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Preface

On-line Document Repositories

* Approved versions of document are stored in Agile under the Radisys document number
* Interim released versions of document are stored here: \\TBD
* Pointers to documents and additional copies are also located in the collaboration site: <Provide link here>

Revision History

All revisions that start with zero (such as 0.5, 0.65, and the like) are preliminary drafts for internal review only.

| 1. Revision History
 |
| --- |
| No. | Date | Author | Description |
| 0.1 | 02/02/2018 | Shaun Missett/Kim Kempf | Initial draft  |
| 0.2 | 02/09/2018 | Shaun Missett/Saurav Das/ONF | OpenFlow Updates/commentsUpdate Table of Contents |
| 0.3 | 02/15/2018 | Shaun Missett/Kim Kempf | Update Figures |
| 0.4 | 02/16/2018 | Shaun Missett | Update Terminology, VOLTHA versus vOLTHAOpenFlow versus Open Flow variants – remove Revision in footer as there are PDF conversion issues – may fix later. |
| 0.5 | 03/19/2018 | Shaun Missett | Clarify Instance Control Use cases – add support for PON Level Instance Control. Add support for Bidirectional/Uni-Down/Ui-Up attributes for Multicast support.Add attribute to allow explicit or automatic control of PON DBA additional bandwidth.  |
| 0.6 | 04/12/2018 | Shaun Missett | Output of AT&T Lockdown meeting review of ‘Service Profile’ proposal:1. Rename to be ‘Technology Profile’
2. Remove ‘Fixed’ (RF ) DBA Bandwidth Component from Profile and add the use of a third Open Flow Meter Band for specifying this.
 |

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# Overview

## Document Overview

This document describes the issues with using Open Flow independent of Technology Specific attributes and provides a solution which does not require extensive development of Technology Specific management interfaces to support different Access Technologies.

## Product Overview

The VOLTHA Adapter supports the Edgecore/Accton OLT which is an OCP 16 Port XGS-PON vOLT design. The ASFvOLT16 design is based on Broadcom Maple PON MAC silicon supporting 16x XFP ports of XGS-PON or NG-PON2 (10Gb/10Gb) and four 100 gigabit QSFP28 Ethernet uplink ports. The design includes a Broadcom StrataDNX (Qumran) switch to bridge the PON ports to the four NNI uplink ports.

## Terminology

| **Term** | **Definition** |
| --- | --- |
|  |  |
| Datapath | The aggregation of components of an OpenFlow logical switch that are directly involved in traffic processing and forwarding. The datapath includes the pipeline of flow tables, the group table and the ports. |
| GEM Port | An abstraction on the G-PON transmission convergence (GTC) adaptation sublayer representing a logical connection associated with a specific client packet flow. |
| GEM | In this Document GEM and XGEM are used interchangeably as are GEM Port and XGEM Port, primarily using the GEM terminology. |
| OpenFlow Protocol | The protocol defined by OpenFlow Switch specification [1]. Also called OpenFlow Switch Protocol |
| Packet | A series of bytes comprising a header, a payload and optionally a trailer, in that order, and treated as a unit for purposes of processing and forwarding.  |
| Pipeline | The set of linked flow tables that provide matching, forwarding, and packet modification in an OpenFlow switch |
| Tag | A header that can be inserted or removed from a packet via push and pop actions |
| XGEM Port | An abstraction in the TWDM TC service adaptation sublayer representing a logical connection associated with a specific client packet flow. |
|  |  |

## Acronyms

Alloc-ID Allocation Identifier

DB Data Base

DBA Dynamic Bandwidth Assignment

GEM Gigabit-capable passive optical network Encapsulation Method

MAC Media Access Control

ODN Optical Distributuion Network

OF OpenFlow

OLT Optical Line Termination

OMCC ONU Management and Control Channel

OMCI ONU Management and Control Interface

ONF Open Networking Foundation

ONU Optical Network Unit

PON Passive Optical Network

QoS Quality of service

*RA* PON traffic flow Assured Bandwidth component (G.989.3 Section 7.1)

*RF* PON traffic flow Fixed Bandwidth component (G.989.3 Section 7.1)

*RM* PON traffic flow Maximum Bandwidth component (G.989.3 Section 7.1)

χ*AB* PON traffic flow Ternary eligibility indicator for additional bandwidth assignment: {none, non‑assured (NA), best-effort (BE)}; (G.989.3 Section 7.1)

RED Random Early Discard

SDN Software-defined networking

SDNC SDN controller

SLA Service level agreement

SP Strict Priority

T-CONT Transmission Container

TOR Top of rack

VID VLAN identifier

VLAN Virtual local area network

VM Virtual machine

VN Virtual network

VNE Virtual network element

WAN Wide area network

WRED Weighted Random Early Discard

WRR Weighted Round Robin

XGEM 10-Gigabit-capable PON Encapsulation Method

# Issues List

This section provides a list of issues that need to be resolved in order to complete the document. Additional are scattered throughout the document, flagged by “!!!!” or formatted as questions.

