Deutsche Telekom Open GPON-OLT Specification

Revision 0.95

First revision proposed for publication

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Based on prior contributions within OCP

Revision History

Revision	Date	Author	Description
0.1	14/09/2017	Paul Wagner	Initial Proposal
0.2	03/11/2017	Paul Wagner	Extensions
0.5	13/11/2017	Paul Wagner	Including first review from Bjoern Nagel
0.6	14/11/2017	Paul Wagner	Introducing workshop outcomes
0.7	31/01/2018	Paul Wagner	Include 64 port version
0.8	16/02/2018	Paul Wagner	Minor updates, for review with external OCP parties
0.9	07/03/2018	Paul Wagner	Reworked general requirements
0.91/0.92	12/03/2018	Paul Wagner	Corrections in EMC rules, clock
0.93	17/04/2018	Paul Wagner	Minor corrections and additions (fan color coding)
0.95	25/05/2018	Paul Wagner	Prep. for initial publication. Chapter Licences updated

Contents

Errata and missing features in this document version

There is a requirement for time and sync support in PON networks.
As this is primarily needed for mobile backhaul and business purposes it shall only be optional.
It has yet to be worked out if this should be realized in separate daughter board or on the main PCB (daughter board allows for factory configurable option, but not in service upgradable – an onboard solution may more cost effective but cannot be retrofitted).

Clock input is to be done with SyncE via the uplink interfaces. Time and phase information is to be realized via IEEE 1588v2 (aka. Precision Time Protocol).
A Telecom Boundary Clock of class B and hardware readiness for class C (ITU-T G8273.2 Draft) with a specified “constant TimeError” (cTE) of 10ns max. is to be provided.
Test & measurement ports are required for timing (e.g. 1pps output as a DIN 1.0/2.3 coaxial 50 ohms female connector that is accessible from the backside and only present if the clock option is installed).
Any configuration & control mechanisms are to be defined yet !

Potentially there is no straightforward way to implement such carrier grade requirements in an OCP OLT with the silicon available as of today.
It may therefore be necessary to postpone definition and implementation to a future OCP specification.

- Comments as for the feasibility of this function are explicitly desired !

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Scope

This document defines a proposal for technical specifications for the Open GPON OLT submitted to the Open Compute Project.

Overview

This document describes the technical specifications of an Open GPON Optical Line Termination System.

Two variants are described : a 32 port single height unit (1 HU) variant and one with 64 port in 2 HUs.

At the time of writing (2017/1Q2018) this specification targets to define mainstream devices fitting most GPON OLT use cases. The larger device will boast a substantially better cost per port ratio including lower operational cost due to power consumption but may be oversized for small deployments or lab use.

It is highly probable that future technical evolution will allow for even a higher capacity. This may be realized in larger chassis or potentially by employing high-density transceivers (dual- or quad-channel optical transceivers). Advances in silicon integration are clearly expected to bring forth as well lower energy consumption. This is why this specification calls for successors upon availability of such technology.

Indoor only

The OLT is one height unit (respectively two for 64p) high and 19” wide and is designed for deployment in Central Offices (CO) with controlled climate and readily available 48V DC power.

The option to use any other power input (e.g. 110/230VAC) is provided as PSUs (Power Supply Units) are field replaceable.

Software Stack

The software to drive the DT Open OLT is not mandated by this specification. The expectation for a first implementation is based on same approach taken for the Open XGS-PON specs.

Fundamentally speaking this hardware specification shall allow for an open and flexible software implementation that may be modified or replaced in the light of changing requirements.

It is composed of two key parts :

Internal (silicon) firmware

As of today there is available merchant silicon for GPON OLTs allowing for 16 ports per SoC.

One known supplier for such a device is Broadcom Limited.

The PON-MAC chip(s) has Firmware and a Driver that runs in the silicon and provides a management interface toward an internal API. This firmware and driver is specific to the merchant silicon and will almost certainly contain proprietary code and mandatory licensing.

