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INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

OVERALL NETWORK ASPECTS AND FUNCTIONS

FUNCTIONAL ARCHITECTURE OF TRANSPORT NETWORKS BASED ON ATM

ITU-T Recommendation I.326

(Previously "CCITT Recommendation")

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The 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.

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The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation I.326 was prepared by ITU-T Study Group 13 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 2nd of November 1995.

NOTE

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

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SUMMARY

This Recommendation describes the functional architecture of the ATM transport assembly using the transport functional architecture defined in Recommendation 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 Recommendations I.326 and I.311.

FUNCTIONAL ARCHITECTURE OF TRANSPORT NETWORKS BASED ON ATM

(Geneva, 1995)

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 Recommendation G.805.

This Recommendation describes the functional architecture of the ATM transport assembly using the transport functional architecture defined in Recommendation 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 Recommendations I.326 and I.311.

2 References

The following ITU-T Recommendations 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 are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations. A list of the currently valid ITU-T Recommendations is regularly published.

– ITU-T Recommendation G.707 (1993), *Synchronous digital hierarchy bit rates.*

– ITU-T Recommendation G.804 (1993), *ATM cell mapping into plesiochronous digital hierarchy (PDH).*

– ITU-T Recommendation G.805 (1995), *Generic functional architecture of transport networks.*

– ITU-T Recommendation I.113 (1993), *Vocabulary of terms for broadband aspects of ISDN.*

– CCITT Recommendation I.233 (1991), *Frame mode bearer services.*

– ITU-T Recommendation I.311 (1993), *B-ISDN general network aspects.*

– ITU-T Recommendation I.361 (1993), *B-ISDN ATM layer specification.*

– ITU-T Recommendation I.363 (1993), *B-ISDN ATM adaptation layer (AAL) specification.*

– ITU-T Recommendation I.364 (1993), *Support of broadband connectionless data service on B-ISDN.*

– ITU-T Recommendation I.610 (1993), *B-ISDN operation and maintenance principles and functions.*

3 Abbreviations

For the purposes of this Recommendation, the following abbreviations are used.

AIS	Alarm Indication Signal (see Recommendation I.610)
ATM	Asynchronous Transfer Mode (see Recommendation I.150)
BCDBS	Broadband Connectionless Data Bearer Service (see Recommendation I.364)
CLP	Cell Loss Priority (see Recommendation I.361)

F4	Maintenance flow at the VP level (see Recommendation I.610)
F5	Maintenance flow at the VC level (see Recommendation I.610)
FMBS	Frame Mode Bearer Service (see Recommendation I.233)
HEC	Header Error Control (see Recommendation I.432)
MPCP	Multipoint Connection Point (see 4.4.1.1)
OAM	Operations and maintenance (see Recommendation I.610)
PDH	Plesiochronous Digital Hierarchy (see Recommendation G.804)
SDH	Synchronous Digital Hierarchy (see Recommendation G.707)
STM	Synchronous Transfer Mode (see Recommendation I.113)
T-path	Trail in the transmission server layer network (see 4.3.2)
VC	Virtual Channel (see Recommendation I.113)
VCC	Virtual Channel Connection (see Recommendation I.311)
VCI	Virtual Channel Identifier (see Recommendation I.113)
VCLC	Virtual Channel Link Connection (see Link connection in Recommendation G.805)
VCNC	Virtual Channel Network Connection (see Network connection in Recommendation G.805)
VCSC	Virtual Channel Subnetwork Connection (see Subnetwork Connection in Recommendation G.805)
VP	Virtual Path (see Recommendation I.113)
VPC	Virtual Path Connection (see Recommendation I.311)
VPI	Virtual Path Identifier (see Recommendation I.113)
VPLC	Virtual Path Link Connection (see Link connection in Recommendation G.805)
VPNC	Virtual Path Network Connection (see Network connection in Recommendation G.805)
VPSC	Virtual Path Subnetwork Connection (see Subnetwork connection in Recommendation 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 Recommendation 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 Recommendation G.805.

In an ATM network two levels of multiplexing are used to provide routing flexibility for the cell streams, the VCI and VPI fields are used to perform this multiplexing function. This is analogous to the use of time-slots and hierarchical multiplexing in STM networks.

4.2 Characteristic information

The ATM characteristic information is a stream of non-continuous ATM cells that have no specific rate. The ATM cell is 53 octet long consisting of a 5 octet header and a 48 octet information field. The characteristic information of the individual VP and VC layer networks are distinguished by the fields within the header that are used to provide routing, multiplexing and maintenance functions. The use of these fields is defined in Recommendation I.361.

4.2.1 Virtual channel layer network

The VC layer network provides the transport of ATM cells through a VC trail between access points. 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 (Recommendation I.610).
- VC trail termination sink (VCT sink): terminates F5 end-to-end OAM cells (Recommendation I.610).
- VC network connection (VCNC).
- VC link connection (VCLC).
- VC subnetwork connection (VCSC).

