∈1..*fpl*.*length*: *isSortCompatible0*(*getStaticSort0*(*apl*[*i*], *bl*), *fpl*[*i*])∧
isSatisfyExpressionCondition0(*bl*, *apl*[*i*])
endlet

The function *getOpAppSort0* gets the static sort of an <operation application>.

getOpAppSort0(*oa*:<operation application>, *bl*: *BINDINGLIST0*): <sort>=$_{def}$
getDefinitionInBindingList0(*oa*.**s-**<operation identifier>.**s-**<name>, *bl*).*operationResultSort0*

The function *isSatisfyMethodAppCondition0* determines if the binding violates any static sort constraints in the <method application>.

isSatisfyMethodAppCondition0(*bl*:*BINDINGLIST0*, *ma*: <method application>): *BOOLEAN*=$_{def}$
let *opDef* = *getDefinitionInBindingList0*(*ma*.**s-**<operation identifier>.**s-**<name>, *bl*) **in**
let *fpl* = *opDef*.*operationParameterSortList0* **in**
let *apl* =*ma*.*actualParameterList0* **in**
fpl.*length* = *apl*.*length* ∧*isSatisfyPrimaryCondition0*(*bl*, *ma*.**s-**<primary>)∧
(∀*i*∈1..*fpl*.*length*: *isSortCompatible0*(*getStaticSort0*(*apl*[*i*], *bl*), *fpl*[*i*])∧
isSatisfyExpressionCondition0(*bl*, *apl*[*i*])
endlet

The function *operationParameterSortList0* gets the operation formal parameter sort list.

operationParameterSortList0(*os*:<operation signature>):<sort>*=$_{def}$
if *os*. *getPredefinedOpParas0* ≠ *undefined* **then**
os.*getPredefinedOpParas0*
else
<*para*.**s-**<sort> : *para* **in** *os*.*operationSignatureParameterList0*>
endif

The function *getDefinitionInBindingList0* gets the corresponding entity definition for a name in a binding list.

getDefinitionInBindingList0 (*n*: <name>, *bl*: *BINDINGLIST0*): *ENTITYDEFINITION0*=$_{def}$
take ({*d*∈*ENTITYDEFINITION0*: ∃*i*∈1..*bl*.*length*: *bl*[*i*].**s-**<name>=*n*∧ *bl*[*i*].**s-***ENTITYDEFINITION0*=*d*})

The function *possibleDefinitionSet0* gets the set of possible entity definition for a name.

possibleDefinitionSet0(*n*: <name>):*ENTITYDEFINITION0***-set** =$_{def}$
{*d*∈*ENTITYDEFINITION0*: ((*d*.*entityName0*=*n*)∨(*isRenamedBy0*(*d*.*entityName0*, *n*)))∧
((*d*.*entityKind0*=*n*.*idKind0*∧*isVisibleIn0*(*d*, *n*.*surroundingScopeUnit0*))∨
(*d*∈*PREDEFINEDLITERAL0*∧ *n*.*idKind0*=**literal**)∨
(*d*∈*PREDEFINEDOPERATION0*∧ *n*.*idKind0*∈{**operator**, **method**}))}

The function *isRenamedBy0* determines if a name is renamed by another one.

isRenamedBy0(*n1*, *n2*: <name>):*BOOLEAN*=$_{def}$
(∃*rp*∈<rename pair>:(*rp*.**s-**<operation name> = *n2*∧ *rp*.**s2-**<operation name>=*n1*)∨
(*rp*.**s-**<literal name> = *n2*∧ *rp*.**s2-**<literal name>=*n1*))∨
(∃*n3*∈<name>: *isRenamedBy0*(*n1*, *n3*)∧ *isRenamedBy0*(*n3*, *n2*))

The function *actualParameterList0* gets the actual parameter list for a <create expression>, a <procedure call body>, a <remote procedure call body>, a <value returning procedure call> or an <operation application> or a <method application>.

actualParameterList0(*d*:
<create expression>∪<procedure call body>∪<remote procedure call body>
∪<value returning procedure call>∪<operation application>): <expression>*=$_{def}$
d.**s-**<actual parameter>**-seq**

The function *getCreatedAgentDefinition0* gets the <agent definition> or <agent type definition> that the <create expression> involves.

```
getCreatedAgentDefinition0 (ce: <create expression>): <agent definition>∪<agent type definition>=def
    let id = ce.s-implicit in
    if id∈<identifier> then getEntityDefinition0(id, id.idKind0)
    elseif id.surroundingScopeUnit0∈<agent definition>∪<agent type definition> then
            id.surroundingScopeUnit0
    else undefined
    endif
```

The function *getStaticSort0* gets the static sort of an expression.

```
getStaticSort0(exp: <expression>, bl:BINDINGLIST0): <sort>=def
case exp of
| <create expression> then getCreateExpSort0(exp)
| <procedure call body> then getProcCallBodySort0(exp)
| <remote procedure call body> then getRemoteProcCallBodySort0(exp, bl)
| <range check expression> then predefinedSort0("Boolean"))
| <equality expression> then predefinedSort0("Boolean"))
| <binary expression> then
    getDefinitionInBindingList0(binaryOpName0(exp), bl).operationResultSort0
| <operand5> then
    case exp.s-implicit of
    | <hyphen> then getDefinitionInBindingList0(mk-<name>("-"), bl).operationResultSort0
    | not then getDefinitionInBindingList0(mk-<name>("not"), bl).operationResultSort0
    otherwise getPrimarySort0(exp.s-<primary>, bl)
    endcase
endcase
```

The function *mismatchNumber0* counts the number of mismatches that the static sort of an <expression> is not the same as the static sort of the <variable> or the static sort of an actual parameter is not the same as the sort of the corresponding formal parameter.

```
mismatchNumber0(bl:BINDINGLIST0, c:CONTEXT0): NAT=def
    case c of
    |<assignment> then mismatchNumberOfAssignment0(bl, c)
    |<decision> then mismatchNumberOfDecision0(bl, c)
    |<expression> then mismatchNumberOfExpression0(bl, c)
    endcase

mismatchNumberOfAssignment0(bl:BINDINGLIST0, ass: <assignment>): NAT=def
    let varSort= getVariableSort0(ass.s-<variable>) in
    let expSort= getStaticSort0(ass.s-<expression>, bl) in
    case ass.s-<variable> of
    | <identifier>∪<field variable> then
        if ¬isSameSort0(varSort, expSort)
        then 1+mismatchNumberOfExpression0(bl, ass.s-<expression>)
        else mismatchNumberOfExpression0(bl, ass.s-<expression>)
        endif
    | <indexed variable> then
        if ¬isSameSort0(varSort, expSort) then
            1 + mismatchNumberOfExpression0(bl, ass.s-<expression>)+
                mismatchNumberInIndexVariable0(bl, ass.s-<variable>)
        else
            mismatchNumberOfExpression0(bl, ass.s-<expression>)+
            mismatchNumberInIndexVariable0(bl, ass.s-<variable>)
        endif
    endcase

mismatchNumberInIndexVariable0(bl:BINDINGLIST0, var:<indexed variable>): NAT=def
    let acp=var.s-<actual parameter>-seq in
        if var.s-<variable>∉<indexed variable> then
            if ¬isSameSort0(getStaticSort0(acp[1],bl), getIndexSort0(getVariableSort0(var))) then 1
            else 0
```

```
            endif
        elseif ¬isSameSort0(getStaticSort0(acp[1],bl), getIndexSort0(getVariableSort0(var))) then
            1 + mismatchNumberInIndexVariable0(bl, var.s-<variable>)
        else mismatchNumberInIndexVariable0(bl, var.s-<variable>)
        endif
    endlet

mismatchNumberOfDecision0(bl:BINDINGLIST0, d: <decision>): NAT=def
    let q=d.s-<question>, rcl=d.rangeConditionList0 in
        mismatchNumberOfExpression0(bl, q) + mismatchNumberOfRangeConditionList0(bl, rcl))
    endlet

mismatchNumberOfRangeConditionList0(bl:BINDINGLIST0, rcl: <range condition>*): NAT=def
    if rcl.= empty then 0
    else
        mismatchNumberOfRangeCond0(bl, rcl.head) +
            mismatchNumberOfRangeConditionList0 (bl, rcl.tail])
    endif

mismatchNumberOfRangeCond0(bl:BINDINGLIST0, rl: <range>*): NAT=def
    if rl = empty then 0
    else
        mismatchNumberOfRange0(bl, rl.head)+ mismatchNumberOfRangeCond0 (bl, rl.tail])
    endif

mismatchNumberOfRange0(bl:BINDINGLIST0, range: <range>): NAT=def
    case range of
    | <closed range> then
        mismatchNumberOfExpression0(bl,range.s-<constant>) +
        mismatchNumberOfExpression0(bl,range.s2-<constant> )
    | <open range> then
        if range∈<constant> then mismatchNumberOfExpression0(bl,range)
        else
            mismatchNumberOfExpression0(bl,range.s-<constant>)+
            mismatchNumberOfExpression0(bl,range.s2-<constant> )
        endif
    endcase

mismatchNumberOfExpression0(bl:BINDINGLIST0, exp: <expression>): NAT=def
    case exp of
    | <binary expression> then
        let opDef = getDefinitionInBindingList0(exp.s-implicit, bl) in
        let fpsl = opDef.operationParameterSortList0 in
            mismatchNumberOfParas0(bl, fpsl, exp.s-<expression>⌒ exp.s2-<expression>)+
            mismatchNumberOfExpression0(bl, exp.s-<expression>)+
            mismatchNumberOfExpression0(bl, exp.s2-<expression>)
        endlet
    | <create expression> then mismatchNumberOfCreateExp0(bl, exp)
    | <equality expression> then
        mismatchNumberOfExpression0(bl,exp.s-<expression>)+
        mismatchNumberOfExpression0(bl,exp.s2-<expression>)
    | <range check expression> then mismatchNumberOfExpression0(bl,exp.s-<expression>)
    | <operand5> then
        let pr = exp.s-<primary> in
        if exp.s-implicit = undefined then
            mismatchNumberOfPrimary0(bl, pr)
        else
            let opDef = getDefinitionInBindingList0(exp.s-implicit, bl) in
            let fpsl = opDef.operationParameterSortList0 in
            if isSameSort0(getStaticSort0(pr, bl), fpsl[1])
            then mismatchNumberOfPrimary0(bl, pr)
            else mismatchNumberOfPrimary0(bl, pr)+1
```

```
            endif
            endlet
            endlet
        endif
        endlet
    | <value returning procedure call> then
        if exp∈<procedure call body> then
            mismatchNumberOfProcedureCallBody0(bl, call)
        else
            mismatchNumberOfRemoteProcCallBody0(bl, call)
        endif
    endcase

mismatchNumberOfCreateExp0(bl: BINDINGLIST0, ce: <create expression>):NAT=def
    let def = ce.getCreatedAgentDefinition0 in
        if def =undefined then 0
        else
            mismatchNumberOfParas0(bl, def.formalParameterSortList0, ce.actualParameterList0) +
                mismatchNumberOfActualParas0(bl, ce.actualParameterList0)
        endif
    endlet

mismatchNumberOfProcedureCallBody0(bl: BINDINGLIST0, body: <procedure call body>): NAT=def
    case body.s-implicit of
    | id=<identifier> then
        let fpsl=getEntityDefinition0(id, procedure).formalParameterSortList0 in
            mismatchNumberOfParas0(bl, fpsl, apl)
        endlet
    | te=<type expression> then
        let fpsl=id.baseType0.formalParameterSortList0 in
        let apl = body.actualParameterList0 in
            mismatchNumberOfParas0(bl, fpsl, apl) + mismatchNumberOfActualParas0(bl, apl)
        endlet
        endlet
    endcase

mismatchNumberOfRemoteProcCallBody0(bl: BINDINGLIST0, body: <remote procedure call body>):
    NAT=def
    let rpd = getEntityDefinition0(body.s- <identifier>,remote procedure) in
    let fpsl= rpd.formalParameterSortList0 in
    let apl = body.actualParameterList0 in
        mismatchNumberOfParas0(bl, fpsl, apl) + mismatchNumberOfActualParas0(bl, apl)
    endlet
    endlet
    endlet

mismatchNumberOfPrimary0(bl: BINDINGLIST0, pr: <primary>):NAT=def
    case pr of
    | <operator application> then mismatchNumberOfOpApp0(bl, pr)
    | <method application> then mismatchNumberOfMethodApp0(bl, pr)
    | <expression> then mismatchNumberOfExpression0(bl, pr)
    | <conditional expression> then
        mismatchNumberOfExpression0(bl, pr.s-<expression>) +
            mismatchNumberOfExpression0(bl, pr.s-<consequence expression>) +
            mismatchNumberOfExpression0(bl, pr.s-<alternative expression>)
    otherwise 0
    endcase

mismatchNumberOfOpApp0(bl:BINDINGLIST0, oa: <operator application>): NAT=def
    let opDef = getDefinitionInBindingList0(oa.s-<operation identifier>.s-<name>, bl) in
    let fpsl = opDef.operationParameterSortList0 in
    let apl =oa.actualParameterList0 in
        mismatchNumberOfParas0(bl, fpsl, apl)+mismatchNumberOfActualParas0(bl, apl)
```

```
    endlet
    endlet
    endlet

mismatchNumberOfMethodApp0(bl:BINDINGLIST0, ma: <method application>):NAT=def
    let opDef = getDefinitionInBindingList0(ma.s-<operation identifier>.s-<name>, bl) in
    let fpsl = opDef.operationParameterSortList0 in
    let apl =ma.actualParameterList0 in
        mismatchNumberOfParas0(bl, fpsl, apl)+mismatchNumberOfActualParas0(bl, apl)+
            mismatchNumberOfPrimary0(bl, ma.s-<primary>)
    endlet
    endlet
    endlet

mismatchNumberOfParas0(bl: BINDINGLIST0, fpsl: <sort>*, apl: <expression>*):NAT=def
    if fpsl = empty then 0
    elseif fpsl.head=undefined∨isSameSort0(fpsl.head, apl.head)
    then mismatchNumberOfParas0(bl, fpsl.tail, apl.tail)
    else mismatchNumberOfParas0(bl, fpsl.tail, apl.tail)+1
    endif

mismatchNumberOfActualParas0(bl: BINDINGLIST0, apl: <expression>*): NAT=def
    if apl = empty then 0
    else mismatchNumberOfExpression0(bl, apl.head)+mismatchNumberOfActualParas0(bl, apl.tail)
    endif

formalParameterSortList0(d:
<agent definition> ∪ <agent type definition> ∪ <composite state definition> ∪
<composite state type definition> ∪ <procedure definition> ∪
<remote procedure definition>):<sort>*= def
    case d of
    | <agent definition> ∪ <agent type definition>∪
            <composite state definition> ∪ <composite state type definition> then
        <fp.parentAS1.s-<sort> | fp in d.agentFormalParameterList0>
    | <procedure definition> then
        <fp.parentAS1.s-<sort> | fp in d.procedureFormalParameterList0>
    | <remote procedure definition> then
        <fp.s-<sort> | fp in d.s-<procedure signature>.s-<formal parameter>>
    endcase
```

The function *staticSortSet0* returns the possible static sort set for an <expression> that is in an <assignment> or a <decision> or <expression>.

```
staticSortSet0(exp: <expression>):<sort>-set =def
    {getStaticSort0(exp, bl) | bl∈getBindingListSet0(exp.contextOfExp0)}
```

The function *staticSort0* gets one of the sorts from possible static sort set for an <expression> that is in an <assignment> or a <decision> or <expression>, and therefore for an expression with all names resolved returns the static sort of the expression as the possible static sort set and has only one member.

```
staticSort0(expr:<expression>):<sort>=def
    let possiblesorts = expr.staticSortSet0 in
    if | possiblesorts | = 1 then take(possiblesorts) else undefined endif
    endlet
```

The function *contextOfExp0* finds the context in AS0 (<assignment> or <decision> or <expression>) that the <expression> is in.

```
contextOfExp0(exp: <expression>):CONTEXT0=def
    if (∃ass∈<assignment>: isAncestorAS0(ass, exp)) then
        parentAS0ofKind(exp, <assignment>)
```

elseif (∃*dec*∈<decision>: *isAncestorAS1*(*dec*, *exp*)) **then**
parentAS0ofKind(*exp*, <decision>)
elseif (∃*exp1*∈<expression>: *isAncestorAS0*(*exp1*, *exp*)) **then**
parentAS0ofKind(*exp*, <expression>).*contextOfExp0*
else *exp*
endif

The function *getPredefinedOpParas0* gets the sort list of the formal parameters of a predefined operation. This function is not formally defined in this Recommendation (ITU-T Z.100).

getPredefinedOpParas0: *PREDEFINEDOPERATION0* → <sort>*

The function *getPredefinedOpResult0* gets the result sort of a predefined operation. This function is not formally defined in this Recommendation (ITU-T Z.100).

getPredefinedOpResult0: *PREDEFINEDOPERATION0* → <sort>

F2.2.2.3 Path item

Abstract syntax

Path-item	=	*Package-qualifier*
	|	*Agent-type-qualifier*
	|	*Agent-qualifier*
	|	*State-type-qualifier*
	|	*State-qualifier*
	|	*Data-type-qualifier*
	|	*Procedure-qualifier*
	|	*Interface-qualifier*
	|	*Compound-node-qualifier*
Package-qualifier	::	*Package-name*
Agent-type-qualifier	::	*Agent-type-name*
Agent-qualifier	::	*Agent-name*
State-type-qualifier	::	*State-type-name*
State-qualifier	::	*State-name*
Data-type-qualifier	::	*Data-type-name*
Procedure-qualifier	::	*Procedure-name*
Interface-qualifier	::	*Interface-name*
Compound-node-qualifier	::	*Compound-node-name*

Concrete syntax

<path item>	::	<scope unit kind> <name>
<scope unit kind>	=	
		package
	|	**system type**
	|	**system**
	|	**block**
	|	**block type**
	|	**process**
	|	**process type**
	|	**state**
	|	**state type**
	|	**procedure**
	|	**signal**
	|	**type**
	|	**operator**
	|	**method**
	|	**interface**

| **composition**

Mapping to abstract syntax

| <path item>(**package**,*n*) **then mk-***Package-qualifier*(*n*)
| <path item>(**system**,*n*) **then mk-***Agent-qualifier*(*n*)
| <path item>(**system type**,*n*) **then mk-***Agent-type-qualifier*(*n*)
| <path item>(**block**,*n*) **then mk-***Agent-qualifier*(*n*)
| <path item>(**block type**,*n*) **then mk-***Agent-type-qualifier*(*n*)
| <path item>(**process**,*n*) **then mk-***Agent-qualifier*(*n*)
| <path item>(**process type**,*n*) **then mk-***Agent-type-qualifier*(*n*)
| <path item>(**state**,*n*) **then mk-***State-qualifier*(*n*)
| <path item>(**statetype**,*n*) **then mk-***State-type-qualifier*(*n*)
| <path item>(**procedure**,*n*) **then mk-***Procedure-qualifier*(*n*)
| <path item>(**operator**,*n*) **then mk-***Procedure-qualifier*(*n*)
| <path item>(**method**,*n*) **then mk-***Procedure-qualifier*(*n*)
| <path item>(**type**,*n*) **then mk-***Data-type-qualifier*(*n*)
| <path item>(**interface**,*n*) **then mk-***Interface-qualifier*(*n*)
| <path item>(**composition**,*n*) **then mk-***Compound-node-qualifier*(*n*)

F2.2.3 Informal text

Abstract syntax

Informal-text :: ...

Concrete syntax

<informal text> :: <character string>

Mapping to abstract syntax

The mapping for informal text is described in clause F2.2.2.1.

F2.2.4 General framework

F2.2.4.1 SDL-2010 specification

Abstract syntax

Sdl-specification :: [*Agent-definition*] *Package-definition*-**set**

Concrete syntax

<sdl specification> ::
{ <textual system specification> | <package definition> } <referenced definition>*

<textual system specification> ::
<agent definition>
| <package use clause>* <textual typebased agent definition>

Transformations

<sdl specification>(*sys*, *r*)
provided *sys* ∈ (<process definition> ∪ <textual typebased process definition> ∪
<block definition> ∪ <textual typebased block definition>)
=5=> <sdl specification>(
<system definition>(*empty*,
<system heading>(*sys.name0*, <agent additional heading>(*undefined*, *empty*)),
<agent structure>(*undefined*, < *sys* >, <agent body>(*undefined*, *empty*))),
r)

A <system specification> being a <process definition> or a <textual typebased process definition> is derived syntax for a <system definition> having the same name as the process, containing implicit channels and containing the <process definition> or <textual typebased process definition> as the only definition. See clause 5.3.1 *Model* of [ITU-T Z.106].

A <system specification> being a <block definition> or a <textual typebased block definition> is derived syntax for a <system definition> having the same name as the block, containing implicit channels and containing the <block definition> or <textual typebased block definition> as the only definition. See clause 5.3.1 *Model* of [ITU-T Z.106].

Mapping to abstract syntax

| <sdl specification>(*s*=<textual system specification>, *refs*) **then**
let *packages* =
{ *p* ∈ (*refs.toSet* ∩ <package definition>) : *p.surroundingScopeUnit0 = undefined* } **in**
mk-*Sdl-specification*(*Mapping*(*s*), { *Mapping*(*p*): *p* ∈ *packages* },)
endlet

| <sdl specification>(*unit*=<package definition>, *refs*) **then**
let *packages = unit* ∪
{ *p* ∈ (*refs.toSet* ∩ <package definition>) : *p.surroundingScopeUnit0 = undefined* } **in**
mk-*Sdl-specification*({ *Mapping*(*p*): *p* ∈ *packages* })
endlet

F2.2.4.2 Package

Abstract syntax

Package-definition	::	*Package-name* *Package-definition*-**set** *Data-type-definition*-**set** *Syntype-definition*-**set** *Signal-definition*-**set** *Agent-type-definition*-**set** *Composite-state-type-definition*-**set** *Procedure-definition*-**set**

Concrete syntax

<package definition> :: <package use clause>* <package heading> <entity in package>*

<package heading> :: <qualifier> <package<name> <package public>

<entity in package> =
<agent type definition>
| <agent type reference>
| <package definition>
| <package reference>
| <signal definition list>
| <signal list definition>
| <remote variable definition>
| <data definition>
| <procedure definition>
| <procedure reference>
| <remote procedure definition>
| <composite state type definition>
| <composite state type reference>
| <select definition>

<package use clause> :: <package<identifier> <definition selection>*

<definition selection> :: [<selected entity kind>] <name>

<selected entity kind> =
system type
| **block type**
| **process type**
| **package**
| **signal**
| **procedure**

| **remote procedure**
| **type**
| **signallist**
| **state type**
| **synonym**
| **remote**
| **interface**

<package public> = <definition selection>*

Conditions on concrete syntax

See clause 7.2 *Concrete grammar* of [ITU-T Z.101].

∀*pi*∈ <package use clause>.**s**-<identifier>:
getEntityDefinition0 (*pi*, **package**) ≠ *undefined*

For each <package<identifier> mentioned in a <package use clause>, there shall exist a corresponding visible <package>.

∀*pd*∈ <package definition>:
pd.*parentAS0*∈<sdl specification> ⇒ *pd*.*contextQualifier0* = *undefined*

There shall be a <qualifier> in <package<identifier> only if the package is logically contained in another package.

∀*ds1*,*ds2*∈<definition selection>:
(*ds1*. *parentAS0* = *ds2*. *parentAS0*∧ *ds1* ≠ *ds2*)⇒
(*ds1*.**s**-<selected entity kind> ≠ *ds2*.**s**-<selected entity kind> ∨ *ds1*.**s**-<name> ≠ *ds2*.**s**-<name>)

Any pair of (<selected entity kind>, <name>) shall be distinct within a <definition selection list>.

∀*ds*∈<definition selection>: *ds*. *parentAS0* ∈<package public> ⇒
(∃!*d*∈*ENTITYDEFINITION0*∪ *REFERENCE0* :
d.*surroundingScopeUnit0* = *ds*.*surroundingScopeUnit0*∧ *d*. *entityName0* = *ds*.**s**-<name> ∧
if *ds*.**s**-<selected entity kind> = *undefined*
then *true*
else *d*.*entityKind0* = *ds*.**s**-<selected entity kind>
endif)

For a <definition selection> in a <package public> clause, the <selected entity kind> is allowed to be omitted only if the name is used for just one defining occurrence directly in the <package>. For a <definition selection> in <package public>, if the <selected entity kind> is not omitted there shall exist an entity definition having the same entity kind and the same name in the package.

∀ *uc* ∈ <package use clause>:∀*ds*∈<definition selection>:
let *pd* = *uc*.*usedPackage0* **in**
ds. *parentAS0* = *uc* ∧ *ds*.**s**-<selected entity kind> = *undefined*⇒
((∃!*ds1*∈<definition selection>:
ds1.*surroundingScopeUnit0*= *pd*∧ *ds*.**s**-<name>= *ds1*.**s**-<name>) ∨
((*pd*.**s**-<package heading>.**s**-<package public> = *undefined*)∧
(∃!*d*∈ *ENTITYDEFINITION0*∪ *REFERENCE0* :
d.*surroundingScopeUnit0*= *pd* ∧ *d*. *entityName0*= *ds*.**s**-<name>)))
endlet

For a <definition selection> in a <package use clause>, <selected entity kind> is allowed to be omitted if and only if either exactly one entity of that name is mentioned in any <definition selection list> for the package or the package has no <definition selection list> and directly contains a unique definition of that name.

Transformations

let *usePredef* = <package use clause>(
<identifier>(*empty*, <name>("Predefined")), *undefined*) **in**
<package definition>(*uses*, *heading*, *entities*)

```
provided uses.head ≠ usePredef
=6=>  <package definition>(< usePredef > ⌒ uses, heading, entities)
endlet

let usePredef = <package use clause>(
    <identifier>(empty, <name>("Predefined") ), undefined) in
    <system definition>(uses, heading, struct)
provided uses.head ≠ usePredef
=6=>  <system definition>(< usePredef > ⌒ uses, heading, struct)
endlet
```

The *Package-definition-**set*** of an *Sdl-specification* always includes the *Package-definition* of **package** `Predefined` defined in [ITU-T Z.104]; consequently this package does not have to be explicitly included as a <referenced definition>. See clause 7.1 *Model* of [ITU-T Z.101].

```
< <package use clause>(id, sel1) > ⌒ something ⌒ < <package use clause>(id, sel2) >
=6=>
    (let newSel =
        if sel1 = undefined then empty
        elseif sel2 = undefined then empty
        else sel1 ⌒ < s in sel2: (s ∉ sel1.toSet) >
        endif
    in
        < <package use clause>(id, newSel) > ⌒ something
    endlet)
```

If a package is mentioned in several <package use clause> items of a definition (in the same text area or different text areas of the definition), these are replaced by one <package use clause> that selects the union of the definitions selected in the <package use clause> items. See clause 7.2 *Model* of [ITU-T Z.101].

Mapping to abstract syntax

```
| <package definition>(*, <package heading>(*, n, *), entities) then
let entitiesSet = { Mapping(entities[i]:i ∈ 1..entities.length} in
mk-Package-definition(n,
    { pkd ∈ entitiesSet: (pkd ∈ Package-definition) },
    { dtd ∈ entitiesSet: (dtd ∈ Data-type-definition) }∪
            { implicitInterface1(atd) | (atd ∈ entitiesSet ∧ atd ∈ Agent-type-definition) },
    { snd ∈ entitiesSet: (snd ∈ Syntype-definition) },
    { sgd ∈ entitiesSet: (sgd ∈ Signal-definition) },
    { atd ∈ entitiesSet: (atd ∈ Agent-type-definition) },
    { std ∈ entitiesSet: (std ∈ Composite-state-type-definition) },
    { pdf ∈ entitiesSet: (pdf ∈ Procedure-definition) } )
endlet // entitiesSet
```

Auxiliary functions

The function *usedPackageDefinitionList0* gets the used package definition list of a scope unit.

```
usedPackageDefinitionList0(su: SCOPEUNIT0): <package definition> *=def
    < u.usedPackage0 | u in su.s-<package use clause>-seq >
```

The function *usedPackage0* gets the package definition for a <package use clause>.

```
usedPackage0 (uc: <package use clause>): <package definition> =def
    getEntityDefinition0 (uc.s-<identifier>, package)
```

The function *implicitInterface1* returns the implicit interface definition associated with an *Agent-type-definition* or an *Agent-definition*. See section F2.2.9.2.

```
implicitInterface1(d: Agent-definition ∪ Agent-type-definition ∪ State-machine): Interface-definition =def
case d of
| Agent-definition then
let sigDefs = getEntityDefinition1(d.s-Agent-type-identifier, agent type).s-Signal-definition-set in
    mk-Interface-definition (d.s-Agent-name, // Sort name – same as the agent
        mk-Literal-signature(mk-Name("null"),
            mk-Result(mk-Identifier(Mapping(d.fullQualifier0), d.s-Agent-type-name), REF),
            0),
        empty, // Data-type-identifier-set
        sigDefs, // Signal-definition-set
        d.baseType1.inputSignalSet1 ∪ { sd.identifier1 | sd ∈ sigDefs } // Signal-identifier-set
    )
endlet
| Agent-type-definition then
let sigDefs = d.s-Signal-definition-set in
    mk-Interface-definition (d.s-Agent-type-name,
        mk-Literal-signature(mk-Name("null"),
            mk-Result(mk-Identifier(Mapping(d.fullQualifier0), d.s-Agent-type-name), REF),
            0),
        empty,
        sigDefs, // Signal-definition-set
        d.baseType1.inputSignalSet1 ∪ { sd.identifier1 | sd ∈ sigDefs } // Signal-identifier-set
    )
endlet
| State-machine then
    mk-Interface-definition (d.s-State-name,
        mk-Literal-signature(mk-Name("null"),
            mk-Result(mk-Identifier(Mapping(d.fullQualifier0), d.s-State-name), REF),
            0),
        empty,
        ∅ // empty Signal-definition-set
        let parent =
            parentAS1ofKind(d, Agent-definition ∪ Agent-type-definition) in
        let siblings =
            if parent ∈ Agent-definition
            then parent.s-Agent-type-definition.s-Agent-definition-set
            else parent.s-Agent-definition-set
            endif in
        ( parent.implicitInterface1.s-Signal-identifier-set // parent interface signals
            \ { siblingsig ∈ sibling.implicitInterface1 : sibling ∈ siblings } ) // except to siblings
        ∪  d.baseType1.inputSignalSet1 // incoming signals of composite state type of state machine
        endlet // siblings
        endlet // parent
    )
endcase
```

The implicit *Interface-definition* for an agent type (or agent or state machine) has a *Sort* with the same *Name* as the agent type (or agent or state machine respectively). See clause 12.1.2 *Semantics* of [ITU-T Z.101].

The implicit *Interface-definition* defined by a state machine of an agent type contains (in its interface specialization – see [ITU-T Z.104]) the interface defined by the agent type itself except any part of that interface concerned only with contained agents. The interface also contains in its interface specialization all interfaces given in the incoming signal lists associated with any gates of the state machine. The interface also contains in its <interface use list> all signals given in the incoming signal lists associated with gates of the state machine. See clause 12.1.2 *Semantics* of [ITU-T Z.101].

F2.2.4.3 Referenced definition

Concrete syntax

<referenced definition> =
    <definition>

<definition> =
    | <package definition>
    | <agent definition>
    | <agent type definition>
    | <composite state definition>
    | <composite state type definition>
    | <procedure definition>
    | <operation definition>

<package reference> :: <package<identifier>

<procedure reference> :: <procedure reference heading>

<procedure reference heading> ::
    <type preamble> [<exported>] [<qualifier>] <procedure<name> [<formal context parameters>]

<block reference> :: <block<name> <number of instances>

<process reference> :: <process<name> <number of instances>

<composite state reference> :: <composite state name>

<agent type reference> =
        <system type reference>
    | <block type reference>
    | <process type reference>

<system type reference> :: <system type<identifier> [<formal context parameters>]

<block type reference> :: <type preamble> <block type<identifier> [<formal context parameters>]

<process type reference> :: <type preamble> <process type<identifier> [<formal context parameters>]

<composite state type reference> :: <type preamble> <composite state type<identifier>

Conditions on concrete syntax

Except as mentioned below (for <formal context parameters>) the following conditions are derived from clause 7.3 of [ITU-T Z.101].

∀*refDef*∈<referenced definition>:*refDef.referencedBy0≠undefined* ∧ *refDef.parentAS0* = <sdl specification>
    ∨ (*refDef*∈<package definition> ∧ *refDef.contextQualifier0 = undefined*)

For each <referenced definition> except any outermost <package definition>, there shall be a reference in the associated <package> or <system specification>.

∀*ref*∈ *REFERENCE0* : *ref.referencedDefinition0* ≠ *undefined*

For each reference, there shall exist a <referenced definition> with the same entity kind as the reference, and whose <qualifier>, if present, denotes a path, from a scope unit enclosing the reference, to the reference.

∀*ref* ∈ *REFERENCE0* : ∀*refDef* ∈<referenced definition>:
ref.**s-**<formal context parameters> ≠ *undefined* ∧ *refDef* = *ref.referencedDefinition0* ⇒
refDef.**s-**<formal context parameters> ≠ *undefined* ∧
isFormalContextParametersMatched0(*ref*,*refDef*)

If there is a <formal context parameters> item in the type reference, this shall be the same as the <formal context parameters> of the <referenced definition>. See clause 8.2 of [ITU-T Z.103].

∀*ref* ∈ <block reference> ∪ <process reference> : ∀*refDef* ∈<referenced definition>:
let *refDefInstances* =
    if *refDef* ∈ <block definition>
    then *refDef*.**s-**<block heading>.**s-**<agent instantiation>.**s-**<number of instances>

else *refDef*.**s-**<process heading>.**s-**<agent instantiation>.**s-**<number of instances>
endif
in
refDef = ref.referencedDefinition0 ∧ *refDefInstances* ≠ *undefined* ∧ *ref*.**s-**<number of instances> ≠ *undefined*
⇒
refDefInstances = ref.**s-**<number of instances>
endlet // *refDefInstances*

If both the <number of instances> in the <agent instantiation> of an <agent definition> and the <number of instances> in the agent reference for the <agent definition> are specified, the two <number of instances> shall be equal. See clause 9 *Concrete grammar* of [ITU-T Z.103].

∀*ref1, ref2* ∈<referenced definition>:
ref1.entityName0= ref2.entityName0∧ *ref1.entityKind0= ref2.entityKind0* ∧ *ref1* ≠ *ref2*⇒
ref1.contextQualifier0≠ *undefined*∧ *ref2.contextQualifier0*≠ *undefined*∧
¬*isPathItemMatched0* (*ref1.contextQualifier0*.**s-**<path item>**-seq**,
ref2.contextQualifier0.**s-**<path item>**-seq**) ∧
¬*isPathItemMatched0* (*ref2.contextQualifier0*.**s-**<path item>**-seq**,
ref1.contextQualifier0.**s-**<path item>**-seq**)

If two <referenced definition> items of the same entity kind have the same <name>, the <qualifier> of one must not constitute the leftmost part of the other <qualifier>, and neither <qualifier> is allowed to be omitted.

∀*rd*∈ <referenced definition>:
(*rd*∈<package definition>
∧ (∃ *ref* ∈ <package reference> : *ref*.**s-**<identifier>.*refersto0 = rd*))
⇒ *rd.contextQualifier0* ≠ *undefined*

The <qualifier> in a <referenced definition> shall be present if the <referenced definition> is a <package definition> referenced from another context except if the <package definition> represents an outermost package definition.

∀ *def* ∈ *ENTITYDEFINITION0*: *def* ∉ <referenced definition> ⇒ *def.contextQualifier0= undefined*

It is not allowed to specify a <qualifier> after the initial keyword(s) for definitions which are not <referenced definition> items.

Transformations

pk= <package reference>(*) =4=> *adaptDefinition*(*pk.referencedDefinition0, undefined*)

pr= <procedure reference>(*,*) =4=> *adaptDefinition*(*pr.referencedDefinition0, undefined*)

bk= <block reference>(*, *inst*) =4=> *adaptDefinition*(*bk.referencedDefinition0, inst*)

ps= <process reference>(*, *inst*) =4=> *adaptDefinition*(*ps.referencedDefinition0, inst*)

cs= <composite state reference>(*) =4=> *adaptDefinition*(*cs.referencedDefinition0, undefined*)

st= <system type reference>(*) =4=> *adaptDefinition*(*st.referencedDefinition0, undefined*)

bt= <block type reference>(*,*) =4=> *adaptDefinition*(*bt.referencedDefinition0, undefined*)

pt= <process type reference>(*,*) =4=> *adaptDefinition*(*pt.referencedDefinition0, undefined*)

ct= <composite state type reference>(*,*) =4=> *adaptDefinition*(*ct.referencedDefinition0, undefined*)

op= <operation reference>(*,*) =4=> *adaptDefinition*(*op.referencedDefinition0, undefined*)

The referenced definition is logically placed at the point of the reference to determine the properties of the system specification (see clause 7.3 of [ITU-T Z.101]).

Auxiliary functions

The function *referencedDefinition0* finds the corresponding entity definition for a given reference.

```
referencedDefinition0(ref: REFERENCE0 ): <referenced definition> =def
    let eKind = ref.referenceKind0 in
    let refName = ref.referenceName0 in
        if (∃! d∈<referenced definition>:
            isAncestorAS0(d.parentAS0, ref) ∧d.entityName0 = refName ∧ d. entityKind0 =eKind) then
            let d = take({d∈<referenced definition>:
                isAncestorAS0(d.parentAS0,ref) ∧ d.entityName0=refName ∧ d. entityKind0 =eKind}) in
                if isQualifierMatched0(d.contextQualifier0, ref.surroundingScopeUnit0) then d
                else
                    undefined
                endif
        else
            undefined
        endif
    endlet
```

The function *referencedBy0* finds the corresponding reference for a <referenced definition>.

```
referencedBy0(rd: <referenced definition>): REFERENCE0 =def
    take({ ref∈ REFERENCE0 : ref.referencedDefinition0 = rd})
```

The function *isPathItemMatched0* is used to determine if the first path item constitutes the leftmost part of the second path item.

```
isPathItemMatched0(seq1: <path item>*, seq2: <path item>*): BOOLEAN =def
    (seq1.length≤ seq2.length∧
        (∀i∈1..seq1.length:
            seq1[i].s-<name> = seq2[i].s-<name> ∧
                seq1[i].s-<scope unit kind> = seq2[i].s-<scope unit kind> ) )
```

The function *adaptDefinition* is used to adapt an inserted referenced definition: the qualifier is defined by context therefore is *undefined* in the syntax, and the number of instances is merged.

```
adaptDefinition(def:<referenced definition>, inst:<number of instances>):<referenced definition> =def
    case def of
    | <package definition>(uses, <package heading>(*, name, intf), entities)
    then mk-<package definition>(uses, mk-<package heading>(undefined, name, intf), entities)
    | <internal procedure definition>(uses,
        <procedure heading>(h1, *, name, h2, h3, h4, h5, h6, h7),
        entities, body)
     then mk-<internal procedure definition>(uses,
            mk-<procedure heading>(h1, undefined, name, h2, h3, h4, h5, h6, h7),
            entities, body)
    | <block definition>(uses, <block heading>(*, name, <agent instantiation>(inst1, addi)), body)
     then mk-<block definition>(uses, mk-<block heading>(undefined, name,
                    mk-<agent instantiation>(mergeNumbers(inst, inst1), addi)), body)
    | <process definition>(uses,
            <process heading>(*, name, <agent instantiation>(inst1, addi)), body)
     then mk-<process definition>(uses, mk-<process heading>(undefined, name,
                    mk-<agent instantiation>(mergeNumbers(inst, inst1), addi)), body)
    | <interface definition> then def
    | <composite state definition>(uses, <composite state heading>(*, name, p), body)
     then mk-<composite state definition>(uses, mk-<composite state heading>(undefined, name, p), body)
    | <system type definition>(uses, <system type heading>(*, name, addi), body)
     then mk-<system type definition>(uses, mk-<system type heading>(undefined, name, addi), body)
    | <block type definition>(uses, <block type heading>(pre, *, name, addi), body)
     then mk-<block type definition>(uses, mk-<block type heading>(pre, undefined, name, addi), body)
    | <process type definition>(uses, <process type heading>(pre, *, name, addi), body)
     then mk-<process type definition>(uses, mk-<process type heading>(pre, undefined, name, addi), body)
```

```
    | <composite state type definition>(compkind)
     then
        case compkind of
        | <composite state type graph>(uses,<composite state type heading>(virt,*,name,fp,vc, sp,afp),css,*)
         then mk-<composite state type definition>(uses,
            mk-<composite state type heading>(virt,undefined,name,fp,vc, sp,afp),
            css,
            name) // composite state type graph
        endcase
        | <state aggregation type>(uses,<state aggregation type heading>(pre,*,name,fp,vc, sp,afp),as,*)
         then mk-<state aggregation type>(uses,
            mk-<state aggregation type heading>(pre,undefined,name,fp,vc, sp,afp),
            as,
            name) // state aggregation type
    | <operation definition>(uses, <operation heading>(opkind, pre, *, name, pars, res), entities, body)
     then mk-<operation definition>(uses,
        mk-<operation heading>(opkind, pre, undefined, name, pars, res),
        entities,
        body)
    otherwise undefined
    endcase
```

The function *mergeNumbers* is used to adapt an inserted referenced definition.

```
mergeNumbers(inst1: <number of instances>, inst2: <number of instances>):
<number of instances> =def
    if inst1 = undefined then inst2
    elseif inst2 = undefined then inst1
    else
        let ini1 = inst1.s-<initial number> in
        let max1 = inst1.s-<maximum number> in
        let lower1 = inst1.s-<lower bound> in
            mk-<number of instances>(if ini1 ≠ undefined then ini1 else inst2.s-<initial number> endif,
                if max1 ≠ undefined then max1 else inst2.s-<maximum number> endif,
                if lower1 ≠ undefined then lower1 else inst2.s-<lower bound> endif
            ) // number of instances
        endlet // lower1
        endlet // max1
        endlet // ini1
    endif // both inst1 and inst2 defined
```

The function *isFormalContextParametersMatched0* is used to determine if two <formal context parameters> match.

```
isFormalContextParametersMatched0(fcpl1: <name>*, fcpl2: <name>*): BOOLEAN =def
    if (fcpl1 = empty) then (fcpl2 = empty)
    else
        isFormalContextParameterMatched0(fcpl1.head, fcpl1.tail) ∧
            isFormalContextParametersMatched0 (fcpl1.tail, fcpl2.tail)
    endif

isFormalContextParameterMatched0(fcp1: <name>*, fcp2: <name>*): BOOLEAN =def
    if (fcp1∈<agent type context parameter>) then (fcp2∈<agent type context parameter>)
    elseif (fcp1∈<agent context parameter>) then (fcp2∈<agent context parameter>)
    elseif (fcp1∈<procedure context parameter>) then (fcp2∈<procedure context parameter>)
    elseif (fcp1∈<remote procedure context parameter>) then (fcp2∈<remote procedure context parameter>)
    elseif (fcp1∈<signal context parameter>) then (fcp2∈<signal context parameter>)
    elseif (fcp1∈<variable context parameter>) then (fcp2∈<variable context parameter>)
    elseif (fcp1∈<remotevariable context parameter>) then (fcp2∈<remotevariable context parameter>)
    elseif (fcp1∈<timer context parameter list>) then (fcp2∈<timer context parameter list>)
    elseif (fcp1∈<synonym context parameter list>) then (fcp2∈<synonym context parameter list>)
    elseif (fcp1∈<sort context parameter>) then (fcp2∈<sort context parameter>)
```

elseif (*fcp1*∈<compositestate type context parameter>)
then (*fcp2*∈<compositestatetype context parameter>)
elseif (*fcp1*∈<gate context parameter>) **then** (*fcp2*∈<gate context parameter>)
elseif (*fcp1*∈<interface context parameter list>) **then** (*fcp2*∈<interface context parameter list>)
endif

F2.2.4.4 Select definition

Concrete syntax

<select definition> ::
<Boolean><simple expression>
{ <agent definition>
| <agent type definition>
| <agent type reference>
| <block reference>
| <channel definition>
| <channel to channel connection>
| <composite state reference>
| <composite state type definition>
| <composite state type reference>
| <composite state definition>
| <data definition>
| <imported procedure specification>
| <imported variable specification>
| <macro definition>
| <operation definition>
| <package definition>
| <package reference>
| <procedure definition>
| <procedure reference>
| <process reference>
| <remote procedure definition>
| <remote variable definition>
| <select definition>
| <signal definition list>
| <signal list definition>
| <state machine>
| <state partition>
| <timer definition>
| <variable definition> }+

Transformations

<select definition>(*cond*, *defs*)
=7=> **if** *value0*(*cond*) = 0 **then** *defs* **else** *empty* **endif**

If the result of the <Boolean><simple expression> of a <select definition> is the predefined Boolean value false, the constructs contained in the <select definition> are not selected. In the other case, the constructs are selected. The <select definition> is deleted at transformation and is replaced by the contained selected constructs, if any. See clause 13.1 *Model* of [ITU-T Z.102].

Auxiliary functions

The function *value0* computes the Natural value for a simple expression from the *Literal-signature* returned by *value1*. The Boolean values do not have any defined *Literal-natural* values, so true is treated as 0 and false is treated as 1.

value0(*e*:<simple expression>): *NAT*=$_{\text{def}}$
if *isSuperType1*(*getEntityDefinition1*(*predefinedId1*("Boolean"), **sort**).**s-***Sort*,
value1(*e*.*simpleMapping*).**s-***Result*.**s-***Sort-reference-identifier*)
then
if *value1*(*e*.*simpleMapping*).**s-***Literal-name* = **mk-***Name*("true") **then** 0 **else** 1 **endif**

else
value1(*e.simpleMapping*).**s-***Literal-natural*
endif

The function *simpleMapping* generates a *Constant-expression* for a <simple expression>. It assumes that transformations of infix operators into operator applications have taken place, and makes use of the restriction that only predefined literals and operations can be used in the <simple expression>.

simpleMapping(*e*:<simple expression>): *Constant-expression* =$_{def}$
case e **of**
| <operand5>(*undefined*, <operator application>(*ident*, *params*)) **then**
mk-*Operation-application*(*Mapping*(*ident*), <*simpleMapping*(x) | *x* **in** *params*>)
| <operand5>(*undefined*, <literal identifier>(*qual*, *name*)) **then**
mk-*Literal-identifier*(*Mapping* (*qual*), *Mapping* (*name*))
| <operand5>(*undefined*, <conditional expression>(*e1*, *e2*, *e3*)) **then**
mk-*Conditional-expression*(*simpleMapping* (*e1*), *simpleMapping* (*e2*), *simpleMapping* (*e3*))
otherwise *undefined*
endcase

F2.2.4.5 Transition option

Concrete syntax

<transition option> :: <alternative question> <textual decision body>

<alternative question> = <simple expression> | <informal text>

Transformations

t=<transition action items>(*a*, *undefined*)
provided *a.last* ∉ <transition option> ∧ *t.parentAS0.parentAS0.parentAS0* ∈ <transition option> ∧
t.findContinueLabel ≠ *undefined*
=7=> <transition action items>(*a*,
<terminator>(*undefined*,<join>(*t.findContinueLabel*)))

If a <transition option> is not terminating, then it is derived syntax for a <transition option> wherein all the <textual answer part>s and the <textual else part> have inserted in their <transition>:

a) if the transition option is the last <action> in a <transition string>, a <join> to the following <terminator>; or

b) else a <join> to the first <action> following the transition option.

<transition option>(*q*, <textual decision body>(*answers*, *elsePart*))
=7=> (**let** *matching* = { *a*.**s-**<transition> | *a* ∈ *answers.toSet*: *q.value0* ∈ *a*.**s-**<answer> } **in**
if *matching* ≠ ∅ **then** *matching.take*
elseif *elsePart* ≠ *undefined* **then** *elsePart*.**s-**<transition>
else *undefined*
endif
endlet)

The <transition> of a <textual answer part> is selected if the <answer> contains the result of the <alternative question>. If no <answer> contains the result of the <alternative question>, the <transition> of the <else part> is selected.

If no <else part> is provided and none of the outgoing paths are selected, the selection is invalid.

On transformation each <transition> not selected is deleted, and the <transition option> is deleted and replaced by the selected <transition>.

F2.2.5 Structural concepts

F2.2.5.1 Structural type definitions

F2.2.5.1.1 Agent types

Abstract syntax

Agent-type-definition :: *Agent-type-name*
Agent-kind
[*Agent-type-identifier*]
*Agent-formal-parameter**
Data-type-definition-**set**
Syntype-definition-**set**
Signal-definition-**set**
Timer-definition-**set**
Variable-definition-**set**
Agent-type-definition-**set**
Composite-state-type-definition-**set**
Procedure-definition-**set**
Agent-definition-**set**
Gate-definition-**set**
Channel-definition-**set**
State-machine
[*Abstract*]

Agent-kind = **SYSTEM** | **BLOCK** | **PROCESS**

Conditions on abstract syntax

$\forall d \in$ *Agent-type-definition*: (*d.agentKind1* = **PROCESS**) $\Rightarrow$
($\forall$ *d1* $\in$ *Agent-type-definition*$\cup$*Agent-definition*: *d1.parentAS1= d* $\Rightarrow$ *d1. agentKind1*= **PROCESS**)

The contained *Agent-definition*s and *Agent-type-definition*s of a Process must all have the *Agent-kind* **PROCESS.**

Concrete syntax

<agent type definition> =
<system type definition>
| <block type definition>
| <process type definition>

<agent type additional heading>::
[<formal context parameters>] [<virtuality constraint>] <agent additional heading>

<type preamble> :: [<virtuality>[<abstract>] | <abstract>[<virtuality>]]

Transformations

a = <agent structure>(*entities*, <agent body>(*startItem*, *items*))
provided
a.parentAS0 $\in$ <system type definition> $\cup$ <block type definition> $\cup$ <process type definition>
$\wedge$ *inheritedAgentBody0*(*a.parentAS0*) = *undefined* // no inherited agent body
=12=>
let *tbcsn* = *newName* // typebased composite state name
in
let *atd* = *a.parentAS0*
in
let *afps* = *expandAgentFormalParams0*(
case *atd* **of**
| <system type definition> **then** *empty*
| <block type definition> **then** *atd*.**s**-<block type heading>.
s-<agent type additional heading>.**s**-<agent additional heading>.**s**-<agent formal parameters>
| <process type definition> **then** *atd*.**s**-<process type heading>.
s-<agent type additional heading>.**s**-<agent additional heading>.**s**-<agent formal parameters>

```
    endcase)
in
let cst =
    mk-<composite state type definition>(
        mk-<composite state type graph>(empty,
            case atd of
            | <system type definition> then
            mk-<composite state type heading>(
                undefined,
                atd.s-<system type heading>.s-<qualifier>,
                newName,
                atd.s-<system type heading>.s-<agent type additional heading>.
                    s-<formal context parameters>,
                undefined,
                undefined,
                empty)
            | <block type definition> then
            mk-<composite state type heading>(
                atd.s-<block type heading>.s-<virtuality>,
                atd.s-<block type heading>.s-<qualifier>,
                if atd.specialization0 = undefined
                then newName
                else atd.specialization0.s-<type expression>.s-<identifier>.refersto0.s-<agent structure>
                    .s-<interaction>.s-<type based composite state>.s-<type expression>
                        .s-<identifier>.s-<name>
                endif,
                atd.s-<block type heading>.s-<agent type additional heading>.
                    s-<formal context parameters>,
                undefined,
                undefined,
                afps)
            | <process type definition> then
            mk-<composite state type heading>(
                atd.s-<process type heading>.s-<virtuality>,
                atd.s-<process type heading>.s-<qualifier>,
                if atd specialization0 = undefined
                then newName
                else atd specialization0.s-<type expression>.s-<identifier>.refersto0.s-<agent structure>
                    .s-<interaction>.s-<type based composite state>.s-<type expression>
                        .s-<identifier>.s-<name>
                endif,
                atd.s-<process type heading>.s-<agent type additional heading>.
                s-<formal context parameters>,
                undefined,
                undefined,
                afps)
            endcase,
            <composite state structure>(empty,
                deriveGateEntities0(entities),
                replaceInSyntaxTree0(atd.fullQualifierWithin0, cst.fullQualifierWithin0,
                    <composite state body>(
                        if startItem = undefined then empty
                        else < startItem.s-<start> >
                        endif,
                        items
    )   )   )   )   )
in
    mk-<agent structure>( entities ⌒ cst,
        mk-<interaction>(deriveChannelEntities0(entities,tbcsn),
            mk-<typebased composite state>(tbcsn,
                mk-<nextstate parameters>(
                    actualParamsNextstate0(afps), //  <actual parameters> of <nextstate parameters>
```

```
                    undefined), // state entry point <name> of <nextstate parameters>
                <type expression>(cst.identifier0, empty)
    ) ) )
endlet
endlet
endlet
endlet
```

The following paragraphs are derived from clause 8.1.1.1 *Model* of [ITU-T Z.103].

If an <agent type definition> (a <system type definition>, <block type definition> or <process type definition>) has an <agent structure> that contains an <agent body> instead of an <interaction>, this is shorthand for an agent type that has no contained agents and a state machine with its type defined by the <agent body>.

A <composite state type definition> is derived from the <agent type definition>. This definition is given a heading with the same <virtuality>, an anonymous name, the same <formal context parameters> and same <agent formal parameters> as the <agent type definition>. The <agent body> is copied as the <composite state body> and any part of a <qualifier> in the body that refers to the enclosing agent type is changed to refer to the composite state type of the agent type. Each <textual gate definition> of the <agent type definition> is copied as a <textual gate definition> of the <composite state type definition> but omitting any <textual endpoint constraint> of the <gate constraint>. Each <textual interface gate definition> of the <agent type definition> is copied as a <textual interface gate definition> of the <composite state type definition> but omitting any <textual endpoint constraint>. A <composite state type reference> for the derived <composite state type definition> is placed in the <agent type definition>. In the <agent type definition>, the <agent body> is replaced by a <state machine> with a <typebased composite state> that has:

an anonymous unique name as the <composite state name>;

the list of names for the <agent formal parameters> of the agent type as the <actual parameters> in the <nextstate parameters> and with no **via** <state entry point> in the <nextstate parameters>;

the (anonymous) name of the composite state type as the <base type> in the <composite state type expression> and the list of names of the <formal context parameters> (if any) of the agent type as the <actual context parameters> in the <composite state type expression>.

Each <channel definition> of the <agent type definition> that had a <channel path> with one <channel endpoint> connected to a <gate> of the environment (**env**) and the other <channel endpoint> connected to the <agent body>, has the <channel endpoint> that was connected to the <agent body> changed to connect to the <gate> with the same name (as the gate of the environment) of the replacement <state machine>. If the <channel definition> has two <channel path> items, the change is made to both <channel path> items.

NOTE – [ITU-T Z.103] describes (see text above) the insertion of a composite state type reference for the derived composite state type in the agent type, but such references are removed and replaced by the referenced definition (in this case the <composite state type definition> which is in the <interaction> that replaces the <agent body> of the <agent structure>).

If the <agent type definition> is defined as a specialization by inheriting another agent type (the supertype), the composite state type of the state machine of the supertype has to be **virtual** and the composite state type name is the same in both the supertype and subtype, because the copied <agent body> adds to the supertype. See clause 8.1.1.1 *Model* of [ITU-T Z.103].

Auxiliary functions

The function *deriveGateEntities0* derives the gates from the entities of an <agent structure> to insert as entities of the <composite state type definition> according to the clause 8.1.1.1 *Model* of [ITU-T Z.103].

deriveGateEntities0(*entities*: <entity in agent>*):<entity in composite state>* =$_{def}$
deriveGateEntity0(*entities.head*) ⌒
(**if** *entities.length* =1 **then** *empty* **else** *deriveGateEntities0*(*entities.tail*) **endif**)

The function *deriveGateEntity0* given an <entity in agent>, if it is a gate returns a one element <entity in composite state> list to insert as an entity of <composite state type definition> according to the clause 8.1.1.1 *Model* of [ITU-T Z.103]. For any other <entity in agent> an empty list is returned.

deriveGateEntity0(*entity*: <entity in agent>):<entity in composite state>* =$_{def}$
case *entity* **of**
| <textual gate definition>(*g*, *enc*, <gate constraint>(**in**,*, *sin*, **out**,*, *sout*)) **then**
< **mk**-<textual gate definition>(*g*, *enc*, **mk**-<gate constraint>(**in**,*undefined*, *sin*, **out**,*undefined*, *sout*)) >
| <textual gate definition>(*g*, *enc*, <gate constraint>(*inout*,*, *sinout*)) **then**
< **mk**-<textual gate definition>(*g*, *enc*, **mk**-<gate constraint>(*inout*,*undefined*, *sinout*)) >
| < textual interface gate definition>(*inout*, *interface*, *encoding*, *) **then**
< **mk**-<textual interface gate definition>(*inout*, *interface*, *encoding*,*undefined*) >
otherwise *empty*
endcase

The function *deriveChannelEntities0* derives the channels from the entities of an <agent structure> to insert as entities of an <interaction> that replaces an <agent body> of the <agent structure> according to the clause 8.1.1.1 *Model* of [ITU-T Z.103]. The <name> parameter is the name of the type based composite state.

deriveChannelEntities0(*entities*: <entity in agent>*, *tbcsn*: <name>):<entity in composite state>* =$_{def}$
deriveChannelEntity0(*entities.head*, *tbcsn*) ⌒
(**if** *entities.length* =1 **then** *empty* **else** *deriveChannelEntities0*(*entities.tail*, *tbcsn*) **endif**)

The function *deriveChannelEntity0* given an <entity in agent> if it is a gate returns a one element <entity in composite state> list to insert in the <interaction> that replaces an <agent body> of the <agent structure> according to the clause 8.1.1.1 *Model* of [ITU-T Z.103]. For any other <entity in agent> an empty list is returned. The <name> parameter is the name of the type based composite state.

deriveChannelEntity0(*entity*: <entity in agent>, *tbcsn*: <name>):<entity in composite state>* =$_{def}$
case *entity* **of**
| <channel definition>(*n*, *e*, *d*,
<channel path>(<channel endpoint>(*e1*,*g1*), <channel endpoint>(*e2*,*g2*), *sl*), *undefined*)
then
if *e1* = **env**
then
< **mk**-<channel definition>(*n*, *e*, *d*,
mk-<channel path>(**mk**-<channel endpoint> **env**,*g1*),**mk**-<channel endpoint>(*tbcsn*,*g1*), *sl*),
undefined) >
elseif *e2* = **env**
< **mk**-<channel definition>(*n*, *e*, *d*,
mk-<channel path>(**mk**-<channel endpoint>(*tbcsn*,*g2*),**mk**-<channel endpoint>(**env**,*g2*), *sl*),
undefined) >
else *empty*
endif
| <channel definition>(*n*, *e*, *d*,
<channel path>(<channel endpoint>(*e1*,*g1*), <channel endpoint>(*e2*,*g2*), *sl1*),
<channel path>(<channel endpoint>(*e2*,*g2*), <channel endpoint>(*e1*,*g1*), *sl2*))
then
if *e1* = **env**
then
< **mk**-<channel definition>(*n*, *e*, *d*,
mk-<channel path>(**mk**-<channel endpoint>(**env**,*g1*),**mk**-<channel endpoint>(*tbcsn*,*g1*), *s1l*),
mk-<channel path>(**mk**-<channel endpoint>(*tbcsn*,*g1*),**mk**-<channel endpoint>(**env**,*g1*), *s12*) >
elseif *e2* = **env**
< **mk**-<channel definition>(*n*, *e*, *d*,

```
        mk-<channel path>(mk-<channel endpoint>(tbcsn,g2),mk-<channel endpoint>(env,g2), s1l),
        mk-<channel path>(mk-<channel endpoint>(env,g2),mk-<channel endpoint>(tbcsn,g2), s12) >
else empty
endif
otherwise empty
endcase
```

The function *actualParamsNextstate0* derives the <actual parameters> in the <nextstate parameters> from <agent formal parameters> for a type based composite state in the transform of <agent structure>. The <agent formal parameters> has to be expanded so that each <parameters of sort> contains only one <name>.

```
actualParamsNextstate0(afps: <agent formal parameters>):<actual parameters> =def
    if afps = empty then empty
    else
        < mk-<operand5>(
            mk-<variable access>(mk-<identifier>(empty,afps.head.s-<parameters of sort>.s-<name>-seq[1]))
        )   > ⌢
        if afps.length =1 then empty
        else actualParamsNextstate0(afps. tail)
        endif
    endif
```

The function *expandAgentFormalParams0* expands an <agent formal parameters> so that each <parameters of sort> contains only one <name>.

```
expandAgentFormalParams0(afps: <agent formal parameters>):<agent formal parameters> =def
    if afps = empty then empty
    else
        if afps.head.s-<parameters of sort>.s-<name>-seq.length = 1
        then afps.head
        else < afps.head.s-<aggregation kind>,
            mk-<parameters of sort>( < afps.head.s-<parameters of sort>.s-<name>-seq[1] >,
                afps.head.s-<parameters of sort>.s-<sort>) > ⌢
            expandAgentFormalParams0(< afps.head.s-<aggregation kind>,
                mk-<parameters of sort>( < afps.head.s-<parameters of sort>.s-<name>-seq.tail>,
                    afps.head.s-<parameters of sort>.s-<sort>
                )   >)
        endif ⌢
        if afps.length =1 then empty
        else expandAgentFormalParams0(mk-<agent formal parameters>(afps.tail))
        endif
    endif
```

The function *validOutputSignalSet0* gets the complete output signal set of an <agent type definition> or an <agent definition>.

```
validOutputSignalSet0(d: <agent type definition>∪<agent definition>):SIGNAL0 =def
    d.localOutputSignalSet0∪ d.inheritedOutputSignalSet0
```

The function *localOutputSignalSet0* gets the local output signal set of an <agent type definition> or an <agent definition>.

```
localOutputSignalSet0(d: <agent type definition>∪<agent definition>):SIGNAL0 =def
    {sid∈SIGNAL0:
        (∃gc∈<gate constraint>:
            (gc.parentAS0∈<textual gate definition>)∧isDefinedIn0(gc.parentAS0, d)∧
            (gc.direction0=out)∧(sid∈signalSet0(gc.s-<signal list item>-seq))) ∨
        (∃cp∈<channel path>:
            (cp.parentAS0∈<channel definition>)∧isDefinedIn0(cp.parentAS0, d)∧
            (cp.destination0.s-env≠undefined)∧(sid∈signalSet0(cp.s-<signal list item>-seq)))}
```

The function *inheritedOutputSignalSet0* gets the inherited output signal set of an <agent type definition> or an <agent definition>.

inheritedOutputSignalSet0(*d*: <agent type definition>∪<agent definition>):*SIGNAL0* =$_{def}$
if *d.specialization0* = *undefined* **then** ∅
else *d.specialization0*.**s-**<type expression>.*baseType0.validOutputSignalSet0*
endif

The function *inheritedAgentBody0* gets an inherited agent body (if any) of an <agent type definition>. If the agent type is not specialized the result is the undefined value. If the base type of the agent has an agent body this is returned, otherwise it returns the inherited agent body (if any) of the base type. Note that if the base type has an agent body and inherits an agent body, the two bodies are not merged.

inheritedAgentBody0 (*atd*: <system type definition> ∪ <block type definition> ∪ <process type definition>):
<agent body> =$_{def}$
let *specialization* =
(**case** *atd* **of**
| <system type definition> **then** *atd*.**s-**<system type heading>
| <block type definition> **then** *atd*.**s-**<block type heading>
| <process type definition> **then** *atd*.**s-**<process type heading>
endcase).**s-**<agent type additional heading>.**s-**<agent additional heading>.**s-**<specialization>
in
if *specialization* = *undefined* **then** *undefined*
else
let *baseType* = *specialization*.**s-**<type expression>.*baseType0* **in**
let *baseTypeBody* = *baseType*.**s-**<agent structure>.**s-**<agent body> **in**
if *baseTypeBody* ≠ *undefined* **then** *baseTypeBody*
else *inheritedAgentBody0* (*baseType*)
endif
endlet // *baseTypeBody*
endlet // *baseType*
endif
endlet // specialization

F2.2.5.1.2 System type

Concrete syntax

<system type definition> ::
<package use clause>* <system type heading> <agent structure>

<system type heading> :: <qualifier> <system<name> <agent type additional heading>

Conditions on concrete syntax

∀*fcp*∈<formal context parameter>:
(*fcp.surroundingScopeUnit0*∈<system type definition>) ⇒
(*fcp*∉<agent context parameter>∪<variable context parameter list>∪<timer context parameter list>)

A <formal context parameter> of <formal context parameters> of <agent type additional heading> of a <system type definition> shall not be an <agent context parameter>, <variable context parameter list> or <timer context parameter list>. See clause 8.1.1.2 *Concrete grammar* of [ITU-T Z.102].

¬(∃*fps*∈<agent formal parameters>: *fps.surroundingScopeUnit0*∈<system type definition>)

The <agent type additional heading> in a <system type definition> shall not include <agent formal parameters>. See clause 8.1.1.2 *Concrete grammar* of [ITU-T Z.101].

Mapping to abstract syntax

| <system type definition>(*, <system type heading>(*, *name*,
<agent type additional heading>(*, *, <agent additional heading>(*spec*, *params*))),
<agent structure>(*entities*, <interaction>(*defs*, *sm*))) **then**
let *entitiesSet* = { *Mapping*(*entities*[*i*]:*i* ∈ 1..*entities.length*} **in**

let *defSet* = { *Mapping*(*defs*[*i*]:*i* ∈ 1..*defs.length*} **in**
mk-*Agent-type-definition*(*Mapping*(*name*),
SYSTEM,
Mapping(*spec*), // specialization
Mapping(*params*), // agent formal parameters
{ *dtd* ∈ *entitiesSet*: (*dtd* ∈ *Data-type-definition*)} ∪
{ *implicitInterface1*(*atd*) : (*atd* ∈ *entitiesSet* ∧ *atd* ∈ *Agent-type-definition*) } ∪
{ *implicitInterface1*(*adf*) : (*adf* ∈ *entitiesSet* ∧ *adf* ∈ *Agent-definition*) } ∪
{ *implicitInterface1*(*at*) : (*at* ∈ *defSet* ∧ *at* ∈ *Agent-type-definition*) } ∪
{ *implicitInterface1*(*ad*) : (*ad* ∈ *defSet* ∧ *adf* ∈ *Agent-definition*) }∪
{ *implicitInterface1*(*sm*) } ∪
{ *choiceForGate1*(*tgd*) : (*tgd* **in** *entities* ∧ *tgd* ∈ <textual gate definition> } ∪ // choices for *Gate-defs*,
{ *choiceForChannel1*(*ch*) : (*ch* **in** *defs* ∧ *ch* ∈ <channel definition> } // choices for *Chan-defs*,
{ *sdf* ∈ *entitiesSet*: (*sdf* ∈ *Syntype-definition*)},
{ *sgd* ∈ *entitiesSet*: (*sgd* ∈ *Signal-definition*)},
{ *tdf* ∈ *entitiesSet*: (*tdf* ∈ *Timer-definition*)},
{ *vdf* ∈ *entitiesSet*: (*vdf* ∈ *Variable-definition*)},
{ *atd* ∈ *entitiesSet*: (*atd* ∈ *Agent-type-definition*)} ∪{ *at* ∈ *defSet*: (*at* ∈ *Agent-type-definition*) },
{ *std* ∈ *entitiesSet*: (*std* ∈ *Composite-state-type-definition*)},
{ *pdf* ∈ *entitiesSet*: (*pdf* ∈ *Procedure-definition*)},
{ *adf* ∈ *entitiesSet*: (*adf* ∈ *Agent-definition*)} ∪{ *ad* ∈ *defSet*: (*ad* ∈ *Agent-definition*) },
{ *gdf* ∈ *entitiesSet*: (*gdf* ∈ *Gate-definition*)},
{ *cdf* ∈ *entitiesSet*: (*cdf* ∈ *Channel-definition*)} ∪{ *ch* ∈ *defSet*: (*ch* ∈ *Channel-definition*) },
Mapping(*sm*)) // State machine
endlet // *defSet*
endlet // *entitiesSet*

The implicitly defined interface for a state machine is defined in the same scope unit as the state machine that defined it: that is, inside the agent type. See clause 12.1.2 *Concrete grammar* of [ITU-T Z.101].

F2.2.5.1.3 Block type

Concrete syntax

<block type definition> ::
<package use clause>* <block type heading> <agent structure>

<block type heading> ::
<type preamble> <qualifier> <block type<name> <agent type additional heading>

Transformations

The special stopping condition property of `set_v` *and* `get_v` *procedures mentioned below is covered by the dynamic semantics.* The two text paragraphs following the transformation code are derived from clause 9.2 *Model* of [ITU-T Z.102]. The first paragraph is an outline of the transform, and the second paragraph gives the detail. The transform of block definition into a typebased block definition and a block type follows the pattern for transforming agent definitions and is given in clause F2.2.6.1.

atd = <agent type definition>(*packages*,
heading,
<agent structure>(*entities*,
<interaction>(*defsAndRefs*,
<typebased composite state>(*statename*, *undefined*, <type expression>(*st*, *empty*))
)
)
)
provided
heading ∈ (<system type heading> ∪ <block type heading>)
∧ (∃*vardef* **in** *entities* : *vardef* ∈ <variable definition>)
∧ (∀*vardef* **in** *entities* : *vardef* ∈ <variable definition> ⇒ // one variable per definition
vardef.**s**-<variables of sort>.*length* =1 ∧ *vardef*.**s**-<variables of sort>-**seq**[1].**s**-<name>-**seq**.*length* =1)

```
=16=>
let st1 = newName in
<agent type definition>(packages,
    heading,
    <agent structure>(
        < e in entities: e ∉ <variable definition> > // delete variable definitions
        ⌒ //add remote procedure definitions for set
        <   mk-<remote procedure definition>(
                mk-<name>("#set_"+ entities[i].s-<variables of sort>-seq[1].s-<name>-seq[1].s-TOKEN),
                mk-<procedure signature>( // sort of variable formal parameter, no result
                    < mk-<formal parameter>(in, entities[i].s-<variables of sort>-seq[1].s-<sort>) >, undefined
                ) // procedure signature - sort of variable formal parameter, no result
            ) //remote procedure definition
        | i in 1..entities.length : entities[i] ∈ <variable definition> >
        ⌒ //add remote procedure definitions for get
        <   mk-<remote procedure definition>(
                mk-<name>("#get_"+ entities[i].s-<variables of sort>-seq[1].s-<name>-seq[1].s-TOKEN),
                mk-<procedure signature>(
                    undefined, mk-<result>(entities[i].s-<variables of sort>-seq[1].s-<sort>)
                ) // procedure signature - no formal parameters, sort of variable result
            ) //remote procedure definition
        | i in 1..entities.length : entities[i] ∈ <variable definition> >
        ⌒ //add state type st1
        let stdef = getEntityDefinition0 (st, state type) in
        mk-<composite state type definition>(
        if stdef.s-<composite state type graph> ≠ undefined
        then
            mk-<composite state type graph>(
                stdef.s-<composite state type graph>.s-<package use clause>-seq,
                let stheading = stdef.s-<composite state type graph>.s-<composite state type heading> in
                mk-<composite state type heading>(
                    stheading.s-<virtuality>,
                    empty, // no qualifier
                    st1, //name
                    stheading.s-<formal context parameters>,
                    stheading.s-<virtuality constraint>,
                    st, // <specialization>, inherit st
                    stheading.s-<agent formal parameters>
                ), // <composite state type heading>
                endlet // stheading
                mk-<composite state type structure>(
                    empty, // no connection points added
                    //add variables and exported procedure definitions for set and get
                    < mkVarSetGet0(entities[i]) | i ∈ 1..entities.length : entities[i] ∈ <variable definition> >,
                    mk-<composite state body>(empty,empty) // no starts added, no states or free actions added
                ),
                st1 // optional name
            ) // <composite state type graph>
        else// stdef is<state aggregation type>
            mk-<state aggregation type>(
                stdef.s-<state aggregation type>.s-<package use clause>-seq,
                let saheading = stdef.s-<state aggregation type>.s-<state aggregation state type heading> in
                mk-<state aggregation type heading>(
                    saheading.s-<type preamble>
                    empty, // no qualifier
                    st1, //name
                    saheading.s-<formal context parameters>,
                    saheading.s-<virtuality constraint>,
                    st, // <specialization>, inherit st
                    saheading.s-<agent formal parameters>
                ), // <state aggregation type heading>
```

```
                endlet // saheading
                mk-<aggregation structure>(
                    //add variables and exported procedure definitions for set and get
                    < mkVarSetGet0(entities[i]) | i ∈ 1..entities.length : entities[i] ∈ <variable definition> >,
                    empty // no change to partitions
                ), // <aggregation structure>
                st1 // optional name
            ) // <state aggregation type>
        endif // stdef is <composite state type graph> (else <state aggregation type>)
        endlet // stdef
        mk-<interaction>(defsAndRefs,
            mk-<typebased composite state>( statename, undefined, mk-<type expression>(st1, empty))
    ) // agent structure
) // agent type definition
endlet // st1
and // transform variable assignments in contained agents.
 ass = <assignment>(var, expr)
provided
    isAncestorAS0(atd, ass) // is an assignment defined in atd – has to be for global variable to be visible
∧  ¬(isAncestorAS0(getEntityDefinition0(st, state type),ass)) // but ass not in the state type st
∧  var ∉ (<indexed variable> ∪ <field variable>) //removed at step 8, so var should be just identifier
∧  getEntityDefinition0(var, variable) in entities //one of the global block variables
=>
mk-<call statement>(
    mk-<remote procedure call body>(
        mk-<identifier>( var.fullQualifier0, mk-<name>("#set_"+ var.s-<name>.s-TOKEN)), //remote proc id
        < expr >, // actual parameters
        empty // communication constraints – empty list
    )
) // call statement
and // transform variable accesses in contained agents.
 va = <variable access>(vid)
provided
    isAncestorAS0(atd, va) // is a variable access defined in atd – has to be for global variable to be visible
∧  ¬(isAncestorAS0(getEntityDefinition0(st, state type),va)) // but variable access not in the state type st
∧  vid ∈ <identifier>
∧  getEntityDefinition0(vid, variable) in entities //one of the global block variables
=>
mk-<value returning procedure call> (
    mk-<remote procedure call body>(
        mk-<identifier>( vid.fullQualifier0, mk-<name>("#get_"+ vid.s-<name>.s-TOKEN)), //remote proc id
        empty, // actual parameters
        empty // communication constraints – empty list
    )
) // call statement
```

A block with a global variable definition (a <variable definition> as an <entity in agent> in the <agent structure> of the block/system type of the block/system) has a state machine that is interpreted concurrently with agents in the block/system. Access from contained agents in the block/system to a global variable of the block is covered by two implicitly defined remote procedures for setting and getting the data item associated with the variable. These procedures are provided by the state machine of the block.

A block type `bt` with global variables is transformed by moving the global variables (each <variable definition> as an <entity in agent>) from the <agent structure> of `bt` to a new (anonymously named) state type `st1` for `bt` that replaces the existing state type `st` for the state machine of `bt`. The state type `st1` has a <specialization> "`inherits st adding`", and adds each <variable definition> deleted from the <agent structure> of `bt` to a <composite state type definition> of `st1`. For each variable `v` in `b`, `st1` has two exported procedures with anonymous implicit names, but here are called `set_v` (with an **in**-parameter of the sort of `v`) and `get_v` (with a return type being the sort of `v`). Each assignment to

`v` from enclosed definitions of `bt` is transformed to a remote call of `set_v`. Each occurrence of `v` in expressions in enclosed definitions is transformed to a remote call of `get_v`. These occurrences also apply to occurrences in procedures defined in `bt`, as these are transformed into procedures local to the calling agents. There is no ambiguity between the remote procedure calls for different instances block type `bt`, because each instance has implicit remote procedure definitions for both procedures. The `set_v` and `get_v` procedures have a special property that means they are handled in the stopping condition of instances of `bt`. This transformation takes place after replacing agent definitions with typebased agent definitions and transforming context parameters, and before the transforming of remote procedures.

Mapping to abstract syntax

| <block type definition>(*, <block type heading>(*,*, *name*,
    <agent type additional heading>(*,*,<agent additional heading>(*spec*,*params*))),
    <agent structure>(*entities*, <interaction>(*defs*, *sm*))) **then**
let *entitiesSet* = { *Mapping*(*entities*[*i*]:*i* ∈ 1..*entities.length*} **in**
let *defSet* = { *Mapping*(*defs*[*i*]:*i* ∈ 1..*defs.length*} **in**
mk-*Agent-type-definition*(*Mapping*(*name*),
    BLOCK,
    Mapping(*spec*), // specialization
    Mapping(*params*), // agent formal parameters
    { *dtd* ∈ *entitiesSet*: (*dtd* ∈ *Data-type-definition*)} ∪
        { *implicitInterface1*(*atd*) : (*atd* ∈ *entitiesSet* ∧ *atd* ∈ *Agent-type-definition*) } ∪
        { *implicitInterface1*(*adf*) : (*adf* ∈ *entitiesSet* ∧ *adf* ∈ *Agent-definition*) }} ∪
        { *implicitInterface1*(*at*) : (*at* ∈ *defSet* ∧ *at* ∈ *Agent-type-definition*) } ∪
        { *implicitInterface1*(*ad*) : (*ad* ∈ *defSet* ∧ *adf* ∈ *Agent-definition*) }∪
        { *implicitInterface1*(*sm*) } ∪
        { *choiceForGate1*(*tgd*) : (*tgd* **in** *entities* ∧ *tgd* ∈ <textual gate definition> } ∪ // choices for *Gate-defs*,
        { *choiceForChannel1*(*ch*) : (*ch* **in** *defs* ∧ *ch* ∈ <channel definition> } // choices for *Chan-defs*,
    { *sdf* ∈ *entitiesSet*: (*sdf* ∈ *Syntype-definition*)},
    { *sgd* ∈ *entitiesSet*: (*sgd* ∈ *Signal-definition*)},
    { *tdf* ∈ *entitiesSet*: (*tdf* ∈ *Timer-definition*)},
    { *vdf* ∈ *entitiesSet*: (*vdf* ∈ *Variable-definition*)},
    { *atd* ∈ *entitiesSet*: (*atd* ∈ *Agent-type-definition*)} ∪{ *at* ∈ *defSet*: (*at* ∈ *Agent-type-definition*) },
    { *std* ∈ *entitiesSet*: (*std* ∈ *Composite-state-type-definition*)},
    { *pdf* ∈ *entitiesSet*: (*pdf* ∈ *Procedure-definition*)},
    { *adf* ∈ *entitiesSet*: (*adf* ∈ *Agent-definition*)} ∪{ *ad* ∈ *defSet*: (*ad* ∈ *Agent-definition*) },
    { *gdf* ∈ *entitiesSet*: (*gdf* ∈ *Gate-definition*)},
    { *cdf* ∈ *entitiesSet*: (*cdf* ∈ *Channel-definition*)} ∪{ *ch* ∈ *defSet*: (*ch* ∈ *Channel-definition*) },
    Mapping(*sm*)) // State machine
endlet // *defSet*
endlet // *entitiesSet*

Auxiliary functions

The function *mkVarSetGet0* makes a local copy of the global block variable given by the *vardef* parameter and the exported *set* and *get* procedures.

mkVarSetGet0(*vardef*: <variable definition>, *st1*: <name>):
    (<variable definition>∪<internal procedure definition>)* =$_{def}$
let *varname* = *vardef*.**s**-<variables of sort>**-seq**[1].**s**-<name>**-seq**[1] **in**
let *qualInSt1* = *vardef.fullQualifier0* ⌒ **mk-**<path item>(**state type**, *st1*) **in**
< // make a sequence
vardef, //variable definition – no modification needed as does not contain qualifier
mk-<internal procedure definition>(//set
    empty, //package use clause
    mk-<procedure heading>(
        mk-<procedure preamble>(
            mk-<type preamble>(**finalized**, *undefined*), // finalized, not abstract

```
            mk-<exported>(
                mk-<identifier>(vardef.fullQualifier0,
                    mk-<name>("#set_"+ varname.s-TOKEN)
                ) // identifier
            ) // exported
        ), // procedure preamble
        empty, // defined in context – no qualifier needed
        mk-<name>("#set_"+ varname.s-TOKEN),
        undefined, // no formal context parameters
        undefined, // defined in context – no virtuality constrant
        undefined, // defined in context – no specialization
        <   mk-<formal variable parameters>(
                in, // parameter kind
                mk-<parameter aggregation>(mk-<aggregation kind>(part)), // aggregation
                mk-<parameters of sort>(< mk-<name>("v") >, vardef.s-<variables of sort>-seq[1].s-<sort>)
            ) // formal variable parameters
        >, // formal variable parameters list
        undefined // result
    ), // <procedure heading>
    empty, // entity in procedure list
    finalized, // virtuality
    mk-<statements>(
        <
            mk-<non terminating statement>(
                undefined, // no connector name before (assignment) non-terminating statement
                mk-<assignment statement>(mk-<assignment>(
                    mk-<identifier>( qualInSt1, varname)// variable defined by local vardef
                    mk-<operand5>(undefined, mk-<variable access>(
                        mk-<identifier>( qualInSt1 ⌒
                            mk-<path item>(procedure,
                                mk-<name>(
                                  "#set_"+ varname.s-TOKEN)
                                ), //name
                            ), //path item
                            mk-<name>("v")) // identifier – v procedure parameter
                    )) //variable access , operand5 expression
                )) // assignment, assignment statement
            ) // non terminating statement
        >, // non terminating statement list
        undefined, // no connector name before terminating statement
        mk-<return statement>(mk-<return body>(undefined)) //return
    ) // statements
), // <internal procedure definition> set
mk-<internal procedure definition>( //get
    empty, //package use clause
    mk-<procedure heading>(
        mk-<procedure preamble>(
            mk-<type preamble>( finalized, undefined), // finalized, not abstract
            mk-<exported>(
                mk-<identifier>(vardef.fullQualifier0,
                    mk-<name>("#get_"+ varname.s-TOKEN)
                ) // identifier
            ) // exported
        ), // procedure preamble
        empty, // defined in context – no qualifier needed
        mk-<name>("#get_"+ varname.s-TOKEN),
        undefined, // no formal context parameters
        undefined, // no virtuality constrant
        undefined, // no specialization
        empty, // no formal variable parameters
        mk-<result>(
            mk-<parameter aggregation>(mk-<aggregation kind>(part)), // aggregation
```

```
                mk-<parameters of sort>(< mk-<name>("v") >, vardef.s-<variables of sort>-seq[1].s-<sort>)
            ) // formal variable parameters
        >, // formal variable parameters list
        undefined // result
    ), // <procedure heading>
    empty, // list of entities in procedure
    finalized, // virtuality
    mk-<statements>(
        undefined, // no connector name before terminating statement
        mk-<return statement>(
            mk-<return body>(
                    mk-<operand5>(undefined, mk-<variable access>(
                        mk-<identifier>( qualInSt1, varname)// variable defined by local vardef
                    )) //variable access , operand5 expression
            ) // return body
        ) //return  statement
    ) // statements
) // <internal procedure definition> get
> // end of sequence
endlet // qualInSt1
endlet // varname
```

The function *isGlobalBlockVar0* returns true if the <variable> given is defined as one of the entities of a block (or system) type and the <variable> usage occurs within the block (or system), but not within the state machine actions of the block (or system) type. The function is used to check that such a global block <variable> is used in a <stimulus>, <timer communication constraint>, <encoded input> or <in choice> only in the state machine of the agent owning the variable.

```
isGlobalBlockVar0(var: <identifier>): BOOLEAN =def
let su = surroundingScopeUnit0(getEntityDefinition0(var, variable)) in
let struct = su.s-<agent structure>.s-implicit in
let sma = // state machine or actions
if struct ∈ <interaction> then
    let sm = struct.s-<interaction>.s-<state machine>
    if sm ∈ <typebased composite state> then
        getEntityDefinition0(
            sm.s-<typebased composite state>.s-<type expression>.s-<base type>,state type)
    else // sm ∈ <composite state list item>
    take({ cs ∈ <composite state definition> :
            (surroundingScopeUnit0(cs) = su)
        ∧  (    (cs.s-<composite state graph>.s-<composite state heading>.s-<name>
                    = sm.s-<composite state list item>.s-<name>)
            ∨   (cs.s-<state aggregation>.s-<composite state heading>.s-<name>
                    = sm.s-<composite state list item>.s-<name>)
            )
        })
    endif
    endlet // sm
else // struct ∈ <agent body>
    struct.s-<agent body>
endif
 in
    su ∈ (<system definition> ∪ <system type definition> ∪ <block definition> ∪ <block type definition>)
∧ isAncestorAS0(su, var) // use within scope surrounding var def
∧ ¬(isAncestorAS0(sma, var)) // but use not within state machine actions of block/system surrounding var def.
endlet // sma
endlet // struct
endlet // su
```

F2.2.5.1.4 Process type

Concrete syntax

<process type definition> ::
<package use clause>* <process type heading> <agent structure>

<process type heading> ::
<type preamble> <qualifier> <process type><name> <agent type additional heading>

Mapping to abstract syntax

| <process type definition>(*, <process type heading>(*,*, *name*,
<agent type additional heading>(*,*,<agent additional heading>(*spec*,*params*))),
<agent structure>(*entities*, <interaction>(*defs*, *sm*))) **then**
let *entitiesSet* = { *Mapping*(*entities*[*i*]:*i* ∈ 1..*entities.length*} **in**
let *defSet* = { *Mapping*(*defs*[*i*]:*i* ∈ 1..*defs.length*} **in**
mk-*Agent-type-definition*(*Mapping*(*name*),
PROCESS,*Mapping*(*spec*), // specialization
Mapping(*params*), // agent formal parameters
{ *dtd* ∈ *entitiesSet*: (*dtd* ∈ *Data-type-definition*)} ∪
{ *implicitInterface1*(*atd*) | (*atd* ∈ *entitiesSet* ∧ *atd* ∈ *Agent-type-definition*) } ∪
{ *implicitInterface1*(*adf*) | (*adf* ∈ *entitiesSet* ∧ *adf* ∈ *Agent-definition*) }} ∪
{ *implicitInterface1*(*at*) : (*at* ∈ *defSet* ∧ *at* ∈ *Agent-type-definition*) } ∪
{ *implicitInterface1*(*ad*) : (*ad* ∈ *defSet* ∧ *adf* ∈ *Agent-definition*) }∪
{ *implicitInterface1*(*sm*) } ∪
{ *choiceForGate1*(*tgd*) : (*tgd* **in** *entities* ∧ *tgd* ∈ <textual gate definition> } ∪ // choices for *Gate-defs*,
{ *choiceForChannel1*(*ch*) : (*ch* **in** *defs* ∧ *ch* ∈ <channel definition> } // choices for *Chan-defs*,
{ *sdf* ∈ *entitiesSet*: (*sdf* ∈ *Syntype-definition*)},
{ *sgd* ∈ *entitiesSet*: (*sgd* ∈ *Signal-definition*)},
{ *tdf* ∈ *entitiesSet*: (*tdf* ∈ *Timer-definition*)},
{ *vdf* ∈ *entitiesSet*: (*vdf* ∈ *Variable-definition*)},
{ *atd* ∈ *entitiesSet*: (*atd* ∈ *Agent-type-definition*)} ∪{ *at* ∈ *defSet*: (*at* ∈ *Agent-type-definition*) },
{ *std* ∈ *entitiesSet*: (*std* ∈ *Composite-state-type-definition*)},
{ *pdf* ∈ *entitiesSet*: (*pdf* ∈ *Procedure-definition*)},
{ *adf* ∈ *entitiesSet*: (*adf* ∈ *Agent-definition*)} ∪{ *ad* ∈ *defSet*: (*ad* ∈ *Agent-definition*) },
{ *gdf* ∈ *entitiesSet*: (*gdf* ∈ *Gate-definition*)},
{ *cdf e* ∈ *entitiesSet*: (*cdf* ∈ *Channel-definition*)} ∪{ *ch* ∈ *defSet*: (*ch* ∈ *Channel-definition*) },
Mapping(*sm*)) // State machine
endlet // *defSet*
endlet // *entitiesSet*

F2.2.5.1.5 Composite state type

Abstract syntax

Composite-state-type-definition	::	*State-type-name* [*Composite-state-type-identifier*] *Composite-state-formal-parameter** *State-entry-point-definition*-**set** *State-exit-point-definition*-**set** *Gate-definition*-**set** *Data-type-definition*-**set** *Syntype-definition*-**set** *Composite-state-type-definition*-**set** *Variable-definition*-**set** *Procedure-definition*-**set** { *Composite-state-graph* | *State-aggregation-node* } [*Abstract*]

Conditions on abstract syntax

∀*d*∈*Composite-state-type-definition*: *d*.**s**-*Gate-definition*-**set** ≠ ∅⇒
(∃*sd*∈*State-machine*:*getEntityDefinition1*(*sd*.**s**-*Composite-state-type-identifier*, **state type**) = *d*)

The *Gate-definition-set* must be empty unless the composite state is used as a *State-machine*.

Concrete syntax

<composite state type definition> ::
    <composite state type graph> | <state aggregation type>

<composite state type graph> ::
    <package use clause>* <composite state type heading> <composite state structure> [<name>]

<composite state type heading> ::
    [<virtuality>] <qualifier> <composite state type<name>
    [<formal context parameters>] [<virtuality constraint>]
    [<specialization>] <agent formal parameters>

<state aggregation type> ::
    <package use clause>* <state aggregation type heading> <aggregation structure> [<name>]

<state aggregation type heading> ::
    <type preamble> <qualifier> <composite state type<name>
    [<formal context parameters>] [<virtuality constraint>]
    [<specialization>] <agent formal parameters>

Transformations

cstd.defaultEntryPoint
provided
cstd ∈ <composite state type definition> ∧
cstd.defaultEntryPoint = undefined
=11=>
(*defaultEntryPoint* \{(*cstd, undefined*)}) ∪ {(*cstd, newName*)}

cstd.defaultExitPoint
provided
cstd ∈ <composite state type definition> ∧
cstd.defaultExitPoint = undefined
=11=>
(*defaultEntryPoint* \{(*cstd, undefined*)}) ∪ {(*cstd, newName*)}

Mapping to abstract syntax

| <composite state type definition>(<composite state type graph>(*,
    <composite state type heading>(*, *, *name*, *, *, *parent*, *params*),
        <composite state structure>(*conns*, *entities*, <composite state body>(*starts*, *items*))) **then**
let *startSet* = { *Mapping*(*starts*[*i*]):*i* ∈ 1..*starts.length*} **in**
let *itemSet* = { *Mapping*(*items*[*i*]):*i* ∈ 1..*items.length*} **in**
let *entitiesSet* = { *Mapping*(*entities*[*i*]):*i* ∈ 1..*entities.length*} **in**
mk-*Composite-state-type-definition*(*Mapping*(*name*),
    Mapping(*parent*),
    Mapping(*params*),
    Mapping(< *cin* : (*cin* **in** *conns*) ∧ (*cin* ∈ <state entry points>) >).*bigSeq.toSet*,
    Mapping(< *cout* : (*cout* **in** *conns*) ∧ (*cout* ∈ <state exit points>) >).*bigSeq.toSet*,
    { *gdf* ∈ *entitiesSet*: (*gdf* ∈ *Gate-definition*)},
    { *dtd* ∈ *entitiesSet*: (*dtd* ∈ *Data-type-definition*)} ∪
        { *choiceForGate1*(*tgd*) : (*tgd* **in** *entities* ∧ *tgd* ∈ <textual gate definition> } // choices for *Gate-defs*,
    { *sdf* ∈ *entitiesSet*: (*sdf* ∈ *Syntype-definition*)},
    { *std* ∈ *entitiesSet*: (*std* ∈ *Composite-state-type-definition*)},
    { *vdf* ∈ *entitiesSet*: (*vdf* ∈ *Variable-definition*)},
    { *pdf* ∈ *entitiesSet*: (*pdf* ∈ *Procedure-definition*)},
    mk-*Composite-state-graph*(
        mk-*State-transition-graph*(< *s* ∈ *startSet*: *s* ∈ *State-start-node* >.*head*,
            { *nsn* ∈ *startSet*: *nsn* ∈ *Named-start-node* },
            { *sn* ∈ *itemSet*: *sn* ∈ *State-node* },
            { *fa* ∈ *itemSet*: *fa* ∈ *Free-action*}), // State-transition-graph

```
        < pe ∈ entitiesSet: (pe ∈ Procedure-definition ∧ pe.s-Procedure-name = "entry") >.head,
        < px ∈ entitiesSet: (px ∈ Procedure-definition ∧ px.s-Procedure-name = "exit") >.head
    ) // Composite-state-graph
) // Composite state type definition
endlet // entitiesSet
endlet // itemSet
endlet // startSet

| <composite state type definition>(<state aggregation type>(*,
    <composite state type heading>(*, *, name, *, *, parent, params), // = <state aggregation type heading>
    <aggregation structure>(conns, body))) then
let entitiesSet = { Mapping(conns[i]):i ∈ 1..conns.length ∧ conns[i] ∈ <entity in state aggregation>} in
let csstd = mk-Composite-state-type-definition(Mapping(name),
    Mapping(parent),
    Mapping(params),
    Mapping(< cin : (cin in conns) ∧ (cin ∈ <state entry points>)>).bigSeq.toSet,
    Mapping(< cout : (cout in conns) ∧ (cout ∈ <state exit points>)>).bigSeq.toSet,
    { gdf ∈ entitiesSet: (gdf ∈ Gate-definition)},
    { dtd ∈ entitiesSetMapping(entities).toSet: (dtd ∈ Data-type-definition)},
    { sdf ∈ entitiesSet: (sdf ∈ Syntype-definition)},
    { std ∈ entitiesSet: (std ∈ Composite-state-type-definition)},
    { vdf ∈ entitiesSet: (vdf ∈ Variable-definition)},
    { pdf ∈ entitiesSet: (pdf ∈ Procedure-definition ∧ pdf.s-Procedure-name ∉ {"entry","exit"})},
    mk-State-aggregation-node(
        { mk-State-partition(Mapping(b.s-<typebased state partition heading>.s-<name>), // partition name
            Mapping(b.s-<typebased state partition heading>.s-<type expression>), // inherits (if any)
            { Mapping(c):c in body∧c ∈ <state partition connection entry>∧c.s2-<identifier>=b.identifier0 }
            ∪ // this union is the Connection-definition-set
            { Mapping(c):c in body∧c ∈ <state partition connection exit>∧c.s2-<identifier>=b.identifier0 }
            ) // State-partition
            : (b in body) ∧ (b ∈ <textual typebased state partition def>) }, // State-partition-set
        head(< pe in Mapping(entitiesSet):
             pe ∈ Procedure-definition ∧ pe.s-Procedure-name = "entry" >),
        head(< px in Mapping(entitiesSet):
             px ∈ Procedure-definition ∧ px.s-Procedure-name = "exit") >)
    ) // State-aggregation-node
) in // Composite-state-type-definition
let unusedSigs = inputSignalSet1(cstd) \
    U { inputSignalSet1(sp) : sp ∈ cstd.s-State-aggregation-node.s-State-partition} in
if unusedSigs = ∅
then cstd
else // add a state partition to the State-aggregation-node to consume the excess symbols
let agg = cstd.s-State-aggregation-node in
let cstname = Mapping(newName) in
let sName = Mapping(newName) in
let stEntry = mk-State-start-node (mk-Transition(empty, sNode)) in
let stExit = mk-Action-return-node() in
let opId = // further study is needed to define an operation that ANDs all the
    // identifiers representing the non-implicit state partition
let sNode = mk-State-node(sName, ∅,
            { mk-Input-node(undefined, sig, undefined, undefined, undefined, undefined,
                    mk-Transition(empty, mk-Terminator(mk-Named-nextstate(sn)))):
                sig∈ unusedSigs }, // Input-node-set
            ∅, // no Spontaneous-transitions
            {mk-Continuous-signal(mk-Operation-application(opId, params)),
                undefined, mk-Transition(empty,mk-Terminator(stExit)))
            }, //Continuous-signal-set
            undefined // no State-timer
        ) in
    mk-Composite-state-type-definition( // revise Composite-state-type-definition to deal with unused signals
        cstd.s-State-type-name
```

cstd.**s-***Composite-state-type-identifier*
cstd.**s-***Composite-state-formal-parameter*-**seq**
cstd.**s-***State-entry-point-definition*-**set**
cstd.**s-***State-exit-point-definition*-**set**
cstd.**s-***Gate-definition*-**set**
cstd.**s-***Data-type-definition*-**set**
cstd.**s-***Syntype-definition*-**set**
cstd.**s-***Composite-state-type-definition*-**set** ∪
{ **mk-***Composite-state-type-definition*(// *Composite-state-type-definition* for unused signals
cstname, undefined, empty, { *stEntry* }, { *stExit* },∅,∅,∅,∅,∅,∅,
mk-*Composite-state-graph*(// this is the part that effectively discards unused signals
mk-*State-transition-graph*(*stEntry,* ∅, { *sNode* }, ∅,), // State-transition-graph
undefined, // no *Entry-procedure-definition*
undefined // no *Exit-procedure-definition*
) // Composite-state-graph
undefined // *Abstract*
) } // *Composite-state-type-definition*
cstd.**s-***Variable-definition*-**set** ∪
{ **mk-***Variable-definition*(*part*.**s-***State-partition*.**s-***Name,*
predefinedId1("Boolean"), **PART**, *Mapping*(*expr*)) : *part* ∈ *agg*.**s-***State-partition*-**set**
} // add an implicit Boolean variable for each partition
cstd.**s-***Procedure-definition*-**set**,
mk-*State-aggregation-node*(
agg.**s-***State-partition*-**set** ∪{ **mk-***State-partition*(*newName, undefined,* ∅) },
agg.**s-***Entry-procedure-definition,*
agg.**s-***Exit-procedure-definition*
), // *State-aggregation-node*
cstd.**s-***Abstract*
) // *Composite-state-type-definition*
endlet // *sNode*
endlet // *stExit*
endlet // *stEntry*
endlet // *sName*
endlet // *cstname*
endlet // *agg*
endif
endlet // *unusedSigs*
endlet // *cstd*
endlet // *entitiesSet*

F2.2.5.2 Type expression

Concrete syntax

<type expression> :: <base type> <actual context parameter list>

<base type> =<identifier>

Conditions on concrete syntax

∀*te*∈<type expression>:
te.actualContextParameterList0 ≠ *empty* ⇒ *isParameterizedType0*(*te.baseType0*)

It is valid to have <actual context parameters> if and only if <base type> denotes a parameterized type. See 8.1.2 *Concrete grammar* of [ITU-T Z.102].

