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Contents

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Foreword

This ETSI Technical Report (ETR) was produced by the Network Aspects (NA) Technical Committee of the European Telecommunications Standards Institute (ETSI).

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

This ETR describes the functional model of a Virtual Path (VP) cross-connect. It includes the main functionalities that a VP cross-connect has to provide both at the Asynchronous Transfer Mode (ATM) layer and at the physical layer, but with particular emphasis on the ATM layer.

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1 Scope

This document describes in detail the functions that should be provided by a Virtual Path (VP) cross-connect. Two types of functions are considered:

- user plane functions; and
- management plane functions.

The user plane functions are further subdivided into Asynchronous Transfer Mode (ATM) layer and physical layer functions. Whereas the management plane functions are subdivided into layer management and system management functions.

This organization of the functions is done according to the Protocol Reference Model (PRM) described in ETS 300 354 [1].

In this ETR, particular emphasis is put on the layer management functionalities, because these are considered of particular importance in a VP cross-connect.

2 References

This ETR incorporates by dated and undated reference, provisions from other publications. These references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETR only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] ETS 300 354: "Broadband Integrated Services Digital Network (B-ISDN); Protocol reference model".

[2] CCITT Recommendation G.702: "Digital hierarchy bit rates".

[3] CCITT Recommendation G.703: "Physical/electrical characteristics of hierarchical digital interfaces".

[4] ITU-T Recommendation G.707: "Synchronous digital hierarchy bit rates".

[5] ITU-T Recommendation G.708: "Network node interface for synchronous digital hierarchy".

[6] ITU-T Recommendation G.783: "Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks".

[7] ITU-T Recommendation G.803: "Architectures of transport networks based on the synchronous digital hierarchy (SDH)".

[8] ITU-T Recommendation G.957: "Optical interfaces for equipments and syatems relating to the synchronous digital hierarchy".

[9] ITU-T Recommendation I.311: "B-ISDN general network aspects".

[10] CCITT Recommendation I.321: "B-ISDN protocol reference model and its application".

[11] ITU-T Recommendation I.432: "B-ISDN user-network interface - Physical layer specification".

[12] ITU-T Recommendation I.610: "B-ISDN operation and maintenance principles and functions".

3 Abbreviations

For the purposes of this ETR, the following abbreviations apply:

AIS	Alarm Indication Signal
ATM	Asynchronous Transfer Mode
AU	Administrative Unit
B-ISDN	Broadband Integrated Services Digital Network
CME	Connection Management Entity
CRC	Cyclic Redundancy Check
FECN	Forward Explicit Congestion Notification
GME	Global Management Entity
HEC	Header Error Control
HPA	Higher order Path Adaptation
HPT	Higher order Path Termination
LME	Layer Management Entity
LPA	Lower order Path Adaptation
LPT	Lower order Path Termination
MSA	Multiplex Section Adaptation
MST	Multiplex Section Termination
NMS	Network Management System
NNI	Network Node Interface
NPC	Network Plane Control
OAM	Operations, Administration and Maintenance
PDH	Plesiochronous Digital Hierarchy
PFA	PDH Frame Adaptation
PFT	PDH Frame Termination
PM	Physical Medium sublayer
POH	Path Overhead
PPI	PDH Physical Interface
PRM	Protocol Reference Model
RES	Resource management
RST	Regenerator Section Termination
SAP	Service Access Point
SDH	Synchronous Digital Hierarchy
SPI	SDH Physical Interface
TC	Transmission Convergence sublayer
TMN	Telecommunications Management Network
TPF	Transmission Path Function
TTF	Transport Terminal Function
UNI	User Network Interface
UPC	User Plane Control
VC	Virtual Channel
VP	Virtual Path
VPE	Virtual Path Entity
VPI	Virtual Path Identifier

4 General architecture

A general architecture of a VP cross-connect is given in figure 1. This description is made up of two parts:

a) user plane functions; and

b) management plane functions.

The **user plane functions** are related to the user information flow on a connection established between two accesses of the equipment:

- User Network Interface (UNI) access; or

- Network Node Interface (NNI) access.

The user plane functions are subdivided into two types, the physical layer functions and the ATM layer functions. A Service Access Point (SAP) is defined between these two layers. Associated with one physical link, there is one instance of the physical layer and one instance of the ATM layer.

The **management plane functions** deal with all the actions which allow the operation of this connection:

- activation and deactivation of the resources;

- flow control;

- quality monitoring;

- etc.

These functions are subdivided into two parts:

- the layer management functions; and

- the system management functions.

The physical layer and the ATM layer each has a SAP connecting them with their Layer Management Entity (LME).

The system management deals with the set of functions applicable to the equipment as a whole or those related to the relationships with management units located outside the equipment. This includes the communication with Telecommunications Management Network (TMN), which could be based on ATM. The modelling of this communication is for further study. The arrows in figure 1 marked **management transfer** refer to this communication.

