International Telecommunication Union

ITU-T

G.7714/Y.1705

(08/2005)

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

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

Data over Transport – Generic aspects – Transport network control aspects

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Internet protocol aspects – Operation, administration and maintenance

---

Generalized automatic discovery for transport entities

ITU-T Recommendation G.7714/Y.1705

ITU-T

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
General	G.7000–G.7099
Transport network control aspects	**G.7700–G.7799**
ETHERNET OVER TRANSPORT ASPECTS	G.8000–G.8999
ACCESS NETWORKS	G.9000–G.9999

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation G.7714/Y.1705

Generalized automatic discovery for transport entities

Summary

This Recommendation describes the discovery process for transport entities, their sub-processes and basic interactions in a protocol-neutral manner.

Source

ITU-T Recommendation G.7714/Y.1705 was approved on 22 August 2005 by ITU-T Study Group 15 (2005-2008) under the ITU-T Recommendation A.8 procedure.

Keywords

Auto-discovery, discovery agent, layer adjacency discovery, transport capability exchange.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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

NOTE

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

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

© ITU 2006

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

CONTENTS

ITU-T Recommendation G.7714/Y.1705

Generalized automatic discovery for transport entities

1 Scope

This Recommendation describes the discovery process for transport entities (Link Connection, Trail and Network Connection). Their sub-processes and basic interactions within the Discovery process are described in a protocol-neutral manner. Other aspects of discovery, such as further specification of mechanisms, protocols and how discovery may be used by applications, is outside the scope of this Recommendation. This version of ITU-T Rec. G.7714/Y.1705 allows the discovery process to be used by the Management Plane as well as the Control Plane[1].

In this Recommendation, the Discovery Agent is broken down into the following discovery processes:

a) Discovery Trigger;

b) Layer Adjacency Discovery;

c) Transport Entity Capability Exchange.

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 Recommendation G.805 (2000), *Generic functional architecture of transport networks*.

– ITU-T Recommendation G.806 (2004), *Characteristics of transport equipment – Description methodology and generic functionality*.

– ITU-T Recommendation G.852.2 (1999), *Enterprise viewpoint description of transport network resource model*.

– ITU-T Recommendation G.853.1 (1999), *Common elements of the information viewpoint for the management of a transport network*.

– ITU-T Recommendation M.3100 (2005), *Generic network information model*.

– ITU-T Recommendation G.8080/Y.1304 (2001), *Architecture for the automatically switched optical network (ASON)*, plus Amendment 2 (2005).

[1] The 2001 version of ITU-T Rec. G.7714/Y.1705 assumed discovery was limited to use by the Control Plane.

3 Terms and definitions

This Recommendation makes use of the following terms defined in other ITU-T Recommendations.

3.1 Access Point (AP): See ITU-T Rec. G.805.

3.2 Connection Termination Point (CTP): See ITU-T Rec. M.3100.

3.3 continuity supervision: See ITU-T Rec. G.806.

3.4 Discovery Agent (DA): See ITU-T Rec. G.8080/Y.1304.

3.5 link: See ITU-T Recs G.852.2 and G.853.1.

3.6 link connection: See ITU-T Rec. G.805.

3.7 network connection: See ITU-T Rec. G.805.

3.8 Subnetwork Point (SNP): See ITU-T Rec. G.8080/Y.1304.

3.9 trail: See ITU-T Rec. G.805.

3.10 Trail Termination Point (TTP): See ITU-T Rec. M.3100.

4 Abbreviations

This Recommendation uses the following abbreviations:

AP Access Point

CI Characteristic Information

CP Connection Point

CTP Connection Termination Point

DA Discovery Agent

DCN Data Communication Network

DT Discovery Trigger

ID Identifier

LAD Layer Adjacency Discovery

LC Link Connection

LCP Link Control Protocol

LRM Link Resource Manager

MS Multiplexing Section

NC Network Connection

NE Network Element

PPP Point-to-Point Protocol

RS Regenerator Section

Rx Receive

SNP Subnetwork Point

TAP Termination and Adaptation Performer

TCE Transport Entity Capability Exchange

TCP Termination Connection Point

TTP Trail Termination Point

Tx Transmit

VC Virtual Container

5 Conventions

In this Recommendation the notation "R-n" is used to identify requirements.

The notation (T)CP is used to represent a TCP or a CP.

6 Discovery process overview

The overall discovery process for transport entities is illustrated in Figure 6-1. It is a generic process that is applicable to any layer of multilayer networks as described in ITU-T Rec. G.805.

There is no proscribed location or distribution for the entities that support the discovery process (e.g., management systems, NEs, etc.). It shall be possible for the Management Plane to enable and disable the discovery process and individual sub-processes that will be discussed in subsequent clauses.

As shown in Figure 6-1, the discovery process is documented for the three sub-processes: Discovery Trigger (DT), Layer Adjacency Discovery (LAD) and Transport Entity Capability Exchange (TCE)[2].

– The DT process is responsible for triggering the LAD and TCE processes. The DT process is realized through the Discovery Agent (DA).
– The LAD process is used for deriving an association between two TCPs/CPs that form a network connection/link connection in a particular layer network. The association discovered through layer adjacency discovery is valid as long as the trail supporting the link connection is valid. Preconditions of the LAD process include knowledge of the (T)CP IDs.
– The TCE process is used for exchanging information about the capabilities of the transport entities (e.g., Link Connections, Trails) in order to facilitate the negotiation of an agreed set of capabilities. Preconditions of the TCE process include knowledge of the Layer Adjacency information and the local capabilities information.

NOTE – If Layer Adjacency has been preconfigured, the LAD process may be omitted.