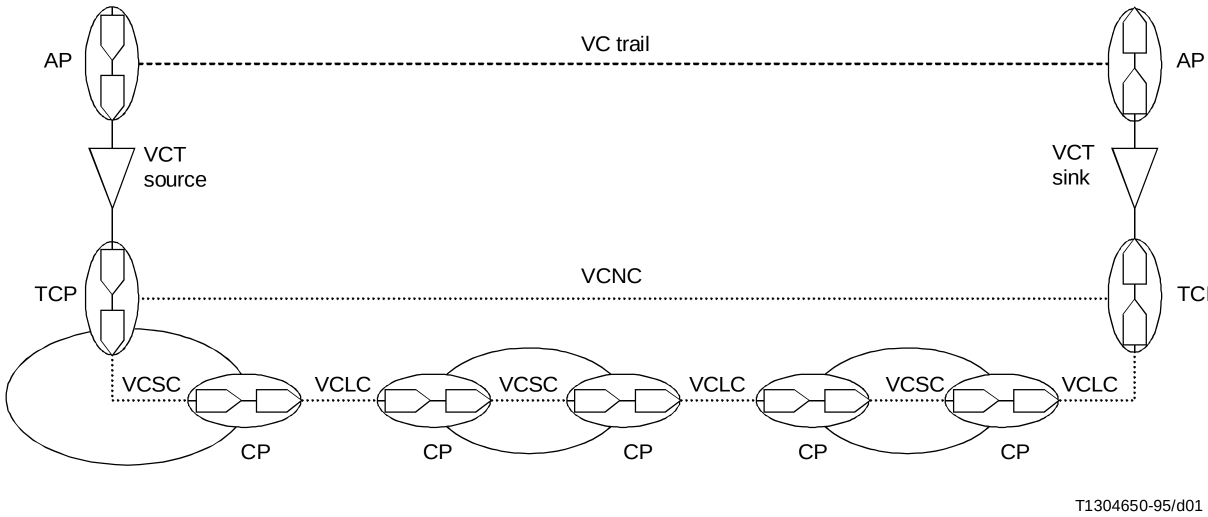


FIGURE 1/I.326

VC layer network example

4.2.1.1 VC trail termination

The VC trail termination source: accepts adapted "characteristic information" from a client layer networks 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 operate without an input from a client layer network.

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 remaining information at its output.

The VC/T trail termination: 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 ATM cells through a VP trail between access points. 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 (Recommendation I.610).

- VP trail termination sink (VPT sink): terminates F4 end-to-end OAM cells (Recommendation I.610).
- VP network connection (VPNC).
- VP link connection (VPLC).
- VP subnetwork connection (VPSC).

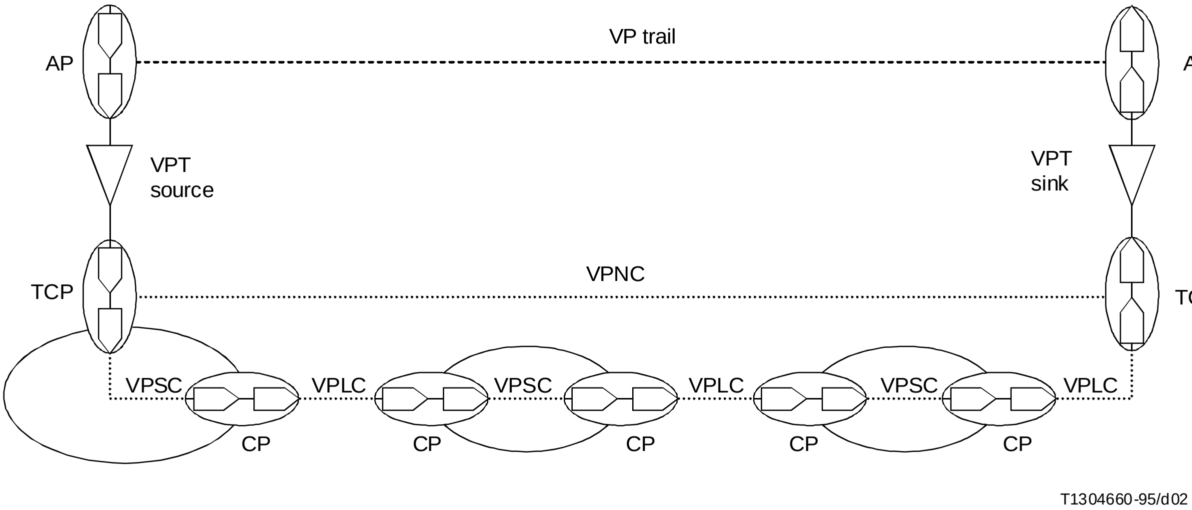


FIGURE 2/I.326

VP layer network example

4.2.2.1 VP trail termination

The VP trail termination source: accepts adapted "characteristic information" from a client layer network at its input, 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 operate without an input from a client layer network.

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 remaining information at its output.

The VP/T trail termination: consists of a co-located VP trail termination source and sink pair.

4.3 Client/server associations

A key feature of the ATM transport assembly 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 Assembly	
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 assembly 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 assembly are dependent on the nature of the service and are not described in this Recommendation. These adaptation functions are defined in Recommendation I.363. Note that the description techniques of Recommendation G.805 may require some extensions to allow the description of the adaptation function for some client layers, e.g. connectionless data.

4.3.1 VC/VP adaptation

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

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

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

4.3.2 VP/T-path adaptation

The transmission path (T-path) 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 VP/SDH or VP/PDH path adaptation

The mapping of ATM cells into SDH payloads is provided in Recommendation G.709, the mapping of ATM cells into PDH payloads is provided in Recommendation G.804.

The VP/T-path adaptation source performs the following functions between its input and its output:

- VPI allocation.
- 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 T-path payload.