1. [Issue # N.] RESOLUTION 🡺 Resolution of Issue #N.

# OpenFlow Abstraction Issue With Managing Non-Ethernet Access Technologies

## Problem Statement

Currently OpenFlow can configure Match/Action rules for unidirectional Service Flows but cannot specify Queue Scheduling Policies or Access Technology Specific attributes:

For xPON:

* T-CONT and GEM Port allocations
* T-CONT Upstream Bandwidth Scheduling Attributes(G.989.3 Section 7)
* GEM Port Scheduling Policy

Similarly for Access Technologies such as EPON or G.fast there is the same problem.

Note that OpenFlow can additionally specify Meters and/or an output Queue for a given Flow on a given interface.

The goal would be to eliminate the need for adding additional Technology Specific Yang models for managing each and every Subscriber Flow on each and every specific Access Technology directly on VOLTHA so that VOLTHA can remain a generic hardware abstraction for OLT based services using OpenFlow.

## Solution Proposal

Instead of supporting technology specific Yang Models in VOLTHA, and implementing the Local and Northbound interfaces required it is proposed that VOLTHA will support a set of ‘Technology Profiles’ which describe technology specific attributes required to implement Subscriber Services on an OpenFlow managed Logical Switch overlaid upon an OLT or other technology specific platform.

Each ‘Technology Profile’ can be an XML encoded(TBD) technology specific Record with an OpenFlow Flow Table ID as part of the Record. Each Service Flow will reference a Flow Table with a Table ID containing a default Flow Entry which will ‘Match All’ Flows, with No Actions and this Flow Table ID will be used to Reference a Technology Profile with the Access Technology Specific information contained within it, examples are provided at the end of the document.

It is proposed that optionally:

1. A Local User Interface will allow creation of each Technology Profile Record,
2. The Technology Profile Records can be created via a Northbound interface to an SDN Controller,
3. The Records can be downloaded via Secure File Transfer from a Server.

Also initially, the Technology Profile Records can be Locally Stored as Fixed Default Entries to Speed development.

Each Subscriber Record within the SADIS Application used by ONOS and the OpenFlow Manager can be updated to indicate a Flow Table ID to use as the Reference to a Technology Profile known to VOLTHA.

A reserved Range of Flow Table IDs could be used for Technology Profile reference (e.g 64 - 255) ONOS Applications will manage the Flow Table ID to Technology Profile reference. Any Service Flow without a Flow Table ID Reference for a Service Flow will default to use Table ID 64.



Figure 1 Adding Technology Profile as Part of VOLTHA

One area of concern from a scalability perspective is the number of Technology Profiles required. It is common for Operators to use Profiles, but in order to avoid many instances of the same Profile with slightly different bandwidth needs (especially with xdsl lines), overrides for the Bandwidth attributes are used. Since we want to support a small number of Technology Profiles it would be more scalable to separate out any bandwidth specific Flow information and use OpenFlow Meters to carry that.

If a Service bandwidth requirement changes then OpenFlow service definition Meter Bands will be updated and the modified bandwidth parameters downloaded independent of the Access Specific Technology Profile and the Bandwidth can change independent of the Technology Profile/Flow Table ID definition.

This approach allows bandwidth changes to occur for Service Flows without change to the Access Specific Technology Profile.

Business Services (MEF) are usually defined in terms of the following attributes:

* CIR – Committed Information Rate
* CBS - Committed Burst Size
* EIR - Excess Information Rate
* EBS - Excess Burst Size

A Residential Service Flow may be defined in terms of PIR and PBS and sometimes in terms of Policy based scheduling models defined by Priority and Weight.

For Access Technologies that use a Downstream Broadcast method with a Multi-Access Upstream mechanism where Upstream Transmission Opportunities are allocated based on Demand or ‘Fixed’ Configuration a third type of Bandwidth can be assigned which we will term ‘Guaranteed’ Information Rate (GIR).

