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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Infrastructure of audiovisual services – Communication procedures

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Gateway control protocol: Stream endpoint interlinkage package

Recommendation ITU-T H.248.92

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Recommendation ITU-T H.248.92

Gateway control protocol: Stream endpoint interlinkage package

Summary

The interlinkage of stream endpoints (SEP) relates to the empowerment of the MG by the MGC to perform the interconnection of two protocol endpoints. The interlinkage relates to abstracted bearer control protocol procedures as mainly part of the bearer establishment and release. The pair of protocol endpoints might be located in a single SEP or in different SEPs, leading to so-called intra-SEP and inter-SEP interlinkage configurations. Recommendation ITU-T H.248.92 defines an ITU-T H.248 package that allows the MGC to signal such interlinkage configurations to the MG. The discussion of use cases, models and examples complements the description of the ITU-T H.248 protocol extensions.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T H.248.92	2014-10-14	16	11.1002/1000/12243

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FOREWORD

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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1 Scope

The ITU-T H.248 media gateway bearer interface protocol stack may contain principally connectionless and connection-oriented protocols. The concerned protocol layer(s) from ITU-T H.248 perspective, i.e., which are in scope of the ITU-T H.248 Stream Descriptors, are typically a network layer (L3) and higher. Connection-oriented protocols are known from L2 onwards in general, and in case of IP from L4 and higher concerning with respect to basic reference models for layered protocol architectures.

Connection-oriented protocols are characterized by explicit bearer connection control procedures, related to the establishment, modification and/or release of a bearer connection. Normally, the media gateway (MG) as slave is triggered by the master media gateway controller (MGC) for a particular bearer connection control procedure, and then autonomously executing such a procedure at the bearer interface related to a particular ITU-T H.248 termination (T)/stream endpoint (SEP).

The end-to-end bearer plane connectivity typically implies scenarios where multiple SEPs are interconnected in an ITU-T H.248 context. SEP-individual bearer control procedures are then often interlinked; e.g., an incoming bearer connection establishment procedure (at one SEP) could lead to an outgoing bearer connection establishment procedure (at a partner SEP), – at the same or at a different protocol layer.

An MGC may wish to individually control each of these procedures (so called MGC-strictly controlled mode). However, there are many use cases where the MGC could benefit from a delegation of "interlinkage work" down to the MG itself.

Such kind of behaviour is the purpose of this Recommendation.

An ITU-T H.248 package, called the "*stream endpoint interlinkage*" package (text codepoint '*seplink*'), is defined in a generic manner, which represents a flexible tool to enable a wide range of interlinkage options.

The supported interlinkage

– is limited to a single context,

– is direction dependent,

and allows the interlinkage

– of protocol endpoints, at the same or different layers, in different SEPs ("inter-SEP interlinkage"), and

– of protocol endpoints at different layers within an individual SEP ("intra-SEP interlinkage"),

and

– allows multiple interlinkage configurations to be assigned to an individual SEP.

1.1 Applicability statements

The capability of "interlinkage" relates to the MG internal forwarding of protocol control information (PCI) between different SEPs and/or different protocol layers. A layered protocol architecture is thus associated with a SEP.

The interlinkage capability is limited to protocol stack segments, which may be unambiguously described via the mechanism in clause 7.1.1.

The defined interlinkage capability is generic, i.e., applicable for all kind of connection-oriented bearer protocols. However, the focus of the initial package version is tightly coupled with protocols related to IP.

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; 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. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T H.248.1] Recommendation ITU-T H.248.1 (2013), *Gateway control protocol: Version 3*.

[ITU-T H.248.89] Recommendation ITU-T H.248.89 (2014), *Gateway control protocol: TCP support packages.*

[ITU-T X.200] Recommendation ITU-T X.200 (1994) | ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The basic model*.

[IETF RFC 4566] IETF RFC 4566 (2006), *SDP: Session Description Protocol*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 stream endpoint (SEP) [ITU-T H.248.1]: Relates to a stream associated to a Termination. A SEP is identified by the tuple of *StreamID* and *TerminationID* values.

3.1.2 stream endpoint pair (SEPP) [ITU-T H.248.1]: Two associated stream endpoints (SEP) of two Terminations within the same Context. The two SEPs share thus the same *StreamID* value. There is always a point-to-point topology for stream endpoint pair configurations (e.g., there is no further associated SEP on a third Termination etc.).

3.2.3 stream endpoint tuple (SEPT) [b-ITU-T H-Sup.13]: The generalization of a stream endpoint pair (SEPP) towards multiple associated stream endpoints (SEPs) within the same Context. All SEPs share thus the same *StreamID* value. The stream topology is given by the topology descriptor settings.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 interlinkage: The media gateway controller (MGC) empowered interconnection of two protocol endpoints. The two protocol endpoints are associated to a single stream endpoint (SEP) or different SEPs within the same context. The media gateway (MG) is enabled for autonomously forwarding of indicated stimuli from the source protocol endpoint to the destination endpoint. The stimuli relates to abstracted control information (and not any real layer x (Lx) protocol control information).

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ABNF	Augmented Backus-Naur Format
EP	Endpoint
IP	Internet Protocol
L2, L3, L4	(Protocol) Layer 2/3/4
Lx	(Protocol) Layer x
MG	Media Gateway
MGC	Media Gateway Controller
MSRP	Message Session Relay Protocol
PCI	Protocol Control Information
RTCP	RTP Control Protocol
RTP	Real-time Transport Protocol
S	Stream
SCTP	Stream Control Transmission Protocol
SDP	Session Description Protocol
SEP	Stream Endpoint
SEPP	Stream Endpoint Pair
SEPT	Stream Endpoint Tuple
T	Termination
TCP	Transmission Control Protocol
TLS	Transport Layer Security
UDP	User Datagram Protocol
UDPTL	User Datagram Protocol Transport Layer

5 Conventions

None.

6 Motivation, use cases and models

ITU-T H.248 controlled media gateways (MGs) may terminate multiple connection-oriented transport layer protocols, like transmission control protocol (TCP), transport layer security (TLS) and stream control transmission protocol (SCTP).

This is outlined in Figure 1 where in a given ITU-T H.248 context each stream endpoint (SEP) hosts at least one or more connection-oriented transport layer endpoints.

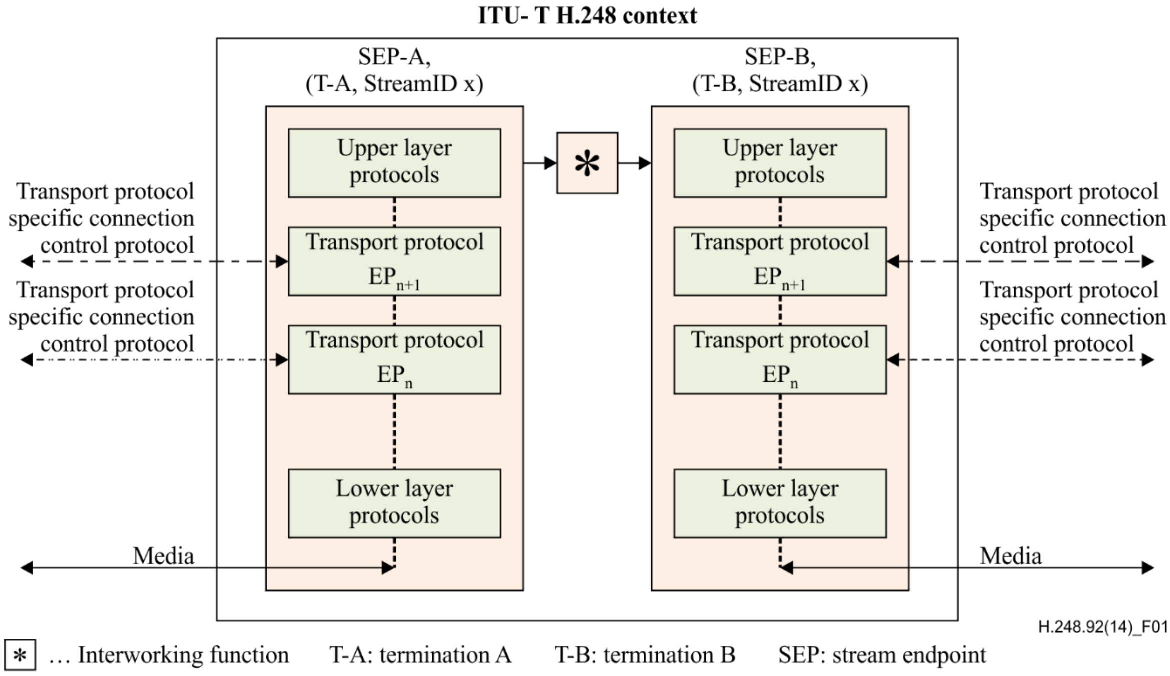

Figure 1 – Two-termination context with multiple connection-oriented protocols in the SEP-specific protocol stack (segments)

The interlinkage concept is constituted by the following characteristics:

– the interlinkage scope is limited to a single context;

– an interlinkage configuration is defined via an ITU-T H.248 Property, which itself is linked to a particular stream endpoint/termination;

– a specific external, incoming bearer control procedure (e.g., establishment event) immediately triggers the execution of an external, outgoing bearer control procedure, at the same or another termination in the context;

– a single interlinkage configuration acts in an unidirectional manner; and

– multiple interlinkage configurations in parallel may be defined for a single SEP.

Thus, three principal interlinkage types may be differentiated (see also illustration in clause I.2):

1. inter-SEP interlinkage (when source and interlinked transport endpoints are located at different terminations);
2. intra-SEP interlinkage (when source and interlinked transport endpoints are located at the same termination); and
3. multi-SEP interlinkage (when a single stimulus is used to trigger multiple outgoing bearer procedures).

