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SERIES I: INTEGRATED SERVICES DIGITAL NETWORK

B-ISDN equipment aspects – ATM equipment

Functional characteristics of ATM equipment

ITU-T Recommendation I.732

(Previously "CCITT Recommendation")

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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.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

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.732 was prepared by ITU-T Study Group 15 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 19th of March 1996.

NOTE

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

CONTENTS

SUMMARY

This Recommendation describes the detailed functional requirements of ATM Network Elements (NEs) based on the general functional architecture described in the companion Recommendation I.731. The functional elements of the ATM equipment (or NE) are described in terms of an equivalent representation of the B-ISDN Protocol Reference Model (PRM) and the equipment modelling methodology derived from Recommendations G.805 and I.326.

The intent of this approach is to enable interoperability between ATM NEs independent of any specific implementation. Based on this, the ATM equipment is decomposed into the individual functional elements for both Transfer Layers and Layer Management. This Recommendation describes the functional requirements for each element in the ATM equipment model, specifically for the ATM Layer functions.

The detailed functional decomposition of the Physical Layer and the ATM Adaptation Layer (AAL) are not addressed here since these are dealt with in other (referenced) Recommendations.

The description of the functional requirements of each element of both Transfer Plane and Layer Management Plane is given in sufficient detail to enable the interoperability between different but compliant implementations of an ATM NE.

The information transfer required between the functional elements of the Transfer Layers, the corresponding Layer Management elements and the Coordination function of the Plane (or System) Management Layer is described in detail. The Coordination function (of Plane Management Layer) provides the internal interface between the Layer Management functional elements and the overall NE System management functions, which are addressed in the companion Recommendation I.751.

Recommendation I.732

FUNCTIONAL CHARACTERISTICS OF ATM EQUIPMENT

(Geneva, 1996)

0 Introduction

The B-ISDN Protocol Reference Model described in Recommendation I.321 partitions ATM equipment into a user (transfer) plane, a layer management plane, a plane management and a control plane.

The user and control planes are decomposed into a Physical Layer, ATM Layer, ATM Adaptation Layer and higher level functions. The plane management may not be layered.

Further decomposition of the layers is possible in order to define functional blocks which can be grouped to provide a logical description of any ATM equipment. The ATM layer may be decomposed into the Virtual Path and Virtual Circuit layers, and the physical layer may be decomposed into a number of path and section layers depending on the transport technology employed.

Within each layer of the transfer plane, the management and processing of user information may be described in terms of three functional elements. These support the termination of layer specific information, adaptation of information between layers, and connection. This methodology provides a logical description of equipment which is aligned with the network level view of ATM transport contained in Recommendation I.326.

1 Scope

The purpose of this Recommendation is to describe the functional requirements for ATM network elements to enable interoperability. The description must be precise enough to enable interoperability, but be generic so as to not constrain implementation.

This Recommendation will provide a more detailed description of the functional blocks identified in Recommendation I.731 and define functional elements within those blocks.

This Recommendation will make references to existing Recommendations where these contain detailed descriptions or specifications for a functional element to avoid duplication of work. This Recommendation provides the basis for defining in detail an ATM network element.

2 References

The following 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; all 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.

[1] CCITT Recommendation G.703 (1991), *Physical/electrical characteristics of hierarchical digital interfaces.*

[2] ITU-T Recommendation G.707 (1996), *Network node interface for the Synchronous Digital Hierarchy (SDH)*.

[3] ITU-T Recommendation G.782 (1994), *Types and general characteristics of Synchronous Digital Hierarchy (SDH) equipment*.

[4] ITU-T Recommendation G.783 (1994), *Characteristics of Synchronous Digital Hierarchy (SDH) equipment functional blocks*.

[5] ITU-T Recommendation G.784 (1994), *Synchronous Digital Hierarchy (SDH) management*.

[6] ITU-T Recommendation G.804 (1993), *ATM cell mapping into Plesiochronous Digital Hierarchy (PDH)*.

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

[8] ITU-T Recommendation I.326 (1995), *Functional architecture of transport networks based on ATM*.

[9] ITU-T Recommendation G.832 (1995), *Transport of SDH elements on PDH networks – Framing and multiplexing structures*.

[10] ITU-T Recommendation G.957 (1995), *Optical interfaces for equipment and systems relating to the synchronous digital hierarchy*.

[11] ITU-T Recommendation I.731 (1996), *Types and general characteristics of ATM equipment*.

[12] ITU-T Recommendation I.211 (1993), *B-ISDN service aspects*.

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

[14] Recommendation I.321 (1991), *B-ISDN protocol reference model and its application*.

[15] ITU-T Recommendation I.353 (1993), *Reference events for defining ISDN performance parameters*.

[16] ITU-T Recommendation I.356 (1993), *B-ISDN ATM layer cell transfer performance*.

[17] ITU-T Recommendation I.361 (1995), *B-ISDN ATM layer specification*.

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

[19] ITU-T Recommendation I.371 (1993), *Traffic control and congestion control in B-ISDN*.

[20] ITU-T Recommendation I.432 (1993), *B-ISDN user-network interface – Physical layer specification*.

[21] ITU-T Recommendation I.610 (1995), *B-ISDN operation and maintenance principles and functions*.

[22] ITU-T Recommendation Q.2931 (1995), *Broadband Integrated Services Digital Network (B-ISDN) – Digital Subscriber Signalling System No. 2 (DSS 2) – User-Network Interface (UNI) layer 3 specification for basic call/connection control*.

[23] ITU-T Recommendation Q.2761 (1995), *Broadband Integrated Services Digital Network (B-ISDN) – Functional description of the B-ISDN User Part (B-ISUP) of Signalling System No. 7*.

[24] ITU-T Recommendation Q.2762 (1995), *Broadband Integrated Services Digital Network (B-ISDN) – General functions of messages and signals of the B-ISDN User Part (B-ISUP) of Signalling System No. 7*.

[25] ITU-T Recommendation Q.2763 (1995), *Broadband Integrated Services Digital Network (B-ISDN) – Signalling System No. 7 B-ISDN User Part (B-ISUP) – Formats and codes*.

[26] ITU-T Recommendation Q.2764 (1995), *Broadband Integrated Services Digital Network (B-ISDN) – Signalling System No. 7 B-ISDN User part (B-ISUP) – Basic call procedures*.

[27] ITU-T Recommendation Q.2120 (1995), *B-ISDN metasignalling protocol*.

[28] ITU-T Recommendation O.191[1)], *Equipment to assess ATM layer cell transfer performance*.

1) Presently at the stage of draft.

3 Abbreviations, Terms and Definitions

3.1 Abbreviations

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

AAL	ATM Adaptation Layer
AD	Activation/Deactivation
AEMF	ATM Equipment Management Function
AESF	ATM Equipment Signalling Function
AIS	Alarm Indication Signal
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband Integrated Services Digital Network
CAC	Connection Admission Control
CC	Continuity Check
CDV	Cell Delay Variation
CLR	Cell Loss Ratio
CoF	Coordination Function
CPCS	Common Part Convergence Sublayer
CT	Correlation Tag
CTD	Cell Transfer Delay
DSS 2	Digital Subscriber Signalling System No. 2
FM	Fault Management
HEC	Header Error Control
IWF	InterWorking Function
LB	Loopback
LCD	Loss of Cell Delineation
LM	Layer Management
LMI	Layer Management Indication
LOC	Loss of Continuity
LOM	Loss of Multiframe
LOP	Loss of Pointer
LOS	Loss of Signal
MCF	Message Communications Function
NE	Network Element
NNI	Network Node Interface
NPC	Network Parameter Control
OAM	Operations and Maintenance
OCD	Out of Cell Delineation
PDH	Plesiochronous Digital Hierarchy
PM	Performance Management/Performance Monitoring
POH	Path Overhead
QOS	Quality of Service
RM	Resource Management
SAAL	B-ISDN signalling ATM adaptation layer
SAP	Service Access Point
SAR	Segmentation and Reassembly

SDH	Synchronous Digital Hierarchy
SOH	Section Overhead
SSCS	Service Specific Convergence Sublayer
TIM	Trace Identifier Mismatch
TM	Transmission Media
TP_T	Transmission Path Termination
TP/VP_A	Transport Path to Virtual Path Adaptation
UNEQ	Unequipped signal
UNI	User Network Interface
UPC	Usage Parameter Control
VC	Virtual Channel
VCCT	VC Connection Termination
VCI	VC Identifier
VCL	VC Link
VP	Virtual Path
VPCT	VP Connection Termination
VPI	VP Identifier
VPL	VP Link
VPME	VP Multiplexing Entity
VP/VC_A	Virtual Path to Virtual Channel Adaptation

3.2 Definitions

This Recommendation uses terms defined in other referenced ITU-T Recommendations.

4 General functional description of the ATM equipment

The generalized ATM network element functional model is described by a set of transport functions: a connection function, a termination function, and an adaptation function. These transport functions and their relationships are defined in Recommendations G.805 and I.326 and are illustrated in Figure 4-1. The ATM network element functional model is thus described by means of these transport functions, or logical groups of these functions called functional blocks.

Figure 4-2 illustrates a generalized logical representation of functions which may be combined to describe an ATM network element functional architecture. This representation constitutes a general functional model for an ATM network element and is based on network architecture principles referenced and discussed in Recommendation I.731. In general, this ATM network element model is layered according to the ATM transport network model given in Recommendation I.326 and the B-ISDN Protocol Reference Model (PRM) given in Recommendation I.321.

The general ATM network element functional architecture in the PRM representation is illustrated in Figure 4-3. The PRM representation of the general ATM network element model is functionally equivalent to the I.326 representation, as described in Annex A.

In Figure 4-2, reference points A and B are defined to indicate information flow directionality. Transport functions are distinguished by this directionality indication [e.g. VPL_T_T (A to B) and VPL_T_T (B to A)]. Furthermore, reference point X is defined in Figure 4-2 for relating the ATM network element functional architecture given in this Recommendation with other network element functional architectures developed in ITU-T Recommendations, e.g. G.782-G.783 for SDH network elements. For example, reference point X corresponds to reference point H in Recommendation G.783 (for SDH higher order paths VC-3, VC-4 and VC-4-Xc) or reference point L in Recommendation G.783 (for SDH lower order paths VC-11, VC-12, VC-2, VC-2-mc, VC-3), depending on the SDH path type carrying ATM.

An overview of the functional blocks decomposition of the Transfer and Layer Management functional blocks is provided in Table 4-1. This functional model is generic and no particular physical partitioning of functions or implementation is implied. However, the logical ordering of the functions given in Table 4-1 must be maintained.

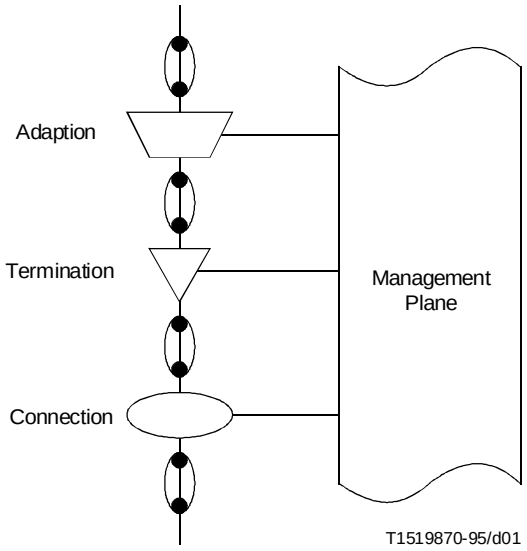


FIGURE 4-1/I.732

Functional modelling principles

5 Transfer functions and Layer Management functions

This clause describes in detail the transfer functions and layer management functions of an ATM Network Element (NE). The Coordination function (CoF) and LMI noted in this clause refer to the LMIs listed in clause 6.

5.1 Section/Path Adaptation, Section Termination and Lower Layer Functions

The section/path adaptation, section termination and lower physical layer functions applicable to ATM NEs are independent of the processing of the ATM cells. These functions are directly associated with the physical layer. They include:

1) electro-optical conversion;

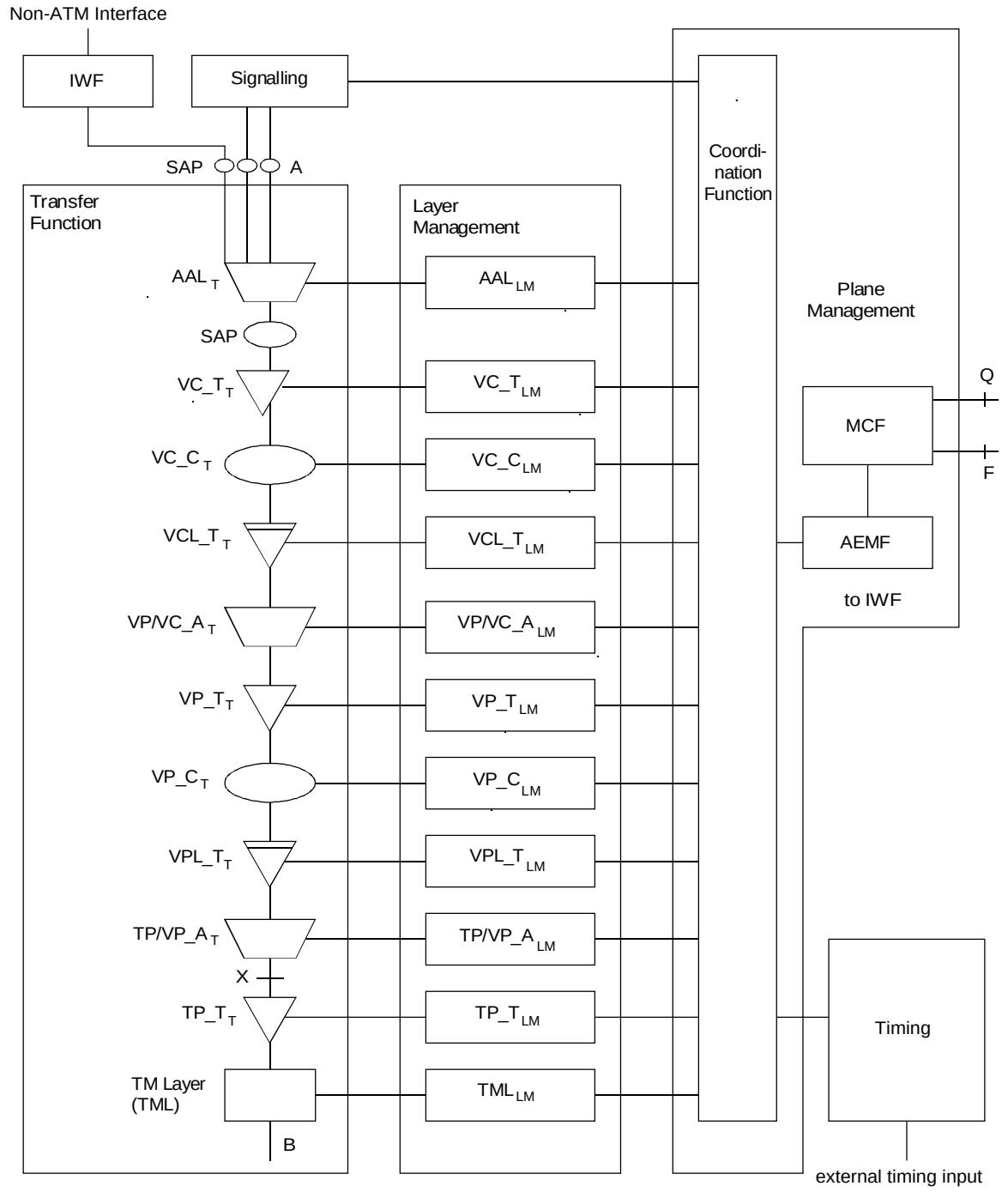
2) line coding;

3) transmission frame generation and recovery;

4) transmission overheads processing.

They provide for input/output termination of the physical medium path, of the physical medium multiplex section, and lower level layers (e.g. photonic layer), as described in existing PDH and SDH ITU-T Recommendations. The physical layer specifications for ATM NEs shall comply with Recommendations I.432 for B-ISDN User-Network Interface (UNI) types and in Recommendations G.707, G.804, G.832, G.957, and G.703 for B-ISDN Network Node Interface (NNI) types.

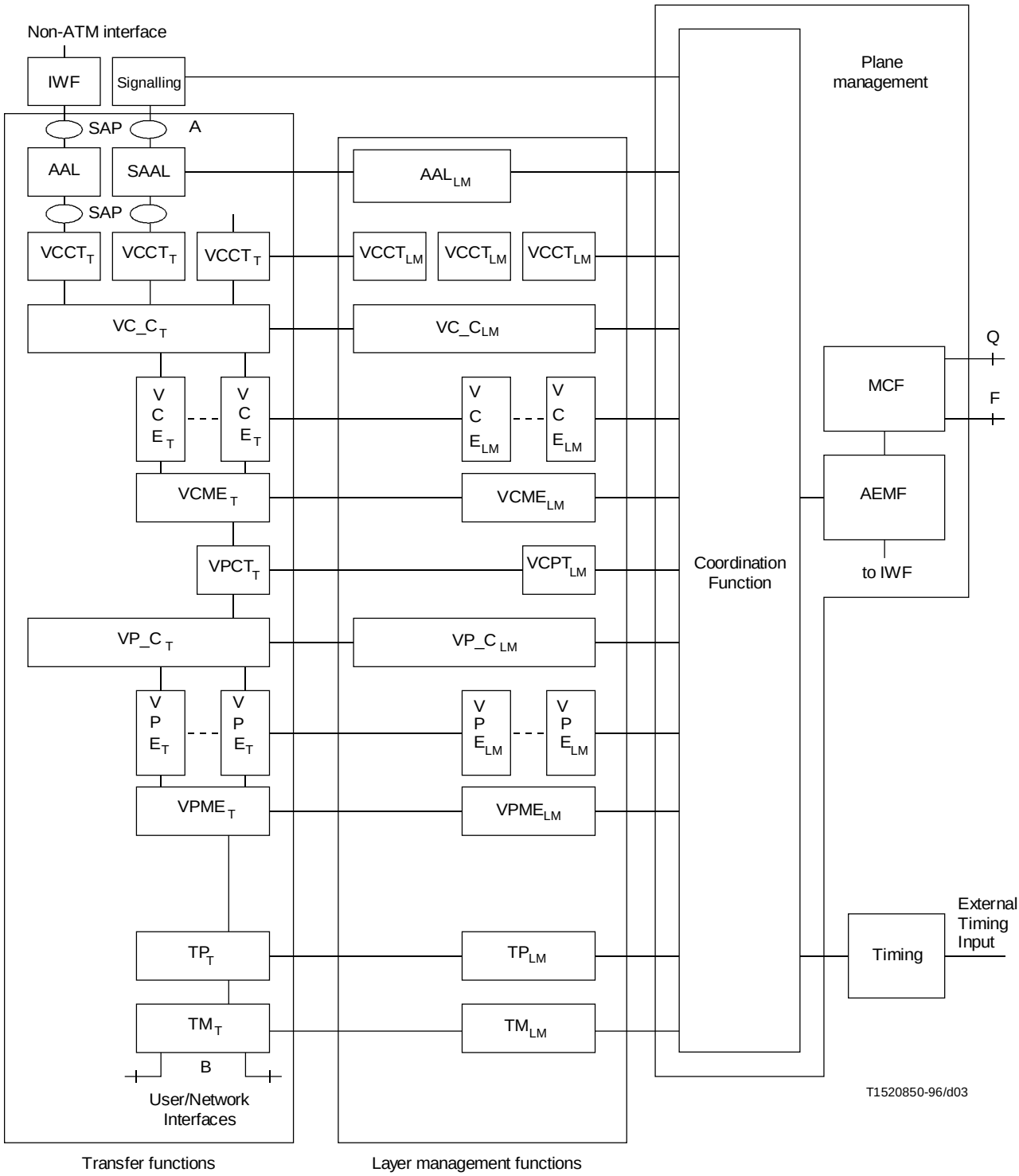
Support of additional interface types is not specified here, but is not precluded as National or Network Provider options.



NOTE – Layer Management of AAL and higher layers is not described in this Recommendation.

FIGURE 4-2/I.732

General functional architecture of an ATM NE (I.326 representation)



NOTE – Layer Management of AAL and higher layers is not described in this Recommendation.

FIGURE 4-3/I.732

General functional architecture of an ATM NE (I.321 PRM representation)

TABLE 4-1/I.732

Functional partitioning

Level		Function	B to A		A to B	
PRM	Rec. I.326		Function description		Function description	
			Transfer	Layer management	Transfer	Layer management
AAL	AAL	- SAR - CPCS - SSCS (Rec. I.363)	- AAL1 - AAL2 - AAL3/4 - AAL5 - SAAL		- AAL1 - AAL2 - AAL3/4 - AAL5 - SAAL	
VCCT	VC_T	F5 OAM cells	extraction of F5 OAM cells	F5 OAM cells processing	insertion of F5 OAM cells	F5 OAM cells processing
VC_C	VC_C	Link interconnection	interconnection of VC links	association of VC links	interconnection of VC links	association of VC links
VCE	VCL_T	F5 OAM	ins/ext of F5 OAM cells	restricted rules for cell ins/ext	ins/ext of F5 OAM cells	restricted rules for cell ins/ext
			resource management cells		resource management cells	
		Resource management		resource management cells processing		resource management cells processing
		F5 OAM non-intrusive monitoring	e-t-e and segment F5 OAM cell copy	e-t-e and segment F5 OAM cell processing	e-t-e and segment F5 OAM cell copy	e-t-e and segment F5 OAM cell processing
		Shaping (Note 1)	VC traffic shaping	Traffic descriptors	VC traffic shaping	Traffic descriptors
		VC UPC/NPC	VC compliance checking and corrective action if necessary	Traffic descriptors, discarded cells and tagged cells counters		
		VC usage measurement	detection of cell arrival	count incoming cells per VC for CLP = 0 + 1 and CLP = 0	detection of cell arrival	count outgoing cells per VC for CLP = 0 + 1 and CLP = 0
		EFCI setting			setting of the EFCI bit of PTI field for user congestion indication	EFCI generation
		VCI setting			VCI field setting	VCI translation
VCME	VP/ VC_A	VC mux	demultiplexing of the VCs according to the VCI values		VC Multiplexing	
		Congestion Control	Selective Cell discard (CLP based)		Selective Cell discard (CLP based)	
		Metasignalling	extraction of metasignalling cells	metasignalling cells processing	insertion of metasignalling cells	metasignalling cells processing

TABLE 4-1/I.732 *(cont.)*

Functional partitioning

Level		Function	B to A		A to B	
PRM	Rec. I.326		Function description		Function description	
			Transfer	Layer management	Transfer	Layer management
VCME	VP/ VC_A	VCI processing	reading of VCI; discarding of cells with invalid VCI	Verification for invalid VCI cell. Count of cells with invalid VCI cells		
VPCT	VP_T	F4 OAM cells	extraction of F4 OAM cells	F4 OAM cells processing	insertion of F4 OAM cells	F4 OAM cells processing
VP_C	VP_C	Link interconnection	interconnection of VP links	association of VP links	interconnection of VP links	association of VP links
VPE	VPL_T	F4 OAM	ins/ext of F4 OAM cells	restricted rules for cell ins/ext	ins/ext of F4 OAM cells	restricted rules for cell ins/ext
		Resource management	resource management cells	resource management cells processing	resource management cells	resource management cells processing
		F4 OAM non-intrusive monitoring	e-t-e and segment F4 OAM cell copy	e-t-e and segment F4 OAM cell processing	e-t-e and segment F4 OAM cell copy	e-t-e and segment F4 OAM cell processing
		VP usage measurement		incoming cells count per VP		outgoing cells count per VP
		Shaping (Note 1)	VP traffic shaping	Traffic descriptors	VP traffic shaping	Traffic descriptors
		VP UPC/NPC	VP compliance checking and corrective action if activated	Traffic descriptors, discarded cells and tagged cells count		
		EFCI setting			setting of the EFCI bit of PTI field for user congestion signalling	EFCI generation
		VPI setting			VPI field setting	VPI translation
VPME	TP/ VP_A	VP mux	demultiplexing of the VPs according to the VPI values		multiplexing of VPs onto TP	
		Congestion Control	Selective Cell discard (CLP based)	Act./deact. of cell discard based on congestion detection	Selective Cell discard (CLP based)	Act./deact. of cell discard based on congestion detection
		VPI processing	reading of VPI; and discarding of unassigned cells and cells with invalid VPI	Verification for invalid VPI cell count of cells with invalid VPI		

TABLE 4-1/I.732 *(concluded)*

Functional partitioning

Level		Function	B to A		A to B	
PRM	Rec. I.326		Function description		Function description	
			Transfer	Layer management	Transfer	Layer management
VPME	TP/ VP_A	GFC	read of GFC field (if applicable)	GFC processing	Setting of GFC field in an unassigned cell or insertion of unassigned cells	GFC processing
		Header processing	read header and discard cells with invalid header pattern			
		TP usage measurement	detection of cell arrival	incoming cells count per TP	detection of cell arrival	outgoing cells count per TP
		Cell rate decoupling	Idle cell discard		Idle cell insertion	
		HEC processing	header verification, correction (if applicable) and discarding of invalid HEC cells	Invalid HEC event. Invalid HEC cell discarded event. Act./deact. of correction mode	HEC generation	
		Scrambling	Cell information field descrambling		Cell information field scrambling	
		Cell delineation	Cell delineation	LCD defect detection		
				OCD anomaly event counter and consequent actions		
		Mapping	Cell stream extraction		Cell stream mapping	
TP	TP_T	SDH or PDH Transmission Path Termination	Transmission path overhead extraction	Transmission path overhead processing	Transmission path overhead insertion	Transmission path overhead processing
TM	TML					

NOTE

1 – The shaping function may not be present in NE.

