Thoughts on Objectives for SMF PMDs for 400GE Study Group

Xiaolu Song, Xinyuan Wang, Kai Cui, Xi Huang.

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HUAWEI

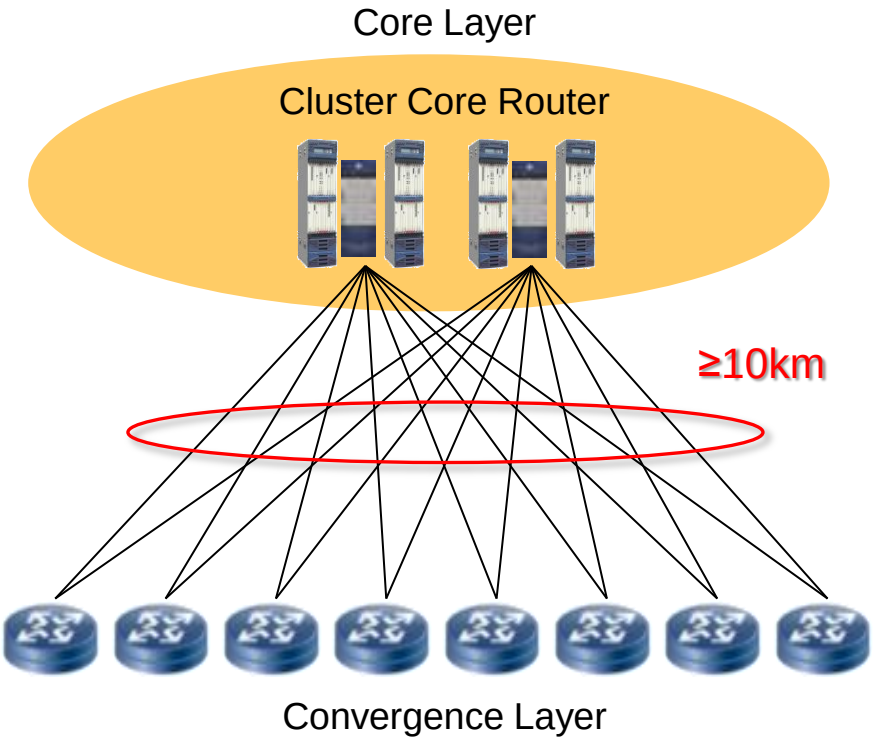
Supporter

- Junjie Li China Telecom
- Haiyi Zhang CATR
- Wenyu Zhao CATR
- Song Shang Semtech
- Keith Conroy Multiphy
- Neal Neslusan Multiphy
- Ali Ghiasi Broadcom

Outline

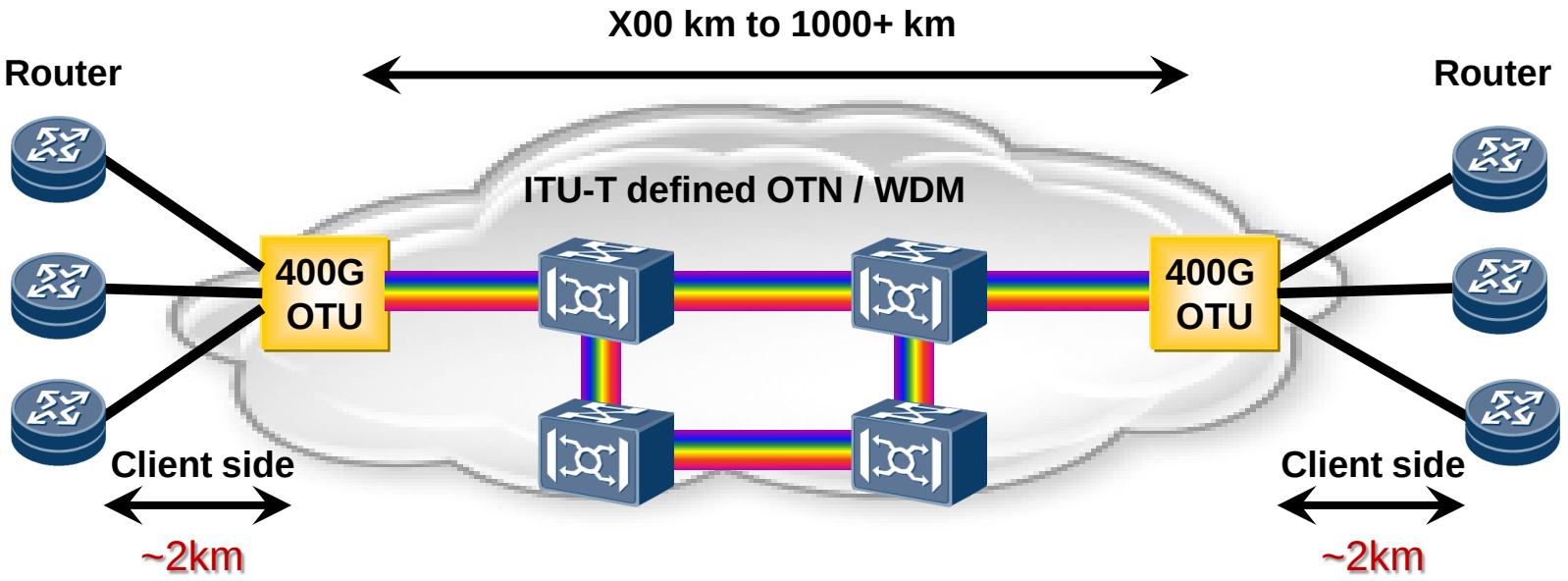
- Typical scenarios for 400GbE
- The Perspective of 400GbE from system vendor
- Lessons learned from previous IEEE standards
- The Perspective on 400GbE SMF PMD objectives
- Summary

