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Foreword

This ETSI Technical Report (ETR) has been produced by the Transmission and Multiplexing (TM) Technical Committee of the European Telecommunications Standards Institute (ETSI).

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1 Scope

This ETR describes the functional architecture of transport networks based on the Plesiochronous Digital Hierarchy (PDH). The document is based on ETR 085 [11], and should be taken as the basis for management standards, performance analysis and equipment specification based on the PDH.

Noting that PDH transport networks will exist for many years to come and that many operators are introducing management features into their PDH transport networks, a rigorously defined transport network architecture provides the necessary foundations for activities such as:

- performance assessment;
- availability estimations and protection considerations;
- event management;
- traffic modelling and topology studies;
- organization of data bases on, for example, routing and inventory;
- clarification of functionality such as termination.

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] ITU-T Recommendation G.702 (1990): "Digital hierarchy bit rates".

[2] ITU-T Recommendation G.703 (1991): "Physical/electrical characteristics of hierarchical digital interfaces".

[3] ITU-T Recommendation G.704 (1991): "Synchronous frame structures used at 1544, 6312, 2048, 8488 and 44 736 kbit/s hierarchical levels".

[4] ITU-T Recommendation G.73x series: "Principal characteristics of primary multiplex equipment".

[5] ITU-T Recommendation G.742 (1990): "Second order digital multiplex equipment operating at 8 448 kbit/s and using positive justification".

[6] ITU-T Recommendation G.751 (1990): " Digital multiplex equipments operating at the third order bit rate of 34 368 kbit/s and the fourth order bit rate of 139 64 kbit/s and using positive justification".

[7] ITU-T Recommendation G.755 (1990): "Digital multiplex equipment operating at 139 264 kbit/s and multiplexing three tributaries at 44 736 kbit/s".

[8] ITU-T Recommendation G.803 (1993): "Architecture of transport networks based on the synchronous digital hierarchy (SDH)".

[9] ITU-T Recommendation G.804 (1994): "ATM cell mapping into plesiochronous digital hierarchy (PDH)".

[10] ITU-T Recommendation G.832 (1994): "Transport of SDH elements on PDH networks: Frame and multiplexing structures".

[11] ETR 085 (1993): "Transmission and Multiplexing (TM); Generic functional architecture of transport network".

[12] ETS 300 166 (1993): "Transmission and Multiplexing (TM); Physical and electrical characteristics of hierarchical digital interfaces for equipment using the 2 048 kbit/s-based plesiochronous or synchronous digital hierarchies".

[13] ETS 300 167 (1993): "Transmission and Multiplexing (TM); Functional characteristics of 2 048 kbit/s interfaces".

[14] ETS 300 174 (1992): "Network Aspects (NA); Digital coding of component television signals for contribution quality applications in the range 34 - 45 Mbit/s".

[15] ETS 300 337 (1995): "Transmission and Multiplexing (TM); Generic frame structures for the transport of various signals (including Asynchronous Transfer Mode (ATM) cells and Synchronous Digital Hierarchy (SDH) elements) at the ITU-T Recommendation G.702 hierarchical rates of 2 048 kbit/s, 34 368 kbit/s and 139 264 kbit/s".

3 Definitions and abbreviations

3.1 Definitions

Clause 4 of ETR 085 [11] provides definitions for all generic terms required to describe functional architecture. For the purposes of this ETR, the following abbreviations apply:

NOTE 1: Where a definition contains a term which is itself defined either in ETR 085 [11] or in this subclause, that term is shown in quotation marks.

path layer network: A "layer network" which is concerned with the transfer of information between path layer "access points" in support of one or more "circuit layer networks".

NOTE 2: In the case of 2 Mbit/s based PDH, there are four "path layer networks" with a "client/server" relationship between adjacent "path layer networks". These "path layer networks" are denoted hereafter as follows:

- **P12:** 2 048 kbit/s path layer network;
- **P22:** 8 448 kbit/s path layer network;
- **P31:** 34 368 kbit/s path layer network;
- **P41:** 39 264 kbit/s path layer network.

transmission media layer network: A "layer network" which may be media dependent and which is concerned with the transfer of information between section layer "access points" in support of one or more "path layer networks". It is further divided into a "section" layer network" and a "physical media layer network".

section layer network: A "layer network" which is concerned with the transfer of information between section layer "access points". In the case of inter-station sections for the PDH, the "characteristic information" of the "section layer network" is proprietary and therefore it is not further sub-divided as in the case of the SDH. In the case of intra-station sections for PDH, the "section layer network" is standardized.

physical media layer network: A "layer network" which is concerned with the actual optical fibre, metallic pair or radio frequency which supports the "section layer network". In the case of inter-station "physical media layer networks" for the PDH, the "characteristic information" is proprietary. In the case of intra-station "physical media layer networks" for the PDH, the "characteristic information" is standardized.