Transformations

te.anonymousTypeName
provided
te ∈ <type expression> ∧
te.**s-**<actual context parameter>-**seq** ≠ *empty* ∧
te.parentAS0 ∉ <specialization> ∧
te.anonymousTypeName = undefined

=11=>
(*anonymousTypeName*\{(*te*, *undefined*)}) ∪ {(*te*, *newName*)}

te=<type expression>(*id*, *params*)
provided
te.**s-**<actual context parameter>**-seq** ≠ *empty* ∧
te.parentAS0 ∉ <specialization> ∧
te.anonymousTypeName ≠ *undefined*
=11=>
mk-<type expression>(
    mk-<identifier>(*te.surroundingQualifier0*,
        te.anonymousTypeName),
    empty)
and
te.surroundingScopeUnit0.getEntities0 // entities in nearest surrounding scope unit
=>
let *basetype* = *id.refersto0* **in**
let *fcpl* = *basetype.FormalContextParameterList0* **in**
te.surroundingScopeUnit0.getEntities0 ⌒
        < *replaceContextParameters0*(*fcpl*, *params*,
            createNewType0(*te.anonymousTypeName*, *basetype*,
                getUnboundFormalContextParameterList0(*fcpl*, *params*))) >
endlet // *fcpl*
endlet // *basetype*

A <type expression> yields either the type identified by the identifier of <base type> in cases where there are no actual context parameters or an anonymous type defined by applying the actual context parameters to the formal context parameters of the parameterized type denoted by the identifier of <base type>. See clause 8.1.2 *Model* of [ITU-T Z.102].

Mapping to abstract syntax

| <type expression>(*x*, *undefined*) **then** *Mapping*(*x*)

Auxiliary functions

The function *anonymousTypeName* is used to store the name of the anonymous type created by applying actual context parameters to a base type of a type expression.

controlled *anonymousTypeName*: <type expression> → <name>
initially ∀ *te* ∈ <type expression>: *te.anonymousTypeName* = *undefined*

The function *isDirectSubType0* determines if a type definition is a direct subtype of an entity definition.

isDirectSubType0(*ed*: *EntityDefinition0*, *td*: *TypeDefinition0*): *Boolean*=$_{\text{def}}$
    ∃*te*∈<type expression>: *te*. *parentAS0=ed*. *specialization0*∧*td=te.baseType0*

The function *isSubtype0* determines if a type definition is a subtype of an entity definition.

isSubtype0(*sub*: *EntityDefinition0*, *sup*: *TypeDefinition0*): *Boolean*=$_{\text{def}}$
    isDirectSubType0(*sub*, *sup*) ∨
    (∃*ttd*∈ *TypeDefinition0* : *isSubtype0*(*sub*, *ttd*) ∧ *isSubtype0*(*ttd*, *sup*))

The function *baseType0* is used to get the base type definition for a type expression.

baseType0(*te*: <type expression>): *TypeDefinition0* =$_{\text{def}}$
    let *bt* = *te*.**s-**<identifier> **in**
    getEntityDefinition0(*bt*, *idKind0*(*bt*))
    endlet

The function *isParameterizedType0* is used to determine if a type definition is a parameterized type.

```
isParameterizedType0(td: TYPEDEFINITION0 ): BOOLEAN=def
    (td.formalContextParameterList0 ≠ empty)
```

Get the formal context parameter list of a type definition.

```
formalContextParameterList0(td: TYPEDEFINITION0 ): <formal context parameter>* =def
    td.inheritedFormalContextParameterList0⌒ td.localFormalContextParameterList0
```

Get the formal context parameter list of the super type of a type definition.

```
inheritedFormalContextParameterList0(td: TYPEDEFINITION0 ): <formal context parameter>* =def
    let sp=td.specialization0 in
        if sp = undefined then empty else
        case sp of
        | <interface specialization> then
            < getUnboundFormalContextParameterList0(tel.baseType0.formalContextParameterList0,
                tel.actualContextParameterList0)
            | tel in sp.s-<type expression>-seq >
        otherwise
            let fcpl=sp.s-<type expression>.baseType0.formalContextParameterList0 in
                let acpl=sp.s-<type expression>.actualContextParameterList0 in
                getUnboundFormalContextParameterList0(fcpl, acpl)
            endlet
        endcase
        endif
    endlet
```

Get the unbound formal context parameter list of a formal context parameter list according to an actual context parameter list.

```
getUnboundFormalContextParameterList0(fcpl: <formal context parameter>*,
        acpl: <actual context parameter>*): <formal context parameter>* =def
    if (fcpl = empty) then empty
    else
        if (acpl.head= undefined) then < fcpl.head > else empty endif
        ⌒getUnboundFormalContextParameterList0(fcpl.tail, acpl.tail)
    endif
```

The function *completeFormalContextParameter0* inserts the <identifier> for the original formal context parameter for the unbound ones.

```
completeFormalContextParameter0(fcpl: <name>*, acpl: <actual context parameter list>):
        <actual context parameter list> =def
    if (fcpl = empty) then empty
    else
        if (acpl.head= undefined) then < mk-<identifier>( undefined, fcpl.head) > else <acpl.head> endif
        ⌒completeFormalContextParameter0(fcpl.tail, acpl.tail)
    endif
```

The function *actualContextParameterList0* gets the actual context parameter list of a type expression. Each item in the list corresponds to [<actual context parameter>]; that is, the item is either *undefined* or an <actual context parameter>.

```
actualContextParameterList0(te: <type expression>): <actual context parameter list> =def
    te.s-<actual context parameter list>
```

Get the formal context parameter list local to a type definition.

```
localFormalContextParameterList0(td: TYPEDEFINITION0 ): <formal context parameter>* =def
    let fcps =take({fcps∈<agent type additional heading> ∪ <composite state type heading> ∪
```

```
                    <procedure heading> ∪ <signal definition> ∪ <data type heading> ∪
                    <interface heading>: fcps.surroundingScopeUnit0 = td}) in
        < fcpl.formalContextParameterSublist0 | fcpl in fcps.s-<formal context parameter>-seq >
    endlet
```

Expand a formal context parameter to a list of formal context parameters so that each item in the list contains just one name.

```
formalContextParameterSublist0(fcp: <formal context parameter>):<formal context parameter>* =def
    case fcp of
    | <agent context parameter> then < fcp >
    | <agent type context parameter> then < fcp >
    | <compositestate type context parameter> then < fcp >
    | <gate context parameter> then < fcp >
    | <interface context parameter list>(names) then
        if names.length = 1 then < fcp >
        else < mk-<interface context parameter list>(names.head) > ⌒
            formalContextParameterSublist0(< mk-<interface context parameter list>(names.tail) >)
        endif
    | <procedure context parameter> then < fcp >
    | <remote procedure context parameter> then <fcp >
    | <remotevariable context parameter list> (items (names, vc)) then
        if items.length = 1 then
            if names.length = 1 then < fcp >
            else
                < mk-<remotevariable context parameter list>(
                    mk-<remotevariable contextparameter names>(names.head, vc)) > ⌒
                formalContextParameterSublist0(
                        < mk-<remotevariable context parameter list>(
                        mk-<remotevariable contextparameter names>(names.tail, vc)) > )
            endif
        else
            if names.length = 1 then
                < mk-<remotevariable context parameter list>(
                    mk-<remotevariable contextparameter names>(names.head, vc)) > ⌒
                formalContextParameterSublist0(items.tail)
            else
                < mk-<remotevariable context parameter list>(
                    mk-<remotevariable contextparameter names>(names.head, vc)) > ⌒
                formalContextParameterSublist0(
                    < mk-<remotevariable context parameter list>(
                        mk-<remotevariable contextparameter names>(names.tail, vc)) >
                    ⌒ items.tail)
            endif
        endif
    | <signal context parameter list>(names) then
        if names.length = 1 then < fcp >
        else < mk-<signal context parameter list>(names.head) > ⌒
            formalContextParameterSublist0(< mk-<signal context parameter list>( names.tail) >)
        endif
    | <sort context parameter> then < fcp >
    | <synonym context parameter list>(names) then
        if names.length = 1 then < fcp >
        else < mk-<synonym context parameter list>(names.head) > ⌒
            formalContextParameterSublist0(< mk-<synonym context parameter list>( names.tail) >)
        endif
    | <timer context parameter list>(names) then
        if names.length = 1 then < fcp >
        else < mk-<timer context parameter list>(names.head) > ⌒
```

formalContextParameterSublist0(< **mk**-<timer context parameter list>(*names.tail*) >)
endif
| <variable context parameter list>(*names*) **then**
if *names.length* = 1 **then** < *fcp* >
else < **mk**-<variable context parameter list>(*names.head*) > ⌒
formalContextParameterSublist0(< **mk**-<variable context parameter list>(*names.tail*) >)
endif
otherwise *empty*
endcase

Replace the formal context parameters by actual context parameters.

replaceContextParameters0(*fcpl*:<formal context parameter>*, *acpl*:<actual context parameter>*,
orig:*DefinitionAS0*): *DefinitionAS0* =$_{\text{def}}$
if *fcpl = empty* **then** *orig*
else *replaceContextParameters0*(*fcpl.tail, acpl.tail,*
if *acpl.head = undefined* **then** *orig* **else** *replaceContextParameter0*(*fcpl.head*, *acpl.head*, *orig*) **endif**)
endif

Replace one formal context parameter by an actual context parameter.

replaceContextParameter0(*fcp*:*DefinitionAS0*, *acp*:<actual context parameter>, *orig*:*DefinitionAS0*):
DefinitionAS0 =$_{\text{def}}$
replaceInSyntaxTree0(*fcp*, *acp*, *orig*)

Create a new type with the specified formal context parameters.

createNewType0(*n*: <name>, *orig*: *DefinitionAS0*, *fcpl*: <formal context parameter list>): *DefinitionAS0* =$_{\text{def}}$
case *orig* **of**
| <system type definition>(*use*,
<system type heading>(*q*, *, <agent type additional heading>(*, *virt*, *add*)), *body*)
then <system type definition>(*use*,
<system type heading>(*q*, *n*, <agent type additional heading>(*fcpl*, *virt*, *add*)), *body*)
| <block type definition>(*use*,
<block type heading>(*pre*, *q*, *, <agent type additional heading>(*, *virt*, *add*)), *body*)
then <block type definition>(*use*,
<block type heading>(*pre*, *q*, *n*, <agent type additional heading>(*fcpl*, *virt*, *add*)), *body*)
| <process type definition>(*use*,
<process type heading>(*pre*, *q*, *, <agent type additional heading>(*, *virt*, *add*)), *body*)
then <process type definition>(*use*,
<process type heading>(*pre*, *q*, *n*, <agent type additional heading>(*fcpl*, *virt*, *add*)), *body*)
| <composite state type definition>(*use*,
<composite state type heading>(*v*, *q*, *, *, *c*, *spec*, *par*), *body*)
then <composite state type definition>(*use*,
<composite state type heading>(*v*, *q*, *n*, *fcpl*, *c*, *spec*, *par*), *body*)
| <data type definition>(*use*, *pre*, <data type heading>(*k*, *, *, *v*), *spec*, *body*)
then <data type definition>(*use*, *pre*, <data type heading>(*k*, *n*, *fcpl*, *v*), *spec*, *body*)
| <internal procedure definition>(*use*, <procedure heading>(*pre*, *q*, *, *, *c*, *spec*, *par*, *res*), *ent*, *body*)
then <internal procedure definition>(*use*,
<procedure heading>(*pre*, *q*, *n*, *fcpl*, *c*, *spec*, *par*, *res*), *ent*, *body*)
| <interface definition>(*use*, *virt*, <interface heading>(*, *, *v*), *spec*, *ent*, *l*)
then <interface definition>(*use*, *virt*, <interface heading>(*n*, *fcpl*, *v*)), *spec*, *ent*, *l*)
| <signal definition>(*pre*, *, *v*, *spec*, *l*)
then <signal definition>(*pre*, *n*, *fcpl*, *v*, *spec*, *l*)
otherwise *undefined*
endcase

F2.2.5.3 Definitions based on types

Concrete syntax

<textual typebased agent definition> =
<textual typebased system definition>
| <textual typebased block definition>

| <textual typebased process definition>

Conditions on concrete syntax

∀*ad*∈<textual typebased agent definition>: ∀*te*∈<type expression>:
(*te.parentAS0.parentAS0= ad*) ⇒
(∃*s*∈<start>: (*s*∈*te.baseType0.startSet0*)∧(*s*.**s-**<name> = *undefined*))

The agent type denoted by <base type> in the type expression of a <textual typebased agent definition> shall contain an unlabelled start transition in its state machine. See clause 9 *Concrete grammar* of [ITU-T Z.101].

F2.2.5.3.1 System definition based on system type

Concrete syntax

<textual typebased system definition>::
<typebased system heading>

<typebased system heading> ::
<system><name> <system><type expression>

Mapping to abstract syntax

| <textual typebased system definition>(<typebased system heading>(*name*,<type expression>(*b*,*))) **then**
mk-*Agent-definition*(*Mapping*(*name*), **mk-***Number-of-instances*(1,1,0), *Mapping*(*b*))

F2.2.5.3.2 Block definition based on block type

Concrete syntax

<textual typebased block definition> ::
<typebased block heading>

<typebased block heading> ::
<block><name> <number of instances> <block><type expression>

Mapping to abstract syntax

| <textual typebased block definition>
(<typebased block heading>(*name*, *inst*, <type expression>(*b*,*))) **then**
mk-*Agent-definition*(*Mapping*(*name*), *Mapping*(*inst*), *Mapping*(*b*))

F2.2.5.3.3 Process definition based on process type

Concrete syntax

<textual typebased process definition> = <typebased process heading>

<typebased process heading> ::
<process><name> <number of instances> <process><type expression>

Mapping to abstract syntax

| <textual typebased process definition> (*name*, *inst*, <type expression>(*b*,*)) **then**
mk-*Agent-definition*(*Mapping*(*name*), *Mapping*(*inst*), *Mapping*(*b*))

F2.2.5.3.4 Composite state definition based on composite state type

Concrete syntax

<typebased composite state> ::
<composite state><name> <nextstate parameters> <composite state><type expression>

<textual typebased state partition def> =
<typebased state partition heading>

<typebased state partition heading> :: <composite state><name> <composite state><type expression>

Mapping to abstract syntax

A composite state based on a type is mapped within the production for states.

F2.2.5.4 Abstract type

Abstract syntax

Abstract :: {}

Concrete syntax

<abstract> :: ()

Conditions on concrete syntax

∀*pd*∈<procedure definition>: *isAbstractType0*(*pd*) ⇒
¬(∃*pc*∈<procedure call>: *pd* = *pc.calledProcedure0*)

An abstract procedure shall not be called.

NOTE – The above text is derived from "An abstract type shall not be instantiated" (see below); a procedure is a type and calling a procedure instantiates the procedure.

∀*ad*∈<textual typebased agent definition>: ∀*te*∈<type expression>:
te.parentAS0.parentAS0= ad ⇒ ¬*isAbstractType0*(*te.baseType0*)

A typebased agent shall not be specified with an abstract agent type as the type.

NOTE – The above text is derived from "An abstract type shall not be instantiated" (see below); a typebased agent is an instantiation of the agent type.

∀*td*∈*TYPEDEFINITION0* : *isAbstractType0*(*td*) ⇒
¬(∃*d*∈<textual typebased agent definition> ∪ <textual typebased state partition def> ∪
<typebased composite state>:∃*te*∈<type expression>:
((*te.parentAS0.parentAS0= d*)∨(*te.parentAS0= d*))∧ (*te.baseType0=td*))

An abstract type shall not be instantiated. See clause 8.1.3 *Semantics* of [ITU-T Z.102]).

NOTE – The abstract property of a type is not inherited; therefore instantiation of a subtype of an abstract data type is permitted, if the subtype is not itself abstract.

Mapping to abstract syntax

| <abstract> **then** *Abstract*

Auxiliary functions

Determine if a type definition is abstract, either because it is defined as abstract by the keyword **abstract** or because it has unbound context parameters.

isAbstractType0(*td*: *TYPEDEFINITION0*): *BOOLEAN*=$_{\text{def}}$
(∃*ab*∈<abstract>: *ab.surroundingScopeUnit0 = td*)
∨ (∃*te* ∈<type expression>: *te.surroundingScopeUnit0 = td* ∧
getUnboundFormalContextParameterList0(*te.baseType0.formalContextParameterList0,*
te.actualContextParameterList0) ≠ *empty*)

Get the <internal procedure definition> denoted by a <procedure call>.

calledProcedure0(*pc*: <procedure call>∪<value returning procedure call>
∪<procedure call body>∪<remote procedure call body>):
<procedure definition>=$_{\text{def}}$
case *pc* **of**
| <procedure call>∪<value returning procedure call> **then**
let *t* = *pc*.**s**-<procedure call body>.**s-implicit in**
if *t*∈<identifier> **then** *getEntityDefinition0*(*t*, **procedure**)
else *t.baseType0* // *t*∈<type expression>

| <procedure call body> **then**
let *t* = *pc*.**s-implicit in**
if *t*∈<identifier> **then** *getEntityDefinition0*(*t*, **procedure**)
else *t.baseType0* // *t*∈<type expression>
| <remote procedure call body> **then** *getEntityDefinition0*(*pc*, **remote procedure**)
otherwise *undefined*
endcase

F2.2.5.5 Type reference

Type references do not have semantics in SDL-2010.

F2.2.5.6 Gate

Abstract syntax

Gate-definition :: *Gate-name*
[*Encoding-rules*]
In-signal-identifier-**set**
Out-signal-identifier-**set**

In-signal-identifier = *Signal-identifier*

Out-signal-identifier = *Signal-identifier*

∀*gd* ∈ *Gate-definition*:
let *supertype* = *gd.parentAS1.baseType1* **in**
supertype = undefined
∨ (∀*stgd* ∈ (*supertype*.**s**-*Gate-definition*-**set**):
(((*gd*.**s**-*Gate-name* = *stgd*.**s**-*Gate-name*) ∧ (*stgd*.**s**-*Encoding-rules* ≠ *undefined*))
⇒ (*gd*.**s**-*Encoding-rules* = *stgd*.**s**-*Encoding-rules*))
endlet // *supertypeid*

The *Encoding-rules* associated with a *Gate-definition* of a type based on a supertype shall specify the same set of *Encoding-rules* as the *Encoding-rules* of the corresponding gate definition in the supertype if that gate has *Encoding-rules*.

Concrete syntax

<gate in definition> = <textual gate definition> | <textual interface gate definition>

<textual gate definition> ::
<gate> [<encoding rules>] <gate constraint>

<textual interface gate definition> ::
{ **out** | **in** } <interface<identifier> [<encoding rules>] [<textual endpoint constraint>]

<gate> = <gate<name>

<gate constraint> ::
in [<textual endpoint constraint>] [<signal list>]
[**out** [<textual endpoint constraint>] [<signal list>]]
| [**out** [<textual endpoint constraint>] [<signal list>]]

<textual endpoint constraint> :: [**atleast**] <identifier>

<as gate> :: <gate<identifier>

NOTE – The derived AS0 for any SDL/PR <gate constraint> with **out** followed by **in** is the AS0 <gate constraint> with **in** followed by **out**.

Conditions on concrete syntax

∀*gd*∈<textual gate definition>: ∀*gc*∈<gate constraint>:
(*gc.parentAS0= gd*) ⇒
(**let** *td* = *gd.surroundingScopeUnit0* **in**
(∃*td1*∈*TYPEDEFINITION0* :
td1 = *getEntityDefinition0*(*gc*.**s**-<textual endpoint constraint>, *td.entityKind0*)) **endlet**)

The <identifier> of <textual endpoint constraint> must denote a type definition of the same entity kind as the type definition in which the gate is defined.

∀*gc* ∈ <gate constraint>:(∀*ce* ∈ <channel endpoint>:(∀*ce1* ∈ <channel endpoint>:(
(*gc*.*parentAS0*.**s**-<gate> = *ce*.**s**-<gate>) ∧
(*ce* ≠ *ce1*) ∧ (*ce*.*parentAS0*= *ce1*.*parentAS0*) ∧ (*ce.parentAS0*∈<channel path>) ∧
(*gc*.*parentAS0*∈<textual gate definition>))))⇒
(**let** *td* = *getEntityDefinition0*(*gc*.**s**-<textual endpoint constraint>,
gc.*surroundingScopeUnit0*.*entityKind0*) **in**
∃*td1* ∈ *ENTITYDEFINITION0*:
((*td*1= *ce1*.*channelEndpointReferTo0*) ∧ ((*td* = *td1*) ∨ *isSubtype0*(*td1*, *td*)))
endlet) ∧
(*ce*.*parentAS0*.**s**-<signal list item>-**seq**.*signalSet0* ⊆ *gc*.**s**-<signal list item>-**seq**.*signalSet0*)

A channel connected to a gate must be compatible with the gate constraint. A channel is compatible with a gate constraint if the other endpoint of the channel is an agent or state of the type denoted by <identifier> in the endpoint constraint or a subtype of this type (in case it contains a <textual endpoint constraint> with **atleast**), and if the set of signals (if specified) on the channel is equal to or is a subset of the set of signals specified for the gate in the respective direction.

∀*tbd*∈<textual typebased block definition> ∪<textual typebased process definition>:
∀*te*∈<type expression>: (*te*.*parentAS0*.*parentAS0*= *tbd*) ⇒
(**let** *td* = *te*.*baseType0* **in**
(*td*.*channelDefinitionSet0* ≠ ∅) ⇒
(∀*gc*∈<gate constraint>:∀*sig* ∈ *SIGNAL0*:
(*gc*.*parentAS0*∈*td*.*gateDefinitionSet0*) ∧
(*sig*∈*gc*.**s**-<signal list item>-**seq**.*signalSet0*) ⇒
(∃*cp*∈<channel path>:
(*cp*.*parentAS0*∈*td*.*channelDefinitionSet0*) ∧
((*gc*.*direction0*=**in**)⇒
(*cp*.*origination0*.**s**-<gate> = *gc*.*parentAS0*.**s**-<gate>) ∧
(*cp*.*origination0*.**s-implicit**=**env**)) ∧
((*gc*.*direction0*=**out**)⇒
(*cp*.*destination0*.**s**-<gate> = *gc*.*parentAS0*.**s**-<gate>) ∧
(*cp*.*destination0*.**s-implicit**=**env**)) ∧
(*sig*∈*cp*.**s**-<signal list item>-**seq**.*signalSet0*))) **endlet**)

If the type denoted by <base type> in a <textual typebased block definition> or <textual typebased process definition> contains channels, the following rule applies: For each combination of (gate, signal, direction) defined by the type, the type must contain at least one channel that - for the given direction - mentions **env** and the gate and either mentions the signal or has no explicit <signal list> associated. In the latter case, it must be possible to derive that the channel is able to carry the signal in the given direction. If the type contains channels mentioning remote procedures or remote variables, a similar rule applies.

∀*gc*, *gc1*∈<gate constraint>:
(*gc* ≠ *gc1*) ∧ (*gc*.*parentAS0*= *gc1*.*parentAS0*) ⇒
(*gc*.**s**-<textual endpoint constraint> = *gc1*.**s**-<textual endpoint constraint>) ∧
((*gc*.*direction0*=**out**) ∧ (*gc1*.*direction0*=**in**)∨(*gc*.*direction0*=**in**)∧(*gc1*.*direction0*=**out**))

Where two <gate constraint>s are specified one must be in the reverse direction to the other, and the <textual endpoint constraint>s of the two <gate constraint>s must be the same.

∀*gd*∈<textual gate definition>: (*gd*.**s-adding** ≠ *undefined*) ⇒
(**let** *td* = *gd*.*surroundingScopeUnit0* **in**
∃*td1*∈*TYPEDEFINITION0* : ∃*gd1*∈<textual gate definition>:
isSubtype0(*td*, *td1*) ∧ (*gd1*∈ *td1*.*gateDefinitionSet0*) ∧
(*gd1*.**s**-<gate> = *gd*.**s**-<gate>.) **endlet**)

adding may only be specified in a subtype definition and only for a gate defined in the supertype.

∀*ec*,*ec1*∈<textual endpoint constraint>:
isSubtype0(*ec.surroundingScopeUnit0*, *ec1.surroundingScopeUnit0*) ∧
(*ec.parentAS0*∈<gate constraint>) ∧ (*ec1.parentAS0*∈<gate constraint>) ∧
(*ec.parentAS0.parentAS0*∈<textual gate definition>) ∧
(*ec1.parentAS0.parentAS0*∈<textual gate definition>) ∧
(*ec.parentAS0.parentAS0*.**s-adding** ≠ *undefined*) ∧
(((*ec.direction0*=**out**) ∧ (*ec1.direction0*=**in**))∨((*ec.direction0*=**in**) ∧ (*ec1.direction0*=**out**))) ∧
(*ec.parentAS0.parentAS0*.**s-**<gate>= *ec1.parentAS0.parentAS0*.**s-**<gate>) ⇒
(**let** *td* = *getEntityDefinition0*(*ec*.**s-**<identifier>, *ec.surroundingScopeUnit0.entityKind0*) **in**
let *td1* = *getEntityDefinition0*(*ec1*.**s-**<identifier>, *ec1.surroundingScopeUnit0.entityKind0*) **in**
(*td* = *td1*) ∨ *isSubtype0*(*td*, *td1*) **endlet**)

If <textual endpoint constraint> is specified for the gate in the supertype, the <identifier> of an (added) <textual endpoint constraint> must denote the same type or a subtype of the type denoted in the <textual endpoint constraint> of the supertype.

∀*gd*∈<textual interface gate definition>:∃*td*∈<interface definition>:
td = *getEntityDefinition0*(*gd*.**s-**<identifier>, **interface**)

The <interface identifier> of a <textual interface gate definition> must not identify the interface implicitly defined by the entity to which the gate is connected.

Transformations

t= <textual interface gate definition>(**out**, *id*=<identifier>(*,*n*))
=8=>
mk-<textual gate definition>(*n*, *undefined*, **mk-**<gate constraint>(**out**, *undefined*, *id*))

t= <textual interface gate definition>(**in**, *id*=<identifier>(*,*n*))
=8=>
mk-<textual gate definition>(*n*, *undefined*, **mk-**<gate constraint>(**in**, *undefined*, *id*))

<textual interface gate definition> is shorthand for a <textual gate definition> having the name of the interface as <gate name> and the <interface identifier> as the <signal list>. See clause 8.1.4 *Model* of [ITU-T Z.103].

gd.asGateName
provided
gd ∈ <textual gate definition>
∧ *gd.asGateName = undefined*
=8=>
(*asGateName* \{(*gd*, *undefined*)}) ∪ {(*gd*, *newName*)}

NOTE – Each <textual gate definition> defines a *Data-type-definition* of a choice data type with a unique anonymous *Sort* name stored in *asGateName*.

<as gate>(*gid*)
provided
gid.refersto0.asGateName ≠ *undefined*
=8=>
mk-<type expression>(**mk-**<identifier>(*gid*.**s-**<qualifier>, *gid.refersto0.asGateName*), *undefined*)

An <as gate> represents the sort of the choice data type introduced by the identified gate definition. See clause 12.1 *Concrete grammar* of [ITU-T Z.104].

Mapping to abstract syntax

| *tgd* = <textual gate definition>(*name*, *,
<gate constraint>(**in**, *, *inlist*, **out**, *, *outlist*)) **then**
mk-*Gate-definition*(
Mapping(*name*),
Mapping(*encodingRules0*(*tgd*)),
{ *Mapping*(*inlist*[*i*]): *i* ∈ 1..*inlist.length*},

{ *Mapping*(*outlist*[*i*]): *i* ∈ 1..*outlist.length*})

| *tgd* = <textual gate definition>(*name*, *,
<gate constraint>(**in**, *, *inlist*, *undefined*,*,*)) **then**
mk-*Gate-definition*(
Mapping(*name*),
Mapping(*encodingRules0*(*tgd*)),
{ *Mapping*(*inlist*[*i*]): *i* ∈ 1..*inlist.length*,
∅)

| *tgd* = <textual gate definition>(*name*, *,
<gate constraint>(**out**, *, *outlist*)) **then**
mk-*Gate-definition*(
Mapping(*name*),
Mapping(*encodingRules0*(*tgd*)),
∅,
{ *Mapping*(*outlist*[*i*]): *i* ∈ 1..*outlist.length*)

If there is no set of <encoding rules> that is associated with a <textual gate definition> of a type based on a supertype, and there is a set of *Encoding-rules* for the gate in the supertype, the inherited gate has this set of *Encoding-rules*. If there is no set of *Encoding-rules* for the gate in the supertype, the presence and value of the inherited gate *Encoding-rules* is determined by the presence and value of the <encoding rules>. See clause 8.1.4 *Concrete grammar* of [ITU-T Z.104].

NOTE – The mapping to a *Data-type-definition* for the choice data type defined by a <textual gate definition> in the following paragraph takes place by invoking the function *choiceForGate1* (defined below), in the mapping to *Agent-type-definition* in F2.2.5.1.2, F2.2.5.1.3 and F2.2.5.1.4, or in the mapping of a <composite state type definition> with a <composite state structure> to a *Composite-state-type-definition* in F2.2.5.1.5.

A <textual gate definition> defines a *Data-type-definition* of a choice data type with a unique anonymous *Sort* name in the context that the *Gate-definition* is visible. A <basic sort> that is <as gate> where <gate identifier> identifies the *Gate-definition* represents this *Data-type-definition*. The *Data-type-definition* is equivalent to defining a choice data type with a <choice of sort> for each distinct *Signal-definition* identified by the *In-signal-identifier-**set*** and *Out-signal-identifier-**set***. Each <choice of sort> has as its <field sort> the data type denoted by <as signal> for the identified signal definition (the `NULL` sort for a signal without parameters; otherwise a structure data type with an anonymous unique name – for an identified signal `signal_id` with parameters the <choice of sort> has a <field sort> with identity as denoted by **`as signal`** `signal_id)`. If an identified *Signal-definition* has a name distinct from any other identified distinct *Signal-definition*, the <choice of sort> has the same <field name> as the name of the corresponding identified signal. If an identified *Signal-definition* has the same name as another identified *Signal-definition*, the <choice of sort> has <field name> with the same name as the anonymous unique name for the <as signal> structure data type. See clause 8.1.4 *Concrete grammar* of [ITU-T Z.104].

Auxiliary functions

The function *origination0* gets the originating channel endpoint of a <channel path>.

origination0(*p*: <channel path>): <channel endpoint> =$_{def}$
p.**s-**<channel endpoint>

The function *destination0* gets the destination channel endpoint of a <channel path>.

destination0(*p*: <channel path>): <channel endpoint> =$_{def}$
p.**s2-**<channel endpoint>

The function *gateDefinitionSet0* gets the <gate in definition>**-set** defined in an <agent type definition>, a <composite state type definition>, a <agent definition> or a <composite state definition>.

gateDefinitionSet0(*td*: <agent type definition> ∪ <composite state type definition> ∪
<agent definition> ∪ <composite state definition>): <gate in definition>-**set** =$_{def}$
td.localGateDefinitionSet0 ∪ *td.inheritedGateDefinitonSet0*

The function *localGateDefinitionSet0* gets the <gate in definition>-**set** defined by the <gate in definition> items of an <agent type definition>, a <composite state type definition>, a <agent definition> or a <composite state definition>.

localGateDefinitionSet0(*td*: <agent type definition> ∪ <composite state type definition> ∪
<agent definition> ∪ <composite state definition>): <gate in definition>-**set** =$_{def}$
{*gd*∈<gate in definition>: *gd.surroundingScopeUnit0 = td*}

The function *inheritedGateDefinitonSet0* gets the <gate in definition>-**set** inherited by an <agent type definition>, a <composite state type definition>, a <agent definition> or a <composite state definition>.

inheritedGateDefinitonSet0(*td*: <agent type definition> ∪ <composite state type definition> ∪
<agent definition> ∪ <composite state definition>): <gate in definition>-**set** =$_{def}$
let *sp=td.specialization0* **in**
if *sp=undefined* **then** ∅
else *sp*.**s**-<type expression>.*baseType0.gateDefinitionSet0*
endif
endlet

The function *encodingRules0* determines the <encoding rules> item to be used for the mapping from a <textual gate definition> to a *Gate-definition*.

encodingRules0(*tgd*: <textual gate definition>): <encoding rules> =$_{def}$
if *tgd*.**s**-<encoding rules> ≠ *undefined* **then** *tgd*.**s**-<encoding rules>
else
let *stgates* =
inheritedGateDefinitonSet0(
parentAS0ofKind(*tgd*,
<agent type definition>∪<composite state type definition>∪<agent definition> ∪<composite state definition>))
in
if *stgates* = ∅ **then** *undefined*
else
if (∃ *stgd* ∈ *stgates*: ((*tgd*.**s**-<name> = *stgd*.**s**-<name>) ∧ (*stgd*.**s**-<encoding rules> ≠ *undefined*))
then
take(*stgd* ∈ *stgates*: *tgd*.**s**-<name> = *stgd*.**s**-<name>).**s**-<encoding rules>
else *undefined*
endif
endif
endlet
endif

The function *channelDefinitionSet0* gets the <channel definition> items defined in an <agent type definition> or an <agent definition>.

channelDefinitionSet0(*td*: <agent type definition> ∪ <agent definition>): <channel definition>-**set** =$_{def}$
td.localChannelDefinitionSet0∪ *td.inheritedChannelDefinitionSet0*

The function *localChannelDefinitionSet0* gets the <channel definition> items defined locally (rather than inherited) in an <agent type definition> or an <agent definition>.

localChannelDefinitionSet0(*td*: <agent type definition> ∪ <agent definition>):
<channel definition>-**set** =$_{def}$
{*cd*∈<channel definition>: *cd.surroundingScopeUnit0 = td*}

The function *inheritedChannelDefinitionSet0* gets the <channel definition> items defined inherited by an <agent type definition> or an <agent definition>.

```
inheritedChannelDefinitionSet0(td:<agent type definition> ∪ <agent definition> ):
    <channel definition>-set =def
    let sp=td.specialization0 in
        if sp=undefined then ∅
        else sp.s-<type expression>.baseType0.channelDefinitionSet0
        endif
    endlet // sp
```

The function *signalSet0* produces the set of identifiers for entities of kind **signal**, **timer**, **remote procedure** or **remote variable** (that is, of domain *SIGNAL0*) for the given <signal list item> list. A <signal list item> of kind **signal**, **timer**, **remote procedure** or **remote variable** has its identifier included in the set. A <signal list item> of kind **interface** is expanded to include the identifiers of each <signal list item> defined and used by the interface.

```
signalSet0(sl:<signal list item>* ): SIGNAL0=def
    case sl.head.idKind0 of
    | {signal, timer, remote procedure, remote variable} then {sl.head} ∪ sl.tail.signalSet0
    | {interface} then
        let id = getEntityDefinition0(sl.head, interface) in
            id.usedSignalSet0 ∪ {sd.identifier0 | sd ∈ id.definedSignalSet0} ∪ sl.tail.signalSet0
        endlet // id
    otherwise ∅
    endcase
```

The function *choiceForGate1* produces the choice *Data-type-definition* that corresponds to a *Gate-definition* and is used when an <as gate> is given for a <basic sort>.

```
choiceForGate1(gd: <textual gate definition>): Data-type-definition =def
Mapping(mk-<data type definition>( mk-<type preamble>(undefined,undefined), // type preamble
    mk-<data type heading>( gd.asGateName, // name for choice type
        undefined, undefined, // no formal parameters or virtuality constraint
    ), // data type heading
    mk-<data type definition body>( empty, // no entities in data type
        mk-<choice definition>( undefined, // visibility
            <   mk-<choice of sort>( undefined, // visibility
                    mk-<field of kind>( part,
                        if sig.s-<name> ∉ { othersigs.s-<name>
                            : othersigs ∈ ((inoutSignals0(gd, in) ∪ inoutSignals0(gd, out)) \ sig )
                        then // unique signal name
                            sig.s-<name>
                        else // not unique signal name – name same as <as signal>
                            sig.asSignal.s-<name>// name of structure sort for signal
                        endif
                    ), // <field of kind>
                    mk-<field sort>(
                        if sig.refersto0.s-implicit  // <sort list> | <named fields sort list> | <sort<identifier>
                            = undefined  // no sort
                        then  predefinedId0("NULL")
                        else sig.asSignal  // structure sort for signal
                        endif
                    ) // <field sort>
                ) // <choice of sort> item
                : sig ∈ (inoutSignals0(gd, in) ∪ inoutSignals0(gd, out))
            > //  <choice of sort> list
        ) <choice definition>(
    ), // data type definition body
    undefined //  default initialization
)) // Mapping of data type definition
```

The function *asGateName* associates each <textual gate definition> with a unique anonymous *Sort* name for the corresponding *Data-type-definition* of the choice data type invoked by <as gate>.

controlled *asGateName*: <textual gate definition>→ <name>
initially ∀ *gd* ∈ <textual gate definition>: *gd.asGateName* = *undefined*

F2.2.5.7 Context parameters

Concrete syntax

<actual context parameter list> = [<actual context parameter>]*

<actual context parameter> :: <identifier> | <constant<primary>

<formal context parameters> = <formal context parameter list>

<formal context parameter list> :: <formal context parameter>+

<formal context parameter> =
    <agent context parameter>
  | <agent type context parameter>
  | <compositestate type context parameter>
  | <gate context parameter>
  | <interface context parameter list>
  | <procedure context parameter>
  | <remote procedure context parameter>
  | <remotevariable context parameter list>
  | <signal context parameter list>
  | <sort context parameter>
  | <synonym context parameter list>
  | <timer context parameter list>
  | <variable context parameter list>

Conditions on concrete syntax

∀*fcp*∈ *FORMALCONTEXTPARAMETER0*:∀*acp*∈<actual context parameter>:
  isContextParameterCorresponded0(*fcp*, *acp*) ∧ (*acp*∈<primary>) ⇒
    (*fcp*∈<synonym context parameter name>)

An <actual context parameter> shall not be a <constant<primary> unless it is for a synonym context parameter.

(∀*te*∈<type expression>: *te.baseType0*∉*FORMALCONTEXTPARAMETER0*) ∧
(∀*fcp*∈ *FORMALCONTEXTPARAMETER0*:
  fcp.contextParameterAtleastDefinition0∉ *FORMALCONTEXTPARAMETER0*)

Formal context parameters can neither be used as <base type> in <type expression> nor in **atleast** constraints of <formal context parameters>.

∀*fcp*∈<agent type context parameter>∪<agent context parameter>∪<procedure context parameter>∪
    <signal context parameter name> ∪<sort context parameter>∪
    <compositestate type context parameter> ∪<interface context parameter name>:
  ∀*acp*∈<actual context parameter>: *isContextParameterCorresponded0*(*fcp*, *acp*) ⇒
    (∀*td1*∈*TYPEDEFINITION0* : (*td1* = *fcp.contextParameterAtleastDefinition0*) ⇒
      (*td1*∉*FORMALCONTEXTPARAMETER0*) ∧ ¬(*isParameterizedType0*(*td1*)) ∧
      (∃*td*∈ *TYPEDEFINITION0* :
        (*td* = *getEntityDefinition0*(*acp*, *td1.entityKind0*) ∧
        ((*td* = *td1*) ∨ *isSubtype0*(*td*, *td1*))))

An **atleast** clause denotes that the formal context parameter must be replaced by an actual context parameter, which is the same type or a subtype of the type identified in the **atleast** clause. Identifiers following the keyword **atleast** in this clause must identify type definitions of the entity kind of the context parameter and must be neither formal context parameters nor parameterized types.

Transformations

<formal context parameter list>(*fcpl*)
provided
fcpl.length < *fcpl.expandFormalContextParams0.length*
=11=>
<formal context parameter list>(*fcpl.expandFormalContextParams0*)

The formal context parameter list is expanded so that each <formal context parameter> that is a list (<remotevariable context parameter list>, <signal context parameter list>, <synonym context parameter list>, <timer context parameter list> or <variable context parameter list>) contains only one named parameter.

<composite state type heading>(*v*, *q*, *n*, *cPar*, *vc*,
    <specialization>(<type expression>(*base*, *actPar*)), *p*)
provided
    getUnboundFormalContextParameterList0
        (*actParams*, *base*.*refersto0*.**s-**<formal context parameter>) ≠ *empty*
=11=>
    (**let** *nCPar* = *cPar* ⁀
        getUnboundFormalContextParameterList0
            (*actParams*, *base*.*refersto0*.**s-**<formal context parameter>)
    in
    let *nActPar* =
        completeFormalContextParameter0(*actParams*, *base*.*refersto0*.**s-**<formal context parameter>)
    in
    <composite state type heading>
        (*v*, *q*, *n*, *nCPar*, *vc*, <specialization>(<type expression>(*b*, *nActPar*)), *p*)
    endlet
    endlet)

<agent type additional heading>(*cPar*, *vc*,
    <agent additional heading>(<specialization>(<type expression>(*base*, *actPar*)), *p*))
provided
    getUnboundFormalContextParameterList0
        (*actParams*, *base*.*refersto0*.**s-**<formal context parameter>) ≠ *empty*
=11=>
    (**let** *nCPar* = *cPar* ⁀
        getUnboundFormalContextParameterList0
            (*actParams*, *base*.*refersto0*.**s-**<formal context parameter>)
    in
    let *nActPar* =
        completeFormalContextParameter0(*actParams*, *base*.*refersto0*.**s-**<formal context parameter>)
    in
        <agent type additional heading>(*nCPar*, *vc*,
            <agent additional heading>
                (<specialization>(<type expression>(*base*, *nActPar*), *undefined*), *p*))
    endlet
    endlet)

<procedure heading>(*v*, *q*, *n*, *cPar*, *vc*, <specialization>(<type expression>(*base*, *actPar*)), *p*, *r*, *x*)
provided
    getUnboundFormalContextParameterList0
        (*actParams*, *base*.*refersto0*.**s-**<formal context parameter>)
        ≠ *empty*
=11=>
    (**let** *nCPar* = *cPar* ⁀
        getUnboundFormalContextParameterList0
            (*actParams*, *base*.*refersto0*.**s-**<formal context parameter>)
    in

```
    let nActPar =
        completeFormalContextParameter0(actParams, base.refersto0.s-<formal context parameter>)
    in
        <procedure heading>(v, q, n, nCPar, vc,
            <specialization>(<type expression>(b, nActPar), undefined), p, r, x)
    endlet
    endlet)

<signal definition>(n, cPar, vc, <specialization>(<type expression>(base, actPar)), p)
provided
    getUnboundFormalContextParameterList0
        (actParams, base.refersto0.s-<formal context parameter>) ≠ empty
=11=>
    (let nCPar = cPar ⌒
        getUnboundFormalContextParameterList0
            (actParams, base.refersto0.s-<formal context parameter>)
    in
    let nActPar =
        completeFormalContextParameter0(actParams, base.refersto0.s-<formal context parameter>)
    in
    <signal definition>
        (n,nCPar, vc, <specialization>(<type expression>(b, nActPar), undefined*), p)
    endlet
    endlet)
```

If the scope unit contains <specialization> and any <actual context parameter> items are omitted in the <type expression>, the <formal context parameter>s are copied (while preserving their order) and inserted in front of the <formal context parameter>s (if any) of the scope unit. In place of omitted <actual context parameter>s, the names of corresponding <formal context parameter>s are inserted. These <actual context parameter> items now have the defining context in the current scope unit.

Auxiliary functions

Expand a <formal context parameter> list so that each <formal context parameter> that is a list (<remotevariable context parameter list>, <signal context parameter list>, <synonym context parameter list>, <timer context parameter list> or <variable context parameter list>) contains only one named parameter.

```
expandFormalContextParams0(fcpl: <formal context parameter>+): <formal context parameter>+ =def
< fcpl.head >.formalContextParameterSublist0 ⌒
    if fcpl.length = 1
    then < >
    else fcpl.tail.expandFormalContextParams0
    endif
```

Get the entity definition referred by the formal context parameter constraint.

```
contextParameterAtleastDefinition0(fcp: FORMALCONTEXTPARAMETER0): ENTITYDEFINITION0 =def
    case fcp of
    | <agent type context parameter> then
        if (fcp.s-<agent type constraint>∈ <identifier>) then
            getEntityDefinition0(fcp.s-<agent type constraint>.<identifier>, agent type)
        else undefined
        endif
    | <agent context parameter> then
        if (fcp.s-<agent constraint>∈<agent constraint atleast>) then
            getEntityDefinition0(fcp.s-<agent constraint>.s-<identifier>, agent type)
        else if (fcp.s-<agent constraint>∈<agent constraint exactly>) then
                getEntityDefinition0(fcp.s-<agent constraint>.s-<identifier>, agent type)
            else undefined
            endif
```

```
        endif
    | <procedure context parameter> then
        if (fcp.s-<procedure constraint>∈<identifier>) then
            getEntityDefinition0(fcp.s-<procedure constraint>, procedure)
        else undefined
        endif
    | <compositestate type context parameter> then
        if (fcp.s-<composite state type constraint>∈<identifier>) then
            getEntityDefinition0(fcp.s-<composite state type constraint>,
                state type)
        else undefined
        endif
    | <signal context parameter name> then
        if (fcp.s-<signal constraint>∈<identifier>) then
            getEntityDefinition0(fcp.s-<signal constraint>, signal)
        else undefined
        endif
    | <sort context parameter> then
        if (fcp.s-<sort constraint>∈<sort>) then
            getEntityDefinition0(fcp.s-<sort constraint>, type)
        else undefined
        endif
    | <interface context parameter name> then
        if (fcp.s-<interface constraint> ≠ undefined) then
            getEntityDefinition0(fcp.s-<interface constraint>.s-<identifier>, interface)
        else undefined
        endif
    otherwise undefined
    endcase
```

F2.2.5.7.1 Agent type context parameter

Concrete syntax

```
<agent type context parameter> ::
        <agent kind> <agent type<name> [<agent type constraint>]

<agent kind> :: process | block

<agent type constraint> =
        <agent type<identifier> | <agent signature>
```

Conditions on concrete syntax

```
∀fcp∈<agent type context parameter>:∀acp∈<actual context parameter>:
    isContextParameterCorresponded0(fcp, acp) ∧ (fcp.s-<agent type constraint> ≠ undefined) ⇒
        (let td=getEntityDefinition0(acp, agent type) in
            (∃td1∈<agent type definition>:
                (td1=fcp.contextParameterAtleastDefinition0) ∧
                (td.agentLocalFormalParameterList0=empty) ∧ isSubtype0(td,td1)) ∨
                ((td.entityKind0 = fcp.entityKind0) ∧
                    (let pl = td.agentFormalParameterList0 in
                    let sl = fcp.s-<agent type constraint>.agentSignatureSortList0 in
                        (pl.length = sl.length) ∧
                        (∀i∈1..pl.length: isSameSort0(pl[i].parentAS0.s-<sort>, sl[i])) endlet)) endlet)
```

An actual agent type parameter must be a subtype of the constraint agent type (**atleast** <agent type identifier>) with no addition of formal parameters to those of the constraint type, or it must be compatible with the formal agent signature.

An agent type definition is compatible with the formal agent signature if it has the same kind and if the formal parameters of the agent type definition have the same sorts as the corresponding <sort>s of the <agent signature>.

Auxiliary functions

Get the sort list defined in an <agent signature>.

agentSignatureSortList0(*as*: <agent signature>):<sort>* =$_{def}$
as.**s-**<sort>**-seq**

Get the formal parameter list of an <agent type definition>, an <agent definition>, a <composite state type definition> or a <composite state definition>.

agentFormalParameterList0(*td*: <agent type definition> ∪<agent definition> ∪
<composite state type definition>∪<composite state definition>): <name>* =$_{def}$
td.agentLocalFormalParameterList0⌒ *td.agentInheritedFormalParameterList0*

agentLocalFormalParameterList0(*td*: <agent type definition> ∪<agent definition> ∪
<composite state type definition>∪<composite state definition>): <name>* =$_{def}$
let *fp=take*({*fp*∈ <agent additional heading>∪
<composite state type heading>∪
<composite state heading>:
fp.surroundingScopeUnit0 = td}) **in**
if (*fp*.**s-**<agent formal parameters>= *undefined*)
then *empty*
else < *psl*.**s-**<name> | *psl* **in** *fp*.**s-**<agent formal parameters>.**s-**<parameters of sort>**-seq** >
endif
endlet

agentInheritedFormalParameterList0(*td*: <agent type definition> ∪<agent definition> ∪
<composite state type definition>∪<composite state definition>): <name>* =$_{def}$
let *sp=td.specialization0* **in**
if (*sp = undefined*) **then** *empty*
else *sp*.**s-**<type expression>.*baseType0.agentFormalParameterList0*
endif
endlet

Determine if a formal context parameter corresponds to an actual context parameter; that is, the position of the formal context parameter in the list of inherited and local formal context parameters for the base type of the type expression containing the actual context parameter is the same as the position of the actual context parameter in the list of actual context parameters.

NOTE – The actual context parameter list is allowed to be shorter than the formal parameter list when items are omitted from the end of the list.

isContextParameterCorresponded0(*fcp*: *FORMALCONTEXTPARAMETER0*,
acp: <actual context parameter>): *BOOLEAN*=$_{def}$
let *te = parentAS0ofKind*(*acp*, <type expression>) **in**
let *fcpl = te.baseType0.formalContextParameterList0* **in**
let *acpl = te.actualContextParameterList0* **in**
(*fcpl.length* ≥ *acpl.length*)∧
(∃!*i*∈1..*acpl.length*: (*fcpl*[*i*]=*fcp*)∧(*acpl*[*i*]=*acp*)
endlet
endlet
endlet

F2.2.5.7.2 Agent context parameter

Concrete syntax

<agent context parameter> ::
<agent kind> <agent<name> [<agent constraint>]

<agent constraint> = <agent constraint atleast> | <agent constraint exactly> | <agent signature>

<agent constraint atleast> :: <agent type<identifier>

<agent constraint exactly> :: <agent type><identifier>

<agent signature> :: <sort list>

Conditions on concrete syntax

∀*fcp*∈<agent context parameter>: ∀*acp*∈<actual context parameter>:
isContextParameterCorresponded0(*fcp*, *acp*) ⇒
(**let** *td* = *getEntityDefinition0*(*acp*, **agent**) **in**
let *td1* = *fcp.contextParameterAtleastDefinition0* **in**
((*fcp*.**s**-<agent constraint>∈ <agent constraint atleast>)) ⇒
isSubtype0(*td*, *td1*) ∧ (*td.agentLocalFormalParameterList0* = *empty*)) ∧
((*fcp*.**s**-<agent constraint> ∈ <agent constraint exactly>)) ⇒ (*td* = *td1*)) ∧
((*fcp*.**s**-<agent constraint> ∈ <agent signature>) ⇒
(*getEntityDefinition0*(*acp*, **agent**).*entityKind0* = *fcp.entityKind0*) ∧
(**let** *pl* = *td.agentFormalParameterList0* **in**
let *sl* = *fcp*.**s**-<agent constraint>.*agentSignatureSortList0* **in**
(*pl.length* = *sl.length*) ∧
(∀*i*∈1..*pl.length*: *isSameSort0*(*pl*[*i*].*parentAS0*.**s**-<sort>, *sl*[*i*])) **endlet**)) **endlet**)

An actual agent parameter must identify an agent definition. Its type must be a subtype of the constraint agent type (**atleast** <agent type identifier>) with no addition of formal parameters to those of the constraint type, or it must be the type denoted by <agent type identifier>, or it must be compatible with the formal <agent signature>.

An agent definition is compatible with the formal <agent signature> if the formal parameters of the agent definition have the same sorts as the corresponding <sort>s of the <sort list> of the <agent signature>, and both definitions have the same *Agent-kind*.

F2.2.5.7.3 Procedure context parameter

Concrete syntax

<procedure context parameter> ::
<procedure><name> <procedure constraint>

<procedure constraint> =
<procedure><identifier> | <procedure signature>

Conditions on concrete syntax

∀*fcp*∈<procedure context parameter>:∀*acp*∈<actual context parameter>:
isContextParameterCorresponded0(*fcp*, *acp*) ⇒
(**let** *td* = *getEntityDefinition0*(*acp*, **procedure**) **in**
((*fcp*.**s**-<procedure constraint>∈<identifier>) ⇒
(**let** *td1* = *fcp.contextParameterAtleastDefinition0* **in**
isDirectSubType0(*td*, *td1*) **endlet**)) ∧
((*fcp*.**s**-<procedure constraint>∈<procedure signature>) ⇒
(**let** *fpl* = *td.procedureFormalParameterList0* **in**
let *fpl1* = *fcp*.**s**-<procedure constraint>.**s**-<formal parameter>**-seq in**
(*fpl.length* = *fpl1.length*) ∧
(∀*i*∈1..*fpl.length*:
(*fpl*[*i*]. *parentAS0.parentAS0*.**s**-<parameter kind> = *fpl1*[*i*].**s**-<parameter kind>) ∨
(*fpl*[*i*]. *parentAS0.parentAS0*.**s**-<parameter kind>∈{**in out**, **out**}) ⇒
isSameSort0(*fpl*[*i*]. *parentAS0*.**s**-<sort>, *fpl*[*i*].**s**-<sort>))
endlet) ∧
(**let** *result* = *td*.**s**-<procedure heading>.**s**-<procedure result> **in**
let *result1*= *fcp*.**s**-<procedure constraint>.**s**-<result> **in**
((*result* = *undefined*) ∧ (*result1*= *undefined*)) ∨
((*result*≠ *undefined*) ∧ (*result1* ≠ *undefined*)∧*isSameResult0*(*result*, *result1*))
endlet))
endlet)

An actual procedure parameter must identify a procedure definition that is either a specialization of the procedure of the constraint (**atleast** <procedure identifier>) or is compatible with the formal procedure signature.

A procedure definition is compatible with the formal procedure signature if:

a) the formal parameters of the procedure definition have the same sorts as the corresponding parameters of the signature, if they have the same <parameter kind>, and if both have a result of the same <sort> or if neither returns a result; or

b) each **in**/**out** and **out** parameter in the procedure definition has the same <sort identifier> or <syntype identifier> as the corresponding parameter of the signature.

F2.2.5.7.4 Remote procedure context parameter

Concrete syntax

<remote procedure context parameter>::
<remote procedure><name> <procedure signature>

Conditions on concrete syntax

∀*fcp*∈<remote procedure context parameter>: ∀*acp*∈<actual context parameter>:
isContextParameterCorresponded0(*fcp*,*acp*) ⇒
(**let** *ps* = *getEntityDefinition0*(*acp*, **remote procedure**).**s**-<procedure signature> **in**
let *ps1*= *fcp*.**s**-<procedure signature> **in**
isSameProcedureSignature0(*ps*, *ps1*) **endlet**)

An actual parameter to a **remote** procedure context parameter must identify a <remote procedure definition> with the same signature.

Auxiliary functions

Determine if two <procedure signature>s are the same.

isSameProcedureSignature0(*ps*, *ps1*: <procedure signature>): *BOOLEAN* =$_{\text{def}}$
let *fpl* = *ps.procedureSignatureParameterList0* **in**
let *fpl1* = *ps1.procedureSignatureParameterList0* **in**
(*fpl*. *length* = *fpl1.length*) ∧
(∀*i*∈1..*fpl.length*:
isSameSort0(*fpl*[*i*].**s**-<sort>, *fpl1*[*i*].**s**-<sort>) ∧
(*fpl*[*i*].**s**-<parameter kind> = *fpl1*[*i*].**s**-<parameter kind>))∧
isSameResult0(*ps*.**s**-<result>, *ps1*.**s**-<result>))
endlet

F2.2.5.7.5 Signal context parameter

Concrete syntax

<signal context parameter list> :: <signal context parameter name>+

<signal context parameter name> :: <signal><name> [<signal constraint>]

<signal constraint> = <signal><identifier> | <signal signature>

<signal signature> = <sort list>

Conditions on concrete syntax

∀*fcp*∈<signal context parameter name>: ∀*acp*∈<actual context parameter>:
isContextParameterCorresponded0(*fcp*, *acp*) ⇒
(**let** *sd* = *getEntityDefinition0*(*acp*, **signal**) **in**
((*fcp*.**s**-<signal constraint>∈<identifier>) ⇒
(**let** *sd1* =*fcp.contextParameterAtleastDefinition0* **in**
isSubtype0(*sd*, *sd1*) **endlet**)) ∧
((*fcp*.**s**-<signal constraint>∈<signal signature>) ⇒

isSameSortList0(*sd*.**s**-<sort>**-seq**, *fcp*.**s**-<signal constraint>))
endlet)

In the case of **atleast** <signal identifier>, an actual signal parameter shall identify a signal definition that is the same as, or a subtype of, the signal type of the constraint. In the case of <signal signature>, an actual signal parameter shall identify a signal definition that is compatible with the formal <signal signature>. A signal definition is compatible with the formal <signal signature> if each parameter of the signal definition has the same aggregation kind and sort as the corresponding parameter of the <signal signature>. See clause 8.3.5 *Concrete grammar* of [ITU-T Z.102].

F2.2.5.7.6 Variable context parameter

Concrete syntax

<variable context parameter list> :: <variable context parameter names>+

<variable context parameter names> :: <variable<name>+ <variable constraint>

<variable constraint> = <sort>

Conditions on concrete syntax

∀*fcp*∈<name>:∀*acp*∈<actual context parameter>:
(*fcp*.*parentAS0*∈<variable context parameter names>) ∧
(*fcp*.*parentAS0*.*parentAS0*∈<variable context parameter list>) ∧
isContextParameterCorresponded0(*fcp*, *acp*) ⇒
(**let** *vd* = *getEntityDefinition0*(*acp*, **variable**) **in**
isSameSort0(*fcp*.*parentAS0*.**s**-<sort>, *vd*.**s**-<sort>)
endlet)

An actual parameter must be a variable or a formal agent or procedure parameter of the same sort as the sort of the constraint.

F2.2.5.7.7 Remote variable context parameter

Concrete syntax

<remotevariable context parameter list> ::
<remotevariable contextparameter names>+

<remotevariable contextparameter names> ::
<remote variable<name>+ <variable constraint>

Conditions on concrete syntax

∀*fcp* ∈ *FORMALCONTEXTPARAMETER0*:∀*acp*∈<actual context parameter>:
(*fcp*.*parentAS0*∈<remotevariable contextparameter names>) ∧
(*fcp*.*parentAS0*.*parentAS0*∈<remotevariable context parameter list>) ∧
isContextParameterCorresponded0(*fcp*, *acp*) ⇒
(**let** *vd* = *getEntityDefinition0*(*acp*, **remote variable**) **in**
isSameSort0(*fcp*.*parentAS0*.**s**-<sort>, *vd*.**s**-<sort>)
endlet)

An actual parameter must identify a <remote variable definition> of the same sort.

F2.2.5.7.8 Timer context parameter

Concrete syntax

<timer context parameter list> :: <timer context parameter name>+

<timer context parameter name> :: <timer<name> [<timer constraint>]

<timer constraint> = <sort list>

Conditions on concrete syntax

∀*fcp*∈<timer context parameter name>: ∀*acp*∈<actual context parameter>:

isContextParameterCorresponded0(*fcp*, *acp*) ⇒
(**let** *td* = *getEntityDefinition0*(*acp*, **timer**) **in**
(*fcp*.**s**-<timer constraint> ≠*undefined*) ⇒
isSameSortList0(*fcp*.**s**-<timer constraint>, *td*.**s**-<sort>-**seq**)
endlet)

An actual timer parameter shall identify a timer definition that is compatible with the formal sort constraint list. A timer definition is compatible with a formal sort constraint list if the sorts of the timer are the same sorts as in the sort constraint list. See clause 8.3.8 *Concrete grammar* of [ITU-T Z.102].

F2.2.5.7.9 Synonym context parameter

Concrete syntax

<synonym context parameter list> ::
<synonym context parameter name>+

<synonym context parameter name> ::
<synonym<name> <synonym constraint>

<synonym constraint> = <sort>

Conditions on concrete syntax

∀*fcp*∈<synonym context parameter name>: ∀*acp*∈<actual context parameter>:
isContextParameterCorresponded0(*fcp*, *acp*) ⇒
isSameSort0(*acp.staticSort0*, *fcp*.**s**-<synonym constraint>)

An actual synonym parameter shall be a constant expression of the same sort as the sort of the constraint. See clause 8.3.9 *Concrete grammar* of [ITU-T Z.102].

F2.2.5.7.10 Sort context parameter

Concrete syntax

<sort context parameter> :: <sort<name> [<sort constraint>]

<sort constraint> = <sort> | <sort signature>

<sort signature> ::
<literal signature>* <operation signature>* <operation signature>*

Conditions on concrete syntax

∀*fcp*∈<sort context parameter>:∀*acp*∈<actual context parameter>:
isContextParameterCorresponded0(*fcp*, *acp*) ∧ (*fcp*.**s**-<sort constraint>≠*undefined*)⇒
(**let** *td* = *getEntityDefinition0*(*acp*, **type**).*derivedDataType0* **in**
((*fcp*.**s**-<sort constraint>∈<sort>)⇒
(**let** *td1* = *fcp.contextParameterAtleastDefinition0* **in**
(*td*.**s**-<data type specialization>.**s**-<renaming>= *undefined*) ∧
isSubtype0(*td*, *td1*) **endlet**)) ∧
((*fcp*.**s**-<sort constraint>∈<sort signature>)⇒
(∀*ls*∈<literal signature>: (*ls*.*parentAS0*= *fcp*.**s**-<sort constraint>)⇒
∃*ls1*∈<literal signature>:
(*ls1*.*surroundingScopeUnit0*= *td*) ∧ *isSameLiteralSignature0*(*ls*,*ls1*)) ∧
(∀*os*∈<operation signature>:
(*os*.*parentAS0*= *fcp*.**s**-<sort constraint>)⇒
∃*os1*∈<operation signature>:
(*os1*.*parentAS0*∈<operator list> ∪ <method list>) ∧
(*os1*.*surroundingScopeUnit0*=*td*) ∧ *isSameOperationSignature0*(*os*, *os1*)))
endlet)

In the case of a <sort constraint> that is **atleast** <sort>, an actual sort parameter shall be the sort given by <sort> or a subtype (without renaming) of this sort. In the case of a <sort constraint> that is <sort signature>, an actual sort parameter shall be compatible with the formal sort signature. A sort is

compatible with the formal sort signature if the literals of the sort include the literals in the formal sort signature and the operations defined by the data type that introduced the sort include the operations in the formal sort signature and the operations have the same signatures. See clause 8.3.10 *Concrete grammar* of [ITU-T Z.102].

∀*ls*∈<literal signature>:
(*ls.parentAS0*∈<sort signature>) ∧ (*ls.parentAS0.parentAS0*∈<sort context parameter>) ⇒
(*ls*∉<named number>)

The <literal signature> of the <sort signature> shall not contain <named number>. See clause 8.3.10 *Concrete grammar* of [ITU-T Z.102].

Auxiliary functions

Get the data type definition from which a syntype definition is derived.

derivedDataType0(*sd*: <syntype definition>∪<data type definition>):<data type definition> =$_{def}$
if (*sd*∈<syntype definition>) **then** *sd.parentDataType0*
else *sd*
endif

Get the parent data type definition of a syntype definition.

parentDataType0(*sd*: <syntype definition>):<data type definition> =$_{def}$
if (*sd*.**s**-<parent sort identifier> = *undefined*) **then** *sd*
else
let *pd* = *getEntityDefinition0*(*sd*.**s**-<parent sort identifier>, **type**) **in**
if (*pd*∈<data type definition>) **then** *pd*
else *pd.parentDataType0*
endif
endlet
endif

Determine if two <literal signature>s are the same.

isSameLiteralSignature0(*ls*: <literal signature>, *ls1*: <literal signature>): *BOOLEAN*=$_{def}$
((*ls*∈<literal name>) ∧ (*ls1*∈<literal name>) ⇒ (*ls* = *ls1*)) ∧
((*ls*∈<named number>) ∧ (*ls1*∈<named number>) ⇒
(*ls*.**s**-<literal name> = *ls1*.**s**-<literal name>) ∧
(*ls*.**s**-<simple expression>.*value0*= *ls1*.**s**-<simple expression>.*value0*))

Determine if two <operation signature>s are the same.

isSameOperationSignature0(*os*: <operation signature>, *os1*: <operation signature>): *BOOLEAN*=$_{def}$
(*os.virtuality0* = *os1*. *virtuality0*) ∧
(*os.visibility0* = *os1.visibility0*) ∧
(*os*.**s-implicit**∈<operation name>⇒*os*.**s-implicit** = *os1*.**s-implicit**) ∧
(**let** *fpl* = *os.operationSignatureParameterList0*,
fpl1 = *os1.operationSignatureParameterList0* **in**
(*fpl.length* = *fpl1.length*) ∧
(∀*i*∈1..*fpl.length*:
(*fpl*[*i*].**s**-<parameter kind> = *fpl1*[*i*].**s**-<parameter kind>) ∧
(*isSameSort0*(*fpl*[*i*].**s**-<sort>, *fpl1*[*i*].**s**-<sort>)) ∧
(*isSameResult0*(*os*.**s**-<result>, *os1*.**s**-<result>)
endlet)

F2.2.5.7.11 Composite state context parameter

Concrete syntax

<compositestate type context parameter>::
<composite state type><name> [<composite state type constraint>]

<composite state type constraint> =

<composite state type><identifier> | <composite state type signature>

<composite state type signature> = <sort list>

Conditions on concrete syntax

∀*fcp*∈<compositestate type context parameter>: ∀*acp*∈<actual context parameter>:
isContextParameterCorresponded0(*fcp*, *acp*)∧
(*fcp*.**s-**<composite state type constraint>≠ *undefined*) ⇒
(**let** *td* = *getEntityDefinition0*(*acp*, **state type**) **in**
((*fcp*.**s-**<composite state type constraint>∈<identifier>) ⇒
(**let** *td1* = *fcp.contextParameterAtleastDefinition0* **in**
(*td.agentLocalFormalParameterList0* = *empty*) ∧ *isSubtype0*(*td*, *td1*) **endlet**)) ∧
((*fcp*.**s-**<composite state type constraint>∈<composite state type signature>) ⇒
(**let** *sl* = *fcp*.**s-**<composite state type constraint> **in**
let *pl* = *td.agentFormalParameterList0* **in**
(*sl.length* = *pl.length*) ∧
(∀*i*∈1..*sl.length*: *isSameSort0*(*sl*[*i*], *pl*[*i*].*parentAS0*.**s-**<sort>))
endlet))
endlet)

An actual composite state type parameter must identify a composite state type definition. Its type must be a subtype of the constraint composite state type (**atleast** <composite state type identifier>) with no addition of formal parameters to those of the constraint type or it must be compatible with the formal composite state type signature.

A composite state type definition is compatible with the formal composite state type signature if the formal parameters to the composite state type definition have the same sorts as the corresponding <sort>s of the <composite state type constraint>.

F2.2.5.7.12 Gate context parameter

Concrete syntax

<gate context parameter> :: <gate> <gate constraint>

Conditions on concrete syntax

∀*fcp*∈<gate context parameter>:∀*acp*∈<actual context parameter>:
isContextParameterCorresponded0(*fcp*, *acp*) ⇒
(**let** *gd*=*getEntityDefinition0*(*acp*, **gate**) **in**
(*gd*.**s-**<gate> = *fcp*.**s-**<gate>) ∧
(∀*gc*∈<gate constraint>:∀*gc1*∈<gate constraint>:
(*gc.parentAS0* = *gd*) ∧ (*gc1.parentAS0*= *fcp*) ∧
((*gc.direction0*=**out**) ∧ (*gc1*. *direction0*=**out**) ⇒
gc1.**s-**<sort>**-seq** *.signalSet0*) ⊆*gc*.**s-**<sort>**-seq** *.signalSet0*) ∧
((*gc*. *direction0*=**in**) ∧ (*gc1*. *direction0*=**in**) ⇒
gc.**s-**<sort>**-seq** *.signalSet0*⊆*gc1*.**s-**<sort>**-seq** *.signalSet0*)
endlet)

An actual gate parameter must identify a gate definition. Its outward gate constraint must contain all elements mentioned in the <signal list> of the corresponding formal gate context parameter. The inward gate constraint of the formal gate context parameter must contain all elements in the <signal list> of the actual gate parameter.

F2.2.5.7.13 Interface context parameter

Concrete syntax

<interface context parameter list> :: <interface context parameter name>+

<interface context parameter name> :: <interface><name> [<interface constraint>]

<interface constraint> :: <interface><identifier>

Conditions on concrete syntax

∀*fcp*∈<interface context parameter name>: ∀*acp*∈<actual context parameter>:
isContextParameterCorresponded0(*fcp, acp*) ∧ (*fcp*.**s-**<interface constraint>≠ *undefined*) ⇒
(∃*td*∈<interface definition>:
(*td =getEntityDefinition0*(*acp*.**s-**<identifier>, **interface**)) ∧
isSubtype0(*td, fcp.contextParameterAtleastDefinition0*))

An actual interface parameter must identify an interface definition. The type of the interface must be a subtype of the interface type of the constraint (**atleast** <interface identifier>).

F2.2.5.8 Specialization

F2.2.5.8.1 Adding properties

Concrete syntax

<specialization> :: <type expression>

Mapping to abstract syntax

| <specialization>(*x*) **then** *Mapping*(*x*)

Auxiliary functions

The function *specialization0* is used to get the specialization part of an entity definition.

specialization0(*def*: *ENTITYDEFINITION0*):
<specialization>∪<data type specialization>∪<interface specialization> =$_{def}$
take({ *s*∈<specialization>∪<data type specialization>∪<interface specialization>:
s.surroundingScopeUnit0 = def})

F2.2.5.8.2 Virtual type

Concrete syntax

<virtuality> = **virtual | redefined | finalized**

<virtuality constraint> :: <identifier>

Conditions on concrete syntax

∀*td*∈<block type definition>∪<process type definition>∪<procedure definition>∪
<composite state type definition>:
isVirtualType0(*td*) ⇒ *td.virtualTypeAtleastDefinition0.entityKind0 = td.entityKind0*

Every virtual type has associated a virtuality constraint which is an <identifier> of the same entity kind as the virtual type.

∀*td*∈<block type definition>∪<process type definition>∪<procedure definition>∪
<composite state type definition>:
td.isVirtualType0 ⇒
¬(*td.isParameterizedType0*) ∧ ¬(*isParameterizedType0*(*td.virtualTypeAtleastDefinition0*))

A virtual type and its constraints cannot have context parameters.

∀*vc*∈<virtuality constraint>: *isVirtualType0*(*vc.surroundingScopeUnit0*)

Only virtual types may have <virtuality constraint> specified.

∀*r*∈<block type reference> ∪<process type reference> ∪<composite state type reference> ∪
<procedure reference>:
∀*d*∈<block type definition>∪<process type definition>∪<composite state type definition>∪
<procedure definition>:
(*r.referencedDefinition0 = d*)∧(*r.virtuality0* ≠ *undefined*)∧(*d.virtuality0* ≠ *undefined*) ⇒
(*r.virtuality0 = d.virtuality0*)

If <virtuality> is present in both the reference and the referenced definition, then they must be equal. If <procedure preamble> is present in both procedure reference and in the referenced procedure definition they must be equal.

∀*td*∈<block type definition>∪<process type definition>: *isVirtualType0*(*td*) ⇒
(**let** *td1 = td.virtualTypeAtleastDefinition0* **in**
(**let** *fpl = td.agentFormalParameterList0***in**
let *fpl1 = td1.agentFormalParameterList0* **in**
isSameAgentFormalParameterList0(*fpl, fpl1*) **endlet**) ∧
(∀*gd1*∈<gate in definition>: *gd1*∈ *td1.gateDefinitionSet0* ⇒
∃*gd*∈<gate in definition>: (*gd*∈ *td.gateDefinitionSet0*) ∧ *isSameGate0*(*gd, gd1*)) ∧
(∀*fd1*∈<interface definition>: *fd1*∈ *td1.interfaceDefinitionSet0* ⇒
∃*fd*∈<interface definition>: (*fd*∈ *td.interfaceDefinitionSet0*) ∧ *isSameInterface0*(*fd, fd1*)) ∧
(∀*ed*∈*ENTITYDEFINITION0*: *ed.surroundingScopeUnit0 = td*⇒
∃*ed1*∈*ENTITYDEFINITION0*: (*ed1.surroundingScopeUnit0 = td1*) ∧ (*ed= ed1*)) **endlet**)

A virtual agent type must have exactly the same formal parameters, and at least the same gates and interfaces with at least the definitions as those of its constraint.

∀*td*∈<composite state type definition>: *isVirtualType0*(*td*) ⇒
(**let** *td1 = td.virtualTypeAtleastDefinition0* **in**
∀*scp1*∈<state connection points>: *scp1*∈*td1.stateConnectionPointSet0* ⇒
∃*scp*∈<state connection points>:
(*scp*∈*td.stateConnectionPointSet0*) ∧ *isSameStateConnectionPoint0*(*scp, scp1*) **endlet**)

A virtual state type must have at least the same state connection points as its constraint.

∀*td*∈<procedure definition>: *isVirtualType0*(*td*) ⇒
(**let** *fpl = td.procedureFormalParameterList0* **in**
let *fpl1 = td.virtualTypeAtleastDefinition0.procedureFormalParameterList0* **in**
isSameProcedureFormalParameterList0(*fpl, fpl1*) **endlet**)

A virtual procedure must have exactly the same formal parameters as its constraint.

∀*td*∈<block type definition>∪<process type definition>∪<procedure definition>∪
<composite state type definition>:
isVirtualType0(*td*) ⇒
(∀*sp*∈<specialization>:∀*vc*∈<virtuality constraint>:
(*sp.surroundingScopeUnit0 = td*) ∧ (*vc.surroundingScopeUnit0 = td*) ⇒
((*td.virtualTypeInheritsDefinition0= td.virtualTypeAtleastDefinition0*) ∨
isSubtype0(*td.virtualTypeInheritsDefinition0, td.virtualTypeAtleastDefinition0*)))

If both **inherits** and **atleast** are used then the inherited type must identical to or be a subtype of the constraint.

∀*td, td1*∈<block type definition>∪<process type definition>∪<procedure definition>∪
<composite state type definition>:
isRedefinedType0(*td*) ∧ (*td1=td.superCounterpart0*) ⇒
(**let** *sp=td.specialization0***in**
let *vc = take*({*vc*∈<virtuality constraint>: *vc.surroundingScopeUnit0 = td1*}) **in**
(*sp≠undefined*) ∧ (*vc=undefined*) ⇒
isSubtype0(*td.virtualTypeInheritsDefinition0, td1.virtualTypeAtleastDefinition0*) **endlet**)

In the case of an implicit constraint, redefinition involving **inherits** must be a subtype of the constraint.

Mapping to abstract syntax

The <virtuality constraint> is always ignored in the mapping.

Auxiliary functions

Determine if a <block type definition>, a <process type definition>, an <internal procedure definition> or a <composite state type definition> is a virtual type.

isVirtualType0(*td*: <block type definition>∪<process type definition>∪<internal procedure definition>∪
<composite state type definition>): *BOOLEAN*=$_{\text{def}}$
td.virtuality0∈{**virtual**, **redefined**}

Determine if a <block type definition>, a <process type definition>, an <internal procedure definition> or a <composite state type definition> is a redefined type.

isRedefinedType0(*td*: <block type definition>∪<process type definition>∪<internal procedure definition>
∪<composite state type definition>): *BOOLEAN*=$_{\text{def}}$
td.virtuality0∈{**redefined**, **finalized**}

Get the virtuality for a definition.

virtuality0(*td*: *DefinitionAS0*): {**virtual**, **redefined**, **finalized**} =$_{\text{def}}$
case *d* **of**
| <block type definition> **then**
d.**s**-<block type heading>.**s**-<type preamble>.**s**-<virtuality>
| <composite state type definition> **then**
d.**s**-<composite state type heading>.**s**-<virtuality>
| <interface definition> **then** *d*.**s**-<virtuality>
| <internal procedure definition> **then**
d.**s**-<procedure heading>.**s**-<procedure preamble>.**s**-<type preamble>.**s**-<virtuality>
| <operation definition> **then**
d.**s**-<operation heading>.**s**-<operation preamble>.**s**-<virtuality>
| <operation signature> **then** *d*.**s**-<operation preamble>.**s**-<virtuality>
| <process type definition> **then**
d.**s**-<process type heading>.**s**-<type preamble>.**s**-<virtuality>
| <statements> **then** *d.parentAS0*.**s**-<virtuality>
| <block type reference> ∪<process type reference> ∪<composite state type reference> ∪
<procedure reference> **then** *d*.**s**-<type preamble>.**s**-<virtuality>
| <start>∪<input part>∪<priority input>∪<save part>∪<spontaneous transition>∪
<continuous signal>∪<connect part>∪<default initialization> **then** *d*.**s**-<virtuality>
otherwise *undefined*
endcase

Get the entity definition referred by a <virtuality constraint>.

virtualTypeAtleastDefinition0(*td*: <block type definition>∪<process type definition>∪
<procedure definition>∪<composite state type definition>): <block type definition>∪
<process type definition>∪<procedure definition>∪<composite state type definition> =$_{\text{def}}$
let *vc*=*take*({*vc*∈<virtuality constraint>: *vc.surroundingScopeUnit0 = td*}) **in**
if *vc* ≠ *undefined* **then** *getEntityDefinition0*(*vc*, *td.entityKind0*) **else** *td* **endif**
endlet

Determine if two agent formal parameter lists are the same.

isSameAgentFormalParameterList0(*fpl*: <name>*, *fpl1*:<name>*): *BOOLEAN*=$_{\text{def}}$
(*fpl.length = fpl1.length*) ∧
(∀*i*∈1..*fpl.length*:(*fpl*[*i*]=*fpl1*[*i*])∧*isSameSort0*(*fpl*[*i*].*parentAS0*.**s**-<sort>,*fpl1*[*i*].*parentAS0*.**s**-<sort>))

Determine if two <gate in definition>s are the same.

isSameGate0(*gd*: <gate in definition>, *gd1*: <gate in definition>): *BOOLEAN*=$_{\text{def}}$
if (*gd*∈<textual gate definition>)∧(*gd1*∈<textual gate definition>) **then**
(*gd*.**s**-<gate>=*gd1*.**s**-<gate>)∧
(∀*gc*∈ *gd*.**s**-<gate constraint>:∃*gc1*∈ *gd1*.**s**-<gate constraint>:
(*gc.direction0 = gc1.direction0*)∧
(*gc*.**s**-<textual endpoint constraint> =*gc1*.**s**-<textual endpoint constraint>)∧
isSameSortList0(*gc*.**s**-<sort>-**seq**, *gc1*.**s**-<sort>-**seq**))∧
(∀*gc1*∈ *gd1*.**s**-<gate constraint>:∃*gc*∈ *gd*.**s**-<gate constraint>:
(*gc.direction0 = gc1.direction0*)∧
(*gc*.**s**-<textual endpoint constraint> =*gc1*.**s**-<textual endpoint constraint>)∧

```
        isSameSortList0(gc.s-<sort>-seq, gc1.s-<sort>-seq ))
    else if (gd∈<textual interface gate definition>)∧(gd1∈<textual interface gate definition>) then
        gd.s-<identifier>=gd1.s-<identifier>
    else false
    endif
```

Determine if two <interface definition>s are the same.

```
isSameInterface0(id:<interface definition>, id1:<interface definition>): BOOLEAN=def
    (id.virtuality0 = id1.virtuality0)∧
    (id.entityName0 = id1.entityName0)∧
    (id.entityDefinitionSet0= id1.entityDefinitionSet0)
```

Get all the entity definitions defined in a scope unit.

```
entityDefinitionSet0(su: SCOPEUNIT0): ENTITYDEFINITION0 =def
    {ed∈ENTITYDEFINITION0: isDefinedIn0(ed, su)}
```

Get all the interface definitions defined in a scope unit.

```
interfaceDefinitionSet0(d: SCOPEUNIT0):<interface definition>-set =def
    {fd∈<interface definition>: isDefinedIn0(fd, d)}
```

Get the set of <state connection points> defined in a <composite state type definition> or a <composite state definition>.

```
stateConnectionPointSet0(td:<composite state type definition>∪<composite state definition> ):
        <state connection points>-set =def
    {scp∈<state connection points>:
        (scp.parentAS0=td)∧
        (∃td1∈<composite state type definition>: isSubtype0(td, td1)∧ (scp.parentAS0=td1))}
```

Determine if two <state connection points>s are the same.

```
isSameStateConnectionPoint0(scp: <state connection points>, scp1: <state connection points>):
    BOOLEAN=def
    {n∈<name>: isAncestorAS0(scp,n)} = {n1∈<name>: isAncestorAS0(scp1,n1)}
```

Determine if two procedure formal parameter lists are the same.

```
isSameProcedureFormalParameterList0(fpl: <name>*, fpl1: <name>*): BOOLEAN=def
    (fpl.length = fpl1.length) ∧
    (∀i∈1..fpl.length:
        (fpl[i].parentAS0.parentAS0.s-<parameter kind> =
            fpl1[i].parentAS0.parentAS0.s-<parameter kind>) ∧
        (fpl[i] = fpl1[i]) ∧ isSameSort0(fpl[i].parentAS0.s-<sort>, fpl1[i].parentAS0.s-<sort>))
```

Get the entity definition specialized by a virtual type.

```
virtualTypeInheritsDefinition0(td: <block type definition>∪<process type definition>∪
        <procedure definition>∪<composite state type definition>): <block type definition>∪
        <process type definition>∪<procedure definition>∪<composite state type definition>=def
    let sp=td.specialization0 in
        if (sp ≠ undefined) then sp.s-<type expression>.baseType0
        else
            let vc=take({vc∈<virtuality constraint>: vc.surroundingScopeUnit0 = td}) in
                case td.virtuality0 of
                | virtual then
                    if (vc = undefined) then undefined else td.virtualTypeAtleastDefinition0 endif
                | redefined then
                    if (vc = undefined) then td.superCounterpart0.virtualTypeAtleastDefinition0
                    else td.virtualTypeAtleastDefinition0
                    endif
```

| **finalized then** *td.superCounterpart0.virtualTypeAtleastDefinition0*
endcase
endlet
endif
endlet

For a given entity definition, get the counterpart in the super type of the surrounding scope unit.

superCounterpart0(*td*: <block type definition>∪<process type definition>∪<procedure definition>∪
<composite state type definition>∪<operation definition>∪<operation signature>):
(<block type definition>∪<process type definition>∪<procedure definition>∪
<composite state type definition>∪<operation definition>)**-set** =$_{def}$
{*td1*∈<block type definition>∪<process type definition>∪<procedure definition>∪
<composite state type definition>∪<operation definition>∪<operation signature>:
isSuperCounterpart0(*td1*, *td*)}

Determine if an entity definition is the counterpart of the other one.

isSuperCounterpart0(*td*: *DefinitionAS0*, *td1*: <block type definition>∪<process type definition>∪
<procedure definition>∪<composite state type definition>∪
<operation definition>): *BOOLEAN* =$_{def}$
(*td.name0= td1.name0*) ∧ (*td.kind0= td1.kind0*) ∧
(*td.virtuality0*∈{**virtual**, **redefined**})∧(*td1.virtuality0*∈{**redefined**, **finalized**}) ∧
isDirectSubType0(*td1.surroundingScopeUnit0*, *td.surroundingScopeUnit0*)

F2.2.5.8.3 Virtual transitions/save

Conditions on concrete syntax

∀*ad*∈<agent definition> ∪<textual typebased agent definition> ∪<composite state definition> ∪
<typebased composite state>:
(∀*s*∈<start>: *s*∈*ad.startSet0*⇒*s.virtuality0 = undefined*) ∧
(∀*s*∈<state>: (*s*∈*ad.stateSet0*)⇒
(*s*.**s-**<input part>.*virtuality0 = undefined*) ∧
(*s*.**s-**<priority input>.*virtuality0 = undefined*) ∧
(*s*.**s-**<save part>.*virtuality0 = undefined*) ∧
(*s*.**s-**<spontaneous transition>.*virtuality0 = undefined*) ∧
(*s*.**s-**<continuous signal>.*virtuality0 = undefined*))

Virtual transitions or saves must not appear in agent (set of instances) definitions, or in composite state definitions.

∀*s*∈<state>: |{*st*∈<spontaneous transition>: (*st.parentAS0*=*s*) ∧ (*st.virtuality0*≠*undefined*)}| ≤ 1

A state must not have more than one virtual spontaneous transition.

(∀*ip*∈<input part>:
(*ip.virtuality0* ≠ *undefined*) ⇒ *ip*.**s-**<input list>.**s-**<asterisk input list> = *undefined*) ∧
(∀*sp*∈<save part>:
(*sp.virtuality0* ≠ *undefined*) ⇒ *sp*.**s-**<save list>.**s-**<asterisk save list> = *undefined*)

An input or save with <virtuality> shall not contain <asterisk>. See item(b) clause 8.4 *Concrete grammar* [ITU-T Z.103].

Auxiliary functions

Get the set of <start> items defined in a given definition.

startSet0(*td*: <agent definition> ∪<textual typebased agent definition> ∪<agent type definition> ∪
<composite state definition> ∪ <typebased composite state>∪<composite state type definition>∪
<textual typebased state partition def> ∪<state partition>∪
<internal procedure definition>):<start>**-set** =$_{def}$
case *td* **of**
| <agent definition>∪

<agent type definition>∪
<composite state type definition>∪
<internal procedure definition> **then**
td.localStartSet0∪*td.inheritedStartSet0*
| <textual typebased agent definition> ∪ <textual typebased state partition def> **then**
let *te=take*({*te*∈<type expression>: *te.parentAS0.parentAS0 = td*}) **in**
te.baseType0.startSet0
endlet
| <composite state definition> **then**
if *td*.**s-**<composite state structure>.**s-implicit** ∈<composite state body> **then**
{*s*∈<start>: *s.parentAS0=td*.**s-**<composite state structure>.**s-implicit**}
else {*s*∈*sp.startSet0*:
sp∈<state partition>∧*sp.parentAS0= td*.**s-**<composite state structure>.**s-implicit**}
endif
| <typebased composite state> **then** *td*.**s-**<type expression>.*baseType0.startSet0*
| <composite state reference> **then** *td.referencedDefinition0.startSet0*
otherwise ∅
endcase

Get the set of <start> items defined locally in a given definition.

localStartSet0(*td*: <agent definition> ∪<agent type definition> ∪<composite state type definition>∪
<internal procedure definition>):<start>-**set** =$_{def}$
case *td* **of**
| <agent definition> ∪ <agent type definition> **then**
if *td*.**s-**<agent structure>.**s-implicit** ∈ <agent body> **then**
{*td*.**s-**<agent structure>.**s-implicit**.**s-**<start>}
else *td*.**s-**<agent structure>.**s-implicit**.**s-**<state partition>.*startSet0*
endif
| <composite state type definition> **then**
if *td*.**s-**<composite state structure>.**s-implicit**∈<composite state body> **then**
{*s*∈<start>: *s.parentAS0=td*.**s-**<composite state structure>.**s-implicit** }
else {*s*∈*sp.startSet0*:
sp∈<state partition>∧*sp.parentAS0=td*.**s-**<composite state structure>.**s-implicit**}
endif
| <internal procedure definition> **then**
if *td*.**s-implicit**∈<procedure body> **then** { *td*.**s-implicit**.**s-**<start>}
else ∅
endif
otherwise ∅
endcase

Get the set of <start> items inherited by a given definition.

inheritedStartSet0(*td*: <agent definition> ∪<agent type definition> ∪
<composite state type definition> ∪<internal procedure definition>): <start>-**set** =$_{def}$
let *sp=td.specialization0* **in**
if *sp=undefined* **then** ∅
else *sp*.**s-**<type expression>.*baseType0.startSet0*
endif
endlet

Get the set of <state> items defined in a given definition.

stateSet0(*td*: <agent definition> ∪<textual typebased agent definition> ∪<agent type definition> ∪
<composite state definition> ∪<typebased composite state>∪<composite state type definition>∪
<textual typebased state partition def> ∪
<internal procedure definition>):<state>-**set** =$_{def}$
case *td* **of**
| <agent definition> ∪
<agent type definition> ∪
<composite state type definition>∪

<internal procedure definition> **then**
td.localStateSet0∪*td.inheritedStateSet0*
| <textual typebased agent definition> ∪<textual typebased state partition def> **then**
let *te* = *take*({*te* ∈ <type expression>: *te.parentAS0.parentAS0* = *td*}) **in**
te.baseType0.stateSet0
endlet
| <composite state definition> **then**
if *td*.**s-**<composite state structure>.**s-implicit** ∈ <composite state body> **then**
{*s*∈<state>: *s.parentAS0*=*td*.**s-**<composite state structure>.**s-implicit**}
else {*s*∈*sp.stateSet0*:
sp∈<state partition>∧*sp.parentAS0*=*td*.**s-**<composite state structure>.**s-implicit**}
endif
| <typebased composite state> **then** *td*.**s-**<type expression>.*baseType0.stateSet0*
| <composite state reference> **then** *td.referencedDefinition0.stateSet0*
otherwise ∅
endcase

Get the set of <state> items defined locally in a given definition.

localStateSet0(*td*: <agent definition> ∪<agent type definition> ∪<composite state type definition>∪
<internal procedure definition>): <state>**-set** =$_{\text{def}}$
case *td* **of**
| <agent definition> ∪ <agent type definition> **then**
if *td*.**s-**<agent structure>.**s-implicit** ∈ <agent body> **then**
{*s*∈<state>: *s.parentAS0* = *td*.**s-**<agent structure>.**s-implicit**}
else *td*.**s-**<agent structure>.**s-**<state machine>.**s-implicit**.*stateSet0*
endif
| <composite state type definition> **then**
if *td*.**s-**<composite state structure>.**s-implicit**∈<composite state body> **then**
{*s*∈<state>: *s.parentAS0*= *td*.**s-**<composite state structure>.**s-implicit** }
else {*s*∈*sp*. *stateSet0*:
sp∈<state partition>∧*sp.parentAS0*=*td*.**s-**<composite state structure>.**s-implicit**}
endif
| <internal procedure definition> **then**
if *td*.**s-implicit**∈<procedure body> **then** { *s*∈<state>: *s.parentAS0*= *td*.**s-implicit**}
else ∅
endif
otherwise ∅
endcase

Get the set of <state> items inherited by a given definition.

inheritedStateSet0(*td*: <agent definition> ∪<agent type definition> ∪
<composite state type definition>∪<internal procedure definition>):<state>**-set** =$_{\text{def}}$
let *sp*=*td.specialization0* **in**
if *sp*=*undefined* **then** ∅
else *sp*.**s-**<type expression>.*baseType0.stateSet0*
endif
endlet

F2.2.5.8.4 Virtual method

Conditions on concrete syntax

∀*os*∈<operation signature>:
(*os.entityKind0*=**method**) ∧ (*os.virtuality0*∈{**redefined**, **finalized**}) ⇒
∃*os1*∈<operation signature>: (*os1*= *os.superCounterpart0*) ∧
isOperationSignatureCompatible0(*os*, *os1*)∧
(**let** *fpl* = *os.operationSignatureParameterList0* **in**
(**let** *fpl1* = *os1.operationSignatureParameterList0* **in**
∀*i*∈1..*fpl.length*:
(*fpl*[*i*].**s-**<formal parameter>.**s-**<parameter kind>=

fpl1[*i*].**s**-<formal parameter>.**s**-<parameter kind>)
endlet)
endlet)

∀*od*∈<operation definition>:
(*od.entityKind0*=**method**) ∧ (*od.virtuality0*∈{**redefined**, **finalized**}) ⇒
∃*od1*∈<operation definition>:
((*od1*= *od.superCounterpart0*) ∧
(*od1*.**s**-<operation heading>.**s**-<operation result>.**s**-<result aggregation> =
od.**s**-<operation heading>.**s**-<operation result>.**s**-<result aggregation>))

When a method is redefined in a specialization, its signature shall be sort compatible with the corresponding signature in the base type, and further, if the *Result* in the *Operation-signature* denotes a sort A, then the *Result* of the redefined method shall only denote a sort B such that B is sort compatible to A. A redefinition of a virtual method shall not change the <parameter kind> in any <argument> of the inherited <operation signature>. A redefinition of a virtual method shall not change the <aggregation kind> of the <operation result> of the inherited <operation definition>. See clause 12.1.3 *Concrete grammar* of [ITU-T Z.107].

Auxiliary functions

Determine if two <operation signature>s are compatible.

isOperationSignatureCompatible0(*os*: <operation signature>, *os1*: <operation signature>):
BOOLEAN=$_{\text{def}}$
isSortCompatible0(*os*.**s**-<result>.**s**-<sort>, *os1*.**s**-<result>.**s**-<sort>) ∧
(**let** *fpl* = *os.operationSignatureParameterList0* **in**
(**let** *fpl1* = *os1.operationSignatureParameterList0* **in**
(*fpl.length* = *fpl1.length*) ∧
(∀*i*∈1..*fpl.length*:
(*isSortCompatible0*(*fpl*[*i*].**s**-<sort>,*fpl1*[*i*].**s**-<sort>)) ∧ (*isSameSort0*(*fpl*[*i*].**s**-<sort>, *fpl1*[*i*].**s**-<sort>)))
endlet)
endlet)

F2.2.6 Agents

Abstract syntax

Agent-definition	::	*Agent-name* *Number-of-instances* *Agent-type-identifier*
Number-of-instances	::	*Initial-number* [*Maximum-number*] *Lower-bound*
Initial-number	=	*NAT*
Maximum-number	=	*NAT*
Lower-bound	=	*NAT*
Agent-formal-parameter	=	*Parameter*
Parameter	::	*Variable-name* *Sort-reference-identifier* *Parameter-aggregation*
Parameter-aggregation	::	*Aggregation-kind*
State-machine	::	*State-name* *Nextstate-parameters* *Composite-state-type-identifier*
State-transition-graph	::	[*State-start-node*] *Named-start-node***-set**

State-node-**set**
Free-action-**set**

Conditions on abstract syntax

$\forall d \in$ *Agent-definition*: *d*. *agentKind1* = **system** $\Rightarrow$ *d.parentAS1* $\notin$ *Agent-type-definition*

An *Agent* with the *Agent-kind* **system** must not be contained in any other *Agent*.

$\forall d \in$ *Agent-definition*: *d*. *agentKind1* = **system** $\Rightarrow$
d.**s**-*Number-of-instances*.**s**-*Initial-number* =1 $\wedge$ *d*.**s**-*Number-of-instances*.**s**-*Maximum-number* = 1

In an *Agent* with the *Agent-kind* **system** the *Initial-number* of instances is 1 and the *Maximum-number* of instances is 1.

$\forall ni \in$ *Number-of-instances*:
(*ni*.**s**-*Maximum-number* $\neq$ *undefined* $\Rightarrow$ *ni*.**s**-*Initial-number* $\leq$ *ni*.**s**-*Maximum-number*)
$\wedge$ (*ni*.**s**-*Lower-bound* $\leq$ *ni*.**s**-*Initial-number*)

If there is a *Maximum-number*, the *Initial-number* of instances shall be less than or equal to *Maximum-number* and *Maximum-number* shall be greater than zero. The *Lower-bound* shall be less than or equal to the *Initial-number*. See clause 9 of [ITU-T Z.101].

Concrete syntax

```
<agent definition> =
        <system definition>
    |   <block definition>
    |   <process definition>

<agent structure> ::
        <entity in agent>*
        { <interaction> | <agent body> }

<interaction> ::
    {   <channel to channel connection>
    |   <channel definition>
    |   <agent definition>
    |   <block reference>
    |   <process reference>
    |   <textual typebased agent definition>}*
    [<state machine>]

<state machine> =
        <typebased composite state>
    |   <composite state list item>

<agent instantiation> ::
        [<number of instances>]<agent additional heading>

<agent additional heading> ::
        [<specialization>] [<agent formal parameters>]

<entity in agent> =
        <block type definition>
    |   <block type reference>
    |   <composite state definition>
    |   <composite state type definition>
    |   <composite state type reference>
    |   <data definition>
    |   <gate in definition>
    |   <procedure definition>
    |   <procedure reference>
    |   <process type definition>
    |   <process type reference>
    |   <remote procedure definition>
    |   <remote variable definition>
    |   <select definition>
```

| <signal definition list>
| <signal list definition>
| <timer definition>
| <valid input signal set>
| <variable definition>

<valid input signal set> :: [<signal list>]

<number of instances> ::
[<initial number>] [<maximum number>] [<lower bound>]

<initial number> = <Natural<simple expression>

<maximum number> = <Natural<simple expression>

<lower bound> = <Natural<simple expression>

<agent formal parameters> :: { <aggregation kind> <parameters of sort> }*

<parameters of sort> :: <variable<name>+ <sort>

<agent body> ::
[<start>] {<state> | <free action>}*

NOTE – In [ITU-T Z.106] <entity in agent> includes <imported procedure specification>/<imported variable specification>, but these have no SDL-2010 meaning (see clause 9 of [ITU-T Z.103]), and <macro definition> is removed by step 1 transformations, therefore none of these three items appears in AS0 <entity in agent>.