Figure 2 outlines the various interlinkage options enabling an MG autonomous establishment/release of a connection-/session-oriented partner transport protocol endpoint (again using the example of a SEPP):

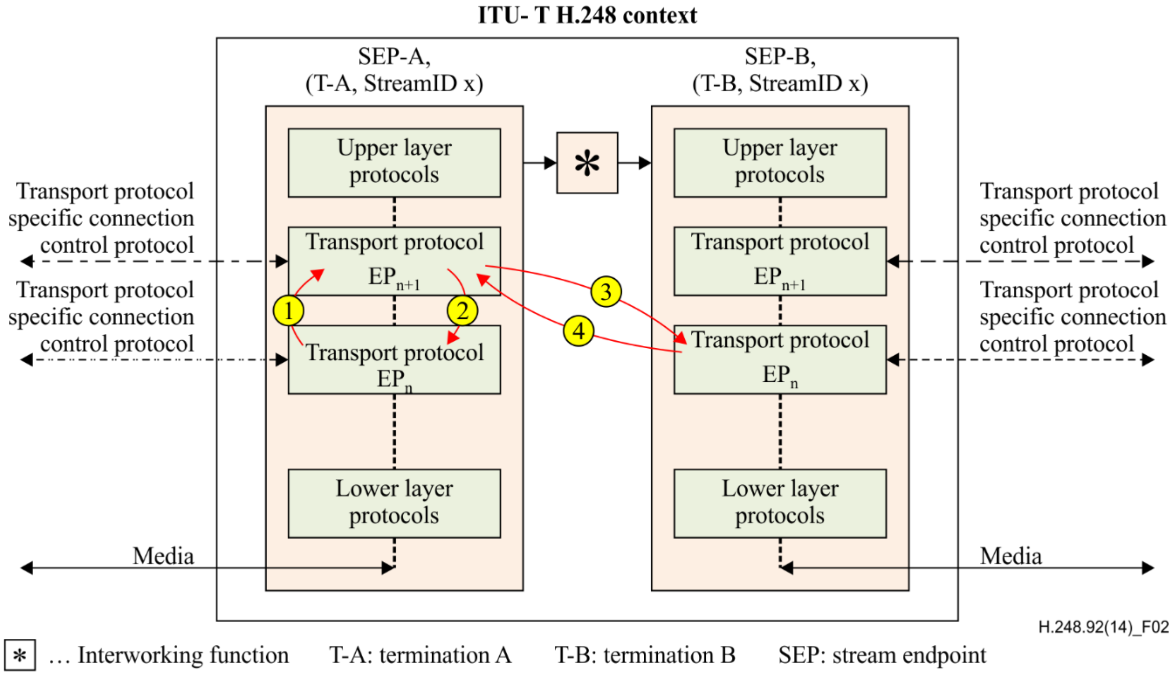

Figure 2 – Principle interlinkage options in a two-termination context from the perspective of a single SEP (here: SEP-A)

Example interlinkage configurations as illustrated by the arrows in Figure 2 are:

1. Intra-SEP interlinkage from lower to higher protocol layer: within one SEP, a lower layer connection-oriented transport protocol endpoint (EP) triggers an upper layer connection-oriented transport protocol EP (Note 1).

2. Intra-SEP interlinkage from higher to lower protocol layer: within one SEP, an upper layer connection-oriented transport protocol EP triggers a lower layer connection-oriented transport protocol EP (Note 1).

3. Inter-SEP interlinkage: Given a SEP pair, SEP-A triggers the connection-oriented transport protocol of the peer SEP-B. Either the same or a different transport protocol can be interlinked, thus for example a SEP-A TCP endpoint could trigger a SEP-B TCP endpoint, or a SEP-A TCP endpoint could trigger e.g., a SEP-B SCTP endpoint.

NOTE 1 – This does not mean that a lower layer service access point is used by the upper layer transport protocol directly, i.e., there might reside other connectionless protocol layers in between them. The first three interlinkage configurations are part of SEP-A. When the third interlinkage configuration (3) should be complemented by interlinkage in reverse direction, then following, fourth interlinkage configuration needs to be associated with SEP-B:

4. Inter-SEP interlinkage: Given a SEP pair, SEP-A receives a trigger regarding a connection-oriented transport protocol from its peer SEP-B. Either the same or different transport protocol can be interlinked, thus for example SEP-B TCP endpoint could trigger a SEP-A TCP endpoint, or a SEP-B TCP endpoint could trigger e.g., a SEP-A SCTP endpoint.

The principal limitations are as follows:

– Inter-SEP interlinkage (also known as "horizontal protocol layer interlinkage") is only permitted between SEPs belonging to the same ITU-T H.248 stream.
– Intra-SEP interlinkage (also known as "vertical protocol layer interlinkage") is only permitted within a SEP, i.e., between its supported transport protocol layers.
– In inter-SEP horizontal protocol layer interlinkage only external, incoming procedures are permitted as stimuli.

– The triggered procedure is always an outgoing procedure.

– Establishment procedures within one SEP shall follow an upwards order, i.e., the initiation of an establishment procedure shall only start when the establishment procedure at the lower layer is completed.

– Release procedures within one SEP should generally follow a downwards order, i.e., the initiation of a release procedure should only start when the release procedure at the upper later is completed. However, depending on the protocol rules, it may be possible to omit an explicit release procedure at the upper layer altogether.

NOTE 2 – The last two limitations are due to basic communication principles in layered protocol architectures (see [ITU-T X.200]: an (N+1)-layer is based on the service of the (N)-layer connection).

An ITU-T H.248 context may contain more than two terminations where these terminations host SEPs belonging to the same ITU-T H.248 stream. In this case, the SEP interlinkage capability needs to be able to address a dedicated stream endpoint tuple (SEPT).

For example, the interlinkage scheme of Figure 3 should be supported in case of an ITU-T H.248 context containing three SEPs (same ITU-T H.248 stream ID).

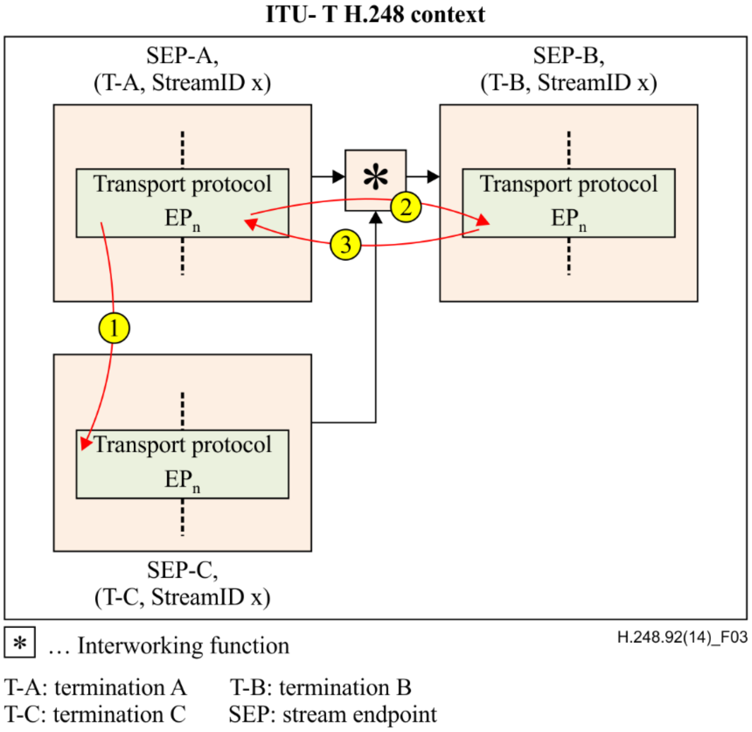

Figure 3 – Interlinkage example for a three-termination context

Whereas SEPP (SEP-A, SEP-B) can trigger each other regarding the identified transport protocol endpoints, the SEP-A connection-oriented transport protocol EP may trigger SEP-C connection-oriented transport protocol EP in addition. However, SEPP (SEP-B, SEP-C) does not have any interlinkage. SEP-C connection-oriented transport protocol EP cannot trigger SEP-A connection-oriented transport protocol EP in any way.

7 Stream endpoint interlinkage package

Package name: Stream endpoint interlinkage package

Package ID: seplink (0x011b)

Description: This package provides the functionality to interlink connection-/session-oriented transport protocol endpoints. If two transport protocol endpoints are interlinked, the establishment and/or release of a connection/session at the source transport protocol endpoint will trigger an MG-autonomous establishment and/or release of the interlinked transport protocol endpoint.

Version: 1

Extends: None

7.1 Properties

7.1.1 Interlinkage topology

Property name: Interlinkage topology

Property ID: linktopo (0x0001)

Description: This property defines the MG interlinkage behaviour regarding connection-/session-oriented transport endpoints. Interlinkage can be specified between the connection-oriented transport layers of a given SEP or between any connection-oriented transport layers of a given SEP pair. Interlinkage defines a unidirectional information flow ("stimuli") from a "SEP-local transport EP" towards another "SEP-local or remote transport EP".

Type: Sublist of Strings

Possible values: Each string instance of the sublist is coded according to the following augmented Backus-Naur format (ABNF) syntax:

```
linktopo = interlinkedSEP COLON
           sourceTransportEP COLON
           interlinkedTransportEP COLON
           mode
interlinkedSEP         = TerminationID
sourceTransportEP      = proto
interlinkedTransportEP = proto
mode = modetypes *(COMMA modtypes)
modetypes = "*" / "est" / "rel"  ; * is all mode types
                                 ; est is Establishment
                                 ; rel is Release
```

`TerminationID`, `COLON` and `COMMA` are as per clause B.2 of [ITU-T H.248.1]. For binary usage of ITU-T H.248.1 the binary *TerminationID* octets should be encoded using a hexadecimal octet coding as per clause B.3 of [ITU-T H.248.1]. The wildcarding field shall be omitted. The only wildcarding allowed is the use of ALL or CHOOSE which shall be indicated using "*" and "$" respectively.

Value `proto` is as per section 9 of [IETF RFC 4566], with the restriction that a single transport protocol value should be selected when the IANA `proto` codepoint represents a protocol stack segment (format e.g., "x/y/z"), rather than a single individual protocol layer (format "x").

Example (looking at the example of a hierarchical IANA `proto` codepoint): the MGC may select value "TLS" in case of an application-agnostic IANA `proto` codepoint "TCP/TLS" or application-aware IANA `proto` codepoint "TCP/TLS/MSRP".