3.2 Abbreviations

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

ATM	Asynchronous Transfer Mode
CMI	Coded Mark Inversion (code)
HDB	High Density Bipolar (code)
OAM	Operation, Administration and Maintenance
PDH	Plesiochronous Digital Hierarchy
SDH	Synchronous Digital Hierarchy
TCP	Termination Connection Point
VC-n	Virtual Container (level) n

4 Introduction

A telecommunications network is a complex network which can be described in a number of different ways depending on the particular purpose of the description. This ETR describes the network as a transport network from the viewpoint of the information transfer capability in the context of the PDH. More specifically, this ETR describes the functional and structural architectures of the 2 Mbit/s based PDH transport networks. Many of the principles are generic and also applicable to the SDH network.

The generic aspects of the architecture are given in ITU-T Recommendation G.803 [8] and ETR 085 [11] and are therefore not reproduced in this ETR. It is assumed that the reader is familiar with the terminology and functional architecture given in these documents.

In addition to rigorously describing the functional architecture, this ETR also gives some examples of the application of the functional architecture to PDH network structures. Annex A to this ETR also gives the characteristics of all PDH transport layers in terms of characteristic information, termination functions and adaptation functions.

This ETR does not consider issues in the circuit layer other than the definition of the inter-layer adaptation between the circuit layer network and the transmission network.

NOTE: For the purposes of this ETR, a definition of circuit layer network is given in clause 4 of ETR 085 [11].

4.1 Structure

Subclause 3.1 contains definitions used for defining network architecture. Clause 5 contains the detailed description of the architecture in functional terms. The degree of rigour used is consistent with that required for the purposes of network design, network management and network performance analysis. Clause 6 uses the functional description and applies it to actual network topologies, structures and network elements which are likely to be required.

5 Transport functional architecture of the PDH network

5.1 Introduction

The functional architecture is described in a generic way in clause 5 of ETR 085 [11]. The description of transport network layers and client/server associations as they relate to the PDH is given below.

5.2 Transport network layers

Figure 1 illustrates the layered model of the transport network. Features of the layered model are as follows:

- it is classified broadly into three classes of layer network: a circuit layer network, a path layer network and a transmission media layer network;

- the association between any two adjacent layers is a server/client association;

- each layer has its own Operation, Administration and Maintenance (OAM) capability.

The three classes of layer networks are described as follows:

- circuit layer networks: provide users with telecommunications services such as circuit switched services, packet switched services and leased line services. Different circuit layer networks can be identified according to the services provided. Circuit layer networks are independent of path layer networks. Examples of equipment in circuit layer networks are switches for various switched services and cross-connects for leased line services;

- path layer networks: are used to support different types of circuit layer networks. In the case of PDH there are four path layer networks: P12, P22, P31 and P4. Path layer networks are independent of transmission media layer networks;

- transmission media layer networks: are dependent on the transmission medium such as optical fibre and radio. Transmission media layer networks are divided into section layer networks and physical media layer networks. Section layer networks are concerned with all the functions which provide for the transfer of information between two nodes in path layer networks whereas physical media layer networks are concerned with the actual fibre, metallic pair or radio frequency which supports a section layer network.

Figure 1 also shows an example of the association between these three classes of layer networks and shows that the topology of each layer is independent. Each layer network consists of architectural components which are outlined in subclause 5.2 of ETR 085 [11].

5.3 Client/server association

The client/server association between adjacent layer networks is one where a link connection in the client layer network is provided by a trail in the server layer network. More specifically:

- a link connection in the circuit layer is provided by a path in the path layer network, or by a (intra-station) section in the section layer network;

- a link connection in the path layer network is provided by a section in the transmission media layer network.

The layered relationship for the PDH based transport network is further illustrated in figure 2. Annex A lists the client/server associations for various PDH transport network layers.

6 Application of functional architecture to examples of PDH transport

In order to illustrate the way that the functional architecture can be used to describe particular transport network scenarios embodying PDH, some examples are given.

Figure 3 shows a possible topology of generic 139 264 kbit/s path and section layer networks supporting different client layer networks.

Figure 4 represents an application of the functional architecture to the case of PDH supporting ATM.

Figure 5 represents an application of the functional architecture to a 64 kbit/s circuit layer supported by various PDH path layers and PDH section layers.

Figure 6 represents an application of the functional architecture to the transparent transport of a 2 048 kbit/s circuit (P12x) supported by various PDH path layers and PDH section layers.

NOTE: The section layer includes both standardized intra-station (E_{xy}) and non-standardized inter-station sections.