The licensing conditions of all required proprietary code and intellectual property MUST be clarified and publicly accessible upon publication as an OCP contribution.

If there are multiple options for proprietary firmware capability sets this MUST be clearly stated :
e.g. accessibility of chip layer SDK and/or proprietary abstraction layers (aka BCM BAL).

Essentially, the firmware / driver layer must not intentionally preclude the use of this OCP OLT with any reasonable alternative control software design be it embedded in the OLT NOS or remotely connected as Voltha or the like.

Control framework and OS

There shall be a control board in the Open OLT that is running an Open Source Network Operating system (e.g. ONL) based on Linux.

There shall be an open boot environment e.g. ONIE.

This environment must then provide the means to install a control plane agent onto the OpenOLT.
This software allows the data plane functions to be controlled by a north-bound control system (e.g. a SDN controller like ONOS).

One mandatory option for the control plane agent is a vOLTHA-Driver effectively providing for an OpenFlow, as well a NETCONF/YANG interface to the controlling system via an IPv4 and IPv6 based management channel (gRPC based). The vOLTHA framework usually resides on an external Server but may potentially reside inside each OpenOLT device.

Other types of control software shall not be precluded by the hardware.

IP based management interface

All management communication with the OLT device MUST use IPv4 or IPv6 – there shall be no proprietary layer 2 protocols required for operation.

This IP-based management channel MUST allow to use :

- outband Ethernet interfaces in the front (RJ45 100/1000bT and optionally a GigE-SFP-cage)
- AND one or more inband channels e.g. via static VLAN assignment in one or more uplinks (aka. the Data-Path) interfaces.

➔ Be aware that such inband communication channels require the central switch component to be fully initialized and provisioned. At the moment of installation of the device software ONLY the two outband Ethernet interfaces (1x 100/1000baseT and the GigE-SFP-cage) allow for IP connectivity to the OLT. As a last resort or for first time setup the serial console and the USB-port may be used.

The use of encryption for security is strongly encouraged : e.g. ssh-tunneling for terminal access (to device OS or driver CLI) or eventually REST/API.

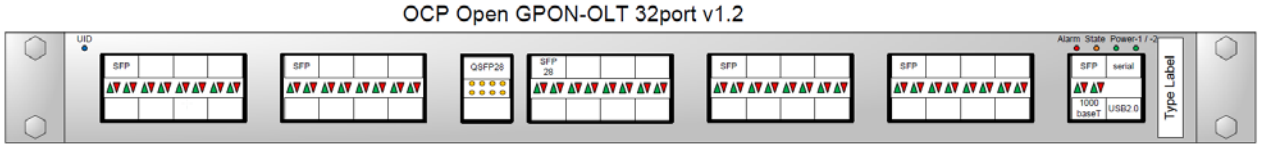
The ON.Labs VOLTHA project is an open multi-protocol management and control plane agent, and can be used to derive OpenFlow, as well as NETCONF/YANG interfaces to the control plane applications and configuration controllers. From these interfaces upwards, the same applications are used that were developed for GPON and XGS-PON in order to configure and control the system as part of an access network.

Physical Overview

Maximum Dimensions

	Inches	Millimeters
Length	Up to 23.9”	Up to 600
Width	19”	477mm
Height – 1 HU (2HU for 64 port version)	1.752” (3,54” for 64 port)	44,5mm (89mm for 64 port)

