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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Infrastructure of audiovisual services – Communication procedures

Gateway Control Protocol: TCP support packages

Recommendation ITU-T H.248.89

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Recommendation ITU-T H.248.89

Gateway Control Protocol: TCP support packages

Summary

The transmission control protocol (TCP) is a connection-oriented IP transport protocol, which leads to specific requirements on ITU-T H.248 support for the control of bearer procedures related to the establishment and release of TCP connections, as well as the MG internal interworking of TCP packets. Recommendation ITU-T H.248.89 provides ITU-T H.248 packages for support of TCP, complemented by models, considerations of package mode operations and signalling flows.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T H.248.89	2014-10-14	16	11.1002/1000/12240

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

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Gateway Control Protocol: TCP support packages

1 Scope

In scope of this Recommendation are ITU-T H.248 IP media gateway TCP-based bearer interfaces. Such an ITU-T H.248 MG provides various functions for processing of TCP/IP packets, TCP payload data and is involved in functions related to TCP protocol control information (based on TCP header flags). This Recommendation focuses primarily on the aspect of TCP connection control, which comprises the establishment and release of TCP bearer connections.

The Recommendation considers:

– connection models with a single or multiple TCP bearer connection endpoints within an ITU-T H.248 context;

– establishment, through-connection and release behaviour in case of end-to-end TCP bearer connections across two ITU-T H.248 TCP terminations ("a so-called ITU-T H.248 TCP media stream");

– different ITU-T H.248 control models.

Further, this Recommendation provides information on existing ITU-T H.248 tools with respect to other TCP support functions.

1.1 Applicability statements

Table 1 summarizes all possible TCP-based interfaces of ITU-T H.248 entities (under the assumption of an underlying IP network) and their relevance for this Recommendation.

Table 1 – Principal TCP-based interfaces of ITU-T H.248 entities and their relevance for this Recommendation

TCP-based transport	ITU-T H.248 entity	Relevance
Call control interface (e.g., SIP)	MGC	Out of scope of this Recommendation.
Gateway control interface (ITU-T H.248)	MGC, MG	Out of scope of this Recommendation. Possible ITU-T H.248 transport modes are indicated by [ITU-T H.248.67]. Usage of a TCP-based ITU-T H.248 transport mode would be typically specified by an ITU-T H.248 profile (as part of clause 6.12 in the profile definition template (see Appendix III in [ITU-T H.248.1])).
Bearer interface	MG	Within the scope of this Recommendation.

1.2 Package-less TCP connection control

Figure 1 summarizes the methods for ITU-T H.248-based TCP connection control (at the MG bearer interface). The required approach for TCP connection control concerning the TCP proxy mode and TCP to non-TCP interworking is based on package-defined ITU-T H.248 elements introduced by this Recommendation. However, the package-less option should be used in the stateless TCP interworking configurations TCP relay and TCP merge mode (see clause 10.1). Furthermore, the package-less option is required for transparent forwarding of TCP traffic. TCP transparent forwarding covers both TCP protocol control information ("the TCP header") and TCP payload data, and is typically characteristic of the application-agnostic TCP relay mode and application-agnostic TCP merge mode (after TCP connection establishment).

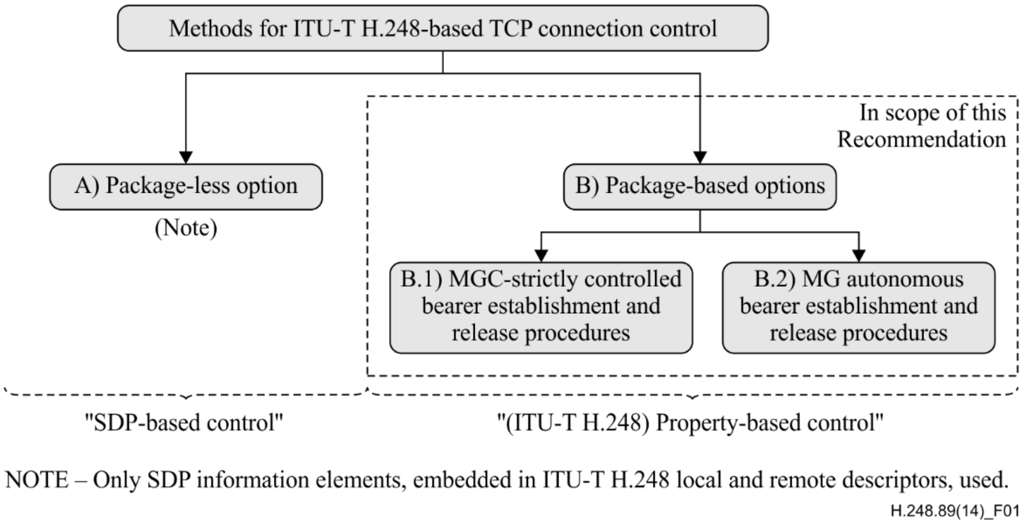


Figure 1 – Overview: Methods for ITU-T H.248-based TCP connection control

The usage of some SDP elements is appropriate in package-based TCP connection control, as long as their semantics do not contradict the ITU-T H.248 elements. The bearer type indication 'TCP' is always required (see clause 10.2.3). The SDP "a=setup" attribute is also used in the package-based approach.

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.248.37] Recommendation ITU-T H.248.37 (2008), *Gateway control protocol: IP NAPT traversal package*.

[ITU-T H.248.40] Recommendation ITU-T H.248.40 (2013), *Gateway control protocol: Application data inactivity detection package*.

[ITU-T H.248.43] Recommendation ITU-T H.248.43 (2008), *Gateway control protocol: Packages for gate management and gate control*.

[ITU-T H.248.50] Recommendation ITU-T H.248.50 (2010), *Gateway control protocol: NAT traversal toolkit packages*.

[ITU-T H.248.53] Recommendation ITU-T H.248.53 (2009), Gateway control protocol: Traffic management packages.

[ITU-T H.248.64] Recommendation ITU-T H.248.64 (2013), *Gateway control protocol: IP router packages*.

[ITU-T H.248.67] Recommendation ITU-T H.248.67 (2009), *Gateway control protocol: Transport mode indication package*.

[ITU-T H.248.69] Recommendation ITU-T H.248.69 (2009), *Gateway control protocol: Packages for interworking between MSRP and H.248*.

[ITU-T H.248.78] Recommendation ITU-T H.248.78 (2013), *Gateway control protocol: Bearer-level application level gateway*.

[ITU-T H.248.79] Recommendation ITU-T H.248.79 (2012), *Gateway control protocol: Guidelines for packet-based streams*.

[ITU-T H.248.84] Recommendation ITU-T H.248.84 (2012), *Gateway control protocol: NAT-traversal for peer-to-peer services*.

[ITU-T H.248.88] Recommendation ITU-T H.248.88 (2014), *Gateway control protocol: RTP topology dependent RTCP handling by ITU-T H.248 media gateways with IP terminations.*

[ITU-T H.248.90] Recommendation ITU-T H.248.90 (2014), *Gateway control protocol: ITU-T H.248 packages for control of transport security using transport layer security (TLS).*

[ITU-T H.248.92] Recommendation ITU-T H.248.92 (2014), *Gateway control protocol: Stream endpoint interlinkage package*.

[ITU-T Q.1950] Recommendation ITU-T Q.1950 (2002), *Bearer independent call bearer control protocol.*

[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 793] IETF RFC 793 (1981), *Transmission Control Protocol*.

[IETF RFC 1191] IETF RFC 1191 (1990), *Path MTU Discovery*.

[IETF RFC 1981] IETF RFC 1981 (1996), *Path MTU Discovery for IP version 6*.

[IETF RFC 4022] IETF RFC 4022 (2005), *Management Information Base for the Transmission Control Protocol (TCP).*

[IETF RFC 4145] IETF RFC 4145 (2005), *TCP-Based Media Transport in the Session Description Protocol (SDP).*

[IETF RFC 4898] IETF RFC 4898 (2007), *TCP Extended Statistics MIB.*

[IETF RFC 4976] IETF RFC 4976 (2007), *Relay Extensions for the Message Session Relay Protocol (MSRP).*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 TCP packet [ITU-T H.248.84]: IP datagram (also known as IP packet) carrying a (single) TCP segment in the payload.

NOTE – Such a L4/L3 PDU is also known as TCP/IP packet (briefly TCP packet).

3.1.2 transparent forwarding [ITU-T H.248.88]: MG packet forwarding behaviour with the characteristic of *Lx-PDU integrity*. This is a unidirectional characteristic of a Lx-PDU flow.

3.1.3 transport (TCP) *proxy* (translator) mode [ITU-T H.248.84] (see clause I.4.1 in [b-ETSI TR 183 068]) (also known as Back-to-Back TCP Endpoint (B2BTE) mode): Stateful forwarding of TCP packets in terms of full protocol termination. The end-to-end TCP connection is partitioned in two TCP connection legs by the BGF. Each H.248 Stream endpoint provides a stateful TCP connection state machine.

NOTE – The term proxy mode is similar as used for HTTP proxy, FTP proxy, SIP proxy, etc.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 TCP proxy types: The basic TCP proxy mode is defined in clause 3.1.3. The following TCP proxy types are useful for the various TCP services as supported by ITU-T H.248 MGs.

The TCP proxy may be an

– *Application-aware* TCP proxy (the MG knows the protocol (stack) carried by TCP packets);

– *Application-agnostic* TCP proxy (the MG is unaware of the TCP payload content).

A TCP proxy may implement the full TCP connection states (stateful) or a sub-set of those states (light).

Example: "application-agnostic, stateful TCP proxy" mode.

3.2.2 TCP transparent forwarding: MG packet forwarding behaviour with the characteristic of *TCP-PDU integrity* (Notes 1 and 2). This is a unidirectional characteristic of a TCP-PDU flow.

NOTE 1 – A TCP-PDU is related to a TCP packet (see [ITU-T H.248.84]), which comprises TCP protocol control information (TCP header) and TCP payload data.

NOTE 2 – Definition based on clause 3.1.2, i.e., the characteristic of *PDU integrity* comprises the properties of *bit integrity* and *data integrity* (see also clauses 3.2.3, 3.1.1 and 3.1.2 in [ITU-T H.248.88]).

NOTE 3 – There is the characteristic of *TCP packet integrity* in the context of "TCP transparent forwarding". The MG might be TCP aware, e.g., support of TCP-related statistics or event detection would not violate transparent forwarding behaviour.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

B2BIH	Back-to-Back IP Host
B2BTE	Back-to-Back TCP Endpoint
BCP	Bearer Control Protocol
BGF	Border Gateway Function
BICC	Bearer Independent Call Control
BNC	Backbone Network Connection
DTLS	Datagram Transport Layer Security
FTP	File Transfer Protocol
GCP	Gateway Control Protocol
HTTP	Hypertext Transfer Protocol
ICE	Interactive Connectivity Establishment
ICMP	Internet Control Message Protocol
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IPv4	Internet Protocol version 4

IPv6	Internet Protocol version 6
IPR	IP Router
IWF	Interworking Function
LCD	Local Control Descriptor
LD	Local Descriptor
MG	Media Gateway
MGC	Media Gateway Controller
MIB	Management Information Base
MPTCP	Multipath TCP
MSRP	Message Session Relay Protocol
MTU	Maximum Transmission Unit
NAT	Network Address Translation
NAT-T	NAT Traversal
NGN	Next Generation Network
NPT	Network Prefix Translation
PMTUD	Path MTU Discovery
RD	Remote Descriptor
RTP	Real-Time Transport Protocol
SCTP	Stream Control Transmission Protocol
SDP	Session Description Protocol
SEP	(ITU-T H.248) Stream Endpoint
SEPP	SEP Pair
SIP	Session Initiation Protocol
TCP	Transmission Control Protocol
TLS	Transport Layer Security
UDP	User Datagram Protocol
UE	User Equipment
WEBRTC	Web-Based Real-Time Communication services

5 Conventions

5.1 Naming of stream endpoints and terminations

The abbreviation L*n* denotes a protocol layer "*n*", e.g., L3 for protocol layer 3.

The notations "T*x*" and "T*x*(S*y*)" are used for naming of terminations and stream endpoints (SEP) respectively, with

– "T*x*" as *TerminationID* value;

– "S*y*" as *StreamID* value and

– numerical variables *x* and *y*.

5.2 TCP bearer

In this Recommendation, the term *TCP bearer connection* refers to a TCP connection in the network user plane. There might be also a TCP connection between MGC and MG in case of a TCP-based ITU-T H.248 transport mode [ITU-T H.248.67]. This connection is not is scope of this Recommendation.

NOTE – This relates to the so called backbone network connection (BNC) concept in [ITU-T Q.1950], which is referred by clause 7.

5.3 TCP bearer control

There are connection control information flows for TCP bearer connections in the network *user plane* (e.g., IP media/data/bearer plane) and in ITU-T H.248 signalling. Figure 2 outlines the used conventions for the differentiation of both control flows.

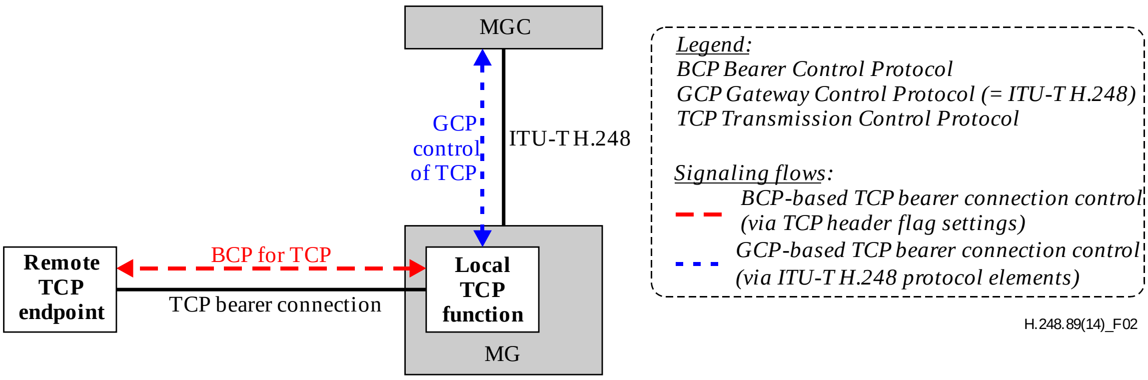


Figure 2 – Conventions for TCP bearer control

5.4 TCP endpoint

The notion of endpoint represents different concepts; see Figure 3.

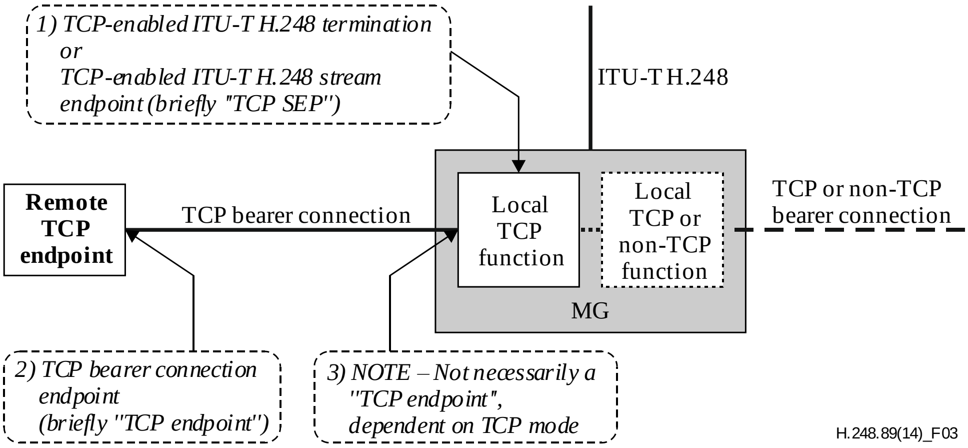


Figure 3 – Conventions for TCP endpoint types

Usage in:

– *ITU-T H.248 control*: ITU-T H.248 terminations/stream endpoints with TCP processing are denoted as TCP-enabled terminations or stream endpoints (SEP), respectively;

– *user plane* (TCP): a *TCP bearer connection endpoint* represents an "(N)-connection-endpoint" according to [ITU-T X.200]. This concept comprises a *terminator* (i.e., TCP protocol termination) plus a *service access point* (i.e., L4+ access).

The SEP subject of the packages and procedures of this Recommendation may or may not act as a TCP bearer connection endpoint:

– The TCP basic connection control package (clause 7) assumes a SEP that is a TCP bearer connection endpoint.

– The interlinkage procedures described in clause 8 using tools specified in [ITU-T H.248.92] assume a SEP or SEP pair that is (are) TCP bearer connection endpoint(s).

– The use of TCP retransmission metrics package (clause 9) is applicable both for SEPs that are TCP bearer connection endpoints and for SEPs that are not.

6 Motivation use cases and models

6.1 Bearer connection network use cases

There are three fundamental use cases from the perspective of ITU-T H.248 MGs and the TCP bearer connection control (see Figure 4):

– Use case #1.1: An ITU-T H.248 IP-IP MG located in the middle of an end-to-end TCP connection. There are two interconnected ITU-T H.248 SEPs (a TCP stream endpoint pair, TCP SEPP) within the ITU-T H.248 context and, from an overall network perspective, two cases can be distinguished:

  ○ Use case #1.1.1: there is a single, continuous end-to-end TCP connection, any interim ITU-T H.248 IP-IP MG does not fully terminate the TCP protocol; this use case relates to a TCP relay or merge mode behaviour of the MG (see [ITU-T H.248.84]);

  ○ Use case #1.1.2: the end-to-end TCP connection is divided in two separate TCP connection segments, the ITU-T H.248 IP-IP MG provides complete TCP protocol terminations towards the remote TCP bearer connection endpoints; this use case relates to the TCP proxy mode behaviour of the MG;

– Use case #1.2 is a TCP to non-TCP interworking scenario. In this case, the ITU-T H.248 MG acts as a single TCP endpoint.

The following use cases are for further study:

– Use case #2: multipath TCP (MPTCP) and ITU-T H.248 MG involvement.

– Use case #3: multiple TCP bearer connection endpoint models such as applied by media servers (e.g., an [ITU-T H.248.69] based MSRP switch).

Figure 4 illustrates the primary network use cases.

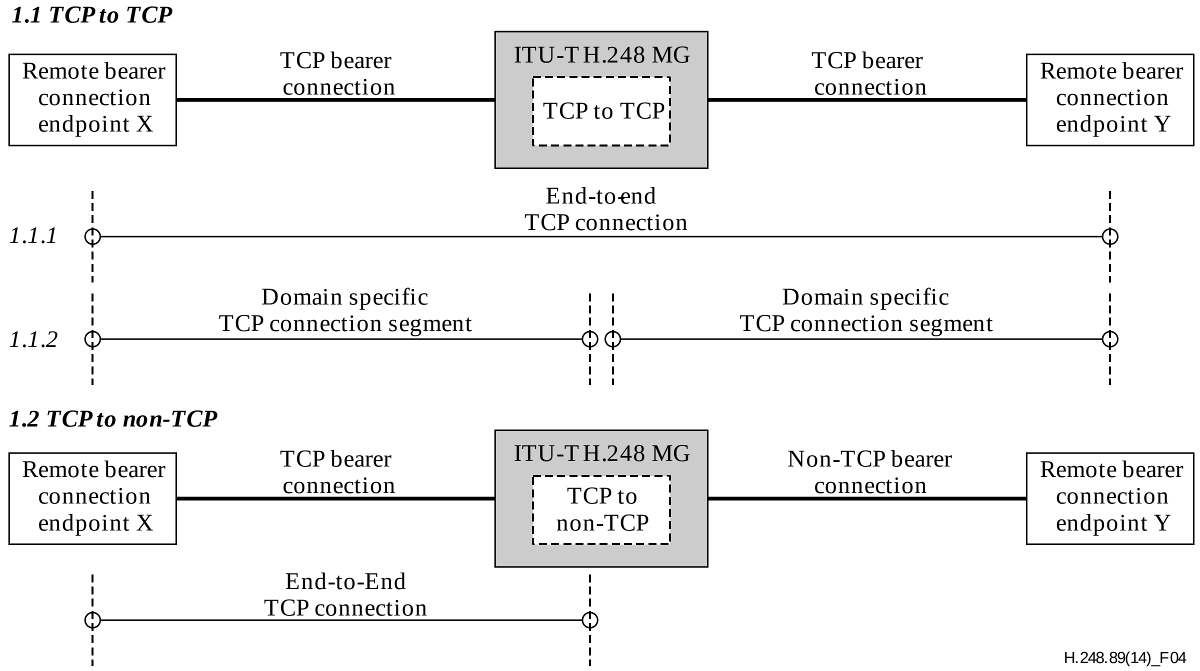


Figure 4 – Bearer connection network use cases with TCP stream endpoints

The TCP connection control aspect is the primary scope of this Recommendation and some general conclusions are described in Table 2.

Table 2 – Use cases and TCP connection control aspects

Use case	TCP connection control aspects
1.1.1	TCP connection establishment (and release) is true end-to-end, meaning that the TCP connection control procedures at the two ITU-T H.248 SEPs are *tightly coupled*. E.g., an incoming TCP connection establishment request (i.e. a TCP SYN packet) from remote endpoint X would lead to an immediate forwarding of that "bearer connection control request" towards remote endpoint Y. This relates to a TCP relay and merge-mode scenario.
1.1.2	TCP connection establishment (and release) is *decoupled* from end-to-end perspective. This looks like a back-to-back TCP endpoint as given by TCP *proxy* mode. The TCP bearer connection control procedures are independent for each SEP.
1.2	The ITU-T H.248 MG provides an IP host function for a single TCP connection endpoint.

6.2 Bearer connection model

All protocol elements and procedures described in this Recommendation are described in a connection model with up to two ITU-T H.248 terminations (Note – there might be one or multiple stream endpoint pairs (SEPP) in case of two terminations). However, they can be applied in connection models with more than two ITU-T H.248 terminations. In addition, no assumptions are made regarding either the lower layer protocols beneath the TCP layer (IPv4 or IPv6) or the upper layer protocols being carried by the TCP payload. This allows the use of the Recommendation's procedures in various connection models and use cases such as illustrated in the subclauses.

6.2.1 Model for a context with a single TCP termination

Figure 5 details the generic connection-model where a TCP-enabled termination is connected to a single non-TCP enabled termination. This model relates to use case #1.2.

