



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

I.732

(10/2000)

SERIES I: INTEGRATED SERVICES DIGITAL
NETWORK

B-ISDN equipment aspects – ATM equipment

Functional characteristics of ATM equipment

ITU-T Recommendation I.732

(Formerly CCITT Recommendation)

ITU-T I-SERIES RECOMMENDATIONS
INTEGRATED SERVICES DIGITAL NETWORK

GENERAL STRUCTURE	
Terminology	I.110–I.119
Description of ISDNs	I.120–I.129
General modelling methods	I.130–I.139
Telecommunication network and service attributes	I.140–I.149
General description of asynchronous transfer mode	I.150–I.199
SERVICE CAPABILITIES	
Scope	I.200–I.209
General aspects of services in ISDN	I.210–I.219
Common aspects of services in the ISDN	I.220–I.229
Bearer services supported by an ISDN	I.230–I.239
Teleservices supported by an ISDN	I.240–I.249
Supplementary services in ISDN	I.250–I.299
OVERALL NETWORK ASPECTS AND FUNCTIONS	
Network functional principles	I.310–I.319
Reference models	I.320–I.329
Numbering, addressing and routing	I.330–I.339
Connection types	I.340–I.349
Performance objectives	I.350–I.359
Protocol layer requirements	I.360–I.369
General network requirements and functions	I.370–I.399
ISDN USER-NETWORK INTERFACES	
Application of I-series Recommendations to ISDN user-network interfaces	I.420–I.429
Layer 1 Recommendations	I.430–I.439
Layer 2 Recommendations	I.440–I.449
Layer 3 Recommendations	I.450–I.459
Multiplexing, rate adaption and support of existing interfaces	I.460–I.469
Aspects of ISDN affecting terminal requirements	I.470–I.499
INTERNETWORK INTERFACES	I.500–I.599
MAINTENANCE PRINCIPLES	I.600–I.699
B-ISDN EQUIPMENT ASPECTS	
ATM equipment	I.730–I.739
Transport functions	I.740–I.749
Management of ATM equipment	I.750–I.759
Multiplexing aspects	I.760–I.769

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

Functional Characteristics of ATM equipment

Summary

ITU-T I.731 and I.732 describe the functional requirements to enable the interoperability between ATM network elements. The detailed characteristics of ATM equipment, or equipment containing ATM aspects, are contained in this Recommendation. The companion Recommendation, ITU-T I.731, provides introductions and covering terms and concepts that did not easily fit into the structure of this Recommendation. ITU-T I.731 introduces the functional model used in this Recommendation.

The functional model approach used in this Recommendation is derived from ITU-T G.805. It is also used by other technologies such as SDH equipment, PDH equipment and optical networking. This allows for equipment with multiple technologies to be easily defined by selecting the appropriate functional blocks.

Annex D defines the atomic functions used in the TP Convergence, ATM VP and VC Layer Networks and their associated adaptation functions.

Source

ITU-T Recommendation I.732 was revised by ITU-T Study Group 15 (1997-2000) and approved by the World Telecommunication Standardization Assembly (Montreal, 27 September – 6 October 2000).

FOREWORD

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

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

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

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

NOTE

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

INTELLECTUAL PROPERTY RIGHTS

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

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

© ITU 2001

All rights reserved. No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from ITU.

CONTENTS

	Page
1 Scope	1
2 References	1
3 Abbreviations, Terms and Definitions	3
3.1 Abbreviations	3
3.2 Definitions	5
4 General functional description of the ATM equipment.....	5
4.1 Transfer functions.....	7
4.1.1 Physical layer	7
4.1.2 ATM Layer.....	8
4.1.3 ATM Adaptation Layer (AAL).....	13
4.1.4 Signalling ATM Adaptation Layer (SAAL)	13
4.2 Layer Management functions	13
4.3 Coordination functions	13
4.4 Guidelines for using the Table structure and corresponding functional descriptions	13
5 Transfer functions and Layer Management functions.....	20
5.1 Section/Path Adaptation, Section Termination and Lower Layer Functions	20
5.1.1 SDH 155.52 Mbit/s Interface	20
5.1.2 SDH 622.08 Mbit/s Interface	20
5.1.3 SDH 2488.32 Mbit/s Interface	20
5.1.4 SDH 9953.28 Mbit/s Interface	20
5.1.5 PDH based interfaces	20
5.1.6 Cell-based UNI.....	20
5.1.7 ATM 25 Mbit/s interface.....	21
5.1.8 IMA interface	21
5.1.9 xDSL interfaces.....	21
5.2 Transmission Path Trail Termination function (TP_TT)	21
5.3 Transmission Path/Virtual Path Adaptation function (TP/VP_A)	21
5.3.1 TP/VP_A (B to A).....	21
5.3.2 TP/VP_A (A to B) for SDH and PDH	25
5.4 VP Traffic Management function (VPTM).....	27
5.4.1 VP usage measurement	28
5.4.2 VP UPC/NPC (B to A only).....	28
5.4.3 Traffic shaping	29
5.4.4 EFCI setting.....	29
5.4.5 Resource management.....	29

	Page
5.5	VP OAM functions..... 29
5.5.1	F4 OAM functions (B to A) between VPTM and VP_C 29
5.5.2	F4 OAM functions (A to B) between VPTM and VP_C 30
5.6	VP Connection function (VP_C)..... 30
5.7	VP Connection End point Loopback function (VPLB_TT)..... 30
5.8	VP Trail Termination function (VP_TT)..... 30
5.9	Virtual Path/Virtual Channel Adaptation function (VP/VC_A)..... 30
5.9.1	VP/VC_A (B to A) 30
5.9.2	VP/VC_A (A to B) 31
5.10	VC Traffic Management function (VCTM) 32
5.10.1	VC usage measurement 33
5.10.2	VC UPC/NPC (B to A only) 33
5.10.3	Traffic shaping 34
5.10.4	EFCI setting..... 34
5.10.5	Resource management..... 34
5.11	VC OAM functions 34
5.11.1	F5 OAM functions (B to A) between VCTM and VC_C 34
5.11.2	F5 OAM functions (A to B) between VCTM and VC_C 35
5.12	VC Connection function (VC_C)..... 35
5.13	VC Connection End point Loopback function (VCLB_TT)..... 35
5.14	VC Trail Termination function (VC_TT)..... 35
5.15	ATM Adaptation Layer function (AAL) 36
5.15.1	Discard of end-to-end and segment F5 OAM cells..... 36
5.15.2	AAL functional modelling 36
5.15.3	Service Specific Coordination functions..... 36
6	Coordination Function (CoF) 36
7	CAC and resource control functions 36
7.1	ATM resource requests to be processed by an ATM equipment 36
7.1.1	Establishing or releasing a VP or VC connection 36
7.1.2	Modification of the traffic characteristics of an established VP or VC connection 37
7.2	General ATM equipment features for processing an ATM resource request..... 38
7.2.1	Processing of resource request messages 38
7.2.2	CAC function 38
7.3	Management, signalling, RM applications 39
7.4	Detailed description of the CAC function 39
7.4.1	Service Acceptance Control SAC 42
7.4.2	Equipment Admission Control (EAC) function..... 45

	Page
7.5 Processing steps of an ATM resource request.....	47
7.5.1 Request to establish or release an ATM VP or VC connection	47
7.5.2 Request to modify the traffic characteristics of an existing ATM VP or VC connection.....	47
7.6 Method for reducing outages on resource modification.....	48
Annex A – Relationship between B-ISDN PRM and I.326 representations of an ATM NE..	48
Annex B – Examples of ATM equipment	49
Annex C – Correspondence between I.732 and I.751 models.....	51
Annex D – Library of Atomic Functions.....	51
D.1 Definitions, abbreviations and symbols	51
D.1.1 Definitions.....	51
D.1.2 Abbreviations	51
D.1.3 Symbols and diagrammatic conventions.....	54
D.1.4 Introduction	54
D.2 Transmission Path to ATM Virtual Path Adaptation Functions	57
D.2.1 S3 Path Adaptation Functions	57
D.2.2 S4 Path Adaptation Functions	67
D.2.3 S4-nc Path Adaptation Functions.....	77
D.2.4 Cell-Based Adaptation Functions.....	86
D.2.5 P12s Path Adaptation Functions	87
D.2.6 P31s Path Adaptation Functions	96
D.3 ATM Virtual Path Layer Network Functions.....	105
D.3.1 ATM Virtual Path Connection Function VP_C	114
D.3.2 ATM Virtual Path Trail Termination Functions	120
D.3.3 ATM Virtual Path Monitoring Functions.....	128
D.3.4 ATM Virtual Path Segment Functions.....	134
D.3.5 ATM Virtual Path Traffic Management Functions.....	148
D.3.6 ATM Virtual Path Loopback Functions.....	152
D.3.7 ATM Virtual Path Linear Trail Protection Functions	171
D.4 ATM Virtual Path to ATM Virtual Channel Adaptation Functions.....	173
D.4.1 ATM Virtual Path to ATM Virtual Channel Adaptation Source Function VP/VC_A_So.....	173
D.4.2 ATM Virtual Path to ATM Virtual Channel Adaptation Sink Function VP/VC_A_Sk.....	176
D.5 ATM Virtual Channel Layer Network Functions	179
D.5.1 ATM Virtual Channel Connection Function VC_C	187
D.5.2 ATM Virtual Channel Trail Termination Functions	193

	Page
D.5.3 ATM Virtual Channel Monitoring Functions	201
D.5.4 ATM Virtual Channel Segment Functions.....	207
D.5.5 ATM Virtual Channel Traffic Management Functions.....	222
D.5.6 ATM Virtual Channel Loopback Functions.....	225
D.5.7 ATM Virtual Channel Linear Trail Protection Functions	239
D.6 ATM Virtual Channel to ATM Client Adaptation Functions	241
D.6.1 ATM Virtual Channel to ATM Client Adaptation Source VC/XXX_A_So	241
D.6.2 ATM Virtual Channel to ATM Client Adaptation Sink VC/XXX_A_Sk....	242
Appendix I – Functional requirements for ABR transfer capability	243
I.1 Location in I.732 Model	243
I.2 Transfer Functions.....	243
I.3 Report to Layer Management	244
I.4 Control from Layer Management	244
I.5 Layer Management Functions	244
I.5.2 BECN Function	244

Copyright International Telecommunication Union/ITU Telecommunication Sector

Introduction

The B-ISDN Protocol Reference Model described in ITU-T 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 additional functions 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 Channel layers. 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 and Layer Management Planes, the management and processing of user information may be described in terms of three functions. 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 ITU-T I.326 and G.805.

ITU-T Recommendation I.732

Functional characteristics of ATM equipment

1 Scope

The purpose of this Recommendation is to describe the functional requirements to enable interoperability between ATM Network Elements (NEs). The description must be precise enough to enable interoperability, but be generic so as to not constrain implementation.

This Recommendation provides a detailed description of the functional requirements identified in ITU-T I.731.

This Recommendation makes references to other existing Recommendations where they contain detailed descriptions or specifications for a function to avoid duplication of work. This Recommendation provides the basis for defining in detail an ATM NE.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; 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] ITU-T G.703 (1998), *Physical/electrical characteristics of hierarchical digital interfaces*.
- [2] ITU-T G.707/Y.1322 (2000), *Network node interface for the synchronous digital hierarchy (SDH)*.
- [3] ITU-T G.783 (2000), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks*.
- [4] ITU-T G.784 (1999), *Synchronous digital hierarchy (SDH) management*.
- [5] ITU-T G.804 (1998), *ATM cell mapping into plesiochronous digital hierarchy (PDH)*.
- [6] ITU-T G.805 (2000), *Generic functional architecture of transport networks*.
- [7] ITU-T I.326 (1995), *Functional architecture of transport networks based on ATM*.
- [8] ITU-T G.832 (1998), *Transport of SDH elements on PDH networks – Framing and multiplexing structures*.
- [9] ITU-T G.957 (1999), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.
- [10] ITU-T I.731 (2000), *Types and general characteristics of ATM equipment*.
- [11] ITU-T I.211 (1993), *B-ISDN service aspects*.
- [12] ITU-T I.311 (1996), *B-ISDN general network aspects*.
- [13] ITU-T I.321 (1991), *B-ISDN protocol reference model and its application*.
- [14] ITU-T I.353 (1996), *Reference events for defining ISDN and B-ISDN performance parameters*.
- [15] ITU-T I.356 (2000), *B-ISDN ATM layer cell transfer performance*.