Where CIR, EIR and PIR can be considered ‘Work Conserving’ i.e. Upstream Transmission Opportunites can be granted based on Demand with no waste, the GIR Upstream Transmission opportunities are allocated based on ‘Fixed’ Configuration independent of Demand and if not used by the Subscriber they are allocated for are ‘lost’ and not available for others to use.

For ITU based PON Systems the GIR Bandwidth represents the ‘Fixed’ FR component of Upstream Bandwidth and for IEEE EPON systems it could represent Upstream Bandwidth configured for Unsolicited Grant Service.

A Flow is a unidirectional construct and there will be both an Upstream and Downstream component of the Technology Profile. Only Upstream Flows will configure Guaranteed Information Rate bandwidth, where Downstream Flows are limited to CIR/EIR/PIR bandwidth.

The parameters CIR/CBS/EIR/EBS can be used for both policing and shaping (MEF 10.3 A.3) both Upstream and Downstream, GIR will also be applied for Policing and Shaping purposes but only in the Upstream direction – the GIR and CIR components are combined for the CIR part of a two rate three color policer.

For the Access nodes the need is primarily for shaping to reduce loss and optimize TCP throughput.

### OpenFlow and PON MEF to Meter Band Conversion

The OpenFlow ‘Meter’ Table will be used to convey the per Flow Bandwidth Profile Parameters of either the Upstream or Downstream traffic depending on the directionality of the Flow(See Section 5.7 of the OpenFlow 1.3.4 specification):

Per the OpenFlow standard the Meter Table consists of Meter Entries and each Meter Entry contains:

* Meter Identifier: a 32 bit unsigned integer uniquely identifying the meter
* Meter Bands: an unordered list of meter bands, where each meter band speciﬁes the rate of the band and the way to process the packet
* Counters: updated when packets are processed by a meter

Each Meter Band is identified by its Rate and contains:

* Band Type : This field represents Optional behaviours, ‘drop’ (1) or ‘dscp remark’ (2) (Note: we would use option 2 set to not change the DSCP value)
* Rate: used by the Meter to select the Meter Band, and defines the lowest rate at which the band can apply(Kb/s)
* Burst: Burst Size in Kbits
* Counters: updated when packets are processed by a meter – See Table 5 OpenFlow Spec 1.3.4
* Band Type Specific Arguments: Increment to DSCP Field (zero increment in this case)

In order to support the Upstream PON DBA model with OpenFlow Meters one Meter Band in a Meter will represent the CIR (Upstream:G.989.3 Section 7, *RA*:Assured bandwidth) and CBS attributes and a second Meter Band will represent the CIR+EIR = PIR(Peak Information Rate) value (Upstream:G.989.3 Section 7, *RM*:Maximum bandwidth) and the CBS+EBS = PBS.

Where ‘Fixed’ Bandwidth (FR) is required a third Meter Band will be used in the Upstream direction only. The Third Meter Band will Specify a Rate with a ‘0’ Burst capability – this will identify the GIR bandwidth component.

The CBS and PBS Meter Band Burst values MUST be > 0.

Downstream the MEF bandwidth model is used as applied to the OpenFlow Meter Band configuration where one meter band represents CIR and CBS, another the PIR(CIR+EIR) and PBS(CBS+EBS).

Bandwidth Rules:

In order to use OpenFlow Meters for PON Scheduling the following conventions apply:

1. **Where No Meter is specified for a Flow:**
	* + Upstream Only:The Flow scheduling bandwidth can be defined by a combination of { ***(RM*** = PON Rate Max***),*** χ*AB* ***(BE)*** }.
		+ If the Extended PON Bandwidth Model is Enabled then Bandwidth is assigned based on Priority and Weight as specified in the Technology Profile.
		+ Downstream Only: Packet Transmission based on Flow Priority and Queue Weight.

