



Proximus Reference Offer for Bitstream Access

Annex 2C:

Technical Specifications of Bitstream services over Ethernet

Delivered by the IP-DSLAM platform

Covering the technology VDSL2

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Our reference: MSO & Servicing version

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1 Scope

The purpose of this document is to describe the technical specifications of the Bitstream VDSL2 service.

Note that the description of the above-mentioned service is available in the Main Body of the present reference offer.

To allow the Beneficiary to set up a service based on this service from Proximus, this document describes the interfaces.

All technical specifications as described in the present document are validated and supported by Proximus unless otherwise stated.

The Beneficiary willing to offer non-validated features which require other technical characteristics than those validated and supported by Proximus as described in the present reference offer can implement them but without commitment of Proximus on their correct functioning. Examples of such features are:

- Non tested protocols on the Proximus network,
- Burst sizes, delay or jitter requirements, beyond the QoS specifications as documented in the chapter "QoS specifications".

The Beneficiary can request on a project mode basis for ad hoc testing to check the transparency of any specific protocol or the correct functioning of any specific feature in the context of the Bitstream VDSL2 service.

Any enumeration of protocols or features listed in this document is not exhaustive and is based on the Proximus best knowledge available at this moment.

Regarding the non-validated features, Proximus assumes no liability for incomplete or incorrect information provided by its equipment suppliers or for protocols or features withdrawn or modified by the latter without any prior notice (whether in the frame of a correction or an upgrade of the equipment and/or a technology evolution).

This document also specifies the technical requirements with regard to the use of the modem and of the internal cabling at End-User premises.

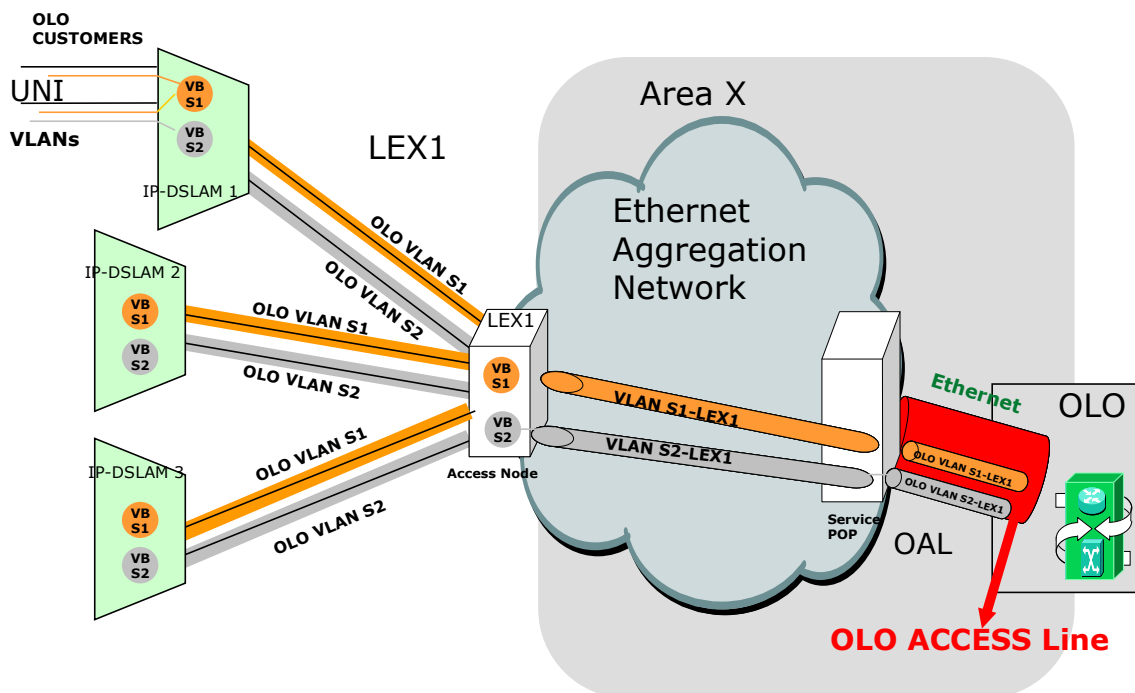
2 Abbreviations

	Description
DHCP	Dynamic Host Configuration Protocol
DS	Downstream
DSCP	Differentiated Services Code Point
GE	Gigabit Ethernet
GUI	Graphical User Interface
IPoE	Internet Protocol over Ethernet
LACP	Link Aggregation Control Protocol
LAG	Link Aggregation
LAN	Local Access Network
LEX	Local Exchange
MTU	Maximum Transmission Unit
MC-LAG	Multichassis LAG
OAL	<u>Q</u> LO (Ethernet) <u>A</u> ccess <u>L</u> ine
OLO	Other Licensed Operator (also mentioned in this document as “Beneficiary”)
p-bit	Priority bit
PoP	Point of Presence
PPP	Point to Point Protocol
PPPoE	Point to Point Protocol over Ethernet
UNI	User Network Interface
US	Upstream
U2U	User to User (communication)
VDSL2	Very High Speed Digital Subscriber Line 2 (= Ethernet based, while VDSL1 is ATM based)
VLAN	Virtual LAN. Unless specified otherwise, the word “VLAN” equally refers to a Shared VLAN or to a Dedicated VLAN.
xDSL	For example: ADSL, Re-ADSL2 (Reach Extended ADSL2), ADSL2+, VDSL2

3 Overall Network Architecture of Bitstream VDSL2 with Shared VLANs

3.1 End-to-End View

Wholesale Broadband Access VDSL2 Solution



Graph 1: end-to-end overview (Shared VLANs)

This **Bitstream VDSL2** service offers an Ethernet connectivity between the OLO Access Line and the VDSL2 lines.

Eight VLAN services are defined on the Ethernet Network, differentiated by a priority level, two VLAN services for each priority:

- Best effort (P0 & P0bis)
- Low priority (P1 & P1bis)
- Medium priority (P3 & P3bis)
- Highest priority (P5 & P5bis) and better performance for jitter and delay sensitive traffic.

The P0 & P0bis VLAN services:

-**transport downstream** in Best Effort QoS Ethernet frames that can be tagged p0 or p1 and hand them over to the IP-DSLAM, tagged with the p-bit (p0 or p1) as received from the OAL;

-**discard in downstream** Ethernet frames, tagged otherwise than p0 & p1, except small volumes¹ of control frames which are received from the OAL with a priority different from p0 or p1 (these control frames are not discarded but retagged to p0);

-**retag in upstream** all Ethernet Frames to p0 except DHCP control frames with the p-bit set to p1 by the CPE, which pass transparently.

The P1 & P1bis, P3 & P3bis and P5 & P5bis VLAN services transport Ethernet frames tagged respectively with p1, p3 & p5 priority values. Ethernet frames not tagged respectively with the corresponding priority values p1, p3 or p5 are retagged to respectively p1, p3 & p5.

Each VDSL2 line can offer to the End-User one or none of the two PO services, one or none of the two P1 services, one or none of the two P3 services and one or none of the two P5 services.

The VLAN-ID scheme on all VDSL2 lines is common for all OLOs.

E.g.: VLAN-ID 10 = Best Effort (PO or PObis) (note that the Ethernet frames can be p0 and p1 tagged).

The IP-DSLAM works as a VLAN Ethernet bridge performing translation between the VLAN-ID on the VDSL line, to a VLAN, dedicated for 1 service and 1 OLO. This bridge is shared amongst all End-Users of the same service of the same OLO.

E.g.: all traffic of OLO1 End-Users conveyed in PO VLAN service is bridged to VLAN 2200 on the IP-DSLAM NT; all traffic of OLO1 End-Users conveyed in PObis VLAN service is bridged to VLAN 2202 on the IP-DSLAM NT.

Per service, the VLANs of the End-User lines of a Beneficiary will be aggregated on LEX level in the Access Node of the Ethernet Aggregation Network and transported in 1 VLAN to the Service PoP, where the standard OLO Access Line is connected. When a Multichassis-LAG OLO Access Line is used, two OALs are connected to the 2 different Service PoPs. There are 2 Service PoPs, located in 2 different buildings, per Aggregation Network, and 5 Aggregation Networks for whole Belgium. Each of the 5 Aggregation Networks covers 1 geographical Area.

When a standard OLO Access Line is used, the VLAN ends in 1 VLAN on the OLO Access Line.

When a Multichassis-LAG OLO Access Line is used, one link is working and the other is standby. The VLAN ends in 1 VLAN on the working OLO Access Line.

Per service and per LEX where the Beneficiary wants to be active, he will need to order 1 separate VLAN between the LEX and one of the 2 Service PoPs of the Aggregation Network to which the LEX belongs (in case of a Multichassis LAG OLO Access Line these VLANs will dynamically be terminated on the Service PoP with the working OLO Access Line). In this LEX, all End-Users of the Beneficiary with the same service (e.g.: PObis) will share this same VLAN separated from the VLAN (e.g.: PO) of the same OLO or any other OLO.

The OLO will connect the OLO Access Lines to his OLO Router or other equipment. When Multichassis LAG OLO Access Lines are used the OLO Router or other equipment must support multichassis LAG.

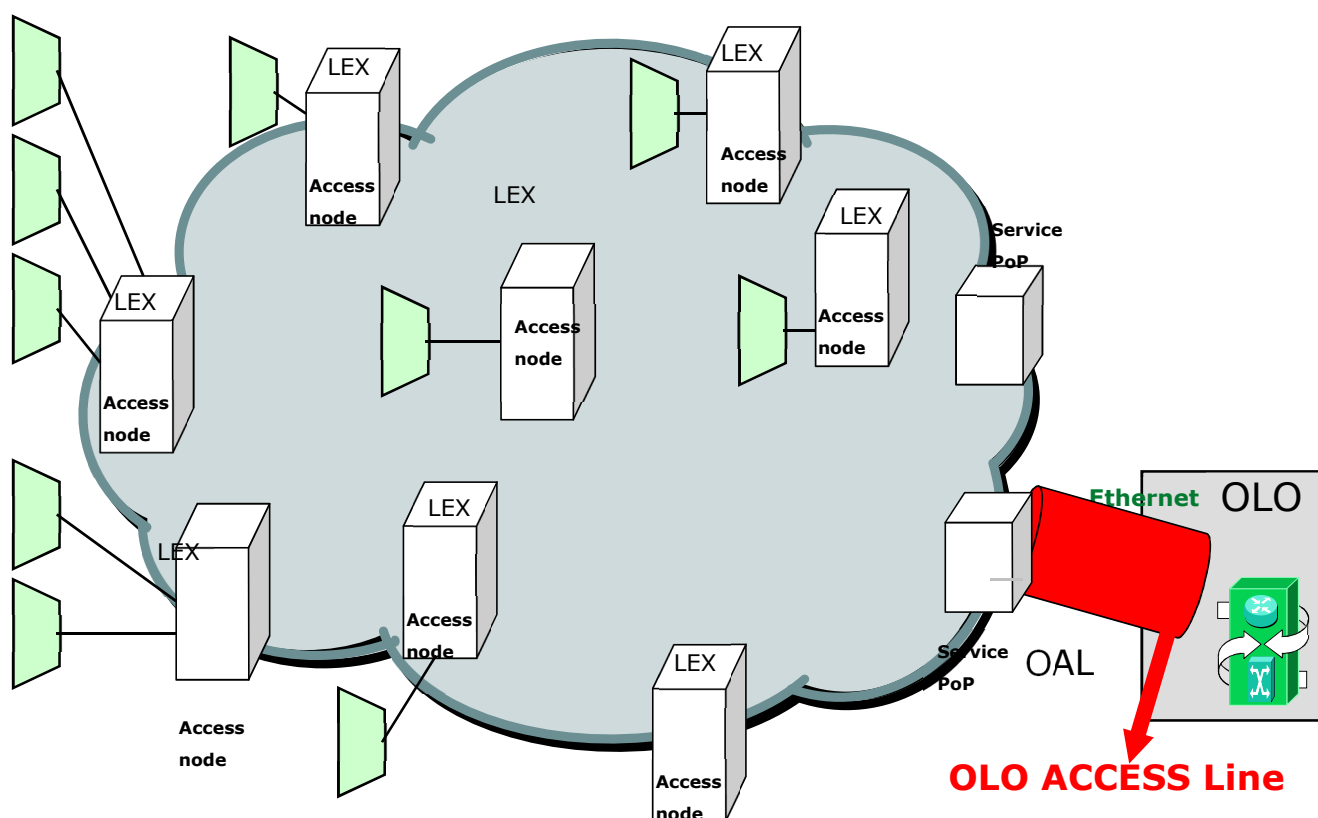
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¹ For security reasons, parameters will not be publicly shared. Beneficiary shall contact Proximus if he has the need to receive this information.