The output is a continuous byte stream at a fixed bit rate.

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

- Cell delineation; extraction of the cell stream from the SDH or PDH T-path 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 VP/T-path adaptation consists of a co-located VP/T-path adaptation source and sink pair.

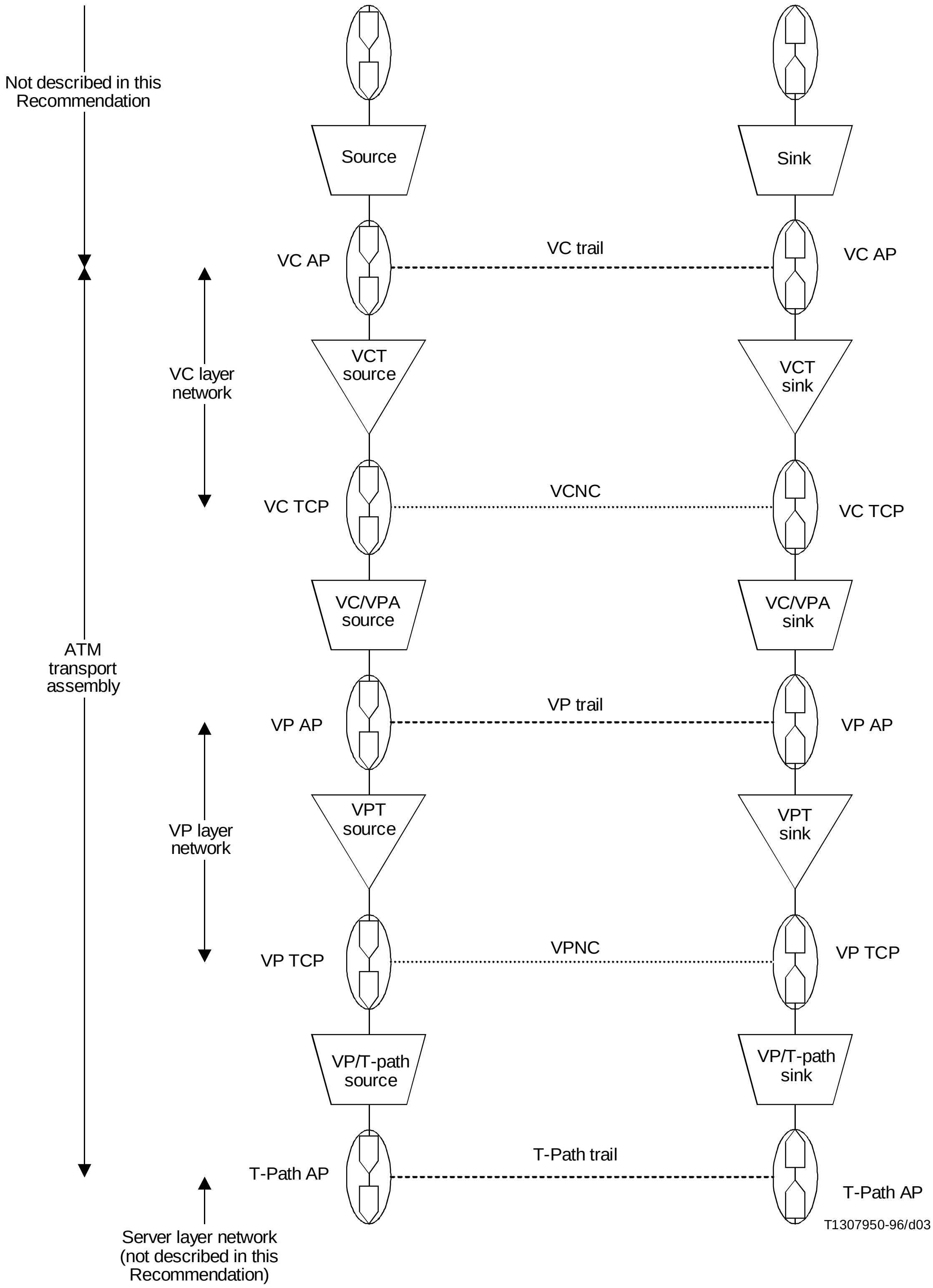


FIGURE 3/I.326

Client/server associations in an ATM transport network

4.3.2.2 VP/cell based adaptation

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

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

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

4.4 Topology

4.4.1 Multipoint connections

4.4.1.1 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.

4.4.1.2 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 4 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 Recommendation I.610).

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 5 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 5 a).