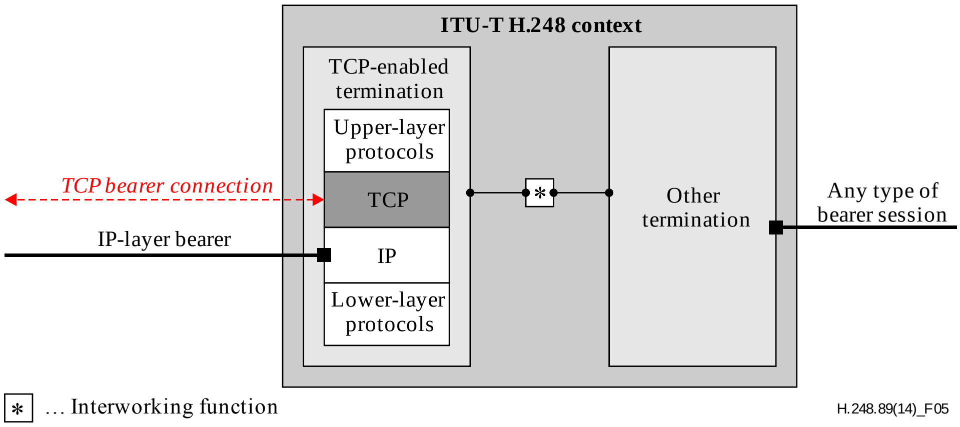


Figure 5 – Two-termination context with a single TCP termination only

6.2.2 Model for a context with two TCP terminations

Figure 6 represents the general model for use case category #1.1. The type of interworking function (IWF) determines the particular MG behaviour concerning TCP handling (see clause 6.2.3).

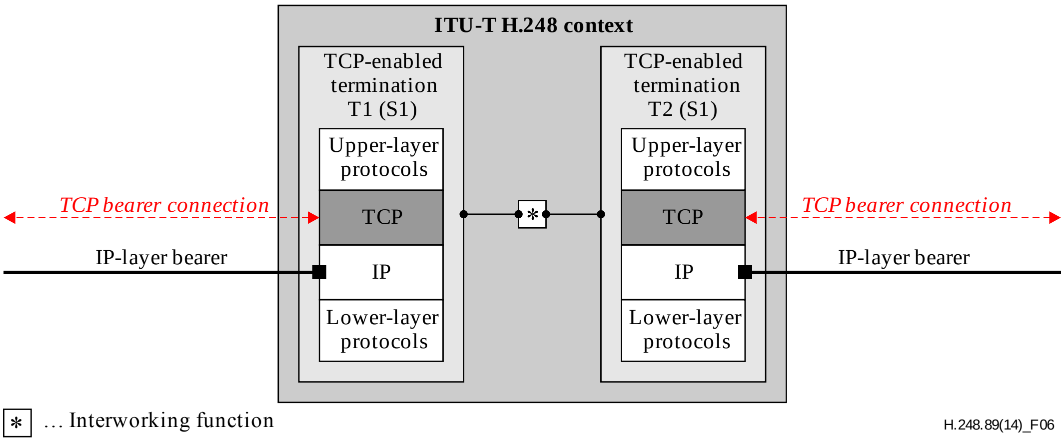


Figure 6 – Two- TCP termination context

6.2.3 Model with focus on context-internal interworking function

Figure 7 depicts interworking functions within a two-termination context with scope on example interworking functions.

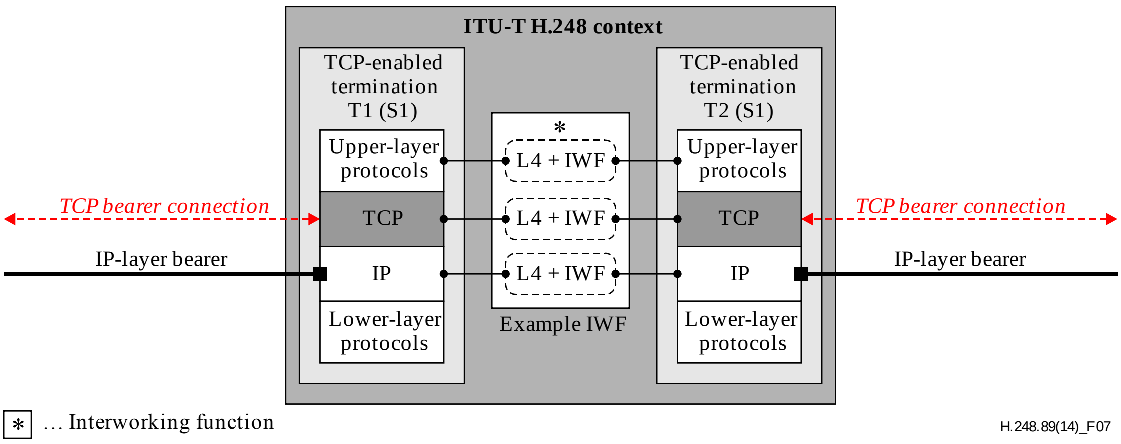


Figure 7 – Two-termination context with context-internal interworking function

The IWF is principally a context-level function, associated to a particular SEPP (here: SEPs T1(S1) and T2(S1)). In the scope of this Recommendation are TCP bearer traffic processing functions (inclusive L4 IWFs), such as:

1. Cut-through characteristic: when the two SEPs are interconnected for enabled traffic flow.
2. BCP (for TCP) information of one SEP as possible stimuli for procedures at a partner SEP, or not. For example, an incoming TCP connection release triggers an outgoing TCP connection release.
3. TCP transparent forwarding: Only the application-agnostic TCP relay mode (i.e., without any L4+-IWF) supports TCP transparent forwarding. Both the TCP merge and TCP proxy mode modify TCP header information, which contradicts TCP transparent forwarding. However, a TCP merge mode usually behaves transparently in the data transfer phase.

L3 IWF is not in scope of this Recommendation. However, TCP modes have usually a dependency on L3 IWF modes:

– The full protocol termination as part of the TCP proxy mode implies two separate, addressable IP transport endpoints, which are only subject of the B2BIH mode.
  ○ The TCP relay mode and TCP merge modes may use an underlying IP Router mode, a B2BIH mode of L3 IWF or a NAT-less mode according to [b-ETSI TR 183 068].

L4+ IWF is not in scope of this Recommendation. However, L4+ IWF may require or be dependent on certain types of L4 IWF:

– Transparent forwarding of TCP-SDUs (i.e., TCP payload data): transparent forwarding is in principle feasible for all TCP modes, unless a specific L4+ IWF impacts bit integrity.
– MSRP switch [ITU-T H.248.69]: this Recommendation could interact with [ITU-T H.248.69] because the MSRP switch relates to an "application-aware, stateful TCP proxy" type.
– MSRP relay [IETF RFC 4976]: the MSRP relay function could be provided by an ITU-T H.248 gateway as part of an application-aware TCP relay or application-aware, lightweight TCP proxy. [ITU-T H.248.69] itself does not provide explicit information concerning an "MGC controlled MSRP relay".
– Bearer-level ALG [ITU-T H.248.78]: a B-ALG service could be enabled for TCP traffic, which would imply the processing of TCP-SDUs (i.e., the TCP payload data). A B-ALG is in principle feasible for all kind of TCP modes (because processing the unstructured octet stream is carried in the TCP payload, which does not require the protocol termination of the TCP). Thus, a B-ALG inherently is characterized by non-transparent TCP forwarding.
– Transport level security [ITU-T H.248.90]: TLS transparent forwarding may be supported by all TCP modes, but TLS/TCP-to-TCP interworking implies an application-aware TCP proxy mode.

7 TCP basic connection control package

Package name: TCP basic connection control package

Package ID: tcpbcc (0x0115)

Description: This package provides the functionality to establish and release a TCP bearer connection.

NOTE – The package design follows conceptually the generic bearer connection (*gb*) package according to clause A.6 of [ITU-T Q.1950] by using an event-/signal-based approach for connection establishment/release control.
Exceptions:

a) bearer modification is not required for TCP;

b) bearer release: uses a package-defined codepoint instead of element *g/cause*.

Furthermore, the package supports bi- and unidirectional TCP bearer connection release procedures.

Version: 1

Extends: None

7.1 Properties

7.1.1 Incoming bearer connection establishment blocking

Property name: Incoming bearer connection establishment blocking

Property ID: bceb (0x0001)

Description: This property defines the MG availability to accept or reject incoming TCP bearer connection establishment procedures.

NOTE 1 – See Annex A concerning a state model based illustration.

NOTE 2 – This capability might be relevant for the prevention of other TCP processing behaviour such as "TCP relay" or "TCP merge" modes (see [ITU-T H.248.84]).

Type: Enumeration

Possible values: See Table 3.

Table 3 – Bearer connection establishment preparedness (of TCP endpoints)

Value	MG behaviour
"blocked" (0x0001)	– Bearer resources are prepared (i.e., resources for TCP endpoint are reserved and allocated to ITU-T H.248 termination/SEP); – TCP role: not determined; prevents assumption of server role; – TCP connection state = "CLOSED" (Figure A.1); – ITU-T H.248 counterpart state = "BLOCKED" (Figure A.3); – Any incoming TCP packet shall be silently discarded (e.g., TCP-SYN requests shall not be acknowledged), there is no state transitioning from "CLOSED" (Note 3). – No outgoing TCP bearer connection control procedures are affected. o Signal *EstBNC* (clause 7.3.1): start 3-way handshake by sending of TCP-SYN; TCP client role is effectively assigned. o Start 3-way handshake by sending of TCP-SYN triggered by an interlinkage procedure [ITU-T H.248.92]; SEP adopts TCP client role.

"unblocked" (0x0002)	– MG shall be ready for incoming TCP bearer connection control procedures; – TCP role: not determined but prepares for a TCP server role effectively ("TCP Passive Open") (Note 4); o Incoming TCP-SYN: TCP server role is confirmed, 3-way handshake proceeded; – Any outgoing TCP bearer connection control procedures are not affected: o Signal *EstBNC* (clause 7.3.1): start 3-way handshake by sending of TCP-SYN; TCP client role is effectively assigned. o Start 3-way handshake by sending of TCP-SYN triggered by an interlinkage procedure [ITU-T H.248.92]; SEP adopts TCP client role. – TCP connection state: transitioning from "CLOSED" to "LISTEN" (Figure A.1); – ITU-T H.248 counterpart state = "IDLE" (Figure A.3);

NOTE 3 – This semantic is analogous to SDP codepoint "`a=setup:holdconn`", see [IETF RFC 4145].

NOTE 4 – This semantic could be correlated with SDP codepoint "`a=setup:actpass`", see [IETF RFC 4145].

Default: "Unblocked" (in order to be consistent with the default behaviour as in [ITU-T H.248.84]).

NOTE 5 – ITU-T H.248 profile specifications could redefine other default values.

Examples: ITU-T H.248 profiles for

1. MGs with support of "TCP proxy" mode only may choose default value "blocked" due to fully separated establishment procedures towards both remote TCP endpoints;
2. MGs with additional support of "TCP relay" and "TCP merge" modes may choose default value "unblocked" in order not to miss any incoming TCP connection establishment requests ("early media").

Defined in: LocalControl

Characteristics: Read/Write

7.1.2 Oneway Release Indicator

Property name: Oneway Release Indicator

Property ID: ori (0x0002)

Description: This property defines the behaviour in the MG in case a TCP-FIN is received for an established TCP connection. It instructs the MG whether to send a TCP-FIN.

Type: Boolean

Possible values: Table 4 defines the protocol semantic per value.

Table 4 – Semantic of property *ori*

Value	MG semantic for TCP bearer connection
False	Indicate the duplex closure of the TCP bearer connection by sending a TCP-FIN autonomously.
True	Keep the TCP bearer connection in the half-closed state, i.e. the MG shall not generate the TCP-FIN autonomously. The MGC explicitly releases the TCP bearer connection via signal *tcpbcc/RelBNC*.

Default: False

Defined in: LocalControl

Characteristics: Read/Write

7.2 Events

7.2.1 TCP connection state change ("BNC change")

Event name: TCP connection state change

Event ID: BNCChange (0x0001)

Description: This event occurs whenever a change to a (TCP) bearer network connection occurs. For example, a bearer has been established or a bearer has been released.

The event is related to the simplified state transitioning model (in contrast to [IETF RFC 793]) described in Annex A.

NOTE – The event design is aligned with event *gb/BNCChange* according clause A.6.2.1 of [ITU-T Q.1950] by using an event/signal-based approach for connection establishment/release control.

7.2.1.1 EventsDescriptor parameters

7.2.1.1.1 Type of state change

Parameter name: Type of state change

Parameter ID: Type (0x0001)

Description: The type of state transitioning, given by the state after the transition.

Type: Sub-list of Enumeration

Optional: Yes

Possible values: Table 5 defines the protocol semantic per value.

Table 5 – Semantic of parameter *Type*

Value	Name	Final state (Figure A.2)	Semantic
Est [0x01]	Bearer Established	ESTABLISHED	Notify MGC successful TCP bearer establishment.
Rel [0x05]	Bearer Released	IDLE	Notify MGC successful TCP bearer release.
NOTE – The numerical codepoint assignments are aligned with [ITU-T Q.1950].			

Default: Est, Rel

7.2.1.2 ObservedEventsDescriptor parameters

7.2.1.2.1 Type of state change

Parameter name: Type of state change

Parameter ID: Type (0x0001)

Description: This is used to indicate what change has occurred to the TCP bearer connection.

Type: Enumeration

Optional: No

Possible values: Est [0x01] Bearer Established

Rel [0x05] Bearer Released

Default: None

7.3 Signals

The signals are related to the simplified state transitioning model (in contrast to [IETF RFC 793]) described in Annex A.

7.3.1 Establish (BNC)

Signal name: Establish BNC

Signal ID: EstBNC (0x0001)

Description: This signal triggers the bearer control function to start bearer establishment (i.e., this signal is used to initiate the TCP bearer connection establishment: the MG takes the TCP client role, sends a TCP SYN segment and completes the TCP active OPEN ("three-way handshake" procedures).

This signal only takes effect in ITU-T H.248 connection states IDLE and BLOCKED (and would be replied by an error code when in ITU-T H.248 connection state ESTABLISHED).

Signal type: Brief

Duration: Not applicable

7.3.1.1 Additional parameters

None.

7.3.2 Release (BNC)

Signal name: Release BNC

Signal ID: RelBNC (0x0002)

Description: This signal triggers the bearer control function to send bearer release (i.e., this signal is used to initiate the TCP closure procedure(s): the MG sends a TCP FIN segment and completes the associated handshake procedure).

This signal only takes effect in ITU-T H.248 connection state ESTABLISHED (and would be replied by an error code when in ITU-T H.248 connection states BLOCKED or IDLE).

Signal type: Brief

Duration: Not applicable

7.3.2.1 Additional parameters

None.

7.4 Statistics

None.

7.5 Error codes

None.

7.6 Procedures

7.6.1 TCP endpoint creation

The MGC is responsible for creating a TCP connection enabled SEP in the MG. This is indicated via the ITU-T H.248 interface by using the SDP "m=" line according the rules as specified in clause 13.4 in [ITU-T H.248.84].

The MG shall reserve "TCP bearer resources" (such as a "TCP connection state machine") and allocates them to the SEP. The TCP endpoint role (client/server) is not determined yet.

NOTE – This functionality is synonymous to the "bearer type indication" semantic as defined by the *BNC Characteristics property (BNCChar)* of the *bearer characteristics package (BCP)*, see clause A.3.1.1 of [ITU-T Q.1950].

7.6.2 TCP endpoint role assumption

The TCP role (client or server) is primarily relevant during the establishment phase of communication (of perspective of ITU-T H.248 gateways). The MGC does not explicitly assign the SEP a TCP role; it is an incoming or outgoing establishment that leads to the assumption of a TCP role. The SEP is prepared for an incoming or outgoing establishment since the moment it is created with an appropriate media descriptor.

The MGC may prevent the assumption of a server role by setting the *bceb* property to "blocked". The MGC may effectively request the SEP to assume the client role by sending the *EstBNC* signal. The SEP may also assume the client role as consequence of interlinkage procedures [ITU-T H.248.92]. If these procedures are allowed, the SEP may assume a client role e.g., as consequence of an incoming procedure in the associated SEP. Table 6 summarizes MGC actions and their results in terms of TCP role adopted by the SEP.

Table 6 – TCP endpoint role assumption (at establishment phase)

No.	ITU-T H.248 indication	MG behaviour:	TCP role
1	1) ITU-T H.248 SEP state "blocked", due to explicit signalling of *bceb* property.	Any incoming TCP packet shall be silently discarded.	Not yet determined
2	2) ITU-T H.248 SEP state "unblocked" either due to explicit signalling of *bceb* property or correspondent default value.	Incoming TCP SYN leads to subsequent completion of 3-way handshake.	Server role
3	ITU-T H.248 signal *EstBNC*. Value of *bceb* property not relevant.	Start of 3-way handshake for TCP connection establishment.	Client role
4	Interlinkage procedures allowed according to [ITU-T H.248.92]. Value of *bcep* property not relevant (although this or similar properties may be relevant at the incoming side of the interlinkage).	An interlinkage establishment procedure [ITU-T H.248.92], e.g., an incoming TCP establishment procedure in the associated SEP leads to the start of 3-way handshake for TCP connection establishment.	Client role

Furthermore, a TCP endpoint role assumption is only meaningful if the TCP-enabled ITU-T H.248 termination/SEP provides an actual TCP endpoint representation, which depends on the TCP mode of operation. Table 7 provides a summary.

Table 7 – State models versus TCP modes of operation

TCP mode	TCP endpoint role	Comments
a) TCP to non-TCP interworking	either TCP ACTIVE or PASSIVE OPEN	Due to complete protocol termination of TCP.
b) TCP to TCP in TCP relay mode	none	Due to TCP bearer connection establishment packets transparently forwarded (stateless).
c) TCP to TCP in TCP merge mode	only TCP PASSIVE OPEN	Due to an end-to-end TCP simultaneous open emulation.
d) TCP to TCP in TCP proxy mode	either TCP ACTIVE or PASSIVE OPEN	Due to an end-to-end TCP simultaneous open emulation.

7.6.3 TCP bearer connection establishment

If the SEP assumes the client role, as result of an EstBNC signal or of an interlinkage procedure [ITU-T H.248.92], the MG shall initiate and complete the TCP connection setup (3-way handshake) without any further involvement of the MGC.

If the SEP assumes the server role, as result of an incoming TCP SYN, and being allowed to do so by the MGC by having the *bceb* property set to "unblocked", the MG shall complete the TCP connection setup handshake without any further involvement of the MGC.

The MGC may arm events *tcpbcc/BNCChange* and *g/cause* (in ITU-T H.248 connection state IDLE) in order to be notified about successful or unsuccessful TCP bearer connection establishment.

The end of the TCP bearer connection establishment phase is summarized in Table 8.

Table 8 – TCP bearer establishment – Results

TCP role	Result of TCP bearer connection establishment	MGC notification?
TCP client (i.e., outgoing establishment side)	Successful	Successful establishment may be notified to the MGC depending on subscription of event and parameter value *tcpbcc/BNCChange{Type=[Est]}*.
	Unsuccessful	Unsuccessful establishment may be indicated to the MGC via a corresponding ServiceChange procedure or event *g/cause*.
TCP server (i.e., incoming establishment side)	Successful	As per client side.
	Unsuccessful	As per client side.

7.6.4 TCP application data transfer

7.6.4.1 MG external

The TCP bearer connection is ready for application data transfer when remote and local TCP endpoints are both transitioned to TCP connection state "ESTAB".

The StreamMode property of the LocalControl Descriptor affects the application data flow rather than the TCP control information used to establish or close the TCP connection. The requested MG behaviour is defined in Table 9.

Table 9 – Impact of StreamMode on TCP bearer traffic at external MG interface

Traffic direction	StreamMode settings	MG behaviour:
Outgoing	Sending enabled (i.e., values *SendOnly*, *SendRecv*, *LoopBack*)	All TCP packets sent
	Sending disabled (i.e., values *RecvOnly*, *Inactive*)	Only TCP packets with active usage of TCP SYN, FIN, RST and PSH information are sent. Optional piggybacked data is sent.
Incoming	Receiving enabled (i.e., values *RecvOnly*, *SendRecv*, *LoopBack*)	All TCP packets accepted
	Receiving disabled (i.e., values *SendOnly*, *Inactive*)	Only TCP packets with active usage of TCP SYN, FIN, RST and PSH information are accepted. Optional piggybacked data is accepted.

TCP provides the application the capability to affect the data application transfer through the PSH- and the URG-flag. The usage of these flags is application specific and therefore must be specified in the application specific procedures.

7.6.4.2 MG internal

This clause is only relevant for ITU-T H.248 contexts with TCP SEPP(s), as outlined in clause 6.2.3.

Application data may be received at a SEP in time where the other SEP of the context is not yet able to process or send the application data. The behaviour of the MG in such a situation is implementation and/or application dependent.

The *interlinkage* capability as profiled by clause 8 may be used to align establishment procedures in both SEPs. This may increase the likelihood that application data received in one SEP is not lost.

7.6.5 TCP bearer connection release

7.6.5.1 Characteristic of TCP bearer connection release

This package only supports bidirectional TCP bearer connection release. Consequently, two TCP half-close procedures shall be performed, resulting in a four-way handshake (see e.g., clause III.4). The transitioning from ITU-T H.248 state ESTABLISHED to IDLE of the local TCP bearer connection endpoint is only done after the successful processing of both TCP half-close procedures.

7.6.5.2 Incoming or outgoing TCP bearer connection release procedure

The TCP bearer connection endpoint shall perform an outgoing TCP bearer connection release procedures when indicated via signal *RelBNC* by the MGC.

The local TCP bearer connection endpoint shall be able to process incoming TCP bearer connection release requests (TCP-FIN packet) at any point in time (whilst in ITU-T H.248 state ESTABLISHED).

7.6.5.3 MG bearer plane procedures

7.6.5.3.1 MGC initiated release (outgoing side)

In order to initiate an outgoing TCP bearer connection release, the local TCP bearer connection endpoint requires an explicit indication from the MGC via signal *RelBNC* by the MGC (Table 10).