– If present, the shaping function can be activated/deactivated in egress side or ingress side per connection.

– The shaping function should not be simultaneously activated on both B to A and A to B of the same connection.

NOTE

2 – Not all above functions need to be present in a given Network Element.

– Selected link termination functions can become segment termination function by management action.

– The extraction of metasignalling could be in the VCL_T or VC_T.

5.1.1 SDH 155.52 Mbit/s Interface

The interface rate and format shall conform to the SDH STM-1 level given in Recommendations G.707 and I.432. These functions are defined in Recommendation G.783.

5.1.2 SDH 622.08 Mbit/s Interface

The interface rate and format shall conform to the SDH STM-4 level/given in Recommendations G.707 and I.432. These functions are defined in Recommendation G.783.

5.1.3 SDH 2488.32 Mbit/s Interface

The interface rate and format shall conform to the SDH STM-16 level given in Recommendation G.707. These functions are defined in Recommendation G.783.

5.1.4 SDH 9953.28 Mbit/s Interface

The interface rate and format shall conform to the SDH STM-64 level given in Recommendation G.707.

5.1.5 PDH based rate

The interfaces rates and formats shall conform to the PDH levels given in Recommendation G.703.

5.1.6 Cell-based UNI

For cell-based interfaces, functionality shall be in accordance with Recommendation I.432.

5.2 Transmission Path Termination (TP_T) // Transmission Path (TP)

The TP_T function terminates a transmission path by extraction and insertion of the appropriate overhead. Both SDH paths and PDH paths apply here.

Specifications for the appropriate SDH overhead shall be in accordance with Recommendation G.707. The SDH TP_T function is further defined in Recommendation G.783.

Specifications for the appropriate PDH overhead shall be in accordance with Recommendations G.804 and G.832.

The information derived from/provided to plane management is defined in Recommendation G.783 for SDH interfaces.

See Tables 5-1(A) and 5-1(B).

TABLE 5-1(A)/I.732

Functional decomposition [TP_T // TP (B to A)]

Level B to A		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
TP	TP_T	SDH or PDH Transmission Path Termination	Transmission path overhead extraction	POH		NOTE – The TP_T_T and TP_T_{LM} functional blocks shall be in accordance with Recs. G.783 and G.707 for SDH, and Rec. G.832/G.804 for PDH	FM1 FM2

TABLE 5-1(B)/I.732

Functional Decomposition [TP_T // TP (B to A)]

Level A to B		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
TP	TP_T	SDH or PDH Transmission Path Termination	Transmission path overhead insertion		POH	NOTE – The TP_T_T and TP_T_{LM} functional blocks shall be in accordance with Recs. G.783 and G.707 for SDH, and Rec. G.832/G.804 for PDH	FM1 FM2

5.3 Transmission Path/Virtual Path Adaptation (TP/VP_A) // Virtual Path Multiplexing Entity (VPME)

This function adapts an ATM cell structure to a transmission path signal structure. See Tables 5-2(A) and 5-2(B).

5.3.1 TP/VP_A // VPME (B to A)

5.3.1.1 Mapping

5.3.1.1.1 Transfer function

The cell stream shall be extracted from transmission path payload which shall be in accordance with Recommendations G.707 for SDH and G.804 for PDH.

5.3.1.2 Cell delineation

5.3.1.2.1 Transfer function

Cell delineation is performed on the continuous cell stream extracted from the TP frames. The cell delineation algorithm should be in accordance with Recommendation I.432.

Indications of OCD anomaly event is to be provided by the transfer function to layer management.

5.3.1.2.2 Layer Management function

The detection of LCD defect shall be in accordance with Recommendation I.432.

5.3.1.3 Scrambling

5.3.1.3.1 Transfer function

For SDH and PDH the information field of each cell is descrambled with a self synchronizing scrambler polynomial $X^{43} + 1$. Operation of the descrambler shall be in accordance with Recommendations I.432 for SDH and G.804 for PDH.

5.3.1.4 HEC Processing

5.3.1.4.1 Transfer function

HEC verification and correction shall be in accordance with Recommendation I.432. Cells determined to have an invalid and incorrectible HEC pattern shall be discarded.

Indications of invalid HEC event and invalid HEC cell discard event are to be provided by the transfer function to layer management.

TABLE 5-2(A)/I.732

Functional decomposition [TP/VP_A // VPME (B to A)]

Level B to A		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VPME	TP/ VP_A	Mapping	cell stream extraction				
		Cell delineation	cell delineation OCD anomaly:	OCD anomaly event		OCD anomaly event count, LCD defect (0-4 ms duration of OCD anomaly) detection and consequent actions	FM3 FM4
		Scrambling	cell information field descrambling				
		HEC processing	HEC verification, header correction (if applicable) and invalid HEC cell discard	Invalid HEC event. Invalid HEC cell discarded event	act/deact	Count of invalid HEC events. Count of invalid HEC discard events selection of correction mode	
		Cell rate decoupling	idle cell discard				
		Usage measurement	detection of cell arrival	cell event	act/deact	count of incoming cells	
		Header verification and protocol monitoring measurement	reading of header; discarding of cells with invalid header pattern	Invalid HEC event. Invalid HEC cell discard event		Count of invalid HEC event. Count of invalid HEC cell discard event (Note 1)	
		GFC (Note 2)	reading of GFC field (if applicable)	GFC		GFC processing (Recs. I.150, I.361)	
		VPI verification	reading of VPI; discarding of unassigned cells and cells with invalid VPI	VPI	discard instruction	count of cells with invalid VPI (Note 1)	

TABLE 5-2(A)/I.732 *(concluded)*

Functional decomposition [TP/VP_A // VPME (B to A)]

Level B to A		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VPME	TP/ VP_A	Congestion control (Note 2)	selective cell discard (CLP based)	cell discard event	discard instruction	activation /deactivation of cell discard based on congestion detection.	
		VP mux	demultiplexing of VPs according to VPI value				
NOTES 1 There is a common counter for invalid header, invalid VPI, invalid VCI cell discard. 2 This function is optional.							

TABLE 5-2(B)/I.732

Functional decomposition [TP/VP_A // VPME (A to B)]

Level A to B		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VPME	TP/ VP_A	VP mux	multiplexing of VPs onto TP				
		Congestion control (Note 1)	selective cell discard (CLP based)	cell discard event	discard instruction	activation/ deactivation of cell discard based on congestion detection	
		GFC (Note 1)	setting of GFC field in an assigned cell or insertion of unassigned cells			GFC processing (Recs. I.150, I.361)	
		Usage measurement	detection of cell arrival	cell event	act/deact	count of outgoing cells	
		Cell rate decoupling	idle cell insertion				
		HEC processing	HEC generation				
		Scrambling	cell information field scrambling				
		Mapping	cell stream mapping				
NOTE 1 – This function is optional.							

5.3.1.4.2 Layer Management function

A count of invalid HEC events and a count of invalid HEC cell discard events are maintained with threshold crossings checked. HEC correction mode may be activated/deactivated by the AEMF. The HEC correction mode should be activated by default.

5.3.1.5 Cell rate decoupling

5.3.1.5.1 Transfer function

Idle cells are extracted from the cell stream

5.3.1.6 TP usage measurement

5.3.1.6.1 Transfer function

Cell reception is indicated to layer management.

5.3.1.6.2 Layer Management function

Received cells are counted for TP usage measurement purposes. Measurement results are maintained and reported to the AEMF periodically. This cell counting is activated/deactivated by the AEMF.

5.3.1.7 Cell Header verification

5.3.1.7.1 Transfer function

The receiving ATM NE shall verify that the first four octets of the ATM cell header are recognizable as being a valid header pattern Cells with unrecognized header patterns shall be discarded. An indication of an invalid header cell discard event is provided to layer management.

5.3.1.7.2 Layer Management function

Specific values of the cell header have been defined in Recommendation I.361 for use by the Physical Layer, e.g. idle cells and Physical Layer OAM cells. The ATM NE shall process these cells in accordance with the procedures defined in Recommendation I.361.

Invalid header patterns for SDH/PDH-based TP-Ts are as follows (except idle cell) (p = any value):

	GFC	VPI	VCI	PTI	CLP
UNI	pppp	0000 0000	0000 0000 0000 0000	ppp	1

	VPI	VCI	PTI	CLP
NNI	0000 0000 0000	0000 0000 0000 0000	ppp	1

These invalid header discard events are counted. A common invalid header/VPI/VCI cell discard count is maintained with setable threshold crossing checked.

5.3.1.8 GFC

5.3.1.8.1 Transfer function

The GFC function is an option at UNIs. If present, the GFC function should be in accordance with Recommendations I.150 and I.361.

5.3.1.8.2 Layer Management function

If present, GFC layer management function shall be in accordance with Recommendations I.150 and I.361.

5.3.1.9 VPI verification

5.3.1.9.1 Transfer function

The ATM NE shall verify that the received cell VPI is valid. If the VPI is determined to be invalid (i.e. out-of-range VPI or not assigned), the cell shall be discarded. An indication of an invalid VPI cell discard event is provided to layer management.

5.3.1.9.2 Layer Management function

The invalid VPI cell discard events are counted. A common invalid header/VPI/VCI cell discard count is maintained with setable threshold crossing checked.

5.3.1.10 Congestion Control

5.3.1.10.1 Transfer function

Selective cell discard according to CLP value.

If a selective cell discard function is present, in the event of congestion, cells with CLP = 1 are subject to be discarded prior to cells with CLP = 0. See Recommendation I.371 for further details about the use of the CLP.

5.3.1.10.2 Layer Management function

For further study.

5.3.1.11 VP demultiplexing

This function enables the flow of cells to be logically separated into individual flows according to the VPI values.

5.3.2 TP/VP_A // VPME (A to B)

5.3.2.1 VP multiplexing

This function enables individual cell flows to be logically combined into a single cell flow according to the VPI values.

5.3.2.2 Congestion Control

5.3.2.2.1 Transfer function

Selective cell discard according to CLP value.

If a selective cell discard function is present, in the event of congestion, cells with CLP = 1 are subject to be discarded prior to cells with CLP = 0. See Recommendation I.371 for further details about the use of the CLP.

5.3.2.2.2 Layer Management function

For further study.

5.3.2.3 GFC

5.3.2.3.1 Transfer function

The GFC function is an option at UNIs. If present, the GFC function should be in accordance with Recommendations I.150 and I.361.

5.3.2.3.2 Layer Management function

If present, GFC layer management function shall be in accordance with Recommendations I.150 and I.361.

5.3.2.4 TP Usage Measurement

5.3.2.4.1 Transfer function

Cell reception is indicated to layer management.

5.3.2.4.2 Layer Management function

Received cells are counted for cell measurement purposes. Measurement results are maintained and reported to the AEMF periodically. This cell counting is activated/deactivated by the AEMF.

5.3.2.5 Cell rate decoupling

5.3.2.5.1 Transfer function

Idle cells are inserted into cell stream to match the rate of the TP payload in accordance with Recommendation I.432. The format of the idle cell should be in accordance with Recommendation I.432.

5.3.2.6 HEC Processing

5.3.2.6.1 Transfer function

HEC value for each cell is calculated and inserted into HEC field. The method of HEC value calculation shall be in accordance with Recommendation I.432.

5.3.2.7 Scrambling

5.3.2.7.1 Transfer function

Information field of each cell is scrambled with a self synchronizing scrambler polynomial $X^{43} + 1$. Operation of the scrambler shall be in accordance with Recommendation I.432.

5.3.2.8 Cell stream mapping

5.3.2.8.1 Transfer function

The cell stream shall be inserted into transmission path payload which shall be in accordance with Recommendations G.707 for SDH and G.804 for PDH. The cell boundaries are aligned with the TP octet boundaries.

5.4 VP link termination (VPL_T) // VP Entity (VPE)

See Table 5-3(A), Figure 5-1(A), Table 5-3(B) and Figure 5-1(B).

5.4.1 VPL_T // VPE (B to A)

5.4.1.1 VP usage measurement

5.4.1.1.1 Transfer function

VPC cell reception is indicated to layer management.

5.4.1.1.2 Layer Management function

Received cells are counted for usage measurement purposes. The following counts shall be maintained:

1) Count of total received VPC cells with CLP = 0 + 1.

2) Count of total received VPC cells with CLP = 0. This count is only maintained when the CLP option is used. See 5.4.1.2 on UPC/NPC.

Measurement results are maintained and reported to the AEMF periodically. Cell counting is activated/deactivated by the AEMF.

5.4.1.2 VP UPC/NPC

UPC/NPC may be performed on each VP connection to detect violations of negotiated traffic parameters for the purpose of protecting the QOS of other VPCs. The use of UPC may be required for VPL_T associated with a TP_T configured as a UNI. The use of NPC is optional for a VPL_T associated with a TP_T configured as an NNI. Actions and requirements of UPC/NPC are described in Recommendation I.371.

NOTE – The use of UPC in ATM equipment on the user side of S_B and T_B reference point is optional.

The VP UPC/NPC function is activated/deactivated by the AEMF.

TABLE 5-3(A)/I.732

Functional decomposition [VPL_T // VPE (B to A)]

Level B to A		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VPE	VPL_T	Usage measurement (Note 2)	detection of cell arrival	cell events CLP value	act/deact	count of incoming cells for CLP = 0 + 1 and CLP = 0.	
		VP UPC/NPC (Notes 2 and 4)	VP compliance checking and corrective action if activated	cell discarding and tagging event	act/deact	traffic descriptor discarded cell count for CLP = 0 + 1 and CLP = 0 tagged cell count	
		Shaping (Notes 2 and 3)	VP traffic shaping		act/deact	traffic descriptor	
		F4 AIS/RDI OAM non-intrusive monitoring	AIS/RDI OAM cell copy	AIS/RDI OAM cell payload	act/deact of F4 AIS/RDI non-intrusive monitoring	F4 AIS/RDI OAM cell processing. Reporting of AIS/RDI state to AEMF	See. 6.2.2
		F4 CC OAM non-intrusive monitoring	detection of cell arrival	report cell event	act/deact of F4 CC non-intrusive monitoring	Reporting of LOC defect to AEMF	FM5
		F4 PM OAM non-intrusive monitoring (Note 4)	e-t-e and segment PM OAM cell copy	PM OAM cell payload	act/deact of F4 PM non-intrusive monitoring	e-t-e and segment F4 PM OAM cell processing. Reporting of performance results to AEMF	PM1/ PM2
		Resource management	resource management cells			resource management cells processing	
		F4 AIS OAM	insertion of F4 AIS OAM cells		AIS OAM cell payload	Insert F4 AIS OAM cells	FM2 FM4 FM5
		extraction of F4 segment CC OAM	extraction of F4 CC OAM cells	extraction of CC OAM cell		Determination and reporting of LOC condition	FM5
		insertion of F4 segment CC OAM	insertion of F4 CC OAM cells		CC OAM cell payload	F4 CC OAM cell generation	
		extraction of F4 segment PM OAM (Note 4)	extraction of F4 segment PM OAM cells	PM OAM cell payload		F4 PM OAM cell processing. Reporting of error measurement	PM3 PM4 PM28

TABLE 5-3(A)/I.732 *(concluded)*

Functional decomposition [VPL_T // VPE (B to A)]

Level B to A		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VPE	VPL_T	Insertion of F4 segment PM OAM	insertion of F4 segment PM OAM cells		PM OAM cell payload	F4 PM OAM cell generation at a segment termination point	PM5 PM27
		F4 loopback at a source point	Seg or e-t-e LB cell insertion	Timer activation	LB cell	LB cell generation is activated by AEMF	FM21
			Seg or e-t-e LB cell copy or extraction	LB cell	LB detection act	LB cell processing and reporting to AEMF	FM22
		F4 loopback at a loopback point	Seg LB cell copy or extraction	LB cell		LB cell processing	FM26
			Seg cell insertion		LB cell		FM25
		F4 loopback seg termination	Seg LB cell discarding at OAM seg termination		act/deact with respect to OAM seg termination	Seg LB cell discarding is activated by AEMF	
		Extraction of F4 segment/ e-t-e AD OAM (Note 2)	extraction of F4 segment/ e-t-e AD OAM cells	AD OAM cell payload		F4 AD OAM cell processing	
		Insertion of F4 segment/e-t-e AD OAM (Note 2)	Insertion of F4 segment/ e-t-e AD OAM cells		AD OAM cell payload	F4 AD OAM cell processing	

NOTES

1 No ordering is implied among AIS/RDI, PM, CC or Loopback functions.

Link terminations can become segment terminations by management action. Extraction of OAM segment cells at the terminations of an OAM segment is required by Recommendation I.610.

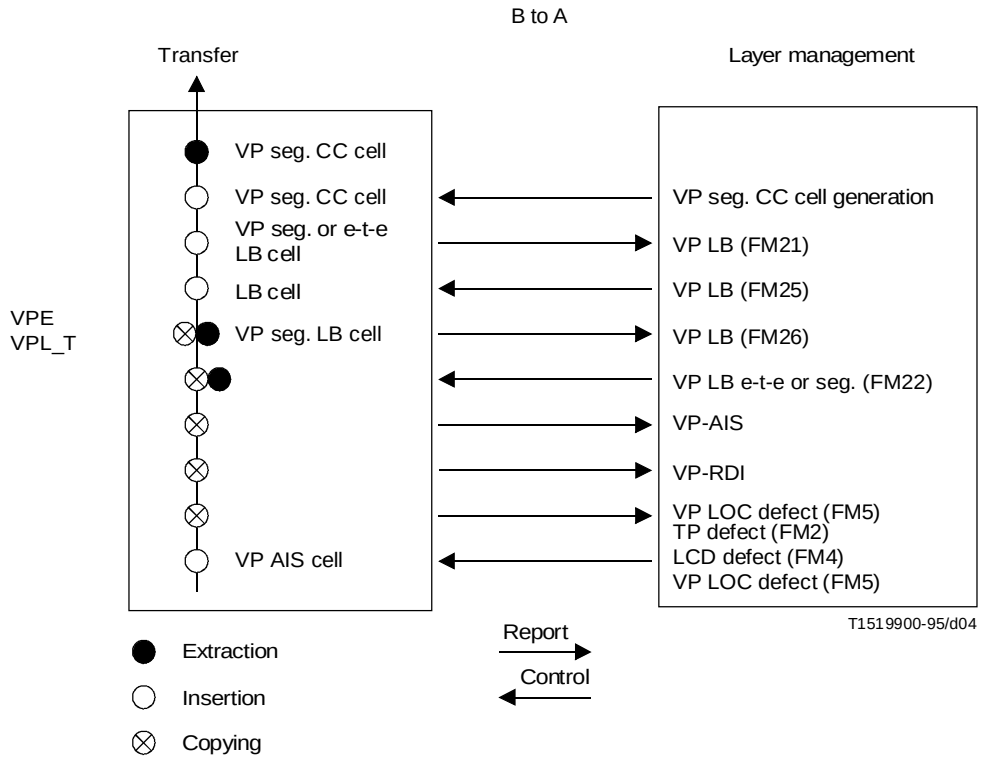
2 This function is optional.

3 – The shaping function may not be present in NE.

– If present, the shaping function can be activated/deactivated in egress side or ingress side per connection.

– The shaping function should not be simultaneously activated on both B to A and A to B of the same connection.

4 For non-conforming cells, there may be potential interference between PM and UPC/NPC actions. This requires further study (see Recommendation I.610).



NOTES

1 No logical order is implied by the sequence of functions in each block.

2 FM numbering refers to Table 6-1.

3 The control for activation/deactivation of these functions are not shown except for the loopback detection and timer activation (FM22).

