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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Broadband and triple-play multimedia services –  
Broadband multimedia services over VDSL

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## **Full service VDSL – System architecture and customer premises equipment**

ITU-T Recommendation H.610

ITU-T H-SERIES RECOMMENDATIONS  
AUDIOVISUAL AND MULTIMEDIA SYSTEMS

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# ITU-T Recommendation H.610

## Full service VDSL – System architecture and customer premises equipment

### Summary

This Recommendation specifies the system architecture (SA) and customer premises equipment (CPE) architecture for the delivery of video, data and voice services across a VDSL access network to an in-home environment, known as a Full Service VDSL network. This Recommendation specifies the SA and CPE architecture at a high level, independent of the underlying broadband physical layer transport mechanism. VDSL is referenced throughout this Recommendation as the physical layer technology; however, the architectural specifications contained herein could be equally applicable to CPE and Access Networks employing other broadband physical layer technologies.

This Recommendation defines an architecture that enables the provisioning of a bundle of triple-play services in a reliable way, with minimal user intervention, respecting the key requirements of security and conditional access to the content and at a cost compatible with mass market deployment.

### Source

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# ITU-T Recommendation H.610

## Full service VDSL – System architecture and customer premises equipment

### 1 Scope

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This Recommendation defines an architecture that enables the provisioning of a bundle of triple-play services in a reliable way, with minimal user intervention, respecting the key requirements of security and conditional access to the content and at a cost compatible with mass market deployment.

This Recommendation is limited to the use of IPv4. Use of IPv6 is for further study.

### 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; 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. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

#### 2.1 Normative references

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### 3 Definitions

This Recommendation defines the following terms:

**3.1 Access Network (AN):** Includes the ONU and the OLT. In the reference model, this is between the U-R2 and the V reference points. The term AN is used to describe the overall capabilities of both the OLT and the ONU. For example, if an attribute *x* should be supported by the Access Network, then either the OLT, the ONU or both should implement attribute *x*. Whenever a requirement addresses a specific network component, it is stated so.

**3.2 access network operator:** The AN Operator operates the physical access system. Encompassing the domain between the U-R and V reference point of the system reference model (see clause 6).

**3.3 content provider:** The Content Provider generates content such as video copies in various digital or analogue formats. The Service Provider is expected to contract the Content Provider in order to have access to its content and to allow access to subscribed users.

**3.4 core network operator:** The Core Network Operator maintains and manages the core network beyond the V reference point and the OLT physical interface.

**3.5 digital broadcast network:** A multicast Network that is used to distribute point to multi-point traffic such as digital TV and radio.

**3.6 Element Management System (EMS):** The system allowing the AN management.

**3.7 Functional Processing (FP):** A point of signal transformation or processing.

**3.8 Functional Processing and Decoding (FPD):** A point of application layer processing of video, audio or data.

**3.9 interactive A/V network:** A unicast network used to deliver point-to-point video and audio services such as VoD.

**3.10 internet network:** Broadband data Network in duplex mode for IP based services, typically Internet services.

- 3.11 InterWorking to Core Network (IWCN):** Any function that may be included in the OLT to interwork with non-ATM core networks. Due to the variety of core network technologies and configurations, this Recommendation only covers the AN requirements up to the V reference point.
- 3.12 M:** Reference point used between the AN and the EMS.
- 3.13 Optical Distribution Network (ODN):** Provides the optical transmission medium, linking the OLT towards the ONUs, and vice versa, between the S/R and R/S reference points.
- 3.14 Optical Line Termination (OLT):** Provides the network interface to several service nodes for multiple ONUs that are connected through the ODN.
- 3.15 Optical Network Unit (ONU):** Provides the user side interfaces and is interconnected to a parent OLT via the ODN.
- 3.16 OTU-C Optical Termination Unit:** Optical termination unit at the OLT.
- 3.17 OTU-R Optical Termination Unit:** Optical termination unit at the ONU.
- 3.18 POTSc/ISDNc:** Interface between the PSTN and the PS splitter at the ONU side.
- 3.19 POTSR/ISDNr:** Interface between narrowband terminals and the PS splitter at the customer premises side.
- 3.20 PS:** POTS or ISDN Splitter. Passive splitter, which combines low frequency signal (e.g., POTS or ISDN) and high frequency signal (i.e., VDSL) at the ONU side and at the Customer premises side.
- 3.21 Q:** Reference point used to describe the interface to the management network, typically for system configuration, maintenance and provisioning.
- 3.22 R:** The output (input) of the FPD towards (from) the residential appliance.
- 3.23 R/S:** Reference point used between the ODN and ONU.
- 3.24 residential centralized model:** When mentioned in this Recommendation, refers to the use of the VTPD as the decoding unit.
- 3.25 residential distributed model:** When mentioned in this Recommendation, refers to the use of multiple FPDs that are connected to the VTP through the residential LAN.
- 3.26 residential network:** Digital network used in an in-home environment for delivering FS-VDSL services.
- 3.27 S/R:** Reference point used between the OLT and the ODN. This can be a point-to-point or a point-to-multipoint optical interface.
- 3.28 service operator:** The Service Operator maintains and manages the physical equipment of multiple or single service nodes that interface the Core/AN and provide users access to various services including data connection, broadcast video, VoD and voice.
- 3.29 service provider:** The Service Provider is the entity that uses the Service Operator's physical platform to provide access to various services, including data services, broadcast video services, VoD services, and voice services.
- 3.30 TCN:** The output (input) of the digital port(s) of the VTP/D toward (from) the digital Network at the customer premises.
- 3.31 terminal:** A physical entity hosting an FPD, e.g., set-top box (STB), PC, IP phone.
- 3.32 U-C:** Reference point used between the splitters, located at the ONU, and the copper network.
- 3.33 U-C2:** Reference point used between the POTS or ISDN splitter and the VTU-C.

- 3.34 U-R:** The network side of the PS located at the customer premises.
- 3.35 U-R2:** The network side input (output) of the VDSL modem.
- 3.36 V:** Reference point used between the OLT and one or more service nodes, either directly or via the Core Network.
- 3.37 voice network:** A network that is capable of delivering toll quality voice and switched voice services. The network is typically a TDM network such as PSTN or ISDN, but can also be a packet based voice network.
- 3.38 VDSL Termination Processing (VTP):** Unit that operates the VDSL modem termination and protocol processing functions. A device that implements the VTP functions includes Ethernet based layer-2 interface to the residential network.
- 3.39 VTP and Decoding (VTPD):** Refers to a unit that operates the video decoding function as well as the VTP functions and interfaces. From the point of view of the access network, the functionalities and interfaces of the VTPD are identical to a VTP.
- 3.40 VTP/D:** When mentioned in this Recommendation, refers to both the VTP and the VTPD.
- 3.41 VTU-C:** VDSL Termination Unit. VDSL transmission unit at the ONU.

## 4 Abbreviations

This Recommendation uses the following abbreviations:

|         |                                                      |
|---------|------------------------------------------------------|
| A/V     | Audio/Video                                          |
| AAL     | ATM Adaptation Layer                                 |
| AIS     | Alarm Indication Signal                              |
| AN      | Access Network                                       |
| ANSI    | American National Standards Institute                |
| API     | Application Programming Interface                    |
| ARP     | Address Resolution Protocol                          |
| ATM     | Asynchronous Transfer Mode                           |
| BAS     | Broadband Access Server                              |
| BER     | Bit Error Ratio                                      |
| BLES    | Broadband Loop Emulation Service                     |
| BPID    | Broadcast Program ID                                 |
| CA      | Conditional Access                                   |
| CAC     | Call Admission Control                               |
| CBR     | Constant Bit Rate                                    |
| CC      | Continuity Check                                     |
| CCF MIM | Channel Change Function Management Information Model |
| CDV     | Cell Delay Variation                                 |
| CHAP    | Challenge Handshake Authentication Protocol          |
| CMIP    | Common Management Information Protocol               |
| CO      | Central Office                                       |

|         |                                                   |
|---------|---------------------------------------------------|
| CORBA   | Common Object Request Broker Architecture         |
| CPE     | Customer Premises Equipment                       |
| DAVIC   | Digital Audio Visual Council                      |
| DBTV    | Digital Broadcast TV                              |
| DHCP    | Dynamic Host Configuration Protocol               |
| DRM     | Digital Rights Management                         |
| DSL     | Digital Subscriber Line                           |
| DSM-CC  | Digital Storage Media – Command and Control       |
| DVB     | Digital Video Broadcasting                        |
| DVD     | Digital Versatile Disc                            |
| EAS     | Emergency Alert System                            |
| EMS     | Element Management System                         |
| EPD     | Early packet Discard                              |
| ER      | Edge Router                                       |
| ETSI    | European Telecommunications Standards Institute   |
| FCC     | Federal Communications Commission                 |
| FPD     | Functional processing and Decoding                |
| FSAN    | Full Service Access Network                       |
| FS-VDSL | Full Service VDSL                                 |
| FTP     | File Transfer Protocol                            |
| HTML    | Hyper Text Mark-up Language                       |
| HTTP    | Hyper Text Transfer Protocol                      |
| HW      | Hardware                                          |
| IAD     | Integrated Access Device                          |
| ICMP    | Internet Control Message Protocol                 |
| IEEE    | Institute of Electrical and Electronics Engineers |
| IETF    | Internet Engineering Task Force                   |
| IGMP    | Internet Group Management Protocol                |
| ILMI    | Integrated Local Management Interface             |
| IP      | Internet Protocol                                 |
| IPv4    | Internet Protocol version 4                       |
| IPv6    | Internet Protocol version 6                       |
| IPCP    | Internet Protocol Control Protocol                |
| ISDN    | Integrated Services Digital Network               |
| IWCN    | InterWorking to Core Network                      |
| LAN     | Local Area Network                                |
| LCP     | Link Control Protocol                             |

|       |                                             |
|-------|---------------------------------------------|
| LT    | Line Termination                            |
| MAC   | Medium Access Control                       |
| MCM   | Multi-Carrier Modulation                    |
| MIB   | Management Information Base                 |
| MPEG  | Moving Picture Experts Group                |
| NAPT  | Network Address and Port Translation        |
| NAT   | Network Address Translation                 |
| NSP   | Network Service Provider                    |
| NT    | Network Termination                         |
| OAM   | Operation and Management                    |
| ODN   | Optical Distribution Network                |
| OLT   | Optical Line Termination                    |
| ONU   | Optical Network Unit                        |
| OSI   | Open Systems Interconnection                |
| OTU-C | Optical Terminal Unit – Central Office side |
| OTU-R | Optical Terminal Unit – Remote side         |
| PAP   | Password Authentication Protocol            |
| PAT   | Port Address Translation                    |
| PBX   | Private Branch Exchange                     |
| PCR   | Peak Cell Rate                              |
| POTS  | Plain Old Telephone Service                 |
| PPD   | Partial Packet Discard                      |
| PPP   | Point-to-Point Protocol                     |
| PPPoA | PPP over ATM                                |
| PPPoE | PPP over Ethernet                           |
| PPTP  | Point-to-Point Tunnelling Protocol          |
| PS    | POTS or ISDN Splitter                       |
| PVC   | Permanent Virtual Circuit                   |
| PVP   | Permanent Virtual Path                      |
| QoS   | Quality of Service                          |
| RDI   | Remote Defect Indication                    |
| RFC   | Request for Comment (IETF standard)         |
| RIP   | Routing Information Protocol                |
| RTP   | Real Time Protocol                          |
| RTSP  | Real Time Streaming Protocol                |
| SAR   | Segmentation And Reassembly                 |
| SCM   | Single Carrier Modulation                   |