Where:

interlinkedSEP: Is the TerminationID of the interlinked SEP where outgoing transport protocol signalling is triggered. The source interlinked SEP is the Termination where the *linktopo* property is set. This may be set to the same value as the source SEP TerminationID in which case it refers to Figure 2 options 1 and 2.

sourceTransportEP: Is the transport protocol endpoint which is the source of the signalling.

interlinkedTransportEP: Is the transport protocol endpoint which sends the outgoing signalling.

In Figure 2 options 1 and 2, the *sourceTransportEP* and *interlinkedTransportEP* shall be set to different transport protocols.

mode: Specifies whether the interlinkage is related to connection/session establishment and/or release procedures.

NOTE – Detailed agreements regarding the admitted <*proto*> values may be defined in an appropriate ITU-T H.248 profile specification. Typically, this is specified in the profile clauses on mandatory/optional support of session description protocol (SDP).

Default: Empty list

Defined in: LocalControl

Characteristics: Read/Write

7.2 Events

None.

7.3 Signals

None.

7.4 Statistics

None.

7.5 Error codes

7.5.1 Incorrect intra-SEP interlinkage

Error code: 488

Error name: Incorrect stream endpoint interlinkage

Definition: The protocol value indicated in the "source transport endpoint" (sourceTransportEP) or "interlinked transport endpoint" (interlinkedTransportEP) parameters in the Interlinkage topology property relates to a protocol which is unsuitable for interlinkage. E.g., all protocols with the characteristic of being "connectionless" (Note).

Background information:

There are the two "mode of communication" concepts (see [ITU-T X.200]) of "connection-oriented" and "connectionless". Connectionless protocols (such as UDP) inherently lack bearer connection control procedures, thus, a connectionless protocol (layer) acting as a) a source transport endpoint: would never generate any stimuli. Hence, interlinkage would never be triggered; and b) an interlinked transport endpoint: would silently discard received stimuli because there are no procedures which could be triggered.

NOTE – There are many protocols (beyond the basic reference model according to [ITU-T X.200]) with an unclear "connectionless / connection-oriented" classification, such as user datagram protocol transport layer (UDPTL) or RTP (the associated "bearer control protocol" RTCP could be e.g., used for "bearer release").

Error text in the Error Descriptor: –

Comment: None.

7.6 Procedures

7.6.1 Configuration of "interlinkage topologies"

7.6.1.1 SEP identification

a) Source of stimuli

The source SEP transport protocol endpoint, i.e., the connection-/session-oriented transport protocol endpoint, which triggers autonomous procedures at another connection-/session-oriented transport protocol endpoint, is specified as follows:

– The TerminationID and StreamID are derived from the termination/stream, the LocalControl descriptor that contains the *seplink/linktopo* property value. The name of the source SEP is thus *implicitly* given.

– The transport protocol is explicitly specified in the *seplink/linktopo* property value (parameter "`sourceTransportEP`").

b) Sink of stimuli

The destination SEP transport protocol endpoint, i.e., the connection-/session-oriented transport protocol endpoint, which receives a trigger to start autonomous procedures from another connection-/session-oriented transport protocol endpoint, is specified as follows:

– The TerminationID is explicitly specified in the *seplink/linktopo* property value (parameter "`interlinkedSEP`").

– The StreamID is derived from the termination/stream the LocalControl descriptor is related to containing the *seplink/linktopo* property value.

– The transport protocol is explicitly specified in the *seplink/linktopo* property value (parameter "`interlinkedTransportEP`").

7.6.1.2 Traffic directions

The *seplink/linktopo* property defines a *unidirectional* behaviour, that is, it specifies the interlinkage behaviour of a source (identified by the TerminationID and StreamID the LocalControl Descriptor is related to) and an interlinked SEP (identified by the TerminationID; same StreamID as source).

In case a bidirectional interlinkage between a SEPP/SEPT is expected, each SEP's Local Descriptor must contain a corresponding interlinkage topology.

7.6.1.3 Wildcard usage

The interlinked SEP can be specified using the ALL wildcard

"`seplink/linktopo = ["*:TCP:TCP:est,rel"]`".

In this case, the specified interlinkage behaviour is valid to all matching SEPPs (i.e., only horizontal interlinkage, vertical interlinkage is specifically excluded, that is an ALL wildcard excludes its own TerminationID). In case a new SEP is added into the ITU-T H.248 context later on, the ALL wildcarded interlinkage topology is applied as well to the new SEP.

The interlinked SEP can be specified using the CHOOSE wildcard

"`seplink/linktopo = ["$:TCP:TCP:est,rel"]`".

The CHOOSE wildcard matches the TerminationID that the MG assigns in the first Add Command that uses a CHOOSE wildcard in the same action. This allows to add a new termination/SEP, and to modify the existing interlinkage topologies (using a modify command) within the same action.

```
Transaction = 1 {
  Context = 1 {
    Add = ip/1/$/$ {
      Media {
        Stream = 1 {
          LocalControl { seplink/linktopo = ["ip/1/1/1:TCP:TCP,est,rel"] }}}}
    Modify = ip/1/1/1 {
      Media {
        Stream = 1 {
          LocalControl { seplink/linktopo = ["$:TCP:TCP:est,rel"] }}}}
```

NOTE – In the above examples mode setting "est,rel" could be replaced by "*".

7.6.1.4 Dynamic aspects

The exact point in time when an interlinkage stimulus should be generated by the source transport endpoint is not explicitly specified by this Recommendation, rather subject of implementations. This might be dependent on the real bearer connection protocol used, the overall protocol stack behind the SEP, the considered state modelling of a bearer connection endpoint, different handling between inter- and intra-SEP interlinkage, etc.

Appendix II provides some general guidelines, state models and examples by consideration of generic protocol layers.

7.6.2 Relation to ITU-T H.248 Stream Mode

A specified interlinkage topology is independent of the LocalControl Descriptor StreamMode property. The StreamMode property affects the application data flow rather than the transport protocol control information used to establish or close the corresponding transport connection.

7.6.3 Relation to ITU-T H.248 Topology Descriptor

The effectiveness or non-effectiveness of a specified horizontal interlinkage topology depends on the context level topology descriptor, i.e., whether the corresponding flow direction in the topology descriptor for a particular SEPP (or in case of wildcard ALL usage: for all matching SEPPs) has been enabled or not.

7.6.4 Error cases

In case if a new interlinkage topology refers to an unknown termination identifier, the MG shall reject the command using Error 430 "*Unknown TerminationID*".

In case if a new interlinkage topology refers to a valid termination identifier but this termination does not contain a SEP for this specific stream identifier, then the MG shall reject this using Error 473, "*Conflicting Property Values*".

In case if a new interlinkage topology refers to a transport protocol not part of the SEP's "m="-line transport protocol, then the MG shall reject this using Error 472, "*Required Information Missing*".

In case a new interlinkage topology is specified referring to a transport protocol which either:

– does not generate an interlinkage stimuli (at the source side); or

– does not trigger a bearer control procedure (at the sink side),

then the MG shall reject this using Error 488, "*Incorrect stream endpoint interlinkage*". Most likely, the cause of lack of stimuli would be the specification of a connectionless protocol in the interlinkage configuration by the MGC.

7.6.5 Examples

7.6.5.1 Example of a "TLS/TCP to SCTP" connection model

i) Example of intra-SEP interlinkage

The example has an SEP-A (T-A) that uses transport layers TLS/TCP. A TCP connection set up autonomously triggers a TLS session set up and a TLS session release autonomously triggers a release of the TCP connection.

ITU-T H.248 command request:

```
Modify = T-A {
  Media {
    Stream = 2 {
      LocalControl {
        seplink/linktopo = ["T-A:TCP:TLS:est","T-A:TLS:TCP:rel"]
} } } }
```

The resulting interlinkage is illustrated in Figure 4.

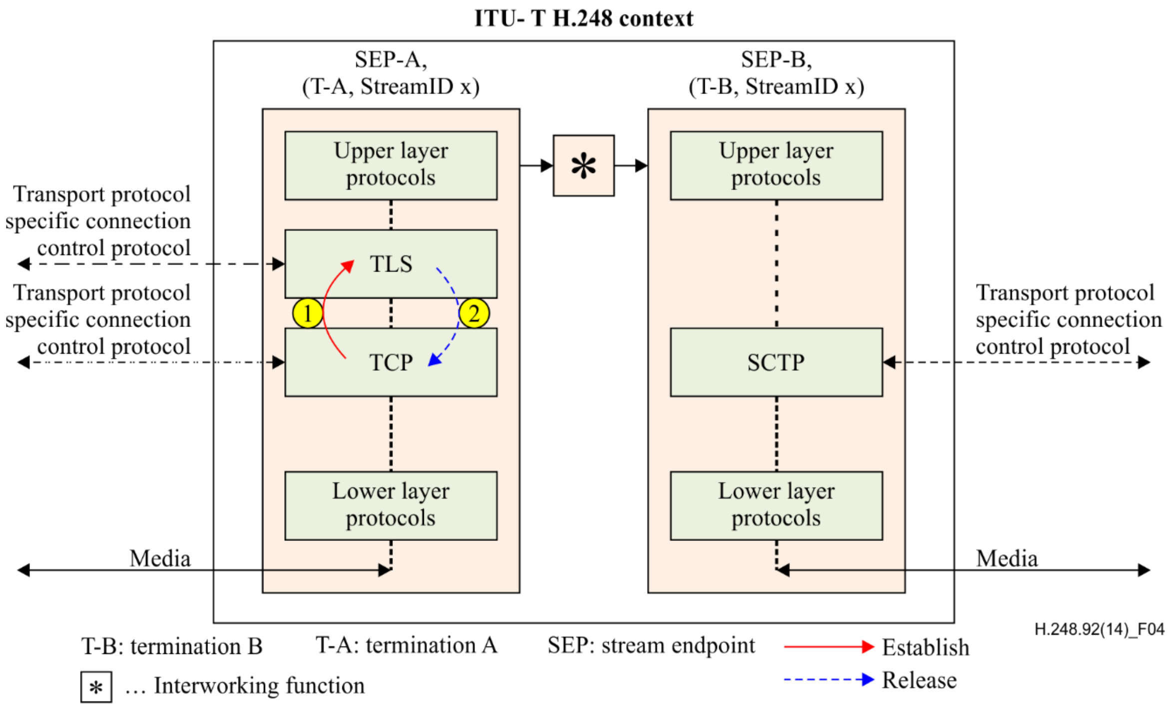

Figure 4 – Example of a "TLS/TCP to SCTP" connection model: Vertical interlinkage configuration at SEP-A

ii) Example of inter-SEP interlinkage

In addition, SEP-A's transport layer TCP can be interlinked with the SEP-B's transport layer SCTP (i.e., SEP-A's TCP connection establishment/release autonomously triggers SEP-B's SCTP connection establishment/release).

