

PON Technology Evolution Discussion

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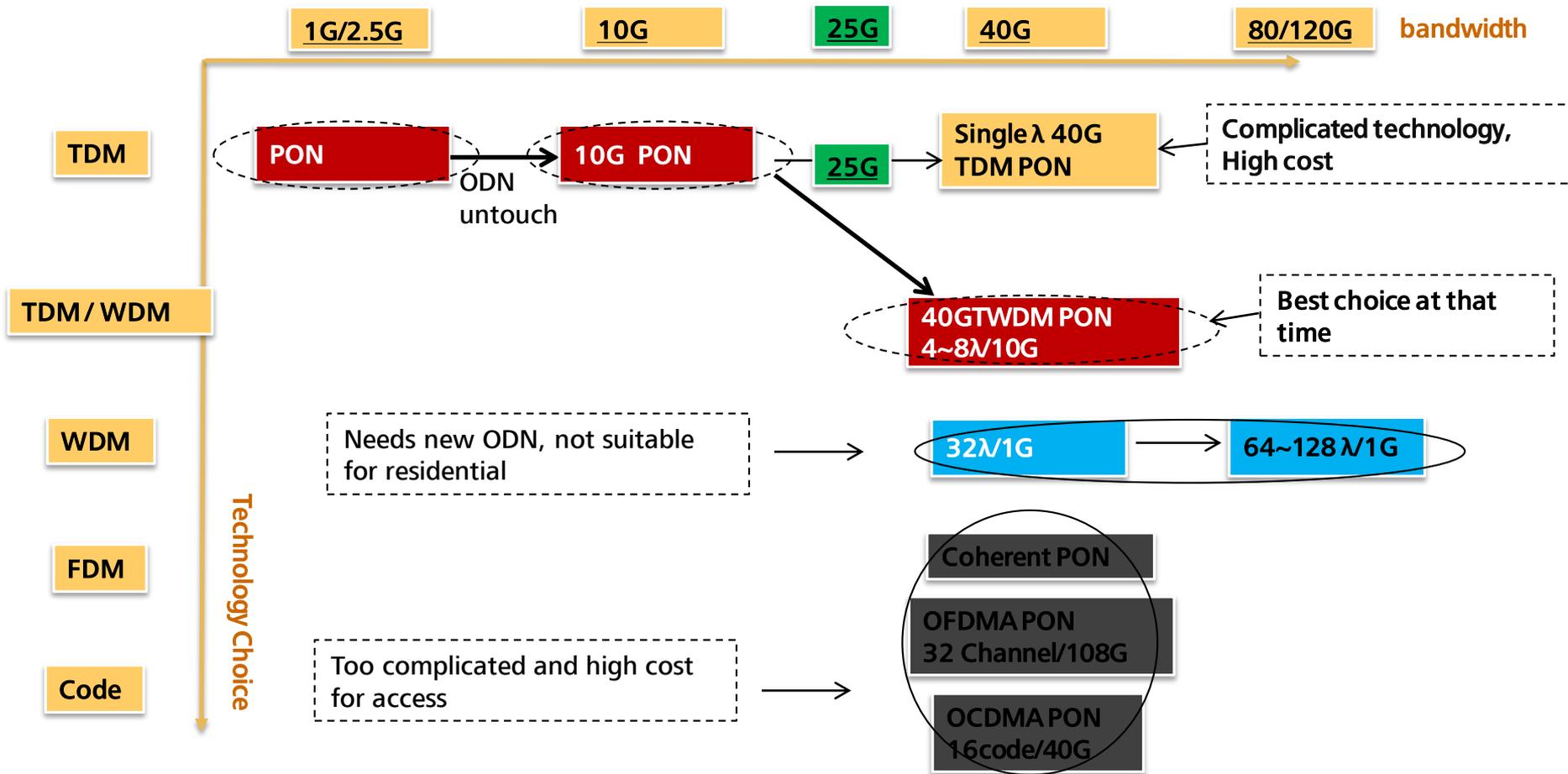
Supporter