1. **Where a Single Meter Band is specified in a Meter and Burst Size > 0:**
	* The Meter Band will represent the PIR(Peak Information Rate) value (Upstream Only:G.989.3 Section 7,***RM*:Maximum bandwidth**) and the PBS(Peak Burst Size).
		+ Upstream Only:The PON scheduling bandwidth can be defined by a combination of {***RM ,*** χ*AB* ***(BE )*** }.
2. **Where a Single Meter Band is specified in a Meter and Burst Size = 0:**
* One Meter Band with Burst == 0 MUST represent the GIR (Upstream Only:G.989.3 Section 7, ***RF*:Fixed bandwidth**).
1. **Where Two Meter Bands are specified in a Meter and Burst Size > 0:**
	* One Meter Band will represent the CIR (Upstream Only:G.989.3 Section 7, ***RA*:Assured bandwidth**) and CBS attributes
	* A second Meter Band will represent the CIR+EIR = PIR(Peak Information Rate) value (Upstream Only:G.989.3 Section 7,***RM*:Maximum bandwidth**) and the CBS+EBS = PBS(Peak Burst Size):
		+ If PIR > CIR: the flow is AF with two rates; {Upstream Only:***RA*** , ***RM ,*** χ*AB* ***(NA )*** }.
		+ If PIR == CIR: the flow is AF with CIR component only; { Upstream Only: ***RA*** = ***RM ,*** χ*AB* ***(None )*** }.
	* Note: CIR <= PIR, so does not matter for order of Band specification
2. **Where Three Meter Bands are specified in a Meter:**
	* One Meter Band with Burst == 0 MUST represent the GIR (Upstream Only:G.989.3 Section 7, ***RF*:Fixed bandwidth**).
	* A Second Meter Band will represent the CIR (Upstream Only:G.989.3 Section 7, ***RA*:Assured bandwidth**) and CBS attributes (Burst > 0 and CIR<PIR).
	* A Third Meter Band will represent the CIR+EIR = PIR(Peak Information Rate) value (Upstream Only:G.989.3 Section 7,***RM*:Maximum bandwidth**) and the CBS+EBS = PBS(Peak Burst Size > 0):
		+ If PIR > CIR: the flow is Type 5 T-CONT with three rates; {Upstream Only: ***RF, RA***, ***RM ,*** χ*AB* ***(NA )*** }.
		+ If PIR == CIR: the flow is Type 5 T-CONT with two rates; { Upstream Only: ***RF, RA*** = ***RM ,*** χ*AB* ***(None )*** }.

**Note1: χ*AB* is inferred from the specification and use of** {**RF** , ***RA*** , ***RM***}. However the Technology Profile allows the χ*AB* Attribute to be overridden by selecting a specific value as opposed to ‘auto’.

**Note2:** An Upstream Meter Band with a Burst Size == 0 can only be specified when there is a Single Meter Band (i.e. only ‘Fixed’ Bandwidth) or there are Three Meter Bands (i.e. a combination of *RF, RA*, *RM* ).

**Note3:** A Downstream Meter supports a Maximum of Two Meter Bands and a Burst Size == 0 has no other meaning.

## xPON Technology Profile

This section describes an xPON Technology Specific Technology Profile:

### Technology Profile Identifiers:

Name: ‘Technology Profile Name’

OpenFlow Table ID; Used by the OpenFlow Service definition to Reference the Technology Profile

Profile Type: xPON

Profile Version: 1.0

### Common Instance Control Attributes:

* Single Instance per ONU or multi-instance
* Single Instance per UNI or multi-instance (Not Applicable if Single Instance per ONU is TRUE)
* Number of GEM Port-ID (Queues)

### Upstream Scheduler Attributes:

* T-CONT; Additional Bandwidth {None | NA | BE | Auto}
* T-CONT; xPON Priority (DBA Scheduling Priority for best-effort bandwidth assignment)
* T-CONT; xPON Weight (DBA Scheduling weight for best-effort bandwidth assignment)
* Queue Scheduling Policy; {WRR | Strict Priority | Hybrid}

### Upstream GEM Port configuration and scheduling attributes:

* Per GEM Port Attributes:
1. P-Bit Map to GEM Port
2. AES Encryption
3. GEM Port Scheduling Policy; {WRR | Strict Priority}
4. GEM Port (Queue) Priority
5. GEM Port (Queue) Weight
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}
7. Discard Control Attributes:
8. Min Threshold
9. Max Threshold
10. Max Probability

### Downstream Aggregate Scheduler Attributes:

* Priority (Scheduling Priority)
* Weight (Scheduling weight)
* Queue Scheduling Policy; {WRR | Strict Priority | Hybrid}

### Downstream GEM Port configuration and scheduling attributes:

* Per GEM Port Attributes:
1. P-Bit Map to GEM Port
2. AES Encryption
3. GEM Port (Queue)Scheduling Policy; {WRR | Strict Priority}
4. GEM Port (Queue) Priority
5. GEM Port (Queue) Weight
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}
7. Discard Control Attributes:
8. Min Threshold
9. Max Threshold
10. Max Probability

## Service Creation Examples

The following sections detail specific Service creation examples and a proposed set of ‘Built-in’ Technology Profiles specifically for xPON, but this can be extended with more Service Specific examples with other access technologies.