NOTE – SEP-A's TCP connection establishment/release can be either stimulated by using the corresponding ITU-T H.248 TCP package capabilities (e.g., [ITU-T H.248.89] properties *tcpbcc/EstBNC* (outgoing establishment procedure (TCP client role)) or *tcpbcc/RelBNC*) or by receiving a TCP connection establishment/release request from the far-end TCP endpoint.

ITU-T H.248 command request:

```
Modify = T-A {
  Media {
    Stream = 2 {
      LocalControl {
        seplink/linktopo = ["T-A:TCP:TLS:est", "T-A:TLS:TCP:rel",
                            "T-B:TCP:SCTP:est,rel"]
} } } }
```

The resulting interlinkage is illustrated in Figure 5.

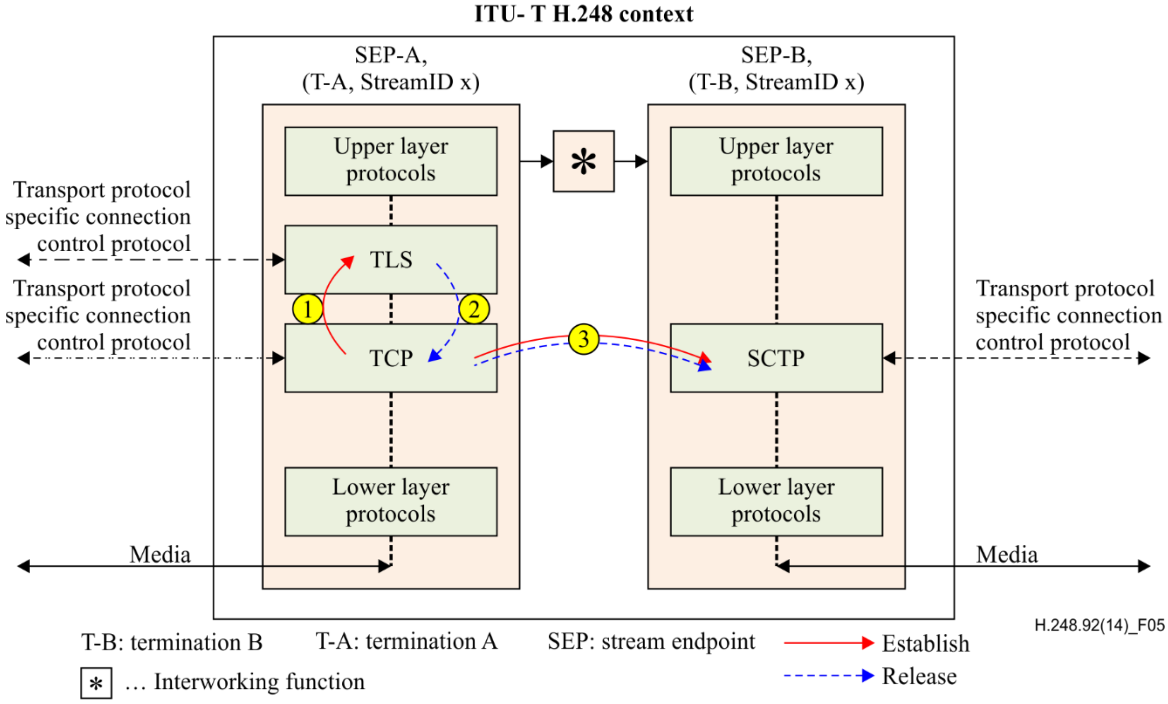

Figure 5 – Example of a "TLS/TCP to SCTP" connection model: Horizontal interlinkage configuration between SEP-A "TCP" and SEP-B "SCTP"

iii) Example of bidirectional inter-SEP interlinkage

To make sure that SCTP connection establishment at SEP-B will also trigger SEP-A TCP connection establishment and that SCTP connection release at SEP-B will also trigger SEP-A TLS session release, the *seplink/linktopo* property has to be applied as follows in SEP-B's LocalControl Descriptor:

ITU-T H.248 command request:

```
Modify = T-B {
  Media {
    Stream = 2 {
      LocalControl {
```

```
         seplink/linktopo = ["T-A:SCTP:TCP:est", "T-A:SCTP:TLS:rel"]
} } } }
```

The resulting interlinkage is illustrated in Figure 6.

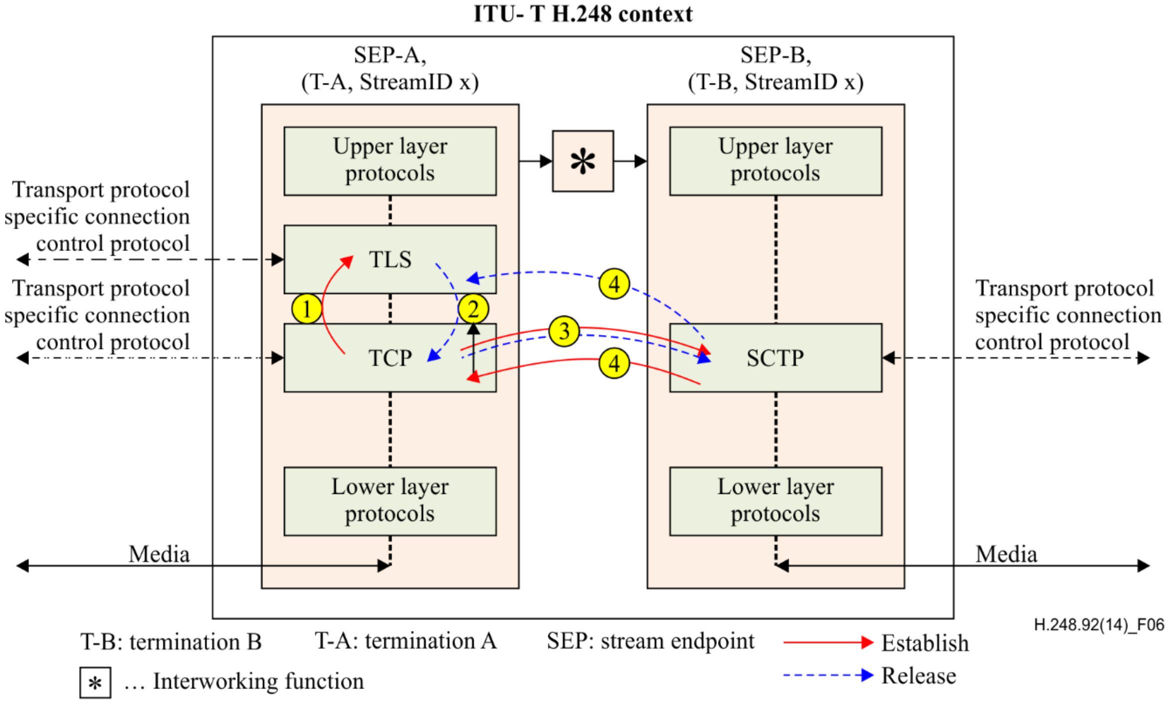

Figure 6 – Example of a "TLS/TCP to SCTP" connection model: Horizontal interlinkage configuration between SEP-B "SCTP" and SEP-A "TLS"

Appendix I

Illustration of interlinkage capabilities

(This appendix does not form an integral part of this Recommendation.)

This appendix illustrates the interlinkage concept and the principal interlinkage types, and indicates some use cases that are beyond current interlinkage capabilities.

I.1 Illustration of concept

Figure I.1 summarizes the terminology used and the principal elements of the *seplink/linktopo* property.

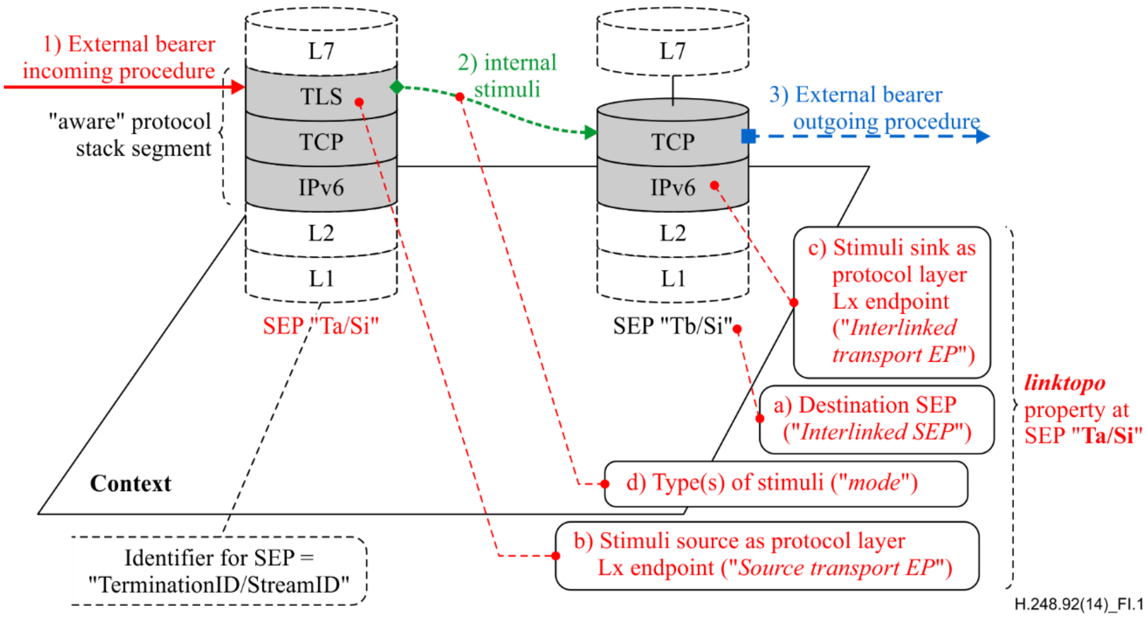

Figure I.1 – Stream endpoint assigned property *linktopo* and their parameters

The *linktopo* property is always associated with a specific stream endpoint (here SEP "Ta/Si").