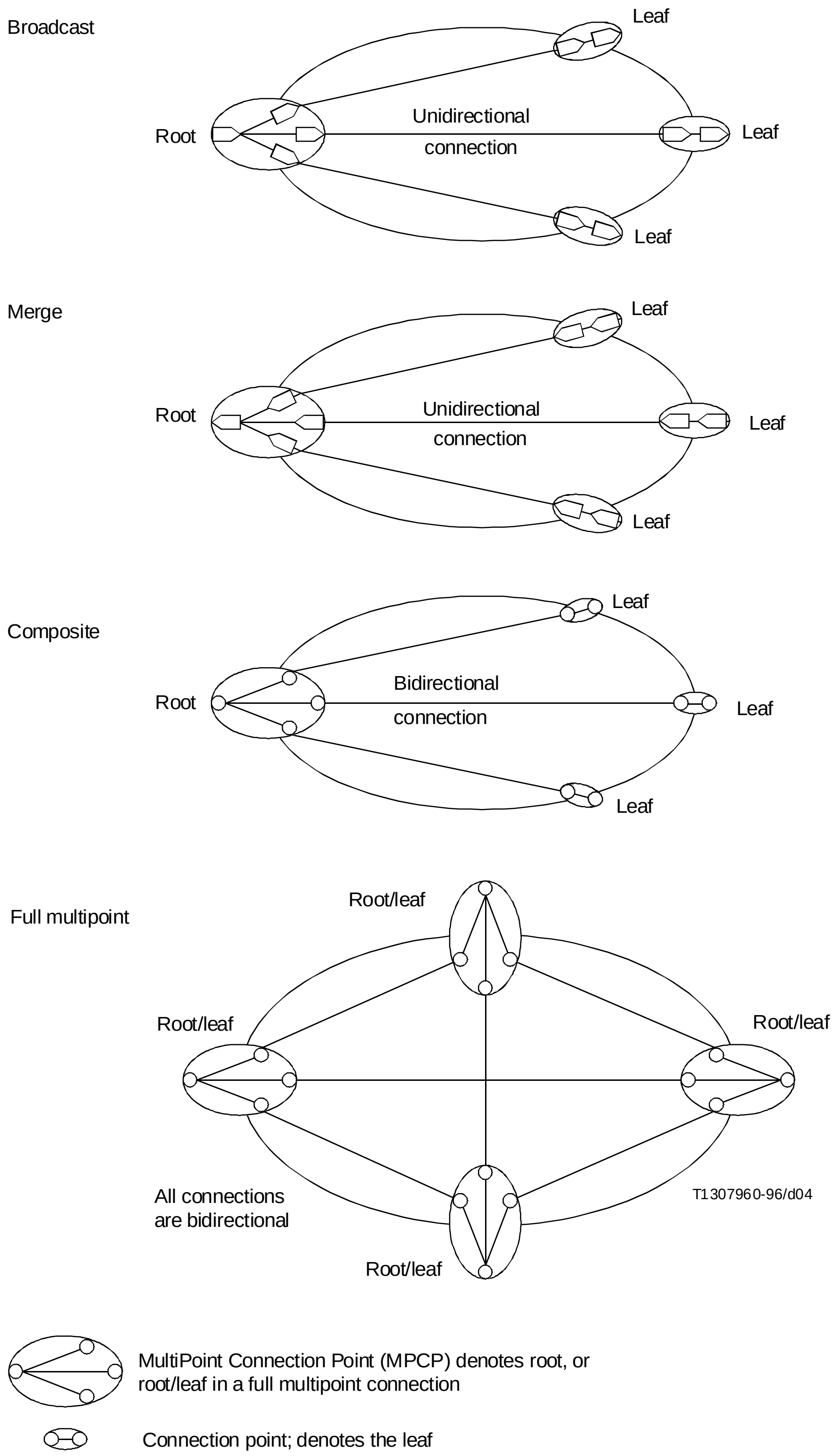


FIGURE 4/I.326

Types of multipoint connections

Figure 5 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 5 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.

