INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.806

(10/2000)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital networks – General aspects

Characteristics of transport equipment – Description methodology and generic functionality

ITU-T Recommendation G.806

(Formerly CCITT Recommendation)

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ITU-T Recommendation G.806

Characteristics of transport equipment – Description methodology and generic functionality

Summary

This Recommendation specifies the methodology, generic functionality and components that should be used in order to specify transport network functionality of network elements; it does not specify individual transport network equipment as such. It is the baseline Recommendation for other standards that specify the characteristic of equipment for specific transport networks (e.g. SDH, PDH).

Source

ITU-T Recommendation G.806 was prepared by ITU-T Study Group 15 (1997-2000) and approved by the World Telecommunication Standardization Assembly (Montreal, 27 September – 6 October, 2000).

Keywords

Atomic functions, equipment functional blocks, transport network.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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CONTENTS

Introduction

This Recommendation is the baseline document for a suite of Recommendations covering the full functionality of transport network equipment and follows the principals defined in ITU-T G.805 [11].

This Recommendation specifies a methodology to describe the characteristics of equipment for transport network. In addition it specifies generic functionality, components and overall performance objectives. The specification method is based on functional decomposition of the equipment into atomic and compound functions and a set of rules by which they may be combined. The equipment is then described by its Equipment Functional Specification (EFS) which lists the constituent atomic and compound functions, their interconnection, and any overall performance objectives (e.g. transfer delay, availability, etc.).

The characteristic of equipment for specific transport networks is described in other Recommendations of this suite (e.g. ITU-T G.783 [9], G.705 [5], G.781 [8]) based on the methodology and generic functionality and processes defined in this Recommendation.

ITU-T Recommendation G.806

Characteristics of transport equipment – Description methodology and generic functionality

1 Scope

This Recommendation specifies a methodology to describe equipment for transport networks based on the transport processing functions and architectural entities defined in ITU-T G.805 [11]. It defines the set of generic atomic and compound functions and the set of rules how to combine them. The detailed characteristic of equipment functional blocks of specific transport networks (e.g. SDH, OTN) will be defined in follow-up Recommendations based on this methodology. Equipment can then be described by an Equipment Functional Specification (EFS) which lists the atomic functions and their interconnection.

In addition generic functionality, processes and overall performance objectives for transport networks are defined in this Recommendation.

The internal structure of the implementation of this functionality (equipment design) need not be identical to the structure of the functional model, as long as all the details of the externally observable behaviour comply with the EFS.

Equipment which is normally stated to be compliant with this Recommendation may not fulfil all the requirements in the case that it is interworking with old equipment that is not compliant with this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[1] ITU-T E.862 (1992), *Dependability planning of telecommunication networks*.

[2] ITU-T G.664 (1999), *Optical safety procedures and requirements for optical transport systems*.

[3] ITU-T G.703 (1998), *Physical/electrical characteristics of hierarchical digital interfaces*.

[4] ITU-T G.704 (1998), *Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels*.

[5] ITU-T G.705 (2000), *Characteristics of Plesiochronous Digital Hierarchy (PDH) Equipment Functional Blocks*.

[6] ITU-T G.707/Y.1322 (2000), *Network node interface for the Synchronous Digital Hierarchy (SDH)*.

[7] ITU-T G.775 (1998), *Loss of signal (LOS), Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) defect detection and clearance criteria for PDH signals*.

[8] ITU-T G.781 (1999), *Synchronization layer functions*.

[9] ITU-T G.783 (2000), *Characteristics of Synchronous Digital Hierarchy (SDH) equipment functional blocks*.

[10] ITU-T G.803 (2000), *Architecture of transport networks based on the Synchronous Digital Hierarchy (SDH)*.

[11] ITU-T G.805 (2000), *Generic functional architecture of transport networks*.

[12] ITU-T G.826 (1999), *Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate*.

[13] ITU-T G.831 (2000), *Management capabilities of transport networks based on the Synchronous Digital Hierarchy (SDH)*.

[14] ITU-T G.832 (1998), *Transport of SDH elements on PDH networks – Frame and multiplexing structure*.

[15] ITU-T G.911 (1997), *Parameters and calculation methodologies for reliability and availability of fibre optic systems*.

[16] ITU-T G.784 (1999), *Synchronous Digital Hierarchy (SDH) management*.

[17] ITU-T M.20 (1992), *Maintenance philosophy for telecommunication networks*.

3 Terms and definitions

This Recommendation defines the following terms:

3.1 Access Point (AP): See ITU-T G.805 [11].

3.2 Access Point Identifier (API): See ITU-T G.831 [13].

3.3 Adaptation function (A): An atomic function that performs the adaptation between client and server layer network.

3.4 Adapted Information (AI): The information passing across an AP. See also ITU-T G.805 [11].

3.5 Alarm: A human observable indication that draws attention to a failure (detected fault) usually giving an indication of the severity of the fault.

3.6 All-ONEs: The entire capacity of the adapted or characteristic information is set to logic "1".

3.7 Anomaly: The smallest discrepancy which can be observed between the actual and desired characteristics of an item. The occurrence of a single anomaly does not constitute an interruption in the ability to perform a required function. Anomalies are used as the input for the Performance Monitoring (PM) process and for the detection of defects.

3.8 Atomic function: A function that if divided into simpler functions would cease to be uniquely defined for digital transmission hierarchies. It is therefore indivisible from a network point of view.

3.9 Automatic Laser Shutdown (ALS): See ITU-T G.664 [2].

3.10 Automatic Power Shutdown (APSD): See ITU-T G.664 [2].

3.11 Bidirectional trail/connection type: A two-way trail/connection through a transport network.

3.12 Broadcast connection type: An input CP is connected to more than one output CP.

3.13 Characteristic Information (CI): The information passing across a CP or TCP. See also ITU-T G.805 [11].

3.14 Client/server layer: Any two adjacent network layers are associated in a client/server relationship. Each transport network layer provides transport to the layer above and uses transport from the layers below. The layer providing transport is termed a server; the layer using transport is termed client.

3.15 Connection: See ITU-T G.805 [11].

3.16 Connection function (C): An atomic function within a layer, which, if connectivity exists, relays a collection of items of information between groups of atomic functions. It does not modify the members of this collection of items of information although it may terminate any switching protocol information and act upon it. Any connectivity restrictions between inputs and outputs shall be stated.

3.17 Connection Matrix (CM): A connection matrix is a matrix of appropriate dimensions which describes the connection pattern for assigning VC-ns on one side of an LPC or HPC function to VC-n capacities on the other side and vice versa.

3.18 Connection Point (CP): A reference point where the output of a trail termination source or a connection is bound to the input of another connection, or where the output of a connection is bound to the input of a trail termination sink or another connection.

3.19 Consolidation: The allocation of server layer trails to client layer connections which ensures that each server layer trail is full before the next is allocated. Consolidation minimizes the number of partially filled server layer trails. It therefore maximizes the fill factor (e.g. a number of partially filled VC-4 paths may be consolidated into a single, fully filled VC-4).

3.20 Compound function: A function that represents a collection of atomic functions within one or more layer(s).

3.21 Defect: The density of anomalies has reached a level where the ability to perform a required function has been interrupted. Defects are used as input for PM, the control of consequent actions, and the determination of fault cause.

3.22 Failure: The fault cause persisted long enough to consider the ability of an item to perform a required function to be terminated. The item may be considered as failed; a fault has now been detected.

3.23 Fault: A fault is the inability of a function to perform a required action. This does not include an inability due to preventive maintenance, lack of external resources, or planned actions.

3.24 Fault cause: A single disturbance or fault may lead to the detection of multiple defects. A fault cause is the result of a correlation process which is intended to identify the defect that is representative of the disturbance or fault that is causing the problem.

3.25 Function: A process defined for digital transmission hierarchies (e.g. PDH, SDH) which acts on a collection of input information to produce a collection of output information. A function is distinguished by the way in which characteristics of the collection of output information differ from the collection of input information.

3.26 Grooming: The allocation of server layer trails to client layer connections which groups together client layer connections whose characteristics are similar or related (e.g. it is possible to groom VC-12 paths by service type, by destination, or by protection category into particular VC-4 paths which can then be managed accordingly).

3.27 Layer Network: See ITU-T G.805 [11].

3.28 Layer Network Interworking Function: An atomic function that provides interworking of characteristic information between two layer networks.

3.29 Management Information (MI): The signal passing across an access point.

3.30 Management Point (MP): A reference point where the output of an atomic function is bound to the input of the element management function, or where the output of the element management function is bound to the input of an atomic function. The MP is not the TMN Q3 interface.

3.31 Network Connection (NC): See ITU-T G.805 [11].

3.32 Path: A trail in a path layer.

3.33 Process: A generic term for an action or a collection of actions.

3.34 Reference point: The delimiter of a function.

3.35 Remote Defect Indication (RDI): A signal that conveys the defect status of the characteristic information received by the Trail Termination sink function back to the network element which originated the characteristic information.

3.36 Remote Error Indication (REI): A signal which conveys either the exact or truncated number of error detection code violations of the characteristic information as detected by the trail termination sink function back to the network element which originated the characteristic information.

3.37 Remote Information (RI): The information passing across a RP; e.g. RDI and REI.

3.38 Remote Point (RP): A reference point where the output of a trail termination sink function of a bidirectional trail termination is bound to the input of its trail termination source function, for the purpose of conveying information to the remote end.

3.39 Section: A trail in a section layer.

3.40 Server Signal Degrade (SSD): A signal degrade indication output at the CP of an adaptation function.

3.41 Server Signal Fail (SSF): A signal fail indication output at the CP of an adaptation function.

3.42 Signal Degrade (SD): A signal indicating the associated data has degraded in the sense that a degraded defect (dDEG) condition is active.

3.43 Signal Fail (SF): A signal indicating the associated data has failed in the sense that a near-end defect condition (not being the degraded defect) is active.

3.44 Sub-Network Connection (SNC): See ITU-T G.805 [11].

3.45 Termination Connection Point (TCP): A special case of a connection point where a trail termination function is bound to an adaptation function or a connection function. In the information model the termination connection point is called Trail Termination Point (TTP).

3.46 Timing Information (TI): The information passing across a TP.

3.47 Timing Point (TP): A reference point where an output of the synchronization distribution layer is bound to the input of an adaptation source or connection function, or where the output of an adaptation sink function is bound to an input of the synchronization distribution layer.

3.48 Trail: See ITU-T G.805 [11].

3.49 Trail Signal Degrade (TSD): A signal degrade indication output at the AP of a termination function.

3.50 Trail Signal Fail (TSF): A signal fail indication output at the AP of a termination function.

3.51 Trail termination function (TT): An atomic function within a layer that generates, adds, and monitors information concerning the integrity and supervision of adapted information.

3.52 Transit Delay: Transit delay is defined as the period of time taken for an information bit arriving at a NE input port to reappear at an output port on the same NE via a defect free trail.

3.53 Undefined bit: If a bit is undefined, its value is set to a logical "0" or a logical "1". See regional standards for further specifications of the value of undefined bits.

3.54 Undefined byte: If a byte is undefined, it contains eight undefined bits.

3.55 Unidirectional trail/connection type: A one-way trail/connection through a transport network.

4 Abbreviations

This Recommendation uses the following abbreviations:

A	Adaptation function
AcSL	Accepted Signal Label
AcTI	Accepted Trace Identifier
AI	Adapted Information
AIS	Alarm Indication Signal
ALS	Automatic Laser Shutdown
AP	Access Point
API	Access Point Identifier
APSD	Automatic Power ShutDown
AU	Administrative Unit
AU-n	Administrative Unit, level n
BER	Bit Error Ratio
BIP	Bit Interleaved Parity
C	Connection function
CI	Characteristic Information
CK	Clock
CM	Connection Matrix
CP	Connection Point
CRC	Cyclic Redundancy Check
CRC-n	Cyclic Redundancy Check, width n
D	Data
DCC	Data Communications Channel
DEG	Degraded
DEGTHR	Degraded Threshold
DS	Defect Second
EBC	Errored Block Count
EDC	Error Detection Code
EDCV	Error Detection Code Violation
EMF	Equipment Management Function
EQ	Equipment
Eq	PDH Electrical signal, bit rate order q
ES	Electrical Section
ES1	Electrical Section, level 1
ES	Errored Second
ExSL	Expected Signal Label

ExtCmd	External Command
ExTI	Expected Trace Identifier
F_B	Far-end Block
F_DS	Far-end Defect Second
F_EBC	Far-end Errored Block Count
FAS	Frame Alignment Signal
FIT	Failure In Time
FM	Fault Management
FOP	Failure Of Protocol
HO	Higher Order
I	layer network Interworking function
ID	Identifier
IEC	Incoming Error Count
IF	In Frame state
IM	In Multiframe state
LC	Link Connection
LO	Lower Order
LOA	Loss Of Alignment; generic for LOF, LOM, LOP
LOF	Loss Of Frame
LOM	Loss Of Multiframe
LOP	Loss Of Pointer
LOS	Loss Of Signal
MI	Management Information
MON	Monitored
MP	Management Point
MS	Multiplex Section
MSB	Most Significant Bit
MSn	Multiplex Section layer, level n
MSnP	Multiplex Section trail Protection layer, level n
MSOH	Multiplex Section OverHead
MTBF	Mean Time Between Failures
N_B	Near-end Block
N_DS	Near-end Defect Second
N_EBC	Near-end Errored Block Count
NE	Network Element
NMON	Not Monitored
NNI	Network Node Interface
OAM	Operation, Administration and Maintenance
OOF	Out Of Frame state
OOM	Out Of Multiframe state
OS	Optical Section
OS	Operation System
OSn	Optical Section layer, level n
P0x	64 kbit/s layer (transparent)
P11x	1544 kbit/s layer (transparent)
P12s	2048 kbit/s PDH path layer with synchronous 125 μs frame structure

P12x	2048 kbit/s layer (transparent)
P21x	6312 kbit/s layer (transparent)
P22e	8448 kbit/s PDH path layer with 4 plesiochronous 2048 kbit/s
P22x	8448 kbit/s layer (transparent)
P31e	34 368 kbit/s PDH path layer with 4 plesiochronous 8448 kbit/s
P31s	34 368 kbit/s PDH path layer with synchronous 125 μs frame structure
P31x	34 368 kbit/s layer (transparent)
P32x	44 736 kbit/s layer (transparent)
P4a	139 264 kbit/s PDH path layer with 3 plesiochronous 44 736 kbit/s
P4e	139 264 kbit/s PDH path layer with 4 plesiochronous 34 368 kbit/s
P4s	139 264 kbit/s PDH path layer with synchronous 125 μs frame structure
P4x	139 264 kbit/s layer (transparent)
PDH	Plesiochronous Digital Hierarchy
PLM	PayLoad Mismatch
PM	Performance Monitoring
POH	Path OverHead
Pq	PDH path layer, bit rate order q
PTR	Pointer
RDI	Remote Defect Indication
REI	Remote Error Indication
RI	Remote Information
RP	Remote Point
RS	Regenerator Section
RSn	Regenerator Section layer, level n
RSOH	Regenerator Section OverHead
RxSL	Received Signal Label
RxTI	Received Trace Identifier
S11	VC-11 path layer
S11D	VC-11 tandem connection sublayer
S11P	VC-11 path protection sublayer
S12	VC-12 path layer
S12D	VC-12 tandem connection sublayer
S12P	VC-12 path protection sublayer
S2	VC-2 path layer
S2D	VC-2 tandem connection sublayer
S2P	VC-2 path protection sublayer
S3	VC-3 path layer
S3D	VC-3 tandem connection sublayer using TCM option 2
S3P	VC-3 path protection sublayer
S3T	VC-3 tandem connection sublayer using TCM option 1
S4	VC-4 path layer
S4D	VC-4 tandem connection sublayer using TCM option 2
S4P	VC-4 path protection sublayer
S4T	VC-4 tandem connection sublayer using TCM option 1
SD	Signal Degrade
SDH	Synchronous Digital Hierarchy

SF	Signal Fail
Sk	Sink
Sn	Higher Order VC-n layer
SNC	Sub-Network Connection
SNC/I	Inherently monitored Sub-Network Connection protection
SNC/N	Non-intrusively monitored Sub-Network Connection protection
SNC/S	Sublayer (tandem connection) monitored Sub-Network Connection protection
So	Source
SOH	Section OverHead
SSD	Server Signal Degrade
SSF	Server Signal Fail
STM	Synchronous Transport Module
TCM	Tandem Connection Monitor
TCP	Termination Connection Point
TDM	Time Division Multiplexing
TF	Transmit Fail
TFAS	trail Trace identifier Frame Alignment Signal
TI	Timing Information
TIM	Trace Identifier Mismatch
TP	Timing Point
TPmode	Termination Point mode
TS	Time Slot
TSD	Trail Signal Degrade
TSF	Trail Signal Fail
TSL	Trail Signal Label
TT	Trail Termination function
TTI	Trail Trace Identifier
TTP	Trail Termination Point
TU	Tributary Unit
TUG	Tributary Unit Group
TU-m	Tributary Unit, level m
TxSL	Transmitted Signal Label
TxTI	Transmitted Trace Identifier
UNEQ	UNEQuipped
VC	Virtual Container
VC-n	Virtual Container, level n
WDM	Wavelength Division Multiplexing

5 Methodology

5.1 Basic methodology

The methodology to describe transport network functionality of network elements is based on the generic functional architecture of transport networks, the architectural entities and transport processing functions defined in ITU-T G.805 [11].

The functionality of transport processing functions within network elements is represented by atomic functions for each layer of the transport network and a set of combination rules for these functions. The basic set of atomic functions of a layer is shown in Figure 5-1 and consists of:

– Trail termination function.

– Adaptation function.

– Connection functions.

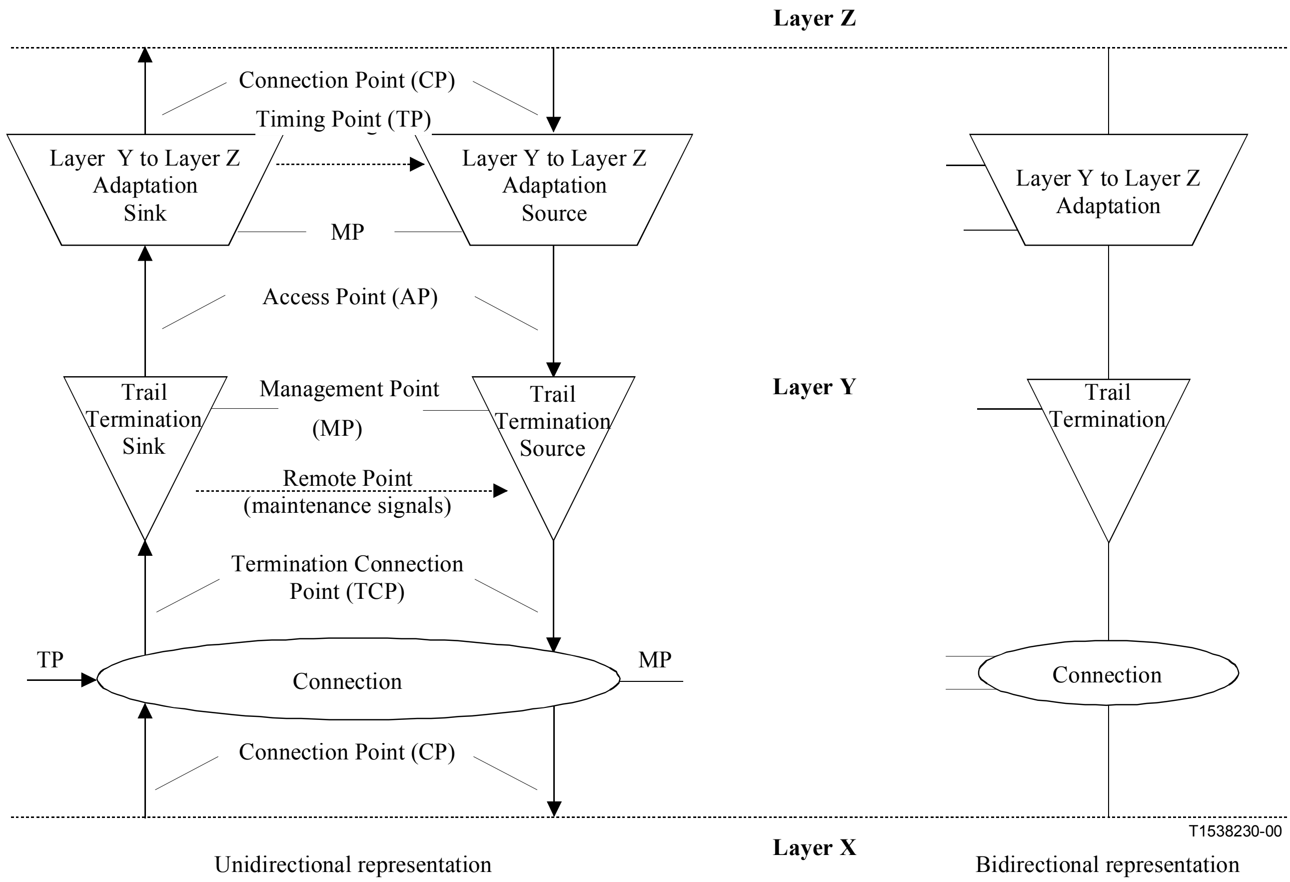


Figure 5-1/G.806 – Atomic functions and reference points

The interworking atomic function shown in Figure 5-2 is used for the special application of interworking between two network layers with similarly characteristic information.

An atomic function is described by the processes within the function, its reference points and the information flow via these reference points.

Within a network element transport processing functions may interact with equipment management functions (EMF) for fault, performance and configuration management. For the SDH equipment management functionality see ITU-T G.784 [16].

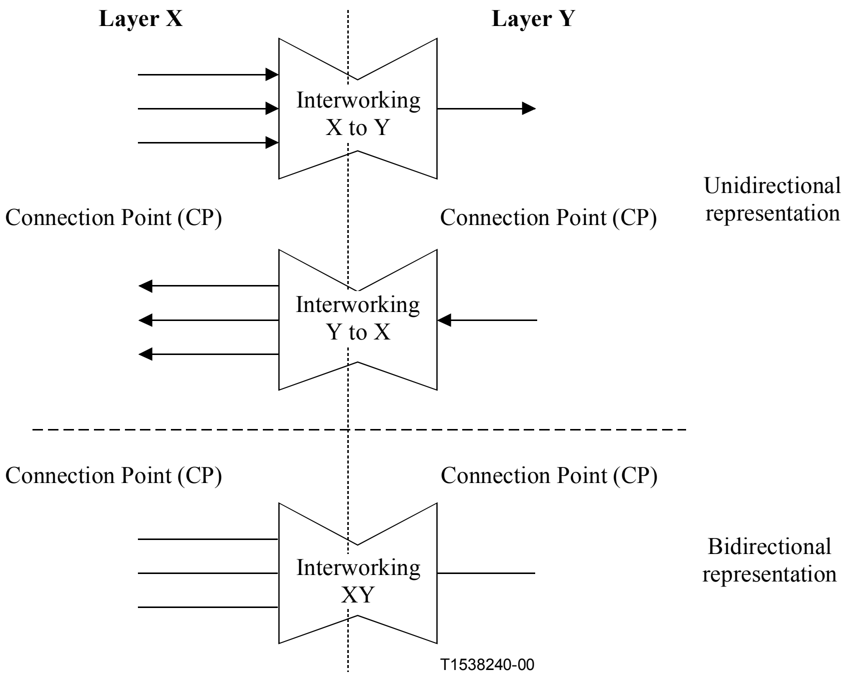


Figure 5-2/G.806 – Layer network interworking function

An atomic function may have several transmission reference points as input or output as shown in Figure 5-2.