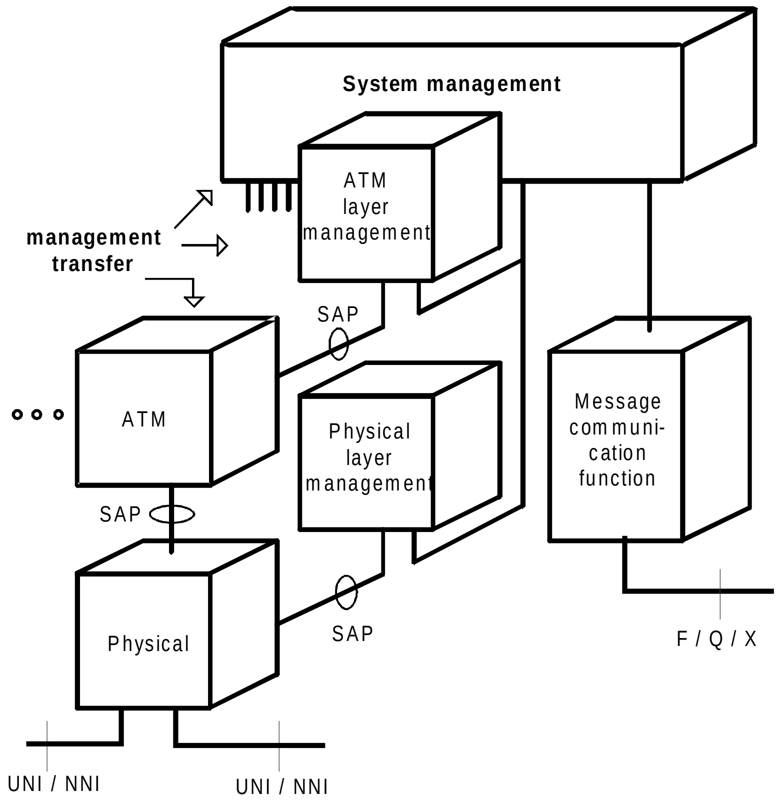

Figure 1: Overall architecture of a VP cross connect

5 Functional architecture

This clause describes the different blocks of the general architecture. This more detailed description is given in figure 2.

5.1 User plane functions at the ATM layer

These functions are essentially:

- the VP cross connection, which is associated with the translation of the Virtual Path Identifier (VPI) value, and which performs the connection of the VP links represented by end points;

- the VP Entity (VPE), grouping the functions specific to a given VP;

- the VP multiplexing and demultiplexing.

5.2 User plane functions at the physical layer

Referring to CCITT Recommendation I.321 [10], the functions of the physical layer are subdivided into two sublayers, the Transmission Convergence sublayer (TC) which includes cell rate decoupling, handling of the Header Error Control (HEC), cell delineation, mapping on the transmission frame (cell based, Plesiochronous Digital Hierarchy (PDH) or Synchronous Digital Hierarchy (SDH)), transmission frame generation and recovery if necessary, and the Physical Medium sublayer (PM) which consists of bit timing and medium.

According to ITU-T Recommendation I.311 [9], the functions of the physical layer are divided into three parts: the Transmission Path (T.PATH), the Digital or multiplexing Section (D.SECTION) and the Regenerator Section (R.SECTION) which is associated with the physical medium. Figure 2 is related to this functional organization.

5.3 Functions of the ATM layer management

The layer management is performed by a LME. Functions of this LME belong to two categories:

- Global Management Entity (GME), related to management functions applicable to the layer as a whole; and

- Connection Management Entity (CME), related to specific connections.

The functions fulfilled by the GME of the ATM layer are error handling and assign functions associating the layer resources to form the internal link for the cell transfer, whereas the CME takes into account the Resource management (RES) and the handling of F4, User Plane Control / Network Plane Control (UPC/NPC) and errors.