4 The reports to the AEMF are not shown on this figure.

FIGURE 5-1(A)/I.732

LMIs for VPL_T // VPE (B to A)

TABLE 5-3(B)/I.732

Functional Decomposition [VPL_T // VPE (A to B)]

Level A to B		Function	Transfer Function			Layer Management Function	CoF
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VPE	VPL_T	F4 AIS OAM	insertion of F4 OAM cells		AIS OAM cell payload	Insert F4 AIS OAM cells due to LOC	FM18
		extraction of F4 segment CC OAM	extraction of F4 CC OAM cells	extraction of CC OAM cell		Determination and reporting of LOC condition	FM18
		insertion of F4 segment CC OAM	insertion of F4 CC OAM cells		CC OAM cell payload	F4 CC OAM cell generation	
		extraction of F4 segment PM OAM	extraction of F4 segment PM OAM cells	PM OAM cell payload		F4 PM OAM processing. Reporting of error measurement to AEMF	PM23 PM24 PM27
		Insertion of F4 segment PM OAM	Insertion of F4 segment PM OAM cells		PM OAM cell payload	F4 PM OAM cell generation at a segment termination point	PM22 PM28
		F4 loopback at a source point	Seg or e-t-e LB cell insertion	Timer activation	LB cell	LB cell generation is activated by AEMF	FM22
			Seg or e-t-e LB cell copy or extraction	LB cell	LB detection act	LB cell processing and reporting to AEMF	FM21
		F4 loopback at a loopback point	Seg LB cell copy or extraction	LB cell		LB cell processing	FM25
			Seg cell insertion		LB cell		FM26
		F4 loopback seg termination	Seg LB cell discarding at OAM seg termination		act/deact with respect to OAM seg termination	Seg LB cell discarding is activated by AEMF	
		Extraction of F4 segment/ e-t-e AD OAM (Note 2)	Extraction of F4 segment/ e-t-e AD OAM cells	F4 AD OAM cell payload		F4 AD OAM cell processing	

TABLE 5-3(B)/I.732 *(concluded)*

Functional Decomposition [VPL_T // VPE (A to B)]

Level A to B		Function	Transfer Function			Layer Management Function	CoF
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VPE	VPL_T	Insertion of F4 segment/ e-t-e AD OAM (Note 2)	Insertion of F4 segment/ e-t-e AD OAM cells		F4 AD OAM cell payload	F4 AD OAM cell processing	
		Resource management	resource management cells			resource management cells processing	
		F4 AIS/RDI OAM non-intrusive monitoring	AIS/RDI OAM cell copy	AIS/RDI OAM cell payload	act/deact of F4 AIS/RDI non-intrusive monitoring	F4 AIS/RDI OAM cell processing. Reporting of AIS/RDI state to AEMF	See 6.2.2
		F4 CC OAM non-intrusive monitoring	detection of cell arrival	report cell event	act/deact of F4 CC non-intrusive monitoring	Reporting of LOC defect to AEMF	FM18
		F4 PM OAM non-intrusive monitoring	e-t-e and segment PM OAM cell copy	PM OAM cell payload	act/deact of F4 PM non-intrusive monitoring	e-t-e and segment F4 PM OAM cell processing. Reporting of performance results to AEMF	PM25 PM26
		Usage measuring (Note 2)	detection of cell arrival	cell event CLP value	act/deact	count of outgoing cells per VP for CLP = 0 + 1 and CLP = 0	
		Shaping (Notes 2 and 3)	VP traffic shaping		act/deact	traffic descriptor	
		EFCI (Note 2)	setting of EFCI bit of PTI field for user congestion signalling		act/deact	EFCI generation	
		VPI setting	VPI field setting			VPI translation	

NOTES

1 No ordering is implied among AIS/RDI, PM, CC or Loopback functions.

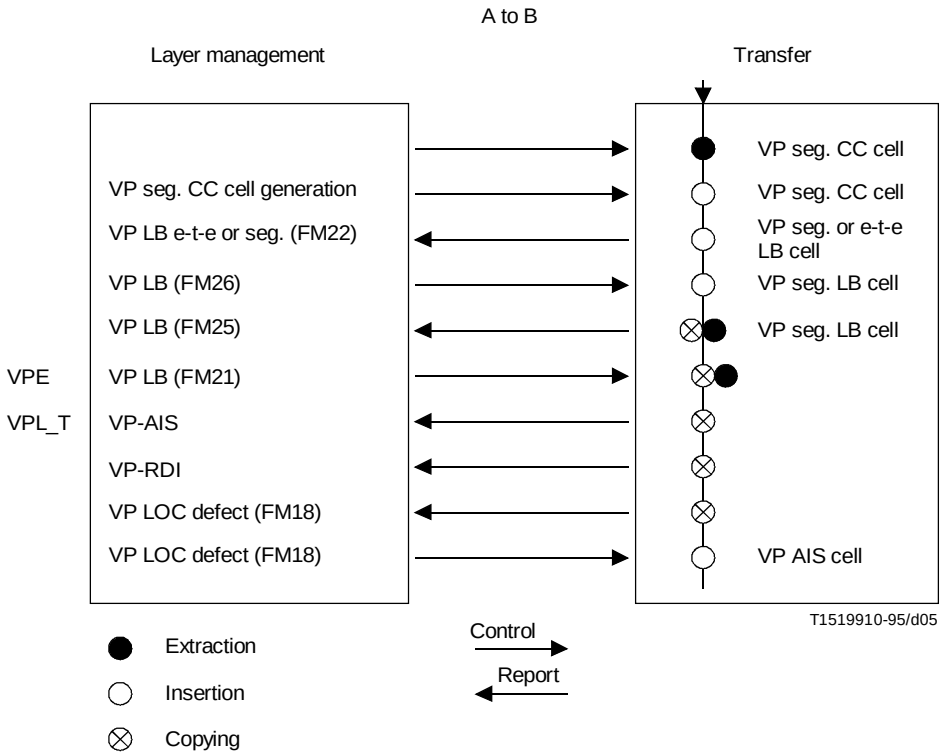
Link terminations can become segment terminations by management action. Extraction of OAM segment cells at the terminations of an OAM segment is required by Recommendation I.610.

2 This function is optional.

3 – The shaping function may not be present in NE.

– If present, the shaping function can be activated/deactivated in egress side or ingress side per connection.

– The shaping function should not be simultaneously activated on both B to A and A to B of the same connection.



NOTES

1 No logical order is implied by the sequence of functions in each block.

2 The FM numbering refers to Table 6-1.

3 The control for activation/deactivation of these functions are not shown except for the loopback detection and timer activation (FM21).

4 The reports to the AEMF are not shown on this figure.

FIGURE 5-1(B)/I.732

LMIs for VPL_T // VPE (A to B)

5.4.1.2.1 Transfer function

VPC cell may be passed, discarded, or tagged (if used), depending on indication from layer management.

5.4.1.2.2 Layer Management function

Traffic descriptions are used by the layer management function to determine if connections are in violation of the negotiated traffic parameters. Plane Management is responsible for the setup and modification of the traffic parameters.

The cell loss priority function explicitly identifies the relative loss priority level in the handling of a cell, (i.e. its discard eligibility depending on network conditions).

Cells with CLP = 0 are handled by an ATM NE as having higher priority than cells with CLP = 1.

The use of the CLP for Resource Management is described in Recommendations I.371 and I.150. The coding of CLP values is defined in Recommendation I.361. The ATM NE should be capable of interpreting the CLP value for the case of relative discard eligibility of a cell in the event of congestion. However, ATM NEs may not interpret the CLP value in some network applications.

The use of the CLP for the tagging function by the UPC is a network option, and is described in I.371. Note that since the same bit is used both for the tagging function by the UPC and explicit CLP indication, the discard eligibility of the UPC tagged cells is the same as that of user set CLP = 1 cells from the equipment perspective.

When the UPC/NPC is activated, the following counts shall be maintained and reported to the AEMF periodically:

1) *Count of discarded cells with CLP = 0 + 1*

   A count of cells discarded due to UPC/NPC of combined CLP = 0 and CLP = 1 traffic.

2) *Count of discarded cells with CLP = 0*

   A count of CLP = 0 cells discarded due to UPC/NPC of CLP = 0 only traffic. This count is maintained only when the CLP option is used.

3) *Count of cells tagged by the UPC/NPC function*

   A count of cells with CLP = 0 that were tagged (i.e. CLP reset to 1) by the UPC/NPC. This count is maintained only when the CLP tagging option is used.

5.4.1.3 Traffic shaping

5.4.1.3.1 Transfer function

The shaping function may not be present in an ATM NE. The shaping function can be activated/deactivated in ingress side or egress side per connection.

If present, the use of the traffic shaper should be in accordance with Recommendation I.371.

5.4.1.3.2 Layer Management function

If present, the function can be activated/deactivated per connection.

The traffic shaping function should not be activated simultaneously on both B to A and A to B sides on the same connection.

5.4.1.4 F4 OAM non-intrusive monitoring

Non-intrusive monitoring provides a capability for assessing the status (e.g. AIS/RDI state). the connectivity, or performance of a VP end-to-end connection or connection segment at intermediate points of the connection. The defined non-intrusive monitoring functions are: VP AIS/RDI state detection, Loss of Continuity defect detection, and connection performance monitoring. These functions may be activated/deactivated separately per connection by the AEMF. They are “non-intrusive” in the sense that, when activated, the ATM cell transfer performance of the connection should not be affected.

5.4.1.4.1 Transfer function

1) *VP-AIS/VP-RDI*

   VP-AIS cells and VP-RDI cells are detected and copied when F4 AIS/RDI non-intrusive monitoring is activated. F4 AIS/RDI non-intrusive monitoring is activated/deactivated by the AEMF.

2) *Continuity Check (CC)*

   CC cells and user cells are detected when F4 CC non-intrusive monitoring is activated. F4 CC non-intrusive monitoring is activated/deactivated by the AEMF.

3) *Performance monitoring (PM)*

   PM cells are copied when F4 PM non-intrusive monitoring is activated. F4 PM non-intrusive monitoring is activated/deactivated by the AEMF.

5.4.1.4.2 Layer Management function

1) *VP-AIS/VP-RDI*

   When activated, VP-AIS state is declared when one VP-AIS cell is detected. The VP-AIS state is removed when a user cell or CC cell is received.

   When activated, VP-RDI state is declared when one VP-RDI cell is detected. The VP-RDI state is removed when no VP-RDI cells are detected for nominally 2.5 seconds with a margin of ± 0.5 seconds.

   Declaration and removal of VP-AIS/RDI state is sent to the AEMF.

2) *Continuity check*

Loss of Continuity (LOC) defect is declared when any user cell or CC cell is not received within a time interval of 3.5 seconds with a margin of ± 0.5 seconds. LOC defect is removed when any user cell or CC cell is received. Declaration and removal of LOC defect is sent to the AEMF.

3) *Performance monitoring*

Performance Monitoring (PM) of end-to-end and segment VPC is done by PM cells over the end-to-end and segment VPC respectively when activated by AEMF. Performance monitoring of the end-to-end and segment VPC is stopped if deactivated by AEMF. A block error result and a total received user cell count may be detected. The performance monitoring results are sent to the AEMF. Backward reporting of performance monitoring results is not provided in the case of non-intrusive monitoring.

5.4.1.5 Resource management

For further study.

5.4.1.6 F4 OAM cell insertion/extraction and processing

5.4.1.6.1 Transfer function

1) *VP-AIS*

VP-AIS cells are inserted if VP-AIS cells are generated in layer management function.

2) *Segment Continuity Check (CC)*

Segment CC cells are inserted and extracted when CC is activated by an Activation/Deactivation (AD) cell or by request from AEMF.

3) *Segment Performance Monitoring (PM)*

Segment PM cells are inserted and extracted when PM is activated by AD cell or by request from AEMF.

4) *Loopback (LB)*

At a source point:

a) Segment or e-t-e LB cell is inserted when requested by AEMF.

b) Segment or e-t-e LB cell is copied or optionally extracted when FM22 is activated and LB cell is detected. This LB cell had been previously inserted by the corresponding A to B VPE block.

At a loopback point:

A Segment LB cell is copied or optionally extracted when LB conditions occurs (see Recommendation I.610). The extraction option might be enabled/disabled on request from AEMF. A Segment LB cell is inserted when Segment LB cell has to be looped from the reverse direction [VPL-T (A to B)].

At an OAM segment termination:

Segment LB cell is discarded.

5) *Segment Activation/Deactivation (AD)*

The Segment AD cell is inserted when AD cell generation is requested by AEMF. The Segment AD cell is extracted at the associated segment end-point.

5.4.1.6.2 Layer Management function

1) *VP-AIS*

If a Loss of Cell Delineation (LCD) defect or a TP defect or a LOC defect is declared, VP-AIS cells shall be generated for all affected active VPCs. VP-AIS cells are generated as soon as possible after defect declaration. VP-AIS generation condition is in accordance with Recommendation I.610. VP-AIS cells are generated during the defect condition. Generation frequency of VP-AIS cells is nominally one cell per second. VP-AIS cell generation shall be stopped as soon as the defect is removed.

2) *Segment CC*

If segment CC is activated, segment CC cell is generated when no user cell is received for a period of nominally 1 second. CC cells can also be sent repetitively with a periodicity of nominally 1 cell per second independent of the user cell flow.

Loss of Continuity (LOC) defect is declared when any user cell or CC cell is not received within a time interval of 3.5 seconds with a margin of ± 0.5 seconds. VP-AIS generation due to LOC defect is initiated. LOC defect is removed when any user cell or CC cell is received. Declaration and removal of LOC defect is sent to the Plane Management.

3) *Segment PM*

If segment PM is activated, segment PM cells are generated. A monitoring cell sequence number, total user cell number, and block error detection code (BIP-16) are calculated from a block of user cells and placed in corresponding fields of the monitoring cell. The calculation method shall be in accordance with Recommendation I.610. A block error result and a total received cell count are placed in corresponding fields in the monitoring cell for backward reporting.

Performance of VPC segment is derived from the comparison between received block of user cells and information in a received PM cell. The comparison method shall be in accordance with Recommendation I.610. PM will determine errored blocks and lost/misinserted cell counts. Performances or backward report results of the received PM cell are sent to the AEMF.

4) *Loopback (LB)*

At a source point:

a) Segment or e-t-e LB cell are generated in accordance with Recommendation I.610 (LI, CT, LLID, SID) when requested by AEMF. The LMI FM21 is activated.

b) If a segment or e-t-e LB cell with the CT matching that of the generated LB cell and with the LI set to "0" is received within 5 seconds after the generation, the LB is successful. The LB results are sent to the AEMF.

At a loopback point:

When a Segment LB cell with the LLID matching the ID of the received point and with the LI set to "1" is received, FM26 is activated and the received LB cell is given to reverse direction [VPL-T (A to B)] after the LI is set to "0".

At an OAM segment termination:

At the termination of an OAM segment, segment LB cell should be discarded (see Recommendation I.610).

5) *Segment AD*

A Segment AD cell is generated to request the activation/deactivation of PM or CC process at the remote segment end-point, when the generation is requested by AEMF. When an associated response AD cell with the correlation tag matching that of the generated AD cell is received, its result (request confirmed or denied) is sent to the AEMF.

When an AD cell to request the activation/deactivation from the remote segment end-point is received, the activation/deactivation request is sent to the AEMF. After the response (request confirmed or denied) to the request is received from the AEMF, the response AD cell is generated.

5.4.2 VPL_T // VPE (A to B)

5.4.2.1 F4 OAM cell insertion/extraction and processing

5.4.2.1.1 Transfer function

1) *VP-AIS*

VP-AIS cells are inserted if VP-AIS cells are generated in layer management function due to a LOC.

2) *Segment Continuity Check (CC)*

Segment CC cells are inserted and extracted when CC is activated by Activation/Deactivation (AD) cell or the request from AEMF.

3) *Segment PM*

Segment PM cells are inserted and extracted when PM is activated by AD cell or the request from AEMF.

4) *Loopback (LB)*

At a source point:

a) Segment or e-t-e LB cell is inserted when requested by AEMF.

b) Segment or e-t-e LB cell is copied or optionally extracted when FM21 is activated and LB cell is detected. This LB cell had been previously inserted by the corresponding B to A VPE block.

At a loopback point:

A Segment LB cell is copied or optionally extracted when LB conditions occurs (see Recommendation I.610). The extraction option might be enabled/disabled on request from AEMF.

A Segment LB cell is inserted when Segment LB cell has to be looped from the reverse direction [VPL-T (A to B)].

At an OAM segment termination:

Segment LB cell is discarded.

5) *Segment Activation/Deactivation (AD)*

Segment AD cell is inserted when AD cell generation is requested by AEMF. Segment AD cell is extracted when it is inserted at the associated segment end-point.

5.4.2.1.2 Layer Management function

1) *VP-AIS*

If a LOC defect is declared, VP-AIS cells shall be generated for all affected active VPCs. VP-AIS cells are generated as soon as possible after LOC defect declaration. VP-AIS generation condition shall be in accordance with Recommendation I.610. VP-AIS cells are generated during the defect condition. Generation frequency of VP-AIS cells is nominally one cell per second. VP-AIS cell generation shall be stopped as soon as the defect is removed.

2) *Segment CC*

If segment CC is activated, segment CC cell is generated when no user cell is received for a period of nominally 1 second. CC cells can also be sent repetitively with a periodicity of nominally 1 cell per second independent of the user cell flow.

Loss of Continuity (LOC) defect is declared when any user cell or CC cell is not received within a time interval of 3.5 seconds with a margin of ± 0.5 seconds. VP-AIS generation due to LOC defect is initiated. LOC defect is removed when any user cell or CC cell is received. Declaration and removal of LOC defect is sent to the AEMF.

3) *Segment PM*

If segment PM is activated, segment PM cells are generated. A monitoring cell sequence number, total user cell number, and block error detection code (BIP-16) are calculated from a block of user cells and placed in corresponding fields of the monitoring cell. The calculation method shall be in accordance with Recommendation I.610. A block error result and a total received cell count are placed in corresponding fields in the monitoring cell for backward reporting.

Performance of VPC segment is derived from the comparison between received block of user cells and information in a received PM cell. The comparison method shall be in accordance with Recommendation I.610. PM will determine errored blocks and lost/misinserted cell counts. Performances or backward report results of the received PM cell are sent to the AEMF.

4) *Loopback*

At a source point:

a) Segment or e-t-e LB cell are generated in accordance with Recommendation I.610 (LI, CT, LLID, SID) when requested by AEMF. The LMI FM22 is activated.

b) If a segment or e-t-e LB cell with the CT matching that of the generated LB cell and with the LI set to "0" is received within 5 seconds after the generation, the LB is successful. The LB results are sent to the AEMF.

At a loopback point:

When a Segment LB cell with the LLID matching the ID of the received point and with the LI set to "1" is received, FM25 is activated and the received LB cell is given to reverse direction [VPL-T (A to B)] after the LI is set to "0".

At an OAM segment termination:

At the termination of an OAM segment, segment LB cell should be discarded (see Recommendation I.610).

5) *Segment AD*

A Segment AD cell is generated to request the activation/deactivation of PM or CC process at the remote segment end-point, when the generation is requested by AEMF. When an associated response AD cell with the correlation tag matching that of the generated AD cell is received, its result (request confirmed or denied) is sent to the AEMF.

When an AD cell to request the activation/deactivation from the remote segment end-point is received, the activation/deactivation request is sent to the AEMF. After the response (request confirmed or denied) to the request is received from the AEMF, the response AD cell is generated.

5.4.2.2 Resource management

For further study.

5.4.2.3 F4 OAM non-intrusive monitoring

The transfer and layer management functions for F4 non-intrusive monitoring are the same as in the B-to-A direction. See 5.4.1.4.

5.4.2.4 VP Usage Measurement

5.4.2.4.1 Transfer function

VPC cell reception and CLP value are indicated to layer management.

5.4.2.4.2 Layer Management function

Outgoing VPC cells are counted for usage measurement purposes. The following counts shall be maintained:

1) Count of total outgoing VPC cells with CLP = 0 + 1:

2) Count of total outgoing VPC cells with CLP = 0. This count is only maintained when the CLP option is used. See 5.4.1.2 on UPC/NPC.

Measurement results are maintained and reported to the AEMF periodically. Cell counting is activated/deactivated on a per VPC basis by the AEMF.

5.4.2.5 EFCI setting

In the event of congestion, this function, if activated, sets PTI values in accordance with Recommendation I.361.

5.4.2.6 VPI setting

5.4.2.6.1 Transfer function

The VPI value is processed in accordance with the assigned values.

5.4.2.6.2 Layer Management function

At the UNI a total of up to 8 bits are available for VPI as defined in Recommendation I.361. At the NNI a total of up to 12 bits are available for VPI as defined in Recommendation I.361. The actual number of active VPI bits may be reduced by negotiation, e.g. in order to reduce interface costs.

The ATM NE associates a unique VPI value for each VP link per transmission path. The VPI values used for VP connection identification on a given transmission path are not available for VCC identification on that interface for the duration of the VP connection.

NOTE – An ATM NE should associate each allocated VPI value per transmission path with only either VP identification or VC identification. This is necessary since in some configurations two different ATM NE's connected on the same transmission path may provide a different switching function. One NE may be a VC Switch/crossconnect and the other a VP Switch/crossconnect. Consequently, the ATM NE needs to identify each cell it processes as belonging to either a VPC or a VCC, as identified by its VPI value. Specific assigned values for VP and VC service are for further study.

The rules for allocation of the VPI/VCI bits and the preassigned values are specified in Recommendation I.361. It should be noted that the VPI/VCI values are to be assigned bidirectionally.

All ATM NE shall comply with the allocation rules and pre-assigned values.

In addition to the pre-assigned VPI/VCI values given in Recommendation I.361, some Network Providers may optionally pre-assign additional values for specific functions. Since, in this case these values are not generally available to the user, mutual negotiation may be necessary to ensure compatible ranges of VPI/VCI values between different Network Providers and users.

From the ATM Equipment perspective, this procedure is similar to the negotiated reduction of the number of active VPI/VCI values (range) to minimize complexity per interface.

The need to standardize a minimum number of VPI/VCI values per interface rate is for further study.

5.5 VP Connection (VP_C) // VP Connection Entity (VP_C)

See Table 5-4.

TABLE 5-4/I.732

Functional decomposition (VP_C)

Level		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VP_C	VP_C	Link inter-connection	inter-connection of VP links			association of VP links	

5.5.1 VP link inter-connection

5.5.1.1 Transfer function

This function assigns VP links at input ports to VP links at output ports.

5.5.1.2 Layer Management function

The assignment of an incoming VP link to an outgoing VP link inter-connection requires the association between incoming port number and VPI value and outgoing port number and VPI value. VP link inter-connection is done by relaying cells in accordance with the port numbers and VPI values.

The VP connection process is a unidirectional function and may support point-to-point, point-to-multipoint, and broadcast VP connections.

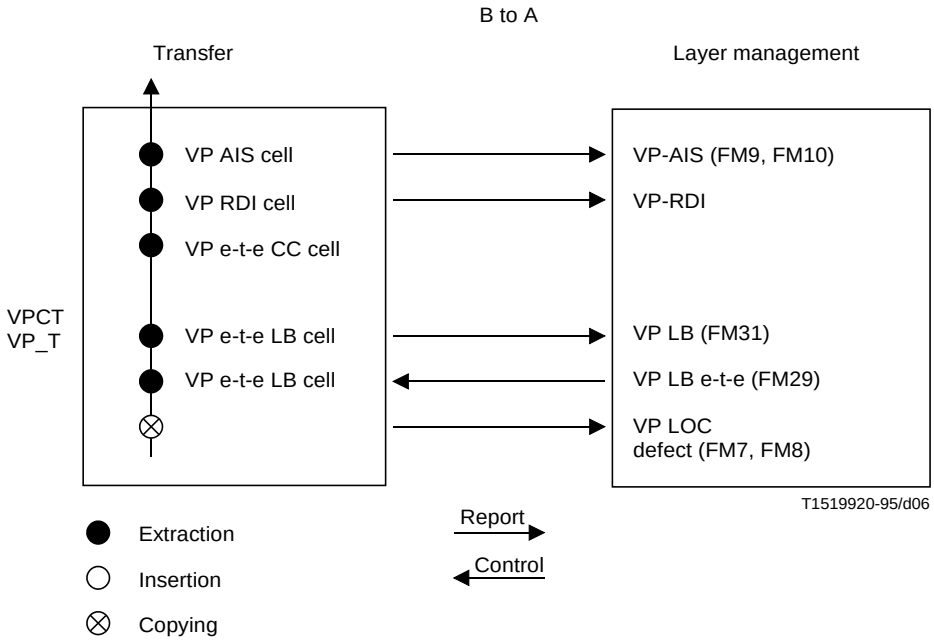
5.6 VP Termination (VP_T) // VP Connection Termination (VPCT)

See Table 5-5(A), Figure 5-2(A), Table 5-5(B) and Figure 5-2(B).