5.2 Transmission layer naming

In order to identify the numerous transmission layers of the transport network hierarchies a specific naming scheme is defined. The naming scheme consists of:

– one or more letters to identify the hierarchy and/or if necessary a specific layer type;

– a number or a number/letter combination that indicates the hierarchy level;

– one or more letters for further details on layer, sublayer or specific frame structure.

Table 1-1 shows the currently defined layer names.

Table 1-1/G.806 – Transmission layers

Name	Layer	Defined in
OSn	STM-n Optical Section	ITU-T G.783 [9]
ES1	STM-1 Electrical Section	ITU-T G.783 [9]
RSn	STM-n Regenerator Section	ITU-T G.783 [9]
MSn	STM-n Multiplex Section	ITU-T G.783 [9]
MSnP	STM-n Multiplex Section Protection sublayer	ITU-T G.783 [9]
Sn	SDH VC-n path layer	ITU-T G.783 [9]
SnP	SDH VC-n trail protection sublayer	ITU-T G.783 [9]
SnD	SDH VC-n TCM option 2 sublayer	ITU-T G.783 [9]
SnT	SDH VC-n TCM option 1 sublayer	ITU-T G.783 [9]
Eq	PDH Electrical Section	ITU-T G.705 [5]
Pqe	Plesiochronous framed PDH layer	ITU-T G.705 [5]
Pqs	Synchronous framed PDH layer	ITU-T G.705 [5]
Pqx	Unframed PDH layer	ITU-T G.705 [5]
NS	Network Synchronization layer	ITU-T G.781 [8]
SD	Synchronization Distribution layer	ITU-T G.781 [8]

5.3 Atomic function naming and diagrammatic conventions

The naming of adaptation, trail termination and connection functions follow the following rules:

Adaptation function <layer>/<client layer>_A[_<direction>]

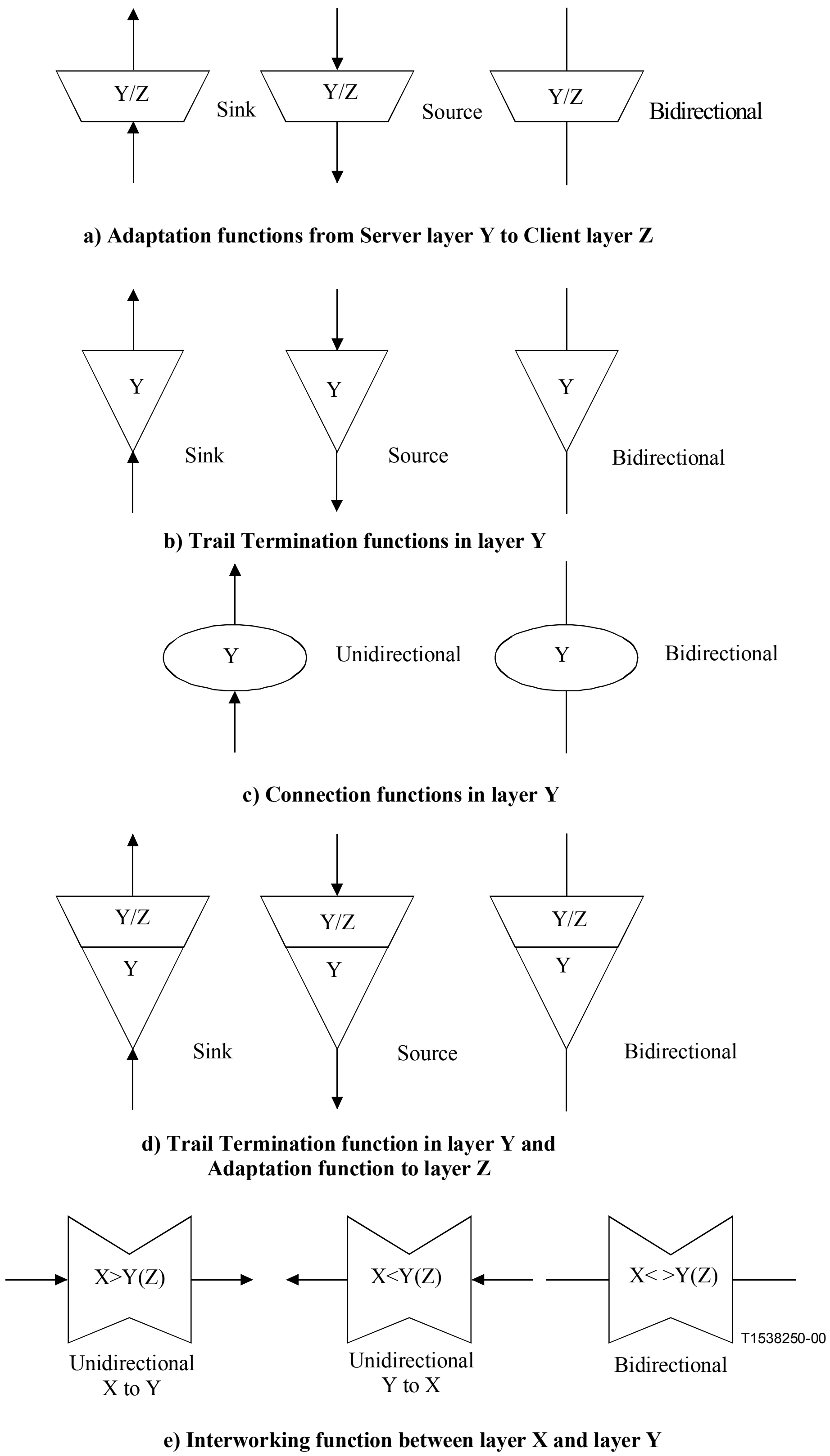
Trail Termination function <layer>_TT[_<direction>]

Connection function <layer>_C

Layer network interworking function <layer>[<>/>/<]<layer>[(set of accepted client layers X)]_I

Examples are: MS1/S4_A, S12/P12s_A_So, S4_TT, RS16_TT_Sk, S3_C.

The diagrammatic conventions and nomenclature for adaptation, termination and connection functions (used to describe the atomic functions) are shown in Figure 5-3.



NOTE 1 – If the above symbols are used for generic figures, i.e. not for specific layers, the layer references Y and Z may be omitted. Alternatively, the references may be to the type of function or layer, e.g. supervision, protection.

NOTE 2 – The order of the layers in the name of an interworking function can be changed (e.g. X>Y is identical to Y<X).

Figure 5-3/G.806 – Symbols and diagrammatic conventions

As an example of the use of this diagrammatic nomenclature, Figure 5-4 shows a unidirectional VC-4 path in an SDH network.

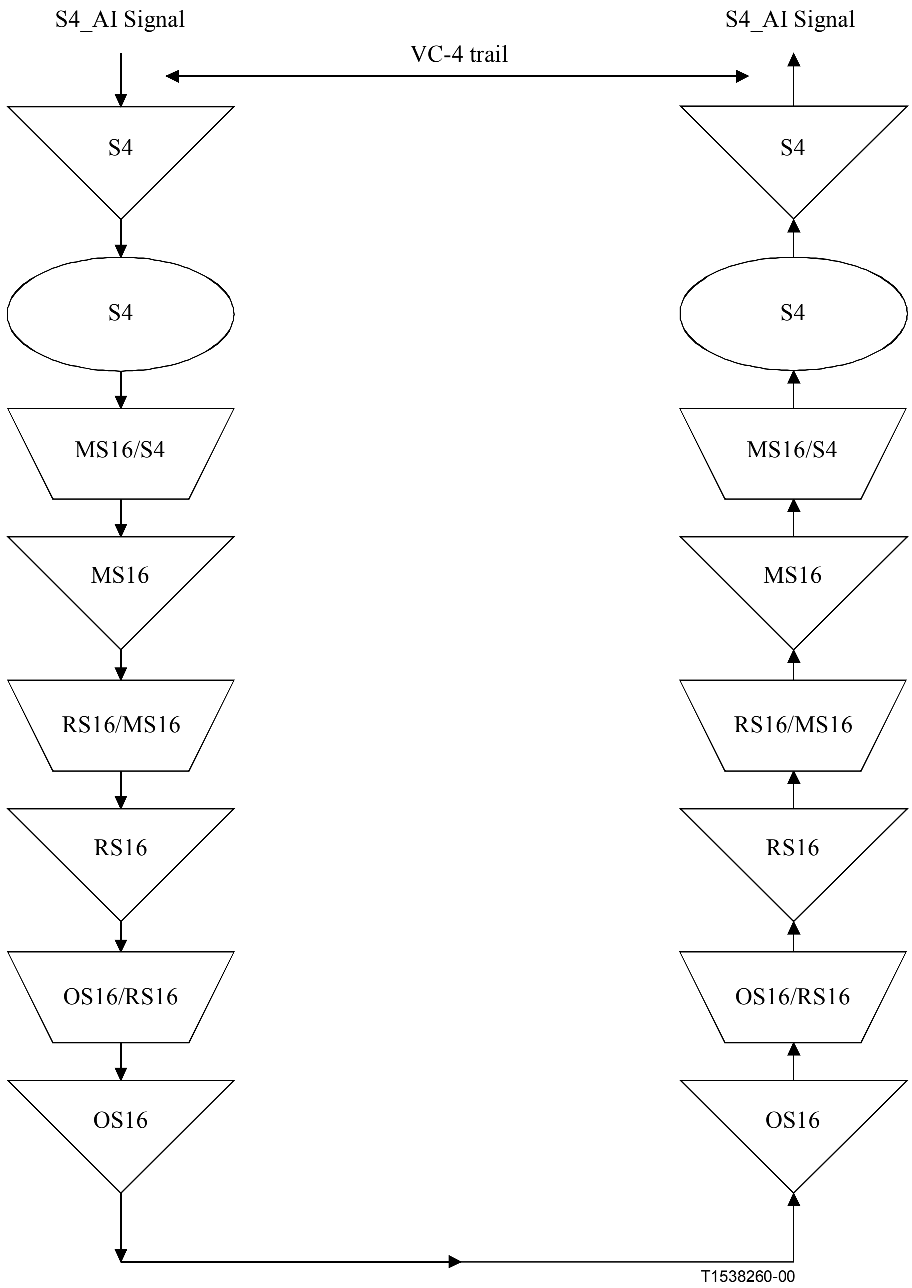


Figure 5-4/G.806 – Example of a unidirectional VC-4 path in an SDH network

As an example of the use of this diagrammatic nomenclature, Figure 5-5 shows an example of a transport level fragment of an Equipment Functional Specification (EFS).

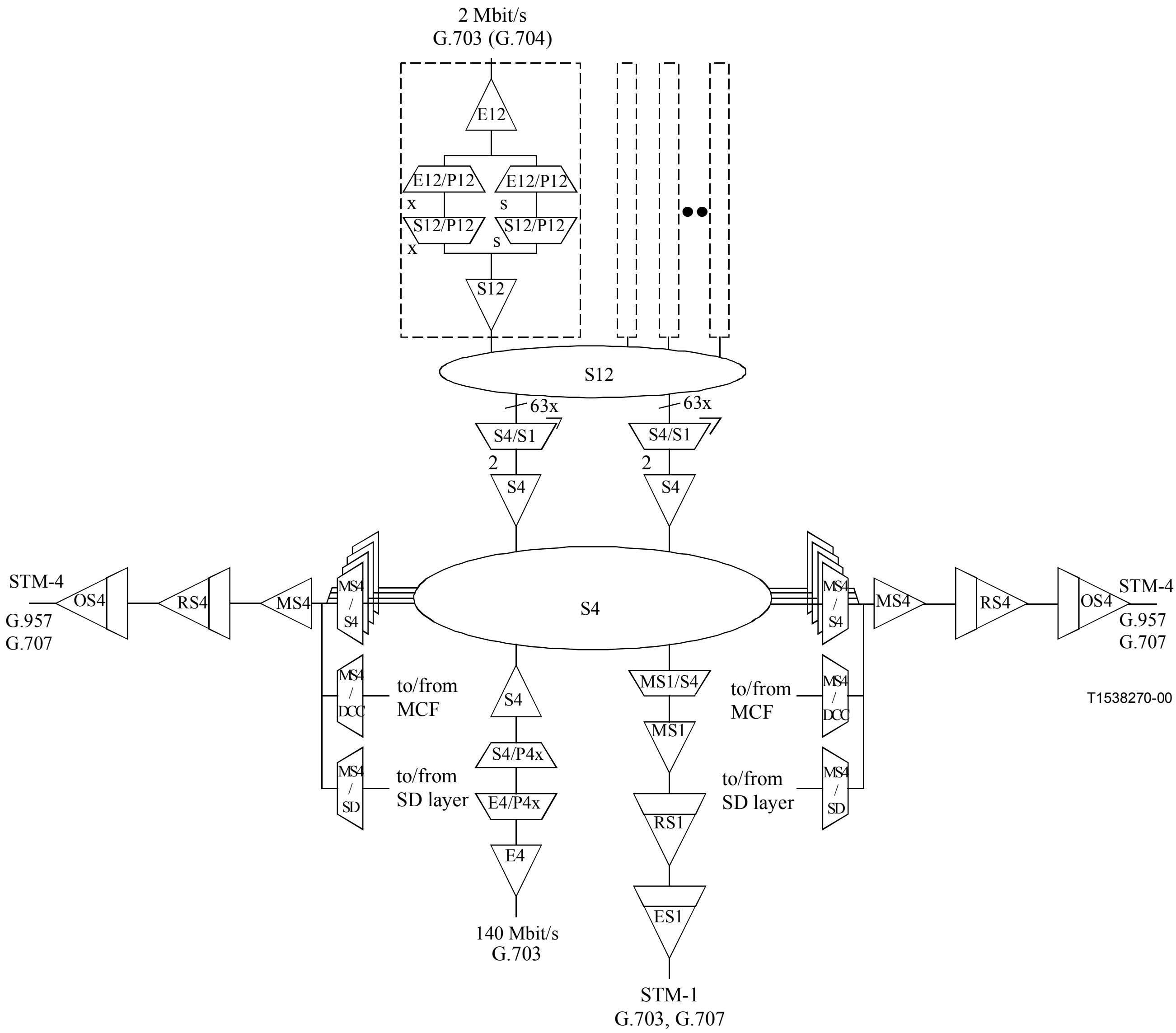


Figure 5-5/G.806 – Example of an SDH equipment functional specification

The equipment represented by the EFS supports the following interfaces: two optical STM-4, one electrical STM-1, one 140 Mbit/s, a number of 2 Mbit/s.

The STM-4 interfaces contain the MS-DCC signal and SSM signal. The STM-4 interfaces can contribute to the synchronization reference selection process in synchronization layers.

NOTE 1 – RS-DCC, RS-USER, RS-OW and MS-OW signals are not supported by the STM-4 interfaces.

NOTE 2 – RS-DCC, RS-USER, RS-OW, MS-DCC, MS-OW and contribution to the synchronization reference selection process are not supported by the STM-1 interface. SSM is not supported on the output STM-1 signal.

The 140 Mbit/s signal is asynchronous mapped into a VC-4.

NOTE 3 – VC4-USER signals are not supported by the VC-4 processing.

The 2 Mbit/s signal is either asynchronous or byte synchronous mapped into the VC-12.

The VC-4 matrix contains twelve inputs and outputs: three towards a VC-4 termination function and the other nine to MSn to VC-4 adaptation functions.

NOTE 4 – Connectivity restrictions related to the VC-4 connection function are not represented in this presentation of the EFS. If applicable, connectivity restrictions can be presented in a further decomposed connection function representation, or by means of connectivity tables as shown in Appendix II.

NOTE 5 – The VC-4 connection function can support SNC protection switching. Such can be represented by means of a "rounded box" around the ellipse, as defined in ITU-T G.803 [10].

Two VC-4 signals can be terminated when they contain a TUG structure with sixty-three TU-12s. The resulting one hundred and twenty-six VC-12 signals are connected to the VC-12 connection function that is also connected to a number of VC-12 termination functions.

NOTE 6 – Connectivity restrictions related to the VC-12 connection function are not represented in this presentation of the EFS. If applicable, connectivity restrictions can be presented in a further decomposed connection function representation, or by means of connectivity tables as shown in Appendix II.

NOTE 7 – The VC-12 connection function can support SNC protection switching. Such can be represented by means of a "rounded box" around the ellipse, as defined in ITU-T G.803 [10].

Examples of possible connectivity are:

– a VC-4 from an STM-4 interface can be passed through to the other STM-4 interface, with or without timeslot interchange;
– a VC-4 from an STM-4 interface can be passed through (or dropped) to the STM-1 interface;
– a VC-4 from an STM-4 interface can be terminated, making the 140 Mbit/s payload available at the 140 Mbit/s interface;
– a VC-4 from an STM-4 interface can be terminated, making the TUG payload accessible for further processing;
– a VC-12 from an STM-4 interface can be passed through to the other STM-4 interface, with or without timeslot interchange between the VC-4 server signals;
– a VC-12 from an STM-4 or the STM-1 interface can be terminated (after VC-4 termination), making the 2 Mbit/s payload available at a 2 Mbit/s interface. Either asynchronous or byte synchronous mapping into the VC-12 is supported;
– a VC-12 from an STM-4 interface can be passed through (dropped) to the STM-1 interface (after VC-4 termination), with or without timeslot interchange between the VC-4 server signals;
– VC-4 SNC/I protection could be supported between, for example, two VC-4s within the two STM-4 signals, or between a VC-4 within an STM-4 signal and the VC-4 in the STM-1 signal;
– VC-12 SNC/I protection could be supported between two VC-12s within the two TUG structured terminated VC-4 signals. These two VC-4 signals can come from the two STM-4 signals or one STM-4 signal and the STM-1 signal.

5.4 Reference point naming

The atomic functions are defined between fixed reference points at which defined information is assumed to be present. That is, at a given reference point, specific types of information can always be assumed to be present. There are several different types of reference points within the functional model, including reference points for:

– Transmission signals;
– Management information;
– Timing references;
– Remote information.

5.4.1 Transmission reference points

Because they are so numerous and their detailed characteristics are so important to the functional model, transmission reference points are designated with a more complex naming convention. A transmission reference point name is formed by a transmission layer designation, followed by an underscore character, followed by either AP or CP, depending on whether that reference point is an Access Point (AP) or a Connection Point (CP). As described in ITU-T G.805 [11], the information at an Access Point is a signal into which the client signal(s) have been mapped, but which does not include the full complement of overhead information for the given layer. The information at a Connection Point is a signal that includes the full complement of overhead information. The Access Point is at the server side of Adaptation functions and the client side of Termination functions. The Connection Point is at the client side of Adaptation functions and the server side of Termination functions (Figure 5-1). Thus, a transmission reference point name is formed according to the syntax:

<TransmissionReferencePointName> = <LayerName>_<AP or CP>

5.4.2 Management reference points

Management reference points are also quite numerous and are therefore named directly after the name of the associated function according to the syntax:

<ManagementReferencePointName> = <FunctionName>_MP

Thus, for example, the management reference point for the OS_TT function is named OS_TT_MP.

5.4.3 Timing reference points

Timing reference points are named directly after the name of the associated layer according to the syntax:

<TimingReferencePointName> = <LayerName>_TP

Thus, for example, the timing reference point for the VC-4 layer is named S4_TP.

5.4.4 Remote reference points

Remote reference points are named directly after the name of the associated function layer to the syntax:

<RemoteReferencePointName> = <LayerName>_RP

Thus, for example, the remote reference point for the VC-12 layer is named S12_RP.

5.5 Reference point information naming

The information passing a CP is called Characteristic Information (CI), the information passing an AP is called Adapted Information (AI), the information passing an MP is called Management Information (MI) and the information passing a TP is called Timing Information (TI).

5.5.1 Transmission reference point information naming

The coding of the Characteristic Information (**CI**) and Adapted Information (**AI**) in the model follows the following rules:

<layer>_<information type>_<signal type>[/<number>].

[...]	optional term
<layer>	represents one of the layer names (e.g. RS1)
<information type>	CI or AI
<signal type>	CK (clock), or D (data), or FS (Frame Start), or SSF (Server Signal Fail), or TSF (Trail Signal Fail) SSD (Server Signal Degrade) TSD (Trail Signal Degrade)
<number>	indication of multiplex/inverse multiplex number; e.g. (1,1,1) for the case of a TU-12 within a VC-4.

AI and CI coding examples are: MS1_CI_D, RS16_AI_CK, P12x_AI_D, S2_AI_So_D(2,3,0).

Within the network each access point is uniquely identified by means of its Access Point Identifier (**API**). See ITU-T G.831 [13]. The Termination Connection Point (TCP) − see Figure 5-1 − can be uniquely identified by means of the same **API**. The Connection Point (CP) − see Figure 5-1 − can be uniquely identified by the **API** extended with the multiplex number, e.g. the AU or TU number.

Example: a VC12 CP (S12_CP) can be identified by means of the **API** of the S4_AP, extended with the TU12 TUG number (K,L,M).

5.5.2 Management reference point information naming

The coding of the **MI** signals follows the following rule:

<atomic function>_MI_<MI signal type>

5.5.3 Timing reference point information naming

The coding of the **TI** signals follows the following rule:

<layer>_TI_<TI signal type: CK or FS>

5.5.4 Remote reference point information naming

The coding of the RI signals follows the following rule:

<layer>_RI_<RI signal type: RDI, REI, ODI, or OEI>

5.6 Atomic function process allocation

5.6.1 Connection function

The connection function provides flexibility within a layer. It may be used by the network operator to provide routing, grooming, protection and restoration.

The model describes the connection function as a space switch that provides connectivity between its inputs and outputs. Connections might be set up or turned down based on management commands via the MI interface and/or based on signal fail/degrade states of the incoming signal itself (e.g. protection switch).

The connectivity between inputs and outputs of the connection function might be limited due to implementation constraints. Several examples are given in Appendix I.

NOTE – The connection function's flexibility process is modelled as a timing transparent switch, also referred to as "space switch". In case of time division multiplexing the switch matrix type may be either a "space switch" or a combination of "space and time switches". If a time switch is involved the adaptation source functionality that performs the alignment to a common time base (Clock) shall be located at the input of the switch matrix (connection function) rather than at the output (as in the functional model).

