WORKING TEXT

Draft
WT-156
Using GPON Access in the context of TR-101

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Version History

Version Number	Date	Version Editor(s)	Changes
0.1	November 2006	Lior Yeheskiel – ECI and Tom Anschutz - BellSouth	Initial proposed draft – accepted at 4Q06 meeting in Atlanta.
0.2	March 2007	Tom Anschutz – AT&T et. al.	This version folded-in textual contributions to the WT in the 1Q07 meeting in Vancouver.
1.0	March 2007	Tom Anschutz – AT&T	This version represents the updates made in review at the 1Q07 meeting in Vancouver. It also incorporates the DSLF standard formatting and layout.
1.1	May 2007	Lior Yeheskiel – ECI Telecom	This version folded-in textual contributions to the WT in the 2Q07 meeting in Beijing.
2.0	July 2007	Tom Anschutz – AT&T	This version represents the updates made in review at the 2Q07 meeting in Beijing. Comments and contributions that were folded in – but not addressed are retained.
2.1	August 2007	Tom Anschutz – AT&T	This version folded-in textual contributions to the WT in the 3Q07 meeting in Nashville. Exception is 525 and 581, which seem to need individual review.
3.0	September 2007	Tom Anschutz – AT&T	This version represents the updates made in review at the 3Q07 meeting in Nashville. Comments and contributions that were folded in – but not addressed are retained.
3.1	December 2007	Tom Anschutz – AT&T	Editorial updates as tracked – except new cover page created without tracking. Incorporated contributions to Lisbon: 667, 683.02, 691, 740, 777, 795, 799, 800, 809. Not included - but noted in sections where applicable: 692, 747, 766, 778, 793
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Summary

This Technical Report provides architectural and network element requirements to allow the use of GPON access nodes in the TR-101 access architecture. TR-101 provides triple play application support in an architecture that migrates from ATM access to Ethernet access technology.

Keywords

access, architecture, broadband, context, DSL, DSLF, Ethernet, forum, GPON, play, QoS, TR-058, TR-059, TR-101, triple

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DSL Forum Working Text
WT-156

Using GPON Access in the context of TR-101

1. Purpose

TR-101 is a popular and successful DSL Forum architecture that enjoys significant success in the marketplace. Moreover, many of the benefits provided by TR-101 are not associated with DSL or DSLAM network elements, and even some the benefits and requirements that do apply to DSL access nodes are abstract enough to apply to many types of access – not just DSL.

Recognizing these benefits, some service providers planning GPON deployments are eager to use elements of the architecture and requirements provided by TR-101, but find that there are some aspects of GPON deployment that require definition and could benefit from standardization. This is especially true of service providers that are planning both GPON deployments as well as DSL deployments, or those that have already deployed DSL in at TR-101-compliant approach and intend to add GPON. Similarly, equipment vendors of the network elements and management systems described in TR-101 are highly interested in determining the requirements and approach to make GPON equipment fit into TR-101 applications with minimal variation among service provider deployments.

This WT is intended to provide the additional architectural basis and requirements needed over and above those in TR-101 to successfully deploy GPON access nodes within a TR-101 architecture either independently or alongside other TR-101 access node types.

2. Scope

This document outlines an Ethernet based aggregation network in the context of TR-101, but where the access nodes include GPON OLT and ONU/ONT components. This document builds on the architectural/topological models of the Ethernet based aggregation network defined in TR-101 and still supports the business requirements in TR-058. In doing so it describes how to add GPON-enabled access nodes as well as hybrid access nodes that support combinations of GPON and DSL in the TR-101 architecture.

The intent of the document is not to specify physical layer requirements for a GPON system, but rather to specify the required configuration of a GPON system in the context of TR-101 architecture, as well as any higher-layer requirements that are needed but have not been specified elsewhere.

Specifically, this WT will:

- Be limited to services and architecture as defined by TR-101.
- Describe DSL and Ethernet U interfaces that support connection to GPON, including defining relationships between the RG and ONU/ONT.
- Take into account requirements for the GPON R/S interface.
- Take into account the topologies of ONU/ONT and RG needed for GPON deployments.

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- Required extensions to interactions between BNGs and GPON ANs.

Specifically out of scope are:

- GPON at the "V" interface of TR-101.
- GPON fed DSLAMs – which are addressed in a separate document.
- GPON transport with ATM Mode or GPON with TDM Mode.
- ATM, TDM and RF Video interfaces on the GPON System.

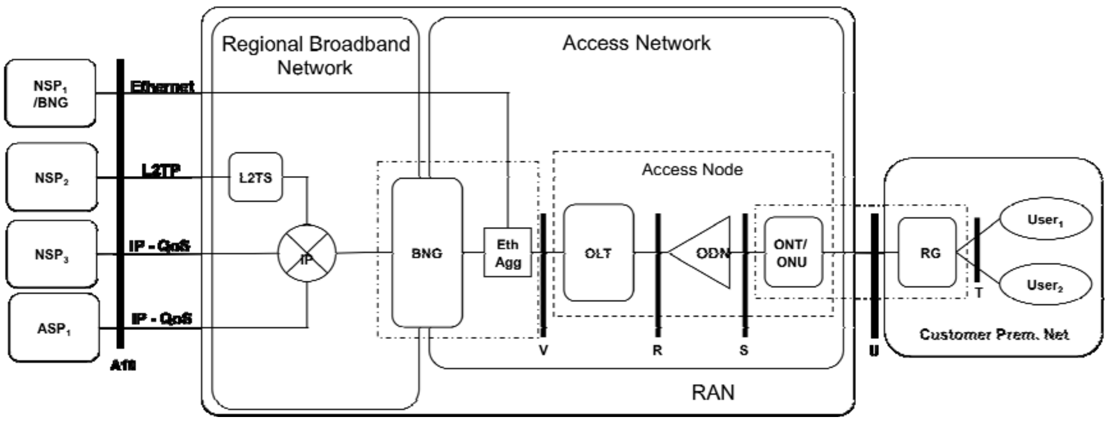

Figure 1 – Network architecture for Ethernet-based GPON aggregation

This specification encompasses OLT, ONU and ONT elements as well as changes in the U interface and the introduction of the R & S interfaces.

2.1 Definitions

G-PON Interface	The G-PON interface is used for transmitting Ethernet data by using the GEM (G-PON Encapsulated Mode) functionalities. The G-PON interface is connected to one-to-many broadband optical transmission systems which uses passive optical components.
GPON Network	A network comprising of an OLT, an ODN connected to one of the OLT's GPON interfaces, and the set of ONTs or ONUs connected to the ODN. A GPON network is a subset of the Access Network.
GEM Encapsulation	The G-PON Encapsulation Mode (GEM) is used for encapsulating data over G-PON. It provides both delineation of the user data frames, and flow identification. Each Ethernet frame can be mapped into a GEM frame, where the Preamble and SFD bytes are not included. In addition, the Ethernet packets can be fragmented over several GEM frames.
GEM Port	A virtual flow over GEM. Identified by a GEM Port Id. A unique GEM Port is assigned per Ethernet flow (or group of flows), and is used for distinguishing between the flows at the GEM layer.
GEM Port Id	The GEM Port Id field is part of the GEM header. It is used to identify a GEM port.

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T-CONT	T-CONTs are used for controlling the upstream bandwidth allocation in the PON. A T-CONT can carry multiple GEM ports. All the ONU traffic in the upstream direction are mapped into the T-CONTs, which carries the GEM frames, based on bandwidth allocations from the OLT.
ONU	The term ONU is used to generically refer to an Optical Network Termination unit, in either a FTTH architecture or FTTB/C architecture.
DBA	Dynamic Bandwidth Assignment (DBA) is a process where the OLT monitors the ONUs requested upstream bandwidth, based buffer status reporting from the ONUs or idle GEM frames monitoring. Based on the required bandwidth in the PON, the OLT reassigns the ONUs upstream bandwidth to the ONU T-CONTs.

2.2 Abbreviations

ADSL	Asymmetric Digital Subscriber Line
AES	Advanced Encryption Standard
ASP	Application Service Provider
ATM	Asynchronous Transfer Mode
CB	Cellular Backhaul
CPE	Customer Premises Equipment
CPN	Customer Premises Network
DSCP	DiffServ Code Point
DSL	Digital Subscriber Line
xDSL	Any variety of DSL
FITH	Fiber into the Home
FE	Fast Ethernet (100Mbps)
FTTB	Fiber to the Business
FTTC	Fiber to the Curb
FTTH	Fiber to the Home
FTTP	Fiber to the Premises
GE	Gigabit Ethernet (1000Mbps)
GEM	Generic Encapsulation Method
GPM	GPON Physical Media layer
GPON	Gigabit-capable Passive Optical Networks
GTC	GPON Transmission Convergence layer
HGU	Home Gateway Unit - ?? see comments
MAC	Media Access Control (used to specify that an address belongs to the Ethernet network)
MDU	Multi-Dwelling Unit
MTU	Multi-Tenant Unit – or Maximum Transmission Unit
NSP	Network Service Provider
ODN	Optical Distribution Network
OLT	Optical Line Termination – as defined in G.984 series
OMCI	ONU Management and Control Interface
ONT	Optical Network Termination– as defined in G.984 series
ONU	Optical Network Unit– as defined in G.984 series

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POTS	Plain Old Telephone Service
RBN	Regional Broadband Network
RG	Residential Gateway
SFU	Single Family Unit – a type of residence
TDM	Time-Division Multiplexing
TLS	Transparent LAN Service
TR	Technical Report
VDSL	Very high speed Digital Subscriber Line

2.3 Conventions

In this document, several words are used to signify the requirements of the specification. These words are always capitalized when used in their requirements sense.

MUST This word, or the adjective "REQUIRED," means that the definition is an absolute requirement of the specification

MUST NOT This phrase means that the definition is an absolute prohibition of the specification.

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

MAY This word, or the adjective "OPTIONAL," means that this item is one of an allowed set of alternatives. An implementation that does not include this option MUST be prepared to inter-operate with another implementation that does include the option.

3. References

The following DSL Forum Technical Reports and other references contain provisions, which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All Technical Reports and other references are subject to revision; users of this Technical Report are therefore encouraged to investigate the possibility of applying the most recent edition of the Technical Report and other references listed below. A list of the currently valid DSL Forum Technical Reports is published at www.dslforum.org.

NOTE – The reference to a document within this Technical Report does not give it, as a stand-alone document, the status of a Technical Report.

[1] DSL Forum TR-101 (April 2006), *Migration to Ethernet-Based DSL Aggregation.*
[2] ITU Specifications G.984 and their amendments: *Gigabit-capable Passive Optical Networks*

4. Fundamental Architectural and Topological Aspects

This section describes those aspects and areas that differ from what is described in TR-101. As most of the changes to TR-101 described in this WT concern the access network downstream from the Access Node, this specification has minor implications on the V-interface, BNGs and Aggregation Nodes as described in TR-101. When such implications occur, the respective requirements are brought in context to increase readability.

The case of a deployment scenario consisting of ONU and OLT can be regarded as an Access Node that is decomposed by two geographical functions. One is the ONU facing the user with the U

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interface and one is the OLT which provides the aggregation and V interface. In this regards, the functionalities described in TR-101 can be distributed between those entities (e.g. ONU handles ATM to Ethernet Interworking and the OLT handles VLAN manipulations).

The approach taken for this document focuses on describing the functionalities that derive from the use of GPON between OLT and ONU, and therefore in the following terminology OLT, ONU and ONT will be used to describe the physical entities. The general term Access Node will be used when describing a functionality which doesn't depend on the physical location but rather on the 'black box' behaviour of OLT and ONU. However, this document does not intend to refine the requirements described in TR-101 unless there is a specific need deriving from the integration of GPON.

The Access Node as described in TR-101 is distributed between the OLT and ONU. The OLT and ONU share the responsibility for Access Node requirements as specified in TR-101. The exception to this would be in the configuration where the ONT also encompasses the RG, and in this configuration the ONU would take on additional responsibility for RG requirements.

4.1 ONU/ONT and the Residential Gateway

There are three main deployment options for GPON ONTs. The following details these options and provides a reference diagram of each option.

The first option is a GPON-fed DSL Access Node. Depicted by Figure 2, the GPON termination is performed in an ONU hosting a GPON uplink on the network side, labelled R/S interface in the figure, and multiple xDSL links on the user side, labelled **U** interface in the figure. Here, the **U** interface is as described in TR-101 and therefore uses standard DSL RGs. The ONU's internal structure is comprised of two main functional blocks: The first, corresponding to the U interface, is providing TR-101 Access Node functionality aggregating traffic from several RGs with the proper Layer 2 functions and interworking. The second functional block provides the adaptation to the GPON uplink, mainly mapping of tagged Ethernet frames to the standard GPON specific scheduling and traffic management mechanisms in the upstream direction and extraction of the relevant traffic from the GPON interface in the downstream direction. The GPON adaptation block is not expected to perform any frame manipulation (e.g. marking, encapsulation adaptation etc.). This specification will cover the GPON adaptation block of the ONU.

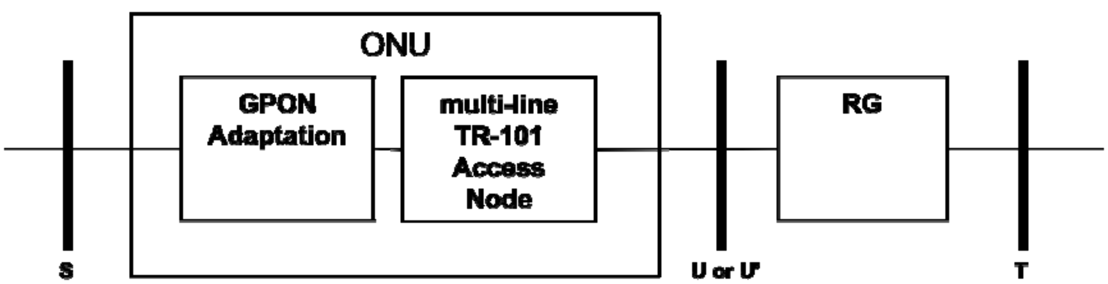

Figure 2 – ONU and RG reference diagram

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Figure 3 depicts the second option, a single-subscriber solution for GPON CPE – where that solution includes a RG as well as an ONT. The first entity is an RG performing standard RG functionality but with a standard Ethernet uplink (e.g. 100 BaseT, 1000BaseX etc.) instead of an xDSL uplink, denoted **U'**. The second entity, the ONT, provides the adaptation to the GPON uplink, providing mapping of tagged Ethernet frames to the standard GPON specific scheduling and traffic management mechanisms in the upstream direction and extraction of the relevant traffic from the GPON interface in the downstream direction. The GPON adaptation block is not expected to perform any frame manipulation (e.g. marking, encapsulation adaptation etc.). Since The RG functionality is standard, this specification will cover both the GPON adaptation functionality inside the ONT, as well as the Ethernet **U'** interface specification. This new **U'** arrangement is also shown in Figure 2 because ONUs are sometimes used in MDU arrangements where they provide access for several Ethernet subscribers.