3.2 Aggregation Network structure

3.2.1 Standard OLO Access Line

Bitstream VDSL2
Aggregation Network structure



Graph 2: Aggregation Network Structure

The IP-DSLAM is connected to one Access node.
The VLAN is routed from the OLO Access Line to the Access node of the LEX.

Redundancy:

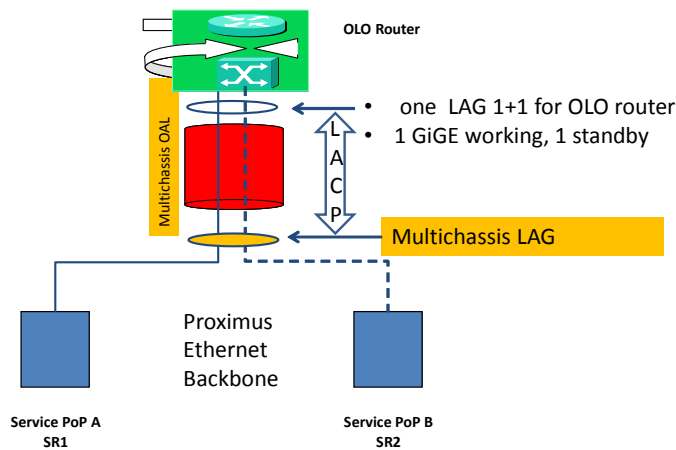
- Rerouting of the VLANs.
- The OLO Access Line redundancy is an option.
- The IP-DSLAM is connected to its Access node via GE lines.

3.2.2 Multichassis LAG OLO Access Line

The “Multichassis LAG OLO Access Line” has 2 links, one to each of the two Service PoPs of the Area.

One link is working, the other is standby.

The VLANs from the LEX are active on the active link (on Service PoP A in the figure below). They are switched to the other link and Service PoP under command of the LACP protocol between the OLO Router and Proximus Multichassis LAG. Stability of the LACP protocol and transparency for LACP protocol on both links of the Multichassis-LAG OAL are required and shall be tested on an empty Multichassis LAG OAL, before taking it into service.



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3.2.3 Distant Intro

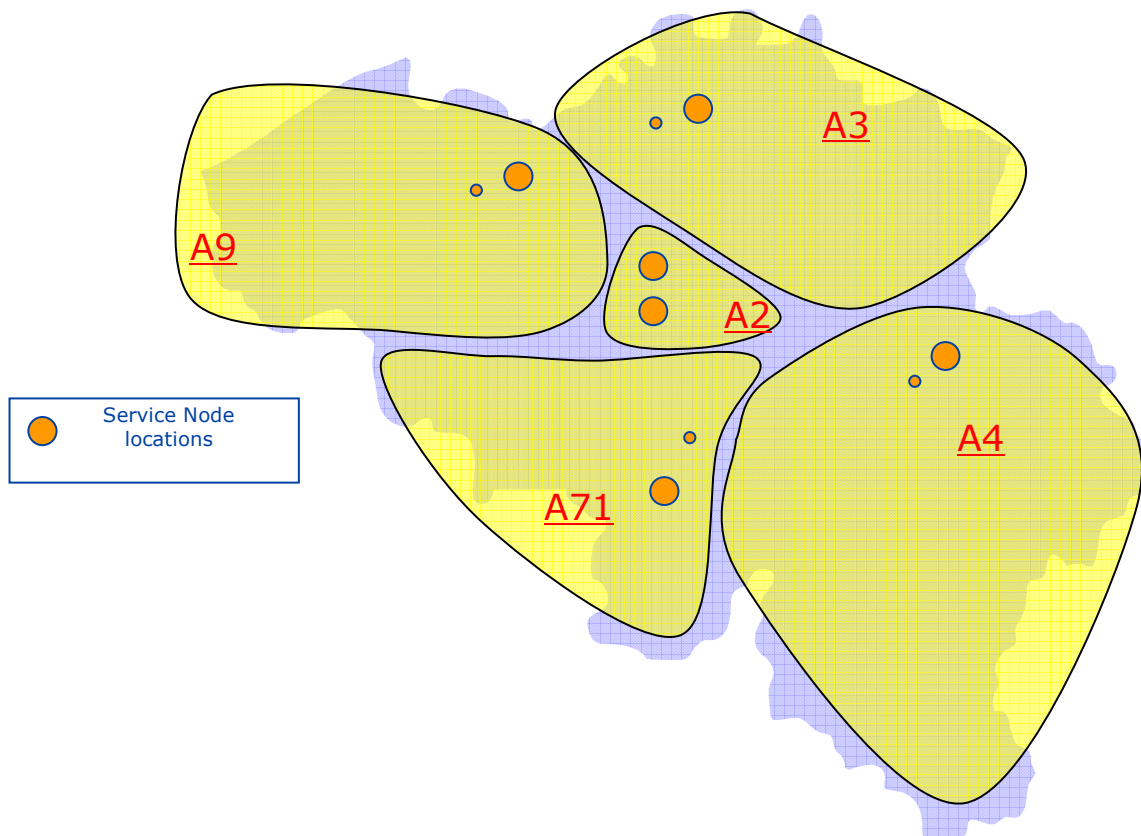
As announced in the document “Network Transformation Outlook 2016-2021” (which is published on the Proximus wholesale website), the Service PoPs 03CEN and 91GKK will respectively move to 03WOM and 91WON.

The “Distant Intro offer” consists in providing a limited number of Distant Intros to the Beneficiary to allow him to reconnect its fibers spliced in different OLO-manholes around the service nodes 03CEN and/or 91GKK via Distant Intros of Proximus towards the OLO colocation rooms in the respective new Service Node buildings 03WOM and/or 91WON.

For a detailed description, reference is made to the Appendix A of the Main Body of the present reference offer.

3.3 Aggregation Areas

Ethernet Aggregation Network: 5 areas



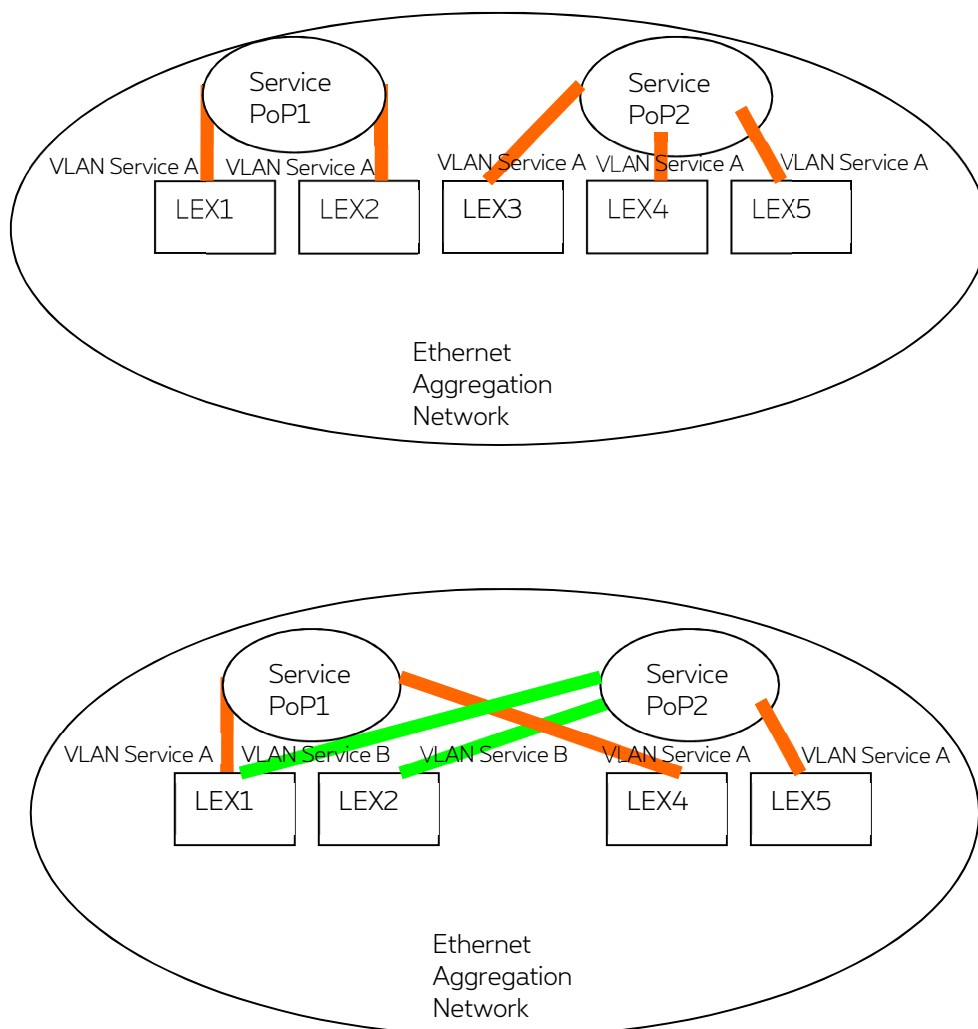
Graph 3: Aggregation Networks and Service PoPs location

As prerequisite to the ordering of the Bitstream VDSL2 service in one of the 5 Areas, the Beneficiary must interconnect with Proximus by ordering at Proximus one or several dedicated Access Lines between the Beneficiary's Equipment and the Proximus Service PoPs of this Area.

To collect and terminate the traffic of an Area, the Beneficiary only needs to connect to 1 of the 2 Service PoPs per area with a standard OAL. The interconnection on the 2 service PoPs of a same area lets the OLO share its traffic over the 2 Service PoPs for more security. Nevertheless, with a standard OAL this is not loadsharing: the OLO must choose himself to which Service PoP he connects the different LEXs. With Multichassis LAG OALs it is possible to protect the traffic against outages of e.g. a service PoP.

E.g.: for one service A, it will be possible to connect LEXs 1 and 2 to Service PoP1 and LEXs 3, 4 and 5 to Service PoP2 (with Service PoP1 and Service PoP2 belonging to the Area of these LEXs). For one service A, it is not possible to connect one LEX to the 2 Service PoPs when standard OALs are used.

Alternatively, with standard OALs, it is also possible to connect the same LEX to Service PoP1 for service A and to service PoP2 for service B (with Service PoP1 and Service PoP2 belonging to the Area of this LEX).



Graph 4: examples of connection between LEXs and Service PoPs

To reach a national coverage, the Beneficiary needs at least 1 interconnection in each Ethernet Aggregation area.

3.4 VLAN characteristics

- The P1 & P1bis, P3 & P3bis and P5 & P5bis Shared VLANs transport only one sort of tagged Ethernet frames: each P_i^2 or $P_{i\text{bis}}$ VLAN transports only p_i^2 -tagged Ethernet frames.

² For $i=1, 3$ or 5 .

- The PO & PObis VLAN services :
 - transport in **downstream** p0 & p1 tagged Ethernet frames, both in **Best Effort QoS** and hand them over to the IP-DSLAM, tagged with the original p-bit, received from the OAL.
 - discard in downstream Ethernet frames, tagged otherwise than p0 & p1, except small volumes³ of control frames which are received from the OAL with a priority different from p0 or p1. These control frames are not discarded but retagged to p0.
 - retag in **upstream** all Ethernet frames to p0 except DHCP control frames with the p-bit set to p1 by the CPE, which pass transparently.
- The offered VLANs allow very little amount of Multicast & Broadcast Ethernet frames => No Multicast service is possible !
- The following table summarizes the VLAN Bandwidths available in function of the service chosen by the OLO:

Offered VLAN Bandwidth (Mbps)	P=0	P=1	P=3	P=5
2	Y	Y	Y	Y
4	Y	Y	Y	Y
6	Y	Y	Y	Y
8	Y	Y	Y	Y
10	Y	Y	Y	Y
12	Y	Y	Y	Y
14	Y	Y	Y	Y
16	Y	Y	Y	Y
18	Y	Y	Y	Y
20	Y	Y	Y	Y
30	Y	Y	Y	Y
40	Y	Y	Y	Y
50	Y	Y	Y	Y
60	Y	Y	Y	Y
70	Y	Y	Y	Y
80	Y	Y	Y	Y
90	Y	Y	Y	Y
100	Y	Y	Y	Y
120	Y	Y	Y	N
140	Y	Y	Y	N
160	Y	Y	Y	N
180	Y	Y	Y	N
200	Y	Y	Y	N
220	Y	Y	Y	N
240	Y	Y	Y	N
260	Y	Y	Y	N
280	Y	Y	Y	N
300	Y	Y	Y	N
320	Y	Y	N	N

³ For security reasons, parameters will not be publicly shared. Beneficiary shall contact Proximus if he has the need to receive this information.