I.2 Illustration of supported use cases

Three principal interlinkage types may be differentiated.

I.2.1 Use case "Inter-SEP interlinkage"

The interlinkage across two terminations is called "inter-SEP interlinkage" (Figure I.2).

Table I.1 summarizes the principal interlinkage description.

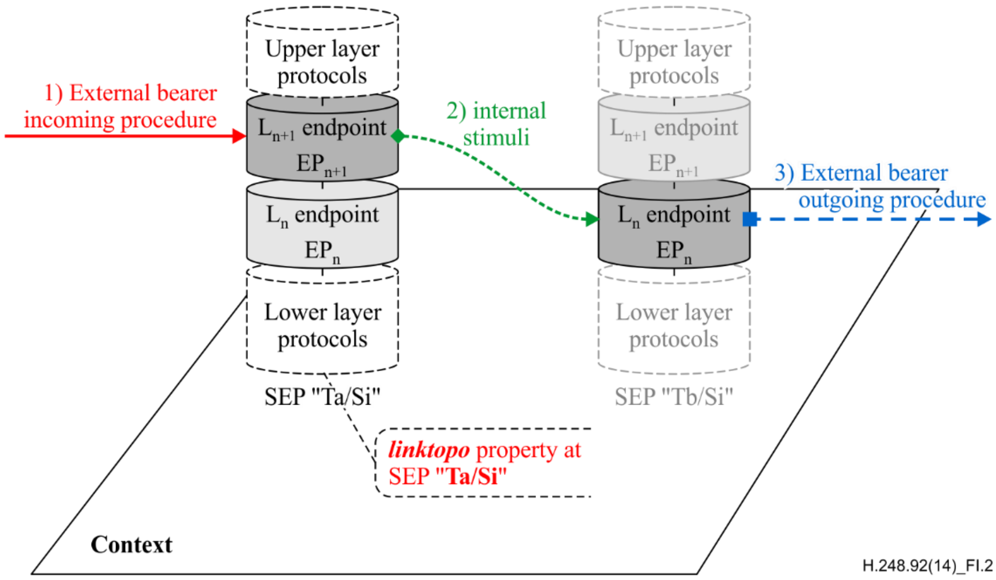

Figure I.2 – Use case "Inter-SEP interlinkage"

Table I.1 – Interlinkage description – Use case "Inter-SEP interlinkage"

<interlinked SEP>	<source transport EP>	<interlinked transport EP>	<mode>	Comment
"Tb"	"EP_{n+1}" (at Ta/Si)	"EP_n" (at Tb/Si)	"…"	The mode codepoint could be *est* or *rel*.

I.2.2 Use case "Intra-SEP interlinkage"

There are two variants of intra-SEP interlinkage:

I.2.2.1 Externally driven "Intra-SEP interlinkage"

The *interlinked transport endpoint* may be located at the same SEP as the *source transport endpoint*, called "intra-SEP interlinkage" (Figure I.3).

Table I.2 summarizes the principal interlinkage description.

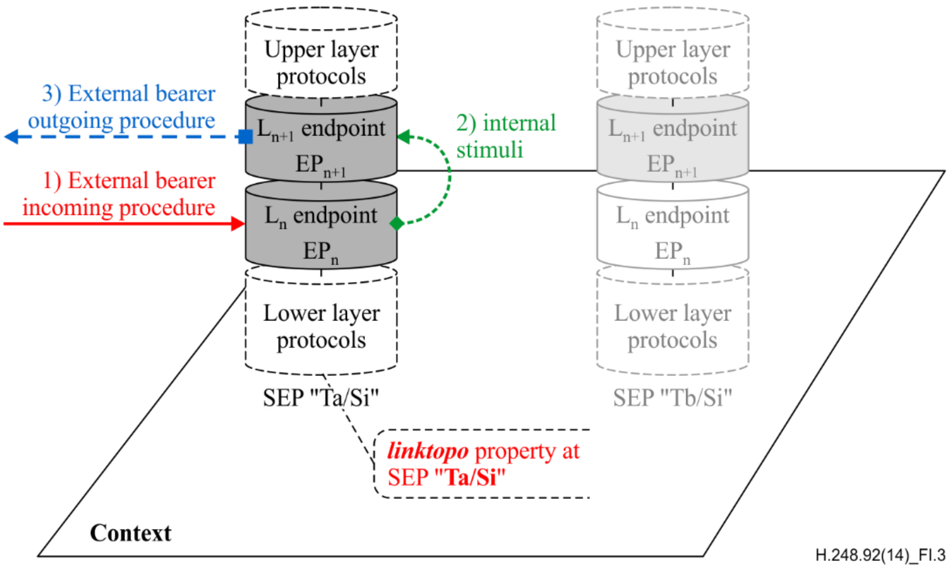

Figure I.3 – Use case: Externally driven "Intra-SEP interlinkage"

Table I.2 – Interlinkage description – Use case "Intra-SEP interlinkage"

<interlinked SEP>	<source transport EP>	<interlinked transport EP>	<mode>	Comment
"Ta"	"EP_n" (at Ta/Si)	"EP_{nn+1}" (at Ta/Si)	"est"	Not possible for this release.

I.2.2.2 Internally driven "Intra-SEP interlinkage"

The following is the difference between the previous externally driven intra-SEP interlinkage case and the internally driven one:

> An MG-internal stimuli (see Figure I.4), – either originating in the MGC (0a) (i.e., related to ITU-T H.248 signalling) or in the MG itself due to a previous interlinkage scenario (0b) –, triggers an external outgoing procedure (1). The internal stimuli (2) will be generated, as usual, when the source transport endpoint successfully transitions its state.

The interlinkage description is identical to the externally driven "Intra-SEP interlinkage" (i.e., according to Table I.2).

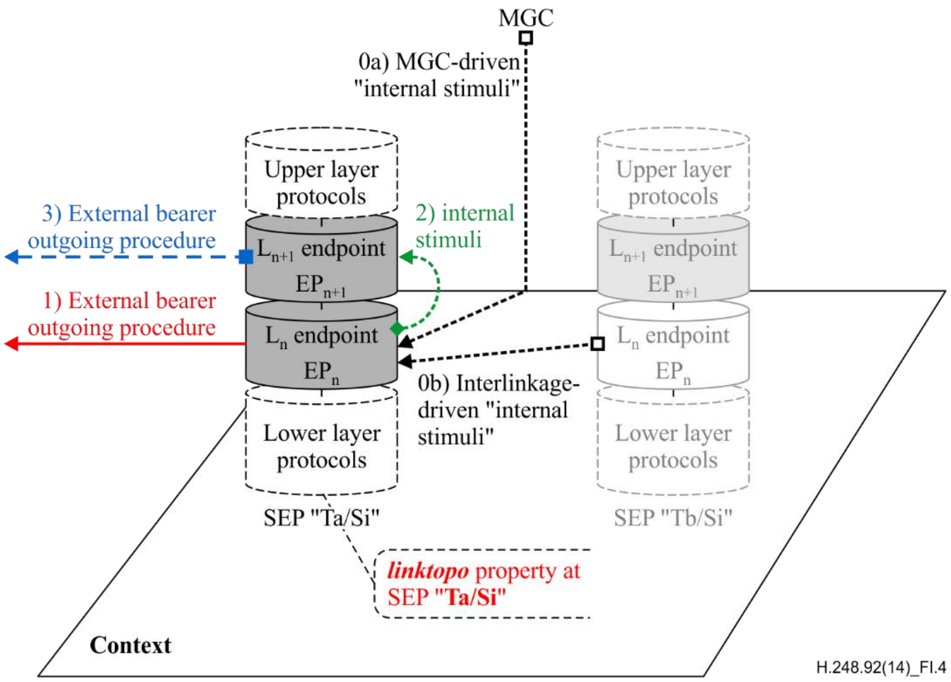

Figure I.4 – Use case: Internally driven "Intra-SEP interlinkage"

I.2.3 Use case "Multi-SEP interlinkages"

A single stimulus may be used to trigger multiple outgoing bearer procedures (of the same or different type). The *interlinked transport endpoints* may be located at the same or different SEP(s). Figure I.5 illustrates such an example.

The linktopo property "value" represents a list structure (Table I.3).

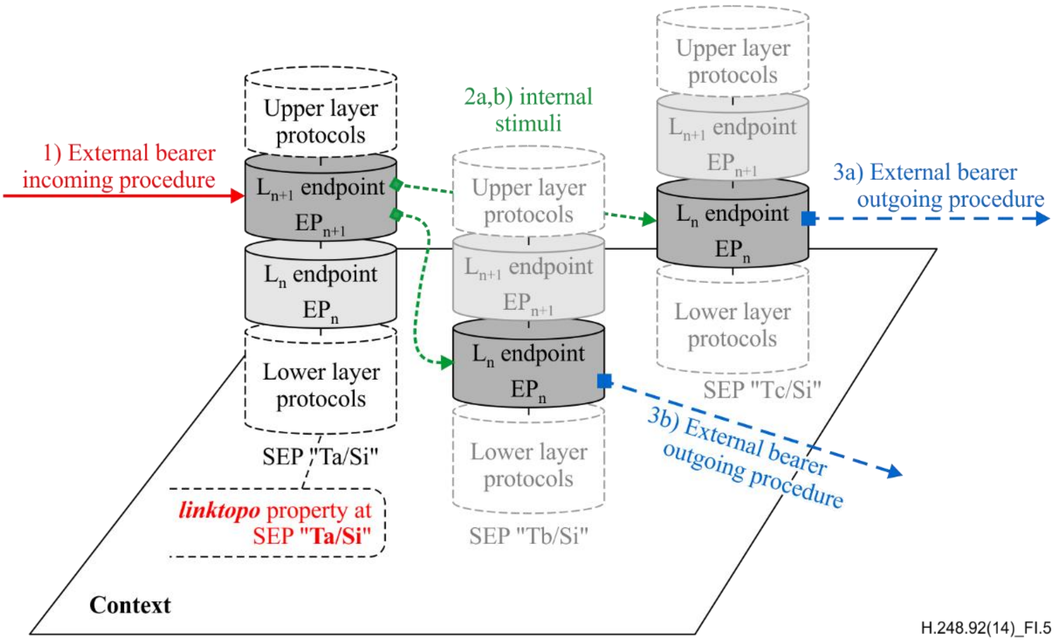

Figure I.5 – Use case "Multi -SEP interlinkage"

Table I.3 – Interlinkage description – Use case "Multi-SEP interlinkage"

<interlinked SEP>	<source transport EP>	<interlinked transport EP>	<mode>	Comment
"Tb"	"EP_{n+1}" (at Ta/Si)	"EP_n" (at Tb/Si)	"…"	The mode codepoint could be *est* or *rel*.
"Tc"	"EP_{n+1}" (at Ta/Si)	"EP_n" (at Tc/Si)	"…"	ditto

I.3 Controversial use cases

I.3.1 Use cases with "self-referential interlinkage"

The case of intra-SEP interlinkage with identical *source transport* and *interlinked transport endpoints* is called self-referential interlinkage.