Comment [LY1]: DSL2008.072.00: U' interface is used in figure 2 but defined only in the context of figure 3. Propose to move the definition to the preceding text - Accepted

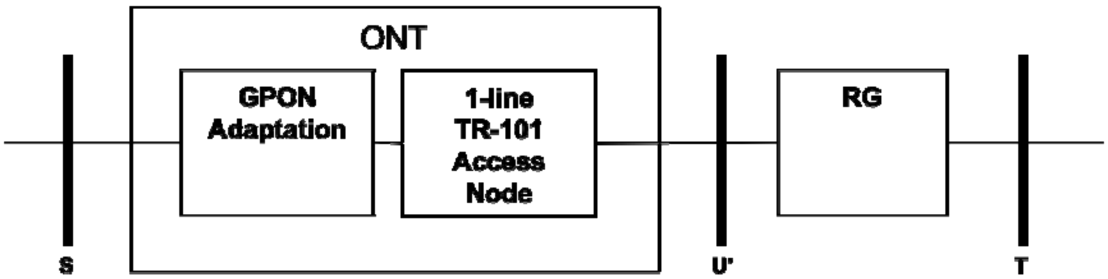

Figure 3 – ONT and RG as separate entities

The third option, depicted in Figure 4, is a single box GPON CPE solution where the ONT encompasses both the RG functionality as well as the GPON adaptation function. As in the previous model, the RG function (and hence the **T** interface) is standard and therefore will not be described in this specification. This specification will cover the GPON adaptation functionality inside the ONT. Note that GPON adaptation function is identical in both single and dual box solutions and there is a strong parallel between Figures 3 and 4 and DSL arrangements where the modem is both apart from and then integrated with an RG.

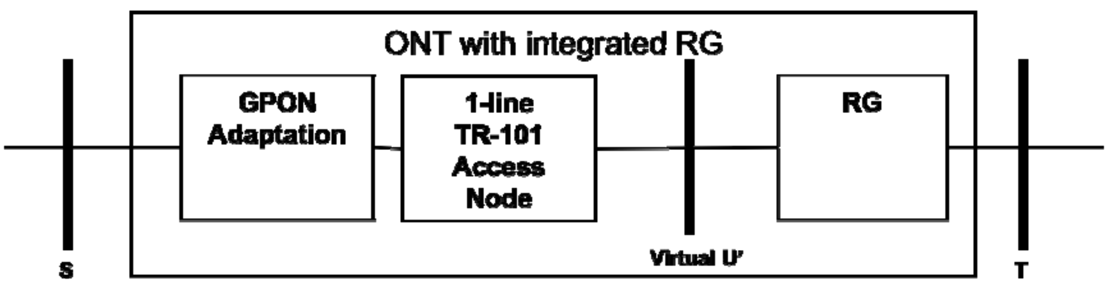

Figure 4 – ONT and RG as a single entity

Figure 4 shows that when an ONT also comprises the RG function the **U'** interface may be virtualized in the device and may not be physically present or accessible. However, from a protocol

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and functional capability, this architecture will treat such as device as if it has an internal **U'** interface that is physical and real, and simply not accessible. This document will not develop the RG requirements of such a device, but will apply the ONT requirements to the portion of such a device that connects the GPON.

Note: Historical deployment perspectives have differed between DSL and PON. Historically, DSL has specified the transport protocol as the customer interface – or the **U** interface. This came from the perspective that the DSL modem would be CPE, and therefore the **U** interface should be on the network side of the modem. PON systems have been defined with an alternate assumption: that the ONU or ONT would be Network Equipment (not CPE) and that they would typically be deployed outside the customer premises. Therefore the ONU/T is described to support customer (**U**) interfaces facing the customer. This is essentially flipped from the DSL modem assumption set.

The third option shows the effect of reduced component count on this PON decision. Having an ONT integrated with the RG and placed inside the premises rather than outside has may have benefits for some service providers; however the result is a conundrum of what should be labelled as the **U** interface. While a natural tendency might be to label the optical PON interface as **U** in option 3, this would cause dissimilar marking between DSL Forum and other standards that describe PON. To maintain maximum compatibility with existing standards, and to avoid defining a **U** interface with an PON protocol, this TR will describe PON equipment that is placed as CPE as shown in option 3.

Finally, it should be noted that hybrid options may exist. For example, option 1 could also support native Ethernet interfaces on the **U** interface – just as option 2 does.

In order to preserve consistency, the RG should maintain the same functionality as described in TR-101 for the new protocol stacks:

R-1 The RG SHOULD support sending and receiving the following frame types: untagged frames, priority-tagged frames and VLAN-tagged Ethernet frames in upstream and downstream directions for the U' interface as described in TR-101.

4.2 U Interface

The U interface as depicted in Figure 2 is as described in TR-101 (Figure 4).

Figure 5 depicts the options for access protocol stacks for the U' interface. Options 'a' and 'b' are refered to as IPoE and PPPoE. Similarly, Option 'c' represents a pure Ethernet network service where there is little or no visibility above the Ethernet layer.
All of these options may also include 802.1Q and 802.1ad headers to carry VLAN TAGs and priority markings.

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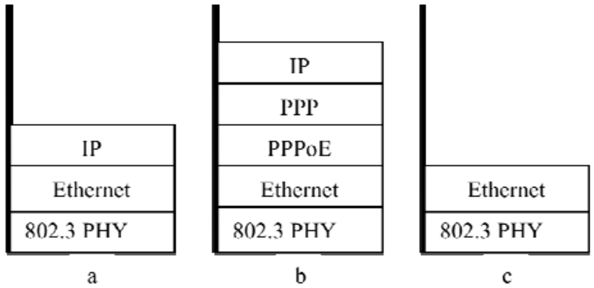

Figure 5 – Protocol stacks at the U' interface

The physical layer of the U' interface is expected to support 802.3 PHY (in addition to DSL options in TR-101).

Note: it is not a requirement that all RGs must support all of the above, but that RGs be available to support each of the above. In particular, when an ONT integrates the RG function, and the **U** interface is not externally accessible, there may not be a physical 802.3 PHY – however there is still an Ethernet layer at this point, and the functionality is no different from that of an ONT where the **U** interface is a physical and external interface.

4.3 R/S Interface

The R/S Interface is a PON-specific interface that supports all the protocol elements necessary to allow transmission between OLT and ONUs. ITU-T G.984.1 defines the R/S Interface. The **S** Interface is the point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice), and the **R** Interface is the point on the optical fibre just before the ONU (Downstream)/ OLT (Upstream) optical connection point (i.e., optical connector or optical splice).

Figure 6 depicts the options for access protocol stacks for the R/S interface. Options 'a' and 'b' are refered to as IPoE and PPPoE. Similarly, Option 'c' represents a pure Ethernet newtork service where there is little or no visibility above the Ethernet layer.
All of these options may also include 802.1Q and 802.1ad headers to carry VLAN TAGs and priority markings.

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The physical layer of the R/S interface is represented by the GPON Physical Media Dependent (GPM) layer as defined in G.984.3.
The GPON Transmission Convergence (GTC) layer is located above the GPM layer. As defined in G.984.3, the GTC layer is comprised of two sub-layers, the GTC Framing sub-layer and the TC adaptation sub-layer.

Note: this document focuses on the Ethernet GEM client carrying Ethernet (GEM) service. This document shall not define any requirements for the GTC or the GPM layers.

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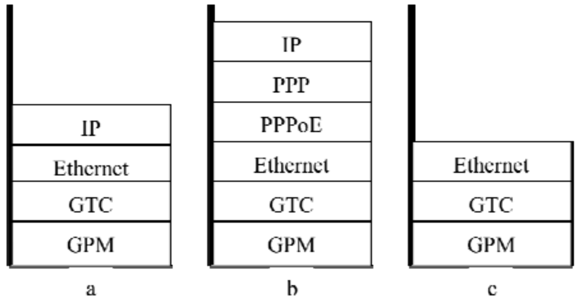

Figure 6 – Protocol stacks at the R/S interface

4.4 OLT change to GPON to Ethernet Adaptation

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Editor note: Some general description of the OLT functionality (e.g. xDSL, GPON, V-interface as in TR-101)

The OLT might be the first aggregation point in both DSL and GPON access scenarios. In addition to terminating the DSL and GPON physical layers it provides the following high level capabilities:

R-2 The OLT MUST be able to terminate the GPON layers (GPM and GTC) on a GPON interface.

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R-3 The OLT MUST be able to support multicast deployments for GPON interfaces.

Comment [LY6]: Remove

R-4 The OLT MUST support user isolation for users located over a GPON interface.

Comment [LY7]: OLT→ONU with multi subscriber

dsl22008.072.00:
Section 4.4 discusses the GPON to Ethernet Adaptation, however it specifies requirements only the OLT to terminate GPON interface:
Proposals:
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R-2 The OLT and ONU/ONT MUST be able to terminate the GPON layers (GPM and GTC) on a GPON
interface.
R-3 The OLT and ONU/ONT MUST be able to support multicast deployments for GPON interfaces.
R-4 The OLT and ONU/ONT MUST support user isolation for users located over a GPON interface.

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When Ethernet is supported on the GPON interface (R/S interface), the OLT has to terminate the GTC layer on the user side and forward the Ethernet frames to the Ethernet layer on the network side. This may require the OLT to snoop, modify or terminate protocols in layers above the GTC. Figure 7 illustrates the termination points for ONU and for ONT scenarios.

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Note that this description implies that no change is required at the V Interface.

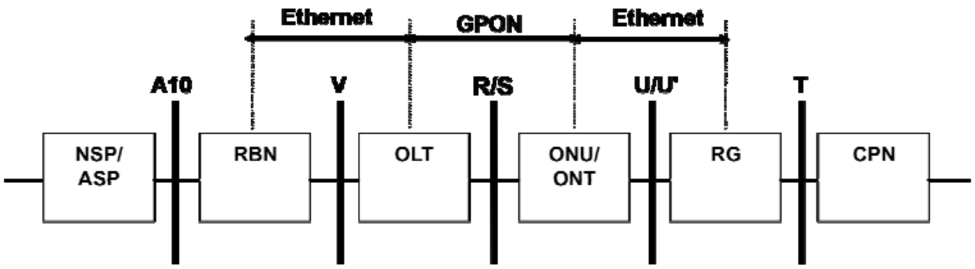

Figure 7 – GPON to Ethernet adaptation

This specification is limited to Ethernet framed traffic when GPON is present at the R/S interface. Although the requirements described in this document add certain networking capabilities to the OLT, this specification does not intend to impart to the OLT any networking capabilities that are not directly derived from the need to interwork between the Ethernet over GPON and Ethernet networks. The general intent is for the Access Network to behave in the same manner as defined by TR-101 providing the same functionality for protocol interworking, multicast support, user isolation etc.

4.5 Deployment Scenarios

The following scenarios are considered typical GPON deployment scenarios:

- FTTH (Fiber To The Home): a residential ONT that does not include RG features.
- FITH (Fiber Into The Home): a residential ONT that is combined with RG features.
- FTTB (Fiber To The Business): a business ONT dedicated to a single business customer feeding appropriate CPE.
- MDU (Multi-Dwelling Unit): a multi-user residential ONU (FTTP/FTTC architecture).
- MTU (Multi-Tenant Unit): a multi-user business ONU (FTTP/FTTC architecture).
- CB (Cellular Backhaul): an ONT or ONU aiming at collecting 2G (TDM-based) and 3G (ATM-based and Ethernet/IP-based in the future) mobile wireless flows.

Different ONU/ONT deployment scenarios are described as below:

Figure 8 depicts a single-family residential deployment scenario using a typical ONT. This scenario corresponds to FTTH architecture. FTTH is deployed at user's premise and connects a single-family unit. FTTH connects the RG, using a single FE/GE Ethernet link, to an ONT that provides the GPON adaptation function. The RG performs standard RG functionality, however the WAN uplink is a physical Ethernet interface. Also, and out of the scope of this document, the ONT typically provides an analog voice port.

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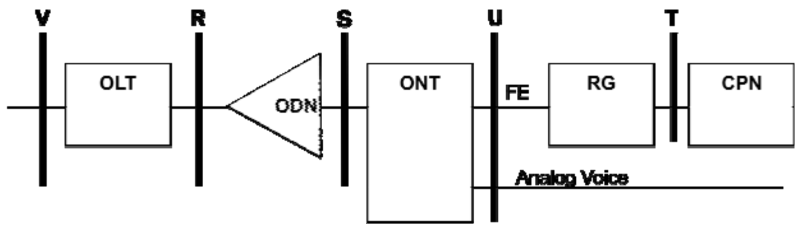

Figure 8 – FTTH deployment scenario

Figure 9 depicts the FITH deployment scenario. This scenario is similar to the FTTH architecture, but with the difference being that the ONT and RG functionality are not provided by separate elements, but rather by a single, combined device. The **U** interface becomes an internal and invisible in this scenario. FITH typically provides 1 or more VoIP ATAs and Ethernet LAN interfaces to the home network of a single-family unit.

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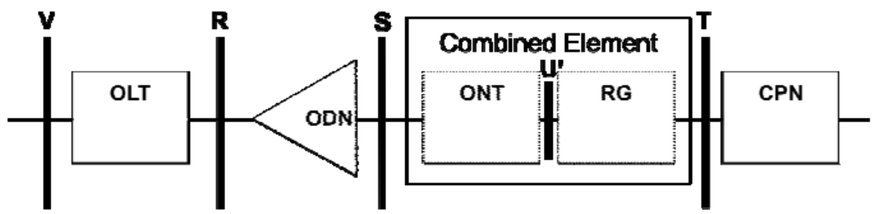

Figure 9 – FITH deployment scenario

Figure 10 depicts the FTTB deployment scenario. This scenario is the business variation of the FTTH architecture. FTTB provides 1 or more lines of TDM service (eg. E1 T1 POTS) and 1 or more FE/GE interface for a single business customer. (Again, the TDM interface is shown as an example, and is not in the scope of this document.)

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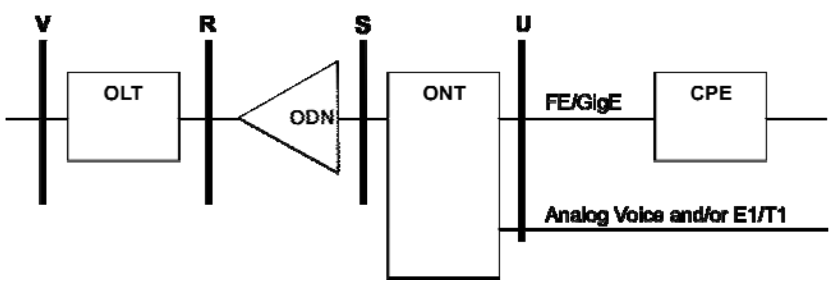

Figure 10 – FTTB deployment scenario

Figure 11 depicts the MDU deployment scenario. This scenario corresponds to FTTP/FTTC architecture. FTTP is deployed within the premises of a multi-dwelling unit, typically in the basement, wiring closet, or other infrastructure area. FTTC is deployed at the curb or another outside location that serves multiple single-family or multi-family dwellings. MDU provides either Ethernet or DSL physical layer access as well as the (out of scope) analog voice capabilities.