TABLE 5-5(A)/I.732

Functional decomposition [VP_T // VPCT (B to A)]

Level B to A		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VPCT	VP_T	The processing of ATM header fields for information to be passed between ATM layer and higher layers (PTI field, CLP field, see Rec. I.361).				For further study	
		Resource management	resource management cells			resource management cells processing	
		F4 OAM: AIS, RDI, CC, and PM	extraction of F4 OAM cells	OAM cell payload		F4 OAM cell processing (Note) Performance monitoring: VP-RDI, VP-AIS, continuity check,	FM7 FM8 FM9 FM10 PM6 PM7 PM29
		F4 OAM Loopback at a source point	e-t-e LB cell extraction	LB cell	Always act	LB cell processing and reporting to AEMF when FM29 is activated	FM29
		F4 OAM loopback at a loopback point	e-t-e LB cell extraction	LB cell	Always act	LB cell processing	FM31
NOTE – No ordering is implied among AIS/RDI, PM, CC or Loopback functions.							



NOTES

1 No logical order is implied by the sequence of functions in each block.

2 FM numbering refers to Table 6-1.

3 The control for activation/deactivation of these functions are not shown except for the loopback detection and timer activation (FM29).

4 The reports to the AEMF are not shown on this figure.

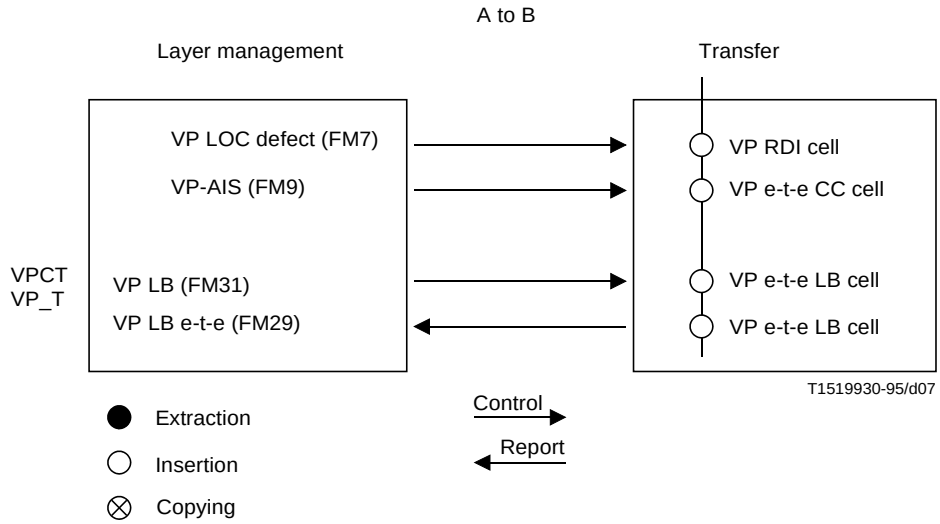
FIGURE 5-2(A)/I.732

LMIs for VP_T // VPCT (B to A)

TABLE 5-5(B)/I.732

Functional decomposition (VP_T (A to B))

Level A to B		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VPCT	VP_T	The processing of ATM header fields for information to be passed between ATM layer and higher layers (PTI field, CLP field, see Rec. I.361).					
		Resource management	Resource management cells			Resource management cells generation	
		F4 OAM: AIS, RDI, CC, PM	insertion of F4 OAM cells		OAM cell payload	F4 OAM cell processing (Note) perf. monitoring VP-RDI continuity check	FM7 FM9 PM21 PM29
		F4 loopback at a source point	e-t-e LB cell insertion	timer activation	LB cell	LB cell generation is activated by AEMF	FM29
		F4 loopback at a loopback point	e-t-e LB cell insertion		LB cell		FM31
NOTE – No ordering is implied among AIS/RDI, PM, CC or Loopback functions.							



NOTES

1 No logical order is implied by the sequence of functions in each block.

2 The FM numbering refers to Table 6-1.

3 Not relevant.

4 The reports to the AEMF are not shown on this figure.

FIGURE 5-2(B)/I.732

LMIs for VP_T // VPCT (A to B)

5.6.1 VP-T // VPCT (B to A)

5.6.1.1 End-to-end F4 OAM cell extraction and processing

5.6.1.1.1 Transfer function

Extraction of end-to-end F4 OAM flows is required for the following functions.

1) *VP-AIS/VP-RDI*

2) *End-to-end CC*

3) *End-to-end PM*

4) *Loopback (LB)*

   At a source point:

   E-t-e LB cell is extracted. This LB cell had been previously inserted by the corresponding A-to-B VPCT block.

   At a loopback point:

   E-t-e LB cell is extracted.

5) *End-to-end AD*

5.6.1.1.2 Layer Management function

1) *VP-AIS/RDI*

   VP-AIS state is declared when one VP-AIS cells is detected. The VP-AIS state is removed when a user cell or CC cell is received. IF CC is not activated the VP-AIS state is also released if VP-AIS cells are absent for nominally 2.5 seconds with a margin of ± 0.5 seconds. VP-RDI state is declared when one VP-RDI cell is detected. The VP-RDI state is removed when no VP-RDI cells are detected for nominally 2.5 seconds with a margin of ± 0.5 seconds. Declaration and removal of VP-AIS/RDI state is sent to the AEMF.

2) *End-to-end CC*

If end-to-end CC is activated, Loss of Continuity (LOC) defect is declared when any user cell or CC cell is not received within a time interval of 3.5 seconds with a margin of ± 0.5 seconds. LOC defect is removed when any user cell or CC cell is received. Declaration and removal of LOC defect is sent to the AEMF.

3) *End-to-end PM*

If end-to-end PM is activated, performance of end-to-end VPC is derived from the comparison between received block of user cells and information in a received PM cell. The comparison method shall be in accordance with Recommendation I.610. PM will detect errored blocks and total received user cell counts. Performances or backward report results of the received PM cell are sent to the AEMF.

4) *Loopback (LB)*

At a source point:

If an e-t-e LB cell with the CT matching that of the generated LB cell and with the LI set to "0" is received within 5 seconds after the generation, the LB is successful. The LB results are sent to the AEMF.

At a loopback point:

When an e-t-e LB cell with the LLID matching the ID of the received point or equal to "All 1s" and with the LI set to "1" is received, FM31 is activated and, the received LB cell is given to reverse direction [VP-T (A to B)] after the LI is set to "0".

5) *End-to-end Activation/Deactivation*

If the Activation/Deactivation (AD) cell process is present in accordance with Recommendation I.610, the following functions are performed.

When a response AD cell with the correlation tag matching that of the generated AD cell is received, its result (request confirmed or denied) is sent to the AEMF.

When a AD cell to request activation/deactivation from the remote VPC end-point is received, the activation/deactivation request is sent to the AEMF.

5.6.2 VP-T // VPCT (A to B)

5.6.2.1 End-to-end F4 OAM insertion

5.6.2.1.1 Transfer function

Insertion of end-to-end F4 OAM flows is required for the following functions.

1) *VP-RDI*

2) *End-to-end CC*

3) *End-to-end PM*

4) *Loopback (LB)*

At a source point:

E-t-e LB cell is inserted when requested by AEMF.

At a loopback point:

An e-t-e LB cell is inserted when Segment LB cell has to be looped from the reverse direction [VPL-T (A to B)].

5) end-to-end AD cell insertion

5.6.2.1.2 Layer management function

1) *VP-RDI*

VP-RDI cells shall be generated as soon as a VP level defect (VP-AIS state declaration, Loss of Continuity) of the reverse direction is detected. VP-RDI cells are generated periodically during the defect condition. Generation frequency of VP-RDI cells is nominally one cell per second. VP-RDI generation shall be stopped as soon as the defect condition is removed.

2) *End-to-end CC*

If end-to-end CC is activated, end-to-end CC cell is generated when no user cell is received for a period of nominally 1 second. CC cells can also be sent repetitively with a periodicity of nominally 1 cell per second independent of the user cell flow .

3) *End-to-end PM*

If end-to-end PM is activated, end-to-end PM cells are generated. A monitoring cell sequence number, total user cell numbers, and block error detection code (BIP-16) are calculated from a block of user cells and placed in corresponding fields of the PM cell. The calculation method is in accordance with Recommendation I.610. A block error result and a total received user cell count are placed in corresponding fields in the backward reporting monitoring cell.

4) *Loopback (LB)*

At a source point:

E-t-e LB cell is generated in accordance with Recommendation I.610 (LI, CT, LLID, SID) when requested by AEMF. The LMI FM29 is activated.

At a loopback point:

When an e-t-e LB cell with the LLID matching the ID of the received point or equal to "All 1s" and with the LI set to "1" is received, FM31 is activated and the received LB cell is given to reverse direction [VP-T (A to B)] after the LI is set to "0".

5) *End-to-end Activation/Deactivation*

If the activation/deactivation cell process is present the following function is performed:

End-to-end AD cell is generated to request activation/deactivation of PM or CC process at the remote VPC end-point, when the generation is requested by AEMF or the end-user.

5.7 Virtual Path/Virtual Channel Adaptation (VP/VC_A)/Virtual Channel Multiplexing Entity (VCME)

See Tables 5-6(A) and 5-6(B).

5.7.1 VP/VC_A // VCME (B to A)

5.7.1.1 VCI verification and invalid VCI cell discard

5.7.1.1.1 Transfer function

The ATM NE shall verify that the received cell VCI is valid. If the VCI is determined to be invalid (i.e. out-of-range VCI or not assigned), the cell shall be discarded. An indication of an invalid VCI cell discard event is provided to layer management.

5.7.1.1.2 Layer Management function

The invalid VCI cell discard events are counted. A common invalid header/VPI/VCI cell discard count is maintained with setable threshold crossing checked.

5.7.1.2 Metasignalling

5.7.1.2.1 Transfer function

Extraction of metasignalling cell. (Format of the metasignalling cell should be in accordance with Recommendation I.361.)

5.7.1.2.2 Layer Management function

Metasignalling processing is not addressed in this Recommendation (see Recommendation Q.2120).

TABLE 5-6(A)/I.732

Functional decomposition [VP/VC_A // VCME (B to A)]

Level B to A		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VCME	VP/VC_A	VCI processing	reading of VCI; discard of cells with invalid VCI	VCI	discard instruction	verification of invalid VCI count of cells with invalid VCI (Note 2)	
		Meta-signalling (Note 1)	extraction of metasignalling cells			meta-signalling cell processing	FFS
		Congestion control (Note 1)	selective cell discard				
		VC mux	demultiplexing of VCs accor-ding to VCI value				

NOTES

1 This function is optional.

2 There is a common counter for invalid header, invalid VPI, invalid VCI cell discard.

TABLE 5-6(B)/I.732

Functional decomposition [VP/VC_A // VCME (A to B)]

Level A to B		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VCME	VP/VC_A	VC mux	VC multiplexing				
		Congestion control (Note)	selective cell discard				
		Meta-signalling (Note)	insertion of meta-signalling cells			metasignalling cell processing	FFS

NOTE – This function is optional.

5.7.1.3 Congestion Control

5.7.1.3.1 Transfer function

Selective cell discard according to CLP value.

If a selective cell discard function is present, in the event of congestion, cells with CLP = 1 are subject to be discarded prior to cells with CLP = 0. See Recommendation I.371 for further details about the use of the CLP.

5.7.1.3.2 Layer Management function

For further study.

5.7.1.4 VC demultiplexing

5.7.1.4.1 Transfer function

This function enables the separation of the individual Virtual Channels from their Virtual Paths according to the VCI values.

5.7.2 VP/VC_A // VCME (A to B)

5.7.2.1 VC multiplexing

5.7.2.1.1 Transfer function

This function enables the individual Virtual Channels to be logically combined into their respective Virtual Paths according to the VCI values.

5.7.2.2 Congestion Control

5.7.2.2.1 Transfer function

Selective cell discard according to CLP value.

If a selective cell discard function is present, in the event of congestion, cells with CLP = 1 are subject to be discarded prior to cells with CLP = 0. See Recommendation I.371 for further details about the use of the CLP.

5.7.2.2.2 Layer Management function

5.7.2.3 Metasignalling

5.7.2.3.1 Transfer function

Insertion of metasignalling cell. (Format of the metasignalling cell should be in accordance with Recommendation I.361.)

5.7.2.3.2 Layer Management function

Metasignalling processing is not addressed in this Recommendation (see Recommendation Q.2120).

5.8 VC Link termination (VCL_T) // VC Entity (VCE)

See Table 5-7(A), Figure 5-3(A), Table 5-7(B) and Figure 5-3(B).

TABLE 5-7(A)/I.732

Functional decomposition [VCL_T // VCE (B to A)]

Level B to A		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VCE	VCL_T	VC Usage measurement (Note 2)	detection of cell arrival	cell events CLP value	act/deact	count of incoming cells for CLP = 0 + 1 and CLP = 0	
		VC UPC/NPC (Notes 2 and 4)	VC compliance checking and corrective action if activated	 cell discarding and tagging event	act/deact	traffic descriptor discarded cell count for CLP = 0 + 1 and CLP = 0 tagged cell count	
		Shaping (Notes 2 and 3)	VC traffic shaping		act/deact	traffic descriptor	
		F5 AIS/RDI OAM non-intrusive monitoring	AIS/RDI OAM cell copy	AIS/RDI OAM cell payload	act/deact of F5 AIS/RDI non-intrusive monitoring	F5 AIS/RDI OAM cell processing. Reporting of AIS/RDI state to AEMF	See 6.2.2
		F5 CC OAM non-intrusive monitoring	detection of cell arrival	report cell event	act/deact of F5 CC non-intrusive monitor-ing	Reporting of LOC defect to AEMF	FM11
		F5 PM OAM non-intrusive monitoring (Note 4)	e-t-e and segment PM OAM cell copy	PM OAM cell payload	act/deact of F5 PM non-intrusive monitoring	e-t-e and segment F5 PM OAM cell processing. Reporting of performance results to AEMF	PM8 PM9
		Resource management	resource management cells			resource management cells processing	
		F5 AIS OAM	insertion of F5 AIS OAM cells		AIS OAM cell payload	Insert F5 AIS OAM cells	FM8 FM10 FM11
		extraction of F5 segment CC OAM	extraction of F5 CC OAM cells	extraction of CC OAM cell		Determination and reporting of LOC condition	FM11
		insertion of F5 segment CC OAM	insertion of F5 CC OAM cells		CC OAM cell payload	F5 CC OAM cell generation	
		extraction of F5 segment PM OAM (Note 4)	extraction of F5 segment PM OAM cells	PM OAM cell payload		F5 PM OAM cell processing. Reporting of error measurement	PM10 PM11 PM31

TABLE 5-7(A)/I.732 (*concluded*)

Functional decomposition [VCL_T // VCE (B to A)]

Level B to A		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VCE	VCL_T	Insertion of F5 segment PM OAM	insertion of F5 segment PM OAM cells		PM OAM cell payload	F5 PM OAM cell generation at a segment termination point	PM12 PM30
		F5 loopback at a source point	Seg or e-t-e LB cell insertion	Timer activation	LB cell	LB cell generation is activated by AEMF.	FM23
			Seg or e-t-e LB cell copy or extraction	LB cell	LB detection act	LB cell processing and reporting to AEMF.	FM24
		F5 loopback at a loopback point	F5 Seg LB cell copy or extraction	LB cell		LB cell processing	FM28
			Seg cell insertion		LB cell		FM27
		F5 loopback seg termination	Seg LB cell discarding at OAM seg termination		act/deact with respect to OAM seg termination	Seg LB cell discarding is activated by AEMF	
		Extraction of F5 segment/ e-t-e AD OAM (Note 2)	extraction of F5 segment/ e-t-e AD OAM cells		AD OAM cell payload	F5 AD OAM cell processing	
		Insertion of F5 segment/ e-t-e AD OAM (Note 2)	Insertion of F5 segment/ e-t-e AD OAM cells		AD OAM cell payload	F5 AD OAM cell processing	

NOTES

1 No ordering is implied among AIS/RDI, PM, CC or Loopback functions.

Link termination can become segment terminations by management action. Extraction of OAM segment cells at the terminations of an OAM segment is required by Recommendation I.610.

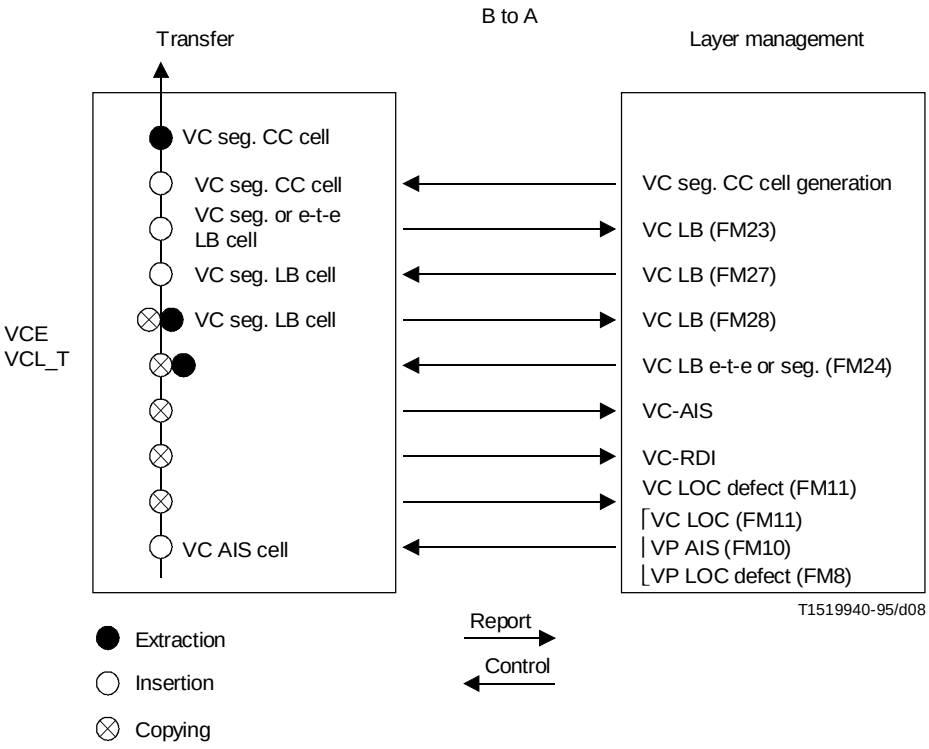
2 This function is optional.

3 – The shaping function may not be present in NE.

– If present, the shaping function can be activated/deactivated in egress side or ingress side per connection.

– The shaping function should not be simultaneously activated on both B to A and A to B of the same connection.

4 For non-conforming cells, there may be potential interference between PM and UPC/NPC actions. This requires further study (see Recommendation I.610).



NOTES

1 No logical order is implied by the sequence of functions in each block.

2 FM numbering refers to Table 6-1.

3 The control for activation/deactivation of these functions are not shown except for the loopback detection and timer activation (FM24).

4 The reports to the AEMF are not shown on this figure.

FIGURE 5-3(A)/I.732

LMIs for VCL_T // VCE (B to A)

TABLE 5-7(B)/I.732

Functional decomposition [(VCL_T // VCE (A to B)]

Level A to B		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VCE	VCL_T	F5 AIS OAM	insertion of F5 OAM cells		AIS OAM cell payload	Insert F5 AIS OAM cells due to LOC	FM16
		extraction of F5 segment CC OAM	extraction of F5 CC OAM cells	extraction of CC OAM cell		Determination and reporting of LOC condition	FM16
		insertion of F5 segment CC OAM	insertion of F5 CC OAM cells		CC OAM cell payload	F5 CC OAM cell generation	
		extraction of F5 segment PM OAM	extraction of F5 segment PM OAM cells	PM OAM cell payload		F5 PM OAM processing. Reporting of error measurement to AEMF	PM17 PM18 PM30
		Insertion of F5 segment PM OAM	Insertion of F5 segment PM OAM cells		PM OAM cell payload	F5 PM OAM cell generation at a segment termination point	PM16 PM31
		F5 loopback at a source point	Seg or e-t-e LB cell insertion Seg or e-t-e LB cell copy or extraction	Timer activation LB cell	LB cell LB detection act	LB cell generation is activated by AEMF LB cell processing and reporting to AEMF	FM24 FM23
		F5 loopback at a loopback point	Seg LB cell copy or extraction Seg cell insertion	LB cell	 LB cell	LB cell processing	FM27 FM28
		F5 loopback seg termin-ation	Seg LB cell discarding at OAM seg termination		act/deact with respect to OAM seg termination	Seg LB cell discarding is activated by AEMF	
		Extraction of F5 segment/ e-t-e AD OAM (Note 2)	Extraction of F5 segment/ e-t-e AD OAM cells	F5 AD OAM cell payload		F5 AD OAM cell processing	

TABLE 5-7(B)/I.732 (*concluded)*

Functional decomposition [(VCL_T // VCE (A to B)]

Level A to B		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VCE	VCL_T	Insertion of F5 segment/ e-t-e AD OAM (Note 2)	Insertion of F5 segment/e-t-e AD OAM cells		F5 AD OAM cell payload	F5 AD OAM cell processing	
		Resource management	resource management cells			resource management cells processing	
		F5 AIS/RDI OAM non-intrusive monitoring	AIS/RDI OAM cell copy	AIS/RDI OAM cell payload	act/deact of F5 AIS/RDI non-intrusive monitoring	F5 AIS/RDI OAM cell processing. Reporting of AIS/RDI state to AEMF	See 6.2.2
		F5 CC OAM non-intrusive monitoring	detection of cell arrival	report cell event	act/deact of F5 CC non-intrusive monitoring	Reporting of LOC defect to AEMF	FM16
		F5 PM OAM non-intrusive monitoring	e-t-e and segment PM OAM cell copy	PM OAM cell payload	act/deact of F5 PM non-intrusive monitoring	e-t-e and segment F5 PM OAM cell processing. Reporting of performance results to AEMF	PM19 PM20
		Usage measuring (Note 2)	detection of cell arrival	cell event CLP value	act/deact	count of outgoing cells per VC for CLP = 0 + 1 and CLP = 0	
		Shaping (Notes 2 and 3)	VC traffic shaping		act/deact	traffic descriptor	
		EFCI (Note 2)	setting of EFCI bit of PTI field for user congestion signalling		act/deact	EFCI generation	
		VCI setting	VCI field setting			VCI translation	

NOTES

1 No ordering is implied among AIS/RDI, PM, CC or Loopback functions.

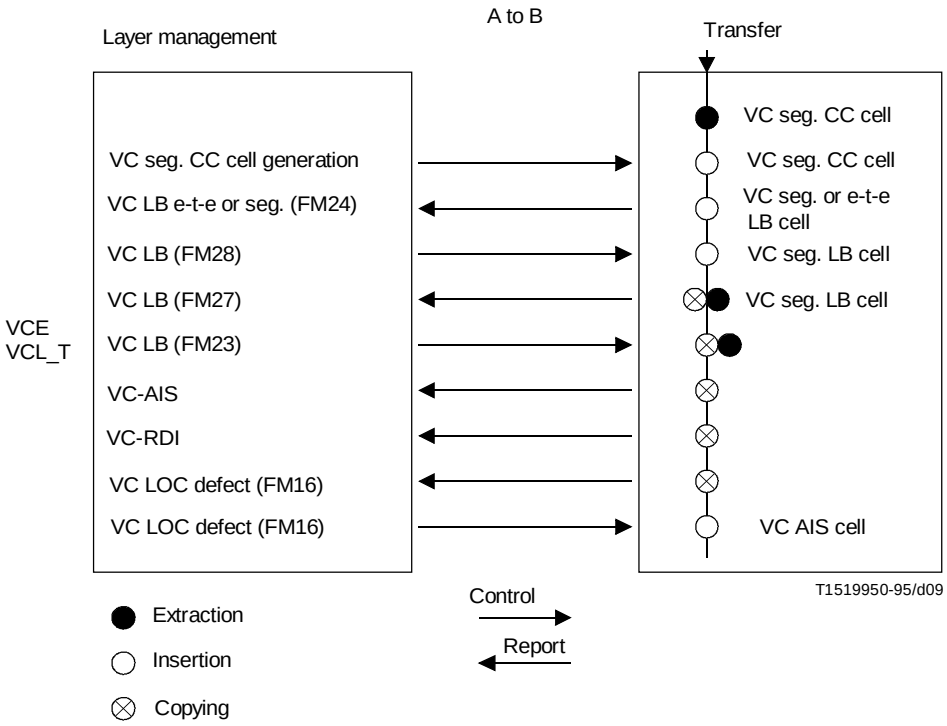
Link termination can become segment terminations by management action. Extraction of OAM segment cells at the terminations of an OAM segment is required by Recommendation I.610.