- Wang Suyi , Fiberhome

Background

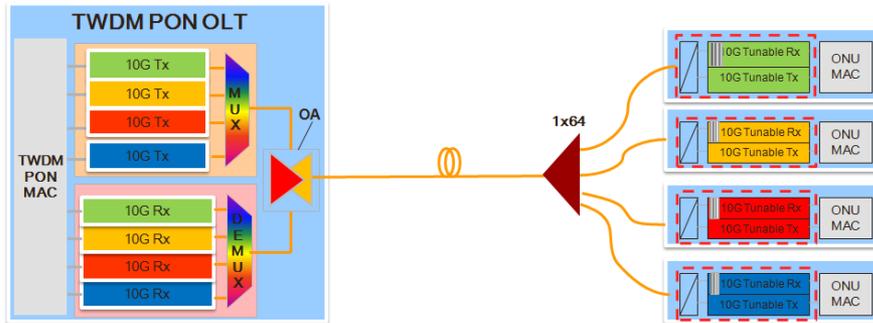
- Last meeting, it was agreed that different solutions , such as 50Gb/s per lane vs 25Gb/s per lane, should be analyzed and compared for 100G EPON.
- This contribution discusses the PON evolution trend based on the technology developed in the past.

Technology consideration for NG-PON2 in 2011

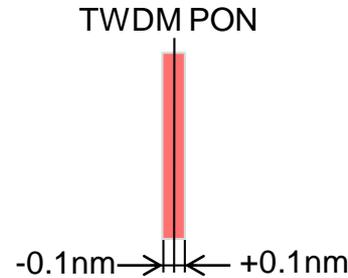


- TWDM technology was the best choice at that time
- The high cost of TWDM and Emergence of 25Gb/s technology make that TWDM-PON continues to loom in the future

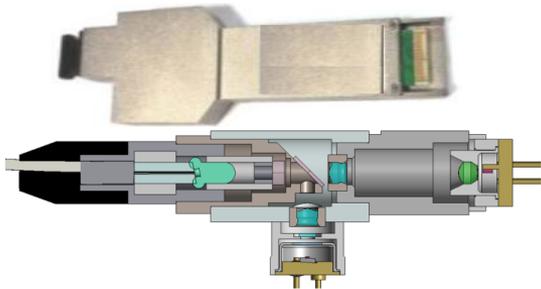
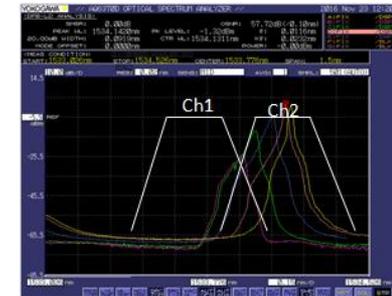
Challenges of tunable optics based multi-chs PON system



Very narrow pass band



ONU wavelength burst mode drifting



Complex package
High cost

Cost too high

- Access is about low cost: 2.5G GPON BOSA is under \$8
- Tunable lasers: ONT optics over \$1000 today

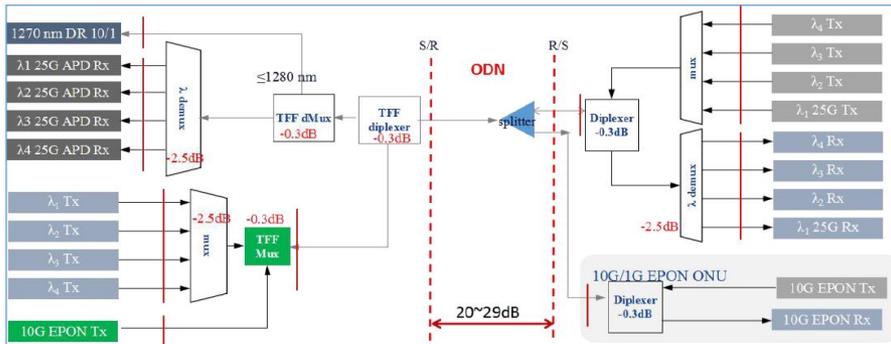
NG-PON2 Cost

- Now NG-PON2 cost is 10x higher than the cost of 10G-PON with fixed wavelength
- NG-PON2 ONU cost is higher than NG-PON2 OLT.