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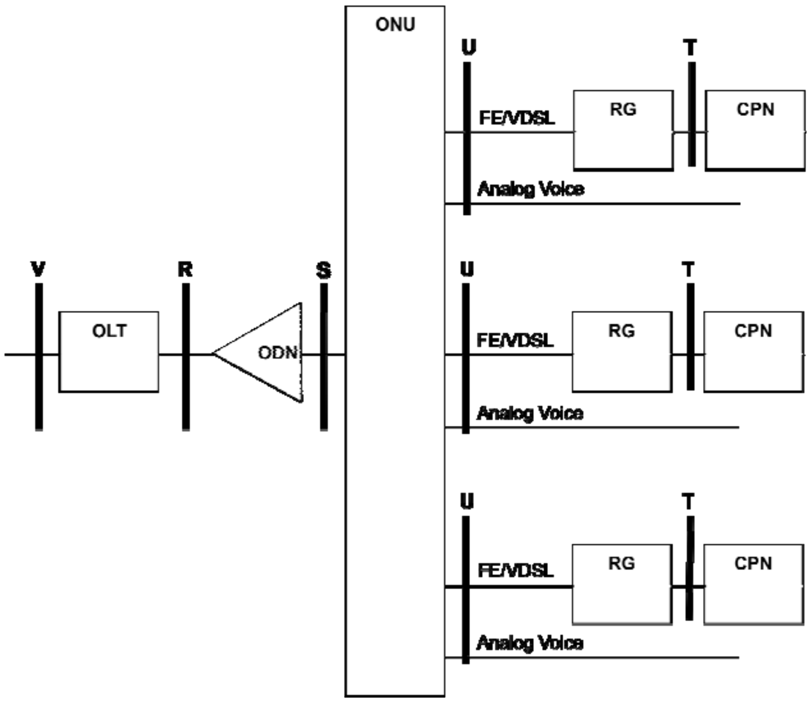

Figure 11 – MDU deployment scenario

Figure 12 depicts MTU deployment scenario. This scenario corresponds to MDU architecture – except that it serves multiple businesses. MTU is similarly deployed within a premesis on at a curb or other common outside location in order to serve multiple business customer workplaces. Additional telecom services (eg. E1 & T1) are typically provided by MTU compared to MDU, and those are out of scope of this document.

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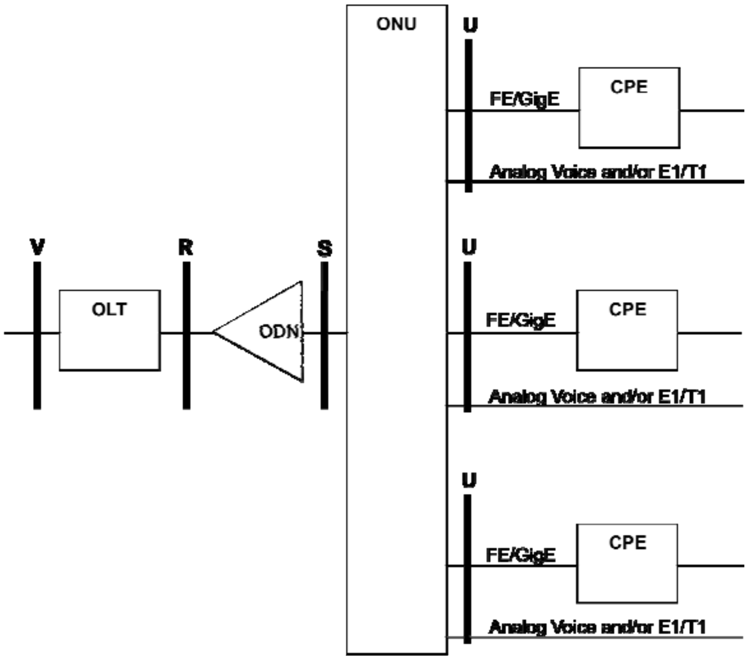

Figure 12 – MTU deployment scenario

Figure 13 depicts the CB deployment scenario. CB aggregates traffic from Base Transceiver Station (BTS) through the access network to a Radio Network Controller (RNC). The interfaces that are typically provided to BTS include TDM (E1, T1), ATM, and Ethernet. Ethernet is supported in this document, and the others are out of scope.

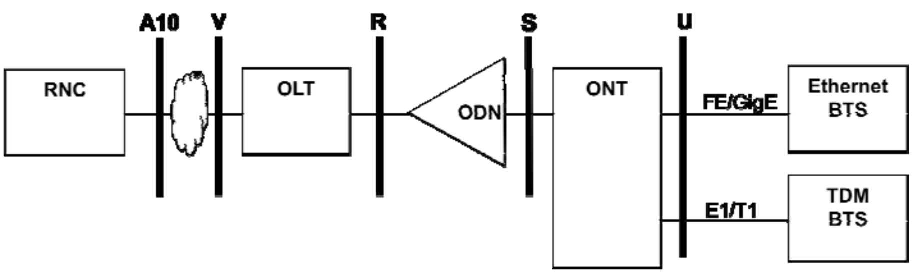

Figure 13 – CB deployment scenario

5. GPON Access Architecture

5.1 VLANs and GEM Ports

The OLT and ONU share the responsibility for Access Node VLAN requirements as specified in TR-101. TR-101 identifies three VLAN configurations and these VLAN configurations still apply when there is a GPON based Access Node.

1. N:1 VLAN
2. 1:1 VLAN
3. Transparent VLAN

The ONU supports equivalent functionality for the **U** Interface side of an Access Node as that specified in TR-101. The ONU assumes the responsibility of ingress traffic classification at the **U** Interface.

GPON technology has introduced the GEM channel as part of its GPON Transmission Convergence (GTC) layer. The GEM channels carry variable-length packets, including Ethernet packets. This allows the GEM ports to support the TR-101 Ethernet-centric architecture. GEM channels are delineated and identified by a uniquely assigned identifier, the GEM Port ID. Since this identifier is assigned by the OLT upon creation of a new channel and since the channel's label remains constant during the entire lifecycle of the channel, the GEM Port IDs are referred as virtual port identifiers that have significance within a given GPON interface. Each GPON interface for a given ONU can have several GEM Ports. GEM Port ID is unique per GPON interface and represents a specific traffic flow between the OLT and one or more ONUs.

GPON allows the OLT (through OMCI) to determine for each GEM channel the allowed transmission directions (i.e. upstream and / or downstream). This is done during configuration process of each GEM channel. This document identifies two types of GEM channels' transmission directions:

- Downstream GEM ports – These channels will be used for the purpose of transmission downstream broadcast or multicast traffic. Upstream transmission for these channels is blocked by the ONU and discarded in the OLT. The frames are transmitted from the OLT into the GPON interface and are forwarded to subscribers by all ONUs which are configured with that GEM port.

- Bi-directional GEM ports – These channels will be uniquely assigned per **U** interface on an ONT. They are used for both upstream and downstream traffic between an ONU and the OLT. The frames are transmitted from the OLT into the GPON interface and are forwarded only on the **U** interface of the ONU on which that GEM port has been assigned.

  Note that the nature of PON systems requires that all ONUs receive all the downstream traffic for every GEM port, however ONUs drop traffic that is not addressed for them. Additionally, AES encryption can be applied over the Bi-directional GEM ports. A special key per ONU is used by the OLT for encryption and by the ONT for decryption.

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Beyond the association of a bidirectional GEM port with a **U** interface, they can also be used to differentiate among traffic classes. So, a given **U** interface may have several GEM ports associated with it that support different classes of service. This arrangement can be described as follows: within the R/S Interface, each GEM Port identifies a specific class of service going to a specific **U** interface on a specific ONU.

Based on ingress classification traffic is forwarded upstream into GEM Ports so that proper QoS can be applied to flows. The ONU can map traffic flows into GEM Ports based on user port, VLAN ID, VLAN priority, Ethernet Type, or DSCP value. In cases where the traffic should get the same QoS treatment, several flows can be mapped into the same GEM port. A GEM Port is mapped into one and only one T-CONT. Similarly; in the downstream direction the ONU is responsible for forwarding traffic received from the PON identified by the GEM Port out the appropriate user port.

The arrangement just described is a subset of the possible arrangements and configurations of GEM ports in a GPON, however, this arrangement has the added value over others because it can be used to reduce operational complexity and interoperability issues between the OLT and the ONU at the R/S interface. Thus, this WT limits the variability of how physical ports and traffic types can be assigned to GEM ports in order to simplify the GPON system requirements. Specifically, the architecture specified in this WT has been crafted to allow the development of compliant ONUs that do not need to perform multi-way MAC bridging or learning of MAC addresses in order to determine how to forward Ethernet frames to **U** interfaces.

R-5 GEM PortIDs MUST be assigned automatically by the OLT based on the requirements that follow which describe how VLAN and UNI Ports are connected and QoS is requested.

5.1.1 N:1 VLAN

In a N:1 VLAN architecture, a GEM port will represent both a physical port as well as a class of service (CoS) and if the ONU supports multiple user ports there will be separate GEM Ports for each **U** interface[1]. This allows for per-subscriber per-service QoS on a multi-port ONU based on GEM Port. A class of service (CoS or p-bit value) can be assigned based on physical port, VLAN ID, VLAN Priority, and/or Ethernet Type. The OLT provides the **V** Interface side of an Access Node as specified in TR-101.

So, for N:1 VLANs, the recommended implementation option is for the ONU to always add an S-TAG or translate an incoming tag to an S-TAG to upstream traffic. The OLT will pass through any upstream packets with an S-TAG on them. The downstream is essentially the opposite operation, except that the OLT will use the S-TAG as well as the MAC address (and precedence bits) to determine the proper downstream GEM port. The ONU will remove or translate the tag and then forward frames from a given GEM port to its associated **U** interface.

N:1 traffic is always single-tagged at the **V** Interface.

[1] It is expected that WT-167 will provide requirements for the case where an ONU is more akin to a DSLAM. In that document GEM ports will represent aggregate classes of service among multiple U interfaces

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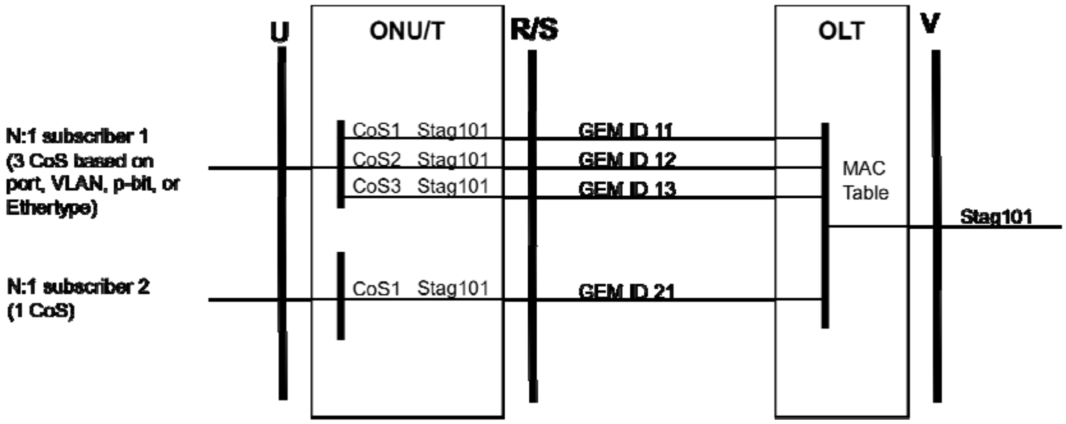

Figure 14 – N:1 VLAN

5.1.2 1:1 VLAN

In a 1:1 VLAN architecture the ONU maps each **U** interface into a unique VLAN. All the traffic may be sent on a single GEM port, or the traffic can be further classified and divided into multiple GEM ports to support different CoS for a given **U** interface. This allows for per-subscriber per-service QoS on a multi-port ONU based on GEM Port. A CoS can be assigned based on physical port, VLAN ID, VLAN Priority, or Ethernet Type. In this model there are two variations on tag assignments. The first variation is where the 1:1 VLANs are double-tagged, and the second variation is where they are single-tagged.

So, for 1:1 VLANs the recommended implementation option is for the ONU to always add a tag or translate an incoming tag to a new one in the upstream direction. For the case where the VLANs will be double tagged at the **V** interface, the ONU is provisioned to add or translate-to a C-TAG, and the OLT adds the S-TAG. Alternately, for the single-tagged VLANs at the **V** interface, the ONU is provisioned to add or translate-to an S-TAG, and the OLT passes-through the tag as was described for N:1 VLANs. The downstream is essentially the opposite operation, with the OLT removing an outer tag if there's one present. The ONU will remove or translate the tag and then forward frames from a given GEM port to its associated **U** interface.

1:1 traffic may be single or double-tagged at the **V** Interface.

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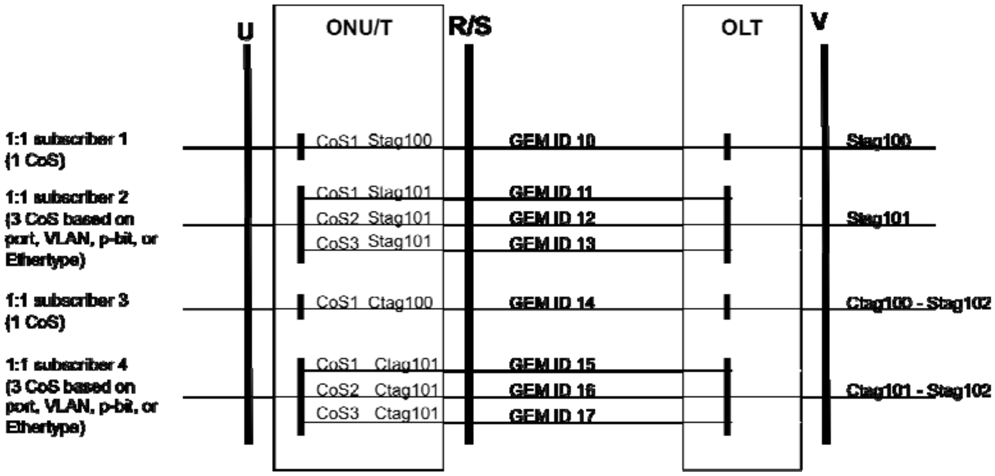

Figure 15 – 1:1 VLAN Example

5.1.3 Transparent LAN

In a transparent LAN architecture, traffic at the **U** interfaces can be untagged, tagged, or priority-tagged. All the traffic may be sent on a single GEM port, or the traffic can be further classified and divided into multiple GEM ports to support different CoS for a given **U** interface. An S-TAG is added at the ONU and passed through at the OLT.

Figure 16 shows several transparent LAN features. TLS subscriber 1 is a customer that does not require a learning bridge in the AN. However, this customer makes use of a special Q-TAG (100), which was selected by the service provider to indicate that those packets are not to be treated as TLS traffic, but rather to be treated as Internet access traffic. In this case, the Internet access traffic fits the 1:1 model. Similarly, Subscriber 1 and Subscriber 2 port 1 are also shown using the Q-TAG (101) to access a similar Internet or ASP access network in a N:1 model. The ONU will typically translate the special Q-TAG into an S-TAG or customer-specific C-TAG for N:1 or 1:1 VLAN access as described in the previous sections. All other C-TAGs from subscriber 1 are sent into that subscribers TLS service and S-TAG 102 is prefixed to all the TLS traffic at the ONU before it is sent into the OLT.

TLS subscriber 2 has multiple ports on the AN. The figure shows an arrangement where the 2 ports are bridged in the AN. For this subscriber the AN needs to learn some of the VLAN/MAC address info to determine which packets to hairpin among the local ports that are part of a TLS service, and which to send further into the network.