|         |                                                          |
|---------|----------------------------------------------------------|
| SCSI    | Small Computer System Interface                          |
| SDH     | Synchronous Digital Hierarchy                            |
| SDP     | Session Description Protocol                             |
| SIP     | Session Initiation Protocol                              |
| SNMP    | Simple Network Management Protocol                       |
| SONET   | Synchronous Optical Network                              |
| SPTS    | Single Program Transport Stream                          |
| STB     | Set Top Box                                              |
| SVC     | Switched Virtual Circuit                                 |
| SW      | Software                                                 |
| TDM     | Time Division Multiplexing                               |
| TE      | Terminal Equipment                                       |
| TFTP    | Trivial File Transfer Protocol                           |
| TM      | Transmission and Multiplexing (ETSI Technical Committee) |
| UBR     | Unspecified Bit Rate                                     |
| UPC     | Usage Parameter Control                                  |
| USB     | Universal Serial Bus                                     |
| UTOPIA  | Universal Test and Operational PHY Interface for ATM     |
| VBR     | Variable Bit Rate                                        |
| VBR-nRT | Variable Bit Rate non-real time                          |
| VBR-RT  | Variable Bit Rate real time                              |
| VC      | Virtual Connection                                       |
| VCi     | Virtual Channel Identifier                               |
| VDSL    | Very High Bit Rate Digital Subscriber Line               |
| VLAN    | Virtual LAN                                              |
| VoD     | Video-on-Demand                                          |
| VoDSL   | Voice over DSL                                           |
| VoIP    | Voice over IP                                            |
| VP      | Virtual Path                                             |
| VPI     | Virtual Path Identifier                                  |
| VPN     | Virtual Private Network                                  |
| VTP     | VDSL Termination Processing                              |
| VTP/D   | VTP or VTPD                                              |
| VTPD    | VDSL Termination Processing and Decoding                 |
| VTPD    | VTP and Decoding                                         |
| VTU-C   | VDSL Terminal Unit – Central Office                      |
| VTU-R   | VDSL Terminal Unit – Remote                              |

## 5 Terminology

The following words are used throughout this Recommendation to signify requirement levels.

"SHALL" This word or the adjective "required," means that the definition is an absolute requirement of this Recommendation.

"SHALL NOT" This phrase means that the definition is an absolute prohibition of this Recommendation.

"SHOULD" This word or the adjective "recommended," means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications must be understood and carefully weighted before choosing a different course.

"MAY" This word or the adjective "optional," means that this item is one of an allowed set of alternatives. An implementation, that does not include this option, shall be interoperable with another implementation that does include the option.

## 6 Reference model

The aim of the reference model in Figure 1 is to clearly define the interfaces and reference points that are used in an FS-VDSL environment.

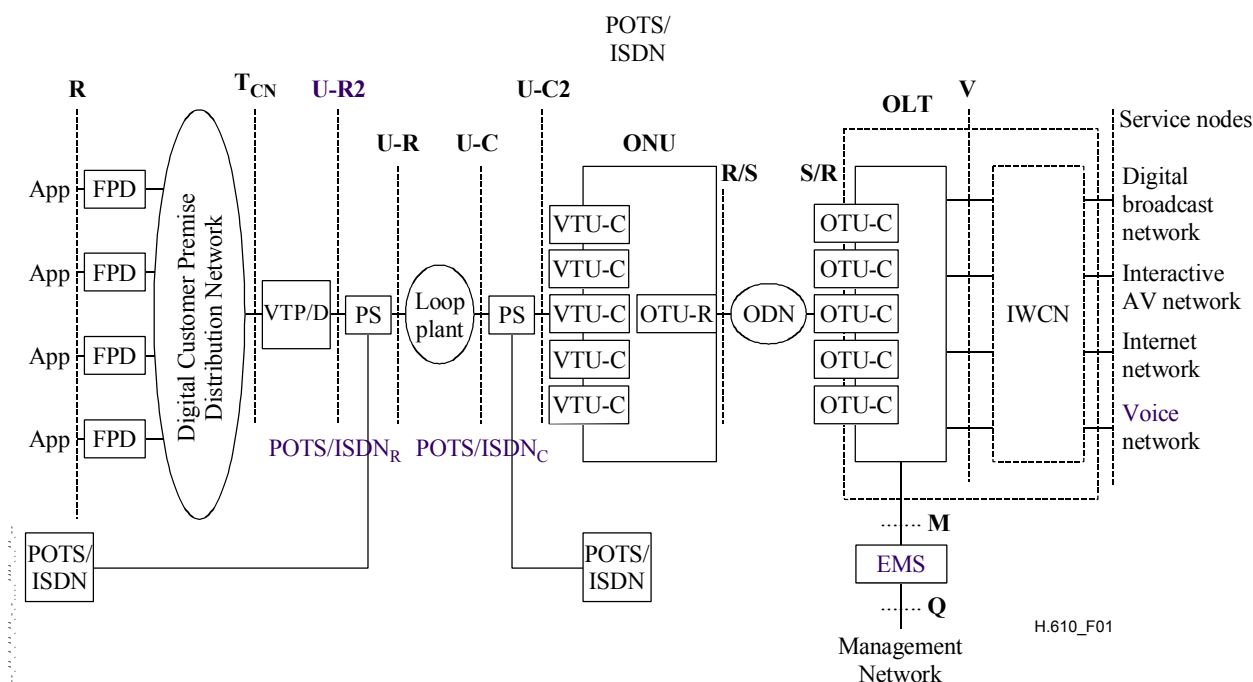


Figure 1/H.610 – FS-VDSL reference model

### 6.1 Residential architectures

Physical implementations of FS-VDSL CPE may perform all processing and decoding in a single customer premises device or distribute functional processing and decoding into two or more customer premises devices. The FP, FPD, VTP or VTPD elements may be combined to describe the following alternative architectures:

- **Distributed** refers to an architecture in which several FPD elements are interconnected together as shown in Figure 2. These elements contain functional processors and possibly the residential appliance itself. The VTP element contains the VDSL modem, together with a protocol and functional processor.

- **Centralized** refers to an architecture in which most if not all processing and decoding is performed within the same physical box termed VTPD as shown in Figure 3. Internal to this box, functional processing and digital signal distribution through busses is also taking place.

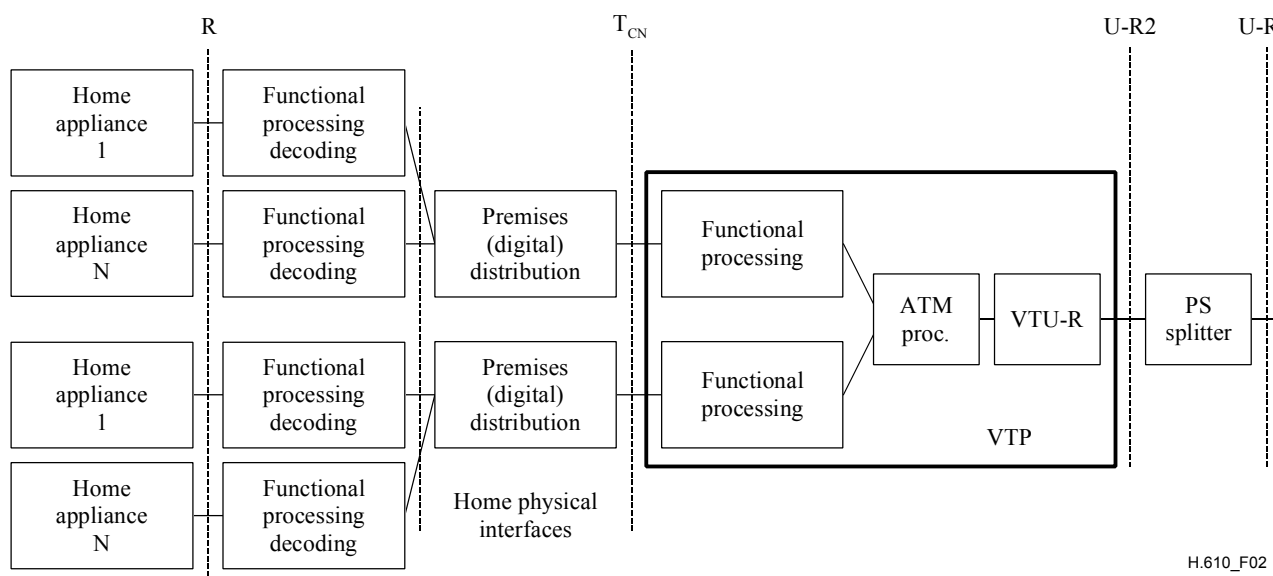


**Figure 2/H.610 – VTP grouping which implements a fully distributed CPE approach**

When the CPE is a combination of centralized and distributed architectures, the  $T_{CN}$  interface shall be provided to the VTPD for connecting to the distributed components.

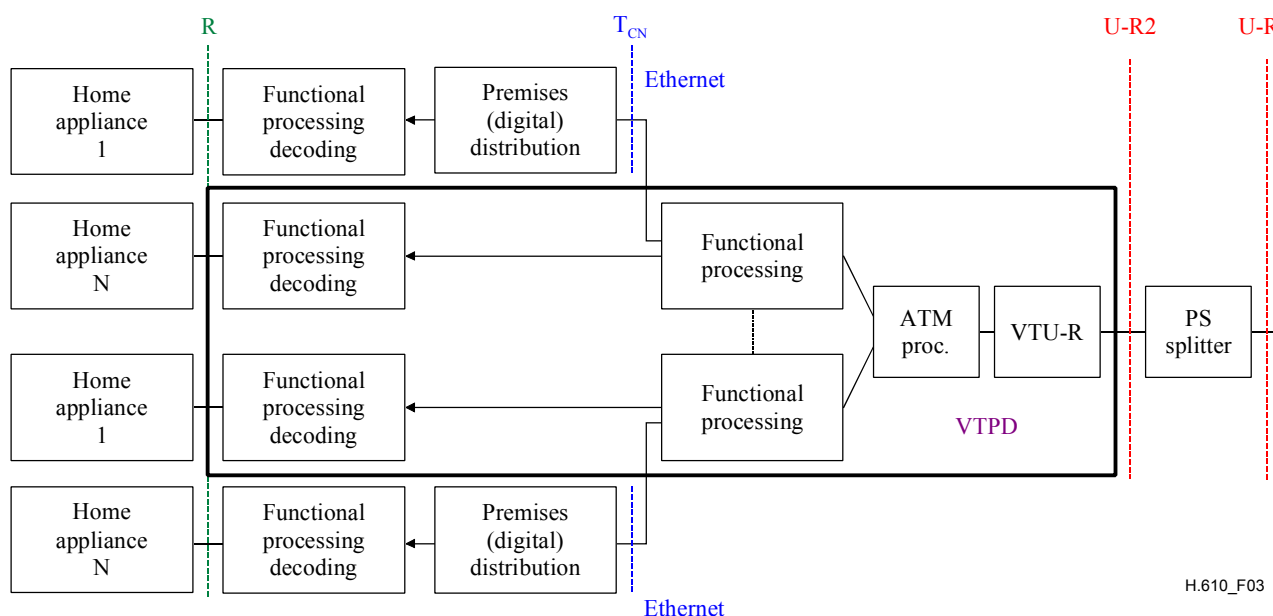


**Figure 3/H.610 – VTPD grouping which implements a centralized CPE approach with optional distributed FPs**

## 6.2 Focal reference points

The relevant architecture reference points are described in Table 1.