For the case of SDH, the location of the adaptation source functionality (i.e. Elastic Store and Pointer Generator) with respect to the connection functionality (i.e. switch matrix) is observable at the STM-N interface when the matrix connection is changed (e.g. due to SNC protection switch). A pointer with "enabled NDF" is generated when the adaptation source functionality is located at the output of the connection functionality. A pointer without "enabled NDF" is generated when the adaptation source functionality is located at the input of the connection functionality.

5.6.2 Trail termination function

The Trail Termination function performs the signal integrity supervision of the layer. This includes:

– connectivity supervision;
– continuity supervision;
– signal quality supervision;
– processing of maintenance information (forward/backward indications).

In the source direction it generates and adds some or all of the following:

– error detection code or forward error indication [e.g. Bit Interleaved Parity (BIP), Cyclic Redundancy Check (CRC), incoming error count];
– trail trace identifier (i.e. source address).

It conveys back the following remote information:

– remote error indicator signal (e.g. REI, OEI, E-bit), containing the number of detected error detection code violations in the received signal;
– remote defect indicator signal (e.g. RDI, ODI, A-bit), representing the defect status of the received signal.

In the sink direction, it monitors for some or all of the following:

– signal quality (e.g. bit errors);
– (mis-)connection;
– near-end performance;
– far-end performance;
– server signal fail [i.e. Alarm Indication Signal (AIS) instead of data];
– signal loss (disconnection, idle signal, unequipped signal).

NOTE – Functionality is reduced in the physical section layer termination functions, which can only monitor the signal loss. The physical section termination source function performs, in addition, logical/optical or logical/electrical conversion. The physical section termination sink function performs, in addition, optical/logical or electrical/logical conversion.

Bit errors are detectable via line code violations, parity violations or CRC violations, i.e. error detection code violations.

To monitor the provisioning of flexibility within a network, Access Points (AP) will be identified (named/numbered). The **API** is inserted in the signal by the Trail Termination source function, in the Trail Trace Identifier (TTI). The Trail Termination sink function checks the received name/number with the expected one (provisioned by the network manager).

To enable single ended maintenance, the defect status and number of error detection code violations detected at the sink trail termination are conveyed back to the source trail termination; the defect status via the Remote Defect Indicator (RDI) signal and the number of error detection code violations via the Remote Error Indicator (REI) signal. The RDI and REI signals are part of the trail overhead.

Degradation of the signal results in the detection of anomalies and defects. As a consequent action of the detection of certain near-end defects, the signal is replaced by the all-ONEs (AIS) signal and RDI is inserted in the return direction. The defects are reported to the fault management process.

The number of near-end block errors[1] per second is counted. The number of far-end block errors[2] per second is counted. A second is indicated as a near-end defect second in cases where a signal fail condition was detected in that second. A second is indicated as a far-end defect second in cases where an RDI defect was detected in that second.

Refer to the anomaly process description (see clause 6) for detailed descriptions.

5.6.3 Adaptation function

An adaptation function represents the conversion process between server and client layers. One or more of the following processes may be present in an adaptation function:

– scrambling/descrambling;
– encoding/decoding;
– alignment (framing, pointer interpretation, FAS/PTR generation);
– bit rate adaptation;
– frequency justification;
– time slot/wavelength assignment/access;
– multiplexing/demultiplexing;
– timing recovery;
– smoothing;
– payload type identification;
– payload composition selection.

A server layer may provide transport for several client layer signals in parallel (e.g. n VC-4 in an STM-n signal), which is referred to as multiplexing. These client layer signals could be of different layer network types (e.g. a mixture of VC-11/12/2/3 within a VC-4, DCCM, EOW, VC-4s in an STM-N multiplex section). According to ITU-T G.805 [11] this is represented in the functional model by one adaptation function that includes specific processes for each client layer signal. In addition common processes for all or a set of client signals could be part of the adaptation function. For the equipment functional specification a different approach is used which provides more flexibility. An adaptation function is defined for each client/server combination. This adaptation function performs the specific processing for this client/server relationship including the time slot/wavelength assignment/access required for the multiplexing/demultiplexing. The individual adaptation functions are then connected to one AP as shown in Figure 5-6 a). This can be viewed in source direction as each adaptation functions sending its AI on different time slots/wavelengths and the AP just combines this information. In sink direction the full AI is distributed to all adaptation functions and each accesses only its specific time slot/wavelength.

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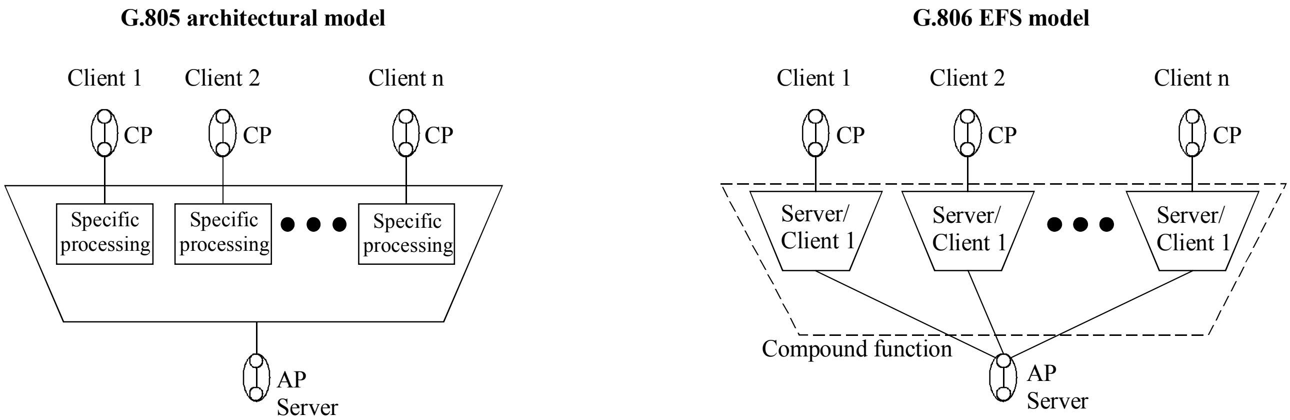
[1] Detected by means of error detection code violation monitoring.

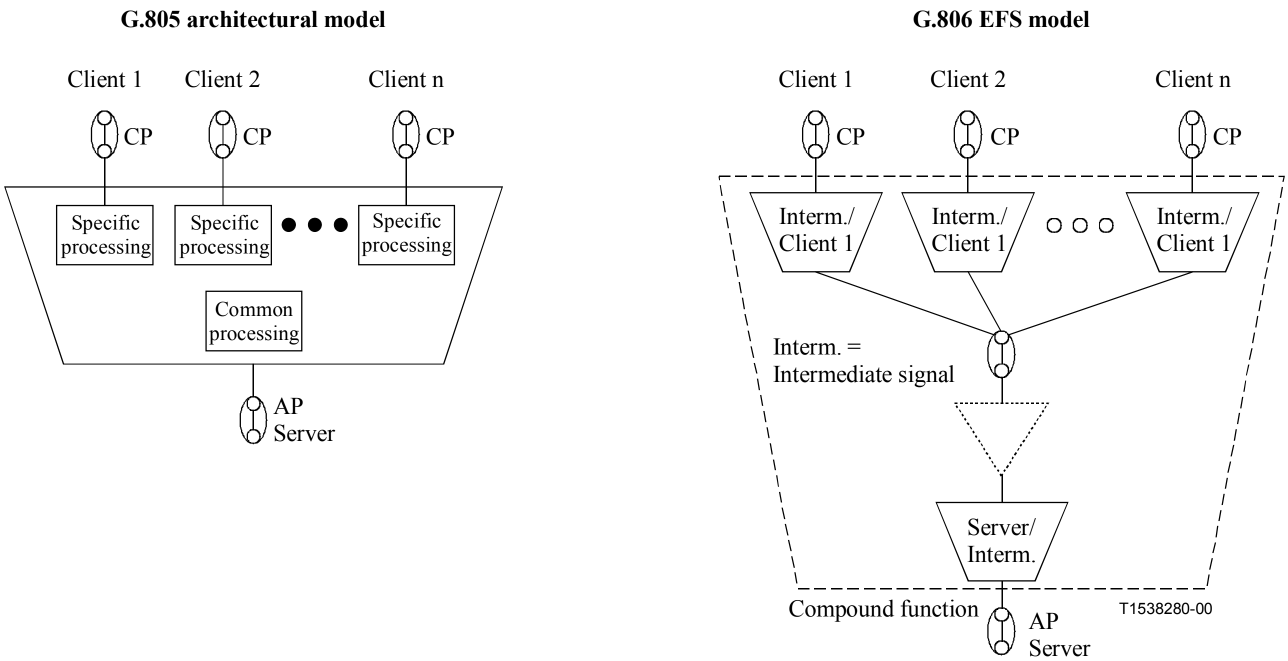
[2] Received via REI.

In case of common processes an intermediate signal is defined between the specific and common processes. The specific adaptation functions are between the client and the intermediate signal and the common adaptation functions are between the server and the intermediate signal as shown in Figure 5-6 b). The dotted trail termination function might be used due to historical reasons when a sublayer approach was used for this kind of modelling.

Note that the individual adaptation functions could be combined into a compound function as defined in 5.7.7.



a) Multiple clients without common processing



b) Multiple clients with common processing

Figure 5-6/G.806 – Comparison with ITU-T G.805 [11] multiplexing model

A client layer signal might be distributed via several server layer signals; this is referred to as inverse multiplexing. According to ITU-T G.805 [11] this is done by creating an inverse multiplexing sublayer with an adaptation function to the set of server layers as shown in Figure 5-7.

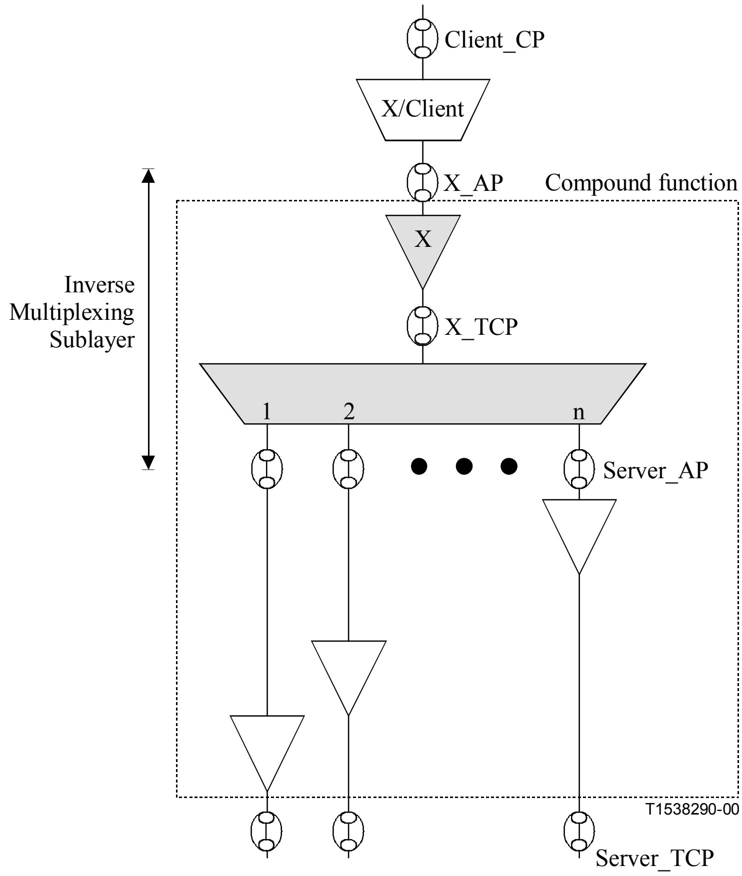


Figure 5-7/G.806 – Inverse multiplexing

The **scrambling** process alters digital data in a pre-defined way to ensure the resulting bit stream has a sufficient density of $0 \rightarrow 1$ and $1 \rightarrow 0$ transitions to allow bit clock recovery from it. The **descrambling** process recovers the original digital data from the scrambled bit stream.

NOTE 1 – The scrambling/descrambling process would be an adaptation process. The historical definition of signals in existing standards causes a violation of this process allocation, hence the scrambling/descrambling processes are often located in the Trail Termination functions. Refer to the individual atomic functions for details.

The **encoding/decoding** process adapts a digital data stream to the characteristics of the physical medium over which it is meant to be transported. The **decoding** process recovers the original digital data from the medium specific form in which it is received.

The **alignment** process locates the first bit/byte of the framed signal [Frame Start (FS)] by means of a search for the Frame Alignment Signal (FAS) or the interpretation of the Pointer (PTR). If the FAS cannot be found or the PTR is corrupted for a specific period, an alignment defect is detected (LOF, LOP). The alignment defect may be the result of the reception of the all-ONEs (AIS) signal. If so, the AIS defect is detected also. The defects are reported to the fault management layer/process.

NOTE 2 – The insertion of a frame alignment signal would be an A_So process. The (historical) definition of the many signals in existing standards causes a violation of this process allocation, hence the frame alignment insertion process is often located in the TT_So function. Refer to the individual atomic functions for details.

A second kind of alignment process aligns several input signals to a common frame start, as it is the case for inverse multiplexing.

The **bit-rate adaptation** process accepts input information at a certain bit rate and outputs that same information at a different bit rate. In the source direction, this process creates gaps in which other functions can add their signals. An example is the S12/P12s_A_So function; the 2 Mbit/s signal input to this function is output at a higher bit rate. The created gaps will be filled with the VC-12 POH.

The **frequency justification** process accepts an input information at a certain frequency and outputs that same information either at the same or at a different frequency. In the source direction, in order to accommodate any frequency (and/or phase) differences between input and output signals, this process may write data into a specific "justification" bit/byte in the outgoing frame structure when the elastic store (buffer) is going to overflow. It will skip data writing when the elastic store is going to underflow. Examples are the S4/S12_A_So and P4e/P31e_A_So functions.

NOTE 3 – The commonly used terms mapping and demapping are covered by bit-rate adaptation and frequency justification processes.

The **time slot/wavelength assignment/access** process assigns the adapted client layer information to specific time slots/wavelength of the server layer in source direction. In sink direction the process provides access to the specific time slot/wavelength of the server layer. Time slots are used in TDM systems. Wavelengths are used in WDM systems. The specific time slot/wavelength is normally fixed for the adaptation function and indicated by an index numbering.

NOTE 4 – Variable connection of client signals to different time slots/wavelengths can be provided by the client layer connection function.

The **multiplexing/demultiplexing** process is modelled by means of multiple adaptation functions, connected to one AP as described above.

If multiple adaptation functions are connected to the same AP and accessing the same timeslots (bits/bytes), a **selection** process controls the actual access to the AP. In the atomic functions this is modelled via the activation/deactivation signal (MI_Active). If only one adaptation function is present, it is selected. Control is not required.

The **timing recovery** process extracts a clock signal, the "recovered clock", from the incoming data signal. The timing recovery process is performed in the adaptation sink function in the physical section layer, e.g. in OS16/RS16_A_Sk.

The **smoothing** process filters the phase step of "gapped input signals". The smoothing process is performed in the adaptation sink function, e.g. in Sm/Xm_A_Sk, Pn/Pm_A_Sk.

Many layers are able to transport a variety of client signals applied to the layer via different adaptation functions. To monitor the provisioning process the source Adaptation inserts the appropriate code in the Trail Signal Label (TSL). The sink adaptation will check the **composition of the payload** comparing the received TSL number with its own one.

5.6.4 Layer network interworking function

A layer network interworking function represents the semantically transparent conversion of characteristic information between two layer networks. The conversion process maintains the integrity of the end-to-end supervision of the trail. Conversion of the adapted information may also be required. The integrity of the client layer characteristic information has to be maintained in this case. The interworking function may be limited to a set of client layer signals.

The process is specific for the interworked layers and may include processes from the adaptation and termination function.

5.7 Combination rules

5.7.1 General

In general, any functions that share the same characteristic or adapted information may be combined.

5.7.2 Binding at connection points

The connection point input (output) of an adaptation function may be bound to the connection point output (input) of either a connection function, layer network interworking function or an adaptation function. The connection point of a layer network interworking function may be bound to the connection point of either a connection function or an adaptation function, as shown in Figure 5-8.

Example: An S12_CP of an S12_C function may be connected to an S12_CP of an S4/S12_A function.

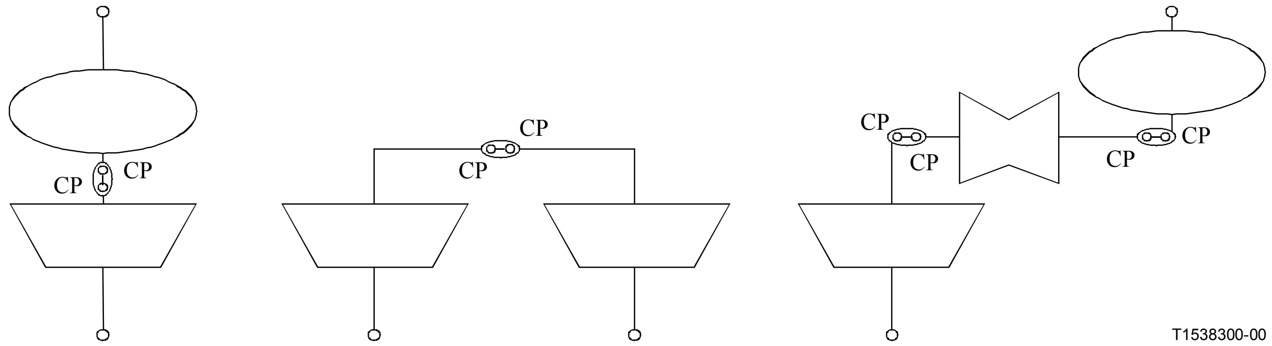


Figure 5-8/G.806 – Binding of connection points (CP-CP binding)

5.7.3 Binding at (termination) connection points

The termination connection point output (input) of a trail termination function may be bound to the connection point input (output) of either an adaptation function, layer network interworking function or a connection function or the termination connection point input (output) of a trail termination function, as shown in Figure 5-9.

NOTE – Once bound the CP and TCP are referred to as a termination connection point.

Example: An S12_TCP of an S12_TT function may be connected to an S12_CP of an S12_C function.

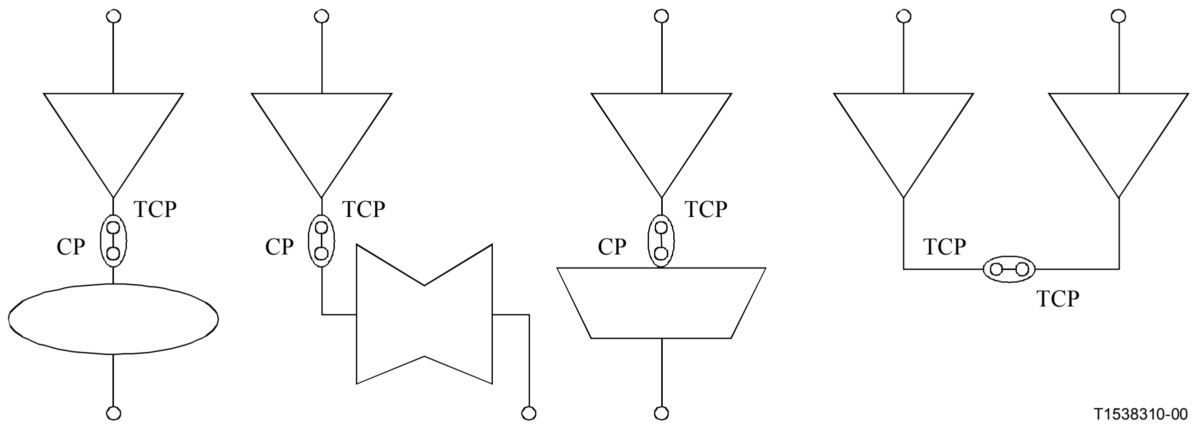


Figure 5-9/G.806 – Binding involving a termination connection point (TCP-CP and TCP-TCP binding)

5.7.4 Binding at access points

The AP input (output) of a trail termination function may be bound to the AP output (input) of an adaptation function as shown in Figure 5-10.

Example: An S4_AP of an S4/S12_A function may be connected to an S4_AP of an S4_TT function.

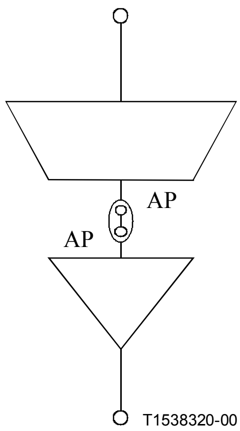


Figure 5-10/G.806 – Binding of Access Points (AP-AP binding)

5.7.5 Alternative binding representations

The binding at reference points can continue, according to the above rules, and create a path such as the one shown in Figures 5-4 and 5-5.

NOTE – The binding at reference points may also be represented as illustrated in Figure 5-11. In an equipment functional specification, the explicit reference to the reference points is not required if the atomic functions are named. In such a case, the names of the reference points are obvious.

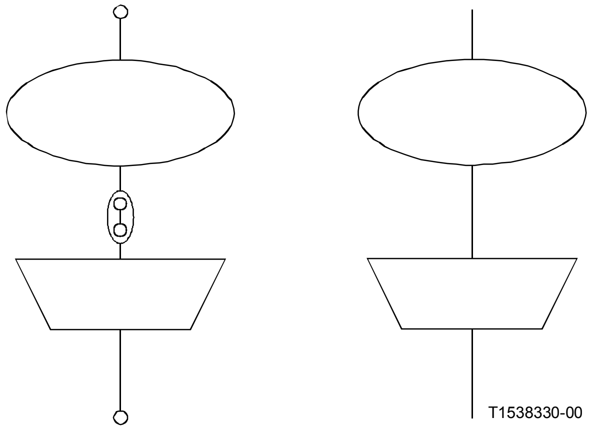


Figure 5-11/G.806 – Alternative binding representation

5.7.6 Directionality

Atomic functions are normally defined with unidirectional functionality, except for certain connection functions. The directionality of trail termination and adaptation functions is identified by the directionality identifier sink/source. The directionality of layer network interworking functions is identified by the direction of the arrow (>).

Two unidirectional atomic functions with opposite directionality may be associated as a bidirectional pair (when a function is referred to without the directionality qualifier it can be taken to be bidirectional). In case of trail termination functions their remote information reference points are connected together in this case.

Bidirectional servers may support bidirectional or unidirectional clients but unidirectional servers may only support unidirectional clients.

5.7.7 Compound functions

Combinations of atomic functions in one or more layer(s) may be identified by a special symbol, a compound function. Three examples are shown in Figures 5-12, 5-13 and 5-14.