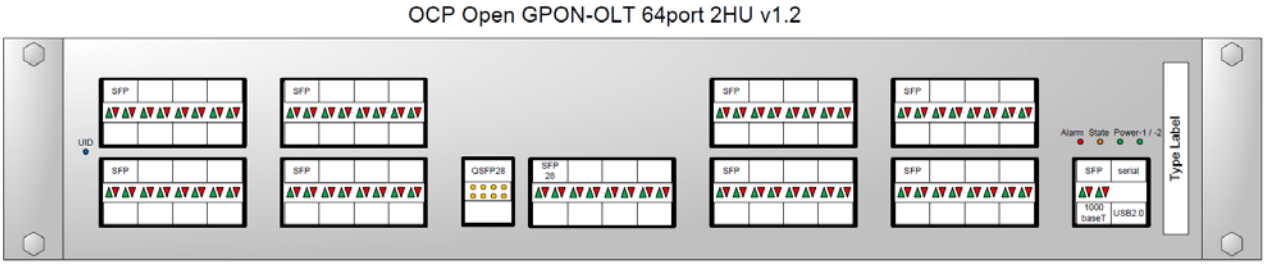
Front View (32 port version)



Remark : It is assumed that a substantial part of the non-occupied front surface needs to be perforated to allow for cooling air intake.

At the same time it shall be taken care that there is little to no airflow through any interface cage populated or vacant to avoid accumulation of dust in electrical or optical interfaces.

Front View (64 port version in 2 height units)



Remark : With respect to airflow the same comments as for the 32 port variant apply.

As for the density of interfaces 64 PONs on 2 HU is deemed an acceptable compromise to allow for reasonable cabling and still substantial scaling in the number of PON-subscribers.

A type label with device type and manufacturer must be visible on the front. A detailed type code (including modell / hardware version) and serial number must be readible from or at least accessible (pull-out label) from the face plate – this label shall include a 2D-barcode (or similar) representation of the clear text.

Panel LED Definitions

LED Name	Description	State
State	LED to indicate system diagnostic test results	Green – Normal Amber – Initializing Red – Fault detected
Power 1 / 2	State of power supply #1 and #2	Green – power output available Red steady – input power missing Red blinking – power supply failure Off – power supply missing
Alarm	Summary alarm pending	Green – normal operation Yellow – minor alarm Red – major alarm
UID	Shall allow to indentify a device upon management command	Blue – blinking “Here I am !” Off – normal operation
PON State LED	LED built into SFP cage to indicate PON state	Green steady – PON link up & 1 or more ONTs in service Off – No ONT in service Amber – port disabled Red – fault detected
PON Activity LED (optional)	LED built into SFP cage to indicate traffic passing over the PON	Green steady - no traffic Green blinking - indicates data traffic on the PON
SFP-28 (and QSFP28) Link LED	LED built into (Q-)SFP cage to indicate the pluggable status -> for QSFP there are 4 LEDs, 1 per lane	On Green – link up (speed 25G) On Amber – link up (speed 10G) On Yellow – link up (speed 1G) [optional] Off – link down (Remark : 4 green LEDs on QSFP usually says 100G link up but could also mean 4 x 25G break-out links up)

SFP-28 (and QSFP28) Activity LED	LED built into SFP cage to indicate traffic passing over the interface -> for QSFP there are 4 LEDs, 1 per lane	Green steady – no traffic Green blinking – indicates data traffic on the PON

Rear View

On the backside of device are located only the fans and the two AC (respectively DC) power supply units (PSU).

A marking for PSU respectively fan numbering must be visible next to each field replaceable module.

There MUST be a “power present” LED on the rear of each PSU indicating that there is live power on the PSUs input.
Each fan sled should carry a state indication LED – green for OK, off or red for failed state is suggested.

Power supplies and fan modules

Fan- and PSU-modules MUST be hot-swappable without requiring special tools beyond a simple screwdriver to untighten an eventual knurled-head locking screw. This screw is optional if there is some other reliable mechanism to lock field replaceable units firmly in place.

Airflow direction (expected to default to front to back) must be indicated with color coding and explicit labeling (This is valid for both PSU-modules with integrated fans and the device fan modules) :

1. It is assumed to be best practice to use RED color marking (e.g. by selecting red colored material for the extraction handle) to indicate exhaust for hot air.
2. In contrast a back-to-front airflow with a cold air ingress on the device back side would be visible by BLUE color marking.