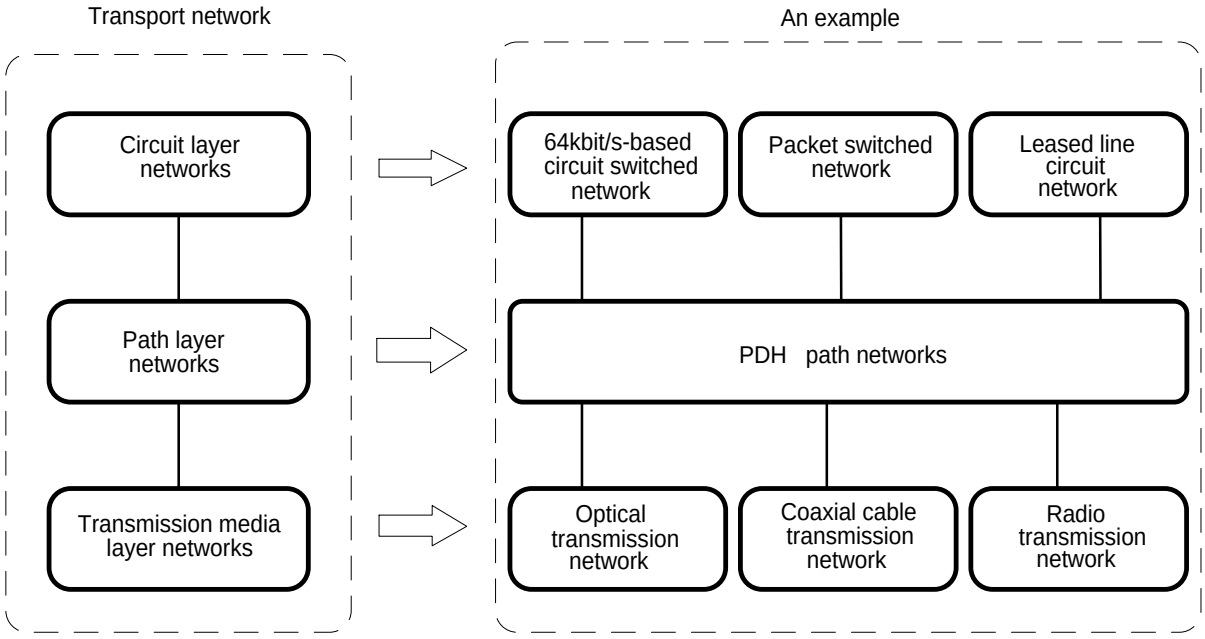
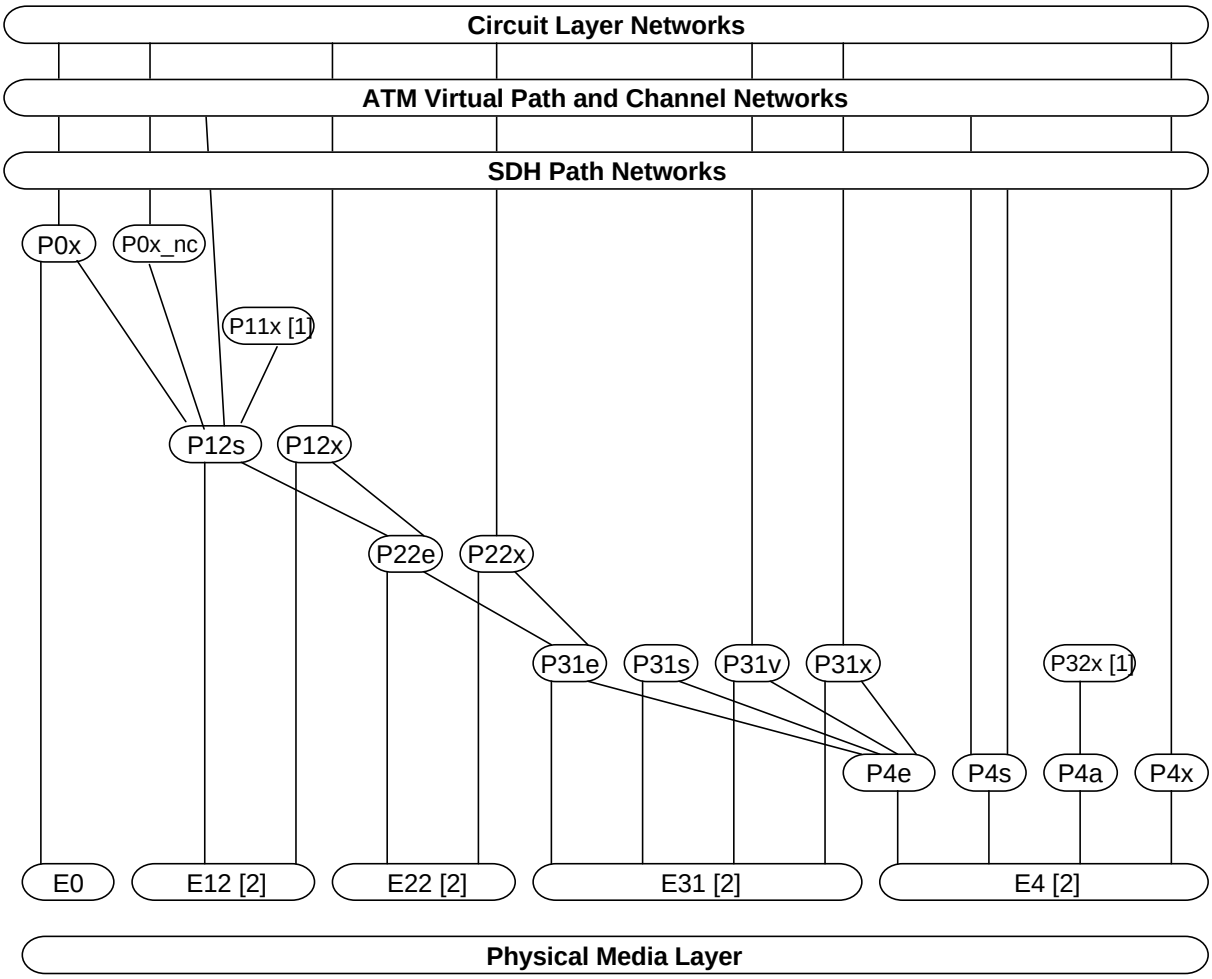