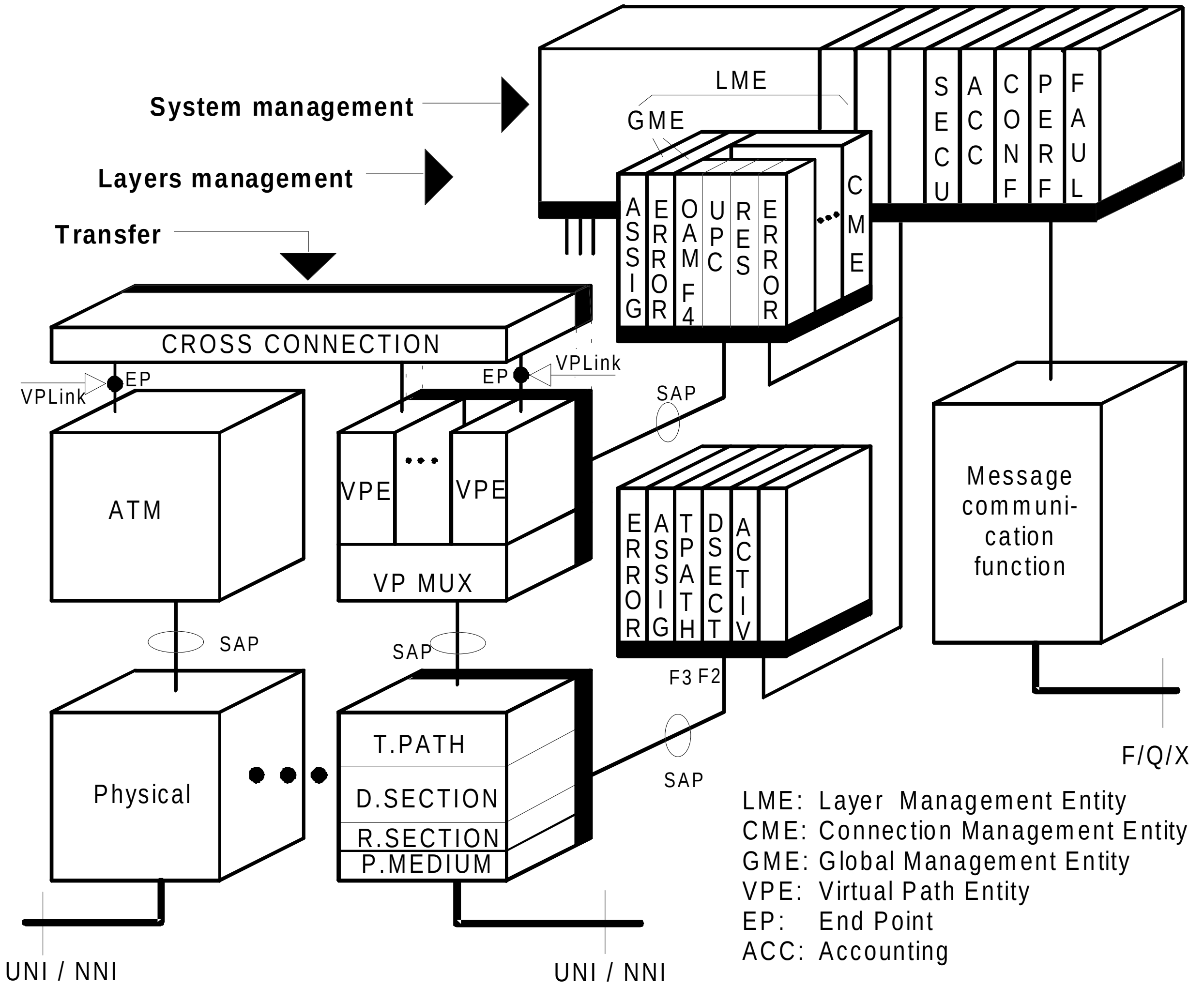

Figure 2: General functional architecture of a VP cross connect

5.4 Functions of the physical layer management

The following management entities, considered as GME, are defined:

- the Assign entity (ASSIG) which associates the layer resources to form the internal link for the transfer of the physical layer information;
- the Transmission Path entity (TPATH) which handles the F3 flow;
- the Digital Section entity (DSECT) which handles the F2 flow;
- the Activation entity (ACTIV) which activates and deactivates the physical medium;
- the Error handling (ERROR) which handles HEC error conditions.

NOTE: The modelling of protection switching is not covered.

5.5 Functions of the system management

These functions are classified into five areas:

- Configuration (CONF), Performance (PERF);
- Fault (FAUL), Accounting (ACC); and
- Security (SECU).

It is necessary to identify precisely, in such areas, what is handled in the equipment and, therefore, what is sent toward other management entities outside the equipment. The message communication function, used to transfer this management information, has also to be identified in this clause.

6 Detailed description of the functional blocks

6.1 Physical layer functional block

The physical layer functional block is composed of the following group of functions:

- Transport Terminal Function (TTF); and
- Transmission Path Function (TPF).

6.1.1 Transport Terminal Function (TTF)

This is a compound function that regroups the transport processing functions of physical media, regenerator section and multiplex section layers.

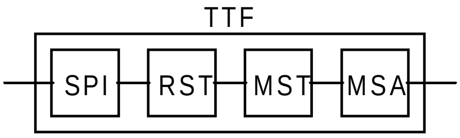

Figure 3: TTF in case of SDH interfaces

Figure 3 shows the composition of block TTF in case of a SDH interface. More details can be found in ITU-T Recommendation G.783 [2]. It comprises the blocks:

- **SDH Physical Interface (SPI)**: SPI provides the interface between the physical transmission medium and the Regenerator Section Termination (RST) function. The interface signal shall be one of those specified in ITU-T Recommendation G.707 [4]. The physical characteristics of the interface signals are specified in ITU-T Recomendation G.957 [8] for optical media and in CCITT Recommendation G.703 [3] for electrical media;

- **Regenerator Section Termination (RST)**: RST acts as a source and sink for the Regenerator Section Overhead (R-SOH). At first, this block will be limited to reduced functionalities (see ITU-T Recommendations G.708 [5] and I.432 [11]);

- **Multiplex Section Termination (MST)**: MST acts as a source and sink for the Multiplex Section Overhead (M-SOH). At first, this block will be limited to reduced functionalities (see ITU-T Recommendations G.708 [5] and I.432 [11]);

- **Multiplex Section Adaptation (MSA)**: MSA provides adaptation of higher order paths into Administrative Units (AUs), assembly and disassembly of AU groups, byte interleaved multiplexing and demultiplexing, and pointer generation, interpretation and processing.