2 This function is optional.

3 – The shaping function may not be present in NE.

– If present, the shaping function can be activated/deactivated in egress side or ingress side per connection.

– The shaping function should not be simultaneously activated on both B to A and A to B of the same connection.



NOTES

1 No logical order is implied by the sequence of functions in each block.

2 The FM numbering refers to Table 6-1.

3 The control for activation/deactivation of these functions are not shown except for the loopback detection and timer activation (FM23).

4 The reports to the AEMF are not shown on this figure.

FIGURE 5-3(B)/I.732

LMIs for VCL_T // VCE (A to B)

5.8.1 VCL_T // VCE (B to A)

5.8.1.1 VC Usage Measurement

5.8.1.1.1 Transfer function

VCC cell reception is indicated to layer management.

5.8.1.1.2 Layer Management function

Received VCC cells are counted for usage measurement purposes. The following counts shall be maintained:

1) Count of total received VCC cells with CLP = 0 + 1.

2) Count of total received VCC cells with CLP = 0. This count is only maintained when the CLP option is used. See 5.8.1.2 on UPC/NPC.

Measurement results are maintained and reported to the AEMF periodically. Cell counting is activated/deactivated on a per VCC basis by the AEMF.

5.8.1.2 VC UPC/NPC

UPC/NPC may be performed on each VC connection to detect violations of negotiated traffic parameters for the purpose of protecting the QOS of other VCCs. The use of UPC may be required for a VCL_T associated with a VP_T configured as a UNI. The use of NPC is optional for a VCL_T associated with a VP_T configured as an NNI. Actions and requirements of UPC/NPC are described in Recommendation I.371.

NOTE – The use of UPC in ATM equipment on the user side of S_B and T_B reference point is optional.

The VC UPC/NPC function is activated/deactivated by the AEMF.

5.8.1.2.1 Transfer function

VCC cell may be passed, discarded, or tagged (if used), depending on indication from layer management.

5.8.1.2.2 Layer management function

Traffic descriptions are used by the layer management function to determine if connections are in violation of the negotiated traffic parameters. Plane Management is responsible for the setup and modification of the traffic parameters.

The cell loss priority function explicitly identifies the relative loss priority level in the handling of a cell (i.e. its discard eligibility depending on network conditions).

Cells with CLP = 0 are handled by an ATM NE as having higher priority than cells with CLP = 1.

The use of the CLP for Resource Management is described in Recommendations I.371 and I.150. The coding of CLP values is defined in Recommendation I.361. The ATM NE should be capable of interpreting the CLP value for the case of relative discard eligibility of a cell in the event of congestion. However, ATM NEs may not interpret the CLP value in some network applications.

The use of the CLP for the tagging function by the UPC is a network option, and is described in Recommendation I.371. Note that since the same bit is used both for the tagging function by the UPC and explicit CLP indication, the discard eligibility of the UPC tagged cells is the same as that of user set CLP = 1 cells from the equipment perspective.

When the UPC/NPC is activated, the following counts shall be maintained and reported to the AEMF periodically:

1) *Count of discarded cells with CLP = 0 + 1*

   A count of cells discarded due to UPC/NPC policing of combined CLP = 0 and CLP = 1 traffic.

2) *Count of discarded cells with CLP = 0*

   A count of CLP = 0 cells discarded due to UPC/NPC policing of CLP = 0 only traffic. This count is maintained only when the CLP option is used.

3) *Count of cells tagged by the UPC/NPC function*

   A count of cells with CLP = 0 that were tagged (i.e. CLP reset to 1) by the UPC/NPC. This count is maintained only when the CLP tagging option is used.

5.8.1.3 Traffic shaping

5.8.1.3.1 Transfer function

The shaping function may not be present in the ATM NE. The shaping function can be activated/deactivated in ingress side or egress side per connection.

If present, the use of traffic shaping should be in accordance with Recommendation I.371.

5.8.1.3.2 Layer Management function

If present, the function may be activated/deactivated egress or ingress side per connection.

The traffic shaping function should not be activated simultaneously on both the B-to-A and A-to-B directions of the same connection.

5.8.1.4 F5 OAM cell non-intrusive monitoring

Non-intrusive monitoring provides a capability for assessing the status (e.g. AIS/RDI state). The connectivity, or performance of a VC end-to-end connection or connection segment at intermediate points of the connection. The defined non-intrusive monitoring functions are: VC AIS/RDI state detection, Loss of Continuity defect detection, and connection performance monitoring. These functions may be activated/deactivated separately per connection by the AEMF. They are "non-intrusive" in the sense that, when activated, the ATM cell transfer performance of the connection should not be affected.

5.8.1.4.1 Transfer function

1) *VC-AIS/VC-RDI*

   VC-AIS cells and VC-RDI cells are detected and copied when F5 AIS/RDI non-intrusive monitoring is activated. F5 AIS/RDI non-intrusive monitoring is activated/deactivated by the AEMF.

2) *Continuity Check (CC) cell*

   CC cells and user cells are detected when F5 CC non-intrusive monitoring is activated. F5 CC non-intrusive monitoring is activated/deactivated by the AEMF.

3) *Performance Monitoring (PM) cell non-intrusive monitoring*

   PM cells are copied when F5 PM non-intrusive monitoring is activated. F5 PM non-intrusive monitoring is activated/deactivated by the AEMF.

5.8.1.4.2 Layer management function

1) *VC-AIS/VC-RDI*

   When activated, VC-AIS state is declared when one VC-AIS cell is detected. The VC-AIS state is removed when a user cell or CC cell is received.

   When activated, VC-RDI state is declared when one VC-RDI cell is detected. The VC-RDI state is removed when no VC-RDI cells are detected for nominally 2.5 seconds with a margin of ± 0.5 seconds.

   Declaration and removal of VC-AIS/RDI state is sent to the AEMF.

2) *Continuity check (CC)*

   Loss of Continuity (LOC) defect is declared when any user cell or CC cell is not received within a time interval of 3.5 seconds with a margin of ± 0.5 seconds. LOC defect is removed when any user cell or CC cell is received. Declaration and removal of LOC defect is sent to the AEMF.

3) *Performance monitoring (PM)*

   Performance Monitoring (PM) of end-to-end and segment VCC is done by PM cells over the end-to-end and segment VCC respectively when activated by AEMF. Performance monitoring of the end-to-end and segment VCC is stopped if deactivated by AEMF. A block error result and a total received user cell count may be detected. The performance monitoring results are sent to the AEMF. Backward reporting of performance monitoring results is not provided in the case of non-intrusive monitoring.

5.8.1.5 Resource management

For further study.

5.8.1.6 F5 OAM insertion/extraction and processing

5.8.1.6.1 Transfer function

1) *VC-AIS*

   VC-AIS cells are inserted if VC-AIS cells are generated in layer management function.

2) *Segment Continuity Check (CC)*

   Segment CC cells are inserted and extracted when CC is activated by an Activation/Deactivation (AD) cell or by request from AEMF.

3) *Segment Performance Monitoring (PM)*

Segment PM cells are inserted and extracted when PM is activated by an AD cell or the request from AEMF.

4) *Loopback (LB)*

At a source point:

a) Segment or e-t-e LB cell is inserted when requested by AEMF.

b) Segment or e-t-e LB cell is copied or optionally extracted when FM24 is activated and LB cell is detected. This LB cell had been previously inserted by the corresponding A to B VCE block.

At a loopback point:

A Segment LB cell is copied or optionally extracted when LB conditions occurs (see Recommendation I.610). The extraction option might be enabled/disabled on request from AEMF.

A Segment LB cell is inserted when Segment LB cell has to be looped from the reverse direction [VCL_T (A to B)].

At an OAM segment termination:

Segment LB cell is discarded.

5) *Segment Activation/Deactivation (AD)*

The Segment AD cell is inserted when AD cell generation is requested by AEMF. The Segment AD cell is extracted at the associated segment end-point.

5.8.1.6.2 Layer management function

1) *VC-AIS*

If a VP-AIS state is declared or a VP/VC LOC defect is declared, VC-AIS cells shall be generated for all affected active VCCs. VC-AIS cells are generated as soon as possible after defect declaration. VC-AIS generation condition is in accordance with Recommendation I.610. VC-AIS cells are generated during the defect condition. Generation frequency of VC-AIS cells is nominally one cell per second. VC-AIS cell generation shall be stopped as soon as the defect is removed.

2) *Segment CC*

If segment CC is activated, segment CC cell is generated when no user cell is received for a period of nominally 1 second. CC cells can also be sent repetitively with a periodicity of nominally 1 cell per second independent of the user cell flow.

Loss of Continuity (LOC) defect is declared when any user cell or CC cell is not received within a time interval of 3.5 seconds with a margin of ± 0.5 seconds. VC-AIS generation due to LOC defect is initiated. LOC defect is removed when any user cell or CC cell is received. Declaration and removal of LOC defect is sent to the Plane Management.

3) *Segment PM*

If segment PM is activated, segment PM cells are generated. A monitoring cell sequence number, total user cell number, and block error detection code (BIP-16) are calculated from a block of user cells and placed in corresponding fields of the monitoring cell. The calculation method shall be in accordance with Recommendation I.610. A block error result and a total received cell count are placed in corresponding fields in the monitoring cell for backward reporting.

Performance of VCC segment is derived from the comparison between received block of user cells and information in a received PM cell. The comparison method shall be in accordance with Recommendation I.610. PM will determine errored blocks and lost/misinserted cell counts. Performances or backward report results of the received PM cell are sent to the AEMF.

4) *Loopback (LB)*

At a source point:

a) Segment or e-t-e LB cell are generated in accordance with Recommendation I.610 (LI, CT, LLID, SID) when requested by AEMF. The LMI FM23 is activated.

b) If a segment or e-t-e LB cell with the CT matching that of the generated LB cell and with the LI set to "0" is received within 5 seconds after the generation, the LB is successful. The LB results are sent to the AEMF.

At a loopback point:

When a Segment LB cell with the LLID matching the ID of the received point and with the LI set to "1" is received, FM28 is activated and the received LB cell is given to reverse direction [VCL_T (A to B)] after the LI is set to "0".

At an OAM segment termination:

At the termination of an OAM segment, segment LB cell should be discarded (see Recommendation I.610).

5) *Segment AD*

A Segment AD cell is generated to request the activation/deactivation of PM or CC process at the remote segment end-point, when the generation is requested by AEMF. When an associated response AD cell with the correlation tag matching that of the generated AD cell is received its result (request confirmed or denied) is sent to the AEMF.

When an AD cell to request the activation/deactivation from the remote segment end-point is received, the activation/deactivation request is sent to the AEMF. After the response (request confirmed or denied) to the request is received from the AEMF, the response AD cell is generated.

5.8.2 VCL_T // VCE (A to B)

5.8.2.1 F5 OAM cell

5.8.2.1.1 Transfer function

1) *VC-AIS*

VC-AIS cells are inserted if VC-AIS cells are generated in layer management function due to a LOC.

2) *Segment Continuity Check (CC)*

Segment CC cells are inserted and extracted when CC is activated by Activation/Deactivation (AD) cell or the request from AEMF.

3) *Segment PM*

Segment PM cells are inserted and extracted when PM is activated by AD cell or the request from AEMF.

4) *Loopback (LB)*

At a source point :

a) Segment or e-t-e LB cell is inserted when requested by AEMF.

b) Segment or e-t-e LB cell is copied or optionally extracted when FM23 is activated and LB cell is detected. This LB cell had been previously inserted by the corresponding B to A VCE block.

At a loopback point:

A Segment LB cell is copied or optionally extracted when LB conditions occurs (see Recommendation I.610). The extraction option might be enabled/disabled on request from AEMF.

A Segment LB cell is inserted when Segment LB cell has to be looped from the reverse direction [VCL_T (A to B)].

At an OAM segment termination:

Segment LB cell is discarded.

5) *Segment Activation/Deactivation (AD)*

Segment AD cell is inserted when AD cell generation is requested by AEMF. Segment AD cell is extracted when it is inserted at the associated segment end-point.

5.8.2.1.2 Layer management function

1) *VC-AIS generation*

If a LOC defect is declared, VC-AIS cells shall be generated for all affected active VCCs. VC-AIS cells are generated as soon as possible after LOC defect declaration. VC-AIS generation condition shall be in accordance with Recommendation I.610. VC-AIS cells are generated during the defect condition. Generation frequency of VC-AIS cells is nominally one cell per second. VC-AIS cell generation shall be stopped as soon as the defect is removed.

2) *Segment CC*

If segment CC is activated, segment CC cell is generated when no user cell is received for a period of nominally 1 second. CC cells can also be sent repetitively with a periodicity of nominally 1 cell per second independent of the user cell flow.

Loss of Continuity (LOC) defect is declared when any user cell or CC cell is not received within a time interval of 3.5 seconds with a margin of ± 0.5 seconds. VC-AIS generation due to LOC defect is initiated. LOC defect is removed when any user cell or CC cell is received. Declaration and removal of LOC defect is sent to the AEMF.

3) *Segment PM*

If segment PM is activated, segment PM cells are generated. A monitoring cell sequence number, total user cell number, and block error detection code (BIP-16) are calculated from a block of user cells and placed in corresponding fields of the monitoring cell. The calculation method shall be in accordance with Recommendation I.610. A block error result and a total received cell count are placed in corresponding fields in the monitoring cell for backward reporting.

Performance of VCC segment is derived from the comparison between received block of user cells and information in a received PM cell. The comparison method shall be in accordance with Recommendation I.610. PM will determine errored blocks and lost/misinserted cell counts. Performances or backward report results of the received PM cell are sent to the AEMF.

4) *Loopback (LB)*

At a source point:

a) Segment or e-t-e LB cell are generated in accordance with Recommendation I.610 (LI, CT, LLID, SID) when requested by AEMF. The LMI FM24 is activated.

b) If a segment or e-t-e LB cell with the CT matching that of the generated LB cell and with the LI set to “0” is received within 5 seconds after the generation, the LB is successful. The LB results are sent to the AEMF.

At a loopback point:

When a Segment LB cell with the LLID matching the ID of the received point and with the LI set to “1” is received, FM27 is activated and the received LB cell is given to reverse direction [VCL_T (A to B)] after the LI is set to “0”.

At an OAM segment termination:

At the termination of an OAM segment, segment LB cell should be discarded (see Recommendation I.610).

5) *Segment AD*

A Segment AD cell is generated to request the activation/deactivation of PM or CC process at the remote segment end-point, when the generation is requested by AEMF. When an associated response AD cell with the correlation tag matching that of the generated AD cell is received, its result (request confirmed or denied) is sent to the AEMF.

When an AD cell to request the activation/deactivation from the remote segment end-point is received, the activation/deactivation request is sent to the AEMF. After the response (request confirmed or denied) to the request is received from the AEMF, the response AD cell is generated.

5.8.2.2 Resource management

For further study.

5.8.2.3 F5 OAM non-intrusive monitoring

The transfer and layer management functions for F5 non-intrusive monitoring are the same as in the B-to-A direction. See 5.8.1.4.

5.8.2.4 VC Usage Measurement

5.8.2.4.1 Transfer function

VCC cell reception and CLP value are indicated to layer management.

5.8.2.4.2 Layer Management function

Outgoing VCC cells are counted for usage measurement purposes. The following counts shall be maintained:

1) Count of total outgoing VCC cells with CLP = 0 + 1.

2) Count of total outgoing VCC cells with CLP = 0. This count is only maintained when the CLP option is used. See Section 5.8.1.2 on UPC/NPC.

Measurement results are maintained and reported to the AEMF periodically. Cell counting is activated/deactivated on a per VCC basis by the AEMF.

5.8.2.5 EFCI setting

In the event of congestion, this function, if activated, sets PTI values in accordance with Recommendation I.361.

5.8.2.6 VCI setting

5.8.2.6.1 Transfer function

The VCI value is processed in accordance with the assigned values.

5.8.2.6.2 Layer Management function

At the UNI/NNI a total of up to 16 bits are available for VCI as defined in Recommendation I.361. The actual number of active VCI bits may be reduced by negotiation, e.g. in order to reduce interface costs.

The ATM NE associates a unique VCI value for each VC link per VP.

The rules for allocation of the VPI/VCI bits and the preassigned values are specified in Recommendation I.361. It should be noted that the VPI/VCI values are to be assigned bidirectionally.

All ATM NE shall comply with the allocation rules and pre-assigned values.

In addition to the pre-assigned VPI/VCI values given in Recommendation I.361, some Network Providers may optionally pre-assign additional values for specific functions. Since, in this case these values are not generally available to the user, mutual negotiation may be necessary to ensure compatible ranges of VPI/VCI values between different Network Providers and users.

From the ATM Equipment perspective, this procedure is similar to the negotiated reduction of the number of active VPI/VCI values (range) to minimize complexity per interface.

The need to standardize a minimum number of VPI/VCI values per interface rate is for further study.

5.9 VC Connection (VC_C) // VC Connection Entity (VC_C)

See Table 5-8.

TABLE 5-8/I.732

Functional decomposition (VC_C)

Level		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VC_C	VC_C	Link inter-connection	interconnection of VC links			association of VC links	

5.9.1 VC link interconnection

5.9.1.1 Transfer function

This function assigns VC links at input ports to VC links at output ports.

5.9.1.2 Layer Management function

The assignment of an incoming VC link to an outgoing VC link interconnection requires the association between incoming port number and VCI value and outgoing port number and VCI value. VC link interconnection is done by relaying cells in accordance with the port numbers and VCI values.

The VC connection process is a unidirectional function and may support point-to-point, point-to-multipoint, and broadcast VC connections.

5.10 VC Termination (VC_T) // VC Connection Termination (VCCT)

See Table 5-9(A), Figure 5-4(A), Table 5-9(B) and Figure 5-4(B).

5.10.1 VC_T // VCCT (B to A)

5.10.1.1 End-to-end F5 OAM extraction and processing

5.10.1.1.1 Transfer function

Extraction of end-to-end F5 OAM flows is required for the following functions.

1) *VC-AIS/VC-RDI*
2) *End-to-end CC*
3) *End-to-end PM*
4) *Loopback (LB)*

   At a source point:

   E-t-e LB cell is extracted. This LB cell had been previously inserted by the corresponding A-to-B VCCT block.

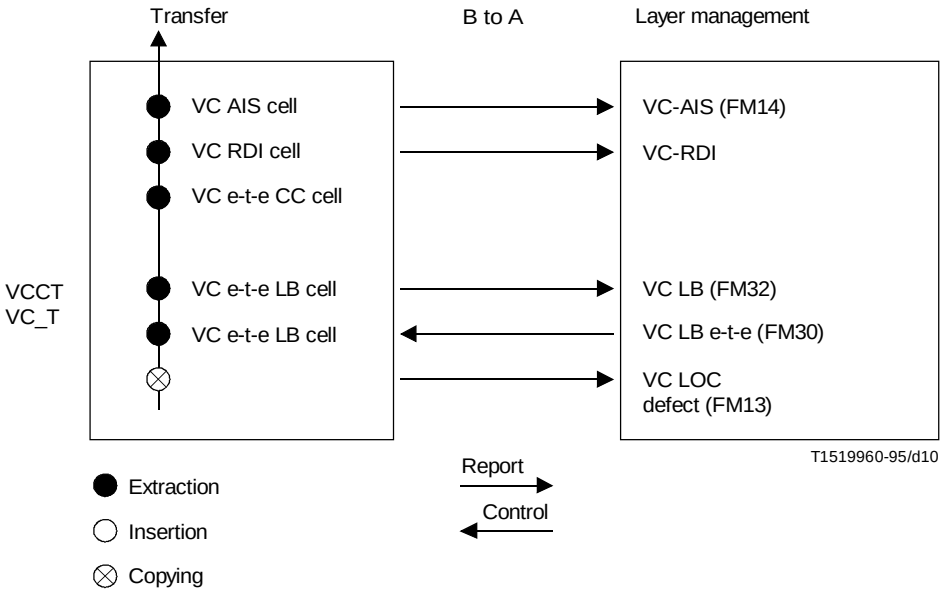
   At a loopback point:

   E-t-e LB cell is extracted.
5) *End-to-end AD*

TABLE 5-9(A)/I.732

Functional decomposition [VC_T // VCCT (B to A)]

Level B to A		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VCCT	VC_T	The processing of ATM header fields for information to be passed between ATM layer and higher layers (PTI field, CLP field, see Rec. I.361)				FFS	
		Resource management	resource management cells			resource management cells processing	
		F5 OAM: AIS, RDI, CC and PM	extraction of F5 OAM cells	OAM cell payload		F5 OAM cell processing (Note) perf. monitoring VC-RDI VC-AIS continuity check	FM13, FM14 PM13, PM14 PM32
		F5 loopback at a source point	e-t-e LB cell extraction	LB cell	Always activated	LB cell processing and reporting to AEMF when FM30 is activated	FM30
		F5 loopback at a loopback point	e-t-e LB cell extraction	LB cell	Always activated	LB cell processing	FM32
NOTE – No ordering is implied among AIS/RDI, PM, CC or Loopback functions.							



NOTES

1 No logical order is implied by the sequence of functions in each block.

2 FM numbering refers to Table 6-1.

3 The control for activation/deactivation of these functions are not shown except for the loopback detection and timer activation (FM30).

