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Required ONU/OLT Bandwidth capacity for Video Services

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ITU-T FS-VDSL Focus Group White Paper

REQUIRED OLT/ONU BANDWIDTH CAPACITY FOR VIDEO SERVICES

Summary

This White Paper addresses OLT/ONU bandwidth requirements to support video services in an FS-VDSL compliant system architecture.

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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FS-VDSL WHITE PAPERS

REQUIRED ONU/OLT BANDWIDTH FOR VIDEO SERVICES

1. INTRODUCTION

Video services are one of the most bandwidth hungry applications currently offered. High quality video services require the reservation of significant bandwidth with specific QoS guarantees. This bandwidth grows linearly per video channel per DSL subscriber when using point-to-point PVCs. Therefore the point-to-point approach does not scale efficiently under consideration of economic conditions.

Instead of the point-to-point architecture, the FS-VDSL Focus Group's target network architecture proposes the point-to-multipoint PVCs within the access network. Point to multipoint reduces the bandwidth requirements at some reference points, but still the broadcast video service will in many cases determine the access network's bandwidth requirements.

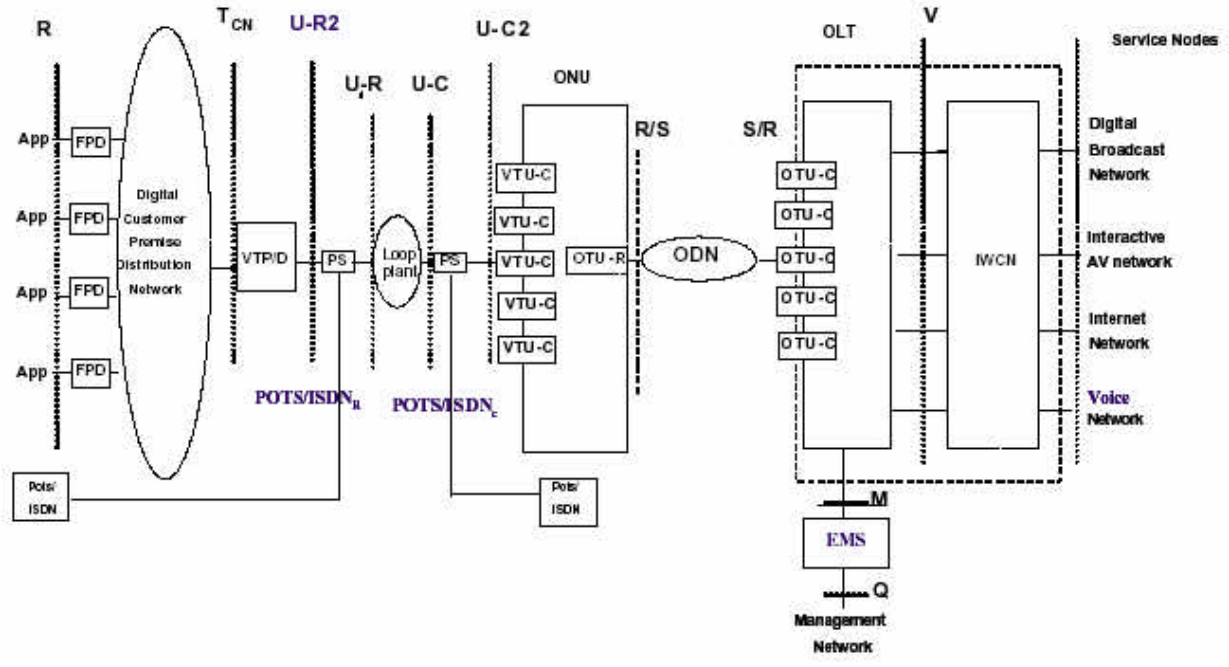

Figure 1: FS-VDSL Reference Model

This document focuses on the bandwidth at the R/S respectively the S/R interface.

2. BANDWIDTH FOR A SINGLE VIDEO STREAM

Video Service Providers have some freedom in determining the bandwidth needed for delivering digital video. The bandwidth depends on the used encoding technique, the used encoding equipment and most important on the quality service provider wants to provide to his customers.

MPEG-2 as today's encoding standard for broadcast services can be used with bitrates between 2 and 15 Mbit/s [3]. The reference for high-quality is currently defined by the DVD (Digital Versatile Disc), which uses a variable bitrate between typically 2 and 9 Mbit/s. For Digital TV, either distributed by Cable or by Satellite or terrestrial, in general lower bitrates – resulting in less quality - are used. For digital TV variable bit-rate encoded material is used, too. Up to 10 TV channels are multiplexed into a single transponder. The peak channel rate can go up to 15 Mbit/s, while the average bitrate is about 3 Mbit/s. DVB-T for example uses in various pilot projects between 3.3 and 4.3 Mbit/s per MPEG Single Program Transport Stream.