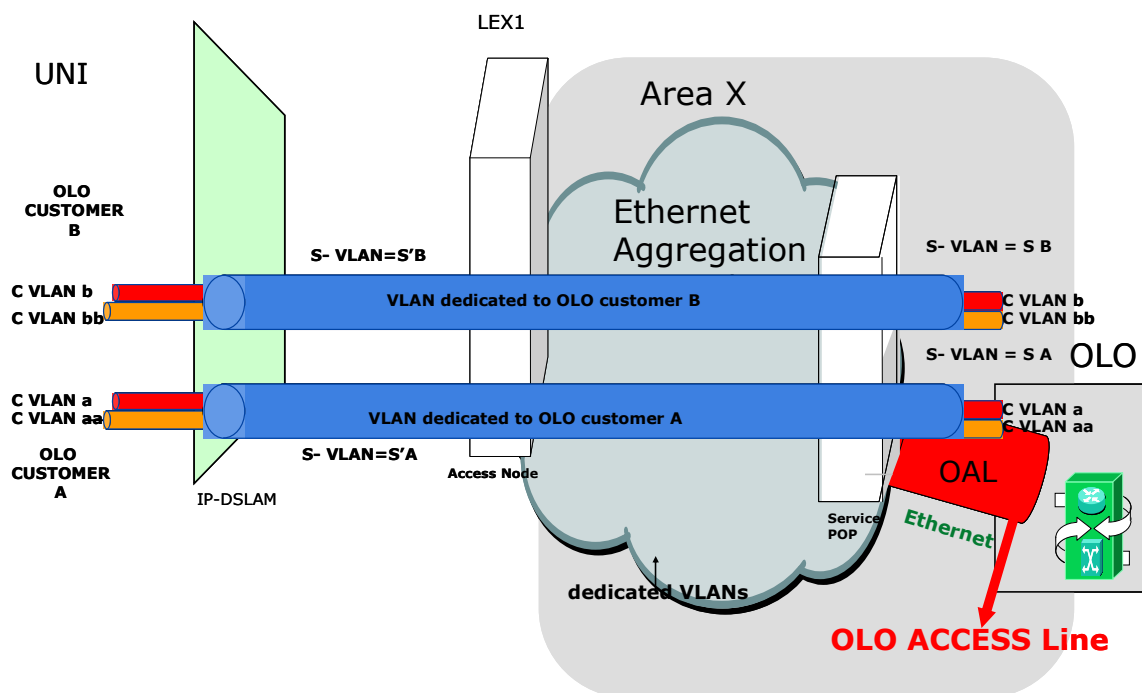
340	Y	Y	N	N
360	Y	Y	N	N
380	Y	Y	N	N
400	Y	Y	N	N
420	Y	Y	N	N
440	Y	Y	N	N
460	Y	Y	N	N
480	Y	Y	N	N
500	Y	Y	N	N
600	Y	N	N	N
700	Y	N	N	N
800	Y	N	N	N
900	Y	N	N	N
1gig	Y	N	N	N

Table 1: VLAN Bandwidth per service

4 Overall Network Architecture of Bitstream VDSL2 with Dedicated VLANs

4.1 End-to-End View

Wholesale Broadband Access VDSL2 with Dedicated VLAN



Graph 5: end-to-end overview (Dedicated VLANs)

This **Bitstream VDSL2** service offers an Ethernet connectivity between the OLO Access Line and the VDSL2 lines. Four services are defined on the Ethernet Network, differentiated by the Ethernet p-bit or Layer 3 IP QoS (IP-precedence bits):

- P=0 : best effort
- P=1 : low priority
- P=3 : medium priority
- P=5 : highest priority

The VLAN-ID scheme on all VDSL2 lines is free (except for management VLANs of the VDSL2 modem) for all OLOs, because it is transparently transported towards the OAL.

For each separate Bitstream VDSL2 line, the IP-DSLAM adds in upstream an S-tag to any VLAN leaving the VDSL2 modem of the line and transports the S-tagged frame up to the OAL of the OLO in a **Dedicated VLAN**, completely dedicated to this OLO End-User.

The **Dedicated VLAN**, carrying the customer C-VLANs, is cross-connected in the Proximus network. The VLAN profile (see section 7.5.2), agreed upon between the OLO and Proximus, is applied and policed on the Dedicated VLAN.

The **Dedicated VLAN** ends on 1 OLO Access Line, connected to a Service PoP of the Area to which the End-User line belongs:

- No “inter Area” Dedicated VLAN is possible.
- No rerouting to any other OAL is foreseen.
- The same OAL may be used for “Shared VLAN” and for “Dedicated VLAN” services.

At the OAL, Proximus will deliver the VLAN, S-tagged carrying all C-VLANs of the VDSL2 line, unchanged. The S-tag takes 1 VLAN-ID. The standardized VLAN-ID field size (12 bits) therefore limits the number of VDSL2 sites, connectable to 1 OAL.

The OAL can also be of type “Multichassis LAG OAL”, which can carry a mix of “Shared VLANs” and “Dedicated VLANs”.

4.2 Aggregation Areas

See Graph 3, “Aggregation Networks and Service PoPs location”, in the section 3.3 “Aggregation Areas”.

As prerequisite to the ordering of the Bitstream VDSL2 service in one of the 5 Areas, the Beneficiary must interconnect with Proximus by ordering at Proximus one or several dedicated Access Lines between the Beneficiary’s Equipment and the Proximus Service PoPs of this Area.

To collect and terminate the traffic of an Area, the Beneficiary only needs to interconnect to 1 of the 2 Service PoPs per area. The interconnection on the 2 service PoPs of a same area lets the OLO share its traffic over the 2 Service PoPs for more security. Nevertheless, this is not loadsharing: the OLO must choose himself to which Service PoP he connects each separate End-User line.

To reach a national coverage, the Beneficiary needs at least 1 interconnection in each Ethernet Aggregation area.

The OAL can also be of type “Multichassis LAG OAL”, which can carry a mix of “Shared VLANs” and “Dedicated VLANs”.

5 Interconnection at LEX level

In addition to the connection of the Beneficiary on Service PoP level as described in sections 3 and 4, which allows the Beneficiary to use Bitstream services to connect End-Users of the whole Service Areas, the Beneficiary may also interconnect with Proximus at LEX level.

In case of interconnection of the Beneficiary on a LEX, the interconnection can only transport Ethernet frames of Bitstream connections serviced from that LEX.

In case of interconnection of the Beneficiary on a LEX, Proximus will provide, on behalf of the Beneficiary who will define their dimensioning, types and protection types:

- One or several OLO Access Lines between the Customer Equipment and the Proximus Ethernet Service Switch, sited in this LEX.
- Bandwidth (VLANs) between the IP-DSLAMs of this LEX and the OAL(s) connected to this LEX. These VLANs can be either shared between several End-Users of a Beneficiary in this LEX or dedicated per individual End-User.
- The OAL at LEX level cannot be of type “Multichassis LAG”.
- The OAL at LEX level cannot be of type 10GE.

5.1 With Shared VLANs

This **Bitstream** service offers an Ethernet connectivity between the OLO Access Line connected to the LEX and the xDSL lines in the same LEX.

For VLAN Bandwidths available in function of the service chosen by the OLO, reference is made to section 3.4.

A Shared VLAN of a specific service in a LEX might be connected to an OAL in the same LEX, while another Shared VLAN of another specific service ending in the same LEX is connected to an OAL in the Service PoP. E.g.: Shared VLAN P0 in LEX x is connected to the OAL in the LEX x, while Shared VLAN P5 ending in the same LEX x is connected to the OAL in the Service PoP of the same Service Area.

5.2 With Dedicated VLANs

This **Bitstream** service offers an Ethernet connectivity between the OLO Access Line connected to the LEX and the xDSL lines in the same LEX.

6 QoS specifications

The QoS specifications as set out hereafter are applicable to both Shared VLANs and Dedicated VLANs. They are to be considered indicative values which serve only for reference purposes.

Service quality	Type	VDSL2 (iFEC)
p5	Delay	< 24 ms
	Jitter	< 9 ms
p3	Delay	< 26 ms
	Jitter	/
p1	Delay	< 31 ms
	Jitter	/
p0	Delay	/
	Jitter	/

Maximum Burst Size:

The P5 and P5bis VLAN services have the highest priority in the network and are also designed to offer better performance for jitter and delay sensitive traffic (e.g. voice and real-time traffic). This performance is obtained with a reduced size of the buffers compared to other service qualities. The traffic sent on VLANs P5 and P5bis should take into account that this service is less tolerant to bursts of data. It is advised to send traffic with an appropriate shaping to avoid packet losses. An appropriate shaping can be implemented as follows: for traffic with priority value p5 the shaper shall be configured slightly below the ordered P5 (resp. P5bis) transport bandwidth and the traffic shall be sent with a constant bitrate to avoid packet loss. For p5-tagged traffic on a Shared P5 (resp. P5bis) VLAN the sum of the shaped bandwidths shall stay slightly below the ordered P5 (resp. P5bis) transport bandwidth.

For the other VLAN services, the Maximum Burst Size is equal to the VLAN bandwidth multiplied by the maximum delay (10 ms). Max 80% load on the DSL line.

Main assumptions:

- Averages over 5 min.
- Frame sizes:

p5 service quality	128 octets
p3 service quality	512 octets
p1 service quality	1400 octets

- Ethernet Service speed of 2Mbps.
- Ethernet traffic aligned with VLAN profile.
- Outside saturation, max 80% load on OAL and DSL line. Max 50% p5 service quality.

7 UNI

Unless specified otherwise, this section equally refers to the two types of service: with Shared and with Dedicated VLANs.

7.1 Physical Transport (Layer 0)

The physical layer is VDSL2 over copper line.

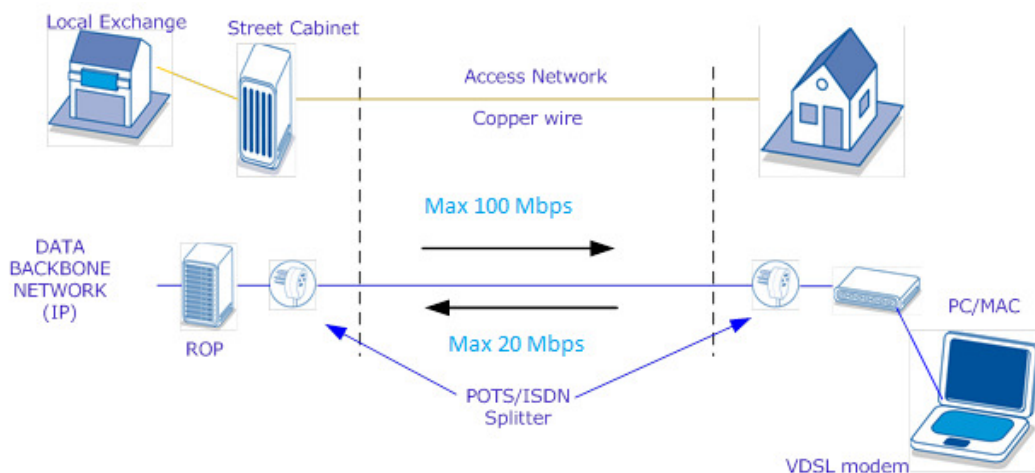
With and without voice products:

- “With voice” means: data service offered in combination with a Proximus PSTN/ISDN line.
- “Without voice” means: data service offered without combination with a Proximus PSTN/ISDN line.