Such an interlinkage is in general controversial concerning what incoming bearer control procedures trigger immediate outgoing control procedures, and what would be correspondent *mode* values.

There are no useful self-referential interlinkage scenarios identified for *seplink* package version 1.

I.3.2 Use cases with "tunnelled (IP) protocol stacks"

The usage of tunnelling is common for many IP access network technologies. The notion of tunnel refers to hierarchical protocol stacks of type e.g., "X-over-IP-over-X-over-IP",

Such an interlinkage seems to be controversial in general concerning the unambiguous identification of *source transport* and/or *interlinked transport endpoints* due to the existing supported value range by *seplink* package version 1. E.g., the indication of "TCP" (in case of a TCP-over-TCP stack) would be ambiguous. Such scenarios are for further study.

I.3.3 Use cases with "extended (IP) protocol stacks"

Extended protocol stacks are also beyond the layered protocol architectures according to basic reference models, but the interlinkage is not necessarily between identical protocol types (as in the "tunnelled scenarios" of clause I.3.2).

The support of such use cases is already in scope of *seplink* package version 1, but conditional. The usage depends on the unambiguous identification of *source transport* and/or *interlinked transport endpoints*.

Appendix II

Considerations about state modelling and dynamics

(This appendix does not form an integral part of this Recommendation.)

II.1 Purpose

This appendix provides some background information concerning the MG-internal generation and forwarding of the stimuli for interlinkage. It clarifies principle differences between inter- and intra-SEP interlinkage. It also analyses the timing of vertical ITU-T H.248 signalling (for interlinkage configurations) versus horizontal bearer control procedures.

Where there are discrepancies between this appendix and this Recommendation, the semantics and procedures of the main body of this Recommendation take precedence.

II.2 State modelling

II.2.1 Used model for a single bearer connection endpoint

The *seplink* package version 1 supports two interlinkage modes, related to bearer connection *establishment* and *release* (see clause 7.1.1, property parameter *mode*). Such bearer connection endpoint behaviour could be modelled by (at least) two states (such as IDLE and ESTABLISHED (synonym to DATA TRANSFER READY)). However, in order to address transient behaviour and unsuccessful cases following (see Figure II.1), a four-state model is considered (with emphasis on the establishment procedure only).

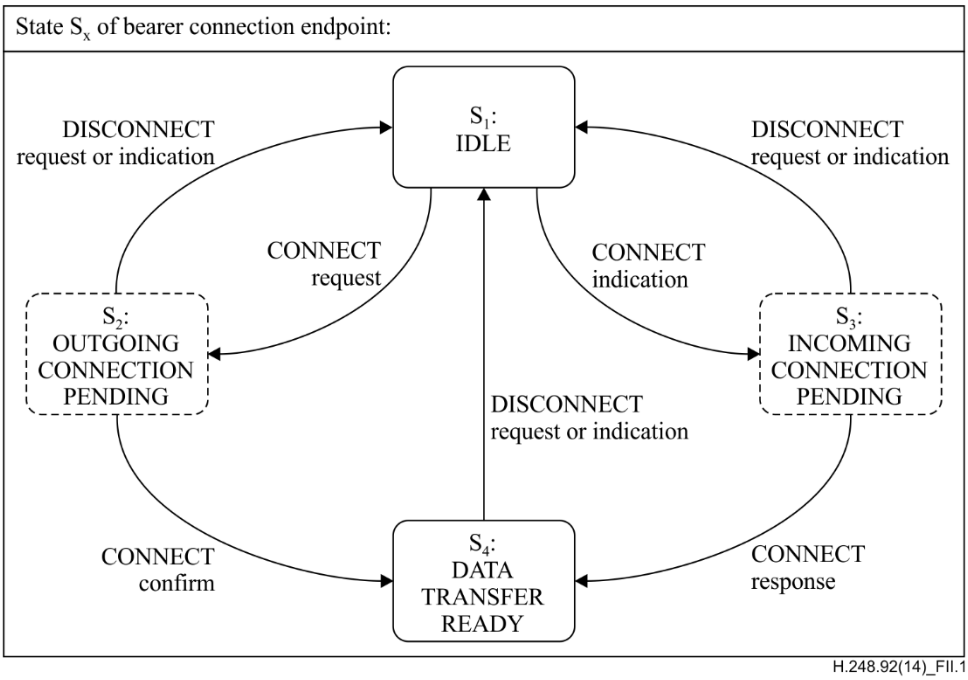

Figure II.1 – State modelling – Bearer connection endpoint

NOTE 1 – The generic model is derived from [ITU-T X.200], e.g., consistent with layer 3 and 4 bearer connection endpoint modelling (see [b-ITU-T X.213], [b-ITU-T X.214]). The transient states S_2 and S_3 are dashed because they are not in the scope of this Recommendation.

The protocol neutral primitives (request, confirm, indication, response) are according to [b-ITU-T X.210]. They allow the modelling of all kinds of protocol-specific bearer control procedures.

NOTE 2 – Example "TCP": the three-way handshake procedures for establishment: the first TCP SYN represents the CONNECT request / CONNECT indication information (for outgoing / incoming directions), and the last TCP ACK the CONNECT confirm / CONNECT response information (for outgoing / incoming directions).

II.2.2 Used model for two interlinked bearer connection endpoints

The two state machines of both bearer connection endpoints are coupled (see Figure II.2). Some state transitions of the *interlinked* endpoint are triggered (by interlinkage stimuli) by the *source* endpoint.

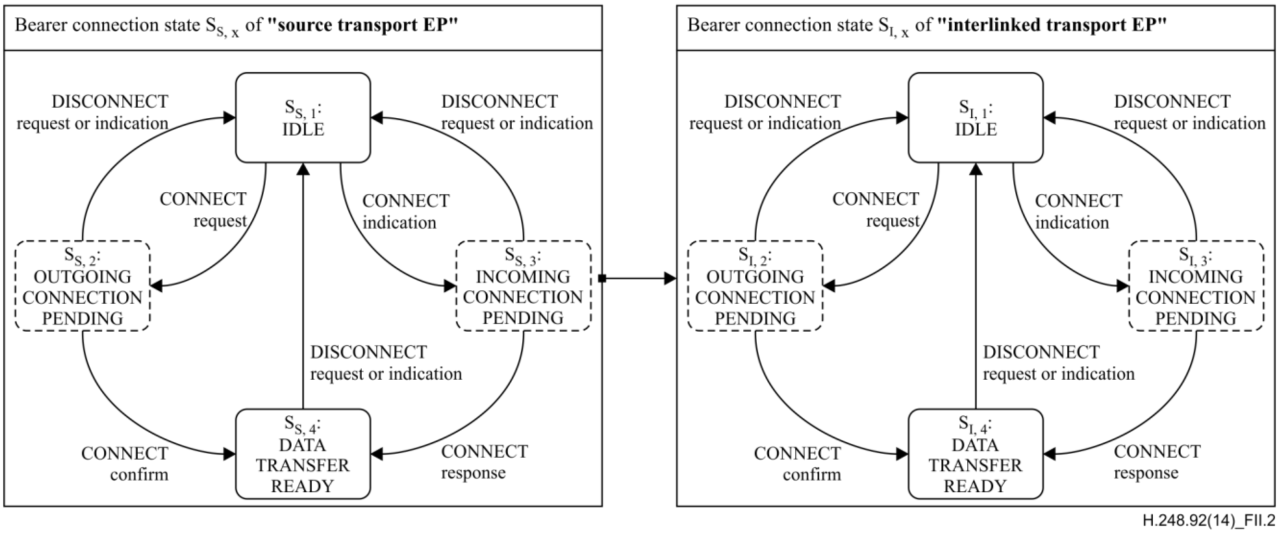

Figure II.2 – State modelling – Interlinked bearer connection endpoints

II.3 Interlinkage behaviour

II.3.1 Principle difference between intra- and inter-SEP interlinkage

There is a principle limitation in the intra-SEP interlinkage due to fundamental principles of layered protocol architectures (see clause 6). E.g., an (N+1)-layer service depends on the existence of an underlying (N)-layer service, thus, an (N+1)-layer establishment procedure may only start when the (N)-layer is already in state "DATA TRANSFER READY" (or ESTABLISHED, etc.).

This leads to the following difference:

– intra-SEP interlinkage ("vertical interlinkage"): only *serial* execution of the two bearer control procedures at the SEP; and

– inter-SEP interlinkage ("horizontal interlinkage"): also *parallel* execution of the bearer control procedures at both SEPs possible.

This aspect impacts the point in time (or the position in the state machine) when the stimulus could be sent as the earliest possible from the source to the interlinked transport endpoint in case of lower to upper layer interlinkage.

II.3.2 Timing of ITU-T H.248 signalling and bearer control procedures

The MGC should be aware of the interlinkage behaviour before the bearer control procedure at the source transport endpoint begins. However, there might be cases of delayed ITU-T H.248 signalling, i.e., the MG receives an ITU-T H.248 command request with an interlinkage configuration when the bearer control procedure at the source transport endpoint is already in process or already completed. An interlinkage request received at that time shall trigger a bearer control procedure at the interlinked transport endpoint based on the bearer protocol state and/or transition. One bearer control state shall not trigger multiple bearer control procedures.