For 110/230V AC power supply the female connector to be used is standardized in IEC 60320-1 type C13 which is equivalent to EN 60 320-1 C13

standard AC connector

An acceptable electrical connector type for 48V DC is DSUB 3W3 male with locking screws.

standard DC connector

System Overview

Preamble : This document expects that a first implementation of such an OpenOLT will be based on the most prevalent merchant silicon vendor for PON devices.

Today (1Q2018) this expectation narrows down to Broadcom Inc. with a PON-SoC family called Maple. The first generation of Maple-Silicon offers a GPON port density of 16 ports per chip. For the aggregation switch chip there is a Broadcom Qumran device that fits the capacity requirements. Even if there seems to be other options for the integrated switching silicon (other device families and even other silicon vendors) it appears to be advantageous to restrict the choice to a single silicon provider as it will simplify the implementation of the lower driver layer. In effect there is the offer of a common driver layer for PON and Switch function known as Broadcom's "BAL" (Broadband Adaptation Layer).

This allows a **single PCB** (Printed Circuit Board) implementation of a 32 GPON port device in a 19" 1HU device.

The variant with 64 ports should ideally be based on the same PCB as its smaller brother but with two more PON-SoCs fitted on the main board. The supplementary 32 SFP-cages may need a small daughterboard if there is a lack of 4-row-stacked cage assemblies.

Different arrangements are acceptable in the scope of this document – this solely depends on manufacturing constraints and shall in no way create functional differences.

Future evolution options

There is also the option of using high-capacity FPGA devices instead of the before mentioned GPON-SoCs; this is expected to allow identical function and port density. Such an approach shall be proposed in a separate document.

The availability of traffic management capabilities and more advanced features for packet handling (e.g. filtering, shaping, accounting) depend on the employed switch device – and will – evidently impact cost. Such variants – either more low-cost, low-power or more potent, high capability – based on any available merchant silicon are welcome as alternative proposals.

PON-Interfaces

The optical interfaces for GPON are available as commercial of the shelf products.

For GPON there is a large number of vendors offering SFP-size pluggable modules with B+ and C+ range (B+ is 28dB optical budget and C+ is 31dB optical budget). These types can be equipped depending on requirements for reach and split ratio. Each pluggable consumes about 1-1.5 Watts @3.3V.
The fiber to the PON-tree connects with a SC/UPC connector.

The PON-Interfaces are arranged in four blocks of 8 each as two rows of 4 aligned cages.

Ethernet uplink

Sufficient Ethernet uplink capacity shall be implemented in the form of 10/25G and 40/100G pluggable interface modules.

The module types chosen for this specification are :

1. QSFP28 (Quad Small Form factor Pluggable 28G) which handles 4 parallel lanes of 25Gigabit/s (28Gigabit/s with FEC) but configurable to 40Gbps(4x10Gbps).
2. SFP28 (Small Form factor Pluggable 28G) which is a single channel 25Gigabit/s interface but may as well be configured to 10Gigabit/s depending on available transceivers.

The suggested single chip switch silicon can handle the capacity of 40G to each of the PON-SoCs and up to 400G as uplink.

In order to allow for flexible configuration of the uplink, we shall use 2 x 100G towards the QSFP28 interfaces and 8x25G to the SFP28 cages.

Support for different Uplink connectivity modes

The Open OLT uplink shall allow for different uplink setups :

- Inside the rack inside a CO (central office) the OLT will use low-cost DAC (direct attached copper) connections. That results in a restriction of distance to only a few meters to the fabric switch [a.k.a. an aggregation device].
- In this context two redundant 100G-links are desirable and one will not use sub tending interfaces nor expensive optical transceivers.
- As a remote device with at least one (but up to 4) single mode transceivers :
  depending on availability of dark fiber as QSFP28-LR or –ER. Alternatively WDM channels may be used with colored SFP-style transceivers. As of today 25Gigabit/s colored SFP-style transceivers availability is limited.
- Less recommended but nevertheless possible would be the use of short distance cabling to a co-located WDM transmission system (-SR4, DAC or AOC).
- In both remote use-cases there is the option to use some of the uplink interfaces for sub tending to co-located OLT-devices (daisy chaining).