Figure 1: Example of association between layer networks



NOTE 1: P11 and P32 can also be considered to be contained within the circuit layer. They are shown within the path layer because of their role in non-ETSI PDH hierarchies.

NOTE 2: Only intra-station sections are shown. Inter-station section support is not standardized.

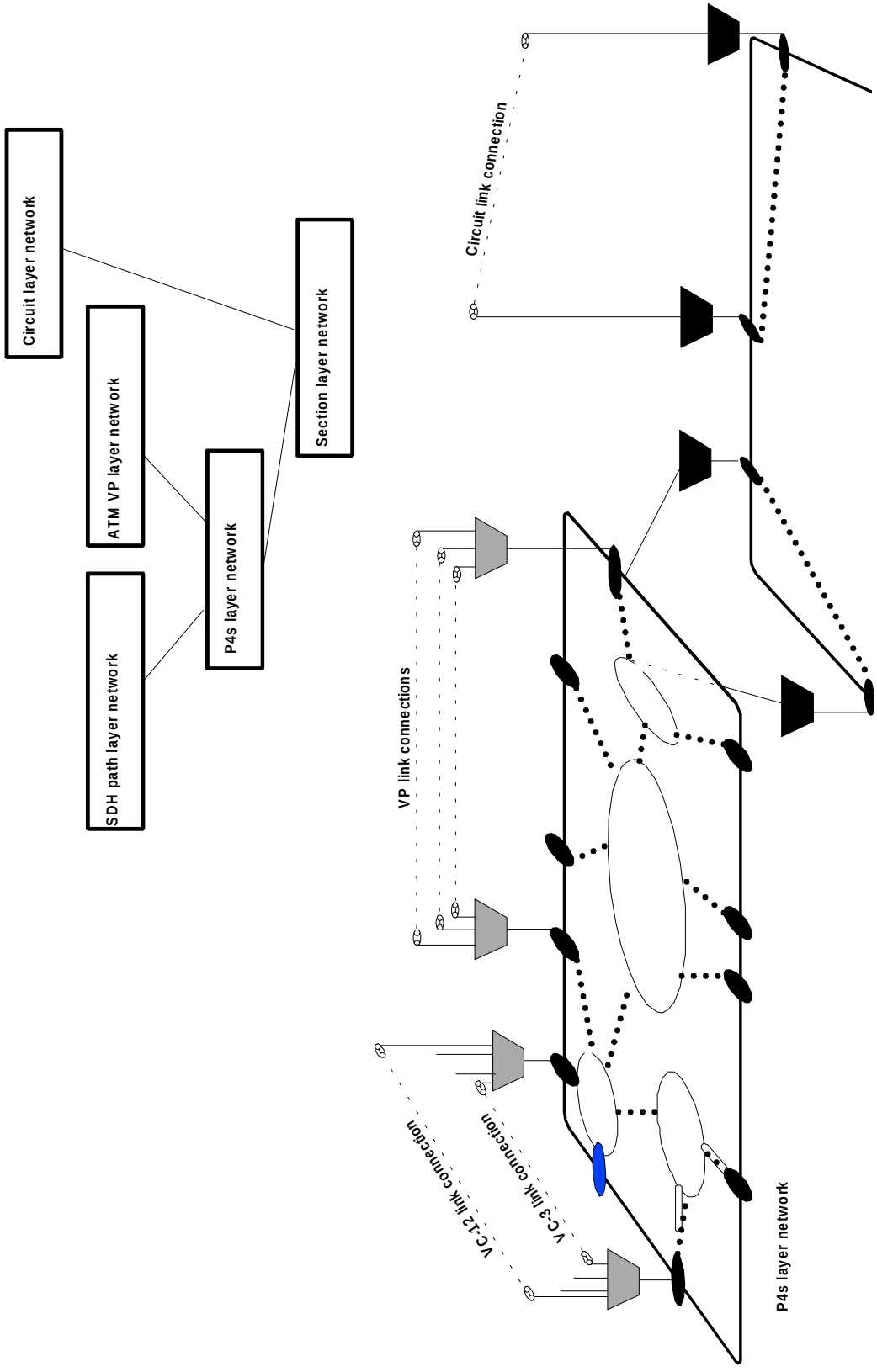


Figure 3: Possible topology of P4s and section layer networks supporting different client layer networks