- [16] ITU-T I.361 (1999), *B-ISDN ATM layer specification.*
- [17] ITU-T I.363.1 (1996), *B-ISDN ATM Adaptation Layer specification: Type 1 AAL.*
- [18] ITU-T I.363.2 (1997), *B-ISDN ATM Adaptation layer specification: Type 2 AAL.*
- [19] ITU-T I.363.3 (1996), *B-ISDN ATM Adaptation Layer specification: Type 3/4 AAL.*
- [20] ITU-T I.363.5 (1996), *B-ISDN ATM Adaptation Layer specification: Type 5 AAL.*
- [21] ITU-T I.371 (2000), *Traffic control and congestion control in B-ISDN.*
- [22] ITU-T I.432.1 (1999), *B-ISDN user-network interface – Physical layer specification: General characteristics.*
- [23] ITU-T I.432.2 (1999), *B-ISDN user-network interface – Physical layer specification: 155 520 kbit/s and 622 080 kbit/s operation.*
- [24] ITU-T I.432.3 (1999), *B-ISDN user-network interface – Physical layer specification: 1544 kbit/s and 2048 kbit/s operation.*
- [25] ITU-T I.432.4 (1999), *B-ISDN User-network interface – Physical layer specification: 51 840 kbit/s operation.*
- [26] ITU-T I.432.5 (1997), *B-ISDN User-network interface – Physical layer specification: 25 600 kbit/s operation.*
- [27] ITU-T I.610 (1999), *B-ISDN operation and maintenance principles and functions.*
- [28] ITU-T Q.2931 (1995), *Digital Subscriber Signalling System No. 2 (DSS 2) – User-Network Interface (UNI) layer 3 specification for basic call/connection control.*
- [29] ITU-T Q.2761 (1999), *Functional description of the B-ISDN user part (B-ISUP) of signalling system No. 7.*
- [30] ITU-T Q.2762 (1999), *General functions of messages and signals of the B-ISDN user part (B-ISUP) of Signalling System No. 7.*
- [31] ITU-T Q.2763 (1999), *Signalling System No. 7 B-ISDN User Part (B-ISUP) – Formats and codes.*
- [32] ITU-T Q.2764 (1995), *Signalling System No. 7 B-ISDN User part (B-ISUP) – Basic call procedures.*
- [33] ITU-T Q.2120 (1995), *B-ISDN metasignalling protocol.*
- [34] ITU-T O.191 (1997), *Equipment to assess ATM layer cell transfer performance.*
- [35] ITU-T G.992.1 (1999), *Asymmetrical digital subscriber line (ADSL) transceivers.*
- [36] ITU-T G.992.2 (1999), *Splitterless asymmetrical digital subscriber line (ADSL) transceivers.*
- [37] ITU-T I.761 (2000), *Inverse multiplexing for ATM (IMA).*
- [38] ITU-T G.806 (2000), *Characteristics of Transport Equipment – Description Methodology and Generic Functionality.*
- [39] ITU-T I.365.1 (1993), *B-ISDN ATM adaptation layer sublayers: Frame relaying service specific convergence sublayer (FR-SSCS).*
- [40] ITU-T I.365.2 (1995), *B-ISDN ATM adaptation layer sublayers: Service-specific coordination function to provide the connection-oriented network service.*
- [41] ITU-T I.365.3 (1995), *B-ISDN ATM adaptation layer sublayers: Service-specific coordination function to provide the connection-oriented transport service.*

- [42] ITU-T I.365.4 (1996), *B-ISDN ATM adaptation layer sublayers: Service-specific convergence sublayer for HDLC applications.*
- [43] ITU-T I.366.1 (1998), *Segmentation and Reassembly Service Specific Convergence Sublayer for the AAL type 2.*
- [44] ITU-T I.366.2 (1999), *AAL Type 2 service specific convergence sublayer for trunking.*
- [45] ITU-T G.995.1 (1999), *Overview of digital subscriber line (DSL) Recommendations.*
- [46] ITU-T G.991.1 (1998), *High bit rate digital subscriber line (HDSL) transceivers.*
- [47] ITU-T G.994.1 (1999), *Handshake procedures for digital subscriber line (DSL) transceivers.*
- [48] ITU-T G.996.1 (1999), *Test procedures for digital subscriber line (DSL) transceivers.*
- [49] ITU-T G.997.1 (1999), *Physical layer management for digital subscriber line (DSL) transceivers.*

3 Abbreviations, Terms and Definitions

3.1 Abbreviations

The main body of this Recommendation and Annex D have their own abbreviation lists. For expansion of abbreviations used in Annex D see abbreviation list in Annex D. For the purposes of this Recommendation, the following abbreviations are used:

AAL	ATM Adaptation Layer
AD	Activation/Deactivation
ADSL	Asymmetrical Digital Subscriber Loop
AEMF	ATM Element 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
DBR	Deterministic Bit Rate
DSS2	Digital Subscriber Signalling System No. 2
EAC	Equipment Admission Control
EPD	Early Packet Discard

FM	Fault Management
FMBS	Frame Mode Bearer Service
HEC	Header Error Control
IMA	Inverse Multiplexed ATM
IWF	InterWorking Function
LB	Loopback
LCD	Loss of Cell Delineation
LM	Layer Management
LMI	Layer Management Indication
LOC	Loss of Continuity
LOP	Loss of Pointer
LOS	Loss of Signal
MCF	Message Communications Function
NE	Network Element
NNI	Network Node Interface
NPC	Network Parameter Control
OAM	Operation, Administration and Maintenance
OCD	Out of Cell Delineation
PDH	Plesiochronous Digital Hierarchy
PLCP	Physical Layer Convergence Protocol
PM	Performance Management/Performance Monitoring
POH	Path OverHead
PPD	Partial Packet Discard
PVC	Permanent Virtual Connection
QoS	Quality of Service
RM	Resource Management
SAAL	B-ISDN Signalling ATM Adaptation Layer
SAC	Service Acceptance Control
SAP	Service Access Point
SAR	Segmentation and Reassembly
SDH	Synchronous Digital Hierarchy
SLAD	Service Level Admission
SOH	Section OverHead
SSCF	Service Specific Coordination Function
SSCS	Service Specific Convergence Sublayer
SSF	Server Signal Fail
SVC	Switched Virtual Connection

TIM	Trace Identifier Mismatch
TM	Transmission Media
TMN	Telecommunication Management Network
TP_T	Transmission Path Termination
TP/VP_A	Transmission Path to Virtual Path Adaptation
UNEQ	Unequipped signal
UNI	User Network Interface
UPC	Usage Parameter Control
VC	Virtual Channel (ATM) or Virtual Container (SDH)
VCCT	VC Connection Termination
VCI	VC Identifier
VCL	VC Link
VoD	Video on Demand
VP	Virtual Path
VP_TT	VP Trail Termination
VPCT	VP Connection Termination
VPI	VP Identifier
VP/VC_A	Virtual Path to Virtual Channel Adaptation

3.2 Definitions

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

Additionally, the following terms are used:

3.2.1 functional block: The ATM NE functional model is described by means of transport functions, or logical groups of these functions called functional blocks. ATM Layer functions and related requirements are associated with multiplexing/demultiplexing and cross-connecting or switching of ATM cells. They are subdivided into two functional blocks respectively processing Virtual Paths and Virtual Channels.

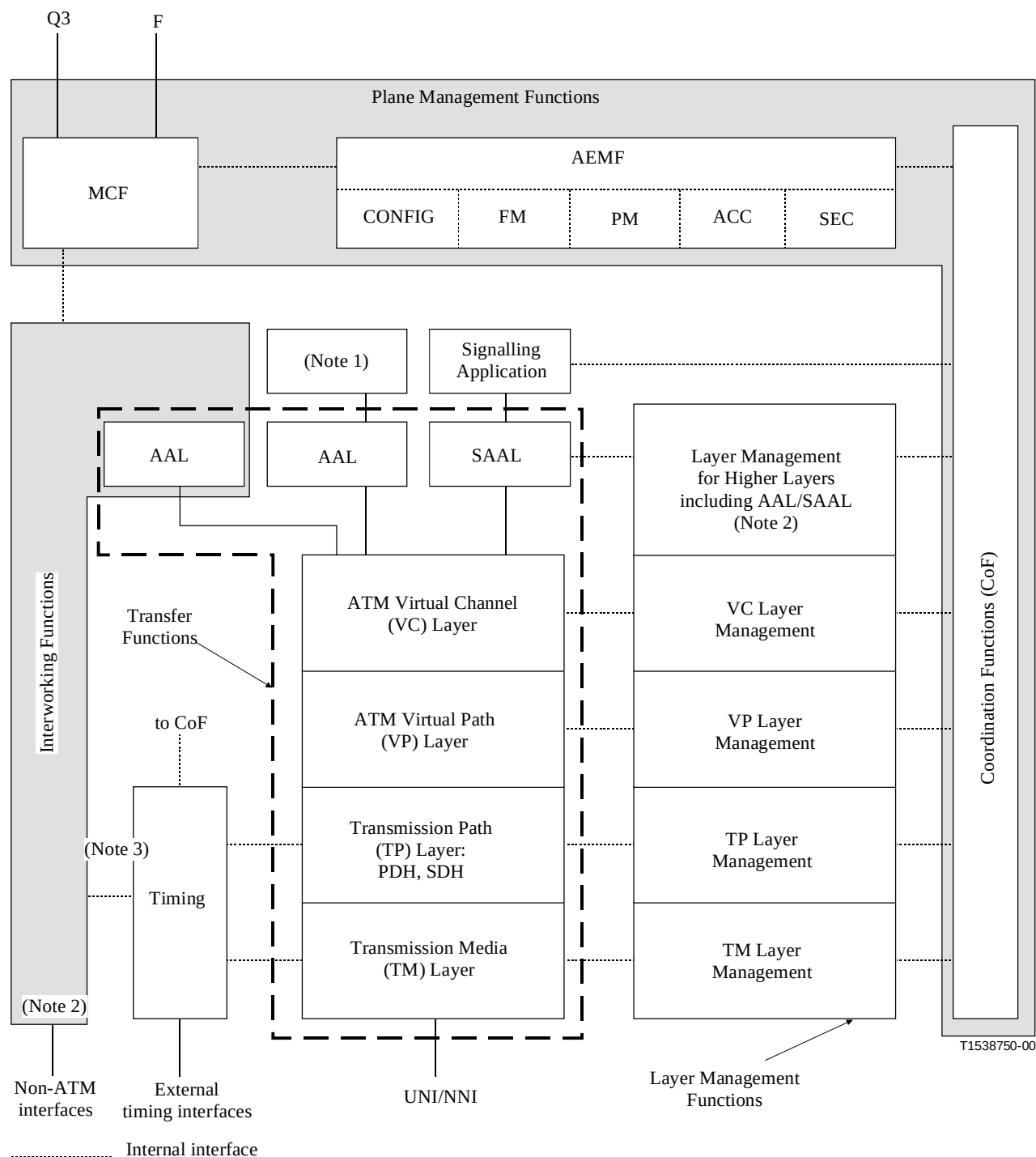
3.2.2 function: Each functional block is decomposed into several functions (e.g. VP Trail Termination function, Loopback function, Traffic Management function, ...) using the atomic function modelling (termination function, adaptation function, connection function).

3.3.3 process: Each function consists of several individual processes (setting or extracting of several fields, inserting or extracting of OAM cells, ...).