The most recent Proximus Physical specification is called “UNI spec for VDSL2” and can be found at:

<https://www.proximus.com/sites/default/files/Documents/Group/Governance/Regulatory/Transmission%20and%20interface%20characteristics%20of%20VDSL%20service.pdf>

Regarding the VDSL2 framing, VDSL2 offers packet transport (PTM) with 64/65B encapsulation as described within EFM (Ethernet in First Mile) standard and ITU VDSL2 standard ITU-T G.993.2.



Graph 6: Physical layer between End-User and Local Exchange

7.2 DSL profiles at UNI (Layer1)

The following profiles are chosen by Proximus, based on the line quality:

LP ⁴	Upstream Max Net Data Rate	Upstream Max Bit Rate	Downstream Max Net Data Rate	Downstream Max Bit Rate
LP001	n/a	576	n/a	9.064
LP002	n/a	576	n/a	7.564
LP003	n/a	2.064	20.000	n/a
LP008	20.000	n/a	100.000	n/a
LP010	15.000	n/a	100.000	n/a
LP012	10.000	n/a	100.000	n/a
LP013	8.000	n/a	100.000	n/a
LP014	6.000	n/a	100.000	n/a
LP015	5.000	n/a	100.000	n/a
LP016	4.000	n/a	100.000	n/a
LP017	n/a	10.064	100.000	n/a
LP018	n/a	8.064	100.000	n/a
LP019	n/a	6.064	100.000	n/a
LP020	n/a	4.064	100.000	n/a
LP025	20.000	n/a	85.000	n/a
LP027	15.000	n/a	85.000	n/a
LP029	10.000	n/a	85.000	n/a
LP030	8.000	n/a	85.000	n/a
LP031	6.000	n/a	85.000	n/a
LP032	5.000	n/a	85.000	n/a
LP033	4.000	n/a	85.000	n/a
LP034	n/a	10.064	85.000	n/a
LP035	n/a	8.064	85.000	n/a
LP036	n/a	6.064	85.000	n/a
LP037	n/a	4.064	85.000	n/a
LP042	20.000	n/a	70.000	n/a
LP044	15.000	n/a	70.000	n/a
LP046	10.000	n/a	70.000	n/a
LP047	8.000	n/a	70.000	n/a
LP048	6.000	n/a	70.000	n/a
LP049	5.000	n/a	70.000	n/a

⁴ Some profiles (like LP017) that mix an Upstream Max Bit Rate>0 with a Downstream Max Net Data Rate>0 are line profiles with Downstream vectoring on which Upstream is not yet vectored.

LP ⁴	Upstream Max Net Data Rate	Upstream Max Bit Rate	Downstream Max Net Data Rate	Downstream Max Bit Rate
LP050	4.000	n/a	70.000	n/a
LP051	n/a	10.064	70.000	n/a
LP052	n/a	8.064	70.000	n/a
LP053	n/a	6.064	70.000	n/a
LP054	n/a	4.064	70.000	n/a
LP059	20.000	n/a	60.000	n/a
LP061	15.000	n/a	60.000	n/a
LP063	10.000	n/a	60.000	n/a
LP064	8.000	n/a	60.000	n/a
LP065	6.000	n/a	60.000	n/a
LP066	5.000	n/a	60.000	n/a
LP067	4.000	n/a	60.000	n/a
LP068	3.000	n/a	60.000	n/a
LP069	2.000	n/a	60.000	n/a
LP072	n/a	10.064	60.000	n/a
LP073	n/a	8.064	60.000	n/a
LP074	n/a	6.064	60.000	n/a
LP075	n/a	4.064	60.000	n/a
LP076	n/a	3.064	60.000	n/a
LP078	n/a	2.064	60.000	n/a
LP083	20.000	n/a	50.000	n/a
LP085	15.000	n/a	50.000	n/a
LP087	10.000	n/a	50.000	n/a
LP088	8.000	n/a	50.000	n/a
LP089	6.000	n/a	50.000	n/a
LP090	5.000	n/a	50.000	n/a
LP091	4.000	n/a	50.000	n/a
LP092	3.000	n/a	50.000	n/a
LP093	2.000	n/a	50.000	n/a
LP096	n/a	10.064	50.000	n/a
LP097	n/a	8.064	50.000	n/a
LP098	n/a	6.064	50.000	n/a
LP099	n/a	4.064	50.000	n/a
LP100	n/a	3.064	50.000	n/a
LP102	n/a	2.064	50.000	n/a
LP107	20.000	n/a	40.000	n/a
LP109	15.000	n/a	40.000	n/a
LP111	10.000	n/a	40.000	n/a
LP112	8.000	n/a	40.000	n/a
LP113	6.000	n/a	40.000	n/a
LP114	5.000	n/a	40.000	n/a

LP ⁴	Upstream Max Net Data Rate	Upstream Max Bit Rate	Downstream Max Net Data Rate	Downstream Max Bit Rate
LP115	4.000	n/a	40.000	n/a
LP116	3.000	n/a	40.000	n/a
LP117	2.000	n/a	40.000	n/a
LP120	n/a	10.064	40.000	n/a
LP121	n/a	8.064	40.000	n/a
LP122	n/a	6.064	40.000	n/a
LP123	n/a	4.064	40.000	n/a
LP124	n/a	3.064	40.000	n/a
LP126	n/a	2.064	40.000	n/a
LP131	20.000	n/a	30.000	n/a
LP133	15.000	n/a	30.000	n/a
LP135	10.000	n/a	30.000	n/a
LP136	8.000	n/a	30.000	n/a
LP137	6.000	n/a	30.000	n/a
LP138	5.000	n/a	30.000	n/a
LP139	4.000	n/a	30.000	n/a
LP140	3.000	n/a	30.000	n/a
LP141	2.000	n/a	30.000	n/a
LP145	n/a	10.064	30.000	n/a
LP146	n/a	8.064	30.000	n/a
LP147	n/a	6.064	30.000	n/a
LP148	n/a	4.064	30.000	n/a
LP149	n/a	3.064	30.000	n/a
LP151	n/a	2.064	30.000	n/a
LP181	5.000	n/a	20.000	n/a
LP182	4.000	n/a	20.000	n/a
LP183	3.000	n/a	20.000	n/a
LP184	2.000	n/a	20.000	n/a
LP205	5.000	n/a	16.500	n/a
LP206	4.000	n/a	16.500	n/a
LP207	3.000	0	16.500	n/a
LP232	n/a	10.064	n/a	70.200
LP233	n/a	8.064	n/a	70.200
LP234	n/a	6.064	n/a	70.200
LP235	n/a	4.064	n/a	70.200
LP236	n/a	10.064	n/a	60.200
LP237	n/a	8.064	n/a	60.200
LP238	n/a	6.064	n/a	60.200
LP239	n/a	4.064	n/a	60.200
LP240	n/a	10.064	n/a	50.200
LP241	n/a	8.064	n/a	50.200

LP ⁴	Upstream Max Net Data Rate	Upstream Max Bit Rate	Downstream Max Net Data Rate	Downstream Max Bit Rate
LP242	n/a	6.064	n/a	50.200
LP243	n/a	4.064	n/a	50.200
LP244	n/a	10.064	n/a	40.200
LP245	n/a	8.064	n/a	40.200
LP246	n/a	6.064	n/a	40.200
LP247	n/a	4.064	n/a	40.200
LP248	n/a	10.064	n/a	30.064
LP249	n/a	8.064	n/a	30.064
LP250	n/a	6.064	n/a	30.064
LP251	n/a	4.064	n/a	30.064
LP252	n/a	3.064	n/a	30.064
LP254	n/a	2.064	n/a	30.064
LP255	n/a	1.064	n/a	30.064
LP256	n/a	10.064	n/a	25.064
LP257	n/a	8.064	n/a	25.064
LP258	n/a	6.064	n/a	25.064
LP259	n/a	4.064	n/a	25.064
LP260	n/a	3.064	n/a	25.064
LP262	n/a	2.064	n/a	25.064
LP263	n/a	1.064	n/a	25.064
LP264	n/a	10.064	n/a	20.064
LP265	n/a	8.064	n/a	20.064
LP266	n/a	6.064	n/a	20.064
LP267	n/a	4.064	n/a	20.064
LP268	n/a	3.064	n/a	20.064
LP270	n/a	2.064	n/a	20.064
LP271	n/a	1.064	n/a	20.064
LP275	n/a	10.064	n/a	16.564
LP276	n/a	8.064	n/a	16.564
LP277	n/a	6.064	n/a	16.564
LP278	n/a	4.064	n/a	16.564
LP279	n/a	3.064	n/a	16.564
LP281	n/a	2.064	n/a	16.564
LP282	n/a	1.064	n/a	16.564
LP283	n/a	704	n/a	16.564
LP284	n/a	576	n/a	16.564
LP285	n/a	516	n/a	16.564
LP288	n/a	6.064	n/a	14.564
LP289	n/a	4.064	n/a	14.564
LP290	n/a	3.064	n/a	14.564
LP292	n/a	2.064	n/a	14.564

LP ⁴	Upstream Max Net Data Rate	Upstream Max Bit Rate	Downstream Max Net Data Rate	Downstream Max Bit Rate
LP293	n/a	1.064	n/a	14.564
LP294	n/a	704	n/a	14.564
LP295	n/a	576	n/a	14.564
LP296	n/a	516	n/a	14.564
LP300	n/a	4.064	n/a	12.064
LP301	n/a	3.064	n/a	12.064
LP303	n/a	2.064	n/a	12.064
LP304	n/a	1.064	n/a	12.064
LP305	n/a	704	n/a	12.064
LP306	n/a	576	n/a	12.064
LP307	n/a	516	n/a	12.064
LP309	n/a	4.064	n/a	10.100
LP310	n/a	3.064	n/a	10.100
LP312	n/a	2.064	n/a	10.100
LP313	n/a	1.064	n/a	10.100
LP314	n/a	704	n/a	10.100
LP315	n/a	576	n/a	10.100
LP316	n/a	516	n/a	10.100
LP318	n/a	4.064	n/a	9.564
LP319	n/a	3.064	n/a	9.564
LP321	n/a	2.064	n/a	9.564
LP322	n/a	1.064	n/a	9.564
LP323	n/a	704	n/a	9.564
LP324	n/a	576	n/a	9.564
LP325	n/a	516	n/a	9.564
LP327	n/a	4.064	n/a	7.064
LP328	n/a	3.064	n/a	7.064
LP329	n/a	2.264	n/a	7.064
LP330	n/a	2.064	n/a	7.064
LP331	n/a	1.064	n/a	7.064
LP332	n/a	704	n/a	7.064
LP333	n/a	576	n/a	7.064
LP334	n/a	516	n/a	7.064
LP341	n/a	576	n/a	5.064
LP004	40.000	n/a	100.000	n/a
LP005	35.000	n/a	100.000	n/a
LP006	30.000	n/a	100.000	n/a
LP007	25.000	n/a	100.000	n/a
LP009	17.500	n/a	100.000	n/a
LP011	12.500	n/a	100.000	n/a
LP021	40.000	n/a	85.000	n/a

LP ⁴	Upstream Max Net Data Rate	Upstream Max Bit Rate	Downstream Max Net Data Rate	Downstream Max Bit Rate
LP022	35.000	n/a	85.000	n/a
LP023	30.000	n/a	85.000	n/a
LP024	25.000	n/a	85.000	n/a
LP026	17.500	n/a	85.000	n/a
LP028	12.500	n/a	85.000	n/a
LP038	40.000	n/a	70.000	n/a
LP039	35.000	n/a	70.000	n/a
LP040	30.000	n/a	70.000	n/a
LP041	25.000	n/a	70.000	n/a
LP043	17.500	n/a	70.000	n/a
LP045	12.500	n/a	70.000	n/a
LP055	40.000	n/a	60.000	n/a
LP056	35.000	n/a	60.000	n/a
LP057	30.000	n/a	60.000	n/a
LP058	25.000	n/a	60.000	n/a
LP060	17.500	n/a	60.000	n/a
LP062	12.500	n/a	60.000	n/a
LP070	1.500	n/a	60.000	n/a
LP071	1.000	n/a	60.000	n/a
LP077	n/a	2.264	60.000	n/a
LP079	40.000	n/a	50.000	n/a
LP080	35.000	n/a	50.000	n/a
LP081	30.000	n/a	50.000	n/a
LP082	25.000	n/a	50.000	n/a
LP084	17.500	n/a	50.000	n/a
LP086	12.500	n/a	50.000	n/a
LP094	1.500	n/a	50.000	n/a
LP095	1.000	n/a	50.000	n/a
LP101	n/a	2.264	50.000	n/a
LP103	40.000	n/a	40.000	n/a
LP104	35.000	n/a	40.000	n/a
LP105	30.000	n/a	40.000	n/a
LP106	25.000	n/a	40.000	n/a
LP108	17.500	n/a	40.000	n/a
LP110	12.500	n/a	40.000	n/a
LP118	1.500	n/a	40.000	n/a
LP119	1.000	n/a	40.000	n/a
LP125	n/a	2.264	40.000	n/a
LP127	40.000	n/a	30.000	n/a
LP128	35.000	n/a	30.000	n/a
LP129	30.000	n/a	30.000	n/a