**Table 1/H.610 – Focal reference points**

| Reference point | Location                                                                                                           |
|-----------------|--------------------------------------------------------------------------------------------------------------------|
| T <sub>CN</sub> | The output (input) of the digital port(s) of the VTP/D towards (from) the digital network at the customer premises |
| U-R2            | The network side input of the DSL Modem                                                                            |
| V               | The reference point located between the ATM-based AN and any IWCN function connecting the AN to a Core Network     |
| M               | The interface between the OLT and the EMS                                                                          |

### 6.2.1 T<sub>CN</sub> reference point

The T<sub>CN</sub> shall present to the VTP/D's protocol processing modules an 802.3 frame as defined in IEEE 802.3 with the Type/Length field specifying the MAC client protocol type. This, however, does not imply that the residential network shall use the 802.3 MAC layer or an Ethernet physical layer. Different types of MAC and physical layers may be used. Where the term 'Ethernet' is used in this Recommendation, within the context of a layer in a protocol stack, it refers to the 802.3 frame format as defined above.

### 6.2.2 U-R2 reference point

At the U-R2 interface, the VTP/D protocol layers shall be as follows:

- The physical layer shall be a standard DSL layer transporting ATM.
- The ATM layer shall be implemented in accordance to subclause 8.3.
- The upper layers implementation shall comply with clause 9.

### 6.2.3 V reference point

This reference point is located between the ATM-based AN and any IWCN function connecting the AN to a Core Network.

This reference point shall provide an ATM layer in accordance to ITU-T Rec. I.361.

### 6.2.4 M reference point

This logical interface enables the OLT to be remotely managed by the EMS, as specified in ITU-T Rec. H.611.

## 7 General overview

This clause describes the general architecture of an FS-VDSL network and is provided for information. No mandatory requirements are defined in this clause. The architecture is designed for providing the infrastructure for delivering data (typically Internet access), video (broadcast and on demand) and voice services, as further detailed in ITU-T Supplement 3 to H-series Recommendations.

### 7.1 Access network architecture

#### 7.1.1 Access network overview

This Recommendation is designed for DSL based AN. The physical layer may be VDSL, ADSL or any other existing or future DSL technology that fulfils the service requirements. The choice of a DSL type for a specific implementation derives from the specific service bundle, e.g., the offered services and the required bit rate.

The AN may be composed of several equipments, depending on the network topology. For example, the CO equipment may or may not include the DSL line cards and the physical links

between the AN components may be point-to-point or point-to-multipoint. It is also possible to have a combination of the two schemes in the same network. Figure 4 illustrates these basic configuration options for the AN.

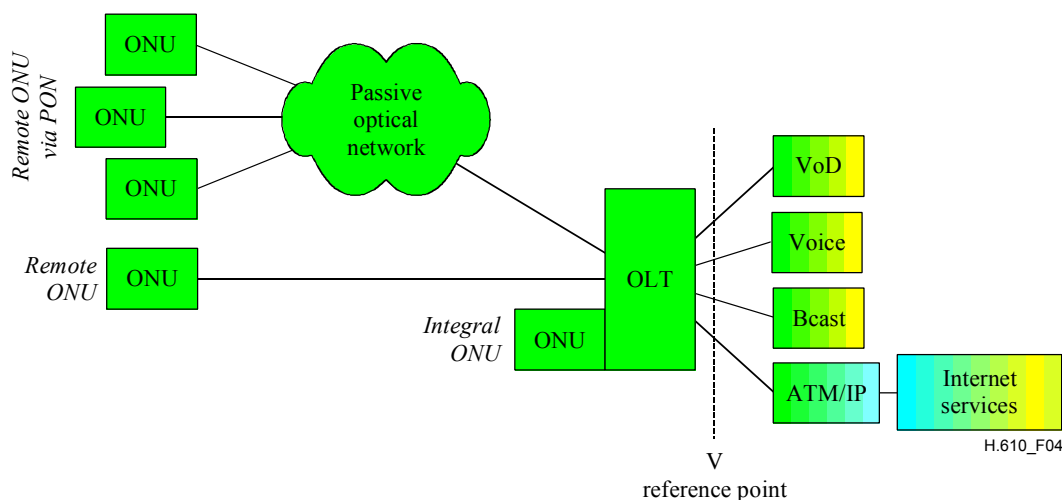


**Figure 4/H.610 – Access network topology options**

### 7.1.2 OLT

The OLT operates as an aggregator for a number of ONUs. In the upstream direction, the OLT aggregates the ATM traffic coming from the ONUs towards the V reference point; while in the downstream direction, it performs the opposite, de-multiplexing to the distributed ONUs.

FS-VDSL systems can perform the combined functionality of the ONU and the OLT in a single physical box. In the case of a unified ONU and OLT system, all (described below) functional elements of the OLT and ONU are present in the unified physical box.

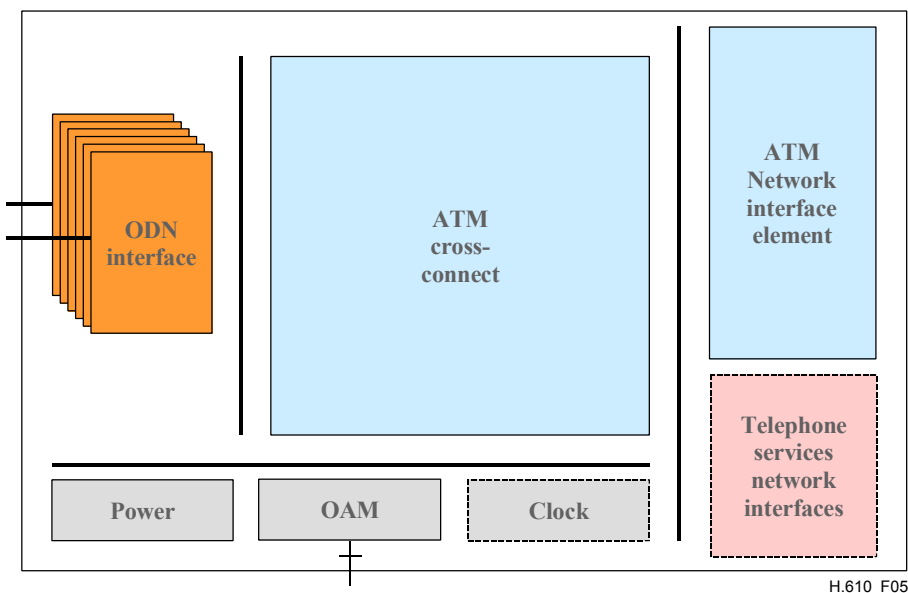


**Figure 5/H.610 – OLT functional blocks**

#### 7.1.2.1 Network interface element

The Network Interface Element performs the ATM and PHY layer functions to interface the OLT to the ATM network. In the case that non-ATM core networks are deployed, the network interface

element performs the protocol conversion between ATM and the core network technology. Multiple Network Interface Elements, supporting unidirectional or bidirectional ATM transmission, may exist in a single OLT.

#### 7.1.2.2 Telephone service network interfaces

The OLT may contain a Telephone Interface Element enabling the OLT to interface the voice network by performing the required protocol adaptations. The Telephone Interface Element may support TDM, ATM or IP voice transports and the associated signalling.

#### 7.1.2.3 ATM cross-connect

This block performs VP/VC cross-connection to and from the appropriate interfaces. Besides an ATM layer, this block should provide higher layer protocol functions like channel change processing, access control and management.

#### 7.1.2.4 Optical Distribution Network interface (ODN)

The block performs the ATM and PHY layer functions of the OLT's interface connecting the OLT to the ONUs through the ODN. The physical layer technology may conform to various optical transmission standards or may be vendor specific.

#### 7.1.2.5 OAM block

The OAM block provides operation, administration and management of the AN via the M interface.

#### 7.1.2.6 Power block

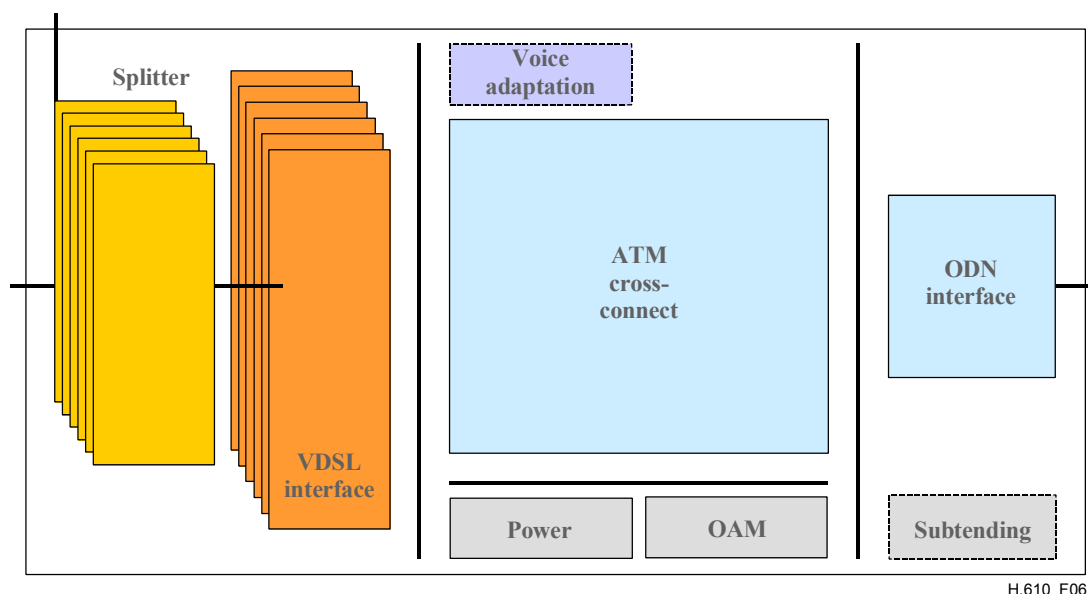
The power block supplies the appropriate voltage and current to all the electronic circuits in the OLT. The OLT, typically located in the Central Office, is not required to have dedicated backup battery.