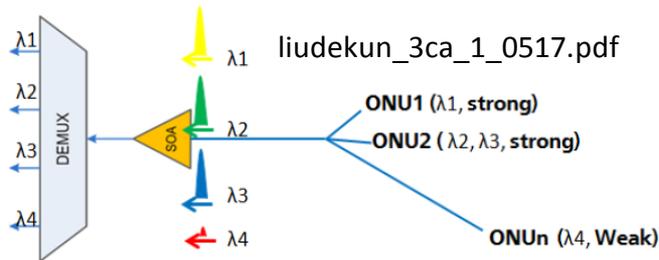
Source : NG-PON2 form in OFC 2017

- TWDM PON has greater complexity, higher component count, and power budget challenge. And the cost issue of tunable optics based multi-chs PON is hard to be overcome by volume.
- That's a structural cost that volumes won't equalize with TDM PON

Challenges of stacking multiple-chs PON system



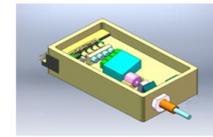
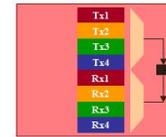
Very high Challenge in Power budget



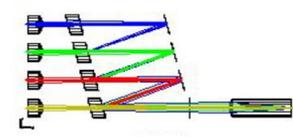
If three strong signal together with one weak signal arrive the OLT at the same time, the SOA will become saturated and can't provide enough gain for weak signal

- The 4 * 25G PON suffers very high power budget challenge, even higher cost per bit than 25G, low OLT ports density and several other technical challenges

4 wavelength Arrays



liu_3ca_1_0316.pdf



- Assumption
 - Single fiber bidirectional 4 λ
 - CWDM, >20nm spacing, uncooled
 - Same launch power /sensitivity
 - Based on discrete components rather than optical integration

4 *10G TRx Array cost		
Cost	Notes	
4* 10G LD	4*1.25 X	3dB more output power from LD chips
4* 10G APD	4*1.5 Y	3dB higher sensitivity
WDM	Z	comparable to X+Y
Total	5X+6Y+Z	~ 6X+7Y

Much higher cost than single channel

Why Not 100G PON?

- There will be a stepping stone before we get to 100G (25G)
- 100G PON (4x25G) will be harder than NG-PON2 (4x10G):
 - 25G components. Need about 5 more dBs of budget
- In comparison to a 25G OLT optical module, we estimate a 100G OLT module to have
 - an order of magnitude higher cost; 3x higher power dissipation; 1/3 density
- By the time operators need >25G PON, it will likely be possible to provide 50G TDM PON.
 - For data centers, IEEE is already defining 50G serial lanes for Ethernet, and 100G serial after that

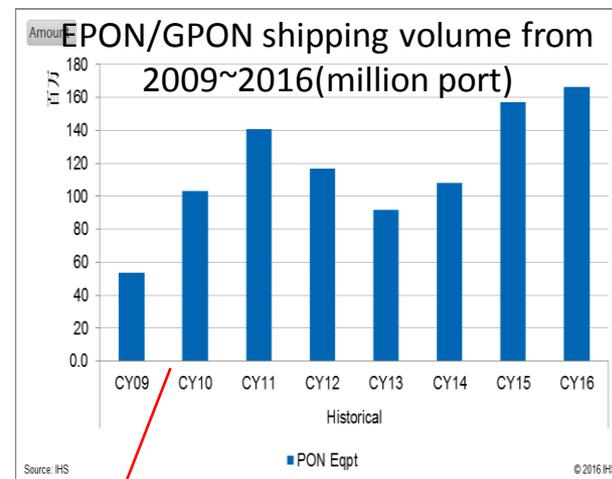
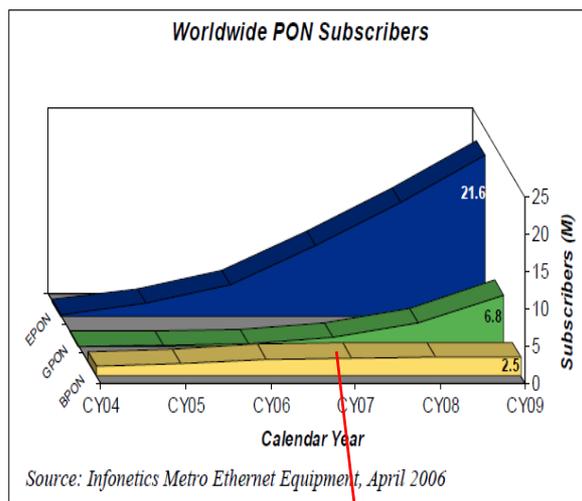
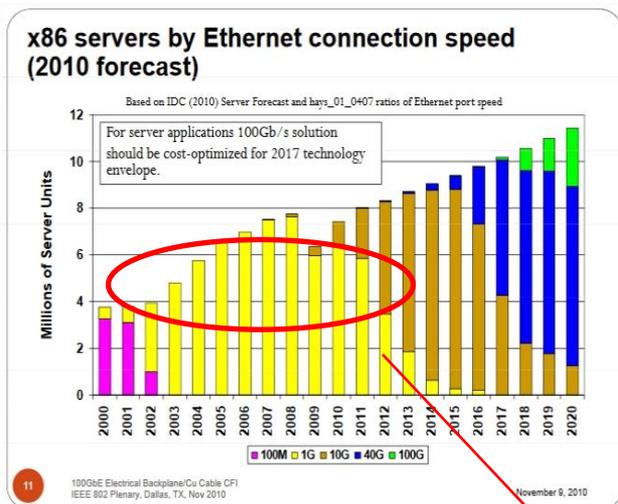
Source: https://www.eiseverywhere.com/file_uploads/c7e1ba72c398a54dac106dcc26106781_9_BuildingtheNextGenerationAccessNetwork_Eckard.pdf