4 General functional description of the ATM equipment

For the purposes of this Recommendation, ATM equipment is described in terms of the functions of the user plane/transfer plane, control plane, layer management plane, plane management and timing functions as illustrated in Figure 4-1. To avoid complication, the control plane is not explicitly shown in Figure 4-1. The control plane comprises of the signalling applications and the associated AAL (SAAL). The ATM equipment may also include interworking function. The transfer functions can be configured by the management plane (PVC) and control plane (SVC). In the case of S-PVCs, which are a combination of PVC accesses connected by network signalled SVC links, the transfer functions are configured by a combination of both management plane and control plane.

The user plane/transfer plane is composed of the TM, TP, VP, VC, AAL transfer functions.



NOTE 1 – Service Specific and higher layers are not addressed in this Recommendation.

NOTE 2 – Not addressed in this Recommendation.

NOTE 3 – Some interworking functions may require an input from the timing functional block.

NOTE 4 – The CAC function is not shown in Figure 4-1. Please refer to Figure 4-3.

NOTE 5 – For reasons of space the following names had to be shortened. These are not adopted acronyms. Accounting was shortened to "ACC", Configuration was shortened to "Config" and Security was shortened to "SEC".

Figure 4-1/I.732 – General functional architecture of an ATM NE

4.1 Transfer functions

Transfer functions include all functions required for the transport of user, signalling, OAM, and RM information. In accordance with the B-ISDN Protocol Reference Model described in ITU-T I.321, the User Plane functions are layered into those for Physical Layer processing and those for ATM Layer processing.

The transfer functions are common for all higher layer services in B-ISDN. The service specific requirements for user information transfer only manifest themselves in the ATM Adaptation Layer (AAL) and higher layers. Descriptions of the higher layers are outside the scope of this Recommendation.

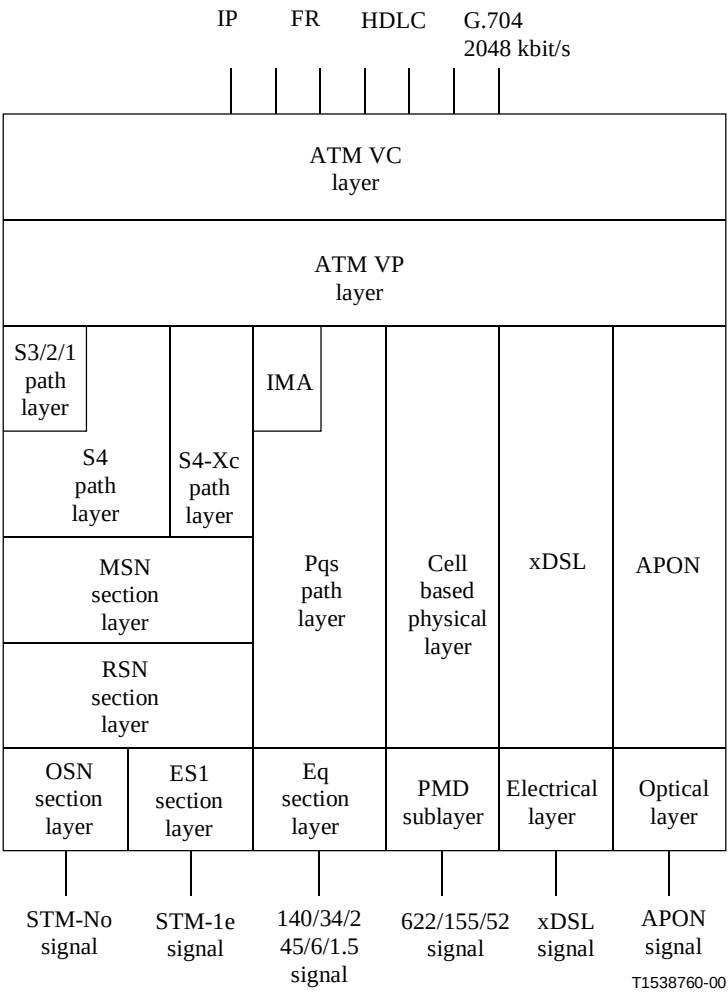
The transfer functions are also common for network related information such as signalling and management communications. The B-ISDN Protocol Reference Model makes a clear separation between User Plane, Control Plane and Management Plane functions. Consequently, the information flows between peer entities of the User Plane, Control Plane and Management Plane should be distinguished by the ATM NE in accordance with the procedures described in ITU-T I.361 [16].

4.1.1 Physical layer

The functions and related requirements associated with the Physical Layer include electro-optical conversion, line coding, timing recovery, frame generation, synchronization, and transmission overheads processing. Some physical layers (e.g. SDH) can be subdivided into Transmission Media Layer (including the digital or multiplex section, the regenerator section and the transmission media) and Transmission Path layers.

Some example physical interfaces for ATM NEs are shown in Figure 4-2.

4.1.1.1 Transmission media and path layers for user and network interfaces



NOTE 1 – The AALs are not shown in Figure 4-2 as AAL is not strictly a layer in the sense of Annex D.

NOTE 2 – Pqs is intended to represent synchronous PDH path options in the style of G.705. One example would be P31s.

NOTE 3 – Eq is intended to represent the synchronous PDH path options in the style of G.705. One example would be E31.

Figure 4-2/I.732 – Examples of transmission layers and interface signals

4.1.1.2 Other interfaces

- 1) TMN interface (e.g. Q interface in accordance with ITU-T G.773, Q.811 and Q.812).
- 2) Local craft interface (e.g. F interface).
- 3) External Timing interfaces (see clause 12/I.731 [10]).

Non-ATM interfaces (e.g. 64 kbit/s, FMBS, ITU-T X.25, etc. Not described in this Recommendation).

4.1.2 ATM Layer

ATM Layer functions and related requirements are associated with multiplexing/demultiplexing and cross-connecting or switching of ATM cells. They are subdivided into two functional blocks respectively processing Virtual Paths and Virtual Channels. The VP layer consists of: TP/VP adaptation, VP Traffic management; VP Loopback; Segment VP Termination; end-to-end VP Monitoring; Segment VP Monitoring; VP Connection, and VP Termination. The VC layer consists of: VP/VC adaptation, VC Traffic management; VC Loopback; Segment VC Termination, end-to-

end VC Monitoring; Segment VC Monitoring; VC Connection, and VC Termination. Figure 4-3 depicts these functions in relation with the general functional architecture of Figure 4-1. The detailed ATM NE 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 ITU-T G.806 [38]. The ATM NE functional model is thus described by means of these transport functions, or logical groups of these functions called functional blocks.

4.1.2.1 TP/VP_A, VP/VC_A

4.1.2.2 VPTM, VCTM

The *VP and VC Loopback Functions* (VPLB and VCLB) include processes that are performed per individual VP and VC trail. These include handling of Loopback cells on both end-to-end and segment level. Reduced functionality loopback options (VPLBR and VCLBR) have also been defined which may be used in certain reduced functionality equipment.

The *Segment VP and VC Termination Functions* (VPS and VCS) include processes that are performed per individual VP and VC trail (i.e. processing of segment F4 and F5 OAM flows).

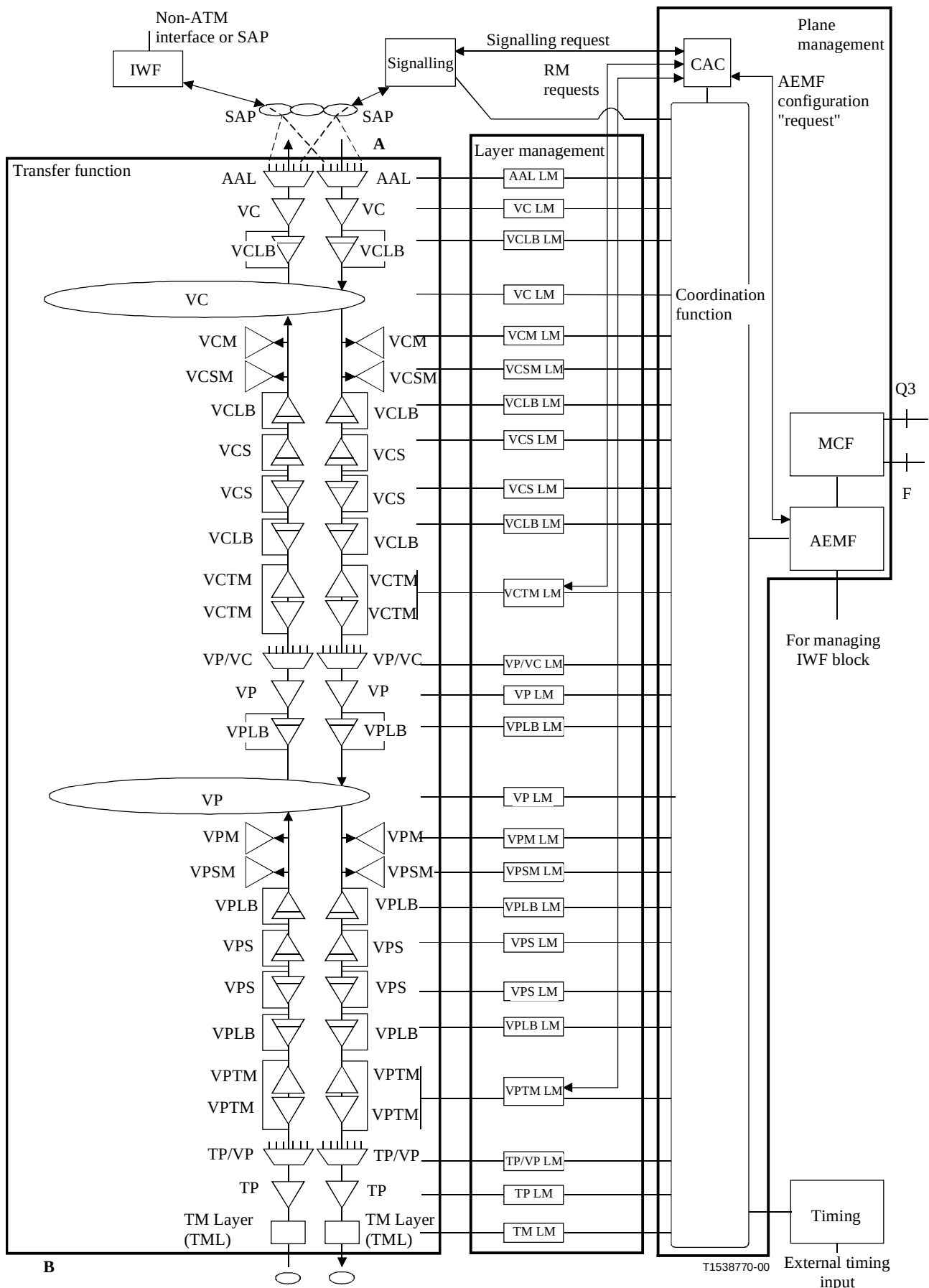
The *end-to-end and Segment VP and VC Monitoring Functions* (VPM, VCM, VPSM, VCSM) include the monitoring of functions that are performed per individual VP and VC trail in the functions VP TT, VC TT, VPS and VCS.

The *VP and VC Connection Functions* (VP_C, VC_C) perform matrix connections at the VP and/or VC layer within the ATM NE according to established ATM connections. The VC connection function (VC_C) performs connections of VC links between VC link End Points within the same NE according to established ATM connections. According to ITU-T I.150, cell sequence integrity shall be maintained between endpoints of a VP Connection for all cells belonging to this VP and between endpoints of a VC Connection for all cells belonging to this VC.

