Comparison of 10 Gbit/s PON vs WDM-PON

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outline

- Introduction and definitions
- Standardization (FSAN)
- Key optical components and cost
- Technical performance
- Power consumption
- Conclusions

Introduction

- From time to time, people question the need for more bandwidth in the access…however not currently:

- With increased demand for bandwidth driven by media consumption such as file-sharing, high-definition video, gaming etc...and the explosion of mobile broadband….

  The question is rather “What will be the next fiber access technology?”

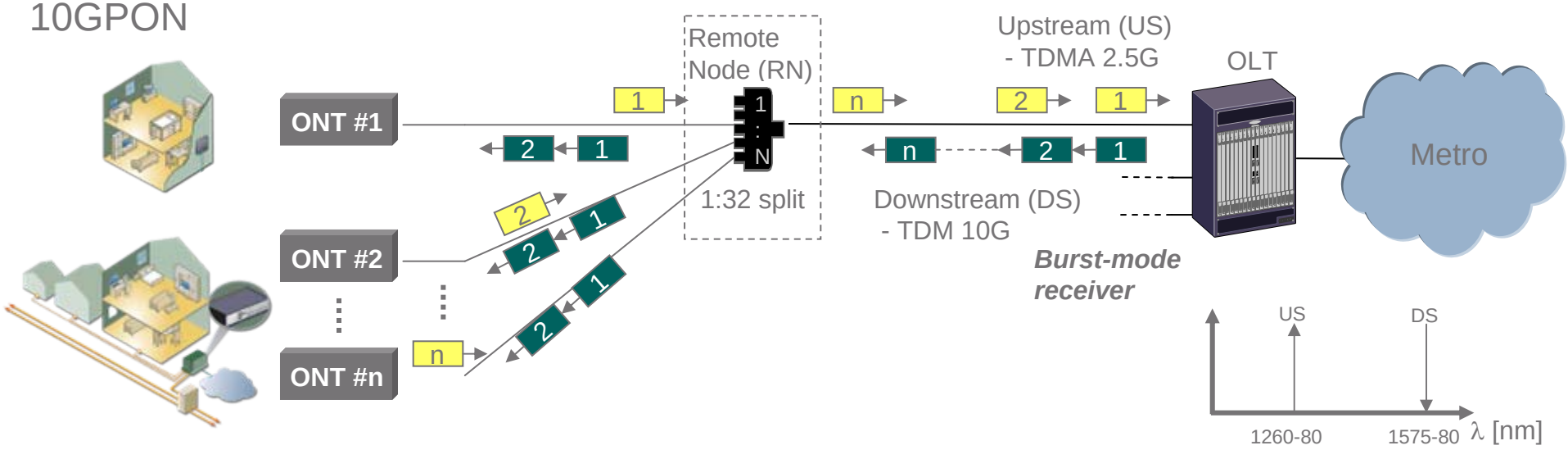
- Two technologies stand out in the industry

  - 10GPON, as a continuation of GPON and/or EPON
  - WDM-PON, taking advantage of the wavelength domain

