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SERIES I: INTEGRATED SERVICES DIGITAL NETWORK

Overall network aspects and functions – Reference models

Functional architecture of transport networks based on ATM

ITU-T Recommendation I.326

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ITU-T Recommendation I.326

Functional architecture of transport networks based on ATM

Summary

This Recommendation describes the functional architecture of the ATM transport assembly using the transport functional architecture defined in ITU-T Rec. G.805. The ATM transport assembly consists of the VC layer network, the VC to VP adaptation, the VP layer network and the VP to Transmission path adaptation. The features described in the I-series Recommendations that are relevant to ATM transport networks are described in this Recommendation. Annex A describes the correspondence between the terms used in ITU-T Recs I.326 and I.311.

Source

ITU-T Recommendation I.326 was revised by ITU-T Study Group 15 (2001-2004) and approved under the WTSA Resolution 1 procedure on 16 March 2003.

FOREWORD

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ITU-T Recommendation I.326

Functional architecture of transport networks based on ATM

1 Scope

This Recommendation describes the ATM network as a transport network from the viewpoint of its information transfer capability. More specifically, the functional and structural architecture of a transport network based on ATM are described using the generic definitions, symbols and abbreviations that are defined in ITU-T Rec. G.805.

This Recommendation describes the functional architecture of the ATM transport network using the transport functional architecture defined in ITU-T Rec. G.805. The ATM transport network consists of the VC layer network, the VC to VP adaptation, the VP layer network and the VP to Transmission path adaptation. The features described in the I-series Recommendations that are relevant to ATM transport networks are described in this Recommendation. Annex A describes the correspondence between the terms used in ITU-T Recs I.326 and I.311.

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.707/Y.1322 (2000), *Network node interface for the synchronous digital hierarchy (SDH)*.

– ITU-T Recommendation G.709/Y.1331 (2003), *Interfaces for the Optical Transport Network (OTN)*.

– ITU-T Recommendation G.804 (1998), *ATM cell mapping into plesiochronous digital hierarchy (PDH)*.

– ITU-T Recommendation G.805 (2000), *Generic functional architecture of transport networks*.

– ITU-T Recommendation I.113 (1997), *Vocabulary of terms for broadband aspects of ISDN*.

– ITU-T Recommendation I.233 (1991), *Frame mode bearer services*.

– ITU-T Recommendation I.311 (1996), *B-ISDN general network aspects*.

– ITU-T Recommendation I.361 (1999), *B-ISDN ATM layer specification*.

– ITU-T Recommendation I.363.1 (1996), *B-ISDN ATM Adaptation Layer Specification: Type 1 AAL*.

– ITU-T Recommendation I.363.2 (2000), *B-ISDN ATM Adaptation Layer Specification: Type 2 AAL*.

– ITU-T Recommendation I.363.3 (1996), *B-ISDN ATM Adaptation Layer Specification: Type 3/4 AAL*.

– ITU-T Recommendation I.363.5 (1996), *B-ISDN ATM Adaptation Layer Specification: Type 5 AAL*.

– ITU-T Recommendation I.364 (1999), *Support of broadband connectionless data service by the B-ISDN*.

– ITU-T Recommendation I.432.2 (1999), *B-ISDN user-network interface – Physical layer specification: 155 520 kbit/s and 622 080 kbit/s operation*.

– ITU-T Recommendation I.432.4 (1999), *B-ISDN user-network interface – Physical layer specification: 51 840 kbit/s operation*.

– ITU-T Recommendation I.432.5 (1997), *B-ISDN user-network interface – Physical layer specification: 25 600 kbit/s operation*.

– ITU-T Recommendation I.610 (1999), *B-ISDN operation and maintenance principles and functions*.

– ITU-T Recommendation I.630 (1999), *ATM protection switching*.

– ITU-T Recommendation I.731 (2000), *Types and general characteristics of ATM equipment*.

_ ITU-T Recommendation I.732 (2000), *Functional characteristics of ATM equipment*.

3 Abbreviations

This Recommendation uses the following abbreviations:

AAL	ATM Adaptation Layer (see ITU-T Rec. I.363.x)
AIS	Alarm Indication Signal (see ITU-T Rec. I.610)
AP	Access Point (see ITU-T Rec. G.805)
APS	Automatic Protection Switching
ATM	Asynchronous Transfer Mode (see ITU-T Rec. I.150)
BCDBS	Broadband Connectionless Data Bearer Service (see ITU-T Rec. I.364)
CLP	Cell Loss Priority (see ITU-T Rec. I.361)
CP	Connection Point (see ITU-T Rec. G.805)
EFCI	Explicit Forward Congestion Indication (see ITU-T Rec. I.371)
ET	Extra Traffic
F4 OAM	Maintenance flow at the VP level (see ITU-T Rec. I.610)
F5 OAM	Maintenance flow at the VC level (see ITU-T Rec. I.610)
FMBS	Frame Mode Bearer Service (see ITU-T Rec. I.233)
GFC	Generic Frame Control (see ITU-T Rec. I.361)
HEC	Header Error Control (see ITU-T Rec. I.432)
MPCP	Multipoint Connection Point (see 4.4.1.1)
OAM	Operation and maintenance (see ITU-T Rec. I.610)
OTN	Optical Transport Network (see ITU-T Rec. G.872)
PDH	Plesiochronous Digital Hierarchy (see ITU-T Rec. G.804)
PMD	Physical Media Dependant Layer (see ITU-T Rec. I.432.x)
SD	Signal Degrade
SDH	Synchronous Digital Hierarchy (see ITU-T Rec. G.707)