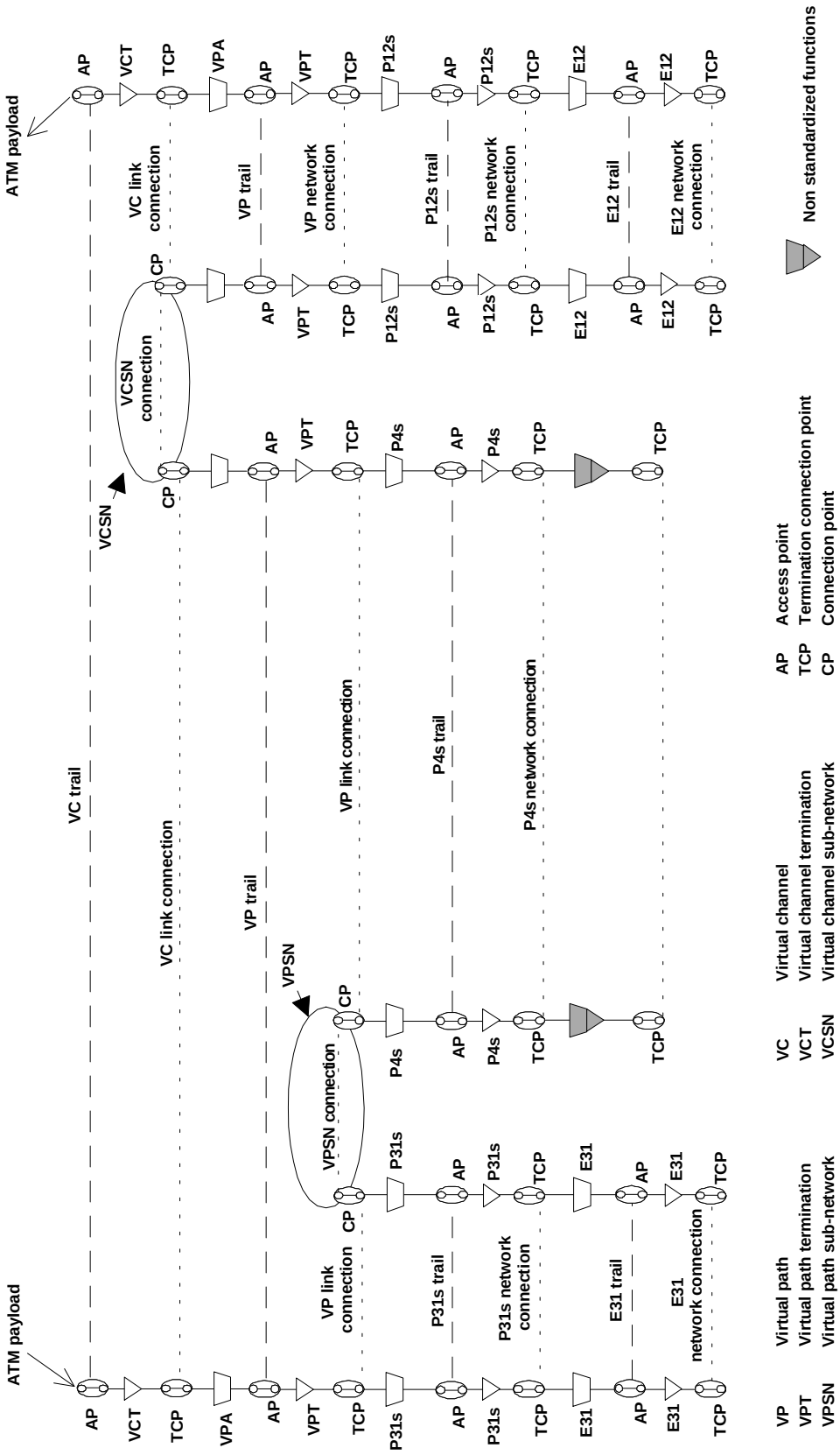


Figure 4: An application of the functional architecture to the case of PDH supporting ATM

