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Full-Service VDSL

Focus Group
White Paper

FS-VDSL Service Scenarios

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FS-VDSL SERVICE SCENARIOS

Summary

This White Paper describes end-to-end network scenarios for offering high speed Internet, digital television and video on demand services.

Source

This White Paper was produced by the CPE-SA Working Group of the ITU-T FS-VDSL Focus Group. Please refer to the FS-VDSL web site at http://www.fs-vdsl.net for more information.

This document contains general overview information and should not be construed as a technical specification.

As the FS-VDSL Specifications are revisited, a revised version of this White Paper may be issued.

This White Paper is part of a set of White Papers, published by the ITU-T FS-VDSL Focus Group; for a complete and updated list of published White Papers please refer to the FS-VDSL Focus Group web pages at www.fs-vdsl.net/whitepapers and at http://www.itu.int/ITU-T/studygroups/com16/fs-vdsl/wps.html

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1. INTRODUCTION

This white paper describes a simplified full-service xDSL network that can be used to deliver the triple-play IP based services of high speed internet (HSI), digital television (DTV) and video on demand (VoD). This document first describes the key elements of the network. Then a description of each of the above services is given. This includes a description of the requirements the service has on the network elements and the information flows that would exist to deliver the service.

The aim of this paper is to give an introduction to the FS-VDSL System Architecture and CPE Specification [1]. The core components, features and possible service scenarios are defined herein. However [1] goes into much more detail and also covers the following aspects.

- The use of a residential gateway where the FPD and VTP are consolidated into a single device.
- The use of DSM-CC as the channel change protocol between the VTP and the DSLAM.
- The use of AAL5/ATM encapsulation of MPEG-2 SPTS.
- The impact of multiple service providers offering the triple-play services.
- The management framework for each of the triple-play services.

The reader is therefore urged to read the actual specifications for more details on the above areas.

1.1. THE FULL SERVICE XDSL NETWORK

Figure 1 shows the end-to-end network used to deliver the triple-play services. The scope of [1] extends to the V-interface. It therefore does not define the core network, service nodes and connections beyond the V-interface. Furthermore, it is specified that the layer 2 technology between the VTP and the V-interface must be ATM.

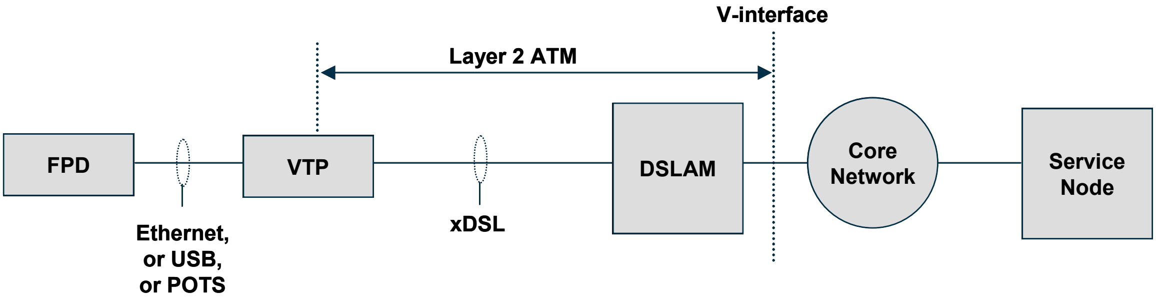

Figure 1. Simplified full-service xDSL network

The end-to-end network comprises of the following key components:

- **FPD** – This is the functional processing unit that resides in the customer premises and terminates the service. The FPD will either be a Set-top-box (STB), personal computer (PC) or Telephone depending on the type of service being received. It is attached to the VTP via an Ethernet, USB or a POTS interface depending on the type of FPD.