4.1.2.7 VP_TT, VC_TT

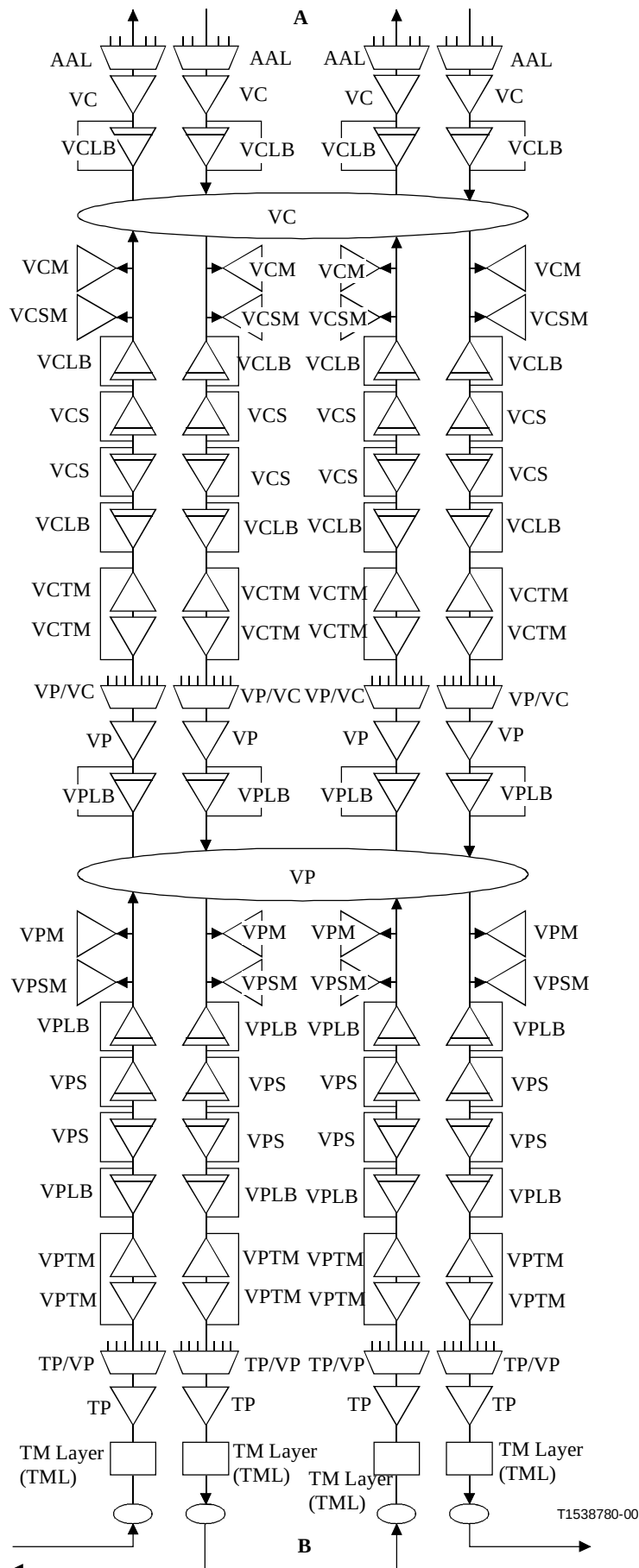
VP and VC Termination Functions (VP_TT, VC_TT) perform functions devoted to ATM Connection Endpoints (e.g. processing of end-to-end F4/F5 OAM flows); there is one instance of these functions per terminated VP and VC link.

10



NOTE – The OAM and traffic management functions may not be present in all ATM Equipments. If present, they may be activated or bypassed. This is represented by the bypass line in Figure 4-3.

Figure 4-3/I.732 – Detailed functional architecture of an ATM NE



NOTE – The OAM and traffic management functions may not be present in all ATM Equipments. If present, they may be activated or bypassed. This is represented by the bypass line in Figure 4-4.

Figure 4-4/I.732 – Information flows when considering two interfaces of an ATM NE

4.1.3 ATM Adaptation Layer (AAL)

The AAL functions enhance the service provided by the ATM Layer functions to enable the service-specific higher layers to use the service-independent ATM layer.

When AAL processing is required in the ATM NE, the AAL functional requirements should be in accordance with the AAL protocols described in ITU-T I.363x.

The AAL types described in ITU-T I.363x are:

- 1) AAL Type 1 in ITU-T I.363.1 [17];
- 2) AAL Type 2 in ITU-T I.363.2 [18];
- 3) AAL Type 3/4 in ITU-T I.363.3 [19];
- 4) AAL Type 5 in ITU-T I.363.5 [20].

Typical AAL functions include:

- 1) Segmentation and Reassembly (SAR).
- 2) Error detection/correction.
- 3) Length indication.
- 4) Timing Recovery.
- 5) Other service specific functions.

These protocols are service specific and are consequently Network/Service Provider Option(s). In general AAL protocols are end-to-end protocols and therefore not processed by intermediate ATM NEs. However, network providers may choose to offer specific services which may require AAL processing in ATM NEs.

4.1.4 Signalling ATM Adaptation Layer (SAAL)

One particular type of AAL service user is the signalling entity wishing to communicate with a peer entity. Each of these entities would require that functions are provided above the common part of the AAL specifically designed to facilitate this task. The AAL functions necessary to support signalling should be in accordance with ITU-T Q.2100, B-ISDN signalling ATM adaptation layer (SAAL). ITU-T Q.2100 also serves as a guide to all other Recommendations required by a user for the implementation of an AAL for the purpose of signalling.

4.2 Layer Management functions

Management information associated with a given transfer layer function is passed to (or received from) the corresponding Layer Management function, e.g. for processing of configuration, fault management, and performance monitoring.

Layer Management functions correspond one-to-one with transfer functions.

Physical layer management functions are provided in ITU-T G.705 (PDH TPs), G.783 [3] (SDH TPs) and G.806 [38] (generic processes).

ATM layer management functions are provided in clause 5 and Annex D.

4.3 Coordination functions

The coordination functions allow management information to flow between the layers for the purposes of communication. The coordination functions have some filtering capabilities. The coordination functions are described in more detail in clause 6.

4.4 Guidelines for using the Table structure and corresponding functional descriptions

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. For direction B to A, the functions in Table 4-1 need to be read in the order from the bottom of the table to the top of the table. Also, the processes within each function are to be read in the order from bottom of the function to the top of the function. For direction A to B, the functions in Table 4-1 need to be read in the order from the top of the table to the bottom of the table.

Table 4-1/I.732 – Functional partitioning

Level	Function	B to A		A to B	
		Function description		Function description	
		Transfer	Layer management	Transfer	Layer management
VC/ client_A	AAL – SAR – CPCS – SSCS	– AAL1 – AAL2 – AAL3/4 – AAL5 – SAAL		– AAL1 – AAL2 – AAL3/4 – AAL5 – SAAL	
	Discard of e-t-e and segment F5 OAM cells	Discard of e-t-e and segment F5 OAM cells	–	–	–
VC_TT	VC Termination function	Extraction of e-t-e F5 OAM cells	e-t-e F5 OAM cells processing	Insertion of e-t-e F5 OAM cells	F5 OAM cells processing
VCLB	VC connection endpoint loopback point and/or loopback source point	VCLB sink See D.5.6.2 or reduced functionality VCLBR Sink refer to D.5.6.4		VCLB source See D.5.6.1 or reduced functionality VCLBR Source refer to D.5.6.3	
VC_C	VC Connection Function	Interconnection of VC links	Association of VC links	Interconnection of VC links	Association of VC links
		Multicasting	FFS	Multicasting	FFS
		VC Protection functions	FFS	VC protection functions	FFS
VCM	e-t-e F5 OAM non-intrusive monitoring	Read e-t-e F5 OAM cell	e-t-e F5 OAM cell processing	Read e-t-e F5 OAM cell	e-t-e F5 OAM cell processing
VCSM	Seg F5 OAM non-intrusive monitoring	Read segment F5 OAM cell	Segment F5 OAM cell processing	Read segment F5 OAM cell	Segment F5 OAM cell processing
VCLB	VC Loopback (e-t-e and/or segment) source point and/or segment loopback point	VCLB source See D.5.6.1 or reduced functionality VCLBR Source refer to D.5.6.3		VCLB sink See D.5.6.2 or reduced functionality VCLBR Sink refer to D.5.6.4	
VCS	Segment VC OAM	Segment VC OAM endpoint Source. Refer to D.5.4.1		Segment VC OAM endpoint Sink. Includes e-t-e VC-AIS insertion Refer to D.5.4.2	
VCS	Segment VC OAM	Segment VC OAM endpoint Sink. Includes e-t-e VC-AIS insertion Refer to D.5.4.2		Segment VC OAM endpoint Source. See D.5.4.1	

Table 4-1/I.732 – Functional partitioning (continued)

Level	Function	B to A		A to B	
		Function description		Function description	
		Transfer	Layer management	Transfer	Layer management
VCLB	VC Loopback (e-t-e and/or segment) source point and/or segment loopback point	VCLB sink refer to D.5.6.2 or reduced functionality VCLBR Sink refer to D.5.6.4		VCLB source refer to D.5.6.1 or reduced functionality VCLBR Source refer to D.5.6.3	
VCTM	Resource management	For further study	For further study	For further study	For further study
	Shaping (Note 1)	VC traffic shaping	Traffic descriptors	VC traffic shaping	Traffic descriptors
	VC usage measurement	–	–	Detection of cell arrival	Count outgoing cells per VC for CLP = 0+1 and CLP = 0
	EPD/PPD functionality (Note 2)	For further study	For further study	For further study	For further study
	VC UPC/NPC	VC compliance checking and corrective action if activated	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	–	–
	EFCI setting	Setting of the EFCI bit of PTI field for user congestion indication	EFCI generation	Setting of the EFCI bit of PTI field for user congestion indication	EFCI generation
VP/ VC_A	VCI setting	–	–	VCI field setting	VCI assignment
	VC multiplexing	Demultiplexing of the VCs according to the VCI values	–	VC Multiplexing into VP	–
	VC-AIS	VC-AIS insertion (Note 5)	Generation of VC-AIS for each configured VC	–	–
	Metasignalling Sink (Note 3)	Extraction of metasignalling cells	Metasignalling cells processing	–	–

Table 4-1/I.732 – Functional partitioning (continued)

Level	Function	B to A		A to B	
		Function description		Function description	
		Transfer	Layer management	Transfer	Layer management
VP/ VC_A (continued)	Congestion Control (Notes 3, 4)	Selective Cell discard (CLP based)	Act./deact. of cell discard based on congestion detection	Detects congestion	Indicates congestion to EPD/PPD, RM and EFCI processing functions
		Detects congestion	Indicates congestion to EPD/PPD (Note 6), RM and EFCI processing functions	Selective Cell discard (CLP based)	Act./deact. of cell discard based on congestion detection
	Metasignalling Source (Note 3)			Insertion of metasignalling cells	Metasignalling cells processing
	VCI processing	Reading of VCI; discarding of cells with invalid VCI	Count of cells with invalid VCI cells (Note 7)	–	–
	Discard of e-t-e and segment F4 OAM cells	Discard of e-t-e and segment F4 OAM cells	–	–	–
VP_TT	F4 OAM cells insertion/extraction	Extraction of F4 OAM cells	F4 OAM cells processing	Insertion of F4 OAM cells	F4 OAM cells processing
VPLB	VP connection endpoint loopback point and/or loopback source point	VPLB Sink refer to D.3.6.2 or reduced functionality VPLBR Sink refer to D.3.6.4		VPLB Source refer to D.3.6.1 or reduced functionality VPLBR Source refer to D.3.6.3	
VP_C	VP connection function	Interconnection of VP links	Association of VP links	Interconnection of VP links	Association of VP links
		Multicasting	FFS	Multicasting	FFS
		VP Protection functions	FFS	VP protection functions	FFS
VPM	e-t-e F4 OAM non-intrusive monitoring	Read e-t-e F4 OAM cell	e-t-e F4 OAM cell processing	Read e-t-e F4 OAM cell	e-t-e F4 OAM cell processing
VPSM	Seg F4 OAM non-intrusive monitoring	Read segment F4 OAM cell	Segment F4 OAM cell processing	Read segment F4 OAM cell	Segment F4 OAM cell processing
VPLB	VP Loopback (e-t-e and/or segment) source point and/or segment loopback point	VPLB Source refer to D.3.6.1 or reduced functionality VPLBR Source refer to D.3.6.3		VPLB Sink refer to D.3.6.2 or reduced functionality VPLBR Sink refer to D.3.6.4	