Conditions on concrete syntax

∀*ainst*∈<agent instantiation>:
ainst.**s-**<agent additional heading>.**s-**<agent formal parameters> ≠ *undefined* ⇒
ainst.**s-**<number of instances> ≠ *undefined*

In <agent instantiation>, if <agent formal parameters> are present, <number of instances> shall be present, even if both <initial number> and <maximum number> are omitted.

∀*afps*∈<agent formal parameters>:
afps.parentAS0 ∈ (<composite state type heading> ∪ <state aggregation type heading> ∪
<agent additional heading> ∪ <composite state heading>) ⇒
afps.*length* > 0

When used in the concrete syntax (occurs in places in the condition above), the <agent formal parameters> list shall have at least one item. However, it is defined with "*" rather than "+" so that it can used as an empty list within conditions, transformations, mappings and functions.

Transformations

< <system definition>(*uses*, <system heading>(*n*, *addHead*), *body*) >
=12=>
let *nn*=*newName* **in**
< <textual typebased system definition>(
<typebased system heading>(*n*, <type expression>(<identifier>(*undefined*, *nn*), *empty*))),
<system type definition>(*uses*,
<system type heading>(*empty*, *nn*,
<agent type additional heading>(*empty*, *undefined*, *addHead*)),
body) >
endlet // *nn*

< <block definition>(*uses*, <block heading>(*, *n*, <agent instantiation>(*inst*, *addHead*)), *body*) >
=12=> // * is optional qualifier which is ignored
let *nn*=*newName* **in**
< <textual typebased block definition>(
<typebased block heading>(*n*, *inst*, <type expression>(<identifier>(*undefined*, *nn*), *empty*))),
<block type definition>(*uses*,
<block type heading>(*empty*, *undefined*, *nn*,
<agent type additional heading>(*empty*, *undefined*, *addHead*)),
body) >

endlet // *nn*

< <process definition>(*uses*, <process heading>(*, *n*, <agent instantiation>(*inst*, *addHead*)), *body*) >
=12=> // * is optional qualifier which is ignored
let *nn*=*newName* **in**
< <textual typebased process definition>(
<typebased process heading>(*n*, *inst*, <type expression>(<identifier>(*undefined*, *nn*), *empty*))),
<process type definition>(*uses*,
<process type heading>(*empty*, *undefined*, *nn*,
<agent type additional heading>(*empty*, *undefined*, *addHead*)),
body) >
endlet // *nn*

An Agent-definition has an implied anonymous agent type that defines the properties of the agent.

NOTE – In F2.2.5.1.1 an <agent structure> with an <agent body> transformed into an <agent structure> with an <interaction>.

<agent formal parameters>(*params*)
provided ∃ *i* ∈ 1..*params*.*length*: *params*[*i*].**s-**<parameters of sort>.**s-**<name>**-seq**.*length* ≠1
=5=>
mk-<agent formal parameters>(
< **if** *params*[*i*].**s-**<parameters of sort>.**s-**<name>**-seq**.*length* ≠1
then // replacement list elements – two (aggregation kind, parameters of sort) pairs
(*params*[*i*].**s-**<aggregation kind>, //
mk-< parameters of sort > (
< *params*[*i*].**s-**<parameters of sort>.**s-**<name>**-seq**.*head* >,
params[*i*].**s-**<parameters of sort>.**s-**<sort>)
), // first (aggregation kind, parameters of sort) pair
(*params*[*i*].**s-**<aggregation kind>,
mk-< parameters of sort > (
params[*i*].**s-**<parameters of sort>.**s-**<name>**-seq**.*tail*, // transform again if >1 name in tail
params[*i*].**s-**<parameters of sort>.**s-**<sort>)
) // second (aggregation kind, parameters of sort) pair
else *params*[*i*] // only one name, no change needed
endif
: *i* ∈ 1..*params*.*length*
> // list of (aggregation kind, parameters of sort) pairs
)

An <agent formal parameters> list item with a <parameters of sort> that defines multiple parameter names is replaced by a sequence of <agent formal parameters> list items with the same <aggregation kind> each <parameters of sort> defining one name. See clause 8.1.1.1 *Model* of [ITU-T Z.101].

The following transformation is covered by the transformation for agent types.

An agent with an <agent body> or an <agent body area> is shorthand for an agent having only a state machine, but no contained agents. This state machine is obtained by replacing the <agent body> or <agent body area> by a composite state definition. This composite state definition has the same name as the agent and its State-transition-graph is represented by the <agent body> or the <agent body area>.

The following transformation is covered by the dynamic semantics.

In all agent instances, four anonymous variables of the pid sort of the agent (for agents not based on an agent type) or the pid sort of the agent type (for type based agents) are declared and are, in the following, referred to by self, parent, offspring and sender. They give a result for:

a) the agent instance (self);

b) the creating agent instance (parent);

c) the most recent agent instance created by the agent instance (offspring);

d) the agent instance from which the last input signal has been consumed (sender) (see also clause 11.3 of [ITU-T Z.101]).

These anonymous variables are accessed using pid expressions as further explained in clause 12.3.4.2 of [ITU-T Z.101].

For all agent instances present at system initialization, parent is initialized to Null.

For all newly created agent instances, sender and offspring are initialized to Null.

Mapping to abstract syntax

| <number of instances>(*init*, *max*, *lower*) **then**
mk-*Number-of-instances*(
if *init* ≠ *undefined* **then** *Mapping*(*init*) **else** 1 **endif**,
if *max* ≠ *undefined* **then** *Mapping*(*max*) **else** *undefined* **endif**,
if *lower* ≠ *undefined* **then** *Mapping*(*lower*) **else** 0 **endif**)

If <initial number> is omitted, then *Initial-number* is 1. If <maximum number> is omitted, then *Maximum-number* is unbounded (it is omitted in *Number-of-instances*). If the <lower bound> is omitted, the *Lower-bound* is zero.

| <agent formal parameters>(*param*) **then** < *Mapping*(*param*[*i*]) : *i* ∈ 1..*param.length*>

| *param*=<parameters of sort>(< *name* >, *s*) **then**
mk-*Parameter*(*Mapping*(*name*), // *Variable-name*
Mapping(*s*), // *Sort-reference-identifier*
case *parent=param.parentAS0* **of** // Parameter aggregation
| <agent formal parameters> **then** *Mapping*(*parent*.**s-**<aggregation kind>)
| <formal variable parameters> **then** *Mapping*(*parent*.**s-**<parameter aggregation>)
endcase // *param*
)

F2.2.6.1 System

Concrete syntax

<system definition> ::
<package use clause>* <system heading> <agent structure>

<system heading> :: <system<name> <agent additional heading>

Conditions on concrete syntax

∀*sd*∈<system heading>: *sd.agentLocalFormalParameterList0 = empty*

The <agent additional heading> in a <system definition> may not include <agent formal parameters>.

Transformations

let *nn*= *newName* **in**
< *c*=<channel definition>(*n*, *d*,
<channel path>(*ep1*=<channel endpoint>(**env**, *undefined*), *ep2*, *list1*),
undefined) >
provided *c.parentAS0.parentAS0.parentAS0* ∈ <system definition> =8=>
< <textual gate definition>(*nn*),
<channel definition>(*n*, *d*,
<channel path>(<channel endpoint>(**env**, *nn*), *ep2*, *list1*), *undefined*) >
endlet // *nn*

let *nn*= *newName* **in**
< *c*=<channel definition>(*n*, *d*,
<channel path>(*ep1*=<channel endpoint>(**env**, *undefined*), *ep2*, *list1*),
<channel path>(*ep2*, *ep1*, *list2*)) >
provided *c.parentAS0.parentAS0.parentAS0* ∈ <system definition> =8=>

< <textual gate definition>(*nn*),
<channel definition>(*n*, *d*,
<channel path>(<channel endpoint>(**env**, *nn*), *ep2*, *list1*),
<channel path>(*ep2*, <channel endpoint>(**env**, *nn*), *list2*)) >
endlet // *nn*

let *nn*= *newName* **in**
< *c*=<channel definition>(*n*, *d*,
<channel path>(*ep1*, *ep2*=<channel endpoint>(**env**, *undefined*), *list1*),
undefined) >
provided *c*.*parentAS0*.*parentAS0*.*parentAS0* ∈ <system definition> =8=>
< <textual gate definition>(*nn*),
<channel definition>(*n*, *d*,
<channel path>(*ep1*, <channel endpoint>(**env**, *nn*), *list1*), *undefined*) >
endlet // *nn*

let *nn*= *newName* **in**
< *c*=<channel definition>(*n*, *d*,
<channel path>(*ep1*, *ep2*=<channel endpoint>(**env**, *undefined*), *list1*),
<channel path>(*ep2*, *ep1*, *list2*)) >
provided *c*.*parentAS0*.*parentAS0*.*parentAS0* ∈ <system definition> =8=>
< <textual gate definition>(*nn*),
<channel definition>(*n*, *d*,
<channel path>(*ep1*, <channel endpoint>(**env**, *nn*), *list1*),
<channel path>(<channel endpoint>(**env**, *nn*), *ep1*, *list2*)) >
endlet // *nn*

For each <channel definition> in a system mentioning **env**, a gate with an anonymous name is added to the Agent-definition. The channel definition is changed to mention this gate in the <channel path> directed to the system environment.

F2.2.6.2 Block

Concrete syntax

<block definition> ::
<package use clause>* <block heading> <agent structure>

<block heading> ::
<qualifier> <block<name> <agent instantiation>

F2.2.6.3 Process

Concrete syntax

<process definition> ::
<package use clause>* <process heading> <agent structure>

<process heading> :: <qualifier> <process<name> <agent instantiation>

F2.2.6.4 Procedure

Abstract syntax

Procedure-definition :: *Procedure-name*
*Procedure-formal-parameter**
[*Result*]
[*Procedure-identifier*]
Data-type-definition-**set**
Syntype-definition-**set**
Variable-definition-**set**
Composite-state-type-definition-**set**
Procedure-definition-**set**
Procedure-graph
[*Abstract*]

Procedure-formal-parameter = *In-parameter*
| *Inout-parameter*
| *Out-parameter*

In-parameter :: *Parameter*

Inout-parameter :: *Parameter*

Out-parameter :: *Parameter*

Procedure-graph ::
[*Procedure-start-node*]
State-node-**set**
Free-action-**set**

Result :: *Sort-reference-identifier*
Result-aggregation

Result-aggregation :: *Aggregation-kind*

Concrete syntax

<procedure definition> =
<external procedure definition>
| <internal procedure definition>

<internal procedure definition> ::
<package use clause>* <procedure heading> <entity in procedure>*
{ <procedure body> | [<virtuality>] <statements> }

<procedure preamble> :: <type preamble> [<exported>]

<exported> :: [<remote procedure<identifier>]

<procedure heading> ::
<procedure preamble> <qualifier> <procedure<name>
[<formal context parameters>]
[<virtuality constraint>]
[<specialization>]
<procedure formal parameters>
[<procedure result>]

<procedure formal parameters> =
<formal variable parameters>*

<entity in procedure> =
<variable definition>
| <data definition>
| <procedure reference>
| <procedure definition>
| <composite state definition>
| <composite state type definition>
| <composite state type reference>
| <select definition>

<procedure body> ::
[<start>] {<state> | <free action>}*

<external procedure definition> :: <procedure<name> <procedure signature>

<formal variable parameters> :: <parameter kind> <parameter aggregation> <parameters of sort>

<parameter aggregation> :: <aggregation kind>

<parameter kind> = [**inout** | **in** | **out**]

<procedure result> :: <result aggregation> [<variable<name>] <sort>

<result aggregation> :: <aggregation kind>

<procedure signature> :: <formal parameter>* [<result>]

Conditions on concrete syntax

∀*pd*∈<procedure definition>:*pd.isExported0* ⇒
pd.formalContextParameterList0 = empty∧
pd.surroundingScopeUnit0 ∈
<agent type definition> ∪ <composite state type definition> ∪
<agent definition> ∪ <composite state definition>

An exported procedure shall not have formal context parameters and its enclosing scope shall be an agent type or a composite state type. See clause 9.4 *Concrete grammar* of [ITU-T Z.102].

NOTE – Although the condition requires the enclosing scope to be an agent type or composite state type, the alternatives for agent and composite state are included, so that these are valid before they are transformed to an agent type or composite state type that surrounds the exported procedure.

∀*vd*∈<variable definition>:
vd.surroundingScopeUnit0∈<procedure definition>⇒ ¬*vd.isExported0*

<variable definition> in an <internal procedure definition>, cannot contain **exported** <variable name>s

∀*pd1*,*pd2*∈<internal procedure definition>:
(*parentAS0ofKind*(*pd1*, <agent type definition>) =
parentAS0ofKind(*pd2*, <agent type definition>) ∧
pd1.isExported0∧ *pd2.isExported0*∧ *pd1* ≠ *pd2*)⇒
(*pd1*.**s-**<procedure heading>.**s-**<procedure preamble>.**s-**<exported>.**s-**<identifier> ≠
pd1.**s-**<procedure heading>.**s-**<procedure preamble>.**s-**<exported>.**s-**<identifier>)

Two exported procedures in an agent type or any enclosed composite state type of the agent type shall not mention the same <remote procedure identifier>. See clause 9.4 *Concrete grammar* of [ITU-T Z.102].

NOTE – The *parentAS0ofKind* search does not need to include enclosed composite state types, because the agent type is a parent of these also. An agent definition that contains an exported procedure definition is transformed to a typebased agent that instantiates an agent type definition, so the check on the agent type definition is sufficient.

∀*te*∈<type expression>: *te.baseType0*∉ <external procedure definition> ∧
∀*procCons*∈<procedure constraint>: *procCons*.**s-**<identifier> ≠ *undefined*⇒
getEntityDefinition0(*procCons*.**s-**<identifier>, **procedure**) ∉
<external procedure definition>

An external procedure cannot be mentioned in a <type expression> or in a <procedure constraint>.

Transformations

<formal variable parameters>(*undefined*,*aggr*,*params*)
=5=>
<formal variable parameters>(**in**,*aggr*,*params*)

A formal parameter with no explicit <parameter kind> has the implicit <parameter kind> **in**. See clause 9.5 *Model* of [ITU-T Z.103].

fvp=<formal variable parameters>(*kind*, *ak*, *params*)
provided
params.**s-**<name>**-seq**.*length* ≠1
=5=>
mk-<formal variable parameters>(*kind*, *ak*, < *params*.**s-**<name>**-seq**.*head* >)

mk-<formal variable parameters>(*kind*, *ak*, *params*.**s-**<name>**-seq**.*tail*) // transform again if >1 name in tail

A <formal variable parameters> with a <parameters of sort> that defines multiple parameter names is replaced by a sequence of <formal variable parameters> with the same <parameter kind> and <aggregation kind>, and each <parameters of sort> defining one name. See clause 9.4 *Model* of [ITU-T Z.101].

ph = <procedure heading>(*pre*,*q*,*n*,*fcp*,*vc*,*sp*,*fpars*,*res*)
=5=>
provided *expandFormalVarParams0*(*fpars*).*length* > *fpars*.*length*
<procedure heading>(*pre*,*q*,*n*,*fcp*,*vc*,*sp*,*expandFormalVarParams0*(*fpars*),*res*)

If any <parameters of sort> in a formal parameter list defines more than one name, the formal parameter list is expanded so that each <parameters of sort> defines only one name. Derived from clause 8.1.1.1 *Concrete grammar* of [ITU-T Z.101].

<internal procedure definition>(*uses*,
h=<procedure heading>(*, *, *, *, *, *, *,
<procedure result>(*resName*, *resSort*), *), *entities*, *body*)
provided *resName* ≠ *undefined* ∧
replaceInSyntaxTree0(<return body>(*undefined*),
<return body>(<expression>(<operand5>(<variable access>(<identifier>(*undefined*, *resName*))))),
body) ≠ *body*
=8=>
<internal procedure definition>(*uses*, *h*, *entities*,
replaceInSyntaxTree0(<return body>(*undefined*),
<return body>(<expression>(<operand5>(<variable access>(<identifier>(*undefined*, *resName*))))),
body))

When a <variable<name> is present in <procedure result>, each <return body> within the procedure graph without an <expression> is replaced by a <return body> containing the <variable<name> as the <expression>.

p=<internal procedure definition>(*uses*,
h=<procedure heading>(*, *, *, *, *, *, *, <procedure result>(*resName*, *resSort*), *),
entities, *body*)
provided *resName* ≠ *undefined* ∧
resName ∉ {*n* **in** *v*.**s-**<name>**-seq** | *v* ∈ <variables of sort>: *v*.*parentAS0*.*parentAS0*.*parentAS0* = *p* }
=8=>
<internal procedure definition>
(*uses*, *h*,
entities ⌒ <variable definition>
(*undefined*,
< <variables of sort>
(< *resName* >, *resSort*, *undefined*)
>
),
body)

A <procedure result> with <variable name> is derived syntax for a <variable definition> with <variable name> and <sort> in <variables of sort>. If there is a <variable definition> involving <variable name> no further <variable definition> is added.

The following statement is covered by the dynamic semantics.

A <procedure start area> which contains <virtuality> of virtual or redefined, a <start> of a <procedure body> which contains <virtuality> of virtual or redefined, or a <statements> in an <internal procedure definition> following <virtuality> of **virtual** or **redefined** is called a virtual procedure start. Virtual procedure start is further described in clause 8.4.3 of [ITU-T Z.102].

< <external procedure definition>(*, *) > =7=> *empty*

An external procedure definition is not considered in the dynamic semantics.

Mapping to abstract syntax

```
| <internal procedure definition>(*,<procedure heading>(*,*,n,*,*,parent,pars,result,*),entities,body) then
let entitiesSet = { Mapping(entities[i]:i ∈ 1..entities.length} in
mk-Procedure-definition(Mapping(n),
    < Mapping(pars[j]): j ∈ 1..pars.length} >,
    Mapping(result),
    Mapping(parent),
    { e ∈ entitiesSet: e ∈ Data-type-definition },
    { e ∈ entitiesSet: e ∈ Syntype-definition },
    { e ∈ entitiesSet: e ∈ Variable-definition },
    { e ∈ entitiesSet: e ∈ Composite-state-type-definition },
    { e ∈ entitiesSet: e ∈ Procedure-definition },
    Mapping(body) )
endlet // entitiesSet

| <formal variable parameters>(in, param) then mk-In-parameter(Mapping(param))

| <formal variable parameters>(out, param) then mk-Out-parameter(Mapping(param))

| <formal variable parameters>(inout, param) then mk-Inout-parameter(Mapping(param))

| <procedure body>(start, nodes) then
let nodeSet = { Mapping(nodes[i]:i ∈ 1..nodes.length} in
mk-Procedure-graph(
    Mapping(start),
    { sn ∈ nodeSet: sn ∈ State-node } // State-node-set
    { fa ∈ nodeSet: fa ∈ Free-action } // Free-action-set
)
endlet // nodeSet
```

Auxiliary functions

Determine if a <variable definition> or an <internal procedure definition> is exported.

```
isExported0(vp: <variable definition>∪<internal procedure definition>): BOOLEAN=def
    case vp of
    | <variable definition>(vlist) then
        if vlist.head ∈ <exported variables of sort> then true else false endif
    | <internal procedure definition> then
        if vp.s-<procedure heading>.s-<procedure preamble>.s-<exported> = undefined
        then false
        else true
        endif
    otherwise false
    endcase
```

Get the formal parameter list for an <internal procedure definition>.

```
procedureFormalParameterList0(pd: <internal procedure definition>): <name>*=def
    pd.localProcedureFormalParameterList0⌒ pd.inheritedProcedureFormalParameterList0

localProcedureFormalParameterList0(pd: <internal procedure definition>): <name>* =def
    let fpl=pd.s-<procedure heading>.s-<formal variable parameters>-seq in
        if fpl = empty then empty
        else
            < f.s-<parameters of sort>.s-<variable<name>-seq | f in fpl >
        endif
    endlet

inheritedProcedureFormalParameterList0(pd: <internal procedure definition>): <name>* =def
    let sp = pd.specialization0 in
```

if *sp* = *undefined* **then** *empty*
else *sp*.**s**-<type expression>.*baseType0.procedureFormalParameterList0*
endlet

Get the formal parameter list for a <procedure signature>.

procedureSignatureParameterList0(*ps*: <procedure signature>):<formal parameter>* =$_{def}$
ps.**s**-<formal parameter>-**seq**

Get the formal parameter list for an *Agent-type-definition*, a *Composite-state-type-definition*, or a *Procedure-definition*.

formalParameterList1
(*d*: *Agent-type-definition*∪*Composite-state-type-definition*∪*Procedure-definition*):
*Parameter**=$_{def}$
d.localFormalParameterList1⌒*d.inheritedFormalParameterList1*

localFormalParameterList1
(*d*: *Agent-type-definition*∪*Composite-state-type-definition*∪*Procedure-definition*):
*Parameter**=$_{def}$
case *d* **of**
| *Agent-type-definition* **then** *d*.**s**-*Agent-formal-parameter*-**seq**
| *Composite-state-type-definition* **then** *d*.**s**-*Composite-state-formal-parameter*-**seq**
| *Procedure-definition* **then** *d*.**s**-*Procedure-formal-parameter*-**seq**
otherwise *empty* **endif**
endcase

inheritedFormalParameterList1(*d*: *Agent-type-definition*∪*Composite-state-type-definition*∪
Procedure-definition): *Parameter**=$_{def}$
let *d1* = *take*({*d1*∈*Agent-type-definition*∪*Composite-state-type-definition*∪*Procedure-definition*:
isDirectSuperType1(*d1*, *d*)}) **in**
if *d1*≠*undefined* **then** *d1*. *formalParameterList1*
else *empty* **endif**
endlet

Determine if the sort list of *Expression*s corresponds by position to the *Sort-reference-identifier* list.

isActualAndFormalParameterMatched1
(*expl*:[*Expression*]*, *fpsl*:*Sort-reference-identifier**):*BOOLEAN*=$_{def}$
(*expl.length* = *fpsl.length*)∧
(∀*i*∈1..*expl.length*:*expl*[*i*]=*undefined*∨*isCompatibleTo1*(*expr*[*i*].*staticSort1*, *fpsl*[*i*]))

Get the sort list of the formal parameters of the given definition.

formalParameterSortList1
(*d*: *Agent-type-definition*∪*Composite-state-type-definition*∪*Procedure-definition*∪
Operation-signature):*Sort-reference-identifier**=$_{def}$
case *d* **of**
| *Agent-type-definition*∪*Composite-state-type-definition*∪*Procedure-definition* **then**
<*param*.**s**-*Sort-reference-identifier* | *param* **in** *d.formalParameterList1*>
| *Operation-signature* **then** <*fa*.**s**-*Argument* | *fa* **in** *d*.**s**-*Formal-argument*-**seq**>
| *Signal-definition*∪*Timer-definition* **then** *d*.**s**-*Sort-reference-identifier*-**seq**
endcase

Get the set of state nodes included in a type definition, state node or a state partition.

stateNodeSet1(*d*: *TYPEDEFINITION1*∪*State-node*∪*State-partition*): *State-node*-**set** =$_{def}$
case *d* **of**
| *TYPEDEFINITION1* **then** *d.localStateNodeSet1*∪*d.inheritedStateNodeSet1*
| *State-node* **then**
if *d*.**s**-*Composite-state-type-identifier* ≠ *undefined* **then** *d.baseType1.stateNodeSet1*∪{*d*}
else {*d*}

```
        | State-partition then d.baseType1.stateNodeSet1
        otherwise ∅
    endcase
```

Get the set of state nodes defined locally in a type definition.

```
localStateNodeSet1(d: TYPEDEFINITION1): State-node-set =def
    case d of
        | Agent-type-definition then
            if d.State-machine ≠ undefined then
                d. State-machine.baseType1.stateNodeSet1
            else ∅
        | Procedure-definition then
            {sn.stateNodeSet1: sn∈d.s-Procedure-graph.s-State-node-set}
        | Composite-state-type-definition then
            if d.s-implicit∈Composite-state-graph then
                {sn.stateNodeSet1: sn∈d.s-implicit.s-State-transition-graph.s-State-node-set}
            else // d.s-implicit∈State-aggregation-node
                {sp.stateNodeSet1: sp∈d.s-implicit.s-State-partition-seq.toSet}
        otherwise ∅
    endcase
```

Get the set of state nodes defined in a super type.

```
inheritedStateNodeSet1(d: TYPEDEFINITION1): State-node-set =def
    case d of
        | Agent-type-definition then
            if d.s-Agent-type-identifier≠ undefined then
                getEntityDefinition1(d.s-Agent-type-identifier, agent type).stateNodeSet1
            else ∅
        | Procedure-definition then
            if d.s-Procedure-identifier≠ undefined then
                getEntityDefinition1(d.s-Procedure-identifier, procedure).stateNodeSet1
            else ∅
        | Composite-state-type-definition then
            if d.s-Composite-state-type-identifier ≠ undefined then
                getEntityDefinition1(d.s-Composite-state-type-identifier, state type).stateNodeSet1
            else ∅
        otherwise ∅
    endcase
```

The function *expandFormalVarParams0* expands an <formal variable parameters> list so that each <parameters of sort> contains only one <name>.

```
expandFormalVarParams0(fvps: <formal variable parameters>*):<formal variable parameters>* =def
    if fvps = empty then empty
    else
        if fvps.head.s-<parameters of sort>.s-<name>-seq.length = 1
        then  fvps.head
        else < fvps.head.s-<parameter kind>, fvps.head.s-<parameter aggregation>,
            mk-<parameters of sort>( < fvps.head.s-<parameters of sort>.s-<name>-seq.head >,
                fvps.head.s-<parameters of sort>.s-<sort>) > ⌒
            expandAgentFormalParams0(< fvps.head.s-<parameter kind>,
                fvps.head.s-<parameter aggregation>,
                mk-<parameters of sort>( < fvps.head.s-<parameters of sort>.s-<name>-seq.tail>,
                    fvps.head.s-<parameters of sort>.s-<sort>
                )   >)
        endif ⌒
        if fvps.length =1 then empty
        else expandAgentFormalParams0(fvps.tail)
        endif
```

endif

F2.2.7 Communication

F2.2.7.1 Channel definition

Abstract syntax

Channel-definition	::	*Channel-name* [*Encoding-rules*] [**NODELAY**] *Channel-path*-**set**
Channel-path	::	*Channel-endpoint* *Originating-gate* *Channel-endpoint* *Destination-gate* *Signal-identifier*-**set**
Originating-gate	=	*Gate-identifier*
Destination-gate	=	*Gate-identifier*
Channel-endpoint	:: | |	*Agent-identifier* *State-identifier* **ENV**

Conditions on abstract syntax

See 10.1 *Abstract grammar* of [ITU-T Z.101] except the condition on *Encoding-rules*.

$\forall c \in$ *Channel-definition*: |*c*.**s**-*Channel-path*-**set**| $\in \{1, 2\}$

The *Channel-path*-**set** contains at least one *Channel-path* and no more than two.

$\forall\ c \in$ *Channel-definition*: |*c*.**s**-*Channel-path*| = 2 $\Rightarrow$
(∀*p1*,*p2*∈*c*.**s**-*Channel-path*: *p1*≠*p2* $\Rightarrow$
p1.**s**-*Originating-gate* = *p2*.**s**-*Destination-gate* $\wedge$ *p2*.**s**-*Originating-gate* = *p1*.**s**-*Destination-gate*)

When there are two paths, the channel is bidirectional and the *Originating-gate* of each *Channel-path* shall be the same as the *Destination-gate* of the other *Channel-path*.

$\forall c \in$ *Channel-definition*: $\forall p \in$ *Channel-path*: $\forall d \in$ *Agent-type-definition*:
(*p*.**s1**-*Channel-endpoint* = *p*.**s2**-*Channel-endpoint*) $\wedge$ \\ same agent
$\forall g1, g2 \in$ *Gate-definition*: (*p.parentAS1= c*) $\wedge$ (*g1.parentAS1= d*) $\wedge$ (*g2.parentAS1= d*) $\wedge$ (*g1* $\neq$ *g2*) $\wedge$
(*p*.**s**-*Originating-gate=g1.identifier1*) $\wedge$ (*p*.**s**-*Destination-gate= g2.identifier1*) $\Rightarrow$
|*c*.**s**-*Channel-path*-**set**|=1

If the *Originating-gate* and the *Destination-gate* are gates of the same agent, the channel shall be unidirectional (there shall be only one element in the *Channel-path*-**set**).

$\forall c \in$ *Channel-definition*: $\forall p \in$ *Channel-path*: $\forall d \in$ *Composite-state-type-definition*:
(*p*.**s1**-*Channel-endpoint* = *p*.**s2**-*Channel-endpoint*) $\wedge$ \\ same state machine
$\forall g1, g2 \in$ *Gate-definition*: (*p.parentAS1= c*) $\wedge$ (*g1.parentAS1= d*) $\wedge$ (*g2. parentAS1= d*) $\wedge$ (*g1* $\neq$ *g2*) $\wedge$
(*p*.**s**-*Originating-gate=g1.identifier1*) $\wedge$ (*p*.**s**-*Destination-gate= g2.identifier1*) $\Rightarrow$
|*c*.**s**-*Channel-path*-**set**|=1

If the *Originating-gate* and the *Destination-gate* are both gates of the same state machine, the channel shall be unidirectional (there shall be only one element in the *Channel-path*-**set**).

$\forall c \in$ *Channel-definition*: $\forall p \in$ *Channel-path*: $\exists g1, g2 \in$ *Gate-definition*:
(*p.parentAS1= c*) $\wedge$
(((*p*.**s**-*Originating-gate=g1.identifier1*) $\wedge$
(*g1.parentAS1= c.parentAS1* $\vee$ *g1.parentAS1.parentAS1= c.parentAS1*)) $\wedge$
((*p*.**s**-*Destination-gate= g2.identifier1*) $\wedge$
(*g2.parentAS1=c.parentAS1* $\vee$ *g2.parentAS1.parentAS1= c.parentAS1*))
)

The *Originating-gate* and *Destination-gate* shall be defined in the same scope unit (which includes directly enclosed scopes) in the abstract syntax in which the channel is defined.

∀*c* ∈ *Channel-definition*: ∀*p* ∈ *c*.**s-***Channel-path***-set**:
getEntityDefinition1(*p*.**s-***Originating-gate*,**gate**).**s-***Encoding-rules* = *c*.**s-***Encoding-rules* ∧
getEntityDefinition1(*p*.**s-***Destination-gate*,**gate**).**s-***Encoding-rules* = *c*.**s-***Encoding-rules*

The *Originating-gate* or *Destination-gate* shall have the same *Encoding-rules* as the *Channel-definition*. If the *Channel-definition* has no *Encoding-rules*, neither the *Originating-gate* nor *Destination-gate* shall have *Encoding-rules*. See clause 10.1 *Abstract grammar* of [ITU-T Z.104]

Concrete syntax

<channel definition> ::
[<channel<name> [<encoding rules>]] [**nodelay**] <channel path> [<channel path>]

<channel path> :: <channel endpoint> <channel endpoint> [<signal list>]

<channel endpoint> :: { <agent<identifier> | <state<identifier> | **env** | **this**}[<gate>]

<as channel> :: <channel<identifier>

Conditions on concrete syntax

∀*ce*∈<channel endpoint>:
let *g* = *ce*.**s-**<gate> **in**
case *id* = *ce*.**s-implicit of**
| <identifier> **then** // agent identifier or state identifier
case *d* = *getEntityDefinition0*(*id*, **agent** ∪ **state**) **of**
| <textual typebased agent definition> ∪ <typebased composite state> **then**
let *td* = *d*.**s-**<type expression>.*baseType0* **in**
g ≠ *undefined* ∧ // the gate is specified in the channel endpoint
(∃*gd*∈<textual gate definition>: ∃*gc*∈<gate constraint>: // exists a gate definition and constraint
gd.name0=*g*∧ // gate definition has the gate name
gd∈*td.localGateDefinitionSet0*∧ // gate definition defined in the agent/state type
gc.parentAS0 =*gd*∧ // is a gate constraint of the gate definition
// at least one common element in the signal lists
gc.**s-**<signal list item>**-seq**.*signalSet0* ∩ *ce.parentAS0*.**s-**<signal list item>**-seq**.*signalSet0*≠∅∧
gc.direction0 =*ce.direction0*)// in the same direction
endlet // td
otherwise *true* // agent/state machine not typebased, condition must hold when transformed to typebased
endcase // d
| **env then** // environment
let *su* = *ce.surroundingScopeUnit0* **in**
su ∈ <agent type definition>) ⇒
g ≠ *undefined* ∧ // the gate is specified in the channel endpoint
(∃*gd*∈<textual gate definition>: ∃*gc*∈<gate constraint>: // exists a gate definition and constraint
gd.name0=*g*∧ // gate definition has the gate name
gd∈*su.localGateDefinitionSet0*∧ // gate definition defined in the agent type
gc.parentAS0 =*gd*∧ // is a gate constraint of the gate definition
// at least one common element in the signal lists
gc.**s-**<signal list item>**-seq**.*signalSet0* ∩ *ce.parentAS0*.**s-**<signal list item>**-seq**.*signalSet0*≠∅∧
gc.direction0 =*ce.direction0*) // in the same direction
endlet // su
| **this then** // the state machine of the enclosing agent
let *su* = *ce.surroundingScopeUnit0* **in**
let *sm* = *su*.**s-**<agent structure>.**s-**<interaction>.**s-**<typebased composite state> **in** // the state machine
let *td* = *sm*.**s-**<type expression>.*baseType0* **in**
g ≠ *undefined* ∧ // the gate is specified in the channel endpoint
(∃*gd*∈<textual gate definition>: ∃*gc*∈<gate constraint>: // exists a gate definition and constraint
gd.name0=*g*∧ // gate definition has the gate name
gd∈*td.localGateDefinitionSet0*∧ // gate definition defined in the state type
gc.parentAS0 =*gd*∧ // is a gate constraint of the gate definition
// at least one common element in the signal lists

gc.**s-**<signal list item>**-seq**.*signalSet0* ∩ *ce.parentAS0*.**s-**<signal list item>**-seq**.*signalSet0*≠∅∧
gc.direction0 =*ce.direction0*)// in the same direction
endlet // td
endlet // sm
endlet // su
otherwise *false* // condition not met -
endcase // id
endlet // g

<gate> shall be specified if:

a) <channel endpoint> with an <agent<identifier> denotes a connection to a <textual typebased agent definition> in which case the <gate> shall be defined directly in the agent type for that agent; or

b) <channel endpoint> with a <state<identifier> identifies the state machine of the enclosing agent, in which case the <gate> shall be defined directly in the state type for that state, and as there is only one state machine it can alternatively be identified by **`this`**; or

c) **`env`** is specified and the channel is defined in an agent type in which case the <gate> shall be defined in this agent type.

If gate is specified the channel is connected to that gate. The gate and channel shall have at least one common element in their signal lists in the same direction. See clause 5.6.1 of [ITU-T Z.106].

∀*c* ∈ <channel definition>:
(*c*.**s1-**<channel path>.**s-**<signal list> = *undefined* ⇒ *c*.**s1-**<channel path>.*derivedSignalList0* ≠ *empty*)
∧ (*c*.**s2-**<channel path> ≠ *undefined*) ⇒
c.**s2-**<channel path>.**s-**<signal list> = *undefined* ⇒ *c*.**s2-**<channel path>.*derivedSignalList0* ≠ *empty*)

If any associated <signal list> is omitted from the <channel path> of a <channel definition>, the corresponding set of signals shall be derivable. See clause 10.1 *Concrete grammar* of [ITU-T Z.103].

Derivation of an omitted channel <signal list> is possible if at least one <channel endpoint> identifies a <textual typebased agent definition> or <typebased composite state> (or **`this`** and the state machine is a <typebased composite state>) or **`env`**, and the gate for the <channel endpoint> has a defined set of signals in the direction for the <signal list>. The set of signals is defined for the gate if it identifies a <textual gate definition> that has a <gate constraint> with a defined <signal list>, or if a signal set is defined for all internal channels connected to this gate. The set is defined for a gate connected to <external channel identifiers> if for each external channel either no <signal list area> is omitted or the set for that external channel is derivable. See clause 5.6.1 of [ITU-T Z.106] which describes derivation for the textual grammar and is based on clause 10.1 *Concrete grammar* of [ITU-T Z.103].

Transformations

<channel definition>(*undefined*, *delay*, *p1*, *p2*)
=5=>
<channel definition>(*newName*, *delay*, *p1*, *p2*)

If the <channel name> is omitted from a <channel definition>, the channel is implicitly and uniquely named. See clause 10.1 *Model* of [ITU-T Z.103].

<channel definition>(*name*, *delay*, *p1*, *p2*)
provided
p1.**s-**<signal list> = *undefined*
=8=>
<channel definition>(
name,
delay,
mk-<channel path>(*p1*.**s1-**<<channel endpoint>, *p1*.**s2-**<<channel endpoint>, *p1.derivedSignalList0*),
p2)

<channel definition>(*name*, *delay*, *p1*, *p2*)
provided
    p2 ≠ *undefined*
∧ *p2*.**s-**<signal list> = *undefined*
=13=>
<channel definition>(
    name,
    delay,
    p1,
    mk-<channel path>(*p2*.**s1-**<<channel endpoint>, *p2*.**s2-**<<channel endpoint>, *p2.derivedSignalList0*)
)

If an associated <signal list> is omitted from a <channel definition>, the <signal list> is replaced by a <signal list> derived from the channel connection (see condition on <signal list> in a <channel definition> above), that corresponds to the *In-signal-identifier-**set*** or *Out-signal-identifier-**set*** for the *Destination-gate* or *Originating-gate*. Modified from clause 10.1 *Model* of [ITU-T Z.103].

NOTE – This transform takes place after the transform of shorthand notations <agent definition>, <agent body> and <composite state definition> in step12, so that the channel endpoint is typebased or **`this`** or **`env`**, and a gate has to be specified.

t = <textual typebased agent definition>
provided *unconnectedGates*(*t*) = *undefined*
=9=>
t
and
unconnectedGates(*t*)=>
let *id* = *take*({ *te*.**s-**<base type> | *te* ∈ <type expression>: *te.parentAS0.parentAS0* = *t* }) **in**
{ *g* ∈ *id.refersto0.getEntities0.toSet*:
    g ∈ <gate in definition> ∧ ¬*isConnected*(*g*, *undefined*, *id.refersto0.getEntities0.toSet*) }
endlet

t = <agent type definition>
provided *unconnectedGates*(*t*) = *undefined*
=9=>
t
and
unconnectedGates(*t*)
=>
{ *g* ∈ *t.getEntities0.toSet*: *g* ∈ <gate in definition> ∧ ¬*isConnected*(*g*, *undefined*, *t.getEntities0.toSet*) }

< *a1* = <textual typebased agent definition> > ⌒ *something* ⌒ < *a2* = <textual typebased agent definition> >
provided *missingConnections*(*a1*,*a2*) ≠ ∅
=10=>
let *c* = <channel definition>(*newName*, *undefined*, *missingConnections*(*a1*,*a2*).*take*, *undefined*) **in**
    < *a1* > ⌒ *something* ⌒ < *a2* > ⌒ < *c* >
endlet

< *a1* = <textual typebased agent definition> > ⌒ *something* ⌒ < *a2* = <textual typebased agent definition> >
provided *missingConnections*(*a2*,*a1*) ≠ ∅
=10=>
let *c* = <channel definition>(*newName*, *undefined*, *missingConnections*(*a2*,*a1*).*take*, *undefined*) **in**
    < *a1* > ⌒ *something* ⌒ < *a2* > ⌒ < *c* >
endlet

< *a* = <textual typebased agent definition> >
provided *missingConnections*(*a*,*a.parentAS0.parentAS0*) ≠ ∅
=10=>
let *c* = <channel definition>(*newName*, *undefined*,
        missingConnections(*a*,*a.parentAS0.parentAS0*).*take*, *undefined*) **in**

< *a* > ⌒ < *c* >
endlet

< *a* = <textual typebased agent definition> >
provided *missingConnections*(*a.parentAS0.parentAS0*,*a*) ≠ ∅
=10=>
let *c* = <channel definition>(*newName*, *undefined*,
missingConnections(*a.parentAS0.parentAS0*,*a*).*take*, *undefined*) **in**
< *a* > ⌒ < *c* >
endlet

The text for the three transforms below is from clause 10.1 Model of [ITU-T Z.103].

If an agent or agent type contains explicit or implicit gates that are not attached by explicit channels, implicit channels are derived according to the following three transforms, which are applied after the transform for typebased creation is applied.

Transform 1:

Insertion of channels between instance sets inside the agent or agent type and between the instance sets and the agent state machine.

Transform 2:

Insertion of channels from a gate on the agent or agent type to gates on instance sets inside the agent or agent type and to gates on the agent state machine.

Transform 3:

Insertion of channels from gates on instance sets inside the agent or agent type and from gates on the agent state machine to gates on the agent or agent type.

In the transforms one signal list element (interface, signal, remote procedure or remote variable) matches another signal list element if:

a) both denote the same interface, signal, remote procedure or remote variable; or

b) the first denotes a signal or remote procedure or remote variable, and the second denotes an interface and the interface includes the signal or remote procedure or remote variable; or

c) both denote interfaces and the second signal list element inherits the first signal list element.

Transform 1: Insertion of implicit channels between entities inside one agent or agent type

a) If an element of the outgoing signal list associated with a gate of an instance in an agent (or agent type) matches an element of an incoming signal list associated with a gate of another instance in the same agent (or agent type respectively); and

b) if neither of these gates has an explicit channel attached to it,

then

a) if no implicit channel exists between the two gates, a unidirectional implicit channel is created from the gate where the element is outgoing to the gate where the element is incoming, and this channel is non-delaying if it is within a process (or process type) and otherwise it is delaying; and

b) the element is added to the signal list of the implied channel.

Transform 2: Insertion of implicit channels from the gates on an agent or agent type

a) If an element of the incoming signal list associated with a gate outside an agent (or agent type) matches an element of an incoming signal list associated with a gate of an instance in the agent (or agent type respectively); and

b) if there is no explicit channel inside the agent (or agent type respectively) attached to the gate outside the agent (or agent type respectively) and no explicit channel attached to the gate of the instance inside the agent (or agent type respectively),

then

a) if no implicit channel exists between the two gates, a unidirectional implicit channel is created from the gate outside the agent (or agent type respectively) to the gate of the instance inside the agent (or agent type respectively), and this channel is non-delaying if it is within a process (or process type) and otherwise it is delaying; and

b) the element is added to the signal list of the implied channel.

Transform 3: Insertion of implicit channels from the gates on instances

The following is applied for insertion of implicit channels from the gates on instance sets within the agent or agent type to the gates on the agent or agent type:

a) If an element of the outgoing signal list associated with a gate outside an agent (or agent type) matches an element of an outgoing signal list associated with a gate of an instance in the agent (or agent type respectively); and

b) if there is no explicit channel attached to the gate outside the agent (or agent type respectively) and no explicit channel connected to the gate of the instance inside the agent (or agent type respectively),

then

a) if no implicit channel exists between the two gates in the direction to the gate outside the agent (or agent type respectively), a unidirectional implicit channel is created from the gate of the instance inside the agent (or agent type respectively) to the gate outside the agent (or agent type respectively), and this channel is non-delaying if it is within a process (or process type) and otherwise it is delaying; and

b) the element is added to the signal list of the implied channel.

The following statement is modelled in the dynamic semantics.

A channel with both endpoints being gates of one <textual typebased agent definition> represents individual channels from each of the agents in this set to all agents in the set, including the originating agent. Any resulting bidirectional channel connecting an agent in the set to the agent itself is split into two unidirectional channels. Modified from clause 10.1 *Model* of [ITU-T Z.103].

cd.*asChannelName*
provided
cd ∈ <channel definition>
∧ *cd*.*asChannelName* = *undefined*
=8=>
(*asChannelName* \{(*cd*, *undefined*)}) ∪ {(*cd*, *newName*)}

NOTE – Each <channel definition> defines a *Data-type-definition* of a choice data type with a unique anonymous *Sort* name stored in *asChannelName*.

<as channel>(*cid*)
provided
cid.*refersto0*.*asChannelName* ≠ *undefined*
=8=>
mk-<type expression>(**mk-**<identifier>(*gid*.**s-**<qualifier>, *gid*.*refersto0*.*asChannelName*), *undefined*)

An <as channel> represents the sort of the choice data type introduced by the identified channel definition. See clause 12.1 *Concrete grammar* of [ITU-T Z.104].

Mapping to abstract syntax

```
| <channel definition>(name, encoding, delayProperty, path1, path2) then
    mk-Channel-definition(Mapping(name),
        if encoding ≠ undefined
        then Mapping(encoding)
        else // encoding rules omitted in channel definition
            if path1.pathEncodings0 ≠ undefined then Mapping(path1.pathEncodings0)
            else
                if path2 ≠ undefined
                then
                    if path2.pathEncodings0 ≠ undefined then Mapping(path2.pathEncodings0)
                    else undefined
                    endif // path2 encoding defined/undefined
                else undefined
                endif // path2 defined/undefined
            endif // path1 encoding defined/undefined
        endif, // encoding rules in channel definition
        if delayProperty = nodelay then NODELAY else undefined endif,
        if path2=undefined
        then { Mapping(path1) }
        else { Mapping(path1), Mapping(path2) }
        endif)
```

If the <encoding rules> item is omitted in a <channel definition> and a <channel path> is connected to a <gate> that identifies a <gate definition> with <encoding rules>, the *Channel-definition* has the same *Encoding-rules* as the *Gate-definition* of the <textual gate definition>. If the *Gate-definition* has no *Encoding-rules*, the *Channel-definition* has no *Encoding-rules*. Derived from See clause 10.1 *Model* of [ITU-T Z.104].

NOTE – The mapping to a *Data-type-definition* for the choice data type defined by a <channel definition> in the following paragraph takes place by invoking the function *choiceForChannel1* (defined below), in the mapping to *Agent-type-definition* in F2.2.5.1.2, F2.2.5.1.3 and F2.2.5.1.4.

A *Channel-definition* implicitly defines a *Data-type-definition* of a choice data type with a unique anonymous *Sort* name in the context that the *Channel-definition* is visible. A <basic sort> that is <as channel> where <channel<identifier> identifies the *Channel-definition* represents this *Data-type-definition*. The *Data-type-definition* is equivalent to defining a choice data type with a <choice of sort> for each distinct *Signal-definition* identified by each *Signal-identifier*-**set** of the *Channel-path*-**set**. The <field name> and <field sort> for each <choice of sort> is determined in the same way as a <choice of sort> for each distinct *Signal-definition* of the *Data-type-definition* defined by a <gate definition>. See clause 10.1 *Concrete grammar* of [ITU-T Z.104].

```
| <channel path>(endp1(*, g1), endp2(*, g2), with) then
     mk-Channel-path(Mapping(endp1), Mapping(g1), Mapping(endp2), Mapping(g2), Mapping(with))

| <channel endpoint>( end, *) then
    mk-Channel-endpoint(
        case end of
        | <identifier> then Mapping(end)
        | env then ENV
        | this then
            let atd = parentAS0ofKind(end,
                <system type definition> ∪ <block type definition> ∪ <process type definition>)
            in
                mk-Identifier(Mapping(atd.identifier0.s-<qualifier>) ⌒
                        < mk-Agent-type-qualifier(Mapping(atd.identifier0.s-<name>) >,
                    Mapping(atd.s-<agent structure>.s-<interaction>.s-<state machine>.s-<name>))
            endlet
        endcase)
```

Auxiliary functions

SIGNALDIRECTION0 =def { **out**, **in** }

Get the direction of a <gate constraint> or a <channel endpoint>.

direction0(*p*: <gate constraint>∪<channel endpoint>): *SIGNALDIRECTION0*=def
case *p* **of**
| <channel endpoint> **then if** *p*=*p.parentAS0*.**s1-**<channel endpoint> **then out else in endif**
| <gate constraint> **then if** *p*.**s-in** ≠ *undefined* **then in else** *p*.**s-out endif** // s-out could be undefined
otherwise *undefined*
endcase

The function *channelEndpointReferTo*0 is used to get the entity definition that the <channel endpoint> referred to.

channelEndpointReferTo0(*ep*:<channel endpoint>): *ENTITYDEFINITION0*=def
let *end* = *ep*.**s-implicit in**
case *end* **of**
| <identifier> **then** *getEntityDefinition0*(*end*, *end.idKind0*)
| **this then** *parentAS0ofKind*(*end*, <agent definition> ∪<agent type definition>)
| **env then** *undefined*
endcase
endlet

The function *unconnectedGates* is used to store the gates that are not explicitly connected.

controlled *unconnectedGates*: <textual typebased agent definition> ∪ <agent type definition> →
<gate in definition>**-set**
initially ∀ *def* ∈ (<textual typebased agent definition> ∪ <agent type definition>):
def.unconnectedGates = undefined

The function *missingConnections* is used to compute the missing implicit connections between two agents.

missingConnections(*ag1*: <textual typebased agent definition> ∪ <agent type definition>,
ag2: <textual typebased agent definition> ∪ <agent type definition>): <channel path>**-set** =def
let *entities* =
if *ag1* ∈ <agent type definition> **then** *ag1.getEntities0*
elseif *ag2* ∈ <agent type definition> **then** *ag2.getEntities0*
else *parentAS0ofKind*(*ag1*, <agent type definition>).*getEntities0*
endif
in
let *id1* =
if *ag1* ∈ <agent type definition> **then env else** *ag1.identifier0* **endif**
in
let *id2* =
if *ag2* ∈ <agent type definition> **then env else** *ag2.identifier0* **endif**
in
U { { **mk-**<channel path>(
mk-<channel endpoint>(*id1*, *g1*),
mk-<channel endpoint>(*id2*, *g2*),
< *siglistitem* ∈ (*inoutSignals0*(*g1*, **out**) ∪ *inoutSignals0*(*g2*, **in**)) >) // channel path
: *g2* ∈ *ag2.unconnectedGates* ∧ ((*inoutSignals0*(*g1*, **out**) ∪ *inoutSignals0*(*g2*, **in**)) ≠ ∅) ∧
¬*isConnected*(*g1*, *g2*, *entities*)}
: *g1* ∈ *ag1.unconnectedGates* }

The function *isConnected* is used to check whether two gates are connected.

isConnected(*g1*:<gate in definition>, *g2*: <gate in definition>, *ent*: *DefinitionAS0*-**set**): *BOOLEAN* =def
let *allPaths* =
U{ { *e*.**s1-**<channel path> } ∪

```
        if e.s2-<channel path> = undefined then ∅ else { e.s2-<channel path> } endif
        | e ∈ ent.toSet: e ∈ <channel definition> }
in
    ∃ p ∈ allPaths: g1=p.s1-<channel endpoint>.s-<gate>.refersto0 ∧
        (g2=p.s2-<channel endpoint>.s-<gate>.refersto0 ∨ g2 = undefined)
endlet
```

The function *inoutSignals0* is used to compute the outbound or inbound signals of a gate based on the <gate constraint>.

```
inoutSignals0(g: <textual gate definition>, kind: SIGNALDIRECTION0 ): <signal list item>-set =def
if kind: = in then
    { sli : sli in gc.s1-<signal list item>-seq ∧ gc ∈ g.s-<gate constraint> ∧ gc.direction0 = in }
else // kind is out
    { sli : sli in gc.s2-<signal list item>-seq ∧ gc ∈ g.s-<gate constraint> ∧ gc.direction0 = in } ∪
    { sli : sli in gc.s1-<signal list item>-seq ∧ gc ∈ g.s-<gate constraint> ∧ gc.direction0 = out }
endif // kind
```

The function *pathEncodings0* is used to get the encoding rules (if any) specified by one of gates (if any) at the channel endpoints of the path. If both channel endpoints have a gate with encoding rules, these rules are required to be the same.

```
pathEncodings0(cp: <channel path>): <encoding rules> =def
let localQualifier = cp.surroundingScopeUnit0.fullQualifierWithin0 in
let g1 = cp.s1-<channel endpoint>.s-<gate> in
let g2 = cp.s2-<channel endpoint>.s-<gate> in
if g1 ≠ undefined then
    let rules1 = mk-<identifier>(localQualifier,g1).refersto0.s-<encoding rules> in
    if rules1≠ undefined then rules1
    else
        if g2 ≠ undefined then mk-<identifier>(localQualifier,g2).refersto0.s-<encoding rules>
        else undefined // g2 undefined, g1 defined but no encoding rules
        endif // rules2 undefined
    endif
    endlet // rules1
else // g1 undefined
    if g2 ≠ undefined then
        let rules2 = mk-<identifier>(localQualifier,g2).refersto0.s-<encoding rules> in
        if rules2≠ undefined then rules2 else undefined endif
        endlet // rules2
    else undefined // g1 undefined and g2 undefined
endif
endlet // g2
endlet  // g1
endlet  // localQualifier
```

The function *choiceForChannel1* produces the choice *Data-type-definition* that corresponds to a *Channel-definition* and is used when an <as channel> is given for a <basic sort>, where each <choice of sort> is for each distinct signal definition identified by each signal identifier that is a signal list item of the signal list of a channel path of the channel definition.

```
choiceForChannel1(cd: <channel definition>): Data-type-definition =def
let chanSigSet =
{ sig :  sig in cd.s1-<channel path>.s-<signal list item>-seq
    ∨  (   cd.s2-<channel path> ≠ undefined
           ∧
           sig in cd.s2-<channel path>.s-<signal list item>-seq
       )
} // chanSigSet
in
Mapping(mk-<data type definition>( mk-<type preamble>(undefined,undefined), // type preamble
```

```
    mk-<data type heading>( cd.asChannelName, // name for choice type
        undefined, undefined, // no formal parameters or virtuality constraint
    ), // data type heading
    mk-<data type definition body>( empty, // no entities in data type
        mk-<choice definition>( undefined, // visibility
            <   mk-<choice of sort>( undefined, // visibility
                    mk-<field of kind>( part,
                        if sig.s-<name> ∉ { othersigs.s-<name>
                            : othersigs ∈ (chanSigSet \ sig )}
                        then // unique signal name
                            sig.s-<name>
                        else // not unique signal name – name same as <as signal>
                            sig.asSignal.s-<name>// name of structure sort for signal
                        endif
                    ), // <field of kind>
                    mk-<field sort>(
                        if sig.refersto0.s-implicit  // <sort list> | <named fields sort list> | <sort<identifier>
                            = undefined  // no sort
                        then  predefinedId0("NULL")
                        else sig.asSignal // structure sort for signal
                        endif
                    ) // <field sort>
                ) // <choice of sort> item
                : sig ∈ chanSigSet
            > //  <choice of sort> list
        ) <choice definition>(
    ), // data type definition body
    undefined //  default initialization
)) // Mapping of data type definition
endlet // chanSigSet
```

The function *derivedSignalList0* produces a derived list of signal <identifier> items, to be used in a <channel path> of a <channel definition> when a <signal list> is omitted from the <channel path> of a <channel definition>. The description of the derivation is in the text for the condition for the missing <signal list> items to be derivable.

```
derivedSignalList0(cp: <channel path>): <signal<identifier>* =def
let orig = cp.s1-<channel endpoint> in
let origgate = orig.s-<gate> in
let origgateDef =
    case orig.s-implicit of // first item of channel endpoint
    | <identifier> then mk-<identifier>(orig.s-implicit.refersto0.fullQualifierWithin0, origgate).refersto0
    | this then
        mk-<identifier>(
            this.surroundingScopeUnit0.s-<typebased composite state>.refersto0.fullQualifierWithin0,
            origgate
        ).refersto0
    | env then
        mk-<identifier>(env.surroundingScopeUnit0.fullQualifierWithin0, origgate).refersto0
    otherwise undefined // any other cases
    endcase // first item of channel endpoint
in
let dest = cp.s2-<channel endpoint> in
let destgate = dest.s-<gate> in
let destgateDef =
    case dest.s-implicit of // first item of channel endpoint
    | <identifier> then mk-<identifier>(dest.s-implicit.refersto0.fullQualifierWithin0, destgate).refersto0
    | this then
        mk-<identifier>(
            this.surroundingScopeUnit0.s-<typebased composite state>.refersto0.fullQualifierWithin0,
            destgate
        ).refersto0
```

```
    | env then
        mk-<identifier>(env.surroundingScopeUnit0.fullQualifierWithin0, destgate).refersto0
    otherwise undefined // any other cases
    endcase // first item of channel endpoint
in
if      orig.s-implicit ∈ <identfier>
    ∧   orig.s-implicit.refersto0 ∈ <textual typebased agent definition> ∪ <typebased composite state>
    ∧   (   (origgate ≠ undefined ∧ inoutSignals0(origgateDef, out) ≠ ∅) // orig defined with out signals
            ∨ // or orig connected to channels in agent that have out signals
            (   (   ∀ connectedchf ∈ connectedChanSet(orig, true) // connected forward path –
                    : connectedchf.s1-<channel path>.s-<signal list> ≠ undefined
                ) // forward channel path – all connected channels – out signals defined
                ∧
                (   ∀ connectedchr ∈ connectedChanSet(orig, false) // connected reverse path – that is
                    : connectedchr.s2-<channel path>.s-<signal list> ≠ undefined
                ) // reverse channel paths – all connected channels – out signals defined, if path defined
            ) // true if out signals defined for all forward paths, and all reverse paths defined
        ) // true if  orig defined with signals, or channels in orig agent have signals defined
then
    if (origgate ≠ undefined ∧ inoutSignals0(origgateDef, out) ≠ ∅)
    then // orig defined with out signals
        < sig : sig ∈ inoutSignals0(origgateDef, out) >
    else    // connection to agent with signals defined for all connected chans
        < sig : sig ∈ toSet(bigSeq(
        < connectedchf.s1-<channel path>.s-<signal list> : connectedchf ∈ connectedChanSet(orig, true) > ⌢
        < connectedchr.s2-<channel path>.s-<signal list> : connectedchr ∈ connectedChanSet(orig, false) >
        )) > // bigSeq, toSet, sequence constructor
    endif
elseif
        orig.s-implicit = this ∧ origgate ≠ undefined
    ∧ this.surroundingScopeUnit0.s-<typebased composite state> ≠ undefined
then
    < sig : sig ∈ inoutSignals0(origgateDef, out) >
elseif
        orig.s-implicit = env ∧ origgate ≠ undefined
then
    < sig : sig ∈ inoutSignals0(origgateDef, in) >
elseif // cannot derive from orig, therefore try dest
        dest.s-implicit ∈ <identfier>
    ∧   dest.s-implicit.refersto0 ∈ <textual typebased agent definition> ∪ <typebased composite state>
    ∧   (   (destgate ≠ undefined ∧ inoutSignals0(destgateDef, in) ≠ ∅) // dest defined with in signals
            ∨ // or dest connected to channels in agent that have out signals
            (   (   ∀ connectedchf ∈ connectedChanSet(dest, true) // connected forward path –
                    : connectedchf.s1-<channel path>.s-<signal list> ≠ undefined
                ) // forward channel path – all connected channels – in signals defined
                ∧
                (   ∀ connectedchr ∈ connectedChanSet(dest, false) // connected reverse path – that is
                    : connectedchr.s2-<channel path>.s-<signal list> ≠ undefined
                ) // reverse channel paths – all connected channels – in signals defined, if path defined
            ) // true if out signals defined for all forward paths, and all reverse paths defined
        ) // true if  dest defined with signals, or channels in dest agent have signals defined
then
    if (destgate ≠ undefined ∧ inoutSignals0(destgateDef, in) ≠ ∅)
    then // dest defined with in signals
        < sig : sig ∈ inoutSignals0(destgateDef, in) >
    else    // connection to agent with signals defined for all connected chans
        < sig : sig ∈ toSet(bigSeq(
        < connectedchf.s2-<channel path>.s-<signal list> : connectedchf ∈ connectedChanSet(dest, true) > ⌢
        < connectedchr.s1-<channel path>.s-<signal list> : connectedchr ∈ connectedChanSet(dest, false) >
        )) > // bigSeq, toSet, sequence constructor
    endif
```

elseif
dest.**s-implicit** = **this** ∧ *destgate* ≠ *undefined*
∧ **this**.*surroundingScopeUnit0*.**s-**<typebased composite state> ≠ *undefined*
then
< *sig* : *sig* ∈ *inoutSignals0*(*destgateDef*, **in**) >
elseif
dest.**s-implicit** = **env** ∧ *destgate* ≠ *undefined*
then
< *sig* : *sig* ∈ *inoutSignals0*(*destgateDef*, **out**) >
else // signals not derivable
empty
endif

The function *connectedChanSet* produces a set of channels connected to a channel endpoint in the agent identified by the channel endpoint in the forward (or reverse) direction.

connectedChanSet(*ce*: <channel endpoint>, *forward*: *BOOLEAN*): <channel defnition>**-set** $=_{def}$
{*ch* : *ch* ∈ <channel defnition> // channels
∧ *ce*.**s-implicit**.*refersto0* = *ch*.*surroundingScopeUnit0* // ch internal to agent at ce
∧ **if** *forward*
then // forward paths
ch.**s1-**<channel path>.**s2-**<channel endpoint>.**s-implicit** = **env** // to env
∧ *ch*.**s1-**<channel path>.**s2-**<channel endpoint>.**s-**<gate> = *ce*.**s-**<gate> // via ce
else // reverse paths
ch.**s2-**<channel path> ≠ *undefined* // reverse path defined
∧ *ch*.**s2-**<channel path>.**s2-**<channel endpoint>.**s-implicit** = **env** // to env
∧ *ch*.**s2-**<channel path>.**s2-**<channel endpoint>.**s-**<gate> = *ce*.**s-**<gate> // via ce
endif
} // all internal channels connected to ce with forward (reverse) path

The function *asChannelName* associates each <channel definition> with a unique anonymous *Sort* name for the corresponding *Data-type-definition* of the choice data type invoked by <as channel>.

controlled *asChannelName*: <channel definition>→ <name>
initially ∀ *cd* ∈ <channel definition>: *gd*.*asChannelName* = *undefined*

F2.2.7.2 Connections

Concrete syntax

<channel to channel connection> ::
<external channel identifiers> <channel<identifier>+

<external channel identifiers> = <channel<identifier>+

Conditions on concrete syntax

∀*c2c* ∈ <channel to channel connection>: *c2c*.*surroundingScopeUnit0* ∉ <agent type definition>

A <channel to channel connection> shall not be directly contained within an <agent type definition>. See clause 5.5 of [ITU-T Z.106].

∀*c1*,*c2*∈<channel to channel connection>:
(**let** *ids1*= *c1*.**s2-**<identifier>**-seq**.*toSet* **in**
let *ids2*= *c2*.**s2-**<identifier>**-seq**.*toSet* **in**
c1.*surroundingScopeUnit0*= *c2*.*surroundingScopeUnit0*∧ *c1* ≠ *c2*⇒ *ids1*∩ *ids2* = ∅
endlet
endlet)

It is not allowed to mention a channel after the keyword **and** in more than one <channel to channel connection> of a given scope unit. See clause 5.6.2 of [ITU-T Z.106].

∀*c1*,*c2*∈<channel to channel connection>:
(**let** *ids1*= *c1*.**s-**<identifier>**-seq**.*toSet* **in**
let *ids2*= *c2*.**s-**<identifier>**-seq**.*toSet* **in**

```
            (c1.surroundingScopeUnit0= c2.surroundingScopeUnit0∧ c1 ≠ c2)
                ⇒(ids1 = ids2 ∨ ids1∩ ids2 = ∅)
        endlet
    endlet)
```

For any pair of <channel to channel connection> items of a given scope unit, the <external channel identifiers>s shall either mention the same set of channels, or shall have no channels in common. See clause 5.6.2 of [ITU-T Z.106].

Transformations

```
ctcc.myImplicitGateIdentifier
provided
    ctcc ∈ <channel to channel connection>
∧   ctcc. myImplicitGateIdentifier = undefined
=8=>
     (myImplicitGateIdentifier \{( ctcc, undefined )} )
∪   {( ctcc, mk-<identifier>(surroundingQualifier0(ctcc), newName))}

ctcc = <channel to channel connection>(*, *)
provided
ctcc.myImplicitGateIdentifier ≠ undefined
=8=>
mk-<textual gate definition>( ctcc.myImplicitGateIdentifier.s-<name>, undefined, // name, no encoding rules
    if allSignalsIn(ctcc).length >1 then
        if allSignalsOut(ctcc).length >1 then
            mk-<gate constraint>(in, allSignalsIn(ctcc), out, allSignalsOut(ctcc))
        else
            mk-<gate constraint>(in, allSignalsIn(ctcc),undefined)
        endif
    else
    if allSignalsOut(ctcc).length >1 then
        mk-<gate constraint>( out, allSignalsOut(ctcc))
    else mk-<gate constraint>(undefined)  // should not occur
    endif
)
and
cendpt=<channel endpoint>(id, undefined)
provided
findconnect(cendpt.parentAS0.parentAS0, id) ≠ undefined
=>
mk-<channel endpoint>(id, findconnect(cendpt.parentAS0.parentAS0, id))
```

Each different <channel to channel connection> in a given scope unit defines one implicit gate on the scope unit. All channels in the <channel to channel connection> are connected to that gate in their respective scope units. The gate constraints of the implicit gate are derived from the channels connected to the gate. The name of the gate is a unique and unambiguous derived name. In the surrounding scope unit the <channel definition> that is identified by the <channel identifier> is extended with a via <gate> part. The via <gate> part is added to the <channel endpoint> that references the current scope unit and it mentions the implicit gate. Inside the scope unit the channels that are associated with the external channel by means of the <channel to channel connection> are modified, by extending the <channel endpoint> that mentions **env** with a via <gate> part for the implicit gate. See clause 5.6.2 of [ITU-T Z.106].

Auxiliary functions

The auxiliary function *myImplicitGateIdentifier* stores the implicitly generated gate identifier of a connection.

```
controlled myImplicitGateIdentifier: <channel to channel connection> → <identifier>
initially ∀ ctcc ∈ <channel to channel connection>: ctcc.myImplicitGateIdentifier = undefined
```

The function *findconnect* computes the implicit gate identifier for a channel that is mentioned in a channel-to-channel connection.

```
findconnect(ch:<channel definition>, id: DefinitionAS0): <identifier> =def
    if id=env then
        let matchingGateIds =
        { c.myImplicitGateIdentifier | c ∈ <channel to channel connection>:
            c.parentAS0 = ch.parentAS0 ∧ fullIdentifier0(ch)  in c.s2-<identifier>-seq} in
                matchingGateIds.take
    else
        let matchingGateIds =
        { c.myImplicitGateIdentifier | c ∈ <channel to channel connection>:
            c.parentAS0 = id.refersto0 ∧ fullIdentifier0(ch) in c.s-<identifier>-seq} in
                matchingGateIds.take
    endif
```

The function *allSignalsIn* computes the input signals belonging to a channel-to-channel connection.

```
allSignalsIn(c: <channel to channel connection>): <signal list item>* =def
< sig : sig ∈ toSet( // removes duplicate signal list items
    bigSeq( < // all external channels to scope round ctcc, or from scope round ctcc
        if extchan.refersto0.s1-<channel path>.s2-<channel endpoint> = ctcc.surroundingScopeUnit0
        then extchan.refersto0.s1-<channel path>.s-<signal list item>-seq
        elseif extchan.refersto0.s2-<channel path> ≠ undefined
        then extchan.refersto0.s2-<channel path>.s-<signal list item>-seq
        else empty
        endif  // external channels to/from scope round ctcc
    : extchan in ctcc.s1-<identifier>-seq // external channels of ctcc
    > ) // list of signal list item lists, bigSeq  – which flattens the list of lists
)> // sig, list of signal list items, toSet removes duplicates
    ⌒
    bigSeq(
    < // all internal channels from env to something, or from something to env
        if intchan.refersto0.s1-<channel path>.s1-<channel endpoint> = env
        then intchan.refersto0.s1-<channel path>.s-<signal list item>-seq
        elseif intchan.refersto0.s2-<channel path> ≠ undefined
        then intchan.refersto0.s2-<channel path>.s-<signal list item>-seq
        else empty
        endif  // all internal channels to/from env
    : intchan in ctcc.s2-<identifier>-seq // internal channels of ctcc
    > ) // list of signal list item lists, bigSeq – which flattens the list of lists
) > // toSet, make set into sequence
```

The function *allSignalsOut* computes the output signals belonging to a channel-to-channel connection.

```
allSignalsOut(ctcc: <channel to channel connection>): <signal list item>* =def
< sig : sig ∈ toSet( // removes duplicate signal list items
    bigSeq( < all external channels from scope round ctcc, or to scope round ctcc
        if extchan.refersto0.s1-<channel path>.s1-<channel endpoint> = ctcc.surroundingScopeUnit0
        then extchan.refersto0.s1-<channel path>.s-<signal list item>-seq
        elseif extchan.refersto0.s2-<channel path> ≠ undefined
        then extchan.refersto0.s2-<channel path>.s-<signal list item>-seq
        else empty
        endif
    : extchan in ctcc.s1-<identifier>-seq // external channels of ctcc
    > ) // list of signal list item lists, bigSeq  – which flattens the list of lists
    ⌒
    bigSeq(
    < // all internal channels from env to something, or from something to env
        if intchan.refersto0.s1-<channel path>.s1-<channel endpoint> = env
```

then
if *intchan.refersto0*.**s2-**<channel path> ≠ *undefined*
then *intchan.refersto0*.**s2-**<channel path>.**s-**<signal list item>**-seq**
else *empty*
endif
else *intchan.refersto0*.**s1-**<channel path>.**s-**<signal list item>**-seq**
endif
: *intchan* **in** *ctcc*.**s2-**<identifier>**-seq** // internal channels of ctcc
>) // list of signal list item lists, bigSeq – which flattens the list of lists
) > toSet, make set into seqeunce

F2.2.7.3 Signal

Abstract syntax

Signal-definition:: *Signal-name*
*Signal-parameter**
[*Signal-identifier*]
[*Abstract*]

Signal-parameter :: *Aggregation-kind Sort-reference-identifier*

Concrete syntax

<signal definition list> :: <signal definition>+

<signal definition> :: <type preamble>
<signal<name>
[<formal context parameters>]
[<virtuality constraint>]
[<specialization>]
[<sort list> | <named fields sort list> | <sort<identifier>]

<named fields sort list> :: [<visibility>]
{ [<visibility>] <aggregation kind> <field<name> <sort> }+

<sort list> :: { <aggregation kind> <sort> }+

<as signal> :: <signal<identifier>

Conditions on concrete syntax

∀*sdi*∈<signal definition>:*sdi.specialization0*.**s-**<type expression>.**s-**<base type>.*idKind0* = **signal**

The <base type> part of <specialization> shall be a <signal identifier>. See clause 12.3 *Concrete grammar* of [ITU-T Z.102].

∀*sid* ∈ <identifier>:
sid.parentAS0∉<type expression>∧ *sid.parentAS0*∉<signal constraint>⇒
¬*getEntityDefinition0*(*sid*, **signal**).*isAbstractType0*

An abstract type shall not be instantiated. See clause 8.1.3 *Semantics* of [ITU-T Z.102]. As a consequence, an abstract signal can only be used in specialization and signal constraints.

∀*sdi* ∈ <signal definition>:
sdi.**s-implicit** ∈ <identifier> ⇒ // sort identifier
sdi.**s-implicit**.*refersto0.derivedDataType0*.**s-**<data type definition body>.**s-**<data type constructor>
∈ <structure definition>

The <sort<identifier> of **struct** <sort<identifier> of a <signal definition> shall identify the sort of a structure data type. See clause 10.3 *Semantics* of [ITU-T Z.104].

Transformations

<signal definition list>(< *item* > ⌒ *rest*) **provided** *rest* ≠ *undefined*

=5=> <signal definition list>(< *item* >) ⌒ <signal definition list>(*rest*)

If several <signal definition> items are specified in one <signal definition list>, this is equivalent to individual <signal definition list>s for each of them. See clause 10.3 *Concrete grammar* of [ITU-T Z.101].

sigId.asSignal
provided
sigId.asSignal = *undefined* ∧
sigId ∈ {*id* ∈ <identifier>: *id.refersto0* ∈ <signal definition>}
=5=>
case *sortlist* = *sigId.refersto0*.**s-implicit of** // sortlist
| *undefined* **then** // parameterless signal
(*asSignal*\{(*sigId, undefined*)}) ∪ {(*sigId*, **mk-**<identifier>(*sigId*.**s-**<qualifier>, *newName*))}
| (<sort list> ∪ <named fields sort list>) **then**
(*asSignal*\{(*sigId, undefined*)}) ∪ {(*sigId*, **mk-**<identifier>(*sigId*.**s-**<qualifier>, *newName*)}
| <identifier> **then** // sortlist = sort identifier
(*asSignal*\{(*sigId, undefined*)}) ∪ {(*sigId, sortlist* }
endcase // sortlist

The following three paragraphs from clause 10.3 *Concrete grammar* of [ITU-T Z.104], describes the implicit type associated (as above) with a <signal definition> by the function *asSignal* and mapped to the abstract syntax as described below.

A <signal definition> that defines a *Signal-definition* with an empty *Signal-parameter* list (a signal definition> without a <sort list> or <named fields sort list> or **struct** <sort identifier>), defines in the same context as the *Signal-definition* a *Syntype-definition* with a unique anonymous *Syntype- name*, NULL, as the *Parent-sort-identifier*, and empty *Range-condition* and no *Default-initialization*. In this case, an <as signal> (for the signal definition) when used as a <basic sort> denotes the data type NULL.

A <signal definition> that defines a *Signal-definition* with a non-empty *Signal-parameter* list defined by a <sort list> or <named fields sort list>, defines in the same context as the *Signal-definition* a *Data-type-definition* for a structure data type with a unique anonymous *Sort* name. In this case, an <as signal> (for the signal definition) when used as a <basic sort> denotes the *Sort* of the *Data-type-definition*. The *Data-type-definition* is equivalent to defining a structure data type with an **optional** <field> for each <aggregation kind> and <sort> item (in order) of the <sort list> or <named fields sort list>, where the <aggregation kind> and <field sort> is the same as those of the <sort list> or <named fields sort list>. If the <signal definition> has a <sort list>, each field has a unique anonymous name and therefore has to be identified using a <field number> and the field present operation is not accessible because its name is unknown. If the <signal definition> has a <named fields sort list>, each <field> has the name given by the <field name> of the <named fields sort list> item.

For a <signal definition> that defines a *Signal-definition* with a non-empty *Signal-parameter* list defined by **struct** <sort identifier>, an <as signal> (for the signal definition) when used as a <basic sort> denotes the same *Sort* as the <sort identifier> of **struct** <sort identifier>.

Mapping to abstract syntax

| <signal definition list>(< *item* >) **then** *Mapping*(*item*)

| *sd* = <signal definition>(*,*name*,*,*,*,*sortlist*) **then**
// type preamble virtuality/virtuality constraint ignored – type preamble abstract derived from sd
// specialization derived from sd: formal params not used here
<
if *sortlist* ∈ <identifier>
then // sortlist is a structure identifier
mk-*Signal-definition*(*Mapping*(*name*),
let *structfields* =
derivedDataType0(*sortlist.refersto0*
).**s-**<data type definition body>.**s-**<data type constructor>.**s-**<field list>

```
        in
        < mk-Signal-parameter(
            Mapping(structfields[i].s-implicit.s-<fields of sort>.s-<field of kind>.head.s-<aggregation kind>),
            Mapping(structfields[i].s-implicit.s-<fields of sort>.s-<field sort>)
            ) // Signal-parameter
        : i ∈ 1..structfields.length
        > // list of Signal-parameters
        endlet // structfields
        Mapping(sd.specialization0.s-<type expression>.baseType0),
        if isAbstractType0(sd) then Abstract else Undefined endif
    ) // Signal-definition
else // sortlist is not a structure identifier – and there is a Signal-definition and a data type definition
    mk-Signal-definition(Mapping(name),
        if sortlist= undefined
        then empty
        else // sortlist is a sort list or a named sort list – sort identifier handled above
        < mk-Signal-parameter(
            Mapping(sortlist[i].s-<aggregation kind>),
            Mapping(sortlist[i].s-<sort>))
        : i ∈ 1..sortlist.length > // list of Signal-parameters
        endif,
        Mapping(sd.specialization0.s-<type expression>.baseType0),
        if isAbstractType0(sd) then Abstract else Undefined endif
    ), // Signal definition followed by data type definition
    case sortlist // undefined, sort list or named fields sort list
    |   undefined then // parameterless signal
        mk-Syntype-definition(sd.identifier0.asSignal, // Syntype name
            predefinedId0("NULL"), // NULL as the Parent-sort-identifier,
            mk-Range-condition(∅), // empty Range-condition
            undefined  // default initialization
        ) // Syntype definition
    |   (<sort list> ∪ <named fields sort list>) then
        let dtd = mk-<data type definition>(
            mk-<type preamble>(undefined),
            mk-<data type heading>(sd.identifier0.asSignal, undefined, undefined),
            mk-<data type definition body>( empty, // entity in data type list
                mk-<data type constructor>(
                    mk-<structure definition>( undefined, // visibility of structure
                    < mk-<optional field>(mk-<fields of sort>(undefined, // visibility of field
                            < mk-<field of kind>( sortlist[i].s-<aggregation kind>,
                                if sortlist ∈ <sort list> then newName else sortlist[i].s-<name> endif)
                            > ,
                            sortlist[i].s-<sort>)):// fields of sort, optional field
                        i ∈ 1..sortlist.length
                    > // list of fields
                    ) // structure definition
                ), // data type constructor
                mk-<operations>(
                    mk-<operation signatures>( undefined, undefined), mk-<operation definitions>( empty )
                ), // operations
                undefined // default initialization
            ) // data type definition body
        ) // data type definition
        in
        Mapping(dtd)
    endcase // sortlist
>
```

Auxiliary functions

The function *asSignal* is used to store the name of the (possibly anonymous) data type or syntype corresponding to a signal definition.

controlled *asSignal*: <identifier> → <identifier> // signal identifier to sort identifier
initially ∀ *sigId* ∈ {*id* ∈ <identifier>: *id.refersto0* ∈ <signal definition>}: *sigId.asSignal* = *undefined*

F2.2.7.4 Signal list definition

Concrete syntax

<signal list definition> ::
    <interface><name> <signal list>

<signal list> =
    <signal list item>+

<signal list item> ::
    <signal><identifier>
  | <timer><identifier>
  | <interface><identifier>
  | <remote procedure><identifier>
  | <remote variable><identifier>

Transformations

<signal list definition>(*n*,*sl*)
=8=>
<interface definition>(*empty*, *undefined*,
  <interface heading>(*n*, *empty*, *undefined*), *undefined*, <entity in interface>(<interface use list>(*sl*)))

A <signal list definition> is an alternative concrete syntax, and is transformed into an <interface definition> using the keyword **interface** with no <package use clause>, no <virtuality>, an <interface heading> containing the <interface name> (but no <formal context parameters> or <virtuality constraint>), no <interface type expression> specialization and no <entity in interface>. The <interface definition> has an <interface use list> with a <signal list> that is the same as the <signal list> of the <signal list definition>. See clause 12.1.2 *Model* of [ITU-T Z.103].

Mapping to abstract syntax

| < <signal list item>(*id*) > **then** *Mapping*(*id*)

F2.2.7.5 Remote procedures

Concrete syntax

<remote procedure definition> ::
    <remote procedure><name> <procedure signature>

<remote procedure call> :: <remote procedure call body>

<remote procedure call body> ::
    <remote procedure><identifier> [<actual parameters>] <communication constraints>

<timer communication constraint> ::
    <timer><identifier> [<variable>]* [<connector><name>]

Conditions on concrete syntax

See clause 10.5 *Concrete grammar* [ITU-T Z.102] unless another reference is given.

∀*pd*∈<procedure definition>:
  let *rpi* = *pd*.**s-**<procedure heading>.**s-**<procedure preamble>.**s-**<exported>.**s-**<identifier> **in**
  let *rpd* =*getEntityDefinition0*(*rpi*, **remote procedure**) **in**
    pd.isExported0 ∧ *rpi*≠ *undefined*⇒
      isSameProcedureAndSignature0(*pd*, *rpd*.**s-**<procedure signature>)
  endlet

The <remote procedure identifier> following **as** in an exported procedure definition shall denote a <remote procedure definition> with the same signature as the exported procedure. See clause 9.4 *Concrete grammar* [ITU-T Z.102].

∀*pd*∈<procedure definition>:
  let *rpi* = *pd*.**s-**<procedure heading>.**s-**<procedure preamble>.**s-**<exported>.**s-**<identifier> **in**
  let *rpd* = *resolveByContainer0*(*pd.surroundingScopeUnit0*,
    mk-<identifier>(*empty*, *pd.name0*),
    remote procedure)
  in
    pd.isExported0 ∧ *rpi* = *undefined*⇒
      (*rpd* ≠ *undefined*∧*isSameProcedureAndSignature0*(*pd*, *rpd*.**s-**<procedure signature>))
  endlet
  endlet

In an exported procedure definition with no **as** clause, there shall be a <remote procedure definition> in a surrounding scope with the same name and signature as the exported procedure and the nearest such <remote procedure definition> is used. See clause 9.4 *Concrete grammar* [ITU-T Z.102].

∀*rpc*∈<remote procedure call>:
  let *d* = *parentAS0ofKind*(*rpc*, <agent definition> ∪<agent type definition>) **in**
    rpc.**s-**<identifier>∈*d.validOutputSignalSet0*
  endlet

A remote procedure mentioned in a <remote procedure call body> shall be in the complete output set of an enclosing agent type or agent set.

∀*rpcb1*, *rpcb2* ∈ <remote procedure call body>:
let *action1* = *parentAS0ofKind*(*rpcb1*, <action>) **in**
let *action2* = *parentAS0ofKind*(*rpcb2*, <action>) **in**
  parentAS0(*rpcb1*) ∉{<remote procedure call> ∪ <call statement>} // is <expression0>
∧ *parentAS0*(*rpcb2*) ∉{<remote procedure call> ∪ <call statement>} // is <expression0>
∧ *rpcb1*.**s-**<identifier> = *rpcb2*.**s-**<identifier> ⇒
    action1 ≠ *action2*
  ∨ ¬*isSameNode0*(*action1*, *action2*)
  ∨ *isSameNode0*(*rpcb1*, *rpcb2*)
endlet
endlet

If a remote procedure is a value returning procedure, each action shall contain no more than one <remote procedure call body> used as an <expression0> for the same remote.

∀(*cc*∈<communication constraints>: (|{*d*∈<destination>: *d* **in** *cc*}| > 1)) ⇒
  cc.parentAS0∉<remote procedure call body>∪<import expression>)

In Basic SDL-2010, a <communication constraints> shall contain at most one **`to`** <destination> clause. See clause 11.13.4 *Concrete grammar* of [ITU-T Z.101].

Comprehensive SDL-2010 <communication constraints> of an <output body> of an <output area> is extended to allow more than one **`to`** <destination> clause. See clause 11.13.4 *Concrete grammar* of [ITU-T Z.103].

NOTE – The rule in Z.101 is only extended in Z.103 for <output body>, therefore a <communication constraints> in a <remote procedure call body> or <import expression> shall contain no more than one <destination>.

∀*tc*∈<timer communication constraint>: *tc.parentAS0.parentAS0*∉<output body>

The <communication constraints> in an <output body> shall not contain a <timer communication constraint>. See clause 11.13.4 *Concrete grammar* of [ITU-T Z.102].

∀(*tc*∈<timer communication constraint>: (|{*tc* **in** *tc.parentAS0*}| ≤ 1)) ⇒
  tc.parentAS0.parentAS0∉ (<remote procedure call body>∪<import expression>):

A <communication constraints> in a <remote procedure call body> shall contain no more than one <timer communication constraint>. A <communication constraints> in an <import expression> shall contain no more than one <timer communication constraint>. See clause 11.13.4 *Concrete grammar* of [ITU-T Z.102].

∀*v* **in** <timer communication constraint>.**s**-<variable>-**seq**: ¬(*isGlobalBlockVar0*(*v*))

A <variable> of a <timer communication constraint> shall not be a global variable of a system (type) or block (type) except if the <timer communication constraint> is within the state machine actions of system (type) or block (type). See clause 10.5 *Model* of [ITU-T Z.102].

Transformations

A remote procedure call body

– `Proc(apar) to destination timer timerinfo via viapath`

is modelled by an exchange of implicitly defined signals. If the **`to`** or **`via`** clauses are omitted from the remote procedure call, they are also omitted in the following transformations. The communication uses the channels where the remote procedure has been mentioned in the <signal list> (the outgoing for the importer and the incoming for the exporter) of at least one gate or channel connected to the importer or exporter. The requesting agent sends a signal containing the actual parameters of the procedure call, except actual parameters corresponding to **`out`**-parameters, to the server agent and waits for the reply. In response to this signal, the server agent interprets the corresponding remote procedure, sends a signal back to the requesting agent with the results of all **`in/out`**-parameters and **`out`**-parameters (**`in`** parameters are excluded), and then interprets the transition for the remote procedure stimulus in the current state.

rpd.*implicitName*
provided
rpd ∈ <remote procedure definition>
∧ *rpd*.*implicitName* = *undefined*
=17=>
(*implicitName*\{(*rpd*, *undefined*)}) ∪ {(*rpd*, *newName*)}

rpd=<remote procedure definition>(*, *sign*)
provided
rpd.*implicitName* ≠ *undefined*
=17=>
let *p* = *rpd*.*implicitName*.**s**-*TOKEN*
let *sortlist* = *sign*.**s**-<formal parameter>-**seq in**
< *rpd*, **mk**-<signal definition list>(*undefined*,
< **mk**-<signal definition>(
undefined, // type preamble
mk-<name >(*p*+"CALL"), // signal name
empty, // formal context parameters
undefined, // specialization
undefined, // virtuality constraint
< **mk**-<sort list>(
< *sortlist*[*n*].**s**-<sort> | *n* **in** 1..*sortlist*.*length* : *sortlist*[*n*].**s-implicit** ≠ **out** > ⌒
< *predefinedId0*("Integer") >)), // end mk sort list, end mk signal definition
< **mk**-<signal definition>(
undefined, // type preamble
mk-<name >(*p*+"REPLY"),// signal name
empty, // formal context parameters
undefined, // specialization
undefined, // virtuality constraint
< **mk**-<sort list>(
< *sortlist*[*n*].**s**-<sort> | *n* **in** 1..*sortlist*.*length* :
(*sortlist*[*n*].**s-implicit** ≠ **in** ∧ *sortlist*[*n*].**s-implicit** ≠ *undefined*)> ⌒

```
                    if sign.s-<result> ≠ undefined then < sign.s-<result> >
                    else empty
                    endif ⌒
                    < predefinedId0("Integer") >)) // end mk sort list, end mk signal definition
        >) > // end mk signal definition list, end of replacement list
    endlet // sortlist
endlet // p
```

There are two anonymously named implicit <signal definition list> items for each <remote procedure definition> in a system definition. The <signal name> items in these <signal definition> items are denoted by `pCALL` and `pREPLY` respectively, where `p` is uniquely determined. The signals are defined in the same scope unit as the <remote procedure definition>. Both `pCALL` and `pREPLY` have a last parameter of the predefined `Integer` sort.

```
< <channel definition>(n, er, delay,
    <channel path>(ep1, ep2,
            sigs1 ⌒ <signal list item>( i=<identifier>(q, *)) ⌒ sigs2),
    path2) >
provided stimulusKind(i) = remote procedure ∧ i.refersto0.implicitName ≠ undefined
=17=>
let p = i.refersto0.implicitName.s-TOKEN in
    <channel definition>(n, er, delay,
        <channel path>(ep1, ep2,
            sigs1⌒ < mk-<signal list item>(<identifier>(q, mk-<name>(p + "CALL"))) > ⌒ sigs2),
        <channel path>(ep2, ep1,
             if path2 = undefined then empty else path2.s-<signal list item>-seq endif ⌒
                < mk-<signal list item>(<identifier>(q, mk-<name>(p + "REPLY")) > )))
endlet
```

On each channel mentioning the remote procedure, the remote procedure is replaced by `pCALL`. For each such channel, if it is unidirectional the channel is made bidirectional. In the opposite direction this channel carries the signal `pREPLY`. The new channel has the same delaying property as the original one.

The transform below replaces an exported procedure definition without an **as** clause by an exported procedure definition with an **as** clause that identifies the remote procedure with the same name as the exported procedure definition.

```
ipd = <internal procedure definition>
provided
    ipd.s-<procedure heading>.s-<procedure preamble>.s-<exported> ≠ undefined
∧   ipd.s-<procedure heading>.s-<procedure preamble>.s-<exported>.s-<identifier> = undefined
// exported procedure without an as clause – change to identify remote procedure
=17=>
mk-<internal procedure definition>(
    ipd.s-<package use clause>-seq,
    mk-<procedure heading>(
        mk-<procedure preamble>(
            ipd.s-<procedure heading>.s-<procedure preamble>.s-implicit // virt/abstract,
            mk-<exported>(
                resolveByContainer0(ipd.surroundingScopeUnit0,
                mk-<identifier>(empty, ipd.s-<procedure heading>.s-<name>),
                remote procedure).identifier0 // id for rpd
            ) // end mk exported
        ), // end of  procedure preamble
        ipd.s-<procedure heading>.s-<qualifier>,
        ipd.s-<procedure heading>.s-<name>,
        ipd.s-<procedure heading>.s-<formal context parameters>,
        ipd.s-<procedure heading>.s-<virtuality constraint>,
```

```
        ipd.s-<procedure heading>.s-<specialization>,
        ipd.s-<procedure heading>.s-<procedure formal parameters>,
        ipd.s-<procedure heading>.s-<procedure result>
    ), // end of procedure heading
    ipd.s-<entity in procedure>-seq,
    ipd.s-implicit // body, statements or compound statement
)  // end mk internal procedure definition
```

The transform below inserts the implicit variable definitions needed for an exported procedure after an exported procedure definition that has an **as** clause that identifies the remote procedure definition.

```
< ipd = <internal procedure definition> >
provided
    ipd.s-<procedure heading>.s-<procedure preamble>.s-<exported> ≠ undefined
∧   ipd.s-<procedure heading>.s-<procedure preamble>.s-<exported>.s-<identifier> ≠ undefined
// exported procedure without an as clause – change to identify remote procedure
∧   ¬(∃ v ∈ <variables of sort> :
        v.s-<name> =
            mk-<name>(ipd.s-<procedure heading>.s-<procedure preamble>
                .s-<exported>.s-<identifier>.refersTo0.implicitName.s-TOKEN+"n")
        ∧ (fullQualifier0(v) = fullQualifier0(ipd)))
    // There is not already a variable with the name p+"n" in the scope ipd defined,
    // where p is the unique name associated with remote procedure definition,
    // therefore the variables need to be defined.
=17=>
let rpd = ipd.s-<procedure heading>.s-<procedure preamble>.s-<exported>.s-<identifier> in
// remote procedure definition id
let p = rpd.refersto0.implicitName.s-TOKEN in
// p is the unique TOKEN associated with remote procedure definition
<   ipd > ⌒
<   variableDefinition0(p + "n", predefinedId0("Integer"), undefined) > ⌒
<   variableDefinition0(p + "ivar", predefinedId0("Pid"), undefined) > ⌒
    if rpd.s-<procedure signature>.s-<result> = undefined then
        empty
    else
    <   variableDefinition0(p + "res", rpd.s-<procedure signature>.s-<result>, undefined) >
    endif ,
    remoteProcParamsDef(ipd.s-<procedure heading>.s-<procedure formal parameters>, p)
> // end of replacement
endlet  // p
endlet  // rpd
```

a) Requesting agent

The remote procedure in a requesting agent has seven transforms. The first transform handles the variable definitions for implicit variables and is invoked only once. The subsequent six transforms insert actions before the action containing the remote procedure call body for the signal exchange. Depending on where the remote procedure call was, the pattern matches one of the six transformations for the enclosing body: an agent body with the remote procedure call in a start, an agent body with the remote procedure call in a state or free action, a composite state body with the remote procedure call in a start, a composite state body with the remote procedure call in a state or free action, a procedure body with the remote procedure call in a start, or a procedure body with the remote procedure call in a state or free action. These are invoked only if the implicit variables are defined. If the procedure is in an expression, the remote procedure call is replaced with an access to the implicit variable for the returned value - otherwise the remote procedure call is removed.

```
items= getEntities0(//entities defined in agent type definition where remote procedure is called
    atd = parentAS0ofKind( // finds agent type definition with import expression
        rpcb = <remote procedure call body>,
        <system type definition> ∪ <block type definition> ∪ <process type definition>))
```

)) //end *parentAS0ofKind*, end of *getEntities0*
provided
¬ *callerVariablesDefined*(*rpcb*)
=17=>
< *variableDefinition0*(*rpcb*.**s-**<identifier>.*refersto0*.*implicitName*.**s-***TOKEN* + "n",
predefinedId0("Integer"),
mk-<operand5>(**mk-**<identifier>(*predefinedQual0*("Integer"), **mk-**<name>("1")))) >
⌒
< *variableDefinition0*(*rpcb*.**s-**<identifier>.*refersto0*.*implicitName*.**s-***TOKEN* + "newn",
predefinedId0("Integer"), *undefined*) >
⌒ **if** *rpd*.**s-**<procedure signature>.**s-**<result> = *undefined* **then** *empty*
else
< *variableDefinition0*(*rpcb*.**s-**<identifier>.*refersto0*.*implicitName*.**s-***TOKEN* + "res",
rpd.**s-**<procedure signature>.**s-**<result>,*undefined*) >
endif // *rpcb* is in an expression
⌒ *items* // variables are in scope and can be used in *items*

– For each imported procedure, two implicit anonymous `Integer` variables (in this description called `n` and `newn`) are defined in the enclosing scope unit of the <remote procedure call body>, and `n` is initialized to 0.

NOTE – The parameter `n` is introduced to recognize and discard reply signals of remote procedure calls that were left through associated timer expiry.