* The use of QSFP28 or SFP28 may require FEC-capabilities (Forward Error Correction) to be included in the Ethernet-MAC-chips in the OLT (obviously on both sides of these links).

Main Block Diagram (32 port version)

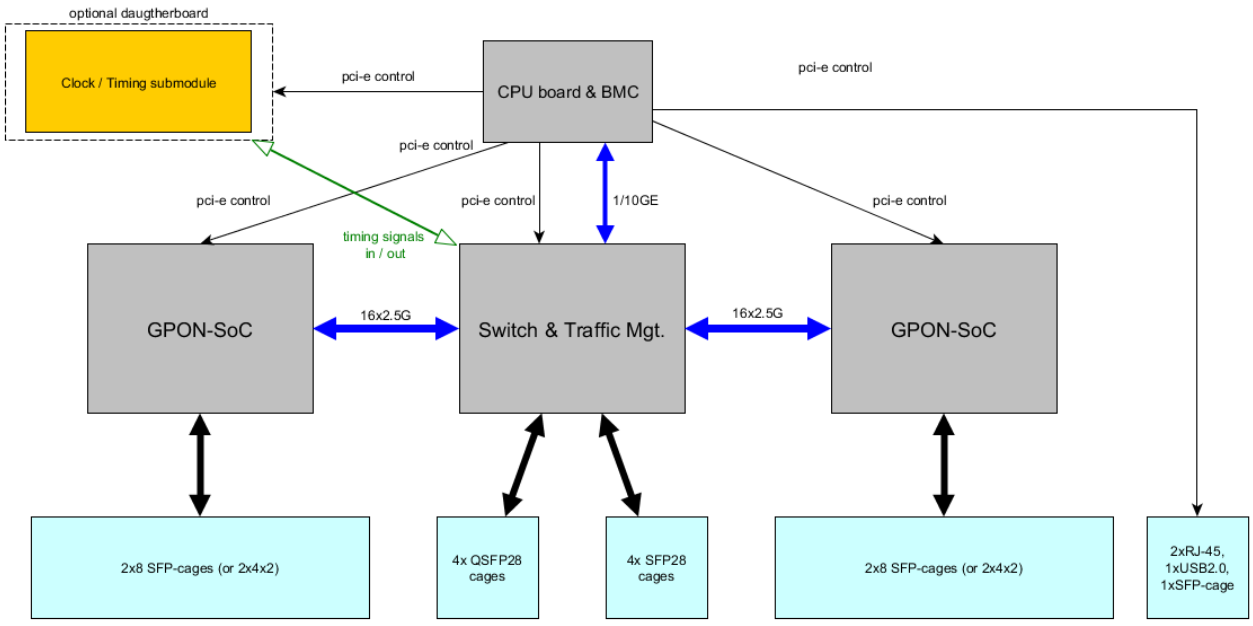


Figure 1 - Main system Block diagram

Main Block Diagram (64 port version)