Documents

Document Sharing Hub

Table 4-1/I.732 – Functional partitioning (continued)

Level	Function	B to A		A to B	
		Function description		Function description	
		Transfer	Layer management	Transfer	Layer management
VPS	Segment VP OAM	Segment VP OAM endpoint Source. See D.3.4.1		Segment VP OAM endpoint Sink. Includes e-t-e VP-AIS insertion See D.3.4.2	
VPS	Segment VP OAM	Segment VP OAM endpoint Sink. Includes e-t-e VP-AIS insertion Refer to D.3.4.2		Segment VP OAM endpoint Source. Refer to D.3.4.1	
VPLB	VP Loopback (e-t-e and/or segment) source point and/or segment loopback point	VPLB Sink refer to D.3.6.2 or reduced functionality VPLBR Sink refer to D.3.6.4		VPLB Source refer to D.3.6.1 or reduced functionality VPLBR Source refer to D.3.6.3	
VPTM	Resource management	For further study	For further study	For further study	For further study
	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 cell counters		
	VP usage measurement	Detection of cell arrival	Incoming cells count per VP for CLP = 0+1 and CLP = 0		Outgoing cells count per VP
	EFCI setting	Setting of the EFCI bit of PTI field for user congestion signalling	EFCI generation	Setting of the EFCI bit of PTI field for user congestion signalling	EFCI generation
TP/VP_A (Note 8)	VPI setting	–	–	VPI field setting	VPI assignment
	VP mux	Demultiplexing of the VPs according to the VPI values		Multiplexing of VPs onto TP	
	VP-AIS insertion	VP-AIS insertion (Note 5)	Generation of VP-AIS for each configured VC	–	–
	Congestion Control (Note 4)	Selective Cell discard (CLP based)	Act./deact. of cell discard based on congestion detection	Congestion detection	Indicates congestion to EPD/PPD, RM and EFCI processing functions if present elsewhere in stack. (Note 9)

Table 4-1/I.732 – Functional partitioning (continued)

Level	Function	B to A		A to B	
		Function description		Function description	
		Transfer	Layer management	Transfer	Layer management
TP/VP_A (Note 8) (continued)		Congestion detection	Indicates congestion which may be used by EPD/PPD, RM and EFCI processing functions if present elsewhere in stack. (Note 9)	Selective Cell discard (CLP based)	Act./deact. Of cell discard based on congestion detection
	VPI verification	Reading of VPI; and discarding of unassigned cells and cells with invalid VPI	Count of cells with invalid VPI (Note 7)	–	–
	GFC	Read GFC field (if applicable) (Note 10)	GFC processing	Setting of GFC field in an assigned cell or insertion of unassigned cells (Note 10)	GFC processing
TP/VP_A	Header verification	Read header and discard cells with invalid header pattern (e.g. F3 OAM on SDH or PDH TPs)	Count of cells with invalid header pattern. (Note 11)	–	–
	TP usage measurement	Detection of cell arrival	Incoming cells count per TP Act./deact. of cell counting	detection of cell arrival	Outgoing cells count per TP Act./deact. of cell counting
	Cell rate decoupling	Idle cell discard (Note 11)	–	Idle cell insertion (Note 11)	–
	HEC processing	Header verification, correction (if applicable) and discarding of invalid HEC cells (see Note 12)	Invalid HEC event. Invalid HEC cell discarded event. Act./deact. of correction mode	HEC generation	–
	Scrambling/Descrambling	Cell information field descrambling	–	Cell information field scrambling	–

Table 4-1/I.732 – Functional partitioning (concluded)

Level	Function	B to A		A to B	
		Function description		Function description	
		Transfer	Layer management	Transfer	Layer management
TP/VP_A (continued)	Cell delineation	Cell delineation (T3 PLCP uses PLCP frame and not the cell headers)	LCD defect detection (except with the T3 PLCP format)	–	–
			OCD anomaly event counter and consequent actions	–	–
	Mapping/ Demapping	Cell stream extraction	–	Cell stream mapping	–
	TP payload specific functions	TP payload specific fields extraction. E.g. for SDH & PDH TPs the trail signal label is processed	TP payload specific fields processing	TP payload specific fields insertion. E.g. for SDH & PDH TPs the trail signal label is set	–
TP_TT	Transmission Path Trail Termination Function	Transmission path overhead extraction	Transmission path overhead processing	Transmission path overhead insertion	Transmission path overhead processing
TML	Transmission Media Layer				

NOTE 1 – Shaping is optional.

NOTE 2 – The modelling of the EPD/PPD and Resource Management functions is for further study. Until the modelling is completed their relative positions could change.

NOTE 3 – The relative location of the Metasignalling (source and sink) functions with respect to Congestion Control is still an open issue.

NOTE 4 – Congestion detection can occur in other functions than VP/VC_A and TP/VP_A. Moreover other mechanisms to react to a congestion detection are possible.

NOTE 5 – This should be end-to-end AIS and optionally segment AIS. See Annex D for options.

NOTE 6 – EPD and PPD are not yet modelled in this Recommendation.

NOTE 7 – The counter is common for invalid header, invalid VPI and invalid VCI.

NOTE 8 – The TP/VP_A currently defined in this Recommendation applies only for SDH and PDH path. For other TP/VP_As reference should be made to TP-specific Recommendations.

NOTE 9 – EPD/PPD is not available at the VP layer.

NOTE 10 – UNI only.

NOTE 11 – For IMA, cell rate decoupling is achieved using IMA Control Protocol cells (ICP) and IMA filler cells.

NOTE 12 – The TP/VP_A shall pass all cells to the IMA sublayer (this includes HEC errored cells); discarding of invalid HEC cells and idle cells insertion/extraction prevents IMA operation.

5 Transfer functions and Layer Management functions

This clause describes in detail the transfer functions and layer management functions of an ATM NE. The structure of the text is intended to follow the ordering of Figure 4-3.

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). The following interfaces have been specified: SDH interfaces according to ITU-T G.707 [2] and G.783 [3], PDH interfaces according to ITU-T G.703 [1], G.705 and G.832 [8], cell-based interfaces (e.g. ATM 155.52 Mbit/s in ITU-T I.432.2 [23], ATM 622 Mbit/s in ITU-T I.432.2 and ATM 25 Mbit/s in ITU-T I.432.5), interfaces that have inverse multiplexing capability (e.g. $n * 2.048$ Mbit/s IMA and $n * 1.544$ Mbit/s IMA in ITU-T I.761 [37]) and interfaces that are xDSL based (e.g. ADSL based interface in ITU-T G.992.1 [35] and splitterless ADSL interfaces in ITU-T G.992.2 [36]).

The physical layer specifications for ATM NEs shall comply with ITU-T I.432 for B-ISDN User-Network Interface (UNI) types. ITU-T G.707, G.783, G.957, and G.703 apply for SDH-based B-ISDN Network Node Interface (NNI) types. ITU-T G.832, G.804, G.705 and G.703 apply for PDH based B-ISDN Network Node Interface (NNI) types. ITU-T I.432 applies for cell based UNIs. ITU-T I.761 applies for IMA interfaces.

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

5.1.1 SDH 155.52 Mbit/s Interface

The interface rate and format shall conform to the SDH STM-1 level given in ITU-T G.707 and ITU-T I.432.2. These functions are defined in ITU-T 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 ITU-T G.707 and I.432.2. These functions are defined in ITU-T 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 ITU-T G.707. These functions are defined in ITU-T 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 ITU-T G.707.

5.1.5 PDH based interfaces

The interfaces rates and formats shall conform to the PDH levels given in ITU-T G.703 and G.705.

5.1.6 Cell-based UNI

For cell-based interfaces, functionality shall be in accordance with ITU-T I.432.2.



5.1.7 ATM 25 Mbit/s interface

The interface rate and format shall be in accordance with ITU-T I.432.5 [26].

5.1.8 IMA interface

The interface rate and format shall be in accordance with ITU-T I.761 and G.703.

5.1.9 xDSL interfaces

An overview of DSL standardization is given in ITU-T G.995.1 [45]. The interface rates and formats shall conform to the ADSL standard given in ITU-T G.992.1 and ADSL Lite standard given in ITU-T G.992.2. Work is in progress in ITU-T SG 15 on Recommendations for VDSL and SHDSL.

5.2 Transmission Path Trail Termination function (TP_TT)

The TP_TT 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 ITU-T G.707. The SDH TP_TT is further defined in ITU-T G.783. Generic functions are in ITU-T G.806.

Specifications for the appropriate PDH overhead shall be in accordance with ITU-T G.804 and G.832 [8]. The PDH TP_TT function is further defined in ITU-T G.705.

Specifications for the appropriate cell-based and ATM 25 overhead shall be in accordance with ITU-T I.432 and I.432.5.

Specifications for the appropriate IMA overhead shall be in accordance with ITU-T I.761. The IMA TP_TT function is further defined in ITU-T G.705 since they use PDH frames.

Specifications for the appropriate ADSL overhead shall be in accordance with ITU-T G.992.1.

Specifications for the appropriate ADSL Lite overhead shall be in accordance with ITU-T G.992.2.

Work is in progress in ITU-T SG 15 on Recommendations for VDSL and SHDSL. The information derived from/provided to plane management is defined in ITU-T G.783 for SDH interfaces.

5.3 Transmission Path/Virtual Path Adaptation function (TP/VP_A)

This function adapts an ATM cell structure to a transmission path signal structure.

Clauses 5.3.1 and 5.3.2 mainly address SDH and PDH interfaces but some of the information is valid for other interfaces. These clauses will be updated in the future to improve the validity of these clauses for cell-based, ATM 25, IMA, and xDSL interfaces.

5.3.1 TP/VP_A (B to A)

See D.2.:

S3/VP_A_Sk

S4/VP_A_Sk

S4-nc/VP_A_Sk

P12s/VP_A_Sk

P31s/VP_A_Sk

5.3.1.1 TP Payload specific functions

Certain TP information fields (e.g. signal label) are payload specific and hence have to be set for ATM equipment use.

NOTE – The payload position indicator (e.g. H4 in C4-POH) is not used for ATM equipment.

Transfer function: Extract the payload specific information from the TP overhead: signal label and path status information. Other fields are not yet defined for use with ATM.

For SDH the trail signal label is defined in ITU-T G.707 and its usage is defined in ITU-T G.783. The defect payload mismatch and consequent actions are defined in ITU-T G.783.

For SDH higher order paths the signal label is contained in the C2 byte. The value for ATM is 13 hex.

For SDH lower order paths, the signal label was defined in ITU-T G.707 to be contained in byte V5 and K4. Since there was an extended period between a mapping being defined and a code-point being assigned, interworking between new and old equipment has been defined in Table 5-1.

- New equipment shall be configured to expect an ATM signal of V5 = 101 binary and a signal label of 0000 1001 carried in bit 1 of the K4 byte. New equipment shall also accept an equipped, non specific code of V5 = 001 binary for backwards compatibility.
- Old equipment shall be reprogrammed to accept V5 = 001 binary and V5 = 101 binary (and expected to ignore K4).
- For old equipment that cannot be reprogrammed, old-new interworking is only possible if:
 - a) payload mismatch detection can be disabled on the old equipment; or
 - b) if payload mismatch is not supported on the old equipment.

There is a risk with this scheme that old equipment will accept a non-ATM payload (such as IP). This risk will decline as old equipment is retired.