Figure 4 shows the composition of block TTF in case of a PDH interface.

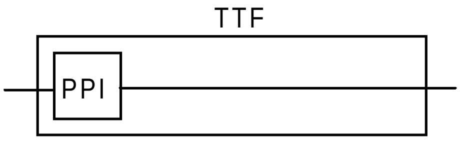

Figure 4: TTF in the case of PDH interfaces

Since regenerator section and multiplex section layers are not used, the only block involved is:

- **PDH Physical Interface (PPI)**: PPI provides the interface between the physical transmission medium and the TPF function. The interface signal shall be one of those specified in CCITT Recommendation G.702 [2]. The physical characteristics of the interface signals are specified in CCITT Recommendation G.703 [3].

6.1.2 Transmission Path Function (TPF)

This is a compound function that regroups the transport processing functions of the transmission path layer network. This function can be further decomposed into two sub-functions:

- transmission system dependent sub-function; and

- ATM related sub-function.

Transmission system dependent function

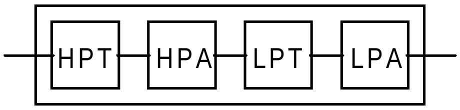

Figure 5: Transmission system dependent block in case of SDH

Figure 5 shows the composition of this sub-block in case of SDH transmission system. It comprises the blocks:

- **HPT (Higher order Path Termination)**: HPT terminates a higher order path by generating and adding the appropriate Virtual Channel (VC) Path Overhead (POH) to the relevant container at the path source and removing the VC POH and reading it at the path sink;

- **Higher order Path Adaptation (HPA)**: HPA adapts the lower order VC to the higher order VC by processing the TU pointer and assembling/disassembling the complete higher order path. When a lower order path is not used, it adapts the ATM flow to the higher order VC by inserting/extracting the cells in the appropriate payload with byte alignment;

- **Lower order Path Termination (LPT)**: LPT terminates a lower order path by generating and adding the appropriate VC POH to the relevant container at the path source and removing the VC POH and reading it at the path sink;

- **Lower order Path Adaptation (LPA)**: LPA adapts the ATM flow to the lower order VC by inserting/extracting cells in the appropriate payload with byte alignment.

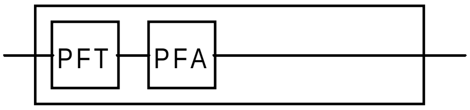

Figure 6: Transmission system dependent block in case of PDH

Figure 6 shows the composition of the transmission system dependent block in case of a PDH transmission system. It comprises the blocks:

- **PDH Frame Termination (PFT)**: PFT terminates the PDH frame by generating and adding the appropriate overhead at the path source and processing the frame alignment, removing the overhead and reading it at the path sink;

- **PDH Frame Adaptation (PFA)**: PFA adapts the ATM flow to the PDH frame by inserting/extracting cells in the appropriate payload with byte alignment.

ATM related function

It includes the following functions at the source:

- generating and adding the appropriate HEC;

- cell scrambling;

- inserting idle cells (cell rate decoupling).

It includes the following functions at the sink:

- processing the HEC and cell delineation;

- cell descrambling;

- extracting idle cells (cell rate decoupling).

6.2 ATM layer functional block

6.2.1 Introduction

Figure 7 contains a detailed description of the ATM functional block.