For DSL access networks, the multiplexing of variable bitrate program streams is not a feasible approach because almost no statistical gain can be obtained by multiplexing a small number of channels (typical up to three) on the customer drop. All video streams either have to be encoded as CBR or have to be transcoded from VBR to CBR streams.

To sum it up, the 4 Mbit/s used in the following considerations for the video bitrate is used as an example. The exact bitrate a service provider will select depends on quality of the used encoder equipment, on the aimed quality, the service provider wants to offer his customers and on the competitive environment.

In addition to the 4 Mbit/s required bitrate for the video stream, 128 kbit/s for the audio stream are assumed (for Dolby Digital 5.1 some more bandwidth will be required, of course). This results in an overall bitrate of 4.3 Mbit/s for a MPEG-2 Single Program Transport Stream (SPTS).

These MPEG data have to be encapsulated into UDP/IP and are transported over an ATM AAL5 PVC using Bridged Ethernet Encapsulation.

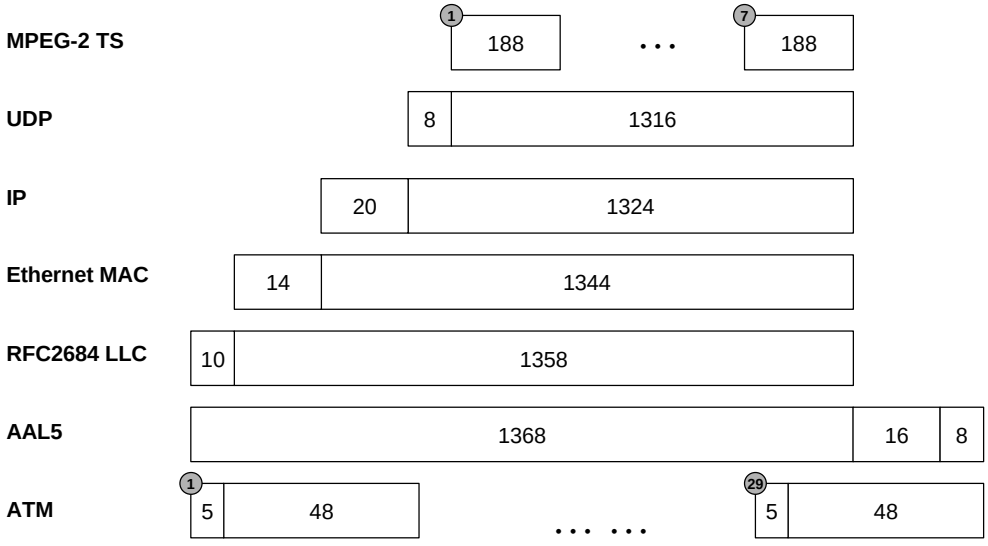

Figure 2: MPEG Encapsulation

The result is an ATM bitrate of approximately 5 Mbit/s. MPEG-2 directly encapsulated in AAL5, which is an option supported by [1] too, will require some less bandwidth due to the missing IP/Ethernet overhead.

3. BANDWIDTH REQUIREMENTS PER ONU

The currently used transport interfaces in the broadband access networks of today are STM-1/OC-3 or – less often – STM-4/OC-12. The gross line rate of such an interface is 155.5 Mbit/s respectively 622 Mbit/s. But considering the SDH/SONET overhead, a remaining bandwidth of 149 Mbit/s respectively 596 Mbit/s is available for ATM data. This results in 29 respectively 119 Broadcast TV channels that can be transported simultaneously. But an additional share of this bandwidth will have to be subtracted for data or voice services. For engineering the required bandwidth for the Internet access, the network operator again has a considerable freedom of choice. As a starting point, a mean value of 100 kbit/s per connected subscriber is assumed. This value of course may increase in future due to a more intensive use of Internet based services.

The Operator Requirements part of the FS-VDSL Specifications [2] listed the average number of VDSL lines served by an ONU. This number varies from 12 to 800 for FTTCab solutions with an average of 48-300 lines and varies from 4 to 160 for FTTBox solutions with an average of 20-40 lines.

The FS-VDSL System Architecture Specification [1] allows several combinations for the realization of the video stream replication.

3.1. OPTION 1: NO VIDEO STREAM REPLICATION IN ONU

The FS-VDSL System Architecture Specification allows the option of an ONU that does not support the replication of video streams by an ATM multicast. This option may be of interest especially for very small ONUs, as they are provided for Fiber To The Building solutions as an instance. The absence of supporting multicast could first of all reduce the costs of this boxes, and secondly reduce the operational procedures by e.g. free the network operator from configuring the access control lists in every small FTTB ONU. The multicast is then only realized in the OLT. The interface between ONU and OLT has to offer enough capacity to transport the maximum number of video streams simultaneously, which can be watched by all subscribers connected to this ONU. This number depends on the number of DSL ports, the average DSL line rate (i.e. the number of possible video streams per DSL line), the percentage of subscribers of the Digital Broadcast TV service and the usage statistic, the service provider may calculate with.