---

2 TCE was called SCE (Service Capability Exchange) in ITU-T Rec. G.7714/Y.1305 (2001).

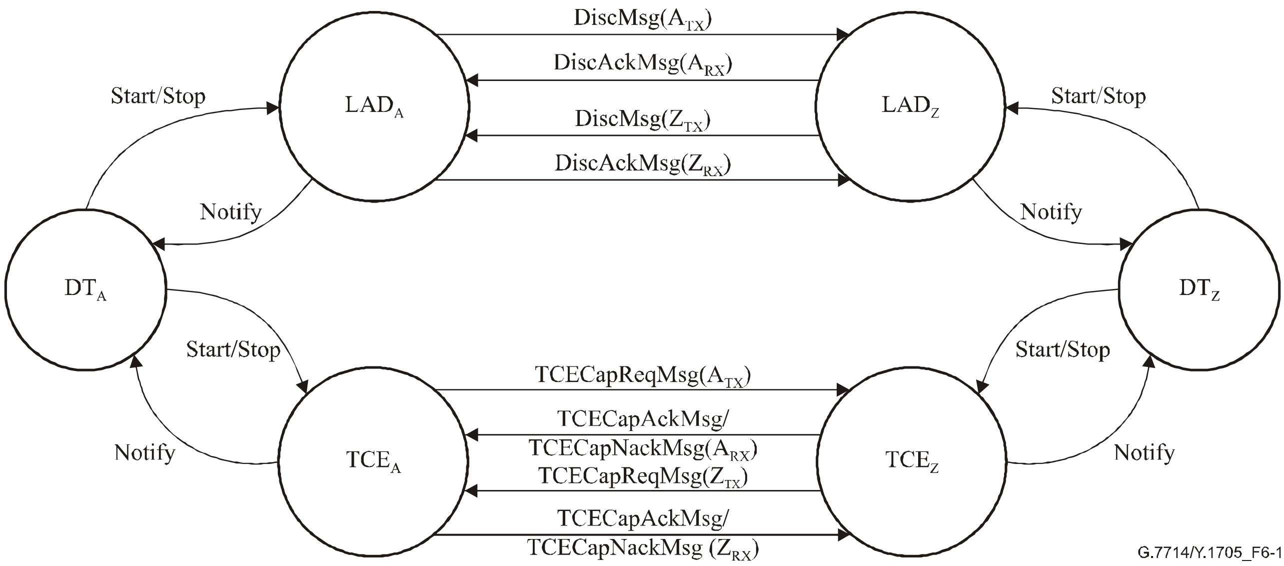

Figure 6-1/G.7714/Y.1705 – Discovery sub-process interaction diagram

The following clauses describe in detail the sub-processes that encompass discovery, i.e., DT, LAD and TCE. A detailed description of the interfaces and message exchanges is provided in clause 11.

7 Discovery trigger process

The discovery trigger process is enabled by the Management Plane, which specifies the types of scenarios that need to be supported. The scenario profile has multiple parameters including whether or not particular discovery sub-processes are supported, what type, under what conditions, and what management information needs to be provided under each condition. The default profile is a policy decision. For example:

– Whether LAD is used. If LAD is not used, the Management Plane shall provide (T)CP binding information. If LAD is used, what type (Type 1 or Type 2 as described in 8.1), and under what conditions (return-to-service triggered or continuous as described in 8.2).
– Whether TCE is used. If TCE is not used, the Management Plane shall provide local and remote end information. If TCE is used, the detailed capabilities of the end point transport entities shall be provided, as governed by policy.

8 Layer Adjacency Discovery (LAD)

The discovery process for transport entities takes place on a per-layer basis, consistent with ITU-T Rec. G.805. The LAD process is used to discover the association between the end points of a link connection (LC) or network connection (NC) within a particular layer (i.e., between the two TCP/CPs that constitute a connection). A pre-condition for the discovery process is that (T)CP IDs shall exist for the end points being discovered. It shall be possible for the Management Plane to enable and disable the LAD process on a per-(T)CP basis.

The LAD process involves the sending of discovery and discovery acknowledgement messages between the end points of a LC or NC in a particular layer, shown as "A" and "Z" in Figure 6-1. The LAD process at the A-end starts by periodically sending discovery messages to the Z-end containing information that allows the Z-end to determine the A-end's (T)CP ID and the Discovery Agent (DA) ID scoping the (T)CP ID. When the Z-end has received that message, it sends a discovery acknowledgement message back to the A-end that contains:

– the information the Z-end has received from the A-end;

– the information about the Z-end where the discovery message was received.

The exchanged information allows both sides to identify the A-Z unidirectional connection. This process is performed in parallel for the Z-A direction to identify the Z-A unidirectional connection.

After both unidirectional connections associated with a (T)CP have been identified, the unidirectional links are verified to be between the same pair of (T)CPs. If they are not, a misconnection is detected and reported. If the two unidirectional links are between the same pair of (T)CPs, the LAD process is assumed to be complete. The Management Plane may then stop the LAD process or keep it active to continually supervise the adjacency.

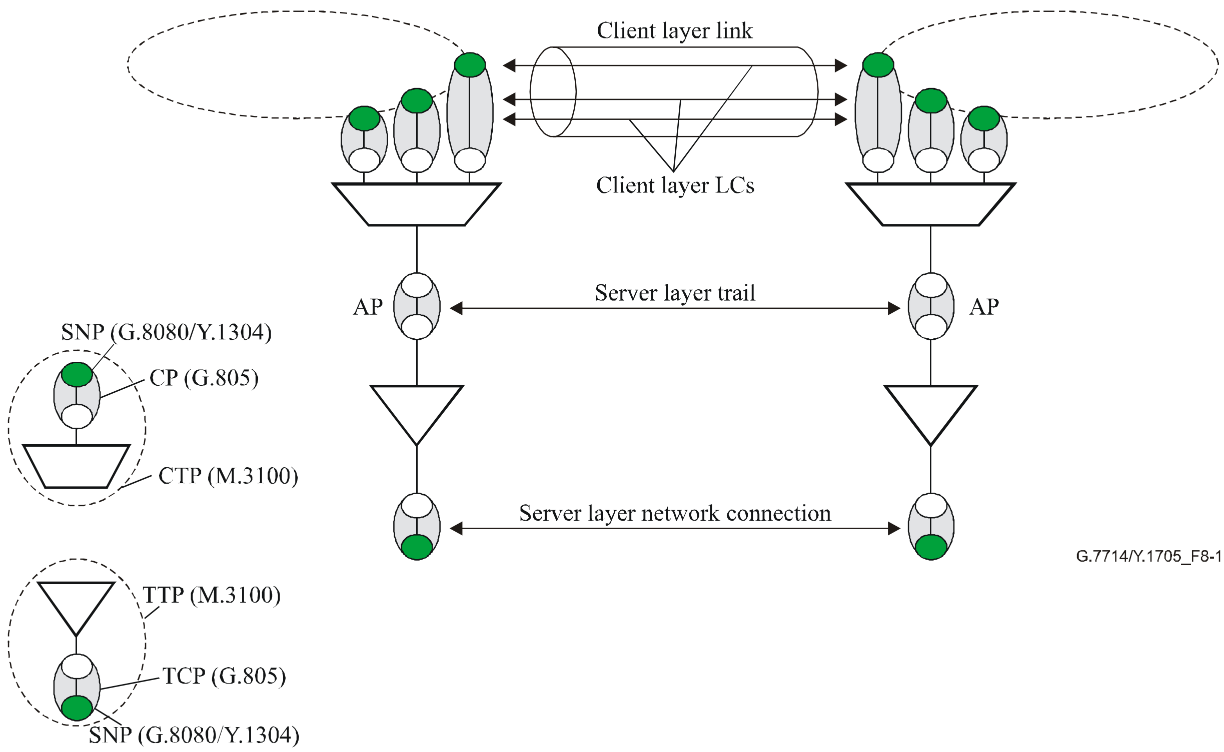

Figure 8-1/G.7714/Y.1705 – Layer adjacency discovery – Example

The example in Figure 8-1 illustrates discovery processes applied in both the client and server layers to discover layer network topology. Two APs that are associated over a server layer network connection form a trail at the server layer. In this example, the server layer trail supports the association of three pairs of CPs in the client layer to form a client layer link composed of three LCs. Here the LAD process discovers the association between the two TCPs in the server layer as well as the relationships between the CPs in the client layer. The associations established at the two layers are valid only as long as the supporting server layer network connection is valid.