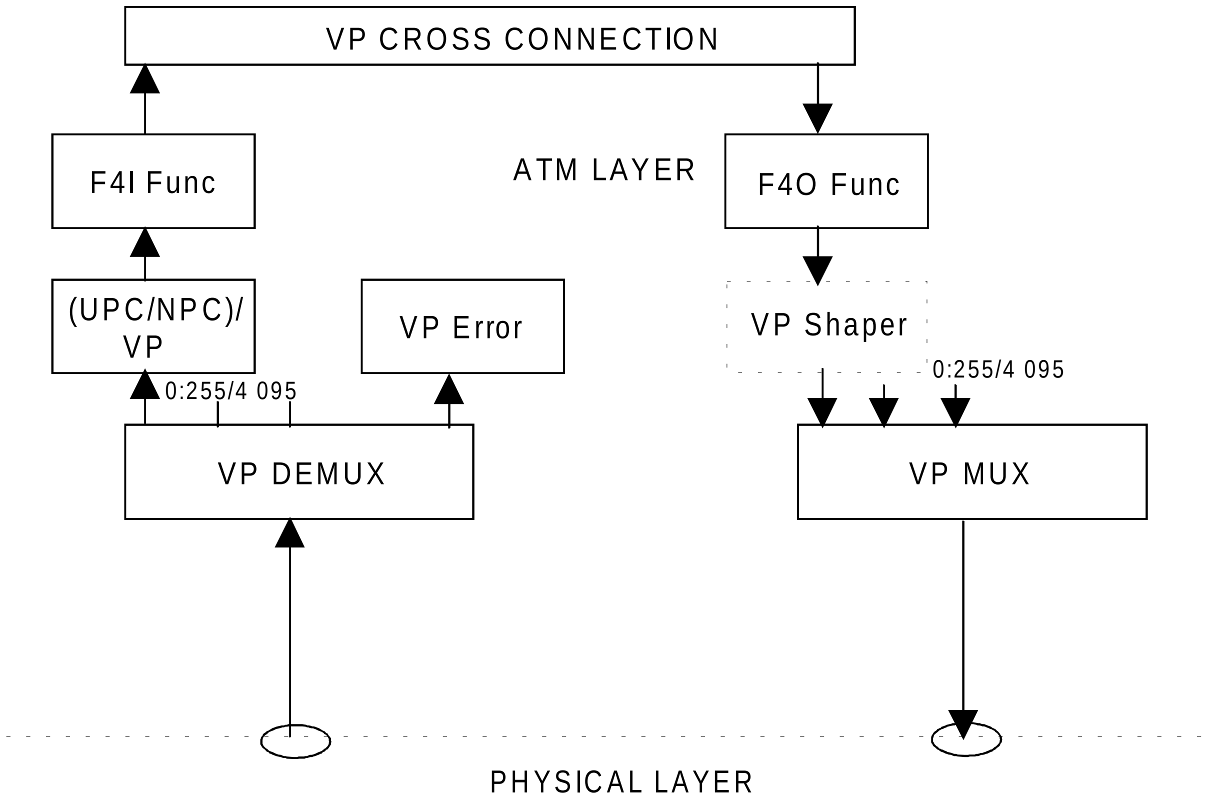

Figure 7: Description of the ATM functional block

NOTE: The allocation of functions as it is shown in figure 7 is in line with the Broadband Integrated Services Digital Network (B-ISDN) PRM, but it is not completely in accordance with the transport model, as described in ITU-T Recommendation G.803 [7]. In fact, in the transport model. the VP multipexing functions belong to the adaptation functions between the VP layer, which is the client layer, and the transmission path layer, which is the server layer, and therefore these functions are allocated to the physical layer. This is in contradiction with the B-ISDN PRM. In this ETR it is adopted the B-ISDN PRM allocation of functions.

The functions shown in figure 7 are the following:

F4 functions

The F4I functions handles the F4 flows and functions needed on the incoming side. This involves insertion and extraction of segment Operations, Administration and Maintenance (OAM) F4 flow cells, Cyclic Redundancy Check (CRC) calculations on user cell payloads and other F4 functionalities. The F4O function handles the same functions as F4I, only at the outgoing side.

The F4 input and F4 output functions can be expanded as shown in figure 8.

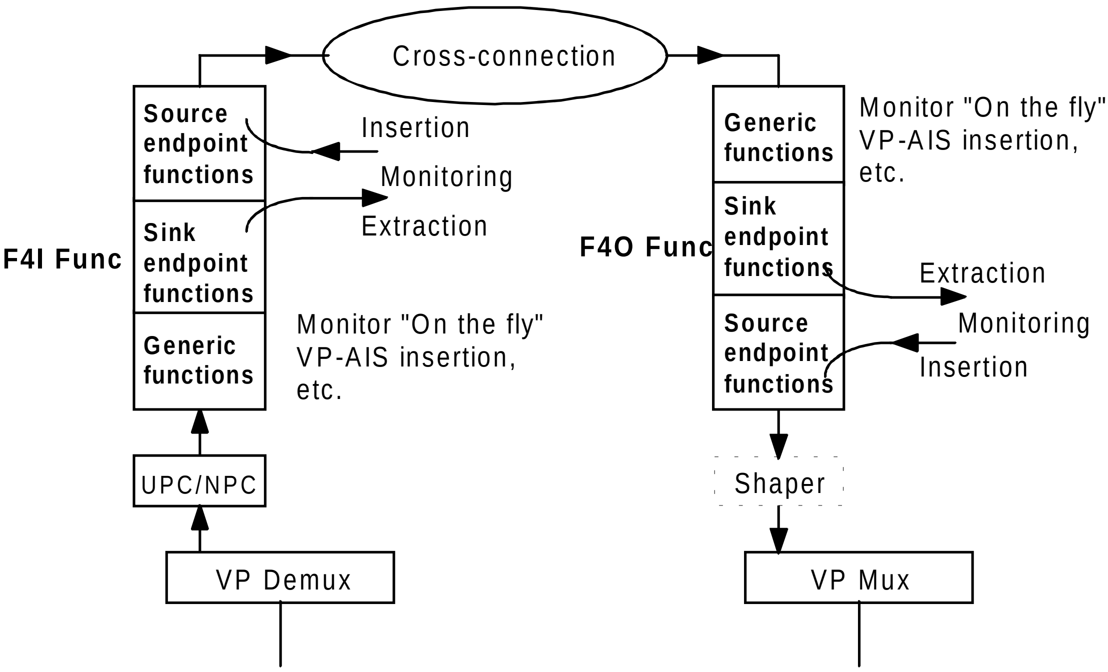

Figure 8: Detailed description of the F4I and F4O functions

The segment F4 endpoint functions may be enabled and disabled and, when not necessary, may also be not implemented. The related layer management entities may be created and deleted, and, when not necessary, may also be not permitted.