This aspect impacts the point in time (or the position in the state machine) when the stimulus is still being generated and sent from the source to the interlinked transport endpoint.

II.3.3 State-driven interlinkage behaviour

A stimulus is principally generated at the source transport endpoint either due to a particular *state transitioning* (dynamic) and/or due to *state value* (static).

II.3.3.1 Intra-SEP interlinkage

II.3.3.1.1 Bearer connection establishment

Intra-SEP interlinkage for establishment implies protocol layer relation with an upper (N+…)-layer interlinked transport endpoint versus a (N)-layer source transport endpoint. The outgoing bearer connection control procedure at the interlinked transport endpoint is then either triggered by a "CONNECT response" (1), a "CONNECT confirm" (2) state transition or when the source transport endpoint is already in state "DATA TRANSFER READY" (3). See Figure II.3.

It should be noted that there is only a single stimulus (i.e., one of the dashed arrows in Figure II.3).

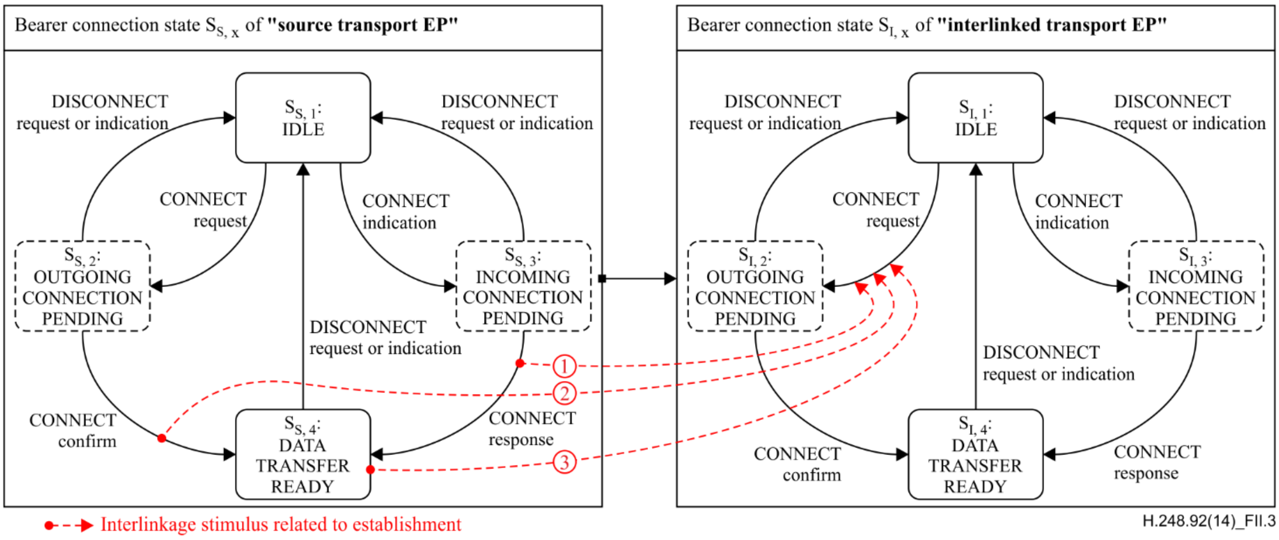

Figure II.3 – Interlinkage behaviour – Stimuli for intra-SEP interlinkage – Bearer connection establishment

II.3.3.1.2 Bearer connection release

For further study.

It may be noted that a more detailed model (as outlined in Figure II.3) might be necessary, in particular for protocols with additional transient states towards state "IDLE".

II.3.3.2 Inter-SEP interlinkage

II.3.3.2.1 Bearer connection establishment

Inter-SEP interlinkage is unconditional with regards to protocol layer dependencies. Thus, the outgoing bearer connection control procedure at the interlinked transport endpoint could be as earliest as possible already started by a "CONNECT indication" (4) besides the intra-SEP interlinkage stimuli according to clause II.3.3.1.1 ("CONNECT response" (1), "CONNECT confirm" (2) state transition, or state "DATA TRANSFER READY" (3)). See Figure II.4.

It should be noted that there is only a single stimulus (i.e., one of the dashed arrows in Figure II.4).

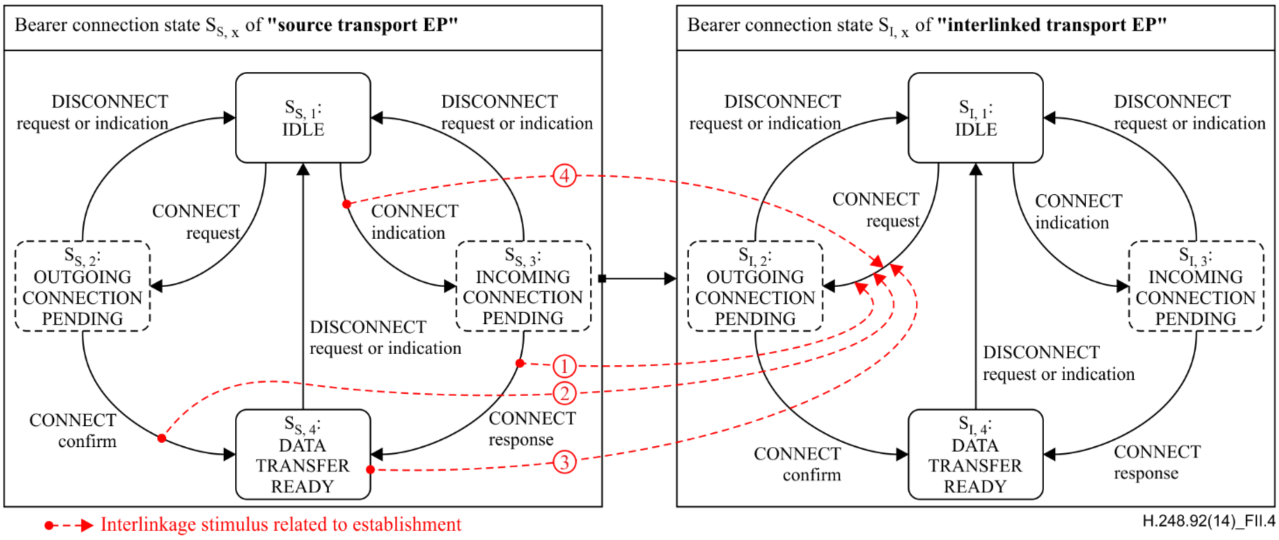

Figure II.4 – Interlinkage behaviour – Stimuli for intra-SEP interlinkage – Bearer connection establishment

II.3.3.2.2 Bearer connection release

For further study.

It may be noted that a more detailed model (as outlined in Figure II.4) might be necessary, in particular for protocols with additional transient states towards state "IDLE".

II.4 Illustration of temporary interlinkage behaviour

II.4.1 Note to example interlinkage scenario

The timing of some scenarios is illustrated in Figures II.5 to II.8. The point in time of the stimuli in the diagrams is only roughly indicated, in order not to overload them with too many details.

II.4.2 Example 1: single establishment-release cycle, interlinked bearer connection follows

The interlinkage configuration is signalled in "IDLE" with modes "*est*" and "*rel*". The state of the interlinked bearer connection follows the source transport endpoint (Figure II.5).

II.4.3 Example 2: alternate establishment-release cycles, interlinked bearer connection follows

In contrast to previous examples, there are multiple, alternate state changes of the source transport endpoint. As before, the state of the interlinked bearer connection follows the source transport endpoint (Figure II.6) because e.g., a subsequent repeated IDLE-to-ESTABLISHED transition generates further stimulus.

II.4.4 Example 3: only establishment interlinked, no effect of subsequent stimuli

In this example, interlinkage is limited only to establishment. Possible subsequent stimuli do not affect the state of the interlinked transport endpoint (Figure II.7).

II.4.5 Example 4: delayed interlinkage signalling

In this example, the interlinkage configuration is signalled behind the schedule, after the source transport endpoint completed its bearer control procedures. A stimulus is still generated (Figure II.8).

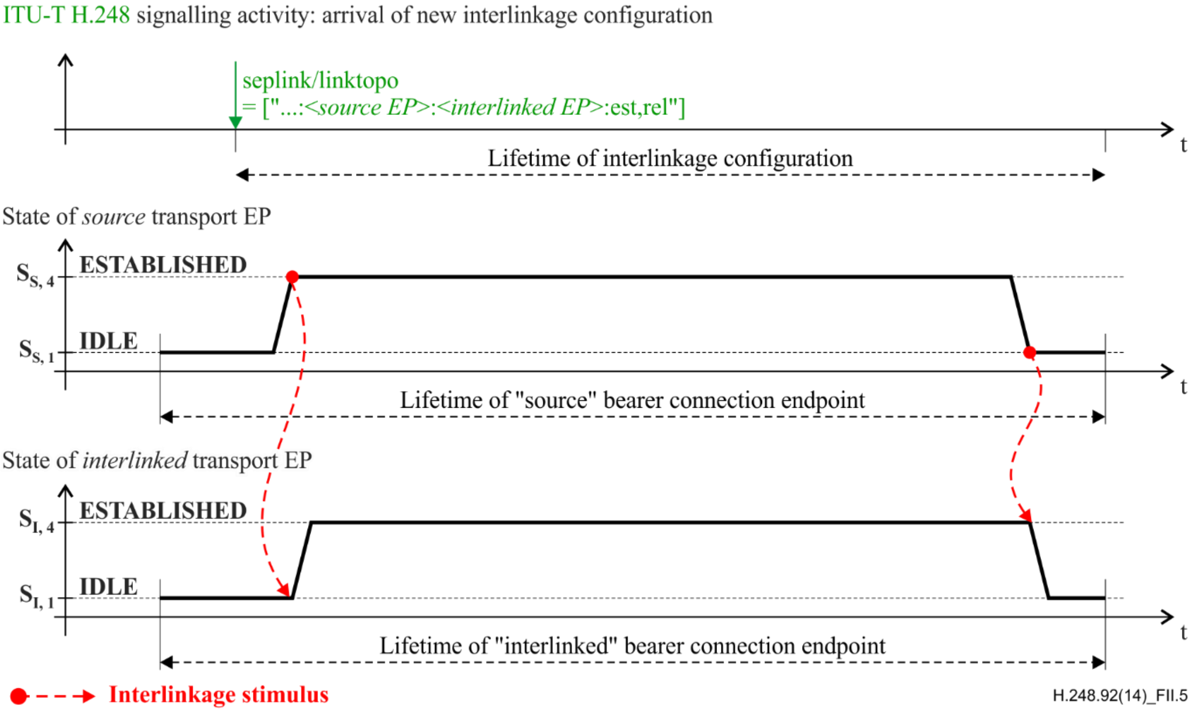

Figure II.5 – Timing for example 1 (single establishment-release cycle, interlinked bearer connection follows)