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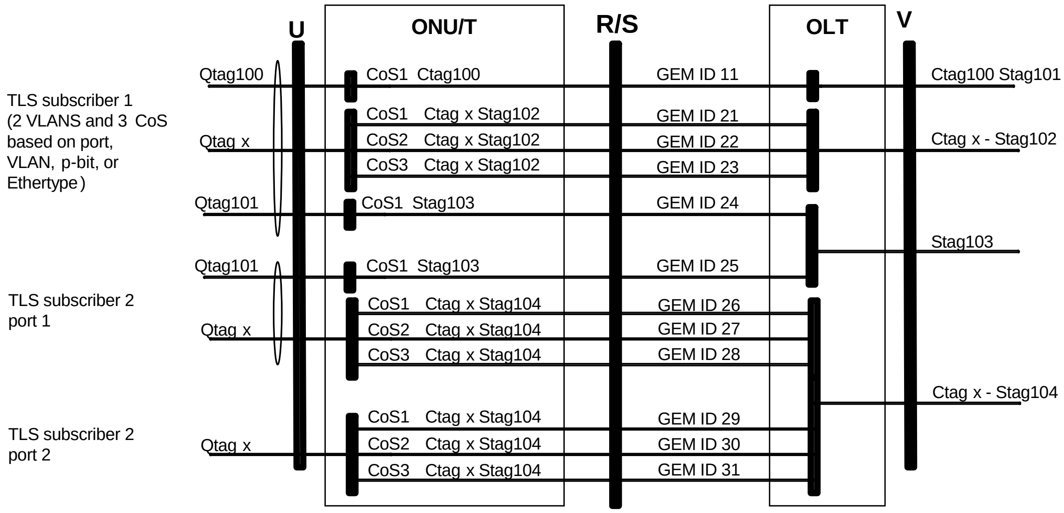

Figure 16 – Transparent LAN

5.1.4 GEM Port Requirements

Supporting TR-101 VLAN paradigms, the combination of OLT and ONU must support the N:1 1:1 and TLS VLAN paradigms. To achieve that, it is vital to keep in mind that in GPON the ONU/ONT is required to support some classification for the upstream traffic and map the flow to the correct GEM port. These functions reduce operational complexity and interoperability issues between the OLT and the ONU at the R/S interface.

N:1 VLANs

In this paradigm the upstream traffic could be received either in a Multi-VC ATM Architecture[2], VLAN tagged **U** or Untagged/Priority tagged **U**. Thus, in order to satisfy simplicity within the R/S interface, the ONU is required classify the traffic accordingly and also to tag the untagged traffic or map a (specific) Q-TAG into a S-TAG with different values.

The following requirements are applied for N:1 VLANs:

R-6 The ONU MUST support adding an S-TAG to upstream untagged traffic received from the **U** interface.

R-7 The ONU MUST support removing an S-TAG from downstream traffic received from the OLT.

R-8 The ONU MUST support one-to-one VID translation of the Q-TAG received from the **U** interface into the S-TAG used in the upstream-tagged traffic.

R-9 The ONU MUST support VID translation of the S-TAG used in the downstream-tagged traffic into the Q-TAG sent to the **U** interface.

R-10 The OLT MUST support passing an S-TAG in the upstream direction.

[2] ATM may be used when an ONU has xDSL **U** interface ports. Typically, ONTs will not have this variant.

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R-11 The OLT MUST support passing an S-TAG in the downstream direction.

R-12 The OLT MUST support forwarding traffic received at the **V** interface (i.e. downstream direction) to GEM Ports on the PON based on S-TAG and destination MAC address.

R-13 The ONU MUST support mapping traffic from one or more GEM Ports to a **U** interface in the downstream direction.

1:1 VLANs

In this paradigm the upstream traffic could be received either in a Multi-VC ATM Architecture, VLAN tagged **U** or Untagged/Priority tagged **U**. Thus, in order to satisfy simplicity within the R/S interface, the ONU is required classify the traffic accordingly and also to tag the untagged traffic or map a Q-TAG into a new C-TAG or S-TAG.

The following requirements are applied for 1:1 VLANs:

R-14 The ONU MUST support adding a C-TAG or S-TAG to upstream untagged traffic.

R-15 The ONU MUST support removing a C-TAG or S-TAG from downstream traffic.

R-16 The ONU MUST support VID translation of the Q-TAG received from the **U** interface into the C-TAG or S-TAG for upstream-tagged traffic.

R-17 The ONU MUST support VID translation of the C-TAG or S-TAG used in the downstream tagged traffic into the Q-TAG sent to the **U** interface.

R-18 The OLT MUST support adding an S-TAG in the upstream direction.

R-19 The OLT MUST support forwarding traffic to the **V** interface (i.e. upstream direction) based on S-VLAN or (S-VLAN & C-VLAN).

R-20 The OLT MUST support forwarding traffic received at the **V** interface (i.e. downstream direction) to GEM Ports on the PON based on S-VLAN or (S-VLAN & C-VLAN).

R-21 The OLT MUST support removal of an S-TAG in the downstream direction when traffic is double-tagged.

R-22 The ONU MUST support mapping traffic from one or more GEM Ports to a **U** interface in the downstream direction.

TLS VLANs

In this paradigm the upstream traffic can only be received on a tagged **U** interface. Thus, in order to satisfy simplicity within the R/S interface, the ONU is required classify the traffic accordingly and also to add a S-TAG.

The following requirements are applied for TLS VLANs:

R-23 The ONU MUST support adding an S-TAG in the upstream direction.

R-24 The ONU MUST support removing an S-TAG in the downstream direction.

R-25 The OLT MUST support forwarding traffic to the **V** interface (i.e. upstream direction) based on S-VLAN.

R-26 The OLT MUST support passing an S-TAG in the upstream direction.

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R-27 The OLT MUST support forwarding traffic in the downstream direction to GEM Ports based on the S-TAG, C-TAG and destination MAC address.

R-28 The OLT MUST support passing an S-TAG in the downstream direction.

R-29 The ONU MUST support mapping traffic from one or more GEM Ports to a **U** interface in the downstream direction.

Dsl2008.104.00:
At the last conference call, it was stated that WT-156 R27 is to allow for hairpinning. This contribution questions that assumption.

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This contribution proposes that R-27 read:

R-27 The OLT MUST support forwarding traffic in the downstream direction to GEM Ports based on the S-TAG, ~~C-TAG~~ and destination MAC address.
During the discussion on the conference call, it was stated that forwarding based on the C-tag was needed to support hairpinning of TLS services at the OLT (or Access Node).

Comment [LY8]: Accepted

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In the “Forwarding in N:1 VLANs” section TR-101 it states:

R-40 The Access Node MUST be able to prevent forwarding traffic between user ports (user isolation). This behavior MUST be configurable per S-VID.

There don’t appear to be any requirements like this in WT-156. Also in the United States, there are some laws (CALEA) that require the Telecommunications Providers to allow eavesdropping on phone calls. This is usually implemented in the BNG. If hairpinning is allowed, then this capability would have to be in the ONT/OLT. Thus the following requirements are proposed for WT-156:

Comment [LY9]: Remove

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R-9.5 The ONT MUST be able to prevent forwarding traffic between user ports (user isolation). This behavior SHOULD be configurable per S-VID.

Comment [LY10]: Remove

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R-12.5 The OLT MUST be able to prevent forwarding traffic between user ports (user isolation). This behavior SHOULD be configurable per S-VID.

Comment [LY11]: Move to MUST

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5.2 QoS

Editor’s note: In principle, we will place the TR-101 requirements into the proper GPON system elements. The consensus is not to change the TR-101 requirements, but to simply show how to support those requirements in a GPON AN.

5.2.1 QoS Architecture

In general the goals for QoS remain those defined in TR-101. The high level goals for the QoS architecture include the following:

- Efficient use of the resource

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- Statistical multiplexing is a key requirement for QoS architecture
- Low latency for flows
- Bandwidth allocation schemes should not sterilize unused bandwidth

In the distributed GPON Access Node, the network **U** and **V** interfaces are Ethernet based. However the OLT-ONU GPON link employs GPON Encapsulation method (GEM) protocol for transport of services, as illustrated by the following figure. The GEM adaptation block performs mapping for transport of Ethernet over GPON. It should be noted that GEM is designed to natively encapsulate also other protocols, e.g. TDM. However the focus of this document is on Ethernet encapsulation.

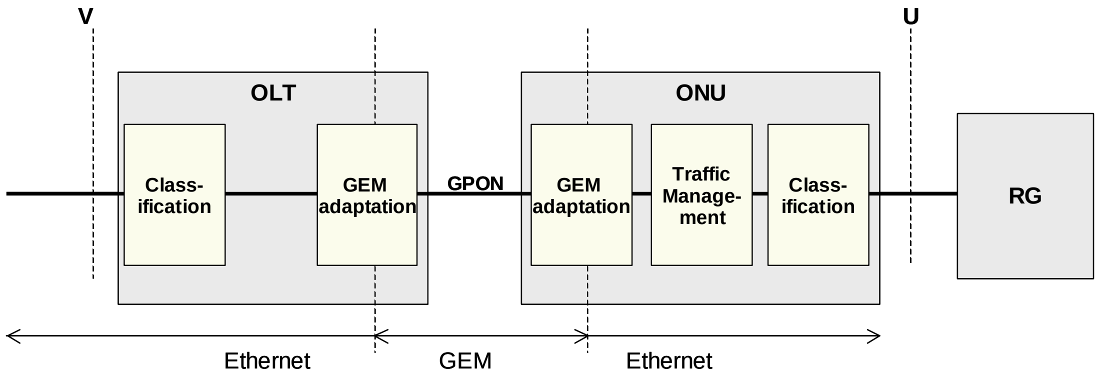

Figure 17 – GPON GEM adaptation of Ethernet

The general requirement for GEM is to provide QoS transparency, that is maintaining the QoS requirements for the flows it transports. By doing that the set of Access Node QoS requirements defined by TR-101 section 3.3, will still apply to the Ethernet domain of the GPON distributed access-node.

In order to discuss the QoS requirements two main aspects need be identified. The first is the scope of services covered, and the second is the resources the GPON network offers to transport those services.

GPON ONUs may potentially terminate multiple services, and have a few types of UNI interfaces. An ONU may have data interface of Ethernet, or DSL technology, and additionally POTS telephony interface, RF video, T1/E1 and more. This variety of services requires a broad range of QoS characteristics. However, the sco3pe of this specification covers only data services. In that context the QoS requirements are specified independently of the existence of other services on the ONU and GPON network. This allows simplifying the requirements and keeping the specification consistent in coverage to TR-101.

Service Class Requirements:

R-30 The GPON system MUST at least 4 queues per user facing port, one per traffic class. Note: User-facing ports share a single set of queues across all VLANs. This does not imply 4 queues per VLAN.

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R-31 The GPON system SHOULD support at least 6 queues per user facing port, one per traffic class.

R-32 The GPON system MUST support scheduling of user queues according to strict priority among at least 4 queues.

R-33 The Access Node SHOULD support scheduling of user queues according to their assigned priority and weight. The number of priorities MUST be at least 4, however multiple queues may be assigned to the same priority. Queues assigned to the same priority MUST be scheduled according to a weighted algorithm (like WFQ) with weights assigned through provisioning. This mechanism provides support for mapping diffserv PHBs (e.g. EF, AF, BE, LE) to the Ethernet queues.

An example for a system that supports 4 queues is shown in the table below. In the table, Queue 1 is scheduled at the highest priority, and since there are no other queues at that level, its weight is ignored. Queue 2 is similarly scheduled at priority 2. Once these two queues are exhausted, Queues 3 and 4 are scheduled with a weight ratio of 150:1. This approach is identical to the queuing arrangement standardized by the DSL Forum for RGs.

Comment [TA12]: This was added as part of the disposition of 07-525 to replace the proposed R1. So, unlike the rest of this section, we have consensus that the GPON system needs to support these TR-101 requirements.

Table 1 - Example Scheduler

Priority 1	**Queue 1 – 100**
Priority 2	**Queue 2 – 15000**
Priority 3	**Queue 3 – 15000**
	Queue 4 – 100
Priority 4	

5.2.2 Upstream Traffic Management

Requirements moved from VLAN sections:

N:1

R-34 The ONU MUST support mapping traffic into individual GEM Ports based on user port in the upstream direction.

R-35 The ONU MUST support mapping traffic into individual GEM Ports based on VLAN priority bits in the upstream direction.

R-36 The ONU MUST support mapping traffic into individual GEM Ports based on VLAN ID in the upstream direction.

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R-37 The ONU SHOULD support mapping traffic into individual GEM Ports based on Ethernet Type in the upstream direction.

R-38 The ONU+RG MUST support marking Ethernet priority based on DSCP value in the upstream direction.

R-39 The ONU/ONT MUST support mapping traffic into individual GEM ports based on user port and CoS in the upstream direction. The CoS can be derived from the priority bits of the Ethernet frame (.1p) or the DSCP or other criteria dependent on the classification process inside the ONT/ONU.

1:1

R-40 The ONU MUST support mapping traffic into individual GEM Ports based on user port in the upstream direction.

R-41 The ONU MUST support mapping traffic into individual GEM Ports based on VLAN priority bits in the upstream direction.

R-42 The ONU MUST support mapping traffic into individual GEM Ports based on VLAN ID in the upstream direction.

R-43 The ONU SHOULD support mapping traffic into individual GEM Ports based on Ethernet Type in the upstream direction.

R-44 The ONU SHOULD support marking Ethernet priority based on DSCP value in the upstream direction.

R-45 The ONU/ONT must support mapping traffic into individual GEM ports based on user port and CoS in the upstream direction. The CoS can be derived from the priority bits of the Ethernet frame (.1p) or the DSCP or other criteria dependent on the classification process inside the ONT/ONU.

TLS

R-46 The ONT MUST support mapping traffic into individual GEM Ports based on user port in the upstream direction.

R-47 The ONU MUST support mapping traffic into individual GEM Ports based on VLAN priority bits in the upstream direction.

Dsl2008.140.00:
In the recently consented G.984.3 revision, the OLT may optionally provision Alloc-IDs (an Alloc-ID is associated with each T-CONT) using an extended traffic descriptor:

$$D^i = \left\langle R_F^i, R_A^i, R_M^i, \chi_{AB}^i, P_i, \omega_i \right\rangle$$

where "i" is the Alloc-ID, R_F is the fixed bandwidth component, R_A is the assured bandwidth component, R_M is the maximum bandwidth that will be allocated to the T-CONT, χ_{AB} is taken from the set {none, NA (non-assured), BE (best effort)}, P is the priority for best-effort bandwidth

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assignment, and ω is the weight for best-effort bandwidth assignment. It is these last two parameters (P,ω) that were added to G.984.3 to accommodate the DSL Forum liaison.

An example of an architecture that can be specified with this new functionality is shown in Figure 7-7 below. In this example there are four classes of service, and each class of service (CoS) is mapped to a separate T-CONT. Each ONT therefore has four T-CONTs, and each T-CONT has an associated extended traffic descriptor, D^i. As an illustration, assume for each T-CONT that $R_F^i=R_A^i=0$ and χ_{AB}=BE. The T-CONTs from the different ONTs associated with the same CoS are assigned the same priority, P. The weights, ω, for T-CONTs of the same priority are assigned according to some criteria, for example according to the committed information rate (CIR) for each T-CONT. This architecture can be used to implement R-55 of TR-101 "The Access Node MUST support scheduling of network queues according to strict priority among at least 4 queues."