#### 7.1.2.7 Clock block

Depending on the implementation of other blocks, an external clock interface may be implemented.

### 7.1.3 ONU

The ONU serves as an ATM cross-connect between the DSL lines and the ODN.



H.610\_F06

**Figure 6/H.610 – ONU functional blocks**

### 7.1.3.1 ODN interface

This block performs the ATM and PHY layer functions on the interface connecting the ONU to the OLT through the ODN.

### 7.1.3.2 Voice adaptation

The ONU may contain a voice adaptation element that performs mapping of base-band voice signals to voice over packet, voice over ATM or voice over IP.

### 7.1.3.3 ATM cross-connect

This block performs VP/VC cross-connection to and from the appropriate interfaces. This block may perform higher layer protocol functions like channel change processing.

### 7.1.3.4 VDSL interfaces

The VDSL interface performs the VTU-C functionality. It terminates the VDSL PHY layer functions and supports ATM transport over the copper lines.

### 7.1.3.5 POTS/ISDN splitter

In the upstream direction, the POTS splitter performs the PHY layer separation of the POTS/ISDN carrier frequency and the VDSL carrier frequency. In the downstream direction, the POTS/ISDN splitter combines the POTS/ISDN PHY carrier and the VDSL PHY carrier into defined separate carrier frequencies over the same copper drop.

### 7.1.3.6 OAM block

The OAM block enables operation, administration and management of the ONU, including the DSL drops. OAM tasks are performed using an in-band ATM connection.

### 7.1.3.7 Power block

The power block supplies the appropriate voltage and current to all the electronic circuits of the ONU. As the ONU may be installed in an outdoor facility, the power block may supply power to both cooling fans and to battery backup circuitry. In addition, if in existence, the ONU Power Block may provide power for environmental sensors or external alarm circuits.

Typical ONU powering schemes are composed of local, remote and backup components.

### 7.1.3.8 Subtending

The ONU may include a subtending block connecting additional secondary ONUs.

## 7.2 Core network architecture

In different deployment cases, the AN may be connected to the service nodes using core networks of different topologies and technologies. The core network is used to flexibly interconnect the AN to various Service Nodes. The core network provides the following capabilities:

- Sufficient bandwidth capacity to support the traffic between the AN and the Service Nodes.
- Support for the appropriate QoS for the various services.
- Routing/Switching of traffic between the AN and the service nodes.
- Multicasting of broadcast traffic at the most optimal points within the core network.
- Admission control if concentration of bandwidth occurs within the core network.
- Interworking of hybrid core network technologies (e.g., ATM to IP).
- If interconnection to third party Networks is allowed, then the appropriate peering points must be provided.

The following subclauses describe possible deployment scenarios.

### 7.2.1 ATM core network scenario

In many network deployments the service nodes are located in a centralized location, e.g., a network operation centre, and therefore, a core network is needed to connect the OLT to the service nodes. As the OLT functions as an ATM cross-connect, it can be connected to an ATM network, offering seamless ATM transport of ATM VCs and ATM VPs. With an ATM core network no protocol interworking is required between the V reference point and the core network. This scenario is illustrated in Figure 7.

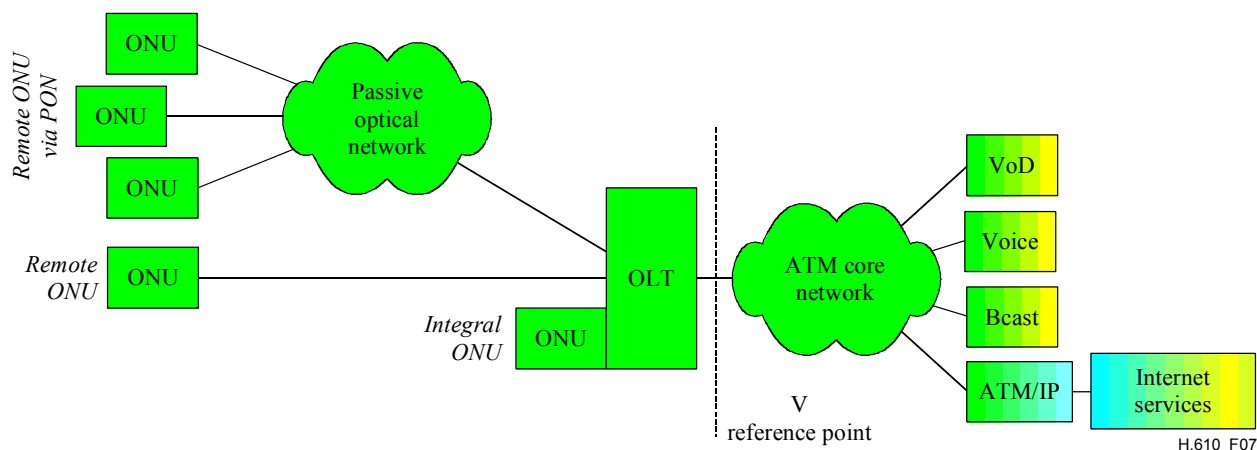
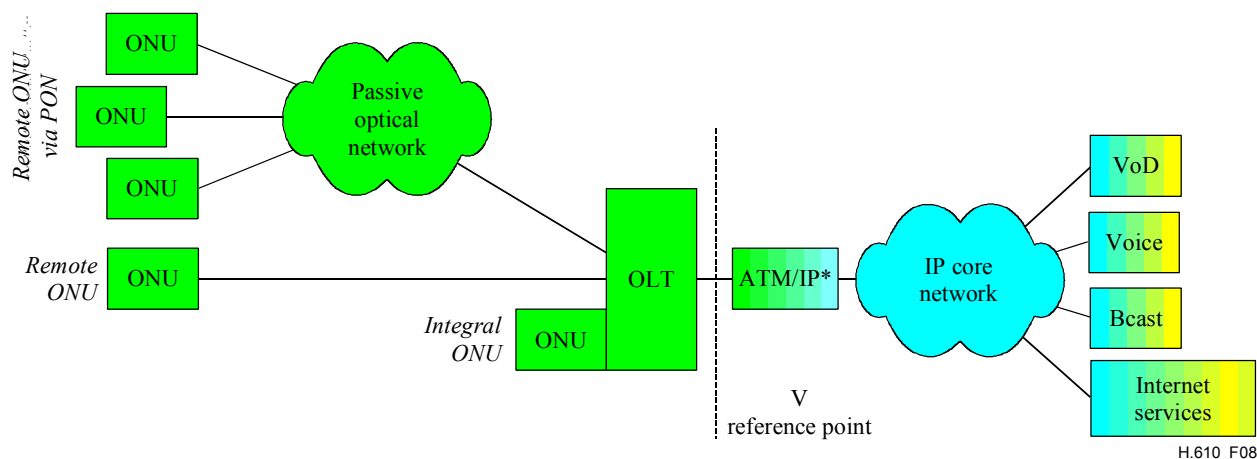


Figure 7/H.610 – ATM core network

### 7.2.2 IP core network scenario

This Recommendation details IP-based architecture for each one of the required FS-VDSL services, for some a native ATM solution is also specified. This means that although the AN is ATM based, the protocols used by the endpoints (i.e., service nodes and residential equipment) for service delivery are from the IP suite. This implies that in many deployment cases the traffic crossing the V reference point is 100% IP PDUs. It is therefore possible to terminate the ATM layer at the V reference point and to connect the OLTs to the service nodes using an IP network. This scenario is illustrated in Figure 8.



\* A local ATM/IP service node may be implemented in the same equipment as the OLT.

Figure 8/H.610 – IP core network

This scenario introduces some technical challenges, mostly concerned with maintaining coherent QoS characteristics within the two networks.

### 7.2.3 Other core network scenario

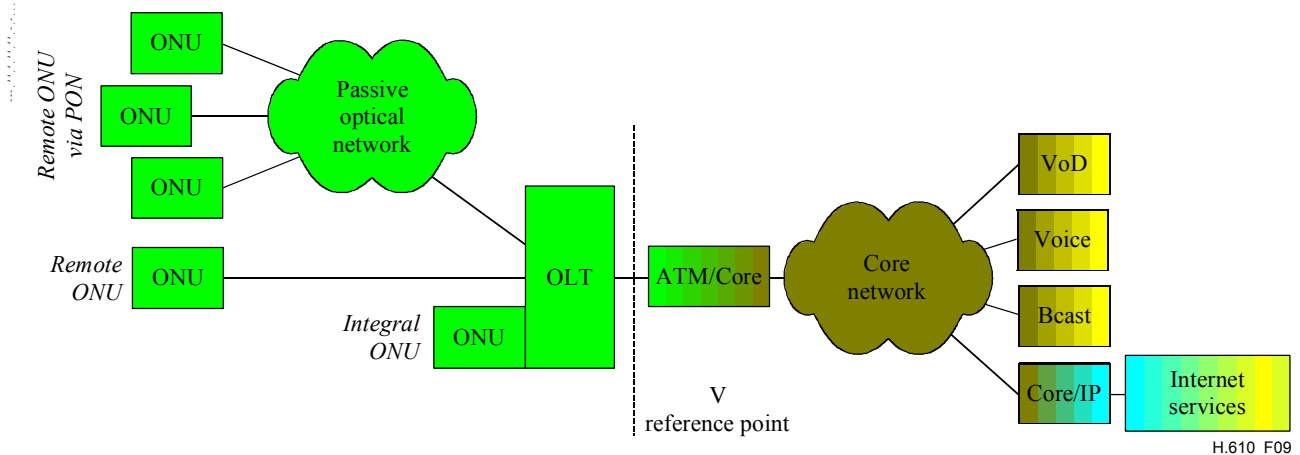
This Recommendation does not limit the core network technology only to ATM or IP. Other network protocols/technologies are possible such as SONET/SDH, Ethernet and MPLS. As the OLT is an ATM device, interworking is required between the OLT and the core network. There are three general ways that the interworking function can work.

Encapsulate and multiplex one or more of the ATM VCs at the V reference point into a conformant transport entity of the core network. In this case, the core network is effectively a layer 1 Network. The core network must transport the bundle of VCs in such a way that, when the encapsulation is removed, the ATM VC can be recreated so that all original VC characteristics are met.

Emulate the ATM VC with the transport entity of the network. In this case, the core network will be a layer-2 network like ATM. This emulation must be done in such a way that all the original VC connection characteristics are met.

Terminate the ATM VCs and transport the higher layers transparently. In this case, the core network is effectively a layer-3 network. This should only be considered when IP is the layer-3 protocol and this case then becomes the IP Core Network scenario above.

This scenario is illustrated in Figure 9. It is assumed that the service node will contain sufficient functionality to terminate the core network protocol as well as the service protocol stack.