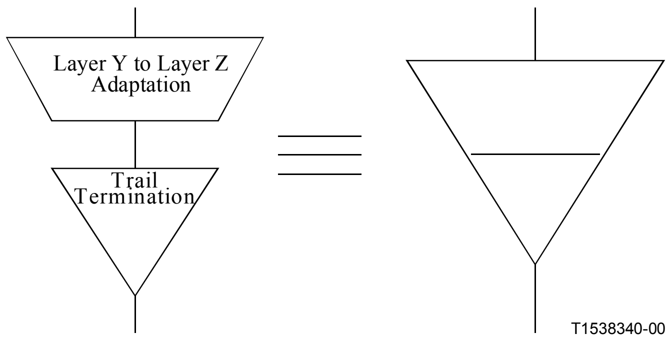


Figure 5-12/G.806 – Compound termination/adaptation function

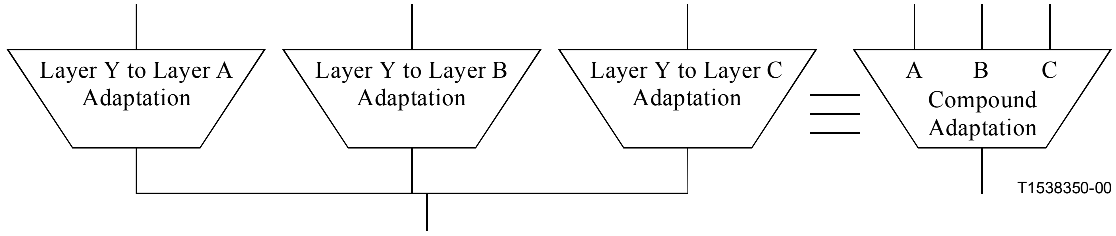


Figure 5-13/G.806 – Compound adaptation function

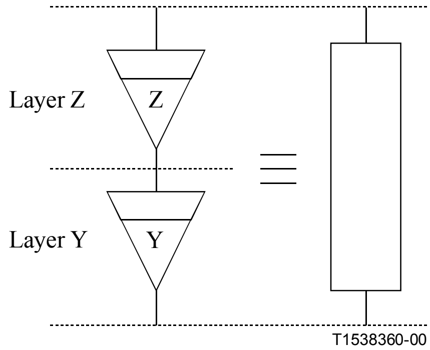


Figure 5-14/G.806 – Compound function spanning multiple layers

5.8 Fault management and performance monitoring naming

The naming of supervision variables follows the following rules (see also Figures 6-1 and 6-2):

The supervision variables are defined as "yZZZ", with:

y	defect:	y = d
	fault cause (i.e. correlated defect):	y = c
	consequent action request:	y = a
	performance parameter:	y = p
	anomaly:	y = n
ZZZ	kind of defect, fault cause, failure, consequent action, performance parameter or command	

dZZZ and cZZZ represent Boolean variables with states TRUE or FALSE. pZZZ represents an integer variable. aZZZ, except aREI, represent a Boolean variable; aREI represents an integer variable.

5.9 Fault management and performance monitoring specification techniques

The defect correlation and consequent action specifications make use of the following supervision equation techniques:

aX ← A or B or C

cY ← D and (not E) and (not F) and G

pZ ← H or J

– "aX" represents the control of consequent action "X". The associated consequent action will be performed if the boolean equation "A or B or C" is true. Otherwise, if the equation is false, the consequent action will not be performed. Consequent actions are e.g.: insertion of all-ONEs (AIS) signal, insertion of RDI signal, insertion of REI signal, activation of signal fail or signal degrade signals.
– "cY" represents the fault cause "Y" which is (will be) declared if the boolean expression "D and (not E) and (not F) and G" is true. Otherwise (expression is false), the fault cause is (will be) cleared. MON will often be a term in this equation (see 2.2.1).
– "pZ" represents the performance monitoring primitive "Z" which value at the end of a one second period represents the number of errored blocks (or error detection code violations) or the occurrence of a defect in that second.
– "A" to "J" represent either defects (e.g. dLOS), reporting control parameters (e.g. AIS_Reported), consequent actions (e.g. aTSF), or the number of errored blocks over a one second period (e.g. Σ nN_B).

NOTE – Hardware faults causing signal transfer interruption is represented by "dEQ". Such faults contribute to the near-end performance monitoring primitive pN_DS.

6 Supervision

Transmission and equipment supervision processes are concerned with the management of the transmission resources in the network and they are only interested in the functionality that is being provided by a Network Element (NE). They require a functional representation of an NE that is implementation independent.

The supervision process describes the way in which the actual occurrence of a disturbance or fault is analysed with the purpose of providing an appropriate indication of performance and/or detected fault condition to maintenance personnel. The following terms are used to describe the supervision process: anomaly, defect, consequent action, fault cause, failure and alarm.

Any equipment faults are represented by the unavailability of the affected functions because the transmission management has no knowledge of the equipment as such. Most functions monitor the signals they are processing for certain characteristics and provide performance information or alarm conditions based on these characteristics. Therefore, transmission supervision processing provides information on the external interface signals that are processed by an NE.

The following basic supervision functions are defined:
– continuity supervision (trail termination);
– connectivity supervision (trail termination);
– signal quality supervision (trail termination);
– payload type supervision (adaptation);
– alignment supervision (adaptation);
– maintenance signal processing (trail termination, adaptation);
– protocol supervision (connection).

The supervision processes and their inter-relationships within atomic functions are depicted in Figures 6-1 and 6-2. The inter-relations between the supervision processes in atomic functions and the equipment management function for the case of SDH are defined in ITU-T G.784 [16].

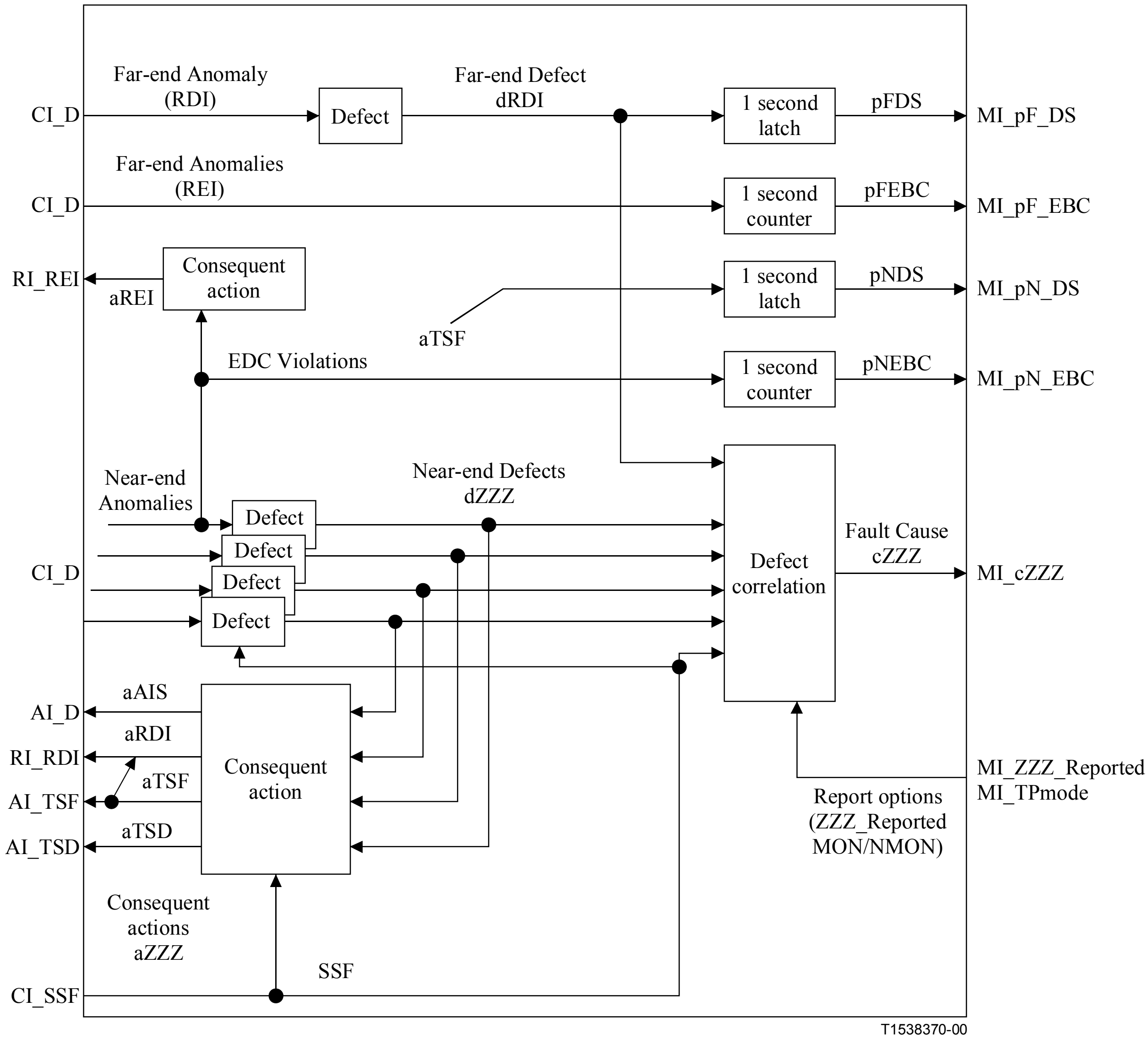


Figure 6-1/G.806 – Supervision process within trail termination functions

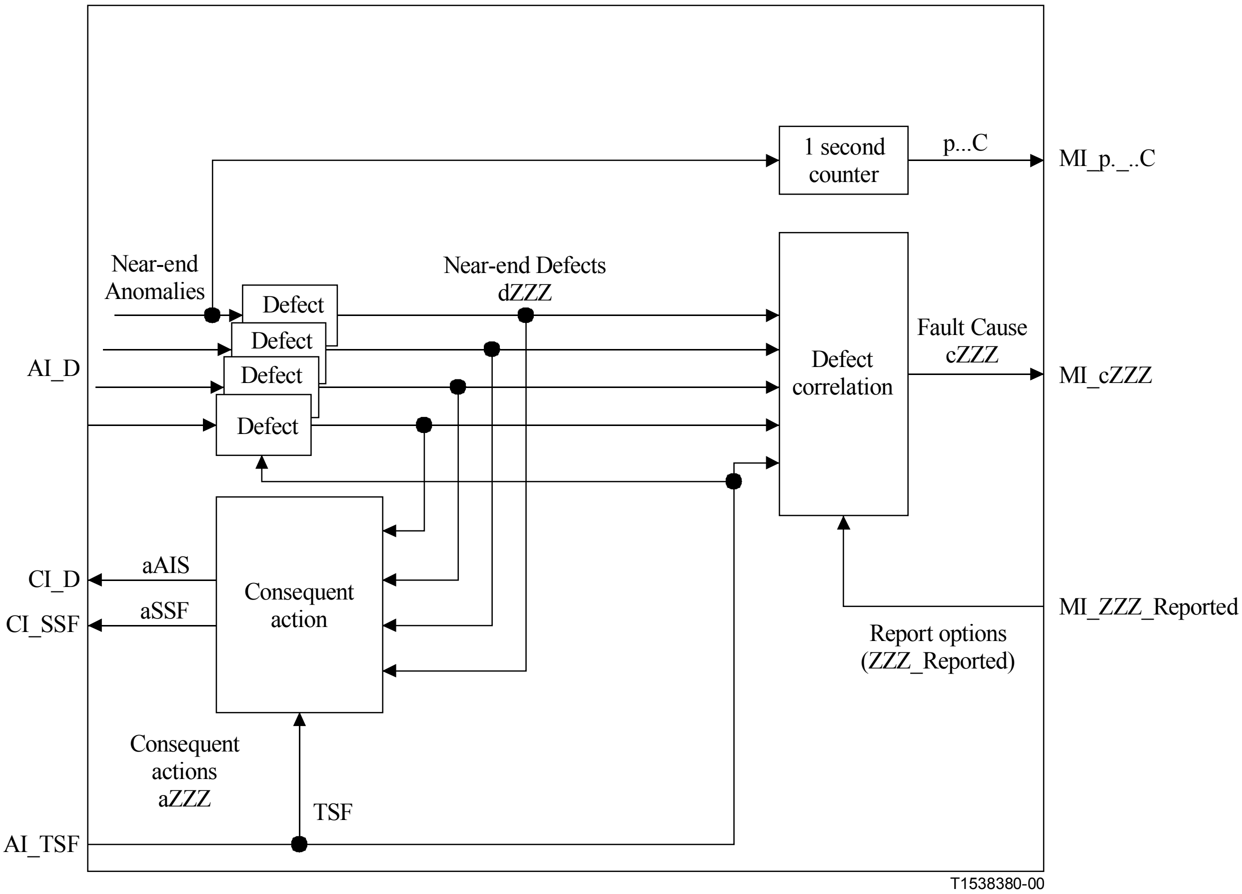


Figure 6-2/G.806 – Supervision process within adaptation functions

The filtering functions provide a data reduction mechanism within atomic functions on the anomalies and defects before being presented at the XXX_MP reference points. Four types of techniques can be distinguished:

– trail termination point and port modes;

– one second integration;

– defect detection;

– fault management and performance monitoring correlations.

6.1 Trail termination point mode and port mode

To prevent alarms from being raised and failures being reported during trail provisioning actions, trail termination functions shall have the ability to enable and disable fault cause declaration. This shall be controlled via their termination point mode or port mode parameter.

The termination point mode (see Figure 6-3) shall be either "monitored" (MON) or "not monitored" (NMON). The state shall be MON if the termination function is part of a trail and provides service and NMON if the termination function is not part of a trail or is part of a trail which is in the process of set-up, breakdown or re-arrangement.

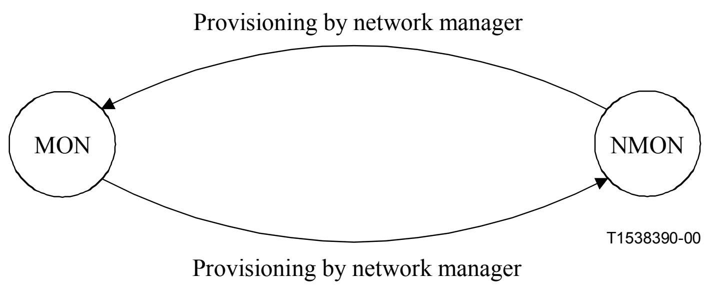


Figure 6-3/G.806 – Trail termination point modes

In physical section layers, the termination point mode is called the port mode. It has three modes (Figure 6-4): MON, AUTO, and NMON. The AUTO mode is like the NMON mode with one exception: if the LOS defect clears, the port mode is automatically changed to MON. This allows for alarm-free installation without the burden of using a management system to change the monitor mode. The AUTO mode is optional. When it is supported, it shall be the default mode; otherwise, NMON shall be the default mode.

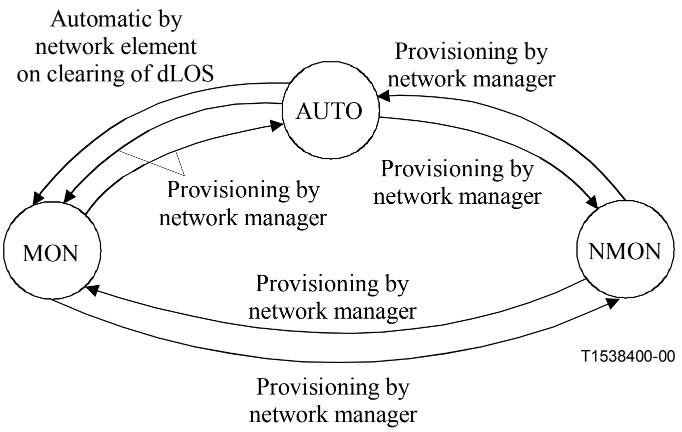


Figure 6-4/G.806 – Port modes

6.2 Defect filter

The (anomaly to) defect filter will provide a persistency check on the anomalies that are detected while monitoring the data stream; when passed, the defect is being detected.

Generic defect filters are defined below. Specific defect filter definitions can be found in the Recommendations for the specific hierarchies.

6.2.1 Continuity supervision

6.2.1.1 Generic behaviour

Continuity supervision monitors the integrity of the continuity of a trail. This is done by monitoring the presence/absence of the CI. The monitoring process can check for the whole CI (e.g. LOS at the physical layer) or a specific mandatory part of it (e.g. multiframe indication for SDH TCM). At path layer networks a replacement signal might be generated by an open connection matrix (e.g. Unequipped signal for SDH). The detection of this replacement signal is then an indication of loss of continuity.

Note that a server layer defect will result in a loss of continuity for client layers. This is normally detected via maintenance signalling (AIS, SSF, TSF) at the client layer and reported as SSF alarm for the client layer (see 6.3).

6.2.1.2 Loss Of Signal defect (dLOS)

LOS signal supervision is used at the physical layer. For the specific detection processes refer to the Recommendations for the specific hierarchies (ITU-T G.783 [9], G.705 [5], G.781 [8]).

6.2.1.3 Unequipped defect (dUNEQ)

Basic function sink direction

The unequipped overhead is recovered from the CP.

The Unequipped defect (dUNEQ) shall be detected if z consecutive frames contain the unequipped activation pattern in the unequipped overhead. The dUNEQ defect shall be cleared if in z consecutive frames the unequipped deactivation pattern is detected in the unequipped overhead. Details for the UNEQ defect are provided in Table 6-1.

NOTE – Some regional standards require a burst proof algorithm of the UNEQ defect.

Table 6-1/G.806 – UNEQ defect details

Hierarchy	Layer	Unequipped overhead	Unequipped activation pattern	Unequipped deactivation pattern	z (Note)
SDH	S3/4 (VC-3/4)	C2 byte	"00000000"	≠ "00000000"	5
	S11/12/2 (VC-11/12/2)	V5, bits 5 to 7	"000"	≠ "000"	5
	S3D/S4D (VC-3/4 TCM option 2)	N1	"00000000"	≠ "00000000"	5
	S11D/S12D/S2D (VC-11/12/2 TCM)	N2	"00000000"	≠ "00000000"	5
PDH with SDH frame	P4s/3s (140/34 Mbit/s)	MA, bits 3 to 5	"000"	≠ "000"	3 to 5
	P4sD/P3sD (140/34 Mbit/s TCM)	NR	"00000000"	≠ "00000000"	5
NOTE – z is not configurable.					

6.2.1.4 TC Loss of Tandem Connection defect (dLTC)

The function shall detect for the presence/absence of the tandem connection overhead in the TCM overhead by evaluating the multiframe alignment signal in the TCM multiframe overhead. The loss of tandem connection defect (dLTC) shall be detected if the multiframe alignment process is in the OOM state. The dLTC shall be cleared if the multiframe alignment process is in the IM state. For details on the alignment process refer to Table 6-2, clause 8.2 and the specific equipment functional Recommendations (ITU-T G.783 [9], G.705 [5]).

Table 6-2/G.806 – LTC defect details

Hierarchy	Layer	TCM multiframe overhead
SDH	S3D/S4D (VC-3/4 TCM option 2)	N1, bits 7 to 8
	S11D/S12D/S2D (VC-11/12/2 TCM)	N2, bits 7 to 8
PDH with SDH frame	P4sD/3sD (140/34 Mbit/s TCM)	NR, bits 7 to 8

6.2.2 Connectivity supervision

6.2.2.1 Generic behaviour

Connectivity supervision monitors the integrity of the routing of the trail between sink and source. Connectivity is normally only required if the layer provides flexible connectivity, both automatically (e.g. cross-connects controlled by the TMN) or manually (e.g. fibre distribution frame). The connectivity is supervised by attaching a unique identifier at the source. If the received identifier does not match this expected identifier a connectivity defect has occurred.

6.2.2.2 Trail trace identifier processing and Trace Identifier Mismatch defect (dTIM)

Basic function source direction

The generation of trail trace identifier (TTI) is optional and in the province of regional standards.

If TTI generation is not required, the content of the TTI overhead is not configurable.

If TTI generation is required, the TTI information derived from the management reference point (MI_TxTI) is placed in the TTI overhead position.

Basic function sink direction

The TTI overhead is recovered from the CP.

The detection of a trace identifier mismatch defect (dTIM) is optional and in the province of the regional standards.

If dTIM detection is not required, the receiver will be able to ignore the received TTI overhead values, and dTIM is considered "false".

If dTIM detection is required, the following applies: The detection of dTIM is based on a comparison between the expected TTI, configured via the management reference point (MI_ExTI), and the accepted TTI (AcTI). If dTIM detection is disabled via an input ("Set") command (MI_TIMdis) at the management reference point, then dTIM is considered "false".

NOTE 1 – Acceptance criteria and defect specification for the TTI is for further study to ensure integrity, and robustness to errors for TIM.

NOTE 2 – A mismatch in the CRC-7 or TFAS signal of the 16-byte trace identifier results in the detection of the dTIM defect.

The accepted TTI shall be reported via the management point (MI_AcTI) to the EMF. The query of the AcTI shall be independent of the dTIM detection process.

NOTE 3 – Some equipment developed prior to the 1997 revision of ITU-T G.783 [9] may not support this query in the event that Trace Identifier mismatch detection is disabled.

Details on the TIM defect are provided in Table 6-3.

Table 6-3/G.806 – TIM defect details

Hierarchy	Layer	TTI overhead	TTI format
SDH	RSn	J0 byte	1/16 byte (see ITU-T G.707 [6])
	S3/4 (VC-3/4) (Note)	J1 byte	16/64 byte (see ITU-T G.707 [6])
	S3D/S4D (VC-3/4 TCM option 2)	N1, bits 7 to 8, frame 9 to 72	16 byte (see ITU-T G.707 [6])
	S11/12/2 (VC-11/12/2) (Note)	J2	16 byte (see ITU-T G.707 [6])
	S11D/S12D/S2D (VC-11/12/2 TCM)	N2, bits 7 to 8, frame 9 to 72	16 byte (see ITU-T G.707 [6])
PDH with SDH frame	P4s/3s (140/34 Mbit/s)	TR	16 byte (see ITU-T G.831 [13], G.832 [14])
	P4sD/3sD (140/34 Mbit/s TCM)	NR, bits 7 to 8, frame 9 to 72	16 byte (see ITU-T G.831 [13], G.832 [14])
NOTE – In order to distinguish between unequipped and supervisory unequipped, the fixed code 00000000 in J1/J2 should not be used in the supervisory unequipped termination source function.			

6.2.3 Signal quality supervision

6.2.3.1 Generic behaviour

Signal quality supervision in general monitors the performance of a trail. If the performance falls below a certain threshold this might activate a defect. For the generic performance monitoring process see 8.3.

For networks where the network operator assumes a *Poisson distribution of errors*, an excessive error defect and a degraded signal defect are to be detected.

For networks where the operator assumes a *bursty distribution of errors*, a degraded signal defect is to be detected. The excessive error defect, for this case, is assumed to be false.

The applicability of the two is in the province of the regional standards.

6.2.3.1.1 Excessive error (dEXC) and degraded signal defects (dDEG) assuming Poisson distribution of errors

Excessive error and degraded signal defects are to be detected according to the following process:

An excessive error defect (dEXC) shall be detected if the equivalent BER exceeds a preset threshold of 10^{-x}, x = 3, 4 or 5. The excessive error defect shall be cleared if the equivalent BER is better than $10^{-(x+1)}$.