SF	Signal Fail
SNC	Subnetwork connection (see ITU-T Rec. G.805)
STM	Synchronous Transfer Mode (see ITU-T Rec. I.113)
TCP	Termination Connection Point (see ITU-T Rec. G.805)
TP	Trail in the transmission path server layer network (see 4.3.2)
TPT	Transmission path trail termination (see "Trail Termination" in ITU-T Rec. G.805)
TSD	Trail Signal Degrade
TSF	Trail Signal Fail
VC	Virtual Channel (see ITU-T Rec. I.113)
VCC	Virtual Channel Connection (see ITU-T Rec. I.311)
VCI	Virtual Channel Identifier (see ITU-T Rec. I.113)
VCLC	Virtual Channel Link Connection (see "Link connection" in ITU-T Rec. G.805)
VCNC	Virtual Channel Network Connection (see "Network Connection" in ITU-T Rec. G.805)
VCSC	Virtual Channel Subnetwork Connection (see "Subnetwork Connection" in ITU-T Rec. G.805)
VCT	Virtual Channel Trail Termination (see "Trail Termination" in ITU-T Rec. G.805)
VP	Virtual Path (see ITU-T Rec. I.113)
VPC	Virtual Path Connection (see ITU-T Rec. I.311)
VPG	Virtual Path Group (see 4.6.1)
VPI	Virtual Path Identifier (see ITU-T Rec. I.113)
VPLC	Virtual Path Link Connection (see "Link connection" in ITU-T Rec. G.805)
VPNC	Virtual Path Network Connection (see "Network Connection" in ITU-T Rec. G.805)
VPSC	Virtual Path Subnetwork Connection (see "Subnetwork Connection" in ITU-T Rec. G.805)
VPT	Virtual Path Trail Termination (see "Trail Termination" in ITU-T Rec. G.805)

4 Transport functional architecture of ATM networks

4.1 General

The functional architecture of ATM transport networks is described using the generic rules defined in ITU-T Rec. G.805. The specific aspects regarding the characteristic information, client/server associations, the topology, the connection supervision and multipoint capabilities of ATM transport networks are provided in this Recommendation. This Recommendation uses the terminology and functional architecture and diagrammatic conventions defined in ITU-T Rec. G.805.

In an ATM network two levels of multiplexing are used to provide routing flexibility for ATM cell streams. An ATM cell is 53 octets long consisting of a 5-octet header and a 48-octet information field. The VCI and VPI fields in the cell header are used to perform two levels of multiplexing. This is analogous to the use of time-slots and hierarchical multiplexing in STM networks.

4.2 ATM layer networks

Two layer networks are defined in the ATM transport network architecture:

- Virtual Channel (VC) Layer Network;
- Virtual Path (VP) Layer Network.

4.2.1 Virtual channel layer network

The VC layer network provides the transport of adapted information through a VC trail between access points. The adapted information is a non-continuous flow of 48 octets plus one bit (used by the client adaptation process) of client data. The VC layer network characteristic information is a non-continuous of flow of adapted information and F5 OAM information (see ITU-T Rec. I.610). The VC layer network contains the following transport processing functions and transport entities (see Figure 1):

- VC trail;
- VC trail termination source (VCT source): generates F5 end-to-end OAM cells;
- VC trail termination sink (VCT sink): terminates F5 end-to-end OAM cells;
- VC network connection (VCNC);
- VC link connection (VCLC);
- VC subnetwork connection (VCSC).