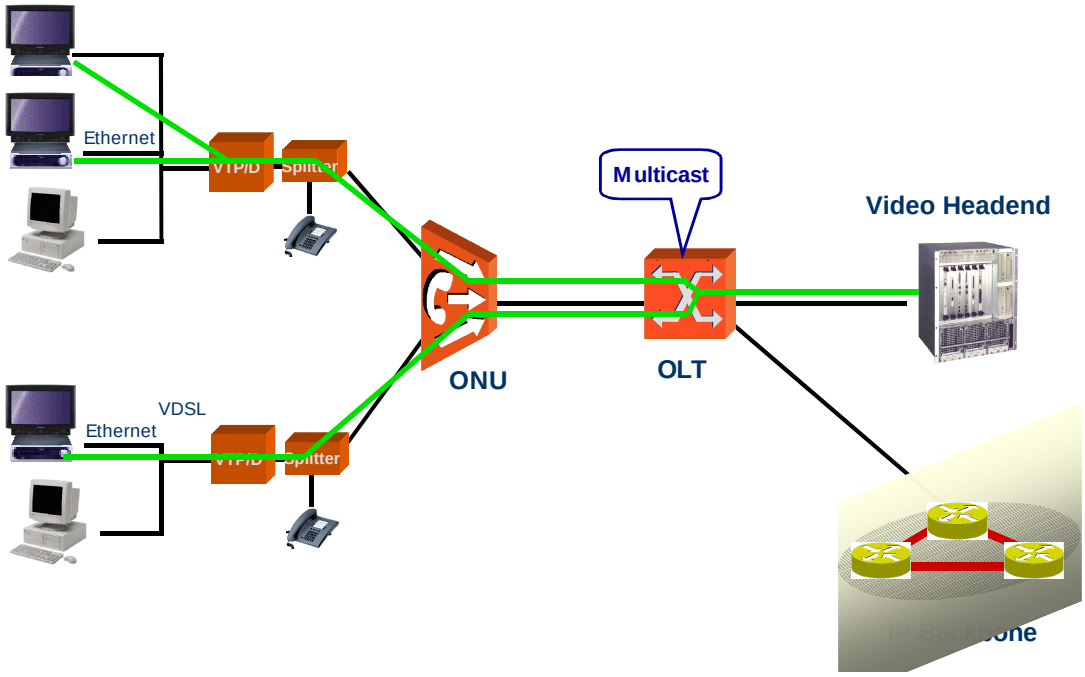

Figure 3: No Multicast support in ONU

An STM-1/OC-3 link could serve ONUs supporting up to 29 channels, an STM-4/OC-12 link ONUs with up to 119 channels. Considering the required additional bandwidth for Internet access, the number of video channels have to be reduced 27 respectively 117.

As an example, an STM-1/OC-3 link could serve an ONU with 18 ports, if the provider calculates with three channels per DSL line and a 50% SDVB service take-rate.

3.2. OPTION 2: VIDEO STREAM REPLICATION IN ONU

The first approach does not scale for larger systems, so the replication of video streams becomes necessary. For ONU supporting video stream replication, there are again two possibilities. If the ONU has the capabilities to request video streams from the OLT or even a more central part of the network, that are currently not available at the R/S interface, only that amount of video channels has to be available at the R/S interface, that is equal to the number of simultaneously watched TV channels. If every TV set is ”tuned” to a different TV channel, the number is identical to the number in chapter 3.1, i.e. 27 for a STM-1/OC-3 interface and 117 for a STM-4/OC-12 interface. In most cases, the overwhelming majority of all users may be watching the same top 10 channels, so even with a STM-1/OC-3 link, potentially much more than 27 channels can be offered simultaneously by the video service provider. The number is than limited by the capacity of the interface between the OLT and the video headend.