LP ⁴	Upstream Max Net Data Rate	Upstream Max Bit Rate	Downstream Max Net Data Rate	Downstream Max Bit Rate
LP130	25.000	n/a	30.000	n/a
LP132	17.500	n/a	30.000	n/a
LP134	12.500	n/a	30.000	n/a
LP142	1.500	n/a	30.000	n/a
LP143	1.000	n/a	30.000	n/a
LP144	800	n/a	30.000	n/a
LP150	n/a	2.264	30.000	n/a
LP152	15.000	n/a	25.000	n/a
LP153	12.500	n/a	25.000	n/a
LP154	10.000	n/a	25.000	n/a
LP155	8.000	n/a	25.000	n/a
LP156	6.000	n/a	25.000	n/a
LP157	5.000	n/a	25.000	n/a
LP158	4.000	n/a	25.000	n/a
LP159	3.000	n/a	25.000	n/a
LP160	2.000	n/a	25.000	n/a
LP161	1.500	n/a	25.000	n/a
LP162	1.000	n/a	25.000	n/a
LP163	800	n/a	25.000	n/a
LP164	15.000	n/a	22.000	n/a
LP165	12.500	n/a	22.000	n/a
LP166	10.000	n/a	22.000	n/a
LP167	8.000	n/a	22.000	n/a
LP168	6.000	n/a	22.000	n/a
LP169	5.000	n/a	22.000	n/a
LP170	4.000	n/a	22.000	n/a
LP171	3.000	n/a	22.000	n/a
LP172	2.000	n/a	22.000	n/a
LP173	1.500	n/a	22.000	n/a
LP174	1.000	n/a	22.000	n/a
LP175	800	n/a	22.000	n/a
LP176	15.000	n/a	20.000	n/a
LP177	12.500	n/a	20.000	n/a
LP178	10.000	n/a	20.000	n/a
LP179	8.000	n/a	20.000	n/a
LP180	6.000	n/a	20.000	n/a
LP185	1.500	n/a	20.000	n/a
LP186	1.000	n/a	20.000	n/a
LP187	800	n/a	20.000	n/a
LP188	15.000	n/a	18.000	n/a
LP189	12.500	n/a	18.000	n/a

LP ⁴	Upstream Max Net Data Rate	Upstream Max Bit Rate	Downstream Max Net Data Rate	Downstream Max Bit Rate
LP190	10.000	n/a	18.000	n/a
LP191	8.000	n/a	18.000	n/a
LP192	6.000	n/a	18.000	n/a
LP193	5.000	n/a	18.000	n/a
LP194	4.000	n/a	18.000	n/a
LP195	3.000	n/a	18.000	n/a
LP196	2.000	n/a	18.000	n/a
LP197	1.500	n/a	18.000	n/a
LP198	1.000	n/a	18.000	n/a
LP199	800	n/a	18.000	n/a
LP200	15.000	n/a	16.500	n/a
LP201	12.500	n/a	16.500	n/a
LP202	10.000	n/a	16.500	n/a
LP203	8.000	n/a	16.500	n/a
LP204	6.000	n/a	16.500	n/a
LP208	2.000	n/a	16.500	n/a
LP209	1.500	n/a	16.500	n/a
LP210	1.000	n/a	16.500	n/a
LP211	800	n/a	16.500	n/a
LP212	15.000	n/a	14.500	n/a
LP213	12.500	n/a	14.500	n/a
LP214	10.000	n/a	14.500	n/a
LP215	8.000	n/a	14.500	n/a
LP216	6.000	n/a	14.500	n/a
LP217	5.000	n/a	14.500	n/a
LP218	4.000	n/a	14.500	n/a
LP219	3.000	n/a	14.500	n/a
LP220	2.000	n/a	14.500	n/a
LP221	1.500	n/a	14.500	n/a
LP222	1.000	n/a	14.500	n/a
LP223	800	n/a	14.500	n/a
LP224	2.000	n/a	12.000	n/a
LP225	1.500	n/a	12.000	n/a
LP226	1.000	n/a	12.000	n/a
LP227	800	n/a	12.000	n/a
LP228	2.000	n/a	11.000	n/a
LP229	1.500	n/a	11.000	n/a
LP230	1.000	n/a	11.000	n/a
LP231	800	n/a	11.000	n/a
LP253	n/a	2.264	n/a	30.064
LP261	n/a	2.264	n/a	25.064

LP ⁴	Upstream Max Net Data Rate	Upstream Max Bit Rate	Downstream Max Net Data Rate	Downstream Max Bit Rate
LP269	n/a	2.264	n/a	20.064
LP272	n/a	704	n/a	20.064
LP273	n/a	576	n/a	20.064
LP274	n/a	516	n/a	20.064
LP280	n/a	2.264	n/a	16.564
LP286	n/a	10.064	n/a	14.564
LP287	n/a	8.064	n/a	14.564
LP291	n/a	2.264	n/a	14.564
LP297	n/a	10.064	n/a	12.064
LP298	n/a	8.064	n/a	12.064
LP299	n/a	6.064	n/a	12.064
LP302	n/a	2.264	n/a	12.064
LP308	n/a	6.064	n/a	10.100
LP311	n/a	2.264	n/a	10.100
LP317	n/a	6.064	n/a	9.564
LP320	n/a	2.264	n/a	9.564
LP326	n/a	6.064	n/a	7.064
LP335	n/a	4.064	n/a	5.064
LP336	n/a	3.064	n/a	5.064
LP337	n/a	2.264	n/a	5.064
LP338	n/a	2.064	n/a	5.064
LP339	n/a	1.064	n/a	5.064
LP340	n/a	704	n/a	5.064
LP342	n/a	516	n/a	5.064

Remark:

- Whilst Legacy profiles are defined with a Maximum speed, Vectoring profiles are defined with a Maximum Net Data Rate (e.g. Line Profile LP042 has a Maximum Net Data Rate of 70 Mbps).

7.3 Ethernet Format on VDSL2

Ethernet format on DSL line:

- Frame format

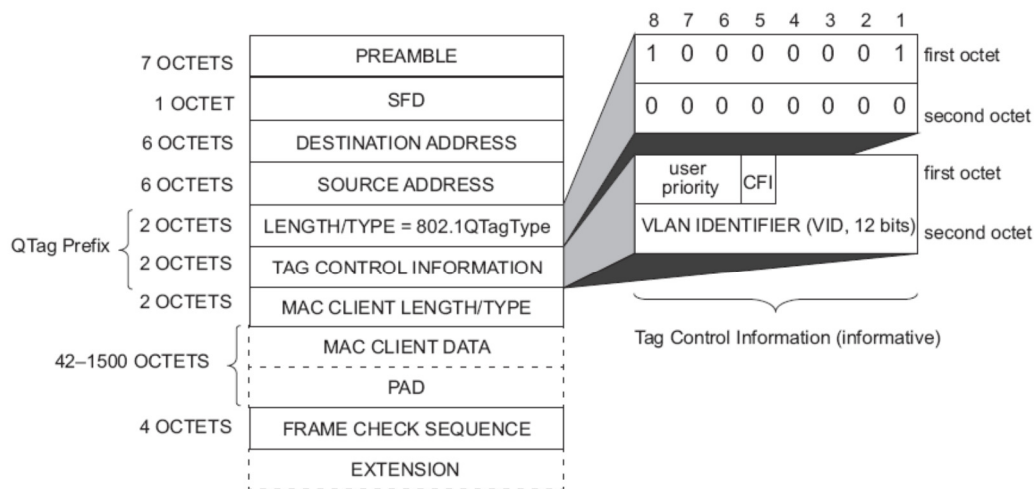


Figure 3-3—Tagged MAC frame format

Graph 7: Tagged MAC frame format

- IEEE 802.1Q also called “Tagged format” (see figure 3-3 from 802.3 – 2005)
- MTU size: the maximum length of the Data – Field (is MAC CLIENT DATA + PAD field in Figure 3-3 from 803.3-2005) is 1500 octets. In case of PPPoE, the PPP header uses 8 octets from those 1500 octets
- Duplex: full duplex (taking into account the asymmetric nature of the VDSL2 physical layer)

7.4 Ethernet Forwarding mechanism

The forwarding mechanism differs in case of Shared or Dedicated VLAN.

The forwarding model for VDSL2 with Shared VLAN can be considered as L2 bridge with additional security features. Within this mode it is possible to associate different logical ports to one Virtual LAN. In the upstream direction, frames are forwarded from a VLAN at the user side to a service VLAN at the network side, with a MAC learning process. In the downstream direction, the frames are forwarded based on the MAC address, with a check on the correctness of the VLAN ID/MAC address usage.

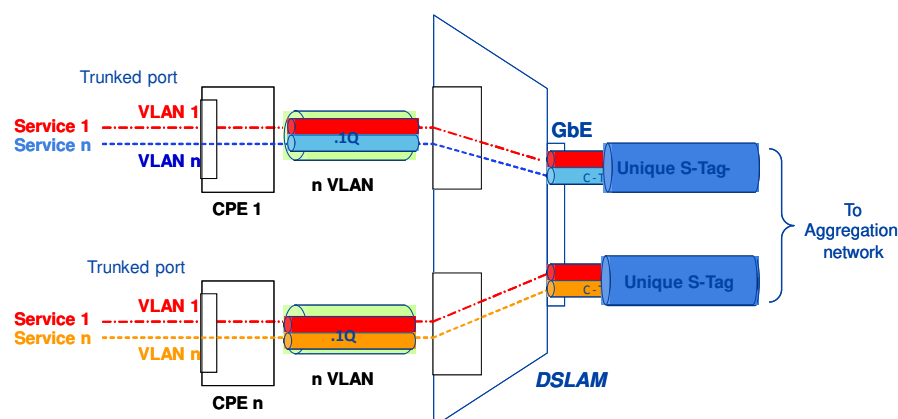
Each subscriber VLAN/Service on UNI is mapped to the Service VLAN(s) of the respective OLO at the uplink of the IP-DSLAM with VLAN Translation.

7.4.2 Dedicated VLAN

The forwarding is transparent for the C-VLANs tags, also for the Management VLAN of the CPE. The Access Node applies an S-Tag per DSL port. The S-Tag must be unique within the Access Node.

The forwarding mode for VDSL2 with Dedicated VLAN can be considered as a (S-VLAN) XC model. In S-VLAN cross-connect mode, two levels of VLAN tags are used:

- the customer VLAN: C-VLAN
- the service provider VLAN: S-VLAN



Graph 9: Ethernet Forwarding Mechanisms on VDSL2 (Dedicated VLANs)

7.5 VLAN ID Allocation and QoS at UNI

The VLAN ID allocation differs in case of Shared or Dedicated VLANs.

7.5.1 Shared VLAN

On UNI it is possible to provision up to 4 VLAN IDs. Proximus will use VLAN 20 for management and upgrade of the CPE.

Mapping Table:

p-bit	0 & 1 *	1	3	5
VLAN ID =	10	50	40	21

Table 2: Mapping p-bit and VLAN ID

* Note about VLAN 10:

Downstream: in the IP-DSLAM, VLAN 10 contains p0 and p1 tagged Ethernet frames, as sent by the Beneficiary. The p1 tagged frames are handled in the IP-DSLAM with the same QoS as p1 tagged frames in VLAN 50.