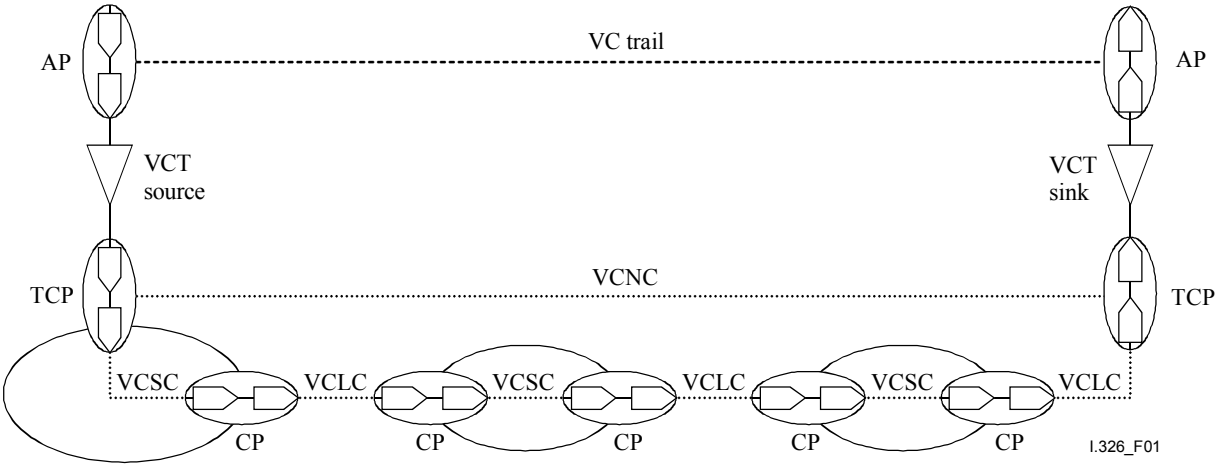

Figure 1/I.326 – VC layer network example

4.2.1.1 VC trail termination

The VC trail termination source accepts adapted information at its input, inserts F5 end-to-end OAM cells and presents the characteristic information of the VC layer network at its output. The VC trail termination source can be used without binding its input to an adaptation function, e.g., for testing purposes.

The VC trail termination sink accepts the characteristic information of the VC layer network at its input, removes the F5 end-to-end OAM cells and presents the adapted information at its output.

The VC trail termination (VCT) consists of a co-located VC trail termination source and sink pair.

4.2.2 Virtual path layer network

The VP layer network provides the transport of adapted information through a VP trail between access points. The adapted information is a non-continuous flow of VC layer network characteristic information plus the VCI and EFCI (Explicit Forward Congestion Indication) header fields. The VP layer network characteristic information is a non-continuous of flow of adapted information and F4

OAM information (see ITU-T Rec. I.610). The VP layer network contains the following transport processing functions and transport entities (see Figure 2):

- VP trail;
- VP trail termination source (VPT source): generates F4 end-to-end OAM cells;
- VP trail termination sink (VPT sink): terminates F4 end-to-end OAM cells;
- VP network connection (VPNC);
- VP link connection (VPLC);
- VP subnetwork connection (VPSC).

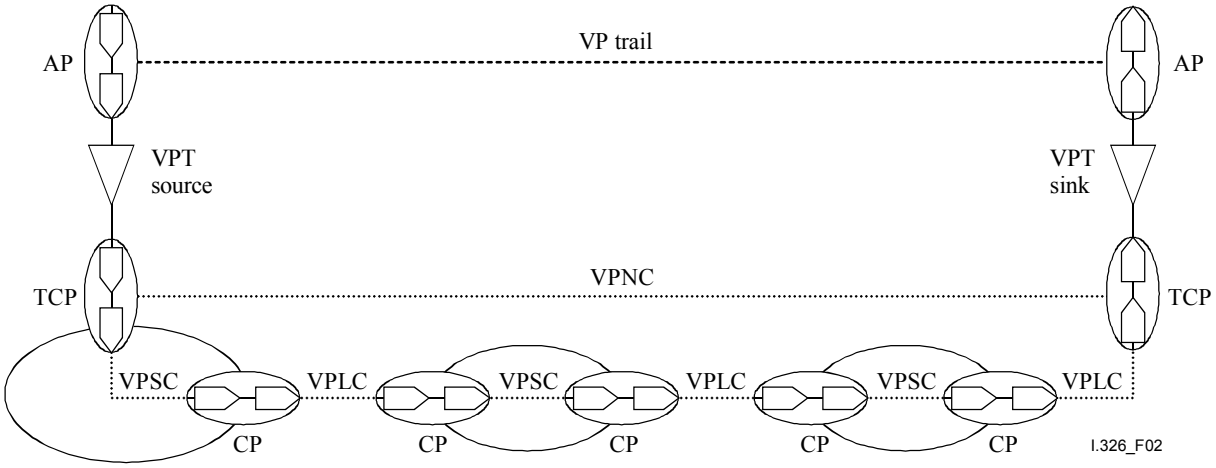

Figure 2/I.326 – VP layer network example

4.2.2.1 VP trail termination

The VP trail termination source accepts adapted information at its input, inserts F4 end-to-end OAM cells and presents the characteristic information of the VP layer network at its output. The VP trail termination source can be used without binding its input to an adaptation function, e.g., for testing purposes.

The VP trail termination sink accepts the characteristic information of the VP layer network at its input, removes the F4 end-to-end OAM cells and presents the adapted information at its output.

The VP trail termination (VPT) consists of a co-located VP trail termination source and sink pair.

4.3 Client/server associations

A key feature of the ATM transport network provides the information transfer capability required to support various types of services of different bit rates by various server layers. Some examples are given below:

Example client layer networks: Connection Oriented Data (Variable Bit Rate), e.g., FMBS Connectionless Data (Variable Bit Rate), e.g., BCDBS Constant Bit Rate, e.g., 64 kbit/s
ATM Transport Network
Example Server Layer Networks: SDH Path Layer Network PDH Path Layer Network Cell based Layer Network

In terms of client/server associations, the ATM transport network offers a VC trail and uses a trail in a server layer network. This is illustrated in Figure 3.