Table 5-1/I.732 – Interworking solution for V5/K4 lower order signal label assignment for ATM

	Equipment "1"		Equipment "2"	
	Transmitter settings	Receiver settings	Transmitter settings	Receiver settings
Old-Old interworking	V5 = 001	Accepts V5 = 001 and V5 = 101. Ignores K4. May alarm on other values received	V5 = 001	Accepts V5 = 001 and V5 = 101. Ignores K4. May alarm on other values received
Old-New interworking	V5 = 001	Accepts V5 = 001 and V5 = 101. Ignores K4. May alarm on other values received	V5 = 101 and ATM signal label in K4 bit 1.	Payload mismatch function is negated by receiving V5 = 001.
New-New interworking	V5 = 101 and K4 = 00000010	Expects V5 = 101 and ATM signal label in K4 bit 1. Will not alarm on V5 = 001	V5 = 101 and ATM signal label in K4 bit 1.	Expects V5 = 101 and ATM signal label in K4 bit 1. Will not alarm on V5 = 001

For PDH the trail signal label (payload type) is defined in ITU-T G.832 and its usage is defined in ITU-T G.705. The defect payload mismatch and consequent actions are defined in G.705.

Layer Management functions:

In the event of payload mismatch as defined by ITU-T G.783, downstream transport is stopped and an internal Server Signal Fail is sent to the end-to-end VP-AIS generation process and segment VP-AIS generation function (if present). The Server Signal Fail is also forwarded to all associated VP/VC_A process. When the payload mismatch state has been cleared, user transport is allowed to continue and SSF is no longer sent to the end-to-end and segment VP-AIS generation process.

There are two notes covering exclusions for segment AIS in ITU-T I.610 that are applicable.

5.3.1.2 Demapping

Transfer function:

The cell stream shall be extracted from the transmission path payload which shall be in accordance with ITU-T G.707 for SDH, ITU-T G.804 for PDH, ITU-T I.761 for IMA, ITU-T I.432.5 for ATM 25, ITU-T G.992.1 for ADSL, and ITU-T G.992.2 for ADSL Lite. Work is in progress in ITU-T SG 15 on Recommendations for VDSL and SHDSL.

5.3.1.3 Cell delineation

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 ITU-T I.432.2 [23] for SDH, ITU-T I.432.1 [21] and I.432.3 [24] for PDH.

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

Layer Management function:

The detection of LCD defect shall be in accordance with ITU-T I.432.2 for SDH, ITU-T I.432.1 and I.432.3 for PDH.

NOTE – The PLCP mapping for T3 (DS3) interfaces does not use the ATM headers for cell delineation.

5.3.1.4 Descrambling

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 ITU-T I.432.2 for SDH and ITU-T I.432.1 and ITU-T I.432.3 for PDH.

For details of whether scramblers are required for other TPs, the TP-specific Recommendation should be consulted, e.g. to determine whether scrambling is required for ATM 25, the ATM 25 interface description, ITU-T I.432.5 [26] should be consulted.

5.3.1.5 HEC Processing

Transfer function:

HEC verification and correction shall be in accordance with ITU-T I.432.2 for SDH, ITU-T I.432.1 and I.432.3 for PDH. Cells determined to have an invalid and uncorrectable HEC pattern shall be discarded. If this function is a TP/VP_A_Sk for IMA, cells determined to have an invalid and uncorrectable HEC pattern are not discarded.

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

Layer Management function:

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

HEC correction mode should be activated by default.

5.3.1.6 Cell rate decoupling

Transfer function:

Idle cells are extracted from the cell stream for SDH and PDH TPs. For IMA TPs the multiple links are more akin to TDM or TDMA and there are no idle cells. Instead the IMA processing will process the IMA control cells and remove the IMA filler cells. The description for other TPs will be found in the TP-specific Recommendations.

5.3.1.7 TP usage measurement

Transfer function:

Cell reception is indicated to layer management.

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.

5.3.1.8 Cell Header verification

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 example of invalid header pattern occurs when cell-based OAM cells are detected on SDH or PDH based physical layers. An indication of an invalid header cell discard event is provided to layer management.

Layer Management function:

Specific values of the cell header have been defined in ITU-T I.361 [16] 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 ITU-T I.361.

Invalid header patterns for SDH/PDH-based TP-TTs are as follows (Table 5-2) (except idle cell) (p = any value):

Table 5-2/I.732 – Invalid header patterns as defined by I.361

Interface type	GFC	VPI	VCI	PTI	CLP
UNI	pppp	0000 0000	0000 0000 0000 0000	ppp	1
NNI	not applicable	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.

5.3.1.9 GFC

Transfer function:

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

Layer Management function:

If present, GFC layer management function shall be in accordance with ITU-T I.150 and I.361. More detail is contained in D.2 for each physical layer (e.g. for S4 physical layer see S4/VP_A_Sk).

5.3.1.10 VPI verification

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.

Layer Management function:

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

5.3.1.11 Congestion Control

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 ITU-T I.371 [21] for further details about the use of the CLP.

Layer Management function:

If enabled, this process shall perform selective cell discard according to the CLP value.

5.3.1.12 End-to-end VP AIS insertion

See D.2 for details on end-to-end VP-AIS insertion.

5.3.1.13 Segment VP AIS insertion

See D.2 for details on segment VP-AIS insertion.

5.3.1.14 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 (A to B) for SDH and PDH

See D.2:

S3/VP_A_So

S4/VP_A_So

S4-nc/VP_A_So

P12s/VP_A_So

P31s/VP_A_So

5.3.2.1 VPI setting

This function provides the possibility to map an internal connection tag to the VPI. The VPI setting is located in the TP/VP_A. It is needed to be associated with a TP since the VPIs may be reused across TPs.

Transfer function:

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

Layer Management function:

At the UNI a total of up to 8 bits are available for VPI as defined in ITU-T I.361. At the NNI a total of up to 12 bits are available for VPI as defined in ITU-T 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 rules for allocation of the VPI/VCI bits and the pre-assigned values are specified in ITU-T I.361. The VPI/VCI values are to be assigned bidirectionally.

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

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

5.3.2.2 VP multiplexing

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

5.3.2.3 Congestion Control

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 ITU-T I.371 for further details about the use of the CLP. In the event of congestion, the EFCI marking in the PTI field is set according to ITU-T I.361.

Layer Management function:

For further study.

5.3.2.4 GFC

Transfer function:

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

Layer Management function:

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

5.3.2.5 TP Usage Measurement

Transfer function:

Cell transmission is indicated to layer management.

Layer Management function:

Transmitted 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.

5.3.2.6 Cell rate decoupling

Transfer function:

Idle cells are inserted into the cell stream to match the rate of the TP payload in accordance with ITU-T I.432.2 [23] for SDH, I.432.1.1 [22] and I.432.3 [24] for PDH. The format of the idle cell

should be in accordance with ITU-T I.432.

5.3.2.7 HEC Processing

Transfer function:

The HEC value for each cell is calculated and inserted into the HEC field. The method of HEC value calculation shall be in accordance with ITU-T I.432.2 for SDH, ITU-T I.432.1 and I.432.3 for PDH.

5.3.2.8 Scrambling

Transfer function:

The 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 ITU-T I.432.2 for SDH, ITU-T I.432.1 and I.432.3 for PDH.

5.3.2.9 Mapping

Transfer function:

The cell stream shall be inserted into the transmission path payload which shall be in accordance with ITU-T G.707 [2] for SDH, ITU-T G.804 for PDH and ITU-T I.761 for IMA. The cell boundaries are aligned with the TP octet boundaries. The cell stream shall be inserted into the transmission path payload which shall be in accordance with ITU-T I.432.5 [26] for ATM 25, ITU-T G.992.1 [35] for ADSL, and ITU-T G.992.2 [36] for ADSL Lite. Work is in progress in ITU-T SG 15 on Recommendations for VDSL and SHDSL.

5.3.2.10 TP Payload specific functions

Certain TP information fields (e.g. signal label and path status) are payload specific and hence have to be set for ATM equipment use.

NOTE 1 – The payload position indicator (e.g. H4 in C4-POH) is not used for ATM equipment.

Transfer function:

For SDH the trail signal label is defined in ITU-T G.707 [2] and its usage is defined in ITU-T G.783 [3] and G.806 [38]. Codepoints exist for ATM for the higher order paths in the C2 byte and the correct value should be used. A specific codepoint has been defined for ATM mapped into lower order paths in the 2000 version of ITU-T G.707 using an escape code $V5 = 101$ and the signal label of 0000 1001 carried in bit 1 of the K4 byte.

NOTE 2 – Old equipment which predates the allocation of a codepoint for ATM in the lower order VC is expected to transmit $V5 = 001$.

Layer Management functions:

For SDH paths, the trail signal label shall be set for ATM equipment. For higher order SDH paths, the layer management should instruct that the G1 byte is set to ATM.

For lower order SDH paths the V5 byte shall be set to 101 and the signal label of 0000 1001 carried in bit 1 of the K4 byte. Old equipment may have V5 set to 001.

For PDH paths, the trail signal label (payload type) shall be set in accordance with ITU-T G.832 [8].

5.4 VP Traffic Management function (VPTM)

The VP traffic management functions are modelled as a set of functions which if activated are always present as a set. The set consists of the following functions of Annex D: VPTM_TT_Sk, and VPTM_TT_So. The functionality is currently modelled as being the same for ingress and egress to the equipment with the exception that UPC/NPC does not occur for egress ports. Modelling of new traffic classes and functionality to support IP is for further study.

A detailed description of the VPTM_TT functions can be found in D.3.5.

5.4.1 VP usage measurement

Transfer function:

For B to A direction cell reception is indicated to layer management. For A to B direction cell transmission is indicated to layer management.

Layer Management function:

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

- 1) Count of total VPC cells with $CLP = 0 + 1$.
- 2) Count of total VPC cells with $CLP = 0$. This count is only maintained when the CLP option is used. See 5.4.2 on UPC/NPC.

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

5.4.2 VP UPC/NPC (B to A only)

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 VPTM_TT_Sk associated with a TP_TT configured as a UNI. The use of NPC is optional for a VPTM_TT_Sk associated with a TP_TT configured as an NNI. Actions and requirements of UPC/NPC are described in ITU-T 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.

Transfer function:

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

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 ITU-T I.371 and I.150. The coding of CLP values is defined in ITU-T 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 ITU-T 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.

5.4.3 Traffic shaping

Transfer function:

If present, the use of the traffic shaper should be in accordance with ITU-T I.371. The shaping function can be activated/deactivated at this point in the model per connection.

Traffic shaping should be incorporated as a mechanism that alters the traffic characteristics of a stream of cells on a specific VPC while maintaining cell sequence integrity on the ATM connection. In general, shaping modifies the traffic characteristics with the consequence of increasing the mean cell transfer delay. Examples of traffic shaping are peak cell rate reduction, burst length limiting, reduction of CDV by spacing cells in time and queue service schemes.

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.

NOTE – This does not preclude shaping at two layers i.e. VP shaping on the B to A side and VC shaping on the A to B side, simultaneously. As a consequence, a VC connection can be shaped twice.

5.4.4 EFCI setting

The modelling of EFCI setting is for further study.

5.4.5 Resource management

For further study. Some material can be found in Appendix I, Functional requirements for ABR.

5.5 VP OAM functions

NOTE – This clause deals with the OAM functions between the VPTM and VP_C. OAM functions are also associated with the TP/VP_A (one of the locations for AIS insertion – see 5.3), and the VPLB (connection end-point associated loopback functions – see 5.7) and the VP_TT (connection end-point associated OAM functions – see 5.8).

5.5.1 F4 OAM functions (B to A) between VPTM and VP_C

Between the VP Traffic management function and the VP connection function are the following OAM functions:

VPLB_Sk compound function	see D.3.6
VPS_Sk compound function	see D.3.4.2 (VPS_TT_Sk) and D.3.4.4 (VPS/VP_A_Sk)
VPS_So compound function	see D.3.4.1 (VPS_TT_So) and D.3.4.3 (VPS/VP_A_So)
VPLB_So compound function	see D.3.6
VPSM_Sk	see D.3.3.2
VPM_Sk	see D.3.3.1

All ATM equipment supporting loopback functionality will implement source point function and loopback point function as described above. For some specific terminal equipment (e.g. PABX, XDSL modem, ...) only loopback point function could be implemented to reduce their complexity. These reduced loopback functions are called VPLBR_TT in Annex D.