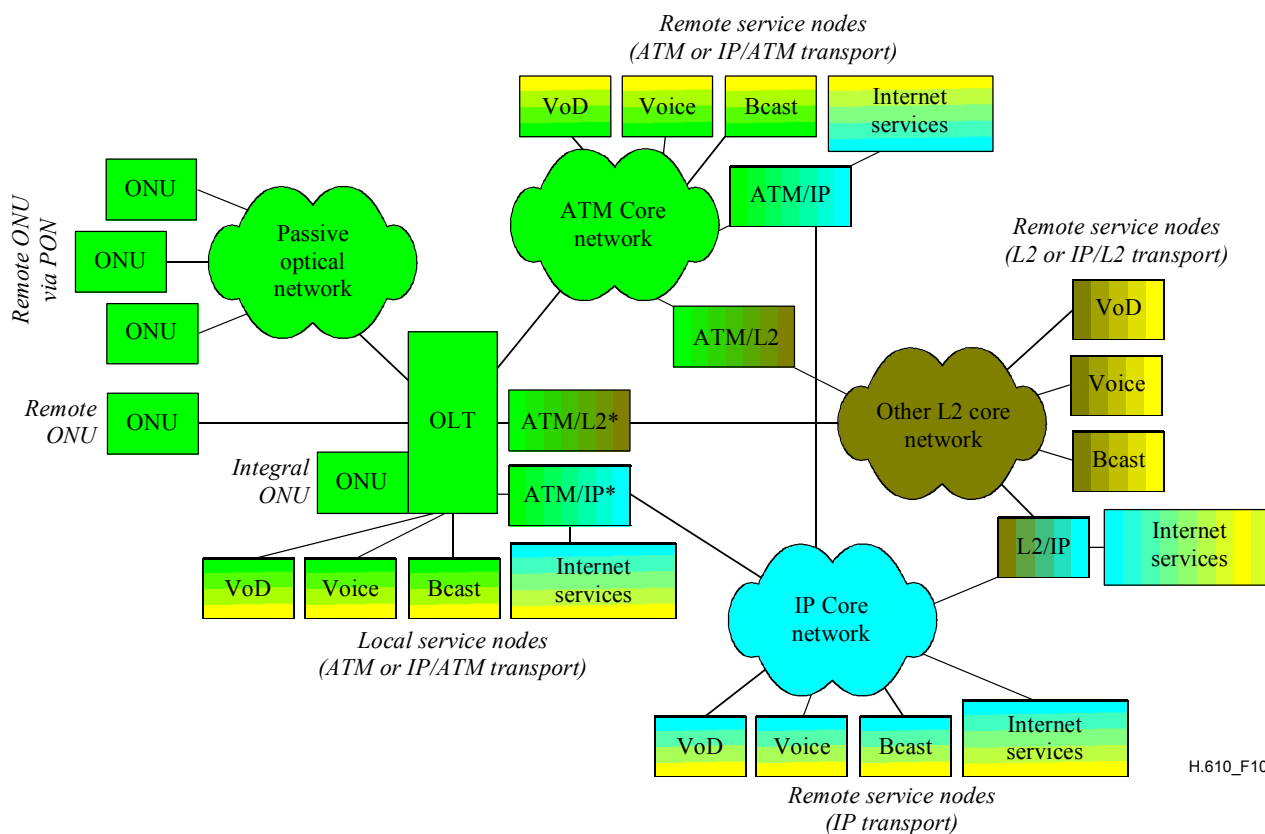


\* A local ATM/Core service node may be implemented in the same equipment as the OLT.

**Figure 9/H.610 – Optional core network**

### 7.2.4 Hybrid core network scenario

Many network operators do not have a single core network scenario. This is highly likely as networks evolve and older generations of equipment remain in use while newer generations are introduced. The scenarios described above are not exclusive and can be combined in a wide variety of ways, many of which are illustrated in Figure 10.



\* A local ATM/IP and/or ATM/L2 service node may be implemented in the same equipment as the OLT (the ATM interface becomes internal to the equipment).

**Figure 10/H.610 – Hybrid core network**

### 7.3 Residential environment

The following types of functionality may be present in an FS-VDSL customer premises environment:

- A service splitter electrically separates the DSL signals from other low frequency services (such as POTS or ISDN). The PS is shown in Figure 1 between the UR and U-R2 interfaces.
- A customer premises VDSL modem, VTU-R (see [1]). The VTU-R function is contained in a VTP or VTPD.
- Protocol processing and in-home distribution interfaces. This is contained by the VTP function.
- MPEG Decoding units for viewing broadcast video and VoD. This is covered by the VTPD and FPD functions.
- PCs and other customer premises IP devices connected to IP data services. These are covered by the FP and FPD functions.
- Analogue or digital voice devices that connect to VoATM or VoIP services. These are also covered by the FPD functions.
- Home appliances, such as TV sets, that are the final destination of the processed and decoded audio/video information. Examples of the interface between the FPD and home appliance are given in Table 2.

**Table 2/H.610 – Example interfaces between  
home appliance and FPD**

|                                                   |
|---------------------------------------------------|
| Coaxial Cable (RF modulated composite video)      |
| S-Video                                           |
| Composite Video                                   |
| Component Video                                   |
| SCART                                             |
| Dolby Digital/AC-3                                |
| L/R Stereo                                        |
| Telephone line                                    |
| Ethernet                                          |
| USB                                               |
| IEEE 1394                                         |
| 5-channel analogue audio                          |
| SCSI                                              |
| LPDT parallel                                     |
| RS-232 serial                                     |
| Bluetooth                                         |
| IR Emitter (for control of IR controlled devices) |
| IEEE 802.11b                                      |
| HomeRF                                            |

As reflected in the above list, the FP category covers very diverse functions. An example of FP and FPD functions is given in Table 3.

**Table 3/H.610 – Example functional processing**

|                                          |
|------------------------------------------|
| MPEG-1 or 2 video decoding               |
| MPEG-4 video decoding                    |
| H.323 Video                              |
| MPEG audio/MP3 decoding                  |
| Dolby Digital (AC-3/AAC)                 |
| Decryption and De-scrambling             |
| Conditional Access processing            |
| Rights Management processing             |
| Application processing                   |
| Middleware                               |
| IP Data processing                       |
| Remote Control and Management            |
| RF                                       |
| IR                                       |
| 64 kbit/s PCM for derived voice services |

## 7.4 Service nodes

Figure 11 proposes schematic description of the Service Nodes in an FS-VDSL system.

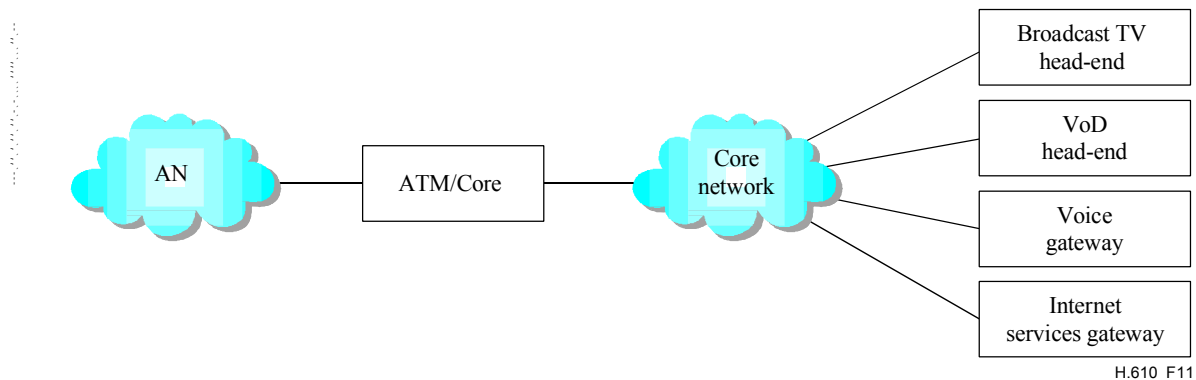


**Figure 11/H.610 – FS-VDSL service nodes**

### 7.4.1 Broadcast TV Head-end

The Head-end system receives video streams in various formats, reformats and encapsulates the video streams, interfaces the core network and transmits the video signal over the core network towards the access network. This Recommendation does not aim to specify any restriction on the video acquisition mechanism applied by the Head-end system.

### 7.4.2 VoD Head-end

The VoD Head-end is comprised of multiple elements, which may include:

- Back office management including asset management, subscriber management, session management and digital rights management (DRM).
- A "server farm" containing the digital content.
- Transport and access network facilities that can insure QoS.
- Compelling server application software in support of the VoD service.

### 7.4.3 Voice gateway

The voice gateway performs the necessary functions to interface the digitally modulated voice traffic from the ATM based AN to the legacy PSTN/ISDN, and vice versa. The voice gateway function may be performed by a single device or by multiple devices (such as media gateways, signalling gateways and media gateway controllers).

The main functions of the gateway include:

- Termination of the TDM voice circuits to interface the PSTN/ISDN.
- Termination of the PSTN/ISDN signalling.
- Call and bearer control.
- AAL 2 termination and (de)multiplexing (a single ATM VC carries all voice connections of one VTP/D) in case of BLES.
- VoIP (de)multiplexing (multiple voice connections may be concentrated on a single IP address) in case of VoIP.
- Voice handling functions (e.g., packetization, compression, echo cancellation, echo suppression, silence suppression, comfort noise generation, tones and announcements).
- FPD to Gateway signalling termination.
- Connectivity to the PSTN/ISDN via an open interface.

- V5.2 support for ETSI and GR-303 support for ANSI.

## 7.5 IP engineering

In order to facilitate multiple services through multiple service operators to specific subscribers, several IP addressing schemes may need to coexist simultaneously at the subscriber residential Network. Network Operators and/or Service Operators must provide guidelines to ensure consistency of all IP addressing schemes. This includes ensuring that all subnetworks that could be simultaneously accessed by a specific VTP/D do not have conflicting IP address ranges.

The following constraints dictate the IP engineering scheme, which could be applied in an FS-VDSL system:

- Limited IPv4 public address spaces, and the "always on" nature of the service, imply a clear preference toward minimum usage of public addresses.
- In the case of applications sensitive to NAT, such as point-to-point gaming and voice over IP, either public address space or private address space may be used.
- The customer is likely to make multiple logical connections to multiple networks within the residential network environment.
- A service or network provider supplying residential equipment, such as STB and Internet appliances, will need to be able to communicate with those devices. This may be for upgrade purposes, reconfiguration or initialization.