Table 10 – MG bearer plane procedures (outgoing side)

<table>
<tr><th>MG bearer plane procedure</th><th>Result</th><th>MGC notification?</th></tr>
<tr><td rowspan="2">Starts first TCP half-close by sending TCP-FIN. Awaits TCP-FIN-ACK and TCP-FIN of second TCP half-close. Subsequent confirmation by a TCP-FIN-ACK. Transition to connection state ITU-T H.248 IDLE (TCP 'CLOSED').</td><td>Successful</td><td>The MGC default assumption is a "successfully released bearer connection" however it may be explicitly notified via the optionally BNCChange event, ObservedEventsDescriptor parameter codepoint "Type=Rel".</td></tr>
<tr><td>Unsuccessful</td><td>There are following options:
1. Via event g/cause (Note 1)
2. Via error code
3. Via event adid/ipstop (see [ITU-T H.248.40]) (Note 2)</td></tr>
<tr><td colspan="3">NOTE 1 – Not all generic codepoints are applicable for TCP.
NOTE 2 – Background: there could be still media activity in case of unsuccessful bearer release. Hence, this event could principally be used to indicate a "hanging TCP connection".</td></tr>
</table>

See Appendix III.4.2 for example traffic flows.

7.6.5.3.2 Bearer initiated release (incoming side)

The local TCP bearer connection endpoint shall be able to process incoming TCP bearer connection release requests (TCP-FIN packet) at any point in time (whilst in ITU-T H.248 state ESTABLISHED). The TCP-FIN packet is the start event for TCP bearer connection release (Table 11).

See Appendix III.4.1 for example traffic flows.

Table 11 – MG bearer plane procedures (incoming side)

MG bearer plane procedure	Result	MGC notification?
Awaits first TCP half-close by detection of incoming TCP-FIN. Subsequent acknowledgment as well as start of second TCP half-close procedures. Transition to connection state ITU-T H.248 Idle (TCP 'CLOSED') after reception of TCP FIN-ACK.	Successful	See Table 5
	Unsuccessful	There are the following options: 1. Via event *g/cause* 2. Via event *adid/ipstop*

7.6.6 Path MTU Discovery

Path MTU discovery (PMTUD) is normally started after successful establishment of TCP bearer connections, see [IETF RFC 1191] (TCP-over-IPv4), [IETF RFC 1981] (TCP-over-IPv6) and [b-IETF RFC 2923] (TCP specific problems with PMTUD). It is expected that bearer plane PMTUD procedures be completely hidden to the MGC.

PMTUD procedures may result in error conditions, such as received ICMP errors from remote side. Whether such situations should lead to error notifications of the MGC by the MG is for further studies.

7.6.7 Interaction of TCP-retransmissions with traffic control functions

Retransmissions of unacknowledged TCP segment leads to an inherent increase of the consumed transport capacity. There might be therefore possible side effects and interactions with traffic control functions, such as traffic policing or traffic shaping.

7.6.7.1 Interaction with traffic policing: IP byterate policing according to [ITU-T H.248.53]

Such a traffic policer entity is enforced at the ingress side of a TCP SEP. The traffic policer function shall consider *all* incoming TCP packets, without distinction between first sent or retransmitted TCP data.

8 TCP-specific stream endpoint interlinkage procedures

8.1 Introduction

Property *interlinkage topology* (linktopo) from clause 7.1.1 of [ITU-T H.248.92] may be used for extended TCP connection control procedures at establishment or release phase. This clause defines TCP-specific stream endpoint interlinkage procedures.

Concerning TCP bearer connection release, the *Oneway Release Indicator* (property *tcpbcc/ori*, see clause 7.1.2) may interact with "release interlinkage". All combinations are considered in the subclauses below.

8.2 Procedures

8.2.1 TCP bearer connection establishment

8.2.1.1 Stream endpoint pair interlinkage disabled

If property *seplink/linktopo* is not used (or disabled per default), then the incoming TCP bearer connection establishment procedure shall be identical to base package *tcpbcc* procedures.

NOTE – Clause IV.3.1 provides signalling examples.

8.2.1.2 Stream endpoint pair interlinkage enabled

The interlinkage property *seplink/linktopo* may be enabled for TCP establishment (see example ITU-T H.248 syntax in Table 12), then the incoming TCP bearer connection establishment request shall be propagated to the partner SEP, triggering there an outgoing TCP-SYN.

NOTE – Clause IV.3.2 provides signalling examples.

Table 12 – TCP bearer connection establishment – Interlinkage enabled

ITU-T H.248 encoding (shortened command)	Comments

`MGC to MG:`
`MEGACO/3 [11.9.19.65]:54321`
`Transaction = 1 {`
` Context = 1 {`
`  Add  = ip/1/$/$ {              ; Termination T1`
`   Media {`
`    Stream = 1 {                 ; SEP S1`
`     LocalControl {`
`      seplink/linktopo = ["<interlinkedSEP>:TCP:TCP:est"]`
`     }}…}`
	Interlinkage (for stream S1) is enabled from termination T1 to termination T2 (given by property parameter value "*interlinkedSEP*").

8.2.2 TCP bearer connection release

Only relevant for incoming TCP bearer connection release requests from MG external bearer interface. Outgoing procedures are not affected.

8.2.2.1 Stream endpoint pair interlinkage disabled and Oneway release indicator disabled

If parameter <*release*> in property *seplink/linktopo* is not used (or disabled per default) and the property *ori* is set to False:

– the incoming TCP bearer connection release procedure shall be not propagated to the partner SEP;

– the incoming TCP bearer connection release procedure shall lead to a bidirectional TCP bearer connection release, hence identical to base package *tcpbcc* procedures.

8.2.2.2 Stream endpoint pair interlinkage enabled and Oneway release indicator disabled

The interlinkage property *seplink/linktopo* is enabled for TCP release (see Table 13) and the property *ori* is set to False:

– the incoming TCP bearer connection release request shall be propagated to the partner SEP, triggering there an outgoing TCP-FIN;

– the incoming TCP bearer connection release procedure shall led to a bidirectional TCP bearer connection release, hence identical to the *tcpbcc* package procedures.

NOTE – Appendix IV.5.3 provides signalling examples.

8.2.2.3 Stream endpoint pair interlinkage disabled and Oneway release indicator enabled

If parameter <*release*> in property *seplink/linktopo* is not used (or disabled per default) and the property *ori* is set to True:

– the incoming TCP bearer connection release procedure shall not be propagated to the partner SEP;

– the incoming TCP bearer connection release procedure shall lead to a one TCP bearer connection release (so called TCP half closure).

8.2.2.4 Stream endpoint pair interlinkage enabled and Oneway release indicator enabled

If the interlinkage property *seplink/linktopo* is enabled for TCP release (see Table 13), and the *ori* property is set to True,

– the incoming TCP bearer connection release request shall be propagated to the partner SEP, triggering there an outgoing TCP-FIN;

– the incoming TCP bearer connection release procedure shall lead to a one TCP bearer connection release (so called TCP half closure).

NOTE – Appendix IV.5.3 provides signalling examples.

Table 13 – TCP bearer connection release – Interlinkage and Oneway release indicator enabled

ITU-T H.248 encoding (shortened command)	Comments

MGC to MG:
MEGACO/3 [11.9.19.65]:54321
Transaction = 1 {
 Context = 1 {
  Add = ip/1/$/$ {   ; **Termination T1**
   Media {
    Stream = 1 {   ; **SEP S1**
     LocalControl {
      seplink/linktopo = ["<*interlinkedSEP*>:TCP:TCP:rel"]
      tcpbcc/ori   = ON
     }}…}
	Both release related capabilities are enabled.

9 TCP retransmission metrics package

Package name: TCP retransmission metrics package

Package ID: tcprm (0x0116)

Description: This package is used to support explicit octet and packet count statistics for the TCP bearer protocol, related to TCP retransmission traffic. The statistics are applicable for all TCP modes of operation, as long as the MG is aware that the ITU-T H.248 Stream carries TCP traffic.

Version: 1

Extends: None

9.1 Properties

None.

9.2 Events

None.

9.3 Signals

None.

9.4 Statistics

9.4.1 Retransmitted TCP Octets Sent

Statistic name: Retransmitted TCP Octets Sent

Statistic ID: tcpros (0x0001)

Description: This Statistic provides the number of retransmitted octets sent on the Termination or Stream since the Termination or Stream has existed and the Statistic has been set. The octets represent the egress retransmitted TCP packets of all TCP flows of an ITU-T H.248 Stream.

It is the total number of octets (i.e., including TCP header) retransmitted in TCP packets. At the Termination level, it is equal to the sum of the egress TCP flows over all Streams.

NOTE – The semantic of this TCP metric is similar with the managed object *tcpEStatsPerfOctetsRetrans* of the TCP MIB [IETF RFC 4898].

Type: Unsigned Integer

Possible values: Any non-negative value

Level: Either

9.4.2 Retransmitted TCP Packets Sent

Statistic name: Retransmitted TCP Packets Sent

Statistic ID: tcprps (0x0002)

Description: Provides the number of retransmitted packets sent on the Termination or Stream since the statistic has been set. The packets represent the egress retransmitted TCP packets of all TCP flows of an ITU-T H.248 Stream.

It is the total number of TCP packets, inclusive of TCP connection establishment, data transfer and connection release phases. At the Termination level, it is equal to the sum of the egress TCP flows over all Streams.

NOTE – The semantic of this TCP metric is similar with the managed object *tcpRetransSegs* of the TCP MIB [IETF RFC 4022].

Type: Unsigned Integer

Possible values: Any non-negative value

Level: Either

9.5 Error codes

None.

9.6 Procedures

9.6.1 Overview – "TCP retransmission traffic" and connection models

Connection models with a single TCP-enabled termination/SEP are uncontroversial. The scope here is therefore on connection models with more than one termination/SEP. Figure 8 illustrates an example with a TCP-enabled stream endpoint pair (SEPP). ITU-T H.248 *tcprm* statistics are activated on $SEP_{T2(S1)}$, thus only the traffic direction from X to Y is relevant.

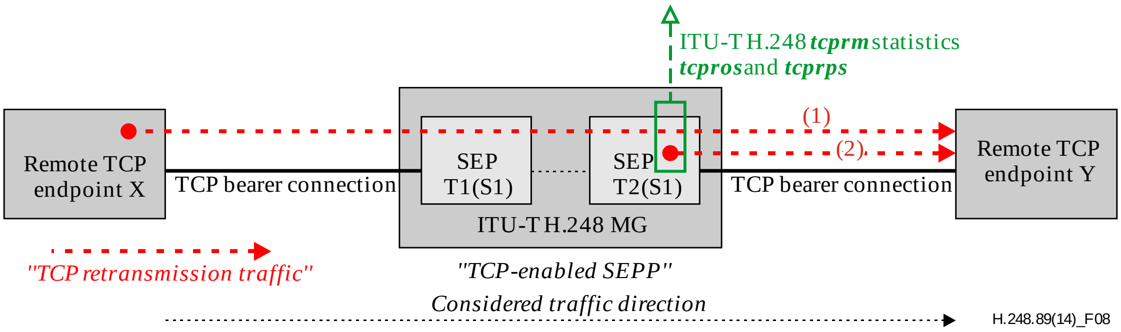


Figure 8 – "TCP retransmission traffic" in (TCP, TCP) connection models

There are two fundamental configurations for a TCP-enabled SEPP:

1. TCP merge or TCP relay mode: TCP retransmission traffic originates in X only; or
2. TCP proxy mode: TCP retransmission traffic only originates in $SEP_{T2(S1)}$.

However, the *tcprm* statistics are applicable to both scenarios.

9.6.2 Egress TCP traffic – Statistic "Retransmitted TCP Packets Sent"

Every outgoing, retransmitted TCP packet, sent from an ITU-T H.248 TCP Stream/Termination, is counted by Statistic *tcprm/tcprps*.

9.6.3 Egress TCP traffic – Statistic "Retransmitted TCP Octets Sent"

The measurement represents the volume of TCP retransmission of all *TCP flows* of an ITU-T H.248 Stream, i.e., across all outgoing, retransmitted TCP packets according to Statistic *tcprm/tcpros*.

9.6.4 Derived statistics

The ITU-T H.248 statistics of this package together with other TCP related statistics (such as from [ITU-T H.248.84] allow the derivation of other TCP performance metrics. This clause provides one example.

9.6.4.1 Performance metric "TCP efficiency"

This metric is defined in clause 4.2 in [b-IETF RFC 6349] according to the following equation:

$$\text{TCP efficiency}\,\% = \frac{\text{Transmitted bytes} - \text{Retransmitted bytes}}{\text{Transmitted bytes}} \times 100$$

Metric *TCP efficiency* for an ITU-T H.248 stream/termination could be calculated (by the MGC), using the two ITU-T H.248 statistics *TCP Octets Sent* (*tcptv/tcpos*, see clause 10.4.1 of [ITU-T H.248.84]) and *Retransmitted TCP Octets Sent* (*tcprm/tcpros*).

10 Package-less TCP control

10.1 Package-less TCP control in other ITU-T H.248.x-Recommendations

Pure SDP is used for the establishment of TCP bearer connection control by following Recommendations:

– [ITU-T H.248.69]: for MSRP-over-TCP bearers in MSRP switch configurations;
– [ITU-T H.248.84], clause 13: TCP merge and TCP relay mode configurations.

The (H.248) Property-based control method (according to clauses 7 to 9) is applied for stateful TCP handling by the MG, which covers TCP to non-TCP interworking (i.e., one SEP realizes a TCP endsystem mode), TCP-to-TCP interworking in TCP proxy mode and context configurations with more than two TCP-enabled ITU-T H.248 terminations which are interconnected.

10.2 Principal ITU-T H.248 control steps for communication establishment

10.2.1 Overview

Figure 9 indicates possible ITU-T H.248 control steps concerning the establishment of TCP connections in environments demanding NAT traversal support.

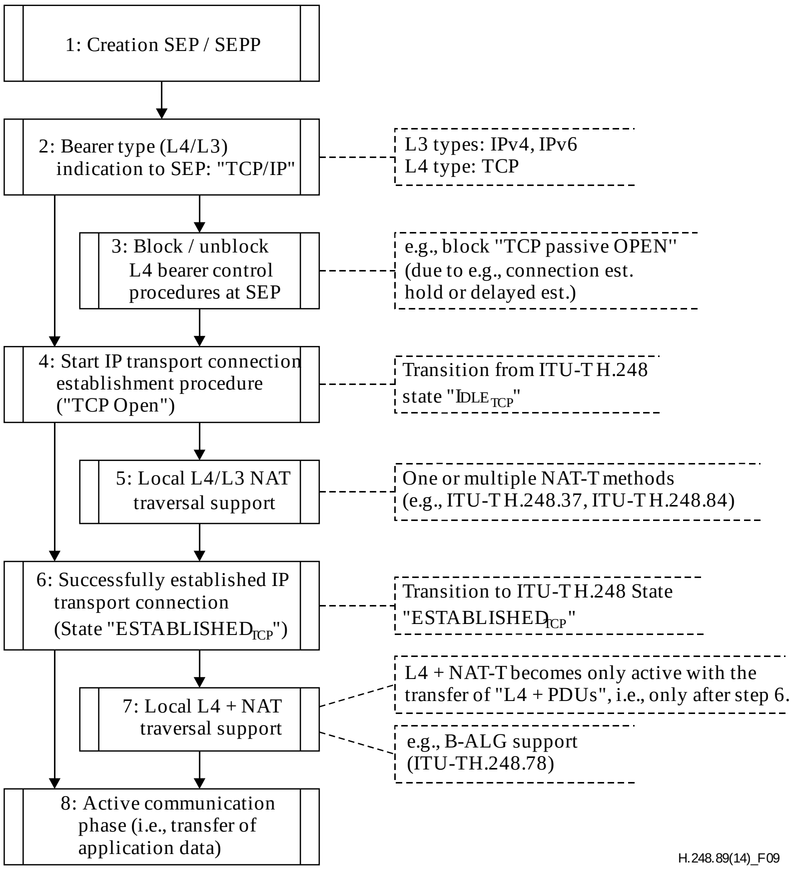


Figure 9 – Principal ITU-T H.248 control steps for establishing a native TCP bearer

It is apparent that some steps might be combined (e.g., 1 and 2) and that specific steps might be optional (e.g., 3, 5, 7).

Table 14 provides an inventory of possible control elements from ITU-T H.248 perspective. The column "H.248/SDP element" refers to "package-less TCP control".

Table 14 – ITU-T H.248 control steps and possible control elements

ITU-T H.248 control step		ITU-T H.248 property	H.248/SDP element	Comments
Establishment phase: "IP transport connection establishment"				
1	Creation SEP / SEPP	ADD.req/MOD.req command		
2	Bearer type (L4/L3) indication to SEP	Indirect: package elements used from TCP-related ITU-T H.248 packages	"m="-line <proto> (clause 13.4 of [ITU-T H.248.84] and clause 6.2 of [ITU-T H.248.69])	1) SDP may be ambiguous due to the "protocol stack" concept (Note 1). 2) bearer type is a LCD level characteristic, but not LD/RD related.
3	Block / Unblock L4 Bearer Control Procedures at SEP	Property: *tcpbcc/bceb*	"a=setup:holdconn"	High level semantic.
4	Start IP Transport Connection Establishment Procedure ("TCP Open")	TCP proxy mode: Event: *tcpbcc/ BNCChange* Signal: *tcpbcc/ EstBNC*	TCP proxy mode: not possible due to [ITU-T H.248.84] "a=setup:" semantics for LD/RD usage	Conditional, dependent on required TCP mode.TCP proxy mode needs to be supported, in TCP ACTIVE and PASSIVE OPEN.
5	Local L4/L3 NAT traversal support	[ITU-T H.248.37]	"a=setup:" for [ITU-T H.248.84] NAT-T	Complementary due to different NAT-T methods
6	Successfully established IP Transport Connection (State "Established$_{TCP}$")	Event: *tcpbcc/ BNCChange*	–	MGC notification might be optional.
7	Local L4+ NAT traversal support	[ITU-T H.248.78]	e.g., "a=msrp-cema"	Note 2
Communication phase				
8	Active communication phase (i.e., transfer of application data)	–		
NOTE 1 – The SDP "m=" line <proto> element allows the indication of a) a single protocol or b) a protocol stack (i.e., multiple protocol layers). The protocol stack based value is inherently ambiguous in case of the requirement in indicating a particular protocol layer out of the stack. This is a well-known issue of this element. NOTE 2 – The SDP based indication seems to be principally deficient ("application protocol specific SDP"), whereas [ITU-T H.248.78] supports the flexibility of different application protocols.				

10.2.2 Step 1: TCP-enabled termination/stream endpoint creation

Not SDP related, based on ITU-T H.248 Command request.

10.2.3 Step 2: Bearer type indication "TCP"

The 'TCP' bearer type must be included according to the SDP-based method as defined by clause 7.6.1. This is applicable for both the package-less and the package-based approaches.

The SDP "m="-line <proto> element may or may not contain upper layer protocol information (above the TCP layer), leading to application-aware or application-agnostic indications.

TCP provides a bidirectional communication service, hence the SDP "m="-line <proto> values need to be consistent in the LD/RD concerning the L4 indication of 'TCP'.

10.2.4 Step 3: Block / Unblock TCP bearer control procedures at SEP

Block / Unblock TCP bearer control procedures at SEP are not supported by SDP, thus property *tcpbcc/bceb* required.

NOTE – [IETF RFC 4145] SDP codepoint "a=setup:holdconn" is intended to hold TCP bearer connection establishment, however, it is semantically unclear how an ITU-T H.248 MG should process any incoming TCP traffic.

10.2.5 Step 4: Start TCP connection establishment procedure ("TCP Open")

When the SEP performs full TCP protocol termination (TCP proxy mode and TCP to non-TCP interworking), the [IETF RFC 4145] SDP "a=setup" attribute cannot be used to derive the semantic of a "TCP active OPEN" or "TCP passive OPEN" procedure since it is mandatory to set the attribute to "actpass" as the indication of the TCP mode. Thus the use of this method (usage of values "active" and "passive" in the "a=setup" attribute) in cases where TCP protocol termination is required (as package-less approach) is deprecated. Furthermore:

– In a TCP active OPEN that method does not allow delayed establishment.

– If the SDP "m=" line <proto> element also contains other protocol layers (e.g., TLS, DTLS), the "a=setup" attribute may also trigger or influence the connection establishment at the upper layer.

The use of the signal *tcpbcc/EstBNC* triggers an immediate TCP bearer connection establishment. The use of this signal also implies TCP protocol termination, which is not applicable to a TCP relay and TCP merge mode.

The TCP proxy mode configuration implies a packaged-based approach and if the SDP "a=setup" attribute is used in the LD/RD then the SDP "a=setup" value settings shall be according to [ITU-T H.248.84], Table 1. Likewise for TCP to non-TCP interworking.

10.2.5.1 Potential benefits of a package based approach for bearer establishment

The package based approach offers services that might be of interest for specific TCP-based communication services and network solutions:

– Capability to monitor the TCP bearer establishment or lack of it with the *tcpbcc*/*BNCChange* event;

– Capability to control, e.g., delay, the timing of a TCP bearer establishment procedure with the *tcpbcc/EstBNC* signal and *tcpbcc/bceb* property;

– Capability to block incoming TCP bearer establishment requests;

– Capability to decouple TCP bearer establishment procedures and upper layer bearer establishment procedures.

10.2.6 Step 5: Local L4/L3 NAT traversal support

Basically, local L4/L3 NAT traversal support is controlled via [ITU-T H.248.37], [ITU-T H.248.50] or/and [ITU-T H.248.84], but could be complemented by SDP-based signalling e.g., in case of "ICE for TCP" [b-IETF RFC 6544].

10.2.7 Step 6: Reporting successfully established TCP connection

Reporting successfully established TCP connection is not possible via SDP, thus event *tcpbcc/BNCChange* is required.

10.2.8 Step 7: Local L4+ NAT traversal support

Local L4+ NAT traversal support is not possible via SDP for general L4+ NAT-T, thus [ITU-T H.248.78] is required.

NOTE – Some application-specific L4+ NAT-T support functions could be associated with application-specific SDP information, however, this is out of scope of this Recommendation.

10.2.9 Step 8: Active communication phase

Control of functions during the active communication phase (such as performance measurements or application data inactivity detection for TCP) is out of scope of the SDP.

10.3 Release of TCP connection

The release of a TCP connection is not possible via SDP. The hard removal of a TCP-enabled stream endpoint via an ITU-T H.248 MODify.req or SUBtract.req command would lead to a complete release of MG level TCP resources but may not always ensure a correct and complete TCP closure handshake with the remote TCP bearer connection endpoint. Usage of signal *tcpbcc/RelBNC* removes the TCP resources but keeps other resources associated with the SEP. This represents a benefit of the package-based approach in the TCP proxy case, especially in TCP to non-TCP scenarios.