With BER $\geq 10^{-x}$ the probability of defect detection within the measuring time shall be ≥ 0.99.

With BER $\leq 10^{-(x+1)}$ the probability of defect detection within the measuring time shall be $\leq 10^{-6}$.

With BER $\geq 10^{-x}$ the probability of defect clearing within the measuring time shall be $\leq 10^{-6}$.

With BER $\leq 10^{-(x+1)}$ the probability of defect clearing within the measuring time shall be ≥ 0.99.

A degraded signal defect (dDEG) shall be detected if the equivalent BER exceeds a preset threshold of 10^{-x}, x = 5, 6, 7, 8 or 9. The degraded signal defect shall be cleared if the equivalent BER is better than $10^{-(x+1)}$.

With BER ≥ 10^{-x} the probability of defect detection within the measuring time shall be ≥ 0.99.

With BER ≤ $10^{-(x+1)}$ the probability of defect detection within the measuring time shall be ≤ 10^{-6}.

With BER ≥ 10^{-x} the probability of defect clearing within the measuring time shall be ≤ 10^{-6}.

With BER ≤ $10^{-(x+1)}$ the probability of defect clearing within the measuring time shall be ≥ 0.99.

Maximum detection and clearing time requirements for the BER calculations for SDH are listed in Tables 6-4, 6-5 and 6-6. For all other signals these values are for further study.

NOTE – The specification in the 1994 revision of ITU-T G.783 [9] could have been interpreted as listed in Table 6-7.

Table 6-4/G.806 – Maximum detection time requirements for VC-4 and VC-3

Detector threshold	Actual BER						
	≥10^{-3}	**10^{-4}**	**10^{-5}**	**10^{-6}**	**10^{-7}**	**10^{-8}**	**10^{-9}**
10^{-3}	10 ms						
10^{-4}	10 ms	100 ms					
10^{-5}	10 ms	100 ms	1 s				
10^{-6}	10 ms	100 ms	1 s	10 s			
10^{-7}	10 ms	100 ms	1 s	10 s	100 s		
10^{-8}	10 ms	100 ms	1 s	10 s	100 s	1 000 s	
10^{-9}	10 ms	100 ms	1 s	10 s	100 s	1 000 s	10 000 s

Table 6-5/G.806 – Maximum detection time requirements for VC-2, VC-12 and VC-11

Detector threshold	Actual BER					
	≥10^{-3}	**10^{-4}**	**10^{-5}**	**10^{-6}**	**10^{-7}**	**10^{-8}**
10^{-3}	40 ms					
10^{-4}	40 ms	400 ms				
10^{-5}	40 ms	400 ms	4 s			
10^{-6}	40 ms	400 ms	4 s	40 s		
10^{-7}	40 ms	400 ms	4 s	40 s	400 s	
10^{-8}	40 ms	400 ms	4 s	40 s	400 s	4 000 s

Table 6-6/G.806 – Clearing time requirements

Detector threshold	Set/Clear values associated with detector threshold	Multiplex section VC-4 VC-3	VC-2 VC-12 VC-11
10^{-3}	$10^{-3}/10^{-4}$	10 ms	40 ms
10^{-4}	$10^{-4}/10^{-5}$	100 ms	400 ms
10^{-5}	$10^{-5}/10^{-6}$	1 s	4 s
10^{-6}	$10^{-6}/10^{-7}$	10 s	40 s
10^{-7}	$10^{-7}/10^{-8}$	100 s	400 s
10^{-8}	$10^{-8}/10^{-9}$	1 000 s	4 000 s
10^{-9}	$10^{-9}/10^{-10}$	10 000 s	

Table 6-7/G.806 – Alternative interpretation of maximum detection and clearing time requirements in the 1994 revision of ITU-T G.783 [9]

Detector threshold	Multiplex section VC-4 VC-3	VC-2 VC-12 VC-11
10^{-3}	10 ms	40 ms
10^{-4}	100 ms	400 ms
10^{-5}	1 s	4 s
10^{-6}	10 s	40 s
10^{-7}	100 s	400 s
10^{-8}	1 000 s	4 000 s
10^{-9}	10 000 s	

6.2.3.1.2 Excessive error (dEXC) and degraded signal defects (dDEG) assuming Bursty distribution of errors

The excessive error defect is not defined, and dEXC is assumed to be false.

The degraded signal defect (dDEG) shall be declared if DEGM consecutive bad intervals (interval is the one second period used for performance monitoring) are detected. An interval is declared bad if the percentage of detected errored blocks in that interval or the number of errored blocks in that interval ≥ Degraded Threshold (DEGTHR).

NOTE 1 – In the case of dDEG in the MSn layer, the errored block is equal to a BIP violation.

The degraded signal defect shall be cleared if M consecutive good intervals are detected. An interval shall be declared good if the percentage of detected errored blocks in that interval or the number of errored blocks in that interval < DEGTHR.

The parameter DEGM shall be provisionable in the range 2 to 10.

The parameter DEGTHR shall be provisioned either as a percentage or as a number of errored blocks. When based on a percentage, it shall be in the range 0 < DEGTHR ≤ 100%. When based on a number of errored blocks, it shall be in the range 0 < DEGTHR ≤ Number of blocks in the interval.

NOTE 2 – When using percentage, for higher rate interfaces, 1% is equal to a large number of blocks. For example, in an STM-16 interface, 1% is equal to a step of 30 720 blocks in the interval for the multiplex section.

6.2.4 Payload type supervision

6.2.4.1 Generic behaviour

Payload type supervision checks that compatible adaptation functions are used at the source and the sink. This is normally done by adding a signal type identifier at the source adaptation function and comparing it with the expected identifier at the sink. If they do not match a payload mismatch is detected.

6.2.4.2 Payload composition and payload mismatch defect (dPLM)

The signal label identifies the presence of a payload and the signal type carried in the payload.

Basic function source direction

The generation of payload identifier in the signal label is required. The value is bound to and represents the selected (activated) adaptation function.

The payload identifier is inserted in the signal label overhead.

Basic function sink direction

The signal label overhead (TSL) is recovered from the AP.

The detection of dPLM is based on a comparison between the expected TSL, representing the selected/activated adaptation function, and the accepted TSL.

A new signal label code value shall be accepted if the signal label overhead carries the same code value in m consecutive (multi)frames with 3 ≤ m ≤ 10.

The Payload Label Mismatch (dPLM) defect shall be detected if the "accepted TSL" code does not match the "expected TSL" code. If the "accepted TSL" is "equipped non-specific", the mismatch is not detected.

In the case of a PLM condition, the dPLM defect shall be cleared if the "accepted TSL" code matches the "expected SL" code or if the "accepted TSL" code is "equipped non-specific".

The dPLM shall be detected within a maximum period of 100 ms in the absence of bit errors.

The dPLM shall be cleared within a maximum period of 100 ms in the absence of bit errors.

The defect shall be cleared during a TSF condition.

The value of the signal label passed to the management system should be an accepted value rather than the received value.

Details on the PLM defect are provided in Table 6-8.

NOTE – An "expected TSL" code of "equipped non-specific" is no longer applicable according to ITU-T G.707 [6].

Table 6-8/G.806 – PLM defect details

Hierarchy	Layer	Signal label overhead	Signal label values
SDH	S3/4 (VC-3/4) (Note 1)	C2 byte	see ITU-T G.707 [6]
	S11/12/2 (VC-11/12/2) (Note 1)	V5, bits 5 to 7 K4, bit 1 (Note 2)	see ITU-T G.707 [6]
PDH with SDH frame	P4s/3s (140/34 Mbit/s)	MA, bits 3 to 5	see ITU-T G.832 [14]
NOTE 1 – In order to distinguish between unequipped and supervisory unequipped, the fixed code 00000000 in J1/J2 should not be used in the supervisory unequipped termination source function. NOTE 2 – K4, bit 1 is used for an extended signal label in a multiframe manner. The signal label overhead is located in frame 12 to 19 of the multiframe (see ITU-T G.707 [6]). If the multiframe cannot be recovered it results in a PLM defect.			

6.2.5 Alignment supervision

6.2.5.1 Generic behaviour

Alignment supervision checks that the client layer frame and frame start can be correctly recovered. The specific processes depend on the signal/frame structure and may include:

– (multi)frame alignment;

– pointer processing;

– alignment of several independent frames to a common frame start in case of inverse multiplexing.

If one of these processes fails a related loss of alignment (dLOA) defect shall be activated. The defect detection process shall be normally tolerant to single frame slips, but should detect for continuous frame slips.

NOTE – dLOA is the generic defect term. Specific defects are loss of frame (dLOF), loss of multiframe (dLOM) or loss of pointer (dLOP).

For generic alignment processes refer to 8.2. For the specific detection processes refer to the specific equipment functional specifications (ITU-T G.783 [9], G.705 [5]).

6.2.6 Maintenance signal supervision

6.2.6.1 Generic behaviour

Maintenance signal supervision is concerned with the detection of maintenance indications in the signal. For the use and generation of maintenance signals see 6.3.

6.2.6.2 AIS defect (dAIS)

For AIS generation see 6.3.1.

Basic function sink direction

If z consecutive frames contain the AIS activation pattern in the AIS overhead, an AIS defect shall be detected. The dAIS defect shall be cleared if z consecutive frames contain the AIS deactivation pattern in the AIS overhead.

Details on the AIS defect are provided in Table 6-9.

Table 6-9/G.806 – AIS defect details

Hierarchy	Layer	Type	AIS overhead	AIS activation pattern	AIS deactivation pattern	z (Note 1)
SDH	MSn	MS-AIS	K2, bits 6 to 8	"111"	≠ "111"	3
	S3/4 (VC-3/4)	AU-AIS	H1, H2	See Annex A/G.783 [9]		
		VC-AIS (Notes 2, 3)	C2 byte	"11111111"	≠"11111111"	5
	S3D/4D (VC-3/4 TCM)	IncAIS	N1, bits 1 to 4	"1110"	≠"1110"	5
	S11/12/2 (VC-11/12/2)	TU-AIS	V1, V2	See Annex A/G.783 [9]		
		VC-AIS (Notes 2, 3)	V5, bits 5 to 7	"111"	≠"111"	5
	S11D/12D/2D (VC-11/12/2 TCM)	IncAIS	N2, bit 4	"1"	"0"	5
PDH with SDH frame	P4s/3s (140/34 Mbit/s)	AIS	MA, bits 3 to 5	"111"	≠"111"	5
	P4sD/3sD (140/34 Mbit/s TCM)	IncAIS	NR, bits 1 to 4	"1110"	≠"1110"	5
PDH	P11s, P12s, P22e, P31e, P32e, P4e, P4a	AIS	See ITU-T G.775 [7]			

NOTE 1 – z is not configurable.

NOTE 2 – Equipment designed prior to this Recommendation may be able to perform VC-AIS detection either as specified above with "frames" being replaced by "samples (not necessarily frames)", or by a comparison of the accepted signal label with the all-ones pattern. If the accepted signal label is not equal to all-ones, the VC-AIS defect is cleared.

NOTE 3 – In networks that do not support/allow the transport of VC-n/VC-m signals with tandem connection overhead, VC-AIS defect is not defined and VC-AIS defect is assumed to be false.

6.2.6.3 Remote/Outgoing Defect Indication defect (dRDI/ODI)

Basic function source direction

The generation of RDI/ODI is required for bidirectional trail termination functions. For RDI/ODI generation see 6.3.2. The value inserted is the value received via RI_RDI/ODI from the associated basic sink function. The RDI/ODI value is inserted into the RDI/ODI overhead.

NOTE – For unidirectional trail termination functions not being paired with a termination sink function, the RDI/ODI signal output should be inactive, but can be undefined in old equipment not explicitly supporting unidirectional transport.

Basic function sink direction

The RDI/ODI overhead is recovered from the CP.

If z consecutive frames contain the RDI/ODI activation pattern in the RDI/ODI overhead, a dRDI/ODI defect shall be detected. The dRDI/ODI defect shall be cleared if z consecutive frames contain the RDI/ODI deactivation pattern in the RDI/ODI overhead.

The defect shall be cleared during an SSF condition.

Details on the RDI/ODI defects are provided in Table 6-10.

Table 6-10/G.806 – RDI/ODI defect details

Hierarchy	Layer	Type	RDI/ODI overhead	RDI/ODI activation pattern	RDI/ODI deactivation pattern	z (Note 1)
SDH	MSn	RDI	K2, bits 6 to 8	"110"	≠ "110"	3 to 5
	S3/4 (VC-3/4) (Note 2)	RDI	G1, bit 5	"1"	"0"	3, 5 or 10
	S3D/4D (VC-3/4 TCM option 2)	RDI	N1, bit 8, frame 73	"1"	"0"	5
		ODI	N1, bit 7, frame 74	"1"	"0"	5
	S11/12/2 (VC-11/12/2)	RDI	V5, bit 8	"1"	"0"	3, 5 or 10
	S11D/12D/2D (VC-11/12/2 TCM)	RDI	N2, bit 8, frame 73	"1"	"0"	5
		ODI	N2, bit 7, frame 74	"1"	"0"	5
PDH with SDH frame	P4s/3s (140/34 Mbit/s)	RDI	MA, bit 1	"1"	"0"	5
	P4sD/3sD (140/34 Mbit/s TCM)	RDI	NR, bit 8, frame 73	"1"	"0"	5
		ODI	NR, bit 7, frame 74	"1"	"0"	5
PDH	P12s	RDI	See ITU-T G.775 [7]			
	P22e,31e,4e	RDI	See ITU-T G.775 [7]			
	P32e	RDI	X	"11"	"00"	1
NOTE 1 – z is not configurable. NOTE 2 – Enhanced RDI processing is for further study.						

6.2.7 Protocol supervision

6.2.7.1 Generic behaviour

Protocol supervision detects failures in the sequence of a protocol exchange.

6.2.7.2 Failure of Protocol (dFOP)

The dFOP defect indicates a failure in the automatic protection switching protocol. The detailed behaviour is defined at the specific atomic functions.

6.3 Consequent actions

This clause presents in generic terms the generation and control of the set of consequent actions. Specific details are presented in each atomic function.

After a defect or anomaly is detected, one or more of the following consequent actions may be requested:

– all-ONEs (AIS) insertion;

– RDI insertion;

– REI insertion;

– ODI insertion;

– OEI insertion;
– unequipped signal insertion;
– generation of "Server Signal Fail (SSF)" signal;
– generation of "Trail Signal Fail (TSF)" signal;
– generation of "Trail Signal Degrade (TSD)" signal.

Figure 6-5 shows how the aAIS, aRDI and aREI consequent action request signals control the associated consequent actions: insertion of all-ONEs, insertion of RDI code and insertion of REI value. Figure 6-5 also shows the location of aSSF, aTSF and aTSD consequent action requests.

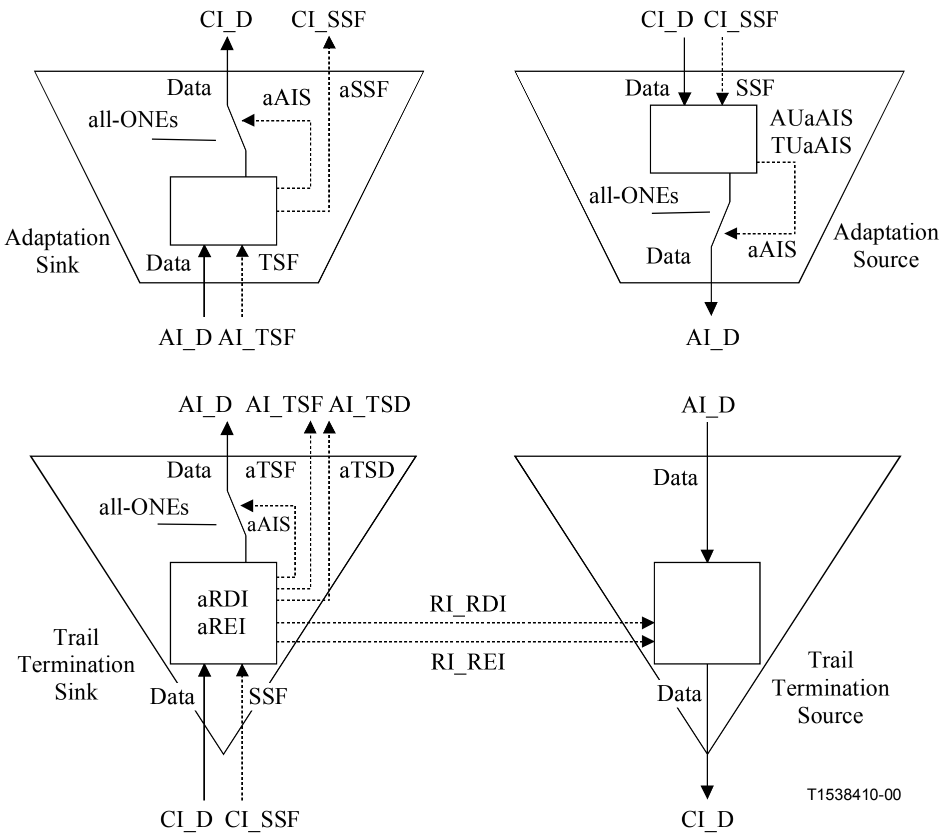


Figure 6-5/G.806 – Consequent action control: AIS, RDI and REI

Certain detected near-end defects cause the insertion of the all-ONEs signal in Trail Termination sink functions. Detected defects cause the insertion of the all-ONEs signal in adaptation sink functions. The reception of a Server Signal Fail (SSF) indication causes the insertion of all-ONEs in the adaptation source.

In cases where the all-ONEs signal is inserted either in a trail termination sink or in the previous adaptation sink function, the RDI code is inserted in the associated trail termination source signal, i.e. the RDI code is inserted on detected defects or the reception of an SSF indication in a trail termination sink function (aRDI).

Every frame, the number of detected EDC violations (aREI) in the trail termination sink function are inserted in the REI bits in the associated trail termination source signal.

A connection function inserts the unequipped VC signal at one of its outputs if that output is not connected to one of its inputs.

6.3.1 Alarm Indication Signal (AIS)

The all-ONEs (AIS) signal replaces the received signal under certain detected near-end defect conditions in order to prevent downstream failures being declared and alarms being raised. See Appendix IV for a description of the application and the insertion control.

Specific details with respect to all-ONEs (AIS) insertion are defined in the individual atomic functions. Generically, the logic equations and the time requirement for the all-ONEs (aAIS) insertion request are:

Adaptation sink functions: aAIS ← dPLM or dAIS/AI_TSF or dLOA

NOTE 1 – dLOA represents either dLOF or dLOM or dLOP whichever is applicable in the atomic function.

NOTE 2 – Certain adaptation sink functions do not detect dAIS. To ensure that the adaptation sink function is aware of the reception of the all-ONEs signal, the termination sink function (which inserted the all-ONEs signal on detected defect conditions) informs the adaptation sink about this condition by means of the AI_TSF signal. In such a case the dAIS term, in the aAIS expression, is replaced by AI_TSF.

NOTE 3 – In the case of 45 Mbit/s interface, the AIS signal is defined in ITU-T M.20 [17] and ITU-T G.704 [4].

Termination sink functions: aAIS ← dAIS or dUNEQ/dLOS or (dTIM and not TIMAISdis)

Some national networks allow enable/disable AIS/TSF activation on detection of dTIM, while others always activate AIS/TSF on detection of dTIM. In the latter case TIMAISdis is always false and not configurable via the management interface.

NOTE 4 – The term dAIS is applicable for the MS_TT function. The term dLOS is applicable for physical section layer termination functions while dUNEQ represents a similar condition for the (SDH) path layers.

Adaptation source functions: aAIS ← CI_SSF

The termination sink, and adaptation sink and source functions shall insert the all-ONEs (AIS) signal within two (multi)frames after AIS request generation (aAIS), and cease the insertion within two (multi)frames after the AIS request has cleared.

6.3.2 Remote Defect Indication (RDI)

If the all-ONEs signal is inserted either in a trail termination sink or in the previous adaptation sink function, the RDI code is inserted in the associated trail termination source signal. See Appendix III for a description of the RDI application and the insertion control.

Specific details with respect to RDI insertion are defined in the individual atomic functions. Generically, the logic equations and the time requirement for the RDI insertion is:

Termination sink functions: aRDI ← dAIS/CI_SSF or dUNEQ or dTIM

Supervisory termination sink functions: aRDI ← CI_SSF or dTIM

NOTE 1 – Some Trail Termination functions do not detect dAIS. To ensure that the Trail Termination function is aware of the reception of the all-ONEs signal, the server layer (which inserted the all-ONEs signal on detected defect conditions) informs the client layer about this condition by means of the CI_SSF signal. In such a case the dAIS term, in the aRDI expression, is replaced by CI_SSF.

NOTE 2 – In the case of supervisory-unequipped termination functions, dUNEQ cannot be used to activate aRDI; an expected supervisory-unequipped VC signal will have the signal label set to all-0s, causing a continuous detection of dUNEQ. If an unequipped VC signal is received, dTIM will be activated and can serve as a trigger for aRDI instead of dUNEQ.

Upon the declaration/clearing of aRDI at the termination sink function the trail termination source function shall have inserted/removed the RDI code within the following time-limits:

– MSn_TT: 1 ms
– S4_TT, S3_TT, S4s_TT, S3s_TT: 1 ms
– S2_TT, S12_TT, S11_TT, S2s_TT, S12s_TT, S11s_TT: 4 ms
– S4D_TT, S3D_TT: 20 ms
– S2D_TT, S12D_TT, S11D_TT: 80 ms

NOTE 3 – RDI is undefined and should be ignored by the receiver (TT_Sk) in the case of a unidirectional trail.

6.3.3 Remote Error Indication (REI)

Every frame, the number of detected EDC violations in the trail termination sink function is inserted in the REI bits in the signal generated by the associated trail termination. See Appendix III for a description of the REI application and the insertion control.

Specific details with respect to REI insertion are defined in the individual atomic functions. Generically, the logic equations and the time requirement for the REI insertion is:

Termination sink function: aREI ← "number of error detection code violations"

Upon the detection of a number of errors at the termination sink function the trail termination source function shall have inserted that value in the REI bit(s) within the following time-limits:

– MSn_TT: 1 ms
– S4_TT, S3_TT, S4s_TT, S3s_TT: 1 ms
– S2_TT, S12_TT, S11_TT, S2s_TT, S12s_TT, S11s_TT: 4 ms
– S4D_TT, S3D_TT: 20 ms
– S2D_TT, S12D_TT, S11D_TT: 80 ms

NOTE – REI is undefined and should be ignored by the receiver (TT_Sk) in the case of a unidirectional trail.