- AAL functions which adapt between the services that require information transfer and the ATM transport network are dependent on the nature of the service and are not described in this Recommendation. These adaptation functions are defined in ITU-T Recs I.363.1, I.363.2, I.363.3 and I.363.5. Note that the description techniques of ITU-T Rec. G.805 may require some extensions to allow the description of the adaptation function for some client layers, e.g., connectionless data.

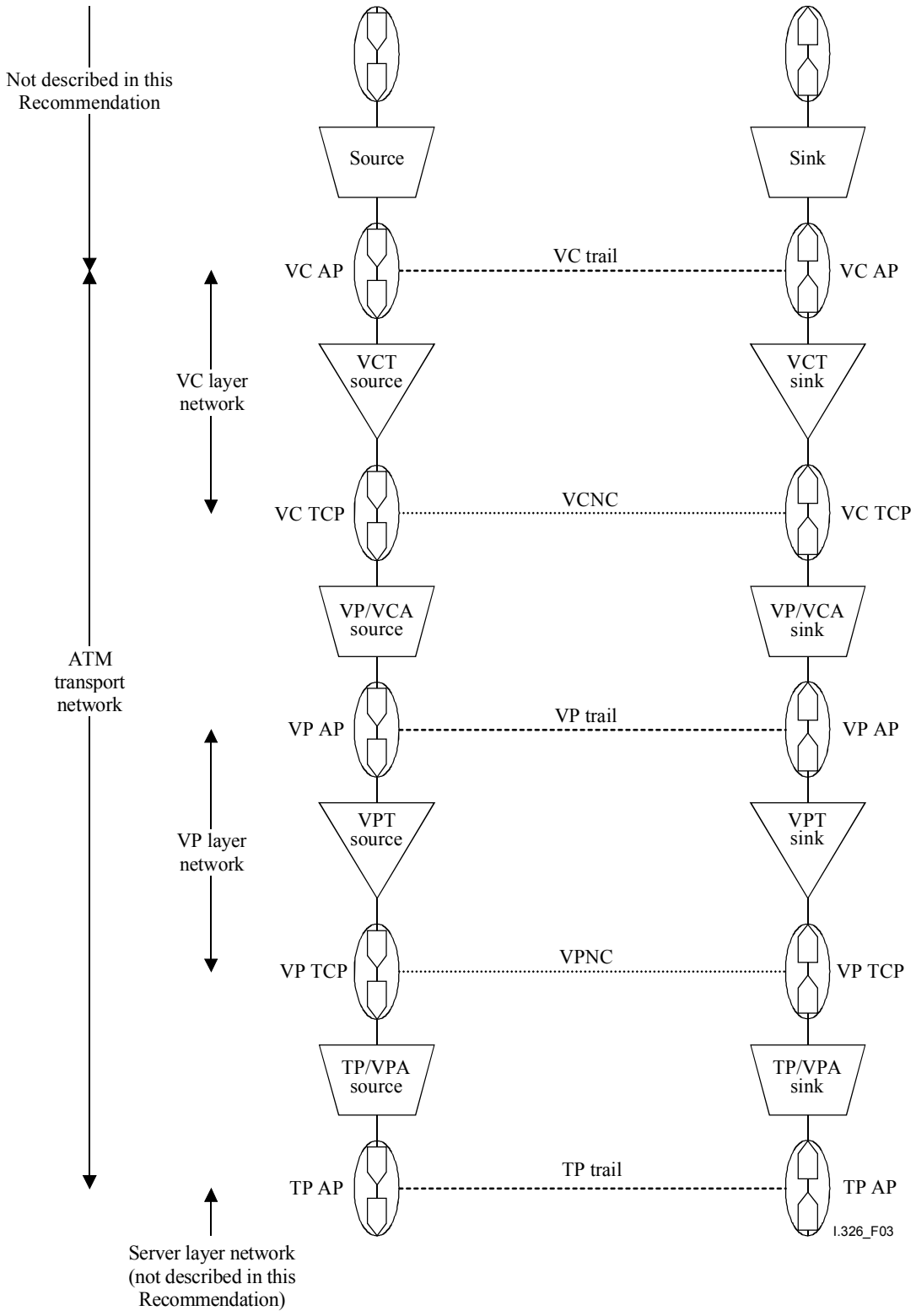

Figure 3/I.326 – Client/server associations in an ATM transport network

4.3.1 VP/VC adaptation

The VP/VC adaptation source performs the following functions between its input and its output:

- Cell multiplexing, including selective cell discard (CLP based) and meta-signalling insertion.

The VP/VC adaptation sink performs the following functions between its input and its output:

- Cell demultiplexing according to the VCI value, meta-signalling extraction, and unmatched VCI cell discard.