Generic functions of the figure are the connecting point functions like insertion of Virtual Path Alarm Indication Signal (VP-AIS) cells in case of fault. They need to be present both in the input and in the output.

The use of segment F4 flow for testing the switch fabric is optional, but in any case a mechanism should be provided for this purpose. A proprietary mechanism could be envisaged.

The main reason to include source and sink endpoint functions for the segment F4 flow, both at the input and output port of the VP cross-connect is to allow the inclusion of this network element in the VP segments for performance monitoring or continuity check purposes. This possibility will allow:

a) the inclusion of the behaviour of the VP cross-connect in what is measured by means of F4 flows. This is particularly important for cell loss due to buffers overflow;

b) the use of contiguous segments able to cover, together, all the ATM functions of the whole connection, without leaving parts of it not monitored.

UPC/NPC functions

The UPC and the NPC perform the policing function for VPs based on parameters supplied by the Network Management System (NMS).

These functions can be present or not depending if the VP cross-connect is local one or a transit one.

VP shaper

The shaper may be needed since a VP may be policed both at the UNI and at the NNI between two PNO areas. Depending on the policing algorithm and the cell clustering effect caused by the design of the cross-connection, shaping is needed or not.

VP error

The error functionality may be very simple depending on the way "spurious" cells are handled. A "spurious" cell is a cell with a VPI value which has not been allocated a path through a cross-connect. These type of cells need to be thrown away by the cross-connect, but it is not yet decided if the occurrence of spurious cells should be notified to an NMS or not.

In the next subclause the functions of the ATM layer management, which were summarized in clause 5, are further detailed.

6.2.2 ATM layer management

Figure 9 shows the input functions of the ATM layer and ATM layer management and figure 10 the output ones. Both of these functions can be located at input port and the output port of the VP cross-connect. Correlation between the two directions of the same link can be considered as made through the management plane (two unidirectional connecting points), or it can reside inside the ATM management layer (one bidirectional connecting point). The main communication paths are:

- management plane ↔ GME;
- GME ↔ CME;
- GME ↔ VP entity;
- GME ↔ resources in the VP layer outside the VP entities.

Upon connection establish request from the management plane, the GME creates a CME and a VP entity and establishes the necessary relations. All necessary parameters, e.g. VPI values, physical interfaces, bandwidth parameters, etc. are provided by the plane management.

Inside the VP entity, as well as inside the CME, some functions are enabled or not, according to the general function assigned to the connecting point. In particular, it can be the sink and/or the source endpoint of a VP segment, where F4 OAM cells handling is required, and it can be the first point in which the ATM layer is accessed in the (sub)network, where UPC/NPC functions are required. Also a VP segment endpoint has functionalities that can be enabled and disabled. In a VP cross connect is not possible to place a VPC endpoint, since it does not terminate a VPC, and, therefore, it does not terminate end-to-end F4 flows.

GME functionalities

GME is responsible for handling management functions having layer wide impact, or at least, impact on a number of connections.

A common entity always enabled in the ATM layer management is the establish entity, related to configuration management area. It receives from management plane the connection set up request associated with VPI values, routeing information and bandwidth characteristics, and it is responsible of creating modifying and deleting VP entities in the ATM layer, and CMEs in the ATM management layer, under the control of management plane.

An error handling entity is required in both directions. On the input side, cells which are formally correct but have a VPI value that is not assigned to any supported VP connection can be received. Their rate is measured by GME and periodically reported to the NMS. If such a rate exceeds a given limit, an alarm notification can be generated. Cells discarded due to buffer overflow can be counted on input and output ports in a "per port" aggregated way (though that could be considered a proprietary solution).

Functionalities for fault localization can be considered at this level (e.g. connection simulation), but require further study, while self test management is probably only a proprietary function, giving results in a standardized way. As an example, through this entity the management plane can verify the content of translation tables in the ATM layer.

Forward VP-AIS notification at, input side, corresponds to the capability that should have the GME to detect out of service situations (e.g. for abnormal buffer overflow or invalid VPI detection) and to communicate the situation to the NMS. On the output side a VP-AIS is generated on all supported VPCs, when on the input a fault is detected on the physical layer.

A filtering function is indicated in figure 9, which corresponds to the way in which the information is transferred from the layer management to the management plane.

CME - connecting point functionalities

CME is responsible for handling management functions related to a single connection, and is structured according to the type of connecting point.

The input side of a connecting point could have the capability of counting the cells discarded due to buffer overflow on a "per connection" basis. A separate, similar count could be performed in the connecting points where UPC/NPC functions are resident.

In case of congestion, an ATM layer resource is able to generate Forward Explicit Congestion Notification (FECN) on the headers of the cells. This is an output function and it has to be decided if it is a CME or LME function. As a corresponding input function, the detection of the FECN state is not strictly a connecting point function, it may, however, be useful that connecting points are able to detect FECN (on a "per connection" basis) and to communicate it to management plane (for further study).