6.3.4 Server Signal Fail (SSF)

SSF signals are used to forward the defect condition of the server to the client in the next (sub)layer, to:

– prevent defect detection in layers without incoming AIS detectors in trail termination sink functions (e.g. S4_TT, S12_TT);
– report the server signal fail condition in layers without incoming AIS detectors in trail termination sink functions;
– control the link connection AIS (e.g. AU-AIS) insertion in adaptation source functions;
– initiate protection switching/restoration in the (protection-) connection function.

Specific details with respect to SSF generation are defined in the individual atomic functions. Generically, the logic equations and the time requirement for the SSF generation is:

Adaptation sink function: aSSF ← dPLM or dAIS/AI_TSF or dLOA

NOTE 1 – If the adaptation function does not detect the AIS defect, the dAIS term will be replaced by AI_TSF generated by the previous TT_Sk.

NOTE 2 – The term dLOA is the general indication for dLOF, dLOM or dLOP whichever is applicable.

Upon the declaration of aSSF the function shall activate CI_SSF (CI_SSF = true), and deactivate CI_SSF (CI_SSF = false) after the SSF request has cleared.

6.3.5 Trail Signal Fail (TSF)

TSF signals are used to forward the defect condition of the trail to the:

– adaptation sink function, to control all-ONEs, (AIS) insertion in the function, when the function does not perform AIS defect detection, e.g. in S12/P12x_A_Sk.

Specific details with respect to TSF generation are defined in the individual atomic functions. Generically, the logic equations and the time requirement for the TSF generation is:

Termination sink function:	aTSF ← dAIS/CI_SSF or dUNEQ/dLOS or (dTIM and not TIMAISdis)
Supervisory termination sink function:	aTSF ← CI_SSF or (dTIM and not TIMAISdis)

Some national networks allow enable/disable AIS/TSF activation on detection of dTIM, while others always activate AIS/TSF on detection of dTIM. In the latter case TIMAISdis is always false and not configurable via the management interface.

NOTE 1 – Some trail termination functions do not detect dAIS. To ensure that the trail termination function is aware of the reception of the all-ONEs signal, the server layer (which inserted the all-ONEs signal on detected defect conditions) informs the client layer about this condition by means of the SSF signal. In such a case the dAIS term, in the aTSF expression, is replaced by CI_SSF.

NOTE 2 – In the case of supervisory-unequipped termination functions, dUNEQ cannot be used to activate; an expected supervisory-unequipped VC signal will have the signal label set to all-0s, causing a continuous detection of dUNEQ. If an unequipped VC signal is received, dTIM will be activated and can serve as a trigger for aTSF instead of dUNEQ.

Upon the declaration of aTSF the function shall activate AI_TSF (AI_TSF = true), and deactivate AI_TSF (AI_TSF = false) after the TSF request has cleared.

6.3.6 Trail Signal Fail protection (TSFprot)

TSFprot signals are used to forward the defect condition of the trail to the:

– protection connection function in the trail protection sublayer, to initiate trail protection switching in that function;

– connection function in the same layer which performs a non-intrusively monitored SNC (SNC/N) protection scheme, to initiate SNC protection switching in that function.

Specific details with respect to TSFprot generation are defined in the individual atomic functions. Generically, the logic equations and the time requirement for the TSF generation is:

Termination sink function: aTSFprot ← aTSF or dEXC

NOTE – aTSFprot and aTSF will be identical for network elements that support error defects assuming bursty distribution of errors. For such networks, dEXC is assumed to be permanently false (see 6.2.3.1.2).

Upon the declaration of aTSFprot the function shall activate AI_TSFprot (AI_TSFprot = true), and deactivate AI_TSFprot (AI_TSFprot = false) after the TSFprot request has cleared.

6.3.7 Trail Signal Degrade (TSD)

TSD signals are used to forward the signal degrade defect condition of the trail to the:

– protection connection function in the trail protection sublayer, to initiate trail protection switching in that function;

– connection function in the layer to initiate subnetwork connection protection switching in that function for the case of a non-intrusive monitored SNC (SNC/N) protection scheme.

Specific details with respect to TSD generation are defined in the individual atomic functions. Generically, the logic equations and the time requirement for the TSD generation is:

Termination sink function: aTSD ← dDEG

Upon the declaration of aTSD the function shall activate AI_TSD (AI_TSD = true), and deactivate AI_TSD (AI_TSD = false) after the TSD request has cleared.

6.3.8 Outgoing Defect Indication (ODI)

Specific details with respect to ODI insertion are defined in the individual atomic functions. Generically, the logic equations and the time requirement for the ODI insertion is:

Termination sink functions: aODI ← CI_SSF or dUNEQ or dTIM or dIncAIS or dLTC

Upon the declaration/clearing of aODI at the termination sink function the trail termination source function shall have inserted/removed the ODI code within the following time-limits:

- S4D_TT, S3D_TT: 20 ms
- S2D_TT, S12D_TT, S11D_TT: 80 ms

NOTE – ODI is undefined and should be ignored by the receiver (TT_Sk) in the case of a unidirectional TC trail.

6.3.9 Outgoing Error Indication (OEI)

Every frame, the number of detected EDC violations in the VC signal in the TC trail termination sink function is inserted in the OEI bit in the signal generated by the associated TC trail termination.

Specific details with respect to OEI insertion are defined in the individual atomic functions. Generically, the logic equations and the time requirement for the OEI insertion is:

TC Termination sink function: aOEI ← "number of error detection code violations in the VC"

Upon the detection of a number of errors at the termination sink function the trail termination source function shall have that value inserted in the OEI bit within the following time-limits:

- S4D_TT, S3D_TT: 20 ms
- S2D_TT, S12D_TT, S11D_TT: 80 ms

NOTE – OEI is undefined and should be ignored by the receiver (TT_Sk) in the case of a unidirectional TC trail.

6.3.10 Unequipped signal

Unequipped indicating signals are generated by connection functions.

If the output of a connection function is not connected to an input of that connection function, the CI originates at that connection function. In this case an unequipped CI shall be generated by the connection function.

6.4 Defect correlations

This clause presents in generic terms the defect correlations within trail termination, adaptation and connection functions. Specific details are presented in each atomic function.

Since all of the defects will appear at the input of the defect correlation filter (Figures 6-1 and 6-2) it provides correlation to reduce the amount of information offered to the EMF.

A fault may cause multiple defect detectors to be activated. To determine, from the activated defects, which fault is present, the activated defects are correlated to obtain the fault cause.

The cZZZ fault causes (correlated defects) shall be activated if the expression is true. cZZZ shall be deactivated if the expression is false.

6.4.1 Termination sink functions

Trail termination sink:	cUNEQ	←	dUNEQ and MON
Supervisory trail termination sink:	cUNEQ	←	dUNEQ and dTIM and (AcTI = all "0"s) and MON
Trail termination sink:	cTIM	←	dTIM and (not dUNEQ) and MON
Supervisory trail termination sink:	cTIM	←	dTIM and not (dUNEQ and AcTI = all "0"s) and MON

cDEG ← dDEG and (not dTIM) and MON

cRDI ← dRDI and (not dUNEQ/LTC) and (not dTIM) and RDI_Reported and MON

cODI ← dODI and (not dUNEQ/LTC) and (not dTIM) and ODI_Reported and MON

cSSF ← CI_SSF/dAIS and MON and SSF_Reported

cLOS ← dLOS and MON

cAIS ← dAIS and AIS_Reported and MON

The reporting of the following defects is provisionable: AIS, SSF, RDI, ODI. These defects are "secondary defects" in that they are the result of a consequent action on a "primary defect" in another network element.

Example: A single STM-16 LOS defect (dLOS) may cause a few thousand AIS defects (e.g. AU4dAISs, TU12dAISs) to be detected in the network and about one thousand RDI defects (e.g. MS16dRDI, VC4dRDIs, VC12dRDIs).

It shall therefore be provisionable to report AIS, SSF, RDI, or ODI as a fault cause. This is controlled by means of the parameters AIS_Reported, SSF_Reported, RDI_Reported, and ODI_Reported, respectively. The default for these parameters is "false".

NOTE 1 – dUNEQ, dTIM, dDEG and dRDI are cleared during an SSF/TSF condition.

NOTE 2 – In the MS_TT function, defects of the server layer are detected by dAIS from the K2 byte and not through SSF.

NOTE 3 – By default, AIS as such is not reported. Instead trail terminations shall report (as an option) that the server (layer) failed to pass the signal (Server Signal Fail) if they receive the all-ONEs (AIS) signal. This reduces the declaration of "AIS failures" to one failure (SSF) at the Trail Termination NE. No failures are generated at intermediate nodes in the (long) trail.

NOTE 4 – Refer to clause 6.1 for a MON description.

NOTE 5 – The detection of an unequipped VC signal is possible in a termination supervisory sink function despite both the supervisory-unequipped VC signal and the unequipped VC signal having signal label code "0". A trace identifier mismatch will be detected with the accepted trace identifier being all-ZEROs. This combination is the signature of the reception of an unequipped VC.

6.4.2 Adaptation sink function

cPLM ← dPLM and (not AI_TSF)

cAIS ← dAIS and (not AI_TSF) and (not dPLM) and AIS_Reported

cLOA ← dLOA and (not dAIS) and (not dPLM)

It shall be provisionable to report AIS as a fault cause. This is controlled by means of the parameter AIS_Reported. The default shall be AIS_Reported = false.

NOTE 1 – dLOA represents dLOF, dLOP or dLOM, whichever is applicable.

NOTE 2 – The specification of the Pointer Interpreter algorithm is such that either dAIS or dLOP can be declared, not both at the same time. Refer to Annex A.

6.4.3 Connection function

cFOP ← dFOP and (not CI_SSF)

6.5 One second performance monitoring filters

The one-second filters perform a simple integration of reported anomalies and defects by counting during a one-second interval. At the end of each one-second interval the contents of the counters is made available to the performance monitoring processes within the EMF for further processing (see ITU-T G.784 [16] for SDH). Generically the following (superset of) counter outputs will be provided:

– near-end/far-end errored block counts;
– near-end/far-end defect seconds;
– pointer justification counts (see ITU-T G.783 [9]).

This clause presents in generic terms the performance monitoring primitive generation within atomic functions. Specific details are presented in each atomic function (see specific equipment functional Recommendations ITU-T G.783 [9], G.705 [5]).

NOTE – Near-end/far-end processing includes also outgoing near-end/far-end processing.

6.5.1 Near-end Errored Block Count (pN_EBC)

Every second, the number of errored near-end blocks (N_Bs) within that second is counted as the Near-end Error Block Count (pN_EBC).

The errored near-end blocks (N_Bs) are defined in Table 6-11.

Table 6-11/G.806 – Near-end errored blocks definition

Hierarchy	Layer	Errored Block definition
SDH	RS1	One or more errors in the STM-1 frame detected by BIP-8
	RSn (n≥4)	For further study
	MS1/4/16/64	Number of errors in the STM-n frame detected by BIP-24*n
	MSn (n≥256)	For further study
	S4/3	One or more errors in the VC frame detected by BIP-8 (Note 2)
	S2/12/11	One or more errors in the VC frame detected by BIP-2 (Note 2)
	S4D/3D	One or more errors in the VC frame detected by IEC
	S2D/12D/11D	One or more errors in the VC frame detected by BIP-2
	S4T/3T	One or more errors in the VC frame detected by IEC
PDH with SDH frame	P4s/3s	One or more errors in the frame
PDH	P12s	One or more errors in the frame detected by CRC-4 or one or more errors detected in the frame alignment word
	P4e/31e/32e/22e	One or more errors detect in the frame alignment word

Table 6-11/G.806 – Near-end errored blocks definition *(concluded)*

NOTE 1 – For error detection refer to 8.3 and the specific equipment functional specifications (ITU-T G.783 [9], G.705 [5]).
NOTE 2 – For backward compatibility the specification is as follows: every second, the number of errors is counted and "translated" into the pN_EBC according to Annex C/G.826 [12].

6.5.2 Near-end Defect Second (pN_DS)

Every second with at least one occurrence of aTSF (e.g. CI_SSF, dAIS, dTIM, dUNEQ) or dEQ shall be indicated as a Near-end Defect Second (pN_DS).

pN_DS ← aTSF or dEQ

6.5.3 Far-end Errored Block Count (pF_EBC)

Every second, the number of errored far-end blocks (F_Bs) within that second is counted as the Far-end Error Block Count (pF_EBC).

The errored far-end blocks (F_Bs) are defined in Table 6-12.

Table 6-12/G.806 – Far-end errored blocks definition

Hierarchy	Layer	Errored Block definition
SDH	MS1/4/16	Number of errors indicated by REI in the STM-n frame
	MSn (n≥64)	For further study
	S4/3/2/12/11	One or more errors indicated by REI in the VC frame (Note 1)
	S4D/3D/2D/12D/11D	One or more errors indicated by REI in the VC frame
	S4T/3T	One or more errors indicated by REI in the VC frame
PDH with SDH frame	P4s/3s	One or more errors indicated by REI in the VC frame
PDH	P12s (Note 2)	One or more errors indicated by REI in the VC frame
NOTE 1 – For backward compatibility the specification is as follows: every second, the number of errors is counted and "translated" into the pF_EBC according to Annex C/G.826 [12].		
NOTE 2 – REI and far-end errored blocks are only supported if a CRC EDC is used.		

6.5.4 Far-end Defect Second (pF_DS)

Every second with at least one occurrence of dRDI shall be indicated as a Far-end Defect Second (pF_DS).

pF_DS ← dRDI

7 Information flow (XXX_MI) across the XXX_MP reference points

Table 7-1 summarizes the generic (superset) of configuration, provisioning and reporting information (MI) that is passed across the XXX_MP reference points for the three types of atomic functions. The information listed under Input ("Set") in this table refers to configuration and provisioning data that is passed from the EMF to the other functional blocks. The information listed under Output ("Get") refers to (autonomous) status reports to the EMF from the atomic functions.

NOTE – The configuration, provisioning and reporting information for a specific atomic function is listed in the I/O table in the atomic function description itself.

As an example we may consider the SDH higher order path trace. The SDH higher order path termination sink function may be provisioned for the HO path trace for what it should expect by a "MI_ExTI" command received from the manager. If the HO path trace that is received does not match the expected HO path trace, this will give rise to a report of a mismatch of the HO path trace across the Sn_TT_MP reference point (MI_cTIM). Having received this mismatch indication, the relevant managed object may then decide to request a report of the HO path trace ID that has been received by a "MI_AcTI" report.

Table 7-1/G.806 – Generic command, configuration, provisioning and reporting information flow over the XXX_MP reference points

Management Point	Process within atomic function	Input ("SET")	Output ("GET")
TT_So_MP	Trace identifier	Transmitted trail trace identifier (MI_TxTI) value	
TT_Sk_MP	Termination point/port mode	Termination Point mode control (MI_TPmode: MON, NMON) Port mode control (MI_Portmode: MON, (AUTO), NMON)	
	Continuity supervision		Signal loss fault cause (MI_cLOS, MI_cUNEQ, MI_cLTC)
	Connectivity supervision	Expected trail trace identifier (MI_ExTI) value Mis-connected traffic defect detection control (MI_TIMdis: true, false) Enable/disable AIS insertion on dTIM detection (MI_TIMAISdis: true, false)	Accepted (received) trail trace identifier value (MI_AcTI) Mis-connected traffic fault cause (MI_cTIM)
	Signal quality supervision	Poisson based excessive defect threshold selection (MI_EXC_X: 10^{-3},10^{-4}, 10^{-5}) Poisson based degraded defect threshold selection (MI_DEG_X: 10^{-5}, 10^{-6}, 10^{-7}, 10^{-8}, 10^{-9}) Burst based degraded defect interval threshold selection (MI_DEGTHR: 0..(30)..100% or 0...N) Burst based degraded defect monitor period selection (MI_DEGM: 2..10)	Poisson based excessive errors fault cause (MI_cEXC) Poisson based degraded errors fault cause (MI_cDEG) Burst based degraded errors fault cause (MI_cDEG)

Table 7-1/G.806 – Generic command, configuration, provisioning and reporting information flow over the XXX_MP reference points *(continued)*

Management Point	Process within atomic function	Input ("SET")	Output ("GET")
	Maintenance signals processing	AIS fault cause reporting control (MI_AIS_Reported: true, false)	AIS fault cause (MI_cAIS, MI_cIncAIS)
		SSF fault cause reporting control (MI_SSF_Reported: true, false)	SSF fault cause (MI_cSSF)
		RDI fault cause reporting control (MI_RDI_Reported: true, false)	RDI fault cause (MI_cRDI)
		ODI fault cause reporting control (MI_ODI_Reported: true, false)	ODI fault cause (MI_cODI)
	Performance monitoring	1 second period indications (MI_1second)	Performance monitoring primitives (MI_pN_EBC, MI_pN_DS, MI_pF_EBC, MI_pF_DS, ...)
A_So_MP	Selection	Payload composition selection (MI_Active: true, false)	
	Performance monitoring		Performance monitoring justification actions (MI_pPJC+, MI_pPJC−)
A_Sk_MP	Selection	Payload composition selection (MI_Active: true, false)	
	Maintenance signal processing	AIS fault cause reporting control (MI_AIS_Reported: true, false)	AIS fault cause (MI_cAIS)
	Payload type supervision		Accepted (received) payload type value (MI_AcSL) Mis-composed traffic fault cause (MI_cPLM)
	Alignment supervision		Alignment loss fault cause (MI_cLOF, MI_cLOM, MI_cLOP)

Table 7-1/G.806 – Generic command, configuration, provisioning and reporting information flow over the XXX_MP reference points ***(concluded)***

Management Point	Process within atomic function	Input ("SET")	Output ("GET")
C_MP	Connection management	Matrix connection selection	
	Protection	Protection group selection (set of connection points, protection architecture: 1+1/1:n/m:n, switching type: uni/bidirectional, operation type: revertive/non-revertive, APS usage: true/false, extra traffic: true/false) External Switch commands (MI_ExtCmd: LO, FS, MS, EXER, CLR) External control command (LOW) HoldOff time value (MI_HOtime) WaitToRestore value (MI_WTRtime: 0..(5)..12 minutes)	Protocol fault cause (MI_cFOP) Protection status (for further study)
NOTE – Underscored values are suggested defaults.			

8 Generic processes

8.1 Line coding and scrambling processes

For the transmission of a digital signal via a physical media special conditioning of the signal is required in order to:

– have sufficient signal changes for clock recovery;

– avoid a DC level for the transmission.

Line coding or scrambling can be used for this task. Refer to the specific equipment functional specifications (ITU-T G.783 [9], G.705 [5]) for details.

8.2 Alignment processes

Alignment processes:

– recover the (multi)frame start of a client signal within the server signal;

– recover the (multi)frame start of overhead information;

– realign individual signals to a common frame phase.

For (multi)frame start recovery two different processes can be used, frame alignment signal processing and pointer processing.

In the case of frame alignment signal processing a distinct bit pattern (the frame alignment signal FAS) is part of the frame that has to be recovered as shown in Figure 8-1. The FAS indicates a position within the frame, normally the frame start. Note that the pattern might be distributed over the frame. The FAS is inserted at the source. The sink searches for the FAS pattern and recovers the frame start based on it. If frame alignment cannot be established this is indicated by the out-of-frame (OOF) condition. If frame alignment is established this is indicated by the in-frame (IF) condition. Based on these conditions a loss of alignment defect (LOA) is generated. For details refer to the specific equipment functional Recommendations (ITU-T G.783 [9], G.705 [5]).

NOTE – In the case of multiframe alignment the terms out of multiframe (OOM) and in multiframe (IM) might be used.

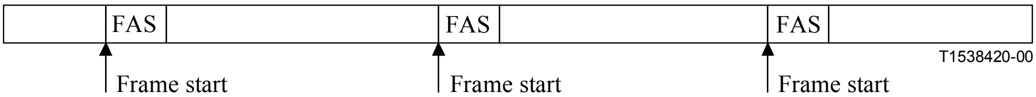


Figure 8-1/G.806 – Frame alignment signal

In the case of pointer processing the position of the client layer frame start within the server layer frame is indicated by a position indicator (the pointer) which is part of the server layer overhead as shown in Figure 8-2. The source generates the pointer based on the position of the client signal within the server frame. The sink recovers the pointer and identifies the client frame start based on the pointer. If the pointer cannot be recovered correctly a loss of pointer defect (LOP) shall be declared. For details refer to the specific equipment functional Recommendation (ITU-T G.783 [9]).

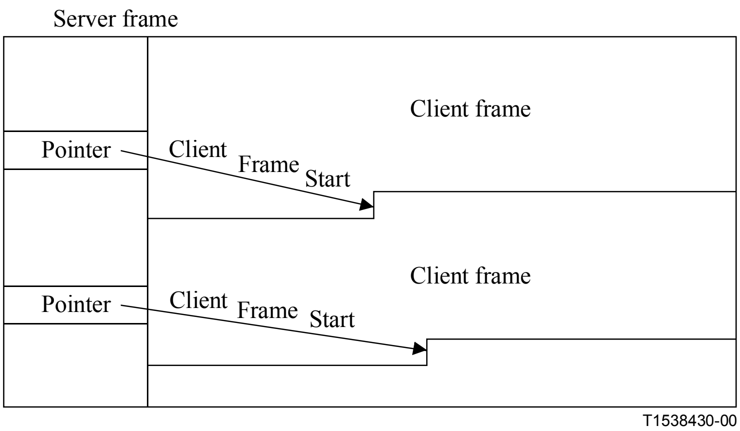


Figure 8-2/G.806 – Pointer

For other specific alignment processes refer to the specific equipment functional specifications (ITU-T G.783 [9], G.705 [5]).

8.3 Performance supervision process

The performance supervision process monitors the quality of the trail between the source and the sink. For a digital signal the process will provide information on bit errors and depends on some kind of error detection code (EDC). Different kinds of supervision processes are possible.

Figure 8-3 shows a pattern based signal quality supervision. A known pattern (e.g. framing pattern) is inserted at the source. The sink extracts this pattern and compares it with the expected one. Any difference between the expected and received pattern is an indication of errors. Note that this kind of error monitoring detects only errors in the supervised pattern and not in the whole signal. It is assumed that the rest of the signal is affected by errors in the same way as the supervised pattern.

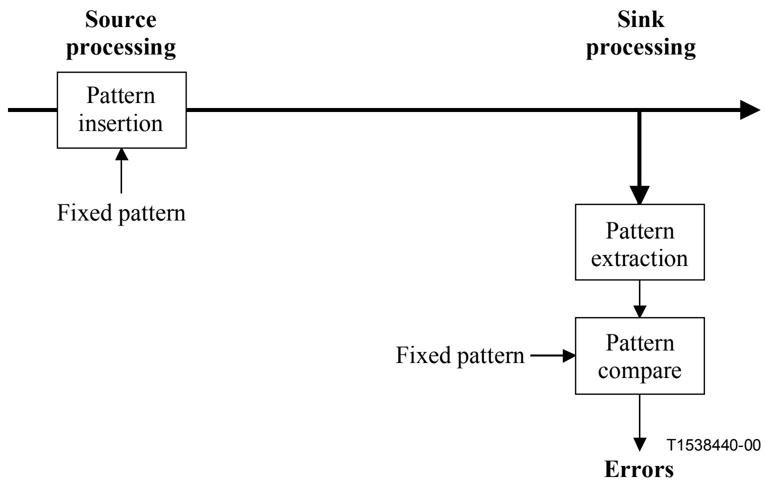


Figure 8-3/G.806 – Pattern based signal quality supervision

Figure 8-4 shows a signature based signal quality supervision. The signature is calculated over the signal or parts of the signal at the source and inserted into the signal. At the sink the signature is calculated again and compared with the received signature. Any difference between calculated and received signature indicates an error. Popular signatures are cyclic redundancy check (CRC) and bit interleaved parity (BIP). Note that the signature itself might be part of the next signature calculation as shown by the dotted lines in Figure 8-4. The signature is calculated over the signal frame and transmitted in the following frame as shown in Figure 8-5. Which part of the frame is included into the calculation depends on the specific layer network.