Upstream: in VLAN 10, the IP-DSLAM retags all Ethernet frames to p0 except DHCP control frames with the p-bit set to p1 by the CPE, which pass transparently.

This VLAN ID scheme is identical for all OLOs.

No multicast Ethernet packets are allowed!

Upstream Marking: p-bit setting on VLAN on bridge port.

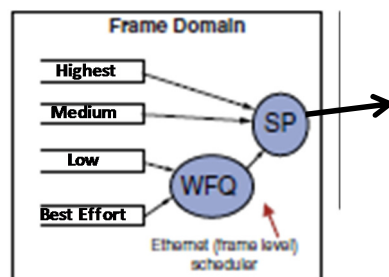
Policing: No policing in upstream in the IP-DSLAM.

Downstream Scheduling:

Hierarchical scheduler:

- P=0: best effort.
- P=1: low priority.
- P=3: medium priority.
- P=5: highest priority.

The highest two priorities (highest priority and medium priority) are served by a Strict Priority (SP) mechanism, assuring that these – mostly – real-time applications do not suffer from too large delays. “Best effort” and “low priority” Ethernet frames compete for bandwidth in a fair manner. The weight of the low priority queue = 66%.



Graph 10: Scheduling mechanism on VDSL in downstream

7.5.2 Dedicated VLAN

Any VLAN at UNI (is C-VLAN ID) is transparently enveloped by the S-tag and not configured neither visible in the Proximus network⁵.

QoS: the OLO shall associate 1 VDSL2 VLAN profile to every VDSL2 line.

The OLO can associate profiles coming from two pools to every VDSL2 line:

- The OLO can define an own pool with up to 10 Dedicated VDSL2 VLAN profiles (for its own use);
- The OLO can choose from a common pool of Dedicated VDSL2 VLAN profiles. These can be used by all OLOs. The specifications of the profiles and the related processes are documented on the secured part of the Proximus wholesale website (in the section “Operational Documentation” of the Regulated Services menu with respect to the present service).

One “VDSL2 VLAN profile” has the following attributes:

- Layer 2 (p-bit) or Layer 3 QoS (IP-precedence), applicable for both upstream and downstream
- P-bit
- Maximum Upstream bandwidth per p-bit (bandwidth p0, bandwidth p1, bandwidth p3, bandwidth p5)
- Maximum Downstream bandwidth per p-bit (bandwidth p0, bandwidth p1, bandwidth p3, bandwidth p5)

The attributes of a VDSL2 VLAN profile are identical for all VDSL2 End-User lines using this profile.

The 4 QoS classes applicable to an Ethernet packet are the same as for the “Shared VLAN” service:

- P=0: best effort.
- P=1: low priority.
- P=3: medium priority.
- P=5: highest priority.

The upstream and downstream Ethernet flows are policed following the VDSL2 VLAN profiles.

The service primarily offers a layer 2 QoS, but in order to accommodate customer equipment that is not able to set p-bits, a one-to-one mapping between each p-bit value (0, 1, 3 & 5) and one corresponding Layer 3 “IP-precedence” value is established upon agreement between the OLO and Proximus about the “VDSL2 VLAN profile”.

E.g.: precedence bits “1” may be set as equivalent for p-bit 1. In this case, the bandwidth of “precedence 1” IP packets will be policed instead of the bandwidth of p-bit 1 Ethernet frames.

In the case of a Layer 3 QoS, all p-bits shall be set to 0 or shall be lower than the corresponding Layer 3 class. E.g.: in case of Layer 3 VDSL2 VLAN profiles, lowest priority Layer 3 packets shall not be Layer 2 tagged to p=5.

The VDSL2 VLAN profile is policing all Ethernet packets of the Dedicated VLAN and cannot differentiate following e.g. the C-tag.

Some retagging rules are applied differently for “Layer 2” and “Layer 3” Dedicated VLANs.

⁵ Also applicable for the VLAN for the VDSL2 modem management (see section “Modem”). Therefore the OLO customer shall not use this VLAN.

For “Layer 2” Dedicated VLANs:

Layer 2 frames with non-conforming p-bit values are retagged to the lowest priority as defined in the VDSL2 VLAN profile.

For example, the application of this rule to a single p-bit Layer 2 VDSL2 VLAN profile implies that all frames carry this single p-bit.

For “Layer 3” Dedicated VLANs:

Layer 3 IP-packets with non-conforming “IP-precedence” values (i.e. “IP-precedence” values without associated bandwidth in the VDSL2 VLAN profile) are not remapped to the corresponding Layer 2 p-bit value: the p-bit of these frames, which carry the L3 IP-packets as payload, is tagged to the lowest priority as defined in the VDSL2 VLAN profile.

For example, the application of this rule to a single “IP-precedence” value Layer 3 VDSL2 VLAN profile implies that all Ethernet frames carry this single p-bit value but the “IP-precedence” values of the transported IP-packets remain unchanged.

It is the responsibility of the OLO to underbook, match or overbook the instantaneous available physical bandwidth on the VDSL2 line (upstream and downstream). It is recommended not to overbook higher QoS bandwidths (P5, P3, P1).

7.6 Line Identification

7.6.1 Dedicated VLAN

Not applicable: the IP-DSLAM doesn’t add any Line IDs to eventual PPP or DHCP frames. The VLAN-ID @ OAL + OAL identity sufficiently define the identity of the line.

7.6.2 Shared VLAN

Line identification will be enabled for both PPPoE and IPoE (DHCP) on each service VLAN of the OLO.

IPoE:

For IPoE access, per service VLAN a layer 2 DHCP relay function is implemented on the DSLAM as described within DSL Forum TR-101. The DHCP packet format is specified in RFC 2131. The DHCP Relay Agent Information option (option 82) format is specified in RFC 3046.

In upstream, the access loop identification will be encoded within the “Agent Circuit ID” sub-option 1 of DHCP Option 82 during the DHCP session setup.

In downstream, the DSLAM will remove DHCP option 82.

PPPoE:

For PPPoE access, per service VLAN the PPPoE Intermediate Agent function is implemented on the DSLAM as described within DSL Forum TR-101.

In upstream, the access loop identification will be encoded within the “Agent Circuit ID” sub-option 1 of the PPPoE vendor specific tag in the discovery messages (PADI, PADR, PADT) of the PPPoE protocol.

Format agent circuit ID for IPoE and PPPoE:

"<Access-Node-Identifier> eth <rack>/<shelf>/<slot>/<dsl-line>:<vlan>"

Example: H02NOR00001 eth 3/2/01/06:20

7.7 Security

This chapter documents the known limitations based on tests performed on the IP-DSLAM firmware R.5.6.02x. Planned IP-DSLAM firmware upgrades will be preceded with tests which validate whether the limitations remain unchanged or not :

- The currently documented known limitations remain valid after IP-DSLAM firmware upgrades if the tests confirmed they remain unchanged.
- The currently documented known limitations will be adapted if a planned IP-DSLAM firmware upgrade adds, changes or removes limitations.
- Would new limitations be discovered on the active IP-DSLAM firmware then the Beneficiaries will be immediately informed of it and the currently documented known limitations will be adapted accordingly afterwards.

7.7.1 Limitations

Known limitations on the IP-DSLAM firmware are:

Protocol	Shared VLAN	Dedicated VLAN
802.1x	Blocked	Transparent
ARP	Policed ⁶	Policed ⁶
RIP	Policed ⁶	Policed ⁶
CFM	Policed ⁶	Transparent
ICMP	Policed ⁶	Transparent
DHCP	Policed ⁶	Transparent
IGMP	Policed ⁶	Transparent
PPPoEDiscovery	Policed ⁶	Transparent
PPP LCP	Transparent	Transparent
PPP control	Transparent	Transparent
PPP LCP termination ack	Transparent	Transparent

⁶ For security reasons, parameters will not be publicly shared. Beneficiary shall contact Proximus if he has the need to receive this information.

- Shared VLAN refers to the residential bridge forwarding mode.
- Dedicated VLAN refers to S-VLAN CC.

L2CP (Layer 2 Control Protocol) PAUSE frames are blocked.

This behaviour is subject to change due e.g. to CPE, IP-DSLAM or aggregation network software upgrade.

Reference is made to the chapter “Modem” for the known limitations of the A-modem configured for “Dedicated VLAN”.

7.7.2 Dedicated VLAN

- Rate limiting control plane (ARP, RIP...). See table in section “Limitations”.
- Layer 2 Control Protocol (L2CP) handling:

L2CP frames	
Frames with following destination MAC@ <ul style="list-style-type: none"> • 01-80-C2-00-00-00 through 01-80-C2-00-00-0F • 01-80-C2-00-00-10 • 01-80-C2-00-00-20 through 01-80-C2-00-00-2F 	Forward
PAUSE frames with following MAC@ 01-80-C2-00-00-01	Blocked

- Transparency of the types of IEEE L2CP frames as listed in the table above has been validated upon Destination MAC address of the L2CP frame, but not on any other field of the L2CP frame.

MAC learning has been disabled on the bridge port of the VDSL2 line-board. For security reasons, further information will not be publicly shared. Beneficiary shall contact Proximus if he has the need to receive the information.

7.7.3 Shared VLAN

- No U2U communication
- Prevention of Broadcast storm:
 - o Downstream:
 - Broadcast frames are dropped.
 - Ethernet frames with unknown destination MAC@ are dropped.
Ageing timer bridge = 900s (=> application shall send a message upstream at startup and every x sec, x<900, in order to keep joinable from the network)
 - o Upstream:
 - Rate limiting control plane (DHCP, IGMP, ARP...). See table in section “Limitations”.
 - Discard L2CP frames (STP, Pause frames...).
 - Multicast blocking.

- Maximum number of MAC@ per DSL port=8
- MAC anti spoofing

8 Technical specifications for the use of distribution cables to provision Bitstream VDSL2

The use of the return pairs of the distribution cables, either in ring topology or not, to deliver a Bitstream VDSL2 service towards the End-User premises is submitted to the limitations regarding distribution cables defined in the Annex C “Technical Specifications” of BRUO, in the section “Common technical specifications for the equipment to be connected to the loop”, sub-section “VDSL2”.

9 Technical specifications for the equipment to be connected on Bitstream VDSL2

In order to use Bitstream VDSL2, the OLO must respect the technical specifications regarding internal cabling defined in the Annex C “Technical Specifications” of BRUO, in the section “Common technical specifications for the equipment to be connected to the loop”, sub-section “VDSL2”.

10 NTP & Splitters

Reference is made to the chapter “Network Termination Point for VDSL2” in the Main Body.

11 Modem

11.1 Possible modems

The modem used by the End-User must be in conformity with the applicable standardization and must be interoperable with the Proximus network. The Beneficiary has two options:

- The Beneficiary can use a standard modem (called Proximus CPE) offered by Proximus. This modem is supported on the Proximus network and may be installed at End-User side in combination with the Bitstream VDSL2 service. Proximus offers the following types of Proximus CPE:
 - The Sagemcom F@ST 3464 configured by SAGEMCOM for the Bitstream VDSL2 service. The technical description of this Proximus CPE is detailed in the section “Technical Description of the Proximus CPE type Sagemcom”. Proximus has discontinued the delivery of this type of modem.
 - The Next Generation Home Gateway (NGHGW CPE) and the NGHGW+ CPE intended for use in a one-box configuration. The technical description of this Proximus CPE is detailed in the section “Technical description of the Proximus CPE type NGHGW and NGHGW+”.
 - Note that Proximus will no longer sell the current NGHGW once the NGHGW+ CPE is launched.
 - The Access Modem (also called A-modem) intended for use in a two-box configuration. The technical description of this Proximus CPE is detailed in the section “Technical description of the Proximus CPE type A-Modem”.
- The Beneficiary can use his own modem (called OLO CPE) that will operate in a similar manner as a standard Proximus CPE. In this case, specific Roles and Responsibilities apply. They are described in Annex 7: Roles & Responsibilities throughout the OLO CPE lifecycle.

11.1.1 Firmware upgrades

The use of a Bitstream End-User line requires that the modem at the End-User side is kept up-to-date. Inappropriate firmware versions lead to perturbations on other VDSL2 lines.