NOTE 1 – The physical media layer is conceptually no different from any other transport entity layer adjacency. In the 2001 version of ITU-T Rec. G.7714/Y.1705, this was called PMAD (Physical Media Adjacency Discovery).

NOTE 2 – The LAD process for multilayer networks may be optimized by deriving the client layer adjacencies from the discovered server layer adjacencies, using the TCE information provided by the TCE process.

8.1 Methods for layer adjacency discovery

The discovery methodology uses the processes defined in the following clauses to determine the TCP-to-TCP relationship. Once the TCP-to-TCP relationship has been determined, the CP-to-CP connectivity relationships are derived using local information. Two types of discovery methodology are available for supporting Layer Adjacency Discovery, one involving usage of the server layer trail overhead (Type 1) and the other utilizing the client layer payload area (Type 2).

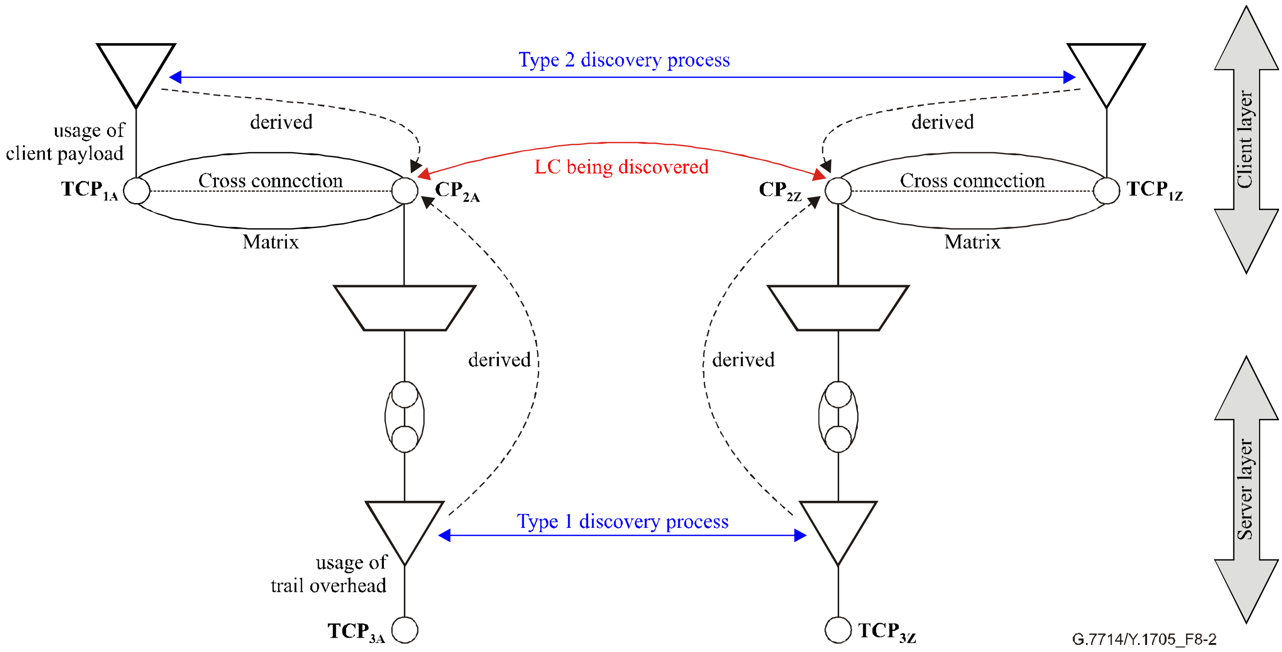

Figure 8-2/G.7714/Y.1705 – Type 1 and Type 2 LAD

In the Type 1 Discovery process, the server layer trail overhead is used to discover the peer TCPs (e.g., TCP_{3A} to TCP_{3Z} in Figure 8-2). The server layer trail overhead is used to carry the discovery message. The CP-to-CP relationships are derived from the TCP-to-TCP relationships using local knowledge of the configuration of the adaptation function and its relationship with the trail termination function.

The Type 2 Discovery Process transmits a discovery message in the client layer payload to discover the peer TCPs (e.g., TCP_{1A} to TCP_{1Z} in Figure 8-2). The CP-to-CP relationship is derived from the local knowledge of the matrix connection that was previously set up to connect the test signal to the desired CP (shown in Figure 8-2).

8.2 Timescales for layer adjacency discovery

The layer adjacency discovery process is responsible for discovering the binding of a local (T)CP to a remote (T)CP created by the transport entity connecting them. There are two different approaches that can be taken regarding when the LAD process needs to be run.

8.2.1 Return-to-service triggered

Many transport technologies manifest certain behaviour whereby it is impossible to change the endpoints of a transport entity without causing a continuity failure (as detected by continuity supervision). When the continuity failure occurs, the transport entity will become operationally out-of-service and the LAD information is invalidated. When the continuity failure is removed, the transport entity will become operationally in-service, and the binding of local and remote (T)CPs needs to be rediscovered. This transition is used to cause the LAD state machine to relearn the binding.

8.2.2 Continuous

Cases also exist where continuous operation of the LAD process is necessary; for example, where no continuity supervision is performed. In such cases, the (T)CP binding created by the transport entity needs to be continually relearned and reviewed for any changes.

9 Transport entity capability exchange

The TCE process exchanges messages to notify the transport entities at either end about the functional capabilities that they are willing to support. These capabilities include supported adaptation(s), Characteristic Information etc., associated with the two adjacent (T)CPs. Unlike the LAD process, this is a multi-stage process wherein the network elements at both ends of the link negotiate a set of capabilities that each is willing to support.

As described earlier, and illustrated in Figure 9-1 below, TCE information can be combined with the results of the LAD process to derive potential client layer CPs.

The capabilities exchanged are listed in 11.2.