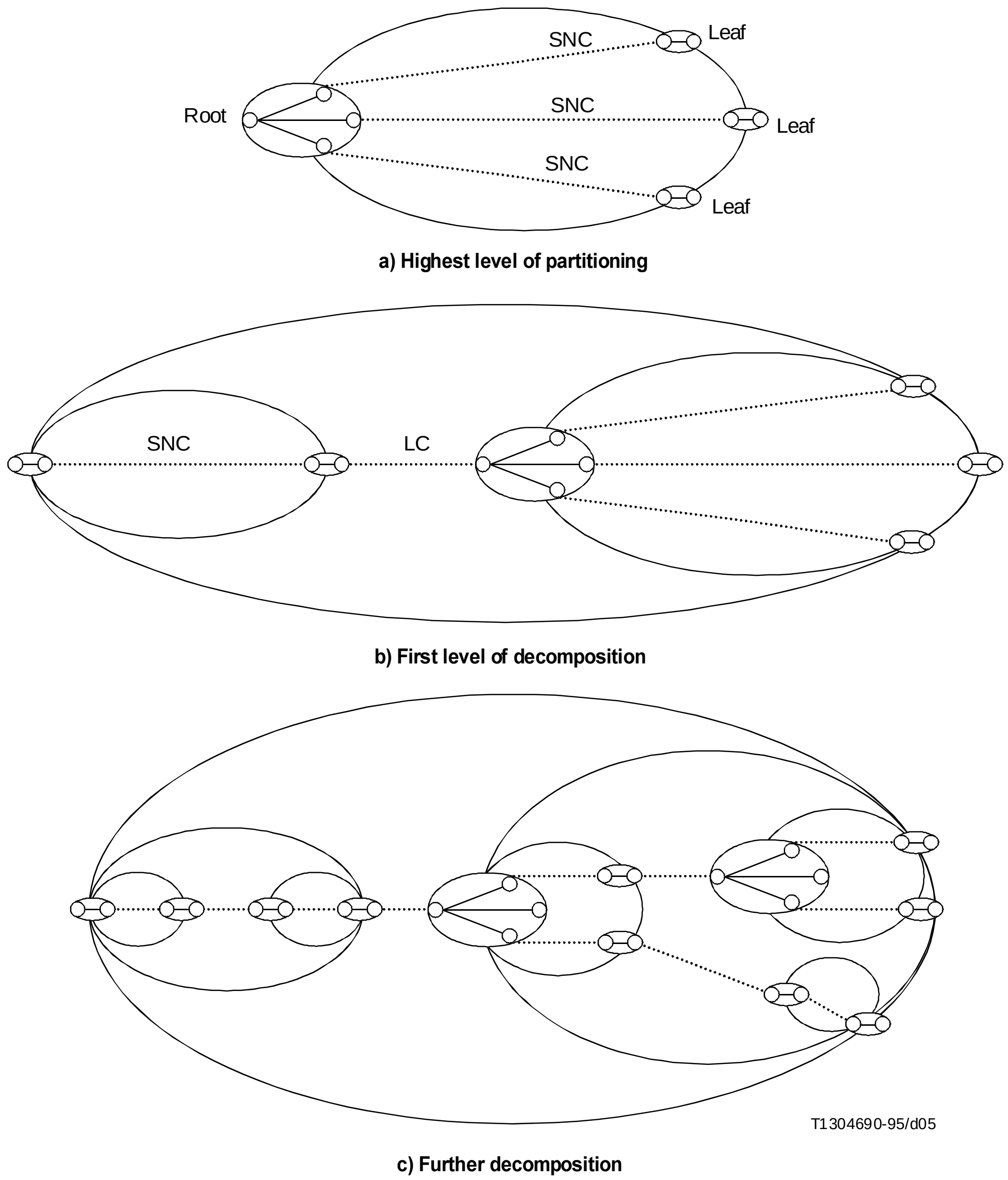


FIGURE 5/I.326

Decomposition of a multipoint connection

4.4.1.3 OAM cell flows

The description of the actual OAM cell flows requires further study, see Recommendation I.610.

4.5 Connection supervision

4.5.1 Connection monitoring techniques

The monitoring methods described in Recommendation G.805 may be applied to VP and VC connections:

- inherent monitoring [Figure 5.12 a)/G.805]: 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 [Figure 5.12 b)/G.805]: available at every CP of the VP and VC layer networks for fault and performance management (both end-to-end and segment);
- intrusive monitoring [Figure 5.12 c)/G.805]: available at every CP of the VP and VC layer networks for fault management. This type of monitoring requires that the connection is removed from service;
- sublayer monitoring (Figure 6): available in the VP and VC layer networks for performance management and fault management of any number of non-overlapping or nested tandem connections. Available in the VP and VC layer networks for traffic management of specific tandem connection.

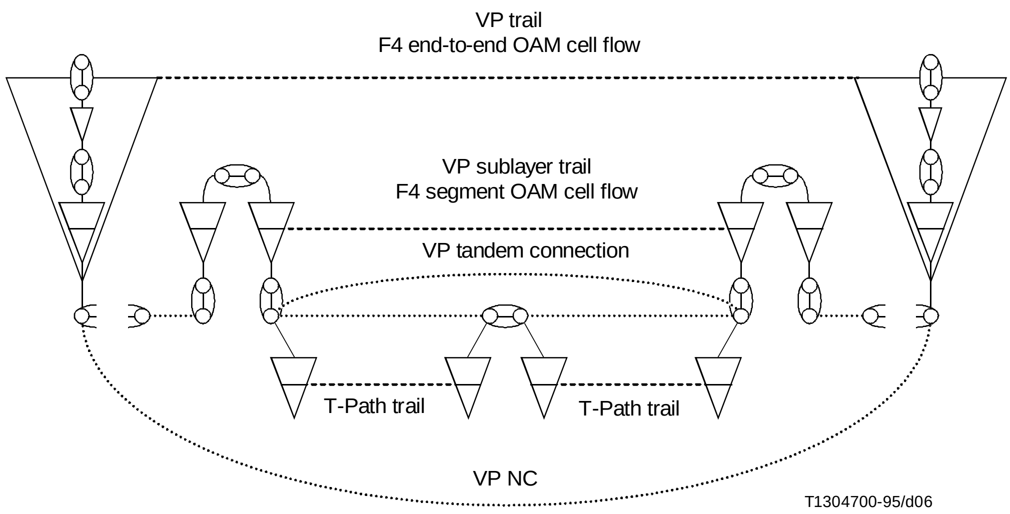


FIGURE 6/I.326

Example of VP sublayer monitoring

4.5.2 Connection monitoring application

4.5.2.1 Monitoring of unused connections

For further study.

4.5.2.2 AIS insertion at the ATM layer

The management functions for tandem connections are described in Recommendation I.610 as segment OAM flows. Sublayer monitoring, inherent monitoring and non-intrusive monitoring are used as shown in Figure 7.