11 Security considerations

The primary focus of this Recommendation is the ITU-T H.248-based control of establishment and release of TCP bearer connections. Especially the establishment phase is critical from security perspective due to a plethora of well-known attack scenarios, see e.g., [b-Bellovin1989] and [b-CPNI-TCP] and the references cited by these publications.

The IETF was (and is still active) developing extensions and practices in order to enhance security for TCP, e.g., [b-IETF RFC 5925] or [b-IETF RFC 6528].

The ITU-T H.248 MG could be consequently subject of a TCP security threat itself (particularly when terminating the TCP protocol, i.e., "TCP endpoint" or "TCP proxy" mode), or forward TCP traffic related to potential attacks of downstream network equipment.

In order to minimize any risk:

– the MGC could actively
  - ○ monitor the TCP bearer connection establishment by requesting notification about successfully established TCP-enabled terminations/stream endpoints;
  - ○ delay/block TCP data transfer as long as the TCP bearer connection establishment process is ongoing;

– the MG could be used for countering security attacks by enforcing policy rules on TCP/IP packets according e.g.,
  - ○ the filtering guidelines by clause 9.1.2.1 of [ITU-T H.248.79]; or
  - ○ a more advanced policing using DPI [b-ITU-T H.248.86].

Any concrete considerations concerning the overall security architecture, trust models, network protection, etc. should be subject of the applied ITU-T H.248 profile specification.

Annex A

State modelling for TCP bearer connection endpoints

(This annex forms an integral part of this Recommendation.)

A.1 Introduction and purpose

The TCP basic connection control package (clause 7) is tightly coupled to a state model, because the event (*tcpbcc/BNCChange*) and signal (*tcpbcc/EstBNC*) are related to state transitioning behaviour. The detailed user plane state model for TCP is given by [IETF RFC 793]. However, a simplified view is sufficient from perspective of ITU-T H.248 gateway control procedures.

The underlying state model of package *tcpbcc* is described by this annex.

A.2 Original state model for TCP bearer connection endpoints

The principle model for TCP is comprised of 12 states and defined by Figure 6 of [IETF RFC 793], see Figure A.1.

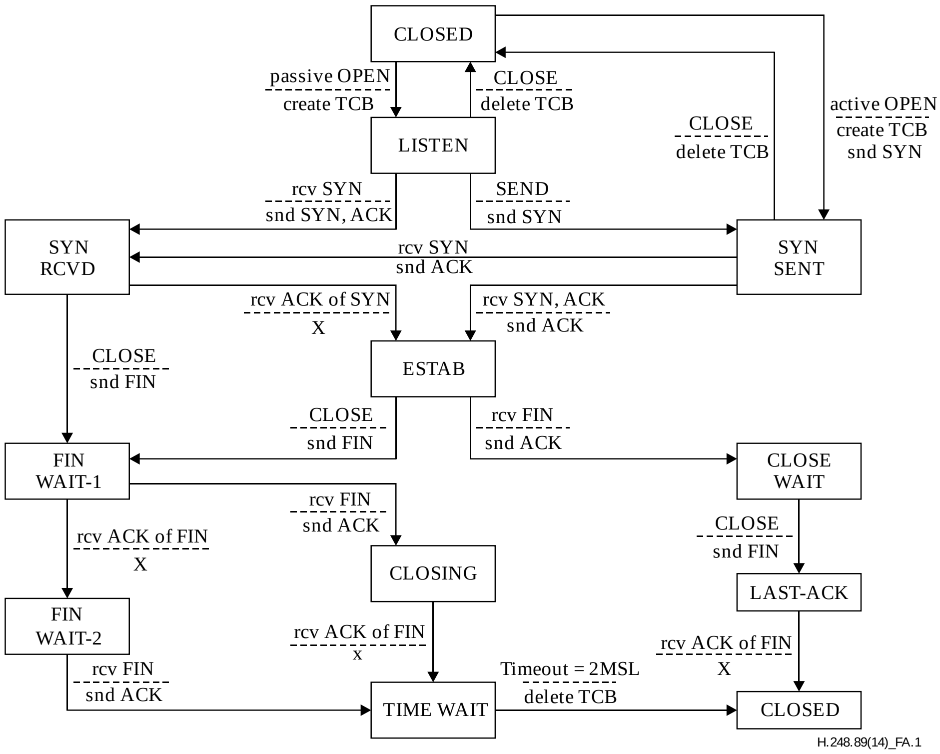


Figure A.1 – TCP connection state diagram [IETF RFC 793]

A.3 Simplified state model for ITU-T H.248-based TCP basic connection control

The TCP basic connection control package makes a couple of assumptions, primarily:

– Bearer establishment:
  - ○ neglects TCP simultaneous open;
  - ○ interim states of 3-way handshake are not needed;

– Bearer release:
  - ○ one-way closure not considered;
  - ○ all interim states between the transitioning from TCP states ESTAB to CLOSED are not needed.

The resulting simplified model is depicted by Figure A.2:

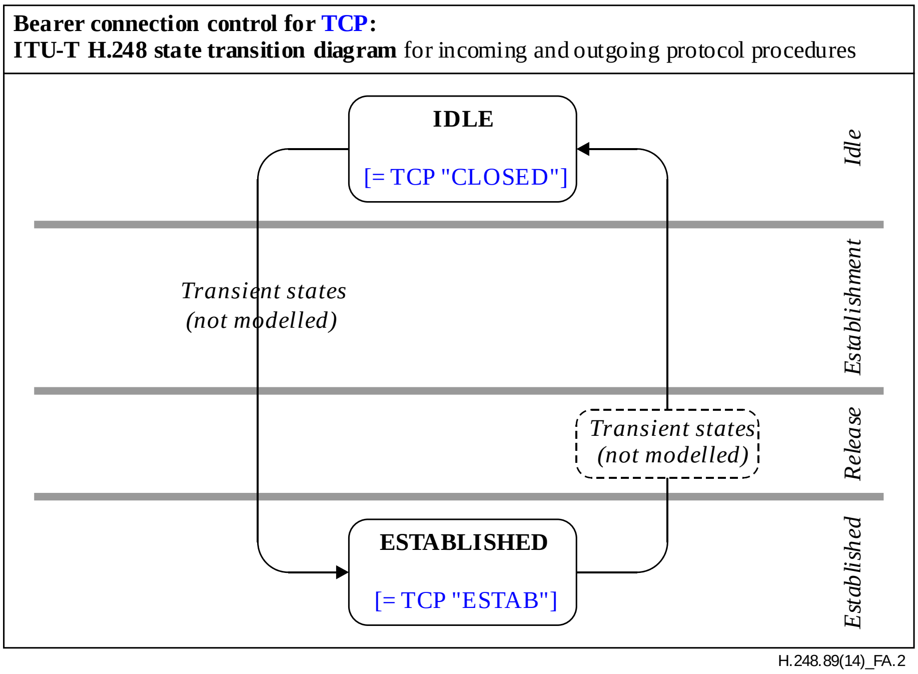


Figure A.2 – Simplified state model for ITU-T H.248-based TCP basic connection control

There are two remaining states, called IDLE and ESTABLISHED in the ITU-T H.248 state model. Signal *tcpbcc/EstBNC* is used for triggering state changes by the MGC, event *tcpbcc/BNCChange* indicates successfully completed state transitions to the MGC. In more detail, transitioning completed:

– to state ESTABLISHED when TCP-ACK (as third element of TCP three-way handshakes)
  ○ received for incoming TCP bearer connection establishment procedure; and
  ○ sent for outgoing TCP bearer connection establishment procedure
– to state IDLE when TCP-FIN-ACK (as fourth element of two TCP half-closures)
  ○ received for incoming TCP bearer connection release procedure; and
  ○ sent for outgoing TCP bearer connection release procedure.

The MGC may block the establishment of an incoming TCP bearer connection request, e.g., whilst TCP role assignment is yet unclear or during ongoing call control signalling procedures, etc. This blockage results in a third state BLOCKED from an ITU-T H.248 perspective, see Figure A.3.

NOTE – The concept of blocking/unblocking of bearer connection procedures is a known concept from BICC (see e.g., [b-ITU-T Q.2630.1]).

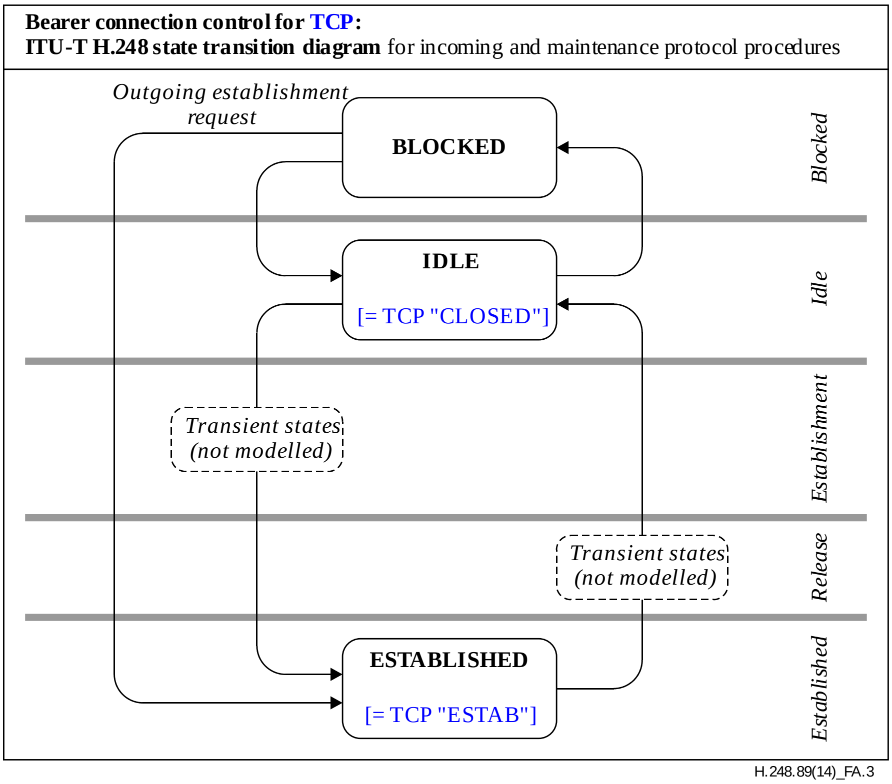


Figure A.3 – Extended state model for ITU-T H.248-based TCP basic connection control

A.4 State models versus TCP modes of operation

Support of different TCP modes of operations is primarily driven by resource related cost factors and performance aspects. The amount of required MG resources nearly correlates with the number of considered TCP connection states. Table A.1 provides an overview about state modeling versus TCP modes.

Table A.1 – State models versus TCP modes of operation

State model	TCP relay	TCP merge	TCP proxy (light)	TCP proxy (full)
Signalling plane (ITU-T H.248 model)	See Figures A.2 or A.3			
Bearer plane (considered TCP connection states)	0 ["stateless"]	2 (Note 1)	2 ≤ … < 12 (Note 2)	12 (see Figure A.1)
NOTE 1 – The MG roughly needs to keep track of transitioning from TCP state "CLOSED" to "ESTAB". NOTE 2 – The *lightweight TCP proxy* mode is not detailed further.				

Appendix I

Sample use-cases of TCP connection control

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

I.1 Use case #1: WebRTC to NGN/IMS interworking function with termination of transport security by MG

This use case shows an MG that provides a transport layer interworking function between a WebRTC-based data application and a UE located in a NGN or IMS network. This is an example for "TCP to non-TCP" interworking (according to use case #1.2 in clause 6.1).

Background:

Web-based real-time communication services (WebRTC) include non-media (data) applications, which are using a datagram connection for data transport (see [b-IETF rtcweb-data]). The selected protocol solution results in a hierarchical protocol layering (data-over-SCTP-over-DTLS-over-ICE/UDP), driven by NAT traversal complexity, multiplexing and security related aspects.

The considered data applications (by WebRTC) would use legacy TCP transport in non-WebRTC IP network environments. ITU-T is currently developing a Recommendation that will address several variants of ITU-T H.248 WebRTC gateways positioned for WebRTC interworking scenarios.

The setup of termination T2 is controlled by the TCP connection control package while the setup of termination T1 is out of scope of this Recommendation.

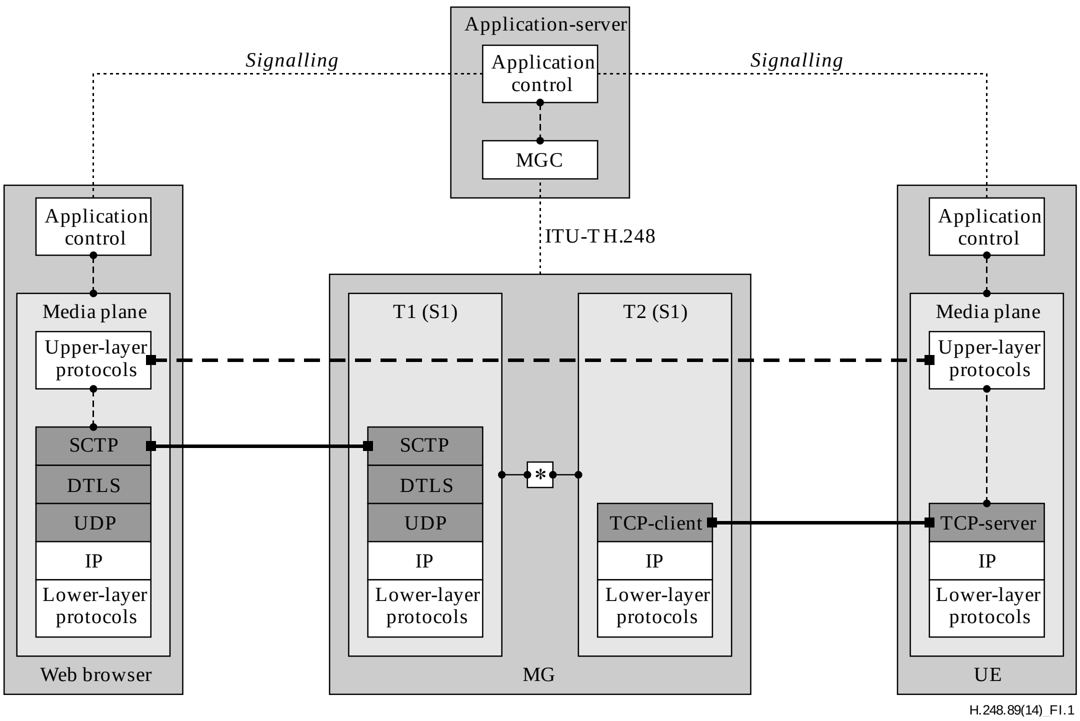


Figure I.1 – Use-case #1: WebRTC to IMS interworking function

Appendix II

Example call flows

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

II.1 Overview

The following example call flows illustrate the typical behaviour for basic TCP connection establishment and release. The establishment behaviour is related to the TCP mode of operation.

II.1.1 Mode type: application agnostic TCP-proxy

The MGC needs to assign the TCP mode of operation to an ITU-T H.248 context. This is fundamentally based on SDP information elements according to clause 13.5 of [ITU-T H.248.84].

The MGC could use also additional explicit ITU-T H.248 signalling elements for the SEP individual assignment of TCP client/server roles, via the indication of incoming or outgoing TCP bearer connection establishment procedures, using the *tcpbcc* package capabilities as defined by this Recommendation, see example in clause II.2.2.

II.2 Basic TCP bearer connection control

II.2.1 Network configuration

The call flow is based on the network configuration as shown in Figure II.1:

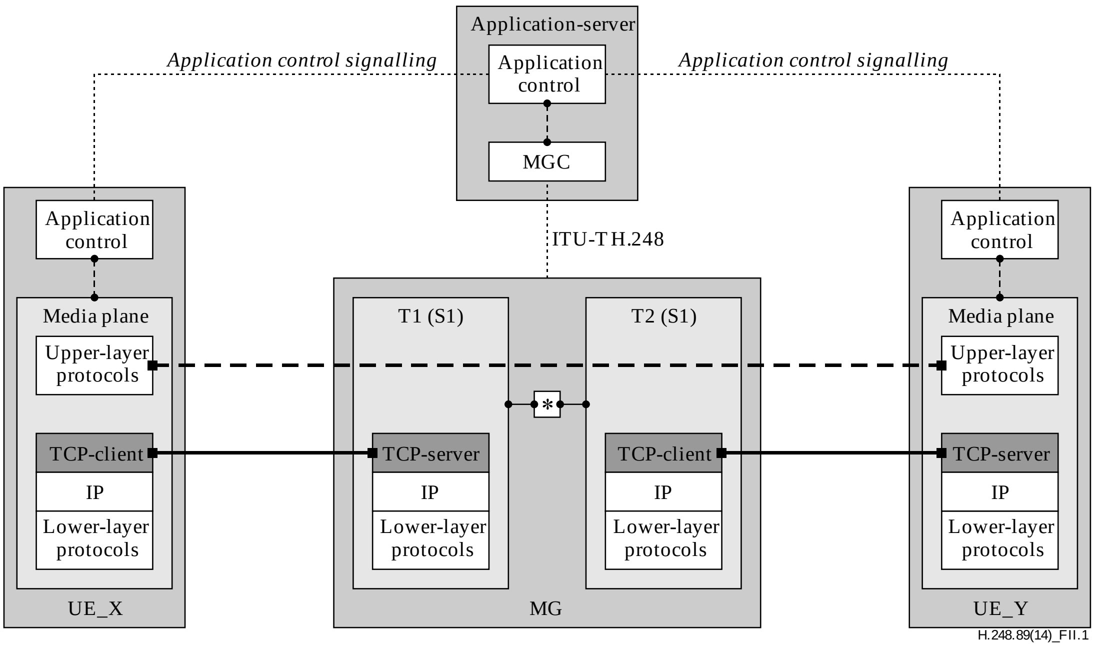


Figure II.1 – Configuration "application agnostic TCP-proxy"

The use case shows an MG with two SEPs (labelled as T1(S1) and T2(S1)) configured in an application agnostic TCP-proxy mode. The configuration and the call flow are characterized as follows:

– MGC strict control of the TCP bearer endpoints on both terminations

– Stream endpoint T1(S1): TCP-server, i.e., providing *incoming* TCP bearer establishment procedures ("TCP passive open" according [IETF RFC 793])

– Stream endpoint T2(S1): TCP-client, i.e., providing *outgoing* TCP bearer establishment procedures ("TCP active open" according [IETF RFC 793])

– TCP-connection for both terminations are setup in parallel
– TCP-connection released by remote TCP-endpoint of termination T1; application data may still flow from UE-Y to UE-X.

II.2.2 Establishment

Figure II.2 illustrates a traffic flow example concerning the establishment of an end-to-end TCP connection between UE-X and UE-Y, which relates to two TCP connection segments from ITU-T H.248 MG perspective (due to TCP proxy mode).

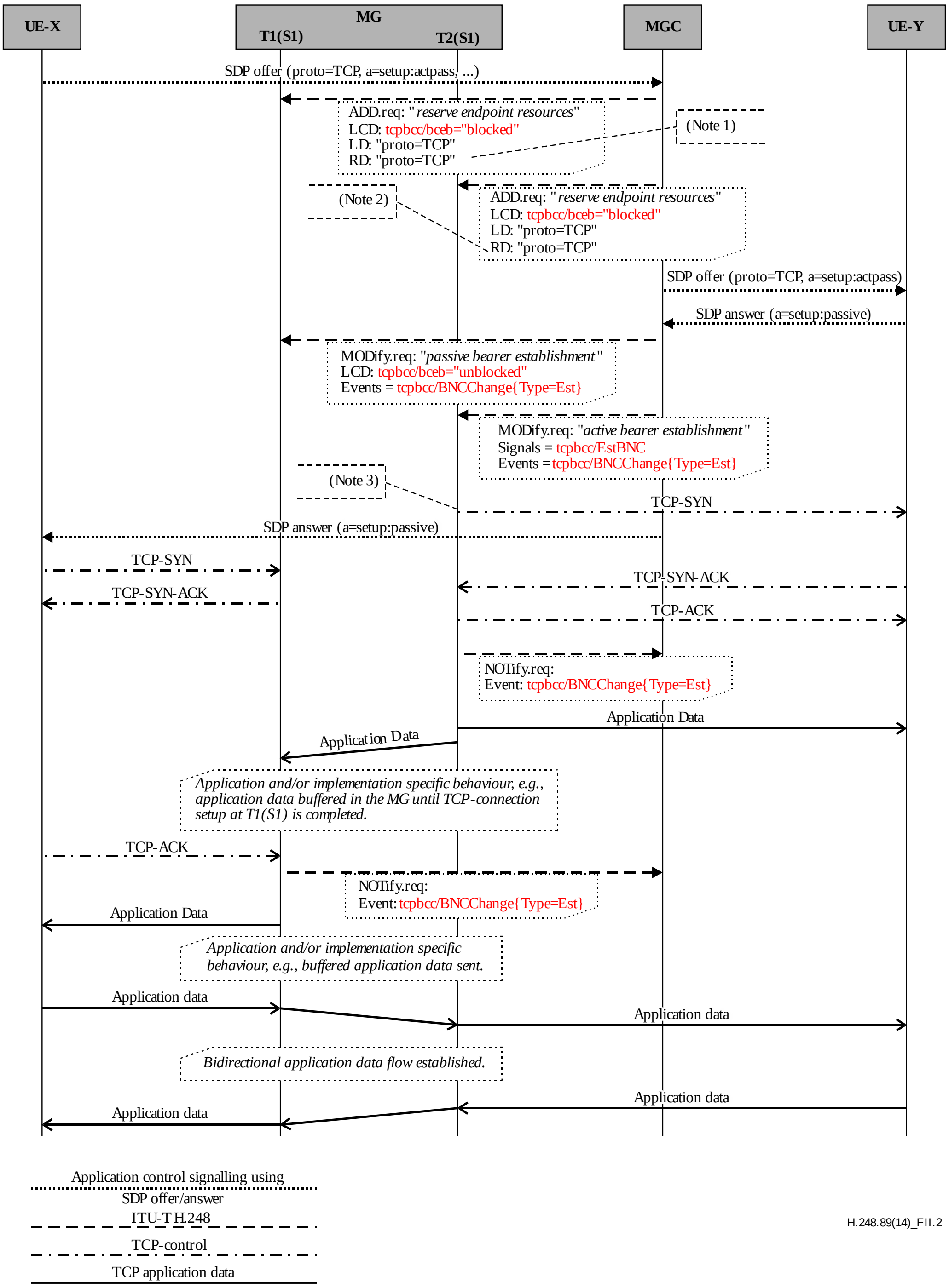
The example traffic flow indicates parts of application control signalling (here SIP/SDP with scope on SDP Offer/Answer information), gateway control signalling (ITU-T H.248) and bearer plane traffic (here TCP packets for connection establishment).