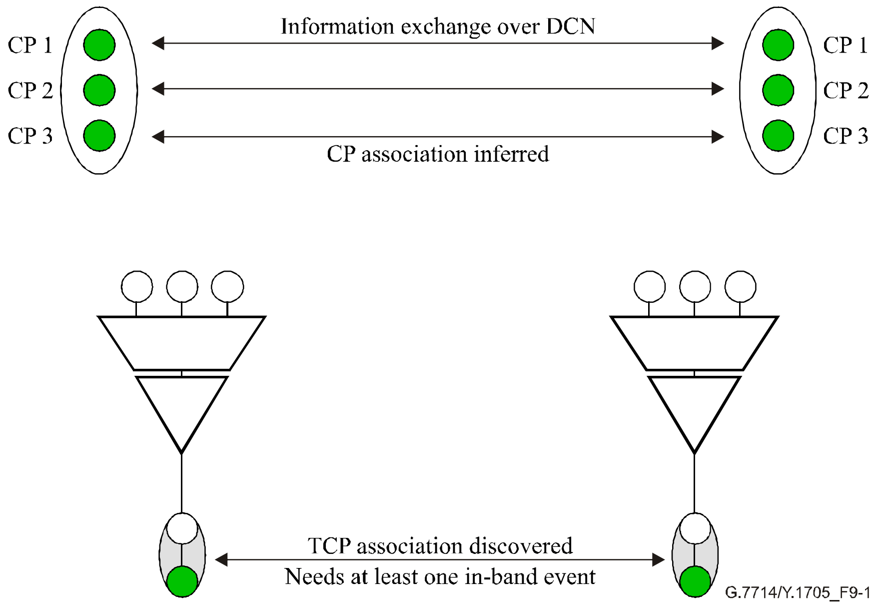

Figure 9-1/G.7714/Y.1705 – Transport entity capability exchange – Example

The TCE processes at each end start by the transmission of TCECapReqMsg messages (as shown in Figure 6-1) containing the capabilities that the local end point supports. When the message is received by the TCE process for the remote end point, it compares the list of capabilities it has received with the ones it is willing to support, and if not matched, it sends a TCECapNackMsg with a modified set of capabilities that it is willing to support. The originating end, on receiving this modified capabilities set, can either agree to support this set of capabilities by sending a TCECapAckMsg, or negotiate further by transmitting a new TCECapReqMsg with a new and modified set of capabilities. Once both ends agree upon a set of capabilities, each end will stop transmission of these capability messages.

It should be noted that the capabilities exchanged could be asymmetric across the two directions of a bidirectional link.

10 Requirements

10.1 Discovery agent

R-1 The Discovery Agent shall discover the link topology supported by its set of (T)CPs.

R-2 The Discovery Agent shall have a unique identifier within the operational region where the Discovery process may be run

R-3 The link topology information for a (T)CP shall be provided by the Discovery Agent to corresponding registered control/management entities.

10.2 (T)CPs under the responsibility of a Discovery Agent

R-4 The (T)CP shall have a unique identifier within the scope of the local (or responsible) Discovery Agent.

R-5 A discovery process instance shall exist for each (T)CP managed by the Discovery Agent.

The following definition applies to all remaining requirements: the (T)CP that a discovery process instance is responsible for shall be referred to as the local (T)CP.

10.3 Discovery process instance

R-6 A discovery process instance shall identify bidirectional transport entities that are bound to the local (T)CP through one of two processes: configuration by the Management Plane or LAD.

R-7 The bidirectional transport entity shall be identified by the combination of the local (T)CP, local DA, remote (T)CP and remote DA Identifiers.

R-8 The discovery process shall be able to identify the capabilities of the remote (T)CP.

R-9 The discovery process shall be able to retrieve the capabilities of the local (T)CP.

R-10 The discovery process shall be able to negotiate the capabilities allowed by remote operator policy for the local (T)CP.

R-11 The discovery process shall be able to negotiate the capabilities allowed by local operator policy for the remote (T)CP.

R-12 The discovery process shall allow the capabilities negotiated for the remote (T)CP and negotiated for the local (T)CP to be different.

10.4 Discovery of a transport entity

R-13 The LAD process shall support use of one or both of the following in-band channels: trail overhead associated with the local (T)CP (Type 1), or trail payload associated with the local (T)CP (Type 2).

R-14 It shall be possible for the Management Plane to enable/disable the transmission of the discovery message.

R-15 The discovery process shall enable the LAD process when the method for identifying a transport entity is set for LAD.

R-16 The LAD process shall not run when the method to identify the transport entity is set to management configuration.

R-17 The discovery process shall be able to stop the transmission of the discovery message once the transport entity has been discovered.

10.5 Discovery of a unidirectional transport entity

R-18 To facilitate the discovery of a unidirectional transport entity, a discovery process shall periodically send a discovery message on the in-band channel associated with the local (T)CP containing information to uniquely identify the local (T)CP.

R-19 The LAD process shall identify the remote (T)CP bound to the inbound unidirectional transport entity by listening to the in-band channel associated with the local (T)CP for a discovery message.

R-20 The local LAD process shall notify the remote LAD process of the inbound unidirectional transport entity identified by sending a discovery acknowledgment containing the received (T)CP ID, received DA ID, and the (T)CP ID and DA ID for the local (T)CP.

10.6 Discovery of a bidirectional transport entity

R-21 The LAD process shall identify the bidirectional transport entity by separately identifying the inbound and outbound unidirectional transport entities associated with the local (T)CP.

R-22 The LAD process shall identify if the two unidirectional transport entities are connected to the same remote (T)CP.

R-23 The LAD process shall notify the discovery process instance if the two unidirectional transport entities are not connected to the same remote (T)CP.

10.7 Discovery of transport entity capabilities

R-24 The TCE process shall support exchanging at a minimum the following type of information:

– Transport plane capabilities of the end point attached to the transport entity.

R-25 A common generic process should exist to support all types of transport entity capability information.

R-26 It shall be possible to add additional TCE information types without complete re-specification of the TCE process.

R-27 The various types of transport entity capability information related to a trail shall be allowed to have separate, independent TCE sessions.

R-28 It shall be possible to update the transport entity capability information without taking a link/trail out of service.

R-29 The TCE process shall count the number of failed capability negotiation attempts and may stop after exceeding a management configurable threshold.

R-30 The TCE process shall continue to use the already negotiated capabilities if a re-negotiation of new capabilities cannot be accomplished.

R-31 The consequent actions for a failed TCE re-negotiation attempt shall be defined by Management Plane policy.

R-32 The TCE process shall only start to use new capabilities after re-negotiation has been completed.

11 Discovery messages

The LAD process uses a message-based scheme which exchanges identity attributes. There is no assumption made on whether the same or different protocols are needed for the different instances of discovery. The actual protocol may operate in either an acknowledged or unacknowledged mode. In the acknowledged mode, the discovery message might carry the near-end identity attributes and the acknowledgement can carry the far-end identity attributes in response to the received near-end attributes. Additionally, the transport entity capability information may also be carried as part of the acknowledgement. In the unacknowledged mode, each end sends its respective identity attributes, and TCE is done at a different time. In either mode, the messages shall be sent until the discovery process is completed. Clauses 11.1 and 11.2 provide the messages and attributes for an acknowledged discovery process.

11.1 LAD process

11.1.1 LAD-LAD interface

Table 11-1/G.7714/Y.1705 – LAD-LAD interface messages

LADDiscMsg	LAD Message contains: (T)CP ID for local (T)CP, DA ID for local (T)CP.
LADDiscAckMsg	LAD Ack Message contains: (T)CP ID for local (T)CP, (T)CP ID received in the LADDiscMsg, DA ID for the local (T)CP, DA ID received in the LADDiscMsg.

NOTE – If the (T)CP ID is from a global name space, then the DA-scoped (T)CP ID and the DA ID can be derived, removing the need to pass the DA ID.