This architecture can also accommodate R-56 of TR-101, "The Access Node SHOULD support scheduling of network queues according to their assigned priority and weight. The number of priorities MUST be at least 4, however multiple queues may be assigned to the same priority. Queues assigned to the same priority MUST be scheduled according to a weighted algorithm (like WFQ) with weights assigned through provisioning. This mechanism provides support for mapping diffserv PHBs (e.g. EF, AF, BE, LE) to the Ethernet queues."

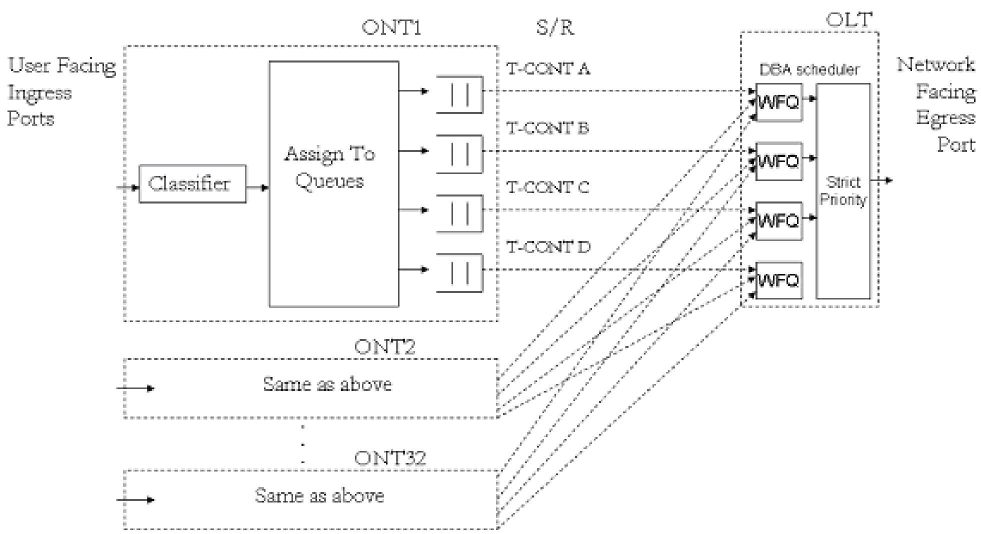

Figure 7-7/G.984.3: An example of a queuing and scheduling architecture that can be specified under the extended bandwidth assignment model

Comment [LY13]: Keep the figures. Remove extra text and stay with relevant description.

"R-xx The OLT MUST support the extended traffic descriptor parameters P_i and ω_i as specified in G.984.3. These parameters MUST be provisionable."

Comment [LY14]: Configurable

Dsl2008.160.01:

Include the follow figures for the mandatory upstream and downstream queuing and scheduling

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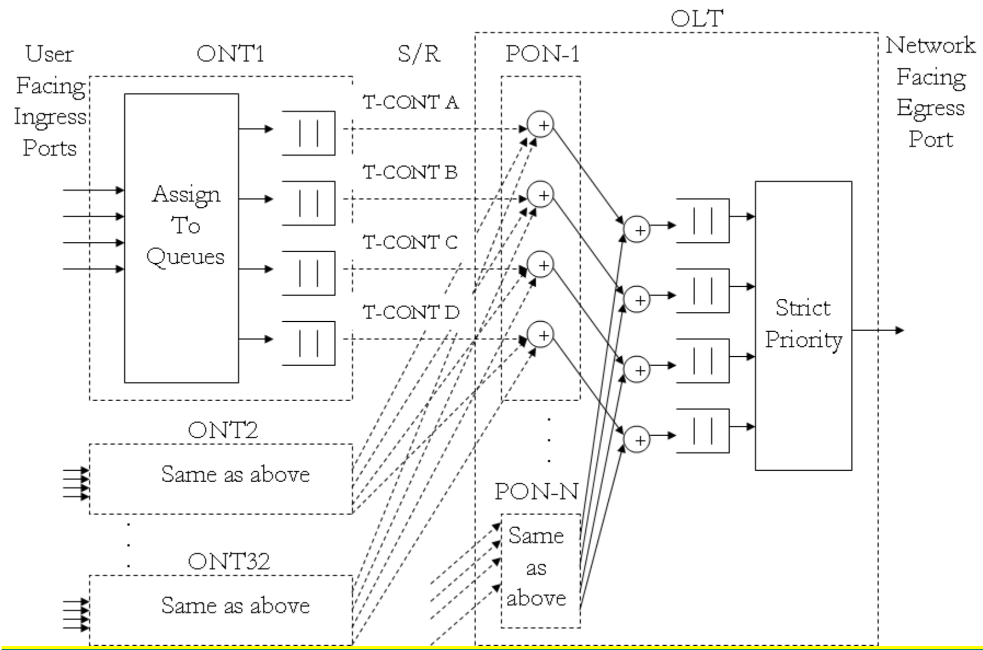

Figure X. Mandatory Upstream Queuing and Scheduling

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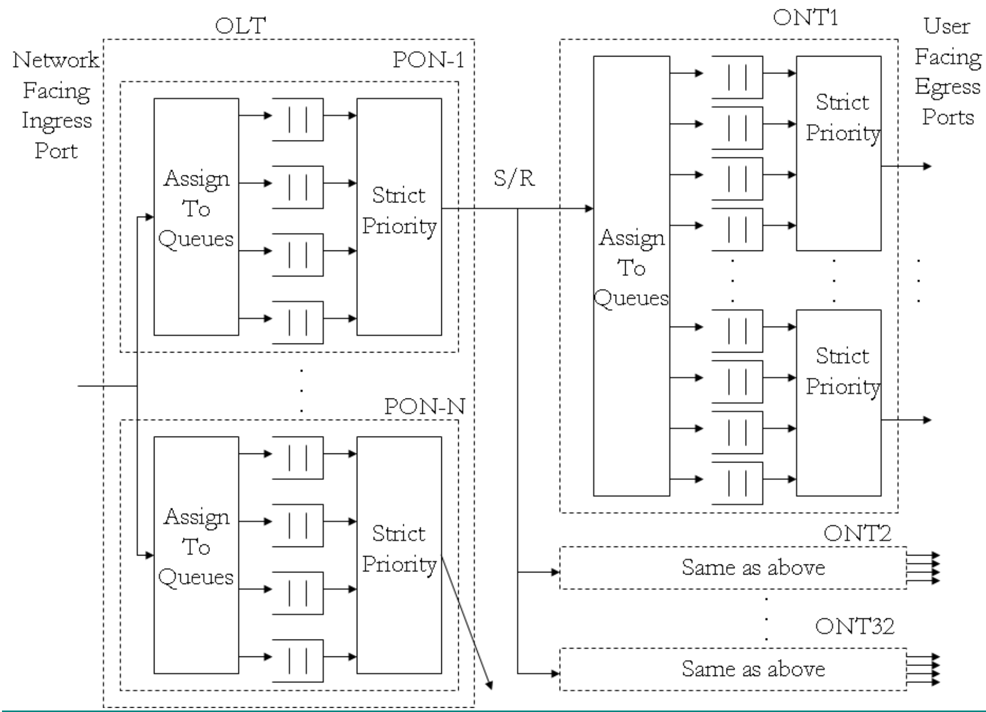

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Figure Y. Mandatory Downstream Queuing and Scheduling

Include the following text for mandatory TR-101 requirements:

(R-45) The OLT and ONT MUST support at least 4 traffic classes for Ethernet frames, and MUST support configurable mapping to these classes from the 8 possible values of the Ethernet priority field.

(R-47) The OLT and ONT MUST support drop precedence within at least 2 traffic classes and MUST support configurable mapping to these classes and drop precedence from the 8 possible values of the Ethernet priority field.

(R-49) In the downstream direction, the ONT MUST support at least 4 queues per user facing port, one per traffic class. In the upstream direction, the ONT MUST support at least 4 user queues, one per traffic class. In the downstream direction, the OLT MUST support at least 4 user facing queues per PON, one per traffic class.

(R-51) The OLT and ONT MUST support scheduling of user queues according to strict priority among at least 4 queues

(R-53) The OLT MUST support at least 4 queues per network facing port, one per traffic class

(R-55) The OLT MUST support scheduling of network queues according to strict priority among at least 4 queues.

(R-57) The OLT and ONT MUST support setting the maximum size/depth of all queues.

(R-xx) The ONT MUST support mapping each traffic class to a unique T-CONT, ~~such that there MUST be one T-CONT and associated queue for every supported class.~~

Include the following text for optional TR-101 requirements:

(R-46) The OLT and ONT SHOULD support at least 6 traffic classes for Ethernet frames, and MUST support configurable mapping to these classes from the 8 possible values of the Ethernet priority field.

(R-48) The OLT and ONT SHOULD support direct indication of drop precedence within all supported traffic classes based on the DEI bit value of the 802.1ad header

(R-50) In the downstream direction, the ONT SHOULD support at least 6 queues per user facing port, one per traffic class. In the upstream direction, the ONT SHOULD support at least 6 user queues, one per traffic class. In the downstream direction, the OLT SHOULD support at least 6 user facing queues per PON, one per traffic class.

(R-52) The OLT and ONT SHOULD support scheduling of user queues according to their assigned priority and weight. The number of priorities MUST be at least 4, however multiple queues may be assigned to the same priority. Queues assigned to the same priority MUST be scheduled according to a weighted algorithm (like WFQ) with weights assigned through provisioning. This mechanism provides support for mapping diffserv PHBs (e.g. EF, AF, BE, LE) to the Ethernet queues.

(R-54) The OLT SHOULD support at least 6 queues per network facing port, one per traffic class.

(R-56) The OLT SHOULD support scheduling of network queues according to their assigned priority and weight. The number of priorities MUST be at least 4, however multiple queues may be assigned to the same priority. Queues assigned to the same priority MUST be scheduled according to a weighted algorithm (like WFQ) with weights assigned through

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Comment [LY15]: Upstream direction

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Comment [LY16]: Delete the uniqueness. "mapping between traffic classes and a separate TCONT"

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Comment [LY17]: What is a traffic class and how many should be maintained. R-XX to be removed. Call for contribution

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provisioning. This mechanism provides support for mapping diffserv PHBs (e.g. EF, AF, BE, LE) to the Ethernet queues.

5.2.3 Downstream Traffic Management

Downstream traffic management over GPON is simpler than upstream. The downstream multiplexing of traffic is performed similarly to point to point links, and the concept of T-CONTs is not used. The same GEM ports are bidirectional and used downstream as well. The CoS assignment for traffic flows is applied by priority queues and scheduling mechanisms at the OLT and ONT. Additional downstream traffic management mechanisms are not mandatory.

5.3 Multicast

5.3.1 Introduction

There are a few unique considerations for deploying multicast services over GPON network:

- **Point to multi-point topology** – a GPON network is a physical point to multi-point network. This means that downstream data sent from the OLT is broadcast at the optical layer and can be received by all ONUs. This may be utilized for multicast. On the upstream direction, however unicast connectivity is needed for any control flows.
- **Bandwidth** – GPON offers significant bandwidth increase, comparing to DSL Access. The bandwidth increase is even more significant, if the content is shared. GPON ONUs may be placed closer to the CPE hence the distance of their U interface link may be shorter, which enable a higher rate on that link as well, whether it is xDSL or Ethernet based.
- **Replication hierarchy** – the hierarchy may be deeper, first due to the OLT-ONT hierarchy, and second, MDUs add another subscriber aggregation point, hence another replication point.
- **Scale** – all of the previous points translate to a much higher scale that a single OLT may need to support comparing to other access-nodes. GPON OLTs may support thousands of ONTs and tens of thousands of hosts (STBs) behind them, all fed from a single V interface. This requires higher attention on scalability of the access network.

Comment [TA18]: 692 should (still?) be presented here

5.3.2 GPON multicast specification

The current GPON G.984.x standards specify some of the aspects of multicast over GPON:
GEM ports allocated for downstream-multicast flow are shared by all ONUs. This enables to send a single instance of the content downstream. The popular approach is that a single GEM port transports the superset of multicast groups required by all ONUs. Hence an ONU needs to perform filtering at the MAC layer to forward only the groups required by its own subscribers. GPON AES encryption is disabled on the GEM port to enable all ONUs to terminate it.
The multicast GEM port is unidirectional. Upstream control flows may use existing data GEM ports or may have dedicated GEM ports. This may depend on whether there is a dedicated VLAN for multicast or whether it is shared with other services. The GPON standards do not specify that.

Comment [LY19]: Dsl2008.136.02: Remove "Upstream control flows may use existing data GEM ports or may have dedicated GEM ports. This may depend on whether there is a dedicated VLAN for multicast or whether it is shared with other services." This description of GEM port configuration for upstream control flows contradicts with the TR-101 multicast baseline attributes.

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Generally, GPON standards do not yet cover a few aspects specified by TR-101. Examples are the support of multiple multicast VLANs, and OMCI modeling for IGMP functions at the ONU as well as management functions such as matching groups.

5.3.3 GPON Specific Multicast Requirements

This section includes the configuration requirements that are specific to GPON, and clarifies the OLT vs. ONU responsibilities.
The following reference diagram illustrates the multicast service architecture. The GEM adaptation blocks are not shown for simplicity.

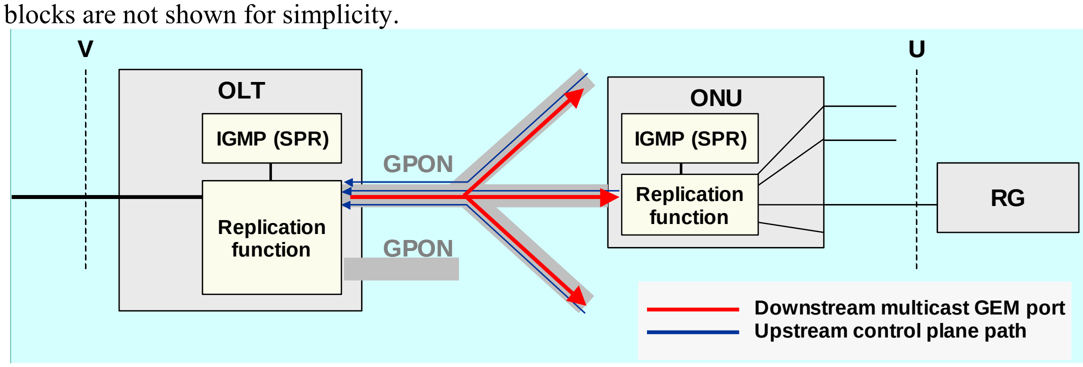

Figure 18 – GPON Multicast GEM ports

Comment [LY20]: **Dsl2008.136.02**: Supposedly, SPR stands for "Snooping with Proxy Reporting". It should be explicitly defined. – accepted

5.3.3.1 Data plane

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dsl2008.072.00:
It was agreed in the 5/2 conference call that there would be a clarification that the downstream GEM port would be multicast however it wasn't agreed that it will be configured per multicast VLAN.
Moreover, this stands in contradiction to the preceding text in WT156:
"GEM ports allocated for downstream-multicast flow are shared by all ONUs. This enables to send a single instance of the content downstream. The popular approach is that a single GEM port transports the superset of multicast groups required by all ONUs."
Proposal:
Change R-48 to the following:

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R-48 The GPON network MUST use a single downstream multicast GEM port per all multicast VLAN

Comment [LY21]: Leave as is until resolution of MC encryption issue

R-48 The GPON network MUST use a single downstream multicast GEM port per multicast VLAN

R-49 The downstream GEM port MUST transport only multicast groups required by ONU users on its GPON interface

Comment [TA22]: Is this already part of the ITU GPON spec? – No. Concerns have been raised about wether this is desired as it precludes provisioning of channels.