Generically all xPON Services Profiles will tend to fall into the following categories:

* Single T-CONT with Single GEM Port
* Single T-CONT with Two GEM Ports
* Single T-CONT with Four GEM Ports
* Single T-CONT with Eight GEM Ports

Operators will vary as to whether the T-CONT is unique per ONU (a PON Class of Service - e.g. TR-156 4+1 model), per UNI per ONU or per Service per UNI per ONU – this usage can be controlled per Technology Profile via the attributes:

* T-CONT; Single Instance per ONU or multi-instance
* T-CONT; Single Instance per UNI or multi-instance

If the model is a single instance per ONU then the Second Attribute ‘instance per UNI’ control is not used. In this case all Service Flows referencing this Technology Profile will share a Single T-CONT (This is the TR156 4+1 model) where 4 Service T-CONTs are created per ONU and each T-CONT represent a distinct PON Class of Service. There will be 4 Technology Profiles required in the TR156 4+1 case each representing a T-CONT Instance per ONU and a single GEM Port Instance per UNI.

Where a T-CONT is shared per ONU then having unique instances of GEM Ports per UNI allows rate limiting the GEM Flows on the ONU such that any given service cannot access the Total available T-CONT Bandwidth since the T-CONT would be assigned the Sum of the Upstream Bandwidths for each of the Flows referencing it.

If the T-CONT per ONU is Multi-Instance instead of Single Instance then each Service Flow referencing the Technology Profile will have its’s own instance of a T-CONT governed by the second T-CONT attribute the Per ‘UNI instance’ field.

If the second T-CONT field indicates Single Instance per UNI there can be a single shared T-CONT per UNI for all Service flows referencing the Profile. Each Service Flow in this case will share the same set of GEM Ports per UNI, and the T-CONT allocated the sum of the Upstream Bandwidths of the Flows referencing it.

 If the second T-CONT field indicates Multi-instance then each Service Flow reference has a unique T-CONT Instance as well as unique GEM Port Instances.

The next TCONT field provides and override to the imputed Additional Bandwidth Field:

* TCONT: Additional Bandwidth {None | NA | BE | Auto}

Since the Technology Profile is allocated to a certain Class of Traffic the T-CONT Priority and Weight are also part of the Technology Profile:

* T-CONT; xPON Priority (DBA Scheduling Priority – Extended Model)
* T-CONT; xPON Weight (DBA Scheduling weight – Extended Model)

Where Additional Bandwidth Assignment is managed via the Priority and Weight Mechanism these two DBA Scheduling Attributes are used.

The T-CONT Queue (GEM Port) Scheduling policy is defined in the Technology Profile:

* Queue Scheduling Policy; {WRR | Strict Priority | Hybrid}

Each Technology Profile will additionally contain information about the number of GEM Ports (Queues) assigned to the service and for each GEM Port the PBits assigned (used to create a GEM Port Mapper ME via OMCI) , whether AES encryption is enabled, the GEM Port Scheduling behavior, its T-CONT Priority Queue Assignment, Weight and Discard Policy.

Operators may select a Technology Profile with a Single T-CONT and 4 GEM Ports but may differ in the PBit Mapping to the GEM Ports, AES, Scheduling and Discard Policies, requiring multiple instances of this Type of Technology Profile (unique OpenFlow Table ID). Once an Operator has selected a Type of Technology Profile then OpenFlow is used to select the Match Action Rules on Ingress and the Bandwidth Profile applied.

The T-CONT and its’ Queue(s) are shown pictorially in the following diagram, Figure 2:



Figure 2 ONU and OLT Traffic Management

.

### Single T-CONT with Four GEM Ports Example (4QueueHybridProfileMap1)

The AT&T Open OMCI document describes an High Speed Internet Access (HSIA) Service with a Single T-CONT and Four Gem Ports (Queues):

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ServiceGEM | TrafficClass | PriorityQueue | PBIT | SchedulingPolicy | UpstreamWeight | DownstreamWeight | Traffic Type |
| GEM4 | TC6 | Q1 | 6,7 | Strict Priority | N/A | N/A | NC, H1(voice) |
| GEM3 | TC4 | Q2 | 5 | Strict Priority | N/A | N/A | EF (igmp) |
| GEM2 | TC2 | Q3 | 1,3,4 | WRR | 75% | 90% | H2, L1(vod/icc) |
| GEM1 | TC0 | Q4 | 0,2 | WRR | 25% | 10% | BE,AF(HSIA) |