11.1.2 DT-LAD interface

Table 11-2/G.7714/Y.1705 – DT-LAD interface message

DTLADStart	LAD Start Message contains: Channel to use for discovery, Selection of continuous or edge-trigger discovery, Local-endpoint DA ID and (T)CP ID.
DTLADStop	LAD Stop Message: No attributes are required.
LADDTMiswire	LAD Miswire Notification Message contains: Local-endpoint DA ID and (T)CP ID, Local-endpoint DA ID and (T)CP ID received in DiscAckMsg, Remote-endpoint DA ID and (T)CP ID received in DiscAckMsg, Remote-endpoint DA ID and (T)CP ID received in DiscMsg.
LADDTLinkDisc	LAD Transport Entity Binding Discovered Message contains: Local-endpoint DA ID and (T)CP ID, Remote-endpoint DA ID and (T)CP ID.
LADDTLinkLost	LAD Transport Entity Binding Lost Message contains: Local-endpoint DA ID and (T)CP ID, Remote-endpoint DA ID and (T)CP ID.

11.2 TCE process

The capability attributes exchanged in these messages include:

i) The client CI types supported.

ii) The ability to support flexible adaptation.

iii) The adaptations supporting the client CI types.

iv) Attributes used by specific applications (e.g., routing, signalling, management applications).

NOTE – The A-end only sends A-end TCE attributes to the Z-end and vice versa. Moreover, the TCE attributes are exchanged on a per-layer basis and the set of TCE attributes defined above is exchanged for each layer (e.g., RS, MS, VC-4, VC-4-nc, VC-12).

11.2.1 TCE-TCE interface

Table 11-3/G.7714/Y.1705 – TCE-TCE interface messages

TCECapReq	TCE Capability Request Message contains: Local-endpoint DA ID and (T)CP ID, Remote-endpoint DA ID and (T)CP ID, Local-endpoint offered capability.
TCECapAck	TCE Capability Ack Message contains: Local-endpoint DA ID and (T)CP ID, Remote-endpoint DA ID and (T)CP ID.
TCECapNack	TCE Capability Nack Message contains: Local-endpoint DA ID and (T)CP ID, Remote-endpoint DA ID and (T)CP ID, Refused capability or capability setting.

11.2.2 DT-TCE interface

Table 11-4/G.7714/Y.1705 – DT-TCE interface messages

DTTCEStart	TCE Negotiation Start Message contains: Local DA ID and (T)CP ID, Remote DA ID and (T)CP ID, Capability of local endpoint, Negotiation Policy for local endpoint, Negotiation Policy for remote endpoint.
DTTCEStop	TCE Stop Message: No attributes are required.
TCEDTCapCom	TCE Negotiation Complete contains: Capability negotiated for local endpoint, Capability negotiated for remote endpoint.

12 Discovery state machine descriptions

The state machines of the discovery process presented in clause 6 are described in the following subclauses.

12.1 LAD state machine

The LAD sub-process shown in Figure 6-1 is elaborated in a state diagram that is depicted in Figure I.1. The state descriptions, event descriptions and state transitions are shown in Tables 12-1 to 12-6.

Within Figure I.1, the LAD sub-process is broken down into two independent state machines. Both state machines need to be run at each end of the transport entity (e.g., trail or link) in order for its end points to be discovered. If one end is not running the LAD process, the end points of the transport entity will not be discovered.

The LAD Tx state machine handles the periodic transmission of discovery messages. The LAD state machine handles the receipt of discovery messages as well as generation of discovery acknowledgments.

The discovery messages being exchanged identify the unidirectional links that make up a bidirectional link. Once both unidirectional links have been identified and validated for miswiring, a notification will be provided to the DT process identifying the end points discovered. If miswiring is identified or a change in the end points is identified, the DT process will be notified.

When the LAD state machine instance is created, the state machine enters State 1 (S_{IDLE}) and the LAD Tx state machine instance is created. The LAD state machine will transition through the left or right branches of the LAD state machine depending on the time sequence of the received discovery messages. Once the LAD state machine identifies the end points of the link, it enters State 4 ($S_{A\text{-}Z,Z\text{-}AKNOWN}$). When transitioning to State 4 of the LAD state machine, the LAD Tx State Machine may be stopped.

Note that the state machine runs at one end of the transport entity, and an identical machine runs at the other end. The left and right branches off the State 1 (S_{IDLE}) do not depict this end and the far end, but specify the behaviour when the Discovery message (from the far end) is received before or after the DiscAck message for the local DiscMsg. Every time the State 1 (S_{IDLE}) is entered it is ensured that the LAD Tx state machine is running.

If the connection is found to be miswired, the state machine remains in states 2 or 3 and a notification is sent to the DT process.

The NULL state is before the LAD state machine is created.

Table 12-1/G.7714/Y.1705 – LAD events

StartLADInstance	This event occurs when the LAD Instance is created by the DT process.
RxDiscMsgMatchedZ	This event occurs when a Discovery Message is received, and the Z-end point identifier contained matches the Z identifier previously observed.
RxDiscMsgUnMatchedZ	This event occurs when a Discovery Message is received, and the Z-end point identifier contained does not match the Z-end point identifier previously observed.
RxDiscAckMatchedZ	This event occurs when a Discovery Ack Message is received, and the Z-end point identifier contained matches the Z-end point identifier previously observed.
RxDiscAckUnMatchedZ	This event occurs when a Discovery Ack Message is received, and the Z-end point identifier contained does not match the Z-end point identifier previously observed.
FAIL	This event occurs when the connectivity supervision lost indication occurs for the (T)CP.
StopLADInstance	This event occurs when the LAD Instance is destroyed by the DT process.

Table 12-2/G.7714/Y.1705 – LAD actions

StartLADTxInstance	This action creates a LADTx Instance operating on the local (T)CP.
TerminateLADTxInstance	This action destroys a LAD Tx Instance operating on the local (T)CP.
SetObservedZIdentifier	This action records the Z-end point identifier received in a DiscMsg or DiscAckMsg.
UnsetObservedZIdentifier	This action invalidates the Z-end point identifier previously observed.
NotifyDTMiswire	This action sends a LADDTMiswire message to DT.
NotifyDTLinkFound	This action sends a LADDTLinkDisc message to DT.
NotifyDTLinkLost	This action sends a LADDTLinkLost message to DT.
TxDiscAck	This action sends a LADDiscAckMsg to the remote LAD instance.

Table 12-3/G.7714/Y.1705 – LADTx events

StartLADTxInstance	This event occurs when the LADTx Instance is created by the LAD process.
Timeout	This event occurs when the transmission timer expires.
StopLADInstance	This event occurs when the LADTx Instance is destroyed by the LAD process.

Table 12-4/G.7714/Y.1705 – LADTx Actions

StartTxTimer	This action sets the transmission timer and starts the timer.
RestartTxTimer	This action resets the transmission timer and starts the timer.
TerminateTxTimer	This action stops the transmission timer. No expiration can occur until the timer is restarted.
TxDiscMsg	This action sends a LADDiscMsg on the local (T)CP to the remote LAD process.