– If remote procedure is a value returning procedure, an implicit anonymous variable (in this description called `res`) is defined in the enclosing scope unit of the <remote procedure call body> with the sort returned by the procedure.

body = <agent body>(// agent body with remote procedure call in start
start = <start>(
virt,
entry,
<transition action items>(
actionItems = *parentAS0ofKind*(
action = *parentAS0ofKind*(
rpcb = <remote procedure call body>,
<action>), // *parentAS0ofKind* for *action*
<action>-**seq**), // *parentAS0ofKind* for *actionItems*,
tr) // tr is the terminator for <transition action items>
), // <start>
bodyitems
) // agent body with remote procedure call in start
provided
callerVariablesDefined(*rpcb*)
=17=>
let *actions1* = < *a*[*n*] **in** *actionItems*.**s-**<action>-**seq** : *action* = *actionItems*.**s-**<action>-**seq**[i] ∧ *n* < i > **in**
let *actions2* = < *a*[*n*] **in** *actionItems*.**s-**<action>-**seq** : *action* = *actionItems*.**s-**<action>-**seq**[i] ∧ *i* < n > **in**
let *oldLabel* = **if** *action*.**s-**<label> = *undefined* **then** *newName* **else** *action*.**s-**<label> **endif in**
// *oldLabel* – where to go for joins previously to *action*
let *newLabel* =
if *rpcb.parentAS0* ∉ <remote procedure call> ∨ *actions2.head*.**s-**<label> = *undefined*
then if *actions2*≠ *empty* **then** *newName* **else** *undefined* **endif**
else *actions2*.*head*.**s-**<label> **endif**
in // *newLabel* – where to go after the replacement for *action*
mk-<agent body>(
mk-<start>(*virt*, *entry*, *newActions1AS0*(*actions1*, *oldlabel*)),
transformItems0(*oldlabel*, *newlabel*, *rpcb*)⌒ *newActions2AS0*(*actions2*, *newlabel*, *rpcb*, *tr*)⌒ *bodyitems*
) // end agent body with remote procedure call in start
endlet // *newLabel*
endlet // *oldLabel*
endlet // *actions2*

```
endlet // actions1

body = <agent body>( // agent body with remote procedure call  in state or free action
    start,
    bodyitems = parentAS0ofKind(
        bodyitem = parentAS0ofKind(
            <transition action items>(
                actionItems = parentAS0ofKind(
                    action = parentAS0ofKind(
                        rpcb = <remote procedure call body>,
                        <action>), // parentAS0ofKind for action
                    <action>-seq), // parentAS0ofKind for actionItems,
                tr), // tr is the terminator for <transition action items>
            (<state> ∪ <free action>)) // parentAS0ofKind for bodyitem
        (<state> ∪ <free action>)-seq) // parentAS0ofKind for bodyitems
    ) // agent body with remote procedure call  in state or free action
provided
callerVariablesDefined(rpcb)
=17=>
let oldLabel = if action.s-<label> = undefined then newName else action.s-<label> endif in
// oldLabel – where to go for joins previously to action
let newLabel =
    if rpcb.parentAS0 ∉ <remote procedure call> ∨ actions2.head.s-<label> = undefined
    then if actions2≠ empty then newName else undefined endif
    else actions2.head.s-<label> endif
in // newLabel – where to go after the replacement for action
mk-<agent body>(
    start,
    bilistpre0(bodyitems, bodyitem)⌒
    if body ∈ <state>
    then < revisedState0(bodyitem, action, newActions1AS0(actions1, oldlabel)) >
    else < mk-<free action>(newactions1AS0(actions1, oldlabel)) >
    endif⌒
    transformItems0(oldlabel, newlabel, rpcb)⌒
    newActions2AS0(actions2, newlabel, rpcb, tr)⌒
    bilistpost0(bodyitems,bodyitem)
) // agent body with remote procedure call  in state or free action
endlet // newLabel
endlet // oldLabel
endlet // actions2
endlet // actions1

body = <composite state body>( // composite state body with remote procedure call in start
    startlist1⌒
    <   start = <start>(
            virt,
            entry,
            <transition action items>(
                actionItems = parentAS0ofKind(
                    action = parentAS0ofKind(
                        rpcb = <remote procedure call body>,
                        <action>), // parentAS0ofKind for action
                    <action>-seq), // parentAS0ofKind for actionItems,
                tr) // tr is the terminator for <transition action items>
            )   > // start  list item containing remote procedure call
    ⌒startlist2,
    bodyitems
) // composite state body with remote procedure call in start
provided
```

callerVariablesDefined(*rpcb*)
=17=>
let *actions1* = < *a*[*n*] **in** *actionItems*.**s**-<action>-**seq** : *action* = *actionItems*.**s**-<action>-**seq**[i] ∧ *n* < i > **in**
let *actions2* = < *a*[*n*] **in** *actionItems*.**s**-<action>-**seq** : *action* = *actionItems*.**s**-<action>-**seq**[i] ∧ *i* < n > **in**
let *oldLabel* = **if** *action*.**s**-<label> = *undefined* **then** *newName* **else** *action*.**s**-<label> **endif in**
// *oldLabel* – where to go for joins previously to *action*
let *newLabel* =
if *rpcb.parentAS0* ∉ <remote procedure call> ∨ *actions2.head*.**s**-<label> = *undefined*
then if *actions2*≠ *empty* **then** *newName* **else** *undefined* **endif**
else *actions2.head*.**s**-<label> **endif**
in // *newLabel* – where to go after the replacement for *action*
<composite state body>(
startlist1⌒
< **mk**-<start>(*virt, entry, newActions1AS0*(*actions1*, *oldlabel*)) >⌒ // revised start as list item
startlist2,
transformItems0(*oldlabel, newlabel, rpcb*)⌒ *newActions2AS0*(*actions2, newlabel, rpcb, tr*)⌒ *bodyitems*
) // composite state body with remote procedure call in start

body = <composite state body>(// agent body with remote procedure call in state or free action
startlist,
bodyitems = *parentAS0ofKind*(
bodyitem = *parentAS0ofKind*(
<transition action items>(
actionItems = *parentAS0ofKind*(
action = *parentAS0ofKind*(
rpcb = <remote procedure call body>,
<action>), // *parentAS0ofKind* for *action*
<action>-**seq**), // *parentAS0ofKind* for *actionItems*,
tr), // tr is the terminator for <transition action items>
(<state> ∪ <free action>)) // *parentAS0ofKind* for *bodyitem*
(<state> ∪ <free action>)-**seq**) // *parentAS0ofKind* for *bodyitems*
) // composite state body with remote procedure call in state or free action
provided
callerVariablesDefined(*rpcb*)
=17=>
let *oldLabel* = **if** *action*.**s**-<label> = *undefined* **then** *newName* **else** *action*.**s**-<label> **endif in**
// *oldLabel* – where to go for joins previously to *action*
let *newLabel* =
if *rpcb.parentAS0* ∉ <remote procedure call> ∨ *actions2.head*.**s**-<label> = *undefined*
then if *actions2*≠ *empty* **then** *newName* **else** *undefined* **endif**
else *actions2.head*.**s**-<label> **endif**
in // *newLabel* – where to go after the replacement for *action*
mk-<composite state body>(
startlist,
bilistpre0(*bodyitems, bodyitem*)⌒
if *body* ∈ <state>
then < *revisedState0*(*bodyitem, action, newActions1AS0*(*actions1, oldlabel*)) >
else < **mk**-<free action>(*newActions1AS0*(*actions1, oldlabel*)) >
endif⌒
transformItems0(*oldlabel, newlabel, rpcb*)⌒
newActions2AS0(*actions2, newlabel, rpcb, tr*)⌒
bilistpost0(*bodyitems,bodyitem*)
) // composite state body with remote procedure call in state or free action
endlet // *newLabel*
endlet // *oldLabel*
endlet // *actions2*
endlet // *actions1*

body = <procedure body>(// agent body with remote procedure call in start
start = <start>(
virt,
entry,
<transition action items>(
actionItems = *parentAS0ofKind*(
action = *parentAS0ofKind*(
rpcb = <remote procedure call body>,
<action>), // *parentAS0ofKind* for *action*
<action>-**seq**), // *parentAS0ofKind* for *actionItems*,
tr) // tr is the terminator for <transition action items>
), // <start>
bodyitems
) // procedure body with remote procedure call in start
provided
callerVariablesDefined(*rpcb*)
=17=>
let *actions1* = < *a*[*n*] **in** *actionItems*.**s**-<action>-**seq** : *action* = *actionItems*.**s**-<action>-**seq**[i] ∧ *n* < i > **in**
let *actions2* = < *a*[*n*] **in** *actionItems*.**s**-<action>-**seq** : *action* = *actionItems*.**s**-<action>-**seq**[i] ∧ *i* < n > **in**
let *oldLabel* = **if** *action*.**s**-<label> = *undefined* **then** *newName* **else** *action*.**s**-<label> **endif in**
// *oldLabel* – where to go for joins previously to *action*
let *newLabel* =
if *rpcb.parentAS0* ∉ <remote procedure call> ∨ *actions2.head*.**s**-<label> = *undefined*
then if *actions2≠ empty* **then** *newName* **else** *undefined* **endif**
else *actions2.head*.**s**-<label> **endif**
in // *newLabel* – where to go after the replacement for *action*
mk-<procedure body>(
mk-<start>(*virt, entry, newActions1AS0*(*actions1, oldlabel*)),
transformItems0(*oldlabel, newlabel, rpcb*)⁀ *newActions2AS0*(*actions2, newlabel, rpcb, tr*)⁀ *bodyitems*
) // end procedure body with remote procedure call in start
endlet // *newLabel*
endlet // *oldLabel*
endlet // *actions2*
endlet // *actions1*

body = <procedure body>(// procedure body with remote procedure call in state or free action
start,
bodyitems = *parentAS0ofKind*(
bodyitem = *parentAS0ofKind*(
<transition action items>(
actionItems = *parentAS0ofKind*(
action = *parentAS0ofKind*(
rpcb = <remote procedure call body>,
<action>), // *parentAS0ofKind* for *action*
<action>-**seq**), // *parentAS0ofKind* for *actionItems*,
tr), // tr is the terminator for <transition action items>
(<state> ∪ <free action>)) // *parentAS0ofKind* for *bodyitem*
(<state> ∪ <free action>)-**seq**) // *parentAS0ofKind* for *bodyitems*
) // procedure body with remote procedure call in state or free action
provided
callerVariablesDefined(*rpcb*)
=17=>
let *oldLabel* = **if** *action*.**s**-<label> = *undefined* **then** *newName* **else** *action*.**s**-<label> **endif in**
// *oldLabel* – where to go for joins previously to *action*
let *newLabel* =
if *rpcb.parentAS0* ∉ <remote procedure call> ∨ *actions2.head*.**s**-<label> = *undefined*
then if *actions2≠ empty* **then** *newName* **else** *undefined* **endif**
else *actions2.head*.**s**-<label> **endif**
in // *newLabel* – where to go after the replacement for *action*
mk-<procedure body>(
start,

bilistpre0(*bodyitems, bodyitem*)⌒

if *body* ∈ <state>

then < *revisedState0*(*bodyitem, action, newActions1AS0*(*actions1, oldlabel*)) >

else < **mk**-<free action>(*newActions1AS0*(*actions1, oldlabel*)) >

endif⌒

transformItems0(*oldlabel, newlabel, rpcb*)⌒

newActions2AS0(*actions2, newlabel, rpcb, tr*)⌒

bilistpost0(*bodyitems,bodyitem*)

) // procedure body with remote procedure call in state or free action

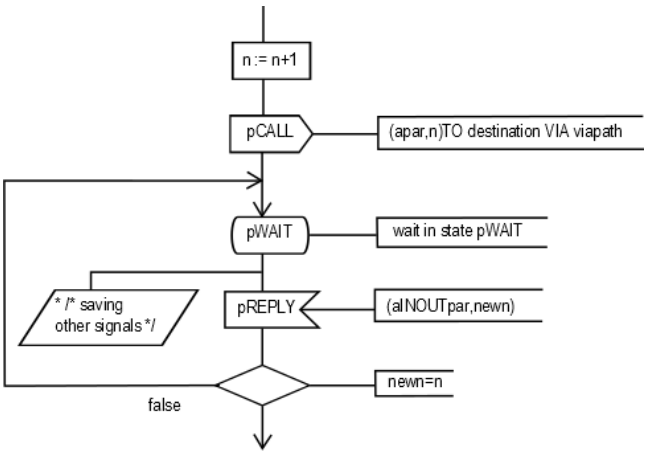
endlet // *newLabel*

endlet // *oldLabel*

endlet // *actions2*

endlet // *actions1*

– The <remote procedure call body> is transformed as below, so that the following is inserted before the action that contained the <remote procedure call body>, where in the output the **to** clause is omitted if the destination is not present, and the **via** clause is omitted if it is not present in the original expression:

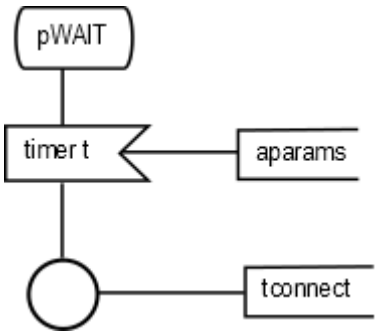


– where `apar` is the list of actual parameters except actual parameters corresponding to **out**-parameters, and `aINOUTpar` is the modified list of actual **in/out**-parameters and **out**-parameters, including the implicit variable `res` as an additional parameter if a value returning remote procedure call is transformed.

– The transform is labelled with the label on the action containing the remote procedure call or a new label if this action is not labelled, and the preceding path is changed to join this label.

– If a value returning remote procedure call is transformed, the true path above is terminated with a join to the action that contained the remote procedure call with a new label, and the remote procedure call is replaced by an access of the implicit variable `res` used to receive the returned value. Otherwise the remote procedure call action is removed and the true path above is joined to the action following the remote procedure call action.

– Additionally, the following will be inserted if a <timer communication constraint> is included in <communication constraints>



where

– `t` is the <timer identifier> in the <timer communication constraint>;

– `aparams` is the optional list of optional <variable> items given after the <timer identifier> in the <timer communication constraint>;

– `tconnect` is the <connector name> if one is given in the <timer communication constraint>; otherwise `tconnect` is the name of the timer.

– In all other states, `pREPLY` is discarded. This is not explicitly modelled: instead the handling of `pREPLY` is left unspecified in the transformed concrete syntax except for the `pWAIT` states with the consequence that there is an implicit transition (see clause 11.8 of [ITU-T Z.103]) for other states that discards the signal.

– If the <remote procedure call body> was directly enclosed by a <remote procedure call>, it is an <action> that is the <remote procedure call> and the transform replaces the <remote procedure call body>. Otherwise the <remote procedure call body> is a <value returning procedure call> as an <expression0>, and transform is inserted before the action that contained the <value returning procedure call>, and the <value returning procedure call> is replaced in this action by an access of the implicit variable `res` used to receive the returned value.

b) Server agent

The ASM for transformations for server agents is given in 3 parts: <input part> where the remote procedure is given explicitly; any <save> where a remote procedure is given explicitly; states in agents that can receive the remote procedure call where the remote procedure is not given explicitly either in an <input part> or a <save part>.

ip = <input part>
provided
    ip.**s-**<input list>.**s-**<asterisk input list> = *undefined* // not asterisk input list
  ∧ *ip*.**s-**<input list>.**s-**<encoded input > = *undefined* // not encoded input
  ∧ *ip*.**s-**<input list>.**s-implicit-seq**.*length* = 1 // assume all input lists one stimulus/list
  ∧ *ip*.**s-**<input list>.**s-implicit-seq**[1].**s-**<stimulus>.**s-**<signal list item>.*refersto0*
      ∈ <remote procedure definition> // the stimulus refers to a remote procedure definition
  ∧ *ip*.**s-**<input list>.**s-implicit-seq**[1].**s-**<signal list item>.*refersto0*.*implicitName* ≠ *undefined*
      // the <remote procedure definition> transformed
=17=>
//replaces the <input part> for *rpc*
let *rpc* = *ip*.**s-**<input list>.**s-implicit-seq**[1].**s-**<stimulus>.**s-**<signal list item> **in** // remote proc call id
let *rpd* = *rpc*.*refersto0* **in** // remote procedure definition
let *fpl* = *rpd*.**s-**<procedure signature>.**s-**<formal parameter>**-seq in** // formal params list
let *p* = *rpd*.*implicitName*.**s-***TOKEN* **in** // unique *TOKEN* associated with remote procedure definition
let *pCALL* = **mk-**<identifier>(*rpd.fullQualifier0*, **mk-**<name>(*p* + "CALL")) **in** // identifier for pCALL
let *pREPLY* = **mk-**<identifier>(*rpd.fullQualifier0*, **mk-**<name>(*p* + "REPLY")) **in** // identifier for pREPLY
let *exportedProc* = *take*({*proc* ∈<internal procedure definition> :
    isExported0(*proc*)
  ∧ *proc*.**s-**<procedure heading>.**s-**<procedure preamble>.**s-**<exported> = *rpc*
  ∧ *parentAS0ofKind*(*proc*, *SCOPEUNIT0*) =

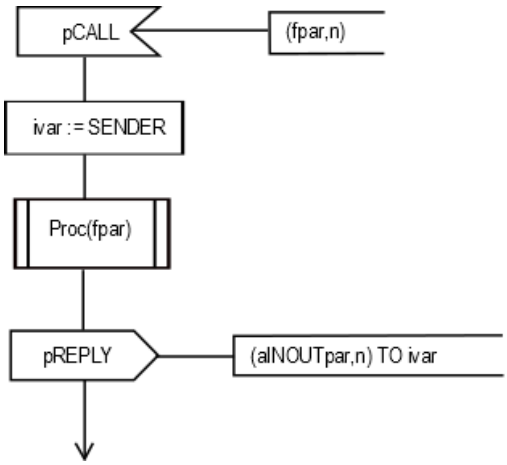
```
        parentAS0ofKind(ip,
            <system type definition> ∪ <block type definition> ∪ <process type definition>)
})
in
let fpar = exportedProcParams(fpl, remoteProcParamsDef(fpl, p)) in
let sq = parentAS0ofKind(exportedProc, SCOPEUNIT0).fullQualifierWithin0 in // qualifier for vars
let n = mk-<identifier>( sq, mk-<name>( p + "n")) in // var for the integer to be returned in reply
let ivar = mk-<identifier>( sq, mk-<name>(p + "ivar")) in // var for the sender Pid
let res = mk-<identifier>( sq, mk-<name>(p + "res")) in // var for the result for a value returning procedure
<input part>(
    ip.s-<virtuality>,
    <   // input list
        mk-<stimulus>(
            mk-<signal list item>( pCALL),
            remoteProcParams(fpl, remoteProcParamsDef(fpl, p)) ⌒ < n >,
            ip.s-<input list>.s-implicit-seq[1].s-<stimulus>.s-<via path>), // via path, end of stimulus
        ip.s-<input list>.s-implicit-seq[1].s-<in choice>, // in choice
        ip.s-<input list>.s-implicit-seq[1].s-<priority clause> // priority
    >, // end of input list
    ip.s-<enabling condition list>, // enabling condition
    mk-<transition action items>( < // <action> list
        assignmentTaskAction0(ivar, mk-<operand5>(undefined, mk-<sender expression>())) ⌒
        if rpd.s-<procedure signature>.s-<result> = undefined then
            mk-<action>(
                undefined, // omitted <label> of <action>
                mk-<procedure call>( mk-<procedure call body>(undefined, exportedProc, fpar)))
        else
            assignmentTaskAction0(res,
                mk-<value returning procedure call>(
                    mk-<procedure call body>(undefined, exportedProc, fpar)))
        endif ⌒
        mk-<output>( pREPLY, aINOUTremoteProcParams(rpc)⌒< n >, ivar) ⌒
        ip.s-<transition>.s-<action>-seq >, // end of <action> list
    ip.s-<transition>.s-<terminator> ) // <terminator> of <transition action items>
) // end of <input part> replacement
endlet // res
endlet // ivar
endlet // n
endlet // sq
endlet // fpar
endlet // exportedProc
endlet // pREPLY
endlet // pCALL
endlet // p
endlet // fpl
endlet // rpd
endlet // rpc

save = <save part> ( // that contains a save using rpc
    virt, // virtuality of <save part>
    < // Save list
        rpc = take({id ∈<identifier> : id.refersto0 ∈ <remote procedure definition>}),
        vp  // via path, end of stimulus
    >, // End of Save list
    ),// end of <save part>
provided
    rpc.refersto0.implicitName ≠ undefined // the <remote procedure definition> transformed
∧   save ≠ undefined // there is a <save part> as defined by save
=17=>
mk-<save part>(virt, < rpc.refersto0.implicitName.s-TOKEN + "CALL", vp  >)
```

```
s = <state>
provided
parentAS0ofKind(s,<system type definition> ∪ <block type definition> ∪ <process type definition>) = def
// def that channel endpoint with remote procedure call is connected to
∧  rpd ∈ <remote procedure definition>
∧  rpd.implicitName ≠ undefined // the <remote procedure definition> transformed
∧  def ∈{cp.s2-<channel endpoint>.refersto0.s-<type expression>.s-<base type>.refersto0:
        cp ∈ <channel path> ∧ sli in cp.s-<signal list>
      ∧ (   (sli.s-<signal list item> =
              <identifier>( rpd.fullQualifier0, <name>(rpd.implicitName.s-TOKEN + "CALL")))
          ∨   (sli.s-<signal list item> = rpd.fullIdentifier0)) // signal list item pCALL or remote proc
      ∧  cp.s2-<channel endpoint>.s- implicit ∈ <identifier> // to <channel endpoint>
   } //  set for def
∧   ¬handled(rpd.fullIdentifier0, s.s-<state list>.head.name0)) // rpc is not handled in s.
=17=>
let rpc = rpd.fullIdentifier0 in // remote procedure id
let p = rpd.implicitName in // unique name associated with remote procedure definition
let pCALL = mk-<identifier>( rpd.fullQualifier0, mk-<name>(p + "CALL")) in // identifier for pCALL
let pREPLY = mk-<identifier>( rpd.fullQualifier0, mk-<name>(p + "REPLY")) in // identifier for pREPLY
let sq = def.fullQualifierWithin0 in // qualifier for items defined in def – the scope for vars
let n = mk-<identifier>( sq, mk-<name>(p + "n")) in // var for the integer to be returned in reply
let ivar = mk-<identifier>( sq, mk-<name>(p + "ivar")) in // var for the sender Pid
let res = mk-<identifier>( sq, mk-<name>(p + "res")) in // var for the result for a value returning procedure
let fpl = rpd.s-<procedure signature>.s-<formal parameter>-seq in
let remoteProcParamVars = remoteProcParamsDef(fpl, p) in
let exportedProc = take({proc ∈<internal procedure definition> :
        isExported0(proc)
    ∧  proc.s-<procedure heading>.s-<procedure preamble>.s-<exported> = rpd.fullIdentifier0
    ∧  parentAS0ofKind(proc, SCOPEUNIT0) = def })
in
let fpar = exportedProcParams(fpl, remoteProcParamVars) in
let actionItems =
    assignmentTaskAction0(ivar, mk-<operand5>(undefined, mk-<sender expression>())) ⌒
    if rpd.s-<procedure signature>.s-<result> = undefined then
        mk-<action>(
            undefined, // omitted <label> of <action>
            mk-<procedure call>( mk-<procedure call body>(undefined, exportedProc, fpar)))
    else
        assignmentTaskAction0(res,
                    mk-<value returning procedure call>(
                        mk-<procedure call body>(undefined, exportedProc, fpar)))
    endif ⌒
    mk-<output>( pREPLY, aINOUTremoteProcParams(rpc)⌒< n >, ivar)
in
mk-<state>(s.s-<state list>, s.s-implicit ⌒
    mk-<input part>(virt,
        <   // input list
            mk-<stimulus>( pCALL,
                remoteProcParams(fpl, remoteProcParamVars) ⌒ < n >,
                vp ), // via path, end of stimulus
            undefined, // in choice
            undefined // priority
        >, // end of input list
        ec, // enabling condition
        mk-<transition action items>( < // <action> list
            actionItems ⌒
            mk-<terminator>(undefined, mk-<dash nextstate>())
            >) // end of <action> list
        > // end of input list
```

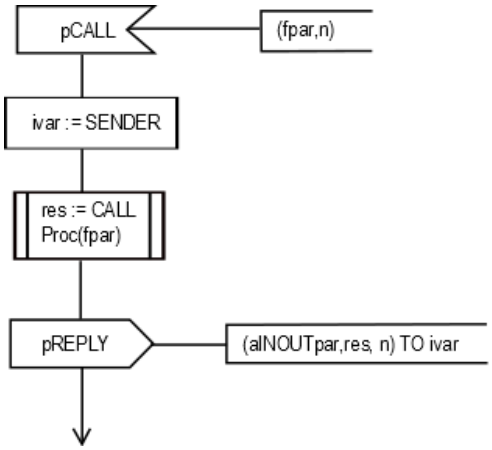
) //) for <input part>
) //) for <state>
endlet // *actionItems*
endlet // *fpar*
endlet // *exportedProc*
endlet // *remoteProcParamsVars*
endlet // *fpl*
endlet // *res*
endlet // *ivar*
endlet // *n*
endlet // *sq*
endlet // *pREPLY*
endlet // *pCALL*
endlet // *p*
endlet // *rpc*

In the server agent, an implicit anonymous Integer variable (in this description called `n`) is defined for each <input> that is a remote-procedure input. Furthermore, there is an implicit anonymous `Pid` variable (in this description called `ivar`) for each such <input> defined in the scope where the remote procedure input occurs. If a value returning remote procedure call is transformed, an implicit anonymous variable (in this description called `res`) with the same sort as <sort> in <procedure result> is defined.

– To all <state> items with a remote procedure input transition, the following <input> replaces the remote procedure input and leads to the transition for the remote procedure:

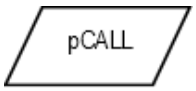


– or,



– if a value returning remote procedure call was transformed.

– To all <state> items with a remote procedure save, the following <save> is added:



– To all other <state> items (excluding implicit states derived from input with `pCALL`) where the remote procedure is not shown, the <input> described above is added and terminates in a next state that returns to the same state.

NOTE – There is a possibility of deadlock using the remote procedure construct, especially if no <destination> is given, or if <destination> does not denote a <pid expression> of an agent which is guaranteed by the specification to exist at the time of receiving the `pCALL` signal. Associated timers allow the deadlock to be avoided.

Auxiliary functions

The function *implicitName* is used to store the implicitly generated name for a remote entity definition.

controlled *implicitName*: <remote procedure definition> ∪ <remote variable definition> → <name>
initially ∀ *r* ∈ <remote procedure definition> ∪ <remote variable definition>: *r.implicitName = undefined*

The function *callerVariablesDefined* checks if AS0 has already been modified to include variable definitions in the agent type surrounding the remote procedure call or remote variable import.

callerVariablesDefined(*rem*: <remote procedure call body> ∪ <import expression>): *BOOLEAN* =def
  rem.**s-**<identifier>.*refersto0.implicitName* ≠ *undefined*
∧ (∃ *v* ∈ <variables of sort> :
    v.**s-**<name>.**s-***TOKEN* =
      (*rem*.**s-**<identifier>.*refersto0.implicitName*.**s-***TOKEN* + "n")
    ∧ (*fullQualifier0*(*v*) = *fullQualifierWithin0*(*parentAS0ofKind*(*rem*,
      <system type definition> ∪ <block type definition> ∪ <process type definition>))))
  // There is already already a variable with the name z +"n" in the type definition surrounding *rem*
  // where z is the *TOKEN*) for the unique name associated with the remote definition
  // (that is, z = *rem*.**s-**<identifier>.*refersto0.implicitName*.**s-***TOKEN*).

The function *variableDefinition0* makes an AS0 <variable definition> for a variable with a <name> that has the given *TOKEN* value, the given <sort> and the given <operand5> constant expression, which should be *undefined* if the variable is not initialized.

variableDefinition0(*token*: *TOKEN*, *sort*: <sort>, *const*: <operand5>): <variable definition> =def
mk-<variable definition>(< **mk-**<variables of sort>(**PART**, < **mk-**<name>(*token*) >, *sort*, *const*) >)

The function *newActions1AS0* makes an AS0 <transition action items> or <terminator> to replace the actions before the action containing the remote procedure call.

newActions1AS0(*actions1*: <action>*, *oldlabel*: <name>): <transition action items> ∪ <terminator> =def
if *actions1= empty*
then mk-<terminator>(**mk-**<join>(*oldLabel*))
else mk-<transition action items>(*actions1*, **mk-**<terminator>(**mk-**<join>(*oldLabel*)))
endif

The function *transformItems0* is used to define a list with a <free action> and a <state> to insert before the action that had the remote procedure call body in the body of an agent, state or procedure.

transformItems0(*oldlabel*: <name>, *newlabel*: <name>, *rpcb*: <remote procedure call body>):
  (<state>∪<free action>)* =def
let *sq* = *fullQualifierWithin0*(*parentAS0ofKind*(*rpcb*,
  <system type definition> ∪ <block type definition> ∪ <process type definition>)) **in**
let *rpd* = *rpcb*.**s-**<identifier>.*refersto0* **in**
let *nid* = **mk-**<identifier>(*sq*, **mk-**<name>(*rpcb*.**s-**<identifier>.*refersto0.implicitName*.**s-***TOKEN* + "n")) **in**
let *n* = **mk-**<operand5>(<variable access>(*nid*) **in**
let *resid* = **mk-**<identifier>(*sq*, **mk-**<name>(*rpcb*.**s-**<identifier>.*refersto0.implicitName*.**s-***TOKEN* + "res")) **in**
let *p* = *rpd.implicitName.TOKEN* **in**

```
let pCALL = mk-<identifier>( rpcb.s-<identifier>.s-<qualifier>, mk-<name>(p + "CALL")) in
let pREPLY = mk-<identifier>( rpcb.s-<identifier>.s-<qualifier>, mk-<name>(p + "REPLY")) in
let pWAIT = mk-<name>(p + "WAIT") in
<   mk-<free action>(
        mk-<transition action items>(<
            mk-<action>( oldLabel, mk-<task>(<assignment>( nid,
                mk-<operator application>("+", < n, predefinedItem0("Integer","1") >)))),
            mk-<action>(undefined,<output>(
                mk-<output body>(
                    mk-<output body item>(pCALL,
                        apar(rpd.s-<procedure signature>.s-<formal parameter>-seq,
                            rpcb.s-<actual parameters>)⌢< n >),
                        commConstrNoTimer0(rpcb.s-<communication constraints>))),
            mk-<terminator>(undefined, mk-<nextstate>( mk-<nextstate body name>(pWAIT)))
        > ), undefined)
    >⌢
    < mk-<state>(< pWAIT >,
        timerInput0(rpcb.s-<communication constraints>.s-<timer communication constraint>) ⌢
        <   mk-<save part>(undefined, <asterisk save list>()),
            mk-<input part>(undefined, //virtuality
                < mk-<stimulus>(mk-<signal list item>(pREPLY),
                        aINOUTpar(rpd.s-<procedure signature>.s-<formal parameter>-seq,
                            rpcb.s-<actual parameter>-seq,
                            if rpd.s-<procedure signature>.s-<result> ≠ undefined
                            then mk-<operand5>( mk <variable access>(resid))
                            else  undefined
                            endif) // aINOUTpar
                        ⌢ <    mk-<identifier>(sq, varNewN) >, undefined) // stimulus,
                    undefined, // in choice
                    undefined // priority clause
                >,
                undefined, // enabling condition
                mk-<transition action items>(
                    mk-<decision>(<operand5>( mk-<operator application>(mk-<name>("="), < newn, n >)),
                        mk-<textual answer part>(predefinedItem0("Boolean","true"),
                            mk-<terminator>( mk-<join>(newLabel)))
                        mk-< textual answer part>(predefinedItem0("Boolean","false"),
                            mk-<terminator>(<nextstate>(pWAIT)))
                ) // transition
        >, // state parts
        undefined ) // state timer part
> // for other states nothing is specified for p + "REPLY" so it is treated as an implicit transition
endlet // pWAIT
endlet // pREPLY
endlet // pCALL
endlet // p
endlet // resid
endlet // n
endlet // nid
endlet // rpd
endlet // sq
```

The function *newActions2AS0* makes an AS0 <transition action items> or <terminator> to replace the actions after the action containing the remote procedure call. If the remote procedure call is in a expression, the action containing the remote procedure call has the call changed to access the implicit variable to the result of the call. Otherwise, the action is the remote procedure call and is removed.

```
newActions2AS0(actions2: <action>*, newlabel: <name>, rpcb: <remote procedure call body>,
    tr: <terminator>): (<state>∪<free action>)* =def
let sq = fullQualifierWithin0( parentAS0ofKind( rpcb,
```

```
    <system type definition> ∪ <block type definition> ∪ <process type definition>)) in
< mk-<free action>(
    mk-<transition action items>(
        if rpcb.parentAS0 ∉ <remote procedure call>
        then // <remote procedure call body> in <expression>
            < mk-<action>(newLabel,
                replaceOnceInSyntaxTree0(rpcb,
                mk-<operand5>(<variable access>(<identifier>(
                    sq,  mk-<name>( rpcb.s-<identifier>.refersto0.implicitName.s-TOKEN + "res")))),
                parentAS0ofKind(rpcb, <action>).s-implicit) //  replace rpcb by res access in action
            > ⌒ actions2
        else // <remote procedure call body> in <remote procedure call> -
            if actions2 ≠ empty
            then < mk-<action>(newLabel, actions2.head.s-implicit) > ⌒ actions2.tail
            else // dummy action n := n+0 so action can be labelled!
                < mk-<action>( newLabel, mk-<task>( mk-<assignment>(
                    mk-<identifier>(sq,rpcb.s-<identifier>.refersto0.implicitName.s-TOKEN + "n"),
                    mk-<operand5>(<variable access>( <identifier>(sq,
                        mk-<name>(rpcb.s-<identifier>.refersto0.implicitName.s-TOKEN+ "n")))),
                    ))) // assignment, task, action
                > // action list
            endif,
        endif,
        tr) //transition action items
) > // free action, sequence
endlet // sq
```

The function *bilistpre0* takes a body list of <state> and <free action> items, and produces a new list where the given item (<state> or <free action>) and all subsequent items are deleted, so that the new list can be used to replace the first part of the body list.

```
bilistpre0(bl:(<state>∪<free action>)*, bsf:<state>∪<free action>):(<state>∪<free action>)* =def
    if bl.length = 1 ∨ bl.tail.head = bsf
    then empty
    else < bl.head > ⌒ bilistpre0(bl.tail,bsf)
    endif
```

The function *revisedState0* takes <state> item, and returns a new <state> item, where each part of the <state> (<input part>, <priority input>, <save>, <state timer input>) is the result of *revisedStatePart0* that returns a modified part only for the part that contains the given action.

```
revisedState0(st(statenames, stateparts, statetimer): <state>, action: <action>,
    newactions1: <transition action items> ∪ <terminator>):<state> =def
    st(  statenames,
        < revisedStatePart0(stateparts[i], action, newactions1) | i in 1..stateparts.length >,
        revisedStatePart0(statetimer, action, newactions1))
```

The function *revisedStatePart0* takes state part, and returns the same state part if it does not contain (is not a parent of) the given action, otherwise it returns a revised part where the transition containing the action is replaced the given transition parameter.

NOTE – Assuming the original transition containing *action* is of the form *actions1*⌒*action*⌒*actions2* then the replacement *newactions1* is a version of *actions1* that ends with a join to the new actions inserted before the old *action*. The replacement for *action* and the subsequent *actions2* are placed in <state> and <free action> items in the body item list of the body. The order of these items does not really matter as they connected by state names and labels that also ensure that no change is needed to the rest of the revised state and any other state. If *action* was labelled, this label is moved to the start actions inserted before *action*, therefore any join to *action* becomes a join to this point.

```
revisedStatePart0(part: STATEPART0, action: <action>,
    newactions1: <transition action items> ∪ <terminator>): STATEPART0 =def
let anspart = parentAS0ofKind(action, <textual answer part>) in
let elsepart = parentAS0ofKind(action, <textual else part>) in
if parentAS0ofKind(action, STATEPART0) ≠ part then part
elseif parentAS0ofKind(anspart, STATEPART0) = part
then
    let d = anspart.parentAS0.parentAS0 in
    replaceInSyntaxTree0(d,
        mk-<decision>(d.s-implicit, // the question
            mk-<textual decision body>(
                revisedAnswers0(
                    d.s-<textual decision body>.s-<textual answer part>-seq,action,newactions1),
                d.s-<textual decision body>.s-<textual else part>)),
         part)
    endlet
elseif parentAS0ofKind(elsepart, STATEPART0) = part
    let d = elsepart.parentAS0.parentAS0 in
    replaceInSyntaxTree0(d,
        mk-<decision>(d.s-implicit, // the question
            mk-<textual decision body>(d.s-<textual decision body>.s-<textual answer part>-seq,
                mk-<textual else part>(newactions1))),
         part)
    endlet
then
else
    case part of
    | <connect part>(v,*,*) then mk-<connect part>(v, part.s-implicit, newactions1)
    | <continuous signal>(v,ce,pri,*) then mk-<continuous signal>(v, ce, pri, newactions1)
    | <input part>(v,*,ec,*) then mk-<input part>(v, part.s-implicit,ec, newactions1)
    | <priority input>(v,*,*) then mk-<priority input>(v, part.s-implicit, newactions1)
    | <save part> then part
    | <spontaneous transition>(v,ec,*) then mk-<spontaneous transition>(v,ec,newactions1)
    | <state timer part>(v,*,*) then mk-<state timer part>(v, part.s-implicit, newactions1)
    endcase
endif
endlet
endlet
```

The function *revisedAnswers0* takes <textual answer part> list of a decision, and produces a new list where the answer that contains the given <action> is replaced by an answer with the *newactions1* list of <actions> as the answer transition.

```
revisedAnswers0(answers:<textual answer part>*, action: <action>,
    newactions1: <transition action items> ∪ <terminator>):<textual answer part>* =def
    if answers = empty then empty
    elseif answers.head.s-<transition action items> =
        parentAS0ofKind(action, <transition action items>)
    then < mk-<textual answer part>( answers.head.s-implicit, newactions1) > ⌒ answers.tail
    else < answers.head > ⌒ revisedAnswers0(answers.tail,action,newactions1)
```

The function *bilistpost0* takes a body list of <state> and <free action> items, and produces a new list where the given item (<state> or <free action>) and all preceding items are deleted, so that the new list can be used to replace the last part of the body list.

```
bilistpost0(bilist:{<state>∪<free action>}*,bodyitem: <state>∪<free action>):{<state>∪<free action>}* =def
    if bilist.length = 1 then empty
    elseif bilist.head = bodyitem then bilist.tail
    else bilistpost0(bilist.tail,bodyitem) endif
```

The function *handled* checks whether a remote procedure call is explicitly handled within a state. The function returns true if (and only if) there exists a state *s* that is in the given *states* list, such that the given *state* name is one of the names in the <state list> of *s*, and for the given identifier *rpc*: either *rpc* (or its `pCALL` replacement) is one of the signal list item identifiers of one of the input list items of an <input part> of *s*, or *rpc* (or its `pCALL` replacement) is one of the save item identifiers of one of the save items of a <save part> of *s*.

```
handled(rpc: <identifier>, state: <name>): BOOLEAN =def
let pCALL =
    mk-<identifier>(rpc.s-<qualifier>, mk-<name>(rpc.refersto0.implicitName.s-TOKEN + "CALL"))
in // id for pCALL
∃ s: state ∈
    {   if si.s-<composite state list item> ≠ undefined
        then si.s-<composite state list item>.s-<name>
        elseif si.s-<typebased composite state> ≠ undefined
        then si.s-<typebased composite state>.s-<name>
        else si.s-<name> // <basic state name>
        endif
        | si ∈ s.s-<state list>.toSet }
∧   (   rpc ∈ ⋃{ { ili.s-<signal list item>.s-<identifier> | ili ∈ input.s-<input list>.toSet }
                | input ∈ s.s-implicit: input ∈ <input part> }          ∨
        pCALL ∈ ⋃{ { ili.s-<signal list item>.s-<identifier> | ili ∈ input.s-<input list>.toSet }
                | input ∈ s.s-implicit: input ∈ <input part> }          ∨
        rpc ∈ ⋃{ { svi.s-<identifier> | svi ∈ save.s-<save list>.toSet }
                | save ∈ s.s-implicit: save ∈ <save part> } ∨
        pCALL ∈ ⋃{ { svi.s-<identifier> | svi ∈ save.s-<save list>.toSet }
                | save ∈ s.s-implicit: save ∈ <save part> }
    )
endlet //pCALL
```

Determine if an <internal procedure definition> and a <procedure signature> are matching.

```
isSameProcedureAndSignature0(pd:<internal procedure definition>, ps: <procedure signature>):BOOLEAN =def
    let fpl = ps.procedureSignatureParameterList0 in
    let fpl1 = pd.procedureFormalParameterList0 in
        (fpl.length = fpl1.length) ∧
        (∀i∈1..fpl.length:
            (fpl[i].s-<parameter kind> = fpl1[i].parentAS0.parentAS0.s-<parameter kind>) ∧
            isSameSort0(fpl[i].s-<sort>, fpl1[i].parentAS0.s-<sort>))∧
        isSameResult0(ps.s-<result>, pd.s-<procedure heading>.s-<procedure result>))
    endlet
```

Determine if two results are matching.

```
isSameResult0(r: <result>∪<procedure result>∪<operation result>,
              r1: <result>∪<procedure result>∪<operation result>): BOOLEAN =def
    isSameSort0(r.s-<sort>,r1.s-<sort>)
```

The function *timerInput0* produces an <input part> list (empty or one element) for <communication constraints> with <timer communication constraint> for a remote procedure call or remote variable import.

```
timerInput0(tcc: <timer communication constraint>): <input part>* =def
if tcc = undefined then empty else
    < mk-<input part>(undefined,
        < mk-<stimulus>( mk-<signal list item>(tcc.s-<identifier>), tcc.s-<variable>-seq,undefined),
            undefined,
            undefined
        >,
        undefined,
```

```
        mk-<terminator>(undefined,
            mk-<join>(
                if tcc.s-<name> ≠ undefined then tcc.s-<name> else tcc.s-<identifier>.s-<name> endif )))
    >
endif
```

The function *apar* produces <actual parameters> for the values for the `pCALL` signal of a remote procedure call in the requesting agent.

```
apar(fpl: <formal parameter>*, params: [ <actual parameter> ]+): [ <actual parameter> ]+=def
if params = undefined then undefined else
    if fpl.head.s-implicit ≠ out then < params.head > else empty endif ⌒
        if fpl.tail.length > 0 then apar(fpl.tail, params.tail) else empty endif
endif
```

The function *commConstrNoTimer0* a list of communication constraints and returns the same list excluding any timer communication constraint in the list.

```
commConstrNoTimer0(ccl: <communication constraints>): <communication constraints> =def
if ccl.head ∈ <timer communication constraint> then empty else ccl.head endif ⌒
    if ccl.tail.length > 0 then commConstrNoTimer0(ccl.tail) else empty endif
```

The function *aINOUTpar* produces the variable list for the `pReply` signal stimulus of a remote procedure call in the requesting agent.

```
aINOUTpar(fpl: <formal parameter>*, params: [ <actual parameter> ]+, res: <variable>): <variable>*=def
if params = undefined then undefined else
    if fpl.head.s-implicit ≠ in ∧ fpl.head.s-implicit ≠ undefined then < params.head > else empty endif ⌒
        if fpl.tail.length > 0 then aINOUTpar(fpl.tail, params.tail)
        else if res ≠ undefined then res else empty endif
        endif
endif
```

The function *remoteProcParamsDef* produces a list of variable definitions for the variables to hold the values passed via the `pCALL` and `pREPLY` signals for a remote procedure call. The function is passed a formal parameter list (of the remote procedure) and a *TOKEN* (which should be the *TOKEN* for the unique implicit name associated with the remote procedure definition). Each variable is given a new unique name formed from the *TOKEN* parameter and the list position of the parameter (counting backwards from the end of the list).

```
remoteProcParamsDef(fpl:<formal parameter>*, p: TOKEN ):<variable definition>*=def
if fpl.length = 0 then empty
else
< mk-<variable definition>(
    < <variables of sort>(
        PART,< <name>(p + natToIntToken(fpl.length)) >, fpl.head.s-<sort>, undefined) >
    ) >
    ⌒remoteProcParamsDef(fpl.tail, p)
endif
```

The function *remoteProcParams* produces a list of variable identifiers to hold the values passed via the `pCALL` signal for a remote procedure call before calling the exported procedure. The *fpl* parameter is the list of formal parameters for the remote procedure and the *vars* parameter is the list of variable definitions in server agent created from the list of formal parameters.

```
remoteProcParams(fpl: <formal parameter>*, vars: <variable definition>*):<identifier>*=def
if fpl.length = 0 then empty
else
    if fpl.head.s-implicit ≠ out then
```

< **mk-**<identifier>(*vars.head.fullQualifier0, vars.head*.**s-**<variables of sort>.**s-**<name>) >
else *empty*
endif
⌒ *remoteProcParams*(*fpl.tail, vars.tail*)
endif

The function *exportedProcParams* produces a list of variable identifiers to use in the call of the exported procedure after the input of `pCALL`. The *fpl* parameter is the list of formal parameters for the remote procedure and the *vars* parameter is the list of variable definitions in server agent created from the list of formal parameters.

exportedProcParams(*fpl*: <formal parameter>*, *vars*: <variable definition>*):<identifier>*=$_{\text{def}}$
if *fpl.length* = 0 **then** *empty*
else
< **mk-**<identifier>(*vars.head.fullQualifier0, vars.head*.**s-**<variables of sort>.**s-**<name>) >
⌒ *exportedProcParams*(*fpl.tail, vars.tail*)
endif

The function *aINOUTremoteProcParams* produces variable identifier list for the values passed via the `pREPLY` signal of a remote procedure call with the list being in the order of each IN/OUT or OUT parameter.

aINOUTremoteProcParams(*fpl*: <formal parameter>*, *vars*: <variable definition>*):<identifier>*=$_{\text{def}}$
if *fpl.length* = 0 **then** *empty*
else
if *fpl.head*.**s-implicit** ≠ **in** ∧ *fpl.head*.**s-implicit** ≠ *undefined* **then**
< **mk-**<identifier>(*vars.head.fullQualifier0, vars.head*.**s-**<variables of sort>.**s-**<name>) >
else *empty*
endif
⌒*aINOUTremoteProcParams*(*fpl.tail, vars.tail*)
endif

F2.2.7.6 Remote variable

NOTE – A remote variable enables an exported value of a variable owned by one agent (the exporter) to be imported into another agent (the importer) by using an <import expression>, and because a remote variable is allowed to be used by more than one exporter, it is allowed to direct the request for the exported value to be to a particular agent (or agent instance set) by the <destination> in the <communications constraint> of the <import expression>. In the transform (described below) the <output> request includes the <destination> of the <import expression>, and output compatibility (that the signal is receivable by the destination) applies for the request. If the <destination> is a <pid<expression> with a pid sort (the sort of an *Interface-definition*) other than `Pid`, AS1 is statically checked for output compatibility. If the sort is `Pid`, output compatibility needs to be checked dynamically.

Concrete syntax

<remote variable definition> :: <remote variables of sort>+

<remote variables of sort> ::
<remote variable<name>+ <sort> [**nodelay**]

<export statement> :: <export body>

<export body> :: <variable<identifier>+

Conditions on concrete syntax

See clause 10.6 *Model* of [ITU-T Z.102] unless another reference is given.

∀*v* ∈ <exported variables of sort>: ∀*ev* **in** *v*.**s-**<exported variable>-**seq**:
ev.**s-**<identifier> ≠ *undefined*⇒
isSameSort0(*ev.parentAS0*.**s-**<sort>,*getEntityDefinition0*(*ev*.**s-**<identifier>,**remote variable**).**s-**<sort>)

The <remote variable identifier> following **as** in an exported variable definition shall denote a <remote variable definition> of the same sort as the exported variable definition.

```
∀v ∈ <exported variables of sort>:∀ev in v.s-<exported variable>-seq:
    let rvd = resolveByContainer0(ev.surroundingScopeUnit0,
        mk-<identifier>(empty, ev.s-<name>),
        remote variable)
    in
    rvd ≠ undefined ∧ ev.s-<identifier> = undefined⇒
        isSameSort0(ev.parentAS0.s-<sort>, rvd.s-<sort>)
    endlet
```

In the case of no **as** clause, the remote variable definition in the nearest enclosing scope unit with the same name and sort as the exported variable definition is denoted.

```
∀vid ∈ <identifier>: vid.parentAS0∈<export body>⇒getEntityDefinition0(vid,variable).isExported0
```

The <variable identifier> in <export statement> shall denote a variable defined with **exported**.

```
∀dest∈<identifier> ∪ this: ∀importExp∈<import expression>:
    dest. parentAS0 = importExp ⇒
        (   let def =
                if dest ∈ <identifier>
                then  getEntityDefinition0(dest, sort)
                else getEntityDefinition0(
                    parentAS0ofKind(dest, <agent definition> ∪ <agent type definition>).s-<identifier>, sort)
                endif
            in
            let rv = getEntityDefinition0(importExp.s-<identifier>, remote variable) in
                def ∈ <interface definition> ∧ isDefinedIn0(rv, def)
            endlet
            endlet)
```

If <destination> in <communication constraints> of an <import expression> is an <agent<identifier> or **`this`**, the <remote variable identifier> shall represent a remote variable contained in the interface of the agent type.

```
∀v ∈ <exported variables of sort>:
    parentAS0ofKind(v, <internal procedure definition>) = undefined

∀ie1, ie2 ∈ <import expression>:
let action1 = parentAS0ofKind(ie1, <action>)  in
let action2 = parentAS0ofKind(ie2, <action>)  in
    ie1.s-<identifier> = ie2.s-<identifier>  ⇒
        action1 ≠ action2
    ∨  ¬isSameNode0(action1, action2)
    ∨  isSameNode0(ie1, ie2)
endlet
endlet
```

Each action shall contain no more than one <import expression> for the same remote variable.

A procedure variable is not allowed to be exported (See clause 9.4 *Semantics* of [ITU-T Z.101]). The definition of **exported** variables is not allowed in a <variable definition> in a <procedure definition> (See clause 9.4 *Concrete grammar* of [ITU-T Z.103]).

Transformations

The use of <import expression> in an expression is shorthand for inserting a task just before the action, where the expression occurs which assigns to an implicit variable the result of the <import expression> and then uses that implicit variable in the expression. If <import expression> occurs several times in an expression, one variable is used for each occurrence. See clause 12.3.4.5 *Model* of [ITU-T Z.104].

An import access is modelled by exchange of implicitly defined signals. The importer sends a signal to the exporter, and waits for the reply. In response to this signal the exporter sends a signal back to the importer with the result contained in the implicit copy of the exported variable. See clause 10.6 *Model* of [ITU-T Z.102].

rvd.implicitName
provided
    rvd ∈ <remote variable definition>
∧ *rvd.implicitName = undefined*
=17=>
(*implicitName*\{(*rvd, undefined*)}) ∪ {(*rvd, newName*)}

rvd=<remote variable definition>(< <remote variables of sort>(< *n* >, *sort, delay*) >)
provided
    rvd.implicitName ≠ *undefined* // implicit name defined
∧ ¬ (∃ *sigdef* ∈ <signal definition>: *sigdef*.**s**-<name>.**s**-*TOKEN* = *rvd.implicitName*.**s**-*TOKEN* +"QUERY")
        // signal xQUERY already defined for this remote variable
=17=>
let *x* = *rvd.implicitName*.**s**-*TOKEN* **in**
rvd ⌒ **mk**-<signal definition list>(
    < **mk**-<signal definition> (*undefined*,
            mk-<name>(*x* + "QUERY"), *empty, undefined, undefined,* < *predefinedId0*("Integer") >) ,
        mk-<signal definition> (*undefined*,
            mk-<name>(*x* + "REPLY"), *empty, undefined, undefined,* < *sort, predefinedId0*("Integer") >)
    >)
endlet // *x*

There are two implicit signal definitions for each variable of a <remote variable definition> in a system definition. A <remote variable definition> that defines multiple variables is expanded to a <remote variable definition> list with one variable per <remote variable definition>. The <signal name>s in the implicit signal definitions are denoted by xQUERY and xREPLY respectively, where x denotes an implicit <name> associated with the <remote variable definition>. The signals are defined in the same scope unit as the <remote variable definition>. The signal xQUERY has an argument of the predefined sort Integer and xREPLY has arguments of the sort of the variable and Integer. See clause 10.6 *Model* of [ITU-T Z.102].

<channel definition>(*n, er, delay,*
    <channel path>(*ep1, ep2,*
            sigs1 ⌒ <signal list item>(*i*=<identifier>(*q, **</identifier>)) ⌒ *sigs2*),
    path2)
provided
    stimulusKind(*i*) = **remote variable**
∧ *i.refersto0.implicitName* ≠ *undefined*
=17=>
let *x* = *i.refersto0.implicitName*.**s**-*TOKEN* **in**
    mk-<channel definition>(*n, er, delay,*
        mk-<channel path>(*ep1, ep2,*
            sigs1 ⌒ < **mk**-<identifier>(*q,* **mk**-<name>(*x* + "QUERY")) > ⌒ *sigs2*),
        mk-<channel path>(*ep2, ep1,*
            if *path2 = undefined* **then** *empty* **else** *path2*.**s**-<signal list item>-**seq endif** ⌒
                < **mk**-<identifier>(*q,* **mk**-<name>*x* + "REPLY")) >))
endlet

On each channel mentioning the remote variable, the remote variable is replaced by xQUERY. For each such channel, if it is unidirectional the channel is made bidirectional. In the opposite direction this channel carries the signal xREPLY. See clause 10.6 *Model* of [ITU-T Z.102].

a) Importer

See clause 10.6 *Model* (a) Importer of [ITU-T Z.102].

The first transformation below inserts variable definitions for the implicit variables needed for an import expression provided a unique name associated with the remote variable has been introduced and the variables have not already been defined. The second transformation updates the access of the remote variable to be an access of the implicit variable used to store the import value from the signal exchange for the import, and is followed by dependent transformations one of which inserts the items for the signal exchange before the variable access. Depending on where the import expression was, the pattern matches one of the six dependent transformations for the enclosing body: an agent body with the import expression in a start, an agent body with the import expression in a state or free action, a composite state body with the import expression in a start, a composite state body with the import expression in a state or free action, a procedure body with the import expression in a start, or a procedure body with the import expression in a state or free action.

items=getEntities0(//entities defined in agent type definition where import expression is used
    atd = parentAS0ofKind(// finds agent type definition with import expression
        r = <import expression>(*rv*, *),
        <system type definition> ∪ <block type definition> ∪ <process type definition>))
)) //end *parentAS0ofKind*, end of *getEntities0*
provided
¬ *callerVariablesDefined*(*r*)
=17=>
< *variableDefinition0*(*rv.refersto0.implicitName*.**s**-*TOKEN* + "xn", *rv.refersto0*.**s**-<sort>, *undefined*),
    variableDefinition0(*rv.refersto0.implicitName*.**s**-*TOKEN* + "n", *predefinedId0*("Integer"),
        <operand5>(<identifier>(*predefinedQual0*("Integer"), <name>("1")))),
    variableDefinition0(*rv.refersto0.implicitName*.**s**-*TOKEN* + "newn", *predefinedId0*("Integer"), *undefined*)
> // end of variable definitions
⌒ *items* // variables are in scope and can be used in *items*

<variable access>(*r* = <import expression>(*rv*=<identifier>(*q*, *), *constr*))
provided
callerVariablesDefined(*r*)
=17=>
mk-<variable access>(**mk**-<identifier>(
    fullQualifierWithin0(*parentAS0ofKind*(*r*,
        <system type definition> ∪ <block type definition> ∪ <process type definition>)),
    mk-<name>(*rv.refersto0.implicitName*.**s**-*TOKEN* + "xn")))
and
body = <agent body>(// agent body with import expression in start
    start = <start>(*virt*,
        entry,
        <transition action items>(
            actionItems = *parentAS0ofKind*(
                action = *parentAS0ofKind*(*r*,
                    <action>), // *parentAS0ofKind* for *action*
                <action>-**seq**), // *parentAS0ofKind* for *actionItems*,
            tr) // tr is the terminator for <transition action items>
        ), // <start>
    bodyitems
) // agent body with import expression in start
=>
let *actions1* = < *a*[*n*] **in** *actionItems*.**s**-<action>-**seq** : *action* = *actionItems*.**s**-<action>-**seq**[i] ∧ *n* < i > **in**
let *actions2* = < *a*[*n*] **in** *actionItems*.**s**-<action>-**seq** : *action* = *actionItems*.**s**-<action>-**seq**[i] ∧ *i* < n > **in**
let *oldLabel* = **if** *action*.**s**-<label> = *undefined* **then** *newName* **else** *action*.**s**-<label> **endif in**
let *newLabel* = *newName* **in**
let *newAction* = **mk**-<action>(*newLabel*, *action*.**s-implicit**) **in**
let *newactions1* = **if** *actions1*= *empty* **then mk**-<terminator>(**mk**-<join>(*oldLabel*))
    else mk-<transition action items>(*actions1*, **mk**-<terminator>(**mk**-<join>(*oldLabel*))) **endif**

```
in
let newactions2 = < mk-<free action>( mk-<transition action items>(< newAction >⌒actions2, tr)) >
in
mk-<agent body>( mk-<start>(virt, entry, newactions1),
    newImportItems(r, oldlabel, newlabel) ⌒ newactions2⌒ bodyitems
)// end agent body with import expression in start
endlet // newactions2
endlet // newactions1
endlet // newAction
endlet // newLabel
endlet // oldLabel
endlet // actions2
endlet // actions1
and
body = <agent body>( // agent body with import expression in state or free action
    start,
    bodyitems = parentAS0ofKind(
        bodyitem = parentAS0ofKind(
            <transition action items>(
                actionItems = parentAS0ofKind(
                    action = parentAS0ofKind(r, <action>),
                <action>-seq), // parentAS0ofKind for actionItems,
                tr), // tr is the terminator for <transition action items>
            (<state> ∪ <free action>)) // parentAS0ofKind for bodyitem
        (<state> ∪ <free action>)-seq) // parentAS0ofKind for bodyitems
) // agent body with import expression in state or free action
=>
let actions1  = < a[n] in actionItems.s-<action>-seq : action = actionItems.s-<action>-seq[i] ∧ n < i > in
let actions2  = < a[n] in actionItems.s-<action>-seq : action = actionItems.s-<action>-seq[i] ∧ i < n > in
let oldLabel = if action.s-<label> = undefined then newName else action.s-<label> endif in
let newLabel = newName in
let newAction = mk-<action>(newLabel, action.s-implicit) in
let newactions1 = if actions1= empty then mk-<terminator>( mk-<join>(oldLabel))
    else mk-<transition action items>(actions1, mk-<terminator>( mk-<join>(oldLabel))) endif
in
let newactions2 = < mk-<free action>( mk-<transition action items>(< newAction >⌒actions2, tr)) >
in
mk-<agent body>( start,
    if  bodyitem ∈ <state>
    then
        bilistpre0(bodyitems,bodyitem)⌒< revisedState0(bodyitem,action,newactions1) >
    ⌒newbodyitems0⌒newactions2⌒bilistpost0(bodyitems,bodyitem)
    else // free action
        bilistpre0(bodyitems,bodyitem)⌒ < mk-<free action>(newactions1) >
    ⌒ newImportItems(r, oldlabel, newlabel)⌒newactions2⌒bilistpost0(bodyitems,bodyitem)
    endif // state or free action
) // agent body with import expression in state or free action
endlet // newactions2
endlet // newactions1
endlet // newAction
endlet // newLabel
endlet // oldLabel
endlet // actions2
endlet // actions1
and
body = <composite state body>( // composite state body with import expression in start
    startlist1⌒
    <   start = <start>(virt,
```

```
            entry,
            <transition action items>(
                actionItems = parentAS0ofKind( action =
                    parentAS0ofKind(r,
                        <action>), // parentAS0ofKind for action
                    <action>-seq), // parentAS0ofKind for actionItems,
                tr) // tr is the terminator for <transition action items>
            )   > // start  list item containing import expression r
    ⌒startlist2,
    bodyitems
) // composite state body with import expression in start
=>
let actions1  = < a[n] in actionItems.s-<action>-seq : action = actionItems.s-<action>-seq[i] ∧ n < i > in
let actions2  = < a[n] in actionItems.s-<action>-seq : action = actionItems.s-<action>-seq[i] ∧ i < n > in
let oldLabel = if action.s-<label> = undefined then newName else action.s-<label> endif in
let newLabel = newName in
let newAction = mk-<action>(newLabel, action.s-implicit) in
let newactions1 = if actions1= empty then mk-<terminator>( mk-<join>(oldLabel))
    else mk-<transition action items>(actions1, mk-<terminator>( mk-<join>(oldLabel))) endif
in
let newactions2 = < mk-<free action>( mk-<transition action items>(< newAction >⌒actions2, tr)) >
in
mk-<composite state body>( startlist1⌒< mk-<start>(virt, entry, newactions1) >⌒startlist2,
    newImportItems(r, oldlabel, newlabel) ⌒ newactions2⌒ bodyitems
) // composite state body with import expression in start
endlet // newactions2
endlet // newactions1
endlet // newAction
endlet // newLabel
endlet // oldLabel
endlet // actions2
endlet // actions1
and
body = <composite state body>( // composite state body with import expression in state or free action
    startlist,
    bodyitems = parentAS0ofKind(
        bodyitem = parentAS0ofKind(
            <transition action items>(
                actionItems = parentAS0ofKind(
                    action = parentAS0ofKind(r, <action>),
                <action>-seq), // parentAS0ofKind for actionItems,
                tr), // tr is the terminator for <transition action items>
            (<state> ∪ <free action>)) // parentAS0ofKind for bodyitem
        (<state> ∪ <free action>)-seq) // parentAS0ofKind for bodyitems
) // composite state body with import expression in state or free action
=>
let actions1  = < a[n] in actionItems.s-<action>-seq : action = actionItems.s-<action>-seq[i] ∧ n < i > in
let actions2  = < a[n] in actionItems.s-<action>-seq : action = actionItems.s-<action>-seq[i] ∧ i < n > in
let oldLabel = if action.s-<label> = undefined then newName else action.s-<label> endif in
let newLabel = newName in
let newAction = mk-<action>(newLabel, action.s-implicit) in
let newactions1 = if actions1= empty then mk-<terminator>( mk-<join>(oldLabel))
    else mk-<transition action items>(actions1, mk-<terminator>( mk-<join>(oldLabel))) endif
in
let newactions2 = < mk-<free action>( mk-<transition action items>(< newAction >⌒actions2, tr)) >
in
mk-<composite state body>( startlist,
    if  bodyitem ∈ <state>
    then
```

```
        bilistpre0(bodyitems,bodyitem)⌒< revisedState0(bodyitem,action,newactions1) >
    ⌒newbodyitems0⌒newactions2⌒bilistpost0(bodyitems,bodyitem)
    else // free action
        bilistpre0(bodyitems,bodyitem)⌒ < mk-<free action>(newactions1) >
    ⌒ newImportItems(r, oldlabel, newlabel)⌒newactions2⌒bilistpost0(bodyitems,bodyitem)
    endif // state or free action
) // composite state body with import expression in state or free action
endlet // newactions2
endlet // newactions1
endlet // newAction
endlet // newLabel
endlet // oldLabel
endlet // actions2
endlet // actions1
and
body = <procedure body>( // procedure body with import expression in start
    start = <start>(virt,
        entry,
        <transition action items>(
            actionItems = parentAS0ofKind( action =
                parentAS0ofKind(r,
                    <action>), // parentAS0ofKind for action
                <action>-seq), // parentAS0ofKind for actionItems,
            tr) // tr is the terminator for <transition action items>
        ), // <start>
    bodyitems
) // procedure body with import expression in start
=>
let actions1  = < a[n] in actionItems.s-<action>-seq : action = actionItems.s-<action>-seq[i] ∧ n < i > in
let actions2  = < a[n] in actionItems.s-<action>-seq : action = actionItems.s-<action>-seq[i] ∧ i < n > in
let oldLabel = if action.s-<label> = undefined then newName else action.s-<label> endif in
let newLabel = newName in
let newAction = mk-<action>(newLabel, action.s-implicit) in
let newactions1 = if actions1= empty then mk-<terminator>( mk-<join>(oldLabel))
    else mk-<transition action items>(actions1, mk-<terminator>( mk-<join>(oldLabel))) endif
in
let newactions2 = < mk-<free action>( mk-<transition action items>(< newAction >⌒actions2, tr)) >
in
mk-<procedure body>( mk-<start>(virt, entry, newactions1),
    newImportItems(r, oldlabel, newlabel) ⌒ newactions2⌒ bodyitems
)// end procedure body with import expression in start
endlet // newactions2
endlet // newactions1
endlet // newAction
endlet // newLabel
endlet // oldLabel
endlet // actions2
endlet // actions1
and
body = <procedure body>( // procedure body with import expression in state or free action
    start,
    bodyitems = parentAS0ofKind(
        bodyitem = parentAS0ofKind(
            <transition action items>(
                actionItems = parentAS0ofKind(
                    action = parentAS0ofKind(r, <action>),
                <action>-seq), // parentAS0ofKind for actionItems,
                tr), // tr is the terminator for <transition action items>
            (<state> ∪ <free action>)) // parentAS0ofKind for bodyitem
```

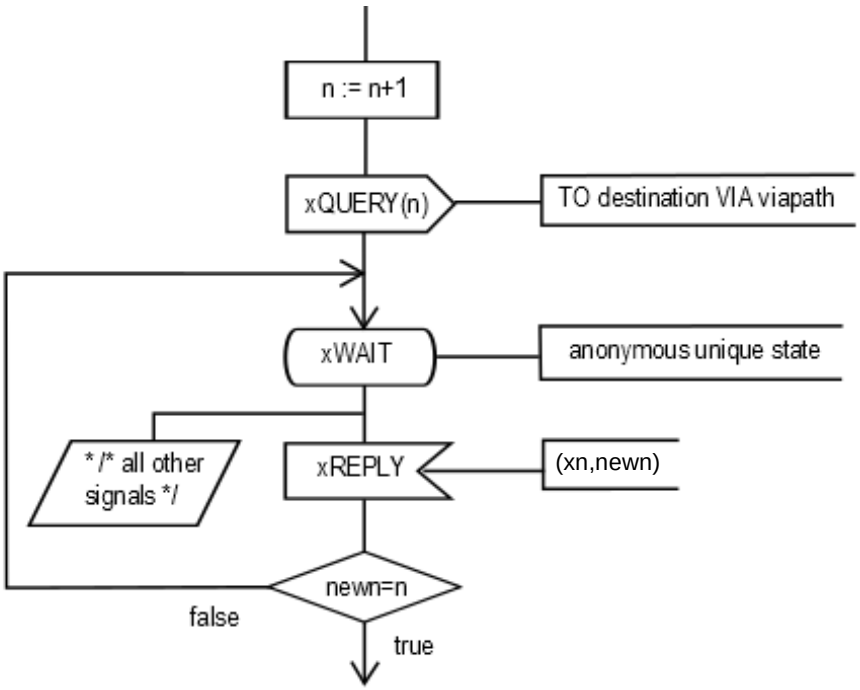
(<state> ∪ <free action>)-**seq**) // *parentAS0ofKind* for *bodyitems*
) // procedure body with import expression in state or free action
=>
let *actions1* = < *a*[*n*] **in** *actionItems*.**s**-<action>-**seq** : *action* = *actionItems*.**s**-<action>-**seq**[i] ∧ *n* < i > **in**
let *actions2* = < *a*[*n*] **in** *actionItems*.**s**-<action>-**seq** : *action* = *actionItems*.**s**-<action>-**seq**[i] ∧ *i* < n > **in**
let *oldLabel* = **if** *action*.**s**-<label> = *undefined* **then** *newName* **else** *action*.**s**-<label> **endif in**
let *newLabel* = *newName* **in**
let *newAction* = **mk**-<action>(*newLabel*, *action*.**s**-**implicit**) **in**
let *newactions1* = **if** *actions1*= *empty* **then mk**-<terminator>(**mk**-<join>(*oldLabel*))
else mk-<transition action items>(*actions1*, **mk**-<terminator>(**mk**-<join>(*oldLabel*))) **endif**
in
let *newactions2* = < **mk**-<free action>(**mk**-<transition action items>(< *newAction* >⌒*actions2*, *tr*)) >
in
mk-<procedure body>(*start*,
if *bodyitem* ∈ <state>
then
bilistpre0(*bodyitems*,*bodyitem*)⌒**<** *revisedState0*(*bodyitem*,*action*,*newactions1*) >
⌒*newbodyitems0*⌒*newactions2*⌒*bilistpost0*(*bodyitems*,*bodyitem*)
else // free action
bilistpre0(*bodyitems*,*bodyitem*)⌒ **<** **mk**-<free action>(*newactions1*) >
⌒ *newImportItems*(*r*, *oldlabel*, *newlabel*)⌒*newactions2*⌒*bilistpost0*(*bodyitems*,*bodyitem*)
endif // state or free action
) // procedure body with import expression in state or free action
endlet // *newactions2*
endlet // *newactions1*
endlet // *newAction*
endlet // *newLabel*
endlet // *oldLabel*
endlet // *actions2*
endlet // *actions1*

– For each imported variable, two implicit `Integer` variables (in this description called `n` and `newn`) are defined in the enclosing scope unit of the <import expression>, and `n` is initialized to 0. In addition, an implicit anonymous variable (in this description called `xn`) of the sort of the remote variable is defined.

– The <import expression>

import (x **to** destination **via** via-path)

is transformed so that the following is inserted before the action that contained the <import expression>, where in the output the **to** clause is omitted if the destination is not present, and the **via** clause is omitted if it is not present in the original expression:



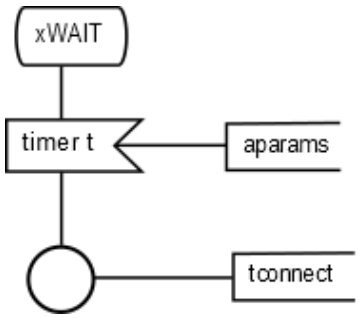
– The insertion is labelled with the label on the action containing the import expression or a new label if this action is not labelled, and the preceding path is changed to join this label.

– The true path above is terminated with a join to the action that contained the import expression with a new label.

– The import expression is changed to an access of the variable `xn`.

– In all other states, xREPLY is discarded. This is not explicitly modelled: instead the handling of xREPLY is left unspecified in the transformed concrete syntax except for the xWAIT states with the consequence that there is an implicit transition (see clause 11.8 of [ITU-T Z.103]) for other states that discards the signal.

– Additionally, the following is inserted for every timer t that is included in <communication constraints>:



where

`t` is the <timer identifier> in the <timer communication constraint>;

`aparams` is the optional list of optional <variable> items given after the <timer identifier> in the <timer communication constraint>;

`tconnect` is the <connector name> if one is given in the <timer communication constraint>; otherwise tconnect is the name of the timer.

b) Exporter

See clause 10.6 *Model* (b) Exporter of [ITU-T Z.102].

The first transform below handles the variable definitions for implicit anonymous variable to store the exported value and the implicit anonymous variable to store the integer passed received in xQUERY and returned in xREPLY. The subsequent three transforms modify the bodies of agents, composite states and procedures (respectively) where an exported variable is in scope to include the xQUERY handler on all states.

v = <variable definition>(< <exported variables of sort>(*ak*, < <exported variable>(*, *rv*) >, *sort*), *const*) >)
provided
rv.refersto0.implicitName ≠ *undefined* // implicit name defined
∧¬(∃ *vos* ∈ <variables of sort>: *vos*.**s**-<name>-**seq**[1].**s**-*TOKEN* = *rv.refersto0.implicitName*.**s**-*TOKEN*+"imcx"
∧ *surroundingQualifier0*(*vos*) = *surroundingQualifier0*(*v*)) // imcx not defined
=17=>
let *imcxName* = **mk**-<name>(*rv.refersto0.implicitName*.**s**-*TOKEN*+"imcx") **in**
v ⌒ **mk**-<variable definition>(< **mk**-<variables of sort>(*ak*, < *imcxName* >, *sort*, *const*) >)
⌒ *variableDefinition0*(*rv.refersto0.implicitName*.**s**-*TOKEN*+"n", *predefinedId0*("Integer"), *undefined*) >)
endlet

For each exported variable, an implicit anonymous variable (in this description denoted by `imcx`) is defined to hold the exported value of the exported variable, and an implicit anonymous variable of type Integer (in this description denoted by `n`) is defined.

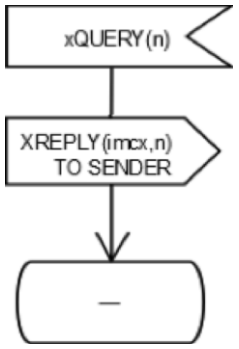
If a default initialization is attached to the export variable or if the export variable `imcx` is initialized when it is defined, then the implicit copy is also initialized with the same result as the export variable.

body = <agent body>(*start*,*bodyitems*)
provided
(∃ *ev* ∈ <exported variable>: *exportedVarScope0*(*ev*, *body*))
//There exists an exported variable ev whose scope encloses the body, with no xQUERY input parts
=17=>
mk-<agent body>(*start*, *newBodyitems0*(*body*))

body = <composite state body>(*startlist*,*bodyitems*)
provided
(∃ *ev* ∈ <exported variable>: *exportedVarScope0*(*ev*, *body*))
//There exists an exported variable ev whose scope encloses the body, with no xQUERY input parts
=17=>
mk-<composite state body>(*startlist*, *newBodyitems0*(*body*))

body = <procedure body>(*start*,*bodyitems*)
provided
(∃ *ev* ∈ <exported variable>: *exportedVarScope0*(*ev*, *body*))
//There exists an exported variable ev whose scope encloses the body, with no xQUERY input parts
=17=>
mk-<procedure body>(*start*, *newBodyitems0*(*body*))

– To all states of the exporter, the following input is added:



<export statement>(<export body>(< *id* >))
=17=>
<task>(<assignment>(*id.refersto0.implicitName*, *id*))

The <export statement>

export x

is transformed to the following:

task imcx:= x;

NOTE – There is a possibility of deadlock using the import construct, especially if no <destination> is given, or if <destination> does not denote a <pid expression> of an agent which is guaranteed by the specification to exist at the time of receiving the xQUERY signal. Specifying a set timer in the <import expression> avoids such a deadlock.

The keyword **nodelay** has no SDL-2010 meaning, though to be compatible with SDL-92 the channel conveying the signals for the remote variable should be a channel without delay.

Auxiliary functions

The function *newImportItems* is used to define a list of <free action> and <state> items to insert into the body of an agent, state or procedure that has an import expression.

```
newImportItems(r: <import expression>, oldlabel: <label>, newlabel: <label>):
    (<free action> ∪ <state>)* =def
let sq = fullQualifierWithin0( parentAS0ofKind( r,
    <system type definition> ∪ <block type definition> ∪ <process type definition>))
in
let rv = r.s-<identifier> in
let constr= r.s-<communication constraints> in
let xnName = mk-<name>(rv.refersto0.implicitName.s-TOKEN + "xn") in
let nName = mk-<name>(rv.refersto0.implicitName.s-TOKEN + "n") in
let n = mk-<operand5>( mk-<variable access>( mk-<identifier>( sq, nName))) in
let newnName = mk-<name>(rv.refersto0.implicitName.s-TOKEN + "newn") in
let newn= mk-<operand5>( mk-<variable access>( mk-<identifier>( sq, newnName ))) in
let xWAIT = newName in
let xQUERY = mk-<name>(rv.refersto0.implicitName.s-TOKEN + "QUERY")in
let xREPLY = mk-<name>(rv.refersto0.implicitName.s-TOKEN + "REPLY")in
< mk-<free action>(
    mk-<transition action items>(<
        mk-<action>( oldLabel, mk-<task>( mk-<assignment>( mk-<identifier>(sq,nName),
            mk-<operator application>("+", < n, predefinedItem0("Integer","1") >)))),
        mk-<action>(undefined, mk-<output>( mk-<output body>(
            mk-<output body item>( mk-<identifier>(q, xQUERY), < n >),
                commConstrNoTimer0(constr))),
        mk-<terminator>(undefined, mk-<nextstate>( mk-<nextstate body name>(xWAIT)))
    > ), undefined)
> ⌒
< mk-<state>(< xWAIT >,
    timerInput0(constr.s-<timer communication constraint>) ⌒
    <   mk-<save part>(undefined, <asterisk save list>()),
        mk-<input part>(undefined, //virtuality
            < mk-<stimulus>( mk-<signal list item>( mk-<identifier>(q, xREPLY)),
                    <   mk-<identifier>(sq, xnName),
                        mk-<identifier>(sq, newnName ) >, undefined) // stimulus,
                undefined, // in choice
                undefined // priority clause
            >,
            undefined, // enabling condition
            mk-<transition action items>(
                mk-<decision>( mk-<operand5>( mk-<operator application>("=", < newn, n >)),
                    mk-<textual answer part>(predefinedItem0("Boolean","true"),
```

```
                    mk-<terminator>( mk-<join>(newLabel)))
                mk-< textual answer part>(predefinedItem0("Boolean","false"),
                    mk-<terminator>( mk-<nextstate>(xWAIT)))
            ) // transition
    >, // state parts
    undefined ) // state timer part
> // for other states nothing is specified for xREPLY so it is treated as an implicit transition
endlet  // xREPLY
endlet  // xQUERY
endlet  // xWAIT
endlet  // newn
endlet  // newnName
endlet  // n
endlet  // nName
endlet  // xnName
endlet  // constr
endlet  // sq
```

The function *exportedVarScope0* determines if there is an agent type definition that has a variable definition where the given exported variable ev is defined, and encloses the given body in which there is no input part that handles the xQUERY signal for the exported variable.

```
exportedVarScope0(ev: <exported variable>,
    body: <agent body> ∪ <composite state body> ∪ <procedure body>): BOOLEAN =def
// ev.s-<identifier> is remote variable identifier
// <exported variable> is only in <variable definition> which at this point has one variable per definition
    ev.s-<identifier>.refersto0.implicitName ≠ undefined // implicit name defined
∧   isSameNode0( // nearest enclosing agent type def of body and ev the same agent type definition
    parentAS0ofKind(body,<system type definition> ∪ <block type definition> ∪ <process type definition>),
    parentAS0ofKind(ev,<system type definition> ∪ <block type definition> ∪ <process type definition>))
∧   ¬ (∃ input ∈ <input part>:
            parentAS0ofKind(input, <agent body> ∪ <composite state body> ∪ <procedure body>) = body
        ∧ parentAS0ofKind(rv.refersto0.implicitName.s-TOKEN +"QUERY", <input part>) = input)
        // does not exist an input part in body for xQUERY
```

The function *newBodyItems0* takes a body (an agent body, composite state body or procedure body), and provides a replacement list for the body items of the body where every state has a handler for xQUERY added.

```
newBodyItems0(body: <agent body> ∪ <composite state body> ∪ <procedure body>):
    (<state> ∪ <free action>)-seq =def
let bodyitems = body.s-(<state> ∪ <free action>)-seq  in
let evar = take({ev ∈ <exported variable> : exportedVarScope0(ev: <exported variable>, body }) in
let rv = evar.s-<identifier> in
let x = rv.refersto0.implicitName.s-TOKEN in
let imcx = <operand5>(
    mk-<variable access>(
        mk-<identifier>(surroundingQualifier0(evar), mk-<name>(x+"imcx"))
    )) // variable access, operand5
in
let nid = mk-<identifier>(surroundingQualifier0(evar), mk-<name>(x+"n")) in
let n = mk-<operand5>(mk-<variable access>(nid)) in
let xQUERY = mk-<name>(rv.refersto0.implicitName.s-TOKEN + "QUERY")in
let xREPLY = mk-<name>(rv.refersto0.implicitName.s-TOKEN + "REPLY")in
<   if bodyitems[i] ∈ <state> // bodyitems is {<state> | <free action>}*
    then // body item is a state, add xQUERY input
        // note – expanded to one state per <state> at ths point
        mk-<state>(
            bodyitems[i].s1-implicit, // state name, typebased comp state …
            bodyitems[i].s2-implicit // old list of connect part, input part …
            ⌒< mk-<input part>( // add input part for xQUERY
```

```
                    undefined, // virtuality
                    < mk-<stimulus>(
                        mk-<signal list item>(
                            mk-<identifier>(rv.s-<qualifier>,xQUERY)), < nid >,undefined), // stimulus
                        undefined, // in choice
                        undefined // priority clause
                    >, // simulus list
                    undefined, // enabling condition
                    mk-<transition action items>( <
                        mk-<action>(undefined, mk-<output>( mk-<output body>(
                            mk-<output body item>(<identifier>(rv.s-<qualifier>  xREPLY),
                                < imcx, n>), // output body item
                                undefined)),  output body, output
                        mk-<terminator>(undefined, mk-<dash nextstate>) // action
                        >) // action list, transition action items
                    ) >, // input part, parts list containing input part
                bodyitems[i].s-<state timer part> // state timer for xQUERY input part
            ) // state
        else // body item is a free action – not changed
            bodyitems[i]
        endif
    | i ∈ 1.. length(bodyitems) > // each item of bodyitems
    endlet //  xREPLY
    endlet //  xQUERY
    endlet //  n
    endlet //  nid
    endlet // imcx
    endlet // x
    endlet //rv
    endlet // evar
    endlet // bodyitems
```

F2.2.7.7 Communication path encoding rules, encode and decode

See clause 10.7 of [ITU-T Z.104].

Abstract syntax

Encoding-rules	::	*Rules-identifier* *Encode-procedure-identifier* *Decode-procedure-identifier*
Encoding-expression	::	*Signal-identifier* [*Expression*]* *Encoding-path*
Encoding-path	::	*Gate-identifier* | *Data-type-identifier Encoding-rules*
Decoding-expression	::	*Expression* *Encoding-path*
Rules-identifier	=	*Literal-identifier*
Encode-procedure-identifier	=	*Procedure-identifier*
Decode-procedure-identifier	=	*Procedure-identifier*

Conditions on abstract syntax

The *Rules-identifier* shall be one of the literal identifiers of the data type `Encoding`. The data type `Encoding` shall be the Predefined data type `Encoding` or a data type with the name `Encoding` that is a specialization (direct or indirect) of the Predefined data type `Encoding`. The specialization shall only add literal names to the Predefined data type `Encoding` and shall not change any other properties.

If the *Rules-identifier* corresponds (by *Name*) to an `Encoding` literal defined in the **`package`** `Predefined`, built-in procedures implied by the standardized sets of encoding rules are invoked (and

other procedures – even if visible with names corresponding as below – are ignored). These built-in encode and decode procedures are implicit parts of **package** Predefined.

If the *Rules-identifier* corresponds to an additional literal added to a specialization of the predefined data type Encoding, there shall be a visible procedure with the appropriate signature for each invocation (implicit or explicit) of the *Encoding-expression* or *Decoding-expression*.

The name of the procedure for encode is the name encode concatenated with the name of an Encoding literal. This procedure shall have one parameter of the implicit choice type for the relevant path for the invocation. The procedure shall return a Charstring, Bitstring or Octetstring.

The name of the procedure for decode is the name decode concatenated with the name of an Encoding literal. This procedure shall have one parameter of the same type (Charstring, Bitstring or Octetstring) as the corresponding procedure for encode, and shall return the choice type for the relevant path for the invocation.

Each encode or decode procedure shall be functional (that is, it shall not contain states and shall not change the value of any variable external to the procedure when it is interpreted).

The length of the optional *Expression* list of an *Encoding-expression* shall be the same as the number of *Sort-reference-identifiers* in the *Signal-definition* denoted by the *Signal-identifier*.

Each *Expression* in an *Encoding-expression* shall be sort compatible to the corresponding (by position) *Sort-reference-identifier* in the *Signal-definition* denoted by the *Signal-identifier*.

For a *Gate-identifier* of an *Encoding-path* of an agent's *Encoding-expression*, the gate shall be a gate of the agent or reachable via a channel with the *Signal-identifier* of the *Encoding-expression* from the agent, and the *Out-signal-identifier-set* of the gate shall include the *Signal-identifier*.

The *Data-type-identifier* of an *Encoding-path* shall identify an *Interface-definition*.

For an *Encoding-path* of an *Encoding-expression* with a *Data-type-identifier* that identifies an *Interface-definition*, the *Signal-identifier* shall identify one of the signals defined or inherited by the interface identified.

The *Expression* in a *Decoding-expression* shall be compatible with the sort generated by an *Encoding-expression* using the same *Encoding-path*.

Concrete syntax

<encoding rules> :: <rules identifier>

<rules identifier> :: <literal>

<encoding expression> :: { <signal<identifier> [<actual parameters>] | <expression> }[<encoding path>]

<encoding path> :: { <channel<identifier> | <gate<identifier> | <interface<identifier> <rules<identifier> }

<decoding expression> :: <expression> [<encoding path>]

Conditions on concrete syntax

Further study required for handling <encoding rules>.

In an <encoding expression> with an <expression>, the sort of the <expression> shall be the sort of the choice data type corresponding to the set of signals for the <encoding path>: normally the choice data type defined for the channel, gate or interface.

The <encoding path> shall only be omitted from <encoding expression> if there is exactly one path (channel or gate) with encoding for output of the signal in the context of the <encoding expression> and, in this case, the encoding for that path is used.

The <encoding path> shall only be omitted from <decoding expression> if there is exactly one path (channel or gate) with encoding for input in the context of the decoding expression and, in this case, the encoding for that path is used.

The encode and decode procedures associated with a <rules identifier> shall be visible where the <rules identifier> is used.

Transformations

If an <encoding expression> contains an <expression>, the choice present is determined from the expression, and the signal with the same name as the choice is output with the values of the signal parameters given by the expression.

If an <encoding path> contains a <channel<identifier>, this is transformed to the (possibly anonymous) <gate<identifier> for the gate of the identified channel nearest to the agent containing the <encoding path>.

Mapping to abstract syntax

Further study required.

F2.2.8 Behaviour

F2.2.8.1 Start

Abstract syntax

State-start-node	::	*Transition*
Procedure-start-node	::	*Transition*

Concrete syntax

<start> :: [<virtuality>] [<state entry point<name>] <transition>

Conditions on concrete syntax

∀*s*∈<start>:
(*s*.**s-**<name> ≠ *undefined*) ⇒
(*s.surroundingScopeUnit0*∈<composite state definition>)∨
(*s.surroundingScopeUnit0*∈<composite state type definition>)

If <state entry point name> is given in a <start>, the <start> shall be the <start> of a composite state. See clause 11.1 *Concrete grammar* of [ITU-T Z.102].

NOTE – A <composite state definition> is transformed into a typebased composite state and a <composite state type definition>.

Mapping to abstract syntax

```
| s=<start>(*,entry,trans) then
    if s.parentAS0 ∈ <procedure body>
    then mk-Procedure-start-node(Mapping(trans))
    elseif entry = undefined
    then mk-State-start-node(Mapping(trans) )
    else mk-Named-start-node(Mapping(entry), Mapping(trans))
    endif
```

F2.2.8.2 State

Abstract syntax

State-node	::	*State-name* *Save-signalset* *Input-node*-**set** {*Spontaneous-transition*-**set** *Continuous-signal*-**set**

| *Composite-state-type-identifier Connect-node*-**set** }
[*State-timer*]

State-timer :: *Time-expression*
Timer-identifier
*Expression**
Transition

Conditions on abstract syntax

∀*sn, sn1* ∈ *State-node*:(*sn*≠*sn1*)∧(*sn.parentAS1*=*sn1*. *parentAS1*)⇒(*sn*.**s**-*Name*≠*sn1*.**s**-*Name*)

Each *State-node* within a graph (*State-transition-graph* or *Procedure-graph*) shall have a *State-name* different from any other *State-name* in the same graph. See clause 11.2 of [ITU-T Z.101].

NOTE – A *State-name* is defined to be the same as a *Name*.

∀ *sn* ∈ *State-node*: ∀*svi,svi1*∈*Save-signalset*: ∀*in,in1*∈*Input-node*:
(*svi*≠*svi1*)∧(*svi.parentAS1*=*sn*)∧(*svi1.parentAS1*=*sn*) // *svi* and *svi1* in same state node
∧ (*in*≠*in1*)∧(*in.parentAS1*=*sn*)∧(*in1.parentAS1*=*sn*) // *in* and *in1* in same state node
⇒
(*in*.**s2**-*Identifier* = *undefined*⇒ // input has no gate implies
(((*in*.**s1**-*Identifier* ≠ *in1*.**s1**-*Identifier*) ∨ (*in1*.**s2**-*Identifier* ≠ *undefined*))//*in1* different signal or has gate
∧ ((*in*.**s1**-*Identifier* ≠ *svi*.**s1**-*Identifier*) ∨ (*svi*.**s2**-*Identifier* ≠ *undefined*))//*svi* diff. signal or has gate
∧ ((*in*.**s1**-*Identifier* ≠ *svi1*.**s1**-*Identifier*) ∨ (*svi1*.**s2**-*Identifier* ≠ *undefined*))//*svi1* diff. signal or has gate
))
∧
(*in*.**s2**-*Identifier*≠*undefined*⇒ // input has a gate implies
((*in*.**s1**-*Identifier* ≠ *in1*.**s1**-*Identifier*) //different signal in *in1*
∨ (*in*.**s2**-*Identifier* ≠ *in1*.**s2**-*Identifier*) //different gate in *in1* (including *undefined* gate)
∨ (*in*.**s1**-*Identifier* ≠ *svi*.**s1**-*Identifier*) //different signal in *svi*
∨ (*in*.**s2**-*Identifier* ≠ *svi*.**s2**-*Identifier*) //different gate in *svi* (including *undefined* gate)
∨ (*in*.**s1**-*Identifier* ≠ *svi1*.**s1**-*Identifier*) //different signal in *svi1*
∨ (*in*.**s2**-*Identifier* ≠ *svi1*.**s2**-*Identifier*) //different gate in *svi1* (including *undefined* gate)
))

In the following, *Save-item* and *Input-node* refer, respectively, to a *Save-item* of the *Save-signalset* of a basic *State-node* and an *Input-node* of the *Input-node-set* of the same basic *State-node*. If an *Input-node* has no *Gate*-identifier, the *Signal-identifier* of that *Input-node* shall not appear without a *Gate-identifier* in another *Input-node* or a *Save-item*. If an *Input-node* has a *Gate-identifier*, the Signal-identifier of that *Input-node* shall not appear with the same *Gate-identifier* in another *Input-node* or a *Save-item*. See clause 11.2 of [ITU-T Z.101].

NOTE – Both *Signal-identifier* and *Gate-identifier* are defined to be the same as an *Identifier*. In both *Input-node* and *Save-item*, the *Signal-identifier* is followed by an optional *Gate-identifier* and are therefore selected by **s1**-*Identifier* and **s2**-*Identifier* respectively.

Concrete syntax

<state> ::
<state list>
{ <connect part>
| <continuous signal>
| <input part>
| <priority input>
| <save part>
| <spontaneous transition>}*
[<state timer part>]

NOTE – Although the concrete grammar allows <continuous signal> and <spontaneous transition> for a <state> with a <state list item> that is a <typebased composite state> or <composite state list item>, for a composite state in the abstract grammar *Spontaneous-transition* and *Continuous-signal* are not allowed, therefore they are only valid for basic state items.

<state list> ::
{<basic state name> | <typebased composite state> | <composite state list item>}+
| <asterisk state list>

<basic state name> = <basic state<name>

<composite state list item> :: <composite state name> <nextstate parameters>

<composite state name> = <composite state<name>

<asterisk state list> :: <state<name>*

<state timer part> ::
[<virtuality>] <state timer> <transition>

<state timer> = <Time<expression> | <set clause>

Conditions on concrete syntax

$\forall bs \in$ <state>:$\forall sn \in$ <name>:
($sn.parentAS0 = bs.$**s-**<state list>$\wedge$ $bs.$**s-**<state list> $\in$ <asterisk state list>) $\Rightarrow$
($\forall sn1 \in$ <name> ($sn.parentAS0 = sn1.parentAS0$) $\Rightarrow$ ($sn \neq sn1$)) $\wedge$
($sn \in bs.surroundingScopeUnit0.stateNameSet0$)

The <state name>s in an <asterisk state list> shall be distinct and shall be contained in other <state list>s in the enclosing body or in the body of a supertype. See 11.2 *Concrete grammar* of [ITU-T Z.103].

$\forall s1,s2 \in$ <state>:
($\exists$ $sn \in$ <name>: ($sn \in s1.stateNameSet0 \wedge sn \in s2.stateNameSet0$)) $\Rightarrow$
(($s1.$**s-**<state timer part> = *undefined*)
$\vee$ ($s2.$**s-**<state timer part> = *undefined*)
$\vee$ ($s1.$**s-**<state timer part> = $s1.$**s-**<state timer part>))

When two <state> items contain the same <state name>, a <state timer> shall not be specified for both <state> items or both <state> items shall specify the same <state timer>. See 11.2 *Concrete grammar* of [ITU-T Z.102].

Transformations

< <state>(< *s* > $\frown$ *rest*, *triggers*, *timer*) >
provided $rest \neq empty$
=8=>
< **mk-**<state>(< *s* >, *triggers*, *timer*), **mk-**<state>(*rest*, *triggers*, *timer*) >

When the <state list> of a <state> contains more than one <state name>, a copy of that <state> is created for each such <state name>. Then the <state> is replaced by these copies. See 11.2 *Model* of [ITU-T Z.103].

< <state>(< *s* >, *triggers1*, *timer1*) > $\frown$ *rest* $\frown$ < <state>(< *s* >, *triggers2*, *timer2*) >
=15=>
rest $\frown$ < **mk-**<state>(< *s* >, *triggers1* $\frown$ *triggers2*, **if** $timer1 \neq undefined$ **then** *timer1* **else** *timer2* **endif**) >

When two <state> items that each contain one <state name>, contain the same <state name>, these <state> items are concatenated into one <state> having that <state name> with the <state timer> specified for one (or both if it is the same) <state> items. See 11.2 *Model* of [ITU-T Z.103].

<composite state list item>(*name*, *nextstateparams*)
provided mk-<identifier>(*name.surroundingQualifier0*, *name*).*anonCompStateTypeName* $\neq$ *undefined*
=12=>
mk-<typebased composite state>(
name,
nextstateparams,
<type expression>(

mk-<identifier>(*name.surroundingQualifier0*, // qualifier of type expression base type
mk-<identifier>(*name.surroundingQualifier0*, *name*).*anonCompStateTypeName* // name base type
), // base type identifer
empty // empty actual context parameters
) // type expression
) // typebased compsoite state

A <composite state list item> is a shorthand that is transformed to a <typebased composite state> that defines the name and an <composite state type<identifier> that references a <composite state type definition> transformed from the <composite state definition>. See 11.2 *Model* of [ITU-T Z.102].

b=<state>(<asterisk state list>(*exceptStates*), *triggers*)
=15=>
mk-<state>(< *s* ∈ ((*b.surroundingScopeUnit0.stateNameSet0*) \ (*exceptStates.toSet*)) >, *triggers*)

A <state> with an <asterisk state list> is transformed to a list of <state>s, one for each <state name> of the body in question, except for those <state name>s contained in the <asterisk state list>. See 11.2 *Model* of [ITU-T Z.103].

st.stateTimerIdentifier
provided
st ∈ <state>
∧ *st*.**s-**<state timer part> ≠ *undefined* // expression or set clause
∧ *st.stateTimerIdentifier = undefined*
=8=>
(*stateTimerIdentifier*\{(*st*, *undefined*)})
∪ {(*st*,
if *st*.**s-**<state timer part>.**s-**<state timer> ∈ <expression>
then *newName* // expression – implicit name for parameterless timer definition
else *st*.**s-**<state timer part>.**s-**<state timer>.**s-**<identifier> // set clause – timer name
endif
)}

stm=<state timer>(*exprn*)
provided
exprn ∈ <Time<expression>
=8=>
if *exprn* ∈ <expression> **then**
mk-<state timer>(**mk-**<set clause>(*exprn*, *st.stateTimerIdentifier*,*empty*))
else // set clause
stm
endif
and
entities = parentAS0ofKind(*stm*,
<system type definition>
∪ <block type definition>
∪ <process type definition>).**s-**<agent structure>.**s-**<entity in agent>**-seq**
=>
entities ⁀ // add implicitly named parameterless timer definition to agent
mk-<timer definition> (< **mk-**<timer definition item>(*st.stateTimerIdentifier*,*empty*,*undefined*) >)

A <state timer> with **state timer** <Time expression> is equivalent to <state timer> with a <set clause> that has an implicitly named, parameterless timer definition, which is set to the <Time expression>. See 11.2 *Model* of [ITU-T Z.102].

Mapping to abstract syntax

| <state>(< <basic state name>(*name*,) >, *triggers*, *statetimerpart*) **then**
mk-*State-node*(*Mapping*(*name*), // *State-name*
let *TriggerSet* = { *Mapping*(*triggers*[*i*]): *i*=1..*triggers.length* } **in**
{ *ss* ∈ *TriggerSet*: *ss* ∈ *Save-signalset*}, // Save-signalset
{ *in* ∈ *TriggerSet*: *in* ∈ *Input-node***-set** }, // Input-node**-set**

```
    // a basic state has (possibly empty) continuous signal or spontaneous transition sets
    {   { cs ∈ TriggerSet: cs ∈ Continuous-signal}, // Continuous-signal-set
        { sp ∈ TriggerSet: sp ∈ Spontaneous-transition} // Spontaneous-transition-set
    },
    endlet // TriggerSet
    Mapping(statetimerpart)
)
```

NOTE – A <state> with a <composite state list item> is transformed to a <state> with a <typebased composite state> before mapping takes place.

```
| <state>(< <typebased composite state>(name, basetypeid) >, triggers, statetimerpart) then
mk-State-node(Mapping(name),
let TriggerSet = { Mapping(triggers[i]): i=1.. triggers.length } in
    { ss ∈ TriggerSet: ss ∈ Save-signalset},
    { in ∈ TriggerSet: in ∈ Input-node},
    // a state with a typebased composite state shall not have continuous signals or spontaneous transitions
    {   Mapping(basetypeid),
        { cn ∈ TriggerSet: cn ∈ Connect-node}
    },
    Mapping(statetimerpart)
)

| stp = <state timer part>(*, statetimer, transition) then
if statetimer ∈ <expression>
then // state timer - time expression
    mk-State-timer(
        Mapping(statetimer), // Time-expression
        Mapping(parentAS0ofKind(stp, <state>).stateTimerIdentifier)), // Timer-identifier
        empty, // empty Expression list
        Mapping(transition)
    )
else // state timer - set clause
    mk-State-timer(
        if statetimer.s-<expression> ≠ undefined // set clause has time expression
        then Mapping(statetimer.s-<expression>) // Time-expression
        else // no Time expresssion -use default value of timer
            Mapping(
                mk-<operator application>("+",
                    now,
                    statetimer.s-<identifier>.refersto0.s-<timer default initialization>
                )
            ) // Time-expression
        endif, // Time expression present/absent
        Mapping(statetimer.s-<identifier>), // Timer-identifier
        Mapping(statetimer.s-<expression>-seq) ,// set cause Expression list (possibly empty)
        Mapping(transition)
    )
endif // state timer kind
```

Auxiliary functions

The auxiliary function *stateTimerIdentifier* stores the name of a state timer for a state.

```
controlled stateTimerIdentifier: <state> → <identifier>
initially ∀ s ∈ <state>: s.stateTimerIdentifier = undefined
```

The function *stateNameSet0* gets the set of <state name> items of a state, an agent definition, an agent type definition, a composite state, a composite state type definition or a procedure definition.

```
stateNameSet0(d: <state>∪<agent definition> ∪<agent type definition> ∪<composite state definition> ∪
        <composite state type definition>∪<internal procedure definition>): <name>-set =def
    if (d∈<state>) then
```

if *d*.**s**-<state list>∈<asterisk state list>**then**
d.surroundingScopeUnit0.stateNameSet0\{*n*∈<name>: *n.parentAS0*=*d*.**s**-<state list>}
else //*d*.**s**-<state list>∈{<basic state name>|<composite state list item>|<typebased composite state>}+
{*n*∈<name>: *n.parentAS0*=*d*.**s**-<state list>}
endif
else {*n*∈<name>: ∃*s*∈<state>: (*s*∈*d.stateSet0*)∧(*n*∈*s.stateNameSet0*)}
endif

F2.2.8.3 Input

Abstract syntax

Input-node :: [*Priority-name*]
Signal-identifier [*Gate-identifier*]
[*Provided-expression*]
[*In-choice*]
[*Variable-identifier*]*
Transition

In-choice :: *Variable-identifier*

Conditions on abstract syntax

∀*in* ∈ *Input-node*: ∀*sd* ∈ *Signal-definition*:
sd= *getEntityDefinition1*(*in*.**s**-*Signal-identifier*, **signal**)⇒
(*in*.**s**-*Variable-identifier*-**seq**.*length*=*sd*.**s**-*Sort-reference-identifier*-**seq**.*length*) ∧
(∀*i* ∈ 1..*in*.**s**-*Variable-identifier*.*length*:
∃*vd* ∈ *Variable-definition*: *vd*=*getEntityDefinition1*(*in*.**s**-*Variable-identifier*[*i*],**variable**)∧
isCompatibleTo1(*vd*.**s**-*Sort-reference-identifier*, *sd*.**s**-*Sort-reference-identifier*[*i*]))

The length of the list of optional *Variable-identifier*s must be the same as the number of items in the *Sort-reference-identifier* list in the *Signal-definition* denoted by the *Signal-identifier* and the sorts of the variables must correspond by position to the sorts of the data items that can be carried by the signal.