- **VTP** – This is the broadband network termination device which resides in the customer premises and terminates the xDSL layer and in certain cases also the ATM layer. Depending on the service being delivered the VTP provides ATM, Ethernet and IP processing functions. The VTP provides Ethernet and/or USB interfaces depending on the type of VTP. The required functions of the VTP are described in more detail later under the various service descriptions.
- **DSLAM** – A DSL access multiplexer that is used to deliver DSL services to customers over a copper local loop. The DSLAM may be distributed in several different configurations depending on the deployment scenario. Here it is shown as a single physical unit providing the functions of DSL access line termination, splitting of the baseband telephony signal for backhaul across the PSTN, QoS and traffic management functions, and aggregation of the broadband traffic towards the core network. The V-interface on the DSLAM is layer 2 ATM. The DSLAM needs to implement additional functions depending on the service delivered across it. These are described later under the various service descriptions.
- **Core Network** – The core network provides a high throughput with quality of service transport for the IP based services. The core network can utilise any layer 1 and layer 2 technologies that are capable of transporting layer 3 IP. However, where the core network does not utilise an ATM layer 2, it has to implement an inter-working function at the edge in order to adapt the ATM layer 2 traffic at the DSLAM to the appropriate layer 2 used within the core network. Note also that in certain instances the core network will be a null function, such that the service node is directly connected to the DSLAM.
- **Service node** – This implements the server side functionality for delivering an IP based service. The various types of service nodes for each service are described under the various service descriptions.

2. SERVICES

2.1. HIGH SPEED INTERNET

The basic broadband service deployment on xDSL networks today is high speed Internet. The service may be deployed in several configurations depending on the type of end-to-end network that exists. This paper only defines two such scenarios. For other possible scenarios please refer to [1]. These would Section 2.1.1 describes how the HSI service is typically deployed in a pure ATM network. Section 2.1.2 describes how the HSI service is typically deployed in where the access network is ATM and the core network is IP. In both cases there are three options in terms of the protocol used to deliver the service and where this protocol terminates.

2.1.1 ATM NETWORK ENVIRONMENT

Figure 2 shows the scenario where the broadband remote access server, which provides access to the Internet, interconnects multiple DSLAMs either through a core ATM network or directly (where the core network is a null function). When the DSLAMs are directly connected to a B-RAS, then the B-RAS typically exists in the network provider's domain and supports a single HSI service provider. When the B-RAS is connected via a core network, then it typically exists at the edge of a service provider's domain. In this case the network provider simply cross-connects the customer PVCs for the HSI service to the appropriate B-RAS. This latter model can therefore support multiple service providers connected through a single network provider but involves a some provisioning overhead because each time a new customer is added to a service provider's B-RAS, the network provider has to provision a PVC across its network between the customer and the B-RAS.

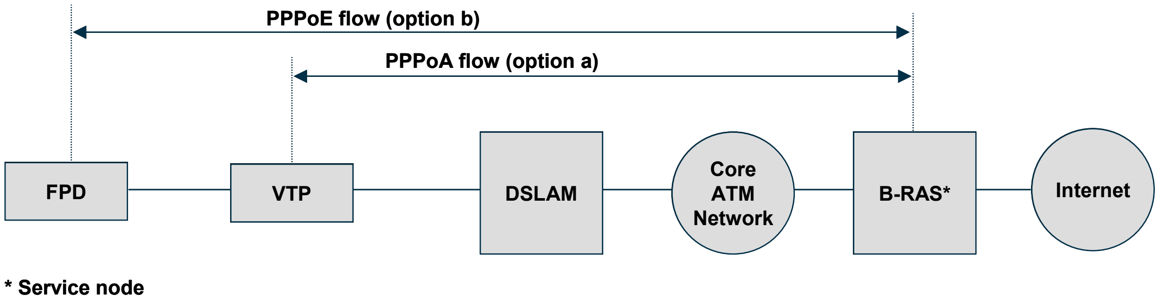

Figure 2. Internet service in an ATM network environment

The key components of this scenario are:

- **FPD** – This is either a PC or STB. The requirement on the FPD is to be able to act as a PPP client. Where the physical interface to the FPD is Ethernet the protocol is PPPoE and when it is USB it can be either PPPoA or PPPoE.
- **VTP** – There are two types of VTP depending on the option used by the service provider.
    - Option a – The VTP contains a PPPoA client and terminates also the ATM layer. It further provides IP routing and NAT functionality to enable sharing of the Internet connection to multiple PCs in the home. As a result it would provide a DHCP server to allocate dynamically private IP addresses to the FPDs.
    - Option b – This VTP provides a simple layer 2 Ethernet bridging function. The modem terminates the ATM layer on the network-side interface and presents an Ethernet interface on the user-side.
- **DSLAM** – Due to the best-effort nature of the HSI service the DSLAM need only provide best-effort QoS. However, it must provide a means to guarantee a minimum amount of both upstream and downstream bandwidth to an end-customer in order to meet service level agreements (SLAs).
- **Core Network** – The core network is ATM in this scenario and when the B-RAS exists within the network provider domain then the core network is a null function. An ATM core network provides the necessary QoS to offer a guaranteed minimum amount of bandwidth to each B-RAS.
- **B-RAS** – The broadband remote access server is the service node for the HSI service and provides the following functionality.
    - Termination of the PPP session.
    - Authentication, authorisation and accounting (AAA) for the HSI service access.
    - Allocation of IP address, default gateway and DNS to the FPD.

There is only one flow associated with the HSI service in this scenario and this is described below.

- **PPP flow** – The connection topology for this flow is point-to-point bi-directional. This flow utilises the PPPoE or PPPoA connection defined in [1] between the VTP and the B-RAS. There is only one instance of this flow per VTP. It carries the PPP protocol between the FPD/VTP and the B-RAS.

2.1.2 ATM ACCESS AND IP CORE NETWORK ENVIRONMENT

Figure 3 shows the scenario where the functionality of the B-RAS is split between two devices, the L2TP Access Concentrator (LAC) and the L2TP Network Server (LNS) in order to allow termination of the ATM layer close to the access network. Note that the scope of the FS-VDSL specifications extends to the V-interface and therefore the service nodes and flows defined beyond the LAC are not part of the specifications. These are shown here in order to describe the end-to-end solution.

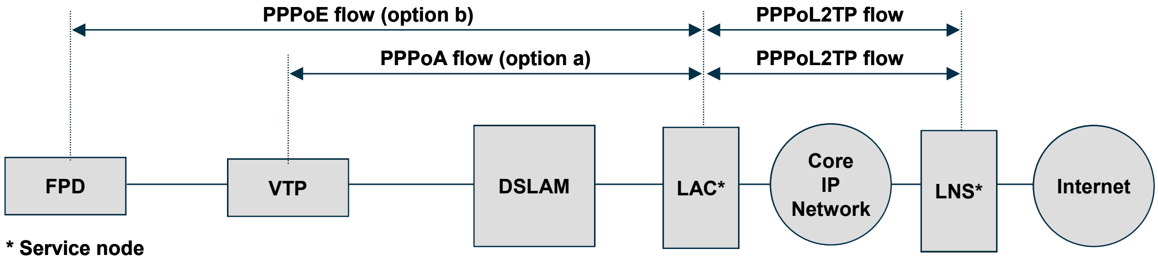

Figure 3. Internet service in an ATM access and IP core network environment

The additional components in this scenario are:

- **LAC** – L2TP Access Concentrator provides termination of the ATM and/or Ethernet and provides a discrimination function to direct the PPP session to the appropriate service provider's gateway router (LNS) over an L2TP tunnel for session termination, authentication and accounting.
- **LNS** – L2TP Network Server sits at the edge of the service provider's network and provides the AAA functions of the B-RAS. This architecture more easily supports a multiple service provider environment because each service provider only needs to have a domain entry in the LAC owned by the network provider. This is usually done during LNS installation. Following this, as each new customer is added to the service provider's LNS, the network provider need not do anything other than provision the ATM VCC between the VTP ad the LAC. This in practice may also be pre-provisioned, since any attempt by a customer to connect to a service will be denied by the appropriate service provider's LNS until the customer has an account with them.
- **Core network** – The core network is IP in this scenario. It must support QoS in order to offer a guaranteed minimum amount of bandwidth to each LAC-LNS pair.