4 The reports to the AEMF are not shown on this figure.

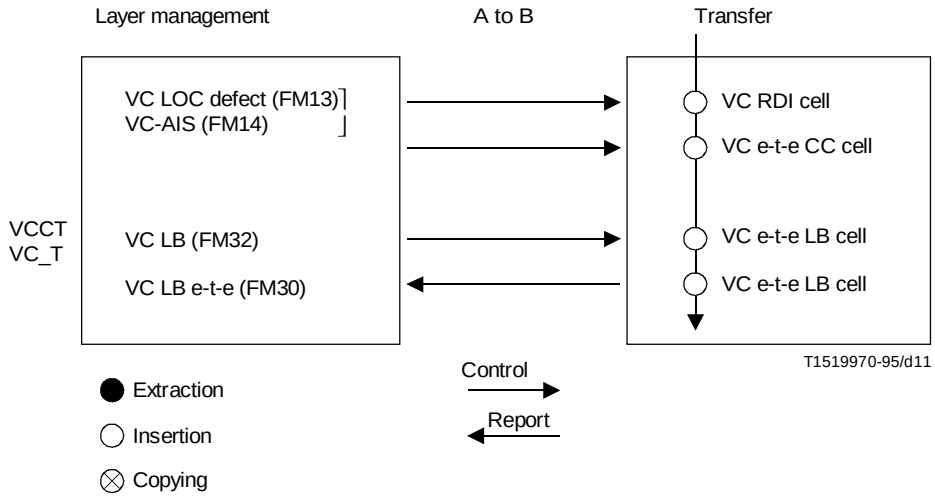
FIGURE 5-4(A)/I.732

LMIs for VC_T // VCCT (B to A)

TABLE 5-9(B)/I.732

Functional decomposition [VC_T // VCCT (A to B)]

Level A to B		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
VCCT	VC_T	The processing of ATM header fields for information to be passed between ATM layer and higher layers (PTI field, CLP field, see Rec. I.361).					
		Resource management	resource management cells			resource management cells processing	
		F5 OAM: AIS, RDI, CC and PM.	insertion of F5 OAM cells		OAM cell payload	F5 OAM cell processing (Note) perf. monitoring VC-RDI continuity check	FM13 FM14 PM15 PM32
		F5 loopback at a source point	e-t-e LB cell insertion	timer activation	LB cell	LB cell generation is activated by AEMF	FM30
		F5 loopback at a loopback point	e-t-e LB cell insertion		LB cell		FM32
NOTE – No ordering is implied among AIS/RDI, PM, CC or Loopback functions.							



NOTES

1 No logical order is implied by the sequence of functions in each block.

2 The FM numbering refers to Table 6-1.

3 Not relevant.

4 The reports to the AEMF are not shown on this figure.

FIGURE 5-4(B)/I.732

LMIs for VC_T // VCCT (A to B)

5.10.1.1.2 Layer management function

1) *VC-AIS/RDI*

VC-AIS state is declared when one VC-AIS cell is detected. The VC-AIS state is removed when a user cell or CC cell is received. If CC is not activated, the VC-AIS state is also released if VC-AIS cells are absent for nominally 2.5 seconds with a margin of ± 0.5 seconds. VC-RDI state is declared when one VC-RDI cell is detected. The VC-RDI state is removed when no VC-RDI cells are detected for nominally 2.5 seconds with a margin of ± 0.5 seconds. Declaration and removal of VC-AIS/RDI state is sent to the AEMF.

2) *End-to-end CC*

If end-to-end CC is activated, Loss of Continuity (LOC) defect is declared when any user cell or CC cell is not received within a time interval of 3.5 seconds with a margin of ± 0.5 seconds. LOC defect is removed when any user cell or CC cell is received. Declaration and removal of LOC defect is sent to the AEMF.

3) *End-to-end PM*

If end-to-end PM is activated, performance of end-to-end VCC is derived from the comparison between received block of user cells and information in a received PM cell. The comparison method shall be in accordance with Recommendation I.610. PM will detect errored blocks and total received user cell counts. Performances or backward report results of the received PM cell are sent to the AEMF.

4) *Loopback (LB)*

At a source point:

If an e-t-e LB cell with the CT matching that of the generated LB cell and with the LI set to "0" is received within 5 seconds after the generation, the LB is successful. The LB results are sent to the AEMF.

At a loopback point:

When an e-t-e LB cell with the LLID matching the ID of the received point or equal to "All 1" and with the LI set to "1" is received, FM32 is activated and the received LB cell is given to reverse direction [VC_T (A to B)] after the LI is set to "0".

5) *End-to-end Activation/Deactivation*

If the Activation/Deactivation (AD) cell process is present in accordance with Recommendation I.610, the following functions are performed.

When a response AD cell with the correlation tag matching that of the generated AD cell is received, its result (request confirmed or denied) is sent to the AEMF.

When a AD cell to request activation/deactivation from the remote VCC end-point is received, the activation/deactivation request is sent to the AEMF.

5.10.2 VC-T // VCCT (A to B)

5.10.2.1 End-to-end F5 OAM insertion

5.10.2.1.1 Transfer function

Insertion of end-to-end F5 OAM flows is required for the following functions.

1) *VC-RDI*
2) *End-to-end CC*
3) *End-to-end PM*
4) *Loopback (LB)*

At a source point:

E-t-e LB cell is inserted when requested by AEMF.

At a loopback point:

An e-t-e LB cell is inserted when Segment LB cell has to be looped from the reverse direction [VCL_T (A to B)].

5) End-to-end AD

5.10.2.1.2 Layer management function

1) *VC-RDI*

VC-RDI cells shall be generated as soon as a VC level defect (VC-AIS state declaration, Loss of Continuity) of the reverse direction is detected. VC-RDI cells are generated periodically during the defect condition. Generation frequency of VC-RDI cells is nominally one cell per second. VC-RDI generation shall be stopped as soon as the defect condition is removed.

2) *End-to-end CC*

If end-to-end CC is activated, end-to-end CC cell is generated when no user cell is received for a period of nominally 1 second. CC cells can also be sent repetitively with a periodicity of nominally 1 cell per second independent of the user cell flow.

3) *End-to-end PM*

If end-to-end PM is activated, end-to-end PM cells are generated. A monitoring cell sequence number, total user cell numbers, and block error detection code (BIP-16) are calculated from a block of user cells and placed in corresponding fields of the PM cell. The calculation method is in accordance with Recommendation I.610. A block error result and a total received user cell count are placed in corresponding fields in the backward reporting monitoring cell.

4) *Loopback (LB)*

At a source point:

E-t-e LB cell are generated in accordance with Recommendation I.610 (LI, CT, LLID, SID) when requested by AEMF. The LMI FM30 is activated.

At a loopback point:

When an e-t-e LB cell with the LLID matching the ID of the received point or equal to "All 1s" and with the LI set to "1" is received, FM32 is activated and the received LB cell is given to reverse direction [VC_T (A to B)] after the LI is set to "0".

5) *End-to-end Activation/Deactivation*

If the activation/deactivation cell process is present the following function is performed.

End-to-end AD cell is generated to request activation/deactivation of PM or CC process at the remote VCC end-point, when the generation is requested by AEMF or the end-user.

5.11 AAL

See Table 5-10.

TABLE 5-10/I.732

Functional decomposition (AAL)

Level		Function	Transfer function			Layer Management function	CoF LMI
PRM	Rec. I.326		Description	Report to LM	Control from LM	Description	
AAL	AAL	– SAR – CPCS – SSCS (Rec. I.363)	– AAL 1 – AAL 2 – AAL 3/4 – AAL 5 – SAAL				

5.12 Multicast/Multipoint requirements

The ATM Switch/Cross connect should be capable of supporting such a point-to-multipoint (multicast) function on a given number of connections.

The point-to-multipoint connections may be established by management plane communications (Service Provisioning) and/or on-demand signalling mechanisms (see Recommendation Q.2971).

The cell sequence integrity of the source should be maintained for the point-to-multipoint connections.

The point-to-multipoint connections may be unidirectional. Requirements for bidirectional point-to-multipoint connection is further study. (For example, for the case of bidirectional point-to-multipoint connections the return peak cell rate on the root link may be required not to exceed the sum of the return peak cell rates on all the leaf ATM links to maintain suitable cell loss performance for the overall connection.)

The ATM links (VPL, VCL) for a point-to-multipoint connection should be of the same type for both the root and leaf links.

The maximum number of leaf ATM links for a given point-to-multipoint connection (either provisioned or on-demand signalled) depends on the network application to a significant extent and is therefore a service provider option, subject to bandwidth and/or resource constraints. However, the ATM NE may support the use of any ingress ATM link (VPL or VCL) on any ingress transmission path as the root link of a point-to-multipoint connection to any combination of leaf ATM links (VPL or VCL) on separate egress transmission paths, subject to the previously stated constraints.

A multipoint-to-multipoint (mpt-mpt) connection is for further study.

The functional requirements for the OAM of point-to-multipoint and multipoint-to-multipoint connections is for further study (see Recommendation I.610).

5.13 Service dependent functions

For further study.

5.14 Interworking requirements

For further study.

6 Coordination Function

The Coordination Function (CoF) provides the following functions:

1) communications between:
   - Layer Management (LM) blocks;
   - the AEMF and LM blocks;
   - the Signalling Applications and LM blocks;

   to support:
   a) configuration management;
   b) fault management;
   c) performance management;
   d) accounting management;
   e) security management.
2) Connection Admission Control (CAC).
3) Appropriate selection and distribution of timing information.

The communications consist of:

1) Layer Management Indications (LMIs) which represent the control and report relations between the CoF and LM blocks.
2) AEMF indications which represent the control and report relations between the AEMF and the CoF.

6.1 Configuration Management

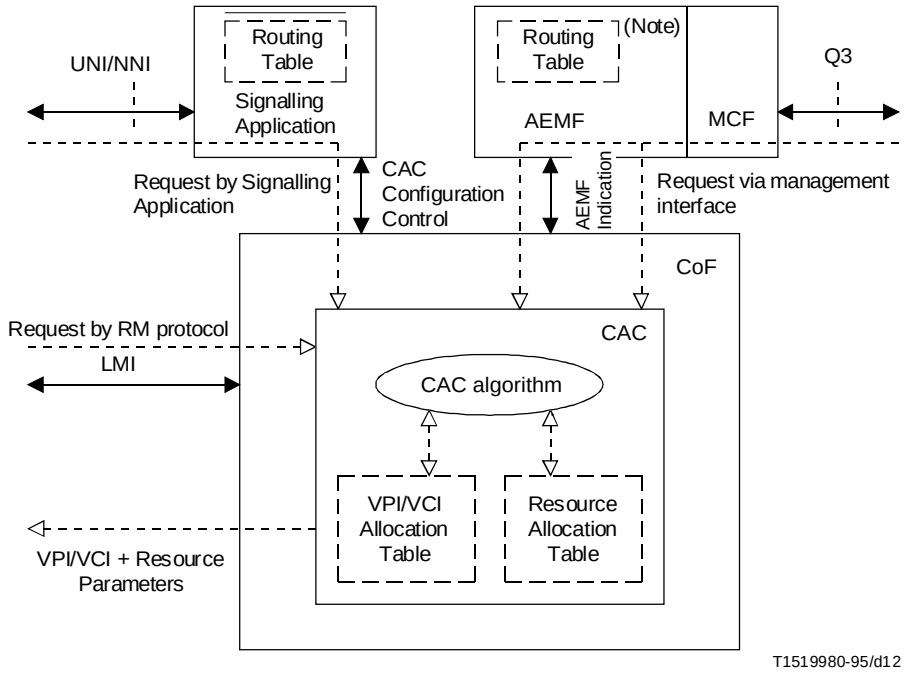
In an ATM NE, a request to establish or release a given VP or VC connection with given bandwidth/QOS parameters may be initiated independently by both the AEMF via the management interface (e.g. Q3) and the Signalling Application. Modification of Bandwidth/QOS parameters may be initiated by the management interface, the Signalling Application or the Resource Management (RM) protocol. The assignment of NE resources to a connection derived from negotiated or renegotiated traffic and QOS parameters is the responsibility of the CAC function in accordance with Recommendation I.371. The CAC function described below relates to the NE, and is a subset of a network level connection admission policy. The routing functions are therefore not included in the NE level CAC. The CAC algorithm used by the ATM NE is implementation specific.

The relationship of the CAC element to the other elements is modelled as shown in Figure 6-1.

6.1.1 Connection Admission Control

6.1.1.1 Procedures

The CAC function may be configured by the AEMF (e.g. via the management interface) for the partitioning of the Transmission Path (TP) bandwidth based on a number of general criteria as described in 6.1.1.2. The configuration procedures and algorithm of the CAC are implementation specific.



NOTE – For a cross-connect NE, the Routing Tables may be accessible to AEMF.

FIGURE 6-1/I.732

ATM NE CAC functional model

In all cases (AEMF request, signalling application request, and RM request as shown in Figure 6-1), the CAC function derives the appropriate TP bandwidth to be assigned to the connection to satisfy the negotiated QOS requirements. If the appropriate bandwidth is available, then the request is accepted, and the resource allocation table is updated. If the appropriate bandwidth is not available, the CAC function may reject the request. On connection release, the CAC updates the resource allocation table. The CAC function may be configured to allow statistical multiplexing capability depending on network operator policy.

6.1.1.2 Partitioning parameters

As noted above, the AEMF may configure the CAC to logically partition TP bandwidth in accordance with a number of general parameters, depending on network applications, service requirements, and customer profile. Although no restrictions on the number of partitions need to be specified, the consequences of bandwidth fragmentation on management complexity and efficient use of resources need to be considered. Congestion threshold(s) may be associated with any given partition.

The partitioning is non-hierarchical and may be identified by attribute(s) such as:

1) partition identifier (e.g. character string);
2) one or a combination of partition type such as:
   - connection type;
   - service classes;
   - traffic/QOS descriptors;
3) partition size (see Recommendation I.751).

6.1.2 Layer Management Indication

The CAC sends a control LMI to LM Plane to configure the LM functions (e.g. UPC/NPC).

6.1.3 AEMF indication

AEMF indications include:

1) The configuration parameters in accordance with Recommendation I.751.
2) The CAC parameters.

6.1.4 Signalling Application Indication

The Signalling Application Indication indicates the configuration parameters in accordance with DSS 2 (Recommendation Q.2931) and B-ISUP (Recommendations Q.2761-Q.2764).

6.2 Fault management

The fault management indications are related to the fault management functions in accordance with Recommendations I.610, G.783 and G.784.

6.2.1 Layer management indications

The layer management indications for fault management are listed and described in Table 6-1. These LMIs are shown in Figure 6-2.

6.2.2 AEMF indications

The LMIs are for further study.

6.2.3 Activation and deactivation cells

The LMIs are for further study.

6.3 Performance Management

6.3.1 Layer Management Indication

The Layer Management Indications (LMIs) for Performance Management (PM) are enumerated and described in Table 6-2. These LMIs are shown in Figure 6-3.

PM processing includes both forward monitoring and backward reporting.

6.3.2 AEMF Indication

Parameters in the AEMF indication for the support of PM function in accordance with Recommendation I.610 include the following:

1) VPC/VCC identifier;
2) segment or end-to-end;
3) direction (B to A or A to B);
4) insertion, extraction, or non-intrusive monitoring;
5) block size;
6) the activation or deactivation of forward monitoring and/or backward reporting.

6.3.3 Activation and Deactivation Cells

The LMIs and AEMF indications are for further study.

6.4 Accounting Management

For further study.

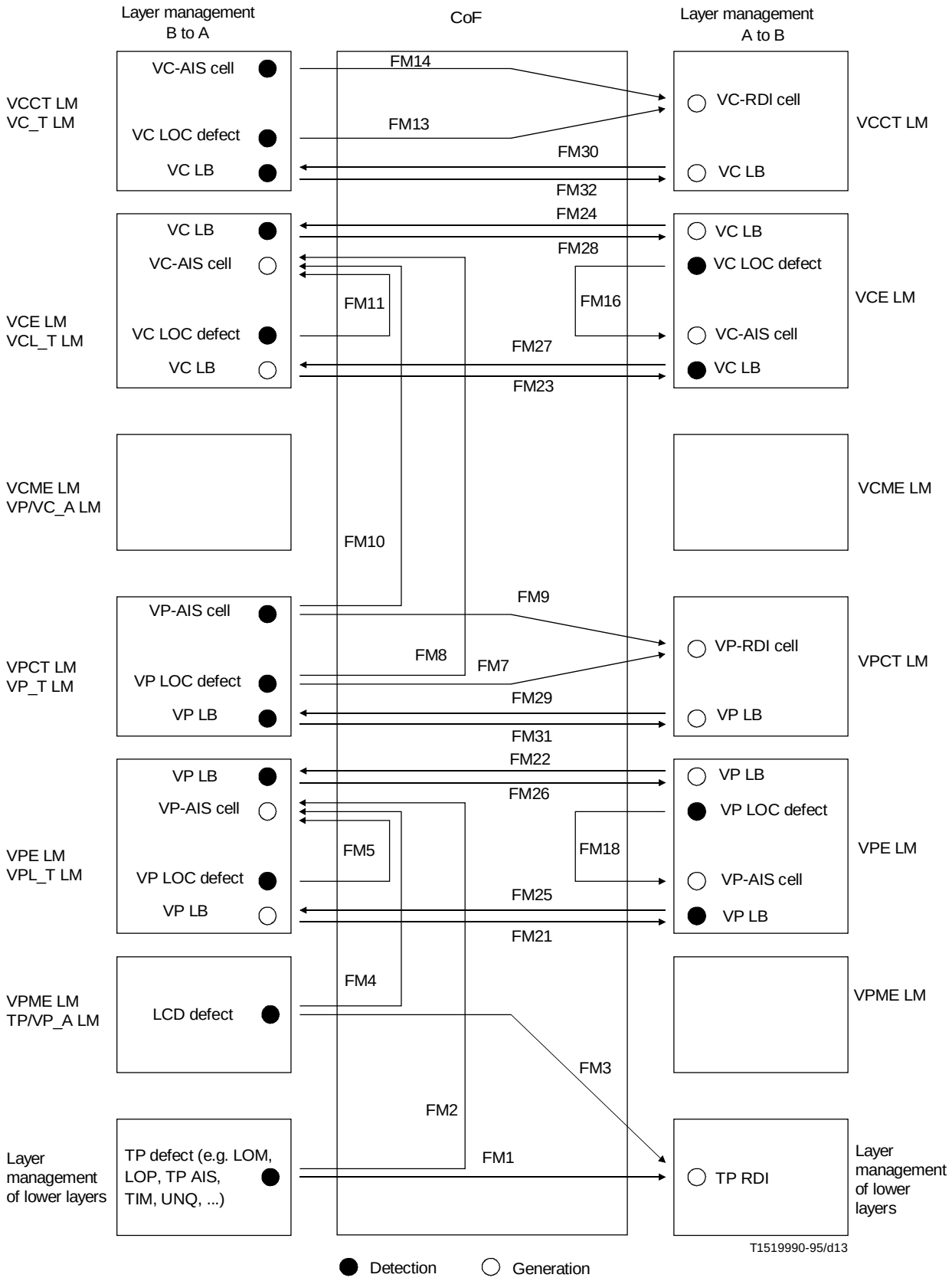
6.5 Security Management

For further study.

TABLE 6-1/I.732

LMIs for FM

LMI	Description	Status
FM1	TP-RDI generation in accordance with Recommendations G.783 and G.784	Present for SDH or PDH interfaces
FM2	VP-AIS generation due to TP defect	Present
FM3	TP-RDI generation due to LCD defect	Present
FM4	VP-AIS generation due to LCD defect	Present
FM5	VP-AIS generation due to VP-LOC defect	Present if Continuity Check is implemented
FM7	VP-RDI generation due to VP-LOC defect	Present if Continuity Check is implemented
FM8	VC-AIS generation due to VP-LOC defect	Present if Continuity Check is implemented
FM9	VP-RDI generation due to VP-AIS detection	Present
FM10	VC-AIS generation due to VP-AIS detection	Present
FM11	VC-AIS generation due to VC-LOC defect	Present if Continuity Check is implemented
FM13	VC-RDI generation due to VC-LOC defect	Present if Continuity Check is implemented
FM14	VC-RDI generation due to VC-AIS detection	Present
FM16	VC-AIS generation due to VC-LOC defect	Present if Continuity Check is implemented
FM18	VP-AIS generation due to VP-LOC defect	Present if Continuity Check is implemented
FM21	VP LB detection and timer activation in A to B due to VP LB generation in B to A at a source point	Present if LB is implemented
FM22	VP LB detection and timer activation in B to A due to VP LB generation in A to B at a source point	Present if LB is implemented
FM23	VC LB detection and timer activation in A to B due to VC LB generation in B to A at a source point	Present if LB is implemented
FM24	VC LB detection and timer activation in B to A due to VC LB generation in A to B at a source point	Present if LB is implemented
FM25	VP LB generation in B to A due to VP LB detection in A to B at a loopback point	Present if LB is implemented
FM26	VP LB generation in A to B due to VP LB detection in B to A at a loopback point	Present if LB is implemented
FM27	VC LB generation in B to A due to VC LB detection in A to B at a loopback point	Present if LB is implemented
FM28	VC LB generation in A to B due to VC LB detection in B to A at a loopback point	Present if LB is implemented
FM29	VP LB detection and timer activation in B to A due to VP LB generation in A to B at a source point	Present if LB is implemented
FM30	VC LB detection and timer activation in B to A due to VC LB generation in A to B at a source point	Present if LB is implemented
FM31	VP LB generation in A to B due to VP LB detection in B to A at a loopback point	Present if LB is implemented
FM32	VC LB generation in A to B due to VC LB detection in B to A at loopback point	Present if LB is implemented
NOTE – There is no significance in the non-contiguous numbering scheme.		



NOTE – Filtering of LMIs due to the same root defect is implementation dependent (e.g. VP-AIS generation caused by FM2, FM4, FM5).