As far as VP-AIS is concerned, each connecting point should be able to generate it when a fault is detected on the physical layer. The considerations above may apply also in this case. In this model the fault situation of the physical layer is communicated by the management plane, through the GME.

Loopback capabilities of a connecting point are described in the new agreed proposals for modification of ITU-T Recommendation I.610 [12]. They can be enabled and disabled. Generation of end-to-end loopback cells on the output side and their monitoring on the input side is allowed under request coming from the management plane.

Each receiving side of a connecting point should have, if enabled, the capability of monitoring "on the fly" end-to-end or segment OAM cells related to its connection. The above mentioned loopback is an application of such a capability (in this case the detection of the looped cell is communicated to the management plane)

CME - VP segment endpoint functionalities

When the connecting point is an endpoint of a VP segment, the CME is responsible for handling OAM segment F4 flows, and evaluating the result of performance monitoring, comparing the measured performance parameters with the limits provided by the NMS.

At the output side of a VP segment endpoint, OAM F4 segment cells are generated and inserted into the user flow. At the input side of a VP segment endpoint, OAM F4 segment cells are terminated and extracted from the flow. The related functions are shown in figures 9 and 10 and are described in ITU-T Recommendation I.610 [12].

Two notes are made here, that correspond to the notes indicated in the figures.

NOTE 1: Performance monitoring is a function requiring real time interaction with user cells. OAM cells are generated looking at the content of user cells, which do not cross the SAP between ATM layer and ATM management layer. Nevertheless, OAM monitoring cells are considered, in a very theoretical way, as SDUs generated by the ATM management layer and passed for transmission at the ATM layer.

NOTE 2: A forward generation of VP-AIS should be considered when a segment endpoint detects a severely degraded performance.

The performance functionalities of the endpoint can be activated and deactivated at any time during a connection. Fault management is mainly an end-to-end function. The segment endpoint does not have to deal with the VP-FERF signal. VP-AIS, when generated, is always an end-to-end flow. Continuity check, when performed at segment level, communicates a detected fault by means of a forward VC-AIS state.

A VP segment endpoint can be created and deleted at any time during a connection, in each connecting point.