The flows associated with the HSI service in this scenario are:

- **PPP flow** – The connection topology for this flow is point-to-point bi-directional. This flow utilises the PPPoE or PPPoA connection defined in [1] between the VTP and the LAC. There is only one instance of this flow per VTP. It carries the PPP protocol between the FPD/VTP and the LAC which in turn carries the HSI service's IP traffic.
- **L2TP flow** – The connection topology for this flow is point-to-point bi-directional. A connection is not defined for this flow in [1] as this flow is outside the scope of the FS-VDSL specifications, but the connection would be an L2TP tunnel between the LAC and LNS traversing the core IP network. The flow carries the L2TP control and data channels which in turn carry all the PPP flows between the LAC and the LNS.

2.2. DIGITAL TELEVISION

Digital television provides a service to receive both satellite and terrestrial broadcast services of television and radio over the customer's DSL connection. Figure 4 shows the components to deliver this service.

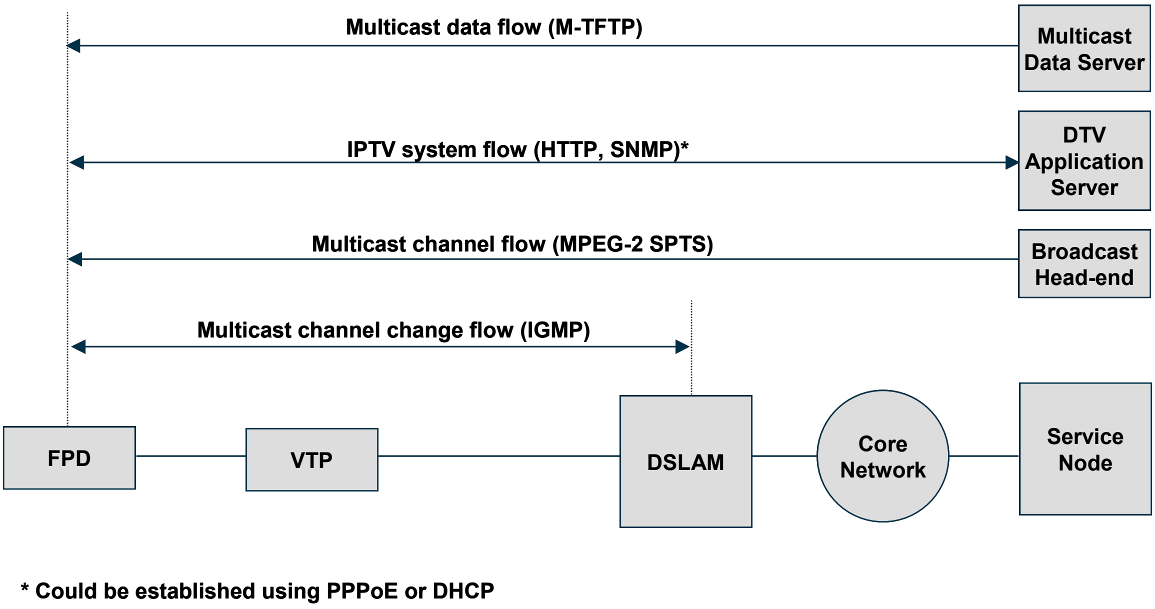

Figure 4. Digital Television components and flows

The key components of this service are:

- **FPD** – The FPD is a STB running an appropriate OS and middleware software providing the necessary applications for the following functions.
  - o Obtaining IP connectivity to the DTV application server using either DHCP or PPPoE.
  - o Downloading the client software containing the STB kernel and DTV applications. To make optimum use of network capacity the recommended protocol for this is multicast TFTP.
  - o Channel change application that uses IGMPv2 for carrying out channel changes.
  - o Browser and video display applications to display the user interface and audio/video signals.
- **VTP** – The VTP terminates both the DSL and ATM layers. It further provides Ethernet bridging functionality to bridge Ethernet traffic between the STB and service nodes. The following requirements must be met by the VTP when supporting DTV services.
  - o IEEE 802.1d bridging without spanning tree. Spanning tree is not required at the B-NT since the home network is not accessible via multiple bridges.
  - o RFC 2684 LLC/SNAP Bridge Encapsulation.
  - o VCC-to-VCC forwarding shall not be allowed.
  - o IGMP proxy function.
  - o Bridge and IP packet filtering to control the flow of packets between the customer side Ethernet interfaces and network side ATM VCCs.
- **DSLAM** – This needs to support a channel change function in order to enable the cross-connection of multicast channels received from the broadcast head-end to the appropriate customer VCC across the DSL UNI. IGMPv2 is used as the channel change protocol.