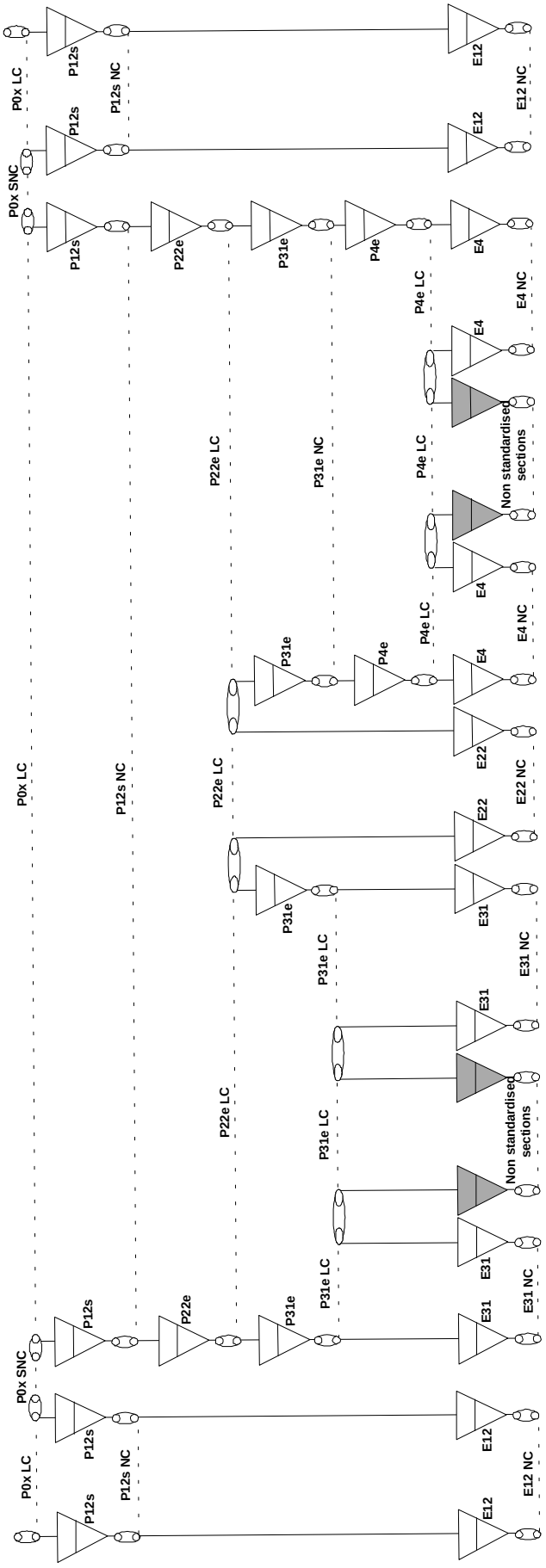


Figure 5: Application of functional architecture to 64 kbit/s circuit layer supported by various PDH path layers and PDH section layers