The ‘Built-in’ Technology Profile which can be used for an instance of this Service is described by the ‘4QueueHybidProfileMap1’ Technology Profile:

Name: ‘4QueueHybridProfileMap1’

OpenFlow Table ID; 64

Profile Type: xPON

Profile Version: 1.0

Upstream Aggregate Scheduler Attributes:

* T-CONT; Single Instance per ONU or multi-instance: Multi-instance
* T-CONT; Single Instance per UNI or multi-instance: Single-instance
* T-CONT; Additional Bandwidth: Auto
* T-CONT; xPON Priority (DBA Scheduling Priority): 0
* T-CONT; xPON Weight (DBA Scheduling weight): 0
* Queue Scheduling Policy; {WRR | Strict Priority | Hybrid}: Hybrid

Upstream GEM Port configuration and scheduling attributes:

* GEM Ports (Queues) per Service: 4
* GEM Port 1 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00000101), PBits 0 and 2
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: WRR
4. GEM Port (Queue) Priority: 0
5. GEM Port (Queue) Weight: 25%
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 2 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00011010), PBits 1, 3 and 4
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: WRR
4. GEM Port (Queue) Priority: 1
5. GEM Port (Queue) Weight: 75%
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 3 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00100000), PBit 5
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 2
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 4 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (11000000), PBits 6 and 7
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 3
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)

Downstream Aggregate Scheduler Attributes:

* Single Instance per ONU or multi-instance: Multi-instance
* Single Instance per UNI or multi-instance: Single-instance
* Priority (Scheduling Priority) : 0
* Weight (Scheduling weight) : 0
* Queue Scheduling Policy; {WRR | Strict Priority | Hybrid}: Hybrid

Downstream GEM Port configuration and scheduling attributes:

* GEM Ports (Queues) per Service: 4
* GEM Port 1 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00000101), PBits 0 and 2
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: WRR
4. GEM Port (Queue) Priority: 0
5. GEM Port (Queue) Weight: 10%
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 2 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00011010), PBits 1, 3 and 4
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: WRR
4. GEM Port (Queue) Priority: 1
5. GEM Port (Queue) Weight: 90%
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 3 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00100000), PBit 5
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 2
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 4 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (11000000), PBits 6 and 7
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 3
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)

#### OpenFlow Mapping to Technology profile ‘4QueueHybridProfileMap1’ Using Table ID

Since the ‘4QueueHybridProfileMap1’ is a ‘Built-in’ Pre-defined Technology Profile it can be allocated a Table ID from a range 64 – 127; Profiles within this ‘Built-in’ range cannot be modified dynamically but new Technology Profiles can be added in the Table ID range 128 – 255.

The ‘4QueueHybridProfileMap1’ Technology Profile is assigned the Table ID value of 64, and assume that the Service Flow associated with Table ID 64 is a HSIA and the Customer C-TAG to be used is 122, with an S-Tag of 2.

The Service Frame is passed Upstream to the ONU UNI and will Ingress the UNI as a Priority Tagged Frame (VLAN = 0) and Egress the NNI as a Double Tagged Frame, S-Tag/C-Tag of 2/122.

Downstream the Customer Traffic will Ingress the OLT NNI as a Double Tagged Frame with S-Tag/C-Tag of 2/122 and Egress the Customer UNI as a Priority Tagged Frame.

The Customer has signed up for a 1G Upstream and 1G Downstream Service.

OpenFlow will create a Meter in the Meter Table for the Customer HSIA Downstream Service Flow: Single Meter Band:

Band Type : NA(No actions on the Packet when Band Exceeded)

Rate: 1Gb/s

Burst: 384 Kbits

OpenFlow will create a Meter in the Meter Table for the Customer HSIA Upstream Service Flow : Single Meter Band:

Band Type : NA(No actions on the Packet when Band Exceeded)

Rate: 1Gb/s

Burst: 384 Kbits

Note that, port 129 is NNI and port 21 is UNI. Also 2/122 are s-tag and c-tag for the given Customer.

OpenFlow Customer 2/122 Downstream Messages:

Table 64 (The Technology Profile Reference) contains a Default Rule of Match-All, No Action.