Concrete syntax

<input part> ::
[<virtuality>] <input list> [<enabling condition>] <transition>

<input list> ::
{ <stimulus> [<in choice>] [<priority clause>]}+
| <asterisk input list> [<in choice>] [<priority clause>]
| <encoded input>

<stimulus> :: <signal list item> [<variable>]* [<via path>]

<asterisk input list> :: {}

<via path> :: <channel<identifier> | <gate<identifier>

<in choice> :: <choice<variable> | <signal expression>

<encoded input> :: <variable> [<encoding path>]

Further study is needed for <encoded input>.

Further study is needed for <in choice>.

Conditions on concrete syntax

∀*s*∈<state>: |*s.asteriskInputListSet0*| ≤ 1

A <state> shall contain at most one <asterisk input list>. See clause 11.3 *Concrete grammar* of [ITU-T Z.103].

∀*s*∈<state>: (*s.asteriskInputListSet0*=∅) ∨ (*s.asteriskSaveListSet0* = ∅)

A <state> shall not contain both <asterisk input list> and <asterisk save list>. See clause 11.3 *Concrete grammar* of [ITU-T Z.103].

```
∀stim∈(<input part> ∪ <priority input> ): ∀sli∈<signal list item>:
    isAncestorAS0(stim,sli)⇒
        (let idKind = sli.s-<identifier>.idKind0in
            (idKind≠ remote variable)∧
            (idKind = remote procedure∨ idKind = signallist⇒
                sli.parentAS0.s-<variable>-seq=empty)
        endlet)
```

A <signal list item> of a <stimulus> (of an <input list> or <priority input>) shall not denote a <remote variable identifier> and if it denotes a <remote procedure identifier> or a <signal list identifier>, the <stimulus> parameters (including the parentheses) shall be omitted. See clause 10.4 *Concrete grammar* of [ITU-T Z.102].

```
∀v in <stimulus>.s-<variable>-seq: ¬(isGlobalBlockVar0(v))
```

A <variable> of a <stimulus> shall not be a global variable of a system (type) or block (type) except if the <stimulus> is within the state machine actions of system (type) or block (type). See clause 11.3 *Concrete grammar* of [ITU-T Z.101].

```
∀chid ∈ { id = stim.s-<via path>.s-<identifier> :
    stim ∈ ( <stimulus> ∪ <save item> ) ∧
    id.refersto0 ∈ <channel definition> ∧ // not a gate definition
    stim.surroundingScopeUnit0 ∈ <composite state type definition> } // only when in compsosite state type
:
(   ∃!gid ∈
        (   reachableSmGates(chid.refersto0.s1-<channel path>.s2-<channel endpoint>.s-<gate>,
                chid.surroundingScopeUnit0)
            ∪
            if chid.refersto0.s2-<channel path> ≠ undefined
            then    reachableSmGates(chid.refersto0.s2-<channel path>.s2-<channel endpoint>.s-<gate>,
                        chid.surroundingScopeUnit0)
            else    ∅
            endif
        )
    :
    (   gid.refersto0.s-<gate constraint>.direction0 = in ∧
        chid.parentAS0.parentAS0 in gid.refersto0.s-<gate constraint>.s1-<signal list>
    )
)
```

The <channel<identifier> for a <via path> of a <stimulus> or <save item> in a composite state type (that is, after application of the models for agent definition, agent structure with an interaction and channel to channel connection) shall identify a channel such that the enclosing state machine of the via path is reachable from the channel with the signal given in the stimulus or save through exactly one gate of the state machine. See clause 11.3 *Concrete grammar* of [ITU-T Z.103].

```
∀chid ∈ { id = cc.s-<via path>.s-<identifier> :
    cc ∈ <comunication constraints> ∧
    id.refersto0 ∈ <channel definition> ∧ // not a gate definition
    cc.surroundingScopeUnit0 ∈ <composite state type definition> } // only when in compsosite state type
:
(   ∃!gid ∈
        (   reachableSmGates(chid.refersto0.s1-<channel path>.s2-<channel endpoint>.s-<gate>,
                chid.surroundingScopeUnit0)
            ∪
            if chid.refersto0.s2-<channel path> ≠ undefined
            then    reachableSmGates(chid.refersto0.s2-<channel path>.s2-<channel endpoint>.s-<gate>,
                        chid.surroundingScopeUnit0)
            else    ∅
```

endif
)
:
(*gid*.*refersto0*.**s-**<gate constraint>.*direction0* = **in** ∧
chid.*parentAS0*.*parentAS0* **in** *gid*.*refersto0*.**s-**<gate constraint>.**s1-**<signal list>
)
)

A <channel<identifier> for a <via path> of <communication constraints> output in a composite state type (that is, after application of the models for agent definition, agent structure with an interaction, channel to channel connection, remote procedure and import expressions) shall identify a channel such that the enclosing state machine of the via path is reachable from the channel with the signal given in the stimulus or save through exactly one gate of the state machine. See clause 11.3 *Concrete grammar* of [ITU-T Z.103].

∀*chid* ∈ { *id* ∈ <identifier> : *id*.*parentAS0* ∈ <via path> ∧ *id*.*refersto0* ∈ <channel definition> }
:
(**let** *ch* = *chid*.*refersto0* **in**
(*ch*.**s2-**<channel path> ≠ *undefined*) // bidirectional
⇒
(*ch*.**s1-**<channel path>.**s2-**<channel endpoint>.**s-**<identifier>.*refersto0* ∉ (<state machine> ∪ **this**)) ∨
(*ch*.**s1-**<channel path>.**s2-**<channel endpoint> ≠ *ch*.**s2-**<channel path>.**s2-**<channel endpoint>)
endlet) // ch

If a <via path> has a <channel identifier> this shall not be a bidirectional channel with both ends connected to the same state machine. See clause 11.3 *Concrete grammar* of [ITU-T Z.103].

∀*v* ∈ <encoded input>.**s-**<variable>: ¬(*isGlobalBlockVar0*(*v*))

A <variable> of an <encoded input> shall not be a global variable of a system (type) or block (type) except if the <encoded input> is within the state machine actions of system (type) or block (type). See clause 11.3 *Concrete grammar* of [ITU-T Z.104].

∀*v* ∈ <in choice>.**s-**<variable>: ¬(*isGlobalBlockVar0*(*v*))

A <variable> of an <in choice> shall not be a global variable of a system (type) or block (type) except if the <in choice> is within the state machine actions of system (type) or block (type). See clause 11.3 *Concrete grammar* of [ITU-T Z.104].

Transformations

< <stimulus>(<signal list item>(**signallist**, *id*), *varlist*, *path*) >
=8=> < **mk-**<stimulus>(*sig*, *varlist*, *path*) | *sig* **in** *id*.*refersto0*.**s-**<signal list item>**-seq** >

A <stimulus> whose <signal list item> is an <interface<identifier> is derived syntax for a list of <stimulus> items that replaces the <interface<identifier> in the enclosing <input list> or <priority input list>. In this list, there is a one to one correspondence between the <stimulus>s and the members of the signal list. See clause 11.3 *Model* of [ITU-T Z.103].

<input part>(*virt*, <input list>(< (*stim*, *choice*, *pri*) > ⌒ *rest*), *cond*, *trans*) **provided** *rest* ≠ *empty*
=8=>
mk-<input part>(*virt*, **mk-**<input list>(< (*stim*, *choice*, *pri*) >), *cond*, *trans*) ⌒
mk-<input part>(*virt*, **mk-**<input list>(*rest*), *cond*, *trans*)

When the <stimulus> list of an <input part> contains more than one <stimulus>, a copy of the <input part> is created for each such <stimulus>. Then the <input part> is replaced by these copies. See clause 11.3 *Model* of [ITU-T Z.103].

<input part>(*virt*, <input list>(< (*stim*, *choice*, *pri*) >), *, *trans*) **provided** *pri* ≠ *undefined*
=8=>
mk-<priority input>(*virt*, **mk-**<priority input list>(< (*stim*, *choice*, *pri*) >), *trans*)

In an <input part> with one <stimulus>, if the <stimulus> is followed by a <priority clause>, the input symbol is replaced by a <priority input> containing the <stimulus> followed by the <priority clause>. See clause 11.3 *Model* of [ITU-T Z.103].

```
v.anonCompVar
provided
v ∈ (<indexed variable> ∪ <field variable>)  ∧
(∃ ip ∈ <input part>:(v in stm.s-<variable>-seq ∧ stm ∈ <stimulus> ∧ stm in ip.s-<input list>.s-implicit )) ∧
v.anonCompVar = undefined
=8=>
(anonCompVar\{( v, undefined )} ) ∪ {( v, newName)}

ip = <input part>(virt, <input list>(< (<stimulus>(item, vars, path), choice, pri) >), cond, trans)
provided
    { v ∈ vars.toSet: v ∈ (<indexed variable> ∪ <field variable>)  ∧ v.anonCompVar ≠ undefined } ≠ ∅
    //  one or more of the stimulus variable items of a <stimulus> is an indexed/field variable
    //  and anonymous name allocated for indexed/field variable
=8=>
let newvars =
< (if v ∈ (<indexed variable> ∪ <field variable>) then v.anonCompVar else v endif) : v in vars >
in
mk-<input part>(
    virt,
    mk-<input list>(< (mk-<stimulus>(item, newvars, path), choice, pri) >),
    cond,
    if trans ∈ <transition action items>
    then // put assigns from newvars to vars before actions and terminator
        mk-<transition action items>(
            < assignNewvarsToExtendedVars0(vars, newvars) > ⌒ trans.s-<action>-seq,
            trans.s-<terminator>) // transition action items
    else // transition was just a terminator, // put assigns from newvars to vars before terminator
        mk-<transition action items>( < assignNewvarsToExtendedVars0(vars, newvars) >, trans)
    endif
) // <input part>
endlet // newvars
and
items = parentAS0ofKind(ip, SCOPEUNIT0).getEntities0
=>
// add implicitly defined variable definitions to the surrounding scope
items ⌒ defineNewvars0(vars,
    < (if v ∈ (<indexed variable> ∪ <field variable>) then v.anonCompVar else v endif) : v in vars >
) // defineNewvars0
```

When one or more of the stimulus variable items of a <stimulus> is an <extended variable> (an <indexed variable> or <field variable>), then each <extended variable> is replaced by a unique, new, anonymous implicitly declared <variable<identifier> of the same sort as the original <extended variable>. Directly following the input area (<input area> or <priority input area>), a <task area> is inserted which in its <task body> contains an <assignment statement> for each of the <extended variable> items, assigning the result of the corresponding new variable to the <extended variable>. The results are assigned in the order from left to right of the <extended variable> list. This <task area> becomes the first <action area> in the <transition area> of the input area. See clause 11.3 *Model* of [ITU-T Z.103].

```
< ip = <input part>( virt,  <input list>(a = <asterisk input list>, choice, pri), cond, trans) >
provided
    parentAS0ofKind(ip,<state>).s-<state list> ∉ <asterisk state list> ∧
    parentAS0ofKind(ip,<state>).s-<state list>.length= 1
=8=>
<
```

```
    if pri = undefined
    then
        mk-<input part>(
            virt,
            mk-<input list>(
            < mk-<stimulus>(item, undefined, undefined), choice, undefined)
            > ),  //input list
            cond,
            trans
        ) // input part
    else
        mk-<priority input>(
            virt,
            mk-<priority input list>(
            < mk-<priority stimulus>(item, undefined, undefined), choice, pri)
            > ),  // priority input list
            trans
        ) // priority input
    endif
    : item ∈ (explicitValidInputSigs0(parentAS0ofKind(ip,<agent type definition>)) \
        { sig ∈ <signal list item>:
            parentAS0ofKind(sig,<state>) = st ∧
            parentAS0ofKind(ip,<state>).s-<state list>.head in st.s-<state list> // same state
        } // set of signals in other inputs or saves of state
    ) //
> // replacement list of input parts
```

An <asterisk input list> is transformed to a list of <input part>s, one for each member of the complete valid input signal set of the enclosing <agent definition>, except for <signal identifier>s of implicit input signals introduced by the concepts in clauses 10.5 and 10.6 of [ITU-T Z.102] and for <signal identifier>s contained in the other <input list>s and <save list>s of the <state>.

```
vp = <via path>( chid)
provided
chid.refersto0 ∈ <channel definition> ∧ //  not gate id
vp.parentAS0 ∈ ( <stimulus> ∪ <save item> ) ∧ // is a via path of a stimulus/save
surroundingScopeUnit0(vp) ∈ <composite state type definition>) ∧
// agent definition and agent type definition have transformed, therefore vp is in a composite state type defn.
(
    let chEndPt12 = chid.refersto0.s1-<channel path>.s2-<channel endpoint> in
    let chEndPt22 = chid.refersto0.s1-<channel path>.s1-<channel endpoint> in
    let sigidIn = vp.parentAS0.s-<signal list item> in //signal identifier of stimulus or save
     (  sigidIn in chEndPt12.s-<signal list> ∧ // signal of stimulus/save carried by the channel - forward path
        chEndPt12.s-<gate> ≠ undefined ∧ // endpoint has gate
        chEndPt12.s-<gate>.refersto0.s-<gate constraint>.direction0 = in ∧ //with in signal list
        sigidIn in chEndPt12.refersto0.s-<gate constraint>.s1-<signal list> ∧ // sig carried by gate
        chEndPt12.s-<gate>.refersto0.surroundingScopeUnit0 = vp.surroundingScopeUnit0(vp) //same scope
    )
∨ // or consider reverse path
    (   chid.refersto0.s2-<channel path> ≠ undefined ∧ // reverse path defined
        sigidIn in chEndPt22.s-<signal list> ∧ // signal of stimulus/save carried by the channel - revese path
        chEndPt22.s-<gate> ≠ undefined ∧ // endpoint has gate
        chEndPt22.s-<gate>.refersto0.s-<gate constraint>.direction0 = in ∧ //with in signal list
        sigidIn in chEndPt22.s-<gate>.refersto0.s-<gate constraint>.s1-<signal list> ∧ // sig carried by gate
        chEndPt22.s-<gate>.refersto0.surroundingScopeUnit0 = vp.surroundingScopeUnit0 // same scope
    )
    endlet // sigidIn
    endlet // chEndPt22
    endlet // chEndPt12
)
=12=>
```

```
<via path>(
    take( // static condition requires there is only one reachable gate in the set
        reachableSmGates(chid.refersto0.s1-<channel path>.s2-<channel endpoint>.s-<gate>,
            vp.surroundingScopeUnit0)
        ∪
        if chid.refersto0.s2-<channel path> ≠ undefined
        then    reachableSmGates(chid.refersto0.s2-<channel path>.s2-<channel endpoint>.s-<gate>,
                    vp.surroundingScopeUnit0)
        else    ∅
        endif
)   ) // take, via path
```

A <via path> of a <stimulus> with a <channel identifier> is transformed to a <via path> with a (possibly anonymous) <gate identifier> for the gate where the channel connects (directly or indirectly) to the enclosing state machine. See clause 11.3 *Model* of [ITU-T Z.103].

```
vp = <via path>( chid)
provided
chid.refersto0 ∈ <channel definition> ∧ //  not gate id
vp.parentAS0 ∈ <output body> ∧ // is a via path of an output body
// remote procedure calls and import expressions transformed
surroundingScopeUnit0(vp) ∈ <composite state type definition>) ∧
// agent definition and agent type definition have transformed, therefore vp is in a composite state type defn.
(
    let chEndPt12 = chid.refersto0.s1-<channel path>.s2-<channel endpoint> in
    let chEndPt22 = chid.refersto0.s1-<channel path>.s1-<channel endpoint> in
    let sigidOut = vp.parentAS0.parentAS0.s-<output body item>-seq[1] in // signal identifier output
     (  sigidOut in chEndPt12.s-<signal list> ∧ // signal of output carried by the channel - forward path
        chEndPt12.s-<gate> ≠ undefined ∧ // endpoint has gate
        chEndPt12.s-<gate>.refersto0.s-<gate constraint>.direction0 = in ∧ //with in signal list
        sigidOut in chEndPt12.s-<gate>.refersto0.s-<gate constraint>.s1-<signal list> ∧ // carried by gate
        chEndPt12.s-<gate>.refersto0.surroundingScopeUnit0 = vp.surroundingScopeUnit0(vp) //same scope
    )
∨ // or consider reverse path
    (   chid.refersto0.s2-<channel path> ≠ undefined ∧ // reverse path defined
        sigidOut in chEndPt22.s-<signal list> // signal of output carried by the channel - revese path
        chEndPt22.s-<gate> ≠ undefined ∧ // endpoint has gate
        chEndPt22.s-<gate>.refersto0.s-<gate constraint>.direction0 = in ∧ //with in signal list
        sigidOut in chEndPt22.s-<gate>.refersto0.s-<gate constraint>.s1-<signal list> ∧ // carried by gate
        chEndPt22.s-<gate>.refersto0.surroundingScopeUnit0 = vp.surroundingScopeUnit0 // same scope
    )
    endlet // sigidOut
    endlet // chEndPt22
    endlet // chEndPt12
)
=12=>
<via path>(
    take( // static condition requires there is only one reachable gate in the set
        reachableSmGates(chid.refersto0.s1-<channel path>.s2-<channel endpoint>.s-<gate>,
            vp.surroundingScopeUnit0)
        ∪
        if chid.refersto0.s2-<channel path> ≠ undefined
        then    reachableSmGates(chid.refersto0.s2-<channel path>.s2-<channel endpoint>.s-<gate>,
                    vp.surroundingScopeUnit0)
        else    ∅
        endif
)   ) // take, via path
```

A <channel<identifier> as a <via path> of <communication constraints> is transformed to the (possibly anonymous) <gate<identifier> for the gate of the channel that connects (directly or indirectly) to the enclosing state machine. See clause 11.3 *Model* of [ITU-T Z.103].

Mapping to abstract syntax

| <input part>(*, < <stimulus>(*item*, *vars*, *vp*), *choice*, *undefined* >, *cond*, *trans*) **then**
mk-*Input-node*(*undefined*, // no priority name – see mapping of priority input
Mapping(*item*), // signal identifier
Mapping(*vp*), // optional gate identifier
Mapping(*cond*), // enabling condition -> optional provided expression
Mapping(*choice*), // optional in choice
< *Mapping*(*vars*[*i*]) : *i* ∈ 1..*vars.length* >, // list - each element is a Varible-identifier or undefined
Mapping(*trans*)) // transition

| <via path>(*id*) **then** *Mapping*(*id*)

| <in choice>(*var*) **then** *Mapping*(*var*)

Auxiliary functions

Find the explicit valid input signal set of an <agent type definition> (that is, a system type definition, a block type definition or process type definition). The explicit valid input signal set is the complete valid input signal set (see clause 9 *Semantics* of [ITU-T Z.101]) excluding implicit signals introduced and therefore includes:

a) the set of signals in all channels or gates leading to the state machine of the agent;

b) the valid input signal set defined explicitly for the agent;

c) the valid input signal set defined explicitly for the state machine of the agent;

d) the timer signals.

explicitValidInputSigs0(*atd*:<agent type definition>):<signal list item>**-set** =$_{def}$
let *stateMachine* = *atd*.**s-**<agent structure>.**s-**<interaction>.**s-**<typebased composite state> **in**
let *stateMachineId* = **mk-**<identifier>(*atd*.*fullQualifierWithin0*, *stateMachine*.**s-**<name>) **in**
let *chanSigs* ={*sig*: *sig* **in** *chPath*.**s-**<signal list item>**-seq** ∧
chPath ∈ <channel path> ∧ *chPath*.**s2-**<channel endpoint>= *stateMachineId*} **in**
let *entitiesInCompType* =
if *stateMachine*.**s-**<type expression>.*refersto0*.**s-implicit** ∈ <composite state type graph>
then *stateMachine*.**s-**<type expression>.*refersto0*.**s-**<composite state type graph>.
s-<composite state structure>.**s-**<entity in composite state>**-seq**
else *stateMachine*.**s-**<type expression>.*refersto0*.**s-**<state aggregationtype>.
s-<aggregation structure>.**s-**<entity in state aggregation>**-seq**
endif
in
let *gateSigs ={sig: sig* ***in*** *gate.****s1-****<signal list item>****-seq*** ∧ *gate.****s-****in* ≠ *undefined* ∧
gate ∈ *<gate in definition>* ∧ *gate* ***in*** *entitiesInCompType}*
in
let *validSigInputSetAgent* ={*visa*: *visa* **in** *viss*.**s-**<signal list item>**-seq** ∧
viss ∈ <valid input signal set> ∧ *viss* **in** *atd*.**s-**<agent structure>.**s-**<entity in agent>**-seq**}
in
let *validSigInputSetComp* ={*visc*: *visc* **in** *viss*.**s-**<signal list item>**-seq** ∧
viss ∈ <valid input signal set> ∧ *viss* **in** *entitiesInCompType*}
in
chanSigs ∪ *gateSigs* ∪ *validSigInputSetAgent* ∪ *validSigInputSetComp*
endlet // validSigInputSetComp
endlet // validSigInputSetAgent
endlet // gateSigs
endlet // entitiesInCompType
endlet // chanSigs
endlet // stateMachineId
endlet // stateMachine

Make an action list that is assignments of new variables to extended variables.

```
assignNewvarsToExtendedVars0(varsl:<variable>*, newvarsl:<variable>*):<action>*=def
if varsl =empty then empty
else
    let v = varsl.head  in
    let newv = newvarsl.head  in
    if v ∈ (<indexed variable> ∪ <field variable>)
    then
    // create an assignment of the result of the corresponding newv to the extended variable v
        <action>(undefined,<task>(<assignment>(v, newv),undefined))⌢
            assignNewvarsToExtendedVars0(varsl.tail, newvarsl.tail)
    else    assignNewvarsToExtendedVars0(varsl.tail, newvarsl.tail)
    endif
    endlet // newv
    endlet // v
endif
```

Definitions for new variables that replace extended variables in a stimulus.

```
defineNewvars0(varsl:<variable>*, newvarsl:<variable>*):<variable definition>*=def
if varsl =empty
then empty
else
    let v = varsl.head  in
    let newv = newvarsl.head  in
    if v ∈ (<indexed variable> ∪ <field variable>)
    then
    // create a definition of the newv that corresponds to the extended variable v
        <variable definition>( <variables of sort>(PART, newv, getVariableSort0(v)))⌢
            defineNewvars0 (varsl.tail, newvarsl.tail)
    else    defineNewvars0 (varsl.tail, newvarsl.tail)
    endif
    endlet // newv
    endlet // v
endif
```

Get the <asterisk input list> for a <state>.

```
asteriskInputListSet0(s: <state>): <asterisk input list>-set =def
{ail∈<asterisk input list>: isAncestorAS0(s,ail)}
```

The function *reachableSmGates* is list of destination gates in instances of the composite state type reachable from the given gate. This function should be used only after any agent definition has been replaced by a typebased agent definition, and any agent structure with an agent body has been replaced by an agent structure with an interaction.

```
reachableSmGates(gid: <identifier>, cstd : <composite state type definition>):<identifier>-set =def
if   gid.refersto0 ∉ <gate definition>
then ∅
elseif   gid.refersto0.surroundingScopeUnit0 = cstd
then { gid }
elseif gid.refersto0.surroundingScopeUnit0 ∈ <composite state type definition> // but not cstd
then ∅
elseif   gid.refersto0.surroundingScopeUnit0  ∈
    ( <block type definition> ∪ <process type definition> ∪ <system type definition> )
then
    U{ if chdef.s1-<channel path>.s2-<channel endpoint>.s-<gate> = gid
        then reachableSmGates(chdef.s1-<channel path>.s1-<channel endpoint>.s-<gate>, cstd)
        else reachableSmGates(chdef.s1-<channel path>.s2-<channel endpoint>.s-<gate>, cstd)
        endif // find reachable state machine gates for the other channel endpoint
    :   gid.refersto0.surroundingScopeUnit0 = chdef.surroundingScopeUnit0 ∧ // same scope as gate def
        (   chdef.s1-<channel path>.s1-<channel endpoint>.s-<gate> = gid // gate originates ch fwd path
        ∨   chdef.s1-<channel path>.s2-<channel endpoint>.s-<gate> = gid // or, gate terminates ch fwd path
```

```
        )   // rev path – if it exists – interchanges the gates
    } // take the distributed union of the set of sets
else ∅
endif
```

The function *anonCompVar* is a mapping from an indexed or extended variable to an anonymous name, used for a temporary variable to store a value to assign to the indexed or extended variable.

```
controlled anonCompVar: (<indexed variable> ∪ <field variable>) → <name>
initially ∀ v ∈ (<indexed variable> ∪ <field variable>) : v.anonCompVar = undefined
```

F2.2.8.4 Priority input

Concrete syntax

```
<priority input> ::
        [<virtuality>] <priority input list> <transition>

<priority input list> =
        <priority stimulus>+
    |   <asterisk input list> [ <in choice> ] [ <priority clause> ]

<priority stimulus> :: <stimulus> [ <in choice> ] [ <priority clause> ]

<priority clause> :: [ <priority name> ]

<priority name> = <Natural<name>
```

NOTE – In [ITU-T Z.103] clause 11.4 Priority Input, *Concrete grammar* <priority name> is defined as a <integer name>, which is equivalent to AS0 <Natural<name>, because AS0 <name> includes the SDL-2010 lexical units <name>, <integer name> and <real name>.

Transformations

```
pc = <priority clause>(pname)
provided
    pname = undefined ∧ // no name give, just the keyword priority
    parentAS0ofKind(pc,<state>).s-<state list> ∉ <asterisk state list> ∧ // not asterisk state list
    parentAS0ofKind(pc,<state>).s-<state list>.length= 1 // only consider when state list reduced to one state
=8=>
let piSet = { pi : pi  ∈  <priority input> ∧
    parentAS0ofKind(pc,<state>).s-<state list>.head in
    parentAS0ofKind(pi,<state>).s-<state list> }
in
let priSet = { ps.s-<priority clause>.s-<priority name>.s-INTTOKEN0.intTokenToNat:
    pi  ∈  piSet ∧ ps in pi.s-<priority stimulus>-seq ∧ ps.s-<priority clause> ≠ undefined}
in
let highest = take({n ∈ NAT
    : (¬∃ m )( m ∈ priSet ∧ m > n) // not exists m
    }) // set for n, take
in
mk-<priority clause>(mk-<priority name>(natToIntToken(highest+1)))
endlet // highest
endlet // priSet
endlet // piSet
```

A <priority clause> without a <priority name> is transformed into a <priority clause> that is **priority** n, where n is one greater than the highest explicit <priority name> for a <priority stimulus> of the same state. The same value is used for all such transformations of the state, so that each priority stimulus without an explicit <priority name> has the same priority. See clause 11.4 *Model* of [ITU-T Z.103].

```
<priority input>(virt, < stim > ⌒ rest, trans) provided rest ≠ empty

=8=> mk-<priority input>(virt, < stim >, trans) ⌒ mk-<priority input>(virt, rest, trans)
```

When the <priority stimulus> list of a <priority input> contains more than one <priority stimulus>, a copy of the <priority input> is created for each such <priority stimulus>. Then the <priority input> is replaced by these copies. See clause 11.4 *Model* of [ITU-T Z.103].

```
< pi = <priority input>( virt,  <priority input list>(a = <asterisk input list>, choice, pri), trans) >
provided
    parentAS0ofKind(pi,<state>).s-<state list> ∉ <asterisk state list> ∧
    parentAS0ofKind(pi,<state>).s-<state list>.length= 1
=8=>
<
    mk-<priority input>(
        virt,
        mk-<priority input list>(
        < mk-<priority stimulus>(item, undefined, undefined), choice, pri)
        > ),  // priority input list
        cond,
        trans
    ) // priority input
    : item ∈ ( explicitValidInputSigs0(parentAS0ofKind(ip,<agent type definition>)) \
        { sig ∈ <signal list item>:
            parentAS0ofKind(sig,<state>) = st ∧
            parentAS0ofKind(pi,<state>).s-<state list>.head in st.s-<state list> // same state
        } // set of signals in other inputs or saves of state
    ) //
> // replacement list of input parts
```

An <asterisk input list> in a <priority input list> is transformed to a <priority stimulus> list in the same way as an <asterisk input list> in an <input list> is transformed to a <stimulus> list.

Mapping to abstract syntax

```
| <priority input>(*, <priority input list>(< <stimulus>(item, vars, vp), choice, pri >), trans) then
    mk-Input-node(natToIntToken(pri.s-TOKEN),
        Mapping(item), // signal identifier
        Mapping(vp), // optional gate identifier
        undefined, // no enabling condition in a priority input
        Mapping(choice), // optional in choice
        < Mapping(vars[i]) : i ∈ 1..vars.length >, // list - each element is a Varible-identifier or undefined
        Mapping(trans)) // transition
```

F2.2.8.5 Continuous signal

Abstract syntax

Continuous-signal	::	*Continuous-expression* [*Priority-name*] *Transition*
Continuous-expression	=	*Boolean-expression*
Priority-name	=	*NAT*

Concrete syntax

```
<continuous signal> ::
    [<virtuality>] <continuous expression> [<priority name>] <transition>

<continuous expression> = <Boolean<expression>
```

Mapping to abstract syntax

```
| <continuous signal>(*, expr, prio, trans) then
    mk-Continuous-signal(Mapping(expr), Mapping(prio), Mapping(trans))
```

F2.2.8.6 Enabling condition

Abstract syntax

Provided-expression = *Boolean-expression*

Boolean-expression = *Expression*

Concrete syntax

<enabling condition> = <provided expression>

<provided expression>:: <Boolean<expression>

Mapping to abstract syntax

| <provided expression>(*expr*) **then** *Mapping*(*expr*)

F2.2.8.7 Save

Abstract syntax

Save-signalset :: *Save-item*-**set**

Save-item = *Signal-identifier* [*Gate-identifier*]

Concrete syntax

<save part> :: [<virtuality>] <save list>

<save list> :: <save item>+ | <asterisk save list>

<asterisk save list> :: ()

<save item> :: <signal list item> [<via path>]

Conditions on concrete syntax

$\forall s \in$ <state>: $|s.asteriskSaveListSet0| \leq 1$

A <state> is allowed to contain at most one <asterisk save list>. See clause 11.7 *Concrete grammar* of [ITU-T Z.103].

$\forall s \in$ <state>: $(s.asteriskInputListSet0 = \emptyset) \vee (s.asteriskSaveListSet0 = \emptyset)$

A <state> shall not contain both <asterisk input list> and <asterisk save list>. See clause 11.3 *Concrete grammar* of [ITU-T Z.103].

Transformations

sp = <save part>(*virt*, <save list>(*a* = <asterisk save list>)) >
provided
parentAS0ofKind(*sp*,<state>).**s-**<state list> $\notin$ <asterisk state list> $\wedge$
parentAS0ofKind(*sp*,<state>).**s-**<state list>.*length*= 1
=8=>
mk-<save part>(
virt,
mk-<save list>(<
mk-<save item>(*item* , *undefined*) // signal list item, omitted via path
: *item* $\in$ (*explicitValidInputSigs0*(*parentAS0ofKind*(*sp*,<agent type definition>)) \
{ *sig* $\in$ <signal list item>:
parentAS0ofKind(*sig*,<state>) = *st* $\wedge$
parentAS0ofKind(*sp*,<state>).**s-**<state list>.*head* **in** *st*.**s-**<state list> // same state
} // set of signals in other inputs or saves of state
>) // list of save items, save list
) // revised save part

An <asterisk save list> is transformed to a list of <stimulus>s containing the complete valid input signal set of the enclosing <agent definition>, except for <signal identifier>s of implicit input signals introduced by the concepts in clauses 10.5 and 10.6 of [ITU-T Z.102] and for <signal identifier>s contained in the other <input list>s and <save list>s of the <state>.

Mapping to abstract syntax

| <save part>(*, *svlist*) **then**
mk-*Save-signalset*({ *Mapping*(*svlist*.**s-**<save item>**-seq**[*i*]) : *i* = 1..*svlist*.**s-**<save item>**-seq**.*length* })

| <save item>(*item*, *via*) **then** < *Mapping*(*item*.**s-**<signal list item>), *Mapping*(*via*) >

Auxiliary functions

Get the set of <asterisk save list> for s <state>.

asteriskSaveListSet0(*s*: <state>): <asterisk save list>**-set** =$_{def}$
{*asl*∈<asterisk save list>: *isAncestorAS0*(*s*,*asl*)}

F2.2.8.8 Implicit transition

Transformations

The following statement is handled by the dynamic semantics.

Any signal not handled by an explicit input or save is consumed by an implicit transition (a transition of an implicit <input association area>) without a change of state.

F2.2.8.9 Spontaneous transition

Abstract syntax

Spontaneous-transition :: [*Provided-expression*]
Transition

Concrete syntax

<spontaneous transition> ::
[<virtuality>] [<enabling condition>] <transition>

Mapping to abstract syntax

| <spontaneous transition>(*, *cond*, *trans*) **then**
mk-*Spontaneous-transition*(*Mapping*(*cond*), *Mapping*(*trans*))

F2.2.8.10 Label

Abstract syntax

Free-action :: *Connector-name Transition*

Concrete syntax

<label> :: <connector name>

<connector name> = <name>

NOTE – An AS0 <connector name> is defined to be the same as an AS0 <name>, therefore the terms <connector name> and <connector<name> are interchangeable. In [ITU-T Z.101] a distinction is made between a <name> and an <integer name>, and a <connector name> can be either a <name> or an <integer name>.

<free action> :: <transition> [<label>]

Conditions on concrete syntax

∀*b*∈<composite state body>∪<operation body>∪<procedure body>∪<agent body>: ∀*l*, *l1*∈<label>:

(*isAncestorAS0*(*b*,*l*) ∧ *isAncestorAS0* (*b*,*l1*) ∧ (*l* ≠ *l1*) ⇒ (*l*.**s-**<name> ≠ *l1*.**s-**<name>))

All the <connector<name>s defined in a body must be distinct.

∀*fa*∈<free action>:
if *fa*.**s-**<transition action items> ≠ *undefined* ∧ *fa*.**s-**<transition action items>.**s-**<action>**-seq** ≠ *empty*
then *fa*.**s-**<transition action items>.**s-**<action>**-seq**.*head*.**s-**<label> ≠ *undefined* ∧
fa.**s-**<transition action items>.**s-**<action>**-seq**.*head*.**s-**<label> = *fa*.**s-**<label>
else *fa*.**s-**<terminator>≠ *undefined* ∧ *fa*.**s-**<terminator>.**s-**<label> ≠ *undefined* ∧
fa.**s-**<terminator>.**s-**<label> = *fa*.**s-**<label>
endif

If the <transition string> of the <transition> in <free action> is non-empty, the first <action> shall have a <label> otherwise the <terminator> shall have a <label>. If present, the <label> ending the <free action> shall be the same as this <label>.

Auxiliary functions

The function *getLabel* extracts the first label from the transition.

getLabel(*t*: <transition>): <label> =$_{def}$
if *t*.**s-**<action> = *empty* **then** *t*.**s-**<terminator>.**s-**<label>
else *t*.**s-**<action>.*head*.**s-**<label>
endif

Transformations

<transition action items>(*actions1* ⌒ **<** *la*=<action>(*l*, ***) > ⌒ *actions2*, *term*=<terminator>(*tl*, *tn*))
provided *actions1* ≠ *empty* ∧ *l* ≠ *undefined*
=5=>
mk-<transition action items>(*actions1* ⌒ **mk-**<terminator>(*undefined*, **mk-**<join>(*l*.**s-**<name>))) ⌒
if *actions2* ≠ *empty* **then**
mk-<free action>(**mk-**<transition action items> (**<** *la* > ⌒ *actions2*, *term*))
elseif *term* ≠ *undefined* **then**
if *tl* ≠ *undefined* **then**
mk-<free action>(**mk-**<transition action items>(**<** *la* > ⌒
mk-<terminator>(*undefined*, **mk-**<join>(*tl*.**s-**<name>)))) ⌒
mk-<free action>(*term*)
else
mk-<free action>(**mk-**<transition action items>(**<** *la* > ⌒ **mk-**<terminator>(*l*, *tn*)))
endif
endif

<transition action items>(*actions*, *term*(*tl*, *tn*))
provided *tl* ≠ *undefined*
=5=>
mk-<transition action items> (*actions* ⌒ < **mk-**<terminator>(*undefined*, **mk-**<join>(*tl*.**s-**<name>)) >) ⌒
mk-<free action>(*term*)

If a <label> is not the first label of a <transition string>, the <transition string> is split into two parts. All <action>s preceding the <label> are preserved in the original transition, which is terminated with a <join> to the <label>. All <action>s following <label> are copied to a new <free action>, which starts with the <label>. If the <transition string> is followed by a <terminator> with a label, the new <free action> is terminated with a <join> to the label of the <terminator> and another <free action> is made that contains the labelled <terminator>. If the <transition string> is followed by a <terminator> without a label, the new <free action> is terminated with the unlabelled <terminator>. If a <transition string> without any labels is followed by a labelled <terminator>, a <free action> is

made that contains the labelled <terminator> and the <terminator> is replaced by a <join> to the label of the <terminator>. See clause 5.7.9 Model of [ITU-T Z.106].

Mapping to abstract syntax

| <free action>(*trans*) **then**
mk-*Free-action*(*Mapping*(*getLabel*(*trans*)), *Mapping*(*trans*))

F2.2.8.11 State machine and composite state

Abstract syntax

Composite-state-formal-parameter	=	*Agent-formal-parameter*
State-entry-point-definition	=	*Name*
State-exit-point-definition	=	*Name*
Exit-procedure-definition	=	*Procedure-definition*
Entry-procedure-definition	=	*Procedure-definition*
Named-start-node	::	*State-entry-point-name* *Transition*

Conditions on abstract syntax

(∀*d* ∈ *Entry-procedure-definition*:
(*d*.**s-***Procedure-name*= "entry")∧(*d.formalParameterList1 = empty*)∧(*d.stateNodeSet1*=∅))

(∀*d* ∈ *Exit-procedure-definition*:
(*d*.**s-***Procedure-name*="exit")∧(*d.formalParameterList1 = empty*)∧(*d. stateNodeSet1*=∅))

Entry-procedure-definition represents a procedure with the name entry. *Exit-procedure-definition* represents a procedure with the name exit. These procedures may not have parameters, and may only contain a single transition.

Concrete syntax

<composite state definition> ::
<composite state graph> | <state aggregation>

Transformations

anonCompStateTypeName(*fullIdentifier0*(
cs = <composite state definition>(*graph*)
)) // fullIdentifier0, anonStateTypeName
provided
cs.fullIdentifier0.anonCompStateTypeName = undefined
=12=>
(*anonCompStateTypeName* \{(*cs.fullIdentifier0, undefined*)}) ∪ {(*cs.fullIdentifier0, newName*)}
and // <state> with a <state list> item that is a <composite state list item> - corr. ref. case (a)
st = <state>(*statellist,triggers,timer*)
provided
st.surroundingScopeUnit0 = cs.surroundingScopeUnit0 ∧
(∃ *i* ∈ 1..*statelist.length* :
statelist[*i*].**s-**<composite state name> = *graph*.**s-**<composite state heading>.**s-**<composite state name>)
=>
let *name* = *graph*.**s-**<composite state heading>.**s-**<composite state name> **in**
mk-<state>(
< **if** *statelist*[*i*].**s-**<composite state name> = *name*
then // modify this element
mk-<typebased composite state>(*name*,
statelist[*i*].**s-**<nextstate parameters>,
mk-<type expression>(
mk-<identifier>(*cs.surroundingQualifier0*,
cs.fullIdentifier0.anonCompStateTypeName)

```
                ), // type expression refering to composite state type
                undefined
            ) // typebased composite state
        else statelist[i] // unmodified elements
        endif
    : i ∈ 1..statelist.length
    >, // state list
    triggers,
    timer
) // state
endlet // name
and // <composite state reference> in a <state partition> - corr. ref. case (b)
sp = <state partition>(csr = <composite state reference>(csrname))
provided
sp.surroundingScopeUnit0 = cs.surroundingScopeUnit0 ∧
csrname = graph.s-<composite state heading>.s-<composite state name>
=>
mk-<typebased state partition heading>( csrname,
    mk-<type expression>(
        mk-<identifier>(cs.surroundingQualifier0, cs.fullIdentifier0.anonCompStateTypeName)
    ), // type expression refering to composite state type
), // typebased state partition heading
and // <state machine> with a <composite state list item> - corr. ref. case (c)
sm = <composite state list item>( smname, smpars)
provided
sm.parentAS0 ∈ <interaction>∧ // the composite state list item is a state machine
sm.surroundingScopeUnit0 = cs.surroundingScopeUnit0 ∧
smname = graph.s-<composite state heading>.s-<composite state name>
=>
mk-<typebased composite state>( smname,
    smpars,
    mk-<type expression>(
        mk-<identifier>(cs.surroundingQualifier0, cs.fullIdentifier0.anonCompStateTypeName),
        empty // actual context parameter list
    ) // type expression refering to composite state type
) // typebased composite state
and // replace any qualifiers in cs structure that refer to cs
q = <qualifier>
provided
let structure =
    if graph ∈ <composite state graph>
    then graph.s-<composite state structure>
    else graph.s-<aggregation structure>
    endif
in
isAncestorAS0(structure, q) ∧ // is a qualifier in the composite state structure
q.parentAS0 ∈ <identifier> ∧ // part of an identifier
∀ i ∈ 1..cs.fullQualifierWithin0.s-<path item>-seq.length: \\ full qualifier match up to end of  qual within cs
q.parentAS0.refersto0.fullQualifier0.s-<path item>-seq[i] = cs.fullQualifierWithin0.s-<path item>-seq[i]
endlet // structure
=>
mk-<qualifier>(<
    if i ≠ cs.fullQualifierWithin0.s-<path item>-seq.length
    then q.parentAS0.refersto0.fullQualifier0.s-<path item>-seq[i]
    else mk-<path item>(state type, cs.fullIdentifier0.anonCompStateTypeName)
    endif :
    i = 1..q.parentAS0.refersto0.fullQualifier0.length
>)

chanStateMachineGate(fullIdentifier0(cd = <channel definition>( *, *, *, cp, *)))
provided // first channel endpoint is a state machine (in which case other endpoint is not)
chanStateMachineGate( cd.fullIdentifier0 ) = undefined ∧
```

cp.**s1-**<channel endpoint>.*refersto0* ∈ <composite state definition> ∧
(∃ *sm* ∈ <composite state list item>:
sm.parentAS0 ∈ <interaction>∧ // composite state list item that is a state machine
sm.surroundingScopeUnit0 =
    cp.**s1-**<channel endpoint>.*refersto0*.*surroundingScopeUnit0* ∧ //same scope as sm
sm.**s-**<name> = //same name as channel endpoint
    cp.**s1-**<channel endpoint>.*refersto0*.**s-**<composite state graph>.**s-**<composite state heading>.**s-**<name>)
=12=>
(*chanStateMachineGate*\{(*cd.fullIdentifier0*, *undefined*)}) ∪ {(*cd.fullIdentifier0*, *newName*)}

chanStateMachineGate(*fullIdentifier0*(*cd* = <channel definition>(*, *, *, *cp*, *)))
provided // second channel endpoint is a state machine (in which case other endpoint is not)
chanStateMachineGate(*cd.fullIdentifier0*) = *undefined* ∧
cp.**s2-**<channel endpoint>.*refersto0* ∈ <composite state definition> ∧
(∃ *sm* ∈ <composite state list item>:
sm.parentAS0 ∈ <interaction>∧ // composite state list item that is a state machine
sm.surroundingScopeUnit0 =
    cp.**s2-**<channel endpoint>.*refersto0*.*surroundingScopeUnit0* ∧ //same scope as sm
sm.**s-**<name> = //same name as channel endpoint
    cp.**s2-**<channel endpoint>.*refersto0*.**s-**<composite state graph>.**s-**<composite state heading>.**s-**<name>)
=12=>
(*chanStateMachineGate*\{(*cd.fullIdentifier0*, *undefined*)}) ∪ {(*cd.fullIdentifier0*, *newName*)}

cs = <composite state definition>(
// transform <composite state definition> cs to <composite state type definition>
    graph = <composite state graph>(*uses*, // package uses
        hdg = <composite state heading>(*virt*, // virtuality
            qual // qualifier – should be undefined = defined in context
            name, // name
            special, // specialization
            params // agent formal parameters
        ), // composite state heading
        structure = <composite state structure>(*connects*, *entities*, *body*)
) // composite state graph
) // composite state
provided
cs.fullIdentifier0.anonCompStateTypeName ≠ *undefined* ∧
((∃ *sm* ∈ <composite state list item>:
    (*sm.parentAS0* ∈ <interaction>∧ // composite state list item that is a state machine
    sm.surroundingScopeUnit0 = *cs.surroundingScopeUnit0* ∧ //same scope as cs
    sm.**s-**<name> = //same name as composite state
        cs.**s-**<composite state graph>.**s-**<composite state heading>.**s-**<name>)
)
⇒ // for a state machine, the gate name for a channel
(∃ *cd* ∈ <channel definition>: // channel with defined gate in state machine
    (*chanStateMachineGate*(*cd.fullIdentifier0*) ≠ *undefined* ∧
    (*cd*.**s-**<channel path>.**s1-**<channel endpoint>.*refersto0* = cs ∨
        cd.**s-**<channel path>.**s2-**<channel endpoint>.*refersto0* = cs))
))
=12=>
mk-<composite state type definition>(
    mk-<composite state type graph>(*uses*, // package uses
        mk-<composite state type heading>(*virt*, // virtuality
            qual // qualifier – should be undefined = defined in context
            cs.fullIdentifier0.anonCompStateTypeName, // anonymous name
            undefined, // formal context parameters
            undefined, // virtuality constraint
            special, // specialization
            params // agent formal parameters
        ), // composite state type heading
        mk-<composite state structure>(*connects*,

```
            entities ⌢ // which includes procedure refs and composite state type refs
            if  (∃ sm ∈ <composite state list item>:
                (sm.parentAS0 ∈ <interaction>∧ // composite state list item that is a state machine
                sm.surroundingScopeUnit0 = cs.surroundingScopeUnit0 ∧ //same scope as cs
                sm.s-<name> = //same name as channel endpoint
                    cs.s-<composite state graph>.s-<composite state heading>.s-<name>))
            then
            <   // list of gate definitions for channels connected to a state machine
                mk-<textual gate definition>(
                    ch.fullIdentifier0.chanStateMachineGate, // name
                    ch.s-<encoding rules>,
                    if ch.s-<channel path>.s2-<channel endpoint>.refersto0 = cs
                    then // channel to state machine
                        if ch.s2-<channel path> ≠ undefined
                        then // in and out signals
                            mk-<gate constraint>(in, undefined, ch.s-<channel path>.s-<signal list>,
                                out, undefined, ch.s2-<channel path>.s-<signal list>)
                        else // in only
                            mk-<gate constraint>(in, undefined, ch.s-<channel path>.s-<signal list>,
                                undefined, undefined, undefined)
                        endif
                    else // channel from state machine
                        if ch.s2-<channel path> ≠ undefined
                        then // in and out signals
                            mk-<gate constraint>(in, undefined, ch.s2-<channel path>.s-<signal list>,
                                out, undefined, ch.s-<channel path>.s-<signal list>)
                        else // out only
                            mk-<gate constraint>(out, undefined, ch.s-<channel path>.s-<signal list)
                        endif
                    endif
                )
                : ch ∈ <channel definition> ∧
                (   (ch.s-<channel path>.s1-<channel endpoint>.refersto0 = cs) ∨
                    (ch.s-<channel path>.s2-<channel endpoint>.refersto0 = cs)
                )
            >   // end of list of gate in definitions for channels connected to a state machine
            else empty
            endif , // entities
            body
        ),
        cs.fullIdentifier0.anonCompStateTypeName // optional matching name
    ) // composite state type graph
) // composite state type definition
and // fill in the gate channel endpoint connecting to a state machine
<channel definition>( cname,
    encoding,
    delay,
    cp1 =  <channel path>(
        ce11 =  <channel endpoint>( id11,  g11),
        ce12 =  <channel endpoint>( id12,  g12),
        signals1
    ), // cp1 channe path
    cp2 =  <channel path>(
        ce21 =  <channel endpoint>( id21,  g21),
        ce22 =  <channel endpoint>( id22,  g22),
        signals2
    ) // cp2 channe1 path
) // channel definition
=>
mk-<channel definition>( cname,
    encoding,
    delay,
```

```
    mk-<channel path>(
        mk-<channel endpoint>( id11,
            if g11 ≠ undefined then g11 else id11.chanStateMachineGate endif
        ), // first channel endpoint of first channel path
        if ce12 =  undefined then undefined else
            mk-<channel endpoint>( id12,
                if g12 ≠ undefined then g12 else id12.chanStateMachineGate endif
        endif), // second channel endpoint of first channel path
        signals1
    ), // first channel path
    if cp2 =  undefined then undefined else
        mk-<channel path>(
            mk-<channel endpoint>( id21,
                if g21 ≠ undefined then g21 else id21.chanStateMachineGate endif
            if ce22 =  undefined then undefined else
                mk-<channel endpoint>( id22,
                    if g22 ≠ undefined then g22 else id22.chanStateMachineGate endif
            endif), // second channel endpoint of second channel path
            signals2
    endif) // second channe1 path
) // channel definition
```

The following paragraph is a general description copied from clause 9 *Model* of [ITU-T Z.103] *and modified to apply to AS0*.

A <composite state definition> is shorthand for a <composite state type definition> and it has a corresponding <state> or <composite state reference> or <state machine> referencing the <composite state definition>. A <state> or <state machine> that references the <composite state definition> contains a <composite state list item> with a <composite state name> that identifies the <composite state definition>. The <composite state list item> is transformed into a <typebased composite state> as described in clause 11.2 of [ITU-T Z.103]. Each <gate> of the transformed <state machine> identifies the anonymously named <textual gate definition> of the <composite state type> that corresponds to the set of channels connected to the original <state machine> at the same point. The identified channels all join the transformed <state machine> at the same <gate in definition> inside the <state machine>. A <composite state reference> that references a <composite state definition> is transformed as described in clause 9.5 of [ITU-T Z.103].

The following paragraphs are further description copied from clause 11.11.1 *Model* of [ITU-T Z.103] *and modified to apply to AS0*.

A <composite state definition> is shorthand for a <composite state type definition> transformed as described after the NOTE below. The corresponding reference references the <composite state definition> by its <state name> and is:

a) a <state> with a <state list> item that is a <composite state list item>; or

b) a <composite state reference> in a <state partition>; or

c) a <state machine> with a <composite state list item>.

A corresponding <state> is shorthand for a <state> containing a <typebased composite state> that uses the <composite state type definition> (see also NOTE below). A corresponding <composite state reference> is shorthand for a <textual typebased state partition def> (that is, a <typebased state partition heading>) that uses the <composite state type definition> (see also NOTE below). A corresponding <state machine> is shorthand for a <state> containing a <typebased composite state> that uses the <composite state type definition> (see also NOTE below).

NOTE – In the graphical grammar a corresponding <state area>, <composite state reference area> or <state machine area> is also shorthand for a <composite state type reference area> to the <composite state type diagram>, but in AS0 such a <composite state type reference> to the <composite state type definition> is not needed because the <composite state type definition> is created in the local scope.

If the composite state is not an aggregation, the <composite state type definition> is formed from the <composite state definition> by inserting the keyword **type** after the keyword **state** in the heading and changing the name to an anonymous name. The <composite state type heading> therefore has the <virtuality> given in the <composite state heading> of the <composite state definition>. The anonymous name is generated in the same way for redefinitions, so that the names match for the virtual type and redefinitions. The <composite state structure> is copied from the <composite state definition> to the <composite state type definition>. In the <composite state structure>, any part of a <qualifier> that refers to the composite state of the <composite state definition> is changed to refer to the composite state type of the <composite state type definition>. If the <composite state definition> is for a state machine, there is also a connected <gate in definition> for the composite state type definition with a unique anonymous name, for each channel attached to the <state machine area> for the <composite state definition>.

The model for a composite state that is an aggregation is described in clause 11.11.2 of [ITU-T Z.103] and is transformed in clause F2.2.8.11.2 below.

The transform for a composite state with only an asterisk state is in F2.2.8.11.1.

A <composite state definition> that has a specialization (with a <composite state heading> that contains a <specialization>) is shorthand for defining an implicit composite state type and one typebased composite state of this type.

A <procedure reference> is moved with the same <procedure reference heading> to the composite state type.

A <composite state type reference> is moved with the same <type preamble>, <qualifier>, <composite state type name> and <formal context parameters> to the composite state type.

Auxiliary functions

The function *anonCompStateTypeName* is a mapping from composite state identities to names, used to store the name of the composite state type created from the transform of a <composite state definition> of a scope unit.

controlled *anonCompStateTypeName*: { *cs.fullIdentifier0*: *cs* ∈ <composite state definition> } → <name>
initially ∀ *cs* ∈ <composite state definition> : *cs.fullIdentifier0 = undefined*

The function *chanStateMachineGate* is a mapping from channel identities to names, used to store the name of the gate for channel connection. The gate is in composite state type from the transform of a <composite state definition>.

controlled *chanStateMachineGate*: { *cd.fullIdentifier0*: *cd* ∈ <channel definition> } → <name>
initially ∀ *cd* ∈ <channel definition> : *cd.fullIdentifier0 = undefined*

F2.2.8.11.1 Composite state graph

Abstract syntax

Composite-state-graph :: *State-transition-graph*
[*Entry-procedure-definition*]
[*Exit-procedure-definition*]

Concrete syntax

<composite state graph> ::
<package use clause>* <composite state heading> <composite state structure>

<composite state heading> ::
<virtuality> [<qualifier>] <composite state name> [<specialization>] <agent formal parameters>

<composite state structure> ::
<state connection points>* <entity in composite state>*
<composite state body>

<entity in composite state> =
    <valid input signal set>
  | <variable definition>
  | <data definition>
  | <select definition>
  | <procedure definition>
  | <procedure reference>
  | <composite state definition>
  | <composite state type definition>
  | <composite state type reference>
  | <gate in definition>

<composite state body> ::
    <start>* {<state> | <free action>}*

Conditions on concrete syntax

∀*csg*∈<composite state body>:
  ∃!s∈<start>: (*s.parentAS0* = *csg*) ∧ (*s*.**s-**<name> = *undefined*)

Exactly one of the <start>s shall be unlabelled.

∀*csd*∈<composite state definition>∪<composite state type definition>:
  (∀*pn*∈<name>: *pn*∈*csd.usedEntryNameSet0*⇒ *pn*∈ *csd.definedEntryNameSet0*)∧
  (∀*pn*∈<name>: *pn*∈*csd.usedExitNameSet0*⇒ *pn*∈ *csd.definedExitNameSet0*)

Each additional labelled entry and exit point must be defined by a corresponding <state connection points>.

∀*csb*∈<composite state body>:∀*s*∈<state>: (*s*∈*csb.surroundingScopeUnit0.stateSet0*) ∧
  ((*s*.**s-**<state list>∉<asterisk state list>))⇒ *csg.surroundingScopeUnit0.startSet0*≠∅

If a <composite state body> contains at least one <state> different from asterisk state, a <start> must be present.

∀*cs*∈<composite state definition>: ∀*vd*∈<variable definition>:
  (*vd.surroundingScopeUnit0* = *cs*) ∧ (*cs.surroundingScopeUnit0*∈<internal procedure definition>) ⇒
    (*vd*.**s-exported** = *undefined*)

<variable definition> in a <composite state definition>, cannot contain **exported** <variable name>s, if the <composite state definition> is enclosed by an <internal procedure definition>.

Transformations

<composite state body>(*empty*,
    items1 ⌒ < <state>(<asterisk state list>(*undefined*), *triggers*, *undefined*) > ⌒ *items2*)

provided < *item* **in** (*items1* ⌒ *items2*): (*item* ∈ <state>) > = *empty*
=8=>
let *nn* = *newName* **in** // anonymous state name
<composite state body>(
  < **mk-**<start>(*undefined*, // virtuality
       undefined, // state entry point name – default entry with no name
       mk-<terminator>(// start <transition> = <terminator>
         undefined, // no label
         mk-<nextstate body name>(*nn*) // <nextstate> = <next state body> = <next state body name>
) // terminator
) // start
  >, // start list
  items1 ⌒ < **mk-**<state>(< *nn* >, *triggers*, *undefined*) > ⌒ *items2*) // state/free-action list
endlet // nn

If a <composite state definition> consists of no <state>s with <state name>s but only a <state> with <asterisk>, the asterisk state is transformed into a <state> with an anonymous <state name> and a <start> leading to this <state>. Modified from clause 11.11.1 *Model* of [ITU-T Z.103].

Auxiliary functions

The function *defaultEntryPoint* associates each <composite state type definition> with an implicit anonymous name for the unnamed start of the graph.

controlled *defaultEntryPoint*: <composite state type definition> → <name>
initially ∀ *cstd* ∈ <composite state type definition>: *cstd.defaultEntryPoint = undefined*

The function *defaultExitPoint* associates each <composite state type definition> with an implicit anonymous name for the unnamed return from the graph.

controlled *defaultExitPoint*: <composite state type definition> → <name>
initially ∀ *cstd* ∈ <composite state type definition>: *cstd.defaultExitPoint = undefined*

Get the set of entry names used in a <composite state definition> or a <composite state type definition>.

usedEntryNameSet0(*csd*: <composite state definition>∪<composite state type definition>):<name>-**set**=$_{def}$
{*n*∈<name>: *n.parentAS0*∈*csd.startSet0*}

Get the set of exit names used in a <composite state definition> or a <composite state type definition>.

usedExitNameSet0(*csd*: <composite state definition>∪<composite state type definition>):<name>-**set**=$_{def}$
{*n*∈<name>: ∃*s*∈*csd.stateSet0*: *isAncestorAS0*(*s*, *n*)∧(*n.parentAS0.parentAS0*∈<return>)}

Get the set of entry names defined in a <composite state definition> or a <composite state type definition>.

definedEntryNameSet0(*csd*: <composite state definition>∪<composite state type definition>):<name>-**set**=$_{def}$
{*n*∈<name>: (*n.parentAS0*∈<state entry points>)∧
(*n.parentAS0.parentAS0*=*csd*.**s-**<composite state structure>)}

Get the set of exit names defined in a <composite state definition> or a <composite state type definition>.

definedExitNameSet0(*csd*: <composite state definition>∪<composite state type definition>):<name>-**set**=$_{def}$
{*n*∈<name>: (*n.parentAS0*∈<state exit points>)∧
(*n.parentAS0.parentAS0*=*csd*.**s-**<composite state structure>)}

F2.2.8.11.2 State aggregation

Abstract syntax

State-aggregation-node	::	*State-partition*-**set** [*Entry-procedure-definition*] [*Exit-procedure-definition*]
State-partition	::	*Name* *Composite-state-type-identifier* *Connection-definition*-**set**
Connection-definition	=	*Entry-connection-definition*
	|	*Exit-connection-definition*
Entry-connection-definition	::	*Outer-entry-point Inner-entry-point*
Outer-entry-point	::	*State-entry-point-name*
Inner-entry-point	::	*Nextstate-parameters*
Exit-connection-definition	::	*Outer-exit-point Inner-exit-point*
Outer-exit-point	::	*State-exit-point-name*
Inner-exit-point	::	*State-exit-point-name*

Conditions on abstract syntax

∀*pn*∈*State-entry-point-name*: (*pn.parentAS1*∈*Outer-entry-point*) ⇒
(*pn*∈ *pn.surroundingScopeUnit0.entryPointSet1*)∧
(*pn.surroundingScopeUnit0*.**s-implicit**∈*State-aggregation-node*)

The *State-entry-point-name* in the *Outer-entry-point* must denote a *State-entry-point-definition* of the *Composite-state-type-definition* where the *State-aggregation-node* occurs.

∀*pn*∈*State-entry-point-name*: (*pn.parentAS1*∈*Inner-entry-point*) ⇒
(*pn*∈*parentAS1ofKind*(*pn, State-partition*).*baseType1.entryPointSet1*)

The *State-entry-point-name* of the *Inner-entry-point* must denote a *State-entry-point-definition* of the composite state in the *State-partition*.

∀*pn*∈*State-exit-point-name*: (*pn.parentAS1*∈*Outer-exit-point*) ⇒
(*pn*∈ *pn.surroundingScopeUnit0.exitPointSet1*)∧
(*pn.surroundingScopeUnit0*.**s-implicit**∈*State-aggregation-node*)

∀*pn*∈*State-exit-point-name*: (*pn.parentAS1*∈*Inner-exit-point*) ⇒
(*pn*∈*parentAS1ofKind*(*pn, State-partition*).*baseType1.exitPointSet1*)

Likewise, the *Outer-exit-point*s must denote exit points in the inner and outer composite state, respectively.

∀*td*∈*Composite-state-type-definition*: (*td*.**s-implicit**∈*State-aggregation-node*)⇒
∃!*cd*∈*Connection-definition*: (*cd.surroundingScopeUnit0=td*)∧
(**let** *pointSet* = {*pn*∈*State-entry-point-definition*∪*State-exit-point-definition*:
(*pn*∈ *td.entryPointSet1*∪*td.exitPointSet1*)∨
(∃*sp*∈*State-partition*: (*sp*. *surroundingScopeUnit0= td*)∧
(*pn*∈*sp.baseType1.entryPointSet1*∪ *sp.baseType1.exitPointSet1*))} **in**
let *pointSet1=*
{*pn*∈*State-entry-point-definition*∪*State-exit-point-definition*: *isAncestorAS1*(*cd*,*pn*)} **in**
pointSet ⊆ *pointSet1*
endlet)

All entry and exit points of both the container state and the state partitions must appear in exactly one *Connection-definition*.

∀*sp*,*sp1*∈ *State-partition*: (*sp*≠*sp1*)∧ (*sp.parentAS1= sp1*. *parentAS1*)⇒
sp.inputSignalSet1 ∩ *sp1*. *inputSignalSet1*=∅

The input signal sets of the *State-partition*s within a composite state must be disjoint.

Concrete syntax

<state aggregation> ::
<package use clause>* <state aggregation heading> <aggregation structure>

<state aggregation heading> =
<composite state heading>

<aggregation structure> ::
{ <state connection points> | <entity in state aggregation> }*
<state aggregation body>

<state aggregation body> = { <state partition> | <state partition connection> }*

<state partition connection> = <state partition connection entry>
| <state partition connection exit>

<state partition connection entry> ::
[<composite state<identifier>] <outer entry points>
<composite state<identifier> <inner entry point>

<outer entry points> :: <state entry point>+ | default

<inner entry point> :: <nextstate parameters> | <state entry point> | **default**

<state entry point> = <state entry point<name>

<state partition connection exit> ::
[<composite state<identifier>] <outer exit point>
<composite state<identifier> <inner exit points>

<outer exit point> :: <state exit point> | **default**

<inner exit points> :: <state exit points> | **default**

<state partition> =
<textual typebased state partition def> | <composite state reference> | <composite state definition>

<entity in state aggregation> =

<valid input signal set>
| <variable definition>
| <data definition>
| <select definition>
| <procedure definition>
| <procedure reference>
| <composite state type definition>
| <composite state type reference>
| <gate in definition>

Transformations

NOTE – The allocation of an anonymous name for the composite state and transform of references is the same for a composite state graph and a state aggregation, and is defined in the first transform (and its dependent transforms) in F2.2.8.11.

cs = <composite state definition>(
// transform <composite state definition> cs to <composite state type definition>
graph = <state aggregation>(*uses*, // package uses
hdg = <composite state heading>(*virt*, // virtuality
qual // qualifier – should be undefined = defined in context
name, // name
special, // specialization
params // agent formal parameters
), // composite state heading (alias state aggregation heading)
structure
) // state aggregation
) // composite state
provided
cs.fullIdentifier0.anonCompStateTypeName ≠ *undefined* ∧
((∃ *sm* ∈ <composite state list item>:
(*sm.parentAS0* ∈ <interaction>∧ // composite state list item that is a state machine
sm.surroundingScopeUnit0 = *cs.surroundingScopeUnit0* ∧ //same scope as cs
sm.**s-**<name> = //same name as composite state
cs.**s-**<composite state graph>.**s-**<composite state heading>.**s-**<name>)
)
⇒ // for a state machine, the gate name for a channel
(∃ *cd* ∈ <channel definition>: // channel with defined gate in state machine
(*chanStateMachineGate*(*cd.fullIdentifier0*) ≠ *undefined* ∧
(*cd*.**s-**<channel path>.**s1-**<channel endpoint>.*refersto0* = cs ∨
cd.**s-**<channel path>.**s2-**<channel endpoint>.*refersto0* = cs))
))
=12=>
mk-<composite state type definition>(
mk-<state aggregation type>(*uses*, // package uses
mk-<state aggregation type heading>(*virt*, // virtuality
qual // qualifier – should be undefined = defined in context
cs.fullIdentifier0.anonCompStateTypeName, // anonymous name
undefined, // formal context parameters
undefined, // virtuality constraint
special, // specialization

```
            params // agent formal parameters
        ), // state aggregation type heading
        structure
    ) // state aggregation type
) // composite state type definition
```

The <composite state type definition> for the aggregation is formed from the <composite state definition> by changing the <state aggregation> into a <state aggregation type> by inserting the keyword **type** after the keyword **aggregation** in the heading and changing the name to an anonymous name. The <state aggregation type heading> therefore has the <virtuality> given in the <state aggregation heading> of the <composite state definition>. The anonymous name is generated in the same way for redefinitions, so that the names match for the virtual type and redefinitions. The <aggregation structure> is copied from the <composite state definition> to the <composite state type definition>. In the <composite state structure>, any part of a <qualifier> that refers to the composite state of the <composite state definition> is changed to refer to the composite state type of the <composite state type definition>. Modified text from clause 11.11.2 *Model* of [ITU-T Z.103].

The following paragraph (see clause 11.11.2 *Semantics* of [ITU-T Z.102]) *is formalized by the dynamic semantics.*

If there are signals in the complete valid input set of the *Composite-state-type-definition* where a *State-aggregation-node* occurs that are not consumed by any *State-partition* of the *State-aggregation-node*, there is an implied additional *State-partition*. The implied *Composite-state-type-definition* for this *State-partition* has a *Composite-state-graph* that is a *State- transition-graph* with a single unlabelled *State-start-node* with a transition to a single *State-node*. This *State-node* has an *Input-node* for each signal handled (including those for exported procedures and exported variables) and a *Continuous-signal*. The *Transition* of each *Input-node* is an empty transition back to the state. The *Continuous-signal* has a *Continuous-expression* that is a logical 'and' that accesses implicit Boolean variables, one for each (non-implicit) partition. These variables are shared by all partitions and each initialized to False. When each of the other partitions has interpreted either an *Action-return-node* or *Named-return-node*, its implicit Boolean variable is set to True. The *Transition* of the *Continuous-signal* contains just an *Action-return-node*. Therefore, when other partitions have completed, and the additional partition has consumed all the signals for it (if any) in the input port, the partition exits through an *Action-return-node*. See clause 11.11.2 *Semantics* of [ITU-T Z.102].

Auxiliary functions

Get the set of input signals appearing in a type definition, a state partition or a state node.

```
inputSignalSet1(sp: TYPEDEFINITION1∪State-partition ∪State-node): SIGNAL1 =def
    if sp∈State-node then
        sp.s-Save-signalset∪{in.s-Signal-identifier | in∈sp.s-Input-node-set}∪
        {getEntityDefinition1(cn.s-Procedure-identifier,procedure).inputSignalSet1 |
            cn∈{cn∈Call-node: isAncestorAS1(sp, cn)}}
    else // sp∈TYPEDEFINITION1∪State-partition
        {sn.inputSignalSet1 | sn∈sp.stateNodeSet1}
    endif
```

Get the base type of a definition.

```
baseType1(as:
    Agent-definition∪Composite-state-type-definition∪State-machine∪State-partition∪State-node):
        Agent-type-definition∪Composite-state-type-definition=def
    case as of
    | Agent-definition then
        if as.s-Agent-type-identifier=undefined
        then undefined
        else getEntityDefinition1(as.s-Agent-type-identifier, agent type)
        endif
```

```
    | Composite-state-type-definition∪State-machine∪State-partition∪State-node then
        if as.s-Composite-state-type-identifier=undefined
        then undefined
        else getEntityDefinition1 (as.s-Composite-state-type-identifier, state type)
        endif
    otherwise undefined
    endcase
```

Get the set of the state entry points of a *Composite-state-type-definition*.

```
entryPointSet1(d: Composite-state-type-definition): Name-set=def
    d.s-State-entry-point-definition-set
```

Get the set of the state exit points of a *Composite-state-type-definition*.

```
exitPointSet1(d: Composite-state-type-definition): Name-set=def
    d.s-State-exit-point-definition-set
```

Mapping to abstract syntax

```
| <state partition connection entry>(<outer entry points>( n1 ), <inner entry point>( n2 )) then
let innerEntryPoint  =
    mk-Inner-entry-point(
        case n2 of
        | <nextstate parameters> then Mapping(n2)
        | <state entry point> then mk-Nextstate-parameters(empty,Mapping(n2))
        otherwise // default
            mk-Nextstate-parameters(empty,Mapping(newName))
        endcase
    )
in
if n1 = default
then {mk-Entry-connection-definition(Mapping(newName), innerEntryPoint)}
else // n1 = state entry point list
    {   mk-Entry-connection-definition(
            mk-Outer-entry-point(n1[i]),
            innerEntryPoint)
        : i ∈ 1.. n1.length
    }
endif
endlet // innerEntryPoint

| <state partition connection exit>(<outer exit point>(n1), <inner exit points>( n2 )) then
let outerExitPoint  =
    mk-Outer-exit-point(
        case n1 of
        | <state exit point> then Mapping(n1)
        otherwise // default
            Mapping(newName)
        endcase
    )
in
if n2 = default
then {mk-Exit-connection-definition(outerExitPoint), Mapping(newName)}
else // n2 = state exit point list
    {   mk-Exit-connection-definition(
            outerExitPoint,
            mk-Inner-exit-point(Mapping(n2[i]))
        : i ∈ 1.. n2.length
    }
endif
endlet // outerExitPoint
```

F2.2.8.11.3 State connection point

Concrete syntax

<state connection points> = <state entry points> | <state exit points>

<state entry points> :: <state entry point>+

<state exit points> :: <state exit point>+

<state exit point> = <state exit point><name>

Mapping to abstract syntax

| <state entry points>(*x*) **then** *Mapping*(*x*)

| <state exit points>(*x*) **then** *Mapping*(*x*)

F2.2.8.11.4 Connect

Abstract syntax

Connect-node :: [*State-exit-point-name*] *Transition*

∀ *sn* ∈ *State-node*: ∀*cn*,*cn1*∈*Connect-node*:
(*cn*≠*cn1*)∧(*in*.*parentAS1*=*sn*)∧(*in1*.*parentAS1*=*sn*)⇒
cn.**s**-*State-exit-point-name*≠*cn1*.**s**-*State-exit-point-name*

The *Connect-node-**set*** shall contain at most one unnamed *Connect-node*. See clause 11.2 of [ITU-T Z.101].

Each *Connect-node* in the *Connect-node-set* of a composite state application shall either be the only *Connect-node* without a *State-exit-point-name* or have a *State-exit-point-name* that is different from every other *Connect-node* in the *Connect-node-set*. See clause 11.2 of [ITU-T Z.102].

Concrete syntax

<connect part> ::
[<virtuality>] <connect list> <exit transition>

<exit transition> = <transition>

<connect list> = <state exit point list> | <asterisk connect list>

<state exit point list> = <state exit point><name>*

<asterisk connect list> :: ()

Conditions on concrete syntax

∀*cl*∈<connect list>: ∀*pn*∈<name>:
isAncestorAS0(*cl*,*pn*) ⇒
(∃*scp*∈<state connection points>: ∃*sep*∈<state exit points>:
isAncestorAS0 (*scp*, *sep*) ∧ *isAncestorAS0* (*scp*.*parentAS0*, *pn*) ∧ (*pn* = *sep*))

The <connect list> must only refer to visible <state exit point>s.

Transformations

< <connect part>(*virt*, < *n* > ⌒ *rest*, *trans*) > **provided** *rest* ≠ *empty*
=8=> < <connect part>(*virt*, < *n* >, *trans*), <connect part>(*virt*, *rest*, *trans*) >

When the <connect list> of a certain <connect part> contains more than one <state exit point>, a copy of the <connect part> is created for each such <state exit point>. Then the <connect part> is replaced by these copies. See clause 11.11.4 *Model* of [ITU-T Z.103].

c=<connect part>(*virt*, <asterisk>, *trans*)
=8=>

(**let** *parentType* = *c*.*parentAS0*.**s-**<state list>.*head*.**s-**<type expression>.*refersto0* **in**
let *allExits* = *bigSeq*(< < *ex*.**s-**<name> | *ex* **in** *exits* > |
exits **in** *parentType*.**s-**<composite state structure>.**s-**<state connection points>**-seq**:
(*exits* ∈ <state exit points>) >) **in**
<connect part>(*virt*, *allExits*, *trans*)
endlet
endlet)

A <connect list> that contains an <asterisk connect list> is transformed into a list of <state exit point>s, one for each <state exit point> of the <composite state definition> in question. The list of <state exit point>s is then transformed as described above. See clause 11.11.4 *Model* of [ITU-T Z.103].

Mapping to abstract syntax

| <connect part>(*, < *name* >, *trans*) **then**
mk-*Connect-node*(*Mapping*(*name*),*Mapping*(*trans*))

F2.2.8.12 Transition

F2.2.8.12.1 Transition body

Abstract syntax

Transition	::	*Graph-node** { *Terminator* | *Decision-node*}
Graph-node	::	{ *Task-node* | *Output-node* | *Create-request-node* | *Call-node* | *Compound-node* | *Set-node* | *Reset-node* }
Terminator	::	{ *Nextstate-node* | *Stop-node* | *Return-node* | *Join-node* | *Continue-node* | *Break-node* }

Concrete syntax

<transition> = <transition action items> | <terminator>

<transition action items> :: <transition string> [<terminator>]

<transition string> = <action>+

<action> :: [<label>] <action item>

<action item> =
<task>
| <output>
| <create request>
| <decision>
| <set>
| <reset>
| <export statement>
| <procedure call>
| <remote procedure call>
| <transition option>

<terminator> :: [<label>] <terminator node>

<terminator node> = <nextstate> | <join> | <stop> | <return>

Conditions on concrete syntax

∀*t* ∈<transition>: (*t* ∉ <terminator>) ∧ (*t*.**s**-<terminator> = *undefined*) ∧
(*t.parentAS0.parentAS0.parentAS0*∉<decision>∪<transition option>) ⇒
(**let** *asl* = *t*.**s**-<action>**-seq in**
(*asl*.*last*.**s**-<action item>∈<decision>∪<transition option>)∧
isTransitionTerminating0(*asl*.*last*.<action item>) **endlet**)

endlet)

If the <terminator> of a <transition> is omitted, then the last action in the <transition> must contain a terminating <decision> or terminating <transition option>, except when a <transition> is contained in a <decision> or <transition option>.

Transformations

The following transformation is handled in the transformations for remote procedure call and import expression.

A transition action may be transformed to a list of actions (possibly containing implicit states) according to the transformation rules for <import expression> and <remote procedure call>.

Mapping to abstract syntax

| <transition action items>(*s*, *t*) **then**
if *t* = *undefined*
then mk-*Transition*(*Mapping*(<*s*[*i*]: *i*=1..*s.length*-1∧ (*s*[*i*] ∉ <decision>) >), *Mapping*(*s.last*))
else mk-*Transition*(*Mapping*(*s*), *Mapping*(*t*))
endif

| <action>(*, *a*) **then** *Mapping*(*a*)

| <terminator>(*l*, *t*) **then**
if *l* ≠ *undefined*
then mk-*Free-action*(*Mapping*(*l*)),**mk-***Transition*(*empty*, *Mapping*(*t*)))
else mk-*Transition*(*empty*, *Mapping*(*t*))
endif

Auxiliary functions

Determine if a <decision> or a <transition option> is terminating.

isTransitionTerminating0(*dt*: <decision>∪<transition option>): *BOOLEAN* =$_{\text{def}}$
∀*t*∈<transition>: (*t.parentAS0.parentAS0.parentAS0*= *dt*) ⇒
((*t*∈<terminator>)∨
((*t*∉<terminator>)∧(*t*.**s**-<terminator> ≠ *undefined*))∨
((*t*∉<terminator>)∧(*t*.**s**-<terminator> = *undefined*)∧
isTransitionTerminating0(*t*.**s**-<action>**-seq**.*last*.<action item>))

F2.2.8.12.2 Nextstate

Abstract syntax

Nextstate-node	=	*Named-nextstate* | *Dash-nextstate*
Dash-nextstate	::	[**HISTORY**]
Named-nextstate	::	*State-name* [*Nextstate-parameters*]
Nextstate-parameters	::	*Actual-parameters* [*State-entry-point-name*]

Conditions on abstract syntax

∀*nn* ∈ *Nextstate-node*: *nn*.**s**-*Nextstate-parameters* ≠ *undefined*⇒
((*nn*.**s**-*State-name* = *sn*.**s**-*State-name*)∧

(*parentAS1ofKind*(*nn, State-transition-graph*∪*Procedure-graph*) =
parentAS1ofKind(*sn, State-transition-graph*∪*Procedure-graph*))∧
(*nn*.**s**-*Nextstate-parameters* ≠ *undefined*))⇒
sn.**s**-*Composite-state-type-identifier*≠ *undefined*)

The *State-name* specified in a nextstate must be the name of a state within the same *State-transition-graph* or *Procedure-graph*. If a *Named-nextstate* includes *Nextstate-parameters*, the *State-name* shall refer to a composite state (a *State-node* with a *Composite-state-type-identifier*).

Concrete syntax

<nextstate> = <nextstate body>

<nextstate body> = <nextstate body name> | <dash nextstate> | <history dash nextstate>

<nextstate body name> ::
<basic state><name>
| <composite state><name> <nextstate parameters>

<nextstate parameters> :: <actual parameters> [<state entry point<name>]

<dash nextstate> :: ()

<history dash nextstate> :: ()

Conditions on concrete syntax

∀*s*∈<state>: ∀*t*∈<transition>:
(*t.parentAS0*∈<input part>∪<priority input>∪<spontaneous transition>∪<continuous signal>) ∧
(*t.parentAS0.parentAS0*= *s*) ∧
(∃*hdn*∈<history dash nextstate>: *isAncestorAS0*(*t*,*hdn*)) ⇒
(*s.surroundingScopeUnit0*∈<composite state definition> ∪<composite state type definition>)

If a transition is terminated by a <history dash nextstate>, the <state> must be a <composite state definition>.

∀*t*∈<transition>: (*t.parentAS0*∈<start>) ⇒ ¬(∃*dn*∈<dash nextstate>: *isAncestorAS0*(*t*,*dn*))

The <transition> contained in a <start> must not lead, directly or indirectly, to a <dash nextstate>.

∀*t*∈<transition>: (*t.parentAS0*∈<start>) ⇒
¬(∃*dn*∈<history dash nextstate>: *isAncestorAS0*(*t*,*dn*))

The <transition> contained in a <start> must not lead, directly or indirectly, to a <history dash nextstate>.

Transformations

The following text is handled by the dynamic semantics.

In each <nextstate> of a <state> the <dash nextstate> is replaced by the <state name> of the <state>. This model is applied after the transformation of <state>s and all other transformations except those for trailing commas, synonyms, priority inputs, continuous signals, enabling conditions, implicit tasks for imperative actions and remote variables or procedures.

Mapping to abstract syntax

| <nextstate parameters>(*params*, *n*) **then mk-***Nextstate-parameters*(*Mapping*(*params*), *Mapping*(*n*))

F2.2.8.12.3 Join

Abstract syntax

Join-node :: *Connector-name*

Concrete syntax

<join> :: <connector<name>

Conditions on concrete syntax

∀*b*∈<agent body>∪<procedure body>∪<operation body>∪<composite state body>:
∀*j*∈<join>: *isAncestorAS0*(*b*, *j*) ⇒
(∃!*l*∈<label>: *isAncestorAS0*(*b*, *l*)∧(*j*.**s**-<name> = *l*.**s**-<name>))

There must be exactly one <connector<name> corresponding to a <join> within the same body.

Mapping to abstract syntax

| <join>(*name*) **then mk**-*Terminator*(**mk**-*Join-node*(*Mapping*(*name*)), *undefined*)

F2.2.8.12.4 Stop

Abstract syntax

Stop-node	::	()

Conditions on abstract syntax

Concrete syntax

<stop>:: ()

Mapping to abstract syntax

| <stop>() **then mk**-*Terminator*(**mk**-*Stop-node*(), *undefined*)

F2.2.8.12.5 Return

Abstract syntax

Return-node	=	*Action-return-node*
	|	*Value-return-node*
	|	*Named-return-node*
Action-return-node	::	()
Value-return-node	::	*Expression*
Named-return-node	::	*State-exit-point-name*

Conditions on abstract syntax

∀*rn* ∈ *Return-node*: ∃*pg* ∈ *Procedure-graph*: *isAncestorAS1*(*pg*, *rn*)

A *Return-node* must be contained in a *Procedure-graph*.

∀*rn* ∈ *Action-return-node*: ∃*d* ∈ *Procedure-definition*:
isAncestorAS1(*d*.**s**-*Procedure-graph*, *rn*) ∧ *d*.**s**-*Result* = *undefined*

An *Action-return-node* must only be contained in the *Procedure-graph* of a *Procedure-definition* without *Result*.

∀*rn* ∈ *Value-return-node*: ∃*d* ∈ *Procedure-definition*:
isAncestorAS1(*d*.**s**-*Procedure-graph*, *rn*) ∧ *d*.**s**-*Result* ≠ *undefined*

A *Value-return-node* must only be contained in the *Procedure-graph* of a *Procedure-definition* containing *Result*.

∀*rn* ∈ *Named-return-node*: ∃*sg* ∈ *Composite-state-graph*: *isAncestorAS1*(*sg*, *rn*)

A *Named-return-node* must only be contained in a *Composite-state-graph*.

Concrete syntax

<return> ::<return body> | <state exit point<name>

<return body> :: [<expression>]

Mapping to abstract syntax

| <return>(*x*) **then**
if *x = undefined* **then mk-***Terminator*(**mk-***Action-return-node*())
elseif *x* ∈ <name> **then mk-***Terminator*(**mk-***Named-return-node*(*Mapping*(*x*)))
else mk-*Terminator*(**mk-***Value-return-node*(*Mapping*(*x*)
endif

F2.2.8.13 Action

F2.2.8.13.1 Task

Abstract syntax

Task-node	=	*Assignment*
	|	*Informal-text*

Concrete syntax

<task> :: { <task body> | <informal text> | <legacy task body> }

<task body> :: <variable definitions> <statements>

<legacy task body> = <assignment>+

Transformations

< <task>(<task body>(<statements>(*, *empty*))) >
=3=> *empty*

If a <task body> of <task> is empty, the <task> is removed. Any syntactic item leading to such an empty <task> shall then lead directly to the item following the <task>. Modified from clause 11.13.1 *Model* of [ITU-T Z.103].

< <task>(<task body>(*vl*, *sl*)) >
=3=> < <compound statement>(*undefined*, *vl*, *sl*) >

Each <non terminating statement> of <task body> of a <task> represents an element of the *Graph-node* list for the *Transition* of the <transition> containing the <task> in the order that each <non terminating statement> occurs in the <task>. See clause 11.13.1 *Concrete grammar* of [ITU-T Z.102].

NOTE 1 – For this mapping of <task body>, the <task body> is transformed into a <compound statement> as above, and then the <compound statement> is transformed and mapped as shown in clause F2.2.8.14.1. As a consequence, the transform of a <task> containing a <task body> is not necessarily mapped onto a Task-node.

< <task>(*al*) >
provided *al* ∉ (<task body> ∪ <informal text>)
=3=> < <compound statement>(*undefined*, *undefined*, *al*) >

NOTE 2 – Similar to the mapping of <task body> with variable definitions and a<statements>, the <task body> with a <legacy task body> is transformed into a <compound statement>, and then the <compound statement> is transformed and mapped as shown in clause F2.2.8.14.1.

NOTE 3 – The concrete syntax of <legacy task body> is distinguished from a <task body> only containing assignments by the punctuation used: a <legacy task body> has assignments separated by commas, whereas in a <task body> each assignment is terminated by a semi-colon. See clause 11.13.1 *Concrete grammar* of [ITU-T Z.103].

Mapping to abstract syntax

| <task>(*t*) **then mk-***Graph-node*(*Mapping*(*t*))

Auxiliary functions

The function *assignmentTaskAction0* provides the representation of a single assignment in a task symbol (used - for example - in the model for remote procedures) as an <action>, where the variable <identifier> and <operand5> expression are given as parameters. This function is therefore used where an <action> to assign to a simple variable is needed. This function is not used in this clause.

assignmentTaskAction0(*v*: <identifier>, *e*: <operand5>): <action> =$_{def}$
mk-<action>(
undefined, // omitted <label> of <action>
mk-<task>(**mk-**<task body>(
empty, // empty variable definition list of <task body>
< // <task body> <statements>=<non terminating statements>=<non terminating statement> list
undefined, // omitted <connector name> of <non terminating statement>
mk-<assignment statement>(*v*, e)
> // end <task body> <statements>=<non terminating statements>=<non terminating statement> list
)) //)<task body>)<task>
) //)<action>

F2.2.8.13.2 Create

Abstract syntax

Create-request-node :: { *Agent-identifier* | **THIS** }
Actual-parameters

Conditions on abstract syntax

$\forall n \in$ *Create-request-node*: $\forall d \in$ *Agent-definition*:
(*d*=*getEntityDefinition1*(*n*.**s**-*Agent-identifier*,**agent**))$\Rightarrow$
($\exists t \in$ *Agent-type-definition*:
(*t*=*getEntityDefinition1*(*d*.**s**-*Agent-type-identifier*,**agent type**)) $\wedge$
isActualAndFormalParameterMatched1(*n*.**s**-*Expression*-**seq**, *t*.*formalParameterSortList1*))

The length of the list of *Actual-parameters* must be the same as the number of *Agent-formal-parameter*s in the *Agent-definition* of the *Agent-identifier* and each *Expression* of *Actual-parameter*s corresponding by position to an *Agent-formal-parameter* must have a sort that is compatible to the sort of the *Agent-formal-parameter* in the *Agent-definition* denoted by *Agent-identifier*.

Concrete syntax

<create request> :: <create body>

<create body> :: { <identifier> | **this** } [<actual parameters>]

Conditions on concrete syntax

$\forall cr \in$ <create body>: (*cr*.**s-implicit** = **this**) $\Rightarrow$
(*cr.surroundingScopeUnit0* $\in$ <agent type definition>) $\wedge$
(*cr.surroundingScopeUnit0.surroundingScopeUnit0* $\in$ <agent type definition>)

this may only be specified in an <agent type definition> and in scopes enclosed by an <agent type definition>.

Transformations

The following statement is formalized in the dynamic semantics.

Stating **this** is derived syntax for the implicit <process identifier> that identifies the set of instances of the agent in which the create is being interpreted.

c=<create request>(<create body>(*id*, *params*))
provided *id.refersto0* $\in$ <agent type definition> $\wedge$ *c.possibleInstances0* $\neq$ *empty*
=8=>
(**let** *inst* = *c.possibleInstances0* **in**

```
    if inst.length = 1 then <create request>(<create body>(inst.head.identifier0, params))
    else <decision>(any, <textual decision body>(<
            <textual answer part>(undefined,
                <transition action items>(<action>(undefined,
                    <create request>(<create body>(elem.identifier0, params)),
                    undefined))
            | elem in inst >, undefined))
    endif
endlet)
```

If <agent type identifier> is used in a <create request> and there exists one instance set of the indicated agent type in the agent containing the instance that performs the create, the <agent type identifier> is derived syntax denoting this instance set.

If there is more than one instance set it is determined at interpretation time in which set the instance will be created. The <create request> is in this case replaced by a non-deterministic decision using any followed by one branch for each instance set. In each of the branches a create request for the corresponding instance set is inserted.

```
let nn = newName in
    c=<create request>(<create body>(id, params)
provided id.refersto0 ∈ <agent type definition> ∧ c.possibleInstances0 = empty
=8=>
    <create request>(<create body>(<identifier>(undefined, nn), params)
and
    entities = parentAS0ofKind(c, <agent definition> ∪ <agent type definition>).getEntities0
    =>
    entities ⌒
    if id.refersto0 ∈ <system type definition>
    then <textual typebased system definition>(
            <typebased system heading>(nn, <type expression>(id, empty)))
    elseif id.refersto0 ∈ <block type definition>
    then <textual typebased block definition>(
            <typebased block heading>(nn, <number of instances>(undefined, undefined),
                <type expression>(id, empty)))
    else id.refersto0 ∈ <process type definition>
    then <textual typebased process definition>(nn, <number of instances>(undefined, undefined),
                <type expression>(id, empty))
    endif
    endlet // nn
```

If there does not exist any instance set of the indicated agent type in the containing agent then:

a) an implicit instance set of the given type with a unique name is created in the containing agent; and

b) the <agent identifier> in the <create request> is derived syntax for this implicit instance set.

Auxiliary functions

The following function aims at finding the possible instances for an agent type create request.

```
possibleInstances0(c: <create request>): <agent definition>* =def
    < e in parentAS0ofKind(c, <agent definition> ∪ <agent type definition>).getEntities0:
        e ∈ <agent definition> ∧ e.s-<type expression>.s-<base type> = c.s-<create body>.s-implicit >
```

Mapping to abstract syntax

```
| <create request>(c then mk-Graph-node(Mapping(c))

| <create body>(id, params) then mk-Create-request-node(Mapping(id), Mapping(params))
```

F2.2.8.13.3 Procedure call

Abstract syntax

Call-node :: [**THIS**] *Procedure-identifier Actual-parameters*

Conditions on abstract syntax

∀*n* ∈ *Call-node* ∪ *Value-returning-call-node*: ∀*d* ∈ *Procedure-definition*:
(*d*=*getEntityDefinition1*(*n*.**s**-*Procedure-identifier*,**procedure**)) ⇒
(*isActualAndFormalParameterMatched1*(*n*.**s**-*Expression*-**seq**, *d*.*formalParameterSortList1*)∧
(∀*i* ∈ 1..*n*.**s**-*Expression*-**seq**.*length*:
d. *formalParameterList1*[*i*] ∈ *Inout-parameter* ∪ *Out-parameter*⇒
n.**s**-*Expression*[*i*]∈ *Identifier*∧*n*.**s**-*Expression*[*i*].*idKind1*= **variable**))

The length of the list of optional *Expression*s must be the same as the number of the *Procedure-formal-parameter*s in the *Procedure-definition* denoted by the *Procedure-identifier* and each *Expression* corresponding by position to an *In-parameter* must be sort compatible to the sort of the *Procedure-formal-parameter*. Each *Expression* corresponding by position to an *Inout-parameter* or *Out-parameter* must be a *Variable-identifier* that is sort compatible to the sort identified by the *Sort-reference-identifier* of the *Procedure-formal-parameter*.

Concrete syntax

<procedure call> :: <procedure call body>

<procedure call body> ::
[**this**] {<procedure<identifier> | <procedure<type expression>} [<actual parameters>]

Conditions on concrete syntax

∀*pc*∈<procedure call>:
(**let** *apl* = *pc*.**s**-<procedure call body>.**s**-<actual parameter>-**seq in**
let *fpl* = *pc.calledProcedure0.procedureFormalParameterList0* **in**
(*fpl.length* = *apl.length*) ∧
(∀*i*∈1..*fpl.length*:
(*fpl*[*i*].*parentAS0.parentAS0*.**s**-<parameter kind>∈{**inout**, **out**}) ⇒
(*apl*[*i*] ≠ *undefined*) ∧ (*apl*[*i*]∈<variable access>∪<extended primary>)) **endlet**)))

An <expression> in <actual parameters> corresponding to a formal **in**/**out** or **out** parameter cannot be omitted and must be a <variable access> or <extended primary>.

∀*pcd*∈<procedure call body>: (*pcd*.**s**-**this** ≠ *undefined*) ⇒
parentAS0ofKind(*pcd*, <internal procedure definition>) =
getEntityDefinition0(*pcd*.**s**-<identifier>, **procedure**)

If **this** is used, <procedure identifier> must denote an enclosing procedure.

Transformations

p=<procedure call body>(*id*, *params*)
provided *parentAS0ofKind*(*id.refersto0*, <agent type definition>) ≠
parentAS0ofKind(*p*, <agent type definition>)
=8=>
let *par*=*parentAS0ofKind*(*p*, <agent type definition>) **in**
mk-<procedure call body>(
mk-<identifier>(*par.fullQualifierWithin0*, *id.refersto0.entityName0*), // local procedure id - same name
params)
endlet // *par*
and // add the new definition if it does not exist
let *par*=*parentAS0ofKind*(*p*, <agent type definition>) **in**
let *defs*= *par*.**s-**<agent structure>.**s-**<entity in agent>**-seq in**
let *procDef* =
mk-<internal procedure definition>(*empty*, // <package use clause>*
mk-<procedure heading>(

mk-<procedure preamble>(
mk-<type preamble>(**finalized**, *undefined*), //finalized, not abstract
undefined), // not exported – end procedure preamble
empty, // defined in context – no qualifier
id.refersto0.entityName0, // same name as original
empty, // no formal context parameters
undefined, // virtuality constraint
mk-<specialization>(**mk-**<type expression>(*id*,*empty*)), // super type, no actual context params
empty, // no additional formal parameters
id.refersto0.**s-**<procedure heading>.**s-**<result> // same result
), // procedure heading
mk-<procedure body>(*undefined*, *empty*) // no additional start, empty {state/free action} list
) // internal procedure definition
in
defs => *defs* ⌒ **if** *procDef* **in** *defs* **then** *empty* **else** < *procDef* > **endif**
endlet // *procDef*
endlet // *defs*
endlet // *par*

If the procedure identified by the <procedure type expression> of the <procedure call body> is not defined within the agent type enclosing the call, within the enclosing agent type there is an implicitly defined local procedure with the same name as identified by the <procedure type expression> and the call uses this local procedure. In the local procedure, identifiers of items (such as variables) external to the procedure definition are bound in the context of the original procedure definition rather than the context of the procedure call if that is different. An implicitly defined local procedure is an inherited subtype of the procedure identified by the <procedure<type expression> of the <procedure call body>. See clause 11.13.3 *Model* of [ITU-T Z.101].

If the <procedure identifier> is not defined within the enclosing agent, the procedure call is transformed into a call of a local, implicitly created subtype of the procedure. See 12.3.5 *Concrete grammar* of [ITU-T Z.104].

The keyword **this** implies that when the procedure is specialized, the <procedure identifier> is replaced by the identifier of the specialized procedure.

Further study is needed for replacement of **this** in a specialized procedure.

Mapping to abstract syntax

| <procedure call>(*p* **then mk-***Graph-node*(*Mapping*(*p*))

| <procedure call body>(*t*, *id*, *params*) **then**
mk-*Call-node*(*Mapping*(*t*), *Mapping*(*id*), *Mapping*(*params*))

F2.2.8.13.4 Output

Abstract syntax

Output-node	::	{ *Signal-identifier Actual-parameters* | *Expression* | *Encoded-expression* } *Activation-delay* *Signal-priority* [*Signal-destination*] *Direct-via*
Activation-delay	=	*Expression*
Signal-priority	=	*Expression*
Signal-destination	=	{ *Expression* | *Agent-identifier* | **THIS** } [*Destination-number*]
Destination-number	=	*Expression*
Direct-via	=	*Gate-identifier*-**set**

Encoded-expression :: *Expression*

Further study is needed for the first element of an *Output-node* being an *Expression* or *Encoded-expression*.

Further study is needed for a *Signal-destination* with a *Destination-number*.

Conditions on abstract syntax

```
∀ onode ∈ Output-node:
    n.s-Identifier ≠ undefined ⇒ // Signal-identifier rather than Expression or Encoded-expression
        (∃sd ∈ Signal-definition:
            (sd=getEntityDefinition1(onode.s-Identifier,signal)) ∧
            isActualAndFormalParameterMatched1(onode.s-Expression-seq, sd.formalParameterSortList1))
```

The length of the *Actual-parameters* list shall be the same as the number of *Signal-parameter* items in the *Signal-definition* denoted by the *Signal-identifier*.