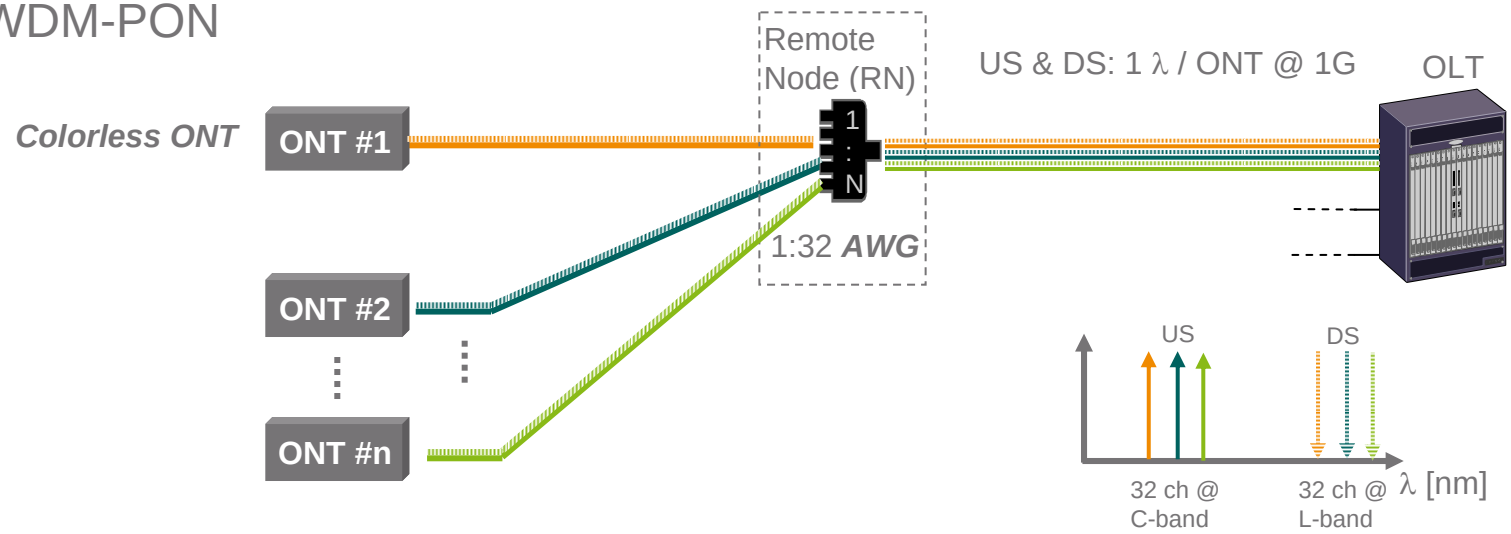
- This presentation will compare these based on *performance, cost* and *power consumption*

10GPON and WDM-PON definitions

10GPON



WDM-PON



Standardization - FSAN

- Much effort on NG-PON is currently being done in pre-standardization and standardization bodies
  - FSAN/ITU-T for 10GPON and IEEE P802.3av task force for 10G EPON.

- **NG-PON1** is required to work over existing ODN's
  - **XG-PON1**: 10G downstream (DS) and 2.5G upstream (US) – this is the current focus of the FSAN operators – framing is "G-PON like"
  - **XG-PON2**: 10G symmetrical – longer term

- **NG-PON2** may require new ODN – loose requirements
  - Typically considering introducing WDM splitter (arrayed waveguide grating, AWG) at the RN
  - WDM-PON is the "hottest" candidate

- XG-PON1 (G.987) is planned to be consented in ITU-T starting 2009
  - Physical layer (PMD) October 2009
  - Transmission convergence (TC) and Management (OMCI) in June 2010.

- It is unclear when and exactly how WDM-PON will be standardized, possibly 1-2 years after XG-PON

Technical challenges and cost issues

- Burst mode receivers (BMR)
  - The main technical challenge in going for higher upstream bitrate in TDM PON – GPON requires ~100 bit lock-in (phase and amplitude)
  - The most probable line coding is NRZ for XG-PON1&2 – same as for GPON
  - Work is ongoing to make commercial BMR components work at 2.5G – both DC- and AC-coupled approaches are considered
  - 10G BMR is still mostly experimental
- Dynamic bandwidth allocation (DBA)
  - XG-PON1 will have higher asymmetry vs GPON (1:4 vs 1:2)
  - More efficient DBA is necessary to efficiently use the US BW
  - Approaches include finding the optimal polling cycle, methods to find and assign the ONT present/future BW needs
- Colorless ONT
  - The key problem with hybrid and WDM-PON is the need for colorless ONTs, which is 2-4 times more expensive than GPON
  - Several approaches exist: seeding RSOAs, re-modulation and tunable lasers
  - The key is understand which approach makes most sense for a given bitrate and distance
  - Ultimately, tunable lasers is probably the best choice if they can be cost optimized for access
- WDM-PON needs one Central Office port per subscriber
  - Adds to cost, footprint and power consumptions

Technical performance (1)

- Table 1 summarizes the technical performance of 10GPON and WDM-PON

Table 1: Technical comparison: 10GPON and WDM-PON (RE: Reach extender)