Refer to ITU-T G.707 [6] for a definition of BIP-N.

Refer to ITU-T G.704 [4] for a definition of CRC-4.

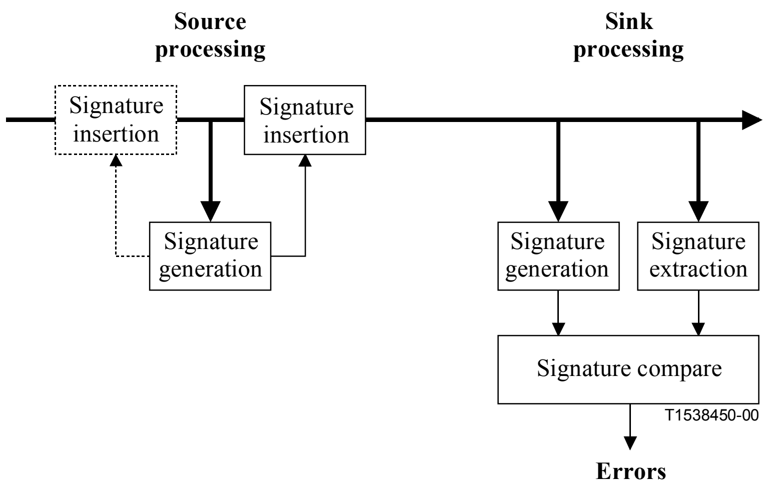


Figure 8-4/G.806 – Signature based signal quality supervision

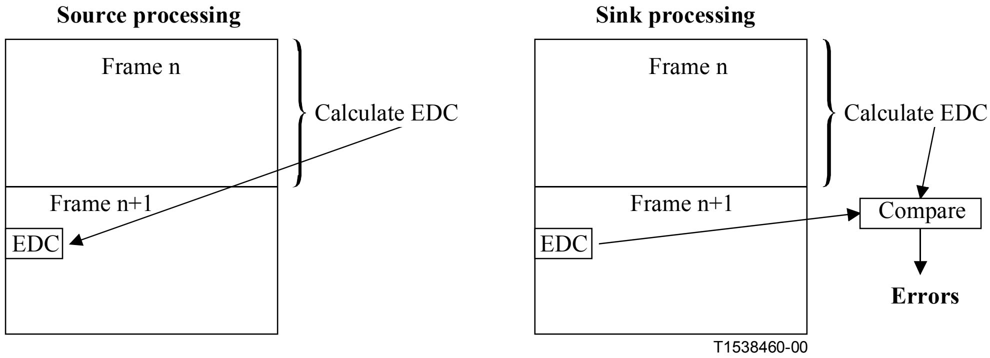


Figure 8-5/G.806 – Signature based signal quality supervision example

If an EDC already exists in the signal (e.g. sublayer supervision) and it can differentiate between different amounts of errors, it can be used for the error supervision as shown in Figure 8-6. At the source the errors are calculated based on the existing EDC. The result is the incoming error count (IEC) which is sent to the sink. At the sink the errors are again calculated based on the existing EDC and compared with the received IEC. Any difference between local errors and received IEC indicates errors between source and sink. Figure 8-7 shows an example for an IEC based signal quality supervision with a BIP EDC. As this kind of supervision depends on an incoming EDC, the behaviour for the case that this incoming EDC is missing has to be carefully defined.

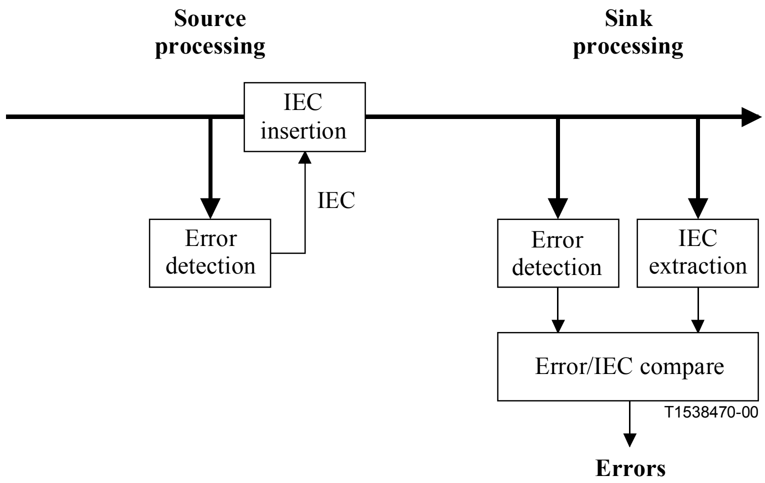


Figure 8-6/G.806 – IEC based signal quality supervision

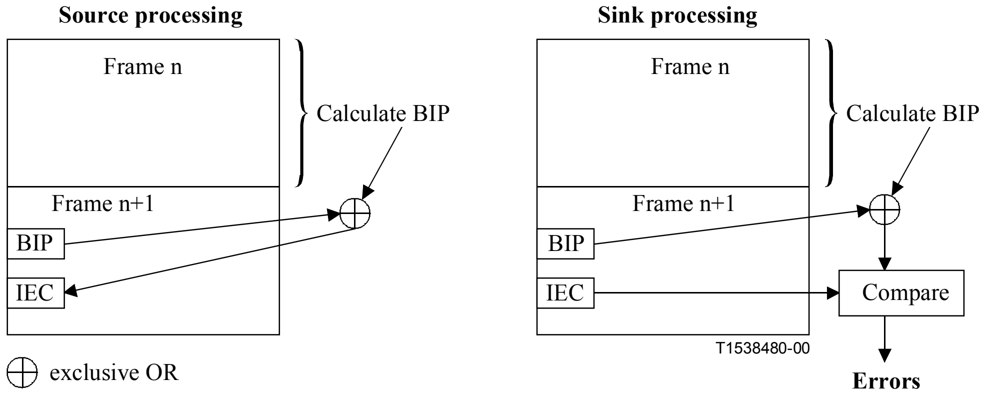


Figure 8-7/G.806 – IEC based signal quality supervision example

8.4 BIP correction

In some cases the overhead of the signal is overwritten along the trail (e.g. sublayer supervision). If this overhead is part of the EDC signature calculation the signature has to be corrected accordingly in order to avoid the detection of errors at the sink. For a BIP type signature the correction can be performed as shown in Figure 8-8. The BIP is calculated before and after the overhead insertion. Both results and the related incoming BIP overhead (which is usually transported in the following frame) are combined via an exclusive OR and form the new BIP overhead for the outgoing signal. The related processes are shown in Figure 8-9.

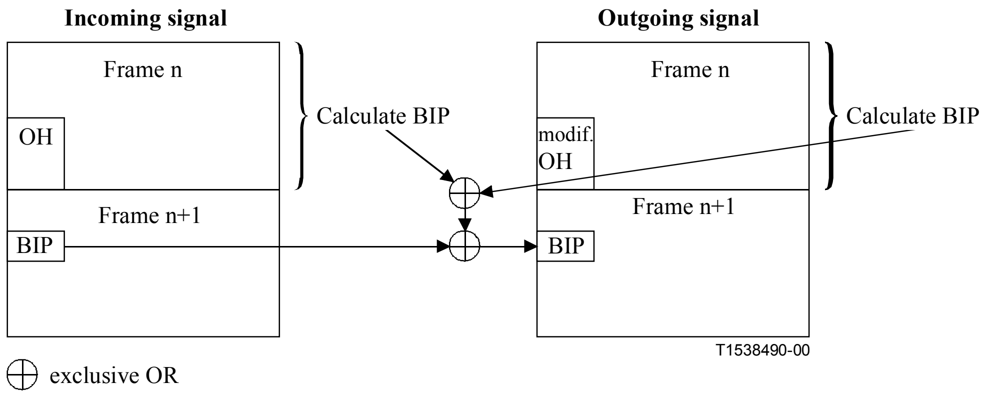


Figure 8-8/G.806 – BIP correction; functionality

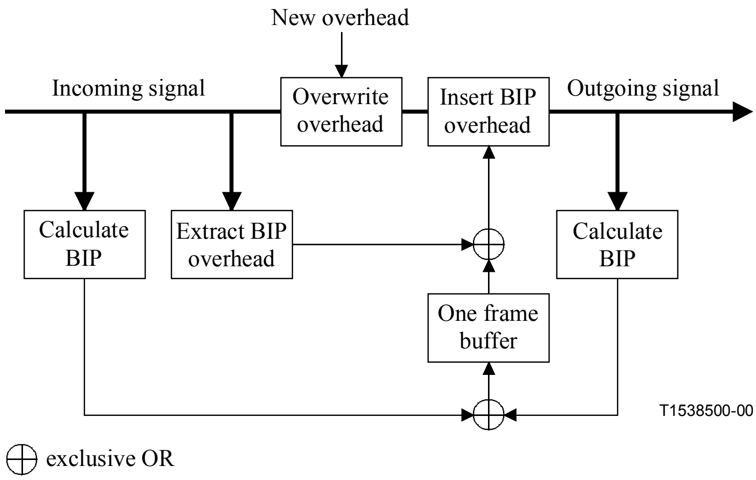


Figure 8-9/G.806 – BIP correction; processes

9 Performance and reliability

9.1 Transit delay

To derive the total transit delay of a signal through a network element, all processes that could contribute non-negligible delay, must be taken into account. Since it is only possible to measure transit delay from NNI to NNI, that value is the only one which must be derived.

The contributing processes which have been identified to date are:

– Pointer buffer processing. (A distinction could be made between pointer buffer threshold spacing and pointer adjustment processes.)
– Fixed stuff processing. Overhead could be regarded as fixed stuffing for a particular signal.
– Processing which is implementation-dependent, e.g. internal interface processing.
– Connection processing.
– Mapping processing.
– Demapping processing.

Depending on NNI and processing levels, several of the above-mentioned processes must be taken into account. The total delay is then calculated as the sum of the processes involved. These values could be given as minimum, average, or maximum values under normal operating conditions or in worst-case failure scenarios.

Another parameter associated with delay is the differential transit delay of path signals within the same server trail.

NOTE – Specifications of transit delay and differential transit delay are outside the scope of this Recommendation.

9.2 Response times

Matrix set-up delay is the time taken from generation of primitive within the EMF to the change of transport information at NNI. It may be necessary to distinguish between preset configurations, subject to an execute primitive and a normal set.

Message processing delay is the time from the end of message at Q until the primitive is generated within the EMF, i.e. the message has been decoded to an actionable level.

NOTE – Specifications of response times are outside the scope of this Recommendation.

9.3 Availability and reliability

For a network provider, the reliability of network elements is of prime concern as it directly influences the availability of connections. However, the availability of a connection depends not only on the reliability of the network elements themselves but also on the level of network redundancy. Furthermore, it depends on the restoration times of the equipment involved. The restoration times depend to a great extent on the Operation, Administration and Management (OAM) philosophy of the network provider.

A manufacturer has, in most cases, requirements from several operators to take into account. Requirements from a certain network provider will depend on the level of economic development of the country concerned, the degree of market competition, customer requirements, the level of network redundancy, the level of maintenance support, etc.

The basis for determining the availability of a network element should be the analytical method for dependability as described in ITU-T E.862 [1].

The main point of the analytical method is that dependability aspects are taken into account as an economic factor. The level of availability is thus dimensioned according to cost-benefit analyses rather than by beforehand stated objectives.

The application of the method to network components is shown in the ITU-T handbook "Handbook on Quality of Service and Network Performance".

Parameters and calculation methodologies for reliability and availability are defined in ITU-T G.911 [15].

NOTE – Availability and reliability specifications for network elements and trail/connections are outside the scope of this Recommendation.

9.4 Laser safety

For safety considerations, it may be necessary to provide for an automatic power shutdown (APSD) or automatic laser shutdown (ALS) facility of the laser in case of cable break. Refer to ITU-T G.664 [2].

APPENDIX I

Connection matrix examples

The connection function as defined in 5.6 is highly flexible, providing full flexibility between its inputs and outputs (see I.1). However the connectivity might be limited due to implementation constrains. Examples are:

– No support of point-to-multipoint connections (broadcast).

– Support of bidirectional connections only.

– Blocking in a multi-stage connection matrix.

– No connections within a group of ports (e.g. between add and drop ports of an add/drop matrix) (see I.2, I.3, I.4, I.5).

If multiplexing is used for the transport of several client signals in a server layer, the client signals have to be assigned to certain address slots (e.g. time slots, frequency/wavelength slots). The address slot assignment is part of the adaptation function to the server layer. An implementation might not support the interchange of address slots of client signals between all or a set of server signals. This is modelled by a connection matrix that allows only connections between ports with identical address slots in the server layer (see I.4, I.6).

NOTE – The model assumes that the address slot is only assigned to the client signal along the server layer trail (between adaptation source and adaptation sink) and no address slot is assigned to the client signal outside of this trail. Some signals, however, have this address slot assigned even outside the server layer trail (e.g. wavelength of an optical signal). If the original assignment is performed in the network element itself possible connections might be modelled as shown above. If the assignment is, however, done in another network element, possible connections can only be identified from the network view and not locally in the network element itself.

One possibility to represent limited connectivity is to group ports together and define the connectivity between these ports as shown below.

I.1 Connection matrix example for full connectivity

The set of input and output ports is not divided into groups, as shown in Figure I-1. This CM allows full connectivity as given in Table I.1.

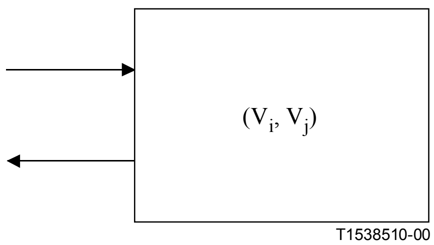


Figure I.1/G.806 – Connection matrix example for full connectivity

Table I.1/G.806 – Connection matrix example for full connectivity

	$\mathbf{V_j}$
$\mathbf{V_i}$	X
X Indicates V_i-V_j connection possible for any i and j	

I.2 Connection matrix example for 2-port groups

The set of input and output ports is divided into two groups, each containing both input and output ports – Line (L) and Tributary (T) as shown in Figure I.2. This CM allows only connectivity between L and T, but not within the L and T group (except for loopbacks) as given in Table I.2.

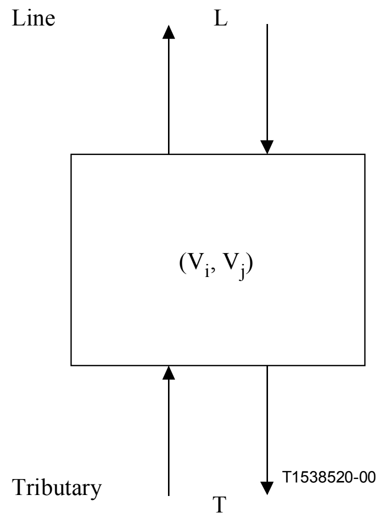


Figure I.2/G.806 – Connection matrix example for 2-port groups

Table I.2/G.806 – Connection matrix example for 2-port groups

		V_i	
		L	**T**
V_j	**L**	i = j	X
	T	X	i = j

X Indicates V_i-V_j connection possible for any i and j

i = j Indicates V_i-V_j connections possible only in the case that i = j (e.g. loopback)

I.3 Connection matrix example for 3-port groups type I

The set of input and output ports is divided into three groups, each containing both input and output ports – West (W), East (E), Add/Drop (A/D) as shown in Figure I.3. This CM allows connectivity between the groups, but not within the groups as given in Table I.3.

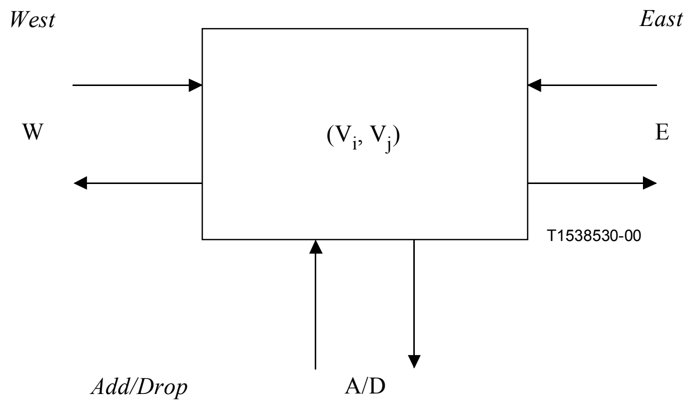


Figure I.3/G.806 – Connection matrix example for 3-port groups

Table I.3/G.806 – Connection matrix example for 3-port groups type I

		V_i		
		W	**E**	**A/D**
V_j	**W**	–	X	X
	E	X	–	X
	A/D	X	X	–

X Indicates V_i-V_j connection possible for any i and j
– Indicates no connection possible

I.4 Connection matrix example for 3-port groups type II

The set of input and output ports is divided into three groups, each containing both input and output ports - West (W), East (E), Add/Drop (A/D) as shown in Figure I.3. In addition to the limitations of type I above connections from W to E and E to W are limited to the same address slot (indicated by identical indices) as shown in Table I.4.

Table I.4/G.806 – Connection matrix example for 3-port groups type II

		V_i		
		W	**E**	**A/D**
V_j	**W**	–	i = j	X
	E	i = j	–	X
	A/D	X	X	–

X Indicates V_i-V_j connection possible for any i and j
i = j indicates V_i-V_j connections possible only in the case that i = j (e.g. no address slot interchange)
– Indicates no connection possible

I.5 Connection matrix example for 4-port groups type I

The set of input and output ports is divided into four groups, each containing both input and output ports – West (W), East (E), Add/Drop East (A/DE), and Add/Drop West (A/DW) as shown in Figure I.4. This CM allows connectivity between W and E, W and DW and E and EW as given in Table I.5.

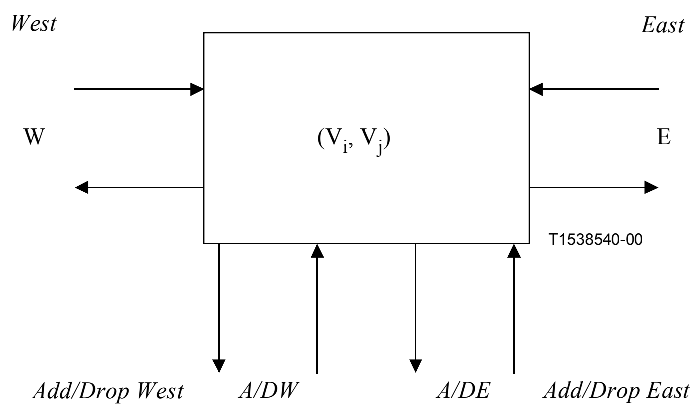


Figure I.4/G.806 – Connection matrix example for 4-port groups

Table I.5/G.806 – Connection matrix example for 4-port groups type I

		V_i			
		W	**E**	**A/DW**	**A/DE**
V_j	**W**	–	X	X	–
	E	X	–	–	X
	A/DW	X	–	–	–
	A/DE	–	X	–	–

X Indicates V_i-V_j connection possible for any i and j
– Indicates no connection possible

I.6 Connection matrix example for 4-port groups type II

The set of input and output ports is divided into four subsets, each containing both input and output ports – West (W), East (E), Add/Drop East (A/DE), and Add/Drop West (A/DW) as shown in Figure I.4. In addition to the limitations of type I above connections from W to E and E to W are limited to the same address slot (indicated by identical indices) as given in Table I.6.

Table I.6/G.806 – Connection matrix example for 4-port groups type II

		V_i			
		W	**E**	**A/DW**	**A/DE**
V_j	**W**	–	i = j	X	–
	E	i = j	–	–	X
	A/DW	X	–	–	–
	A/DE	–	X	–	–

X Indicates V_i-V_j connection possible for any i and j
i = j Indicates V_i-V_j connections possible only in the case that i = j (i.e. loopback, no reconfiguration)
– Indicates no connection possible

I.7 Example of a provisioned connection matrix

Table I.7 shows an example of a provisioned connection matrix with unconnected connection points and unprotected, 1+1 SNC/I protected, 1+1 SNC/N protected, unidirectional and bidirectional matrix connections.

Table I.7/G.806 – Example of a provisioned connection matrix

Connection Inputs Id	Connection Outputs Id	Traffic direction	Protection
id #01	–	–	–
id #25	–	–	–
id #65	id #52	Unidirectional	unprotected
id #91	id #22	Bidirectional	unprotected
id #69	(N: id #88, P: id #35)	Unidirectional	1+1 SNC/N
(N: id #88, P: id #35)	id #69	Unidirectional	1+1 SNC/N
id #03	(N: id #11, P: id #13)	bidirectional	1+1 SNC/N
id #77	(N: id #88, P: id #35)	Unidirectional	1+1 SNC/I
(N: id #09, P: id #51)	id #42	Unidirectional	1+1 SNC/I
id #10	(N: id #56, P: id #15)	Bidirectional	1+1 SNC/I
...			
NOTE 1 – In order to simplify the content of this table, the connection inputs and outputs are simply identified by an identifier number (id #). In case of SDH refer to ITU-T G.784 [16] for the correct identification. NOTE 2 – The notation (N: xxx, P: yyy) identifies the normal and protection trails in case of SNC protection.			

APPENDIX II

Example of remote indication operation

In order to support single ended operation, the defect status and the number of detected error detection code violations of the characteristic information monitored at the trail termination sink shall be conveyed back to the far-end trail termination source (via RDI and REI signals). Hence, in the case where the terminations lie in the domains of different operators, the Operations Systems (OS) in both networks will have access to performance information from both trail ends, without the need for OS to OS information exchange.

II.1 Remote Defect Indication (RDI)

RDI signals convey the defect status of the trail signal at the trail destination (i.e. at trail termination sink function) back to the trail origin (i.e. trail termination source function). This mechanism allows alignment of the near-end and far-end performance monitoring processes.

Examples of RDI signals are the RDI bits in SDH signals, the A-bit in ITU-T G.704 [4] structured 2 Mbit/s signals and the alarm indication bit in other PDH multiplex signals.