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Dsl2008.136.02:
In the context of supporting multiple multicast VLANs per user-facing port, there is no obvious benefit in requiring one downstream multicast GEM port per multicast VLAN. Based on TR-101, the uniqueness of group address is only ensured within a single multicast VLAN, but not across multiple multicast VLANs. So even if downstream multicast traffic from different multicast VLANs is segregated by unique downstream multicast GEM ports, it is still possible to trap a multicast message from a target VLAN in an unintended ONU if both of the following conditions are true:
1. The same group address is enabled (for a different multicast VLAN) in the multicast filter.
2. The target multicast VLAN is also configured in the same ONU.
In fact, multicast filters are increasingly capable of supporting MAC-level filter configuration based on a combination of group address and VID (R-211, TR-101). This multicast filtering capability further reduces the justification to provide another layer of separation via multiple multicast GEM ports, given the fact the S-TAG is present in the downstream multicast frames received by the ONU.
However, it is noted the GPON standard stipulates supporting multicast services over GEM using a single Port-ID for all streams, while the optional method uses multiple Port-IDs. Furthermore, separating multicast VLAN downstream into multiple multicast GEM ports allows some OLTs to perform policing the downstream bandwidth on a per VLAN basis.
Propose to change this to an optional requirement.

5.3.3.2 Control Plane

R-50 Single subscriber ONUs MUST support transparent snooping

R-51 Multiple Subscriber ONUs (e.g. MDUs) MUST support transparent snooping.
~~Whereas a single user ONT may not need suppression functions, since the RG behind it should implement an IGMP Proxy, there's a higher likelihood that a MDU that supports many subscribers, may need to provide this function for scalability. (Make versions consistent with TR-101)~~ response

R-52 ~~Multiple Subscriber ONUs (e.g. MDUs) SHOULD support snooping with proxy reporting~~.

R-53 The OLT MUST support transparent snooping
For dense service deployment, an OLT is likely to require suppression functions in order prevent exposure of the network to IGMP traffic from potentially a very large number of hosts.

R-54 The OLT MUST support snooping with proxy reporting.

R-55 GPON ONUs and OLTs MUST support limiting upstream IGMP rate per user port basis for multicast VLANs.

dsl2008.072.00:
Since the Data Plane Multicast GEM port is unidirectional, IGMP messages cannot be delivered upstream on that GEM.
Therefore it is required to use another bi-directional GEM port to deliver IGMP messages.

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Comment [LY23]: Call for contribution to cover all TR101 MC requirements.
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Comment [AT24]: While trying to execute this instruction, the editor got confused how multicast could be avoided at an ONU. It seems that ONUs – regardless of how many subscribers MUST always perform the multicast filter function from TR-101. The upshot is that the editor suspects that this paragraph is wrong.
Comment [LY25]: **Dsl2008.136.02**: Transparent snooping typically implies the inclusion of multicast filter function in the ONUs.
This is covered by R-50 ad R-51. In this paragraph, the term "suppression functions" refers to suppressing IGMP messages (i.e. Membership Query, Membership Report, and Leave Group in IGMPv2). This suppression function corresponds to "snooping with proxy reporting" in R-52.
The existing text and the associated requirement (R-52) are correct. "Proxy reporting" is typically not a requirement for single subscriber ONUs
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Downstream IGMP messages can be delivered either by downstream multicast GEM port or by several downstream unicast GEM ports (one per subscriber). The latter option creates a scalability challenge that should be avoided.
Therefore, it is recommended to use a downstream multicast GEM port for downstream IGMP messages.

Proposals:

R-XX The GPON network MUST use a bi-directional GEM port for all upstream IGMP messages. This GEM Port could shared with another VLAN (e.g. N:1 VLAN)

R-XX The GPON network MUST use a multicast GEM port for all downstream IGMP messages. This GEM Port could is shared by all multicast VLANs.

Editor note: Contributions are desired to explain how IGMP goes upstream.

Dsl2008.136.02:
Sections 5.3.3.1 and 5.3.3.2 are proposed to be revised as follows:
5.3.3.1 Data Plan
R-48 The GPON network SHOULD use a single downstream multicast GEM port per multicast VLAN.
R-49 The downstream GEM port MUST transport only multicast groups required by ONU users on its GPON interface.
R-50 The GPON network MUST support multicast VLANs through the use of N:1 VLANs.
R-51 The GPON network MUST support multiple multicast VLANs per user port per ONU.
R-52 The GPON network MUST support associations of a single user port to multiple multicast VLANs based on a configured list of multicast groups per multicast VLAN per user port.
5.3.3.2 Control Plan
In general, all downstream IGMP messages are transported via a multicast GEM port designated for the multicast VLAN. In the case where a multicast bridge model is used in the ONT, the message is flooded toward the user ports belonging to the same multicast VLAN.
In the upstream direction, by adopting the dedicated multicast VLAN model, the IGMP messages are segregated from other user traffic. All upstream IGMP messages are trapped for the snooping function and any configured VLAN manipulation is performed before being forwarded upstream.
In the context of multiple multicast VLANs, additional classification functions are required to support matching multicast groups to multicast VLANs. The S-TAG of the multicast VLAN is then used to map the IGMP messages to a particular GEM port going upstream. This GEM port is created one per multicast VLAN and is shared by upstream IGMP messages from all user ports belonging to the same multicast VLAN.
From the perspective of OMCI modeling, it is typical to split the downstream multicast traffic from the upstream multicast traffic, primarily due to the unidirectional nature of the downstream multicast GEM port, and to prevent flooding of upstream multicast messages from one user port to another user port. Various modeling scenarios exist, but essentially upstream IGMP messages from each user port are first transported in isolation to the AN side, then the messages belonging to the same multicast VLAN are mapped to the same GEM port going upstream. In this case, the

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GEM port would be unidirectional UNI-to-ANI.
R-53 Single subscriber ONUs MUST support transparent snooping.
R-54 Multiple subscriber ONUs (e.g. MDUs) MUST support transparent snooping.
R-55 The GPON network MUST support the transport of IGMP messages over the same multicast VLAN used to receive downstream multicast messages.
R-56 The GPON network MUST support the transport of downstream IGMP messages using the same downstream multicast GEM port assigned to the multicast VLAN.
R-57 The GPON network MUST support a dedicated GEM port for upstream IGMP messages per multicast VLAN per ONU.
Whereas a single user ONT may not need suppression functions, since the RG behind it should implement an IGMP Proxy, there's a higher likelihood that a MDU that supports many subscribers, may need to provide this function for scalability.
R-58 Multiple Subscriber ONUs (e.g. MDUs) SHOULD support snooping with proxy reporting.
R-59 The OLT MUST support transparent snooping.
For dense service deployment, an OLT is likely to require suppression functions in order to prevent exposure of the network to IGMP traffic from potentially a very large number of hosts.
R-60 The OLT MUST support snooping with proxy reporting.

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5.4 Security Considerations

Editor note: Describe how TR-101 security features need to be enhanced (if at all) when applied to GPON based Access.

5.5 Port Identification and Characterization

The syntax configurability of TR-101 line identifiers is retained for GPON, however, a new identifier is added to the flexible syntax list: the static identifier for the ONU.

R-56 The OLT MUST create the Agent Circuit ID and Remote ID as described in TR-101.
dsl2008.072.00:
There are several ways to obtain and map the ONU identifier to the equipment"
1) Map the device serial number to the ONU identifier
2) Map the device password to the ONU identifier
3) Map the combination of the device serial number and password to the ONU identifier
4) Identify the device by pre-configuration or by a captive portal and then map it to the ONU identifier
5) Any other method (see dsl2007.691.00)

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The various ways are derived directly from the diversity of the operators' business models. In some case the ONU is supplied by the network operator, in others it is bought in the market by the subscribers themselves. In the latter scenario, the device (including serial number and password) cannot be regarded as trusted and therefore it requires some management intervention.

Thus, different operators may use different methods to assign an identification number to the ONU devices plugged in their network, and therefore Option 82 must reflect a flexibility to cope with them.

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R-57 The OLT MUST use a static identifier for the ONU change to 'ONU identifier in a PON interface'. This identifier should remain the same across re-initialization, software and firmware updates, and adds, moves, and other changes that don't involve that ONU.

Comment [LY26]: DSL2008.07 2.00

Description of the variable	Possible name for the variable	Type of variable and max length	Range of values for the variable
Logical name of the Access Node.	Access_Node_ID	Variable. Note that total length of the overall agent-circuit-id must not to exceed 63 bytes	
Chassis number in the access node	Chassis	Char(2)	"0".."99"
ONU "serial" number in the access node change to 'ONU identifier in a PON interface'	SONUID	Char(3)	"0".."999"
Rack number in the access node	Rack	Char(2)	"0".."99"
Frame number in the rack	Frame	Char(2)	"0".."99"
Slot number in the chassis or rack or frame	Slot	Char(2)	"0".."99"
Sub-slot number	Sub-slot	Char(2)	"0".."99"
Port number in the slot	Port	Char(3)	"0".."999"
VPI on U interface in case of ATM over DSL	VPI	Char(4)	"0".."4095"
VCI on U interface in case of ATM over DSL	VCI	Char(5)	"0".."65535"
VLAN ID on U interface (when applicable)	Q-VID	Char(4)	"0".."4095"
Ethernet Priority bits on V interface	Ethernet Priority	Char(1)	"0".."7"

Comment [TA28]: Call for clarification on this identifier.

Comment [LY27]: DSL2008.07 2.00

Dsl2008.083.00:
As we know the serial number is unique for ONU, but it can be changed by operator, and when one ONU changes its physical location, OLT can't detect such change.
Is there any other information suitable for end users identification, as we know, G.984 recommendations propose a mechanism to obtain ranging information of fiber, for the PON system, the architecture of point to multipoint indicate that different user connect unique fiber, it is an static status for the network, after the planting fiber, the length of fiber don't change unless special issue. So ranging information could be used to figure out the physical location of the ONU.
In figure 1, there are two unique information of GPON ONU, length and serial number.

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In some application, we can use the serial number when the reconfiguration of serial number is forbidden except operator, serial number means unique ONU.
In some application, the ranging information can be used for port identification when the ranging information is different between ONUs, ranging information means unique ONU .
In case of the ranging information is same, how we can do? If we use the serial number and ranging information simultaneously, for same ranging information ONU, the serial number can be used to indicate the difference, and when in case of exchanging ONUs under same OLT port, the ranging information can be used for indicate these changes.

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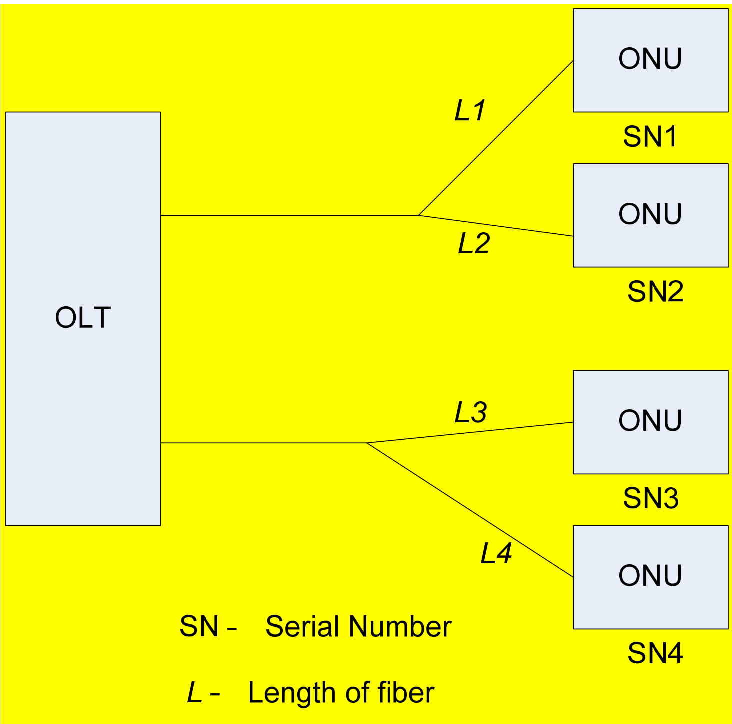
For example:
If SN1 and SN2 are forbid to change, the SN can be used for SONUID.
If the L1≠L2 then Ranging information can be used for SONUID.
If L3=L4, SN3 and SN4 can be used to distinguish different ONU, and if SN3 and SN4 exchange, the L2 and L3 may be used for distinguish for indicating this change. So combine L and SN for mapping to SONUID can solve some issues like these scenarios.
It is very few occasion that L2=L3 and the ONU-SN3 exchange with ONU-SN4.
So SOUNID can map to serial number and/or ranging information.



According the syntax, we should need find a way to obtain these slot/port information of multi-port ONU, for example, ONU fill the information in the DHCP option 82 or PPPoE intermediate Agent Circuit ID field, and OLT can intercept these information.
So we suggest: Multi-ports ONU that have several slots should provide the function of DHCP option 82 or PPPoE intermediate.

R-57: The OLT MUST use a static identifier for the ONU. This identifier should remain the same across re-initialization, software and firmware updates, and adds, moves, and other changes that don't involve that ONU. SERIAL_NUMBER and/or RANGING may map to SONUID for port identification and characterization. Where RINGING means ranging information, SERIAL_NUMBER means serial number of ONU.

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R-xx: Multi-ports ONU that have several slots should provide the function of DHCP option 82 and PPPoE intermediate.

R-58 The Access Node DHCP Relay Agent and PPPoE Intermediate Agent MUST use the following default syntax to automatically generate the Agent Circuit ID field, identifying access loop logical ports as follows:
"Access-Node-Identifier atm slot/port/SONUID/slot/port:vpi.vci" (when ATM/DSL is used)
"Access-Node-Identifier eth slot/port/SONUID/slot/port[:vlan-id]" (when Ethernet[/DSL] is used)
In this syntax, Access-Node-Identifier MUST be a unique ASCII string (not using character spaces). The Access-node-identifier, L2 type (ATM, ETH) field and the slot/port fields are separated using a single space character. The slot identifier MUST NOT exceed 6 characters in length and the port identifier MUST NOT to exceed 3 characters in length using a '/' as a delimiter[3]. The vpi, vci and vlan-id fields (when applicable) are related to a given access loop (U-interface) [4].

R-59 The OLT SHOULD perform the DHCP option 82 and PPPoE intermediate function.

6. OAM

Ethernet OAM, or Configuration Fault Management (CFM) as it is referred to in IEEE 802.1ag, behaves somewhat differently for 1:1 VLANs and N:1 VLANs.

OAM for 1:1 VLANs
Figure 19 shows where the required MEPs (triangles) and MIPs (circles) shall be for GPON, when 1:1 VLANs are used.

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Figure 19

[3] The exact way to identify slots is implementation-dependent. In some cases, the slot field may convey some additional semantics (e.g. the "705" value could mean rack #7 and slot #5). Concepts like chassis (for a multi-chassis system), racks or shelves may also be captured in the same way (e.g. "9-9-99" for a rack-shelf-slot construct) by further structuring the slot field.
[4] In other words, in the ATM case, vpi/vci will always be used. In the EFM case, *if the DHCP or PPPoE message is received with a VLAN TAG, the received VLAN ID will be appended to the string*.