- **Core network** – The core network needs to support sufficient QoS and bandwidth for the digital TV service. It further needs to support multicasting of broadcast traffic at the most optimal points within the core network.
- **Broadcast Head-end** – Each TV and radio channel is encoded as an MPEG-2 single program transport stream which is then encapsulated over UDP/IP and streamed into the core network on a unique class D IP multicast address.
- **DTV application server** – This provides the server side business logic for the digital television service and consists usually of a web server, application server and database.
- **Multicast data server** – This server holds the STB software and other data related to the digital television service. It is streamed upon request by a STB using multicast TFTP.

The flows associated with the DTV service are:

- **Multicast channel change flow** – The connection topology for this flow is point-to-point bi-directional. This flow utilises the channel change connection defined in [1] between the VTP and the DSLAM. There is only one instance of this flow per VTP. It carries the IGMP version 2 protocol between the FPD and VTP and then either IGMPv2 or DSM-CC between the VTP and the DSLAM.
- **Multicast channel flow** – The connection topology for this flow is point-to-multipoint uni-directional. It utilises the digital broadcast connection defined in [1] between the DSLAM and the VTP. Multiple multicast channel flows exist within the network between the Broadcast head-end and the DSLAM, each carrying a separate digital television programme. Similarly, multiple multicast channel flows may be delivered simultaneously to the VTP depending on the bandwidth availability across the DSL UNI.
- **IPTV system flow** – The connection topology for this flow is point-to-point bi-directional. The flow utilises either the PPPoE connection, the bridge connection or the routed connection as defined in [1] depending on the service provider. There is only one instance of this flow per VTP. The flow carries all the necessary control and management traffic pertaining to the digital television service to and from the DTV application server.
- **Multicast data flow** – The connection topology for this flow is point-to-multipoint uni-directional. The flow utilises the digital broadcast connection defined in [1] between the DSLAM and the VTP, but does not carry audio/video traffic. There is only one instance of this flow per VTP and it is used to carry data related to the digital television service to the STB, e.g. client software and EPG data.

2.3. VIDEO ON DEMAND

Figure 5 shows the various components to deliver video on demand. The VoD service may be offered independently of digital television or as a bundle. If offered as a bundle some of the components and flows shown in Figure 5 will be shared by the two services.