The VP/VC adaptation consists of a co-located VP/VC adaptation source and sink pair.

4.3.2 TP/VP adaptation

The transmission path (TP) is the trail provided by the server layer network (for example a VC-4 if SDH is used for the server layer).

4.3.2.1 SDH/VP or PDH/VP or OTN/VP path adaptation

The mapping of ATM cells into SDH payloads is provided in ITU-T Rec. G.707, the mapping of ATM cells into PDH payloads is provided in ITU-T Rec. G.804, the mapping of ATM cells into OTN payloads is provided in ITU-T Rec. G.709.

The TP/VP adaptation source performs the following functions (see ITU-T Rec. I.732 for further details) between its input and its output:

- Cell multiplexing, including selective cell discard (CLP based), GFC setting or unassigned cell insertion;
- Idle cell insertion;
- Cell scrambling;
- HEC generation;
- Cell stream mapping into the TP payload;
- Generation of ATM payload specific overhead functions, e.g., signal label, remote indication of Loss of Cell Delineation.

The output is a continuous byte stream at a fixed bit rate. The TP/VP adaptation sink performs the following functions (see ITU-T Rec. I.732 for further details) between its input and its output:

- Processing of ATM payload specific overhead functions, e.g., signal label, remote indication of Loss of Cell Delineation;
- Cell delineation; extraction of the cell stream from the SDH or PDH TP payload;
- Cell descrambling;
- HEC processing;
- Idle cell removal;
- Cell demultiplexing according to the VPI value, including unmatched VPI cell discard and selective cell discard (CLP based).

The TP/VP adaptation consists of a co-located TP/VP adaptation source and sink pair.

4.3.2.2 Cell based/VP adaptation

The transport of ATM cells in cell-based systems is defined in ITU-T Recs I.432.2, I.432.4 and I.432.5. The cell-based/VP adaptation source performs the following functions between its input and its output:

- cell multiplexing, including selective cell discard (CLP based), GFC setting or unassigned cell insertion.

The cell-based/VP adaptation sink performs the following functions between its input and its output:

- cell demultiplexing according to the VPI value, including unmatched VPI cell discard and selective cell discard (CLP based).

The cell-based/VP adaptation consists of a co-located cell-based/VP adaptation source and sink pair.

4.4 Connection supervision

4.4.1 Connection monitoring techniques

The monitoring methods described in ITU-T Rec. G.805 may be applied to VP and VC connections:

- inherent monitoring: may be used for fault management; difficult to apply in a uniform way for performance management in the VP layer network due to the possibility of various server layer networks (e.g., SDH based, PDH based, cell based);
- non-intrusive monitoring: available at every CP of the VP and VC layer networks for fault and performance management (both end-to-end and segment);
- intrusive monitoring: available at every CP of the VP and VC layer networks. For ATM, this type of monitoring does not require that the connection is removed from service: cells may be inserted with limited perturbations on the cells flow;
- sublayer monitoring: available in the VP and VC layer networks for performance management and fault management of any number of non-overlapping VP or VC connection segments. Available in the VP and VC layer networks for traffic management of specific VP or VC link connections.

4.4.2 Application of connection monitoring techniques to OAM

The detailed OAM techniques that can be used are described in ITU-T Rec. I.732. It should be noted that ITU-T Rec. I.610 specifies OAM cell flow for point to point connection only; an architectural representation of multipoint connections is contained in Appendix I.

4.5 Survivability techniques

ITU-T Rec. G.805 defines techniques for transport network survivability that may be applied to ATM transport networks. These survivability techniques are classified as protection or restoration type. ATM network protection techniques are described below. ATM network restoration techniques are for further study.

4.5.1 Protection

ATM layer protection switching capabilities may be provided at VP or VC layer, according to ITU-T Rec. I.630. Five different ATM VP and VC protection schemes have been defined:

1) 1+1/1:1 trail protection;
2) 1+1/1:1 SNC/S protection;
3) 1+1 SNC/N protection (unidirectional only);
4) 1+1/1:1 trail/T group protection;
5) 1+1/1:1 SNC/T group protection.

Further descriptions of these protections mechanisms can be found in ITU-T Recs I.731 and I.732.

Annex A

Correspondence of vocabulary between ITU-T Recs I.311 and I.326

A.1 ATM network layering

The layering concepts used in ITU-T Recs I.326 and I.311 are illustrated in Figure A.1.