Each *Expression* of the *Actual-parameters* shall be sort compatible with the *Sort-reference-identifier* of the corresponding (by position) *Signal-parameter* of the *Signal-definition.*

NOTE – The ASM code above requires both the conditions above are met.

```
∀ onode ∈ Output-node:
let sigid = onode.s-Identifier // Signal-identifier
in
let dv = onode.s-Identifier-set // Direct-via
in
    sigid ≠ undefined ∧ dv ≠ ∅ ⇒
        (∀ gi ∈ dv:
                gi ∈ reachableGatesWithSignal1(
                    enclosingScopeGates1(parentAS1ofKind(onode, Composite-state-type-definition)), sigid)
            ∧   sigid ∈ getEntityDefinition1(gi, gate).s-Out-signal-identifier-set)
endlet
endlet
```

For each *Gate-identifier* in *Direct-via*, there shall exist zero or more channels such that the gate via this path is reachable with the *Signal-identifier* from the agent and the *Out-signal-identifier-**set*** of the gate shall include the *Signal-identifier*.

```
∀ onode(*, *, *, sd(d,*), *) ∈ Output-node: // sd ∈ Signal-destination
let sigid = onode.s-Identifier // Signal-identifier
in
    sigid ≠ undefined ∧ sd ≠ undefined ⇒
        case d of
        | Expression then
            if staticSort1(d) = predefinedId1("Pid") then true
            else
                let ifd = getEntityDefinition1(staticSort1(d), sort)
                in
                    if ifd = undefined ∨ ifd ∉ Interface-definition then false
                    else sigid ∈ ifd.s-Identifier-set
                    endif
                endlet
            endif
        | Identifier then
            d ∈ reachableAgentsWithSignal1(
                enclosingScopeGates1(parentAS1ofKind(onode, Composite-state-type-definition)), sigid)
        otherwise true
        endcase
```

The sort of *Expression* of a *Signal-destination* shall either be the sort Pid (see clause 12.1.5), or the sort *Interface-definition* with the *Signal-identifier* in its *Signal-identifier-**set***.

The *Agent-identifier* of a *Signal-destination* shall identify an agent reachable from the originating agent.

NOTE – The ASM code above requires both the conditions above are met.

∀ *sigdest* ∈ *Signal-destination*: *sigdest*.**s-implicit** ∈ *Expression* ⇒ *sigdest*.**s**-*Destination-number = undefined*

The *Destination-number* is always omitted for a *Signal-destination* that is an *Expression*.

Concrete syntax

<output> :: <output body>

<output body> :: <output body item>+ <communication constraints>

<output body item> ::
{ <signal<identifier> [<actual parameters>] | <expression output> | <encoded output> }
[<activation delay>][<signal priority>]

<expression output> :: <expression>

<encoded output> :: <expression>

<communication constraints> = { <timer communication constraint> | <destination> | <via path> }*

<destination> :: { <pid<expression> | { <agent<identifier> | **this** } [<destination number>] }

<activation delay> :: < Duration<expression>

<signal priority> :: <Natural<expression>

<destination number> :: <Natural<expression>

Further study is needed for <expression output>, <encoded output> and <destination number>.

Conditions on concrete syntax

Transformations

<output>(<output body>(*olist*, *clist*))
provided < *clist*[*i*] | *i* **in** 1..*clist.length*] : *clist*[*i*] ∈ <destination> >.*length* > 1
=8=>
<output>(<output body>(*olist*, // list with just first dest
< *clist*[*i*] | *i* **in** 1..*clist.length* :
(*clist*[*i*] ∉ <destination>) ∨ ¬(∃ j ∈ 1..*clist.length* : j < i ∧ *clist*[*j*] ∈ <destination>)
>
))
⌒
<output>(<output body>(*olist*, // list without first dest
< *clist*[*i*] | *i* **in** 1..*clist.length* :
(*clist*[*i*] ∉ <destination>) ∨ (∃ j ∈ 1..*clist.length* : j < i ∧ *clist*[*j*] ∈ <destination>)
>
))

If <communication constraints> of an <output body> of an <output area> contains more than one **to** <destination> clause, this is a shorthand for replacing the <output area> by an <output area> sequence, one for each **to** <destination>. Each <output area> has the same original <output body item> list, but in each case the <communication constraints> contains only one **to** <destination> taken in order from the original <communication constraints>. See clause 11.13.4 *Model* of [ITU-T Z.103].

<output>(<output body>(< *o* > ⌒ *rest*, *constr*)) **provided** *rest* ≠ *empty* =8=>
<output>(<output body>(< *o* >, *constr*)) ⌒ <output>(<output body>(*rest*, *constr*))

If there is more than one <output body item> specified in an <output body> of an <output>, the <output> is transformed into an <output> sequence each with a single <output body item> in the

same order as specified in the original <output >. The <communication constraints> are repeated in each <output body>. See clause 11.13.4 *Model* of [ITU-T Z.103].

The following statement is covered by the dynamic semantics.

Stating **this** in <destination> is derived syntax for the implicit <agent identifier> that identifies the set of instances for the agent in which the output is being interpreted.

Mapping to abstract syntax

| <output>(*o*) **then mk-***Graph-node*(*Mapping*(*o*)
| <output body>(< <output body item>(*id*, *params*, *delay*, *priority*) >, *constr*) **then**
mk-*Output-node*(*Mapping*(*id*), *Mapping*(*params*), *Mapping*(*delay*), *Mapping*(*priority*),
Mapping(*head*(< *c* **in** *constr*: (*c* ∈ <destination>) >)),
{ *Mapping*(*c* **in** *constr*): *c* ∈ <via path> } // set of via path gate id mappings
| <destination>(*d*) **then** *Mapping*(*d*)
| <via path>(*gate_id*) **then** *Mapping*(*gate_id*)
| <activation delay>(*delay*) **then**
if *delay=undefined*
then <Duration<expression>(0)
else <Duration<expression>(*delay*)
endif
| <signal priority>(*priority*) **then**
if *priority=undefined*
then <Natural<expression>(0)
else < Natural<expression>(*priority*)
endif

Auxiliary functions

The function *usedSignalSet0* provides the set of signal identifiers defined by the list of signal list items in the interface use lists of the given interface definition and any interface use lists of inherited interface definitions. It does not include signals defined by the interface definition or defined by inherited interface definitions.

usedSignalSet0(*id*: <interface definition>): *SIGNAL0* =$_{def}$
{*sig*∈(*interfaceUseList*.s-<signal list item>-**seq**.*signalSet0*):
(*interfaceUseList* ∈ <interface use list>
∧ *parentAS0ofKind* (*interfaceUseList*, <interface definition>) = *id*
)}
∪
{ *sig*∈(*interfaceUseList1*.**s**-<signal list item>-**seq**.*signalSet0*):
(*interfaceUseList1* ∈ <interface use list>
∧ (∃*id1*∈<interface definition>: (*isSubtype0*(*id*, *id1*))
∧ *parentAS0ofKind* (*interfaceUseList1*, <interface definition>) = *id1*)
)}

The function *definedSignalSet0* provides the set of signal definitions in the signal definition list items of the given interface definition and any signal definitions of inherited interface definitions.

definedSignalSet0(*id*: <interface definition>): <signal definition>-**set** =$_{def}$
{*sd*∈<signal definition>:
((*sd*.*parentAS0*∈<signal definition list>) ∧ (*sd*.*parentAS0*.*parentAS0* = *id*))
∨
((∃*id1*∈<interface definition>: *isSubtype0*(*id*, *id1*)) ∧
(*sd*.*parentAS0*∈<signal definition list>) ∧ (*sd*.*parentAS0*.*parentAS0* = *id1*))}

The function *enclosingScopeGates1* is used to find the nearest *Composite-state-type-definition* or *Agent-type-definition* item with gates that encloses an *Output-node*, and returns a gate *Identifier*-**set** for the gates.

```
enclosingScopeGates1(td: Composite-state-type-definition ∪ Agent-type-definition):
    Identifier-set =def
if td = undefined then ∅
else
    if td.s-Gate-definition-set = ∅
    then
        enclosingScopeGates1(parentAS1ofKind(td,Composite-state-type-definition ∪ Agent-type-definition))
    else
        { gd.identifier1 | gd ∈ td.s-Gate-definition-set }
    endif
endif
```

The function *reachableGatesWithSignal1* returns the gate *Identifier*-**set** for gates that are reachable from the given gate *Identifier*-**set** with the given signal *Identifier*. A gate is reachable from one of the gates given if there is a channel path with the one of the given gates as an originating gate and the gate as a destination gate. The given signal has to be conveyed by the channel. The originating gate has to be a gate defined for the origin channel endpoint and the signal has to be a valid signal in the correct direction for this gate. The destination gate has to be a gate defined for the destination channel endpoint and the signal has to be a valid signal in the correct direction for this gate.

```
reachableGatesWithSignal1(gset: Identifier-set, sigid: Identifier): Identifier-set =def
let gis = { gi |
        cp ∈ Channel-path
    ∧   cp.s-Originating-gate ∈ gset
    ∧   gi ∈ cp.s-Destination-gate
    ∧   sigid ∈ cp.s-Identifier-set
    ∧   getEntityDefinition1(cp.s-Originating-gate, gate) ∈
            case cp.s1-Channel-endpoint of
            | id = Identifier then
                if getEntityDefinition1(id, agent) ≠ undefined
                then
                getEntityDefinition1(getEntityDefinition1(aid, agent).s-Identifier,
                    agent type).s-Gate-definition-set
                else
                getEntityDefinition1(parentAS1ofKind(cp, Agent-type-definition).s-State-machine.s-Identifier,
                    state type).s-Gate-definition-set
                endif
            | ENV then
                parentAS1ofKind(cp, Agent-type-definition).s-Gate-definition-set
            endcase
    ∧   sigid ∈
            case cp.s1-Channel-endpoint of
            | Identifier then getEntityDefinition1(cp.s-Originating-gate, gate).s2-Identifier-set
            | ENV then getEntityDefinition1(cp.s-Originating-gate, gate).s1-Identifier-set
            endcase
    ∧   getEntityDefinition1(cp.s-Destination-gate, gate) ∈
            case cp.s2-Channel-endpoint of
            | id = Identifier then
                if getEntityDefinition1(id, agent) ≠ undefined
                then
                getEntityDefinition1(getEntityDefinition1(aid, agent).s-Identifier,
                    agent type).s-Gate-definition-set
                else
                getEntityDefinition1(parentAS1ofKind(cp, Agent-type-definition).s-State-machine.s-Identifier,
                    state type).s-Gate-definition-set
                endif
            | ENV then
                parentAS1ofKind(cp, Agent-type-definition).s-Gate-definition-set
            endcase
    ∧   sigid ∈
            case cp.s2-Channel-endpoint of
```

```
            | Identifier then getEntityDefinition1(cp.s-Destination-gate, gate).s1-Identifier-set
            | ENV then getEntityDefinition1(cp.s-Destination-gate, gate).s2-Identifier-set
            endcase }
in
    gset ∪ if gis = ∅ then ∅ else reachableGatesWithSignal1(gis, sigid) endif
endlet
```

The function *reachableAgentsWithSignal1* returns the agent *Identifier*-**set** for agents that are reachable from the given gates with the given signal *Identifier*. The function is called with a gate *Identifier*-**set** for the gates on an agent. The paths from these gates that carry the given signal are found. The *Identifier*-**set** with the name agents is the set of agents directly reachable via these paths. If there are paths that lead to gates for environment of the agent, there can be additional agents reachable from these gates.

```
reachableAgentsWithSignal1(sourceGates: Identifier-set, sigid: Identifier): Identifier-set =def
let  paths = {cp ∈ Channel-path:
        cp.s1-Channel-endpoint ∈ sourceGates
    ∧   sigid ∈ cp.s-Identifier-set
    ∧   sigid ∈
            case cp.s1-Channel-endpoint of
            | Identifier then getEntityDefinition1(cp.s-Originating-gate, gate).s2-Identifier-set
            | ENV then getEntityDefinition1(cp.s-Originating-gate, gate).s1-Identifier-set
            endcase
    ∧   sigid ∈
            case cp.s2-Channel-endpoint of
            | Identifier then getEntityDefinition1(cp.s-Destination-gate, gate).s1-Identifier-set
            | ENV then getEntityDefinition1(cp.s-Destination-gate, gate).s2-Identifier-set
            endcase }
in
let  agents = {a ∈ Identifier:
        cp ∈ paths
    ∧   a ∈ cp.s2-Channel-endpoint
    ∧   atd ∈ Agent-type-definition
    ∧   a = atd.Identifier1}
in
let  gates = {g ∈ Identifier:
        cp ∈ paths
    ∧   g ∈ cp.s2-Identifier}
in
    agents ∪ if gates = ∅ then ∅ else reachableAgentsWithSignal1(gates, sigid) endif
endlet
endlet
endlet
```

F2.2.8.13.5 Decision

Abstract syntax

Decision-node	::	*Decision-body* | *Any-decision*
Decision-body	::	*Decision-question* *Decision-answer*-**set** [*Else-answer*]
Decision-question	=	*Expression* | *Informal-text*
Decision-answer	::	{ *Range-condition* | *Informal-text* } *Transition*
Else-answer	::	*Transition*
Any-decision	::	*Transition*-**set**

Conditions on abstract syntax

∀*dn* ∈ *Decision-question*: ∀*r, r1* ∈ *Range-condition*: ∀*ce,ce1* ∈ *Constant-expression*:
isAncestorAS1(*r,ce*)∧ *isAncestorAS1*(*r1,ce1*) ∧ (*ce*≠*ce1*)∧
r1. *parentAS1*∈ *dn*.**s**-*Decision-answer*-**set** ∧ *r*. *parentAS1*∈ *dn*.**s**-*Decision-answer*-**set**⇒
(*isCompatibleTo1*(*ce*. *staticSort1, ce1*. *staticSort1*)∨
isCompatibleTo1(*ce1*. *staticSort1, ce*. *staticSort1*)) ∧
(*dn*.**s**-*Decision-question*∈*Expression*⇒
isCompatibleTo1(*ce*. *staticSort1, dn*.**s**-*Decision-question*. *staticSort1*))

Each *Constant-expression* of the *Range-condition* shall be sort compatible with the sort of the *Decision-question*. If the *Decision-question* is an *Expression*, the *Range-condition* of each *Decision-answer* shall be sort compatible with the sort of the *Decision-question*. See clause 11.13.5 *Abstract grammar* of [ITU-T Z.106].

Concrete syntax

<decision> :: <question> <textual decision body>

<textual decision body> :: <textual answer part>+ [<textual else part>]

<textual answer part> :: [<answer>] [<transition>]

<answer> = <range condition> | <informal text>

<textual else part> :: [<transition>]

<question> = <expression> | <informal text> | **any**

Conditions on concrete syntax

∀*d*∈<decision>: (*d*.**s**-<question> = **any**) ⇔
¬(∃*ap*∈<textual answer part>: (*ap*.*parentAS0*.*parentAS0*= *d*)) ∧ (*ap*.**s**-<answer> ≠ *undefined*) ∧
(*d*.**s**-<textual decision body>.**s**-<textual else part> = *undefined*)

The <answer> of <textual answer part> shall be omitted if and only if the <question> consists of the keyword **any**. In this case, a <textual else part> shall be absent. See clause 5.7.12.5 [ITU-T Z.106].

Transformations

See clause 5.7.12.5 [ITU-T Z.106].

<textual else part>(*undefined*) =5=>
<textual else part>(<transition action items>(*empty*, *undefined*))

<textual answer part>(*a*, *undefined*) =5=>
<textual answer part>(*a*, <transition action items>(*empty*, *undefined*))

These first two transformations are used to insert an empty transition instead of an undefined one. This empty transition will be filled with a terminator within the step below (inserting terminating actions into the transition).

t=<transition action items>(*a*, *undefined*)
provided *a*.*last* ∉ <decision> ∧ *t.parentAS0.parentAS0.parentAS0* ∈ <decision> ∧
t.findContinueLabel ≠ *undefined*
=5=> <transition action items>(*a*,
<terminator>(*undefined*,<join>(*findContinueLabel*(*t*))))

If a <decision> is not terminating, it is derived syntax for a <decision> where all not terminating <textual answer part>s and the <textual else part> (if not terminating) have inserted at the end of their <transition> a <join> to the first <action> following the decision or (if the decision is the last <action> in a <transition string>) to the following <terminator>.

< *d* =<decision>(*, *), <action>(*undefined, a*) > **provided** ¬ *terminatingDecision*(*d*)
=5=> < *d*, <action>(*newName, a*) >

<transition action items>(*str*, <terminator>(*undefined*, *t*))
provided *str*.*last* ∈ <decision> ∧ ¬ *str*.*last*.*terminatingDecision*
=5=> <transition action items>(*str*, <terminator>(*newName*, *t*))

The rules above insert a new label after a non-terminating decision.

Mapping to abstract syntax

| <decision>(*q*, <textual decision body>(*answers*, *elseAnswer*)) **then**
if *q*≠ **any**
then mk-*Decision-node*(*Mapping*(*q*), *Mapping*(*answers*).*toSet*, *Mapping*(*elseAnswer*))
else mk-*Any-decision*(*Mapping*(*answers*))
endif

| <textual answer part>(*ans*, *trans*) **then**
if *ans≠undefined*
then mk-*Decision-answer*(*Mapping*(*ans*), *Mapping*(*trans*))
else mk-*Transition*(*Mapping*(*trans*))
endif

If *ans≠undefined* the <textual answer part> is the *Decision-answer* of a *Decision-body*, otherwise the <textual answer part> is the *Transition* of an *Any-decision*.

| <textual else part>(*trans*) **then**
if *trans=undefined*
then *undefined*
else mk-*Else-answer*(*Mapping*(*trans*))
endif

Auxiliary functions

rangeConditionList0(*d*:<decision>):<range condition>*=$_{\text{def}}$
let *apl* = *d*.**s-**<textual decision body>.**s-**<textual answer part> **in**
apl.*answerPartRangeConditionList0*
endlet

answerPartRangeConditionList0(*apl*:<textual answer part>*):<range condition>*=$_{\text{def}}$
if *apl*.*head*.**s-**<answer>∈<range condition> **then**
apl.*head*.**s-**<answer>⌒*apl*.*tail*. *answerPartRangeConditionList0*
else *apl*.*tail*. *answerPartRangeConditionList0*

The function *findContinueLabel* computes the continuation label after a decision within a transition string.

findContinueLabel(*x*: *DefinitionAS0*): <name> =$_{\text{def}}$
if *x* ∈ <transition action items> ∧ *x*.**s-**<terminator> ≠ *undefined* ∧
x.**s-**<terminator>.**s-**<label> = *undefined* ∧
x.**s-**<terminator>.**s-**<terminator node> ∈ <join>
then *x*.**s-**<terminator>.**s-**<terminator node>.**s-**<name>
else *findContinueLabel*(*x*.*parentAS0*)
endif

terminatingDecision(*d*: <decision>): *BOOLEAN* =$_{\text{def}}$
(∀ *a* ∈ *d*.**s-**<textual answer part>: *terminatingTransition*(*a*.**s-**<transition>)) ∧
(*d*.**s-**<textual else part> = *undefined* ∨
terminatingTransition(*d*.**s-**<textual else part>.**s-**<transition>))

A <decision> is a terminating decision, if each <textual answer part> and <textual else part> in its <textual decision body> is a terminating <textual answer part> or <textual else part> respectively.

terminatingTransition(*t*: <transition>): *BOOLEAN* =$_{\text{def}}$
t ∈ <terminator> ∨

t.**s-**<terminator node> ≠ *undefined* ∨
(**let** *d*= *t*.**s-**<action>.*last* **in** *d* ∈ <decision> ∧ *terminatingDecision* (*d*) **endlet**)

A <textual answer part> or <textual else part> in a decision is a terminating <textual answer part> or <textual else part> respectively if it contains a <transition> where a <terminator> is specified, or contains a <transition string> whose last <action> contains a terminating decision.

F2.2.8.14 Statement lists

Concrete syntax

<statements> ::
<non terminating statements> [[<connector name>] <terminating statement>]
| [<connector name>] <terminating statement>

<non terminating statements> = <non terminating statement>+

<non terminating statement> ::
[<connector name>] <statement>
| <compound statement>
| <loop statement>
| <decision statement>

<statement> =
<assignment statement>
| <set statement>
| <reset statement>
| <output statement>
| <create statement>
| <export statement>
| <call statement>
| <expression statement>

<set statement> = <set body>

<reset statement> = <reset body>

<output statement> = <output body>

<create statement> = <create body>

<terminating statement> =
<return statement>
| <break statement>
| <stop statement>

<variable definitions> = <variable definition statement>*

<variable definition statement> :: <local variables of sort>+

<local variables of sort> :: <aggregation kind> <variable<name>+ <sort> [<expression>]

Transformations

<local variables of sort>(*ak*, < *v* > ⌒ *rest*, *s*, *expr*) **provided** *rest* ≠ *empty* =5=>
<local variables of sort>(*ak*, < *v* >, *s*, *expr*) ⌒ <local variables of sort>(*ak*, *rest*, *s*, *expr*)

A <local variables of sort> contains one or more several <variable<name> items. This is derived syntax for specifying a sequence of <local variables of sort> items, one for each <variable<name>. See clause 11.14.1 *Concrete grammar* of [ITU-T Z.102].

<variable definition statement>(< *v* > ⌒ *rest*) **provided** *rest* ≠ *empty* =5=>
<variable definition statement>(< *v* >), <variable definition statement>(*rest*)

A <variable definition statement> contains one or more <local variables of sort> items. This is derived syntax for specifying a sequence of <variable definition statement> items, one for each <local variables of sort>. See clause 11.14.1 *Concrete grammar* of [ITU-T Z.102].

Mapping to abstract syntax

| <variable definition statement>(< *var* >) **then** *Mapping*(*var*)

| <local variables of sort>(*ak*, < *var* >, *s*, *expr*) **then**
mk-*Variable-definition*(*Mapping*(*var*), *Mapping*(*s*), *Mapping*(*ak*), *Mapping*(*expr*))

F2.2.8.14.1 Compound statement

Abstract syntax

Compound-node	::	*Connector-name* *Variable-definition*-**set** *Init-graph-node** *While-graph-node* *Transition* *Step-graph-node**
Init-graph-node	=	*Graph-node*
While-graph-node	=	*Expression** [*Finalization-node*]
Finalization-node	=	*Graph-node*
Step-graph-node	=	*Graph-node*
Continue-node	::	*Connector-name*
Break-node	::	*Connector-name*

Concrete syntax

<compound statement> :: [<connector name>] [<variable definitions>] <statements>

Conditions on abstract syntax

∀*cn*∈*Continue-node*: ∃*comp*∈ (*Compound-node*) :
isAncestorAS1(*comp, cn*) ∧ (*cn*.**s**-*Connector-name* = *comp*.**s**-*Connector-name*)

A *Continue-node* shall be contained in a *Compound-node* that has been labelled with the given *Connector-name*.

∀*bn*∈*Break-node*: ∃*comp*∈ (*Compound-node*) :
isAncestorAS1(*comp, bn*) ∧ (*bn*.**s**-*Connector-name* = *comp*.**s**-*Connector-name*)

A *Break-node* shall be contained in a *Compound-node* that has been labelled with the given *Connector-name*.

Transformations

<compound statement>(*undefined*,*vardefs*,*stmts*)
=5=> <compound statement>(*newName*,*vardefs*,*stmts*)

If the <compound statement> has a <connector name> this represents the *Connector-name*; otherwise a newly created anonymous name represents the *Connector-name*. See clause 11.14.1 *Concrete grammar* of [ITU-T Z.102].

The following statements are handled by the Mapping.

A <compound statement> creates its own scope for any variables defined in the statement and the connector name.

If the <compound statement> contains <variable definitions>, the following is performed for each <variable definition statement>. A new <variable name> is created for each <variable name> in the <variable definition statement>. Each occurrence of <variable name> in the following <variable definition statement>s and within <statements> is replaced by the corresponding newly created <variable name>.

For each <variable definition statement>, a <variable definition> is formed from the <variable definition statement> by omitting the initializing <expression> (if present) and inserted as a <variable definition statement> in place of the original <variable definition statement>. If an initializing <expression> is present, an <assignment statement> is constructed for each <variable name> mentioned in the <local variables of sort> in the order of their occurrence, where <variable name> is given the result of <expression>. These <assignment statement> items are inserted at the front of <statement> items in the order of their occurrence.

If the <statements> list does not end in a <terminating statement>, the *Transition* is a *Graph-node* list represented by the <non terminating statements> of the <statements> list followed by a *Break-node* with the *Connector-name* as the *Terminator* of the *Transition*. If the <statements> list ends in a <terminating statement>, the *Transition* is a *Graph-node* list represented by the <non terminating statements> of the <statements> list followed by the *Terminator* represented by the <terminating statement>.

If the <statements> list is omitted, the *Transition* is an empty *Graph-node* list followed by a *Break-node* with the *Connector-name* as the *Terminator* of the *Transition*.

Mapping to abstract syntax

| <compound statement>(*cn*, *vars*, *allstats* = *stats* ⌒ < *laststatement* >) **then**
mk-*Compound-node*(*Mapping*(*cn*), *Mapping*(*vars*).*toSet*, *undefined*, *empty*,
if *laststatement* ∈ <terminating statement>
then mk-*Transition*(*Mapping*(*stats*), *Mapping*(*laststatement*))
else mk-*Transition*(*Mapping*(*allstats*), **mk-***Break-node*(*Mapping*(*cn*)))
endif,
empty)

| <compound statement>(*cn*, *vars*, *empty*) **then**
mk-*Compound-node*(*Mapping*(*cn*), *Mapping*(*vars*).*toSet*, *undefined*, *empty*,
mk-*Transition*(*Mapping*(*empty*), **mk-***Break-node*(*Mapping*(*cn*))), *empty*)

F2.2.8.14.2 Transition actions and terminators as statements

Concrete syntax

<assignment statement> :: <assignment>

<return statement> :: <return body>

<call statement> :: <procedure call body> | <remote procedure call body>

Conditions on concrete syntax

∀*rs*∈<return statement>:
(*parentAS0ofKind*(*rs*, <internal procedure definition>)≠*undefined*)∨
(*parentAS0ofKind*(*rs*,<operation definition>)≠*undefined*)

A <return statement> is only allowed within an <internal procedure definition> or within an <operation definition>.

Transformations

The following statements are handled by the Mapping.

<assignment statement> is transformed into the <task>

task <assignment>;

A <call statement> is derived syntax for <procedure call> and is transformed into a <procedure call> with the same <procedure call body>:

call <procedure call body>;

The transform of an <algorithm action statement> and a <return statement> is obtained by dropping the trailing <end>.

Mapping to abstract syntax

| <assignment statement>(*a*) **then** *Mapping*(*a*)

| <return statement>(*r*) **then** *Mapping*(*r*)

| <call statement>(*c*) **then** *Mapping*(*c*)

F2.2.8.14.3 Expressions as statements

Concrete syntax

<expression statement> :: <operator application>

Transformations

let *nn*=*newName* **in**
<expression statement>(*expr*) =3=>
    <compound statement>(
        < <variable definition statement>
            (< <local variables of sort>(< *nn* >, *expr.staticSort0*, *undefined*) >) >,
        < <assignment statement>(<assignment>(<identifier>(*undefined*, *nn*), *expr*)) >
)
endlet // *nn*

A new <variable name> is created. A <variable definition> is constructed that declares the newly created <variable name> to be of the same sort as the result of <operation application>. Finally, the expression statement is transformed to a <compound statement> consisting of the newly constructed <variable definition>, followed by an <assignment> between the variable with <variable name> and the <operation application>.

F2.2.8.14.4 If statements

Concrete syntax

<if statement> ::
        [<connector name>] <Boolean<expression> <consequence statement> [<alternative statement>]

<consequence statement> = [<non terminating statement>]

<alternative statement> = <non terminating statement> | <terminating statement>

<loop if statement> ::
        [<connector name>]
        <Boolean<expression> <loop consequence statement> [<loop alternative statement>]

<loop consequence statement> = [<statement in loop> | <loop terminating statement>]

Transformations

<if statement>(*connectorname*, *expr*, *cons*, *alt*) =3=>
    <decision statement>(*connectorname*, *expr*,
        <decision statement body>(<
            <algorithm answer part>("true", *cons*),
            if *alt* ≠ *undefined* **then** <algorithm else part>(*alt*) **endif**
            >, *undefined*))

<loop if statement>(*connectorname*, *expr*, *cons*, *alt*) =3=>
    <loop decision statement>(*connectorname*, *expr*,
        <decision statement body>(<
            <algorithm answer part>("true", *cons*),
            if *alt* ≠ *undefined* **then** <algorithm else part>(*alt*) **endif**
            >, *undefined*))

The <if statement> (or <loop if statement>) is transformed to the following <decision statement> (or <loop decision statement> respectively):

decision *boolean expression* {
(true): consequence statement
else : alternative statement
};

where *boolean_expression*, *consequence_statement* and *alternative_statement* represent actual text for the <Boolean expression>, <consequence statement> (<loop consequence statement> respectively) and <alternative statement> (<loop alternative statement> respectively).

F2.2.8.14.5 Decision statements

Concrete syntax

<decision statement> ::
[<connector name>] <question> <decision statement body>
| <if statement>

<decision statement body> :: <algorithm answer part>+ [<algorithm else part>]

<algorithm answer part> :: <answer> [<non terminating statement> | <terminating statement>]

<algorithm else part> :: <alternative statement>

<loop decision statement> ::
[<connector name>] <question> <loop decision statement body>
| <loop if statement>

<loop decision statement body> :: <loop answer part>+ [<loop else part>]

<loop answer part> ::<answer> { <statement in loop> | <loop terminating statement> }

<loop else part> :: <loop alternative statement>

<loop alternative statement> = <statement in loop> | <loop terminating statement>

A <loop decision statement> differs from a <decision statement> only because it uses <loop decision statement body> instead of <decision statement body> (or <loop if statement> instead of <if statement>) so that <loop break statement> and <loop continue statement> are allowed in the loop. Similarly <loop answer part>, <loop else part>, <loop alternative statement>, <statement in loop> and <loop terminating statement> are used instead of <algorithm answer part>, <algorithm else part>, <alternative statement>, <non terminating statement> and <loop terminating statement>, respectively.

Mapping to abstract syntax

| <decision statement>(*connectorname*, *ques*, *body*) **then**
Mapping(<loop decision statement>(*connectorname*, *ques*, *body*))

The main difference between a <decision statement> and a <loop decision statement> is the inclusion of <loop continue statement> and <loop break statement>, but these are syntactically excluded from <decision statement>, therefore the *Mapping* for <loop decision statement> is used here.

Each <algorithm answer part> of a <decision statement> represents a *Decision-answer* of the *Decision-node* of the *Transition* of the *Compound-node*. If the <algorithm answer part> is a <terminating statement>, the *Transition* of the *Decision-answer* is the *Terminator* represented by the <terminating statement>. If there is no <non terminating statement> or <terminating statement> in the <algorithm answer part>, the *Transition* of the *Decision-answer* is an empty *Graph-node* list followed by a *Break-node* with the *Connector-name* of the *Compound-node*. If the <algorithm answer part> is a <non terminating statement>, the *Transition* of the *Decision-answer* is the *Graph-node* represented by the <non terminating statement> followed by a *Break-node* with the *Connector-name* of the *Compound-node*.

An <algorithm else part> of a <decision statement> represents the *Else-answer* of the *Decision-node* of the *Transition* of the *Compound-node*. If the <alternative statement> is a <terminating statement>, the *Transition* of the *Else-answer* is the *Terminator* represented by the <terminating statement>. If there is no <alternative statement> or no <algorithm else part> in the <decision statement> the *Transition* of the *Else-answer* contains only a *Break-node* with the *Connector-name* of the *Compound-node*. If the <alternative statement> is a <non terminating statement>, the *Transition* of the *Else-answer* is the *Graph-node* represented by the <non terminating statement>.

The mapping of <algorithm answer part> and <algorithm else part> is included in the mapping of <decision statement>. The <if statement> alternative of <decision statement> is removed by a transformation in F2.2.8.14.4 If statements.

```
| <loop decision statement>( connectorname, ques, <loop decision statement body>(answers, elsePart)) then
    let cn= if connectorname = undefined then newName else connectorname endif in
        mk-Compound-node(Mapping(cn), ∅, empty,
            mk-Transition(
                mk-Decision-node(
                    mk-Decision-body(
                        Mapping(ques),
                        {   mk-Decision-answer(
                            Mapping(ans),
                            if stat(cc) ∈ <loop continue statement>
                            then mk-Transition(empty,
                                if cc = undefined
                                then mk-Continue-node(cn)
                                else mk-Continue-node(cc)
                                endif)
                            elseif stat ∈ <loop terminating statement>
                            then mk-Transition(empty, Mapping(stat))
                            elseif stat = undefined
                            then mk-Transition(empty,  mk-Break-node(cn))
                            else mk-Transition(Mapping(stat),  mk-Break-node(cn))
                            endif)
                            | aap(ans,stat) in answers },
                        mk-Else-answer(
                            if elsePart ∈ <loop terminating statement>
                            then mk-Transition(empty, Mapping(elsePart))
                            elseif elsePart = undefined
                            then mk-Transition(empty,  mk-Break-node(cn))
                            else mk-Transition(Mapping(elsePart),  mk-Break-node(cn))
                            endif
                        )
                    )
                )
            )
        )
    endlet
```

A <loop decision statement> represents a *Compound-node* in the same way as <decision statement> except that a *Transition* of a *Decision-answer* or *Else-answer* has a *Break-node* for a <loop break statement> or a *Continue-node* for a <loop continue statement>. The mapping of <loop answer part> and <loop else part> is included in the mapping of <loop decision statement>. The <loop if statement> alternative of <loop decision statement> is removed by a transformation in in F2.2.8.14.4 If statements.

F2.2.8.14.6 Loop statements

Concrete syntax

```
<loop statement> ::
        [ <connector name> ] <loop clause>* <loop body statement> [<finalization statement>]
```

<loop body statement> = <statement in loop>

<statement in loop> =
<statement>
| <loop statement>
| <loop compound statement>
| <loop decision statement>

<loop compound statement> ::
[<connector name>] <variable definitions> <loop statements>

A <loop compound statement> differs from a <compound statement> because it uses <loop statements> instead of <statements>.

<loop statements> ::
<statement in loop>+ [<loop terminating statement>]
| <loop terminating statement>

A <loop statements> list differs from a <statements> because it optionally ends with a <loop terminating statement> instead of <terminating statement>, and also because it has <statement in loop> instead of <statement>.

<loop terminating statement> =
<terminating statement>
| <loop break statement>
| <loop continue statement>

A <loop terminating statement> allows <loop break statement> and <loop continue statement> as well as <terminating statement>.

<finalization statement> = <statement> | <compound statement>

<loop clause> ::
[<loop variable indication>] [<Boolean<expression>] <loop step>

<loop step> = [<expression> | <procedure call body>]

<loop variable indication> =
<loop variable definition> | <loop variable indication identifier>

<loop variable indication identifier> :: <variable<identifier> [<expression>]

<loop variable definition> :: <aggregation kind> <variable<name> <sort> <expression>

<loop break statement> :: ()

<loop continue statement> :: [<connector<name>]

Conditions on concrete syntax

∀*lc*∈<loop clause>:
if = *lc*.**s**-<loop step>∈<expression> ∪ <procedure call body> **then**
then *lc*.**s**-<loop variable indication> ≠ *undefined*
end**if**

If a <loop step> of a <loop clause> has an <expression> or <procedure call body> the <loop variable indication> of the <loop clause> shall not be omitted.

∀*ls*∈<loop step>:
(**let** *pd* = *ls*.**s**-<procedure call body>.*calledProcedure0* **in**
pd ≠*undefined*∧*pd*.**s**-<procedure heading>.**s**-<procedure result> = *undefined*
endlet)

The <procedure identifier> in the <procedure call body> of a <loop step> must not refer to a value returning procedure call.

Transformations

l=<loop statement> ∧ *l*.**s**-<connector name> = *undefined* =3=>

l.**s-**<connector name> = *newName*

Generate a name for every unlabelled <loop statement>.

Mapping to abstract syntax

```
| l=<loop statement>(cn, lc, body, final) then
    mk-Compound-node(Mapping(cn),
      // Variable-definition-set of the Compound-node
      { mk-Variable-definition(
            Mapping(c.s-<loop variable indication>.s-<name>),
            Mapping(c.s-<loop variable indication>.s-<sort>),
            PART,
            undefined) // Variable definition
        | c ∈ lc.toSet ∧ c.s-<loop variable indication> ∈ <loop variable definition>
      }, // Variable-definition-set of the Compound-node
      // Init-graph-node list of the Compound-node
      < let lvi=lc.s-<loop variable indication> in
        if lvi ∈ <loop variable definition>
        then mk-Graph-node(mk-Task-node(
              mk-Assignment(
                Mapping(mk-<identifier>(<mk-<path item>(composition, cn)>,lvi.s-<name>)),
                Mapping(lvi.s-<expression>))
            ))
        elseif // lvi ∈ <loop variable definition indicator>
            lvi.s-<expression> ≠ undefined
        then mk-Graph-node(mk-Task-node(
              mk-Assignment(Mapping(lvi.s-<identifier>), Mapping(lvi.s-<expression>))
            ))
        endif
        endlet
      | c in lc: c.s-<loop variable indication> ≠ undefined >,
      // While-graph-node of the Compound-node
      mk-While-graph-node(
        < mk-Expression(c.s-<expression>) | c in lc: c.s-<expression> ≠ undefined >,
        // Finalization-node of the Compound-node
        if final ≠ undefined then mk-Graph-node(Mapping(final)) endif
      ),
      // Transition of the Compound-node
      if body(cc) ∈ <loop continue statement>
      then mk-Transition(empty,
        if cc = undefined
        then mk-Continue-node(Mapping(cn))
        else mk-Continue-node(Mapping(cc))
        endif)
      elseif body ∈ <loop terminating statement>
      then mk-Transition(empty, Mapping(body))
      elseif body = undefined
      then mk-Transition(empty, mk-Continue-node(Mapping(cn)))
      else mk-Transition(< Mapping(body) >, mk-Continue-node(Mapping(cn)))
      endif,
      // Step-graph-node of the Compound-node
      < let lvi=c.s-<loop variable indication> in
        let ls=c.s-<loop step> in
        if lvi ∈ <loop variable definition>
        then mk-Graph-node(mk-Task-node(
              mk-Assignment (
                Mapping(mk-<identifier>(<mk-<path item>(composition, cn)>,lvi.s-<name>),
                Mapping(ls))
            ))
        else mk-Graph-node(mk-Task-node(
              mk-Assignment (Mapping(lvi.s-<identifier>), Mapping(ls))
            ))
```

```
            endif
            endlet
            endlet
        | c in lc: c.s-<loop step> ≠ undefined >
    ) // end of Compound-node for <loop statement>
```

A <loop statement> represents a *Compound-node*. If the <loop statement> has a <connector name> this represents the *Connector-name*; otherwise a newly created anonymous name represents the *Connector-name*.

Each <aggregation kind> <variable name> <sort> set in a <loop variable definition> represents the *Aggregation-kind*, *Variable-name* and *Sort-reference-identifier* of an element of the *Variable-definition-**set*** of the *Compound-node*. Each <variable name> and associated <expression> in a <loop variable definition> also represents the *Variable-identifier* and *Expression* of an *Assignment* in a *Task-node* of the *Init-graph-node* list of the *Compound-node*. The <variable name> in a <loop variable definition> also represents the *Variable-identifier* in any *Step-graph-node* for the <loop step> following the <loop variable indication>.

Each <variable identifier> and associated <expression> in a <loop variable indication> represents the *Variable-identifier* and *Expression* of an *Assignment* in a *Task-node* of the *Init-graph-node* list of the *Compound-node*. The <variable identifier> in a <loop variable indication> also represents the *Variable-identifier* in the *Step-graph-node* for the <loop step> following the <loop variable indication>. The <variable identifier> in the <loop variable indication> also represents the *Variable-identifier* in any *Step-graph-node* for the <loop step> following the <loop variable indication>.

The *Task-node* items from the <loop variable indication> items occur in the *Init-graph-node* list in the same order (left to right, top to bottom) as the <loop clause> items in the <loop statement>.

Each <Boolean expression> in a <loop clause> represents a Boolean *Expression* in the *While-graph-node* of the *Compound-node* for the <loop statement> in the order of each <loop clause> in the <loop statement>.

A <loop body statement> represents the *Transition* of the *Compound-node*. The *Transition* is the *Graph-node* represented by the <statement in loop> (a <non terminating statement> or <loop statement> or <loop compound statement> or <loop decision statement>) followed by a *Continue-node* with the *Connector-name* of the *Compound-node*.

Each <expression> or <procedure call body> of a <loop step> represents an *Expression* of an *Assignment* in a *Task-node* of the *Step-graph-node* list of the *Compound-node*. The *Variable-identifier* of the *Assignment* is the one represented by the <variable identifier> or <variable name> of the preceding <loop variable indication>.

The *Task-node* items from the <loop step> items occur in the *Step-graph-node* list in the same order (left to right, top to bottom) as the <loop clause> items in the <loop statement>.

The mapping of <finalization statement>, <loop clause>, <loop step>, <loop variable indication>, <loop variable indication identifier> and <loop variable definition> is included in the mapping of <loop statement>.

```
| <loop compound statement>( cn, vars, allstats = stats ⌒ < laststatement >) then
    mk-Compound-node(Mapping(cn), Mapping(vars).toSet, undefined, empty,
        if laststatement ∈ <loop terminating statement>
        then mk-Transition(Mapping(stats), Mapping(laststatement))
        else mk-Transition(Mapping(allstats), mk-Break-node(Mapping(cn)))
        endif,
        empty)
```

A <loop compound statement> represents a *Compound-node* in the same way as a <compound statement> except that the *Transition* represented by <loop statements> optionally ends with a *Break-node* for a <loop break statement> or a *Continue-node* for a <loop continue statement>.

| *lbs* = <loop break statement> **then**
mk-*Break-node*(*Mapping*(*parentAS0ofKind*(*lbs*, <loop statement>).**s-**<connector name>))

A <loop break statement> represents a *Break-node* with the *Connector-name* of the immediately enclosing *Compound-node* for a <loop statement>.

| *lcs* = <loop continue statement>(*cn*) **then**
if *cn = undefined*
then mk-*Continue-node*(*Mapping*(*parentAS0ofKind*(*lcs*, <loop statement>).**s-**<connector name>))
else mk-*Continue-node*(*Mapping*(*cn*))
endif,

A <loop continue statement> without a <connector name> represents a *Continue-node* with the *Connector-name* of the immediately enclosing *Compound-node* for a <loop statement>. A <connector name> in a <loop continue statement> represents the *Connector-name* of the *Continue-node*.

F2.2.8.14.7 Break statement

Conditions on abstract syntax

∀*bs*∈*Break-node*: ∃*ls*∈ (*Compound-node*) :
isAncestorAS1(*ls*, *bs*) ∧ (*bs*.**s**-*Connector-name* = *ls*.**s**-*Connector-name*)

A *Break-node* shall be contained in a *Compound-node* that has been labelled with the given *Connector-name*.

Concrete syntax

<break statement> :: <connector<name>

Mapping to abstract syntax

| <break statement>(*name*) **then mk-***Break-node*(*Mapping*(*name*))

F2.2.8.15 Timer

Abstract syntax

Timer-definition	::	*Timer-name* *Sort-reference-identifier** [*Timer-default-initialization*]
Timer-default-initialization	=	*Constant-expression*
Set-node	::	*Time-expression Timer-identifier Expression**
Time-expression	=	*Expression*
Reset-node	::	*Timer-identifier Expression**

Conditions on abstract syntax

∀*n* ∈ *Set-node* ∪ *Reset-node*: ∀*d* ∈ *Timer-definition*:
(*d*=*getEntityDefinition1*(*n*.**s**-*Timer-identifier*,**timer**)) ⇒
isActualAndFormalParameterMatched1(*n*.**s**-*Expression*-**seq**, *d*.*formalParameterSortList1*)

The sorts of the list of *Expression*s in the *Set-node* and *Reset-node* must correspond by position to the list of *Sort-reference-identifier*s directly following the *Timer-name* identified by the *Timer-identifier*.

Concrete syntax

<timer definition> :: <timer definition item>+

<timer definition item> ::
<timer><name> [<sort list>] [<timer default initialization>]

<timer default initialization> :: <Duration><constant expression>

<set> :: <set body>

<set body> :: <set clause>+

<set clause> :: [<Time><expression>] <timer><identifier> <expression>*

<reset> :: <reset body>

<reset body> :: <reset clause>+

<reset clause> :: <timer><identifier> <expression>*

Transformations

<set clause>(*undefined*, *id*, *exprList*)
=8=> <set clause>
(<operator application>("+", **now**, *id.refersto0*.**s-**<timer default initialization>), *id*, *exprList*)

A <set clause> with no <Time expression> is derived syntax for a <set clause> where <Time expression> is

now + <Duration constant expression>

where <Duration constant expression> is derived from the <timer default initialization> in timer definition.

<set>(<set body>(< *s* > ⌒ *rest*)) **provided** *rest* ≠ *empty* =5=>
<set>(<set body>(< *s* >)) ⌒ <set>((<set body>(*rest*))

A <set> is allowed to contain several <set clause> items. This is derived syntax for specifying a sequence of <set> items, one for each <set clause> such that the original order in which they were specified in the <set> is retained.

<set statement>(<set body>(< *s* > ⌒ *rest*)) **provided** *rest* ≠ *empty* =5=>
<set statement>(<set body>(< *s* >)) ⌒ <set statement>((<set body>(*rest*))

A <set statement> is allowed to contain several <set clause> items. This is derived syntax for specifying a sequence of <set statement> items, one for each <set clause> such that the original order in which they were specified in the <set> is retained.

<reset>(<reset body>(< *r* > ⌒ *rest*)) **provided** *rest* ≠ *empty* =5=>
<reset>(<set body>(< *r* >)) ⌒ <reset>(<set body>(*rest*)) >

A <reset> is allowed to contain several <reset clause> items. This is derived syntax for specifying a sequence of <reset> items, one for each <reset clause> such that the original order in which they were specified in the <reset> is retained.

<reset statement>(<reset body>(< *s* > ⌒ *rest*)) **provided** *rest* ≠ *empty* =5=>
<reset statement>(<reset body>(< *s* >)) ⌒ <reset statement>((<reset body>(*rest*))

A <reset statement> is allowed to contain several <reset clause> items. This is derived syntax for specifying a sequence of <reset statement> items, one for each <reset clause> such that the original order in which they were specified in the <reset> is retained.

The shorthand items for <set>, <set statement>, <reset> and <reset statement> are expanded before shorthand items in the contained expressions are expanded. The shorthand items are in clause 11.5 *Model* of [ITU-T Z.103].

<timer definition>(< *t* > ⌒ *rest*) **provided** *rest* ≠ *empty* =5=>

<timer definition>(< *s* >) ⌒ <timer definition>(*rest*)

A <timer definition> is allowed to contain several <timer definition item>s. This is derived syntax for specifying a sequence of <timer definitions>s, one for each <timer definition item>. See clause 11.5 *Model* of [ITU-T Z.103].

Mapping to abstract syntax

| <timer definition>(< *item* >) **then** *Mapping*(*item*)

| <timer definition item>(*name*, *sortList*, *) **then**
mk-*Timer-definition*(*Mapping*(*name*), *Mapping*(*sortList*))

| <set>(< *clause* > **then mk-***Graph-node*(*Mapping*(*clause*))

| <set clause>(*expr*, *id*, *params*) **then mk-***Set-node*(*Mapping*(*expr*), *Mapping*(*id*), *Mapping*(*params*))

| <reset>(< *clause* > **then mk-***Graph-node*(*Mapping*(*clause*))

| <reset clause>(*id*, *params*) **then mk-***Reset-node*(*Mapping*(*id*), *Mapping*(*params*))

F2.2.9 Data

F2.2.9.1 Data definitions

Concrete syntax

<data definition> =
<entity in data type> | <interface definition>

<sort> ::
<basic sort> [<range condition>]
| <anchored sort>
| <pid sort>
| <inline data type definition>
| <inline syntype definition>

<basic sort> =
<datatype<type expression>
| <as signal>
| <as interface>
| <as channel>
| <as gate>
| <syntype>

<anchored sort> :: { **this** | **parent** } [<basic sort>]

<pid sort> = <sort<identifier>

<inline data type definition> :: [<data type specialization>] <data type definition body>

<inline syntype definition> :: <basic sort> { <default initialization> [<constraint>] | <constraint> }

Conditions on concrete syntax

∀*s*∈<sort>:
(∀*bsd* = *getEntityDefinition0*(*s*.**s-**<basic sort>.**s-**<identifier>, **sort**): *s*.**s-**<basic sort> ∈ <type expression>)
∧
(∀*rc* = *s*.**s-**<range condition>:(*rc* ≠ *undefined*))
⇒
bsd.**s-**<data type definition body>.**s-implicit** ∈ <literal list>
∨ *isSizeConstraintValid* (*bs*)

A <range condition> after a <basic sort> of a sort is only valid if the <basic sort> has been constructed using the literal data type constructor and the **constants (**<range condition>**)** is valid as a <constraint> for the <basic sort>, or if the **size (**<range condition>**)** is valid as a <constraint> for the <basic sort>. See clause 12.1 *Concrete grammar* of [ITU-T Z.104].

Transformations

s = < sort>(*anchSort* = <anchored sort>)
=14=>
mk-< sort>(
    mk-<type expression>(*sortId0*(*s*),*empty*),
    undefined) // range condition omitted

An <anchored sort> without a <basic sort> is a shorthand for specifying a <basic sort> with the name of the data type definition (or syntype definition) in the context where the <anchored sort> occurs. See clause 12.1 *Model* of [ITU-T Z.104].

Every occurrence of an <anchored sort> of the form **parent** T in a specialization of T, the <anchored sort> is replaced by an unambiguous qualified <basic sort> for the base type T: that is, the qualified <identifier> for T. Every occurrence of an <anchored sort> of the form **this** T in a specialization of T, the <anchored sort> is replaced by the <basic sort> of the subsort: that is, the <identifier> for the subsort ST. See clause 12.1.9 *Model* of [ITU-T Z.104].

let *nn* = *newName* **in**
s = <sort>(<type expression>(*bsort*, *empty*), *rc*)
=8=>
mk-< sort>(**mk-**<syntype<identifier>(*s.surroundingScopeUnit0.fullQualifierWithin0, nn*),*undefined*)
and // add the implicit syntype definition
=>
let *parent* = *s.surroundingScopeUnit0* **in** *entities=parent.getEntities0* **in**
entities ⌒
mk-<syntype definition>(*empty*,
    mk-<syntype definition syntype>(*nn*,
        bsort,
        undefined,
        if *getEntityDefinition0*(*bsort*, **sort**).**s-**<data type definition body>.**s-implicit** ∈ <literal list>
        then *rc*
        else mk-<size constraint>(*rc*)
        endif
))
endlet // *parent*
endlet // *nn*

A <sort> that is a <basic sort> with a <range condition> is derived concrete syntax for a <syntype> of an implied <syntype definition> having an anonymous name for the <syntype name> and the <basic sort> as the <parent sort identifier>. This anonymously named <syntype definition> is defined with no <default initialization> and with its elements restricted by a <constraint> based on the <range condition>. If the <basic sort> has been constructed using the literal data type constructor the <range condition> is transformed to a <constraint> of the <syntype definition> that is **constants (** <range condition> **)**; otherwise, the <range condition> is transformed to a <constraint> of the <syntype definition> that is **size (** <range condition> **).** See clause 12.1 *Model* of [ITU-T Z.104].

NOTE – The conditions on concrete syntax described below (in section F2.2.9.8.4Constraint) apply to the <syntype> and its <constraint> based respectively on <basic sort> and <range condition>.

let *nn* = *newName* **in**
s = <inline data type definition>(*dtspecial*, *dtdbody*)
=2=>
let *parent* = *s.surroundingScopeUnit0* **in**
mk-<type expression>(**mk-**<identifier>(*parent.fullQualifierWithin0,nn*), *empty*)

and // add the implicit data type definition
entities=parent.getEntities0
=>
entities ⌒ **mk-**<data type definition>(*empty*, *undefined*, *nn*, *dtspecial*, *dtdbody*, *undefined*)
endlet // parent
endlet // nn

An <inline data type definition> is derived concrete syntax for a <basic sort> of an implied <data type definition> having an anonymous name. This anonymously named <data type definition> is derived from the <inline data type definition> by inserting **type** and the anonymous name after **value** in the <inline data type definition>. Each <inline data type definition> defines a different implied <data type definition>. See clause 12.1 *Model* of [ITU-T Z.104].

<inline syntype definition>(*bsort*, *x*)
=2=>
case *x* **of**
| <default initialization> **then mk-**<inline syntype definition>(*bsort*, *x*, *undefined*)
| <constraint> **then mk-**<inline syntype definition>(*bsort*, *undefined*, *x*)
endcase

let *nn* = *newName* **in**
s = <inline syntype definition>(*bsort*, *init*, *constr*)
=2=>
mk-<syntype<identifier>(*s.surroundingScopeUnit0.fullQualifierWithin0*, *nn*)>
and // add the implicit syntype definition
let *parent* = *s.surroundingScopeUnit0* **in**
entities=parent.getEntities0
=>
entities ⌒ **mk-**<syntype definition>(*empty*, **mk-**<syntype definition syntype>(*nn*, *bsort*, *init*, *constr*))
endlet // parent
endlet // nn

An <inline syntype definition> is derived concrete syntax for a <basic sort> of an implied <syntype definition> having an anonymous name. This anonymously named <syntype definition> is derived from the <inline syntype definition> by inserting the anonymous name and <equals sign> after syntype in the <inline syntype definition>. See clause 12.1 *Model* of [ITU-T Z.104].

Auxiliary functions

The function *parentSortId0* gets the <identifier> of the parent data type definition of a sort, which is the same as the given sort except if it as a syntype, in which case it returns the identity of the data type definition on which the syntype is based.

parentSortId0(*s*: <sort<identifier>): <sort <identifier>=$_{def}$
getEntityDefinition0(*s*, **type**).*derivedDataType0.identifier0*

The function *sortId0* gets the <identifier> of a <sort>. Any <inline data type definition> or <inline syntype definition> is replaced at transformation step 2 by a <basic sort> or <syntype> (respectively), therefore these would not be offered as a parameter to *sortId0*.

sortId0(*s*: <sort>): <identifier>=$_{def}$
case *s* **of**
| <type expression> **then** *s*.**s-**<type expression>.**s-**<identifier>
| <as signal>(*sigId*) **then** *sigId.asSignal*
| <as interface> **then** *undefined*
| <as channel> **then** *undefined*
| <as gate>(*gid*) **then**
  if *gid.refersto0.asGateName* ≠ *undefined*
  then mk-<type expression>(**mk-**<identifier>(*gid*.**s-**<qualifier>, *gid.refersto0.asGateName*), *undefined*)
  else *undefined*
  endif

```
| anchSort = <anchored sort> then
    let parentDataTypeDef = parentAS0ofKind(anchSort, <data type definition>) in
    let basicSort = anchSort.s-<type expression>.s-<identifier> in
    case anchSort.s-implicit of
    | this then
        if basicSort = undefined ∨ isSubSort0(basicSort, parentDataTypeDef.identifier0)
        then parentDataTypeDef.identifier0  // change to subsort id if  basic sort undefined or supersort
        else basicSort // otherwise specified basic sort id
        endif
    | parent then
        if basicSort = undefined
        then // if  basic sort undefined
            if parentDataTypeDef.specialization0 ≠ undefined // if a specialized sort
            then parentDataTypeDef.specialization0.s-<type expression>.s-<identifier> // sort id of supersort
            else parentDataTypeDef.identifier0 // otherwise the sort id of the enclosing data type
            endif
        elseif isSubSort0(basicSort, parentDataTypeDef.identifier0) // basic sort defined and supersort
        then basicSort // if enclosing data type subsort of basic sort, change to basic sort id
        else parentDataTypeDef.identifier0 // otherwise the sort of the enclosing data type
        endif
    endcase
    endlet // basicSort
    endlet // parentDataTypeDef
| <identifier> then s.s-<identifier> // pid sort or syntype
| <inline data type definition> then undefined
| inlsd = <inline syntype definition> then inlsd.s-<basic sort>.sortId0
otherwise undefined
endcase
```

Further study is needed for <as channel>, <as interface> and <inline data type definition>.

The function *isSizeConstraintValid* determines if the range condition is a valid size constraint for the data type definition.

A <size constraint> shall only be used in the concrete syntax of a <constraint> if `Length` has been defined as an operation with the <operation signature>:

```
length (in P ) -> <<package Predefined>>Integer;
```

Where `P` is the sort of the syntype for the context of the <constraint>. See clause 12.1.8.2 *Concrete grammar* of [ITU-T Z.101].

```
isSizeConstraintValid(dtd: <data type definition>): BOOLEAN =def
(∃ opSig ∈ <operation signature>:
        opSig.s-<name> = mk-<name>("length")
    ∧   opSig.s-<arguments>.length = 1
    ∧   opSig.s-<arguments>[1].s-<formal parameter> =
            mk-<formal parameter> (in, mk-<sort>(mk-<type expression>(dtd.identifier0,empty)))
    ∧   opSig.s-<result> = mk-<sort>(mk-<type expression>( predefinedId0("Integer"),empty)
)
```

F2.2.9.2 Data type definition

Abstract syntax

Data-type-definition	=	*Value-data-type-definition*
	|	*Interface-definition*
Value-data-type-definition	::	*Sort* [*Data-type-identifier*] *Literal-signature*-**set** *Null-literal-signature* *Static-operation-signature*-**set** *Dynamic-operation-signature*-**set**

Procedure-definition-**set**
Data-type-definition-**set**
Syntype-definition-**set**
Variable-definition-**set**
[*Default-initialization*]
[*Abstract*]

Concrete syntax

<data type definition> ::
<package use clause>* <type preamble> <data type heading> [<data type specialization>]
[<data type definition body>]

<data type heading> ::
<data type<name> [<formal context parameters>] [<virtuality constraint>]

<data type definition body> ::
<entity in data type>* [<data type constructor>] <operations> [<default initialization>]

<entity in data type> =
<data type definition> | <syntype definition> | <synonym definition>

<operations> :: <operation signatures> <operation definitions>

<operation definitions> :: <operation definition item>*

Conditions on concrete syntax

∀*dtd*∈<data type definition>:∀*fcp*∈ <formal context parameter>:
fcp∈*dtd.localFormalContextParameterList0.toSet* ⇒
fcp∈<sort context parameter> ∪<synonym context parameter list>

A <formal context parameter> of <formal context parameters> must be either a <sort context parameter> or a <synonym context parameter list>.

∀*anchSort*∈<anchored sort>:
parentAS0ofKind(*anchSort*, <data type definition>) ≠ *undefined*

An <anchored sort> is legal concrete syntax only if it occurs within a <data type definition>. The <basic sort> in the <anchored sort> shall name the <sort> introduced by an enclosing <data type definition>. See clause 12.1 *Model* of [ITU-T Z.104].

∀*sid*∈<pid sort>:*isPidSort0*(*sid*)

The <sort<identifier> in a <pid sort> shall identify a pid sort. See clause 12.1 *Concrete grammar* of [ITU-T Z.101].

Mapping to abstract syntax

| *dtd*=<data type definition>(*, // package use clause
tp, // type preamble
<data type heading>(*name*, *, *),
base, // data type specialization
body) // data type definition body
then
let *bodyMapping* = *Mapping*(*body*)
in
mk-*Value-data-type-definition*(*Mapping*(*name*), *Mapping* (*base*),
{ *ls* ∈ *bodyMapping* : *ls* ∈ *Literal-signature* },
mk-*Literal-signature*(**mk-***Name*("null"), //null literal signature - literal name
mk-*Result*(**mk-***Identifier*(*Mapping*(*dtd.fullQualifier0*), *Mapping*(*name*)), **REF**)
*), //null literal signature - literal natural – arbitrary value as not used
{ *so* ∈ *bodyMapping* : *so* ∈ *Static-operation-signature* },
{ *do* ∈ *bodyMapping* : *do* ∈ *Dynamic-operation-signature* },
{ *pr* ∈ *bodyMapping* : *pr* ∈ *Procedure-definition* },
{ *dt* ∈ *bodyMapping* : *dt* ∈ *Data-type-definition* },
{ *sy* ∈ *bodyMapping* : *sy* ∈ *Syntype-definition*},

```
    { vd ∈ bodyMapping  : vd ∈ Variable-definition },
    if body.s-<default initialization> ≠ undefined
    then Mapping(body.s-<default initialization>.s-<operand5>)
    else undefined
    endif,
    if tp.s-<abstract> ≠ undefined then mk-Abstract else undefined endif
) // Value-data-type-definition
endlet // bodyMapping

| body  = <data type definition body>(entities, ctor, operations, init)
then
case ctor of
| <literal list>  then
    { Mapping(entities[i]) | i ∈ 1..entities.length } ∪ Mapping(ctor) ∪ Mapping(operations)
| <structure definition>(visi, fields) then
    let d= parentAS0ofKind(body, <data type definition>) in
    Mapping(
        mk-<data type definition body>(
            entities, undefined,
            mk-<operations>(
                mk-<operation signatures>(
                    mk-<operator list> (
                        d.getOpSigs0⌒d.structMakeSig0⌒d.structOpSigs0
                    ), // operator list
                 empty // method list – changed to operators and included in operators list
                ), // operation signatures
                operations.s-<operation definitions>⌒ d.structMakeDef0⌒ d.structOpDefs0
            ), // operations
            init // default initialization
        ) // data type definition body
    ) // Mapping
    endlet // d
| <choice definition>(visi, choices) then
    let nn= newName in // name for anonPresent
    let d= parentAS0ofKind(body, <data type definition>) in
    Mapping(
        mk-<data type definition body>(
            entities⌒ anonLiterals0(ctor, nn), undefined,
            mk-<operations>(
                mk-<operation signatures>(
                    mk-<operator list>( d.getOpSigs0⌒d.choiceOpSigs0(d, nn) )
                 empty // method list – changed to operators and included in operators list
                ), // operation signatures
                operations.s-<operation definitions>⌒ choiceOpDefs0(d, nn)
            ), // operations
             init // default initialization
        ) // data type definition body
    ) // Mapping
    endlet // d
    endlet // nn
otherwise
    { Mapping(entities[i]) | i ∈ 1.. entities.length } ∪ Mapping(operations) // ctor is undefined
endcase
```

The parameter *ctor* of the <data type definition body> is an optional <data type constructor>, which is a <literal list>, a <structure definition> or a <choice definition>.

```
| <operations>( operationsignatues, operationdefinitions)
then
    Mapping(operationsignatures) ∪ Mapping(operationdefinitions)
```

| <operation definitions>(*operationdefinitionitems*)
then
{ *Mapping*(*operationdefinitionitems*[*i*]) | *i* ∈ 1..*operationdefinitionitems.length* }

The following paragraphs are from clause 12.1.2 *Concrete grammar* of [ITU-T Z.101], and appear here because they are concerned with implicit *Interface-definition* items added to *Data-type-definition* sets.

Each agent type (and agent and state machine) implicitly defines an *Interface-definition*. This *Interface-definition* is in the same context as the definition of the agent type (or agent or state machine), so that (for example) the implicit *Interface-definition* for an item of the *Agent-type-definition-**set*** of an *Agent-type-definition* is an item of the *Data-type-definition-**set*** of the *Agent-type-definition*.

Interfaces are implicitly defined by each agent type definition and each agent definition (except the outermost agent) and by the state machine of each agent type definition. The implicitly defined interface for an agent or an agent type has the same name and is defined in the same scope unit as the agent or agent type that defined it. The implicitly defined interface for a state machine has the same name as the containing agent type but is defined in the same scope unit as the state machine that defined it: that is, inside the agent type.

An <interface name> represents the *Sort* of the *Interface-definition*, and this <name> is the *Interface-qualifier* as the <name> of a <path item> for a <qualifier> to identify the *Interface-definition* as a scope unit.

A <signal list> of an <interface use list> denotes items in the *Signal-identifier-**set*** of the *Interface-definition* as follows.

a) Each <signal identifier> of a <signal list> of an <interface use list> represents a corresponding *Signal-identifier* in the *Signal-identifier-**set*** that identifies a *Signal-definition*.

b) Each <timer identifier> of a <signal list> of an <interface use list> represents a corresponding *Signal-identifier* in the *Signal-identifier-**set*** that identifies a *Timer-definition*.

c) Each <interface identifier> of a <signal list> of an <interface use list> represents corresponding *Signal-identifier* items in the *Signal-identifier-**set***: one for each *Signal-definition* of *Signal-definition-**set*** of the identified *Interface-definition*.

d) Each *Signal-identifier* in the *Signal-identifier-**set*** appears only once, even if it corresponds to more than one item in the <signal list> of an <interface use list>.

The defining context of entities defined in the interface (<entity in interface>) is the scope unit of the interface, and the entities defined are visible where the interface is visible.

The following paragraphs are from clause 12.1.2 *Semantics* of [ITU-T Z.101].

The *Sort* of an *Interface-definition* is a pid sort. Each element of the *Sort* is the identity of an agent instance that is able to receive each of the signals identified by the *Signal-identifier-**set*** of the *Interface-definition*.

The *Null-literal-signature* of an *Interface-definition* is the signature for the null literal operator.

The *Data-type-identifier* set of an *Interface-definition* identifies the base interface types (super types) of an interface specialization. `Pid` is directly or indirectly the base interface types of any *Interface-definition* for a pid sort.

The *Signal-identifier-**set*** of an *Interface-definition* identifies signals defined outside the interface that are used by the interface and also each signal defined by a *Signal-definition* of the *Interface-definition*.

The *Signal-definition-**set*** of an *Interface-definition* is the set of signals defined for the interface. The scope of the signals is such that they are visible wherever the interface is visible. These signals are included in the *Signal-identifier-**set*** of the *Interface-definition*.

The *Signal-identifier-**set*** of an *Interface-definition* is the set of signal identities that apply when the interface appears in the syntax, and the set of signal identities for the pid sort of the *Interface-definition*. An identity of an agent instance is compatible with the pid sort if every *Signal-identifier* set of the pid sort is in the valid input signal set of the agent.

The implicit *Interface-definition* for an agent type (or agent or state machine) has a *Sort* with the same *Name* as the agent type (or agent or state machine respectively).

Internally connected gates of an agent type are gates of the agent type that are connected via channels to the gates of either a contained agent or the state machine of the agent type. The internally connected gates of an agent are the gates of the agent that correspond to the internally connected gates of the agent type for the agent.

The implicit *Interface-definition* defined by an agent type contains (in its interface specialization – see [ITU-T Z.104]) all interfaces given in the incoming signal lists associated with internally connected gates. The *Interface-definition* contains in its *Signal-identifier-**set*** all signals given in the incoming signal lists associated with internally connected gates.

The implicit *Interface-definition* defined by a state machine of an agent type contains (in its interface specialization – see [ITU-T Z.104]) the interface defined by the agent type itself except any part of that interface concerned only with contained agents. The interface also contains in its interface specialization all interfaces given in the incoming signal lists associated with any gates of the state machine. The interface also contains in its <interface use list> all signals given in the incoming signal lists associated with gates of the state machine.

The *Signal-identifier-**set*** of an implicit *Interface-definition* for an agent type (or agent or state machine) has a *Signal-identifier* for each different signal in the set of signals in all channels or gates for which the destination is the agent type (or agent or state machine respectively), plus the valid input signal set defined explicitly for the agent type (or agent or state machine respectively).

The implicit *Interface-definition* of a typebased agent contains the same *Signal-identifier-**set*** as the *Interface-definition* defined by its type.

NOTE – Because every agent and agent type has an implicitly defined interface with the same name, any explicitly defined interface has to have a different name from every agent and agent type defined in the same scope; otherwise, there are name clashes.

The following paragraph is from clause 12.1.2 *Concrete grammar* of [ITU-T Z.104].

An <interface definition> (or implicit interface definition) defines a *Data-type-definition* of a choice data type with a unique anonymous *Sort* name in the context that the *Interface-definition* is visible. A <basic sort> that is <as interface> where <interface identifier> identifies the *Interface-definition*, represents this *Data-type-definition*. The *Data-type-definition* is equivalent to defining a choice data type with a <choice of sort> for each distinct *Signal-definition* identified by the *Signal-identifier-**set*** of the *Interface-definition*. The <field name> and <field sort> for each <choice of sort> is determined in the same way as a <choice of sort> for each distinct *Signal-definition* of the *Data-type-definition* defined by a <gate definition>.

From [ITU-T Z.101] clause 12.1.6.2 *Concrete grammar*:

The <structure definition> for a structure `S` represents (in the *Operation-signature* set of the *Data-type-definition* for `S`):

a) in the absence of data type specialization (see [ITU-T Z.104] clause 12.1.9), if no operator named `Make` is given with an *Operation-result* that is the *Sort-reference-identifier* of the `S` structure sort (an `S` structure result), an *Operation-signature* for a generic operator named `Make` with:

i. a *Formal-argument* list where each item is the *Sort-reference-identifier* of the corresponding (in order) <field name> if the referenced <field> does not contain **optional** and does not contain a <field default initialization>;,

ii. an *Operation-result* that is the `S` structure result;

iii. the procedure identified by the *Operation-signature* having each formal parameter of its *Parameter-aggregation* derived from the <aggregation kind> of the corresponding <field name>, and a *Result-aggregation* that is **PART**.

From [ITU-T Z.104] clause 12.1.6.2 *Concrete grammar* and *Semantics*:

b) if `S` has a <data type specialization> and no *Operation-signature* for an operator named `Make` is given with an *Operation-result* that is the *Sort-reference-identifier* of the `S` structure sort (an `S` structure result), represents (in the *Operation-signature* set of the *Data-type-definition* for `S`) an *Operation-signature* for a generic operator named `Make` for each inherited *Operation-signature* for an operator named `Make` with:

i. a *Formal-argument* list that begins with *Sort-reference-identifier* items of the *Formal-argument* list of the inherited `Make` operator and where each subsequent item is the *Sort-reference-identifier* of the corresponding (in order) <field name> if the referenced <field> does not contain **optional** and does not contain a <field default initialization>;

ii. an *Operation-result* that is the `S` structure result;

iii. the procedure identified by the *Operation-signature* having each formal parameter of its *Parameter-aggregation* derived from the <aggregation kind> of the corresponding <field name>, and a *Result-aggregation* that is **PART**.

The remaining paragraphs of this clause are from [ITU-T Z.101] clause 12.1.6.2 *Concrete grammar*:

c) for each field, if the <field name> is `fn` and the <field sort> is `fs`, an *Operation-signature* for the <operation signature>
`fnExtract ( S ) -> fs;`
for a generic operator where
`fnExtract` is a *field-extract-name* formed from the concatenation of the field name and "Extract",
`S` is an **in/out** parameter with an empty <aggregation kind>,
and the result has the same <aggregation kind> as the field `fn`.

d) for each field, if the <field name> is `fn` and the <field sort> is `fs`, an *Operation-signature* for the <operation signature>
`fnModify ( S, fs ) -> S;`
for a generic operator where
`fnModify` is a *field-modify-name* formed from the concatenation of the field name and "Modify",
`S` is an **in/out** parameter with an empty <aggregation kind>,
`fs` is an **in** parameter with the same <aggregation kind> as the field `fn`,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **PART**.

e) for each field, if the <field name> is `fn`, an *Operation-signature* for the <operation signature>
`fnPresent ( S ) -> <<`**`package`** `Predefined>>Boolean;`
for a generic operator where
`fnPresent` is a *field-present-name* formed from the concatenation of the field name and "`Present`",
`S` is an **in/out** parameter with an empty <aggregation kind>,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **PART**.

f) an *Operation-signature* for a generic operator named `Undefined` based on the <operation signature>
`Undefined ( S )-> <<`**`package`** `Predefined>>Boolean;`
which is `true` if the structure is "undefined": that is, every field of the structure is "undefined",
`S` is an **in/out** parameter with an empty <aggregation kind>,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **PART**.

The generic operations to create structure values are applied as operators.

The generic operations for structure values that have an initial **in/out** parameter (to modify fields, access fields, test for the presence of field and test for the structure value being undefined) are treated as methods.

A structure sort has elements that are all the tuples constructed from data items belonging to the sorts given in the field list. An element of a structure sort has as many component elements as there are fields in the field list. An optional field is a field that does not have to be present. The associated operations determine the semantics of the structures sort.

The result of the generic operator `equal` is `true` if and only if for each field of the structure sort:

a) the field is not present in both operands of `equal`; or

b) the field is present in both operands of `equal`, and `equal` for the sort of the field between the values of the field in two structures is `true`.

The generic operator `copy` behaves as if the following is interpreted:

a) a new structure is created in which each field has no value (it is "undefined"); then

b) for each field that is present in the operand of `copy`, the corresponding field of the structure is associated with the data item associated with that field in the operand of `copy`;

c) for each field that is not present in the operand of `copy`, and the corresponding field of the structure has a default initialization, the field of the structure is associated with the data item for that field in the default initialization.

Additional generic operations exist for the sort defined as a structure as follows:

a) operations to create structure values;

b) operations to modify structures and to access component data items of structures values; and

c) an operation to test for the presence of optional component data items in structures values, or if the structure is "undefined".

A `Make` operation with an empty *Formal-argument* list creates a structure value with values associated with fields that have default initialization and all other fields "undefined".

A `Make` operation with a non-empty *Formal-argument* list creates a new structure and associates each field with the result of the corresponding formal parameter, or if no actual argument is given for the field, the default initialization for that field, or "undefined" if there is no default initialization for the field.

Where there is a `Make` operation that corresponds to a `Make` operation in a parent type, the `Make` operation in the parent type is invoked first with the actual arguments corresponding to the parameters of that `Make` operation given as actual arguments before associating the fields of the data type with the results of the remaining formal parameters.

If, during interpretation, a field of a structure is "undefined", applying the operation to access this field (with a *field-extract-name*) to the structure causes the predefined exception `UndefinedField` to be raised. Otherwise, the operation to access a field returns the data item associated with that field.

The value associated with a structure is not changed by interpretation of the operation to access a field of the structure.

The operation to modify a field (with a *field-modify-name*) associates the field with the result of its argument *Expression*. The value associated with the structure after interpreting the operation has the field associated with the argument value, but no change to the value associated with any other field.

The operation to test for the presence of a field data item based on the field name (with a *field-present-name*) returns the predefined `Boolean` value `false` if this field is "undefined", and the predefined `Boolean` value `true` otherwise. The value associated with a structure is not changed by interpretation of the operation to test presence of a field of the structure.

The `Undefined` operation tests if the structure is "undefined", and returns the `Boolean` value `true` if each of the fields of the structure is "undefined". The value associated with a structure is not changed by interpretation of the operation to test if the structure is "undefined".

Auxiliary functions

The function *localDataTypeDefinitionSet0* gets the local defined <data type definition>s in a scope unit.

localDataTypeDefinitionSet0(*su*: *SCOPEUNIT0*): <data type definition>-**set**=$_{\text{def}}$
{*d*∈<data type definition>: *d.surroundingScopeUnit0* = *su*}

The function *structMakeSig0* delivers a single-item sequence containing the <operation signature> for the Make operation implied by a structure definition.

structMakeSig0(*d* :<data type definition>):<operation signature>***** =$_{\text{def}}$
let *sort* = *d*.**s-**<data type definition body>.*parentAS0.identifier0* **in**
let *struct* = *d*.**s-**<data type definition body>.**s-**<structure definition> **in**
let *opsigs* = *d*.**s-**<data type definition body>.**s-**<operations>.
s-<operation signatures>.**s-**<operator list>.**s-**<operation signature>**-seq in**
let *makeSig* = { *os* ∈ *opsigs.toSet* : *os*.**s-**<operation name> = "Make" ∧ *os*.**s-**<result>.**s-**<sort> = *sort* }.*take* **in**
let *makeArgs* = *makeSig*.**s-**<arguments> **in**
< **mk-**<operation signature>(
mk-<operation preamble>(*undefined*),
mk-<name>("Make"),
if *makeArgs* = *undefined* **then** *empty* **else** *makeArgs* **endif** ⁀
< **mk-**<argument>(**in**, *struct.fieldSortList0*[*n*]) : *n* **in** 1..*struct.fieldNameList0.length* ∧
expandfieldsSt0(*fields*)[*n*] ∈ <mandatory field> ∧
expandfieldsSt0(*fields*)[*n*].**s-**<field default initialization> = *undefined*
>, //arguments list
mk-<result>(**mk-**<sort>(**mk-**<type expression>(*d.identifier0*, *sort*)))
) // operation signature
> // list of signatures with one element – signature for Make
endlet // makeArgs
endlet // makeSig
endlet // opsigs
endlet // struct
endlet // sort

The function *structMakeDef0* delivers the single-item sequence containing the <operation definition> for the Make operation implied by a structure definition.

structMakeDef0(*d* :<data type definition>):<operation definition>***** =$_{\text{def}}$
let *sort* = *d*.**s-**<data type definition body>.*parentAS0.identifier0* **in**
let *struct* = *d*.**s-**<data type definition body>.**s-**<structure definition> **in**
let *opdefs* = *d*.**s-**<data type definition body>.**s-**<operations>.
s-<operation definitions>.**s-**<operation definition>**-seq in**
let *makeDef* = { *od* ∈ *opdefs.toSet* : *od*.**s-**<operation heading>.**s-**<operation name> = "Make" ∧
od **s-**<operation heading>.**s-**<result>.**s-**<sort> = *sort* }.*take* **in**
let *makeParms* = *makeDef*. **s-**<operation heading>.**s-**<formal variable parameters>**-seq in**

```
    <   mk-<operation definition> (
        mk-<operation heading>( operator,
            mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
            mk-<name>("Make"),
            mk-<formal operation parameters>(
            if makeParms = undefined then empty else makeParms endif
            <   mk-<formal variable parameters>( in,
                    fok.s-<aggregation kind>,
                    mk-<parameters of sort>( fok.s-<name>, fok.s-<sort>)
                ) // formal variable parameters
            : fok in
                <   struct.s-<field>-seq[i].s-<mandatory field>.s-<fields of sort>.s-<field of kind>-seq[1]
                :   i in 1..struct.s-<field>-seq.length ∧
                    struct.s-<field>-seq[i] ∈ <mandatory field> ∧
                    struct.s-<field>-seq[i].s-<mandatory field>.s-<field default initialization> = undefined
                >
            >), // list of f fields, formal operation parameters
            mk-<result>(mk-<sort>(mk-<type expression>(d.identifier0,empty)))
    > // Make definition
endlet // makeParms
endlet // makeDef
endlet // opdefs
endlet // struct
endlet // sort
```

The function *structOpSigs0 delivers a list of* <operation signature>s *for methods to modify and access* the fields of a Structure data type. Each signature is constructed as an <operation signature> with the identifier of its parent <data type definition> as an additional argument, required when a <operation signature> is transferred from a <method list> to an <operator list> (see section F2.2.9.5).

The function *structOpDefs0* delivers the corresponding <operation definition>s.

```
structOpSigs0(d :<data type definition>):<operation signature>* =def
let struct = d.s-<data type definition body>.s-<structure definition> in
<   mk-<operation signature>(
        mk-<name>(s.fieldNameList0[n].s-TOKEN + "Modify"),
        < mk-<argument>(inout, d.identifier0) >⌒
            < mk-<argument>(in, s.fieldSortList0[n]) >,
        mk-<result>(sort) | n in 1..s.fieldNameList0.length > ⌒
< mk-<operation signature>(
        mk-<name>(s.fieldNameList0[n].s-TOKEN + "Extract"),
        < mk-<argument>(inout, d.identifier0) >,
        mk-<result>( s.fieldSortList0[n]),empty) | n in 1..s.fieldNameList0.length > ⌒
< mk-<operation signature>(
        mk-<name>( s.fieldNameList0[n].s-TOKEN + "Present"),
        < mk-<argument>(inout, d.identifier0) >,
        mk-<result>(predefinedId0("Boolean"))
    | n in 1..s.fieldNameList0.length  ∧ fields[n] ∈ <optional field> >⌒
<   mk-<operation signature> (
        mk-<operation preamble> (undefined, undefined),
        mk-<name>("Undefined"),
        mk-<arguments>( <
            mk-<formal parameter>(inout, mk-<sort>(mk-<type expression>(d.identifier0,empty)))
        >), // arguments
        mk-<result>(mk-<sort>(mk-<type expression>(predefinedId0("Boolean"),empty)))
> // Undefined signature
endlet
```

The function *structOpDefs0* delivers *a list of* <operation definition> *for methods to modify and access* the fields of a Structure data type.

```
structOpDefs0(d :<data type definition>):<operation definition>* =def
let struct = d.s-<data type definition body>.s-<structure definition> in
let allFields = struct.s-<field list>.s-<optional field>.s-<fields of sort>⌒
        struct.s-<field list>.s-<mandatory field>.s-<fields of sort> in
< mk-<operation definition> (empty, // package use
    mk-<operation heading> (operator,
        mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
        mk-<name>(f.s-<field of kind>-seq[1].s-<name>.s-TOKEN + "Modify"),
        <   mk-<formal variable parameters>(inout, part,
                <parameters of sort>(< mk-<name>("structValue") >,
                    mk-<sort>(mk-<type expression>(d.identifier0,empty))
                ) // parameters of sort
            ), // formal variable parameters
            mk-<formal variable parameters>(in, part,
                <parameters of sort>(< mk-<name>("fieldValue") >, f.s-<sort>)
            ) // formal variable parameters
        >, // formal operation parameters = list of formal variable parameters
        mk-<operation result> (part, undefined, mk-<sort>(mk-<type expression>(d.identifier0,empty)))
    ) // operation heading
    empty, // entity list in operator
    mk-<statements> (undefined, // connector name, followed by terminating (dummy return) statement
        mk-<return statement>(mk-<return body>(undefined)) // replaced by actual body in F3
    ) // statements
) // operation definition
: f in allFields
> // list of Modify definitions for each field
⌒

< mk-<operation definition> (empty, // package use
    mk-<operation heading> (operator,
        mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
        mk-<name>(f.s-<field of kind>-seq[1].s-<name>.s-TOKEN + "Extract"),
        <   mk-<formal variable parameters>(inout, part,
                <parameters of sort>(< mk-<name>("structValue") >,
                    mk-<sort>(mk-<type expression>(d.identifier0,empty))
                ) // parameters of sort
            ) // formal variable parameters
        >, // formal operation parameters = list of formal variable parameters
        mk-<operation result> (part, undefined, f.s-<sort>),
    ) // operation heading
    empty, // entity list in operator
    mk-<statements> (undefined, // connector name, followed by terminating (dummy return) statement
        mk-<return statement>(mk-<return body>(undefined)) // replaced by actual body in F3
    ) // statements
) // operation definition
: f in allFields
> // list of Extract definitions for each field
⌒

< mk-<operation definition> (empty, // package use
    mk-<operation heading> (operator,
        mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
        mk-<name>(f.s-<field of kind>-seq[1].s-<name>.s-TOKEN + "Present",
        <   mk-<formal variable parameters>(inout, part,
                <parameters of sort>(< mk-<name>("structValue") >,
                    mk-<sort>(mk-<type expression>(d.identifier0,empty))
                ) // parameters of sort
            ) // formal variable parameters
        >, // formal operation parameters = list of formal variable parameters
        mk-<operation result>(part, undefined,
            mk-<sort>(mk-<type expression>(predefinedId0("Boolean"),empty)))
        ) //operation result
    ) // operation heading
```

```
    empty, // entity list in operator
    mk-<statements> (undefined, // connector name, followed by terminating (dummy return) statement
        mk-<return statement>(mk-<return body>(undefined)) // replaced by actual body in F3
    ) // statements
) // operation definition
: f in allFields
> // list of Present definitions for each field
⁀

<   mk-<operation definition> (
    mk-<operation heading> (operator,
        mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
        mk-<name>("Undefined"),
        <   mk-<formal variable parameters>(inout, part,
                <parameters of sort>(< mk-<name>("structureValue") >,
                    mk-<sort>(mk-<type expression>(d.identifier0,empty))
                ) // parameters of sort
            ) // formal variable parameters
        >, // formal operation parameters = list of formal variable parameters
        mk-<operation result>(part, undefined,
            mk-<sort>(mk-<type expression>(predefinedId0("Boolean"),empty)))
        ) //operation result
    ) // operation heading
    empty, // entity list in operator
    mk-<statements> (undefined, // connector name, followed by terminating (dummy return) statement
        mk-<return statement>(mk-<return body> (undefined,)) // replaced by actual body in F3
    ) // statements
) // operation definition
> // Undefined operation definition
endlet // allFields
endlet // struct
```

The function *anonLiterals0 delivers an anonymous* <data type definition> with a <literal list> containing all the <field name>s from the <choice of sort>s in a Choice data type as <literal name>s.

```
anonLiterals0(cdef: <choice definition>, nn: <name>):<data type definition> =def
mk-<data type definition>(empty, undefined,
    mk-<data type heading> (mk-<name>(nn.s-TOKEN + "Present"), empty, undefined ), undefined,
    mk-<data type definition body>(empty,
        mk-<literal list> (undefined, // visibility
            < c.s-<name> : c in ( cdef.s-<choice list> ) > // list of literal names
        ) , // literal list
        mk-<operations>(<operation signatures>(<operator list>(empty), <method list>(empty)), empty),
         undefined // initialization
    ) // data type definition body
) // data type definition
endlet
```

The function *choiceOpSigs0 delivers an* <operation signature> list for operations to: make an undefined choice value, create a choice value with the specified field with the given value, *to modify and access* the fields of a choice, test if a field is present, find which field is present in a choice, and check if all fields of a choice are undefined. That is,
the operator `Make()-> C;` to make an undefined value,
plus for each field `fn`
the operator `fn(fs)->C;` create a choice value,
the operator `fnModify(C,fs)->C;` modify a choice,
the operator `fnExtract(C)->fs;` extract the current choice value and
the operator `fnPresent(C)-> Boolean;` test if the field is present
plus for the Choice data type as a whole
the operator `PresentExtract(C)-> AnonPresent;` name of the present field and
the operator `Undefined(C)-> Boolean;` check if choice undefined.

```
choiceOpSigs0(d :<data type definition>, nn :<name>):<operation signature>* =def
<   mk-<operation signature> (
        mk-<operation preamble> (virtual, undefined), mk-<name>("Make"),
        undefined, // no arguments
        mk-<result>(mk-<sort>(mk-<type expression>(d.identifier0,empty)))
> // Make signature
⌒

<   mk-<operation signature>(
        mk-<operation preamble>(undefined, undefined),
        c.s-<field of kind>-seq[1].s-<name>,
        mk-<arguments>( < mk-<argument>(in, c.s-<sort>) >),
        mk-<result>(mk-<sort>(mk-<type expression>(d.identifier0,empty)))
    ), // operation signature for fn
: c in d.s-<data type definition body>.s-<choice definition>.s-<choice list>
> // operation signature list – all fn signatures
⌒

<   mk-<operation signature> (
        mk-<operation preamble>(virtual, undefined),
        mk-<name>(c.s-<field of kind>-seq[1].s-<name>.s-TOKEN + "Modify"),
        mk-<arguments>( <
            mk-<formal parameter>(inout, mk-<sort>(mk-<type expression>(d.identifier0,empty))),
            mk-<formal parameter> (in, c.s-<sort>)
        >), // arguments
        mk-<result>(mk-<sort>(mk-<type expression>(d.identifier0,empty)))
    ), // operation signature for Modify
: c in d.s-<data type definition body>.s-<choice definition>.s-<choice list>
> // operation signature list – all Modify signatures
⌒

<   mk-<operation signature>(
        mk-<operation preamble>(virtual, undefined),
        mk-<name>(c.s-<field of kind>-seq[1].s-<name>.s-TOKEN + "Extract"),
        mk-<arguments>( <
            mk-<formal parameter>(inout, mk-<sort>(mk-<type expression>(d.identifier0,empty)))
        >), // arguments
        mk-<result>(c.s-<sort>)
    ), // operation signature for Extract
: c in d.s-<data type definition body>.s-<choice definition>.s-<choice list>
> // operation signature list
⌒

<   mk-<operation signature>(
        mk-<operation preamble>( virtual, undefined),
        mk-<name>(c.s-<field of kind>-seq[1].s-<name>.s-TOKEN + "Present"),
        mk-<arguments>( <
            mk-<formal parameter>(inout, mk-<sort>(mk-<type expression>(d.identifier0,empty)))
        >), // arguments
        mk-<result>(mk-<sort>(mk-<type expression>(predefinedId0("Boolean"),empty)))
    ), // operation signature for Present
: c in d.s-<data type definition body>.s-<choice definition>.s-<choice list>
> // operation signature list – all Present signatures
⌒

<   mk-<operation signature> (
        mk-<operation preamble> (undefined, undefined),
        mk-<name>("PresentExtract"),
        mk-<arguments>( <
            mk-<formal parameter>(inout, mk-<sort>(mk-<type expression>(d.identifier0,empty)))
        >), // arguments
        mk-<result>(mk-<sort>(
            mk-<type expression>(mk-<identifier>(d.fullQualifier0, mk-<name>(nn.s-TOKEN + “Present”)),
                empty) // empty actual conext parameter list of type expression
        )) // sort , result
```

```
> // PresentExtract signature
⌒
<   mk-<operation signature> (
        mk-<operation preamble> (undefined, undefined),
        mk-<name>("Undefined"),
        mk-<arguments>( <
            mk-<formal parameter>(inout, mk-<sort>(mk-<type expression>(d.identifier0,empty)))
        >), // arguments
        mk-<result>(mk-<sort>(mk-<type expression>(predefinedId0("Boolean"),empty)))
> // Undefined signature
```

The function *choiceOpDefs0* delivers *an* <operation definition> list for choice operations as listed in the description of *choiceOpSigs0*. The body of each operation is here given as a dummy return, which is copied to the implicit procedure for the operation and replaced in the dynamic semantics in F3 by the action needed.

```
choiceOpDefs0(d :<data type definition>, nn: <name>):<operation definition>* =def
<   mk-<operation definition> (
    mk-<operation heading>( operator,
        mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
        mk-<name>("Make"),
        undefined, // no formal variable parameters
        mk-<result>(mk-<sort>(mk-<type expression>(d.identifier0,empty)))
> // Make definition
⌒

<   mk-<operation definition>(empty, // package use
    mk-<operation heading>( operator,
        mk-<operation preamble>(undefined, undefined), empty, //preamble, qualifier
        c.s-<field of kind>-seq[1].s-<name>, // op name fn
        < mk-<formal variable parameters>( // formal operation parameters is single item list
            in, part, // kind, aggregation
            mk-<parameters of sort>(
                < mk-<name>("fieldValue") >, // list of one name for field value
                c.s-<sort> // sort of field
            ) // parameters of sort
        ) // formal variable parameters
        >, // formal operation parameters = list of formal variable parameters
        mk-<operation result>(part, undefined, mk-<sort>(mk-<type expression>(d.identifier0,empty)))
    ),  // operation heading
    empty, // entity list in operator
    mk-<statements> (undefined, // connector name, followed by terminating (dummy return) statement
        mk-<return statement>(mk-<return body> (undefined,)) // replaced by actual body in F3
    ) // statements
) // operation definition
: c in d.s-<data type definition body>.s-<choice definition>.s-<choice list>
> // list of operation definitions – all fn definitions
⌒

< mk-<operation definition> (empty, // package use
    mk-<operation heading> (operator,
        mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
        mk-<name>(c.s-<field of kind>-seq[1].s-<name>.s-TOKEN + "Modify"),
        <   mk-<formal variable parameters>(inout, part,
                <parameters of sort>(< mk-<name>("choiceValue") >,
                    mk-<sort>(mk-<type expression>(d.identifier0,empty))
                ) // parameters of sort
            ), // formal variable parameters
            mk-<formal variable parameters>(in, part,
                <parameters of sort>(< mk-<name>("fieldValue") >, c.s-<sort>)
            ) // formal variable parameters
        >, // formal operation parameters = list of formal variable parameters
        mk-<operation result> (part, undefined, mk-<sort>(mk-<type expression>(d.identifier0,empty)))
```

```
    ) // operation heading
    empty, // entity list in operator
    mk-<statements> (undefined, // connector name, followed by terminating (dummy return) statement
        mk-<return statement>(mk-<return body> (undefined,)) // replaced by actual body in F3
    ) // statements
) // operation definition
: c in d.s-<data type definition body>.s-<choice definition>.s-<choice list>
> // list of Modify definitions for each choice
⌒

< mk-<operation definition> (empty, // package use
    mk-<operation heading> (operator,
        mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
        mk-<name>(c.s-<field of kind>-seq[1].s-<name>.s-TOKEN + "Extract"),
        <   mk-<formal variable parameters>(inout, part,
                <parameters of sort>(< mk-<name>("choiceValue") >,
                    mk-<sort>(mk-<type expression>(d.identifier0,empty))
                ) // parameters of sort
            ) // formal variable parameters
        >, // formal operation parameters = list of formal variable parameters
        mk-<operation result> (part, undefined, c.s-<sort>),
    ) // operation heading
    empty, // entity list in operator
    mk-<statements> (undefined, // connector name, followed by terminating (dummy return) statement
        mk-<return statement>(mk-<return body> (undefined,)) // replaced by actual body in F3
    ) // statements
) // operation definition
: c in d.s-<data type definition body>.s-<choice definition>.s-<choice list>
> // list of Extract definitions for each choice
⌒

< mk-<operation definition> (empty, // package use
    mk-<operation heading> (operator,
        mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
        mk-<name>(c.s-<field of kind>-seq[1].s-<name>.s-TOKEN + "Present",
        <   mk-<formal variable parameters>(inout, part,
                <parameters of sort>(< mk-<name>("choiceValue") >,
                    mk-<sort>(mk-<type expression>(d.identifier0,empty))
                ) // parameters of sort
            ) // formal variable parameters
        >, // formal operation parameters = list of formal variable parameters
        mk-<operation result>(part, undefined,
            mk-<sort>(mk-<type expression>(predefinedId0("Boolean"),empty)))
        ) //operation result
    ) // operation heading
    empty, // entity list in operator
    mk-<statements> (undefined, // connector name, followed by terminating (dummy return) statement
        mk-<return statement>(mk-<return body> (undefined,)) // replaced by actual body in F3
    ) // statements
) // operation definition
: c in d.s-<data type definition body>.s-<choice definition>.s-<choice list>
> // list of Present definitions for each choice
⌒

<mk-<operation definition> (
    mk-<operation heading> (operator,
        mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
        mk-<name>("PresentExtract"),
        <   mk-<formal variable parameters>(inout, part,
                <parameters of sort>(< mk-<name>("choiceValue") >,
                    mk-<sort>(mk-<type expression>(d.identifier0,empty))
                ) // parameters of sort
            ) // formal variable parameters
        >, // formal operation parameters = list of formal variable parameters
```

```
        mk-<operation result>(part, undefined, mk-<sort>(
            mk-<type expression>(mk-<identifier>(d.fullQualifier0, mk-<name>(nn.s-TOKEN + "Present")),
                empty) // empty actual conext parameter list of type expression
        )) // sort , operation result
        ) //operation result
    ) // operation heading
    empty, // entity list in operator
    mk-<statements> (undefined, // connector name, followed by terminating (dummy return) statement
        mk-<return statement>(mk-<return body>(undefined,)) // replaced by actual body in F3
    ) // statements
) // operation definition
> // PresentExtract operation definition
⌒

<   mk-<operation definition> (
    mk-<operation heading> (operator,
        mk-<operation preamble> (virtual, undefined), empty, //preamble, qualifier
        mk-<name>("Undefined"),
        <   mk-<formal variable parameters>(inout, part,
                <parameters of sort>(< mk-<name>("choiceValue") >,
                    mk-<sort>(mk-<type expression>(d.identifier0,empty))
                ) // parameters of sort
            ) // formal variable parameters
        >, // formal operation parameters = list of formal variable parameters
        mk-<operation result>(part, undefined,
            mk-<sort>(mk-<type expression>(predefinedId0("Boolean"),empty)))
        ) //operation result
    ) // operation heading
    empty, // entity list in operator
    mk-<statements> (undefined, // connector name, followed by terminating (dummy return) statement
        mk-<return statement>(mk-<return body>(undefined,)) // replaced by actual body in F3
    ) // statements
) // operation definition
> // Undefined operation definition
```

Given a <data type definition>, the function *getOpSigs0 delivers a list of* <operation signature>s. The list is formed by concatenating the <operator list> from the <data type definition> with modified <operation signature>s from the <method list> of the <data type definition>. The modification entails adding the identifier of the parent <data type definition> as an additional argument to each <operation signature> in the <method list> (see section F2.2.9.5).

```
getOpSigs0(d :<data type definition>):<operation signature>* =def
let ops = d.s-<data type definition body>.s-<operations>.s-<operation signatures>.s-<operator list> in
let meths = d.s-<data type definition body>.s-<operations>.s-<operation signatures>.s-<method list> in
ops⌒
< mk-<operation signature>(
    m.s-<operation preamble>,
    m.s-<operation name>,
    mk-<arguments>(
        <   mk-<argument>(inout, mk-<sort>(mk-<type expression>(d.identifier0,empty))) > ⌒
        if m.s-<arguments> = undefined then empty else m.s-<arguments> endif,
    ) // arguments
    if m.s-<result>= undefined
    then mk-<sort>(mk-<type expression>(d.identifier0,empty))
    else m.s-<result>
    endif
)  // operation signature
: m in meths >
endlet // meths
endlet // ops
```

F2.2.9.3 Interface type

Abstract syntax

Interface-definition :: *Sort*
Null-literal-signature
Data-type-identifier-**set**
Signal-definition-**set**
Signal-identifier-**set**

Null-literal-signature = *Literal-signature*

Sort = *Name*

Concrete syntax

<interface definition> ::
<package use clause>* [<virtuality>] <interface heading> [<interface specialization>]
<entity in interface>*
| <signal list definition>

<interface heading> ::
<interface<name> [<formal context parameters>] [<virtuality constraint>]

<entity in interface> =
<signal definition list>
| <interface variable definition>
| <interface procedure definition>
| <interface use list>

<interface use list> :: [<signal list>]

<interface variable definition> :: <remote variable<name>+ <sort>

<interface procedure definition> :: <remote procedure<name> <procedure signature>

<as interface> :: <interface<identifier>

Further study is needed for the handling of <as interface>. See also Interface definition, which should implicitly define the choice type for <as interface>

Conditions on concrete syntax

$\forall$*ifd*$\in$<interface definition>:
isRestrictedByInterface0(*ifd*.**s-**<entity in interface>.**s-**<interface use list>.**s-**<signal list item>-**seq**)

Each <signal list item> of the <signal list> in an <interface use list> of an <interface<definition> shall be a <signal<identifier> or an <interface<identifier> or a <remote procedure<identifier> or a <remote variable<identifier>. An <interface<identifier> that is part of the <signal list> shall also respect the restriction. See clause 12.1.2 *Concrete grammar* of [ITU-T Z.101] and clause 10.4 *Concrete grammar* of [ITU-T Z.102].