Figure 12 illustrates the addressing schemes considered:

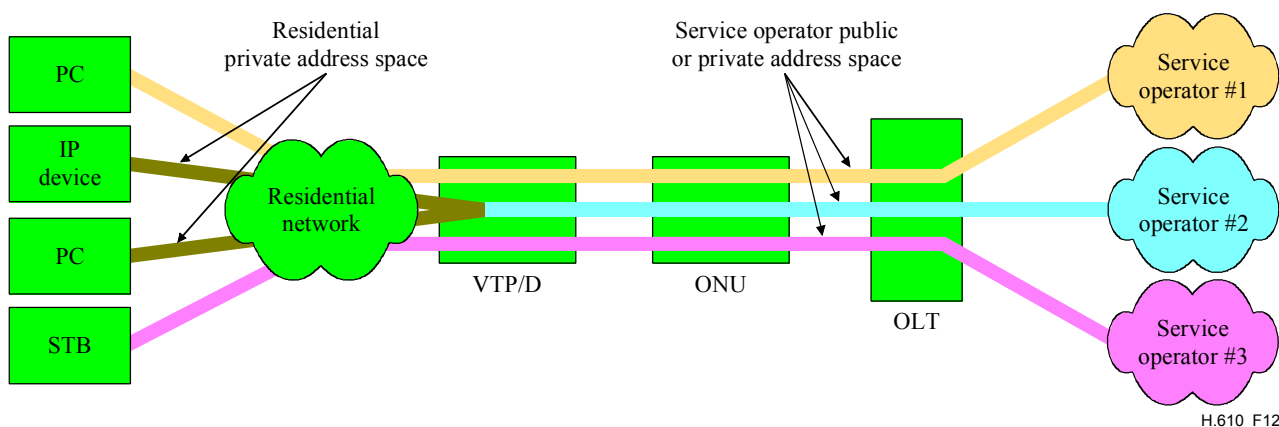


**Figure 12/H.610 – Network addressing schemes**

There may be up to four simultaneous distinct IP addressing schemes:

- VTP/D  $T_{CN}$  addressing scheme.
- VTP/D U-R2 addressing scheme.
- Terminal session based service operator addressing scheme.
- Terminal non-session based service operator addressing scheme.

### 7.5.1 VTP/D $T_{CN}$ addressing scheme

In this scheme the VTP/D allocates designated terminals a private IP address through its DHCP IETF RFC 2131 server. Optionally, this scheme can be implemented by static IP configuration. However, the use of static IP configuration in this scheme is not recommended.

### 7.5.2 VTP/D U-R2 addressing scheme

In this scheme, the service operator implements the below methods to assign the VTP/D with an IP address. Multiple IP addresses may be simultaneously assigned to a single VTP/D by different Service Operators for distinct IP interfaces. In such case, the routing function of the VTP/D must manage the correct forwarding of IP packets to the appropriate IP interface:

- Session based – The VTP/D initiates a PPP session with the service operator edge router.
- Non-session based – The VTP/D obtains an IP address from the Service Operator's DHCP/BOOTP server.
- Static configuration – Static configuration is possible but is not recommended.

### 7.5.3 Terminal session based service operator addressing scheme

In this scheme, the terminal initiates a PPPoE session with the service operator data service node. Multiple residential terminals can use this scheme simultaneously to connect to the same or to different service operator(s).

### 7.5.4 Terminal non-session based service operator addressing scheme

In this scheme, the service operator assigns IP addresses to the residential terminals using one of the following methods.

- Dynamic configuration – The terminal IP addresses are assigned by the Service Operator's DHCP server.
- Static configuration – Static configuration is possible but is not recommended.

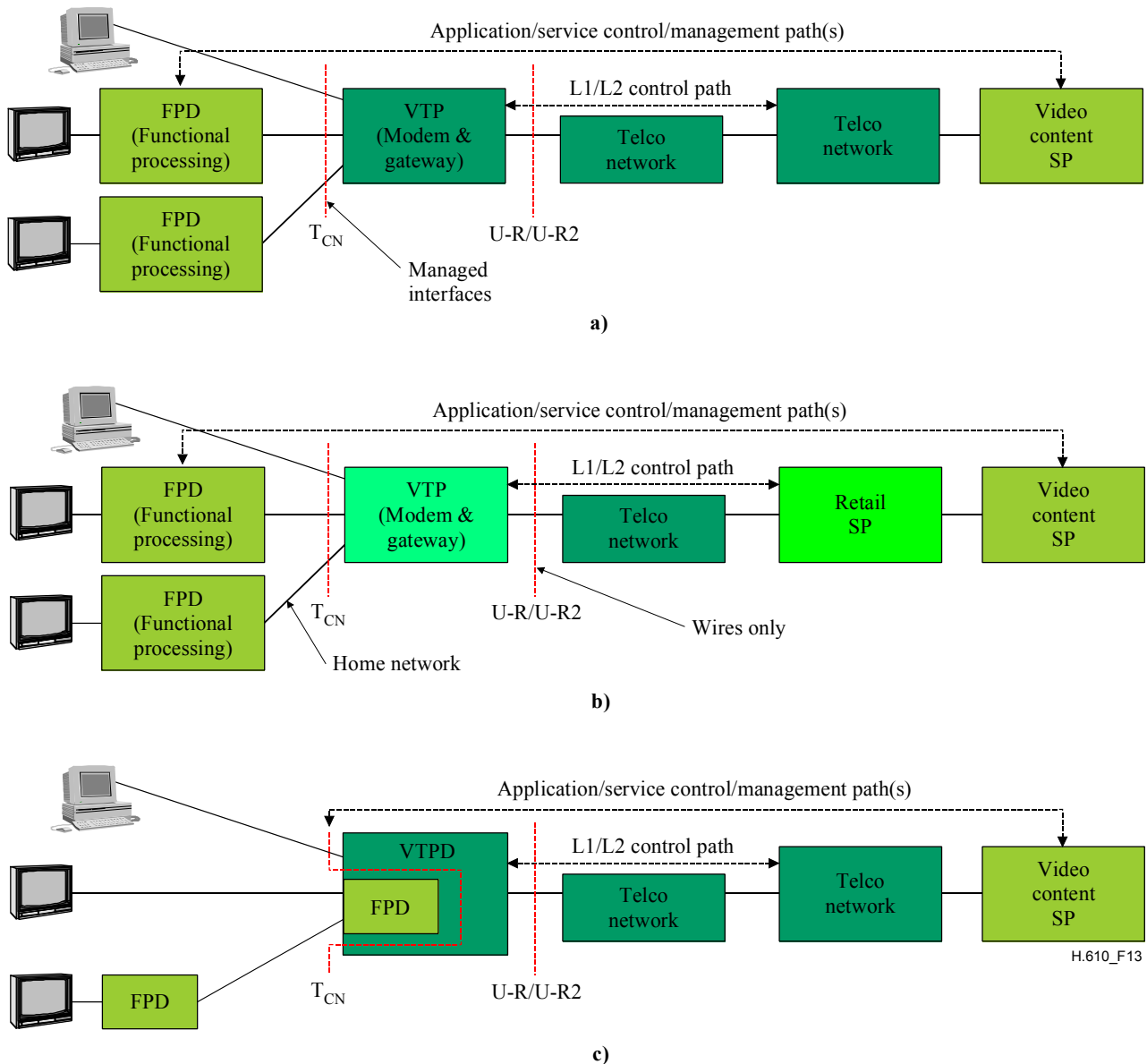
Multiple residential terminals can use this scheme simultaneously to connect to the same or to different service operator(s).

### 7.5.5 IP addressing policy using DHCP

Multiple DHCP servers may operate simultaneously in an FS-VDSL system. In order to ensure that the correct DHCP server responds to DHCP messages, an FS-VDSL compliant system must conform to some constraints on the residential network side and on the Service Operator side to guarantee the addressing scheme integrity. This issue is further detailed in 10.3.4.

## 7.6 Demarcation points

Some providers may include the equipment providing the residential CPE as part of their service offering. This is illustrated in parts a) and c) in Figure 13. Alternatively, network providers may provide a service at the U-R or U-R2 differentiation point and, therefore, the VTP or VTPD functions are provided by the service providers. The VTP case is shown in part b) in Figure 13. Interface U-R2 includes the cabling from the splitter U-R interface up to the VTP connector. Control by the provider for QoS and Management may extend to the T<sub>CN</sub> interface or even to the R interface, depending on the implementation. The residential service delivery control extends through the FPD. The demarcation points may vary based on network operator and regulatory requirements.



- a) The VTP is controlled from the network domain and the service offerings are managed interfaces.  
b) The VTP is controlled by the service provider.  
c) Instead of the VTP in a) a VTPD is shown.

**Figure 13/H.610 – Reference model showing business solutions**

## 8 ATM requirements

The following subclause describes the OLT, ONU and VTP/D ATM functional requirements.

The DSL physical layer shall support ATM transport.

### 8.1 Access network

- The AN shall support cross-connection of ATM Virtual Path (VP) connections.
- The AN shall support cross-connection of ATM Virtual Channel (VC) connections.
- The AN shall support the termination of VC connections for specific functions like TV channel change, management etc.
- The AN shall be able to act as an ATM OAM endpoint, as described in ITU-T Rec. I.610 [1], for VC and VP connections (i.e., F5 and F4, respectively) that terminate on it.

- The AN shall be able to act as an OAM segment point for the VC or VP connections that are cross-connected through it.
- The AN shall support ATM point-to-multipoint connections by which the broadcast TV streams are replicated according to the channel change function.
- The AN shall support traffic policing (i.e., UPC) of user connections as described in the ATM Forum Traffic Management Specification Version 4.0 [2].
- The AN shall support the following ATM Service Categories: CBR, VBR-RT, VBR-nRT, UBR as defined in ATM Forum Specification af-tm-0056.000 [2].
- The AN shall support frame based discard (i.e., EPD, PPD) on a per connection basis designated for AAL 5 traffic.
- The AN may support Switched Virtual Connections (SVCs).
- If the AN supports SVCs, it shall support ATM User Network Interface (UNI) signalling ATM Forum Specification af-sig-0061.002 [I-5].

### 8.1.1 OAM F4 and F5 support

The following requirements apply to the OAM implementation as specified in ITU-T Rec. I.610 [1]. Note that the access network's behaviour on a specific connection should be according to its configured function on the specific connection (e.g., endpoint, segment point etc.).

- The AN shall respond to OAM loop-backs.
- The AN shall generate defect indication messages (i.e., AIS, RDI).
- The AN should report detected defect indication messages to the OAM blocks.
- The AN should be function as a continuity check (CC) sink point.

## 8.2 OLT

The OLT should support shaping of VP connections towards the Network (i.e., at the V reference point).

### 8.2.1 F4 and F5 support

The following requirements apply to the OAM implementation as specified in ITU-T Rec. I.610 [1]:

- The OLT should be able to function as a continuity check (CC) source point towards the Access Network.
- The OLT should be able to generate loop-back cells (LB) towards the Access Network.

## 8.3 VTP/D

The following requirements are mandatory for the U-R2 Reference point:

- The VTP/D shall support ATM adaptation layer 5 (as per ITU-T Rec. I.363.5 [8]) and ATM segmentation and reassembly (SAR) function.
- A VTP/D that supports voice over ATM (VoATM) service shall support ATM adaptation layer 2 (as per ITU-T Rec. I.363.2 [I-6]) for that purpose.
- A VTP/D shall support the termination of permanent virtual path connections (PVPs).
- A VTP/D shall support the termination of permanent virtual circuit connections (PVCs).
- A VTP/D may support switched virtual circuit connections (SVCs).
- A VTP/D supporting SVCs shall comply with ATM Forum Specification af-sig-0061.002 [I-5].