The MGC follows an early reservation strategy of MG resources, thus initiates the creation of a "TCP-TCP" context in the MG already during still ongoing capability negotiations at application control level. In order to prevent accidental TCP state transitioning in the MG due to "too early TCP media", the MGC decides to block explicitly TCP bearer connection establishment (via property *tcpbcc/bceb*).

As soon as application control signalling allows, the MGC enforces *incoming* (at SEP T1(S1)) and *outgoing* (at SEP T2(S1)) TCP bearer connection establishment procedures.

The MGC requests to be notified of successfully established TCP bearer connection segments by setting the *tcpbcc/BNCchange* event in this example.

The signalling scenario is termed as "MGC strictly controlled" due to the fact that only the *TCP basic connection control* package is used. The interlinkage capability (according to [ITU-T H.248.92]) as described in clause 8 would tightly couple both TCP connection control procedures, see clause IV.3.2.

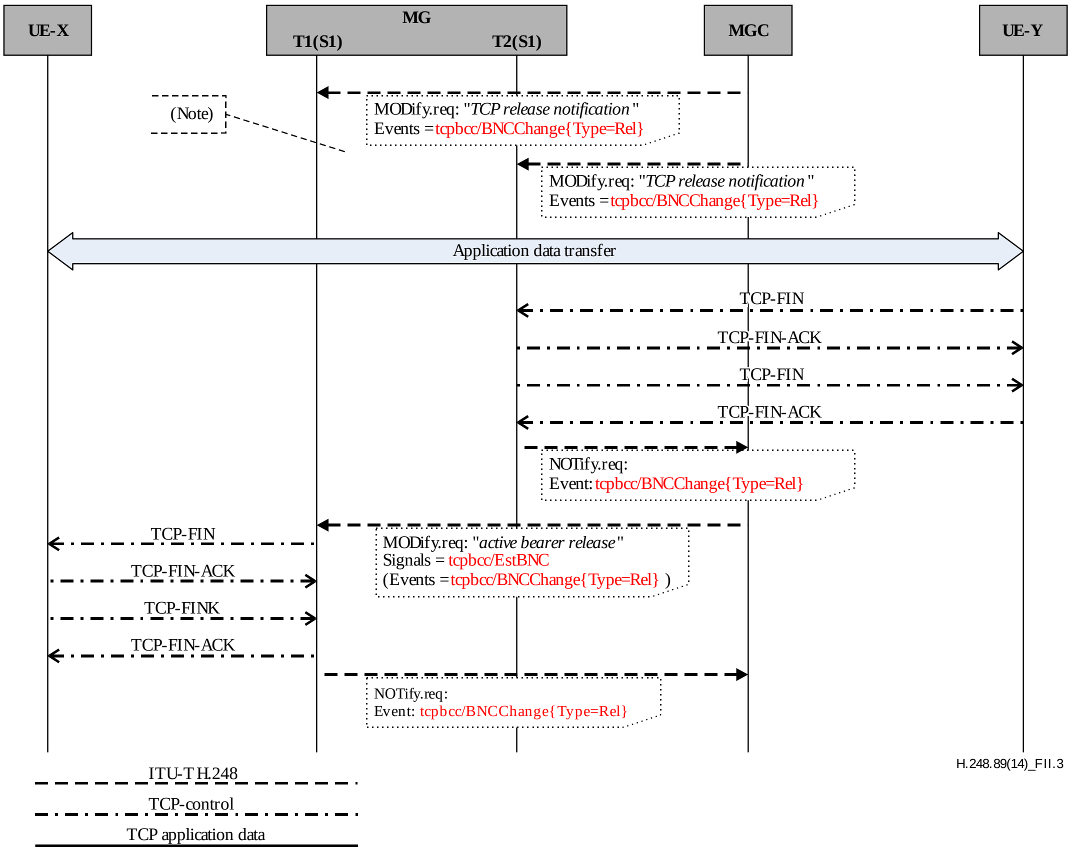


NOTE 1 – SDP-based, TCP information shall not trigger TCP bearer connection control procedures!
NOTE 2 – RD could be either re-moved, or provide already the bearer type indication (for TCP).
NOTE 3 – The establishment procedures for the two TCP connection segments towards UE-X and UE-Y are both independent.

Figure II.2 – Traffic flow example for an MGC strictly controlled TCP bearer connection establishment using the TCP-proxy mode

II.2.3 Release

Figure II.3 illustrates the traffic flow for the use case when the MGC does not know which remote TCP endpoint initiates TCP CLOSE procedures. Further, the default case of a bidirectional TCP bearer connection release is described. The MGC subscribes to event *tcpbcc/BNCChange* in order to be notified about release activities. It may be reminded that the notification is only issued when the local SEP has successfully transitioned to ITU-T H.248 connection state IDLE.



NOTE – MGC does not know whether X or Y initiates a TCP CLOSE procedures. Thus, release notification enabled at both SEPs.

Figure II.3 – Traffic flow example for an incoming TCP bearer connection release, explicitly propagated by the MGC in outgoing direction

Figure II.4 provides another release example: the MGC enforces a TCP bearer release by initiating parallel TCP bearer connection release procedures towards both remote TCP endpoints X and Y.

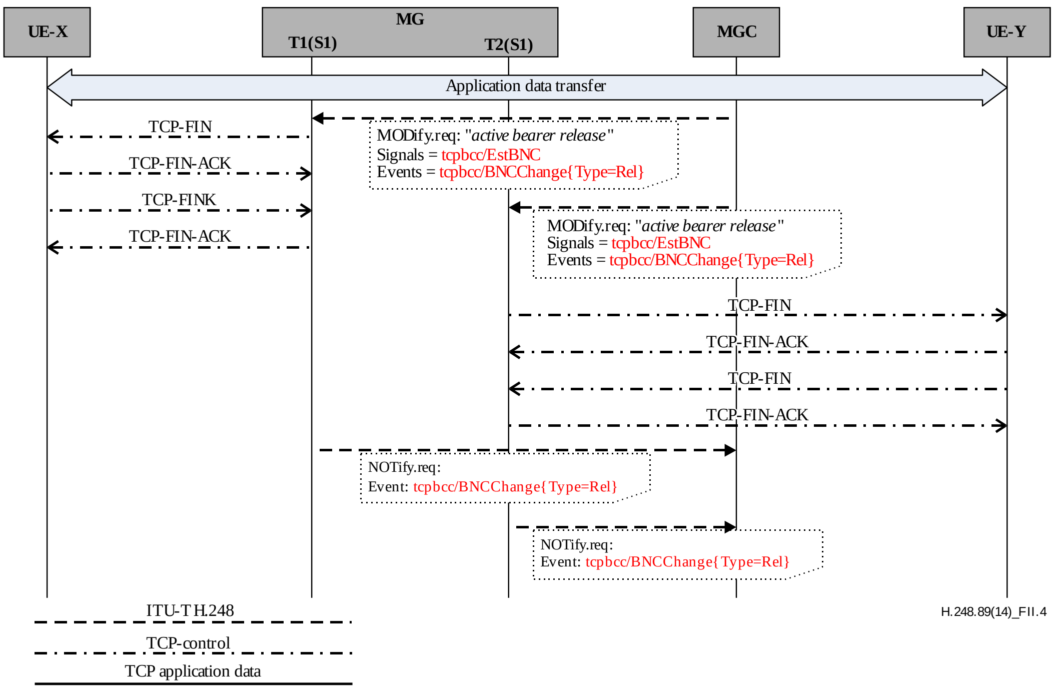


Figure II.4 – Traffic flow example for outgoing TCP bearer connection release procedures towards both remote TCP endpoints X and Y

II.3 Extended TCP bearer connection control

II.3.1 Establishment

This use case applies to the same configuration as the previous use case depicted in Figure II.2. There is no necessity for explicit TCP bearer establishment control by the MGC in this example, because e.g., of lacking NAT traversal support, or application specific, or security dedicated requirements. The direction of TCP bearer establishment is also unimportant from MGC point of view. The MGC only wants to wait with TCP establishment as long as application control level capability negotiations become stable, hence the MGC initially blocks possible establishment. Later on, TCP bearer establishment is unblocked and the interlinkage at the concerned stream endpoint pair is enabled, in both directions in the example of Figure II.5.

The notification of successful TCP bearer establishment is again an optional feature, up to the MGC level application/service control logic.

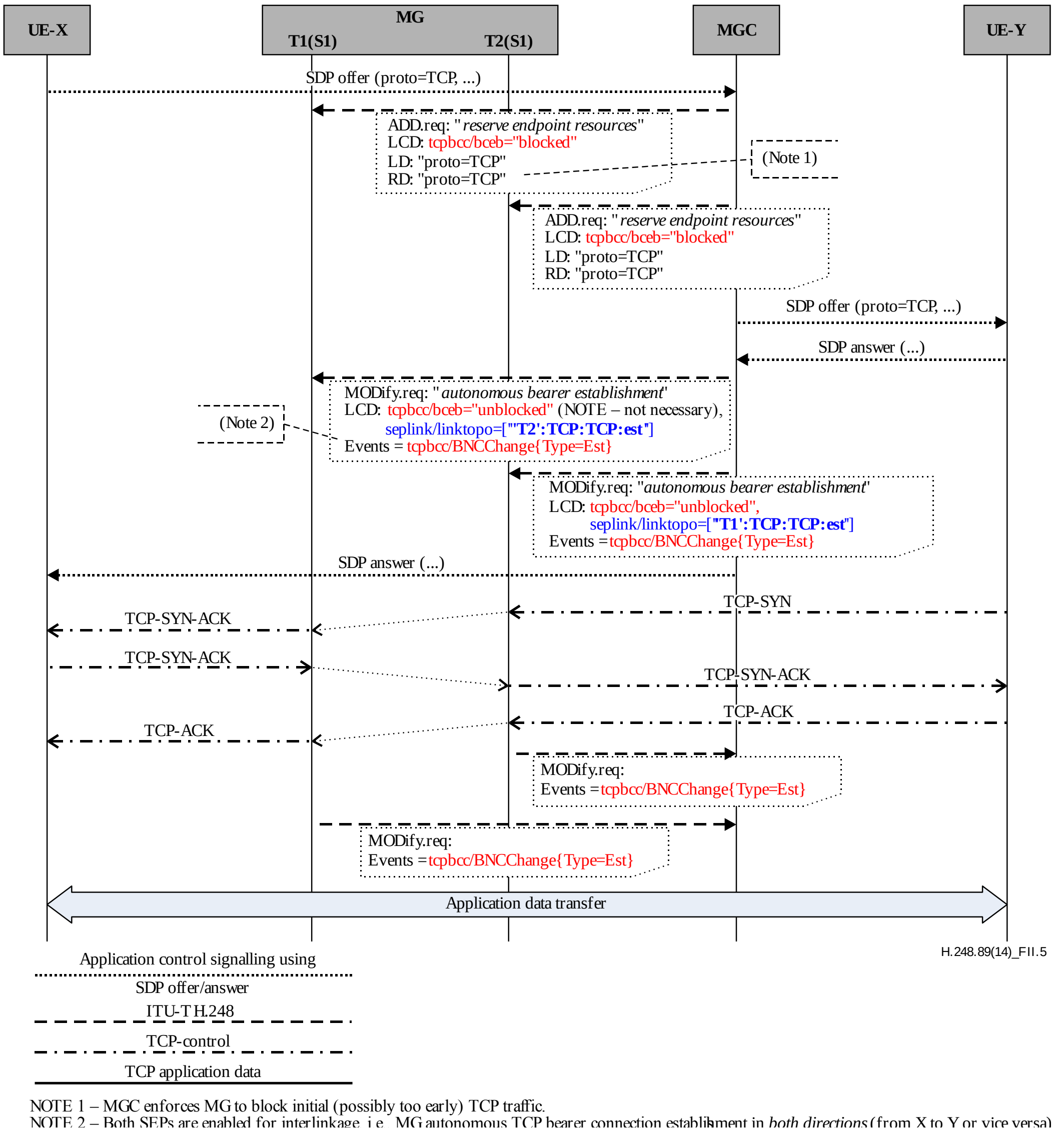
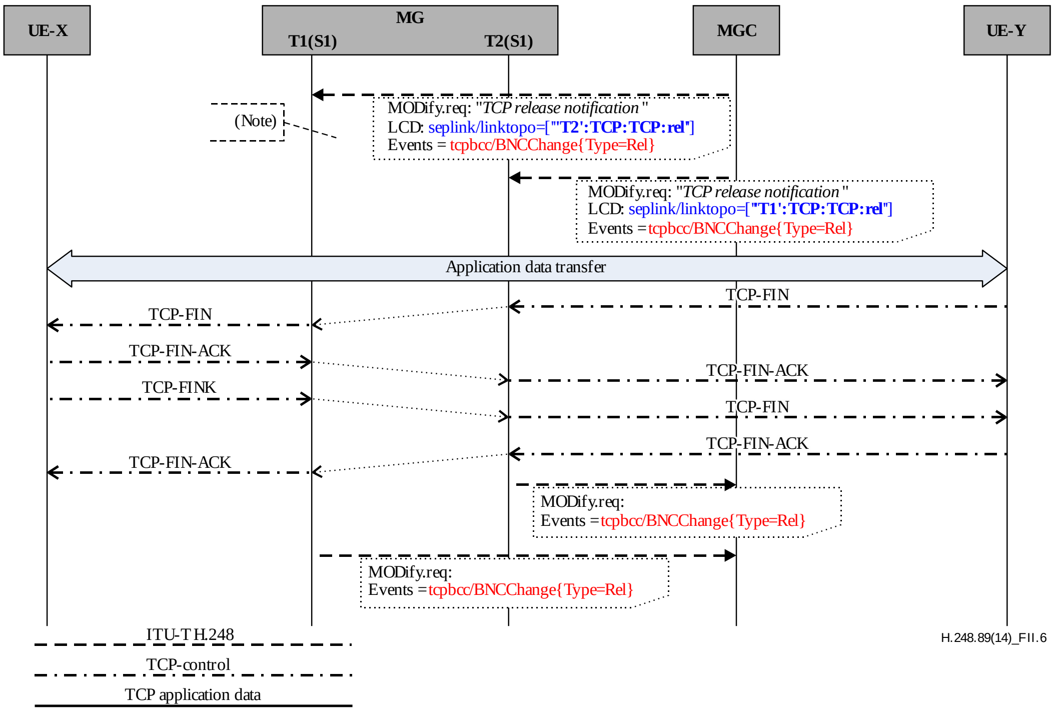


Figure II.5 – Traffic flow example for an extended TCP bearer connection establishment

II.3.2 Release

Figure II.6 provides an example for an MG autonomous release of the TCP bearer connection. The MGC enables interlinkage in both traffic directions in this example, e.g., because the MGC does not know which remote TCP endpoint is initiating a TCP release.



NOTE – MGC enables "SEPP interlinkage" in both directions.

Figure II.6 – Traffic flow example for an extended TCP bearer connection release

Appendix III

Illustration of the TCP basic connection control package protocol semantics

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

III.1 Overview

The *tcpbcc* package (clause 7) defines the basic TCP bearer connection control with scope on support for establishment and release. The illustrated use cases are abstracted examples.

III.2 Conventions

An ITU-T H.248 context with a single SEPP; only one SEP (labelled as T1(S1)) is considered. The MG bearer interface (TCP) is highlighted besides the ITU-T H.248 interface.

Furthermore all Figures indicate possible Event notifications to the MGC by the MG. The particular event(s) would be related to state changes of the local TCP bearer connection endpoint.

III.3 Establishment of TCP bearer connections

III.3.1 Successful establishment – Terminating side

See Figure III.1, termed as use case (E.1):

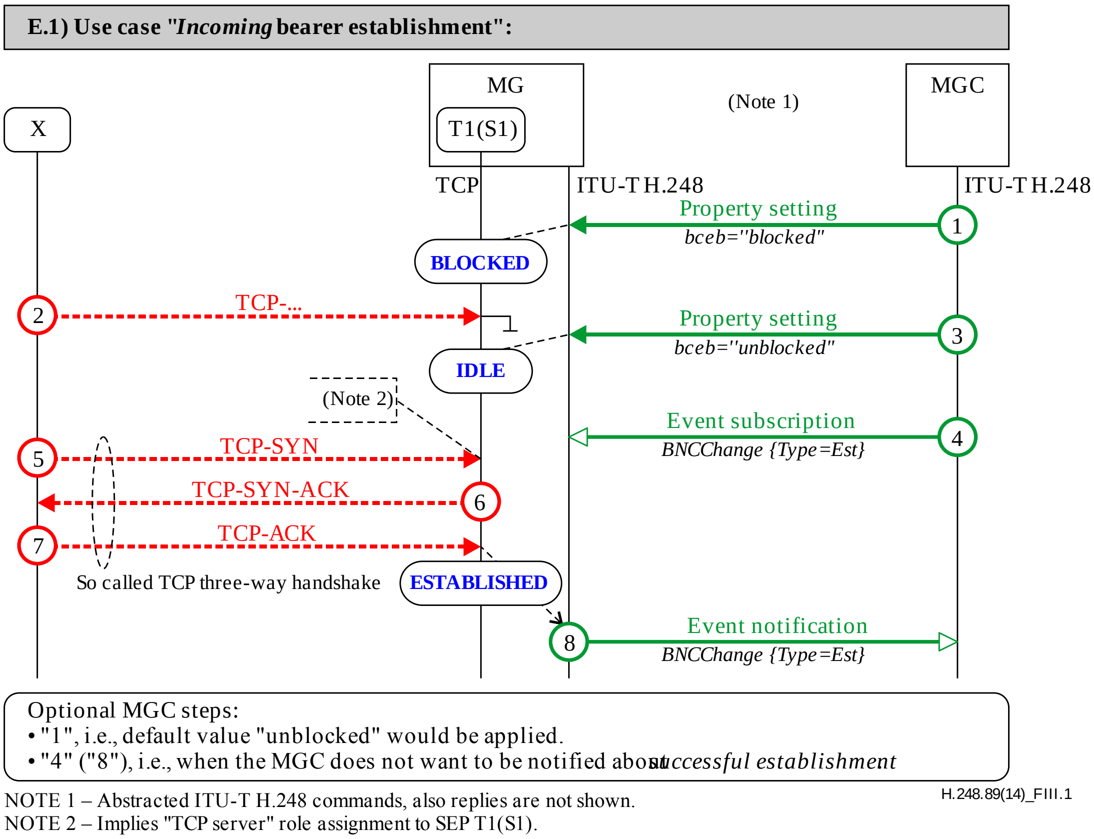
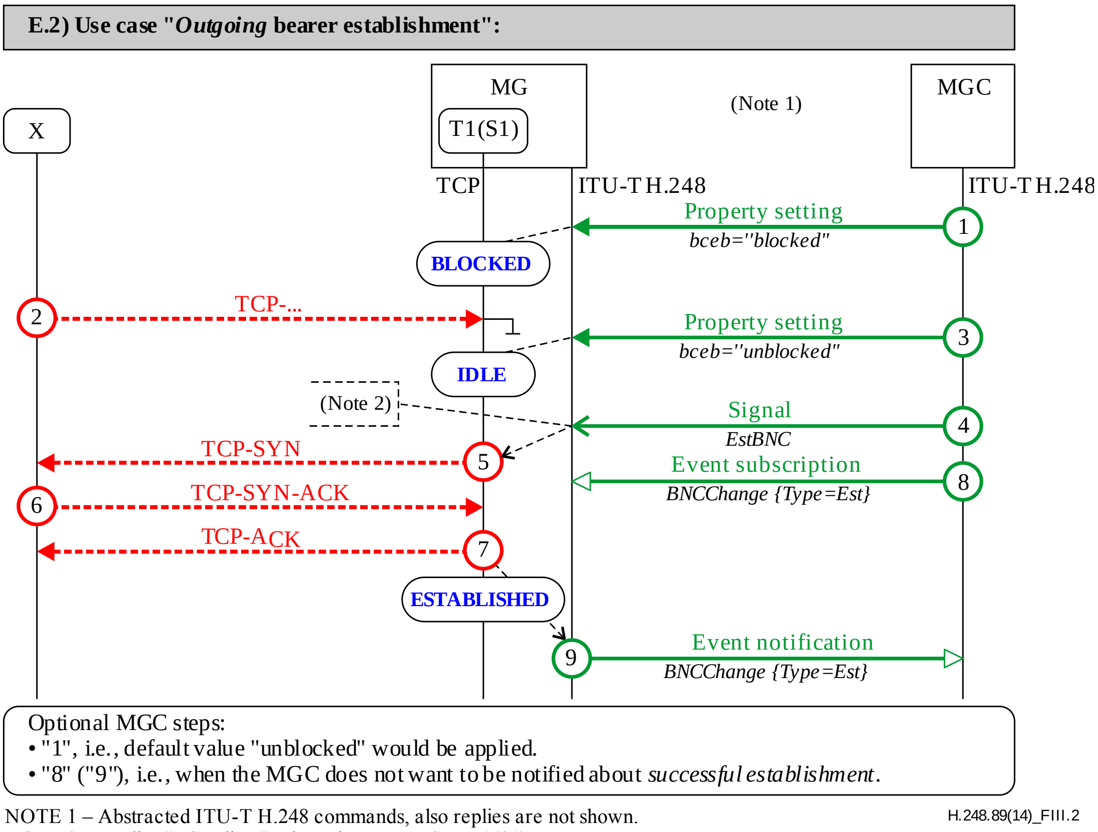


Figure III.1 – Successful establishment – Terminating side

The MGC explicitly blocks incoming TCP traffic handling (1). The MG discards any incoming TCP traffic (2). The MGC unblocks the SEP (3) and subscribes for state transitioning related to TCP bearer connection establishment (4). There is an incoming TCP bearer connection establishment procedure, given by a TCP three-way handshake (5, 6, 7). The TCP-ACK (7) leads to an H.248 state transition from IDLE to ESTABLISHED, which again leads to the notification of the MGC (8).