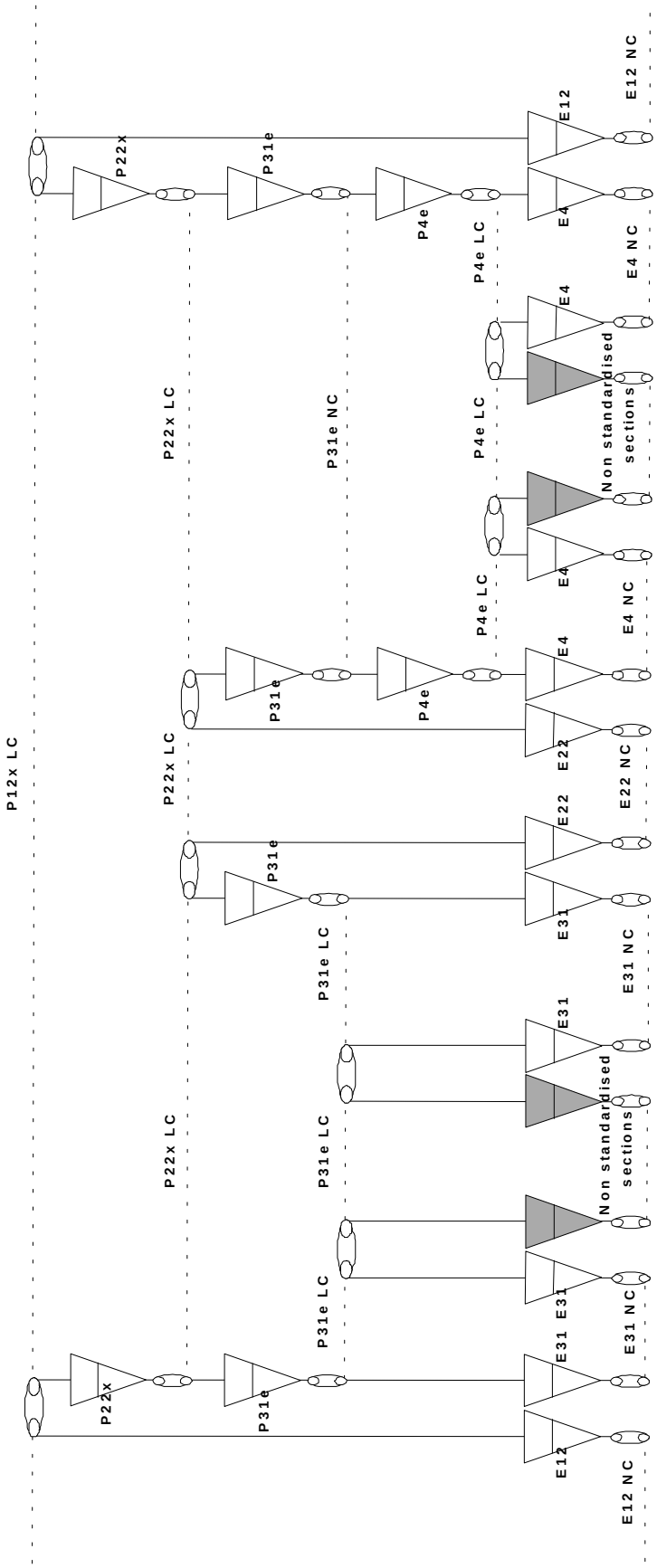


Figure 6: Application of functional architecture to the transparent transport of a 2 048 kbit/s circuit supported by various PDH path layers and PDH section layers

Annex A: Characteristics of PDH transport network layers

This annex gives the characteristics of the PDH transport network layers defined in ITU-T Recommendations. For each layer a template is given which identifies the characteristic information, the available overhead and the client layers which the layer can support. It also identifies the client/server adaptation functions required to support the client layers. Where possible, relevant ITU-T Recommendations and ETSI Standards are referenced for the detailed characteristics. In some cases, the relevant recommendations do not contain the information in a form which is readily applicable to the template approach. Where this is the case, additional information is given in the template.

For reasons of brevity, a naming convention for the transport network layers is used as follows:

NAMING CONVENTION:

The general scheme for the naming of any path layers is as follows:

- XYYZ

where:

- X = "S" for "SDH";
  "P" for "PDH";
- YY = 1 to 2 digits identifying the hierarchical level;
- Z = "s" for synchronous;
  "e" for plesiochronous European mappings;
  "v" for video;
  "a" for plesiochronous mappings of ANSI signals;
  "x" for transparent (or unknown structure for client layers).

Table A.1: PDH ITU-T Recommendation G.702 [1] path and circuit layers

Layer	Transmission speed	Description
P0x	64 kbit/s	
P0x_nc	n x 64 kbit/s	
P11x[note]	1 544 kbit/s	
P12x	2 048 kbit/s	
P12s	2 048 kbit/s	synchronous 125 µs frame structure according to ETS 300 167 [13]
P22x	8 448 kbit/s	
P22e	8 448 kbit/s	with 4 plesiochronous 2 048 kbit/s
P31x	34 368 kbit/s	
P31e	34 368 kbit/s	with 4 plesiochronous 8 448 kbit/s
P31s	34 368 kbit/s	synchronous 125 µs frame structure according to ETS 300 337 [15]
P31v	34 368 kbit/s	supporting video circuits according to ETS 300 174 [14]
P32x (note)	44 736 kbit/s	
P4x	139 264 kbit/s	
P4e	139 264 kbit/s	with 4 plesiochronous 34 368 kbit/s
P4s	139 264 kbit/s	synchronous 125 µs frame structure according to ETS 300 337 [15]
P4a	139 264 kbit/s	with 3 plesiochronous 44 736 kbit/s signals
NOTE:	Paths not belonging to the 2 048 kbit/s based hierarchy are only supported for interworking with networks based on the 1 544 kbit/s hierarchy.	

Table A.2: PDH ITU-T Recommendation G.703 intra-station section layers

Layer	Transmission speed
E0	64 kbit/s
E12	2 048 kbit/s
E22	8 448 kbit/s
E31	34 368 kbit/s
E4	139 264 kbit/s

A.1 Path layers description and references

The following templates describe the essential features of PDH path layers (characteristic information, overhead and supported client layers).

P12s	Description	Reference
Layer	PDH 2 048 kbit/s path	ITU-T Recommendation G.702 [1]
Characteristic information	125 µs frame	ITU-T Recommendations G.702 [1], G.704 [3], G.804 [9], ETS 300167 [13], ETS 300 337 [15]
Overhead	Bits 1 to 8 of each frame	ITU-T Recommendations G.704 [3], G.804 [9]. ETS 300 167 [13], ETS 300 337 [15]
Client layers	P0x, P0x_nc (31-byte interleave or 30-byte interleave with associated signalling in time slot 16); ATM virtual paths	ITU-T Recommendations G.704 [3], G.73x series [4], G.804 [9]. ETS 300 167 [13]; ETS 300 337 [15]

P22e	Description	Reference
Layer	PDH 8 448 kbit/s path	ITU-T Recommendation G.702 [1]
Characteristic Information	100,4 µs frame	ITU-T Recommendation G.742 [5]
Overhead	Bits 1 to 12 of each frame	ITU-T Recommendation G.742 [5]
Client Layers	P12s, P12x (positive justification, bit interleave)	ITU-T Recommendation G.742 [5]

P31e	Description	Reference
Layer	PDH 34 368 kbit/s path	ITU-T Recommendation G.702 [1]
Characteristic information	44,69 µs frame	ITU-T Recommendation G.751 [6]
Overhead	Bits 1 to 12 of each frame	ITU-T Recommendation G.751 [6]
Client Layers	P22e, P22x, transparent 8 448 kbit/s circuits, (positive justification, bit interleave)	ITU-T Recommendation G.751 [6]