Table 12-5/G.7714/Y.1705 – LAD state machine

Events	Actions
StartLADInstance	slt = StartLADTxInstance
	tlt = TerminateLADTxInstance
RxDiscMsgMatchedZ	
RxDiscMsgUnMatchedZ	uoz = UnsetObservedZIdentifier
	soz = SetObservedZIdentifier
RxDiscAckMatchedZ	
RxDiscAckUnMatchedZ	ndm = NotifyDTMiswire
	nlf = NotifyDTLinkFound
FAIL	nll = NotifyDTLinkLost
StopLADInstance	tda = TxDiscAck

Events \ States	0 NULL	1 S_{IDLE}	2 $S_{A\text{-}ZKnown}$	3 $S_{Z\text{-}AKnown}$	4 $S_{A\text{-}Z,Z\text{-}AKnown}$
StartLADInstance	1 slt,uoz	–	–	–	–
RxDiscAckMatchedZ	–	2 soz	2 soz	4 tlt (Note),nlf	4
RxDiscAckUnMatchedZ	–	2 soz	2 soz	3 ndm	1 slt,uoz,nll
RxDiscMsgMatchedZ	–	3 soz,tda	4 tlt (Note), nlf,tda	3 soz,tda	4 tda
RxDiscMsgUnMatchedZ	–	3 soz,tda	2 ndm,tda	3 soz,tda	3 slt,soz,nll,tda
FAIL	–	1	1 uoz	1 uoz	1 slt,uoz,nll
StopLADInstance	–	0 tlt (Note)	0 tlt (Note)	0 tlt (Note)	0

NOTE – The LAD Tx Instance may be stopped when transitioning to State 4, allowing the in-band channel to be used by other applications. Transitions out of State 4 to other states requires restarting the LADTxInstance. If the LADTxInstance is not stopped when transitioning to State 4, then it must be stopped when a StopLADInstance event occurs in State 4.

Table 12-6/G.7714/Y.1705 – LAD Tx state machine

Events	Actions
StartLADTxInstance	stt = StartTxTimer
StopLADTxInstance	rtt = RestartTxTimer
	ttt = TerminateTxTimer
Timeout	tdm = TxDiscMsg

States / Events	0 NULL	1 S_{IDLE}
StartLADInstance	1 stt,tdm	–
Timeout	–	1 rtt,tdm
StopLADTxInstance	–	0 ttt

12.2 TCE state machine

The state table shown in Table 12-9 defines the state machine for the TCE process. A separate instance of the TCE state machine is created for each (T)CP for which discovery is enabled. Therefore, for any transport entity discovered by LAD, a separate instance of the TCE state machine will exist for each end of the transport entity. These instances will communicate with each other using the messages defined in Table 11-2 as well as their respective Discovery Trigger (DT) processes. As messages are received, they cause the events shown in Table 12-7. These events in turn cause state transitions and/or the actions defined in Table 12-8[3].

The state machine starts in State 2 when created. The Discover Trigger process will start the TCE process with a DTTCEStart message, causing the TCE process to initialize the retransmission timer and send a TCECapReq message to the remote TCE process. As TCECapReq or TCECapAck messages are received from the remote TCE process, the state machine will transition to either state 7 or 8, depending on the order the messages are received. If TCECapReq messages are received containing capabilities that are supported, a TCECapAck message will be sent, otherwise a TCECapNak will be sent containing the capability that is not supported/allowed by the local (T)CP. If an excessive number of renegotiations occur (as defined by management), then the state machine will stop, and enter State 3. It will only be restarted if the DT Process terminates and restarts TCE.

When both sides have successfully negotiated capabilities information, the state machine will transition to State 9. It is possible to negotiate a change in capabilities while in State 9 by sending a TCECapReq message to the far TCE process containing the set of capabilities already negotiated and the requested new capabilities. If the far TCE process will support/allow the capabilities in the TCECapReq message, then a TCECapAck will be returned. If not supported/allowed, then a TCECapNak will be returned.

If the DT process wishes to stop the TCE process, it will send a DTTCEStop message to the TCE instance. If the DT process is in States 6, 7, 8, 9 or 10, it will attempt to gracefully stop the TCE process by sending a TCETermReq message. This will be retransmitted until either a TCETermAck message is received, or the retransmission count is exceeded.

[3] The specific transitions and actions are found by locating the intersection of current state of the state machine and the event received in the state table. The numeric value indicates the resulting state, while the mnemonics indicate the actions to perform.

The TCE state machine is shown in Figure I.2. The state descriptions, event descriptions and state transitions are shown in Tables 12-7 to 12-9.

Table 12-7/G.7714/Y.1705 – TCE events

StartTCE	This event occurs when the TCE instance receives a DTTCEStart message.
TerminateTCE	This event occurs when the TCE instance receives a DTTCEStop message.
Change Capabilities	This event occurs when the capabilities of the local (T)CP is changed.
Timeout with counter >0	This event occurs when the transmission timer expires, and the transmission counter is not less than zero.
Timeout with counter expired	This event occurs when the transmission timer expires, and the transmission counter is 0.
Receive-Capability-Request (Good)	This event occurs when a TCECapReqMsg is received, and the capabilities included are acceptable given the local policy for the (T)CP.
Receive-Capability-Request (Bad)	This event occurs when a TCECapReqMsg is received, and the capabilities included are not acceptable given the local policy for the (T)CP.
Receive-Capability-Ack	This event occurs when a TCECapAckMsg is received indicating that the capabilities previously sent are acceptable to the remote discovery TCE instance.
Receive-Capability-Nak/Rej	This event occurs when a TCECapNakMsg is received indicating that the capabilities previously sent are not acceptable to the remote discovery TCE instance.
Receive-Terminate-Request	This event occurs when a TCETermReq is received indicating that the remote discovery TCE instance is going out-of-service.
Receive-Terminate-Ack	This event occurs when a TCETermAck is received indicating that the remote discovery TCE instance has received the locally generated TCETermReq.

Table 12-8/G.7714/Y.1705 – TCE actions

NotifyDTCapNegComplete	This action sends a TCEDTCapCom message to the DT
NotifyDTCapNegLost	This action sends a TCEDTCapLost message to the DT indicating that TCE Negotiation has been terminated at the request of the remote TCE instance.
Initialize-Restart-Count	This action resets the retransmission counter to a maximum number of retransmission attempts specified by the management plane.
Zero-Restart-Count	This action sets the transmission counter to zero.
Send-Capability-Request	This action sends a TCECapReq message to the remote TCE, and decrements the retransmission counter.
Send-Capability-Ack	This action sends a TCECapAck message to the remote TCE. It does not decrement the retransmission timer.
Send-Capability-Nack/Rej	This action sends a TCECapNack message to the remote TCE. It does not decrement the retransmission timer.
Send-Terminate-Request	This action sends a TCETermReq message to the remote TCE notifying it that Capabilities Exchange is being stopped. It decrements the retransmission counter.
Send-Terminate-Ack	This action sends a TCETermAck message to the remote TCE acknowledging a received TCETermReq message. It does not decrement the retransmission counter.