III.3.2 Successful establishment – Originating side

See Figure III.2, use case (E.2).



NOTE 1 – Abstracted ITU-T H.248 commands, also replies are not shown.
NOTE 2 – Implies "TCP client" role assignment to SEP T1(S1).

Figure III.2 – Successful establishment – Originating side

This scenario is similar to the previous one, with the exception of the following behaviour:

– MGC triggers outgoing TCP bearer connection establishment by signal *EstBNC* (4); and

– a corresponding TCP three-way handshake (5, 6, 7) in the opposite direction.

III.3.3 Unsuccessful establishment

Figure III.3 illustrates principle unsuccessful establishment scenarios.

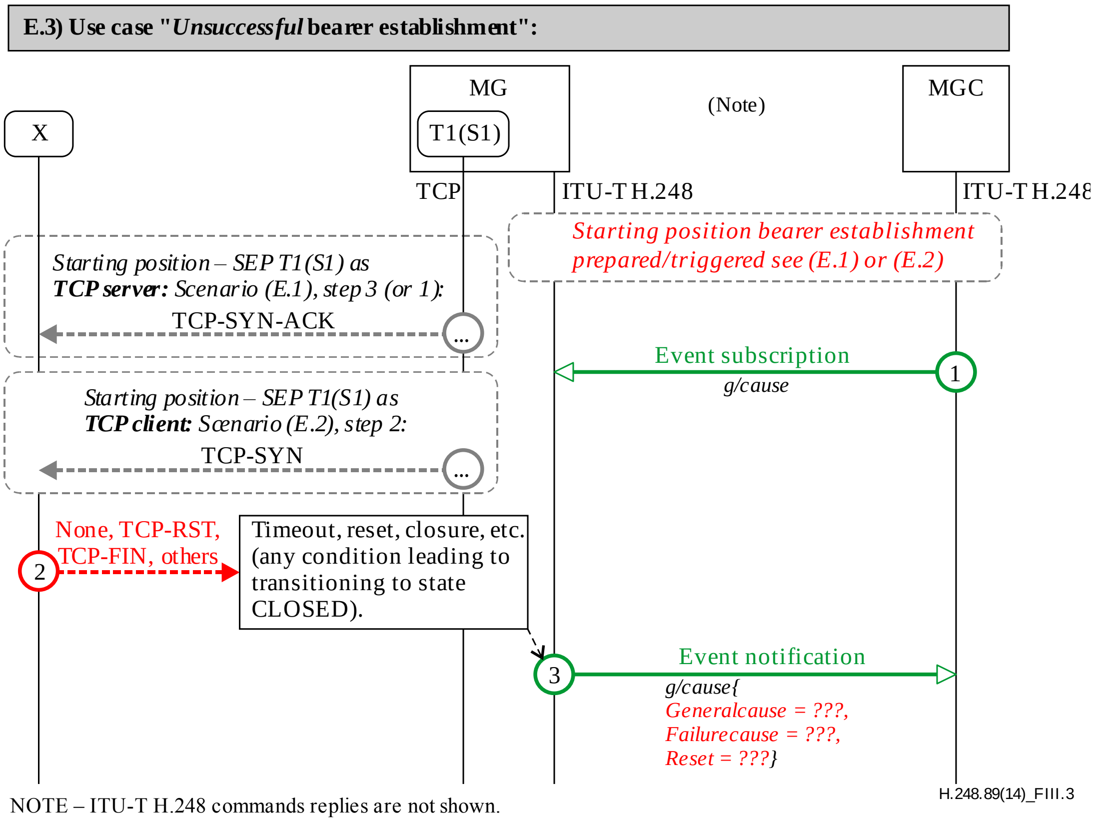


Figure III.3 – Unsuccessful establishment

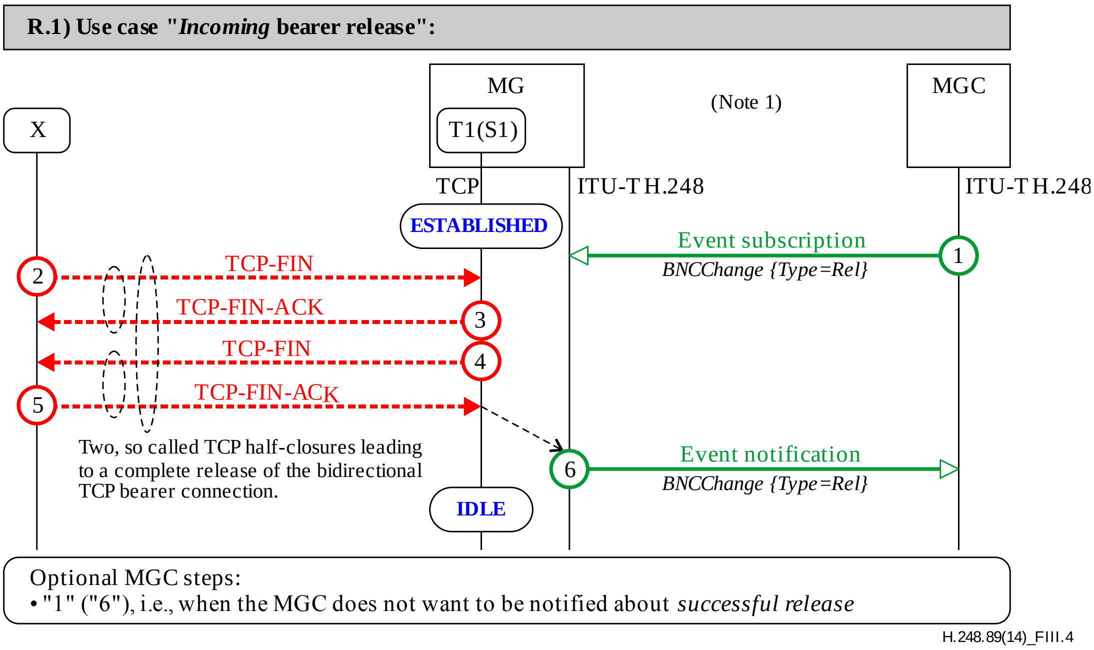
The TCP three-way handshake is basically not completed, either in the incoming (see scenario (E.1), clause III.3.1) or outgoing (see scenario (E.2), clause III.3.2) direction. The ITU-T H.248 state remains in IDLE. The MGC may explicitly supervise the establishment process (1), see also clause 7.6.5.3.1.

The MG is able to detect unsuccessful establishment in this example, e.g., due to received TCP protocol control information (2).

III.4 Release of TCP bearer connections

III.4.1 Successful release – Terminating side

See Figure III.4, termed as use case (R.1).



NOTE 1 – Abstracted ITU-T H.248 commands, also replies are not shown.

NOTE 2 – The event subscription (Rel) [1] may be sent before ESTABLISHED state (this comment is valid not only for this example).

Figure III.4 – Successful release – Terminating side

The MGC wants to be notified of successfully release TCP bearer connection (1). The MG receives a TCP-FIN (2) which starts a TCP bearer connection release by the remote TCP endpoint. The MG acknowledges the release requests (3) and initiates the closure of the other TCP traffic direction (4). The second TCP half-closure procedures is completed by (5), which leads to an ITU-T H.248 state transition from ESTABLISHED to IDLE, and the notification of the MGC (6).

III.4.2 Successful release – Originating side

See Figure III.5, use cases (R.2) illustrates an outgoing, bidirectional TCP bearer connection release.

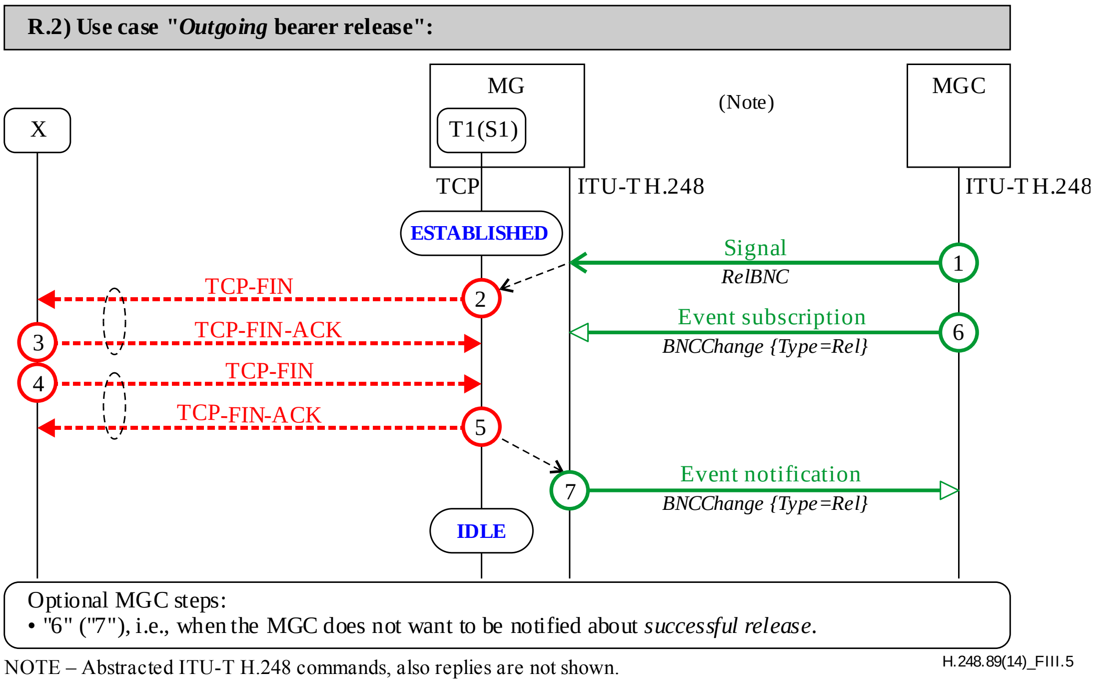


Figure III.5 – Successful release – Originating side

III.4.3 Unsuccessful release

An unsuccessful TCP bearer connection release procedure (Figure III.6) implies that the MG still remains in ITU-T H.248 state ESTABLISHED and that the MGC could possibly suspect a yet to be established TCP bearer connection. There are multiple options how such protocol deadlocks could be resolved. The situation is cleared in this example by the subtraction of the termination by the MGC (1).

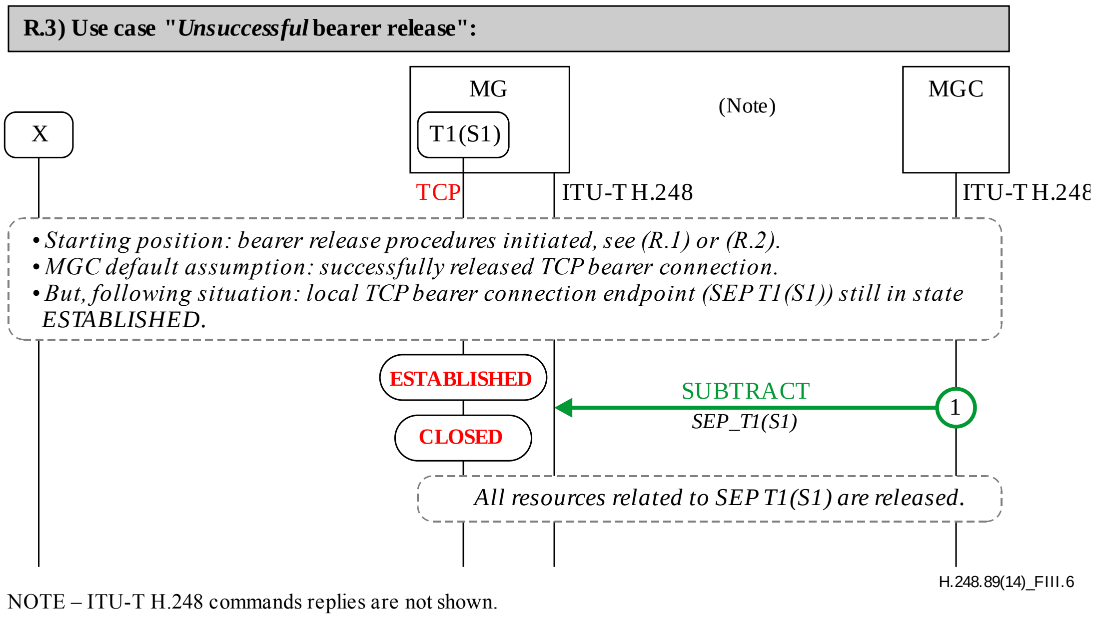


Figure III.6 – Unsuccessful release

Appendix IV

Illustration of the TCP-specific interlinkage procedures

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

IV.1 Overview

Clause 8 describes TCP-specific stream endpoint interlinkage procedures based on [ITU-T H.248.92]. The effect of the interlinkage capability is illustrated in clause IV.3 ([ITU-T H.248.92] property *seplink/linktopo* applied on TCP; only the inter-SEP interlinkage variant is used). Clause IV.4 illustrates the application of the Oneway release indicator (property *tcpbcc*/*ori*). Clause IV.5 describes examples of combined usage of both capabilities.

The illustrated use cases represent just a few examples. An exhaustive consideration of all possible combinations is out of scope.

IV.2 Conventions

An ITU-T H.248 context with a single SEPP, given by SEPs T1(S1) and T2(S1), is considered. The two properties (*seplink/linktopo* and *tcpbcc*/*ori*) are related to individual SEPs (as opposed to Context-level properties); however, the scope is on SEP T1(S1) property settings only.

Furthermore, all Figures indicate possible Event notifications to the MGC by the MG. The particular event(s) are not discussed, but could be for instance related to state changes of the local TCP bearer connection endpoint(s) (as defined by the *tcpbcc* package).

IV.3 Usage of stream endpoint interlinkage capability

Property *seplink/linktopo* is defined in clause 7.1.1 of [ITU-T H.248.92] and TCP-specific interlinkage procedures are defined in clause 8. Interlinkage may be used for TCP bearer connection establishment *and* release procedures.

IV.3.1 Property "*seplink/linktopo*" not used for interlinkage

There will be decoupled SEPs in case of unused interlinkage (abstracted by semantic FALSE in Figure IV.1), i.e., reflects the semantic of the *tcpbcc* package. From the perspective of the MG, there are two separate TCP bearer connection segments: the two segments related to TCP connections "X ↔ MG ($SEP_{T1(S1)}$)", and "Y ↔ MG ($SEP_{T2(S1)}$)".

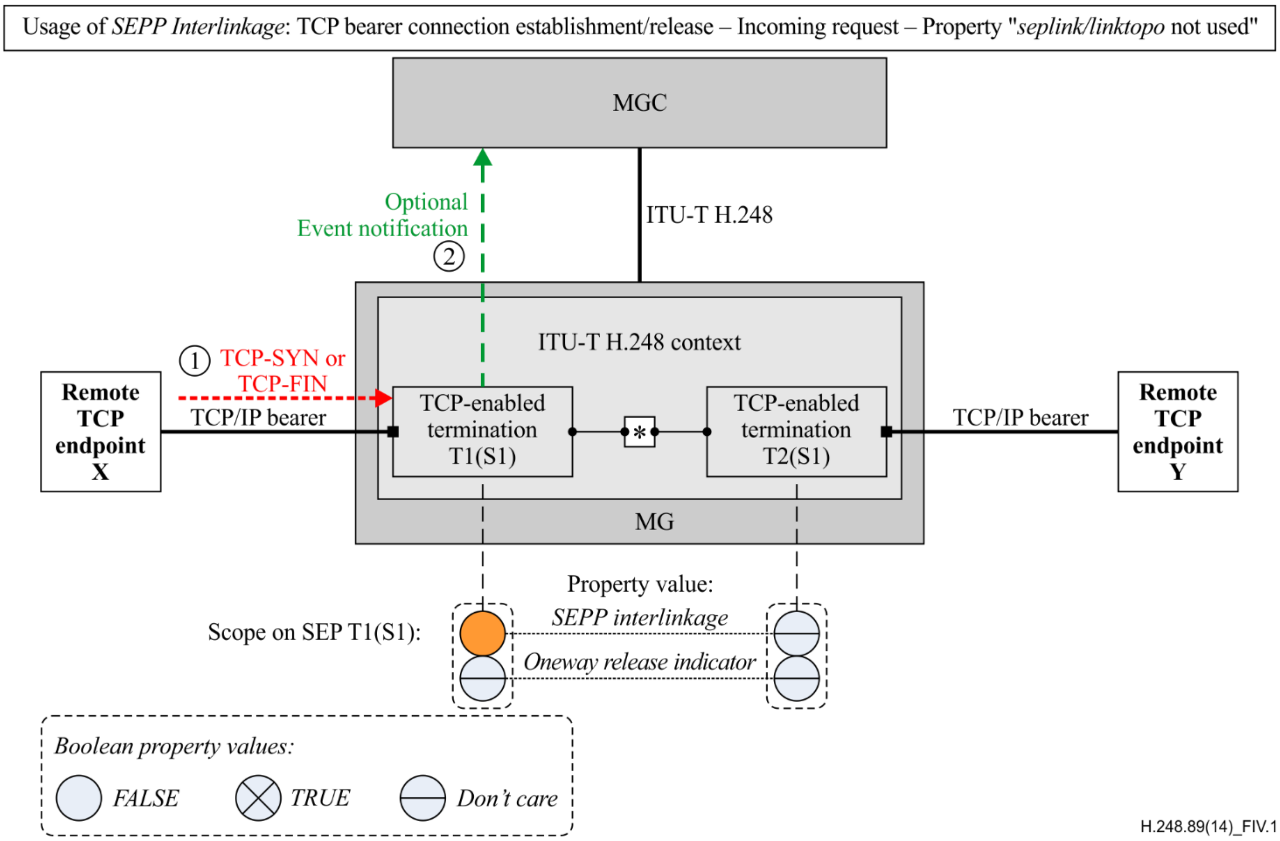
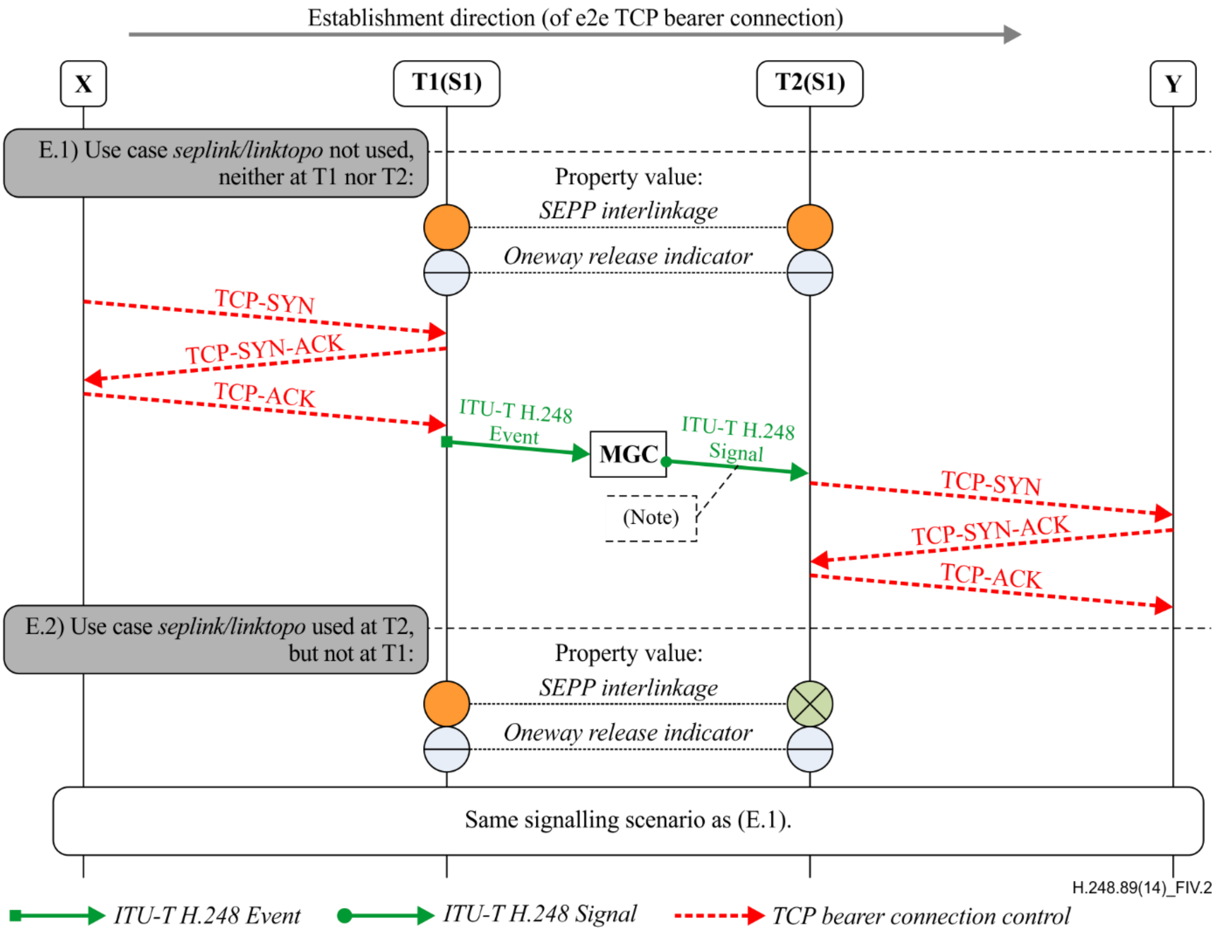


Figure IV.1 – Property "*seplink/linktopo*" not used for interlinkage

Here: an incoming TCP bearer connection establishment request (via TCP-SYN) or release request (via TCP-FIN) at SEP T1(S1) does not affect SEP T2(S1).