$\forall$*interfaceDef*$\in$<interface definition>: $\neg$ *isInterfaceDefContaining0*(*interfaceDef, interfaceDef*)

The <interface definition> shall not contain the <interface<identifier> defined by the <interface definition> either directly or indirectly (via another <interface<identifier>). See clause 12.1.2 *Concrete grammar* of [ITU-T Z.101].

$\forall$*ind*$\in$<interface definition>:$\forall$*fcp*$\in$<formal context parameter>:
fcp$\in$*ind.localFormalContextParameterList0* $\Rightarrow$
fcp$\in$<signal context parameter list> $\cup$<remote procedure context parameter> $\cup$
<remotevariable context parameter list> $\cup$ <sort context parameter>

The <formal context parameters> shall only contain <signal context parameter list>, <remote procedure context parameter>, <remotevariable context parameter list> or <sort context parameter>.

Mapping to abstract syntax

```
| idef = <interface definition>(*, *, <interface heading>(name, *, *), spec, entities) then
mk-Interface-definition(Mapping(name),
    mk-Literal-signature(mk-Name("null"),
        mk-Result(mk-Identifier(Mapping(idef.fullQualifier0), Mapping(name)), REF),
        0), // null literal signature
    Mapping(spec), // set of identities of inherited interface definitions
    { e ∈ Mapping(entities).toSet: (e ∈ Signal-definition)}, // signal definitions defined in the interface
    { sigid ∈ idef.usedSignalSet0 ∪ {sd.identifier0 | sd ∈ idef.definedSignalSet0} //ids of sigs def for i/f
)
```

Auxiliary functions

The function *localInterfaceDefinitionSet0* gets the local defined interface definition list of a scope unit.

```
localInterfaceDefinitionSet0(su: SCOPEUNIT0): <interface definition>-set=def
    {d∈<interface definition>:d.surroundingScopeUnit0 = su}
```

The function *isRestrictedByInterface0* decides if each <signal list item> of a list is a <signal<identifier>, <remote procedure<identifier>, <remote variable<identifier> or <interface<identifier>. An <interface<identifier> that is part of the list shall also respect the restriction.

```
isRestrictedByInterface0(sl: <signal list item>*): BOOLEAN =def
    if sl = empty then true
    else
        case sl.head.s-implicit of
            | {signal, remote procedure, remote variable} then isRestrictedByInterface0(sl.tail)
            | {interface} then
                let sl1=getEntityDefinition0(sl.head.s-<identifier>, interface).s-<signal list item>-seq in
                    isRestrictedByInterface0(sl1)∧isRestrictedByInterface0(sl.tail)
            otherwise false
        endcase
    endif
```

The function *isInterfaceDefContaining0* is used to determine if the first interface definition contains the second interface definition, either directly or indirectly.

```
isInterfaceDefContaining0(id1: <interface definition>, id2: <interface definition>): BOOLEAN =def
 (∃ useList ∈ <interface use list>:
    useList.parentAS0 = id1
∧  (∃ident∈<identifier>:
        ident.idKind0 = interface
    ∧   ident = useListItem.s-<signal list item>
    ∧   useListItem in useList
    ∧   (       getEntityDefinition0(ident, interface) = id2
            ∨   ( ∃ id3∈<interface definition>:
                    isInterfaceDefContaining0 (id1, id3) ∧ isInterfaceDefContaining0 (id3, id2)
                ) // id3
        ) // getEntityDefinition0 …
    ) // ident
) // useList
```

F2.2.9.4 Specialization of data types

Concrete syntax

<data type specialization> :: <data type<type expression> <renaming>

<renaming> :: <rename list>

<rename list> = <rename pair>*

<rename pair> =
<rename pair operation name> | <rename pair literal name>

<rename pair operation name> :: <operation name> <base type<operation name>

<rename pair literal name> :: <literal name> <base type<literal name>

<interface specialization> :: <interface<type expression>+

Conditions on concrete syntax

∀*dataDef*∈<data type definition>:∀*superTypeDef*∈<data type definition>:
isSubtype0(*dataDef*, *superTypeDef*) ⇒
superTypeDef.**s-**<data type definition body>.**s-**<data type constructor>= *undefined* ∨
isSameConstructorKind0(
superTypeDef.**s-**<data type definition body>.**s-**<data type constructor>,
dataDef.**s-**<data type definition body>.**s-**<data type constructor>)

The <data type constructor> must be of the same kind as the <data type constructor> used in the <data type definition> of the sort referenced by <data type type expression> in the <data type specialization>.

∀*rn*∈<renaming>:
let *lnl* = << *rp*.**s-**<literal name>, *rp*.**s2-**<literal name>> | *rp* **in** *rn*.**s-**<rename pair>**-seq** > **in**
let *onl* = << *rp*.**s-**<operation name>, *rp*.**s2-**<operation name>> | *rp* **in** *rn*.**s-**<rename pair>**-seq** > **in**
(∀*i*,*j*∈1..*lnl*.*length*: *i*≠*j*⇒ *lnl*[*i*]≠ *lnl*[*j*])∧
(∀*i*,*j*∈1..*onl*.*length*: *i*≠*j*⇒ *onl*[*i*]≠ *onl*[*j*])

All <literal name>s and all <base type literal name>s in a <rename list> must be distinct. All <operation name>s and all <base type operation name>s in a <rename list> must be distinct.

∀*sp*∈<data type specialization>:
(**let** *bt* = *sp*.**s-**<type expression>.*BaseType0* **in**
let *onl* = <*rp*.**s2-**<operation name> |
rp **in** *sp*.**s-**<renaming>.**s-**<rename pair>**-seq**: *rp*∈<rename pair operation name>> **in**
∀*on*∈<operation name>: *on* **in** *onl*⇒
(∃*os*∈<operation signature>: *os*.*surroundingScopeUnit0* = *bt* ∧ *on* = *os*.*name0*)
endlet)

A <base type operation name> specified in a <rename list> must be an operation with <operation name> defined in the data type definition defining the <base type> of <data type type expression>.

∀*sp*∈<data type specialization>:∀*te*∈ *sp*.**s-**<type expression>:
¬*isAbstractType0*(*te*.*BaseType0*) ⇒∀*te′*∈ *sp*.**s-**<type expression>\{*te*}:*isAbstractType0*(*te′*.*BaseType0*)

At most one of the <data type<type expression>s is allowed to be not abstract.

Transformations

The model for specialization in clause 8.4 of [ITU-T Z.102] is used, augmented by clause 12.1.9 *Model of* [ITU-T Z.104] for data type specialization.

<data type definition>(*use*, *preamble*, *heading*, *spec*, *undefined*) // no data type definition body
=11=>
<data type definition>(*use*, *preamble*, *heading*, *spec*,
<data type definition body>(*undefined*, // entities
undefined, // data type constructor
inheritedOperations0(*spec*), // operations
undefined)) // default initialization

<data type definition>
(*use*, *preamble*, *heading*, *spec*, *dtdb*=<data type definition body>
(*entities*, *constr*, <operations>

(<operation signatures> (<operator list>(*ops*), <method list> (*meths*)), *opDefsAndRefs*), *init*))
provided *dtdb* ≠ *undefined* // separate transformation
=11=>
<data type definition>(*use*, *preamble*, *heading*, spec,
<data type definition body>(*entities*, *constr*,
<operations>(<operation signatures>(
if *dttb*.**s-**<operation signatures>.**s-**<operator list> ≠ *undefined*
then <operator list>(*ops*)
else empty
endif ⌒
inheritedOperations0(*spec*).**s-**<operation signatures>.**s-**<operator list>,
if *dttb*.**s-**<operation signatures>.**s-**<method list> ≠ *undefined*
then <method list> (*meths*)
else empty
endif ⌒
inheritedOperations0(*spec*).**s-**<operation signatures>.**s-**<method list>),
opDefsAndRefs ⌒ *inheritedOperations0*(*spec*).**s-**<operation definitions>), *init*))

The following paragraphs are from clause 12.1.9 *Model of* [ITU-T Z.104].

A specialized data type is based on another (base) data type by using a <data type definition> in combination with a <data type specialization>. The sort defined by the specialization is disjoint from the sort defined by the base type.

If the sort defined by the base type has literals defined, the literal names are inherited as names for literals of the sort defined by the specialized type unless literal renaming has taken place for that literal. Literal renaming has taken place for a literal if the base type literal name appears as the second name in a <rename pair> in which case the literal is renamed to the first name in that pair.

If the base type has operators or methods defined, the operation names are inherited as names for operators or methods of the sort being defined, unless the operator or method has been declared as private (see clause 12.1.8.4 of [ITU-T Z.104]) or operation renaming has taken place for that operator or method. Operation renaming has taken place for an operator or method if the inherited operation name appears as the second name in a <rename pair> in which case the operator or method is renamed to the first name in that pair.

When several operators or methods of the <base type> of <sort type expression> have the same name as the <base type operation name> in a <rename pair>, then all of these operators or methods are renamed.

In the following paragraphs ST is a subsort that is a specialization of a data type T, and Tid is an <identifier> for data type T.

For every occurrence of a <basic sort> of the form Tid in a specialization of T, the <basic sort> is replaced by the <basic sort> of the subsort: that is, the <identifier> for the subsort ST. Every occurrence of an <anchored sort> of the form **parent** T in a specialization of T, the <anchored sort> is replaced by an unambiguous qualified <basic sort> for the base type T: that is, the qualified <identifier> for T. Every occurrence of an <anchored sort> of the form **this** T in a specialization of T, the <anchored sort> is replaced by the <basic sort> of the subsort: that is, the <identifier> for the subsort ST.

The argument sorts and result of an inherited operator or method are the same as those of the corresponding operator or method of the base type, except that every <argument> in T that is a <basic sort> T or an <anchored sort> of the form **this** T, in the inherited operator or method the <anchored sort> is replaced by the subsort ST.

NOTE – Anchored sorts are handled in the functions *inheritedOperations0* and *doRename*.

Mapping to abstract syntax

| <data type specialization>(*base*, *) **then** *Mapping*(*base*)

| <interface specialization>(*bases*, *) **then**
{ *Mapping*(*bases*[i]) | i ∈ 1..*bases.length* }// set of inherited interface identifiers

Auxiliary functions

The function *isRenamedBySpec0* determines if a <literal signature> or an <operation signature> is renamed by a <data type specialization>.

isRenamedBySpec0(*sn*:<literal signature>∪<operation signature>, *spec*:<data type specialization>):
BOOLEAN=$_{\text{def}}$
(∃*rp*∈<rename pair>:
(*rp*. *parentAS0*.*parentAS0* = *spec*)∧
(*rp*.**s2-**<literal name> = *sn*.*name0* ∨ *rp*.**s2-**<operation name> = *sn*.*name0*))

The function *isSameConstructorKind0* is used to determine if two data type constructor items are of the same kind.

isSameConstructorKind0(*c1*:<data type constructor>, *c2*:<data type constructor>): *BOOLEAN* =$_{\text{def}}$
(*c1*∈<literal list>∧*c2*∈<literal list>)∨
(*c1*∈<structure definition>∧*c2*∈<structure definition>)∨
(*c1*∈<choice definition>∧*c2*∈<choice definition>)

Sort compatibility determines when a sort can be used in place of another sort, and when it cannot. The function *isSortCompatible0* is used to determine if the first sort is sort compatible to the second one.

isSortCompatible0(*sort1*:<sort>, *sort2*:<sort>): *BOOLEAN* =$_{\text{def}}$
isSameSort0(*sort1*, *sort2*) ∨
isDirectlySortCompatible0(*sort1*, *sort2*) ∨
(*isPidSort0*(*sort2*) ∧
∃*sort3*∈<sort>: *isSortCompatible0*(*sort1*, *sort3*) ∧ *isSortCompatible0*(*sort3*, *sort2*))

The function *isSameSort0* is used to determine if the given two sorts are the same. As well as being the same if they are equal, they are treated as if: they are the same if they have the same derived data type (as long as this is not *undefined*); or they both anchored sorts and *sortId0* is equal.

isSameSort0(*sort1*: <sort>, *sort2*: <sort>): *BOOLEAN* =$_{\text{def}}$
(*sort1* = *sort2*) // simple case
∨
(*getEntityDefinition0*(*sort1*.*sortId0*,**sort**).*derivedDataType0* =
getEntityDefinition0(*sort2*.*sortId0*, **sort**).*derivedDataType0*
∧ *getEntityDefinition0*(*sort1*.*sortId0*,**sort**).*derivedDataType0* ≠ *undefined*
) // same sort when syntypes changed to sort derived from
∨
(*sort1*.**s-**<anchored sort> ≠ *undefined* ∧ *sort2*.**s-**<anchored sort> ≠ *undefined* ∧
sort1.*sortId0* = *sort2*.*sortId0*
) // both anchored sorts that expand to the same sort id
∨
(**let** *def1* = *getEntityDefinition0*(*sort1*.*sortId0*, **interface**) **in**
def1 ∈ <interface definition> ∧ *def1* = *getEntityDefinition0*(*sort2*.*sortId0*, **interface**)
endlet // *def1*
)

Further study is needed to refine *isSameSort0* for other alternatives of <sort> that are not handled here, to check that <basic sort> includes data type and syntype definitions, and an anchored sort that is the same as a data type.

Determine if two sort lists are the same.

```
isSameSortList0(sl, sl1: <sort>*): BOOLEAN =def
    (sl.length = sl1.length) ∧
    (∀i∈1.. sl.length: isSameSort0(sl[i], sl1[i]))
```

The function *isDirectlySortCompatible0* is used to determine if the sort in the first argument is directly sort compatible to the one in the second.

```
isDirectlySortCompatible0(sort1:<sort>, sort2:<sort>): BOOLEAN =def
(sort1 ∈ <anchored sort> ∧ sort1.s-<basic sort> = sort2) ∨
(sort1 ∈ <pid sort> ∧ isSubSort0(sort1, sort2))
```

The function *isPidSort0* is used to determine if a sort is a pid sort.

```
isPidSort0(sort: <sort>): BOOLEAN =def
    getEntityDefinition0(sort.sortId0,interface) ∈ <interface definition>
∨   sort.sortId0 = predefinedId0("Pid")
```

The function *isSubSort0* is used to determine if the sort given in the first argument is a super sort of the one in the second.

```
isSubSort0(sort1: <sort>, sort2: <sort>): BOOLEAN =def
let td1 = getEntityDefinition0(sort1.sortId0, sort) in
let td2 = getEntityDefinition0(sort2.sortId0, sort) in
    (td1∈<interface definition>⇒isSubtype0(td1, td2)) ∧
    (td1∈<data type definition>∪<syntype definition>⇒
        isSubtype0(td1.derivedDataType0, td2.derivedDataType0))
endlet
endlet
```

The function *inheritedOperations0* computes the operations inherited from the base type.

```
inheritedOperations0(spec: <data type specialization>): <operations> =def
    let ops = { o ∈ <operation signature>: isVisibleThroughBaseType0(o, spec.parentAS0)
        ∧ o.parentAS0 ∈ <operator list>} in
    let meths = { o ∈ <operation signature>: isVisibleThroughBaseType0(o, spec.parentAS0)
        ∧ o.parentAS0 ∈ <method list>in
    mk-<operations>(
        mk-<operation signatures>(
            if ops ≠ undefined then mk-<operator list>(doRename(ops, spec)) endif, // sigs of operators
            if meths ≠ undefined then mk-<method list>(doRename(meths, spec)) endif // sigs methods
        ),
        undefined // Further study needed here to include operation definitions
            // copied from base type, with name replaced if renamed,
            // parameters/result updated and body updated (inherited sort changed).
    )
    endlet // meths
    endlet // ops
```

The function *doRename* takes a set of operation signatures (in a data type definition) and produces a revised list of the operation signatures where the names are updated according to the renaming given in a data type specialization (of a data type definition) and arguments and results updated in the signatures to take account of anchored sorts and to use the subsort to replace the sort in the data type specialization.

```
doRename( sigsset: <operation signature>-set, spec: <data type specialization>): <operation signature>*=def
let sig ∈ sigset in
        <   mk-<operation signature>( sig.s-<operation preamble>,
            if isRenamedBySpec0(sig, spec) then
                take({ n ∈ <name>: n = renamepair.s1-<name> ∧ renamepair in spec.s-<renaming>})
            else sig.s-<name>
```

```
            endif,
            < reviseArgResSort0(a, spec): a in sig.s-<arguments> >,
            reviseArgResSort0(sig.s-<result>, spec))
        >
    ⌒
    if | sigsset | = 1 then empty
    else doRename(sigsset \ { sig }, spec )
    endif
endlet // sig
```

The function *reviseArgResSort0* takes an argument or result and updates the sort if necessary according to the given data type specialization. The function can also handle a sort parameter, but this is only for the function to call itself recursively. When called with an argument (or result or sort), an argument (or result or sort respectively) is returned. For sort that is an anchored sort with **this**, the function returns the subsort to the recursive call (except if the subsort is not a specialization of the basic sort given with the anchored sort in which case the basic sort is returned). For sort that is an anchored sort with **parent**, the function returns to the recursive call: the sort in the data type specialization to the recursive call if no basic sort is given; anchored sort unchanged if the subsort is not a specialization of the basic sort given with the anchored sort; otherwise the basic sort given. For a sort that is not an anchored sort, the function returns to the recursive call the sort any occurrence of the identifier of the sort in the data type specialization changed to the identifier of the subsort.

```
reviseArgResSort0(arg: <argument> ∪ <result> ∪ <sort>, spec: <data type specialization>):
    <argument> ∪ <result> ∪ <sort> =def
let subsortId = spec.parentAS0.identifier0 in
let subsort = mk-<sort>(
    mk-<type expression>(getEntityDefinition0(subsortId,sort).derivedDataType0,empty),undefined) in
let supersortId = spec.s-<type expression>.s-<identifier> in
let supersort =
    mk-<sort>(mk-<type expression>(getEntityDefinition0(supersortId, sort),empty),undefined) in
case arg of
| <argument>( kind, sort) then
    mk-<argument>( kind, reviseArgResSort0(sort, spec))
| <result>(sort) then mk-<result>( reviseArgResSort0(sort, spec))
| <anchored sort> (this) then subsort)
| <anchored sort> (this, basicsort) then
    if isSubSort0(basicSort.sortId0, subsortId) then subsort else basicsort endif
| <anchored sort> (parent) then supersort
| <anchored sort> (parent, basicsort) then
    if isSubSort0(basicSort.sortId0, subsortId) then arg else basicsort endif // remains anchored if subsort
otherwise
    replaceInSyntaxTree0(supersortId, subsortId, arg) // change sort to subsort
endcase
endlet // supersort
endlet // supersortId
endlet // subsort
endlet // subsortId
```

F2.2.9.5 Operations

Abstract syntax

Static-operation-signature	::	*Operation-signature*
Dynamic-operation-signature	::	*Operation-signature*
Operation-signature	::	*Operation-name Formal-argument** [*Operation-result*] *Procedure-identifier*
Formal-argument	=	*Argument*
Operation-result	=	*Sort-reference-identifier*
Argument	=	*Sort-reference-identifier*

Conditions on abstract syntax

Concrete syntax

<operation signatures> :: [<operator list>] [<method list>]

<operator list> :: <operation signature>+

<method list> :: <operation signature>+

<operation signature> :: <operation preamble> <operation name> [<arguments>] [<result>]

<operation preamble> :: [<visibility> [<virtuality>]] | [<virtuality> [<visibility>]]

<arguments> :: <argument> +

<argument> = <formal parameter>

<formal parameter> :: <parameter kind> <sort>

<result> :: <sort>

Transformations

osigs = <operation signatures>((
<operator list>(*operations*),
<method list> (<operation signature>(*pre*, *name*, *args*, *result*) ⌒ *rest*))
=2=>
<operation signatures>(<operator list>(*operations* ⌒
<operation signature>(*pre*, *name*,
<argument>(**inout,** *parentAS0ofKind*(*osigs*, <data type definition>).*identifier0*) ⌒
if *args* = *undefined* **then** *empty* **else** *args* **endif**,
if *result* ≠ *undefined* **then** *result*
else *parentAS0ofKind*(*osigs*, <data type definition>).*identifier0*
endif))),
<method list>(*rest*))

If <operation signature> is contained in a <method list> this is derived syntax and is transformed as follows: An <argument> is constructed from the <parameter kind> **in/out**, and the <sort identifier> of the sort being defined by the enclosing <data type definition>. If there are no <arguments> (that is the argument list was empty), then <arguments> is formed from the constructed <argument> and inserted into the <operation signature>. If there are <arguments>, the constructed <argument> is added to the start of the original list of <argument>s in the <arguments>. If the <result> was omitted, the <result> is the <sort<identifier> of the sort being defined by the enclosing <data type definition>. See clause 12.1.3 *Model* of [ITU-T Z.104].

<formal parameter>(*undefined*, *sort*) =2=> <formal parameter>(**in**, *sort*)

A <formal parameter> with no explicit <parameter kind> has the implicit <parameter kind> **in**. See clause 9.4 *Model* of [ITU-T Z.103].

Mapping to abstract syntax

| <operation signatures>(*operators*, *)
then
{ *Mapping*(*operators*[*i*]) | *i* ∈ 1.. *operators.length*}

| *os* = <operation signature>(*pre*, *name*, *arguments*, *result*) **then**
let *opsig* = **mk-***Operation-signature*(
uniqueOperationName0(*name*,
< *arguments*[*i*].**s-**<formal parameter>.**s-**<sort> **|** *i* ∈ 1..*arguments.length* >
result.**s-**<sort>,
mk-<sort>(**mk-**<type expression>(*parentAS0ofKind*(*os*, <data type definition>).*identifier0 empty*))),
Mapping(*arguments*),

```
    Mapping(result),
    Mapping(os.operatorProcedureId)) in
    if pre.s-<virtuality> = virtual ∨ pre.s-<virtuality> = redefined
    then
        mk-Dynamic-operation-signature(opsig)
    else
        mk-Static-operation-signature(opsig)
    endif
endlet // opsig
```

The following three text paragraphs are from clause 12.1.3 *Concrete grammar* of [ITU-T Z.101].

An <operation signature> of an <operator list> represents a *Static-operation-signature*.

In an *Operation-signature*, each *Sort-reference-identifier* in *Formal-argument* is represented by an argument <sort>, and the *Operation-result* is represented by the result <sort>. The <sort> in the <formal parameter> of an <argument> of an operation represents the *Formal-argument*.

The *Operation-name* is unique within the defining scope unit in the abstract syntax even though the corresponding <operation name> is not necessarily unique. The unique *Operation-name* is derived from:

a) the <operation name>; plus

b) the (possible empty) list of argument sort identifiers; plus

c) the result sort identifier; plus

d) the sort identifier of the data type definition in which the <operation name> is defined.

An <operation signature> with <virtuality> **virtual** or **redefined** in the <operation preamble> represents a *Dynamic-operation-signature*. See clause 12.1.3 *Concrete grammar* of [ITU-T Z.107].

Auxiliary functions

The function *operatorProcedureId* associates each operation signature with its implicit anonymous procedure identifier.

```
controlled operatorProcedureId: <operation signature> → <identifier>
initially ∀ o ∈ <operation signature>: o.operatorProcedureId = undefined
```

The function *operationSignatureParameterList0* gets the list of the arguments of an operation signature.

```
operationSignatureParameterList0(os: <operation signature>):<formal parameter>* =def
    (os.s-<formal parameter>-seq)
```

The function *uniqueOperationName0* generates a unique *Operation-name* from the <operation name>, argument sort list, result sort and sort of the data type in which the operation is defined. Any algorithm that generates a unique *Name* is suitable. The one given here turns the parameters into a *TOKEN* string value that is made into a *Name*. The *TOKEN* string is a concatenation of the *TOKEN* string for the name and a list of *TOKEN* strings representing <identifier> items. Each *TOKEN* string for an <identifier> starts with separator ("#") that cannot appear in a <name>, therefore ensuring that every *Operation-name* is distinct any *Name* mapped simply from a <name>. The strings are in the following order: string for the result sort, string for the data type, and the strings for each argument sort (in order of the arguments).

NOTE – This algorithm is clearly inefficient and it is expected that analysis tools use a more efficient function to ensure unique *Operation-name* values.

```
uniqueOperationName0(n:<name>, argsorts:<sort>*, ressort:<sort>, datatype:<sort>):
    Operation-name =def
mk-Name(
    n.s-TOKEN ⌒ // character string for <name>
```

```
    sortOpName0(ressort) ⌒ // string for the result sort
    sortOpName0(datatype) ⌒ // string for the data type sort
    < sortOpName0(argsorts[i]) | i in 1..argsorts.length > // strings for argument sorts
)
```

The function *sortOpName0* generates the string for a <sort> to use in the functions *uniqueOperationName0 and uniqueLiteralName0*. The identifier for the sort is determined. The string starts with the separator ("#") followed by a string for the full qualifier of the identifier followed by the string for the name of the identifier. The string for the full qualifier is enclosed by "<<" and ">>" and each path item is the string for the scope unit kind, followed by a space, followed by the string for name of the path item with the character "/" separating path items. That is, the fully qualified identifier string is the same as in the SDL- 2010 concrete syntax.

```
sortOpName0(s:<sort>): TOKEN =def
let id = s.sortId0 in
"#" ⌒
"<<" ⌒
    <   let pathitem = id.s-<path item>-seq[i] in
            case pathitem.s-<scope unit kind> of
            |   package then "package"
            |   system type then "system type"
            |   system then "system"
            |   block then "block"
            |   block type then "block type"
            |   process then "process"
            |   process type then "process type"
            |   state then "state"
            |   state type then "state type"
            |   procedure then "procedure"
            |   signal then "signal"
            |   type then "type"
            |   operator then "operator"
            |   method then "method"
            |   interface then "interface"
            |   composition then "composition"
            endcase // pathitem.s-<scope unit kind>
            ⌒ " "
            ⌒ pathitem.s-<name>.s-TOKEN
            ⌒ if i < pathitem.length then "/" else empty endif
        endlet // pathitem
        | i in 1..id.s-<path item>-seq[i].length
    >
⌒ ">>"
⌒ id.s-<name>.s-TOKEN
endlet // id
```

F2.2.9.6 Data type constructors

Concrete syntax

<data type constructor> = <literal list> | <structure definition> | <choice definition>

F2.2.9.6.1 Literals

Abstract syntax

Literal-signature	::	*Literal-name* *Result*

Literal-natural

Literal-natural = *Nat*

Conditions on abstract syntax

∀*ls1*, *ls2*∈ *Literal-signature*: *ls1.parentAS1*=*ls2.parentAS1*∧*ls1*≠*ls2*⇒
ls1.**s-***Literal-natural* ≠ *ls2.Literal-natural*

Each *Literal-signature* in the *Literal-signature* set of a *Value-data-type-definition* shall have a different *Literal-natural*. See clause 12.1.6.1 *Abstract grammar* of [ITU-T Z.101].

Concrete syntax

<literal list> :: [<visibility>] <literal signature>+

<literal signature> = <literal name> | <named number>

<named number> :: <literal name> <Natural<simple expression>

Mapping to abstract syntax

| *litlist* = <literal list>(*,*literals*)
then
let *signatures* = *addNamedNumbers0*(*literals*, 1) **in**
let *nopreamble* = <operation preamble>(*undefined*, *undefined*) **in**
let *sort* = *litlist.parentAS0.parentAS0.identifier0* **in**
let *arg* = **mk-**<argument>(**in**, **mk-**<anchored sort>(*sort*)) **in**
let *resbool* = **mk-**<result>(*predefinedId0*("Boolean")) **in**
let *reslit* = **mk-**<result>(**mk-**<anchored sort>(*sort*)) **in**
{ *Mapping*(*signatures*[*i*]) | *i* ∈ 1..*signatures.length* }
∪ { *Mapping*(**mk-**<operation signature>(*nopreamble*, **mk-**<name>("num"), < *arg*, *arg* >,
mk-<result>(*predefinedId0*("Natural")))))
Mapping(**mk-**<operation signature>(*nopreamble*, **mk-**<name>("<"), < *arg*, *arg* >, *resbool*)),
Mapping(**mk-**<operation signature>(*nopreamble*, **mk-**<name>(">"), < *arg*, *arg* >, *resbool*)),
Mapping(**mk-**<operation signature>(*nopreamble*, **mk-**<name>(">="), < *arg*, *arg* >, *resbool*)),
Mapping(**mk-**<operation signature>(*nopreamble*, **mk-**<name>("<="), < *arg*, *arg* >, *resbool*)),
Mapping(**mk-**<operation signature>(*nopreamble*, **mk-**<name>("first"), < >, *reslit*)),
Mapping(**mk-**<operation signature>(*nopreamble*, **mk-**<name>("last"), < >, *reslit*)),
Mapping(**mk-**<operation signature>(*nopreamble*, **mk-**<name>("pred"), < *arg* >, *reslit*)),
Mapping(**mk-**<operation signature>(*nopreamble*, **mk-**<name>("succ"), < *arg* >, *reslit*)),
Mapping(**mk-**<operation signature>(*nopreamble*, **mk-**<name>("num"), < *arg*, *arg* >,
mk-<result>(*predefinedId0*("Natural")))))
} // operation signatures for generic operators
endlet // *reslit*
endlet // *resbool*
endlet // *arg*
endlet // *sort*
endlet // *nopreamble*
endlet // *signatures*

The following text is from clause 12.1.6.1 *Concrete grammar* of [ITU-T Z.101].

Each <literal name> in a <literal list> is given the lowest possible Natural simple expression value for the *Literal-natural* of the *Literal-signature* not occurring for any other <literal signature>s of the same <literal list>, considering the <literal name>s one by one from left to right. The result is, for example,

```
literals B, A = 2, C, D;
```

has B < C , C < A , A < D , num(C) = 1, num(D) = 3

The following text is from clause 12.1.6.1 *Semantics* of [ITU-T Z.101].

Additional generic operators exist for a sort defined by a constructor that creates a *Literal-signature* set, as follows:

a) an operator that gives the position of each data item in the ordering as the corresponding Natural simple expression value;

b) operators that compare two data items with respect to the established ordering; and

c) operators that return the first, last, next or previous data item in the ordering.

For a sort named S that is defined by a constructor that creates a *Literal-signature* set, there is a *Static-operation-signature* list equivalent to the following:

```
num ( S )    -> Natural;
"<" ( S, S ) -> Boolean;
">" ( S, S ) -> Boolean;
"<="( S, S ) -> Boolean;
">="( S, S ) -> Boolean;
first        -> S;
last         -> S;
succ( S )    -> S;
pred( S )    -> S;
```

where Boolean is the predefined Boolean sort and Natural is the predefined Natural sort, and the parameters and the results correspond to an *Aggregation-kind* of **PART**.

The operator `num` returns the Natural simple expression value corresponding to the *Literal-natural* of the literal.

The comparison operators `"<"` (`">"`,`"<="`,`">="`) represent the standard less-than (greater-than, less-or-equal-than, and greater-or-equal-than) comparison between the Natural simple expression values corresponding to each *Literal-natural* of the two literals. The operator `first` returns the first data item in the ordering (the literal with the lowest Natural simple expression value corresponding to the *Literal-natural*). The operator `last` returns the last data item in the ordering (the literal with the highest Natural simple expression value corresponding to the *Literal-natural*). The operator `pred` returns the preceding data item (that is, the literal with the highest *Literal-natural* that is less than the *Literal-natural* corresponding to the actual parameter), if one exists, or the same as the operator `last`, otherwise. The operator `succ` returns the successor data item (that is, the literal with the lowest *Literal-natural* that is greater than the *Literal-natural* corresponding to the actual parameter) in the ordering, if one exists, or the same as the operator `first`, otherwise.

| *nn* = <named number>(*name*, *number*) **then**
  mk-*Literal-signature*
    (*uniqueLiteralName0* (*name*),
      mk-*Result*(*Mapping*(
        identifier0(*parentAS0ofKind*(*nn*, <data type definition>))))
      mk-*Literal-natural*(*Mapping*(*number*)))

The following text is from clause 12.1.6.1 *Concrete grammar* of [ITU-T Z.101].

The *Literal-name* is unique within the defining scope unit in the abstract syntax even if the corresponding <literal name> is not unique. The unique *Literal-name* is derived from:

a) the <literal name>; plus

b) the sort identifier of the data type definition in which the <literal name> is defined.

In a *Literal-signature*, the *Result* is the sort introduced by the <data type definition> defining the <literal signature>.

The Natural simple expression value of the <Natural simple expression> occurring in a <named number> represents the *Literal-natural* of the *Literal-signature*.

Auxiliary functions

The function *uniqueLiteralName0* generates a unique *Literal-name* from the <literal name>, and sort of the data type in which the operation is defined. Any algorithm that generates a unique *Name* is suitable. The one given here turns the parameters into a *TOKEN* string value that is made into a *Name*. The *TOKEN* string is a concatenation of the *TOKEN* string for the name and a *TOKEN* string representing the sort <identifier>. The *TOKEN* string for an <identifier> starts with separator ("#") that cannot appear in a <name>, therefore ensuring that every *Literal-name* is distinct from any *Name* mapped simply from a <name>. The result is distinct from an *Operation-name* without parameters of the same sort, because an *Operation-name* includes a result sort.

uniqueLiteralName0(*n*:<name>, *datatype*:<sort>):
    Literal-name =$_{def}$
mk-*Name*(
    n.**s-***TOKEN* ⌒ // character string for <name>
    sortOpName0(*datatype*) ⌒ // string for the data type sort
)

The function *visibility0* provides the visibility of an operation or literal.

visibility0(*s*:<operation signature>∪<literal signature>):<visibility>=$_{def}$
    if *s*∈<operation signature> **then** *s*.**s-**<visibility>
    else *s.parentAS0*.**s-**<visibility>

The function *addNamedNumbers0* changes the <literal signature> list (of a <literal list>) so that each <literal name> in turn is changed into a <named number>.

addNamedNumbers0(*literals*: <literal signature>*, *i*: *NAT*): <literal signature>* =$_{def}$
    if *i* > *literals.length* **then** *literals*
    else
        addNamedNumbers0(
            if *literals*[*i*] ∈ <literal name> **then** *changeLitsig0*(*literals*, *i*) **else** *literals* **endif**,
            i+1)
    endif

The function *changeLitsig0* changes the item i of a <literal signature> list from a <literal name> into a <named number>.

changeLitsig0(*literals*: <literal signature>*, *i*: *NAT*): <literal signature>* =$_{def}$
    headLitsigs0(*literals*, *i*) ⌒
        < **mk-**<named number>(
            literals[*i*], **mk-**<operand5>(**mk-**<identifier>(*predefinedQual0*("Integer"),
                mk-<name>(*nextNumber0*(*literals*, 0))))
) > ⌒
    tailLitsigs0(*literals*, *i*)

The function *headLitsigs0* produces a list of the items before item i of a <literal signature> list.

headLitsigs0(*literals*: <literal signature>*, *i*: *NAT*): <literal signature>* =$_{def}$
    if *i* = 1 **then** *empty*
    else *literals.head* ⌒ *headLitsigs0*(*literals.tail*, *i*-1)

The function *tailLitsigs0* produces a list of the items after item i of a <literal signature> list.

tailLitsigs0(*literals*: <literal signature>*, *i*: *NAT*): <literal signature>* =$_{def}$
    if *i* = *literals.length* **then** *empty*
    else *literals*[*i*+1] ⌒ *tailLitsigs0*(*literals*, *i*+1)

The function *nextNumber0* produces a *TOKEN* corresponding to the lowest available Natural number not occurring as a <simple expression> of any <named number> in the given <literal signature> list, and equal or higher than the initial value given. The function *natToIntToken* is in clause F2.2.1.6.5, Function definitions on AS0. The *simpleMapping* converts each <simple expression> into a *Constant-expression* that is evaluated by *value1* to produce an integer *TOKEN* compared with the current value of the counter *i* until one is found not already in the <literal signature> list.

nextNumber0(*literals*: <literal signature>*, *i*: *NAT*): *TOKEN* =$_{\text{def}}$
if (¬∃ *n* ∈ <named number> : *n* **in** *literals*
∧ (*n*.**s-**<simple expression>.*simpleMapping*.*value1*.*intTokenToNat*= *i*))
then
i.*natToIntToken*
else
nextNumber0(*literals*, *i*+1)
endif

F2.2.9.6.2 Structure data types

Concrete syntax

<structure definition> :: [<visibility>] <field list>

<field list> = <field>+

<field> =
<optional field> | <mandatory field>

<optional field> :: <fields of sort>

<mandatory field> :: <fields of sort> [<field default initialization>]

<field default initialization> :: <constant expression>

<fields of sort> :: [<visibility>] <field of kind>+ <field sort>

<field of kind> :: <aggregation kind> <field<name>

<field sort> = <sort>

Conditions on concrete syntax

∀*sd*∈<structure definition>: *sd*.*fieldNameList0*.*length* = |*sd*.*fieldNameList0*.*toSet*|

Each <field<name> of a structure sort shall be different from every other <field<name> of the same <structure definition>.

Transformations

< <optional field>(<fields of sort>(*vis*, < *f* > ⌒ *rest*, *sort*))> **provided** *rest* ≠ *empty* =5=>
< <optional field>(<fields of sort>(*vis*, < *f* >, *sort*)),
<optional field>(<fields of sort>(*vis*, *rest*, *sort*)) >

< <mandatory field>(<fields of sort>(*vis*, < *f* > ⌒ *rest*, *sort*), *init*)> **provided** *rest* ≠ *empty* =5=>
< <mandatory field>(<fields of sort>(*vis*, < *f* >, *sort*), *init*),
<mandatory field>(<fields of sort>(*vis*, *rest*, *sort*), *init*) >

A <field list> containing a <field> that has a <fields of sort> with an <field of kind> list is derived concrete syntax where this <field> is replaced by a list of <field>s separated by <end>, one for each <field of kind> in the order of occurrence of each <field of kind>. Each <field> in the replacement list has a <fields of sort> with same <visibility> and <field sort> as the original <fields of sort>. Each <field> in the replacement list is **`optional`** if the original <field> was **`optional`**, or has the <field default initialization> of the original <field> if there was one. See clause 12.1.6.2 *Model* of [ITU-T Z.104].

<operator application>(*ident*, *params* = *first* ⌒ < *param* > ⌒ *last*)
provided *ident*.**s-**<operation name>.**s-***TOKEN* = "Make" ∧
param = *undefined* ∧
∃ *sd*(*, *fields*) ∈ <structure definition>: *sd*.*parentAS0*. *parentAS0* =
parentAS0ofKind(*ident.refersto0*, <data type definition>) ∧
expandfieldsSt0(*fields*)[*first.length* + 1] ∈ <mandatory field> ∧
expandfieldsSt0(*fields*)[*first.length* + 1].**s-**<field default initialization> ≠ *undefined*
=8=>
<method application>(<operator application>(*ident*, *params*),
<identifier>(*parentAS0ofKind*(*ident.refersto0*, <data type definition>).*fullQualifier0*,
<name>(*sd.fieldNameList0*[*first.length* + 1].**s-***TOKEN* + "Modify")),
< *expandfieldsSt0*(*fields*)[*first.length* + 1].**s-**<field default initialization>>)

A Make operation with a non-empty *Formal-argument* list creates a new structure and associates each field with the result of the corresponding formal parameter, or if no actual argument is given for the field, the default initialization for that field, or "undefined" if there is no default initialization for the field. See clause 12.1.6.2 *Semantics* of [ITU-T Z.101].

Mapping to abstract syntax

The following paragraphs are from clause 12.1.6.2 *Concrete grammar* of [ITU-T Z.101] and describe the mapping to abstract syntax for <structure definition> as part of the mapping is a <data type definition body> in clause F2.2.9.2 Data type definition.

The <structure definition> for a structure `S` represents (in the *Operation-signature* set of the *Data-type-definition* for `S`):

a) in the absence of data type specialization, if no operator named `Make` is given with an *Operation-result* that is the *Sort-reference-identifier* of the `S` structure sort (an `S` structure result), an *Operation-signature* for a generic operator named `Make` with:

   i. a *Formal-argument* list where each item is the *Sort-reference-identifier* of the corresponding (in order) <field name> if the referenced <field> does not contain **`optional`** and does not contain a <field default initialization>;

   ii. an *Operation-result* that is the `S` structure result;

   iii. the procedure identified by the *Operation-signature* having each formal parameter of its *Parameter-aggregation* derived from the <aggregation kind> of the corresponding <field name>, and a *Result-aggregation* that is **`PART`**.

b) if `S` has a <data type specialization> and no constructor (an operator named `Make` with an *Operation-result* that is the *Sort-reference-identifier* of the `S` structure sort) is given, an *Operation-signature* for a generic operator named `Make` for each (normally one) inherited *Operation-signature* for an operator named `Make` with:

   i. a *Formal-argument* list that begins with *Sort-reference-identifier* items of the *Formal-argument* list of the inherited `Make` operator and where each subsequent item is the *Sort-reference-identifier* of the corresponding (in order) <field name> if the referenced <field> does not contain **`optional`** and does not contain a <field default initialization>;

   ii. an *Operation-result* that is the `S` structure result;

   iii. the procedure identified by the *Operation-signature* having each formal parameter of its *Parameter-aggregation* derived from the <aggregation kind> of the corresponding <field name>, and a *Result-aggregation* that is **`PART`**.

c) for each field, if the <field name> is `fn` and the <field sort> is `fs`, an *Operation-signature* for the <operation signature>
`fnExtract ( S ) -> fs;`
for a generic operator where
`fnExtract` is a *field-extract-name* formed from the concatenation of the field name and "Extract",
`S` is an **`in/out`** parameter with an empty <aggregation kind>,
and the result has the same <aggregation kind> as the field `fn`.

d) for each field, if the <field name> is `fn` and the <field sort> is `fs`, an *Operation-signature* for the <operation signature>
`fnModify ( S, fs ) -> S;`
for a generic operator where
`fnModify` is a *field-modify-name* formed from the concatenation of the field name and "Modify",
`S` is an **`in/out`** parameter with an empty <aggregation kind>,
`fs` is an **`in`** parameter with the same <aggregation kind> as the field `fn`,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **`PART`**.

e) for each field, if the <field name> is `fn`, an *Operation-signature* for the <operation signature>
`fnPresent ( S ) -> <<`**`package`** `Predefined>>Boolean;`
for a generic operator where
`fnPresent` is a *field-present-name* formed from the concatenation of the field name and "`Present`",
`S` is an **`in/out`** parameter with an empty <aggregation kind>,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **`PART`**.

f) an *Operation-signature* for a generic operator named `Undefined` based on the <operation signature>
`Undefined ( S )-> <<`**`package`** `Predefined>>Boolean;`
which is `true` if the structure is "undefined": that is, every field of the structure is "undefined",
`S` is an **`in/out`** parameter with an empty <aggregation kind>,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **`PART`**.

Auxiliary functions

The function *implicitSignaturesAdded* records whether the implicit signatures for structure operators have been added into a data type.

controlled *implicitSignaturesAdded*: <identifier> → *BOOLEAN*
initially ∀ *id* ∈ <identifier>: (*getEntityDefinition0*(*id*, <data type definition>) ≠ *undefined* ∧
(*getEntityDefinition0*(*id*, <data type definition>).**s-**<data type definition body>.**s-**<data type constructor>
∈ <structure definition>))
⇒
id.implicitSignaturesAdded = false

The function *expandfieldsSt0* expands a list of structure fields to produce a new list where each field contains one name.

expandfieldsSt0(*fl*: {<optional field> ∪ <mandatory field>}*):
{<optional field> ∪ <mandatory field>}*=$_{def}$
if *fl.length* = 0 **then** *undefined*
elseif *fl.length* = 1 **then**
if *fl.head* ∈ <optional field> **then**

```
        < mk-<optional field>(
            mk-<fields of sort>(
                fl.head.s-<fields of sort>.s-<visibility>,
                < fl.head.s-<fields of sort>.s-<field of kind>-seq.head >,
                fl.head.s-<fields of sort>.s-<field sort>
        )   ) >
    else
        < mk-<mandatory field>(
            mk-<fields of sort>(
                fl.head.s-<fields of sort>.s-<visibility>,
                < fl.head.s-<fields of sort>.s-<field of kind>-seq.head >,
                fl.head.s-<fields of sort>.s-<field sort>),
            fl.head.s-<field default initialization>
        ) >
    endif ⌒
    if fl.head.s-<fields of sort>.s-<field of kind>-seq.length = 1
    then empty
    else
    expandfieldsSt0(
    if fl.head ∈ <optional field> then
        < mk-<optional field>(
            mk-<fields of sort>(
                fl.head.s-<fields of sort>.s-<visibility>,
                fl.head.s-<fields of sort>.s-<field of kind>-seq.tail,
                fl.head.s-<fields of sort>.s-<field sort>
        )   ) >
    else
        < mk-<mandatory field>(
            mk-<fields of sort>(
                fl.head.s-<fields of sort>.s-<visibility>,
                fl.head.s-<fields of sort>.s-<field of kind>-seq.tail,
                fl.head.s-<fields of sort>.s-<field sort>),
            fl.head.s-<field default initialization>
        ) >
    endif)
else
    expandfieldsSt0(< fl.head >) ⌒ expandfieldsSt0(fl.tail)
endif
```

The function *fieldNameList0* gives the list of structure field or choice names for a structure definition or choice definition in the order the fields appear in the definition.

```
fieldNameList0(d(*,lst):<structure definition>∪<choice definition>): <name>*=def
if d∈ <structure definition> then fieldNameListSt0(lst) else fieldNameListCh0(lst) endif
```

The function *fieldNameListSt0* gives the list of structure field names from a list of fields in the order the fields appear in the list.

```
fieldNameListSt0(fl: {<optional field> ∪ <mandatory field>}*): <name>*=def
if fl.length = 0 then undefined
elseif fl.length = 1 then
    < fl.head.s-<fields of sort>.s-<field of kind>-seq.head.s-<name> > ⌒
    if fl.head.s-<fields of sort>.s-<field of kind>-seq.length = 1
    then empty
    else fieldNameListSt0(fl.head.s -<fields of sort>.s-<field of kind>-seq.tail)
    endif
else
    fieldNameListSt0(< fl.head >)⌒fieldNameListSt0(fl.tail)
endif
```

The function *fieldNameListCh0* gives the list of choice field names from a list of fields in the order the fields appear in the list.

fieldNameListCh0(*cl*: <choice of sort>*): <name>*=$_{def}$
if *cl*.*length* = 0 **then** *undefined*
elseif *cl*.*length* = 1 **then**
    < *cl*.*head*.**s-**<choice of sort>.**s-**<field of kind>**-seq**.*head*.**s-**<name> > ⌒
    if *cl*.*head*.**s-**<choice of sort>.**s-**<field of kind>**-seq**.*length* = 1
    then *empty*
    else *fieldNameListCh0*(*cl*.*head*.**s** -<choice of sort>.**s-**<field of kind>**-seq**.*tail*)
    endif
else
    fieldNameListCh0(< *cl*.*head* >)⌒*fieldNameListCh0*(*cl*.*tail*)
endif

The function *fieldSortList0* gives the list of structure field sorts from a list of fields in the order the fields appear in the list.

fieldSortList0(*d*(*,*lst*): <structure definition>∪<choice definition>):<sort>*=$_{def}$
if *d*∈ <structure definition> **then** *fieldSortListSt0*(*lst*) **else** *fieldSortListCh0*(*lst*) **endif**

The function *fieldSortListSt0* gives the list of structure field sorts from a list of fields in the order the fields appear in the list.

fieldSortListSt0(*fl*: {<optional field> ∪ <mandatory field>}*): <name>*=$_{def}$
if *fl*.*length* = 0 **then** *undefined*
elseif *fl*.*length* = 1 **then**
    < *fl*.*head*.**s-**<fields of sort>.**s-**<field sort> > ⌒
    if *fl*.*head*.**s-**<fields of sort>.**s-**<field of kind>**-seq**.*length* = 1
    then *empty*
    else *fieldSortListSt0*(*fl*.*head*.**s** -<fields of sort>.**s-**<field of kind>**-seq**.*tail*)
    endif
else
    fieldSortListSt0(< *fl*.*head* >)⌒ *fieldSortListSt0*(*fl*.*tail*)
endif

The function *fieldSortListCh0* gives the list of choice sorts from a list of fields in the order the fields appear in the list.

fieldSortListCh0(*cl*: <choice of sort>*): <name>*=$_{def}$
if *cl*.*length* = 0 **then** *undefined*
elseif *cl*.*length* = 1 **then**
    < *cl*.*head*.**s-**<choice of sort>.**s-**<field sort> > ⌒
    if *cl*.*head*.**s-**<choice of sort>.**s-**<field of kind>**-seq**.*length* = 1
    then *empty*
    else *fieldSortListCh0*(*cl*.*head*.**s** -<choice of sort>.**s-**<field of kind>**-seq**.*tail*)
    endif
else
    fieldSortListCh0(< *cl*.*head* >)⌒*fieldSortListCh0*(*cl*.*tail*)
endif

defaultValue(*n*: <name>): <constant expression> =$_{def}$
    case *n*.*parentAS0* **in**
    | <mandatory field>(*, <field default initialization>(*e*)) **then** *e*
    otherwise
        undefined
    endif

F2.2.9.6.3 Choice data types

Concrete syntax

<choice definition> :: [<visibility>] [<choice list>]

<choice list> = <choice of sort>+

<choice of sort> :: [<visibility>] <field of kind>+ <field sort>

Conditions on concrete syntax

∀*cd*∈<choice definition>: *cd.fieldNameList0.length* = |*cd.fieldNameList0.toSet*|

Each <field<name> of a choice sort shall be different from every other <field<name> of the same <choice definition>. See clause 12.1.6.3 *Concrete grammar* of [ITU-T Z.101].

Transformations

< <choice of sort>(*vis*, < *c* > ⌒ *rest*, *sort*) >
provided *rest* ≠ *empty*
=5=>
< <choice of sort>(*vis*, < *c* >, *sort*), <choice of sort>(*vis*, *rest*, *sort*) >

A <choice list> containing a <choice of sort> with an <aggregation kind> <field name> pair list is derived concrete syntax where this <choice of sort> is replaced by a list of <choice of sort> items separated by <end>, one for each <aggregation kind> <field name> pair in the order of occurrence of each <aggregation kind> <field name> pair. Each <choice of sort> in the replacement list has the same <visibility> and <field sort> as the original <choice of sort>. See clause 12.1.6.3 *Model* of [ITU-T Z.104].

Mapping to abstract syntax

The following paragraphs are from clause 12.1.6.3 *Concrete syntax* of [ITU-T Z.101] and describe the mapping to abstract syntax for <choice definition> as part of the mapping is a <data type definition body> in clause F2.2.9.2 Data type definition.

The <choice definition> for a choice sort `C` represents (in the *Operation-signature* set of the *Data-type-definition* for `C`):

a) an *Operation-signature* for a generic operator named `Make` with an empty *Formal-argument* list and an *Operation-result* that is the *Sort-reference-identifier* of the `C` choice sort, and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **`PART`**.

b) for each field, if the <field name> is `fn` and the <field sort> is `fs`, an *Operation-signature* for the operation signature
```
fn ( fs ) -> C;
```
for a generic field association operator where
`fn` is a *field-associate-name* which is the same as the field name,
`fs` is an `in` parameter with the same <aggregation kind> as the field `fn`,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **`PART`**.

c) for each field, if the <field name> is `fn` and the <field sort> is `fs`, an *Operation-signature* for the <operation signature>
```
fnExtract ( C ) -> fs;
```
for a generic operator where
`fnExtract` is a *field-extract-name* formed from the concatenation of the field name and "Extract",
`C` is an **`in/out`** parameter with an empty <aggregation kind>,
and the result has the same <aggregation kind> as the field `fn`.

d) for each field, if the <field name> is `fn` and the <field sort> is `fs`, an *Operation-signature* for the <operation signature>
`fnModify ( C, fs ) -> C;`
for a generic operator where
`fnModify` is a *field-modify-name* formed from the concatenation of the field name and "Modify",
`C` is an **`in/out`** parameter with an empty <aggregation kind>,
`fs` is an **in** parameter with an empty <aggregation kind>,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **`PART`**.

e) for each field, if the <field name> is `fn`, an Operation-signature for the <operation signature>

`fnPresent ( C ) -> <<`**`package`** `Predefined>>Boolean;`
for a generic operator where
`fnPresent` is a *field-present-name* formed from the concatenation of the field name and "`Present`",
`C` is an **in/out** parameter with an empty <aggregation kind>,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **`PART`**.

f) an *Operation-signature* for a generic operator named `PresentExtract` based on the <operation signature>
`PresentExtract ( C )-> AnonPresent;.`
where `AnonPresent` is defined as a literal constructor data type that uses the field names of the choice as literals as described below,
`C` is an **`in/out`** parameter with an empty <aggregation kind>,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **`PART`**.

g) an *Operation-signature* for a generic operator named `Undefined` based on the <operation signature>
`Undefined (C )-> <<`**`package`** `Predefined>>Boolean;`
which is `true` if the choice is "undefined",
where `C` is an **in/out** parameter with an empty <aggregation kind>,
and the procedure identified by the *Operation-signature* has a *Result-aggregation* that is **`PART`**.

The <choice definition> for a choice sort `C` also represents an additional (anonymous) *Data-type-definition*, that for description above is called `AnonPresent`. This *Data-type-definition* is placed in the context that the *Data-type-definition* for `C`, therefore both `AnonPresent` and its contained *Literal-signature-**set*** are visible where `C` is visible. This is defined with a *Literal-signature-**set*** where each <field name> of the choice sort `C` represents a *Literal-signature*. The order of the literals is the same as the order in which the <field name>s are specified left to right in the choice sort `C`. The purpose of this data type is to allow the operation `PresentExtract` with a result that corresponds to the field name. The name of this data type being unknown prevents it being used for other purposes.

F2.2.9.7 Behaviour of operations

Concrete syntax

<operation definition item> =
<operation definition> | <operation reference> | <external operation definition>

<operation reference> :: <operation kind> <operation signature>

<external operation definition> :: <operation kind> <operation signature>

<operation definition> ::
<package use clause>* <operation heading> <entity in operation>*
{ <operation body> | <statements> }

<operation heading> ::
<operation kind> <operation preamble> [<qualifier>] <operation name>
<formal operation parameters> [<operation result>]

<formal operation parameters> = <formal variable parameters>*

<operation kind> :: **operator** | **method**

<operation identifier> :: [<qualifier>] <operation name>

<entity in operation> =
<data definition>
| <variable definition>
| <select definition>

<operation body> ::
<start> {<free action>}*

<operation result> :: <result aggregation> [<variable<name>] <sort>

<operation definition> is an alternative textual concrete syntax to <operation diagram> and therefore defines a scope unit. See clause 6 of [ITU-T Z.106].

Conditions on concrete syntax

$\forall opRef \in$ <operation reference>:
($opRef$.**s-**<operation signature>.**s-**<arguments> = *undefined* $\vee$
$opRef$.**s-**<operation signature>.**s-**< result> = *undefined*)$\Rightarrow$
($\forall opRef1 \in$ <operation reference>:
$opRef1 \neq opRef \wedge opRef.parentAS0 = opRef1.parentAS0 \Rightarrow opRef1.name0 \neq opRef.name0$)

<arguments> and <result> of the <operation signature> in an <operation reference> are allowed to be omitted if there is no other <operation reference> within the same sort of data that has the same name. In this case, the referenced <operation definition> is identified simply by its name. The <operation reference> enables the referenced <operation definition> to be located, so that it is possible to map the concrete definition to the enclosing data type definition in the logical hierarchy in the abstract grammar. Modified from clause 8.2 *Concrete grammar* of [ITU-T Z.101].

$\forall opDef \in$ <external operation definition>:
($opDef$.**s-**<operation signature>.**s-**<arguments> = *undefined* $\wedge$
$opDef$.**s-**<operation signature>.**s-**<result> = *undefined*)$\Rightarrow$
$\neg$ ($\exists$ *opDef1* $\in$ <external operation definition> \ { *opDef* }:
$opDef.parentAS0 = opDef1.parentAS0 \wedge$
$opDef$.**s-**<operation signature>.**s-**<name> = $opDef1$.**s-**<operation signature>.**s-**<name>)
$\wedge$ ($\exists$ *opSig* $\in$ <operation signature> :
$opDef.parentAS0 = opSig.parentAS0 \wedge$
$opDef$.**s-**<operation signature>.**s-**<name> = $opSig.name0$)

It is allowed to omit <arguments> and <result> in <external operation definition> if there is no other <external operation definition> within the same sort which has the same name, and an <operation signature> is present. In this case, the <arguments> and the <result> are derived from the <operation signature>. See clause 12.1.7 *Concrete grammar* of [ITU-T Z.104].

$\forall od \in$ <operation definition>: $\exists! os \in$ <operation signature>:
$od.name0 = os.name0 \wedge od.parentAS0 = os.parentAS0 \Rightarrow isSameOperationAndSignature0(od, os)$

In an <operation signature> of <operation signatures> there shall be one and only one corresponding definition (<operation reference> or <external operation definition>) in the <operation definitions> of the <operations>. See clause 12.1.1 *Concrete grammar* of [ITU-T Z.104].

For each <operation definition> if there exists an <operation signature> in the same scope unit having the same <operation name>, then it must have the same <argument sort>s and <parameter kind>s as

specified in the <formal operation parameters> (if present) and the same <result sort> as specified in <operation result> (if present).

∀*os*∈<operation signature>: ∃!*od*∈(<operation reference>∪<external operation definition>):
od.parentAS0= os.parentAS0∧ *od.name0= os.name0*∧ *isSameOperationAndSignature0*(*od, os*)

For an <operation signature> of <operation signatures> there shall be one and only one corresponding definition (<operation reference> or <external operation definition>) in the <operation definitions> of the <operations>. See clause 12.1.1 *Concrete grammar* of [ITU-T Z.104].

∀*bs*∈<operation body>∪<statement>: *parentAS0ofKind*(*bs*, <operation definition>)≠*undefined* ⇒
(¬∃*ie*∈<imperative expression>: *isAncestorAS0*(*bs, ie*))∧
(∀*id*∈<identifier>: *id.idKind0*∉{**synonym**, **procedure**}∧ *isAncestorAS0*(*bs, id*)⇒
isDefinedIn0(*getEntityDefinition0*(*id, id.idKind0*),
parentAS0ofKind(*bs,* <operation definition>)))

<operation body> as well as the <statement>s in <operation definition> may contain neither an <imperative expression> nor an <identifier> defined outside the enclosing <operation definition>, except for <synonym identifier>s, <operation identifier>s, <literal identifier>s and <sort>s.

Transformations

<operations>(*opsigs, opdefs*)
provided
∃ *opdef* **in** *opdefs*: (
opdef ∈ <operation definition> ∧
if *opdefs*[*i*].**s-**<operation heading>.**s-**<operation kind> = **operator**
then
if *opsigs*.**s-**<operator list> ≠ *undefined*
then ¬∃ *opsig* **in** *opsigs*.**s-**<operator list>:
isSameOperationSignature0(*operationSignature0*(*opdef*), *opsig*)
else *true*
endif // operator
else // method
if *opsigs*.**s-**<method list> ≠ *undefined*
then ¬∃ *opsig* **in** *opsigs*.**s-**<method list>:
isSameOperationSignature0(*operationSignature0*(*opdef*), *opsig*)
else *true*
endif // method
endif *true* // operator or method
) // exists opdef in opdefs such that no corresponding signature in opsigs
=8=>
mk-<operations>(
mk-<operation signatures>(
mk-<operator list>(
if *opsigs*.**s-**<operator list> ≠ *undefined* **then** *opsigs*.**s-**<operator list> **else** *empty* **endif** ⁀
< **mk-**<operation signature>(*operationSignature0*(*opdef*[*i*])) :
i ∈ 1..*opdefs.length* ∧
if *opsigs*.**s-**<operator list> ≠ *undefined*
then ¬∃ *opsig* **in** *opsigs*.**s-**<operator list>:
isSameOperationSignature0(*operationSignature0*(*opdef*[*i*]), *opsig*)
else *true*
endif
> // list of new operator signatures
), // operator list
mk-<method list>(
if *opsigs*.**s-**<method list> ≠ *undefined* **then** *opsigs*.**s-**<operator list> **else** *empty* **endif** ⁀
< **mk-**<operation signature>(*operationSignature0*(*opdef*[*i*])) :
i ∈ 1..*opdefs.length* ∧
if *opsigs*.**s-**<method list> ≠ *undefined*
then ¬∃ *opsig* **in** *opsigs*.**s-**<operator list>:
isSameOperationSignature0(*operationSignature0*(*opdef*[*i*]), *opsig*)

```
                    else true
                    endif
                > // list of new method signatures
            ), // method list
        ), // operation signatures
        opdefs
)
```

For every <operation definition> which does not have a corresponding <operation signature>, an <operation signature> is constructed. See clause 12.1.7 *Model* of [ITU-T Z.104].

```
eod = <external operation definition>(kind, <operation signature>(pre, name, undefined, undefined))
=8=>
let opSig = take({os ∈ <operation signature> : eod.parentAS0 = opSig.parentAS0 ∧ os.name0 = name}) in
mk-<external operation definition>( kind,
    mk-<operation signature>(pre, name, opSig.s-<arguments>, opSig.s-<result>))
endlet
```

It is allowed to omit <arguments> and <result> in <external operation definition>. In this case, the <arguments> and the <result> are derived from the <operation signature>. See clause 12.1.7 *Concrete grammar* of [ITU-T Z.104].

```
od.operatorProcedureId
provided
    od ∈ <operation definition>
∧   od.operatorProcedureId = undefined
=??=>
(operatorProcedureId \{( od, undefined )} ) ∪ {( od, newName)}

od = <operation definition>(use, <operation heading>(kind, *, *, name, *, params,
    <operation result>(var, sort)), entities, body)
provided od.operatorProcedureId ≠ undefined
=8=>
    od // the operation definition
and
    od.getEntities0 // the procedure is placed in the data type definition
=> od.getEntities0 ⌒
    < mk-<internal procedure definition>(use,
        mk-<procedure heading>(undefined, undefined,
            od.operatorProcedureId.s-<name>, empty, undefined, undefined,
            (if kind = method then
                < mk-<formal variable parameters>(inout,
                    mk-<parameters of sort>(od.operatorProcedureId,
                        parentAS0ofKind(od, <data type definition>).identifier0)) >
                    // has the same anonymous name as the procedure
            else empty endif) ⌒
            < mk-<formal variable parameters>(p.s-<parameter kind>, p.s-<parameters of sort>) |
                p in params >,
            mk-<procedure result>(var, sort)),
        entities, makeProcedureBody(body))
    >
```

Further study is needed for the above transform because in Z.101 to Z.107, a procedure definition is not allowed as <entity in data type>; therefore this needs to be changed to a *Mapping* according see text below from Z.101. Therefore this transform is not listed at the end of the document.

An <operation definition> represents a *Procedure-definition* in the *Procedure-definition-**set*** of the directly enclosing *Data-type-definition*. The *Procedure-name* of the *Procedure-definition* is an anonymous unique name, and the *Procedure-definition* is associated with the *Operation-signature* by the *Procedure-identifier* in the *Operation-signature*. The <formal operation parameters> list for the operator represents the *Procedure-formal-parameter* list of the *Procedure-definition* in the same way

as the formal parameters for a procedure. The <operation result> represents the *Result* of the *Procedure-definition*, therefore the <result aggregation> represents the *Result-aggregation*. The components of the <operation body area> are used in the same way as the components of a <procedure body area> to represent the *Data-type-definition-**set**, Syntype-definition-**set**, Variable-definition-**set**, Procedure-definition-**set*** and *Procedure-graph* of the *Procedure-definition*. See clause 12.1.7 *Concrete grammar* of [ITU-T Z.101].

If the <operation kind> is **operator**, each item in the <formal operation parameters> represents an item (in the same order) in the *Procedure-formal-parameter* list of the *Procedure-definition* for the operator. If the <operation kind> is **method**, the first item in the *Procedure-formal-parameter* list of the *Procedure-definition* for the method is an *Inout-parameter* with an anonymous *Variable-name* and a *Sort-reference-identifier* that identifies the sort for the data type in which the method is defined. Each item in the <formal operation parameters> of a method represents a subsequent item (in the same order) in the *Procedure-formal-parameter* list of the *Procedure-definition* for the method. See clause 12.1.7 *Concrete grammar* of [ITU-T Z.104].

If the <operation heading> begins with the keyword **operator**, then <operation definition> defines the behaviour of an operator. If the <operation heading> begins with the keyword **method**, then <operation definition> defines the behaviour of a method. Whether an operation is an operator or method is part of the operation signature and therefore part of the identity of the operation. See clause 12.1.7 *Concrete grammar* of [ITU-T Z.104].

If an operation contains informal text, the interpretation of expressions involving application of the corresponding operation is not formally defined by the Specification and Description Language but is determined from the informal text by the interpreter. If informal text is specified, a complete formal specification has not been given in the Specification and Description Language. See clause 12.1.7 *Model* of [ITU-T Z.104].

Auxiliary functions

The Boolean function *isSameOperationAndSignature0* is true if the given operation is an <operation definition> has the same result as the given signature, both have the same number of parameters and each the parameters of the operation has the same sort and parameter kind as the given signature.

```
isSameOperationAndSignature0(od: <operation definition>∪<external operation definition>,
    os: <operation signature> ): BOOLEAN =def
if od ∈ <operation definition> then
    let seq1 = od.operationFormalparameterList0 in
    let seq2 = os.operationSignatureParameterList0 in
    (od.s-<operation heading>.s-<operation result> ≠ undefined ⇒
        isSameResult0(od.s-<operation heading>.s-<operation result>, os.s-<result>) ∧
        (seq1≠empty ⇒
            seq1.length = seq2.length∧
            (∀i∈1..seq1.length: isSameSort0(seq1[i].parentAS0.s-<sort>, seq2[i].s-<sort>) ∧
                seq1[i].parentAS0.s-<parameter kind>= seq2[i].s-<parameter kind>)))
    endlet // seq2
    endlet // seq1
else // od ∈ <external operation definition>
    od.s-<operation signature> = os
endif
```

The function *operationFormalparameterList0* gets the list of names of the formal parameters of an operation definition.

```
operationFormalparameterList0(od: <operation definition>): <name>* =def
< opl.s-<parameters of sort>.s-<name>-seq |
    opl in od.s-<operation heading>.s-<formal variable parameters>-seq >
```

The function *idKind0* determines the entity kind of an <identifier> according to its syntactic position. For an <identifier> in an <actual context parameter>, the result is the entity kind of the formal context parameter which matches the list position of the actual parameter in the formal context parameter list of the base type <identifier> of the enclosing <type expression>. For a base type <identifier> in an <type expression>, the result is determined by context of the <type expression> and in most cases is **sort**. For an <identifier> in an <encoding path>, the result is determined by number of items in the <encoding expression>: if there is one item it is a channel or gate, and if there are two items the <identifier> gives the literal in the `Encoding` data type.

idKind0(*i*: <identifier>): *ENTITYKIND0* =$_{\text{def}}$
case *i.parentAS0* **of**
| <active agents expression> **then agent**
| *a*=<actual context parameter> **then**
take({*f* ∈ <formal context parameter>:
isContextParameterCorresponded0(*f*, *a*)
∧ *parentAS0ofKind*(*f*, *ENTITYDEFINITION0*) = *a.parentAS0.baseType0*
}).*entityKind0*
| <agent constraint atleast> **then agent type**
| <agent constraint exactly> **then agent type**
| <agent type context parameter> **then agent type**
| <any expression> **then sort**
| <as channel> **then channel**
| <as gate> **then gate**
| <as signal> **then signal**
| <assignment> **then variable**
| <block type reference> **then block type**
| <channel endpoint> **then**
if *getEntityDefinition0*(*i*, **agent**) ≠ *undefined* **then agent else state endif**
| <channel to channel connection> **then channel**
| <composite state type reference> **then state type**
| <compositestate type context parameter> **then state type**
| <create body> **then**
if *getEntityDefinition0*(*i*, **agent**) ≠ *undefined* **then agent**
else agent type
endif
| <destination> **then agent**
| <encoding expression> **then signal**
| <encoding path> (*i*) **then**
if *getEntityDefinition0*(*i*, **channel**) ≠ *undefined* **then channel else gate endif**
| <encoding path> (*,*) **then literal**
| <exported> **then remote procedure**
| <export body> **then variable**
| <exported variable> **then remote variable**
| <external synonym definition item> **then sort**
| <formal parameter> **then sort**
| <import expression> **then remote variable**
| <indexed variable> **then variable**
| <interface constraint> **then interface**
| <interface variable definition> **then sort**
| <internal synonym definition item> **then sort**
| <local variables of sort> **then sort**
| <loop variable definition> **then sort**
| <loop variable indication identifier> **then variable**
| <operation result> **then sort**
| <output body item> **then signal**
| <package reference> **then package**
| <package use clause> **then package**
| <parameters of sort> **then sort**
| <procedure call body> **then procedure**
| <procedure context parameter> **then procedure**
| <procedure result> **then sort**

| <process type reference> **then process type**
| <range check constrained sort> **then sort**
| <range check expression> **then sort**
| <remote procedure call body> **then remote procedure**
| <reset clause> **then timer**
| <result> **then sort**
| <set clause> **then timer**
| <signal constraint> **then signal**
| <signal definition> **then sort**
| <signal list item> **then** *stimulusKind*(*i*)
| <sort> **then sort**
| <sort constraint> **then sort**
| <state partition connection entry> **then state**
| <state partition connection exit> **then state**
| <stimulus> **then variable**
| <synonym> **then synonym**
| <syntype definition syntype> **then sort**
| <syntype> **then syntype**
| <system type reference> **then system type**
| <textual endpoint constraint> **then**
if *i*.*parentAS0*.*parentAS0* ∈ <textual interface gate definition> **then interface**
elseif *getEntityDefinition0*(*i*, **block type**) ≠ *undefined* **then block type**
elseif *getEntityDefinition0*(*i*, **process type**) ≠ *undefined* **then process type**
else state type
endif
| <textual interface gate definition> **then interface**
| <timer active expression> **then timer**
| <timer communication constraint> **then**
if *i*.*parentAS0*.**s1-**<identifier>= *i* **then timer else variable endif**
| *te* = <type expression> **then**
case *te*.*parentAS0* **of**
| <interface specialization> **then interface**
| <procedure call body> **then procedure**
| *sp* = <specialization> **then**
case *sp*.*parentAS0* **of**
| *aah* = <agent additional heading> **then**
case *aah*.*parentAS0* **of**
| *ai* = <agent instantiation> **then**
if *ai*.*parentAS0* ∈ <block heading> **then block type else process type endif**
| *atah* = <agent type additional heading> **then**
case *atah*.*parentAS0* **of**
| <block type heading> **then block type**
| <process type heading> **then process type**
otherwise system type
endcase
| <system heading> **then system type**
endcase
| <composite state heading> **then state type**
| <composite state type heading> **then state type**
| <procedure heading> **then procedure**
| <signal definition> **then signal**
| <state aggregation type heading> **then state type**
endcase
| <typebased block heading> **then block type**
| <typebased composite state> **then state type**
| <typebased process heading> **then process type**
| <typebased state partition heading> **then state type**
| <typebased system heading> **then system type**
otherwise sort
endcase
| <valid input signal set> **then** *stimulusKind*(*i*)
| <variables of sort> **then sort**
| <virtuality constraint> **then** *parentAS0ofKind*(*i*, *TYPEDEFINITION0*).*kind0*

```
    | <via path> then
        if getEntityDefinition0(i, channel) ≠ undefined then channel
        else gate
        endif
    endcase
```

The function *stimulusKind* determines the entity kind of an <identifier> that is known to be a stimulus.

```
stimulusKind(i: <identifier>): ENTITYKIND0 =def
    if getEntityDefinition0(i, signal) ≠ undefined then signal
    elseif getEntityDefinition0(i, timer) ≠ undefined then timer
    elseif getEntityDefinition0(i, remote procedure) ≠ undefined then remote procedure
    elseif getEntityDefinition0(i, remote variable) ≠ undefined then remote variable
    elseif getEntityDefinition0(i, signallist) ≠ undefined then interface
    else interface
    endif
```

The function *makeProcedureBody* makes <operation body> or statement list into the <procedure body> or <compound statement> for the procedure called for the operation.

```
makeProcedureBody(b:<operation body> ∪ <statements>): <procedure body> ∪ <statements> =def
    case b of
    | <operation body>(onexc, start, actions) then mk-<procedure body>(onexc, start, actions)
    | <statements> then b
    endcase
```

The function *operationSignature0* produces the operation signature for a given operation definition.

```
operationSignature0(opdef: <operation definition>): < operation signature > =def
let hdg = opdef.s-<operation heading> in
let pars = hdg.s-<formal operation parameters> in
mk-<operation signature>(
        hdg.s-<operation preamble>,
        hdg.s-<operation name>,
        mk-<arguments>(
            <   mk-<formal parameter>(pars[i].s-<parameter kind>, pars[i].s-<sort>): i ∈ 1..pars.length > ),
        opdef.s-<operation heading>.s-<operation result>.s-<sort>
) // operation signature
endlet // pars
endlet // hdg
```

F2.2.9.8 Additional data definition constructs

F2.2.9.8.1 Name class mapping

Name class mapping is defined in clause A.2.10 of [ITU-T Z.104] and is intended for use only to define SDL-2010 language features and is not part of the SDL-2010 language itself. It is no longer formally described in Annex F.

F2.2.9.8.2 Restricted visibility

Concrete syntax

```
<visibility> = public | protected | private
```

Conditions on concrete syntax

```
∀d∈<data type definition>: d.specialization0≠ undefined ⇒
    (∀cons∈<data type constructor>:
        cons.surroundingScopeUnit0 = d ⇒ cons.s-<visibility> = undefined)
```

<visibility> must not precede a <literal list>, <structure definition>, or <choice definition> in a <data type definition> containing <data type specialization>.

∀*os*∈<operation signature>:
os.virtuality0 ∈{**redefined**, **finalized**}⇒*os.visibility0=undefined*

<visibility> must not be used in an <operation signature> that redefines an inherited operation signature.

Transformations

<operation preamble>(*virt*, *vis*) **provided** *vis* ≠ *undefined*
=2=><operation preamble>(*virt*, *undefined*)

<literal list>(*vis*, *sigs*) **provided** *vis* ≠ *undefined*
=2=> <literal list>(*undefined*, *sigs*)

<structure definition>(*vis*, *fields*) **provided** *vis* ≠ *undefined*
=2=> <structure definition>(*undefined*, *fields*)

<fields of sort>(*vis*, *fields*, *sort*) **provided** *vis* ≠ *undefined* =2=> <fields of sort>(*undefined*, *fields*, *sort*)

<choice definition>(*vis*, *fields*) **provided** *vis* ≠ *undefined* =2=> <choice definition>(*undefined*, *fields*)

<choice of sort>(*vis*, *fields*, *sort*) **provided** *vis* ≠ *undefined*
=2=> <choice of sort>(*undefined*, *fields*, *sort*)

If a <literal signature> or <operation signature> contains the keyword **public** in <visibility>, this is derived syntax for a signature having no protection. See clause 12.1.9 of [ITU-T Z.104].

Auxiliary functions

The function *isPrivate0* determines if a <literal signature> or an <operation signature> is private.

isPrivate0 (*s*: <literal signature> ∪ <operation signature>): *BOOLEAN* =$_{\text{def}}$
(*s.visibility0* = **private**)

The function *isPublic0* determines if a <literal signature> or an <operation signature> is public.

isPublic0 (*s*: <literal signature> ∪ <operation signature>): *BOOLEAN* =$_{\text{def}}$
(*s.visibility0* ≠ **private**) ∧ (*s.visibility0* ≠ **protected**)

F2.2.9.8.3 Syntypes

Abstract syntax

Syntype-definition	::	*Syntype-name* *Parent-sort-identifier* *Range-condition* [*Default-initialization*]
Parent-sort-identifier	=	*Sort-identifier*

Concrete syntax

<syntype> = <syntype<identifier>

<syntype definition> ::
<package use clause>*
{ <syntype definition syntype> | <syntype definition data type> }

<syntype definition syntype> ::
<syntype<name> <parent sort identifier>
[<default initialization>] [<constraint>]

<syntype definition data type> ::
<type preamble> <data type heading> [<data type specialization>]
<data type definition body> <constraint>

<parent sort identifier> = <sort>

Transformations

< <syntype definition>(*uses*,
<syntype definition data type>(*preamble*,
<data type heading>(*kind*, *name*, *params*, *vconstr*), *spec*, *body*, *constr*)) >
=8=>
let *nn* = *newName* **in**
< <syntype definition>(*uses*,
<syntype definition syntype>(name, <identifier>(*empty*, nn), *undefined*, *constr*)),
<data type definition>(*uses*, *preamble*, <data type heading>(*kind*, *nn*, *params*, *vconstr*),
spec, *body*) >
endlet // *newName*

A <syntype definition data type> is distinguished from a <data type definition> by the inclusion of a <constraint>. Such a <syntype definition> is shorthand for introducing a <data type definition> with an anonymous name without the <constraint>, followed by a <syntype definition> with <syntype definition syntype> based on this anonymously named sort and including <constraint>. See clause 12.1.8.1 *Model* of [ITU-T Z.104].

Mapping to abstract syntax

| <syntype definition>(*, <syntype definition syntype>(*name*, *parent*, *, *constr*)) **then**
mk-*Syntype-definition*(*Mapping*(*name*), *Mapping*(*parent*), *Mapping*(*constr*))

F2.2.9.8.4 Constraint

Abstract syntax

Range-condition	::	*Condition-item*-**set**
Condition-item	=	*Open-range* | *Closed-range* | *Size-constraint*
Open-range	::	*Operation-identifier Constant-expression*
Closed-range	::	*Constant-expression Constant-expression*
Size-constraint	::	*Operation-identifier* { *Open-range* | *Closed-range* }*

Concrete syntax

<constraint> = <range condition> | <size constraint>

<range condition> = <range>+

<range> = <closed range> | <open range>

<open range> = <constant> | <open range with operator>

<open range with operator> ::
{ <equals sign> | <not equals sign> | <less than sign> | <greater than sign> |
<less than or equals sign> | <greater than or equals sign> } <constant>

<constant> = <constant expression>

<closed range> :: <constant> <constant>

<size constraint> :: <range condition>

Conditions on concrete syntax

The text items below for conditions are from clause 12.1.8.2 of [ITU-T Z.101].

∀*sd*∈<syntype definition>: *sd*.**s-implicit**.**s-**<constraint>∈<range condition> ⇒
(**let** *rc* = *sd*.**s-implicit**.**s-**<constraint> **in**
(∀*sym*∈<less than sign>: *isAncestorAS0*(*rc*, *sym*)⇒ *isDefinedSym0*(*sd*, "<"))∧
(∀*sym*∈<greater than sign>: *isAncestorAS0*(*rc*, *sym*)⇒ *isDefinedSym0*(*sd*, ">"))∧
(∀*sym*∈<less than or equals sign>: *isAncestorAS0*(*rc*, *sym*)⇒ *isDefinedSym0*(*sd*, "<="))∧
(∀*sym*∈<greater than or equals sign>: *isAncestorAS0*(*rc*, *sym*)⇒ *isDefinedSym0*(*sd*, ">="))
endlet)

The symbol "<" shall only be used in the concrete syntax of the <range condition> if that symbol has been defined with an <operation signature>: "<" (P, P) -> <<**package** Predefined>>Boolean; where P is the sort of the syntype, and similarly for the symbols ("<=", ">", ">=", respectively).

∀*sd*∈<syntype definition>: *sd*.**s-implicit**.**s-**<constraint>∈<range condition>⇒
∀*cr*∈<closed range>:
isAncestorAS0(*sd*.**s-implicit**.**s-**<range condition>,*cr*)⇒ *isDefinedSym0*(*sd*, "<=")

A <closed range> shall only be used if the symbol "<=" is defined with an <operation signature>: "<=" (P, P) -> <<**package** Predefined>>Boolean; where P is the sort of the syntype.

∀*sd*∈<syntype definition>:∀*rc*∈<range condition>:∀*ce*∈<constant expression>:
isAncestorAS0(*rc*, *ce*)∧*rc.surroundingScopeUnit0=sd*⇒*isSameSort0*(*ce.staticSort0*, *sd.identifier0*)

A <constant expression> in a <range condition> shall have the same sort as the sort of the syntype.

∀*sd*∈<syntype definition>: ∀*sc*∈<size constraint>:
sc=*sd*.**s-implicit**.**s-**<constraint>⇒*isDefinedSym0*(*sd*, "length")

A <size constraint> shall only be used in the concrete syntax of the <range condition> if the symbol length has been defined with an <operation signature>: length (**in** P) -> <<**package** Predefined>> Natural; where P is the sort of the syntype.

Mapping to abstract syntax

| *r* = <range condition> **then**
mk-*Range-condition*(
< **if** *item* ∈ *EXPRESSION0* **then mk-***Open-range*(*rangeOperator*(r, "="), *Mapping*(*item*))
else *Mapping*(*item*) **endif** : *item* **in** *r* >.*toSet*)

| *r* = <open range with operator>(<equals sign>(), *const*) **then**
mk-*Open-range*(*rangeOperator*(r, "="), *Mapping*(*const*))

| *r* = <open range with operator>(<not equals sign>(), *const*) **then**
mk-*Open-range*(*rangeOperator*(r, "/="), *Mapping*(*const*))

| *r* = <open range with operator>(<less than sign>(), *const*) **then**
mk-*Open-range*(*rangeOperator*(r, "<"), *Mapping*(*const*))

| *r* = <open range gen with operator>(<greater than sign>(), *const*) **then**
mk-*Open-range*(*rangeOperator*(r, ">"), *Mapping*(*const*))

| *r* = <open range with operator>(<less than or equals sign>(), *const*) **then**
mk-*Open-range*(*rangeOperator*(r, "<="), *Mapping*(*const*))

| *r* = <open range with operator>(<greater than or equals sign>(), *const*) **then**
mk-*Open-range*(*rangeOperator*(r, ">="), *Mapping*(*const*))

| <closed range>(*c1*, *c2*) **then**
mk-*Closed-range*(**mk-***Open-range*(*rangeOperator*(r, ">="), *Mapping*(*c1*),
mk-*Open-range*(*rangeOperator*(r, "<="), *Mapping*(*c2*)) }

| *sc*=<size constraint>(*rc*) **then**
mk-*Size-constraint*(*rangeOperator*(*sc*,"length"), *Mapping*(*rc*))

Auxiliary functions

The function *isPredefSort0* is used to determine if a sort is one of the predefined sorts.

isPredefSort0(*s*: <sort>): *BOOLEAN* =$_{\text{def}}$
getEntityDefinition0(s, **sort**)=*undefined*∧*s*.**s-**<name>∈*PREDEFINEDSORT0*

The function *isDefinedSym0* is used to determine if the given symbol is defined and the each parameter's sort is the same as that of the specified syntype.

```
isDefinedSym0(sd:<syntype definition>, sym: SYMBOL0): BOOLEAN =def
    (let dtd=sd.derivedDataType0 in
        if sym∈{"<",">","<=",">="} then
            (∃ll∈<literal list>: ll.surroundingScopeUnit0 = dtd)∨
            (∃os∈<operation signature>: (os.surroundingScopeUnit0=dtd)∧
                (let fpl= os.operationSignatureParameterList0 in
                    os.entityName0= sym ∧
                    isPredefSort0(os.s-<result>.s-<sort>) ∧ os.s-<result>.s-<sort>.s-<name>= "Boolean" ∧
                    fpl.length = 2 ∧
                    getEntityDefinition0(fpl[1].s-<sort>, sort) =sd∧
                    getEntityDefinition0(fpl[2].s-<sort>, sort) =sd
                endlet))
        else // sym∈{"length"}
            (∃os∈<operation signature>: os.surroundingScopeUnit0=dtd∧
                (let fpl=os.operationSignatureParameterList0 in
                    os.name0= "length"∧
                    os.s-<result>.s-<sort>.sortId0 = predefinedId0("Natural")∧
                    fpl.length= 1∧
                    getEntityDefinition0(fpl[1].s-<sort>, sort).derivedDataType0=dtd
                endlet))
    endlet)

rangeOperator(rc: <range condition>, t: TOKEN): Identifier
mk-Identifier(
    Mapping( // qualifier within the sort defined by the construct enclosing rc
        getEntityDefinition0(
        case p =parentAS0ofKind(rc,
                <inline syntype definition>
            ∪ <range check constrained sort>
            ∪ <size constraint>
            ∪ <sort>
            ∪ <syntype definition data type>
            ∪ < syntype definition syntype >
            ∪ <textual answer part>)
        of
        | <inline syntype definition> then p.s-<basic sort>.sortId0
        | <range check constrained sort> then p.s-<identifier>
        | <size constraint> then
            case gp = parentAS0ofKind(p,
                    <range check constrined sort>
                ∪ <syntype definition data type>
                ∪ < syntype definition syntype >)
            of
            | <range check constrained sort> then gp.s-<identifier>
            | <syntype definition data type> then gp.identifier0
            | < syntype definition syntype > then gp.identifier0
            endcase // sort id from size constraint
        | <sort> then p.sortId0
        | <syntype definition data type> then p.identifier0
        | <syntype definition syntype > then p.identifier0
        | <textual answer part> then
            let decision = p.parentAS0.parentAS0 in
            let question = take({quest ∈ EXPRESSION0 : quest.parentAS0 = decision }) in
            let questionsorts = staticSortSet0(question) in // possible question sorts
            let answerconsts = { const ∈ EXPRESSION0 : const.parentAS0.parentAS0.parentAS0 = decision ∧
                const.parentAS0 ∈ <textual answer part> } in // possible answer sorts
            let answersorts = ⋃ { staticSortSet0(const) : const ∈ answerconsts } in
                take(questionsorts ∩ answersorts) // one of the sorts in both sets – there should be exactly one
```

endlet // answersorts
endlet // answerconsts
endlet // questionsorts
endlet // question
endlet // decision
endcase, // sort id
sort).*derivedDataType0.fullQualifierWithin0* // sort def - derived type – qualifier within
), // Mapping – for qualifier
mk-*Name*(*t*))

F2.2.9.8.5 Synonym definition

Concrete syntax

<synonym definition> :: <synonym definition item>+

<synonym definition item> =
<internal synonym definition item> | <external synonym definition item>

<internal synonym definition item> ::
<synonym<name> [<sort>] <constant expression>

<external synonym definition item> ::
<synonym<name> <predefined<sort>

Conditions on concrete syntax

The conditions below are from clause 12.1.8.3 *Concrete grammar* of [ITU-T Z.104].

∀*syno*∈<internal synonym definition item>:
¬ *isContainedInConsExp0*(*syno*, *syno*.**s-**<constant expression>)

The <constant expression> shall not refer to the synonym defined by the <synonym definition> either directly or indirectly (via another synonym).

∀*sdi*∈<internal synonym definition item>:*sdi*.**s-**<sort> ≠ *undefined*⇒
∃*s*∈<sort>: *s*∈*sdi*.**s-**<constant expression>.*staticSortSet0*∧*isSameSort0*(*s*, *sdi*.**s-**<sort>)

If a <sort> is specified, the sort of the <constant expression> has to be compatible with this sort.

∀ *sdi*∈<internal synonym definition item>:
|*sdi*.**s-**<constant expression>.*staticSortSet0*|>1⇒ *sdi*.**s-**<sort> ≠ *undefined*

If the sort of the <constant expression> is unique (that is, the expression belongs to only one sort), it is allowed to omit the <sort> in the <synonym definition>. and the *Sort-reference-identifier* is derived from the constant expression sort.

Transformations

<synonym definition> (< *sd* > ⌒ *rest*) **provided** *rest* ≠ *empty* =5=>

mk-<synonym definition> (< *sd* >) ⌒ **mk-**<synonym definition> (*rest*)

A <synonym definition> that defines multiple synonyms is a shorthand for a sequence of <synonym definition> items, each defining one synonym. See clause 12.1.8.3 *Model* of [ITU-T Z.104].

<external synonym definition item> (*name*, *sort*) =7=>
mk-<internal synonym definition item>(*name*, *sort*, *take*({*s* ∈ *sort*}))

An <external synonym definition item> defines a <synonym> whose result is not defined in a specification. See clause 12.1.8.3 *Concrete grammar* of [ITU-T Z.104].

Mapping to abstract syntax

| <synonym definition>(*sdi*)
then
mk-*Variable-definition*(*Mapping*(*sdi*.**s-**<name>),

if *sdi* ∈ <internal synonym definition item> ∧ |*sdi*.**s-**<constant expression>.*staticSortSet0*|=1
then *Mapping*(*sdi*.**s-**<constant expression>.*staticSortSet0*)
else *Mapping*(*sdi*.**s-**<sort>)
endif, // sort
PART, // aggregation
if *sdi* ∈ <internal synonym definition item>
then *Mapping*(*sdi*.**s-**<constant expression>)
else *undefined*
endif // constant expression
)

The paragraphs below are from clause 12.1.8.3 *Concrete grammar* of [ITU-T Z.104].

A <synonym definition> represents a *Variable-definition* in the context in which the synonym definition appears with the special property that the variable is read-only. The <synonym<name> represents the *Variable-name*.

If a <sort> is specified, this determines the *Sort-reference-identifier* of the *Variable-definition*.

If the <sort> in the <synonym definition> is omitted the *Sort-reference-identifier* of the *Variable-definition* is derived from the constant expression sort.

The *Variable-definition* has a **PART** has *Aggregation-kind*.

The <constant expression> in the concrete syntax denotes a *Constant-expression* in the abstract syntax.

Auxiliary functions

The function *isContainedInConsExp0* is used to determine if a <constant expression> refers to the synonym defined by the enclosing <synonym definition> either directly or indirectly.

isContainedInConsExp0(*def*: <internal synonym definition item>, *exp*: <constant expression>):
BOOLEAN =$_{def}$
∃*synoId*∈<synonym>: *isAncestorAS0*(*exp*, *synId*) ∧
(*def* = *getEntityDefinition0*(*synoId*, **synonym**)∨
isContainedInConsExp0
(*def*, *getEntityDefinition0*(*synoId*, **synonym**).**s-**<constant expression>))

F2.2.9.9 Use of data

F2.2.9.9.1 Expressions and expressions as actual parameters

Abstract syntax

Expression	=	*Constant-expression*
	|	*Active-expression*
Constant-expression	=	*Literal*
	|	*Conditional-expression*
	|	*Equality-expression*
	|	*Operation-application*
	|	*Range-check-expression*
	|	*Type-check-expression*
	|	*Type-coercion*
	|	*Agent-instance-pid-value*
Active-expression	=	*Variable-access*
	|	*Conditional-expression*
	|	*Operation-application*
	|	*Equality-expression*
	|	*Imperative-expression*
	|	*Range-check-expression*
	|	*Type-check-expression*
	|	*Type-coercion*

| | *Value-returning-call-node*
| | *Encoding-expression*
| | *Decoding-expression*
| | *Agent-instance-pid-value*

Agent-instance-pid-value :: *Agent-instance**

Agent-instance = *Agent-name Instance-number*

Instance-number = *Expression*

Imperative-expression = *Now-expression*
| *Pid-expression*
| *Timer-active-expression*
| *Timer-remaining-duration*
| *Active-agents-expression*
| *Any-expression*
| *State-expression*
| *Signal-expression*
| *Signallist-expression*

Actual-parameters :: { *Expression* | UNDEFINED }*

Please note that the above definition could be simplified. This can be done by omitting the difference between active expressions and constant expressions. This difference does not show up at any place, so it could be simply dropped.

Conditions on abstract syntax

Further study needed to formulate the condition.

The leftmost item in the *Agent-instance* list of an *Agent-instance-pid-value* shall have an *Agent-name* that is the *Agent-name* of an *Agent-definition* directly contained by the *Agent-definition* for the system. The *Agent-definition* for the system has an *Agent-type-identifier* for an *Agent-type-definition* with the *Agent-kind* **SYSTEM**.

Except the leftmost item, each other item in the list *Agent-instance* list of an *Agent-instance-pid-value* shall have an *Agent-name* that is the *Agent-name* of an *Agent-definition* directly contained by the *Agent-instance* item immediately to the left.

The *Instance-number* of an *Agent-instance* in the *Agent-instance-pid-value* of a *Constant-expression* shall be a positive `Natural` *Constant-expression* less than or equal to the *Initial-number* of the *Number-of-instances* of the *Agent-definition* for the *Agent-name* in the same *Agent-instance*.

See clause 12.2.1 *Abstract grammar* of [ITU-T Z.104].

Concrete syntax

<expression> =
    <expression0>
  | <range check expression>
  | <type coercion>

<expression0> =
    <binary expression>
  | <operand5>
  | <equality expression>
  | <create expression>
  | <value returning procedure call>
  | <decoding expression>
  | <encoding expression>

<simple expression> = <constant expression>

<actual parameters> = <actual parameter list>

<actual parameter list> = [<actual parameter>]+

<actual parameter> = <expression>

<constant expression> = <constant<expression0>

<binary expression> ::
    <expression> <infix operation name> <expression>

<operand5> ::[<hyphen> | **not**] <primary>

<primary> =
    <operator application>
  | <literal>
  | <expression>
  | <conditional expression>
  | <extended primary>
  | <active primary>
  | <synonym>

<active primary> = <variable access> | <imperative expression>

<expression list> = <expression>+

<imperative expression> =
    <now expression>
  | <pid expression>
  | <timer active expression>
  | <timer remaining duration>
  | <active agents expression>
  | <any expression>
  | <state expression>
  | <signal expression>
  | <signallist expression>

<agent instance pid value> :: [<system<name>] [<agent instance>]

<agent instance> :: <agent instance>* <agent<name> [<Natural<expression>]

Conditions on concrete syntax

∀*consExp*∈<expression0>: *consExp.parentAS0* ∈
    <alternative question>∪
    <closed range>∪
    <default initialization>∪
    <exported variables of sort>∪
    <field default initialization> ∪
    <internal synonym definition item>∪
    <named number>∪
    <number of instances>∪
    <open range>∪
    <open range with operator>∪
    <timer default initialization>∪
    <transition option>∪
    <variables of sort>

⇒

¬∃*activePri*∈<active primary>: *isAncestorAS0*(*consExp*, *activePri*) ∧
¬∃*vrpc*∈<value returning procedure call>: *isAncestorAS0*(*consExp*, *vrpc*)

An <expression0> that does not contain any <active primary>, or a <value returning procedure call> is a <constant expression>. In the contexts where a <constant expression> is required, there shall not exist an <active primary> or <value returning procedure call> within an <expression0>.

∀*id*∈<identifier>: ∀*expr*∈<expression>:
(*expr.parentAS0* ∈
    <alternative question> ∪
    <named number> ∪
    <number of instances> ∪
    <transition option>)

$\wedge$ *isAncestorAS0*(*expr*, *id*)$\wedge$*id.idKind0*$\in${**literal**, **operator**, **method**}$\Rightarrow$
getEntityDefinition0(*id*, *id.idKind0*)$\in$*PREDEFINEDDEFINITION0*

A <simple expression> shall contain only literals, and operations defined within the **package** `Predefined`, as defined in clause 14 of [ITU-T Z.104]. In the contexts where a <simple expression> is required, there shall only be identifiers for literals, operators or methods that are defined in **package** `Predefined`.

<agent instance pid value>.**s-**<name> $\neq$ *undefined* $\Rightarrow$
<agent instance pid value>.**s-**<name> = *take*({*s* $\in$ *Sdl-specification*}).**s-***Agent-definition*.**s-***Agent-name*

If a <name> is given in an <agent instance pid value>, it shall be the name of the system.

Transformations

<binary expression>(*x*,<implies sign>,*y*)	=8=> <operator application>("=>",<*x*,*y*>)
<binary expression>(*x*,**or**,*y*)	=8=> <operator application>("or",<*x*,*y*>)
<binary expression>(*x*,**xor**,*y*)	=8=> <operator application>("xor",<*x*,*y*>)
<binary expression>(*x*,**and,***y*)	=8=> <operator application>("and",<*x*,*y*>)
<binary expression>(*x*,<greater than sign>,*y*)	=8=> <operator application>(">",<*x*,*y*>)
<binary expression>(*x*,<greater than or equals sign>,*y*)	=8=> <operator application>(">=",<*x*,*y*>)
<binary expression>(*x*,<less than sign>,*y*)	=8=> <operator application>("<",<*x*,*y*>)
<binary expression>(*x*,<less than or equals sign>,*y*)	=8=> <operator application>("<=",<*x*,*y*>)
<binary expression>(*x*,**in,***y*)	=8=> <operator application>("in",<*x*,*y*>)
<binary expression>(*x*,<plus sign>,*y*)	=8=> <operator application>("+",<*x*,*y*>)
<binary expression>(*x*,<hyphen>,*y*)	=8=> <operator application>("-",<*x*,*y*>)
<binary expression>(*x*,<concatenation sign>,*y*)	=8=> <operator application>("//",<*x*,*y*>)
<binary expression>(*x*,<asterisk>,*y*)	=8=> <operator application>("*",<*x*,*y*>)
<binary expression>(*x*,<solidus>,*y*)	=8=> <operator application>("/",<*x*,*y*>)
<binary expression>(*x*,**mod**,*y*)	=8=> <operator application>("mod",<*x*,*y*>)
<binary expression>(*x*,**rem**,*y*)	=8=> <operator application>("rem",<*x*,*y*>)
<operand5>(<hyphen>,*x*)	=8=> <operator application>("-",<*x*>)
<operand5>(**not**,*x*)	=8=> <operator application>("not",<*x*>)

An expression of the form

<expression> <infix operation name> <expression>

is derived syntax for

<quotation mark> <infix operation name> <quotation mark> (<expression>, <expression>)

where <quotation mark> <infix operation name> <quotation mark> represents an Operation-name.