Table 12-9/G.7714/Y.1705 – TCE state machine

Events	Actions
STCE = Start TCE	tlu = NotifyDTPCapNegComplete
TTCE = Terminate TCE	tld = NotifyDTPCapNegLost
CC = ChangeCapabilities	
TO+ = Timeout with counter > 0	irc = Initialize-Restart-Count
TO– = Timeout with counter expired	zrc = Zero-Restart-Count
RCR+ = Receive-Capability-Request (Good)	scr = Send-Capability-Request
RCR– = Receive-Capability-Request (Bad)	
RCA = Receive-Capability-Ack	sca = Send-Capability-Ack
RCN = Receive-Capability-Nak/Rej	scn = Send-Capability-Nak/Rej
RTR = Receive-Terminate-Request	str = Send-Terminate-Request
RTA = Receive-Terminate-Ack	sta = Send-Terminate-Ack

Events \ States	2 A-Z/Z-A Unknown	3 Stopped	4 Closing	5 Stopping	6 CapReq-Sent	7 A-ZOK, Z-AUnkn	8 Z-AOK, A-ZUnkn	9 A-ZOK, Z-AOK	10 Z-AOK, A-ZReneg
STCE	6 irc,scr	3	5	5	6	7	8	9	10
TTCE	2	2	4	4	4 irc,str	4 irc,str	4 irc,str	4 tld,irc,str	4 tld,irc,str
CC	2	3	4	5	6 scr	6 scr	8 scr	10 scr	10 scr
TO+	–	–	4 str	5 str	6 scr	6 scr	8 scr	–	10 scr
TO–	–	–	2	3	3	3	3	–	9
RCR+	2 sta	8 irc,scr,sca	4	5	8 sca	9 sca,tlu	8 sca	9 tlu,sca	10 sca
RCR–	2 sta	6 irc,scr,scn	4	5	6 scn	7 scn	6 scn	9 scn	10 scn
RCA	2 sta	3 sta	4	5	7 irc	6 scr	9 irc,tlu	6 tld,scr	9 tlu
RCN	2 sta	3 sta	4	5	6 irc,scr	6 scr	8 irc,scr	6 tld,scr	10 scr
RTR	2 sta	3 sta	4 sta	5 sta	6 sta	6 sta	6 sta	5 tld,zrc,sta	5 tld,zrc,sta
RTA	2	3	2	3	6	6	8	6 tld,scr	6 tld,scr