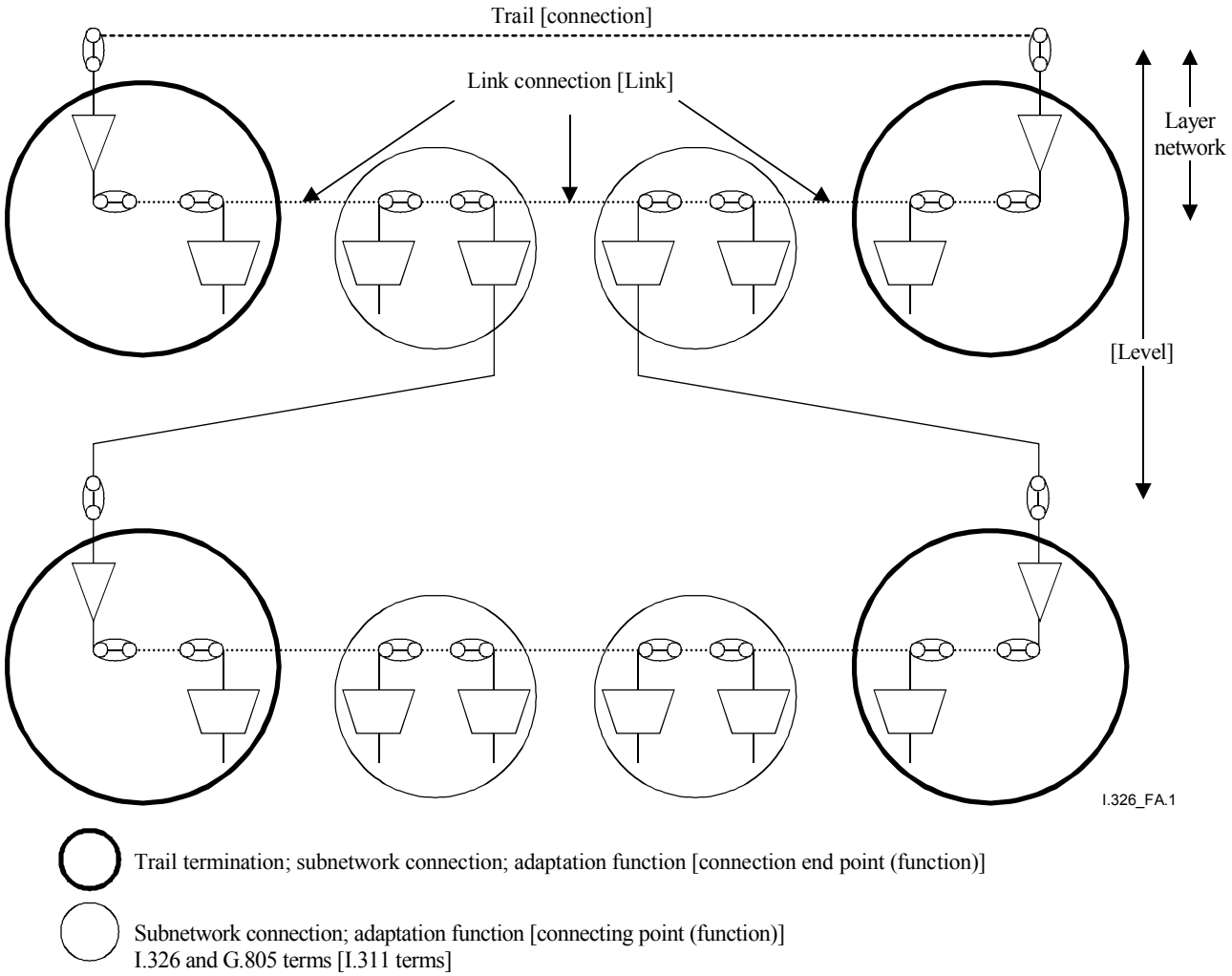

Figure A.1/I.326 – The layer structures of ITU-T Recs I.326 and I.311

A.2 Topological components inside a layer network

ITU-T Rec. G.805 defines two topological components inside a layer network: the subnetwork and the link. There is no counterpart in ITU-T Rec. I.311[1]. Those concepts are very important to describe a VPNC provided by two network operators and to describe related OAM flows.

[1] The link as defined in ITU-T Rec. I.311 has a different meaning.

A.3 Transport entities and transport functions

ITU-T Rec. I.326	ITU-T Rec. I.311
Trail	Connection
Link connection	Link
Network connection	–
Tandem connection	Segment (ITU-T Rec. I.610)

Figure A.1 gives the correspondence regarding connecting point and connection endpoints. This figure shows that ITU-T Rec. I.326 provides a more detailed description of the functional architecture of ATM transport networks.

A.4 Reference points

There is no counterpart in ITU-T Rec. I.311 of the reference points (connection point, termination connection point and access point) used in this Recommendation. The reference points provides no function. It just binds transport entities and transport functions together.

Appendix I

Multipoint connection

I.1 Multipoint connection point (MPCP)

The MPCP is a reference point that binds a port to a set of connections. It represents the root of a multipoint connection. When the binding includes an output port (the output of a link connection or trail termination source), the cells appearing on that port are broadcasted to the input of the connections that are bound by the MPCP. When the binding includes an input port (the input of a link connection or trail termination sink) the cells arriving on the output of the connections that are bound by the MPCP are merged into a single flow at the port. When the binding includes a bidirectional port both the broadcast and merge functions are performed.

I.2 Representation of multipoint connections

The broadcast function provided by the MPCP binding is limited to the subnetwork in which it exists. It may form part of a multicast (selective broadcast) function within a larger (containing) subnetwork.