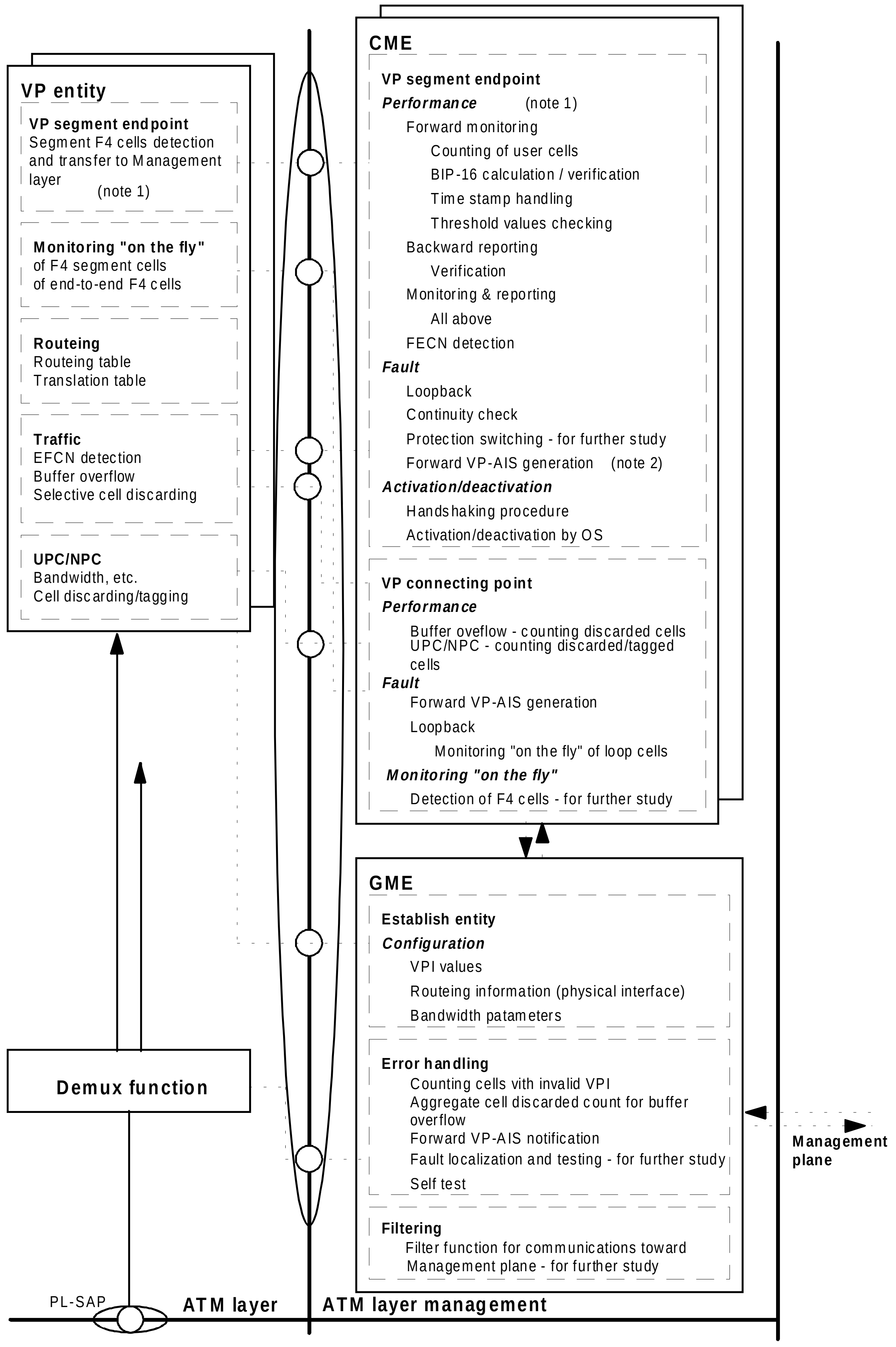

Figure 9: Layer management - input functions supported by cross connect

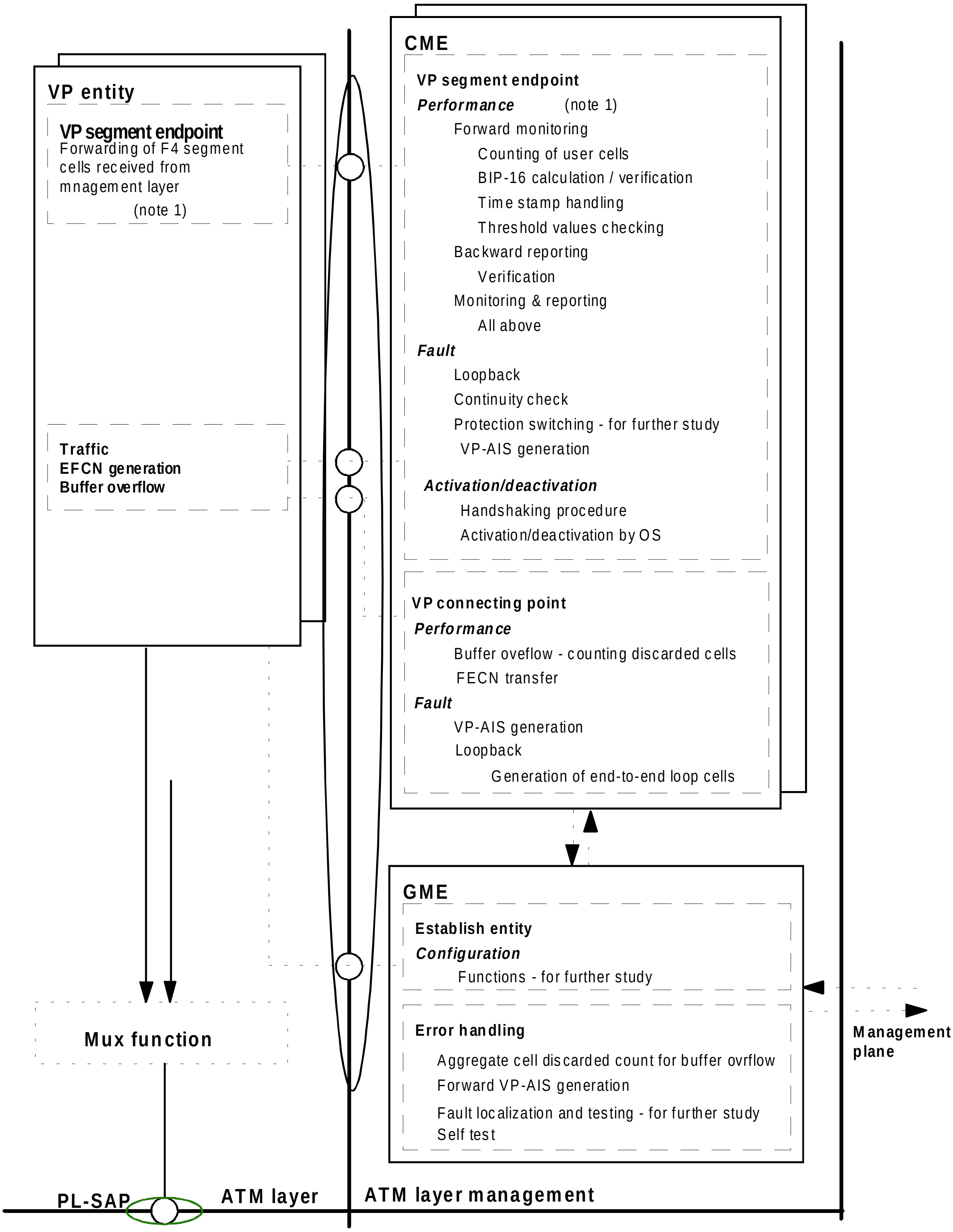

Figure 10: Layer management - output functions supported by a cross connect

History

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