NOTE 1 – There are no VPSM_So or VPM_So functions corresponding to the VPSM_Sk and VPM_Sk non-intrusive monitors by definition of it being a non-intrusive function.

NOTE 2 – As artefacts of the functional modelling, the Loopback termination points are accompanied by adaptation functions that are actually null functions.

NOTE 3 – An option exists to replace the Loopback functions VPLB_Sk and VPLB_So with reduced functionality loopback functions VPLBR_Sk and VPLBR_So. These are also described in D.3.6.

5.5.2 F4 OAM functions (A to B) between VPTM and VP_C

Between the VP Traffic management function and the VP connection function are the following OAM functions:

VPM_Sk	see D.3.3.1
VPSM_Sk	see D.3.3.2
VPLB_Sk compound function	see D.3.6
VPS_Sk compound function	see D.3.4.2 (VPS_TT_Sk) and D.3.4.4 (VPS/VP_A_Sk)
VPS_So compound function	see D.3.4.1 (VPS_TT_So) and 3.4.3 (VPS/VP_A_So)
VPLB_So compound function	see D.3.6

NOTE 1 – There are no VPSM_So and VPM_So functions corresponding to the VPSM_Sk and VPM_Sk non-intrusive monitors by definition.

NOTE 2 – As artefacts of the functional modelling, the Loopback termination points are accompanied by adaptation functions that are forsooth null functions.

NOTE 3 – An option exists to replace the Loopback functions VPLB_Sk and VPLB_So with reduced functionality loopback functions VPLBR_Sk and VPLBR_So. These are also described in D.3.6.

5.6 VP Connection function (VP_C)

See VP_C in D.3.1. The model includes VP layer Subnetwork Protection functions as part of the VP_C.

5.7 VP Connection End point Loopback function (VPLB_TT)

The specific functions for the VPLB_TT can be found in D.3.6. An artifact of the model is that the loopback termination functions are accompanied by adaptation functions although these are actually null functions.

5.8 VP Trail Termination function (VP_TT)

The specific functions for the VP Termination point can be found in D.3.2.

5.9 Virtual Path/Virtual Channel Adaptation function (VP/VC_A)

5.9.1 VP/VC_A (B to A)

See VP/VC_A_Sk, D.4.2.

5.9.1.1 Discard of end-to-end and segment F4 OAM cells

This function removes any end-to-end and segment F4 OAM cells that failed to get extracted by the termination point or any trail protection functionality.

5.9.1.2 VCI verification and invalid VCI cell discard

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.

Layer Management function:

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

5.9.1.3 Congestion Control

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 ITU-T I.371 for further details about the use of the CLP.

Layer Management function:

If enabled, this process shall perform selective cell discard according to the CLP value.

5.9.1.4 Metasignalling

Transfer function:

Extraction of metasignalling cell. This function is optional. The modelling of metasignalling functionality is for further study. (Format of the metasignalling cell should be in accordance with ITU-T I.361.)

Layer Management function:

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

5.9.1.5 End-to-end VC AIS insertion

See D.4.2 of for detail on end-to-end VC-AIS insertion.

5.9.1.6 Segment VC AIS insertion

See D.4.2 for detail on segment VC-AIS insertion.

5.9.1.7 VC demultiplexing

Transfer function:

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

5.9.2 VP/VC_A (A to B)

See VP/VC_A_So, D.4.1.

5.9.2.1 VCI setting

Transfer function:

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

Layer Management function:

At the UNI/NNI a total of up to 16 bits are available for VCI as defined in ITU-T 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 pre-assigned values are specified in ITU-T I.361. The VPI/VCI values are to be assigned bidirectionally.

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

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

5.9.2.2 VC multiplexing

Transfer function:

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

NOTE – When the VCCs are multiplexed into a VPC, the multiplexing function should respect the traffic characteristics of the VP level.

5.9.2.3 Congestion Control

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 ITU-T I.371 for further details about the use of the CLP. In the event of congestion, the EFCI marking in the PTI field is set according to ITU-T I.361.

Layer Management function:

For further study.

5.9.2.4 Metasignalling

Transfer function:

Insertion of metasignalling cell. This function is optional. The modelling of metasignalling functionality is for further study. (Format of the metasignalling cell should be in accordance with ITU-T I.361.)

Layer Management function:

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

5.10 VC Traffic Management function (VCTM)

The VC traffic management functions are modelled as a set of functions which if activated are always present as a set. The set consists of the following functions of Annex D: VCTM_TT_Sk, and VCTM_TT_So. The functionality is currently modelled as being the same for ingress and egress to the equipment with the exception that UPC/NPC does not occur for egress ports. Modelling of new traffic classes and functionality to support IP is for further study.

A detailed description of the VCTM_TT functions can be found in D.5.5.

5.10.1 VC usage measurement

Transfer function:

For B to A direction cell reception is indicated to layer management. For A to B direction cell transmission is indicated to layer management.

Layer Management function:

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

- 1) Count of total VCC cells with $CLP = 0 + 1$.
- 2) Count of total VCC cells with $CLP = 0$. This count is only maintained when the CLP option is used. See 5.10.2 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.

5.10.2 VC UPC/NPC (B to A only)

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 VCTM_TT_Sk associated with a VP_TT configured as a UNI. The use of NPC is optional for a VCTM_TT_Sk associated with a VP_TT configured as an NNI. Actions and requirements of UPC/NPC are described in ITU-T 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.

Transfer function:

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

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 ITU-T I.371 and I.150. The coding of CLP values is defined in ITU-T 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 ITU-T 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.

5.10.3 Traffic shaping

Transfer function:

If present, the use of traffic shaping should be in accordance with ITU-T I.371. The shaping function can be activated/deactivated at this point in the model per connection.

Traffic shaping should be incorporated as a mechanism that alters the traffic characteristics of a stream of cells on a specific VCC while maintaining cell sequence integrity on the ATM connection. In general, shaping modifies the traffic characteristics with the consequence of increasing the mean cell transfer delay. Examples of traffic shaping are peak cell rate reduction, burst length limiting, reduction of CDV by spacing cells in time and queue service schemes.

Layer Management function:

If present, the function can be activated/deactivated 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.

NOTE – This does not preclude shaping at two layers i.e. VC shaping on the B to A side and VP shaping on the A to B side, simultaneously. As a consequence, a VC connection can be shaped twice.

5.10.4 EFCI setting

The modelling of EFCI setting is for further study.

5.10.5 Resource management

For further study. Some material can be found in Appendix I, Functional requirements for ABR.

5.11 VC OAM functions

NOTE – This clause deals with the OAM functions between the VCTM and VC_C. OAM functions are also associated with the VP/VC_A (one of the locations for AIS insertion – see 5.9), and the VCLB (connection end-point associated loopback functions – see 5.7) and the VC_TT (connection end-point associated OAM functions – see 5.14).

5.11.1 F5 OAM functions (B to A) between VCTM and VC_C

Between the VC Traffic management function and the VC connection function are the following OAM functions:

VCLB_Sk compound function	see D.5.6
VCS_Sk compound function	see D.5.4.2 (VCS_TT_Sk) and D.5.4.4 (VCS/VC_A_Sk)
VCS_So compound function	see D.5.4.1 (VCS_TT_So) and D.5.4.3 (VCS/VC_A_So)
VCLB_So compound function	see D.5.6
VCSM_Sk	see D.5.3.2
VCSM_Sk	see D.5.3.1

All ATM equipment supporting loopback functionality will implement source point function and loopback point function as described above. For some specific terminal equipment (e.g. PABX, XDSL modem, ...) only loopback point function could be implemented to reduce their complexity. These reduced loopback functions are called VCLBR_TT in Annex D.

NOTE 1 – There are no VCSM_So or VCM_So functions corresponding to the VCSM_Sk or VCM_Sk non-intrusive monitors by definition of it being a non-intrusive function.

NOTE 2 – As artefacts of the functional modelling, the Loopback termination points are accompanied by adaptation functions that are actually null functions.

NOTE 3 – An option exists to replace the Loopback functions VCLB_Sk and VCLB_So with reduced functionality loopback functions VCLBR_Sk and VCLBR_So. These are also described in D.5.6.

5.11.2 F5 OAM functions (A to B) between VCTM and VC_C

VC OAM functions occur in three locations in the model: the first two sets are between the VC traffic management functions and the third set is associated with the VC connection end-point.

Between the VC Traffic management function and the VC connection function are the following OAM functions:

VCM_Sk	see D.5.3.1
VCSM_Sk	see D.5.3.2
VCLB_Sk compound function	see D.5.6
VCS_Sk compound function	see D.5.4.2 (VCS_TT_Sk) and D.5.4.4 (VCS/VC_A_Sk)
VCS_So compound function	see D.5.4.1 (VCS_TT_So) and D.5.4.3 (VCS/VC_A_So)
VCLB_So compound function	see D.5.6

NOTE 1 – There are no VCSM_So and VCM_So functions corresponding to the VCSM_Sk and VCM_Sk non-intrusive monitors by definition.

NOTE 2 – As artefacts of the functional modelling, the Loopback termination points are accompanied by adaptation functions that are actually null functions.

NOTE 3 – An option exists to replace the Loopback functions VCLB_Sk and VCLB_So with reduced functionality loopback functions VCLBR_Sk and VCLBR_So. These are also described in D.5.6.

5.12 VC Connection function (VC_C)

See VC_C in D.5.1. The model includes VC layer Subnetwork Protection functions as part of the VC_C.

5.13 VC Connection End point Loopback function (VCLB_TT)

The specific functions for the VCLB_TT can be found in D.5.6. An artifact of the model is that the loopback termination functions are accompanied by adaptation functions although these are actually null functions. Reduced functionality loopback (VCLBR) functions have been defined which may be used in certain reduced functionality equipment.

5.14 VC Trail Termination function (VC_TT)

The specific functions for the VC Termination point can be found in D.5.2.

The issue of the processing of the PTI (mainly for AAL 5), CLP field needs to be clarified. These information involve exchange of information between the higher layers and the ATM layer.

5.15 ATM Adaptation Layer function (AAL)

5.15.1 Discard of end-to-end and segment F5 OAM cells

This function removes any end-to-end and segment F5 OAM cells that failed to get extracted by the termination point or any trail protection functionality.

5.15.2 AAL functional modelling

The functional modelling of AALs is partially covered in D.6. Enhancements are for further study.

5.15.3 Service Specific Coordination functions

Service dependent functions e.g. SSCF of ITU-T I.365x are for further study. Service dependent functions e.g. SSCS of ITU-T I.366x [43] and [44] are for further study. Signalling ATM Adaptation Layer (SAAL) is also for further study.

6 Coordination Function (CoF)

The Coordination Function (CoF) provides the following functions:

- 1) communications between:
 - Layer Management (LM) blocks;
 - the AEMF and LM blocks;
 - signalling applications and LM block;
 - the CAC and the LM block.to support:
 - a) configuration management;
 - b) fault management;
 - c) performance management;
 - d) accounting management;
 - e) security management.

The communications consist of Management Indication (MI) signals described in Annex D. Annex D covers fault management, performance, and configuration management.

- 2) Appropriate selection and distribution of timing information.

7 CAC and resource control functions

This clause aims at providing the modelling of the way in which an ATM resource request is handled in an equipment, but there are no requirements implied.

7.1 ATM resource requests to be processed by an ATM equipment

Two types of ATM resource requests can be considered from an equipment point of view:

- a request to establish or release a given VP or VC connection;
- a request for modifying the traffic characteristics of an already established VP or VC connection.