Four types of Multipoint connections Broadcast, Merge, Composite, and Full Multipoint are shown in Figure I.1 using a MultiPoint Connection Point (MPCP). The MPCP denotes the Root of the Multipoint connection for the Broadcast, Merge, and Composite types, where the Connection Point (CP) denotes the leaf. For the Full Multipoint connection, the MPCP denotes a hybrid Root/Leaf. Note that the directionality refers only to the traffic flow, the OAM flow are for further study (see ITU-T Rec. I.610).

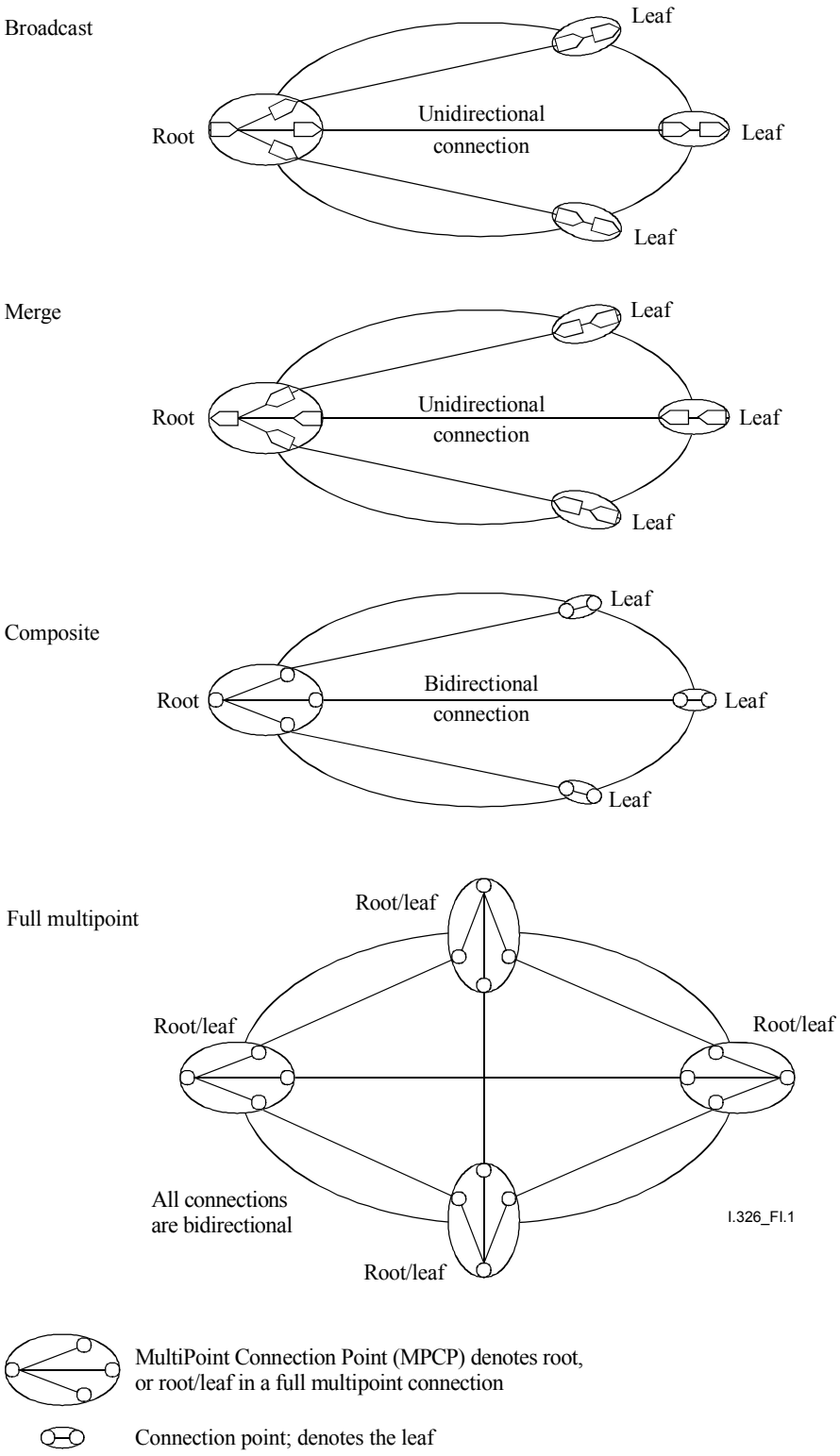

Figure I.1/I.326 – Types of multipoint connections

The following types of multipoint connection transport entities may be defined:

- unidirectional broadcast multipoint connection: consists of a set of connections with the inputs bound by a single MPCP;
- unidirectional merge multipoint connection: consists of a set of connections with the outputs bound by a single MPCP;
- bidirectional composite multipoint connection: consists of an associated pair of unidirectional merge multipoint and unidirectional broadcast multipoint connection;
- bidirectional full multipoint connection: consists of a set of bidirectional composite multipoint connections that provide full connectivity between all MPCPs in the set.