Defects that occur in the server layer network will cause a server signal defect indication. This will result in:

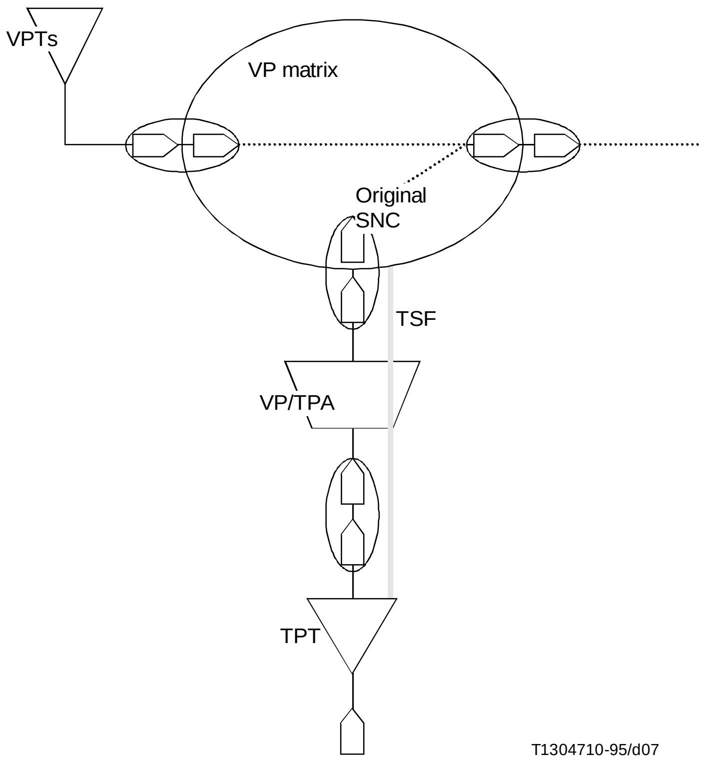
- disconnection of the original subnetwork connection;
- establishment of a new subnetwork connection to a supervisory trail termination source function (VPTs or VCTs). The VPTs (or VCTs) will generate AIS cells as defined in Recommendation I.610.

Figure 7A illustrates the case of a T-path defect producing VP AIS on all the VPs supported by the transmission path.

Figure 7B illustrates the case of a VP defect producing VC AIS on all the VCs supported by the VP.

Figure 7C illustrates the case of a VP sublayer trail termination detecting a loss of continuity defect that results in the generation of VP AIS on the VP monitored by the tandem connection. If AIS is detected by the non-intrusive monitoring function (VPTm) the original subnetwork connection is not disconnected so that no additional AIS cells are inserted (see Recommendation I.610).

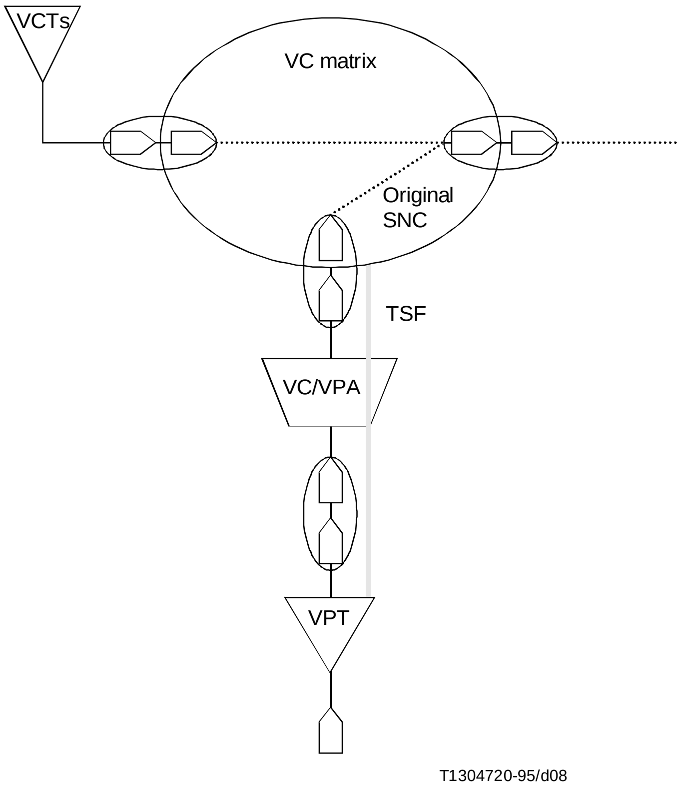
Figure 7D illustrates the case of a VC sublayer trail termination detecting a loss of continuity defect that results in the generation of VC AIS on the VC monitored by the tandem connection. If AIS is detected by the non-intrusive monitoring function (VCTm) the original subnetwork connection is not disconnected so that no additional AIS cells are inserted (see Recommendation I.610).



VPTs VP supervisory trail termination
VP/TPA VP to T-path adaptation
TPT T-path trail termination
TSF Trail Signal Fail