- A VTP/D shall support at least the CBR, VBR-nRT and UBR traffic types as defined in [2]. The VTP/D shall be able to shape these traffic types in the upstream (i.e., network) direction. The VTP/D shall support a UBR service with a specified PCR.
- A VTP/D shall support priority based queuing and scheduling of ATM cells in the upstream direction.
- A VTP/D shall support packet-based discard of AAL 5 PDUs, namely it shall not transmit to the network incomplete AAL 5 frames.

### 8.3.1 OAM F4 and F5 support

The following requirements apply to the OAM implementation as specified in ITU-T Rec. I.610 [1]:

- A VTP/D shall support ATM OAM flows of the F4 and F5 levels.
- A VTP/D shall support end-to-end ATM OAM.
- A VTP/D shall support ATM OAM loop-back function.
- A VTP/D shall support ATM OAM defect indications, AIS and RDI.
- A VTP/D should support ATM OAM continuity check (CC) sink function. Activation and deactivation may be performed by sending an activation/deactivation cell or by remote management (i.e., TMN).
- A VTP/D may support ATM OAM performance monitoring (PM) backward reporting (BR) function.
- A VTP/D should be able to receive AIS cells over point-to-multipoint connections. In such a case, the VTP/D will enter a defect state as specified for a point-to-point connection (except for the transmission of cells).

## 9 Connections and service flows

Different services may require different connection characteristics. In the following, an ATM connection type is determined by the higher layer protocol processing that is associated with it at the endpoints. A full service network shall simultaneously support the following connection types, as defined in the subclauses below:

- Bridge connection (subclause 9.1).
- PPPoE connection (subclause 9.2).
- Translated routed connection (subclause 9.3).
- Non-translated routed connection (subclause 9.4).
- Channel change connection (subclause 9.5).
- Digital broadcast connection (subclause 9.6).
- VTP/D remote management connection (subclause 9.7).
- BLES connection (subclause 9.8).

These connections are initiated at the VTP/D and may extend to the V reference point. The traffic that is transmitted and received by the endpoints on a specific connection type is named respectively a *flow*, for example the Bridge flow, the PPPoE flow and so on. While the first 4 connection types in the above list are generic in the sense that they can be used to transport a wide range of services, the last 3 connection types are dedicated for a specific function or service.

### 9.1 Bridge connection

This connection type supports the bridging of Ethernet frames between the residential network and a service node. Multiple bridge connections may be initiated on a single VTP/D, so that different services may simultaneously use different connections. Every instantiation is identified as a **Bridge**

**Connection.** The Network shall have the capability to support multiple bridge connections per DSL line. The bidirectional flow of PDUs received and transmitted on the Bridge connection is identified as the **bridging flow**.

The two bridge points shall ensure security by explicitly preventing VC-to-VC forwarding. The Ethernet encapsulation at the V reference point and U-R2 interface shall be in accordance with RFC 2684 bridge mode using LLC/SNAP without FCS as described in IETF RFC 2684.

| Terminal | Residential network | VTP/D    |                            | AN  | V reference point          |
|----------|---------------------|----------|----------------------------|-----|----------------------------|
| Ethernet | Ethernet            | Physical | Ethernet                   | DSL | Ethernet                   |
|          |                     |          | RFC 2684 bridge (LLC/SNAP) |     | RFC 2684 bridge (LLC/SNAP) |
|          |                     |          | AAL 5                      |     | AAL 5                      |
|          |                     |          | ATM                        | ATM | ATM                        |
| Physical | Physical            | Physical | DSL                        | DSL |                            |

**Figure 14/H.610 – Bridge connection protocol stack**

## 9.2 PPPoE connection

This connection type supports the transport PPPoE traffic between designated residential terminals and a service node. Multiple PPPoE sessions may be established onto the same ATM VC. The bidirectional flow of PDUs received and transmitted on the PPPoE connection is identified as the **PPPoE flow**.

PPPoE implementation in the terminal and the service node shall be in accordance with IETF RFC 2516 [7]. The Network shall have the capability to support one PPPoE connection per DSL line.

The encapsulation at the U-R2 and V reference point of the PPPoE connection shall be in accordance with RFC 2684 bridge mode using LLC/SNAP without FCS. Figure 15 depicts the end-to-end protocol processing associated with a PPPoE connection.

| Terminal | Residential network | VTP/D    |                            | AN  |  | V reference point          |
|----------|---------------------|----------|----------------------------|-----|--|----------------------------|
| IP       |                     |          | Filter function            |     |  | IP                         |
| PPP      |                     |          |                            |     |  | PPP                        |
| PPPoE    |                     |          |                            |     |  | PPPoE                      |
| Ethernet |                     | Ethernet | Ethernet                   |     |  | Ethernet                   |
|          |                     |          | RFC 2684 bridge (LLC/SNAP) |     |  | RFC 2684 bridge (LLC/SNAP) |
|          |                     |          | AAL 5                      |     |  | AAL 5                      |
|          |                     |          | ATM                        | ATM |  |                            |
| Physical | Physical            | Physical | DSL                        | DSL |  |                            |

**Figure 15/H.610 – PPPoE connection protocol stack**

## 9.3 Translated routed connection

This connection type allows sharing of a single IP address for accessing the public Network by multiple end devices. It supports a routed connection between the VTP/D and a service node. The IP addresses of the residential terminals are mapped using a NAT (network address translation IETF RFC 3022 [16]) function to the VTP IP address assigned by the service operator. The associated

Port Address Translation (PAT) allows mapping of a single IP address on one interface of a router to multiple (private) IP addresses on the other interfaces. The network shall have the capability to support one translated routed connection per DSL line.

Both the VTP/D and the service node terminating the ATM VC shall support PPP as defined in RFC 1661. PPP transport can be done using PPPoA in accordance with RFC 2364 [17] using the VC-multiplexing encapsulation option or PPPoE in accordance with RFC 2516 using RFC 2684 bridge mode using LLC/SNAP without FCS.

The bidirectional flow of PDUs received and transmitted on the translated routed connection is identified as the translated routed flow. Figures 16 and 17 depict the end-to-end protocol processing associated with a translated routed connection.

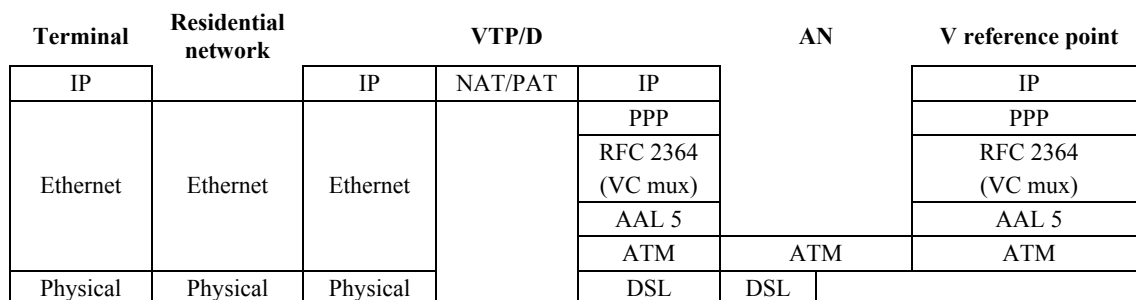


**Figure 16/H.610 – Translated routed connection protocol stack with PPPoA**

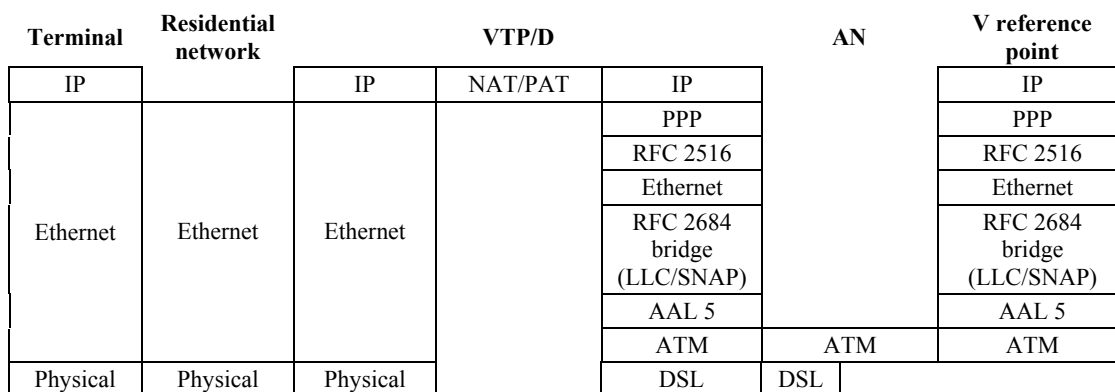


**Figure 17/H.610 – Translated routed connection protocol stack with PPPoE**

## 9.4 Non-translated routed connection

This connection type supports a routed connection between the VTP/D and a service node. Every connection is identified as a **Non-translated Routed Connection**. The Network shall support multiple such connections per DSL line. The bidirectional flow of PDUs received and transmitted on this connection is identified as the **non-translated routed flow**.

Several types of non-translated routed connections are possible. These are identified according to their IP encapsulation: IP over ATM, PPPoA or PPPoE.

### 9.4.1 IP over ATM

IP over ATM is performed through RFC 2684 routed mode connections. Both the VTP/D and the service node terminating the ATM layer shall support RFC 2684 routed mode using LLC/SNAP. Unlike all other types of non-translated routed connection, this encapsulation method does not

support inherent user authentication. Figure 18 depicts the end-to-end protocol processing associated with an IP over ATM route connection.

| Terminal | Residential network | VTP/D    |                           | AN  | V reference point         |
|----------|---------------------|----------|---------------------------|-----|---------------------------|
| IP       |                     | IP       |                           |     | IP                        |
| Ethernet | Ethernet            | Ethernet | RFC 2684 route (LLC/SNAP) | ATM | RFC 2684 route (LLC/SNAP) |
|          |                     |          | AAL 5                     |     | AAL 5                     |
|          |                     |          | ATM                       |     | ATM                       |
| Physical | Physical            | Physical | DSL                       | DSL |                           |

**Figure 18/H.610 – IP over ATM connection**

#### 9.4.2 Non-translated routed PPPoA

This connection type supports the routing of data traffic to and from residential terminals into a PPP connection established between the VTP/D and the service node.

In order to support this type of connection, both the VTP/D and the service node terminating the ATM VC shall support PPPoA, in accordance with RFC 2364 using VC-multiplexing encapsulation option. Figure 19 depicts the end-to-end protocol processing associated with a non-translated routed PPPoA connection.

| Terminal | Residential network | VTP/D    |                   | AN  | V reference point |
|----------|---------------------|----------|-------------------|-----|-------------------|
| IP       |                     | IP       |                   |     | IP                |
| Ethernet | Ethernet            | Ethernet | PPP               | ATM | PPP               |
|          |                     |          | RFC 2364 (VC mux) |     | RFC 2364 (VC mux) |
|          |                     |          | AAL 5             |     | AAL 5             |
|          |                     |          | ATM               |     | ATM               |
| Physical | Physical            | Physical | DSL               | DSL |                   |

**Figure 19/H.610 – Non-translated routed PPPoA connection protocol stack**

#### 9.4.3 Non-translated routed PPPoE

This connection type supports the routing of data traffic to and from residential terminals into a PPPoE connection established between the VTP/D and the service node.