PON industry should leverage “Hand-me-down effect” of device platform in external ecosystem

PON mainly target for cost-sensitive residential application.

PON should leverage the “Hand-me-down effect” of device platform in other area such as DC and metro

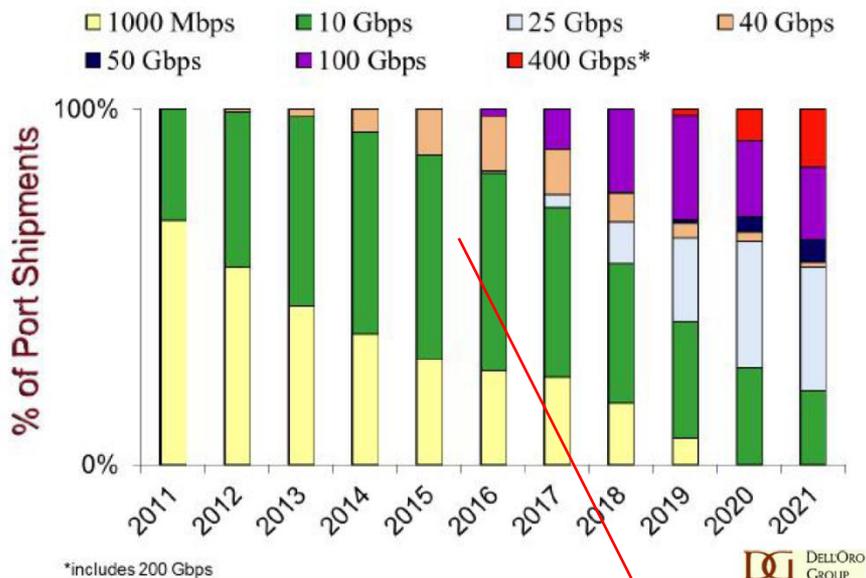
- It implied the optical and electrical device platform of PON is one generation lagging behind the one of DC and Metro



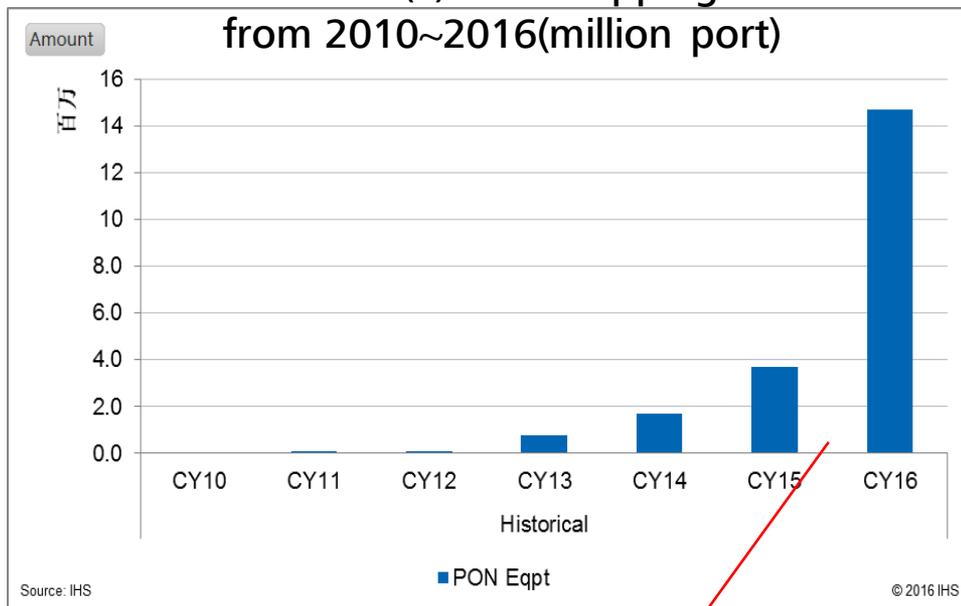
- GE was mainstream and reach shipping peak in 2008. And then 10GE ramped up.
 - EPON and GPON commenced massive deployment in ~2006(Japan) and ~2008(China)