Appendix I

Discovery process state machines

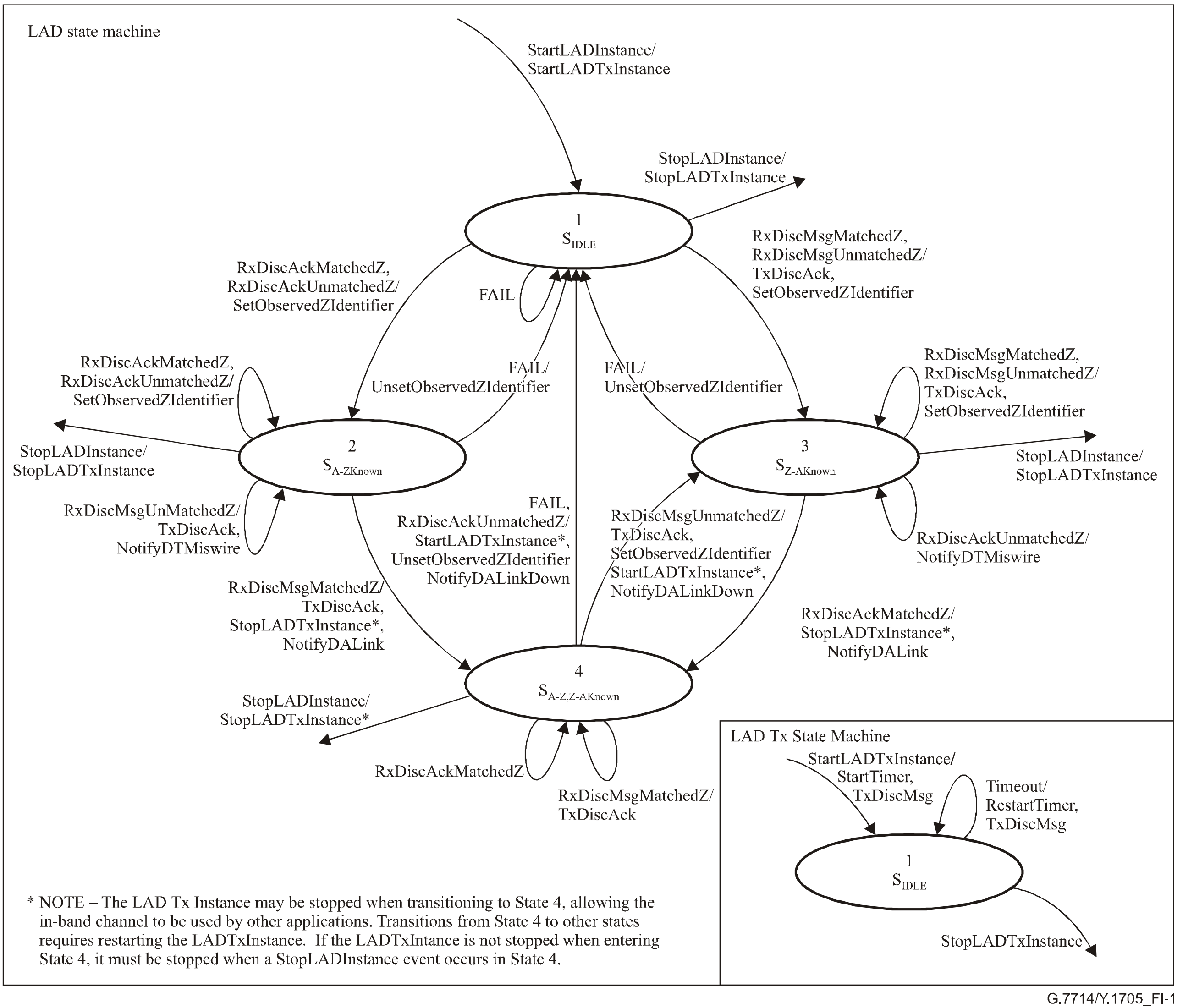

Figure I.1/G.7714/Y.1705 – LAD state Machine

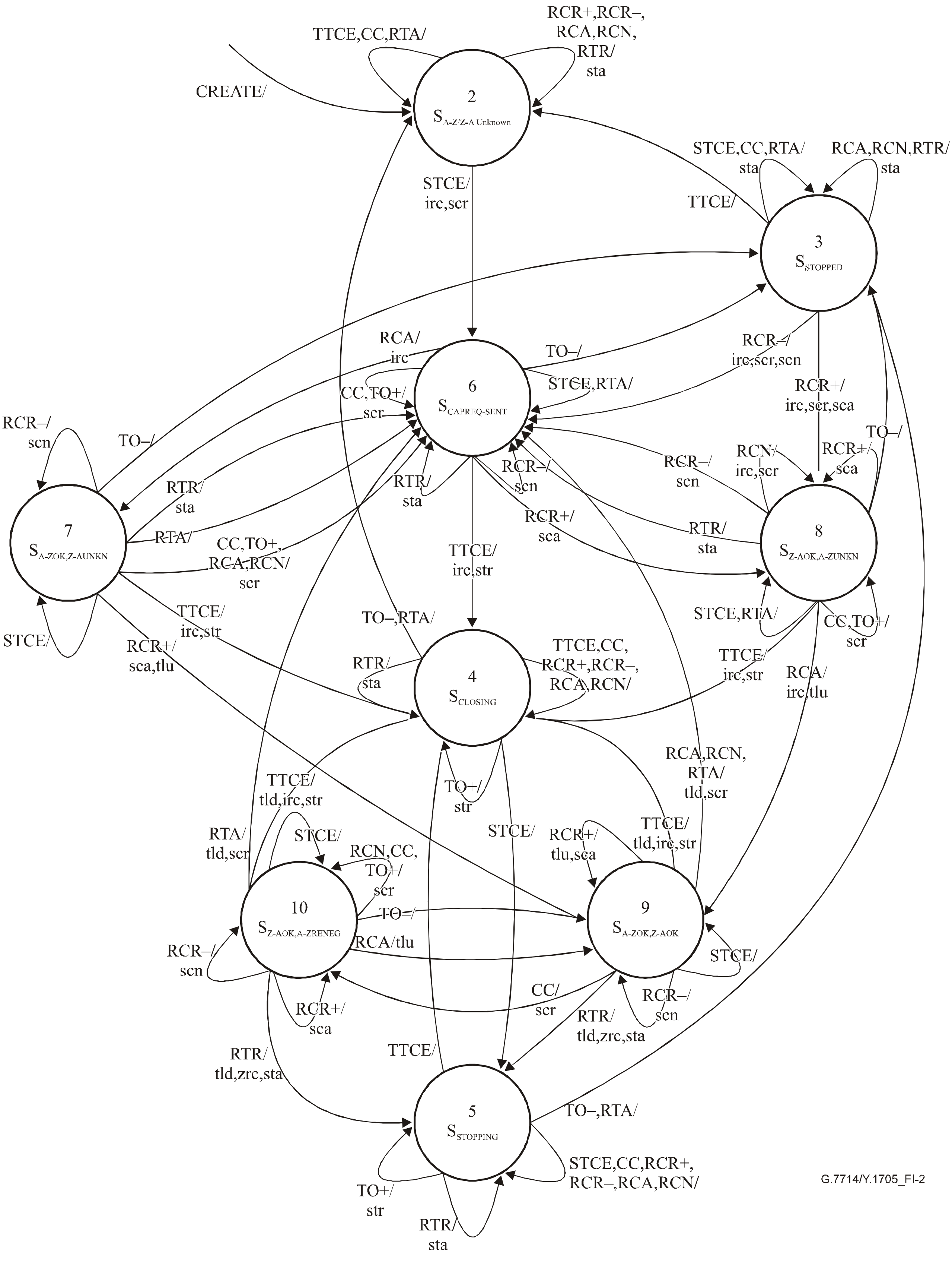

Figure I.2/G.7714/Y.1705 – TCE state machine

NOTE – The numbering of the states in this figure is consistent with the description contained in Appendix II.

Appendix II

Mapping of TCE state machine to RFC 1661 LCP state machine

The TCE state machine defined in this Recommendation is derived from the Link Control Protocol (LCP) state machine defined in IETF RFC 1661, "Point-to-Point Protocol". This state machine is used by PPP to negotiate the configuration details, including the capabilities of an endpoint, for packet layer protocols operating over a point-to-point connection. This state machine has been widely deployed in systems using many different interoperable implementations. The modifications from the LCP state machine are described in this Appendix.

Removal of operational state change-events

The TCE process is initiated by the Discovery Trigger process. This process already handles the transitions related to Administrative State (OPEN and CLOSE) and Operational State (UP and DOWN), making the handling of Operational State change-events in the TCE state machine unnecessary. With the removal of UP and DOWN events, the state machine now starts in *State 2: Closed*, instead of *State 0: Initial*. Furthermore *State 1: Starting*, previously used to handle the transition to Administrative Enabled while Operationally Out-of-Service, is also no longer necessary.

Addition of change capabilities negotiation

Requirement R-28 states that it must be possible to change the capabilities information for an endpoint and notify the endpoint bound to the other end of the transport entity without taking the transport entity out of service. However, LCP does not allow for configuration information to change without taking the connection out of service. To handle this, the *Receive Cap Req (RCR)* event is now processed in *State 9: A-ZOK*, *Z-AOK* instead of transitioning to *State 6: CapReqSent* or *State 8: Z-AOK, A-ZUNKN*. Additionally, a new event *ChangeCap* and a new state State *10: Renegotiation* has been added to handle the reception of a *ChangeCap* event while in *State 9: A-ZOK*, *Z-AOK*.

Change of state names

The state names for LCP focus on the events that have occurred in the past without describing the amount of information known. The TCE state names focus on the information known as each state is achieved. To assist those familiar with LCP states, the mapping between LCP states and TCE states is shown in Table II.1.

Table II.1/G.7714/Y.1705 – Mapping of LCP states to TCE states

RFC 1661 LCP State Name	G.7714/Y.1705 TCE State Name
State 0: Initial	–
State 1: Starting	–
State 2: Closed	State 2: A-Z, Z-A Unknown
State 3: Stopped	State 3: Stopped
State 4: Closing	State 4: Closing
State 5: Stopping	State 5: Stopping
State 6: ConfReq Sent	State 6: CapReq Sent
State 7: Ack-Rcvd	State 7: A-Z OK, Z-A Unkn
State 8: Ack-Sent	State 8: Z-A OK, A-Z Unkn
State 9: Opened	State 9: A-Z OK, Z-A OK
–	State 10: Z-A OK, A-Z Reneg

Appendix III

Rationale for removal of CELA process

The 2001 version of ITU-T Rec. G.7714/Y.1705 included discussion of Control Entity Logical Adjacency, or CELA. This was previously defined as the association that existed between two discovery processes to facilitate communication between a pair of control entities across the SCN. The term CELA was utilized prior to the development of the G.8080 discovery architecture, and prior to consideration that the Management Plane could benefit from the automatic discovery process.

This version of ITU-T Rec. G.7714/Y.1705 allows the discovery process to be used by the Management Plane as well as the Control Plane, making the term CELA inappropriate. As the G.8080 architectural construct is the DA (Discovery Agent), the appropriate term to substitute for CELA would be Discovery Agent adjacency. However, after further inspection, it was determined that the adjacency did not need to be pre-established; it could be created dynamically while other parts of the discovery process (i.e., LAD and TCE) were being executed. Furthermore, it was determined that the communications that occurred across the adjacency were not scoped by the adjacency, removing the distinction from the messaging services provided by the DCN.

Consequently, discussion of the Discovery Agent adjacency is not included in this Recommendation.

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	**Y.1700–Y.1799**
Charging	Y.1800–Y.1899
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Numbering, naming and addressing	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899

For further details, please refer to the list of ITU-T Recommendations.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	**Transmission systems and media, digital systems and networks**
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects and next-generation networks**
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2006