Item	10GPON	WDM-PON
DS line rate	10G	1G
US line rate	2.5G	1G
Sub/feeder fiber (split)	N= up to128	N= up to 64
Reach w/o RE	20 km	50 km
Reach w RE	60 km	100 km
GPON co-existence	Yes	Maybe
BW/sub DS	10G/N	1G
BW/Sub US	2.5G/N	1G

- For 10GPON, the BW / subscriber is difficult to place a number on:
  - BW per subs can be provisioned
  - DS depends on the relation between broadcast and unicast traffic.
  - In a triple-play scenario, the DS BW would be something between full broadcast (ie 10G capacity per ONT) and full unicast (10G/N) depending on the service mix.
  - The oversubscription factor puts a limit to the available subscriber bandwidth:
    - up to 10G uplink (from OLT to metro network), 10GPON and WDM-PON can be made the same
    - >10G uplink, WDM-PON can offer more BW per subs.

Technical performance (2)

- The system reach is in the 10GPON case determined by the split. For example for a 32 split and a 28 dB link budget, typically equates to about 20 km
- For WDM-PON, the AWG has much lower loss that a power splitter
  - 50 km looks achievable
- Both 10GPON and WDM-PON can be adapted to long-reach scenarios by introducing mid-span reach extenders
  - For 10GPON either opto-electric-optic (OEO) or SOA extenders can be used to reach up to 60 km (limited by GPON protocol)
  - WDM-PON in C/L-band using erbium-doped amplifiers could reach up to 100 km

Power consumption

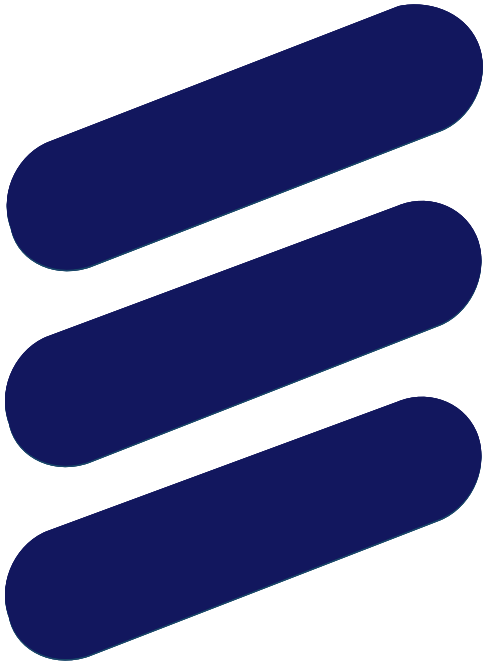
- OLT Side: With its shared OLT port, 10GPON has an advantage when it comes to power consumption compared to WDM-PON, which needs one dedicated OLT port per subscriber
  - However, as WDM-PON typically has lower power budget (due to much lower loss from the splitter), the power consumption per transmitter may be lower than 10GPON
  - Additional WDM-PON power savings
    - Integration (Tx, Rx arrays)
    - Unused OLT ports could be switched off

- ONT side (the main part of the power consumption): 10GPON gains from not needing cooled lasers while WDM-PON can make use of lower speed and lower power budget components
  - It is expected that both a 10GPON ONT and WDM-PON ONTs can be made with a power consumption in the order of 10-15 W
  - A “simple” GPON ONT has today a power consumption of ~9W

Conclusions

- An overview of the differences of 10GPON and WDM-PON has been presented
- 10GPON has a advantage in terms of standardization, maturity, cost and power consumption
- WDM-PON can offer higher bandwidth and reach and additional advantages with respect to
  - Security: WDM-PON with its dedicated wavelength channel per subscriber is often considered to be more secure
  - Management: Point-to-point systems are typically easier to manage than point-to-multipoint systems (e.g. fault handling)
- Thus, the trend is that 10GPON is envisioned for residential applications while WDM-PON is investigated for business or bandwidth intensive backhaul

The conclusion on the best choice between 10GPON or WDM-PON may end up in both being used, albeit for different applications.



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