PON industry should leverage “Hand-me-down effect” of device platform in external ecosystem (cont.)

Datacenter Ethernet port shipment

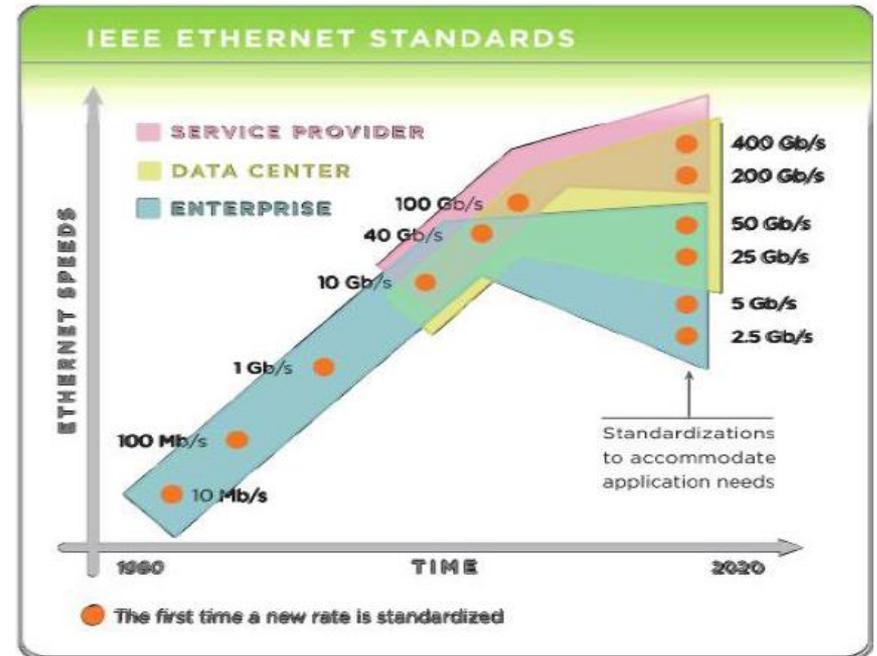
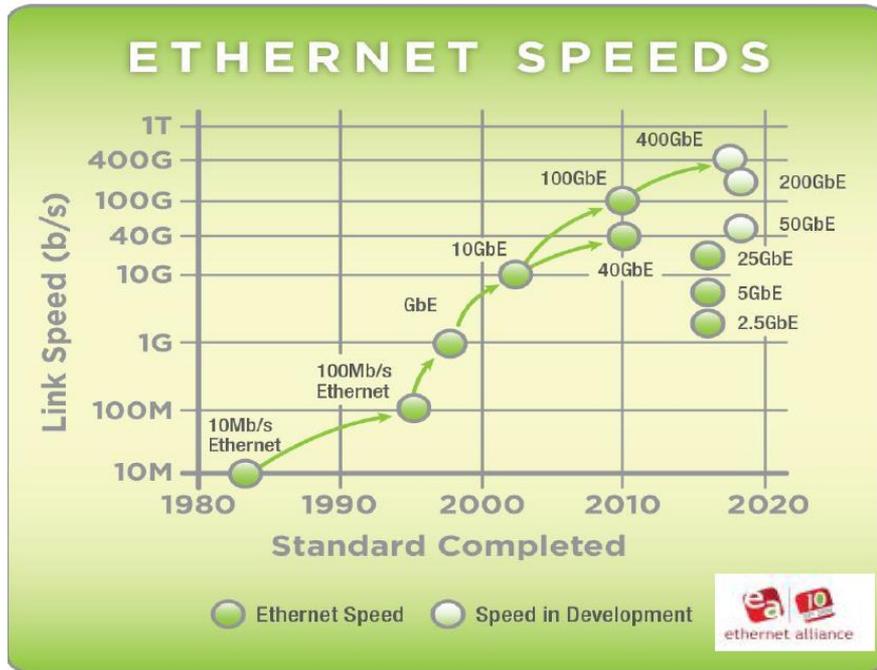