Similarly,

<monadic operation name> <expression>

is derived syntax for

<quotation mark> <monadic operation name> <quotation mark> (<expression>)

where <quotation mark> <monadic operation name> <quotation mark> represents an Operation-name.

If the <Natural<expression> of an <agent instance pid value> is omitted, this represents the `Natural` number "1". If the <Natural<expression> value of an <agent instance pid value> is zero or greater than the number of active instances of the agent instance set, the <agent instance pid value> represents the `Pid` value `Null`. See clause 12.2.1 of [ITU-T Z.104].

Special visibility rules apply for an <agent<name> within an <agent instance>. The <agent instance> list before the <agent<name> in an <agent instance> identifies the heirarchical context for the <agent<name>. The <agent<name> is visible if it is visible in the last item of the <agent instance> list to the immediate left of the <agent<name>, or if it visible in the system. The <agent instance> list items to the left can be omitted provided the agent instance is uniquely identifiable (in the same way as omitting parts of a <qualifier> of an <identifier>) and each omitted <agent instance> list item

represents the correponding *Agent-name* with an *Instance-number* for the `Natural` number "1". See clause 12.2.1 of [ITU-T Z.104].

F2.2.9.9.2 Literal

See clause 12.2.2 *Concrete grammar* of [ITU-T Z.101].

Abstract syntax

Literal :: *Literal-identifier*

Concrete syntax

<literal> = <literal identifier>

<literal identifier> :: <qualifier> <literal name>

Conditions on concrete syntax

Further study needed to formulate the condition.

It shall be possible to bind each unqualified <literal identifier> to exactly one defined *Literal-identifier* that satisfies the conditions in the construct in which the <literal identifier> is used.

Mapping to abstract syntax

| <literal identifier>(*qual*, *name*) **then mk-***Literal-identifier*(*Mapping*(*qual*), *Mapping*(*name*))

Whenever a <literal identifier> is specified, the unique *Literal-name* in *Literal-identifier* is derived in the same way, with the result sort derived from context. A *Literal-identifier* is derived from context (see clause 6.2) so that if the <literal identifier> is overloaded (that is, the same name is used for more than one literal or operation), then the *Literal-name* identifies a visible literal with the same name and result sort consistent with the literal. If there are two literals with the same <name> but differing by result sorts, each has a different *Literal-name*.

Wherever a <qualifier> of a <literal identifier> ends with a <path item> with the keyword **type**, then the <sort name> is used as the result sort to derive the unique *Name* of the *Identifier*. The *Qualifier* is formed in the usual way from <qualifier>, therefore the <sort name> after the keyword **type** is used for both the *Qualifier* and deriving the *Name* of the *Identifier*.

Further study needed to distinguish the case of the qualifier being empty (and the sort determined by context) and qualifier specifying the sort.

F2.2.9.9.3 Synonym

Concrete syntax

<synonym> :: <synonym<identifier>

Transformations

<synonym>(*ident*)
provided *ident.refersto0* ∈ <internal synonym definition item>
=8=>
ident.refersto0.**s-**<constant expression>

A <synonym> represents the <constant expression> defined by the <synonym definition> identified by the <synonym identifier>. An <identifier> used in the <constant expression> represents an *Identifier* in the abstract syntax according to the context of the <synonym definition>.

Further study needed because synonym semantics has changed.

F2.2.9.9.4 Extended primary

Concrete syntax

<extended primary> =
    <indexed primary>
  | <field primary>
  | <composite primary>

<indexed primary> :: <primary> <actual parameter list>

<field primary> :: [<primary>] { <field name> | <field number> | <as signal> }

<field name> = <name>

<field number> = <Natural<name>

<composite primary> :: <qualifier> <actual parameter list>

Conditions on concrete syntax

$\forall$*fp*$\in$<field primary>:
  (*fp*.**s-**<primary> = *undefined* $\Rightarrow$ *fp*.**s-implicit** $\in$ <field name>)

The condition is needed because AS0 is simplified with respect to clause 12.2.3 *Concrete grammar* of [ITU-T Z.104] where <primary> is only optional when a <field name> is given.

Transformations

<indexed primary>(*prim*, *params*)
  =8=> **mk-**<method application>(*prim*, **mk-**<identifier>(*empty*, "Extract"), *params*)

An <indexed primary> is derived concrete syntax for

Extract (<primary>, <actual parameter list>)

See clause 12.2.3 *Model* of [ITU-T Z.101]. The abstract syntax is determined from this concrete expression according to clause 12.2.1 of [ITU-T Z.101].

<field primary>(*prim*, *field*)
provided prim $\neq$ *undefined* $\wedge$ *field* $\notin$ (<field number> $\cup$ <as signal>)
 =8=> **mk-**<method application>(*prim*, *modifyExtractName*(*field*, "Extract"), *empty*)

A <field primary> is derived concrete syntax for

field-extract-name(<primary>)

where the *field-extract-name* is formed from the concatenation of the field name and "`Extract`" in that order. The abstract syntax is determined from this concrete expression according to clause 12.2.1 of [ITU-T Z.101]. See clause 12.2.3 *Model* of [ITU-T Z.101]. The transformation according to this model is performed before the modification of the signature of methods in clause 12.1.3 of [ITU-T Z.104].

<field primary>(*prim*, *fieldnum*)
provided prim $\neq$ *undefined* $\wedge$ *fieldnum* $\in$ <field number>
 =8=>
let *td* = **mk-**<operand5>(*undefined*, *prim*).*staticSort0*.*refersto0* **in** // type definition
mk-<field primary>(*prim*,
  fieldNameList0(// list of field names for the data type definition
    if *td* $\in$ <data type definition> **then** *td*
    else *td*.*parentDataType0* // td is syntype definition, get the parent data type
    endif.**s-**<data type definition body>.**s-implicit**
)[*intTokenToNat*(*fieldnum*)] // field number selects field name from field name list
) // revised field primary
endlet // td

A <field number> is a shorthand for the <field name> of a field of the sort of <field primary> or <field variable>, where the value 1 represents the first field, the value 2 the second field and the value n the nth field. See clause 12.2.3 *Model* of [ITU-T Z.104].

<field primary>(*prim, asSig*)
provided prim ≠ *undefined* ∧ *asSig* ∈ <as signal>
=8=>
<field primary>(*prim, asSig*.**s-**<identifier>.*asSignal*.**s-**<name>)

An <as signal> in a <field primary> is a shorthand for the <field name> of a field of the sort of the <field primary>, where the <field name> is the same as the unique anonymous name of the structure data type defined by the <signal definition> identified by the <signal identifier> of <as signal>. See clause 12.2.3 *Model* of [ITU-T Z.104].

<field primary>(*undefined, field*)
=8=> **mk-**<field primary>(**mk-**<varible access>(**this**), *field*)

When the <field primary> has the form <field name>, this is derived syntax for:

this ! <field name>

See clause 12.2.3 *Model* of [ITU-T Z.104].

<composite primary>(*qual, params*)
=8=>
mk-<operator application>(**mk-**<identifier>(*qual*, "Make"), *params*)

A <composite primary> is derived concrete syntax for:

<qualifier> Make (<actual parameter list>)

if any actual parameters were present, or

<qualifier> Make

otherwise, and where the <qualifier> is inserted only if it was present in the <composite primary>. See clause 12.2.3 *Model* of [ITU-T Z.101]. The abstract syntax is determined from this concrete expression according to clause 12.2.1 of [ITU-T Z.101].

F2.2.9.9.5 Equality expression

Abstract syntax

Equality-expression	=	*Positive-equality-expression* | *Negative-equality-expression*
Positive-equality-expression	::	*First-operand Second-operand*
Negative-equality-expression	::	*First-operand Second-operand*
First-operand	=	*Expression*
Second-operand	=	*Expression*

Concrete syntax

<equality expression> ::
<expression> { <equals sign> | <not equals sign> } <expression>

Conditions on concrete syntax

∀*ee*∈<equality expression>:
(**let** *set1* = *ee*.**s-**<expression>.*staticSortSet0* **in**
let *set2* = *ee*.**s2-**<expression>.*staticSortSet0* **in**
∃*s1*∈*set1*:∃*s2*∈*set2*:*isSortCompatible0*(*s1, s2*)∨ *isSortCompatible0*(*s2, s1*)
endlet)

An <equality expression> is legal concrete syntax only if the sort of one of its operand is sort compatible to the sort of the other operand.

Mapping to abstract syntax

| <equality expression>(*first*, <equals sign>, *second*) **then**
mk-*Positive-equality-expression*(*Mapping*(*first*), *Mapping*(*second*))

| <equality expression>(*first*, <not equals sign>, *second*) **then**
mk-*Negative-equality-expression*(*Mapping*(*first*), *Mapping*(*second*))

F2.2.9.9.6 Conditional expression

Abstract syntax

Conditional-expression	::	*Boolean-expression* *Consequence-expression* *Alternative-expression*
Consequence-expression	=	*Expression*
Alternative-expression	=	*Expression*

Conditions on abstract syntax

∀*c* ∈ *Conditional-expression*:
(*c*.**s-***Consequence-expression.staticSort1*= *c*.**s-***Alternative-expression.staticSort1*) ∧
(*c*.**s-***Boolean-expression.staticSort1*= *predefinedId1*("Boolean"))

For any *Conditional-expression*, the sort of the *Consequence-expression* must be the same as that of the *Alternative-expression*, and the sort of a *Boolean-expression* must be *BOOLEAN*.

Concrete syntax

<conditional expression> ::
<Boolean<expression> <consequence expression> <alternative expression>

<consequence expression> = <expression>

<alternative expression> = <expression>

Conditions on concrete syntax

∀*ce*∈<conditional expression>:
let *set1*=*ce*.**s-**<consequence expression>.*staticSortSet0* **in**
let *set2*=*ce*.**s-**<alternative expression>.*staticSortSet0* **in**
|*set1*| =1 ∧ |*set2*| =1∧ *isSameSort0*(*set1.take*, *set2.take*)
endlet

The sort of the <consequence expression> must be the same as the sort of the <alternative expression>.

Mapping to abstract syntax

| <conditional expression>(*e1*, *e2*, *e3*) **then**
mk-*Conditional-expression*(*Mapping*(*e1*), *Mapping*(*e2*), *Mapping*(*e3*))

F2.2.9.9.7 Operation application

Abstract syntax

Operation-application	::	*Operation-identifier Actual-parameters*

Conditions on abstract syntax

∀*oa* ∈ *Operation-application*:
let *os* = *getEntityDefinition1*(*oa*, **operation**) **in**
isActualAndFormalParameterMatched1(*oa*.**s-***Expression*-**seq**, *os.formalParameterSortList1*)
endlet

The *Operation-identifier* in the *Operation-application* must be visible. Each *Expression* in the list of *Expression*s after the *Operation-identifier* must be sort compatible to the corresponding (by position) sort in the list of *Formal-arguments* of the *Operation-signature*.

Concrete syntax

<operation application> = <operator application> | <method application>

<operator application> :: <operation identifier> [<actual parameters>]

<method application> :: <primary> <operation identifier> [<actual parameters>]

Conditions on concrete syntax

∀*methodApp*∈<method application>:
getEntityDefinition0(*methodApp*.**s**-<identifier>, **method**) ≠ *undefined*

A <method application> is legal concrete syntax only if <operation identifier> represents a method.

Transformations

<method application>(*prim*, *ident*, *params*) =8=>
<operator application>(*ident*, < *prim* > ⌒ *params*)

The concrete syntax form

<expression> <full stop> <operation identifier> [<actual parameters>]

is derived concrete syntax for

<operation identifier> new-actual-parameters

where new-actual-parameters is <actual parameters> containing only <expression>, if <actual parameters> was not present; otherwise new-actual-parameters is obtained by inserting <expression> before the first optional expression in <actual parameters>.

Mapping to abstract syntax

<operator application>(*ident*, *params*) **then**
mk-*Operation-application*(*Mapping*(*ident*),*Mapping*(*params*))

Auxiliary functions

Get the actual parameter list associated with the *Operation-identifier*.

actualParameterListOfOpId1(*id*: *Operation-identifier*): [*Expression*]*=$_{\text{def}}$
case *id*.*parentAS1* **of**
| *Open-range* **then** <*id*.*parentAS1*.**s**-*Constant-expression*>
| *Operation-application* **then** < *exp* | *exp* **in** *id*.*parentAS1*.**s**-*Expression*-**seq**>
endcase

F2.2.9.9.8 Range check expression

Abstract syntax

Type-check-expression	::	*Expression Parent-sort-identifier*
Range-check-expression	::	*Expression Parent-sort-identifier Range-condition*

Conditions on abstract syntax

∀*rce* ∈ *Range-check-expression*:
(*isCompatibleTo1*(*rce*.**s**-*Expression*.*staticSort1*, *rce*.**s**-*Parent-sort-identifier*))
∨ (*getEntityDefinition1*(*rce*.**s**-*Parent-sort-identifier*, **interface**) ≠ *undefined*
∧ *isCompatibleTo1*(*rce*.**s**-*Expression*.*staticSort1*, *Mapping*(*predefinedId0*("Pid"))))

The sort of the *Expression* of a *Range-check-expression* shall be sort compatible with the sort identified by the *Parent-sort-identifier*, or the sort Pid if the *Parent-sort-identifier* is a pid sort. See clause 12.1.7 *Abstract grammar* [ITU-T Z.101].

Concrete syntax

<range check expression> ::
    <expression>
        { <range check constrained sort> | <syntype> | <pid sort> | <datatype<type expression> }

<range check constrained sort> :: <sort<identifier> <constraint>

Conditions on concrete syntax

∀*rccs* ∈<range check constained sort>:
    rccs.**s**-<identifier>.*fullIdentifier0* ≠ *predefinedId0*("Pid")
∨ *getEntityDefinition0*(*rccs*.**s**-<identifier>,**interface**) ≠ *undefined*

The <sort<identifier> of a <range check constrained sort> shall not be Pid or a pid sort. See clause 12.1.7 *Concrete grammar* [ITU-T Z.101].

Mapping to abstract syntax

| <range check expression>(*expr*, *srt*) **then**
case *srt* **of**
| <range check constrained sort> **then**
    mk-*Range-check-expression*(
        Mapping(*expr*),
        Mapping(*srt*.**s-**<identifier>),
        Mapping(*srt*.**s-**<constraint>)
)
| <syntype> **then**
    mk-*Range-check-expression*(
        Mapping(*expr*),
        Mapping(*srt*),
        Mapping(*srt.refersto0*.s-**implicit**.**s-**<constraint>)
)
| <pid sort> **then**
    mk-*Range-check-expression*(
        Mapping(*expr*),
        Mapping(*srt*),
        mk-*Range-check-expression*(∅)
)
| <datatype<type expression> **then**
    mk-*Type-check-expression*(
        Mapping(*expr*),
        Mapping(*srt*),
)
endcase // *srt*

The <expression> represents the *Expression*. If the form <range check constrained sort> is used, the <sort<identifier> represents the *Parent-sort-identifier* that applies to the <constraint>, which represents the *Range-condition* as described in clause 12.1.8.2. If the <sort<identifier> in <range check constrained sort> identifies a syntype, this is the same as specifying the parent sort identifier of the syntype, and the <constraint> is not restricted to the range of the syntype. If the form <syntype> is used, *Parent-sort-identifier* and *Range-condition* are the *Parent-sort-identifier* and *Range-condition* (respectively) of the identified syntype. If the form <pid sort> is used, it determines the *Parent-sort-identifier* and the *Range-condition* is empty. See clause 12.1.7 *Concrete grammar* [ITU-T Z.101] (with <operand2> replaced by <expression>).

If the form <datatype<type expression> is used, the <range check expression> represents a *Type-check-expression*. The <expression> represents the *Expression*. The <datatype type expression> determines the *Parent-sort-identifier*. See clause 12.1.7 *Concrete grammar* [ITU-T Z.107] (with <operand2> replaced by <expression>)

F2.2.9.9.9 Variable definition

Abstract syntax

Variable-definition :: *Variable-name*
Sort-reference-identifier
Aggregation-kind
[*Constant-expression*]

Aggregation-kind = **PART** | **REF**

Conditions on abstract syntax

$\forall d \in$ *Variable-definition*: *d*.**s-***Constant-expression* $\neq$ *undefined* $\Rightarrow$
d.**s-***Constant-expression*. *staticSort1* = *d*.**s-***Sort-reference-identifier*

If the *Constant-expression* is present, it must be of the same sort as the one denoted by *Sort-reference-identifier*.

Concrete syntax

<variable definition> :: <variables of sort>+ | <exported variables of sort>+

<variables of sort> ::
<aggregation kind> <variable<name>+ <sort> [<constant expression>]

<exported variables of sort> ::
<aggregation kind> <exported variable>+ <sort> [<constant expression>]

<exported variable> :: <variable<name> <remote variable<identifier>

<aggregation kind> :: [**part** | **ref**]

Further study is needed for <aggregation kind> and all the places it is used (not just variable definition). The <aggregation kind> has been added for <variables of sort> but there are many other places where it needs to be added. If <aggregation kind> is empty or **part** the *Aggregation-kind* is **PART**. If <aggregation kind> is **ref** the *Aggregation-kind* is **REF**. Needs to be written below as a Mapping.

Conditions on concrete syntax

$\forall d \in$ <agent definition> $\cup$ <agent type definition>:
$\neg(\exists v1, v2 \in$ <exported variable>: *v1* $\neq$ *v2* $\wedge$ *v1*.**s-**<identifier> = *v2*.**s-**<identifier> $\wedge$
v1. *parentAS0*.*parentAS0* $\in$ <variable definition> $\wedge$
v2. *parentAS0*.*parentAS0* $\in$ <variable definition> $\wedge$
v1.*surroundingScopeUnit0* = *d* $\wedge$ *v2*.*surroundingScopeUnit0* = *d*)

Two exported variables in an agent cannot mention the same <remote variable identifier>.

Transformations

<variables of sort> (*ak*, < *n* > $\frown$ *rest*, *sort*, *expr*) **provided** *rest* $\neq$ *empty* =5=>

<variables of sort> (*ak*, < *n* >, *sort*, *expr*) $\frown$ <variables of sort> (*ak*, *rest*, *sort*, *expr*)

A <variables of sort> that defines multiple variables is a shorthand for a sequence of <variables of sort> items, each defining one variable.

<exported variables of sort> (*ak*, < *ev* > $\frown$ *rest*, *sort*, *expr*) **provided** *rest* $\neq$ *empty* =5=>

<exported variables of sort> (*ak*, < *ev* >, *sort*, *expr*) $\frown$ <exported variables of sort> (*ak*, *rest*, *sort*, *expr*)

An <exported variables of sort> that defines multiple variables is a shorthand for a sequence of <exported variables of sort> items, each defining one variable.

<variable definition>(< *v* > ⌒ *rest*) **provided** *rest* ≠ *empty* =5=>
<variable definition> (< *v* >) ⌒ <variable definition> (*rest*)

A <variable definition> that defines multiple <variables of sort> or <exported variables of sort> items is a shorthand for a sequence of <variable definition>s, each defining one item. Combined with the transforms for <variables of sort> and <exported variables of sort>, the consequence is each <variable definition> defines one variable.

Mapping to abstract syntax

| <variable definition>(*, < *var* >) **then** *Mapping*(*var*)
| <variables of sort>(*ak*, <*name*>, *sort*, *const*) **then**
mk-*Variable-definition*(*Mapping*(*name*), *Mapping*(*sort*), *Mapping*(*ak*), *Mapping*(*const*))
| <exported variables of sort>(*ak*, <*ev*>, *sort*, *const*) **then**
mk-*Variable-definition*(*Mapping*(*ev*.**s-**<name>), *Mapping*(*sort*), *Mapping*(*ak*), *Mapping*(*const*))

F2.2.9.9.10 Variable access

Abstract syntax

Variable-access :: *Variable-identifier*

Concrete syntax

<variable access> :: { <variable<identifier> | **this** | <import expression> }

Conditions on concrete syntax

∀*va*∈<variable access>: *va*.**s-implicit** = **this** ⇒
(*parentAS0ofKind*(*va*, <operation definition>) ≠ *undefined* ∧
parentAS0ofKind(*va*, <operation definition>).*kind0*=**method**) // before transformation to a procedure
∨ (∃*od* ∈ <operation definition> :
od.*operatorProcedureId* ≠ *undefined* ∧ *od*.*kind0*=**method**
∧ *od*.*operatorProcedureId*.*refersto0* = *parentAS0ofKind*(*va*, <internal procedure definition >)
) // after method body transformed into an anonymous procedure

this must only occur in method definitions.

Transformations

va = <variable access>(**this**)
provided *parentAS0ofKind*(*va*, <internal procedure definition >) ≠ *undefined* // anon proc for method
=8=> <variable access>(*parentAS0ofKind*(va, <internal procedure definition >).**s-**<procedure heading>.
s-<formal variable parameters>.*head*.**s-**<parameters of sort>.**s-**<name>.*head*)

A <variable access> using the keyword **this** is replaced by the anonymous name introduced as the name of the leading parameter in <arguments> according to clause 12.1.3 *Model* of [ITU-T Z.104]. See clause 12.3.2 *Model* of [ITU-T Z.104].

Mapping to abstract syntax

| <variable access>(*identifier*) **then** **mk-***Variable-identifier*(*Mapping*(*identifier*))

F2.2.9.9.11 Assignment

Abstract syntax

Assignment :: *Variable-identifier Expression*

Conditions on abstract syntax

∀*a* ∈ *Assignment*: ∃*d* ∈ *Variable-definition*:
(*d*=*getEntityDefinition1*(*a*.**s**-*Variable-identifier*,**variable**)) ∧
isCompatibleTo1(*a*.**s**-*Expression*.*staticSort1*, *d*.**s**-*Sort-reference-identifier*)

In an *Assignment*, the sort of the *Expression* must be sort compatible to the sort of the *Variable-identifier*.

Concrete syntax

<assignment> :: <variable> <expression>

<variable> = <variable><identifier> | <extended variable>

Mapping to abstract syntax

| <assignment>(*var*,*expr*) **then mk-***Assignment*(*var*,*expr*)

F2.2.9.9.12 Extended variable

Concrete syntax

<extended variable> = <indexed variable> | <field variable>

<indexed variable> :: <variable> <actual parameter list>

<field variable> :: <variable> { <field name> | <field number> | <as signal> }

Transformations

<assignment>(<indexed variable>(*var*, *params*), *expr*)
=8=>
<assignment>(*var*, <method application>(*var*, <identifier>(*empty*, "Modify"), *expr*))

<indexed variable> is derived concrete syntax for

<variable> <is assigned sign> <variable> <full stop> Modify (expressionlist)

where expressionlist is constructed by appending <expression> to the <actual parameter list>. The abstract grammar is determined from this concrete expression according to clause 12.2.1 of [ITU-T Z.101]. The same model applies to the second form of <indexed variable>.

<assignment>(<field variable>(*var*, *fieldname*), *expr*)
=8=>
<assignment>
(*var*, <method application>(*var*, *modifyExtractName*(*fieldname*, "Modify"), *expr*))

The concrete syntax form

<variable> <exclamation mark> <field name> <is assigned sign> <expression>

is derived concrete syntax for

<variable> <full stop> field-modify-operation-name (<expression>)

where the field-modify-operation-name is formed from the concatenation of the field name and "Modify". The abstract syntax is determined from this concrete expression according to clause 12.2.1 of [ITU-T Z.101]. The same model applies to the second form of <field variable>.

Auxiliary functions

modifyExtractName(*name*: <identifier>, *suffix*: *TOKEN*):<identifier> =$_{def}$
mk-<identifier>(*name*.**s-**<qualifier>, *name*.**s-**<name> + *suffix*)

F2.2.9.9.13 Default initialization

Abstract syntax

Default-initialization = *Constant-expression*

Concrete syntax

<default initialization> ::[<virtuality>] [<constant expression>]

Conditions on concrete syntax

∀*init*∈<default initialization>:
init.**s-**<constant expression> = *undefined* ⇒*init.virtuality0* ∈{**redefined**, **finalized**}

The <constant expression> shall only be omitted if <virtuality> is **redefined** or **finalized**.

Transformations

<variables of sort>(*ak*, *names*, *sort*, *undefined*)
provided
getEntityDefinition0(*sort*, **sort**).*getDefaultInitialization0* ≠ *undefined*
=8=>
<variables of sort>(*ak*, *names*, *sort*,
getEntityDefinition0(*sort*, **sort**). *getDefaultInitialization0*)

Further study needed because in SDL-2010 there should be a mapping to *Default-initialization*, which should be used to determine the *Constant-expression* of a *Variable-definition*, and the range initialization of a syntype should be checked.

A default initialization is shorthand for specifying an explicit initialization for all those variables that are declared to be of <sort>, but where the <variable definition> was not given a <constant expression>.

If no <default initialization> is given in <syntype definition>, then the syntype has the <default initialization> of the <parent sort identifier> provided its result is in the range.

Any pid sort is treated as if implicitly given a <default initialization> of Null.

If the <constant expression> is omitted in a redefined default initialization, the explicit initialization is not added.

Auxiliary functions

The function *getDefaultInitialization0* computes the default initialization for a data type or syntype.

```
getDefaultInitialization0(type: <data type definition> ∪ <syntype definition>): <default initialization> =def
    case type in
    | <data type definition> then
        let tb = type.s-<data type definition body> in
        if tb ≠ undefined then
            let di = tb.s-<default initialization> ∧ di.s-<constant expression> in
            if di ≠ undefined then
                if di.s-<constant expression> ≠ undefined then di else undefined endif
            else
                type.s-<data type specialization>.s-<base type>-seq.baseInitialization0
            endif
            endlet
        else sds.s-<parent sort identifier>.getDefaultInitialization0
        endif
        endlet
    | <syntype definition> then
        let sds = type.s-<syntype definition syntype> in
        let di = sds.s-<default initialization>  in
        if di ≠ undefined then di
```

else *sds*.**s-**<parent sort identifier>.*getDefaultInitialization0*
endif
endlet
endlet
endcase

The function *baseInitialization0* returns the <default initialization> for the first <base type> (in the list of a <data type specialization>) that has a <default initialization> or *undefined* if there is no <default initialization>.

baseInitialization0(*bl*: <base type>*): <default initialization> $=_{def}$
if *bl* ≠ *undefined*
then
let *di* = *bl.head.getDefaultInitialization0* **in**
if *di* ≠ *undefined* **then** *di*
else
let *blt* = *bl.tail* **in**
if *blt.length* ≠ 0 **then** *blt.baseInitialization0* **else** *undefined* **endif**
endif
else *undefined*
endif

F2.2.9.9.14 Now expression

Abstract syntax

Now-expression :: ()

Concrete syntax

<now expression> :: ()

Mapping to abstract syntax

| <now expression> **then** **mk-***Now-expression*()

F2.2.9.9.15 Import expression

Concrete syntax

<import expression> :: <remote variable><identifier> <communication constraints>

Conditions on concrete syntax

∀*exp*∈<import expression>: *exp*.**s-**<identifier>∈
(**let** *d*=*parentAS0ofKind*(*exp*, <agent definition> ∪<agent type definition>) **in**
exp.**s-**<identifier>∈*d.validOutputSignalSet0*
endlet)

A remote variable mentioned in an <import expression> shall be in the complete output set of an enclosing agent type or agent set. See clause 10.6 *Concrete grammar* of [ITU-T Z.102].

NOTE – The <destination> in the <communication constraints> of an <import expression> has to be compatible with the remote variable, which is described in more detail in clause F2.2.7.6, Remote variable.

Transformations

The import expression has implied syntax for the importing of the result as defined in clause 10.6 of [ITU-T Z.102] and it also has an implied Variable-access of the implied variable for the import in the context where the <import expression> appears. See clause 12.3.4.5 *Model* of [ITU-T Z.104].

NOTE – The transformation of <import expression> is described in clause F2.2.7.6, Remote variable.

F2.2.9.9.16 Pid expression

Abstract syntax

Pid-expression = *Self-expression*
| *Parent-expression*
| *Offspring-expression*
| *Sender-expression*

Self-expression :: ()

Parent-expression :: ()

Offspring-expression :: ()

Sender-expression :: ()

Concrete syntax

<pid expression> =
<self expression>
| <parent expression>
| <offspring expression>
| <sender expression>

<self expression> :: ()

<parent expression> :: ()

<offspring expression> :: ()

<sender expression> :: ()

<create expression> = <create body>

Transformations

The use of <create expression> in an expression is a shorthand for inserting a create request just before the action where the <create expression> occurs followed by an assignment of offspring to an implicitly declared anonymous variable of the same sort as the static sort of the <create expression>. The implicit variable is then used in the expression. If <create expression> occurs several times in an expression, one distinct variable is used for each occurrence. In this case the order of the inserted create requests and variable assignments is the same as the order of the <create expression>s.

If the <create expression> contains an <agent type identifier> then the transformations that are applied to a create statement that contains an <agent type identifier> are also applied to the implicit create statements resulting from the transformation of a <create expression> (see clause 11.13.2 of [ITU-T Z.103]).

Mapping to abstract syntax

| <self expression> **then** **mk-***Self-expression*()
| <parent expression> **then** **mk-***Parent-expression*()
| <offspring expression> **then** **mk-***Offspring-expression*()
| <sender expression> **then** **mk-***Sender-expression*()

F2.2.9.9.17 Timer active expression and timer remaining duration

Abstract syntax

Timer-active-expression :: *Timer-identifier Expression**

Timer-remaining-duration :: *Timer-identifier Expression**

Conditions on abstract syntax

$\forall t \in$ *Timer-active-expression* $\cup$ *Timer-remaining-duration*:
let *d* = *getEntityDefinition1*(*t*.**s-***Timer-identifier*, **timer**) **in**
t.**s-***Expression*.*length* = *d*.**s-***Sort-reference-identifier*. *length* $\wedge$

(∀*i* ∈ 1.. *t*.**s-***Expression*. *length*:
isCompatibleTo1(*t*.**s-***Expression*[*i*].*staticSort1*, *d*.**s-***Sort-reference-identifier*[*i*]))
endlet

The sorts of the *Expression* list in the *Timer-active-expression* or *Timer-remaining-duration* shall correspond by position to the *Sort-reference-identifier* list directly following the *Timer-name* identified by the *Timer-identifier*.

Concrete syntax

<timer active expression> :: <timer<identifier> [<expression list>]

<timer remaining duration> :: <timer<identifier> [<expression list>]

Mapping to abstract syntax

| <timer active expression>(*id*,*l*) **then**
mk-*Timer-active-expression*(*Mapping*(*id*), *Mapping*(*l*))

| <timer remaining duration>(*id*,*l*) **then**
mk-*Timer-remaining-duration*(*Mapping*(*id*), *Mapping*(*l*))

F2.2.9.9.18 Active agents expression

Abstract syntax

Active-agents-expression :: { *Agent-identifier* | **THIS** }

Concrete syntax

<active agents expression> ::{ <agent<identifier> | **this** }

Conditions on abstract syntax

∀*exp*∈<create body>: (*exp*.**s-implicit** = **this**) ⇒
(*exp.surroundingScopeUnit0*∈<agent type definition>) ∧
(*exp.surroundingScopeUnit0.surroundingScopeUnit0*∈<agent type definition>)

this shall only be specified in an <agent type diagram> and in scopes enclosed by an <agent type diagram> and represents **THIS**.

Mapping to abstract syntax

| <active agents expression>(id=<identifier>) **then mk-***Active-agents-expression*(*Mapping*(*id*))

| <active agents expression>(**this**) **then mk-***Active-agents-expression*(**THIS**)

F2.2.9.9.19 Any expression

Abstract syntax

Any-expression :: *Sort-reference-identifier*

Concrete syntax

<any expression> :: <sort>

Conditions on abstract syntax

∀*exp*∈<any expression>: *isContainingElements0*(*exp*.**s-**<sort>)

The <sort> must contain elements.

Mapping to abstract syntax

| <any expression>() **then mk-***Any-expression*

Auxiliary functions

isContainingElements0(*s*:<sort>):*BOOLEAN*=$_{def}$
let *d* = *getEntityDefinition0*(*s*, **sort**) **in**
(*d*∈*PREDEFINEDSORT0*)∨
(∃*cons*∈<data type constructor>: *cons.surroundingScopeUnit0* = *d* ∧
(*cons*∈<structure definition>∪<choice definition>⇒
∀*sort*∈<sort>:*sort* **in** *cons.fieldSortList0*⇒*isContainingElements0*(*sort*)))∨
(*d.specialization0*≠*undefined*∧
isContainingElements0(*d.specialization0*.**s-**<type expression>.*baseType0*)∧
(∀*acp*∈<actual context parameter>:
acp **in**
d.actualContextParameterList0∧*acp.idKind0* = **sort**⇒ *isContainingElements0*(*acp*))
endlet

F2.2.9.9.20 State expression

Abstract syntax

State-expression :: ()

Concrete syntax

<state expression> :: ()

Mapping to abstract syntax

| <state expression>() **then** **mk-***State-expression*

F2.2.9.9.21 Signal expression

Abstract syntax

Signal-expression :: ()

Concrete syntax

<signal expression> :: ()

Mapping to abstract syntax

| <signal expression>() **then** **mk-***Signal-expression*

F2.2.9.9.22 Signallist expression

Abstract syntax

Signallist-expression :: ()

Concrete syntax

<signallist expression> ::()

Mapping to abstract syntax

| <signallist expression>() **then** **mk-***Signallist-expression*

F2.2.9.9.23 Value returning procedure call

Abstract syntax

Value-returning-call-node :: [**THIS**]
Procedure-identifier
Actual-parameters

Concrete syntax

<value returning procedure call> =
    <procedure call body>
  | <remote procedure call body>

Conditions on concrete syntax

∀*exp*∈<continuous expression>: *exp.parentAS0*∈<continuous signal> ⇒
  ¬∃*procCall*∈<value returning procedure call>: *isAncestorAS0*(*exp, procCall*)

∀*exp*∈<provided expression>: *exp*. *parentAS0*∈<input part> ⇒
  ¬∃*procCall*∈<value returning procedure call>: *isAncestorAS0* (*exp, procCall*)

A <value returning procedure call> must not occur in the <Boolean expression> of a <continuous signal> or <enabling condition>.

∀*procId*∈<identifier>: *procId*. *parentAS0*∈<value returning procedure call>⇒
  getEntityDefinition0(*procId*, **procedure**).**s-**<procedure heading>.**s-**<procedure result> ≠ *undefined*

The <procedure identifier> in a <value returning procedure call> must identify a procedure having a <procedure result>.

∀*procCall*∈<procedure call body>:
  procCall ∈<value returning procedure call> ∧ *procCall*.**s-this** ≠ *undefined* ⇒
    getEntityDefinition0(*procId*, **procedure**) =
      parentAS0ofKind(*procCall*, <procedure definition>)

If **this** is used, <procedure identifier> must denote an enclosing procedure.

Transformations

let *nn*= *newName* **in**
p=<value returning procedure call>(<procedure call body>(*id*, *params*))
  provided *parentAS0ofKind*(*id.refersto0*, <agent type definition>) ≠
      parentAS0ofKind(*p*, <agent type definition>)
=8=>
  let *par*=*parentAS0ofKind*(*p*, <agent type definition>) **in**
    <value returning procedure call>(<procedure call body>(
      <identifier>(*par.fullQualifier0*⌒<path item>(*par.entityKind0*, *par.entityName0*), *nn*),
      params))
  endlet
and // add the new definition
  let *defs*=
    parentAS0ofKind(*p*, <agent type definition>).**s-**<agent structure>.**s-**<entity in agent>**-seq in**
    defs => *defs* ⌒
      <internal procedure definition>(*empty*,
        <procedure heading>(
          <procedure preamble>(*undefined*, *undefined*),
          empty, *nn*, *empty*, *undefined*, *undefined*, *empty*, *undefined*, *empty*),
        empty,
        <procedure body>(*undefined*, *undefined*, *empty*))
  endlet // defs
endlet // nn

If the <procedure identifier> is not defined within the enclosing agent, the procedure call is transformed into a call of a local, implicitly created, subtype of the procedure.

The keyword **this** implies that when the procedure is specialized, the <procedure identifier> is replaced by the identifier of the specialized procedure.

Mapping to abstract syntax

| <value returning procedure call>(<procedure call body>(*t*, *id*, *params*)) **then**
mk-*Value-returning-call-node*(*Mapping*(*t*), *Mapping*(*id*), *Mapping*(*params*))

F2.2.9.9.24 Type coercion

Abstract syntax

Type-coercion :: *Expression Sort-reference-identifier*

Conditions on abstract syntax

The static sort of *Expression* shall be the sort identified by *Sort-reference-identifier*, or a parent sort of that sort.

∀ *t* ∈ *Type-coercion*:*isCompatibleTo1*(*staticSort1*(*t*.**s-***Expression*), *t*.**s-***Sort-reference-identifier*)

Concrete syntax

<type coercion> :: <expression> <sort>

Mapping to abstract syntax

| <type coercion>(*e*, *s*) **then mk-***Type-coercion*(*Mapping*(*e*), *Mapping*(*s*))

F2.2.10 Computing constants

This clause contains auxiliary functions used to compute values for constants.

Auxiliary functions

value1 returns a member of *VALUE1* (a *Literal-signature*).

value1(*e*: *Constant-expression*):*VALUE1* =$_{\text{def}}$
case *e* **of**
| *Literal*(*lid*) **then** *computeLiteral1*(*lid*)
| *Conditional-expression*(*bool*, *consequence*, *alternative*) **then**
if *bool.value1.semvalueBool1* **then** *consequence.value1* **else** *alternative.value1* **endif**
| *Positive-equality-expression*(*a*, *b*) **then** *computeEquality1*(*a.value1*, *b.value1*)
| *Negative-equality-expression*(*a*, *b*) **then** *computeInEquality1*(*a.value1*, *b.value1*)
| *Operation-application*(*op*, *values*) **then** *computeConstant1*(*op*, < *v.value1*: *v* **in** *values*>)
| *Range-check-expression*(*range*, *expr*) **then** *expr.value1* ∈ *range.range1*
| *Type-check-expression*(*expr*, *parent*) **then**
isCompatibleTo1(*getEntityDefinition1*(*expr.value1*.**s-***Result*.**s-***Sort-reference-identifier*, **sort**),
getEntityDefinition1(*parent*.**s-***Result*.**s-***Sort-reference-identifier*, **sort**))
| *Type-coercion*(*expr*, *) **then** *expr.value1*
| *Agent-instance-pid-value*(*ail*) **then** *computeAgentPid1*(*ail*)
endcase

computeLiteral1 returns the *Literal-signature* corresponding to the literal.

computeLiteral1(*id*: *Literal-identifier*): *VALUE1* =$_{\text{def}}$
getEntityDefinition1(*id*, *idKind1*(*id*)).**s-***Literal-signature*

semvalueBool1 returns the *BOOLEAN* value true if the *Literal-signature* is the Boolean value true, otherwise it returns the *BOOLEAN* value false.

semvalueBool1(*b*: *Literal-signature*): *BOOLEAN* =$_{\text{def}}$
if *b*= **mk-***Literal-signature*(**mk-***Name*("true"), **mk-***Result*(*predefinedId1*("Boolean"), **PART**), 0)
then *true* **else** *false* **endif** // Nat value for true is 0, Nat value for false is 1

computeEquality1 returns the Boolean *Literal-signature* for true if the value of both expressions is the same, and the Boolean *Literal-signature* for false otherwise.

computeEquality1(*a*: *Literal-signature*, *b*: *Literal-signature*): *Literal-signature* =$_{\text{def}}$

```
    mk-Literal-signature (
        if a = b then mk-Name("true") else mk-Name("false") endif,
        mk-Result(predefinedId1("Boolean"), PART),
        if a = b then 0 else 1 endif)
```

computeInEquality1 returns the Boolean *Literal-signature* for false if the value of *computeEquality1* is the Boolean *Literal-signature* for true, and the Boolean *Literal-signature* for true otherwise.

```
computeInEquality1(a: Literal-signature, b: Literal-signature): Literal-signature =def
    let eq = computeEquality1 (a, b).s-Name.s-TOKEN = "true" in
    mk-Literal-signature (
        if eq then mk-Name("false") else mk-Name("true") endif,
        mk-Result(predefinedId1("Boolean"), PART),
        if eq then 1 else 0 endif)
    endlet
```

computeConstant1 returns the *Literal-signature* for the value of applying the operation to the constant expression argument values for the operation. The name of the data type is derived from the *Operation-identifier*: the operation is defined within a data type; therefore the last *Path-item* of the *Qualifier* of the *Operation-identifier* is the *Data-type-name* of this data type. If the part of the *Qualifier* of the *Operation-identifier* before the *Data-type-name* is the **package** Predefined, the data type is one of the predefined data types there is select ion of the appropriate compute function.

```
computeConstant1(op: Operation-identifier, values: VALUE1*): Literal-signature =def
    // Further study needed for the otherwise case.
if  op.s-Qualifier.length = 2
    ∧ op.s-Qualifier.head ∈ Package-qualifier
    ∧ op.s-Qualifier.head.s-Package-name = "Predefined"
    ∧ op.s-Qualifier.last ∈ Data-type-qualifier
then // predefined, unparameterised data type
    case op.s-Qualifier.last.s-Data-type-name in
    | "Boolean" then computeBoolean1(op, values)
    | "Character" then computeChar1(op, values) // alias "IA5Char"
    | "Charstring" then computeCharstring1(op, values) // alias "IA5String"
    | "Integer" then computeInteger1(op, values)
    | "Real" then computeReal1(op, values)
    | "Duration" then computeDuration1(op, values)
    | "Time" then computeTime1(op, values)
    | "Bit" then computeBit1(op, values)
    | "Bitstring" then computeBitstring1(op, values)
//  Octet is a syntype of Bitstring constrained to length 8 bits
    | "Octetstring" then computeOctetstring1(op, values)
    | "Pid" then computePid1(op, values)
//  NumericChar is a syntype of Character constrained to numerical characters and SPACE
//  NumericCharString is a syntype of Charstring constrained to numerical characters and SPACE
//  PrintableChar is a syntype of Character constrained to printable characters and SPACE
//  PrintableCharString is a syntype of Charstring constrained to printable characters and SPACE
    | "TeletexChar" then computeTeletexChar1(op, values)
    | "TeletexCharString" then computeTeletexCharString1(op, values)
    | "VideotexChar" then computeVideotexChar1(op, values)
    | "VideotexCharString" then computeVideotexCharString1(op, values)
    | "UniversalChar" then computeUniversalChar1(op, values) // ISO/IEC 10646 character (32 bits)
    | "UniversalCharString" then computeUniversalCharString1(op, values)
//  UTF8String is a syntype of UniversalCharString
//  GeneralChar is a syntype of UniversalChar constrained to G set, C set, SPACE and DEL
//  GeneralCharString is a syntype of UniversalCharString constrained to G set, C set, SPACE and DEL
//  GraphicChar is a syntype of UniversalChar constrained to G set and SPACE
//  GraphicCharString is a syntype of UniversalCharString constrained to G set and SPACE
//  VisibleChar is a syntype of Character constrained to visible characters and SPACE
//  VisibleString is a syntype of Charstring constrained to visible characters and SPACE
//  BMPChar is a syntype of UniversalChar constrained to the Basic Multilingual Plane (16 bit characters)
//  BMPCharString is a syntype of UniversalCharString constrained to the Basic Multilingual Plane
```

```
    | "NULL" then
        mk-Literal-signature(mk-Name("null"), mk-Result(predefinedId1("NULL"), PART), 0)
    otherwise undefined // should not occur
    endcase
else // not predefined, unparameterised data type
    if isSpecialLiteralOp1(op) then computeLiteralOp1(op, values)
    elseif isSpecialStructOp1(op) then computeStructOp1(op, values)
    elseif isSpecialChoiceOp1 (op) then computeChoiceOp1(op, values)
    else undefined // This covers all other operations that do not have an active primary
    // as a parameter, but in general it is not practical to interpret the operation to determine the result.
    endif
endif // is it predefined, unparameterised data type
```

computeBoolean1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Boolean operation to the constant expression argument values.

```
computeBoolean1(op: Operation-identifier, values: VALUE1*): Literal-signature =def
// Nat value for true is 0, Nat value for false is 1
let truelt=mk-Literal-signature(mk-Name("true"),mk-Result(predefinedId1("Boolean"),PART),0) in
let falslt=mk-Literal-signature(mk-Name("false"),mk-Result(predefinedId1("Boolean"), PART),1)in
case op.s-Name in
| """not""" then //
    if values.length = 1
    then
        if values.head = truelt then falslt else truelt endif
    else undefined //should not occur
    endif
| """and""" then
    if values.length = 2
    then
        if values.head = truelt ∧ values.last = truelt then truelt
        else falslt
        endif
    else undefined //should not occur
    endif
| """or""" then
    if values.length = 2
    then
        if values.head = truelt ∨ values.last = truelt then truelt
        else falslt
        endif
    else undefined //should not occur
    endif
| """xor""" then
    if values.length = 2
    then
        if values.head ≠ values.last = true then truelt
        else falslt
        endif
    else undefined //should not occur
    endif
| """=>""" then
    if values.length = 2
    then
        if values.head = truelt ∧ values.last = falslt then falslt
        else truelt
        endif
    else undefined //should not occur
    endif
otherwise //should not occur
endcase
endlet // falslt
endlet // truelt
```

computeCharacter1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Character operation to the Character constant expression argument values.

```
computeCharacter1(op: Operation-identifier, values: VALUE1*): Literal-signature =def
case op.s-Name in
| "chr" then // the Character for any given integer value
    if values.length = 1 ∧ values.head.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
    then // parameter is an Integer literal for which the literal natural is 2*n for n>0 and -2*n-1 for n<0
        case intval = if (values.head.s-NAT/2)*2 = values.head.s-NAT // is it even
        then values.head.s-NAT/2 // yes divide by 2
        else -(values.head.s-NAT +1) /2
        endif
        in
        | < 0 then computeCharacter1(op,
            Literal-signature(natToIntToken(intval + 128),
                mk-Result(predefinedId1("Integer"),PART),
                values.head.s-NAT - if intval + 128 > 0 then 257 else 256 endif))
        | > 128 then computeCharacter1(op,
            Literal-signature(natToIntToken(intval - 128),
                mk-Result(predefinedId1("Integer"),PART),
                values.head.s-NAT-256))
        // Each name is enclosed in a QUOTATION MARK pair
        | 0 then Literal-signature(mk-Name("NUL"),mk-Result(predefinedId1("Character"),PART),0)
        | 1 then Literal-signature(mk-Name("SOH"),mk-Result(predefinedId1("Character"),PART),1)
        | 2 then Literal-signature(mk-Name("STX"),mk-Result(predefinedId1("Character"),PART),2)
        | 3 then Literal-signature(mk-Name("ETX"),mk-Result(predefinedId1("Character"),PART),3)
        | 4 then Literal-signature(mk-Name("EOT"),mk-Result(predefinedId1("Character"),PART),4)
        | 5 then Literal-signature(mk-Name("ENQ"),mk-Result(predefinedId1("Character"),PART),5)
        | 6 then Literal-signature(mk-Name("ACK"),mk-Result(predefinedId1("Character"),PART),6)
        | 7 then Literal-signature(mk-Name("BEL"),mk-Result(predefinedId1("Character"),PART),7)
        | 8 then Literal-signature(mk-Name("BS"),mk-Result(predefinedId1("Character"),PART),8)
        | 9 then Literal-signature(mk-Name("HT"),mk-Result(predefinedId1("Character"),PART),9)
        | 10 then Literal-signature(mk-Name("LF"),mk-Result(predefinedId1("Character"),PART),10)
        | 11 then Literal-signature(mk-Name("VT"),mk-Result(predefinedId1("Character"),PART),11)
        | 12 then Literal-signature(mk-Name("FF"),mk-Result(predefinedId1("Character"),PART),12)
        | 13 then Literal-signature(mk-Name("CR"),mk-Result(predefinedId1("Character"),PART),13)
        | 14 then Literal-signature(mk-Name("SO"),mk-Result(predefinedId1("Character"),PART),14)
        | 15 then Literal-signature(mk-Name("SI"),mk-Result(predefinedId1("Character"),PART),15)
        | 16 then Literal-signature(mk-Name("DLE"),mk-Result(predefinedId1("Character"),PART),16)
        | 17 then Literal-signature(mk-Name("DC1"),mk-Result(predefinedId1("Character"),PART),17)
        | 18 then Literal-signature(mk-Name("DC2"),mk-Result(predefinedId1("Character"),PART),18)
        | 19 then Literal-signature(mk-Name("DC3"),mk-Result(predefinedId1("Character"),PART),19)
        | 20 then Literal-signature(mk-Name("DC4"),mk-Result(predefinedId1("Character"),PART),20)
        | 21 then Literal-signature(mk-Name("NAK"),mk-Result(predefinedId1("Character"),PART),21)
        | 22 then Literal-signature(mk-Name("SYN"),mk-Result(predefinedId1("Character"),PART),22)
        | 23 then Literal-signature(mk-Name("ETB"),mk-Result(predefinedId1("Character"),PART),23)
        | 24 then Literal-signature(mk-Name("CAN"),mk-Result(predefinedId1("Character"),PART),24)
        | 25 then Literal-signature(mk-Name("EM"),mk-Result(predefinedId1("Character"),PART),25)
        | 26 then Literal-signature(mk-Name("SUB"),mk-Result(predefinedId1("Character"),PART),26)
        | 27 then Literal-signature(mk-Name("ESC"),mk-Result(predefinedId1("Character"),PART),27)
        | 28 then Literal-signature(mk-Name("IS4"),mk-Result(predefinedId1("Character"),PART),28)
        | 29 then Literal-signature(mk-Name("IS3"),mk-Result(predefinedId1("Character"),PART),29)
        | 30 then Literal-signature(mk-Name("IS2"),mk-Result(predefinedId1("Character"),PART),30)
        | 31 then Literal-signature(mk-Name("IS1"),mk-Result(predefinedId1("Character"),PART),31)
        | 127 then Literal-signature(mk-Name("DEL"),mk-Result(predefinedId1("Character"),PART),127)
        //Each of the following names starts and ends with an APOSTROPHE
        | 32 then Literal-signature(mk-Name("' '"),mk-Result(predefinedId1("Character"),PART),32)
        | 33 then Literal-signature(mk-Name("'!'"),mk-Result(predefinedId1("Character"),PART),33)
        | 34 then Literal-signature(mk-Name("'''"),mk-Result(predefinedId1("Character"),PART),34)
        // the name character for 34 is APOSTROPHE QUOTATION-MARK APOSTROPHE
        // and is enclosed in a QUOTATION-MARK pair
        | 35 then Literal-signature(mk-Name("'#'"),mk-Result(predefinedId1("Character"),PART),35)
```

| 36 **then** *Literal-signature*(**mk-***Name*("'$'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),36)
| 37 **then** *Literal-signature*(**mk-***Name*("'%'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),37)
| 38 **then** *Literal-signature*(**mk-***Name*("'&'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),38)
| 39 **then** *Literal-signature*(**mk-***Name*("''''"),**mk-***Result*(*predefinedId1*("Character"),**PART**),39)
// the name character for 39 is four APOSTROPHE items, representing the apostrophe character
// and is enclosed in a QUOTATION-MARK pair
| 40 **then** *Literal-signature*(**mk-***Name*("'('"),**mk-***Result*(*predefinedId1*("Character"),**PART**),40)
| 41 **then** *Literal-signature*(**mk-***Name*("')'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),41)
| 42 **then** *Literal-signature*(**mk-***Name*("'*'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),42)
| 43 **then** *Literal-signature*(**mk-***Name*("'+'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),43)
| 44 **then** *Literal-signature*(**mk-***Name*("','"),**mk-***Result*(*predefinedId1*("Character"),**PART**),44)
| 45 **then** *Literal-signature*(**mk-***Name*("'-'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),45)
| 46 **then** *Literal-signature*(**mk-***Name*("'.'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),46)
| 47 **then** *Literal-signature*(**mk-***Name*("'/'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),47)
| 48 **then** *Literal-signature*(**mk-***Name*("'0'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),48)
| 49 **then** *Literal-signature*(**mk-***Name*("'1'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),49)
| 50 **then** *Literal-signature*(**mk-***Name*("'2'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),50)
| 51 **then** *Literal-signature*(**mk-***Name*("'3'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),51)
| 52 **then** *Literal-signature*(**mk-***Name*("'4'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),52)
| 53 **then** *Literal-signature*(**mk-***Name*("'5'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),53)
| 54 **then** *Literal-signature*(**mk-***Name*("'6'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),54)
| 55 **then** *Literal-signature*(**mk-***Name*("'7'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),55)
| 56 **then** *Literal-signature*(**mk-***Name*("'8'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),56)
| 57 **then** *Literal-signature*(**mk-***Name*("'9'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),57)
| 58 **then** *Literal-signature*(**mk-***Name*("':'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),58)
| 59 **then** *Literal-signature*(**mk-***Name*("';'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),59)
| 60 **then** *Literal-signature*(**mk-***Name*("'<'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),60)
| 61 **then** *Literal-signature*(**mk-***Name*("'='"),**mk-***Result*(*predefinedId1*("Character"),**PART**),61)
| 62 **then** *Literal-signature*(**mk-***Name*("'>'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),62)
| 63 **then** *Literal-signature*(**mk-***Name*("'?'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),63)
| 64 **then** *Literal-signature*(**mk-***Name*("'@'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),64)
| 65 **then** *Literal-signature*(**mk-***Name*("'A'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),65)
| 66 **then** *Literal-signature*(**mk-***Name*("'B'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),66)
| 67 **then** *Literal-signature*(**mk-***Name*("'C'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),67)
| 68 **then** *Literal-signature*(**mk-***Name*("'D'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),68)
| 69 **then** *Literal-signature*(**mk-***Name*("'E'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),69)
| 70 **then** *Literal-signature*(**mk-***Name*("'F'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),70)
| 71 **then** *Literal-signature*(**mk-***Name*("'G'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),71)
| 72 **then** *Literal-signature*(**mk-***Name*("'H'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),72)
| 73 **then** *Literal-signature*(**mk-***Name*("'I'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),73)
| 74 **then** *Literal-signature*(**mk-***Name*("'J'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),74)
| 75 **then** *Literal-signature*(**mk-***Name*("'K'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),75)
| 76 **then** *Literal-signature*(**mk-***Name*("'L'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),76)
| 77 **then** *Literal-signature*(**mk-***Name*("'M'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),77)
| 78 **then** *Literal-signature*(**mk-***Name*("'N'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),78)
| 79 **then** *Literal-signature*(**mk-***Name*("'O'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),79)
| 80 **then** *Literal-signature*(**mk-***Name*("'P'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),80)
| 81 **then** *Literal-signature*(**mk-***Name*("'Q'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),81)
| 82 **then** *Literal-signature*(**mk-***Name*("'R'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),82)
| 83 **then** *Literal-signature*(**mk-***Name*("'S'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),83)
| 84 **then** *Literal-signature*(**mk-***Name*("'T'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),84)
| 85 **then** *Literal-signature*(**mk-***Name*("'U'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),85)
| 86 **then** *Literal-signature*(**mk-***Name*("'V'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),86)
| 87 **then** *Literal-signature*(**mk-***Name*("'W'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),87)
| 88 **then** *Literal-signature*(**mk-***Name*("'X'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),88)
| 89 **then** *Literal-signature*(**mk-***Name*("'Y'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),89)
| 90 **then** *Literal-signature*(**mk-***Name*("'Z'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),90)
| 91 **then** *Literal-signature*(**mk-***Name*("'['"),**mk-***Result*(*predefinedId1*("Character"),**PART**),91)
| 92 **then** *Literal-signature*(**mk-***Name*("'\'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),92)
| 93 **then** *Literal-signature*(**mk-***Name*("']'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),93)
| 94 **then** *Literal-signature*(**mk-***Name*("'^'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),94)
| 95 **then** *Literal-signature*(**mk-***Name*("'_'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),95)
| 96 **then** *Literal-signature*(**mk-***Name*("'`'"),**mk-***Result*(*predefinedId1*("Character"),**PART**),96)

```
        // the name character for 96 is APOSTROPHE GRAVE-ACCENT APOSTROPHE
        // and is enclosed in a QUOTATION-MARK pair
        | 97 then Literal-signature(mk-Name("'a'"),mk-Result(predefinedId1("Character"),PART),97)
        | 98 then Literal-signature(mk-Name("'b'"),mk-Result(predefinedId1("Character"),PART),98)
        | 99 then Literal-signature(mk-Name("'c'"),mk-Result(predefinedId1("Character"),PART),99)
        | 100 then Literal-signature(mk-Name("'d'"),mk-Result(predefinedId1("Character"),PART),100)
        | 101 then Literal-signature(mk-Name("'e"),mk-Result(predefinedId1("Character"),PART),101)
        | 102 then Literal-signature(mk-Name("'f'"),mk-Result(predefinedId1("Character"),PART),102)
        | 103 then Literal-signature(mk-Name("'g'"),mk-Result(predefinedId1("Character"),PART),103)
        | 104 then Literal-signature(mk-Name("'h'"),mk-Result(predefinedId1("Character"),PART),104)
        | 105 then Literal-signature(mk-Name("'i'"),mk-Result(predefinedId1("Character"),PART),105)
        | 106 then Literal-signature(mk-Name("'j'"),mk-Result(predefinedId1("Character"),PART),106)
        | 107 then Literal-signature(mk-Name("'k'"),mk-Result(predefinedId1("Character"),PART),107)
        | 108 then Literal-signature(mk-Name("'l'"),mk-Result(predefinedId1("Character"),PART),108)
        | 109 then Literal-signature(mk-Name("'m'"),mk-Result(predefinedId1("Character"),PART),109)
        | 110 then Literal-signature(mk-Name("'n'"),mk-Result(predefinedId1("Character"),PART),110)
        | 111 then Literal-signature(mk-Name("'o"),mk-Result(predefinedId1("Character"),PART),111)
        | 112 then Literal-signature(mk-Name("'p'"),mk-Result(predefinedId1("Character"),PART),112)
        | 113 then Literal-signature(mk-Name("'q'"),mk-Result(predefinedId1("Character"),PART),113)
        | 114 then Literal-signature(mk-Name("'r'"),mk-Result(predefinedId1("Character"),PART),114)
        | 115 then Literal-signature(mk-Name("'s'"),mk-Result(predefinedId1("Character"),PART),115)
        | 116 then Literal-signature(mk-Name("'t'"),mk-Result(predefinedId1("Character"),PART),116)
        | 117 then Literal-signature(mk-Name("'u'"),mk-Result(predefinedId1("Character"),PART),117)
        | 118 then Literal-signature(mk-Name("'v'"),mk-Result(predefinedId1("Character"),PART),118)
        | 119 then Literal-signature(mk-Name("'w'"),mk-Result(predefinedId1("Character"),PART),119)
        | 120 then Literal-signature(mk-Name("'x'"),mk-Result(predefinedId1("Character"),PART),120)
        | 121 then Literal-signature(mk-Name("'y"),mk-Result(predefinedId1("Character"),PART),121)
        | 122 then Literal-signature(mk-Name("'z'"),mk-Result(predefinedId1("Character"),PART),122)
        | 123 then Literal-signature(mk-Name("'{'"),mk-Result(predefinedId1("Character"),PART),123)
        | 124 then Literal-signature(mk-Name("'|'"),mk-Result(predefinedId1("Character"),PART),124)
        | 125 then Literal-signature(mk-Name("'}'"),mk-Result(predefinedId1("Character"),PART),125)
        | 126 then Literal-signature(mk-Name("'~'"),mk-Result(predefinedId1("Character"),PART),126)
        endcase // integer value parameter of chr
    else undefined //should not occur – more than one parameter for chr
    endif
| """<""" then //
    if values.length = 2
    then
        if values.head.s-Nat < values.last.s-Nat
        then mk-Literal-signature(mk-Name("true"),mk-Result(predefinedId1("Boolean"),PART),0)
        else mk-Literal-signature(mk-Name("false"),mk-Result(predefinedId1("Boolean"), PART),1)
        endif
    else undefined //should not occur – exactly two parameters for <
    endif
| """<=""" then //
    if values.length = 2
    then
        if values.head.s-Nat <= values.last.s-Nat
        then mk-Literal-signature(mk-Name("true"),mk-Result(predefinedId1("Boolean"),PART),0)
        else mk-Literal-signature(mk-Name("false"),mk-Result(predefinedId1("Boolean"), PART),1)
        endif
    else undefined //should not occur – exactly two parameters for <=
    endif
| """>""" then //
    if values.length = 2
    then
        if values.head.s-Nat > values.last.s-Nat
        then mk-Literal-signature(mk-Name("true"),mk-Result(predefinedId1("Boolean"),PART),0)
        else mk-Literal-signature(mk-Name("false"),mk-Result(predefinedId1("Boolean"), PART),1)
        endif
    else undefined //should not occur – exactly two parameters for >
    endif
| """>=""" then //
```

```
    if values.length = 2
    then
        if values.head.s-Nat >= values.last.s-Nat
        then mk-Literal-signature(mk-Name("true"),mk-Result(predefinedId1("Boolean"),PART),0)
        else mk-Literal-signature(mk-Name("false"),mk-Result(predefinedId1("Boolean"), PART),1)
        endif
    else undefined //should not occur – exactly two parameters for >=
    endif
| "num" then // natural value of a Character
    if values.length = 1
    then
    Literal-signature(natToIntToken({i : values.head.s-Nat = i.chr.s-Nat ∧ i > 0 ∧ i < 128}.take),
        mk-Result(predefinedId1("Integer"),PART),
        2 * values.head.s-NAT)
    else undefined //should not occur – more than one parameter for num
    endif
otherwise //should not occur – not one of the operators for Character
endcase
```

computeCharstring1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Charstring operation to the Charstring constant expression argument values.

```
computeCharstring1(op: Operation-identifier, values: VALUE1*): Literal-signature =def
case op.s-Name in
| """ then // emptystring - APOSTROPHE APOSTROPHE enclosed in a QUOTATION-MARK pair
    if values.length = 0
    then
        mk-Literal-signature(mk-Name(""""),mk-Result(predefinedId1("Charstring"),PART),0)
    else undefined // should not occur – some parameters given
    endif
| "mkstring" ∨ "Make" then // make a string from a Character
    if values.length = 1 ∧ values.head.s-Result.s-Sort-reference-identifier.s-Name = "Character"
    then
        mk-Literal-signature(
            mk-Name("" // APOSTROPHE
                + values.head.s-NAT.chr // character that has this numerical value
                + """ ) // APOSTROPHE, // same Token for Name as character for most characters
            mk-Result(predefinedId1("Charstring"),PART),
            values.head.s-NAT+1) // one more than the corresponding Character natural
    else undefined // should not occur – wrong number of parameters, or parameter not a Character literal
    endif
| """//""" then // concatentate two Charstrings
    if      values.length = 2
        ∧   values.head.s-Result.s-Sort-reference-identifier.s-Name = "Charstring"
        ∧   values.last.s-Result.s-Sort-reference-identifier.s-Name = "Charstring"
    then
        if  values.head.s-NAT = 0 // empty first string
        then values.last // result is second string
        elseif values.last.s-NAT = 0 // empty second string
        then values.head // result is first string
        else
        let revisedChStr = // concatenate characters for Names
                substring(values.head.s-Name ,2,values.head.s-Name.length-1) // omit apostrophes
            +   substring(values.last.s-Name,2,values.last.s-Name.length-1)) // omit apostrophes
        in
            mk-Literal-signature(
                mk-Name("" + revisedChStr + """ ), // APOSTROPHE + revisedChStr + APOSTROPHE
                mk-Result(predefinedId1("Charstring"),PART),
                computeCharstringNat1(revisedChStr) )
        endlet // revisedChStr
        endif // neither string empty
    else undefined // should not occur – wrong number of parameters, or parameters not Charstring
    endif
```

```
| "length" then // length of a Charstring – derived from the name of the charstring
    if values.length = 1 ∧ values.head.s-Result.s-Sort-reference-identifier.s-Name = "Charstring"
    then
        mk-Literal-signature((values.head.s-Name.length-2).natToIntToken,
            mk-Result(predefinedId1("Integer"),PART),
            2*(values.head.s-Name.length-2)) // nat value for integer literal
    else undefined // should not occur – wrong number of parameters, or parameter not a Charstring
    endif
| "first" then // first character of a Charstring
    if      values.length = 1
        ∧ values.head.s-Result.s-Sort-reference-identifier.s-Name = "Charstring"
        ∧ values.head.s-NAT ≠ 0 // not emptystring
    then
        mk-Literal-signature(
            mk-Name("'" // APOSTROPHE
                + substring(values.head,2,1)
                + "'" ) // APOSTROPHE,
            mk-Result(predefinedId1("Character"),PART),
            substring(values.head.s-Name,2,1).num) // nat for character
    else undefined // should not occur – wrong number of parameters, or not a Charstring, or emptystring
    endif
| "last" then // last character of a Charstring
    if      values.length = 1
        ∧ values.head.s-Result.s-Sort-reference-identifier.s-Name = "Charstring"
        ∧ values.head.s-NAT ≠ 0 // not emptystring
    then
        mk-Literal-signature(
            mk-Name("'" // APOSTROPHE
                + substring(values.head.s-Name,values.head.s-Name.length-1,1)
                + "'" ) // APOSTROPHE,
            mk-Result(predefinedId1("Character"),PART),
            substring(values.head.s-Name,values.head.s-Name.length-1,1).num) // nat for character
    else undefined // should not occur – wrong number of parameters, or not a Charstring, or emptystring
    endif
| "Extract" then // extract a character of a Charstring
    if      values.length = 2
        ∧ values.head.s-Result.s-Sort-reference-identifier.s-Name = "Charstring"
        ∧ values.head.s-NAT ≠ 0 // not emptystring
        ∧ values.last.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
        ∧ values.last.s-NAT ≠ 0 // not zero
        ∧ (values.last.s-NAT /2) * 2 = values.last.s-NAT // is positive integer
        ∧ values.last.s-NAT /2 < values.head.s-Name.length -1 // in range of Charstring
    then
        mk-Literal-signature(
            mk-Name("'" // APOSTROPHE
                + substring(values.head.s-Name,(values.last.s-NAT /2)+1,1).chr
                + "'" ) // APOSTROPHE,
            mk-Result(predefinedId1("Character"),PART),
            substring(values.head.s-Name, (values.last.s-NAT /2)+1,1)+1) // nat value for character literal
    else undefined // should not occur
    endif
| "Modify" then // change a character of a Charstring
    if      values.length = 3
        ∧ values.head.s-Result.s-Sort-reference-identifier.s-Name = "Charstring"
        ∧ values.head.s-NAT ≠ 0 // not emptystring
        ∧ values.tail.head.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
        ∧ values.tail.head.s-NAT ≠ 0 // not zero
        ∧ (values.tail.head.s-NAT /2) * 2 = values.last.s-NAT // is positive integer
        ∧ values.tail.head.s-NAT /2 < values.head.s-Name.length -1 // in range of Charstring
        ∧ values.last.s-Result.s-Sort-reference-identifier.s-Name = "Character"
    then
        let revisedChStr =
```

```
            <   if i = values.tail.head.s-NAT /2
                then values.last.s-NAT.chr // character to add to name
                else values.head.s-Name[i+1]
                endif:
                i ∈ 1..(values.head.s-Name.length-2)
             >
        in
        mk-Literal-signature(
            mk-Name(""" + revisedChStr + """ ), // APOSTROPHE + revisedChStr + APOSTROPHE
            mk-Result(predefinedId1("Charstring"),PART),
            computeCharstringNat1(revisedChStr) )
        endlet // revisedChStr
    else undefined // should not occur
    endif
| "substring" then // substring of a Charstring
    if      values.length = 3
        ∧ values.head.s-Result.s-Sort-reference-identifier.s-Name = "Charstring"
        ∧ values.head.s-NAT ≠ 0 // not emptystring
        ∧ values.tail.head.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
        ∧ values.tail.head.s-NAT ≠ 0 // not zero
        ∧ (values.tail.head.s-NAT /2) * 2 = values.last.s-NAT // is positive integer  – starting element
        ∧ values.tail.head.s-NAT /2 < values.head.s-Name.length -1 // in range of Charstring
        ∧ values.last.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
        ∧ (values.last.s-NAT /2) * 2 = values.last.s-NAT // is positive integer  – length
        ∧ values.tail.head.s-NAT/2+values.last.s-NAT /2 < values.head.s-Name.length-2 // in range
    then
        let revisedChStr =
            < values.head.s-Name[i+1] :
                i ∈ values.tail.head.s-NAT/2..( values.tail.head.s-NAT/2+values.last.s-NAT/2) >
        in
        mk-Literal-signature(
            mk-Name(""" + revisedChStr + """ ), // APOSTROPHE + revisedChStr + APOSTROPHE
            mk-Result(predefinedId1("Charstring"),PART),
            computeCharstringNat1(revisedChStr) )
        endlet // revisedChStr
    else undefined // should not occur
    endif
| "remove" then // remove substring from a Charstring
    if      values.length = 3
        ∧ values.head.s-Result.s-Sort-reference-identifier.s-Name = "Charstring"
        ∧ values.head.s-NAT ≠ 0 // not emptystring
        ∧ values.tail.head.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
        ∧ values.tail.head.s-NAT ≠ 0 // not zero
        ∧ (values.tail.head.s-NAT /2) * 2 = values.tail.head.s-NAT // is positive integer – starting element
        ∧ values.tail.head.s-NAT /2 < values.head.s-Name.length -1 // in range of Charstring
        ∧ values.last.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
        ∧ (values.last.s-NAT /2) * 2 = values.last.s-NAT // is positive integer  - length
        ∧ values.tail.head.s-NAT/2+values.last.s-NAT/2 < values.head.s-Name.length-2 // in range
    then
        let revisedChStr =
            < values.head.s-Name[i+1] :
                i ∈ (if values.tail.head.s-NAT/2=1 then ∅ else 1..values.tail.head.s-NAT/2-1 endif ∪
                    if values.tail.head.s-NAT/2+values.last.s-NAT/2 > values.head.s-Name.length-2 then ∅
                    else values.tail.head.s-NAT/2+values.last.s-NAT/2..values.head.s-Name.length-1
                    endif ) >
        in
        mk-Literal-signature(
            mk-Name(""" + revisedChStr + """ ), // APOSTROPHE + revisedChStr + APOSTROPHE
            mk-Result(predefinedId1("Charstring"),PART),
            computeCharstringNat1(revisedChStr) )
        endlet // revisedChStr
```

```
    else undefined // should not occur
    endif
otherwise //should not occur – not one of the operators for Charstring
endcase
```

computeCharstringNat1 returns (to *computeCharstring1*) the *Literal-natural* for the *Literal-signature* for the *Name* given as its *Literal-name*.

```
computeCharstringNat1(nm: Name): NAT =def
if  nm = """ then 0 // emptystring
else (nm.head.num+1)*128^(nm.length-1) + computeCharstringNat1(nm.tail)
endif
```

computeInteger1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Integer operation to the Integer constant expression argument values. There are no integer literals for negative integers in the concrete grammar: instead negative values are represented by the application of the unary minus operation. However, in the formal model *Literal-signature* items are defined for negative values with the integer *Name* preceded by a "-". The *Literal-natural* value for an integer for positive integers is twice the integer value. For a negative integer n the *Literal-natural* value is -2*n-1.

```
computeInteger1(op: Operation-identifier, values: VALUE1*): Literal-signature =def
let isIntIntOp = (values.length = 2
    ∧  values.head.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
    ∧  values.last.s-Result.s-Sort-reference-identifier.s-Name = "Integer")
in
let a =
if (values.head.s-NAT/2) * 2 = values.head.s-NAT
then values.head.s-NAT/2
else –(values.head.s-NAT/2+1)
endif
in
let b =
if (values.last.s-NAT/2) * 2 = values.last.s-NAT
then values.last.s-NAT/2
else –(values.last.s-NAT/2+1)
endif
in
let truelt=mk-Literal-signature(mk-Name("true"),mk-Result(predefinedId1("Boolean"),PART),0) in
let falslt=mk-Literal-signature(mk-Name("false"),mk-Result(predefinedId1("Boolean"), PART),1)in
case op.s-Name in
| ""-"" then // unary minus of an Integer, or subtraction of Integers
    if      values.length = 1
        ∧  values.head.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
    then // unary minus of an Integer
        mk-Literal-signature(
            if   (values.head.s-NAT /2) * 2 = values.head.s-NAT
            then    "-" + values.head.s-Name
            else    substring(values.head.s-Name,2, values.head.length-1)
            endif ,
            mk-Result(predefinedId1("Integer"),PART),
            values.head.s-NAT + if (values.head.s-NAT /2) * 2 = values.head.s-NAT then -1 else +1 endif
        ) // Literal-signature
    elseif isIntIntOp then // subtraction of Integers
        mk-Literal-signature(
            if a - b < 0
            then    "-" + natToIntToken(-a + b)
            else natToIntToken(a - b)
            endif ,
            mk-Result(predefinedId1("Integer"),PART),
            if a - b < 0
            then    (-a + b) * 2 -1
```

```
            else (a - b) * 2
            endif
        ) // Literal-signature
    else undefined // should not occur
    endif
| ""+"" then // addition of Integers
    if isIntIntOp then
        mk-Literal-signature(
            if a + b < 0
            then    "-" + natToIntToken(-a - b)
            else natToIntToken(a + b)
            endif ,
            mk-Result(predefinedId1("Integer"),PART),
            if a + b < 0
            then    (-a - b) * 2 -1
            else (a + b) * 2
            endif
        ) // Literal-signature
    else undefined // should not occur
    endif
| ""*"" then // multiplication of Integers
    if isIntIntOp then
        mk-Literal-signature(
            if a * b < 0
            then    "-" + natToIntToken(-a * b)
            else natToIntToken(a * b)
            endif ,
            mk-Result(predefinedId1("Integer"),PART),
            if a * b < 0
            then    (-a * b) * 2 -1
            else a * b * 2
            endif
        ) // Literal-signature
    else undefined // should not occur
    endif
| ""/"" then // division of Integers
    if isIntIntOp ∧ values.last.s-NAT ≠ 0 then
        mk-Literal-signature(
            if a / b < 0
            then    "-" + natToIntToken(-a / b)
            else natToIntToken(a / b)
            endif ,
            mk-Result(predefinedId1("Integer"),PART),
            if a / b < 0
            then    (-a / b) * 2 -1
            else (a / b) * 2
            endif
        ) // Literal-signature
    else undefined // should not occur
    endif
| ""mod"" then // modulus of Integers
    if isIntIntOp ∧ values.last.s-NAT ≠ 0 then
        if a >= 0 ∧ b >= 0 then computeInteger1(""rem"", values) // that is – a rem b
        elseif b < 0 then computeInteger1(""mod"", < a, computeInteger1(""-"", < b >)>)
        elseif a < 0 ∧ b > 0 ∧ computeInteger1(""rem"", values).s-NAT =0
        then mk-Literal-signature("0", mk-Result(predefinedId1("Integer"),PART), 0)
        elseif a < 0 ∧ b > 0 ∧ computeInteger1(""rem"", values).s-Name.head = "-")
        then computeInteger1(""+"", < b, computeInteger1(""rem"", values)>)
        else undefined // should not occur
        endif
    else undefined // should not occur
    endif
| ""rem"" then // remainder of Integer division
```

```
    if isIntIntOp ∧ values.last.s-NAT ≠ 0
    then
            if a – (b *( a / b)) < 0
        mk-Literal-signature(
            if a – (b *( a / b)) < 0
            then    "-" + natToIntToken(-a + (b *( a / b)))
            else natToIntToken(-a – (b *( a / b)))
            endif ,
            mk-Result(predefinedId1("Integer"),PART),
            if a – (b *( a / b)) < 0
            then     (-a + (b *( a / b)) * 2 -1
            else (a / b) * 2
            endif
        ) // Literal-signature
    else undefined // should not occur
    endif
| ""<"" then // less than for Integers
    if isIntIntOp then
        if a < b then truelt else falselt endif
    else undefined // should not occur
    endif
| ""<="" then // less than or equal to for Integers
    if isIntIntOp then
        if a <= b then truelt else falselt endif
    else undefined // should not occur
    endif
| "">"" then // greater than for Integers
    if isIntIntOp then
        if a > b then truelt else falselt endif
    else undefined // should not occur
    endif
| "">="" then // greater than or equal to for Integers
    if isIntIntOp then
        if a >= b then truelt else falselt endif
    else undefined // should not occur
    endif
| "power" then // a to the power b
    if isIntIntOp then
        if b = 0 then 1
        elseif a = 1 then mk-Literal-signature("1", mk-Result(predefinedId1("Integer"),PART), 2)
        elseif a = -1 then
            if ((b/2) * 2 ≠ b)
            then mk-Literal-signature("1", mk-Result(predefinedId1("Integer"),PART), 2)
            else mk-Literal-signature("-1", mk-Result(predefinedId1("Integer"),PART), 2-1)
            endif
        elseif (a < -1 ∨ a > 1) ∧ b < 0
            then mk-Literal-signature("0", mk-Result(predefinedId1("Integer"),PART), 0)
        elseif a < 0 ∧ (b/2) * 2 ≠ b // a negative and b odd
        then computeInteger1(""-"",
            < computeInteger1("power", < computeInteger1("-", < values.head >), values.last >
            >) // - power(-a,b)
        else // b > 0
            computeInteger1(""*"",
            < values.head,
            computeInteger1("power",
                values.head,
                computeInteger1("-",
                < values.last,
                    mk-Literal-signature("1",
                        mk-Result(predefinedId1("Integer"),PART),
                        2)
                >)
            >) // a*power(a,b-1)
```

```
        endif
    else undefined // should not occur
    endif
| "integer" then // integer operation – used to turn an integer into a subtype of integer
    if      values.length = 1
        ∧   values.head.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
    then
        values.head
| "num" then // num operation – used to turn a subtype of integer into an integer
    if      values.length = 1
        ∧   values.head.s-Result.s-Sort-reference-identifier.s-Name = "Integer"
    then
        values.head
// the formalisation of the equivalent integer literal for bitstring and hex literals is left for further study
otherwise undefined // should not occur – not one of the operators for Integer
endcase
endlet // falselt
endlet // truelt
endlet // b
endlet // a
endlet // isIntIntOp
```

computeReal1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Real operation to the constant expression argument values. Each Real is actually a rational number that can be written as a/b, and these are counted as in the following table, where the rational is given before the = sign and the number after the sign is the count. The shaded cells with an X, each denote a rational that has the same value as one already counted: for example, 8/6 and 4/3. The count is doubled for the literal natural value, so that if the count for positive real r is n its literal natural is the even number 2 * n and the literal natural for –r is the odd number 2 * n -1.

Divisor/	1	2	3	4	5	6	7	8
1	1/1 = 1	1/2 = 3	1/3 = 4	1/4 = 9	1/5 = 10	1/6 = 17	1/7 = 18	1/8 = 27
2	2/1 = 2	2/2 = X	2/3 = 8	2/4 = X	2/5 = 16	2/6 = X	2/7 = 26	2/8 = X
3	3/1 = 5	3/2 = 7	3/3 = X	3/4 = 15	3/5 = 19	3/6 = X	3/7 = 29	3/8 = 39
4	4/1 = 6	4/2 = X	4/3 = 14	4/4 = X	4/5 = 25	4/6 = X	4/7 = 48	4/8 = X
5	5/1 = 11	5/2 = 13	5/3 = 20	5/4 = 24	5/5 = X	5/6 = 37	5/7	5/8
6	6/1 = 12	6/2 = X	6/3 = X	6/4 = X	6/5 = 36	6/6 = X	6/7	6/8 = X
7	7/1 = 21	7/2 = 23	7/3 = 30	7/4 = 35	7/5	7/6	7/7 = X	7/8
8	8/1 = 22	8/2 = X	8/3 = 34	8/4 = X	8/5	8/6 = X	8/7	8/8 = X

computeReal1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =$_{def}$
// Further study required for the formulation of this function.

computeDuration1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Duration operation to the constant expression argument values. Duration inherits from Real and uses the same method for deriving literal natural values.

computeDuration1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =$_{def}$
// Further study required for the formulation of this function

computeTime1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Time operation to the constant expression argument values. Time inherits from Real and uses the same method for deriving literal natural values.

computeTime1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =$_{def}$
// Further study required for the formulation of this function.

computeBit1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Bit operation to the constant expression argument values.

computeBit1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =$_{def}$
// Further study required for the formulation of this function.

computeBitstring1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Bitstring operation to the constant expression argument values.

computeBitstring1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =$_{def}$
// Further study required for the formulation of this function.

computeOctetstring1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Octetstring operation to the constant expression argument values.

computeOctetstring1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =$_{def}$
// Further study required for the formulation of this function.

computePid1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the Pid operation to the constant expression argument values.

computePid1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =$_{def}$
// Further study needed to determine whether this function is needed and its formulation (if it is needed).

computeTeletexChar1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the TeletexChar operation to the constant expression argument values.

computeTeletexChar1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =$_{def}$
// Further study required for the formulation of this function.

computeTeletexCharString1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the TeletexCharString operation to the constant expression argument values.

computeTeletexCharString1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =$_{def}$
// Further study required for the formulation of this function.

computeVideotexChar1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the VideotexChar operation to the constant expression argument values.

computeVideotexChar1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =$_{def}$
// Further study required for the formulation of this function.

computeVideotexCharString1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the VideotexCharString operation to the constant expression argument values.

computeVideotexCharString1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =def
// Further study required for the formulation of this function.

computeUniversalChar1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the UniversalChar operation to the constant expression argument values.

computeUniversalChar1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =def
// Further study required for the formulation of this function.

computeUniversalCharString1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the UniversalCharString operation to the constant expression argument values.

computeUniversalCharString1(*op*: *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =def
// Further study required for the formulation of this function

isSpecialLiteralOp1 determines if the operator is one of the implicit literal operators (num, "<", ">", "<=", ">=", first, last, succ, pred) of a data type created from a literals list constructor (that is, with a non-empty *Literal-signature*-**set**).

isSpecialLiteralOp1(*op* : *Operation-identifier*): *BOOLEAN*=def
// Further study required for the formulation of this function

computeLiteralOp1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the special literal operation (see *isSpecialLiteralOp1*) to the constant expression argument values.

computeLiteralOp1(*op* : *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =def
// Further study required for the formulation of this function

isSpecialStructOp1 determines if the operator is one of the operators (Make, fnExtract, fnModify, fnPresent, undefined) of a data type created from a structure definition, which is distinguished from a choice definition by the presence of parameters to Make, and the absence of PresentExtract.

isSpecialStructOp1(*op* : *Operation-identifier*): *BOOLEAN*=def
// Further study required for the formulation of this function

computeStructOp1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the special struct operation (see *isSpecialStructOp1*) to the constant expression argument values.

computeStructOp1(*op* : *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =def
// Further study required for the formulation of this function

isSpecialChoiceOp1 determines if the operator is one of the operators (Make, fn, fnExtract, fnModify, fnPresent, PresentExtract, undefined) of a data type created from a choice definition.

isSpecialChoiceOp1(*op* : *Operation-identifier*): *BOOLEAN*=def
// Further study required for the formulation of this function

computeChoiceOp1 returns (to *computeConstant1*) the *Literal-signature* for the value of applying the special choice operation (see *isSpecialChoiceOp1*) to the constant expression argument values.

computeChoiceOp1(*op* : *Operation-identifier*, *values*: *VALUE1**): *Literal-signature* =def
// Further study required for the formulation of this function

computeAgentPid1 returns (to *computeConstant1*) the `Pid` value identified by the *Agent-instance* list.

computeAgentPid1(*ail*: *Agent-instance**): *Literal-signature* =def
// Further study required for the formulation of this function

F2.3 Transformation of SDL-2010 shorthands

This clause details the transformation of the SDL-2010 constructs, whose dynamic semantics are given after a transformation to the subset of SDL-2010 for which *Abstract Grammar* exists. These shorthand notations are constructs for which a *Model* section exists.

The properties of a shorthand notation are derived from the way it is modelled in terms of (or transformed to) the primitive concepts. In order to ensure easy and unambiguous use of the shorthand notations, and to reduce side effects when several shorthand notations are combined, these concepts are transformed in a specified order as detailed in this clause.

The specified order of transformation means that in the result of the transformation of a shorthand notation of order *m*, another shorthand notation of order *n* may be used, provided *n*>*m*. The order of the transformation is given as a number inside the transformation arrow, e.g., =5=> for a transformation of order 5.

The transformations are described as a number of enumerated steps. One step may describe the transformation of several concepts and thus consist of a number of sub-steps, either because these concepts must be transformed as a group or because the transformation order between these concepts is not significant.

If entities are moved to different scopes during the subsequent transformation steps, the <qualifier>s in every <identifier> bound to such an entity are updated to reflect this change. In fact, this case should not happen in the new version of SDL-2010.

The following enumeration details the transformation steps to be performed in order.

1) Lexical transformations:
   a) <macro definition> items and <macro call> items (see clause 6.7 of [ITU-T Z.102]) are identified lexically and <macro call> items are expanded;
   b) <macro definition> items are removed (also in <package definition> items).
   – These transformations are not described formally, i.e., no macros are considered in the formal semantics.
   – This step also includes simple transformations (such as removal of separators) that just adapt the AS0.
2) operations are handled, **public** removed from <operation signature> and <literal signature> items:
   – omitted parameter kind replaced by **in**. See clause 9.4 *Model* of [ITU-T Z.103];
   – the <operation signature> of each method is transformed to an <operation signature> of the equivalent operator. See clause 12.1.3 of [ITU-T Z.104];
   – <operation definition> items are transformed into procedures having anonymous names and having the result as <procedure result>. See clause 12.1.7 of [ITU-T Z.101] and clause 12.1.7 of [ITU-T Z.104].
   – <inline data type definition> (see clause 12.1 of [ITU-T Z.104]);
   – <inline syntype definition> (see clause 12.1 of [ITU-T Z.104]);
   – remove **public** (see clause 12.1.9 of [ITU-T Z.104]).
3) <task> items and <statements> lists are transformed as defined in clause 11.13.1 of [ITU-T Z.103], clause 11.14 of [ITU-T Z.102] and clause 11.14 of [ITU-T Z.103].
4) Definition references are replaced by <referenced definition>s (see clause 7.3 of [ITU-T Z.101]).
5) The graphs are normalized, name lists are expanded to one name per item, omitted items with defaults set to the default:
   – non-terminating decisions and non-terminating transition options are transformed into terminating decisions and terminating transition options respectively (clause 5.7.12.5 [ITU-T Z.106]);

– the actions and/or terminator statement following the decisions and transition options are moved to appear as <free action>s. Those generated <free action>s which have no label attached are given anonymous labels;
– action lists (including the terminator statement which follows) where the first action (if any, otherwise the following terminator statement) has a label attached, are replaced by a join to the label and the action list appears as a <free action>;
– a system specification that is a process or block is replaced by a system enclosing the process or block as in clause 7.1 of [ITU-T Z.103];
– each <signal definition list> that has multiple <signal definition> items is replaced by multiple <signal definition list> items each containing one <signal definition> as described in clause 10.3 of [ITU-T Z.101];
– each <signal definition> has a (usually anonymous) name defined for the associated data type as in clause 10.3 of [ITU-T Z.104];
– each <variables of sort>/<exported variables of sort> that has multiple <name>/<exported variable> (respectively) items is replaced by multiple <variables of sort>/<exported variables of sort> (respectively) items each containing one <name>/<exported variable> (respectively), and each <variable definition> that has multiple <variables of sort>/<exported variables of sort> items is replaced by multiple <variable definition> items each containing one <variables of sort>/<exported variables of sort>, so that each replacement <variable definition> defines one variable;
– each <fields of sort> that has multiple <field of kind> items is replaced by multiple <fields of sort> items each containing one <field<name>, so that each <field> contains only one <field<name> (clause 12.1.6.2 of [ITU-T Z.104]);
– each <synonym definition> that has more than one <synonym definition item> is replaced by multiple <synonym definition> items each containing one <internal synonym definition item>/<external synonym definition item>;
– the local variables of compound and loop statements are expanded so that each <variable definition statement> defines one variable (clause 11.14.1 of [ITU-T Z.102]);
– multiple timer set/reset clauses in a <set>/<set statement>/<reset>/<reset statement> are replaced by multiple <set>/<set statement>/<reset>/<reset statement> items each containing one set/reset clause, and multiple timer definition items in a timer definition are replaced by multiple timer definitions (clause 11.15 of [ITU-T Z.103]);
– formal variable parameters have omitted parameter kind items set to **in** (clause 9.5 of [ITU-T Z.103]);
– procedure formal parameters are expanded so that each <formal variable parameters> defines the name of only one parameter (derived from clause 8.1.1.1 of [ITU-T Z.101]);
– add unique implicit connector name for a compound statement without a <connector name>(clause 11.14.1 of [ITU-T Z.102]);
– add unique implicit names for unnamed channels (clause 10.1 [ITU-T Z.103]).

6) Package use is transformed:

– the package Predefined is included in the <sdl specification> as in clause 7.1 of [ITU-T Z.101];
– if the same <package<identifier> occurs in multiple <package use clause> items associated with a definition, these <package use clause> items are replaced by a single <package use clause> for that <package<identifier> as in clause 7.2 *Model* of [ITU-T Z.101].

7) Transformation of:

- generic system (see clause 13 of [ITU-T Z.102]) and external data (an <external synonym definition item> – see clause 12.1.8.3 of [ITU-T Z.104], an operation defined by an <external operation definition> – see clause 12.1.7 of [ITU-T Z.104], a procedure defined by an <external procedure definition> – see clause 9.4 of [ITU-T Z.103], or <informal text> in a transition option):
- identifiers in <simple expression> items contained in the <sdl specification> are bound to definitions. During this binding, only <data definition> items defined in the predefined package Predefined and <external synonym definition> items are considered (that is, all other <data definition> items are ignored);
- <simple expression> items are evaluated and <select definition> items <transition option> items are replaced by the selected items.

8) Transformation of:

- <synonym> to a <constant expression> (see clause 12.1 of [ITU-T Z.104]);
- <basic sort> with a <range condition> (see clause 12.1 of [ITU-T Z.104]);
- non-deterministic decision (see clause 11.13.5 of [ITU-T Z.102]);
- operations involving <infix operation name>s and their operands transformed to the prefix form (see clause 12.2.1 of [ITU-T Z.104]);
- for every <operation definition> which does not have a corresponding <operation signature>, construct an <operation signature>: see clause 12.1.7 of [ITU-T Z.104];
- structure data type (<structure definition>: see clause 12.1.6.2 of [ITU-T Z.101] and clause 12.1.6.2 of [ITU-T Z.104]);
- state list (<state list>: see clause 11.2 of [ITU-T Z.103]);
- more than one <stimulus> or asterisk in an <input list> (see clause 11.3 of [ITU-T Z.103]);
- more than one <priority stimulus> or asterisk in an <priority input> (see clause 11.4 of [ITU-T Z.103]);
- more than one <save item> or asterisk in a <save list> (see clause 11.7 of [ITU-T Z.103]);
- more than one <state exit point> or asterisk in a <connect list> of a <connect part> (see clause 11.11.4 of [ITU-T Z.103]);
- field primary (see clause 12.2.3 of [ITU-T Z.101] and clause 12.2.3 of [ITU-T Z.104]);
- composite primary (for structure or array values: or clause 12.2.3 of [ITU-T Z.101]);
- the range constraint for <syntype definition>s (see clause 12.1.8.2 of [ITU-T Z.101]);
- multiple signals and multiple destinations in <output body> (see clause 11.13.4 of [ITU-T Z.103]);
- multiple timers in <set body> and <reset body> (see clause 11.15 of [ITU-T Z.103]);
- channel to channel connections replacing them with gates on the (implicit) agent type (see clause 10.2 of [ITU-T Z.103]);
- default duration value for timer set (see clause 11.15 of [ITU-T Z.101]);
- initialization of variables of sorts with default initialization (see clause 12.3.1 of [ITU-T Z.101], clause 12.3.3.2 of [ITU-T Z.101] and clause 12.3.3.2 of [ITU-T Z.104]);
- <stimulus> containing <indexed variable>s and <field variable>s are transformed (see clause 11.3 of [ITU-T Z.103]);
- replacing signallist definitions by interface definitions (see clause 12.1.2 Model of [ITU-T Z.103]);

– replacing interface gate definitions by gate definitions (see clause 8.1.4 Model of [ITU-T Z.103]);
– replacing interface identifiers from interface definitions by a list of signal identifiers (see clause 10.4 Semantics of [ITU-T Z.101]);
– indexed primary (see clause 12.2.3 of [ITU-T Z.101] and clause 12.2.3 of [ITU-T Z.104]);
– field variable (see clause 12.3.3.1 of [ITU-T Z.101]);
– indexed variable (see clause 12.3.3.1 of [ITU-T Z.101]);
– <return body> with <expression> (see clause 11.12.2.4 of [ITU-T Z.101]) ;
– <procedure call body> that calls a procedure defined outside the agent type, transformed into a call of an implicitly defined local procedure (see clause 11.13.3 of [ITU-T Z.101]);
– <value returning procedure call> containing a <procedure call body> so that an implicit procedure is added (see clause 11.13.3 of [ITU-T Z.101]);
– implicit name for state timer with an expression (rather than a set clause);
– implicitly named parameterless timer definition for state timer with an expression;
– anonymous names for choice data types defined by gate definitions for use by <as gate> (see clause 8.1.4 of [ITU-T Z.104];
– empty parameters of Make (see clause 12.1.6.2 of [ITU-T Z.101]);
– <field number> of <field primary> to a <field name> (see clause 12.2.3 of [ITU-T Z.104]);
– <as signal> of <field primary> to a <field name> (see clause 12.2.3 of [ITU-T Z.104]);
– <syntype definition data type> (see clause 12.1.8.1 of [ITU-T Z.104]).

9) Insertion of implicit channels as described in clause 10.1 of [ITU-T Z.103].

10) Insertion of implicit signal lists as described in clauses 10.5 and 10.6 of [ITU-T Z.102].

11) Handle context parameters, specialize data types and generate anonymous names
– expand list context parameters so that only one name in each list (clauses 8.3.5 to 8.3.9 and 8.3.13 of [ITU-T Z.102];
– replacement of context parameters described in clause 8.1.2 of [ITU-T Z.102] and clause 8.3 of [ITU-T Z.102];
– specialize data types as described in clause 8.4 of [ITU-T Z.102] augmented by clause 12.1.9 of [ITU-T Z.104];
– allocate anonymous type name for type expressions as in clause 8.1.2 of [ITU-T Z.102];
– allocate anonymous names for unnamed default start and unnamed return of composite state types for default entry and exits clause 11.11.2 of [ITU-T Z.102].

12) Transformation of shorthand notations <agent definition>, <agent body> and <composite state definition>:
– each <agent definition> into an <agent type definition> and a <textual typebased agent definition> as described in clause 9 of [ITU-T Z.103];
– each <agent body> of an <agent type definition> into a <composite state type definition> and a <textual typebased composite state> as described in clause 8.1.1.1 of [ITU-T Z.103];
– each <composite state definition> into a <composite state type definition> and a <typebased composite state> as described in clauses 9, 9.5 and 11.2 of [ITU-T Z.103];

– each <via path> in a resulting <composite state type definition> that is a <channel identifier> into a <gate identifier> as described 11.3 of [ITU-T Z.103].

13) Derivation of signal list for any channel path with omitted signal list:

– If an associated <signal list> is omitted from a <channel definition>, the <signal list> is replaced by a <signal list> derived from the channel connection (see clause 10.1 of [ITU-T Z.103]).

14) Full qualifiers are inserted:

– According to the visibility rules and the rules for resolution by context (see clause 6.6 of [ITU-T Z.101]), qualifiers are extended to denote the full path. This binding takes into account specialization such as: the replacement of an <anchored sort> by the <basic sort> of the **parent** base type or **this** local subsort (see clause 12.1 and 12.1.9 of [ITU-T Z.104]).

15) Transformation of asterisk state:

– A body originating from an agent definition or procedure definition has its asterisk states expanded according to the model defined in clause 11.2 of [ITU-T Z.103].

– Multiple appearance of state is merged (see clause 11.2 of [ITU-T Z.103]).

16) Transformation of global block variables:

– A block with a global variable definition (a <variable definition> as an <entity in agent> in the <agent structure> of the block/system type of the block/system) has a state machine that is interpreted concurrently with agents in the block/system. Access from contained agents in the block/system to a global variable of the block is covered by two implicitly defined remote procedures for setting and getting the data item associated with the variable. See clause 9.2 of [ITU-T Z.102].

17) Implicit declarations for remote procedures and remote variables (see clauses 10.5 and 10.6 of [ITU-T Z.102]) are generated. Imported and exported values (see clause 10.6 of [ITU-T Z.102])) are transformed. Then remote procedures (see clause 10.5 of [ITU-T Z.102])) are transformed.

NOTE – Text in [ITU-T Z.101], [ITU-T Z.102], [ITU-T Z.103] and [ITU-T Z.104] referenced above describes SDL-GR, therefore needs modifying for the equivalent SDL-PR and AS0 (for example: <agent diagram> becomes <agent definition>).

Unused items (bookmarked text)

FunctionName: defaultValue – currently not used. Should it be deleted?

FunctionName: isConstantExpression0 – replaced by a static condition in F2.2.9.9.1

FunctionName: isSameNode1 – not used – imported from F1

FunctionName: parentSortId0 – currently not used. Should it be deleted?

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