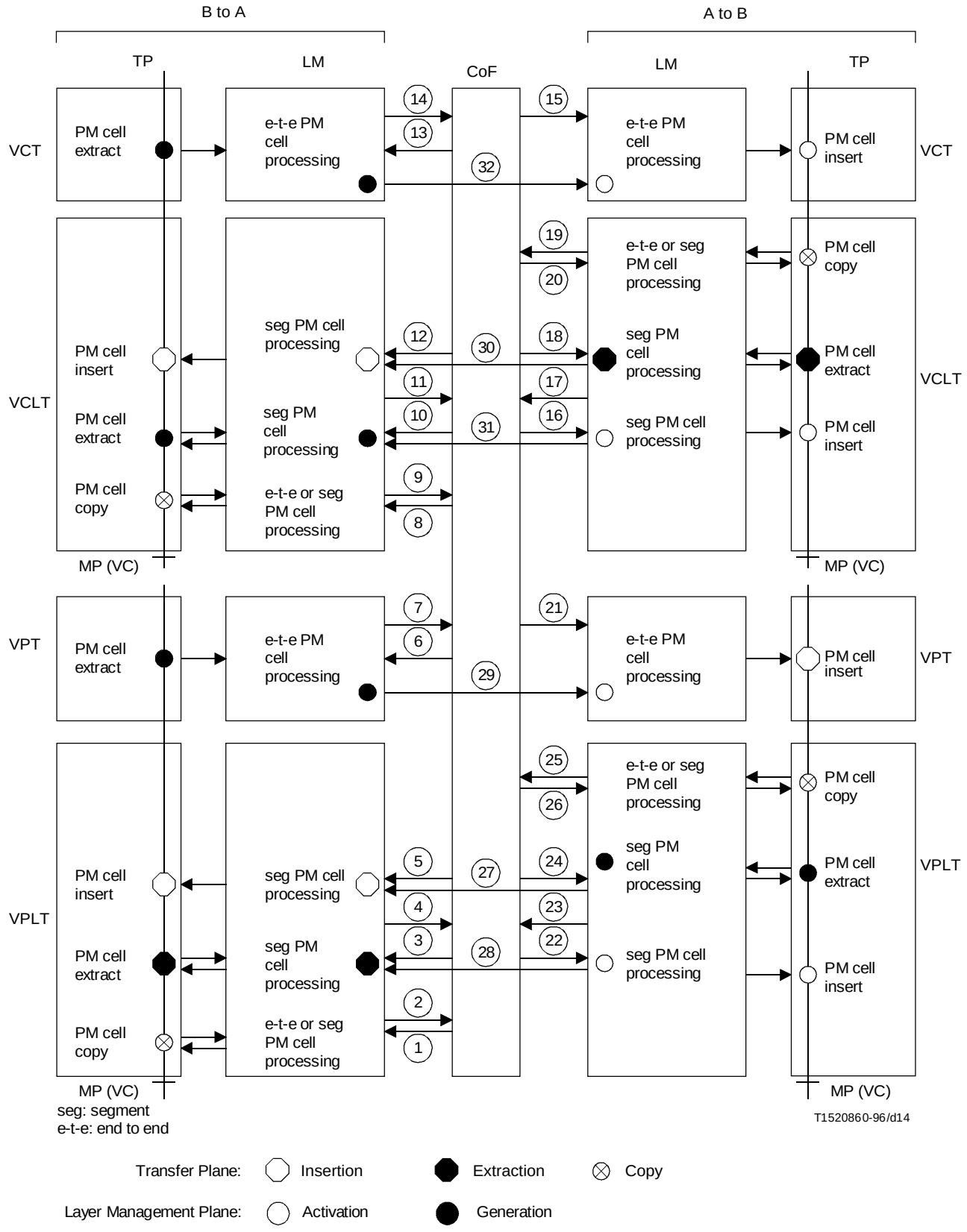
FIGURE 6-2/I.732

LMIs for FM

TABLE 6-2/I.732

LMIs for Performance Management

LMI	Description	Control or report
PM1	VP segment or end-to-end PM non-intrusive monitoring activation	Control
PM2	VP segment or end-to-end PM result	Report
PM3	VP segment PM activation	Control
PM4	VP segment PM result	Report
PM5	VP segment PM generation	Control
PM6	VP end-to-end PM activation	Control
PM7	VP end-to-end PM result	Report
PM8	VC segment or end-to-end PM non-intrusive monitoring activation	Control
PM9	VC segment or end-to-end PM result	Report
PM10	VC segment PM activation	Control
PM11	VC segment PM result	Report
PM12	VC segment PM generation	Control
PM13	VC end-to-end PM activation	Control
PM14	VC end-to-end PM result	Report
PM15	VC end-to-end PM generation	Control
PM16	VC segment PM generation	Control
PM17	VC segment PM result	Report
PM18	VC segment PM activation	Control
PM19	VC segment or end-to-end PM result	Report
PM20	VC segment or end-to-end PM non-intrusive monitoring activation	Control
PM21	VP end-to-end PM generation	Control
PM22	VP segment PM generation	Control
PM23	VP segment PM result	Report
PM24	VP segment PM activation	Control
PM25	VP segment or end-to-end PM result	Report
PM26	VP segment or end-to-end PM non-intrusive monitoring activation	Control
PM27	VP segment PM activation in B to A due to VP segment PM generation in A to B at a segment end point	
PM28	VP segment PM activation in A to B due to VP segment PM generation in B to A at a segment end point	
PM29	VP end-to-end PM activation in A to B due to VP end-to-end PM generation in B to A at a connection end point	
PM30	VC segment PM activation in B to A due to VC segment PM generation in A to B at a segment end point	
PM31	VC segment PM activation in A to B due to VC segment PM generation in B to A at a segment end point	
PM32	VC end-to-end PM activation in A to B due to VC end-to-end PM generation in B to A at a connection end point	



NOTE – The theoretical Measurement Point (MP) locations according to Recommendation I.353 are indicated by the dashes. The reference points are generally not accessible (see Recommendation O.191). For reasons of clarity, the VPME, VCME, VCC and VPC do not appear on the figure.

FIGURE 6-3/I.732

LMIs for Performance Management

7 Adaptation functions

7.1 AAL Type 1 functions/requirements

For further study.

7.2 AAL Type 2 functions/requirements

For further study.

7.3 AAL Type 3/4 functions/requirements

For further study.

7.4 AAL Type 5 functions/requirements

For further study.

Annex A

Relationship between B-ISDN PRM and I.326 representations of an ATM NE

(This annex forms an integral part of this Recommendation)

The relationship between the generic B-ISDN Protocol Reference Model (PRM) and the generic equipment modelling methodology derived from Recommendations G.805 and I.326 is used to establish the equivalence between the two representations.

For the modelling of an ATM NE, the important result of the B-ISDN PRM is the relationship between the User (Transfer) Plane, Layer Management, AEMF and Control Plane functions in the support of all B-ISDN services.

However, the B-ISDN PRM, although necessary for the overall description of an ATM NE, is not sufficient for the detailed functional description required to enable interoperability between ATM equipment, since each layer in the PRM may consist of numerous functional elements.

To represent the detailed function model, the equipment modelling methodology used in Recommendations G.805 and I.326 is employed for the functions within each layer of the PRM. Consequently each layer of the PRM is further decomposed into the Termination, Adaptation and Connection functional blocks described in Recommendation I.326.

In addition, each of these functional blocks needs to be further decomposed into the individual functional elements required for the operation of the ATM equipment. The relationship between the individual elements must also be defined within the context of the overall PRM. This is illustrated in Figure A.1.

The relationship and consequent equivalence between the PRM and the G.805 modelling methodology is given in Figure A.2.

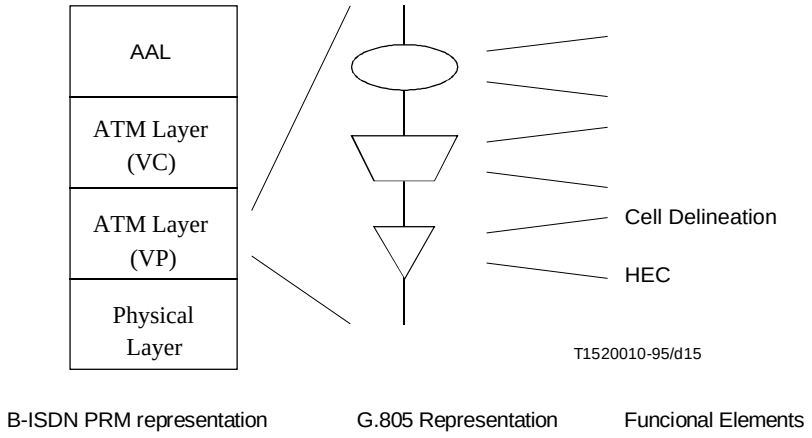
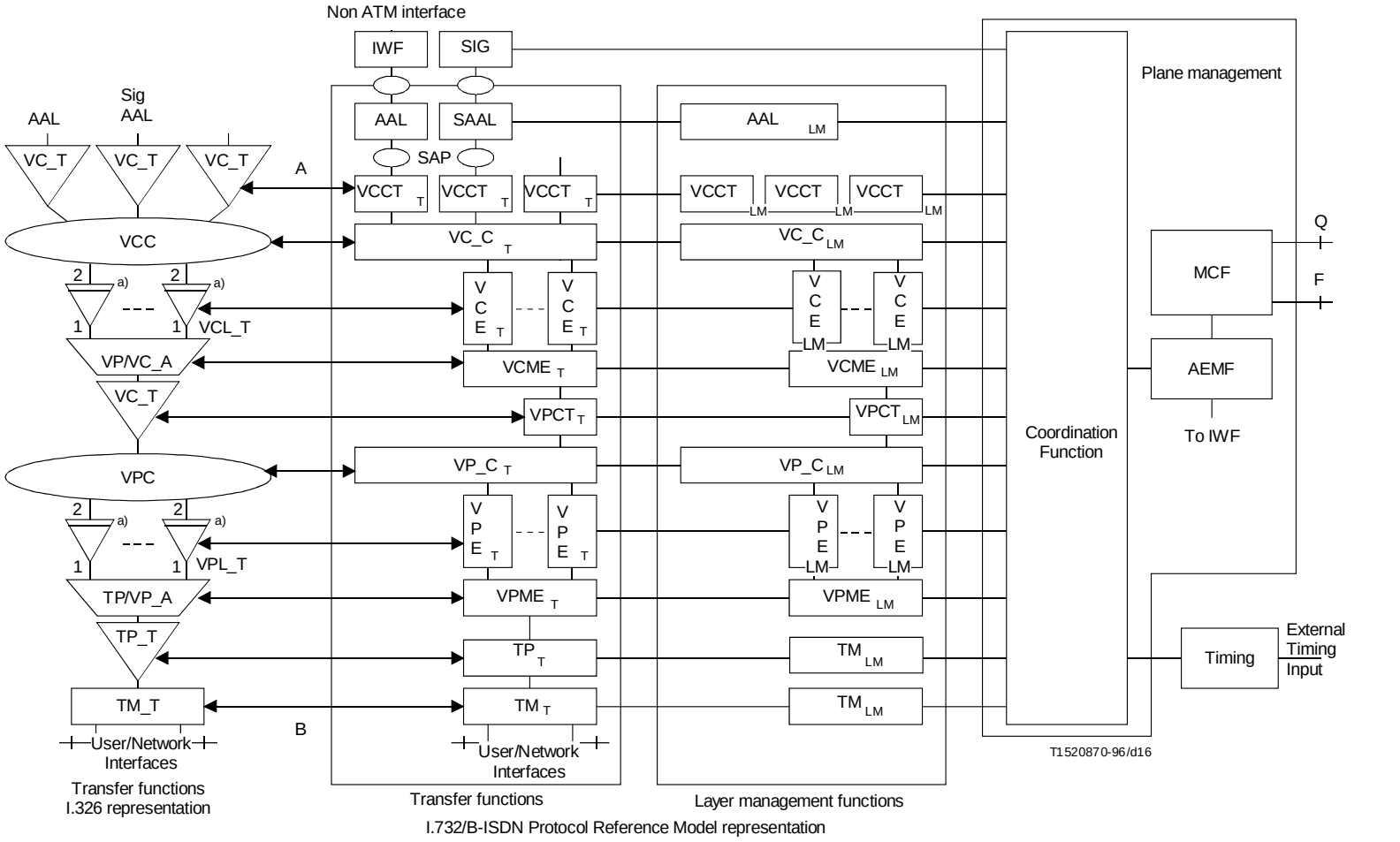


FIGURE A.1/I.732

Relationship between PRM and G.805 Model



VPL_T and VCL_T blocks are not described in Rec. I.326, but have been introduced in this Recommendation. They include the VPSLT/VCSLT, VPTm/VCTm and VPTs/VCTs as defined in Rec. I.326. The reason is that in a Network view, those functions have been distinguished but not in a Network Element View.

a) This figure is a simplified representation. Detailed representation should be in accordance with Recommendation I.326.

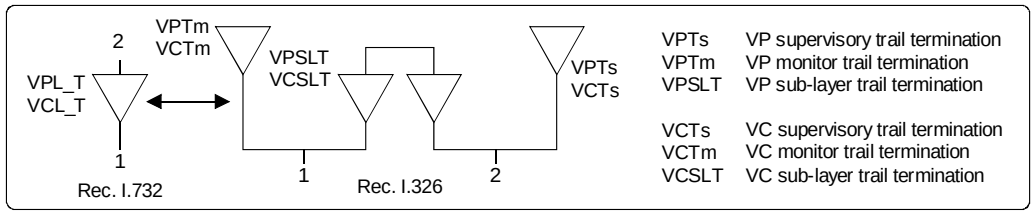


FIGURE A.2/I.732

Equivalence berween PRM and I.326 representations

Annex B

Examples of ATM equipment

(This annex forms an integral part of this Recommendation)

This annex intends to provide examples of ATM equipment. This annex is not aimed to be exhaustive. Other combinations of blocks may be possible (see clause 6/I.731).

Classification of ATM equipment

The basic criteria used for classification of equipment types are:

1) signalling capability, which refers to the presence of signalling applications inside the equipment;

2) connectivity.

Restricted connectivity implies that:

a) the equipment has multiple transfer interfaces towards user side and only one transfer interface towards the network;

b) there is no connectivity between the user side interfaces.

Unrestricted connectivity implies that a) and/or b) above may not apply.

Those basic criteria lead to the following equipment types (see Table B.1):

TABLE B.1/I.732

ATM equipment types

Basic equipment types	Signalling	Capability
	No	Yes
Unrestricted connectivity	Cross-connect	Switch
Restricted connectivity	Multiplexer	On-demand multiplexer

Additional distinguishing characteristics are:

1) VPI based connectivity or (VPI, VCI) based connectivity;

2) presence of Interworking functions for support of non-ATM interfaces.

Those additional distinguishing characteristics lead to the following derived equipment types (see Tables B.2 to B.5 and Figures B.1 to B.5.

TABLE B.2/I.732

Cross-connect types

Cross-connect types		VPI based connectivity	(VPI, VCI) based connectivity
Interworking function for support of non-ATM interfaces	No	VP Cross-connect	VC Cross-connect
	Yes	Interworking VP Cross-connect	Interworking VC Cross-connect

TABLE B.3/I.732

Switch types

Switch types		VPI based connectivity	(VPI, VCI) based connectivity
Interworking function for support of non-ATM interfaces	No	VP Switch	VC Switch
	Yes	Interworking VP Switch	Interworking VC Switch

TABLE B.4/I.732

Multiplexer types

Multiplexer types		VPI based connectivity	(VPI, VCI) based connectivity
Interworking function for support of non-ATM interfaces	No	VP multiplexer	VC multiplexer
	Yes	Interworking VP multiplexer (Note)	Interworking VC multiplexer (Note)
NOTE – Interworking multiplexer is sometimes called a “Services Multiplexer”.			

TABLE B.5/I.732

On-demand multiplexer types

On-demand multiplexer types		VPI based connectivity	(VPI, VCI) based connectivity
Interworking function for support of non-ATM interfaces	No	VP On-demand multiplexer	VC On-demand multiplexer
	Yes	Interworking On-demand VP multiplexer (Note)	Interworking On-demand VC multiplexer (Note)
NOTE – Interworking multiplexer is sometimes called a “Services Multiplexer”.			

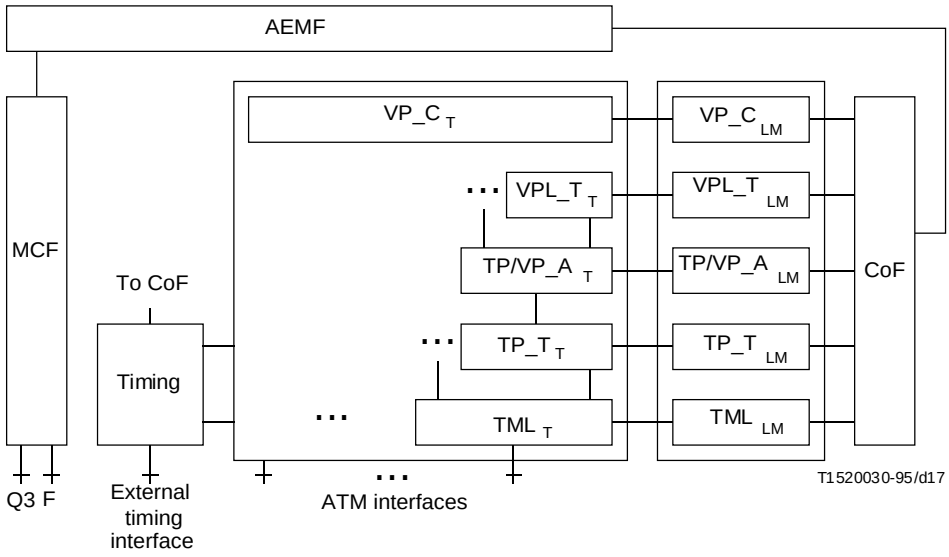
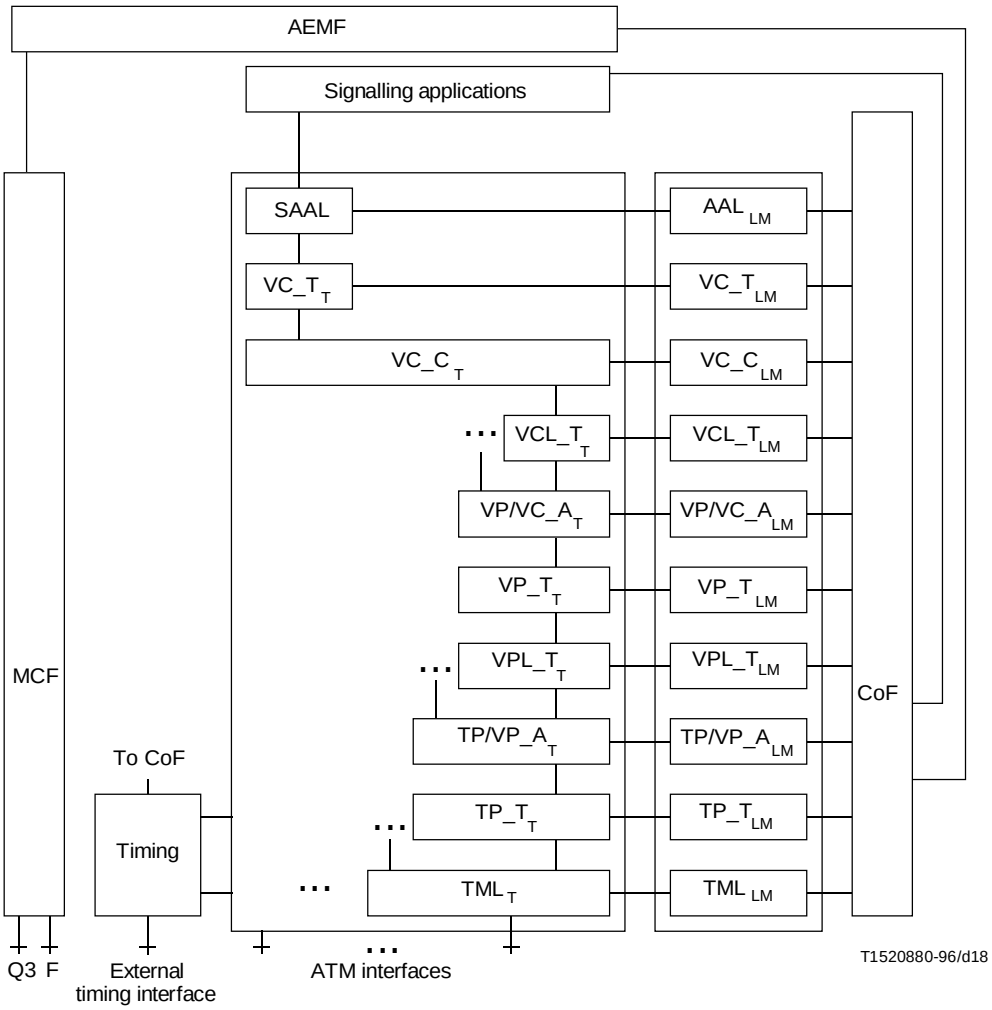


FIGURE B.1/I.732

VP Cross-Connect



NOTE – Layer Management of AAL and higher layers is not described in this Recommendation.