10G EPON/XG(S)-PON shipping volume from 2010~2016(million port)



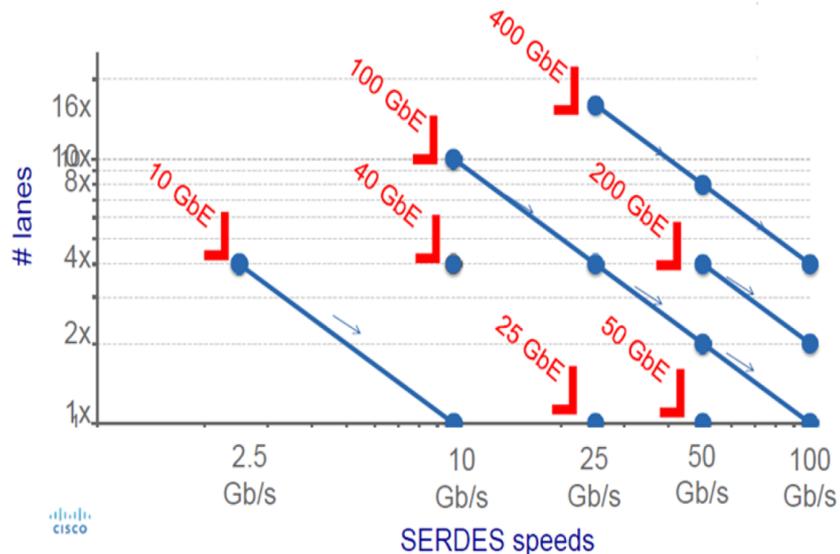
- 10GE reach shipping peak in ~2015, and 10G PON started massive deployment in ~2016

Next mainstream data rate per lane in DC and metro: 25Gbps & 50Gbps w/t ~25G optics platform



- 25GbE Ethernet standard has been finished, single lane 25Gb/s
- 50GbE/200GbE standard is planned to be finished in 2018~2019, 50Gb/s or 25Gb/s per lane
- 400GbE standard is planned to be finished in 2017, 50Gb/s (long distance) or 25Gb/s (short distance, multimode fiber) per lane

PON industry evolution may refer the history of Ethernet

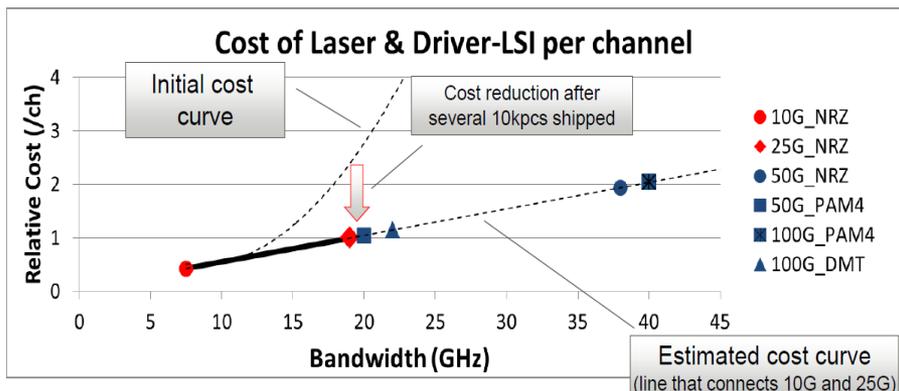


- Ethernet stacks wavelength when serial technology does not meet demand
- Each class of Ethernet will be driven to the serial rate for the most cost effective implementation
- When higher serial line rate is available , Lane numbers will be decreased to lower down the cost
- PON is not likely to require more than what serial rates can deliver