FIGURE 7A/I.326

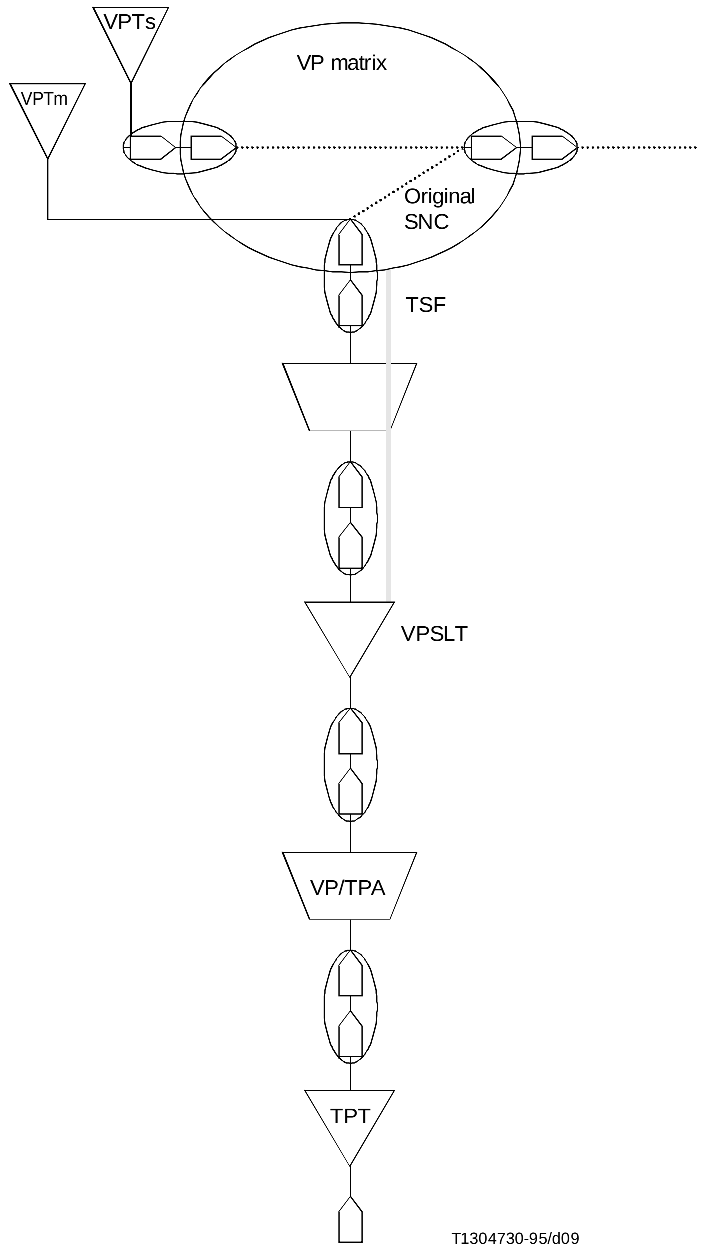
Example of VP AIS insertion based on inherent monitoring



VCTs VC supervisory trail termination
VC/VPA VC to VP adaptation
VPT VP trail termination
TSF Trail Signal Fail

FIGURE 7B/I.326

Example of VC AIS insertion based on inherent monitoring

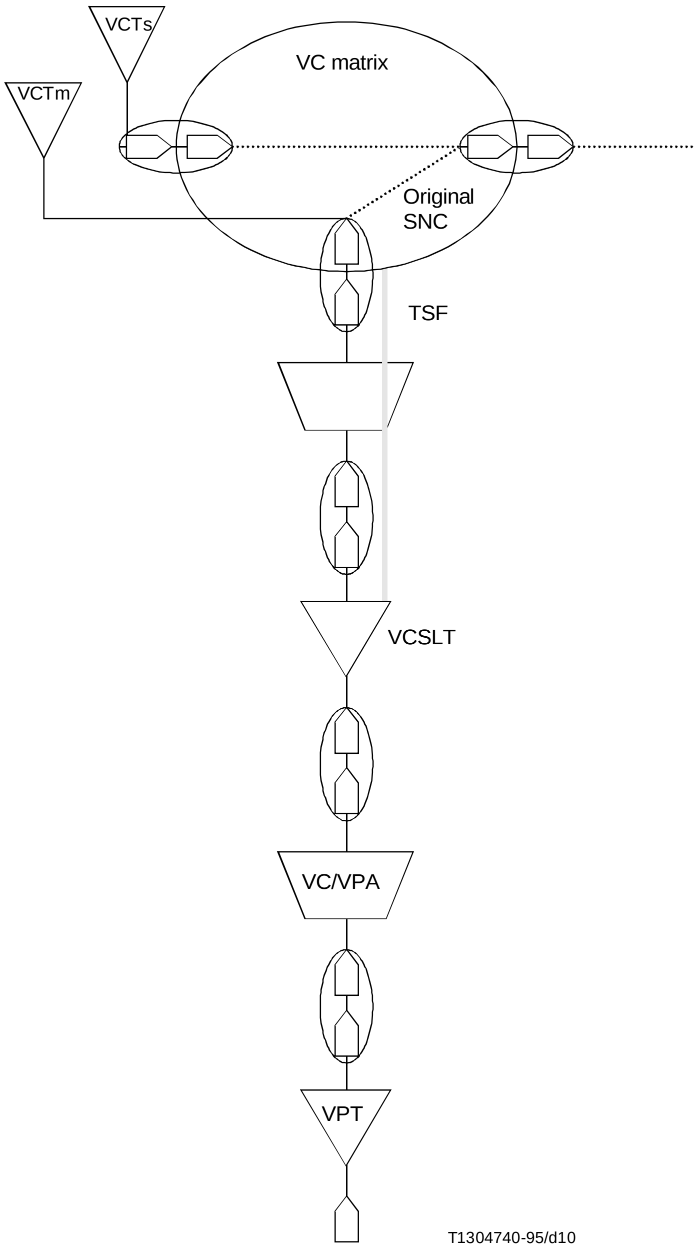


Adaptation function – VP-VPSLA

VP/VPSLA	VP to VP sublayer adaptation
VPTm	VP monitor trail termination
VPSLT	VP sublayer trail termination
VPTs	VP supervisory trail termination
VP/TPA	VP to T-path adaptation
TPT	T-path trail termination
TSF	Trail signal fail

FIGURE 7C/I.326

Example of VP AIS insertion based on non-intrusive monitoring and sublayer monitoring



Adaptation function – VC-VCSLA
VC/VCSLA VC to VC sublayer adaptation
VCTm VC monitor trail termination
VCSLT VC sublayer trail termination
VCTs VC supervisory trail termination
VC/VPA VC to VP adaptation
VPT VP trail termination
TSF Trail Signal Fail

FIGURE 7D/I.326

Example of VC AIS insertion based on non-intrusive monitoring and sublayer monitoring

Annex A

Correspondence of vocabulary between Recommendations I.311 and I.326

(This annex forms an integral part of this Recommendation

A.1 ATM network layering

The layering concepts used in Recommendations I.326 and I.311 are illustrated in Figure A.1.