Figure II.1 illustrates the RDI insertion and detection/processing for a multiplex section. Figure II.2 illustrates the process for a VC-4 Path:

– at node A the near-end information represents the performance of the unidirectional section/path from B to A, while the far-end information represents the performance of the unidirectional section/path from A to B;

– at node B the near-end information represents the performance of the unidirectional section/path from A to B, while the far-end information represents the performance of the unidirectional section/path from B to A.

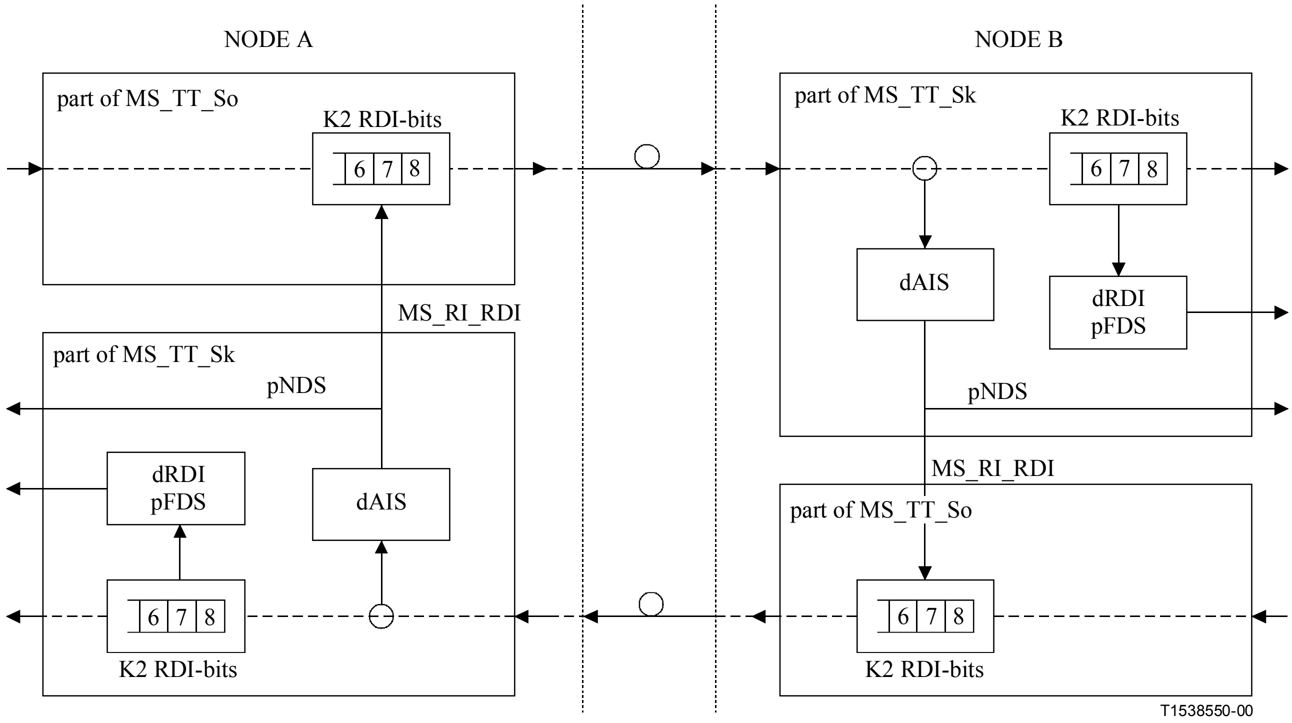


Figure II.1/G.806 – RDI insertion control example (multiplex section)

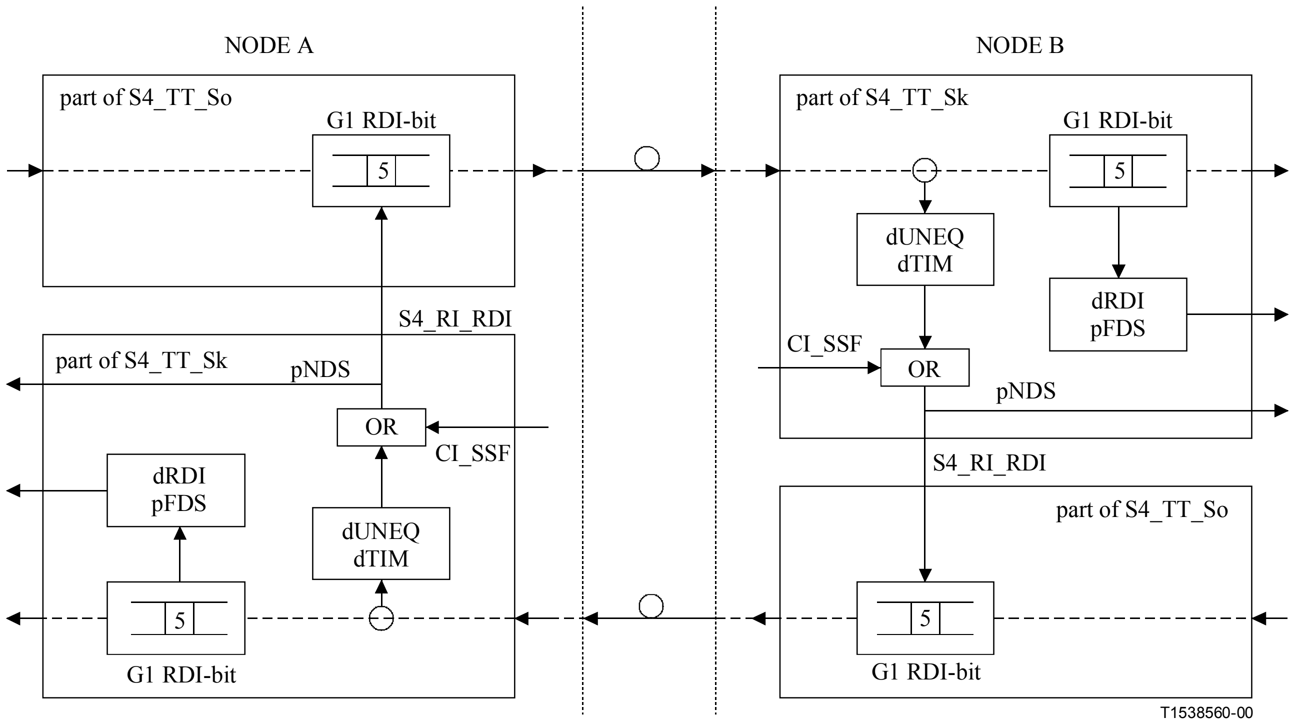


Figure II.2/G.806 – RDI insertion control example (VC-4 path)

II.2 Remote Error Indication (REI)

REI signals contain either the exact or truncated[3] number of error detection code violations detected in the trail signal at the trail termination sink. This information is conveyed to the trail termination source. This mechanism allows alignment of the near-end and far-end performance monitoring processes. Examples of REI signals are the REI bits in SDH signals and the E-bit in ITU-T G.704 [4] structured 2 Mbit/s signals.

Figure II.3 illustrates the REI insertion and extraction/processing for a VC-4 bidirectional path:

– at node A the near-end information represents the performance of the unidirectional path from B to A, while the far-end information represents the performance of the unidirectional path from A to B;

– at node B the near-end information represents the performance of the unidirectional path from A to B, while the far-end information represents the performance of the unidirectional path from B to A.

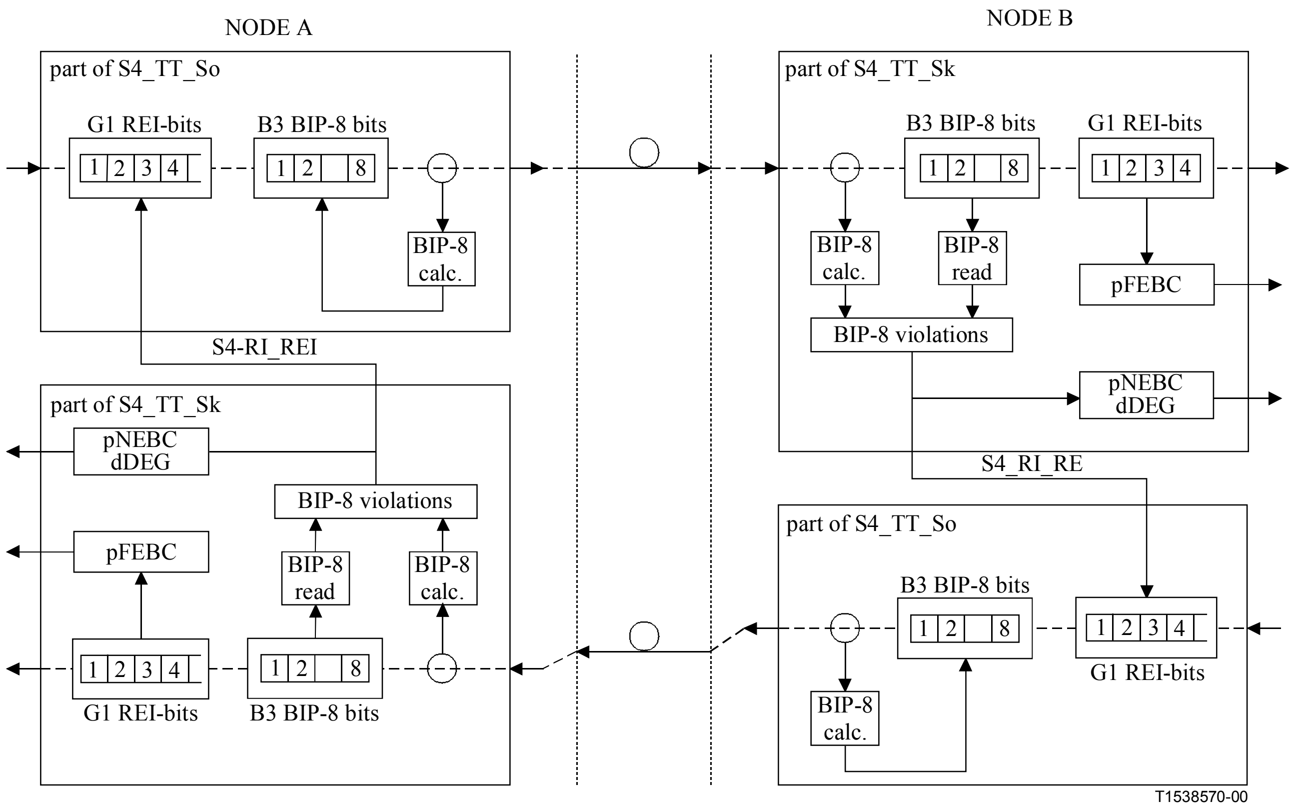


Figure II.3/G.806 – REI insertion control example (VC-4 path)

[3] Refer to the specific atomic functions to determine between exact or truncated number of EDCV transport in the REI.

APPENDIX III

Alarm Indication Signal (AIS)

The AlS is an all-ONEs characteristic or adapted information signal. It is generated to replace the normal traffic signal when it contains a defect condition in order to prevent consequential downstream failures being declared and alarms being raised.

All-ONEs (AIS) insertion in the sink direction is controlled as follows: every atomic function inserts all-ONEs on locally detected defects only, with one of the defects being incoming AIS from upstream atomic functions.

Figure III.1 illustrates this process. Due to a LOF defect (STM1dLOF) the OS1/RS1_A_Sk inserts the all-ONEs signal. This signal is propagated through the RS1 layer. The MS1_TT_Sk detects this all-ONEs signal by monitoring bits 6 to 8 of K2. The MS1/S4_A_Sk detects the all-ONEs signal by monitoring the pointer bytes H1, H2. As a consequence both functions insert all-ONEs at their outputs (i.e. they "refresh" the all-ONEs signal). This behaviour is continued in the other client layers.

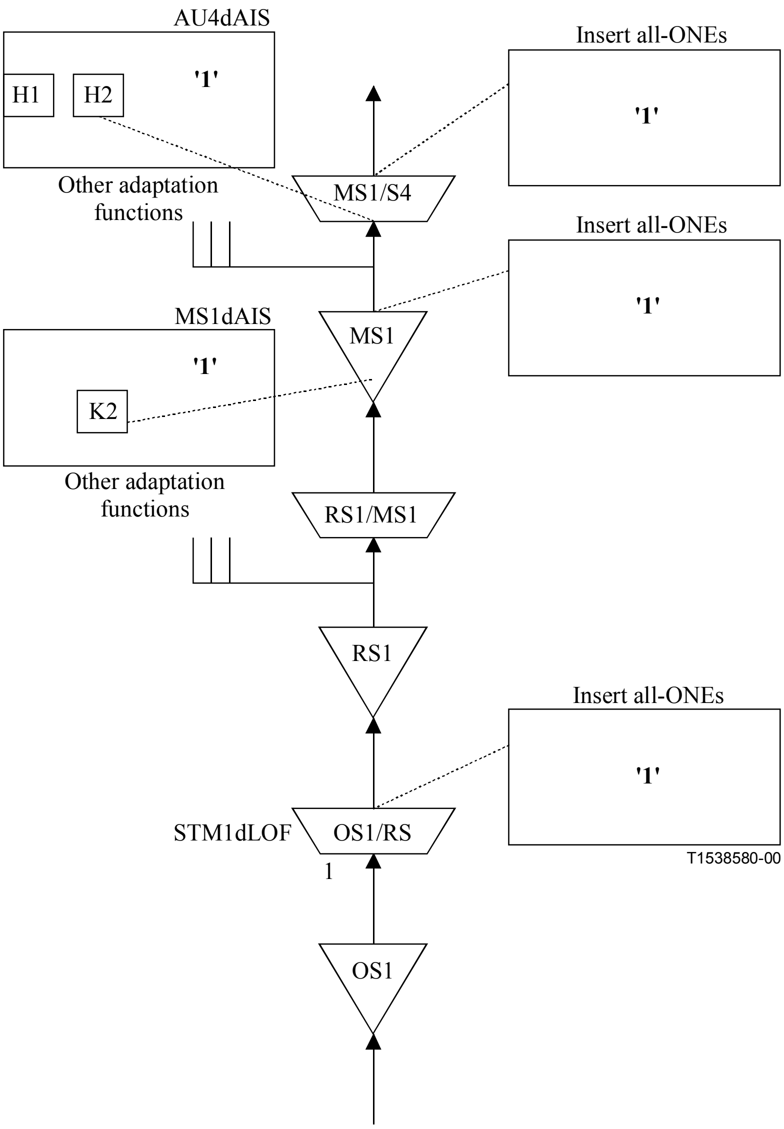


Figure III.1/G.806 – All-ONEs (AIS) insertion and propagation in the sink direction in case of STM1dLOF

As soon as the direction through the layered structure reverts from the sink direction into the source direction, the all-ONEs (AIS) signal becomes one of the defined AIS patterns:

– MSn-AIS (n=1,4,16) in case the RSn/MSn_A_Sk is connected to the RSn/MSn_A_So. This is the case in an STM-n regenerator;

– AU-4-AIS in case the MSn/S4_A_Sk is connected to the MSn/S4_A_So. This is the case in a VC-4 Add-Drop Multiplexer and a VC-4 Digital Cross-Connect (Figure III.2);

– TUm-AIS (m=12,2,3) in case the S4/Sm_A_Sk is connected to the S4/Sm_A_So. This is the case in a VC-m ADM and a VC-m DXC;

– PDH AIS: Ex-AIS, a complete all-ONEs signal, in the G.703 type signal.

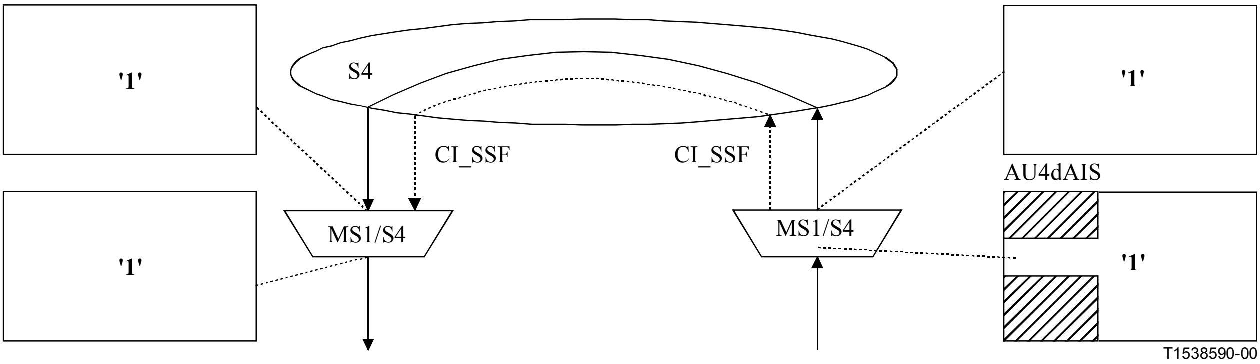


Figure III.2/G.806 – All-ONEs propagation from sink to source direction

The all-ONEs and CI_SSF signal applied at the input of the MS1/S4_A_So (Figure III.3) results in the generation of an all-ONEs signal at the output. The MS1_TT_So and the other MS1 adaptation functions (e.g. MS1/OW_A_So) add the MSOH to the all-ONEs signal. The RS1_TT_So and the RS1 adaptation functions add the RSOH. The result is the so-called AU-4 AIS signal. This signal is transmitted to the far-end. The STM-1 signal passes through the functions up to the MS1_TT_Sk. Then the MS1/S4_A_Sk function detects AU-4 AIS. It declares the AU4dAIS defect and inserts all-ONEs at its output.

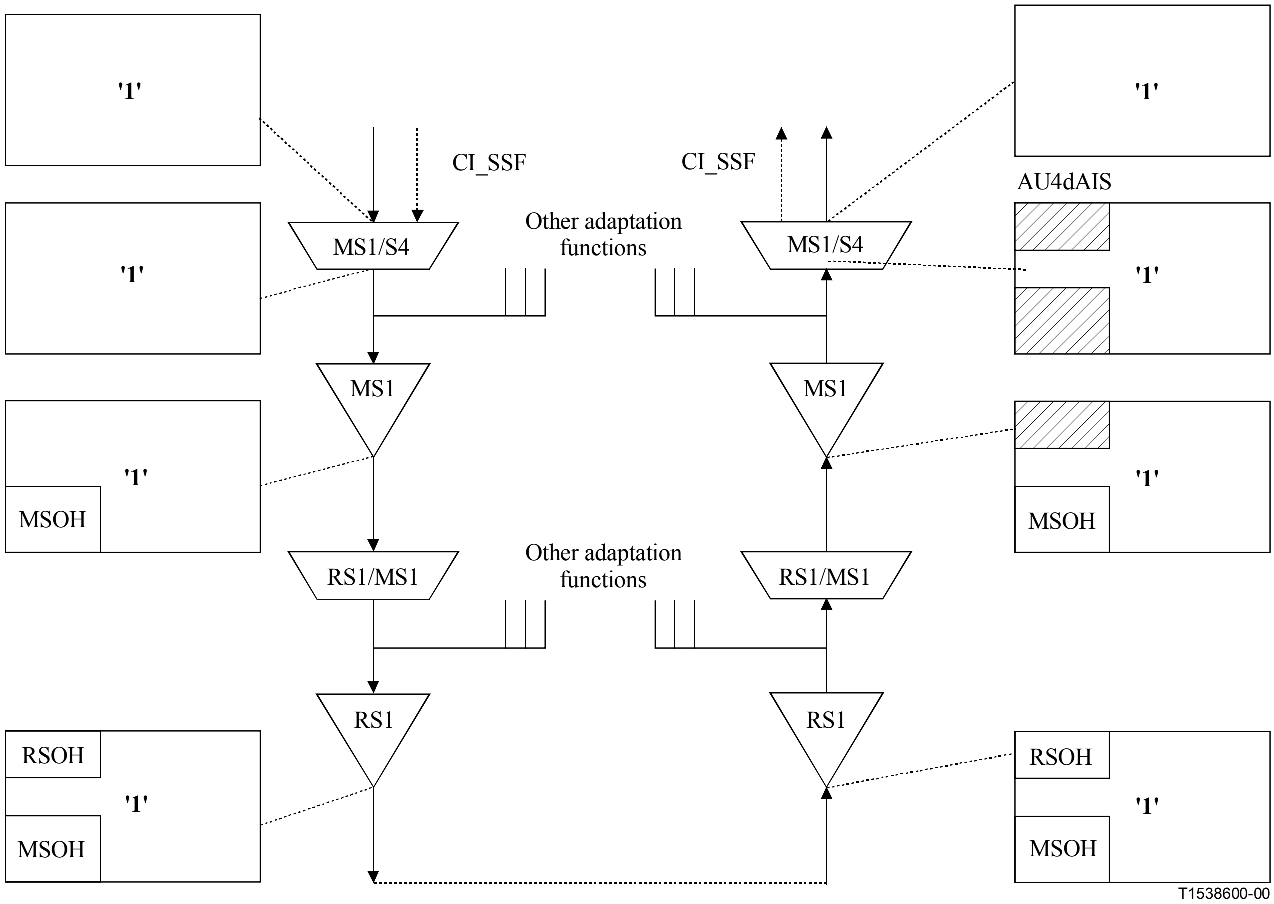


Figure III.3/G.806 – All-ONEs (AIS) generation in the source and detection in the sink direction

Similarly, the reception of an all-ONEs signal at the S4/S12_A_So results in the generation of an all-ONEs (TU) signal at the output of the function. This signal is multiplexed with the other TUs, after which the VC-4 overhead, AU-4 pointer, MSOH and RSOH are added. The result is an STM-N signal with a TU carrying TU-AIS.

APPENDIX IV

Signal Fail (SF) and Signal Degrade (SD)

IV.1 Server Signal Fail (SSF) signal

The CI_SSF signal (generated by the adaptation sink function under control of aSSF) informs the next downstream function of the "signal fail" condition of the associated data signal [which contains, due to that "signal fail" condition, the all-ONEs (AIS) pattern].

The CI_SSF signal, when connected to a connection function with protection functionality, represents the Signal Fail (SF) conditions.

IV.2 Server Signal Degrade (aSSD) signal

The CI_SSD signal informs the next downstream function of the "signal degrade" condition of the associated data signal.

The CI_SSD signal is defined only in adaptation sink function in protection sublayers. The signal relays the AI_TSD signal generated by the trail termination sink function towards the protection connection function in the protection sublayer.

IV.3 Trail Signal Fail (TSF) signal

The AI_TSF signal (generated by a trail termination sink function under control of aTSF) informs the next downstream function(s) of the "signal fail" condition of the associated data signal [which contains, due to that "signal fail" condition, the all-ONEs (AIS) pattern].

The AI_TSF signal, when connected to a connection function with protection functionality, represents a Signal Fail (SF) condition.

IV.4 Trail Signal Degrade (TSD) signal

The AI_TSD signal (generated by a trail termination sink function under control of aTSD) informs the next function(s) of the "signal degrade" condition of the associated data signal.

The AI_TSD signal is only connected to a connection function with protection functionality, and represents the Signal Degrade (SD) conditions.

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Geneva, 2001