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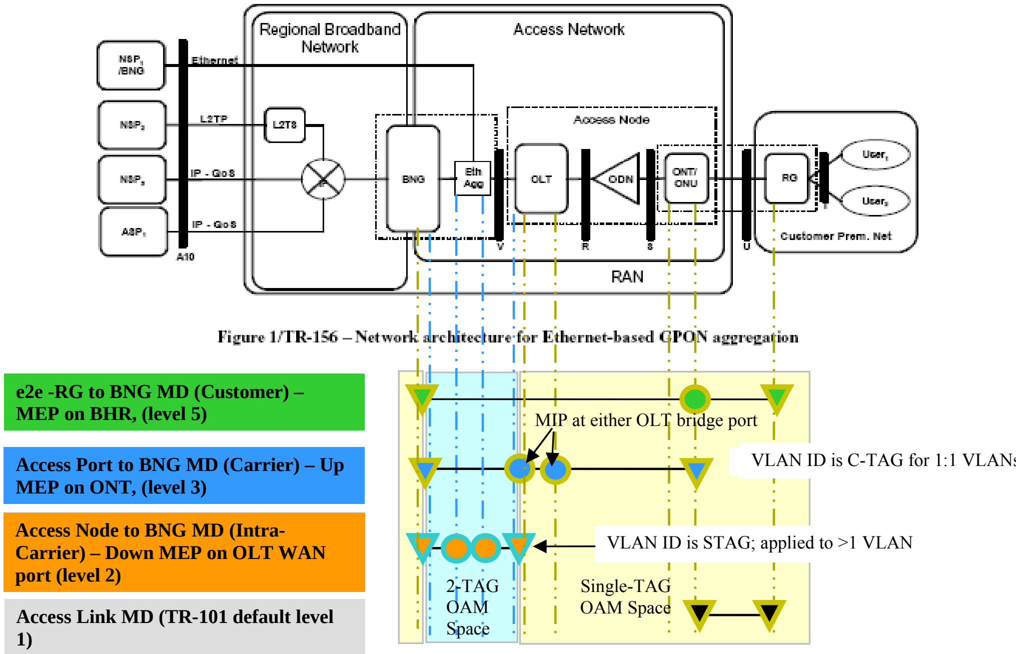

Figure 19 – Ethernet CFM for 1:1 VLANs

R-80 For the 1:1 VLAN case, for an Intra-Carrier Access Node to BNG Maintenance Domain (MD), the MEP in the Access Node must be created on the OLT at the interface facing the BNG.

R-81 For the 1:1 VLAN case, for an Access Port to BNG Carrier MD, the MEP in the Access node must be created on the user port on the ONT.

R-82 For the 1:1 VLAN case, for an Access Port to BNG Carrier MD, the only required Maintenance Intermediate Point (MIP) must be created on the OLT at either the interface facing the PON or the interface facing the BNG.

Note that the location of the MIP may affect the implementation of Ethernet CFM on the OLT depending on whether it resides before or after the addition of the S-TAG for double-tagged applications. The details of implementation are left to the vendor to ensure VLAN TAGs for the CFM messages are compliant at the interface locations A, B and C per Figure 20.

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R-83 For the 1:1 VLAN case, for end-to-end RG to BNG Customer MD, the only required Maintenance Intermediate Point (MIP) must be created on the ONT at the interface facing the user.

In the case of 1:1 VLANs, the Ethernet VC is presumed to be using double TAGs per IEEE 802.1ad Provider Bridges. The usage of the double TAGs is accomplished in the following manner:

- The Ethernet VC frames between the RG and ONT are untagged or single tagged in the case of TLS, or P-bit tagged
- The Ethernet VC frames between the ONT and OLT use single tagged frames (C-TAG).
- The Ethernet VC frames between the OLT and BNG use double tagged frames (S-TAG and C-TAG).

Since the VLAN TAGs for the Ethernet VC are different depending on the device location in the network, it affects Ethernet OAM frames as well.

There are three major points depicted in Figure 1 with regard to resultant OAM space that is created by the type of TAGs used at the various nodes:

1. The Double-tagged OAM Space begins and ends at the "east-west" points where the outer tag is added and removed.
2. The Double-tagged OAM Space has free access to all eight MD levels, and it can use the same levels as the Single-tagged OAM Space and not cause a conflict.
3. The Single-tagged OAM Flow Space has no access to OAM processing points at devices where the frame still has two TAGs.

The OAM Flow Space is not a division of MD Levels. The MD Level concept, and the OAM Space concept, are independent.

R-84 For the 1:1 VLAN case, for the Intra-Carrier Access Node to BNG MD, the Access Port to BNG Carrier MD, and the end-to-end RG to BNG Customer MD, the BNG must support MEP functionality at all 3 levels at the same time.

Figure 20 describes the VLAN TAGs in relation to the Intra-Carrier, Carrier and Customer MDs for the 1:1 VLAN case. Note that either untagged frames or single tagged frames (in the case of TLS) may be used at C.

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Note that at A, the double-tagged OAM frames of the Carrier MD and Customer MD levels would not receive OAM processing.

Also note that it is required that the BNG will terminate the S-tagged flow and process the OAM frames of the Double-tagged OAM Flow Space. It would then process the C-tagged flow and process the OAM frames of the Single-tagged OAM Flow Space.

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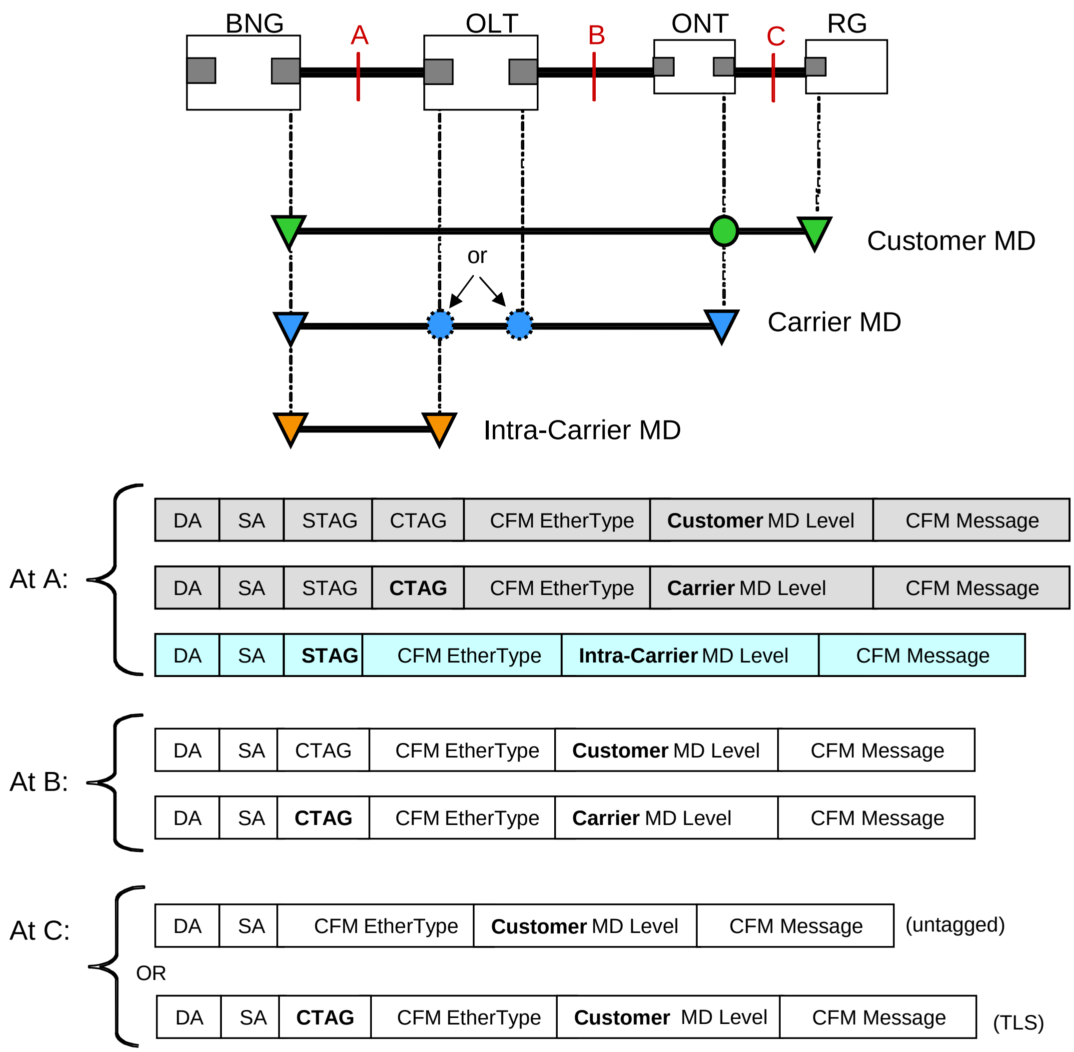

Figure 20 – Ethernet CFM for 1:1 VLANs

6.1 OAM for N:1 VLANs

Figure 21 shows where the required MEPs (triangles) and MIPs (circles) shall be for GPON, when N:1 VLANs are used.

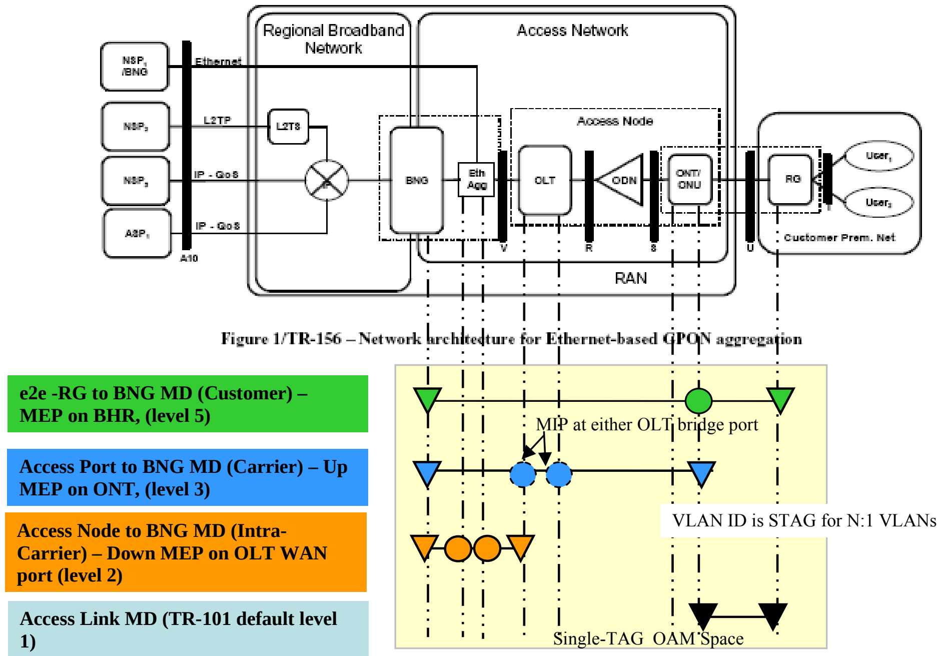

Figure 21 – Ethernet CFM for N:1 VLANs

R-85 For the N:1 VLAN case, for an Intra-Carrier Access Node to BNG Maintenance Domain (MD), the MEP in the Access Node should be created on the OLT at the interface facing the BNG.

R-86 For the N:1 VLAN case, for an Access Port to BNG Carrier MD, the MEP in the Access node must be created on the user port on the ONT.

R-87 For the N:1 VLAN case, for an Access Port to BNG Carrier MD, the only required Maintenance Intermediate Point (MIP) must be created on the OLT at either the interface facing the PON or the interface facing the BNG.

R-88 For the N:1 VLAN case, for end-to-end RG to BNG Customer MD, the only required Maintenance Intermediate Point (MIP) must be created on the ONT interface facing the user.

In the case of N:1 VLANs, the Ethernet VC is presumed to be using a specific S-TAG.

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- The Ethernet VC frames between the RG and ONT are untagged or single tagged in the case of TLS (C-TAG), or P-bit tagged
- The Ethernet VC frames between the BNG and ONT use single tagged frames (S-TAG).
- At the Customer MD level, the untagged or TLS service OAM frames from the RG are mapped into S-tagged frames at the ONT, and vice versa.

Therefore, all Ethernet OAM frames for the N:1 Ethernet VC would also use the same S-TAGs for the Intra-Carrier, Carrier and Customer MDs between the BNG and the ONT.

R-89 For the N:1 VLAN case, for the Intra-Carrier Access Node to BNG MD, the Access Port to BNG Carrier MD, and the end-to-end RG to BNG Customer MD, the BNG must support MEP functionality at all 3 levels at the same time.

6.1.1 Efficient Method for Forwarding CFM Messages in N:1 VLANs

Comment [TA29]: On the call, the editor claimed that the whole OAM section had been worked out by a large group of contributors. That was a mistake. It was noted that from here to the end of section 6 is a separate contribution on OAM – 809, and that there would need to be coordination between the proposal and IEEE and ITU before we could make such a specification. Please review carefully.

According to existing Connectivity Fault Management (CFM) standards (i.e. IEEE P802.1.ag and ITU-T Y.1731), each Maintenance Point (MP) has to support CFM frame inspection based on the CFM Ethertype, MAC DA, MD Level and VLAN ID. The destination MAC address on the CFM message is then used by the MPs for taking one of the following decisions:

- Process the CFM message
- Discard the CFM message
- Forward the CFM message

A CFM PDU can carry either a unicast destination MAC address or a multicast destination MAC address, depending on its op-code value.

In order for a node to send unicast CFM message it needs to know a-priori the destination MEP’s MAC address. This can be done either by configuration of all MEPs MAC addresses using network management systems (NMS) or by dynamic learning that is done by the node itself, based on the receipt of CFM messages generated by all MEP in the same MD. The latter is based on MEPs emitting CCM messages. The two methods described above are not scalable when it comes to MEPs located at the customer premises (i.e. ONTs and RGs)[5] for the following reasons:

1. Operators are reluctant to have their NMS systems aware of CPE MAC addresses due to the operational challenges (the need to deal with duplication of addresses, the need to update whenever a new equipment is installed or replaced, etc.).
2. Activating CCM from every residential CPE will cause flooding of the aggregation network with many thousands of multicast CCM flows. Aside from wasting considerable bandwidth it might saturate the CFM processing modules in the aggregation and access network nodes. TR-101 recommends turning CCM off in any residential CPE.

[5] For the sake of clarity, in the following the term CPE will be used to describe both ONTs and RGs, although in some deployments the ONT is located at the demarcation point and is not actually in the customer premises.

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So the other alternative, and the only one that makes sense for residential customers, is sending CFM with multicast destination address. However, forwarding a multicast CFM message on an N:1 VLAN construct might be very inefficient as in the trivial forwarding scheme it will include flooding the CFM message on all physical and virtual ports. This will be further highlighted by the following example.