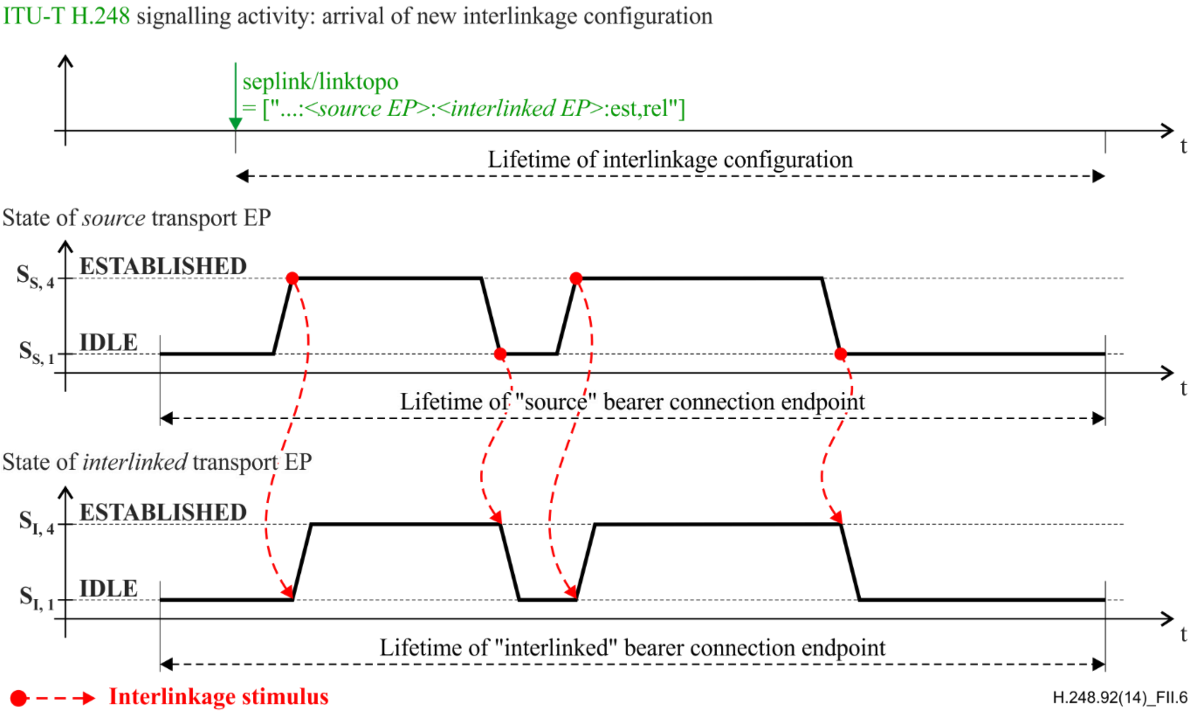

Figure II.6 – Timing for example 2 (alternate establishment-release cycles, interlinked bearer connection follows)

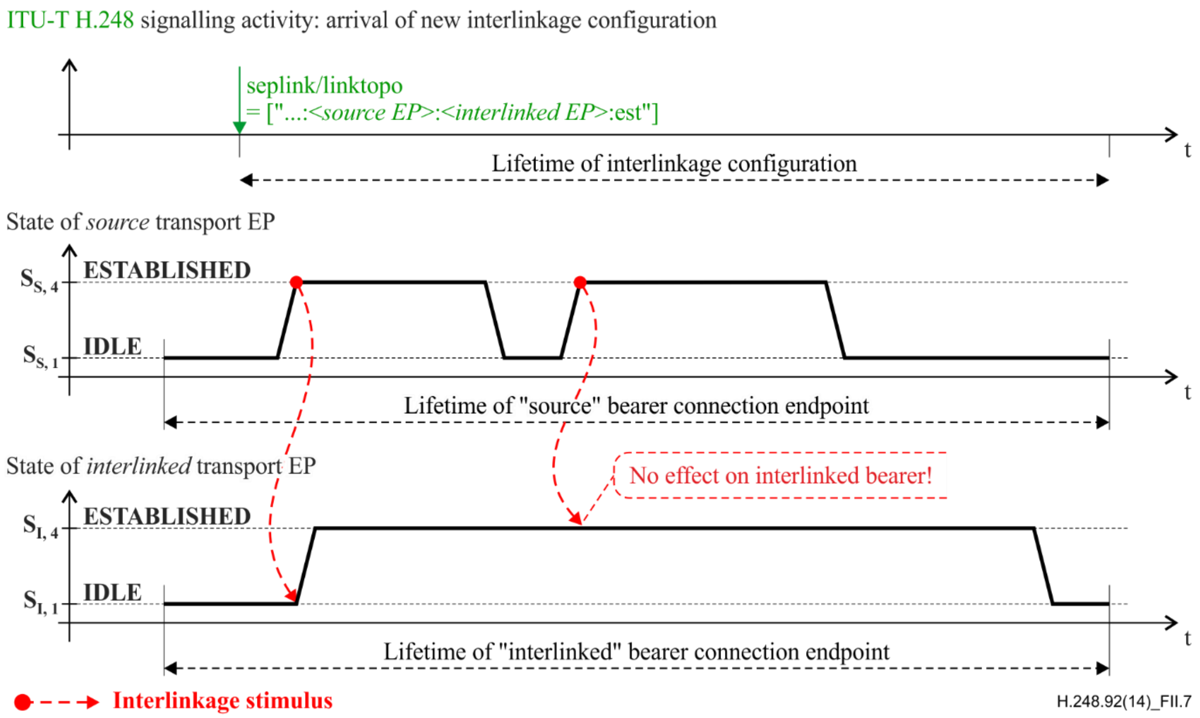

Figure II.7 – Timing example 3 (only establishment interlinked, no effect of subsequent stimuli)

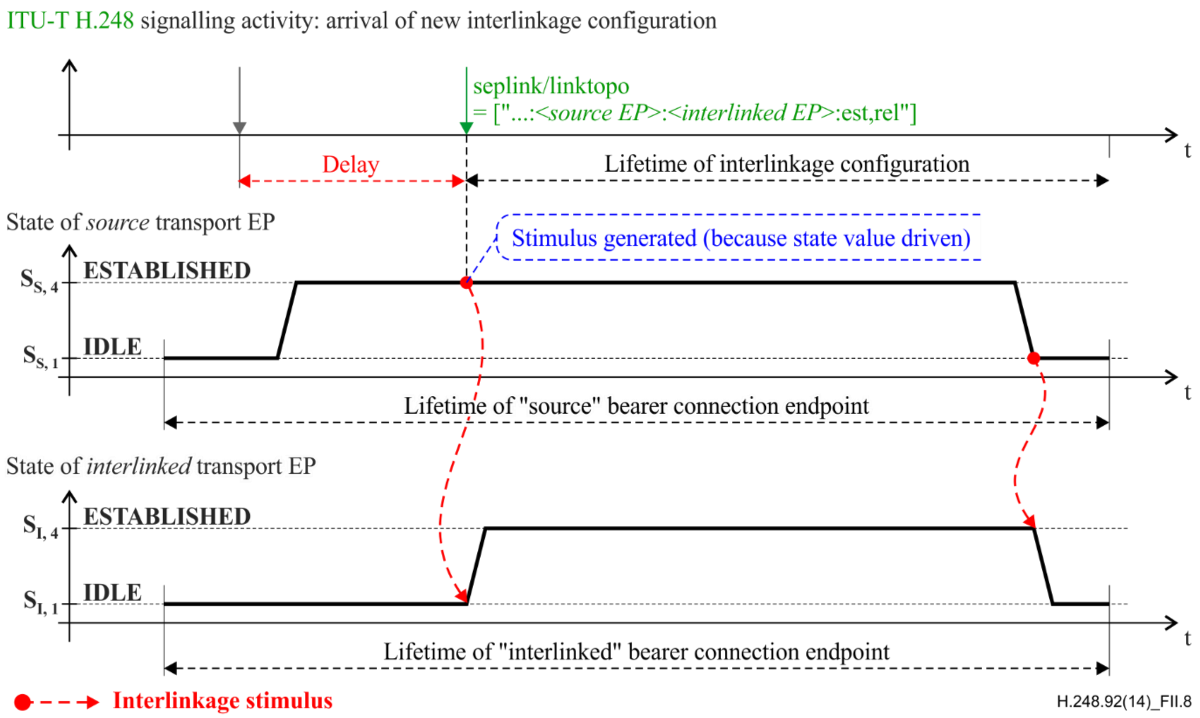

Figure II.8 – Timing for example 4 (delayed interlinkage signalling)

Bibliography

[b-ITU-T H-Sup.13] ITU-T H-series Recommendations – Supplement 13 (2014), *Gateway control protocol: Common ITU-T H.248 terminology – Release 1*.

[b-ITU-T X.210] Recommendation ITU-T X.210 (1993), *Information technology – Open Systems Interconnection – Basic Reference Model: Conventions for the definition of OSI services*.

[b-ITU-T X.213] Recommendation ITU-T X.213 (2001), *Information technology – Open Systems Interconnection – Network service definition*.

[b-ITU-T X.214] Recommendation ITU-T X.214 (1995), *Information technology – Open Systems Interconnection – Transport service definition*.

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