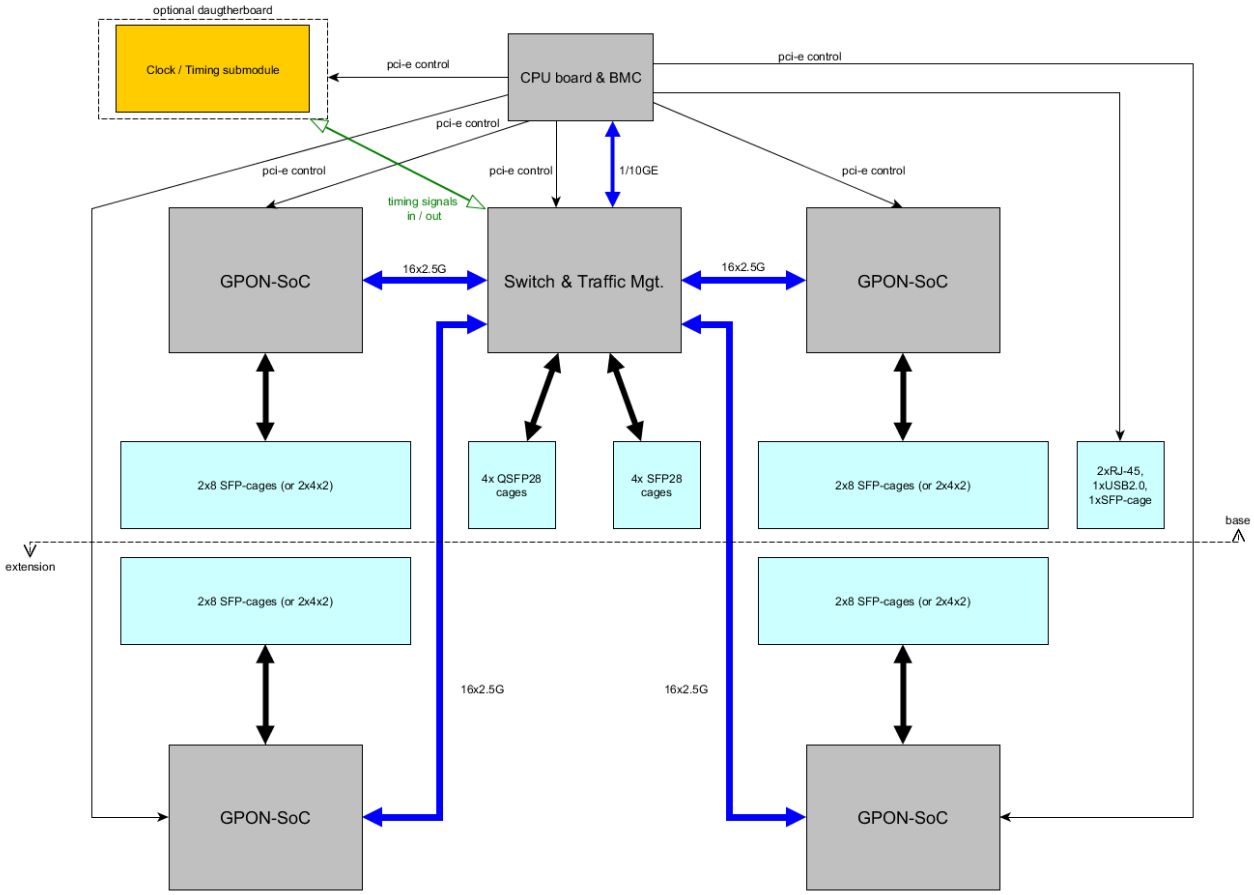


Figure 10 - Main system Block diagram (64 port version)

The block diagram in Figure 1 shows :

- Two grey boxes on the left and right representing the GPON-OLT-SoC. These complex devices shall be wired directly to the transceiver cages in the faceplate – there should be no need for additional driver circuits.
- An Ethernet switch chip is located in the middle aggregating the OLTs traffic towards the transceivers placed in the center of the faceplate.
- Reigning on top of this arrangement is to be found a compute board with direct control links (Ethernet or PCIe lanes) to the OLT and Switch devices. These links must allow for ingressing and egressing specific data frames into the CPU (control packets as for example IGMP, L2CP or Routing Protocol PDUs). They are responsible also for managing the firmware.
- The compute board's design should reuse existing OCP contributions.
  note : There should be a separate specification for reusable compute boards allowing for different cost / performance options and allowing for independent technological evolution of this component.

- Not shown on the diagram are two OCP-standard power supplies (48VDC or 110/230VAC) in load sharing mode.

note : There should be a separate specification for a reusable range of interchangeable Power Supply modules with different ratings: different power levels, different temperature ratings, potentially multiple efficiency grades.