An example of Multipoint connection is shown in Figure I.2 with three levels of subnetwork partitioning. The Multipoint Connection is comprised of its Branches, where a branch is defined as the connectivity that exists between a Root and a Leaf. At the highest level of partitioning, each branch is represented by a Subnetwork Connection, the MPCP represents the Root. This is shown in Figure I.2 a).

Figure I.2 b) illustrates that the multipoint connection may be decomposed into a subnetwork connection (with no cell duplication performed within this subnetwork), a link connection and another multipoint connection.

Figure I.2 c) shows a further decomposition of the multipoint into two multipoint connections, with the associated link connections and subnetwork connections. In general a multipoint connection may be decomposed into an arbitrary set of multipoint connections, SNCs and LCs. At the limit of recursive partitioning the MPCP will always be associated with a Matrix.

The single SNC and LC on the root illustrates that traffic from the branches cannot be distinguished within this layer network.

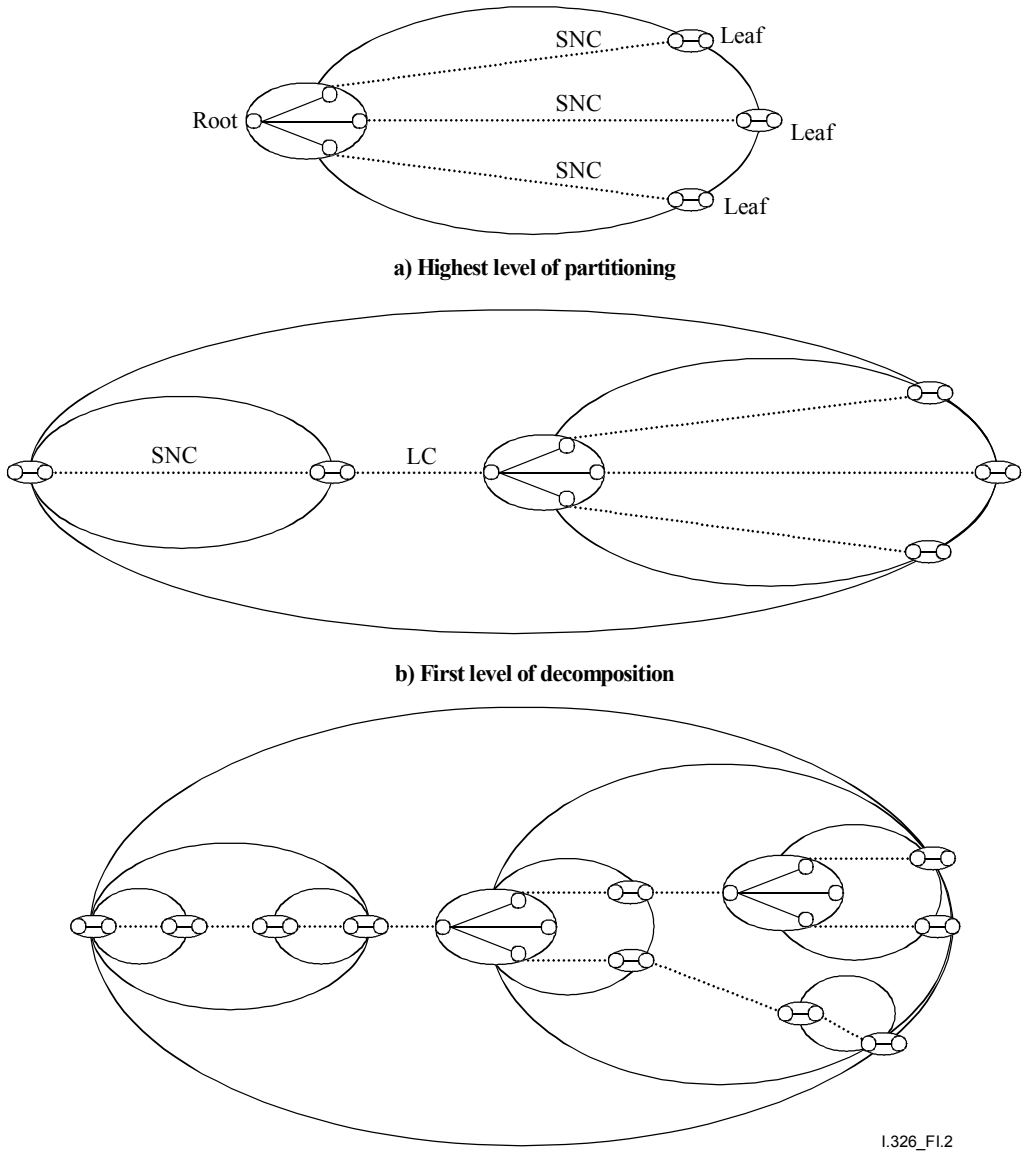

Figure I.2/I.326 – Decomposition of a multipoint connection

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