P31s	Description	Reference
Layer	PDH 34 368 kbit/s path	ITU-T Recommendation G.702 [1]
Characteristic information	125 µs frame	ITU-T Recommendation G.804. ETS 300 337 [15]
Overhead	7 bytes	ITU-T Recommendations G.804, G.832, ETS 300 337 [15]
Client layers	ATM virtual path SDH VC-12 path SDH VC-2, VC-2_nc path	ITU-T Recommendations G.804, G.832, ETS 300 337 [15]

P31v	Description	Reference
Layer	PDH 34 368 kbit/s path	ITU-T Recommendation G.702 [1]
Characteristic information	8 ms multiframe based on 179 ITU-T Recommendation G.751 [6] frames	ETS 300 174 [14]
Overhead	bits 1 to 14 of each frame	ETS 300 174 [14]
Client layers	video container organized in a 125 µs frame	ETS 300 174 [14]

P4e	Description	Reference
Layer	PDH 139 264 kbit/s path	ITU-T Recommendation G.702 [1]
Characteristic Information	21,02 µs frame	ITU-T Recommendation G.751 [6]
Overhead	Bits 1 to 16 of each frame	ITU-T Recommendation G.751 [6]
Client Layers	P31e, P31s, P31v, P31x, transparent 34 368 kbit/s circuit (positive justification, bit interleave)	ITU-T Recommendation G.751 [6]

P4s	Description	Reference
Layer	PDH 139 264 kbit/s path	ITU-T Recommendation G.702 [1]
Characteristic Information	125 µs frame	ITU-T Recommendation G.804 [9]. ETS 300 337 [15]
Overhead	16 bytes	ITU-T Recommendation G.804 [9], G.832 [10] ETS 300 337 [15]
Client layers	ATM virtual path SDH VC-12 path SDH VC-2, VC-2-nc path SDH VC-3 path	ITU-T Recommendation G.804 [9], G.832 [10], ETS 300 337 [15]

P4a	Description	Reference
Layer	PDH 139 264 kbit/s path	ITU-T Recommendation G.702 [1]
Characteristic information	6,85 µs frame	ITU-T Recommendation G.755 [7]
Overhead	18 bits	ITU-T Recommendation G.755 [7]
Client layers	P32x (positive justification, bit interleave)	ITU-T Recommendation G.755 [7]

A.2 Intra-station sections description and references

The following templates describe the essential features of PDH intra-station section layers (characteristic information, overhead and supported client layers).

E0	Description	Reference
Layer	PDH ITU-T Recommendation G.703 [2] 64 kbit/s intra-station section	ITU-T Recommendation G.703 [2] ETS 300 166 [12]
Characteristic information	unstructured	ITU-T Recommendation G.703 [2] ETS 300 166 [12]
Overhead	none	ITU-T Recommendation G.703 [2] ETS 300 166 [12]
Client layers	unstructured (transparent) 64 kbit/s circuit	ITU-T Recommendation G.703 [2] ETS 300 166 [12]

E12	Description	Reference
Layer	PDH ITU-T Recommendation G.703 [1] 2 048 kbit/s intra-station section	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Characteristic information	2 048 kbit/s High Density Bipolar (HDB)-3 coded	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Overhead	HDB-3 coding redundancy	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Client layers	P12x, P12s (HDB-3 coding/decoding), unstructured (transparent) 2 048 kbit/s circuit	ITU-T Recommendation G.703 [1] ETS 300 166 [12]

E22	Description	Reference
Layer	PDH 8 448 kbit/s intra-station section	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Characteristic information	8 448 kbit/s HDB-3 coded	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Overhead	HDB-3 coding redundancy	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Client layers	P22x, P22e (HDB-3 coding/decoding), unstructured (transparent) 8 448 kbit/s circuit	ITU-T Recommendation G.703 [1] ETS 300 166 [12]

E31	Description	Reference
Layer	PDH 34 368 kbit/s intra-station section	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Characteristic information	34 368 kbit/s HDB-3 coded	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Overhead	HDB-3 coding redundancy	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Client layers	P31e, P31s, P31v, P31x (HDB-3 coding/decoding), unstructured (transparent) 34 368 kbit/s circuit	ITU-T Recommendation G.703 [1] ETS 300 166 [12]

E4	Description	Reference
Layer	PDH 139 264 kbit/s intra-station section	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Characteristic information	139 264 kbit/s Coded Mark Inversion (CMI) coded	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Overhead	CMI coding redundancy	ITU-T Recommendation G.703 [1] ETS 300 166 [12]
Client layers	P4e, P4s, P4a, P4x (CMI coding/decoding), unstructured (transparent) 139 264 kbit/s circuit	ITU-T Recommendation G.703 [1] ETS 300 166 [12]

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