- Blocks of SFP-cages to hold GPON-OLT-transceivers may be arranged as two arrays of 2x4 cages.
- -> arrays of 4x4 cages are desired for the 64p version.

- One block of 2 QSFP28 cages (uplink and subtending)
- One block of 2x4 SFP28 cages (uplink transceivers : allowing for colored single lambda optics)

- An additional block with Ethernet, Serial console and USB towards the CPU-board

Figure 11: Examples for transceiver cages

Comparison of properties between 32 and 64 port version.

Why does this specification call for two different sizes of an OCP OLT ?

Because the size or number of PON-ports of such a device is the fundamental variable that influences its cost !

The two variants proposed here are based on the granularity of the available silicon devices and according to the desired housing format – that is non-modular, self-contained 19” boxes with one or two height units (~45mm or ~90mm respectively). The choice of 32 and 64 ports are still somewhat arbitrary – values of 24, 48 or even 96 ports might be feasible as well – but too many options may turn out to be bad for a market of limited size.

Different aspects to be examined :

- The larger the OLT the smaller the number of uplinks (per PON); this is evidently cost efficient.
- All single box devices have 2 power supply units for redundancy – which means decreasing relative cost for power for larger sizes.
- Similarly the cost for cooling is reduced because of smaller number of fans per port. This effect will amplify by using larger fan sizes which boosts efficiency and reduces noise and extends fan lifetime because of lower rpm values.
- At the same time it is evident, that cost for the embedded compute board is quasi-constant independent of the device size – a clear advantage for big boxes.
- The major downside of high capacity appliances is unused capacity : large granularity means a high probability for unused ports – a fact worsened when deploying in small networks (small COs).
- One could as well argue that larger entities mean larger crater size in the event of failure giving a subjective advantage to smaller boxes.

Functional Hardware Blocks

We could add a detailed description of the 2 ASIC devices here.

Compute board

An implementation of Com Express® seems to be a viable option for interchangeable, standardized embedded compute boards. For cost reasons functionally equivalent options could be offered.

The specification in release 3.0 March 2017 is available for purchase at

https://www.picmg.org/openstandards/com-express/

The interface type 7 would allow for the required interfaces specifically pci-e & 10G-Ethernet :

> There shall be at least 1 electrical 100/1000-baseT Ethernet directly from the compute board towards the front plate of the device for outband management. This interface needs no configuration and must be operational on boot time of the device for network boot process (aka ZTP). This interface shall be internally bridged with the BMC.
>
> Control paths to the merchant silicon devices on the main board are expected to be realized via direct PCIe channels. Ideally there are enough direct connections to the CPU board available to avoid the need for a PCI switch chip.

There are multiple specified board formats including this “basic” version – probably sufficient or alternatively “compact” which is 95x95mm.

A mainstream definition of memory size, mass storage, cpu types and interfaces toward the PON-PCB and external interfaces should be discussed.

Optimized configurations either more low-cost, low-power or more powerful may be defined in further revisions of this document.

Software Support

Chapter to be extended !

BMC support

OpenBMC should be part of the CPU module.

Optional : “Redfish” as hardware management protocol.

ONIE (Open Network Install Environment)

The device shall always be pre-loaded at least with ONIE.
This allows installation and boot of ONL (linux based network operation system).

Refer to :
http://www.onie.org/
for more information.

Open Network Linux

See http://opennetlinux.org/ for latest supported version.

General Specifications

System Lifetime

Telecommunications networks are designed for operation over a much longer time span than a typical server computer. The planned system life time to reach without renewal of any FRU (Field Replaceable Units : PSUs, fans, transceivers) shall exceed 10 years in normal operating conditions.

It is obvious that high temperature will have adverse effect on life time. Therefore due diligence must be observed when doing thermal design – e.g. cooling airflow and heat sink design.

The most vulnerable components of the proposed OCP OLT are fans and power supply modules. Particular care must be used to design these to obtain MTBF values (mean time between failures) appropriate to the planned lifetime.