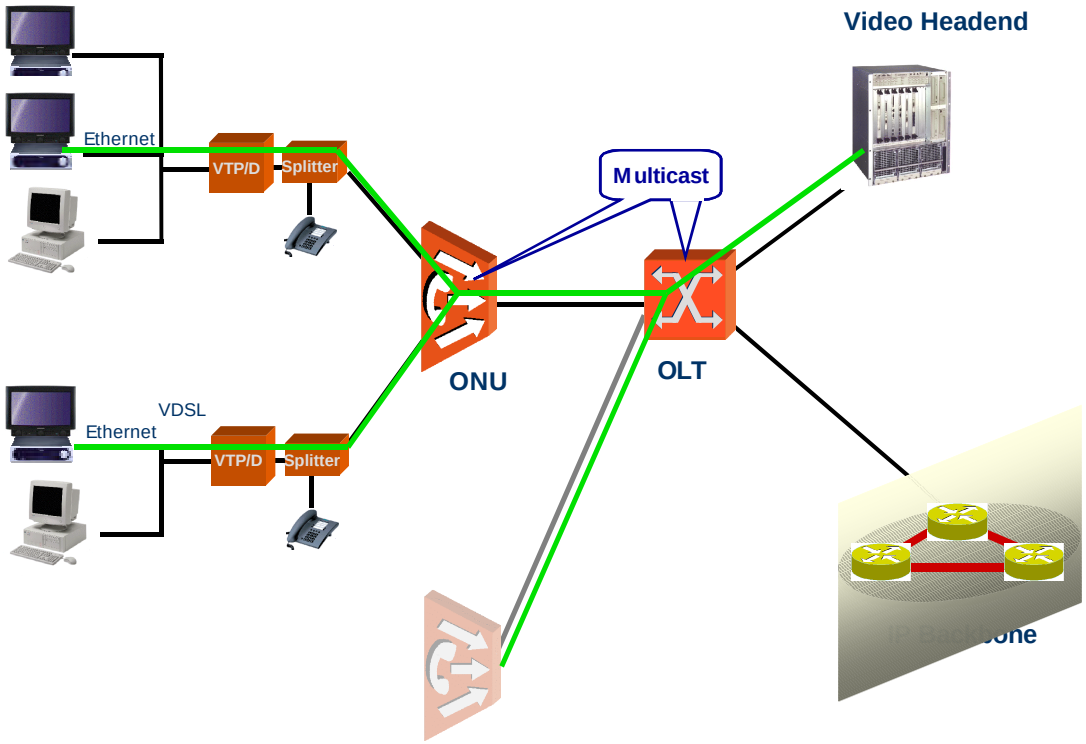

Figure 4: Multicast support in ONU and OLT

If the ONU does not have the capability to request additional channels from the OLT, all channels, that the video service provider wants to offer, have to be available at the ONU interface at any time. So the bandwidth of the link between ONU and OLT determines the number of possible channels. No gain from statistical usage can be realized.

This would result again in a limit of 27 possible video streams if a STM-1/OC-3 interface is used and 117 possible video streams if a STM-4/OC-12 interface is used. The following tabel gives an exemplary calculation for an ONU100, which may require about 10 Mbit/s for Internet access.

	5 Mbit/s per video stream (e.g. MPEG-2)		**2.5 Mbit/s per video stream (e.g. MPEG-4)**	
Interface capacity between ONU and OLT	STM-1/OC-3	STM-4/OC-12	STM-1/OC-3	STM-4OC-12
ONU not supporting	27 limit is the	117 limit is the	55 limit is the	234 limit is the

	5 Mbit/s per video stream (e.g. MPEG-2)		2.5 Mbit/s per video stream (e.g. MPEG-4)	
supporting replication	number of subscribers	number of subscribers	number of subscribers	number of subscribers
ONU supporting replication, but no multicast signaling	27 limit is the number of channels	117 limit is the number of channels	55 limit is the number of channels	234 limit is the number of channels
ONU supporting replication and multicast signaling	≥ 27 depending on statistical effects	≥ 117 depending on statistical effects	≥ 55 depending on statistical effects	≥ 234 depending on statistical effects

Table 1: Number of possible video channels for an ONU100

4. CONCLUSIONS

The MPEG standards have defined only the decoding process. This leaves some freedom for the encoding equipment manufacturers to improve the efficiency of the encoding process and with it the perceived video quality without changing the used encoding standard. So even if a video service provider could or does not want to change the used encoding standard, the required bandwidth could be significantly reduced over time without decreasing the perceived video quality. The bitrate used for the video part may than be reduced for instance from 4 Mbit/s to 3 Mbit/s over time, resulting in an overall bitrate for the entire Transport Stream of approximately 4 Mbit/s.

More dramatic improvements could be expected by the introduction of MPEG-4 AVC (Advanced Video Coding) [4], which is expected to reduce the bitrate to about 50%. Resulting in an overall bitrate of e.g. 2.5 Mbit/s, the number off video streams that can be transported by an Access Network can easily be doubled without adding additional resources to the infrastructure.

5. REFERENCES

[1] ITU-T FS-VDSL Focus Group Technical Specification Part 2

[2] FS-VDSL Specification Part 1

[3] ISO/IEC 13818-2 – Information Technology – Generic Coding of moving pictures and associated audio information – "Video"

[4] ISO/ITU H.264 Part 10

6. 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`