FIGURE B.2-4/I.732

VC switch

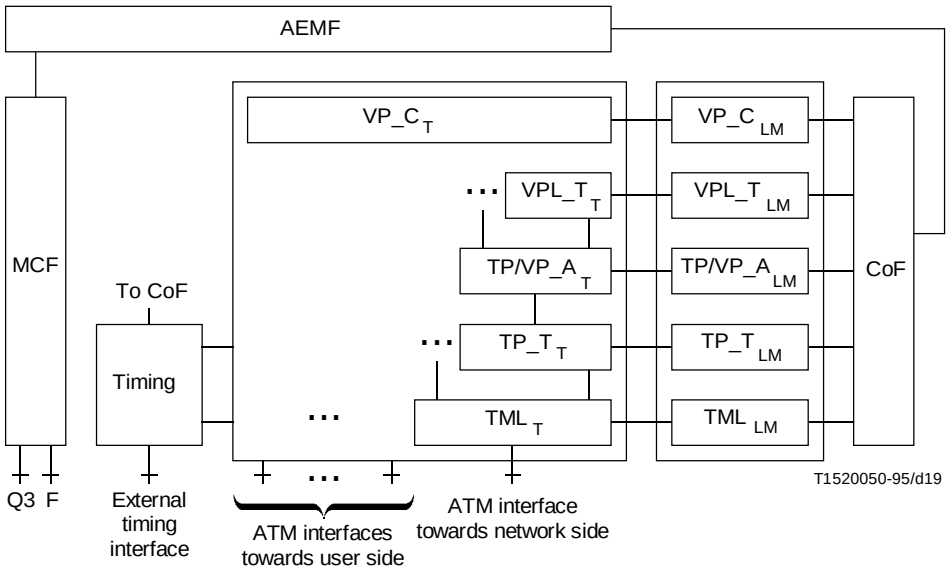
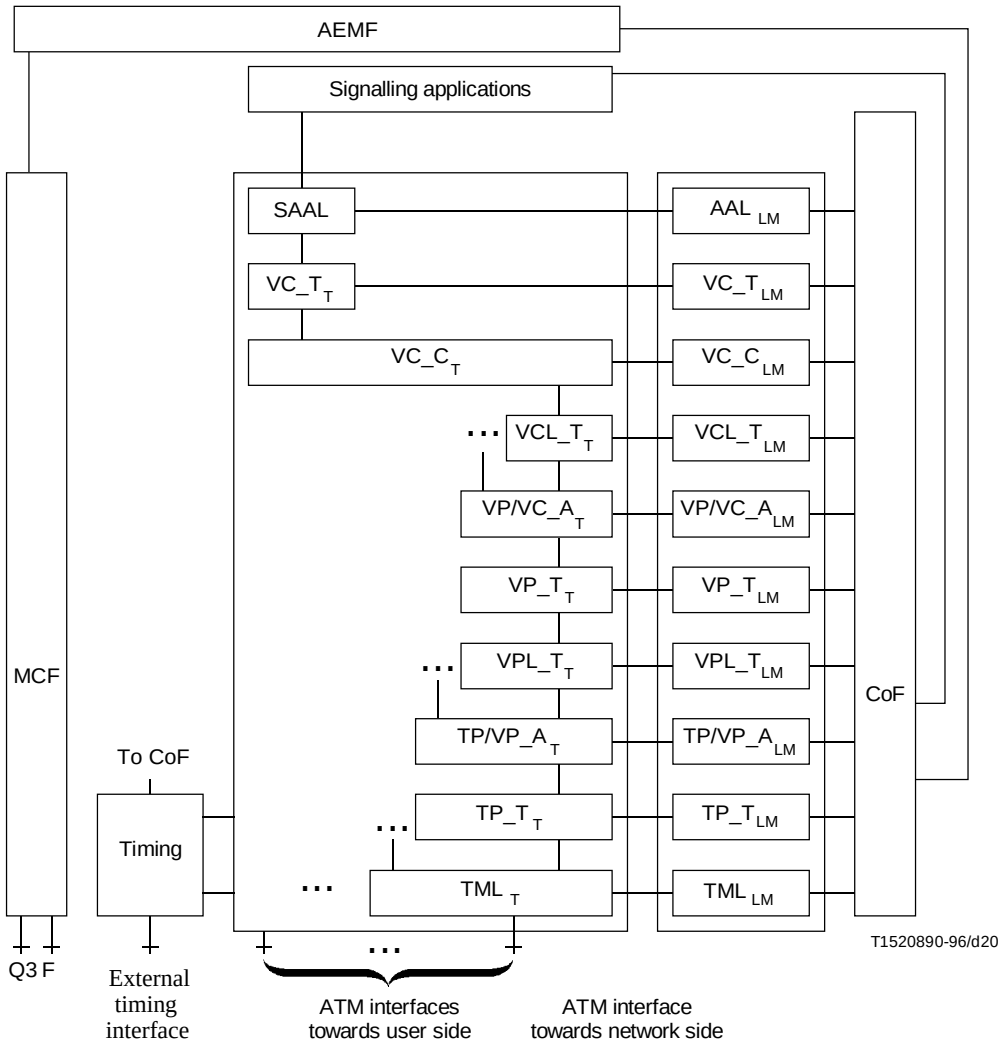


FIGURE B.3/I.732

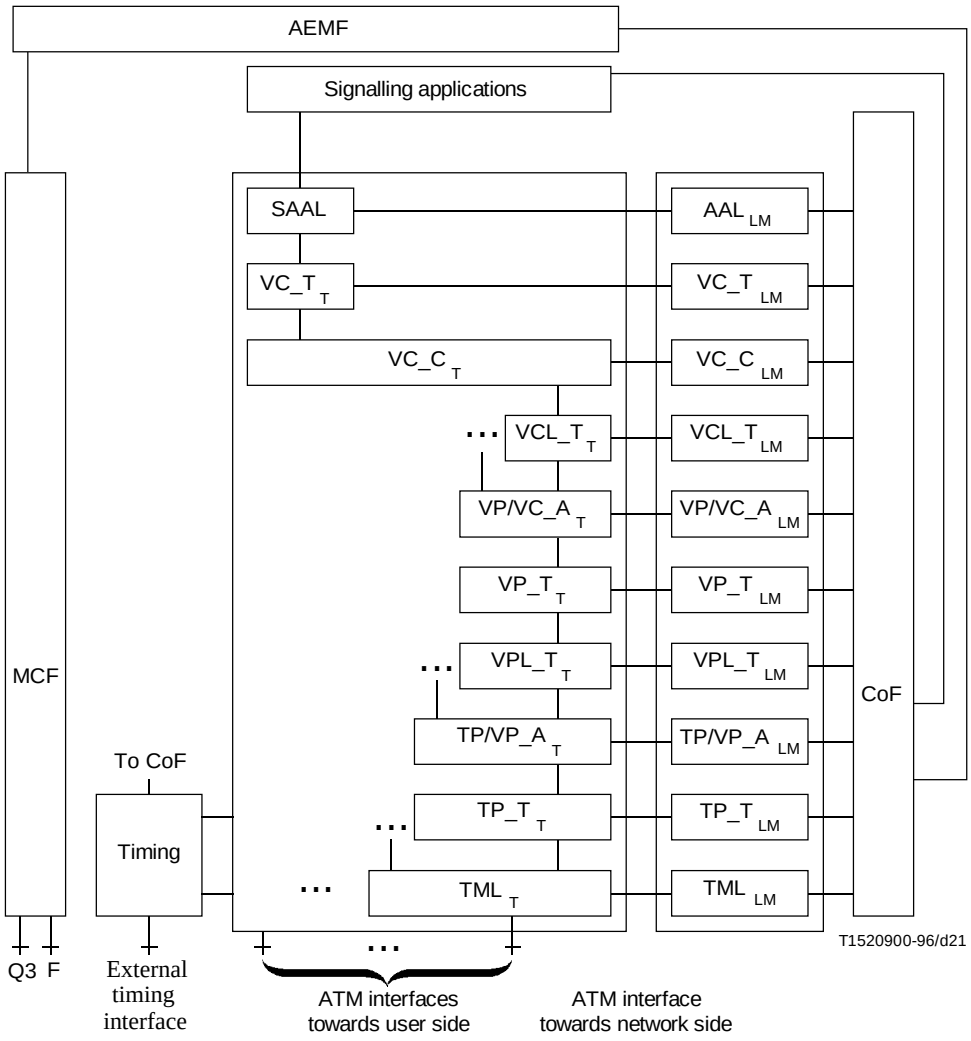
VP multiplexer



NOTE – Layer Management of AAL and higher layers is not described in this Recommendation.

FIGURE B.4/I.732

On-demand VC multiplexer



NOTE – Layer Management of AAL and higher layers is not described in this Recommendation.

FIGURE B.5/I.732

Interworking on-demand VC multiplexer

Appendix I

Loopback examples

(This appendix does not form part of this Recommendation)

This appendix shows five examples of VP loopback between ATM network elements. These examples are intended to clarify Tables 5-3(A) and 5-3(B). See Figures I.1 to I.5.

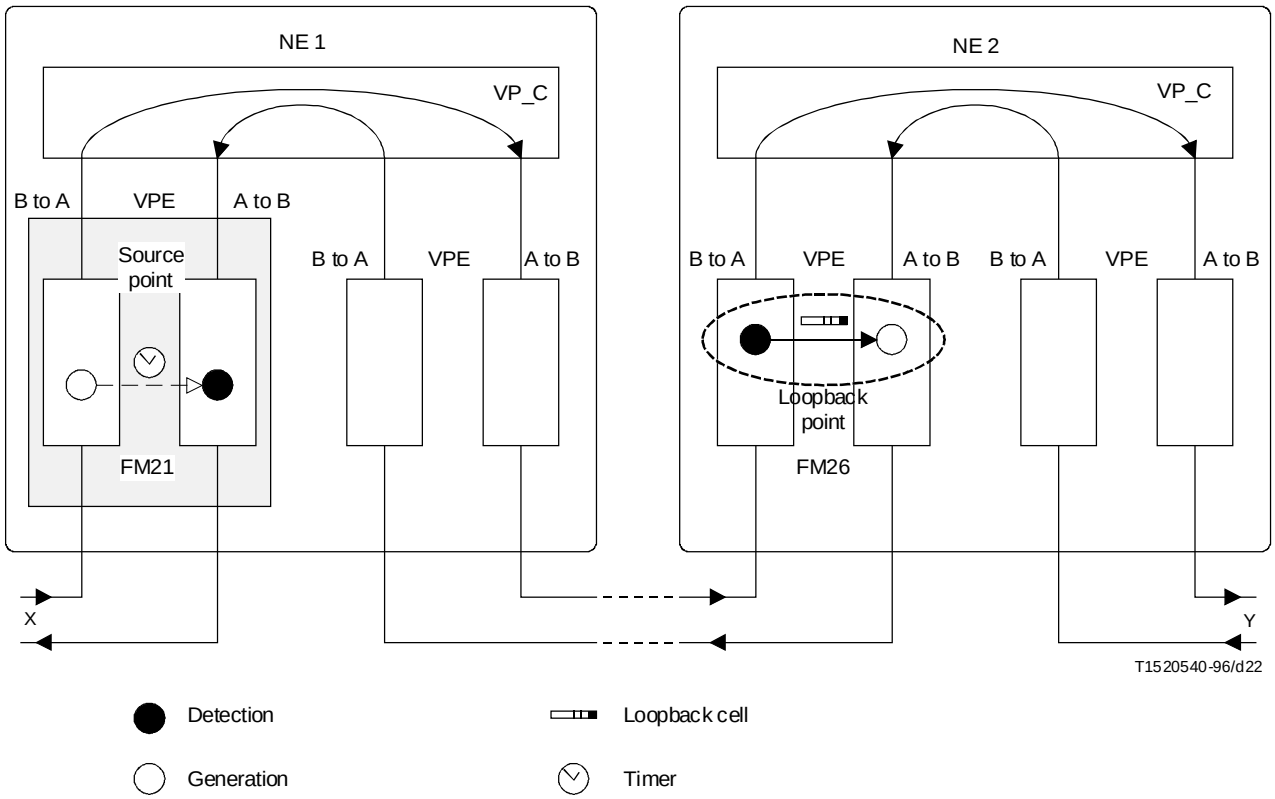


FIGURE I.1/I.732

Example No. 1 of VP loopback

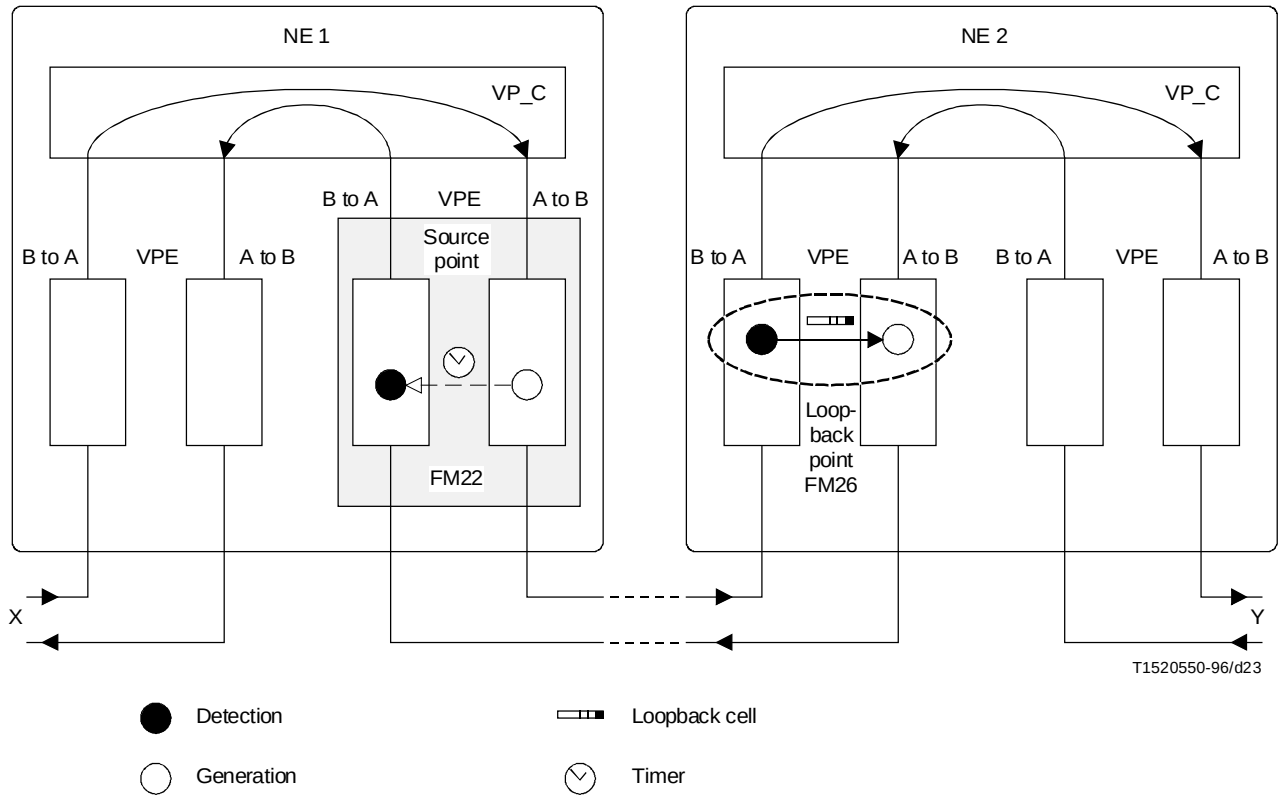


FIGURE I.2/I.732

Example No. 2 of VP loopback

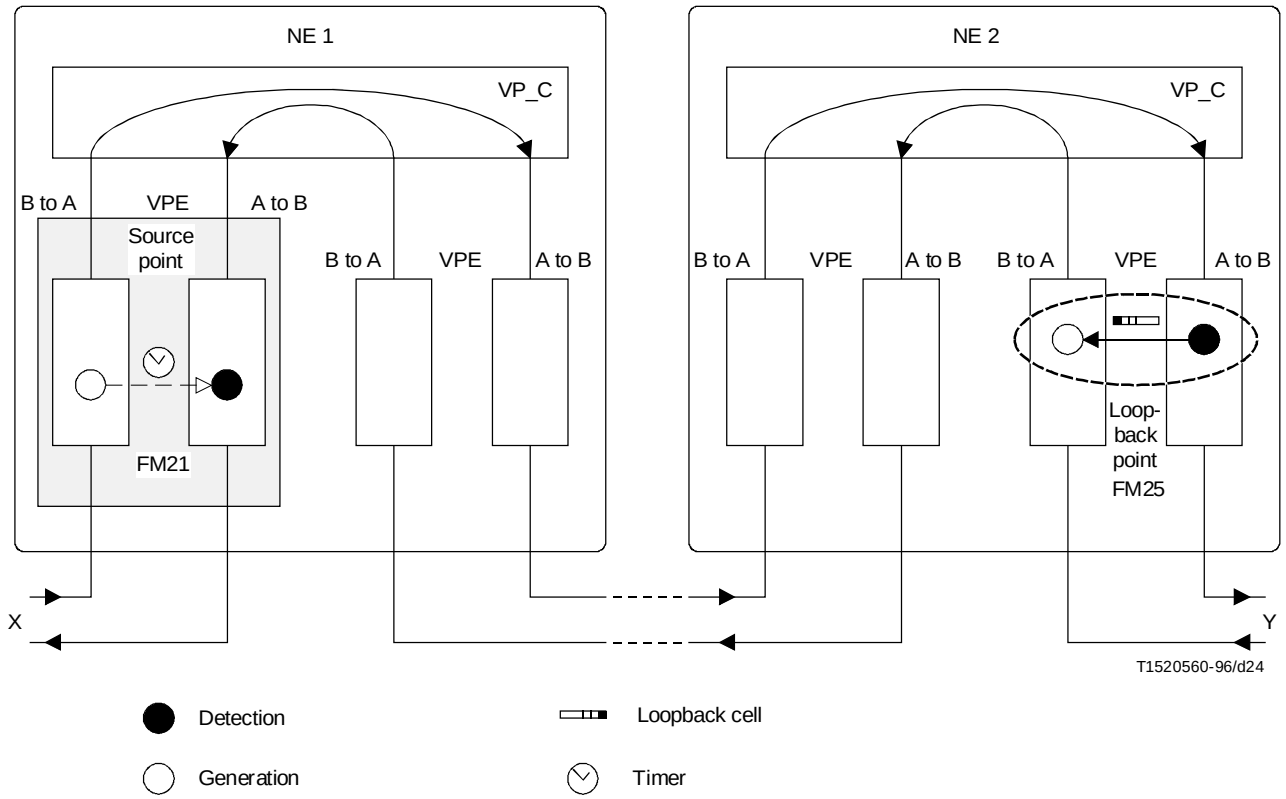


FIGURE I.3/I.732

Example No. 3 of VP loopback

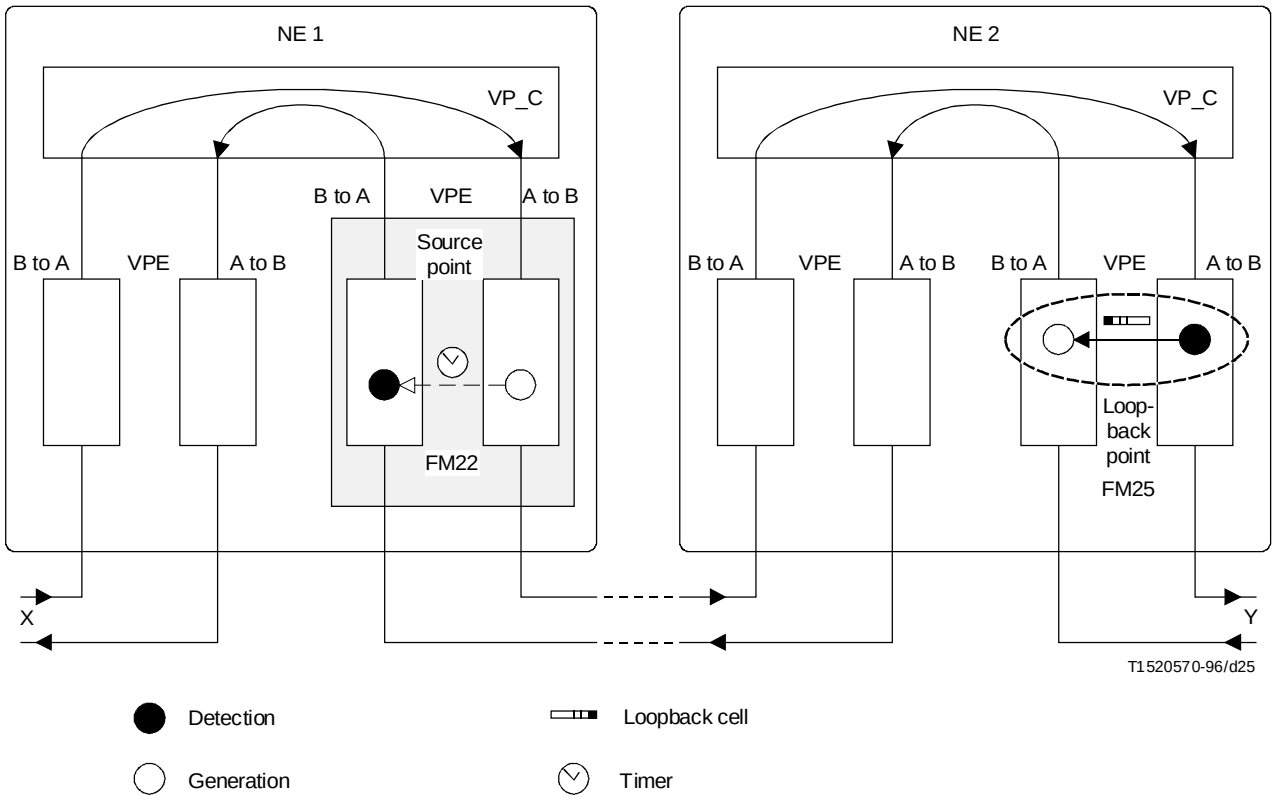


FIGURE I.4/I.732

Example No. 4 of VP loopback

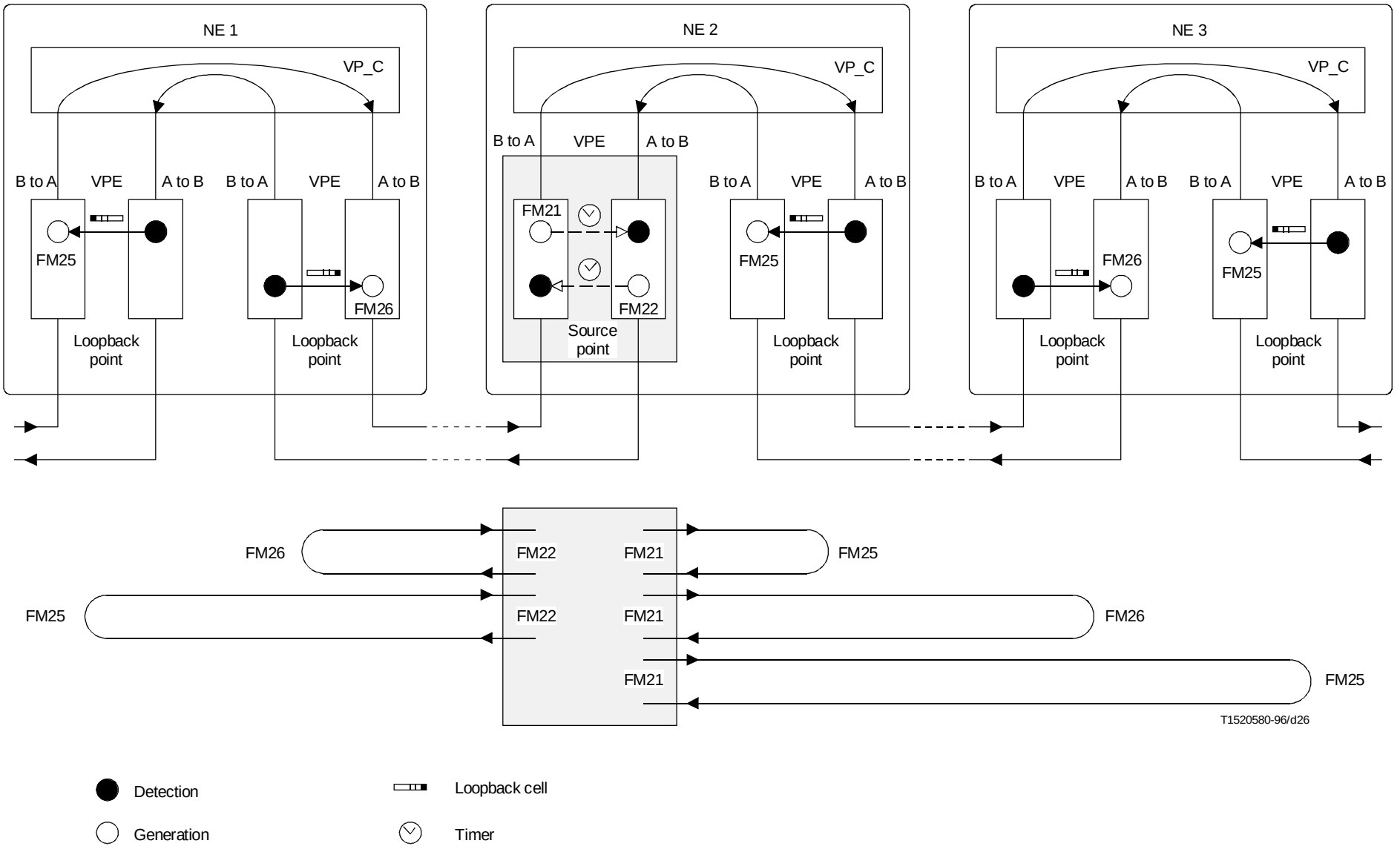


FIGURE I.5/I.732

Example No. 5 of VP loopback

ITU-T RECOMMENDATIONS SERIES

Series A	Organization of the work of the ITU-T
Series B	Means of expression
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Telephone network and ISDN
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media
Series H	Transmission of non-telephone signals
Series I	**Integrated services digital network**
Series J	Transmission of sound-programme and television signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound-programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminal equipments and protocols for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communication
Series Z	Programming languages