Proximus regularly performs remote upgrades on all Proximus CPE that are upgradable to bring them to the appropriate firmware version. Nevertheless, some of the modems are not upgradable by the Proximus upgrade platform. **The Beneficiary is responsible to upgrade or replace the non-upgradable modems on request of Proximus 4 months after a request (for Shared VLAN and Dedicated VLAN).** Proximus therefore communicates to the Beneficiary a list of non-upgradable modems and the possible solutions to upgrade them.

Proximus CPE can be non-upgradable for the following reasons:

- The management VLAN is not accessible by Proximus on a Bitstream Dedicated VLAN product,
- The management VLAN has been de-activated by the OLO,
- There is a bug in the modem firmware,
- A wrong firmware has been installed,
- The OLO has not upgraded the rescue firmware and the operational firmware to the same version,
- Possible other causes.

The timeline used by Proximus to communicate all necessary information is the following:

Timing	Process
4 months before deadline	Proximus provides OLO with: <ul style="list-style-type: none"> - Request to upgrade CPE, - List of the CPE to be upgraded, - Process on how to upgrade the CPE, - New CPE firmware.
Deadline	As from this deadline, Proximus can assign a fall-back line profile on End-User lines with a non-compliant CPE that could impact other End-User lines.

11.1.2 Non-compliant CPE

Non-compliant CPE impact other End-Users. Therefore, after the upgrade deadline, Proximus reserves the right to **change the service delivered to a fall-back profile** for all the End-Users with a non-compliant CPE.

A non-compliant CPE is

- Proximus CPE: a CPE with an outdated firmware,
- OLO CPE: a CPE with a firmware that does not comply with the obligations described in the Annex "Roles & Responsibilities throughout the OLO CPE lifecycle" of the present reference offer,
- Other cases: all CPE that are not described in this offer.

11.1.3 Connection of a CPE to the network

When a **new CPE** is connected to the network, it should be in the **latest version of the appropriate Bitstream VDSL2 firmware**. The Beneficiary therefore has to upgrade the CPE to the latest firmware version provided by Proximus if needed. The Beneficiary has to make sure that the upgrade occurred correctly before the connection.

11.2 Technical description of the Proximus CPE type Sagemcom

The modem configured by SAGEMCOM for the Bitstream VDSL2 service (Proximus CPE) is based on the generic SAGEMCOM F@st3464. All information on this product must be requested directly by the Beneficiary to SAGEMCOM.

11.2.1 Configuration for the Bitstream VDSL2 offer with Shared VLANs

Proximus has specified for this modem a firmware interoperable with its Bitstream VDSL2 service with Shared VLANs. The specific settings for this modem are listed hereafter.

11.2.1.1 Specific configuration

- The CPE shows a GUI, which allows the choice between 2 options:
 - Option 0: all 4 Ethernet ports of the CPE are routed to the High Speed Internet Access VLAN (VLAN 10).
 - Option 1: transparent L2 bridging for 4 Ethernet services with Layer 2 QoS.
- The VLAN 20 is used by Proximus for remote management. This will allow Proximus to upgrade the VDSL2 datapump of this specific SAGEMCOM modem model.
- The TR-069 parameters are configured so that the TR-069 client of the CPE contacts the Proximus TR-069 ACS server via the management VLAN (VLAN 20).

11.2.1.2 Firmware upgrades

VDSL2 technology is currently a work in progress. Since the VDSL2 datapump is expected to evolve after the product launch, Proximus will possibly upgrade remotely the firmware of this specific SAGEMCOM modem, after its installation at End-User site. Only the datapump part of the firmware will be modified.

The firmware upgrade will preserve the PPP settings of the SAGEMCOM modem.

Until interoperability of the VDSL2 technology, the OLO may not modify the firmware of this modem.

11.2.2 Configuration for the Bitstream VDSL2 offer with Dedicated VLANs

Proximus has specified for this modem a firmware interoperable with its Bitstream VDSL2 service with Dedicated VLANs. The specific settings for this modem are listed hereafter.

11.2.2.1 Specific configuration

The VDSL2 modem connects the (“C-VLANs”) VLANs between the VDSL2 line and the End-User CPE. The interface with the CPE is 100Mbps and is in trunked mode only (IEEE 802.1Q) (No native Ethernet).

Known limitations in the Proximus CPE SAGEM F@ST 3464 configuration for “Dedicated VLAN” are:

- MAC learning in the CPE limits to 256 the number of learned MAC addresses. Beneficiary shall contact Proximus if it has the intention to exceed this limitation.
- Some “C-VLANs” are blocked in the modem:
 - VLAN 1, which is advised not to use, because CPEs use it often as default.
 - VLAN 4090 (remote management & upgrade of modem)

For confidentiality reasons, further information on bugs will not be publicly shared.

11.2.2.2 Firmware upgrades

VDSL2 technology is currently a work in progress. Since the VDSL2 datapump is expected to evolve after the product launch, an upgrade of the firmware of this specific VDSL2 modem, after its installation at End-User site, or remotely via VLAN 4090, is possible. Only the datapump part of the firmware will be modified.

Since all VLANs (also the management VLAN 4090 of the VDSL2 modem) are transparently transported to the OAL and further to the OLO network, Proximus cannot perform this firmware upgrade. The OLO will be responsible to upgrade the Bitstream VDSL2 Dedicated VLAN CPE as explained in the section 'Firmware Upgrades' of the Main Body of the present reference offer.

Proximus practice (for information):

- use VLAN 4090 (C-tag) for IP connectivity between VDSL2 modem and OLO network
- use static IP address (/23) on Sagemcom
- use TFTP for firmware upgrades on SAGEMCOM CPE; no DHCP
- Password protected

11.3 Technical description of the Proximus CPE type NGHGW and NGHGW+

The VDSL2 home gateways are specifically developed for Proximus. They are intended for use in a one-box configuration.

They offer the following features:

- DSL/WAN Interface:
 - ADSL/2/+
 - VDSL2
 - DSM (Vectoring)
 - WAN Gigabit Ethernet (RJ45)
- Interface LAN :
 - 4x Gigabit Ethernet
 - 2x USB 2.0
 - 2 ports FXS (RJ11 ports to plug Analog phone)
 - Wifi B/G/N
- IP & routing
 - O&M: remote management via TR181 (= next gen TR69)
 - IPv4 & IPv6 dual stack
 - LAN QoS
 - WAN QoS
- Resident services
 - User friendly interface
 - VoIP IP phones “ready”
 - Wholesale VoIP
 - DynDNS
- Architecture & powering
 - Power consumption: Energy Code of Conduct V4
 - Software modularity: more flexible SW rollout
- Branding
 - No branding for the NGHGW

The following additional functionalities are only applicable to the NGHGW+ CPE:

- Interface LAN :
 - Wifi B/G/N/AC
- Resident services
 - Built-in DECT base station
- Branding
 - The NGHGW+ is only available in a Proximus branded version

11.3.1 Configuration of the NGHGW for the Bitstream VDSL2 offer with Shared VLAN

Proximus has specified for this modem a configuration interoperable with its Bitstream VDSL2 service with Shared VLANs. The specific settings for this modem are listed hereafter.

11.3.1.1 Specific configuration

By default all 4 Ethernet ports of the CPE are routed to the High Speed Internet Access VLAN (VLAN 10).

The VLAN 20 is used by Proximus for remote management. This will allow Proximus to upgrade the Firmware including the VDSL2 datapump of the NGHGW.

The TR-069 parameters are configured so that the TR-069 client of the CPE contacts the Proximus TR-069 ACS server via the management VLAN (VLAN 20).

11.3.1.2 Firmware upgrades

VDSL2 technology is currently a work in progress. Since the VDSL2 datapump is expected to evolve after the product launch, Proximus will possibly upgrade remotely the firmware of this specific NGHGW modem or NGHGW+ modem, after its installation at End-User site.

The firmware upgrade will preserve the PPP settings of the NGHGW modem and the NGHGW+ modem.

11.3.2 Configuration of the NGHGW(+) for the Bitstream VDSL2 offer with Dedicated VLAN

It is not foreseen to use the NGHGW nor the NGHGW+ in combination with Bitstream VDSL2 Dedicated VLAN. Proximus does not provide support for this combination.

11.4 Technical description of the Proximus CPE type A-modem

This VDSL2 A-Modem is specifically developed for Proximus. It is intended for use in a two-box configuration where this A-modem acts as bridge between the WAN and a second device (OLO-box) offering local services.

The A-modem offers the following features:

- DSL/WAN Interface:
 - ADSL/2/+
 - VDSL2
 - DSM (Vectoring)
- Interface LAN :
 - 4x Gigabit Ethernet
- IP & routing
 - Pure pass-through (bridging)
 - O&M: remote management via TR181 (= next gen TR69)
- Branding
 - No branding

11.4.1 Configuration of the A-modem for the Bitstream VDSL2 offer with Shared VLAN

Proximus has specified for this modem a configuration interoperable with its Bitstream VDSL2 service with Shared VLANs. The specific settings for this modem are listed hereafter.

11.4.1.1 Specific configuration

Transparent L2 bridging for 4 Ethernet services with Layer 2 QoS.

The VLAN 20 is used by Proximus for remote management. This will allow Proximus to upgrade the Firmware including the VDSL2 datapump of the A-modem.

The TR-069 parameters are configured so that the TR-069 client of the CPE contacts the Proximus TR-069 ACS server via the management VLAN (VLAN 20).

11.4.1.2 Firmware upgrades

VDSL2 technology is currently a work in progress. Since the VDSL2 data pump is expected to evolve after the product launch, Proximus will possibly upgrade remotely the firmware of this specific NGHGW modem, after its installation at End-User site.

The firmware upgrade will preserve the settings of the A-modem.

Until interoperability of the VDSL2 technology, the OLO may not modify the firmware of this modem.

11.4.2 Configuration of the A-modem for the Bitstream VDSL2 offer with Dedicated VLAN

Proximus has specified for this modem a firmware interoperable with its Bitstream VDSL2 service with Dedicated VLANs. The specific settings for this modem are listed hereafter.

11.4.2.1 Specific configuration

The VDSL2 modem connects transparently the VLANs between the VDSL2 line and the customer CPE. The interface with the CPE is 1Gbit/s and is in trunked mode (IEEE 802.1Q).

VLAN20 or VLAN 4090 are used for remote management and firmware upgrade.

11.4.2.2 Limitations

Known limitations in the A-modem configuration for “Dedicated VLAN”:

Known limitations related to IEEE L2CP transparency using the A-modem for “Dedicated VLAN”⁷:

⁷ Tested on firmware version 10.5.L.4.AW

	DA Ethernet	A-mod Upstream
Pause Frames	01-80-c2-00-00-01	blocked
LACP/LAMP	01-80-c2-00-00-02	Policed ⁶
802.3 ah	01-80-c2-00-00-02	Policed ⁶
Port authentication	01-80-c2-00-00-03	Policed ⁶
E-LMI	01-80-c2-00-00-07	Policed ⁶
LLDP	01-80-c2-00-00-0E	Policed ⁶
MMRP	01-80-c2-00-00-20	Policed ⁶
MVRP	01-80-c2-00-00-21	Policed ⁶

- Transparency of the types of IEEE L2CP frames as listed in the table above has been validated upon Destination MAC address of the L2CP frame but not on any other field of the L2CP frame.
- MAC learning in the CPE limits to 4000 the number of learned MAC addresses. However, MAC-learning capabilities for all users within the network are not unlimited. Therefore, Beneficiary shall contact Proximus if it has the intention to exceed the 256 MAC addresses limitation.
- Some “C-VLANs” are blocked in the modem:
 - The Local Management VLAN which is set to VLAN tag 4091
 - The Remote Management VLAN which the Beneficiary can choose to:
 - Configure to be either VLAN 20 or VLAN 4090 leaving the other VLAN to be configured transparently
 - or
 - Disable to configure both VLAN 20 and VLAN 4090 so that they are transparently transported.

11.4.2.3 Firmware upgrades

VDSL2 technology is currently a work in progress. Since the VDSL2 data pump is expected to evolve after the product launch, an upgrade of the firmware of this specific VDSL2 modem, after its installation at End-User site, or remotely via VLAN 20 or VLAN 4090, is possible. Only the data pump part of the firmware will be modified.

Since all VLANs (also the management VLAN (VLAN 20 or VLAN 4090) of the VDSL2 modem) are transparently transported to the OAL and further to the OLO network, Proximus cannot perform this firmware upgrade.