ADDED, bytes=0, packets=0, table=0, priority=1000, selector=[IN\_PORT:129, METADATA:15, VLAN\_VID:2], treatment=[immediate=[VLAN\_POP], transition=TABLE:1]

ADDED, bytes=0, packets=0, table=1, priority=1000, selector=[IN\_PORT:129, VLAN\_VID:122], treatment=[immediate=[VLAN\_ID:0], deferred=[OUTPUT:21], meter=ID, transition=TABLE:64]

In “table 1” we say that if the frame customer C-tag 122 is coming in from NNI port 129, we want to change the vlan to be Priority Tagged VLAN 0 and associate the meter (ID) with this flow, following which we want to go to “table 64” for the rest of the Technology profile, and we will defer the output action (to port 21) once the packet has gone through table 64. Since the Default flows in table 64 are Match-All and No Action, the pipeline execution will stop and the accumulated action-set will be executed.

Note: The ONU will automatically Reverse the Upstream Tagging Action for Downstream Frames without needing to be explicitly configured.

OpenFlow Customer 2/122 Upstream Messages:

ADDED, bytes=0, packets=0, table=0, priority=1000, selector=[IN\_PORT:21, VLAN\_VID:0], treatment=[immediate=[VLAN\_ID:122], transition=TABLE:1]

ADDED, bytes=0, packets=0, table=1, priority=1000, selector=[IN\_PORT:21, VLAN\_VID:122], treatment=[immediate=[VLAN\_PUSH:vlan, VLAN\_ID:2], deferred=[OUTPUT:129], meter=ID, transition=TABLE:64]

### Single T-CONT with Eight GEM Ports Example (‘8QueueStrictProfileMap1’)

The DT Service Presentation document describes a High Speed Internet Access (HSIA) Service with a Single T-CONT and Eight Gem Ports (Queues):

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Service****GEM** | **Traffic****Class** | **Priority****Queue** | **PBIT** | **Scheduling****Policy** | **Upstream****Weight** | **Downstream****Weight** | **Traffic Type** |
| **GEM8** | TC7 | Q0 | 7 | Strict Priority | N/A | N/A | ? |
| **GEM7** | TC6 | Q1 | 6 | Strict Priority | N/A | N/A | ? |
| **GEM6** | TC5 | Q2 | 5 | Strict Priority | N/A | N/A | ? |
| **GEM5** | TC4 | Q3 | 4 | Strict Priority | N/A | N/A | ? |
| **GEM4** | TC3 | Q4 | 3 | Strict Priority | N/A | N/A | ? |
| **GEM3** | TC2 | Q5 | 2 | Strict Priority | N/A | N/A | ? |
| **GEM2** | TC1 | Q6 | 1 | Strict Priority | N/A | N/A | ? |
| **GEM1** | TC0 | Q7 | 0 | Strict Priority | N/A | N/A | ? |

The ‘Built-in’ Technology Profile which can be used for an instance of this Service is described by the ‘8QueueStrictProfileMap1’ Technology Profile:

Name: ‘8QueueStrictProfileMap1’

OpenFlow Table ID; 65

Profile Type: xPON

Profile Version: 1.0

Upstream Aggregate Scheduler Attributes:

* T-CONT; Single Instance per ONU or multi-instance: Multi-instance
* T-CONT; Single Instance per UNI or multi-instance: Single-instance
* T-CONT; Additional Bandwidth: Auto
* T-CONT; xPON Priority (DBA Scheduling Priority): 0
* T-CONT; xPON Weight (DBA Scheduling weight): 0
* Queue Scheduling Policy; {WRR | Strict Priority | Hybrid}: Strict Priority

Upstream and Downstream (identical) GEM Port configuration and scheduling attributes:

* GEM Ports (Queues) per Service: 8
* GEM Port 1 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00000001), PBit 0
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 0
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
	1. Min Threshold:0 (N/A)
	2. Max Threshold:0 (N/A)
	3. Max Probability:0 (N/A)
* GEM Port 2 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00000010), PBit 1
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 1
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 3 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00000100), PBit 2
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 2
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 4 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00001000), PBit 3
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 3
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 5 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00010000), PBit 4
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 4
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 6 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (00100000), PBit 5
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 5
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 7 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (01000000), PBit 6
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 6
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)
* GEM Port 8 Attributes:
1. P-Bit Map to GEM Port: PBit Mask (10000000), PBit 7
2. AES Encryption: True
3. GEM Port Scheduling Policy; {WRR | Strict Priority}: Strict Priority
4. GEM Port (Queue) Priority: 7
5. GEM Port (Queue) Weight: 0
6. Queue Discard Policy; {Tail-drop | WTail-drop | RED | WRED}: Tail-drop
7. Min Threshold:0 (N/A)
8. Max Threshold:0 (N/A)
9. Max Probability:0 (N/A)

#### OpenFlow Mapping to Technology Profile ‘8QueueStrictProfileMap1’ Using Table ID

Since the ‘8QueueStrictProfileMap1’ is a ‘Built-in’ Pre-defined Technology Profile it can be allocated a Table ID from a range (TBD) 64 – 127; Profiles within this ‘Built-in’ range cannot be modified dynamically but new Technology Profiles can be added in the Table ID range 128 – 255.