Power Consumption

The energy consumption of any telecommunications device is of major importance for its operational cost and at the same time of prime relevance for its ecological impact.

This results in a very clear prescription to aim for an optimum energy efficiency.

While this applies evidently to all system components, the most relevant parts to allow for optimization are expected to be :

- Fans : they must be chosen to be energy efficient, low-noise and variable speed.
- Power supply units : they must operate at an optimum efficiency level even when running in load-sharing mode (both PSUs in operation is expected to be the normal state).

Specifically for a first incarnation of our OCP OLT the total estimated system power consumption shall be analyzed below :

This calculation shall be based upon assumptions for a worst case and an estimated typical case for traffic, optics used and environmental conditions.

It is to be noted that – as expected – the larger device (64 GPON ports) is estimated to consume only some 25% more energy for a 100% higher port count. This clearly means a much better energy efficiency !

Estimated figures provided by EdgeCore. Values after the slash pertain to the 64 port version.

Main Blocks	Qnt.	Typ. (W)	Max. (W)	Total Typ. (W)	Total Max. (W)
16 port GPON-SoC	2 / 4		12		24 / 48
Traffic aggregation & management switch	1		58		58
GPON OLT SFP transceiver	32 / 64	1.0	1.5		48 / 96
Uplink Ethernet transceivers (alternatively) :					
QSFP28 100GE-LR4	1-2		5		10
SFP28G 25GE SMF (potentially WDM)	1-8		1.5		12
CPU board (including BMC)					60
DRAM & flash memory, glue chips etc.					10
Fans	4-6		18		72 / 108
PSUs (thermal loss for x% efficiency)	2				34 / 42
Optional clock / timing subboard	1		6		6
Total estimated power					**360 / 440**

Environmental Requirements

Environmental placement requirements differ for the outdoors and indoors units.

It is not expected that a high port-count OLT is deployed in an outdoor scenario. The specification shall nevertheless not preclude the implementation of an outdoor version of this OLT.

Indoor requirements

- 0 to 40 Degrees C operating range
- -40 to 40 Degrees C storage temperate range
- Humidity 5% to 95% non-condensing (operational and storage)
- Vibration – IEC 68-2-36, IEC 68-2-6
- Shock – IEC 68-2-29
- Acoustic Noise Level – Under 60dB in 40 degree C
- Altitude - 15,000 (4572 meters) tested operational altitude

Safety

This chapter is for informational purposes only – it cannot relieve the manufacturer of a device from the responsibility to comply to any relevant standards that apply for the countries where the system is intended to be operated.

Non-exhaustive list of required labels for international use :

- CE certification
- UL/ Canada
- CB (Issued by TUV/RH)
- China CCC
- Grounding & electrical safety of :
  ETSI EN 300 253, DIN VDE 0800, Part 2, DIN EN 50310 and DIN EN 50174-2.
- Labeling (input voltage range, frequency, max. input current) according to DIN EN 60950-1
- Cables and the individual conductors (e.g., for power supply, equipotential bonding) must be

marked in accordance with DIN EN 60445 (VDE 0197) and DIN EN 60446 (VDE 0198).

Electromagnetic Compatibility

This chapter is for informational purposes only – it cannot relieve the manufacturer of a device from the responsibility to comply to any relevant standards that apply for the countries where the system is intended to be operated.

Non-exhaustive list of required labels for international use :

- GR-1089-CORE
- FCC Title 47, Part 15, Subpart B Class A
- European standards for Electro Magnetic Compatibility : EN 300 386 in conjunction with EN 55022 (Class A) / EN 55032 (Class A)

ROHS & Environmental standards

For this equipment all applicable standards pertaining to environmental safety must be respected.

List of required certifications – again non-exhaustive:

Restriction of Hazardous Substances (6/6)

Compliance with Environmental procedure 020499-00 primarily focused on Restriction of Hazardous Substances (ROHS Directive 2002/95/EC) and

Waste and Electrical and Electronic Equipment (WEEE Directive 2002/96/EC).

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