Figure IV.2 illustrates correspondent example TCP bearer establishment signalling scenarios:



NOTE – The Signal for $SEP_{T2(S1)}$ may be *independent* of Event from $SEP_{T1(S1)}$

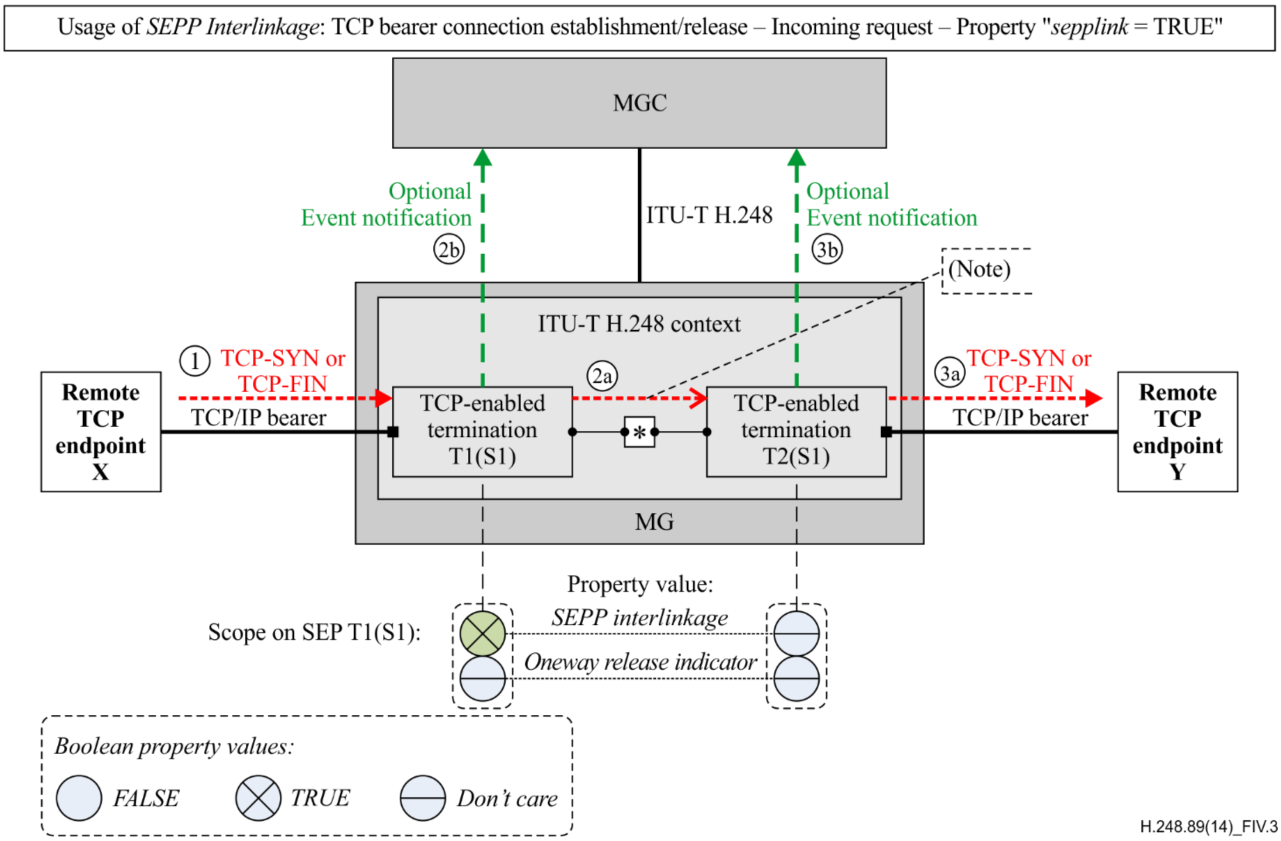
Figure IV.2 – Signalling example for TCP bearer connection establishment, property "*seplink/linktopo*" not used for interlinkage

It may be emphasized that the *seplink/linktopo* setting at SEP T2(S1) does not have any impact in these scenarios.

If an incoming TCP bearer connection establishment request from remote X should also lead to establishment procedures towards remote TCP endpoint Y, then the MGC needs to be involved (see E.1 in the example).

IV.3.2 Property "*seplink/linktopo*" enabled for establishment and release

A property value setting of *seplink/linktopo* equal to *"<interlinkedSEP>:**TCP**:**TCP**:**est**,**rel**"* leads to a forwarding of the TCP bearer connection control request within a SEPP (see Figure IV.3.).

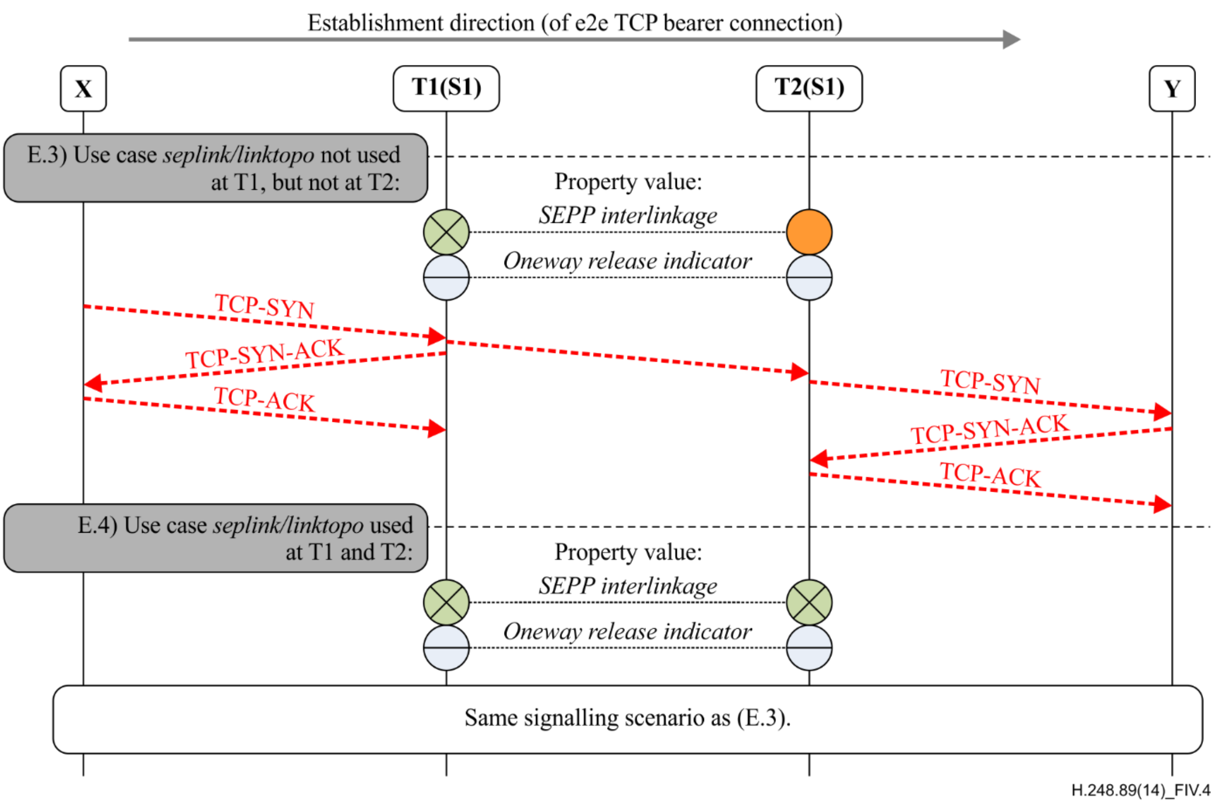


NOTE – Information flow "2a" relates to an *abstract stimulus*, but not any explicit TCP PCI (such as e.g., forwarding of TCP flag setting)!

Figure IV.3 – Property "*seplink/linktopo*" enabled for establishment and release at SEP T1(S1)

The TCP open and closure procedures, when initiated by remote TCP endpoints (X or Y), could now have an end-to-end scope. E.g., the three-way handshake for TCP bearer connection establishment or a TCP half-closure for oneway TCP bearer connection release would be led by remote TCP endpoints (X, Y) and forwarded via the SEPP, under the condition that both *seplink/linktopo* properties (of $SEP_{T1(S1)}$ and $SEP_{T2(S1)}$) would be enabled for interlinkage.

Figure IV.4 illustrates correspondent signalling scenarios at the example of TCP bearer establishment:



NOTE – It should be noted that the first received TCP-SYN at T1(S1) is not MG-internally forwarded as a "TCP/IP packet", rather an internal, abstracted stimuli is generated which triggers the outgoing TCP-SYN at T2(S1).

Figure IV.4 – Signalling example for TCP bearer connection establishment, property "*seplink/linktopo*"

It may be emphasized that the *seplink/linktopo* setting at SEP T2(S1) does not have any impact in these scenarios (because the property only considers incoming procedures at SEP T1(S1)).

IV.4 Usage of Oneway Release Indicator property

Property *tcpbcc/ori* is defined in clause 7.1.2. The property affects *only* TCP bearer connection *release* procedures.

IV.4.1 Property "*ori* = FALSE"

See Figure IV.5. Semantic FALSE implies base package behaviour, i.e., a complete TCP bearer connection release.

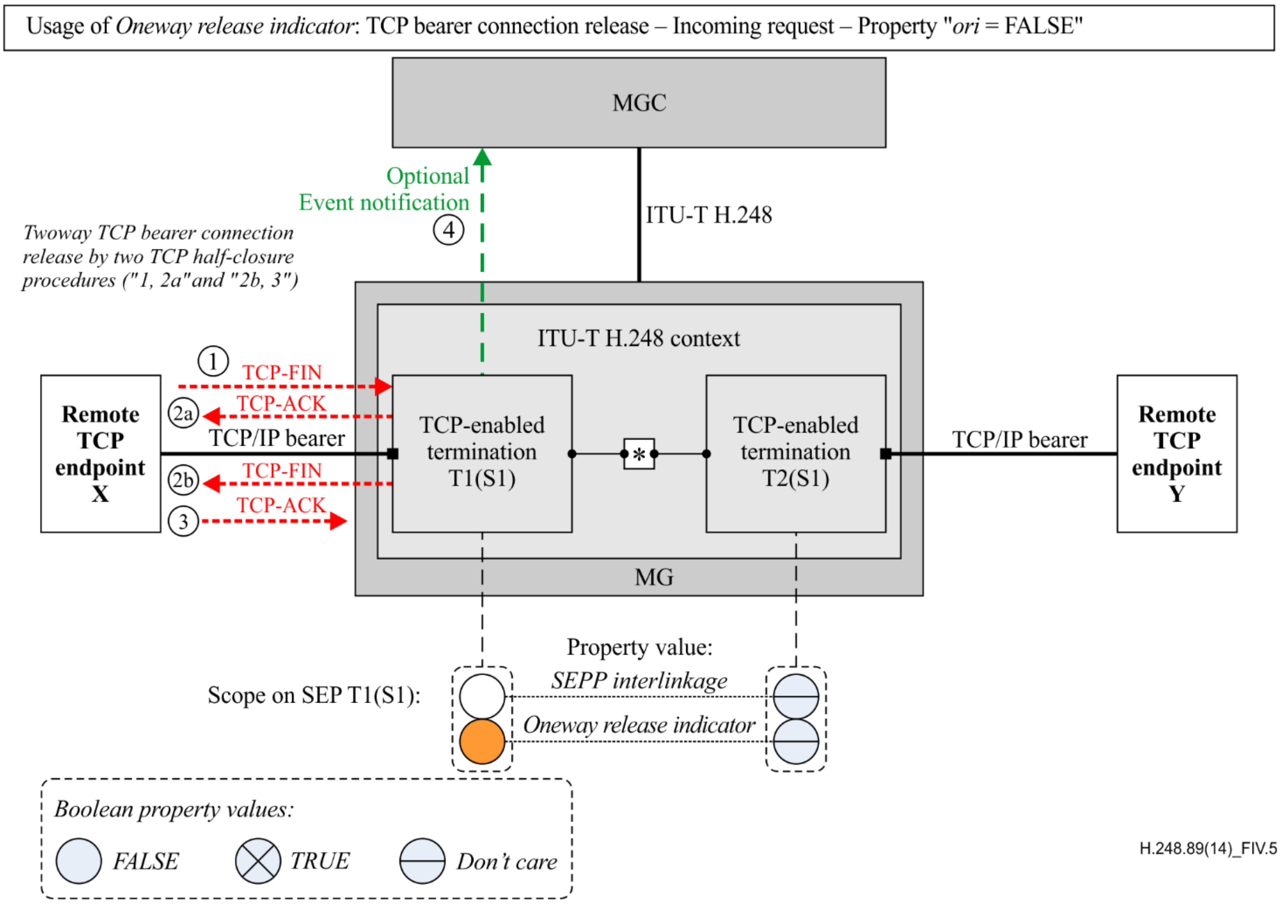


Figure IV.5 – Property "*ori* = FALSE"

Here: an incoming TCP bearer connection release request (via TCP-FIN) at $SEP_{T1(S1)}$ triggers an immediate TCP half-closure of the reverse direction towards X, but does not affect $SEP_{T2(S1)}$.

IV.4.2 Property "*ori* = TRUE"

Semantic TRUE results in a one-way TCP bearer connection release, see Figure IV.6.

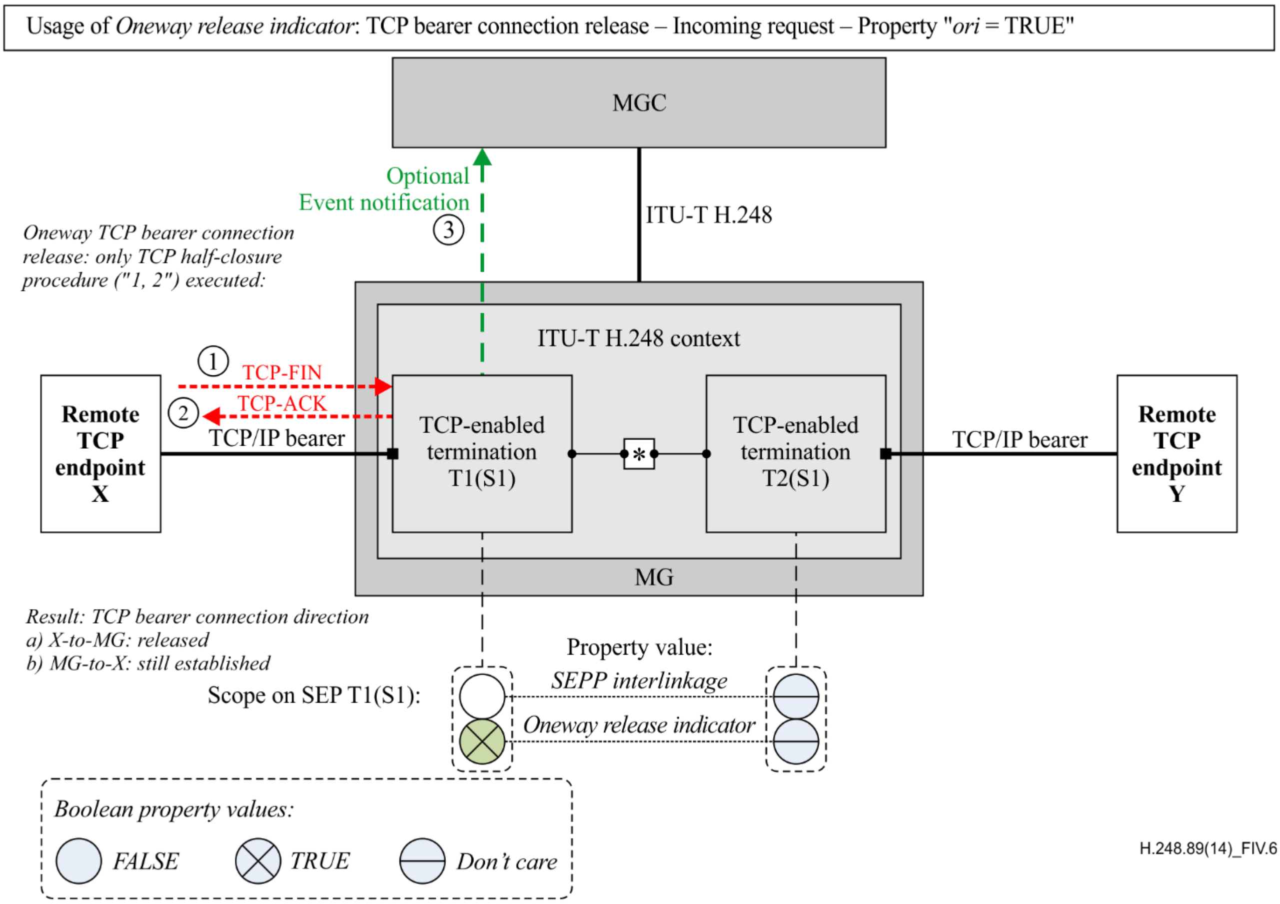


Figure IV.6 – Property "*ori* = TRUE"

IV.5 Combined consideration of both properties

Only TCP bearer connection *release* (due to *ori* property) needs to be considered.

IV.5.1 Property settings: "*ori* = FALSE" and "*seplink/linktopo*" enabled for release

See Figure IV.7. The *ori* property codepoint leads to a complete TCP bearer connection release between MG and remote TCP endpoint X, and the *seplink/linktopo* property codepoint results in an initiation of a TCP half-closure procedure from $SEP_{T2(S1)}$ towards remote TCP endpoint Y. Whether the entire TCP bearer connection with Y will be completely released depends on remote TCP endpoint Y.

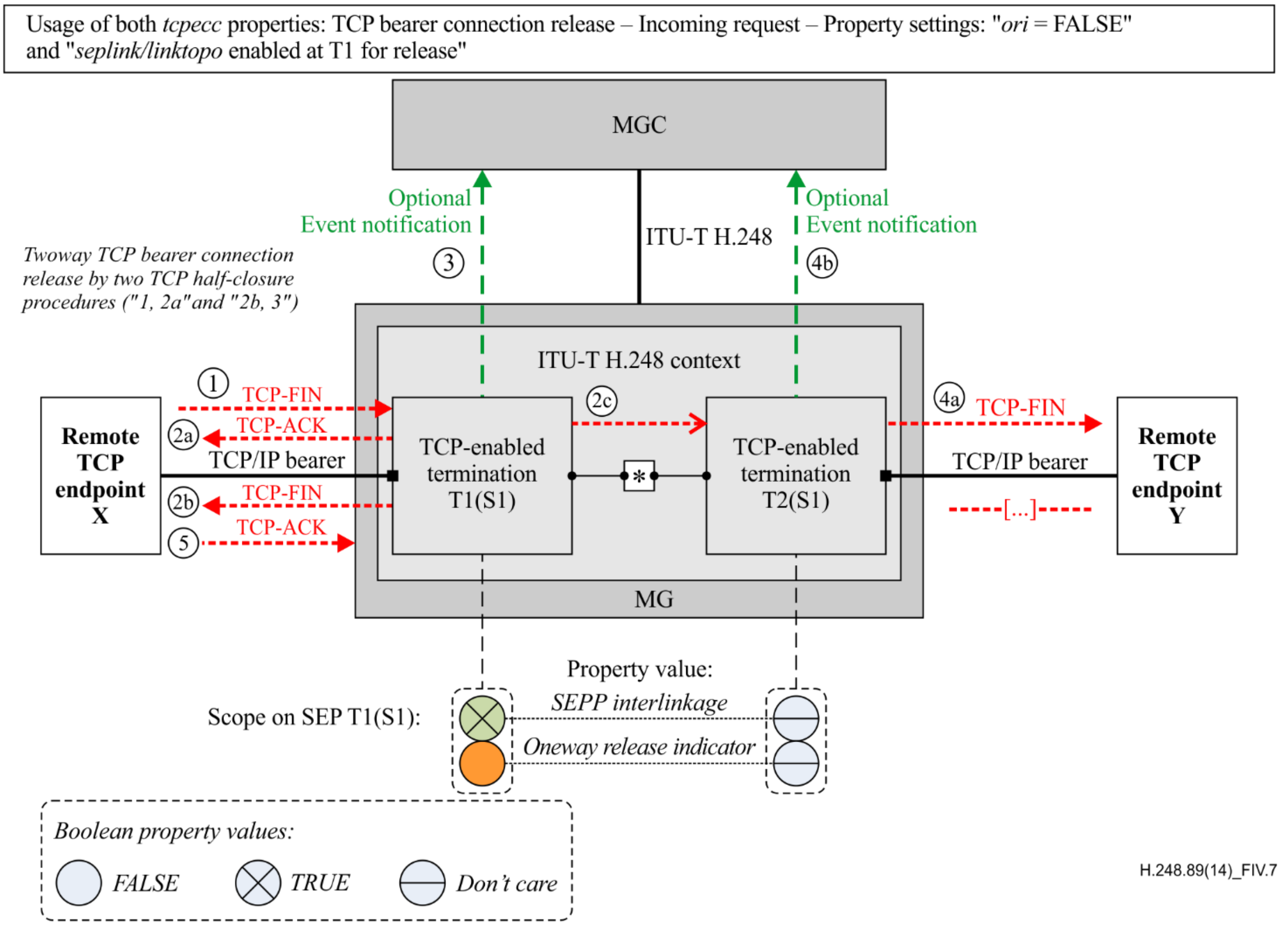


Figure IV.7 – Property settings: "*ori* = FALSE" and "*seplink/linktopo*" enabled for release

IV.5.2 Property settings: "*ori* = TRUE" and "*seplink/linktopo*" enabled for release

See Figure IV.8. The *ori* property codepoint leads to an oneway TCP bearer connection release only between MG and remote TCP endpoint X, and the *seplink/linktopo* property codepoint results again in an initiation of a TCP half-closure procedure from $SEP_{T2(S1)}$ towards remote TCP endpoint Y. Whether the entire TCP bearer connection with Y will be completely released depends on remote TCP endpoint Y.