7.1.1 Establishing or releasing a VP or VC connection

Establishing a connection means to create a new point-to-point VPC or VCC or to add a leaf in a tree of multipoint connections with leaf initiated join.

Releasing a connection means to delete any VPC or VCC.

A request to establish or release a given VP or VC connection may be initiated independently by:

- **management procedure**, for establishing cross-connected connections VPCs or VCCs. The equipment configuration management is controlled from either the Network equipment layer (e.g. via the Q3 interface) or directly from the local craft terminal through the F interface. The network equipment layer is controlled by the management layer. Request can be made to the management layer directly by the network operator or by customers or services communicating to the management layer via the service layer;
- **signalling procedure**, for establishing switched VCCs. The signalling messages are generally transported through a dedicated VCC. The protocols involved are DSS2, B-ISUP, Broadband Bearer Channel Control (BBCC) for VB5, Metasignalling, QSIG.

These ATM resource requests include (see Figure 7-1):

- some routing parameters;
- the traffic and QoS characteristics of the connection to be set.

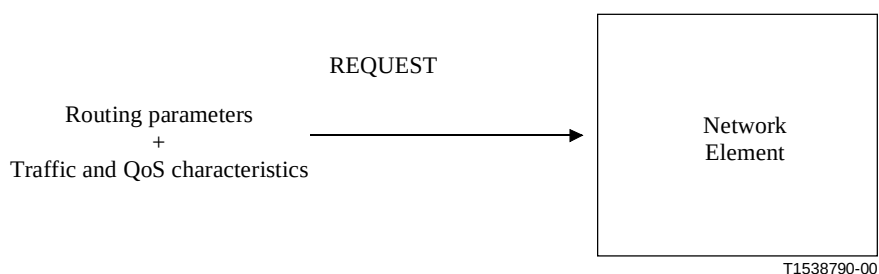


Figure 7-1/I.732 – Establishing or releasing a VP/VC connection

The routing parameters can be for example an input interface identification and e.g. an E.164 destination address.

The traffic and QoS characteristics of the connection are respectively defined in ITU-T I.371 [21] and I.356 [15]. These characteristics are summarized in Table 7-1.

Table 7-1/I.732 – Traffic characteristics associated with a connection

General traffic characteristics	ATM Transport Capability (ATC)
	STD and CDV tolerances associated with each cell rate included in the given ATC
ABR & ABT additional specific characteristics	ATC tuning parameters for ABT and ABR connections (e.g. RIF, RDF, etc.)
Quality of Service (QoS) required	QoS parameters (CTD, CDV 2 points, Cell Loss Ratio (CLR ₀ , CLR ₀₊₁ , CLR ₁) (CLR))

7.1.2 Modification of the traffic characteristics of an established VP or VC connection

Modification of the traffic characteristics (see Table 7-1 and Figure 7-2) of an already established connection may be initiated by:

- management procedure via an equipment management interface;
- signalling procedure;
- RM procedure.

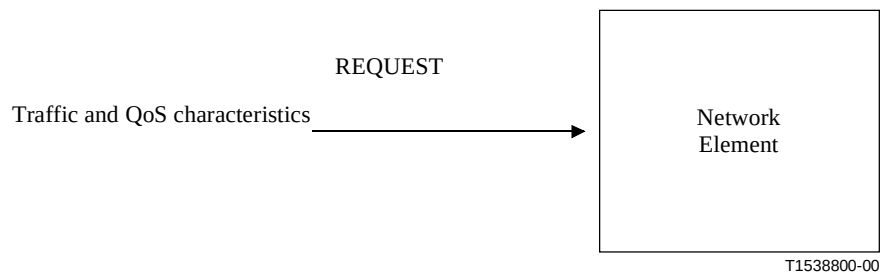


Figure 7-2/I.732 – Modification of the traffic characteristics of an existing VP/VC connection

These ATM resource requests only include the new re-negotiated parameters for the existing connection. That means that this kind of request does not include any routing parameters.

7.2 General ATM equipment features for processing an ATM resource request

The processing of an ATM resource request by the equipment involves two main functions described in Figure 7-3.

7.2.1 Processing of resource request messages

Resource request messages can be processed using different procedures (management, signalling or RM procedures). This processing is done by:

- the Management Applications for dealing with the Management Procedures;
- the Signalling Applications for dealing with the Signalling Procedures;
- the RM Applications for dealing with the RM procedures.

These functions allow for exchanging information following the protocol rules through the appropriate interface (Q3/F, User Network Interface (UNI)/Network Node Interface (NNI)). The applications are also strongly constrained by the specific time characteristics of the associated procedures (e.g. on the fly processing of RM cells in the case of ABR and ABT support). When an ATM resource request is identified, it is addressed to the Connection Admission Control (CAC) function for admission by the equipment. The timing scale to take into account the request originated by the Management, Signalling or RM procedures are very different.

7.2.2 CAC function

The equipment CAC function is part of the network level CAC function as defined in ITU-T I.371, but at an equipment level. The CAC function takes as input the ATM resource request as defined in 7.1, and accepts or rejects the request. An intermediate admission level (e.g. request "partially accepted") needs further studies.

NOTE – "Partially accepted" means for example that the request could be accepted with lower Peak Cell rates (PCRs). Another example involves a request for setting up a point-to-multipoint connection with n leaves: the connection could be accepted for only p leaves ($p < n$).

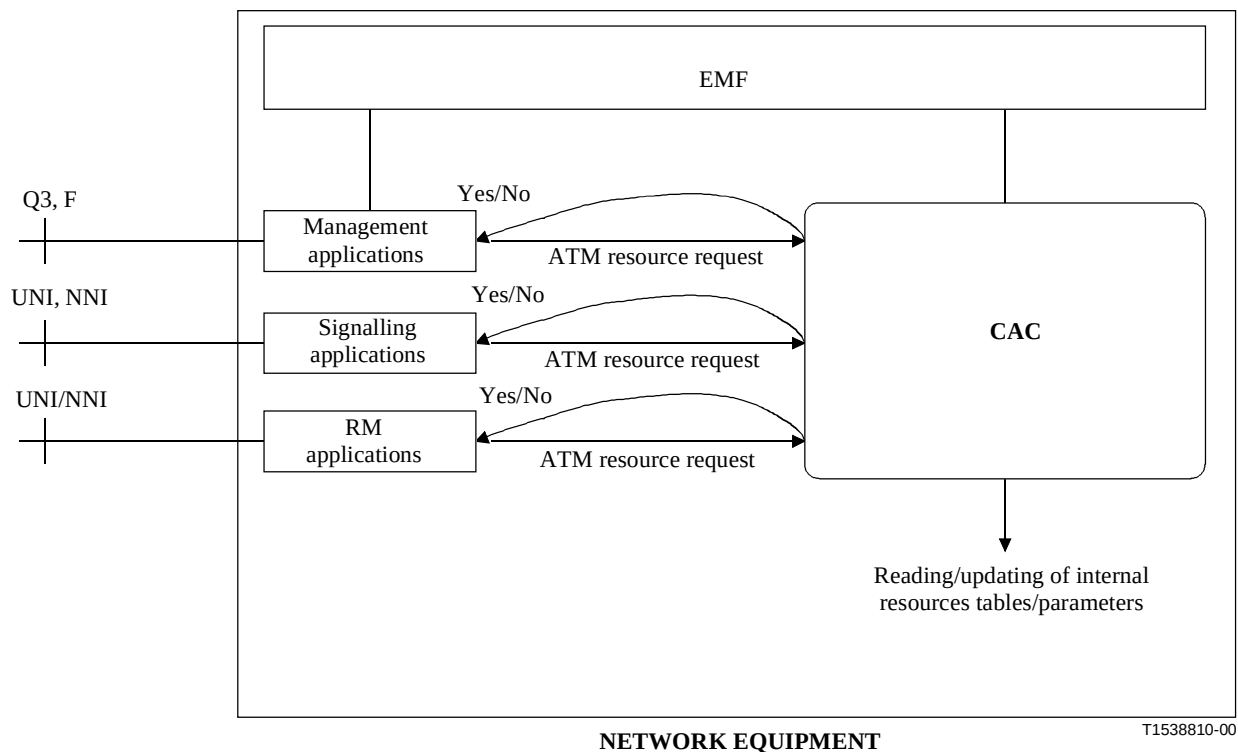


Figure 7-3/I.732 – Functions involved for processing an ATM resource request

7.3 Management, signalling, RM applications

For further study.

7.4 Detailed description of the CAC function

The **CAC** function can be considered as two processes named Service Admission Control (**SAC**) and Equipment Admission Control (**EAC**) (Figure 7-4).

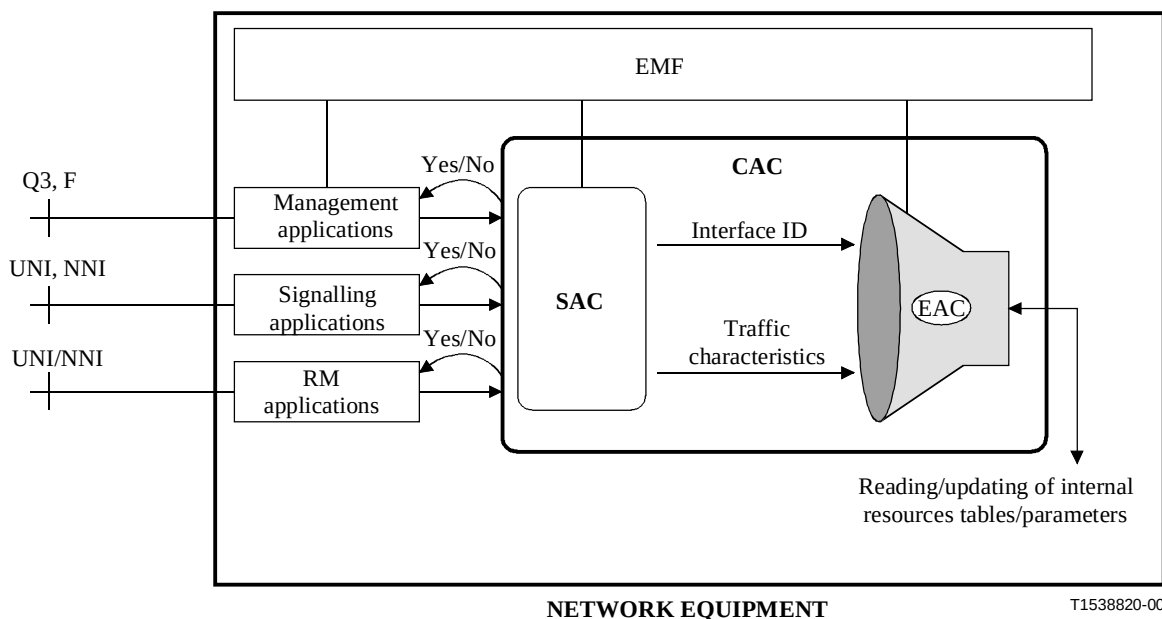


Figure 7-4/I.732 – Architecture of the CAC

- The **SAC**: this step corresponds to the part of the admission which **does not need the knowledge of the real time availability of the resources of the equipment**. The SAC function is divided into two subfunctions: the Service Level ADmission (SLAD) and the routing function. The admission of a connection on a statistical basis is done by the SAC function. This function, or parts of this function, can be centralized, partially centralized, or distributed, depending on operator/vendor policy. That means that this function may or may not be present within the equipment.
- The **EAC**: this step implies a more detailed process, which consists of **checking the current availability of the resources of the equipment**. This function can only be done at an equipment level, since the availability of the resources can change depending on the load of the equipment at a given moment. This function is implementation specific, considering that the load of the equipment depends on its implementation (e.g. presence of queues, blocking matrix), and works on a real time basis.

The YES/NO response between the CAC block and the different applications is the final response of the equipment to the ATM resource request. This final response results from the exchanges between the SAC and the EAC. These exchanges are illustrated in Figure 7-5.

Figure 7-5: CAC exchanges