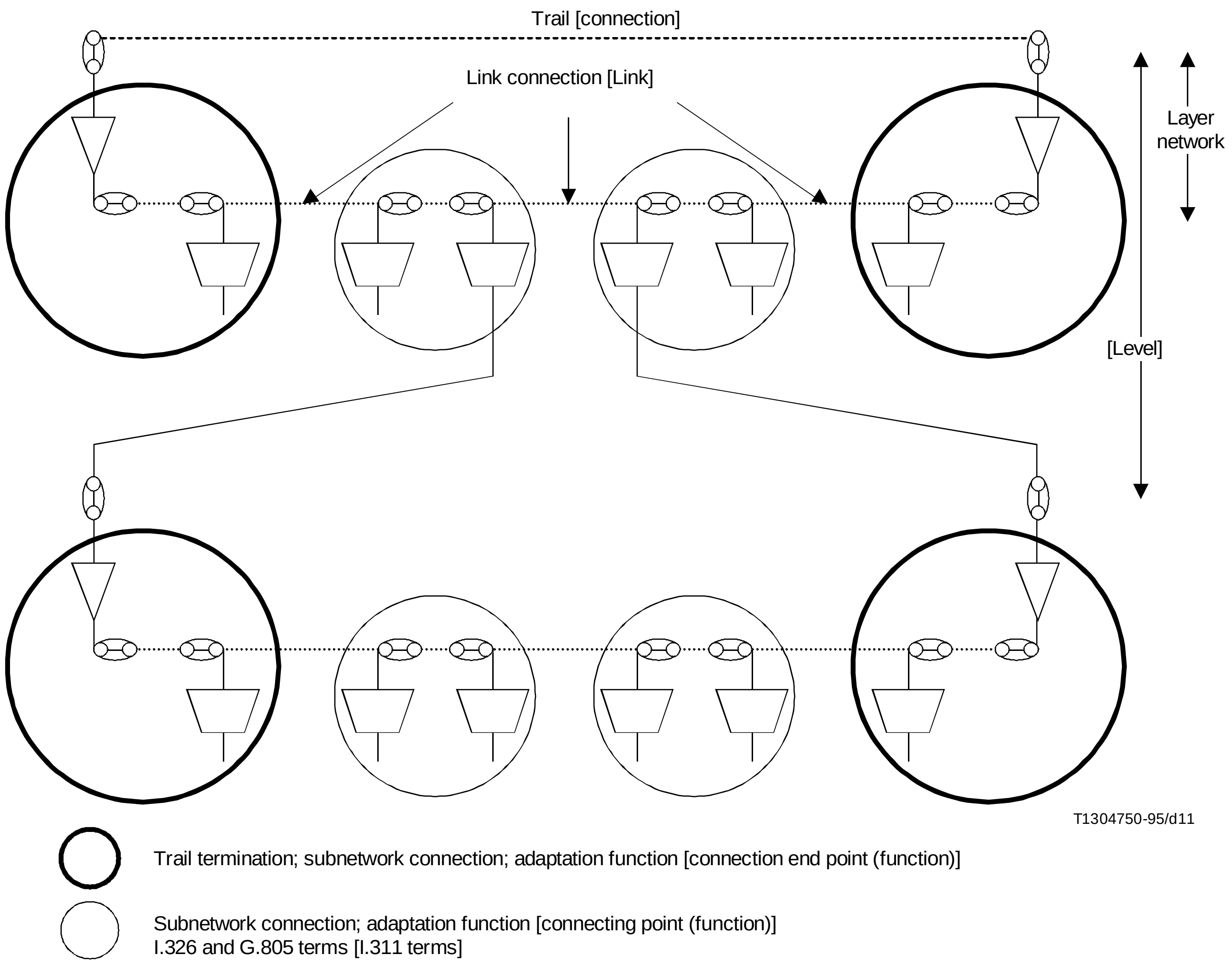


FIGURE A.1/I.326

The layer structures of Recommendations I.326 and I.311

A.2 Topological components inside a layer network

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

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[1] The link as defined in Recommendation I.311 has a different meaning.

A.3 Transport entities and transport functions

Recommendation I.326	Recommendation I.311
Trail	Connection
Link connection	Link
Network connection	–
Tandem connection	Segment (Recommendation I.610)

Figure A.1 gives the correspondence regarding connecting point and connection end points. This figure shows that Recommendation I.326 provides a more detailed description of the functional architecture of ATM transport networks.

A.4 Reference points

There is no counterpart in Recommendation I.311 of the reference points (connection point, termination connection point and access point) used in Recommendation I.326. The reference points provides no function. It just binds transport entities and transport functions together.