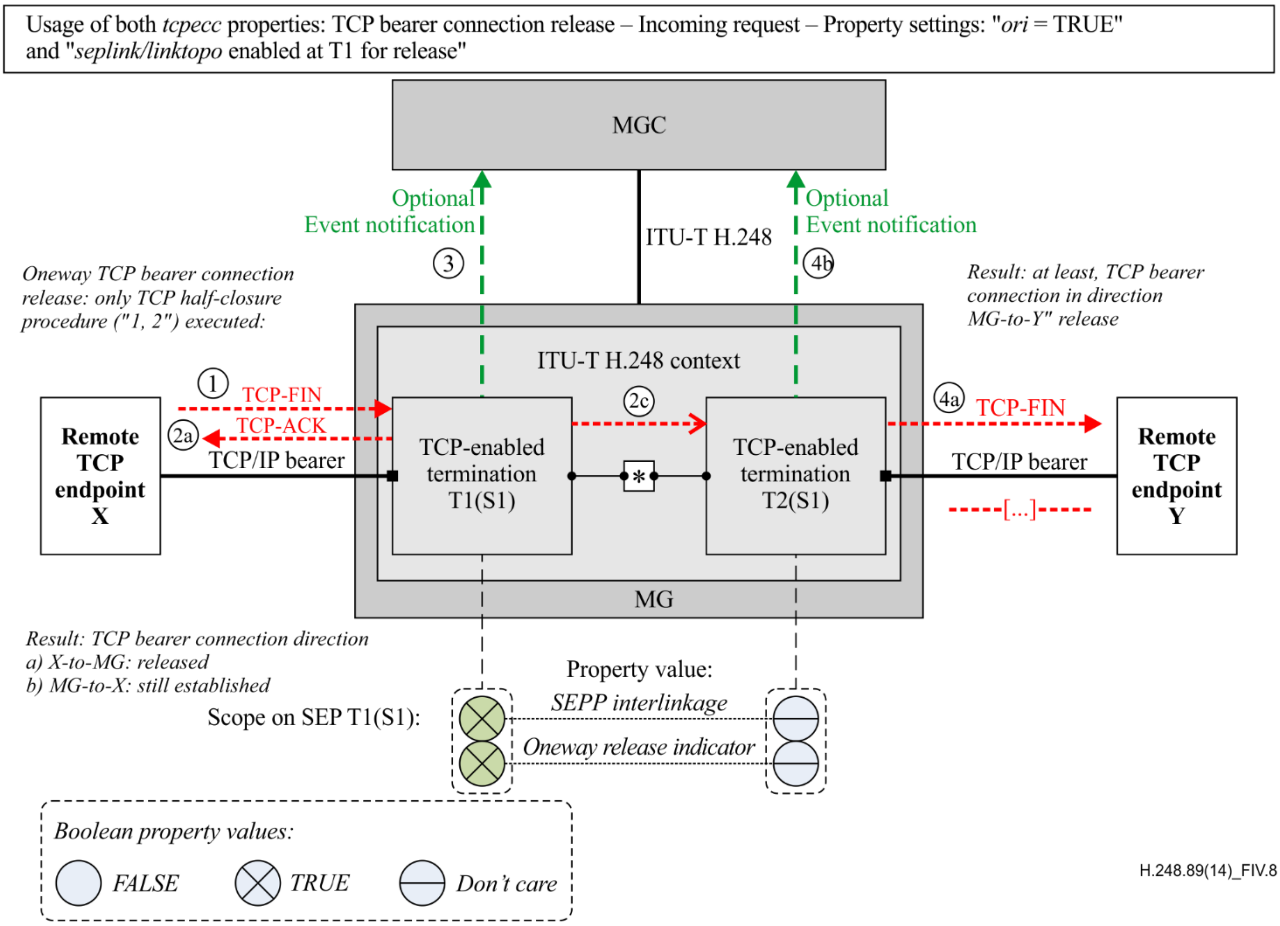


Figure IV.8 – Property settings: "*ori* = TRUE" and "*seplink/linktopo*" enabled for release

IV.5.3 Signalling examples

Figure IV.9 summarizes the impact of both properties (NOTE – Only enabled *seplink/linktopo* depicted; unused interlinkage does not provide any new information).

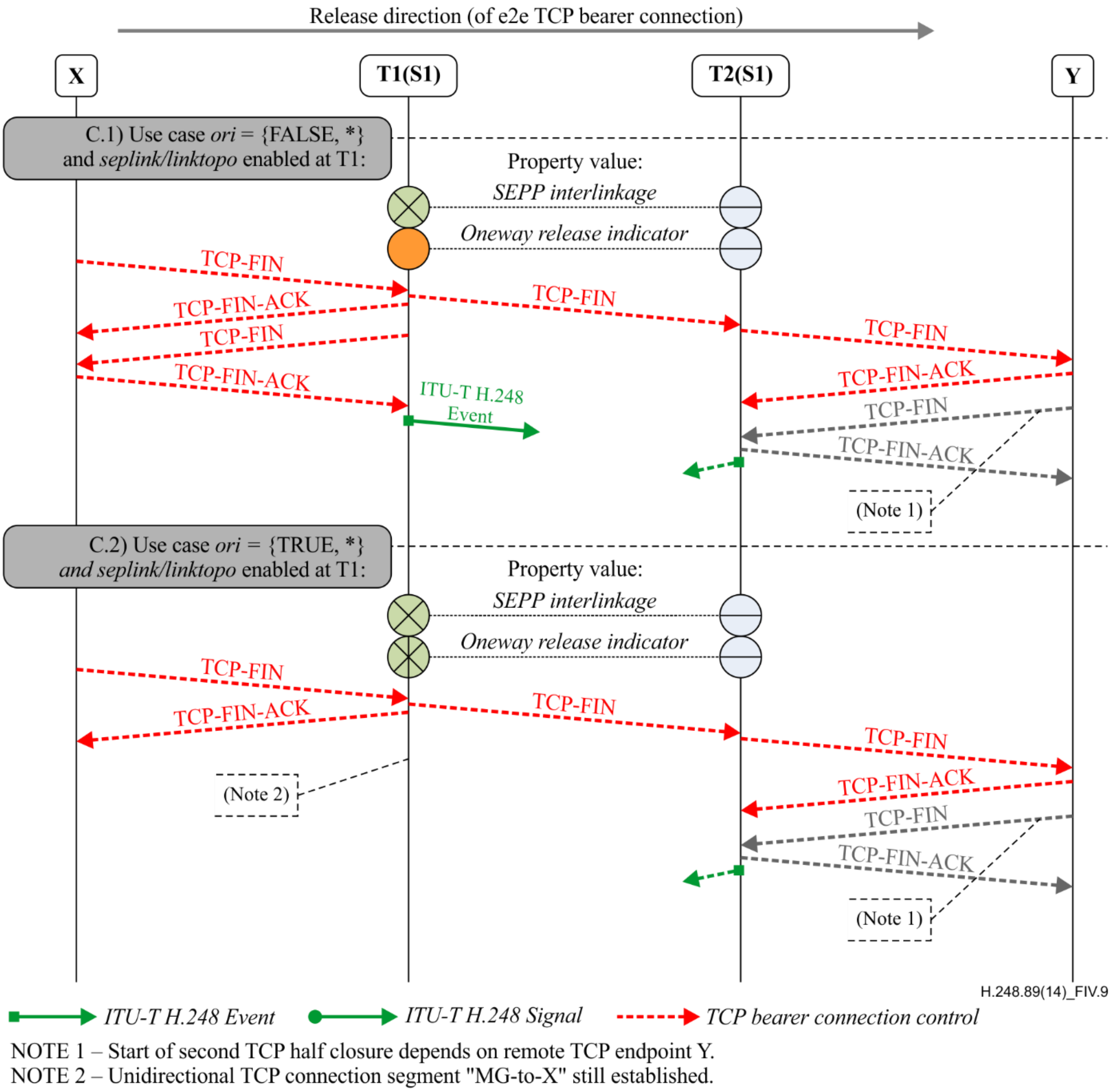


Figure IV.9 – Signalling example for TCP bearer connection release and example value combinations for both properties

Use case (C.1): the incoming TCP bearer connection release request from remote TCP endpoint X is propagated on the other side to remote TCP endpoint Y, and the *tcpbcc* package behaviour of a *bidirectional* TCP connection release towards X.

Use case (C.2): Property *ori* enforces a TCP half-closure in the direction to X, and *seplink/linktopo* the start of TCP bearer connection release towards Y.

Appendix V

Relation to similar ITU-T H.248 packages

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

V.1 Overview of TCP related packages

There are some existing packages which either are defined for TCP or could be theoretically reused for TCP, see Figure V.1.

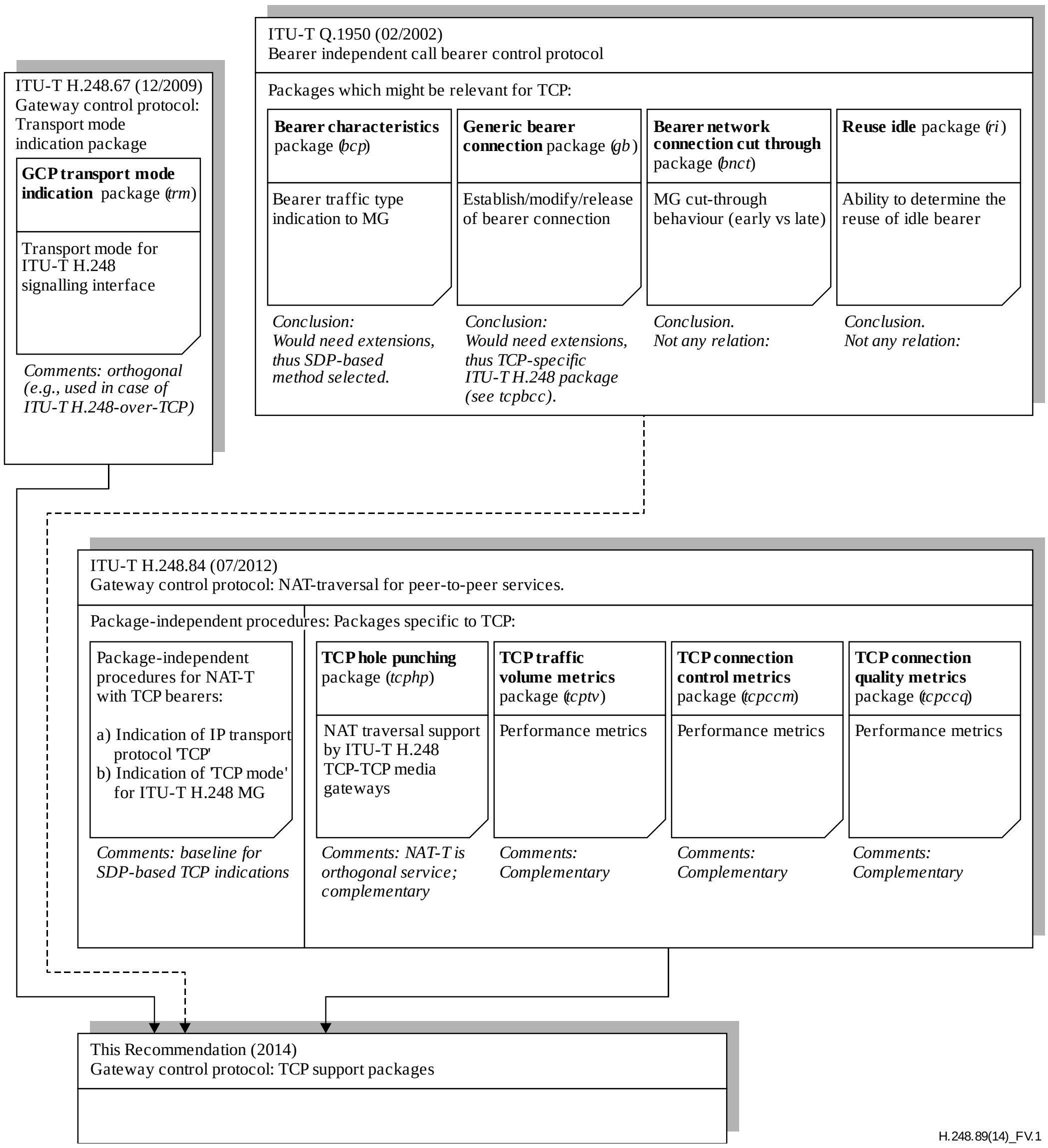


Figure V.1 – Overview of TCP related packages

The specific relation to this Recommendation is described below.

V.2 ITU-T Q.1950

This Recommendation introduces 11 ITU-T H.248 packages for usage in so-called Bearer-Independent Call Control type of network architectures. Two out of the eleven could be principally applied (with extensions) for TCP networks:

V.2.1 Package '*gb*' (generic bearer connection)

TCP is a connection-oriented protocol, which implies a connection state model (see Figure 6 in [IETF RFC 793]) in the bearer connection endpoints. This is a common characteristic with the *gb* package (Table V.1).

Table V.1 – Q.1950-defined ITU-T H.248 packages – *gb* package

<table>
<tr><th>Package name</th><th>Purpose</th></tr>
<tr><td>Generic bearer connection package</td><td>The gb package provides control elements for such stateful bearer technologies, which implies basic stimuli for the bearer control signalling protocol as well as a basic connection state concept.
The bearer connection endpoint models supports also incoming and outgoing bearer control protocol procedures, which is e.g., required for the modelling of active/passive open (or close) procedures or client/server behaviour.</td></tr>
<tr><th colspan="2">Possible relation to this Recommendation:</th></tr>
<tr><td colspan="2">The TCP connection state model could be basically mapped on the underlying gb package state model. The gb package could be used for the majority of TCP connection control procedures.
Open/differences:
– TCP explicitly supports simultaneous bearer connection establishment and release, which would be so called collision scenarios in case of the gb package.
– TCP bearer connection release: unidirectional concept (called half close), whereas the gb package considers bi-directionality only.</td></tr>
</table>

V.2.2 Package '*bcp*' (bearer characteristics)

The notion of *bearer characteristics* relates to a particular (or multiple) protocol layer(s) in the bearer plane (see Table V.2):

Table V.2 – Q.1950-defined ITU-T H.248 packages – *bcp* package

<table>
<tr><th>Package name</th><th>Purpose</th></tr>
<tr><td>Bearer characteristics package</td><td>The existing bcp package supports an initial set of bearer technologies such as RTP/IP for IP-based networks.
However, bearer type "TCP" is not supported.</td></tr>
<tr><th colspan="2">Possible relation to this Recommendation</th></tr>
<tr><td colspan="2">Usage of the gb package would imply the need for an explicit bearer type indication such as supported by the bcp package.
Open/differences:
– A new version or an extension package with additional codepoints would be required (at least bearer type "TCP", but possibly also "TLS", "TLS/TCP", "DTLS", "SCTP", "DCCP").
– Instead of the Property-based bearer type indication (via bcp package) at LCD level exists the alternative of the SDP-based bearer type indication (via "m=" line element proto) at LD/RD level.
– Use case TLS-over-TCP: the establishment/release of the TCP connection and the TLS session could be controlled via the gb package. The bearer connection control procedures at TCP and TLS level could be temporarily decoupled, which would imply the modification of the bcp/BNCChar property value, a scenario originally out of scope of the bcp package.</td></tr>
</table>

V.2.3 Package '*bnct*' (bearer network connection cut through)

See Table V.3.

Table V.3 – Q.1950-defined ITU-T H.248 packages – *bnct* package

Package name	Purpose
Bearer network connection cut through package	The MG can indicate whether the cut through will occur "*early*" or "*late*", which are effectively related to bearer control protocol signalling events. Early relates to the bearer cutting-through on the *establishment*. Late refers to cutting-through on the *confirmation*.
Possible relation to this Recommendation	
The aspect of "cut-through" control is relevant for TCP as well, perhaps even more important due to a) the assured transport characteristic of TCP (e.g., handling of acknowledgments, loss, retransmission) and ITU-T H.248 MG TCP modes (such as relay, merge or proxy). Questions for clarification: – The explicit cut-through semantic might be also an implicit capability of TCP modes. – Unclear is the interaction with StreamMode property settings? Understanding: The "BNC Cut through" package does not actually control cut through, i.e., from clause A.4.5 of [ITU-T Q.1950]: The MGC can ask the MG using the *BNCCT* property as to when the cut through of a particular bearer will occur. The MG can indicate whether the cut through will occur "early" or "late". Early relates to the bearer cutting-through on the establishment. Late refers to cutting-through on the confirmation. The *BNCCT* property in this package does not actually order the cut through nor does it indicate when the Cut-through has occurred. Furthermore, clause 4.4.10 of [ITU-T Q.1950] BNC-cut-through-capability: Used by the bearer interworking function (BIWF) to inform the call state machine (CSM) of the bearer cut-through capability (i.e., commits resources on the receipt of a Bearer SetupReq or confirm). The transactions in [ITU-T Q.1950] show that the usage depends on the BICC call setup direction i.e., forward direction. See also clause 7.2.1.2.2 of [b-ITU-T Q.1902.4]. There is also no interaction with ITU-T H.248 *StreamMode* settings. See [b-ITU-T Q.Supp.32] for call flows showing the interaction. There is also more of a discussion on the use of the Cut-through capability in clause 5.3.2 of [b-ITU-T Q.Supp.32], step 9. Conclusion: No relation to this Recommendation.	

V.2.4 Package '*ri*' (reuse idle)

See Table V.4.

Table V.4 – Q.1950-defined ITU-T H.248 packages – *ri* package

Package name	Purpose
Reuse idle package	The *ri/RII* property is used by the MG to indicate to the MGC that an *idle bearer* is to be reused.
Possible relation to this Recommendation:	
Reuse of *existing TCP connections* is a supported concept, such as in SIP networks by [IETF RFC 4145]. See also clause 13.6 of [ITU-T H.248.84]. Open/differences: – Possible models of MG-level TCP resources, e.g.,: ○ resource component "TCP local source/destination transport address"; ○ resource component "TCP local stateful bearer connection endpoint" which would imply the TCP connection state machine;	

Table V.4 – Q.1950-defined ITU-T H.248 packages – *ri* package

Package name	Purpose
○ resource component "end-to-end TCP bearer connection", based on the n-tuple of local and remote transport source/destination addresses and connection state; – The semantic of *reuse idle* bearer would be then dependent on the agreed TCP resource model. It might be even transparent for the MG. Understanding: The reuse of idle procedures is a BICC Network option. Annex B of [b-ITU-T Q.1902.4] describes the overall procedures. MLPP (multi-level precedence and preemption) is a service that supports the reuse of IDLE bearers (i.e., clause 9 of [b-ITU-T Q.850]). [b-IETF RFC 4411] discusses the use of this cause with respect to SIP and, in summary, it says that it is not valid in an IP environment. The Reuse idle package is used within the framework of a call control that supports an application (i.e., MLPP) that has re-use logic. The RII property is used in conjunction with the BNC-ID etc. to choose an existing bearer (i.e., bearer independent situations). Whereas the SDP "a=connection" attribute is really a flag to use an existing bearer because you do not want to release it rather than selecting an idle TCP connection i.e., can be used in "bearer dependent" situations. Conclusion: Whilst it is possible to reuse a TCP connection, there is not any real relation of this ITU-T Q.1950 package to this Recommendation.	

V.3 ITU-T H.248.67

V.3.1 Package '*trm*' (GCP transport mode indication)

See Table V.5.

Table V.5 – ITU-T H.248.67-defined ITU-T H.248 package – *trm* package

Package name	Purpose
GCP transport mode indication package	Related to the ITU-T H.248 Control Association, which may use TCP-based transport modes.
Possible relation to this Recommendation	
None: [ITU-T H.248.67] and this Recommendation are both diametrically opposed. TCP usage for the ITU-T H.248 signalling interface is out of scope of this Recommendation.	

V.4 ITU-T H.248.84

The TCP enabled SEP will be activated through the indication of the TCP-proxy mode as defined in [ITU-T H.248.84]. This Recommendation only defines properties that are needed on top of [ITU-T H.248.84] for the control of a TCP enabled SEP.

This Recommendation does not define TCP-related statistics and events that are already covered by [ITU-T H.248.84]. Whenever needed, the statistics and events of the related package as defined by [ITU-T H.248.84] must be used.

V.4.1 Package-independent procedures for NAT-T with TCP bearers

See Table V.6.

Table V.6 – ITU-T H.248.84-defined package-independent procedures for NAT-T with TCP bearers

Procedures	Purpose
Clause 13 of [ITU-T H.248.84]	a) Indication of IP transport protocol 'TCP' b) Indication of 'TCP mode' for ITU-T H.248 MG
Possible relation to this Recommendation	
To a): – Normative for SDP-based bearer type indication "TCP". To b): – The TCP merge mode could be used as NAT traversal service. The TCP modes as such could interact with TCP connection control. E.g., the tcpcc package would be not required (and should be not used) for TCP connection establishment when NAT-T is used (because it provides already end-to-end TCP connection establishment (NOTE – TCP connection release is different).	

V.4.2 Package '*tcphp*' (TCP hole punching)

See Table V.7.

Table V.7 – ITU-T H.248.84-defined ITU-T H.248 package – *tcphp* package

Package name	Purpose
TCP hole punching package	NAT traversal support service for TCP.
Possible relation to this Recommendation	
Orthogonal to this Recommendation; the *tcphp* package could be used in conjunction with this Recommendation.	

V.4.3 Package '*tcptv*' (TCP traffic volume metrics)

See Table V.8.

Table V.8 – ITU-T H.248.84-defined ITU-T H.248 package – *tcptv* package

Package name	Purpose
TCP traffic volume metrics package	Support of octet and packet count statistics for TCP bearer protocol.
Possible relation to this Recommendation	
Performance monitoring is an orthogonal application; hence, the ITU-T H.248 statistics could be basically used in conjunction with this Recommendation.	

V.4.4 Package '*tcpccm*' (TCP connection control metrics)

See Table V.9.

Table V.9 – ITU-T H.248.84-defined ITU-T H.248 package – *tcpccm* package

Package name	Purpose
TCP connection control metrics package	Statistics related to the establishment process of the TCP bearer connections.
Possible relation to this Recommendation	
Basically, all three statistics could be used.	

V.4.5 Package '*tcpcqm*' (TCP connection quality metrics)

See Table V.10.

Table V.10 – ITU-T H.248.84-defined ITU-T H.248 package – *tcpcqm* package

Package name	Purpose
TCP connection quality metrics package	Additional statistic related to the establishment process of TCP bearer connections.
Possible relation to this Recommendation	
The round-trip time based statistic may be used as well.	

V.4.6 Inventory of TCP functions and their possible impact on ITU-T H.248 TCP gateways

See Table V.11.

Table V.11 – ITU-T H.248.84– Inventory of TCP functions

Inventory in:	Purpose:
Appendix II/ [ITU-T H.248.84]	– TCP Functions versus ITU-T H.248 TCP Modes of Operation, in ten areas: – Basic Capabilities – Topology Hiding – Protocol Encryption – Security – Application Data Inactivity Detection – Interactions with other policy rules – Performance measurements & statistics" – Connection keep alive support – Add-on's to TCP – IP layer operations
Possible relation to this Recommendation:	
This informative analysis is principally valid as well.	

V.5 ITU-T H.248.43 and ITU-T H.248.79

[ITU-T H.248.43] and [ITU-T H.248.79] are related to the filtering of TCP traffic. See overview in clause 9 of [ITU-T H.248.79].

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