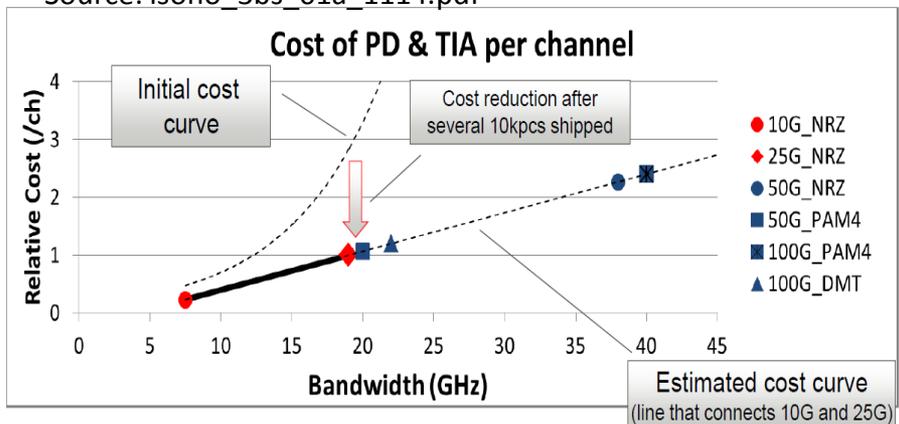
https://www.eiseverywhere.com/file_uploads/c7e1ba72c398a54dac106dcc26106781_9_BuildingtheNextGenerationAccessNetwork_Eckard.pdf

Always reach the serial rate limitation first , then WDM!

General cost trend of optical components



Source: isono_3bs_01a_1114.pdf



□ Asymptotic "Cost" for Long Reach (10km) vs. Short Reach (<300m) shows that market can tolerate > 2x Cost per Gb Δ based on reach / application.

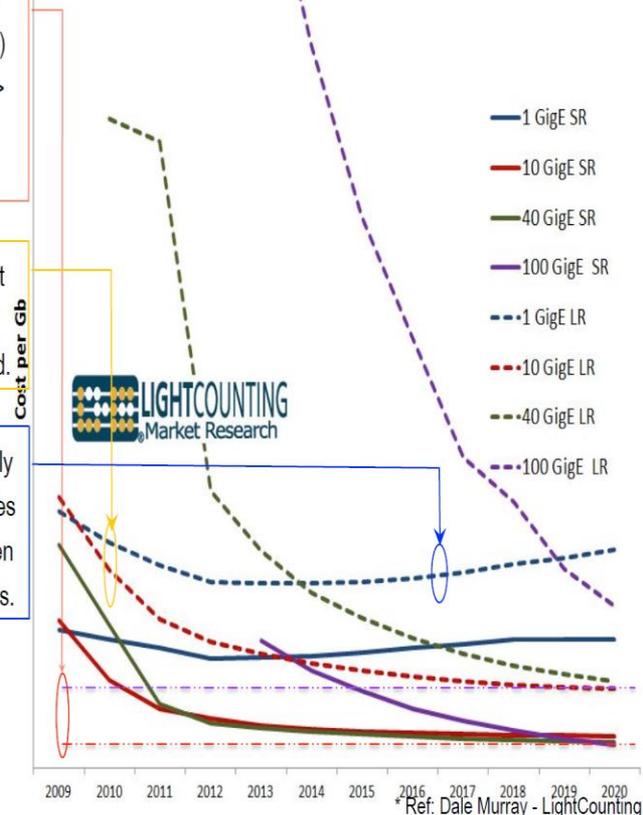
□ Observe that as market matures, it is expected that "Cost per Gb" should be lower than prior speed.

□ Observe that "Cost per Gb" actually increases for mature technologies as their use / volume is overtaken by newer and faster technologies.

Relative Cost Asymptote

- Long Reach (10km)
- Short Reach (<300m)

Source: dove_400_01a_0114.pdf



- The cost increasing rate for higher line rate is much lower than bit rate increasing when it becomes mature, faster technology will have distinct cost/Gb advantage finally .
- Stacking multiple channels will never have lower cost per Gbit.

Summary :

- Based on the past , PON industry should leverage the "Hand-me-down effect" of device platform in Ethernet ecosystem
- The optical and electrical device platform of PON was generally one generation lagging behind the one of DC and Metro
- From the economic consideration , PON system should try to reach the serial rate limitation with TDM first, and then do WDM.

Thank you

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