The detailed procedure is provided on the e-dedicated library.

12 OLO Access Line

The following bandwidths and protection modes are possible :

- Standard OAL:
 - 1 GE,
 - 1+1 GE, capacity is 1Gig; 1 GE is working and 1GE is standby,
 - 10 GE,
 - 10GE + 10GE, capacity is 10Gig; one 10GE is working and one 10GE is standby.
- Multichassis LAG OAL:
 - 1 +1 GE, capacity is 1Gig; 1 GE is working and 1GE is standby,
 - 10GE + 10GE, capacity is 10Gig; one 10GE is working and one 10GE is standby.

Prerequisites:

- LAG and LACP at OLO router must be configured on the LAG.
- Proximus LACP shall peer with LACP on the LAG of the OLO router (i.a. transparency for LACP is required on both links of the MC LAG OAL).
- Correct functioning shall be tested first on a test OAL.

Ethernet aspects of 1GE & 10GE port:

- MAC frame format for “Shared VLAN”: IEEE 802.1Q also called “Tagged format” (see figure 3-3 from 802.3 – 2005)

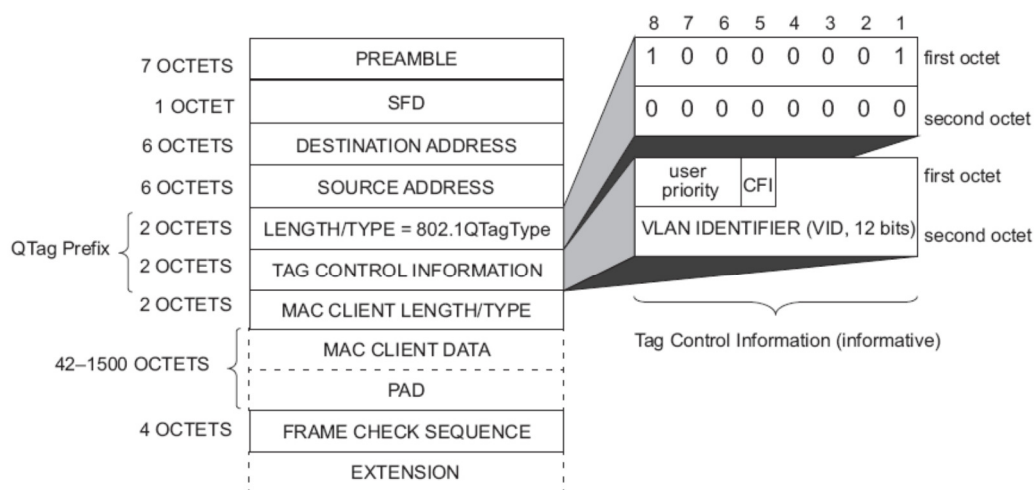
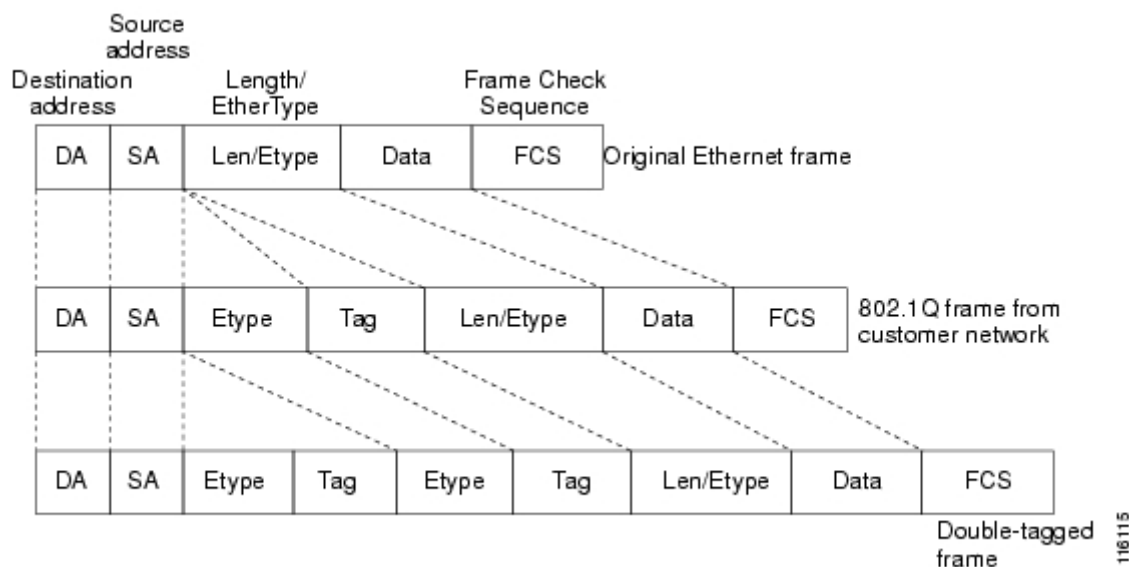


Figure 3-3—Tagged MAC frame format

Graph 11: Tagged MAC frame format

- MAC format for “Dedicated VLAN”

In case of Dedicated VLAN, an S-Tag will be added to the C-tags on the VDSL2 line, following IEEE802.1ad (“Q in Q”). The latter are transparently carried by the Proximus core Ethernet network.



- The Physical connectivity for 1 GE and 10GE is specified in (IEEE 802.3z) and for multiple GE's, bundled in LAG⁸, using LACP⁹, as specified in (IEEE 802.3ad).
- MTU size: the maximum length of the Data – Field (is MAC CLIENT DATA + PAD field in Figure 3-3 from 803.3-2005) is 1500 octets. In case of PPPoE, the PPP header uses 8 octets from those 1500 octets.
- Duplex: full duplex (taking into account the asymmetric nature of the VDSL2 physical layer).
- Autonegotiation: **OFF (ON for 10GE)**.

12.1 Proximus-Sited

Optical: 1 GigE type LX; wavelength 1310nm; Range 10Km

Optical: 10GigE type LR; wavelength 1310nm; Range 10Km

Connectivity: 1GE and 10GE

In the colocation, the OLO can connect to an Optical Distribution Frame. The standard optical connector at Proximus will be **SC/APC 8°**.

It is available at Proximus as 900μ pigtail which needs to be fusion spliced on the fiber (4m of 900μ fiber, 2* SC/APC installed, meant to be cut in two and spliced on the fiber).

12.2 Customer-Sited

Optical: 1 GigE type LX; wavelength 1310nm; Range 10Km

⁸ LAG = Link Aggregation (also 1 GE/10GE will be configured in LAG, in order to be able to add easily other GE's).

⁹ LACP= Link Aggregation Control Protocol (not activated for 1 single GE/10GE).

Optical 10GE: choice amongst :

- 10GigE type LR; wavelength 1310nm; Range 10Km
- 10GigE type SR multimode

Connectivity

The Optical Line Termination (e.g. OSN1800) will be installed by Proximus in the Proximus rack.

The OLO can connect using male Optical SC/PC connectors (= default) or LC/PC connectors on his request.

12.3 Backhaul

Optical: 1 GigE type LX; wavelength 1310nm; Range 10Km

Optical: 10GigE type LR; wavelength 1310nm; Range 10Km

Connectivity

In the colocation, the OLO can connect to an Optical Distribution Frame. The standard optical connector at Proximus will be **SC/APC 8°**.

It is available at Proximus as 900µ pigtail which needs to be fusion spliced on the fiber (4m of 900µ fiber , 2* SC/APC installed, meant to be cut in two and spliced on the fiber).

12.4 Testing the OAL

The testing of the OAL is in 3 phases:

- stand alone from Optical Modem to Optical Modem (only in case of Customer-Sited)
- RFC 2544 test (only in case of Customer-Sited)
- ping test between Proximus access router and Beneficiary router: 1000 pings of 64bytes (may loose 2 pings); 1000 pings of 1500bytes (may loose 2 pings); (10exp -9 quality)

This last phase could be the equivalent of the ATM Access Line tests also defined in the Bitstream offer.

It could be implemented as follows:

1. Proximus temporarily provides an IP address to the OLO for the tests (Bitstream VDSL2 does not offer IP connectivity => no IP addresses); the OLO implements it as loopback address on the OLO Router.
2. Make the ping test described above and let the OLO do the same ping test from his side.
3. Exchange the results.
4. The OLO deconfigures the IP address; it will be reused for other OLO tests (other OLOs and / or other OALs).

12.5 VLAN ID allocation on the OAL

Shared VLAN: for the Bitstream VDSL2 service, Proximus allocates the VLAN ID in the range 120 to 799.

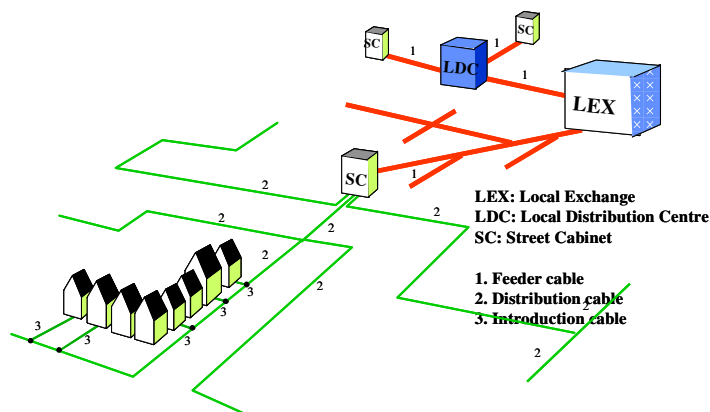
Dedicated VLAN: S-tags 800 – 4095.

The Ethernet tests use VLANs 100 and 101 (at delivery and in case of later problems).

13 Characteristics of Cabling - Transmission properties of the access network

13.1 Generalities

A subscriber loop consists of sections of twisted pairs cables of different gauges. All the sections are buried and connected together by means of electrical joints, called splices, directly placed in the ground or sometimes in a manhole.



In the ideal situation, the Access Network has a star configuration with the feeder cable bundles going from the main distribution frame to the street cabinet. From the street cabinet, via distribution cables and drop wires, the wire pairs are terminated at the NTP (Network Termination Point) in the individual customer sites. The reality shows that cable arrangements lead sometimes to a meshed structure in the feeding network.

Each telecom cable consists of a number of copper conductors grouped in quads; these quads can be arranged in bundles or in layers, depending on the type of cable.

13.2 Physical characteristics of the cables

A conductor can be isolated by a layer of paper (in the old generation cables) or synthetic material, usually polyethylene.

Most of the conductors have a 0.5 mm or 0.6 mm diameter; distant customers however need to be connected via conductors of 0.8 and 1.0 mm; 2000 pairs cables going out of the central office are sometimes made of 0.4 mm conductors.

In paper insulated cables, the conductors are surrounded by a lead sheath, generally protected by armoring and polyethylene sheath.

In plastic insulated cables used in the distribution network, the conductors are surrounded by a polyethylene sheath.

In plastic insulated cables used in the feeding network, the conductors are surrounded by an aluminium screen, a polyethylene internal sheath, an armoring and a polyethylene external sheath.

The plastic cables are in the majority of the cases longitudinally waterproof.

13.3 Electrical characteristics of the cables

The table below gives some typical characteristics of the access network cables [figures given by the cable manufacturers or by measurements in the field]:

Diameter	LR	KC	A800	A40.000	A150.000	A300.000
0.4 mm	275	55	2.0	7.5	11.5	14.5
0.5 mm	180	50-55	1.3	6	9	11
0.6 mm	123	38.5-46	1.0	4	6	8
0.8 mm	69	38.5	0.7	2.5	4	5.5

LR = Loop Resistance in ohm/km

KC = average Kilometric Capacity in nF/km (it depends on the type of cable)

A800 = Attenuation measured at 800 Hz in dB/km

A40.000 = Attenuation measured at 40.000 Hz in dB/km

A150.000 = Attenuation measured at 150.000 Hz in dB/km

A300.000 = Attenuation measured at 300.000 Hz in dB/km

NB: the attenuation values are conditional. The reader must note that these figures are given for cable. A loop is made of several pieces of cables and then additional attenuation and reflections due to the splices and the different cable gauges will occur.

The insulation resistance between the 'a' and 'b' wires of a pair (without terminal equipment) or between wire and earth is supposed to be at least 750 kohms.

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