In order to support this type of connection, both the VTP/D and the service node terminating the ATM VC shall support PPPoE, in accordance with RFC 2516 using LLC/SNAP encapsulation option without FCS. Figure 20 depicts the end-to-end protocol processing associated with a non-translated routed PPPoE connection.

| Terminal | Residential network | VTP/D    |                            | AN  | V reference point          |
|----------|---------------------|----------|----------------------------|-----|----------------------------|
| IP       |                     | IP       | IP                         |     | IP                         |
| Ethernet | Ethernet            | Ethernet | PPP                        | ATM | PPP                        |
|          |                     |          | RFC 2516                   |     | RFC 2516                   |
|          |                     |          | Ethernet                   |     | Ethernet                   |
|          |                     |          | RFC 2684 bridge (LLC/SNAP) |     | RFC 2684 bridge (LLC/SNAP) |
|          |                     |          | AAL 5                      |     | AAL 5                      |
|          |                     |          | ATM                        |     | ATM                        |
| Physical | Physical            | Physical | DSL                        | DSL |                            |

**Figure 20/H.610 – Non-translated routed PPPoE connection protocol stack**

## 9.5 Channel change connection

This connection type supports channel change messaging between the VTP/D and the access network. On this connection, channel change messages shall be IGMPv2 RFC 2236 [18] or DSM-CC ISO/IEC 13818-6 [10].

A channel change connection shall use a dedicated ATM VC between the VTP/D and the access Network. The bidirectional flow of PDUs received and transmitted on this connection is identified as the **channel change flow**.

The Network shall support one channel change connection per DSL line.

### 9.5.1 Use of IGMPv2

In the case that IGMPv2 is used, the encapsulation of the channel change Connection shall be in accordance with RFC 2684 routed mode using LLC/SNAP. Figure 21 describes the end-to-end protocol processing associated with an IGMP based channel change connection.

| Terminal | Residential network | VTP        |                                 | AN                              |
|----------|---------------------|------------|---------------------------------|---------------------------------|
| IGMPv2   |                     | IGMP proxy |                                 | IGMPv2                          |
| IP       |                     | IP         |                                 | IP                              |
| Ethernet |                     | Ethernet   | RFC 2684<br>route<br>(LLC/SNAP) | RFC 2684<br>route<br>(LLC/SNAP) |
|          |                     |            | AAL 5                           | AAL 5                           |
|          |                     |            | ATM                             | ATM                             |
| Physical | Physical            | Physical   | DSL                             | DSL                             |

**Figure 21/H.610 – IGMP end-to-end protocol stack**

### 9.5.2 Use of DSM-CC

Figure 22 depicts end-to-end protocol processing associated with a DSM-CC based channel change connection. Note that the figure describes an IGMP to DSM-CC translation performed at the VTP. DSM-CC is encapsulated directly over AAL 5 (i.e., VC multiplexing).

| Terminal | Residential network | VTP           |       | AN     |
|----------|---------------------|---------------|-------|--------|
| IGMPv2   | Ethernet            | IGMPv2/DSM-CC |       | DSM-CC |
| IP       |                     | IP            | AAL 5 | AAL 5  |
| Ethernet |                     | Ethernet      |       |        |
| Physical |                     | Physical      | ATM   | ATM    |
|          | Physical            | Physical      | DSL   | DSL    |

**Figure 22/H.610 – IGMP to DSM-CC protocol stack**

## 9.6 Digital broadcast connection

This connection type supports unidirectional distribution of digital broadcast information. It is implemented as a point-to-multipoint leaf VC link, which can be dynamically connected to a point-to-multipoint root in the access network. The Network shall have the capability to support multiple such connections per DSL line. The unidirectional flow of PDUs received on this connection is identified as the **digital broadcast flow**. Two methods of digital broadcast delivery are possible, MPEG-2 over AAL 5 and MPEG-2 over UDP/IP/Ethernet over AAL 5. In both cases, the network maps a single MPEG-2 SPTS to a single point-to-multipoint ATM connection.

### 9.6.1 MPEG over UDP/IP/Ethernet over AAL 5

In this method, MPEG-2 TS shall be encapsulated in UDP, IP and Ethernet and carried over AAL 5 using LLC/SNAP header without FCS, as per RFC 2684. Figure 23 depicts the associated end-to-end protocol processing. Note that in case of a VTPD only the three rightmost columns described in Figure 23 are applicable (the IP and upper layers shown in the Terminal column are processed in the VTPD).

| Terminal       | Residential network | VTP                      |                         | AN  |  | V reference point        |
|----------------|---------------------|--------------------------|-------------------------|-----|--|--------------------------|
| Single program |                     |                          |                         |     |  | Single program           |
| MPEG-2 TS      |                     |                          |                         |     |  | MPEG-2 TS                |
| UDP            |                     |                          |                         |     |  | UDP                      |
| IP             |                     |                          |                         |     |  | IP                       |
| Ethernet       | Ethernet            | Ethernet                 |                         |     |  | Ethernet                 |
|                |                     | RFC 2684 bridge LLC/SNAP |                         |     |  | RFC 2684 bridge LLC/SNAP |
|                |                     | AAL 5                    |                         |     |  | AAL 5                    |
|                |                     | ATM                      | ATM point-to-multipoint |     |  | ATM                      |
| Physical       | Physical            | Physical                 | DSL                     | DSL |  |                          |

**Figure 23/H.610 – MPEG-2 over UDP/IP/Ethernet over AAL 5**

### 9.6.2 MPEG-2 over AAL 5

In this method, MPEG-2 TS shall be carried directly over AAL5 conforming to clause 8/J.82 [13]. Figure 24 depicts the associated end-to-end protocol processing. Note that in case of a VTPD only the three rightmost columns described in Figure 24 are applicable (the MPEG-2 TS and upper layers shown in the Terminal column are processed in the VTPD).

| Terminal       | Residential network | VTP      |       | AN                      | V reference point |
|----------------|---------------------|----------|-------|-------------------------|-------------------|
| Single program |                     |          |       |                         | Single program    |
| MPEG-2 TS      |                     |          |       |                         | MPEG-2 TS         |
| UDP            |                     | UDP      | AAL 5 |                         | AAL 5             |
| IP             |                     | IP       |       |                         |                   |
| Ethernet       | Ethernet            | Ethernet | ATM   | ATM point-to-multipoint | ATM               |
| Physical       | Physical            | Physical | DSL   | DSL                     |                   |

**Figure 24/H.610 – MPEG-2 over AAL 5**

### 9.6.3 Future IP-based delivery methods

The AN and VTP shall be transparent to the payload of the IP PDUs received over the digital broadcast connection. This enables future use of other IP-based delivery methods, like RTP IETF RFC 3350 [I-7] and MPEG-4, by upgrading only the endpoints (i.e., the encoder and decoder).

### 9.7 VTP/D remote management connection

This connection type supports bidirectional traffic flow between the VTP/D and management agents in the network. It is used for the remote management and configuration of the VTP/D. The Network shall have the capability to support one remote VTP/D management connection per DSL line.

The bidirectional flow of PDUs received and transmitted on this connection is identified as the **VTP/D remote management flow**. Figure 25 depicts the end-to-end protocol processing associated with the VTP/D remote management connection.

The VTP/D shall use DHCP IETF RFC 2131 [3] to dynamically retrieve IP configuration for this connection.

| VTP/D                             | AN  | V reference point                 |
|-----------------------------------|-----|-----------------------------------|
| IP                                |     | IP                                |
| Ethernet                          |     | Ethernet                          |
| RFC 2684 bridged LLC/SNAP w/o FCS |     | RFC 2684 bridged LLC/SNAP w/o FCS |
| AAL 5                             |     | AAL 5                             |
| ATM                               | ATM | ATM                               |
| DSL                               | DSL |                                   |

**Figure 25/H.610 – VTP/D remote management connection**

### 9.8 BLES connection

This connection type supports voice over ATM traffic between the VTP/D and a designated voice gateway. The bidirectional flow of PDUs received and transmitted on this connection is identified as the **BLES flow**. The VTP/D's and Voice gateway's implementation should be in accordance to af-vmoa-0145.000 [I-8]. Figure 26 depicts the protocol processing associated with this flow.

| VTP/D | AN  | V reference point |
|-------|-----|-------------------|
| AAL 2 |     | AAL 2             |
| ATM   | ATM | ATM               |
| DSL   | DSL |                   |

**Figure 26/H.610 – BLES connection**

## 10 VTP/D functional model

This clause specifies the functional blocks encompassing the capabilities of the VTP/D. An actual VTP/D is an implementation of a number of these functional blocks. The selection of the functional blocks for a particular implementation is determined by the flows that the VTP/D is required to support. Clause 11 specifies the functional blocks required for a baseline VTP/D. Other implementations of VTP/D are possible through alternative selections of functional blocks. In all cases, the chosen functional blocks shall comply with the specification given in this clause.

The following terms will be used throughout this clause:

- Upstream – refers to the data flowing from the  $T_{CN}$  to U-R2 interface.
- Downstream – refers to the data flowing from the U-R2 to  $T_{CN}$  interface.
- Routed flow – includes the translated and non-translated routed flows.
- Bridged flow – includes the 'Bridging' and 'PPPoE' flows.
- Routed VCs – ATM VCs carrying routed flows.
- Bridged VCs – ATM VCs carrying bridged flows.
- Routed frames – Ethernet frames arriving at the  $T_{CN}$  interface which are carrying a routed flow in the residential network and therefore, in the upstream, these are PDUs with Ethernet MAC header containing the VTP/D  $T_{CN}$  MAC address as the destination address and a unicast IP destination address.
- Bridged frames – Ethernet frames arriving at the  $T_{CN}$  interface, which are carrying a bridged flow in the residential network.

### 10.1 The ATM block

The *ATM* block performs the ATM and AAL layers as described in 8.3.

### 10.2 The DSL block

The *DSL* block implements the physical layer at the UR-2 interface.

### 10.3 The router block

The router block handles two packet flows, the translated routed flow and the non-translated routed flow. At the UR-2 interface, the translated flow uses the translated routed connection and the non-translated flow uses the non-translated routed connections. A router block shall support at least a single translated routed connection and at least 4 non-translated routed connections.

#### 10.3.1 Translated routed flow

This type of packet flow carries packets that require network address translation (NAT) and port address translation (PAT) within the VTP/D. The translation is performed from IP address domains on the  $T_{CN}$  interface to one IP address on the U-R2 interface. Note that video services should not use this flow because of jitter and implementation implications. Table 4 describes how this flow is processed at the VTP/D.