Assume the ‘8QueueStrictProfileMap1’ is assigned the Table ID value of 65, and assume that the Service Flow associated with Table ID 65 is a HSIA – the DT HSIA model requires the UNI Ingress frames to be Tagged (could be more than one Tag) and the ONU must pass through the Frame Unchanged with the OLT adding a Single S-Tagbefore Egressing the NNI Upstream. Assume the Customer is identified by the S-Tag of 1000.

Downstream the Customer Traffic will Ingress the OLT NNI as a Tagged Frame (more than Single Tagged) with S-Tag of 1000, which will be removed and Egress the Customer UNI again as a Tagged Frame.

The Customer has signed up for a PIR of 1G Upstream and 1G Downstream Service, with CIR of 100 Mb/s in both directions.

OpenFlow will create a Meter in the Meter Table for the Customer HSIA Downstream Service Flow: Two Meter Bands:

Band 1:

Band Type : NA(No actions on the Packet when Band Exceeded)

Rate: 1Gb/s

Burst: 384 Kbits

Band 2:

Band Type : NA(No actions on the Packet when Band Exceeded)

Rate: 100 Mb/s

Burst: 384 Kbits

OpenFlow will create a Meter in the Meter Table for the Customer HSIA Upstream Service Flow: Two Meter Bands:

Band 1:

Band Type : NA(No actions on the Packet when Band Exceeded)

Rate: 1Gb/s

Burst: 384 Kbits

Band 2:

Band Type : NA(No actions on the Packet when Band Exceeded)

Rate: 100 Mb/s

Burst: 384 Kbits

Note that, port 129 is NNI and port 21 is UNI. Also s-tag = 1000.

OpenFlow Customer S-Tag=1000 Downstream Messages:

    ADDED, bytes=0, packets=0, table=0, priority=1000, selector=[IN\_PORT:129, METADATA:15, VLAN\_VID:1000], treatment=[defer=[VLAN\_POP], transition=TABLE:1]

    ADDED, bytes=0, packets=0, table=1, priority=1000, selector=[IN\_PORT:129,VLAN\_VID:1000], treatment=[deferred=[OUTPUT:21], meter=ID, transition=TABLE:65]

OpenFlow Customer S-Tag=1000 Upstream Messages:

ADDED, bytes=0, packets=0, table=0, priority=1000, selector=[IN\_PORT:21, VLAN\_VID: OFPVID\_PRESENT], treatment=[immediate=[], deferred=[], transition=TABLE:1]

ADDED, bytes=0, packets=0, table=0, priority=500, selector=[IN\_PORT:21], treatment=[immediate=[], deferred=[]]

Tagged Frames coming in at UNI port 21 will get forwarded (OFPVID\_PRESENT). All other packets (untagged) on port 21 will match the lower priority flow, and get dropped (no actions, no goto-table).

ADDED, bytes=0, packets=0, table=1, priority=1000, selector=[IN\_PORT:21, VLAN\_VID: OFPVID\_PRESENT], treatment=[immediate=[VLAN\_PUSH:QinQ, VLAN\_ID:1000], deferred=[OUTPUT:129], meter=ID, transition=TABLE:65]

Note: If you wanted the TPID to be 0x88a8, then the VLAN\_PUSH action would have the tpid 0x88a8 and the ONOS representation would be VLAN\_PUSH:QinQ, if tpid 0x8100 then represented in the ONOS flow as ‘vlan’.

## Documentation

1. **References**
	1. **Related Documents**
		1. Radisys Documents
		2. Other Documents
		3. Industry-Standard References
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3. OpenFlow Management and Configuration Protocol, OF-CONFIG, Version 1.2, 2014
4. ITU G.989 Series; 40-Gigabit-capable passive optical networks (NGPON2)
5. ITU G.984 Series;Gigabit-capable passive optical networks (G‑PON)