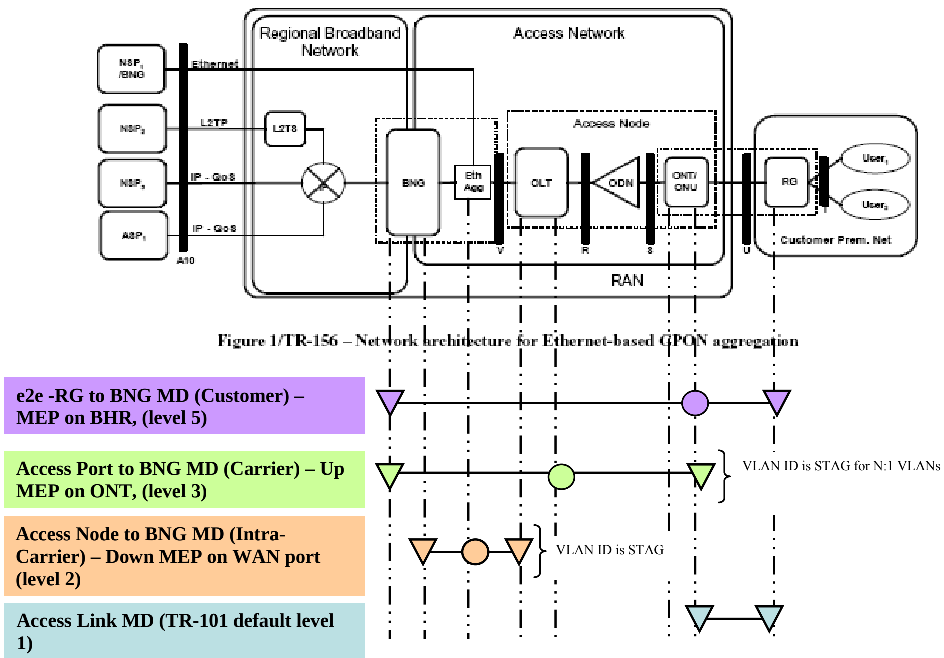

Figure 22 - CFM entities scheme

Figure 22 depicts CFM MD levels and MPs within N:1 VLAN ID scheme (as defined in WT-156).

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Any residential user installation has Maintenance End Points (MEPs) in two MD levels, Customer and Carrier:

- MEP per each VID on the Customer MD level at the RG
- MEP per each VID on the Carrier MD level at the ONT

Lets look at an OLT hosting 60 PON interfaces with 32 split each and with an N:1 VLAN that is shared by all ONTs (one example for such VLAN may be VLAN for VoIP service). Assuming, there is a Carrier-level MEP on every ONT, then in this case there are 60 x 32 = 1920 MEPs reachable on this VLAN. Therefore any Multicast LBM request sent by a BNG on this VLAN will cause 1920 LBRs with the same Transaction ID. Surely, a very undesired phenomenon.

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This document proposes a method for resolving the problem of inefficient forwarding of multicast CFM messages in N:1 VLANs. The method proposed utilizes the standard tools of IEEE 802.1.ag and ITU-T Y.1731 together with the operational concepts put forward by TR-101.

6.1.1.1 CFM Messages and TLVs

As described in IEEE802.1ag, the CFM header is composed from three parts:

- Common CFM header
- Unique parameters per CFM op-code
- Type Length Value (TLV) fields

The common CFM header appears in all CFM message types. Its attributes are shown in Figure 23 and detailed in Table 2.

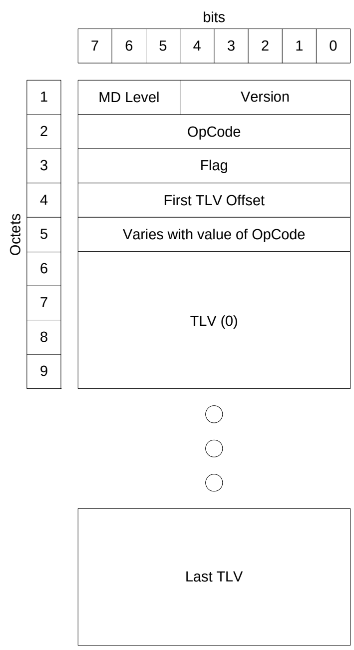

Figure 23 – Common CFM Header

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Octets	Field Name	Field Description
1	MD Level	Identifying the Maintenance Domain Level of the packet
	Version	The protocol version number
2	OpCode	Specifies the format and meaning of the remainder of the CFM PDU
3	Flags	Varies per op-code value
4	First Type, Length, Value (TLV) Offset	The offset in the CFM PDU following current field. Varies per op-code value.
5	Varies per op-code value	Varies per op-code value
6-9	Type, Length, Value (TLV0)	Several TLVs can be carried within a single CFM PDU

Table 2- CFM Message Fields

Several CFM message types (e.g. LBM, LTM, CCM…) have some dedicated unique parameters. These parameters are carried within the Flag and the 'Varies per op-code value' fields.

Additionally, several TLVs can be added to the CFM message.

Octets	
1	Type
2-3	Length
4 - (Length + 3)	Value

Figure 24 – CFM TLV Format

The TLV field is constructed as follows (see Figure 24):

- Type – Indicates the TLV type. Table 3 details currently allocated Type values. Value '9' and 64-255 are reserved for the IEEE. Values 33-63 are reserved for the ITU-T.
- Length - Indicates the length of the Value field
- Value – Different values are defined according to the Type

Type values	Type Name
'0'	End TLV
'1'	Sender ID TLV
'2'	Port status TLV
'3'	I/F status TLV
'4'	Data TLV
'5'	LTM Egress ID TLV
'6'	LTR Egress ID TLV
'7'	Reply Ingress TLV
'8'	Reply Egress TLV
'9'	Reserved
'31'	Organization specific TLV
32	ITUT Y.1731 – Test TLV
'33'-'63'	Reserved for ITUT
'64'-'255'	Reserved for IEEE

Table 3 - Type Values

6.1.1.2 The Main Idea

The main idea is to attach to every CFM request message sent by the BNG a new TLV, called *port_id TLV,* that describes the virtual (or physical) port on the Access Node for which the CFM message is destined. The information carried by the Port_id TLV shall be identical in syntax to the one supported in the option 82 (i.e. circuit_id field) and will be represented as a DSL Forum TLV.

The Access Node receiving a CFM message from the BNG on an N:1 VLAN will inspect the TLV message and will forward it only to the destination virtual port (without flooding). Every such CFM message shall generate at most a single response (by the destination MEP). The reply CFM (when applicable), with unicast destination, will be forwarded using the bridging tables of the OLT, as regular data frame.

The benefits of this idea are the following:

1. Optimal efficiency in network utilization
2. Utilizing an existing mechanism for addressing/identifying user ports that is already implemented in Access Nodes, BNGs, and provisioning systems.
3. Using standard CFM message constructs (allocating the type value should be coordinated with ITU-T/IEEE)
4. Lightweight implementation at the Access Node.
5. Method is usable on both DSLAMs (DSL ports) and OLTs (PON ports)

The syntax of the circuit_id described in TR-101 and WT-156 ensures deterministic forwarding by the Access Node.

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6.1.1.3 Method Explained in Details

Figure 25 depicts an example flow for Multicast CFM messages in N:1 VLAN scheme. Figure 26 describes the CFM message formats for reference points 'A', 'B', 'C' and 'D'.

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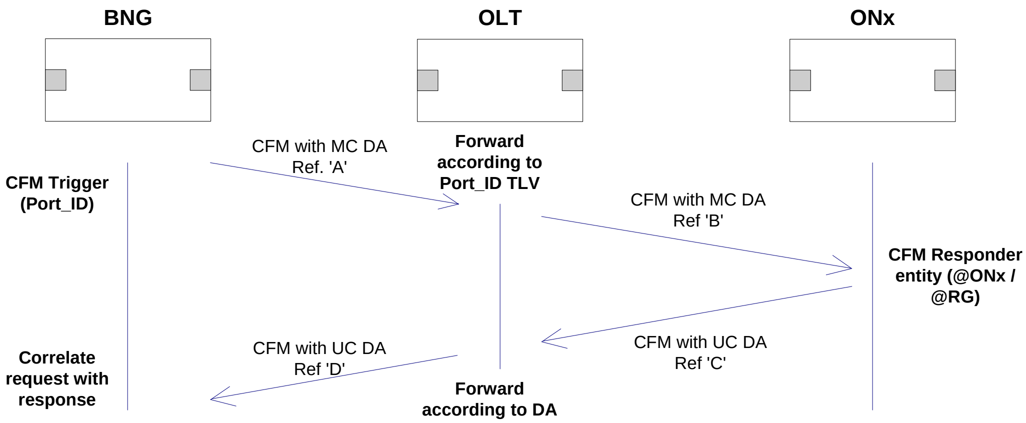

Figure 25 – CFM Message Packet Flow

The BNG is triggered, for example by the network management entity, to send a multicast loopback request message (LBM) to a specific virtual user port that is identified by a port_id of the format:

Access-Node-Identifier gpon slot/port/SONUID:VLAN_ID.

The BNG creates a new LBM, adds the port_id TLV with the requested port identification string and encapsulates it with an Ethernet frame having the BNG MAC address as SA and a multicast address as DA (The multicast address can be allocated according to IEEE 802.1ag Linktrace Message Group Destination MAC Addresses table). The CFM is sent in Format ‘A’, forwarded by the aggregation network[6] and is received by the OLT.

[6] The Ethernet frame carrying the CFM message is tagged with a specific S-VLAN and since S-VLANs are not frequently shared by Access Nodes the forwarding by the Aggregation network is deterministic.

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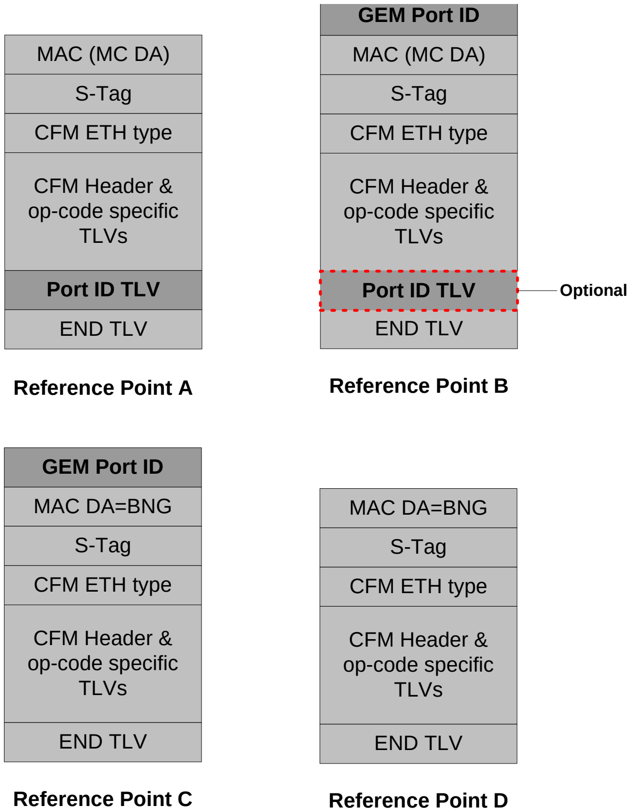

Figure 26 – CFM Message Frame Formats

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Field Code Changed
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Having received an LBM on an N:1 VLAN, the OLT looks for the port_id TLV. The port identification string is used by the OLT to determine the destination virtual port (a specific GEM port id on a specific PON interface). In the context of WT-156 the OLT should probably remove the port_id TLV, but in the context of WT-167, GPON fed-DSLAM, the TLV must not be removed since it may be used by the ONU for a further forwarding decision (i.e. the port_id string may address also the DSL port number on the ONU). In any case, the OLT does not change the Ethernet header and forwards the LBM in format 'B'.

Assuming the LBM was intended for a MEP at the ONU, the ONU will receive it and will generate an LBR. The LBR will be encapsulated in an Ethernet frame with the ONU MAC address as SA and the BNG unicast MAC address that is copied from the LBM, as DA. Frame format is described in 'C'. The ONU does not need to echo the port_id TLV as it has meaning only for downstream forwarding (i.e. BNG to ONT, RG etc.).

The LBR will be received by the OLT, since it does not concern the OLT it will strip the GEM encapsulation and will forward the Ethernet frame unchanged using its MAC learning tables (as any

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other data frame in an N:1 VLAN). The LBR will be of format 'D' when sent to the Aggregation Network.

The BNG will receive the LBR, will correlate it to the LBM and will sent a notification to the Management entity that initiated the OAM action.

7. Network Management

Editor note: Describe any specific network management requirements added to the Access Network as result of support for GPON. Architectural requirements in this document may implication on the required coverage by OMCI for management. This should require standardization via ITU SG15 Q2 group that maintains GPON specifications.

As the GPON based access network may give rise to the number of managed elements, it is foreseen that in some cases the OLT and ONU will be managed as a single manage entity. This is also supported by the architecture of the OMCI protocol that enables the specific configuration of an ONU by an OLT.

R-90 Local management via LAN ports must be limited to initiate the GPON NT with a registration ID that will enable the ONT to be identified by the OLT as pertaining to a given subscriber.

R-91 The NT must implement one logical IP interface, accessible through any of its LAN ports and any VLAN ID, and activate this logical IP interface only when it has not ever been ranged previously on any PON.

R-92 The IP interface specified in section § R-91 must be pre-provisioned in factory with any public IP address.

R-93 The NT must implement a DHCP server, a PPPoE server, a DNS and a HTTP server, accessible through any of its LAN ports and any VLAN ID, and activate these servers only when it has not ever been ranged previously on any PON.

R-94 The DHCP server specified in section §R-93 must respond to any DHCP request (addressed to the ONT on the well known port 67), whatever the parameters the DHCP request contain, and return an IP configuration with an IP subnet to which the NT's local IP address belongs, together with the NT's local IP address as a Domain Name Server and a Lease Time of 60 seconds.

R-95 The PPPoE server specified in section §R-93 must respond to any PPPoE request (addressed to the ONT on the well known Ethertype 0x8863), whatever the parameters the PPPoE request contain, and return an IP configuration, together with the NT's local IP address as a Domain Name Server. The period of LCP keepalive messages must be 30 seconds.

R-96 The Domain Name Server specified in section §R-93 must respond to any DNS request (addressed to the ONT on the well known port 53), whatever the targeted domain name it contains, with the NT's local IP address, and a Time To Live of 60 seconds.

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R-97 The HTTP server specified in section §R-93 must respond to any HTTP request, whatever the targeted URL it contains, and return an HTML page, with no-cache directive, that provides a graphical interface asking to enter a registration ID.

R-98 The ONT must switch off all its LAN interfaces while ranging with the OLT.

R-99 The ONT must store the registration ID in a non volatile memory.

R-100 The ONT must store in a non volatile memory whether it has ever been ranged previously on any PON.

R-101 The ONT must implement as described in section a physical means to force the ONT returning to its factory state (i.e. to flush its memory from the information stored as per the two previous requirements).

Comment [TA31]: **691** – has references to missing chapters. **ED:** Is this in scope of 156? Is this an ITU spec? If all this is required, then there may be a lot of additional work needed in this area/management chapter?!? The editor is worried about the document time lines if this is in scope.

In some case the ONU is supplied by the network operator, in others it is bought in the market by the subscribers themselves. In the latter scenario, the device (including serial number and password) cannot be regarded as trusted and therefore it requires some management intervention. Therefore the ONU identifier in a PON interface must support configuration:

R-102 R-XX The OLT MUST allow reading the configuring the ONU identifier.

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