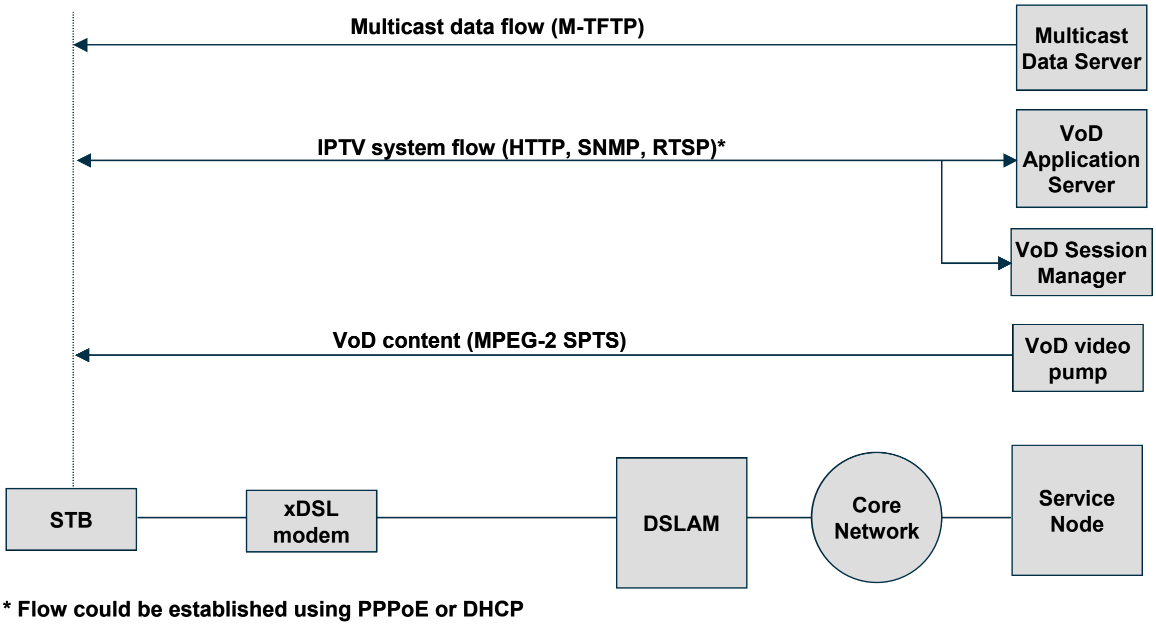

Figure 5. Video on demand components and flows

The key components here are the following.

- **FPD** – The FPD is a STB running an appropriate OS and middleware software providing the necessary applications for the following functions.
    - RTSP client appropriate for communicating with the VoD session manager and implementing the VCR controls.
    - VoD application for browsing, selecting, purchasing and playing VoD movies.
    - Browser and video display applications to display the user interface and audio/video signals.
- **VTP** – The VTP terminates both the DSL and ATM layers. It further provides Ethernet bridging functionality to bridge Ethernet traffic between the STB and service nodes. The following requirements must be met by the xDSL modem when supporting DTV services.
    - IEEE 802.1d bridging without spanning tree. Spanning tree is not required at the B-NT since the home network is not accessible via multiple bridges.
- **DSLAM** – The DSLAM needs to offer both guaranteed QoS in addition to best-effort QoS. In addition due to the high demand for bandwidth for VoD, the DSLAM needs to provide high speed network interfaces connecting it to the core network.
- **Core network** – VoD is a bandwidth intensive application due to its session based nature. The bandwidth requirements from the core network grow linearly as the number of VoD subscribers grows. This means that the core network must provide both sufficient QoS for the VoD service and high capacity.
- **VoD session manager** – This handles the VoD session set-up, control and teardown.
- **VoD video pump** – streams the VoD content under the command of the VoD session manager.
- **VoD application server** – This provides the server side functionality of the VoD service, e.g. VoD content directory, item purchase authentication and authorisation. It typically consists of a web server, application server and database. Where DTV and VoD are offered simultaneously by the service provider then the application server will be a shared component between these two services.

- **Multicast data server** – as described in DTV section. Where DTV and VoD are offered simultaneously by the service provider then the multicast data server will be a shared component between these two services.

The flows associated with the VoD service are:

- **VoD content flow** – The connection topology for this flow is point-to-point unidirectional[1]. It utilises the bridge connection defined in [1] between the DSLAM and VTP. The flow carries digital audio/video content encoded using MPEG-2 single program transport streams and encapsulated using UDP/IP before being transmitted into the network. There is one instance of this flow per VTP. The bandwidth of the flow is dependent on the number of simultaneous VoD sessions that can be active across the DSL UNI.
- **IPTV system flow** – This is the same flow as that described in section 2.2 except that it carries in addition the VoD control protocol that is RTSP. Note that only a single instance of this flow needs to exist if both VoD and DTV services exist.
- **Multicast data flow** – This is the same flow as that described in section 2.2. Note that only a single instance of this flow needs to exist if both VoD and DTV services exist.

[1] [1] allows for the possibility for having a point-to-multipoint uni-directional connection topology for this flow in order to provide a better co-ordination between VoD and Digital Television services being delivered to the same DSL customer.

3. REFERENCES

[1] Full-Service VDSL Focus Group Technical Specification – Part 2: System Architecture and Customer Premises Equipment, Version 1.00, November 2002.

4. GLOSSARY OF TERMS

A glossary of terms is available on the FS-VDSL Focus Group White Papers web pages at `www.fs-vdsl.net/whitepapers` and at `http://www.itu.int/ITU-T/studygroups/com16/fs-vdsl/wps.html`.