Scenario 1: Optical Interconnection of IP Core



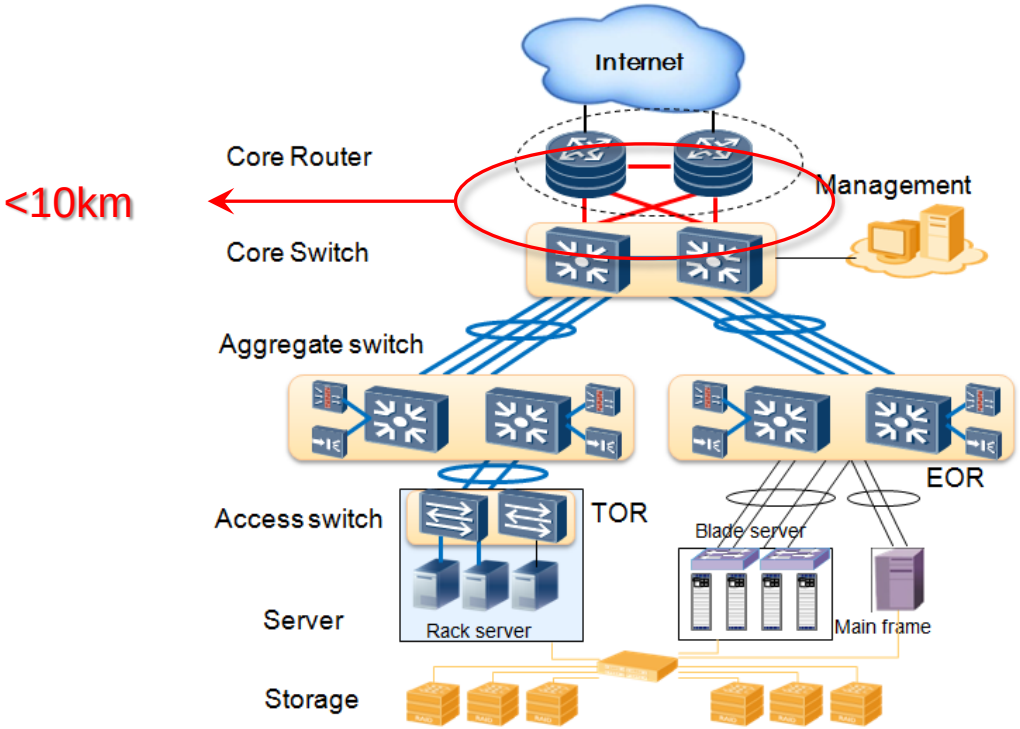
- **The typical application:** the interconnection between the cluster core Router in the core layer and the router in convergence layer.
- **The typical reach:** from 10km of SMF and above.

Scenario 2: Optical Interconnection between IP Core & Transport



- **The typical application:** the interconnection between core Router and OTN transport inside the central office of Carrier.
- **The typical reach:** the Router and the OTN are always in the different site (office), the most application is about 2km and some of the scenario may over 2km. Carriers are interested in the usage of duplex SMF, except for some shorter reach interconnections.

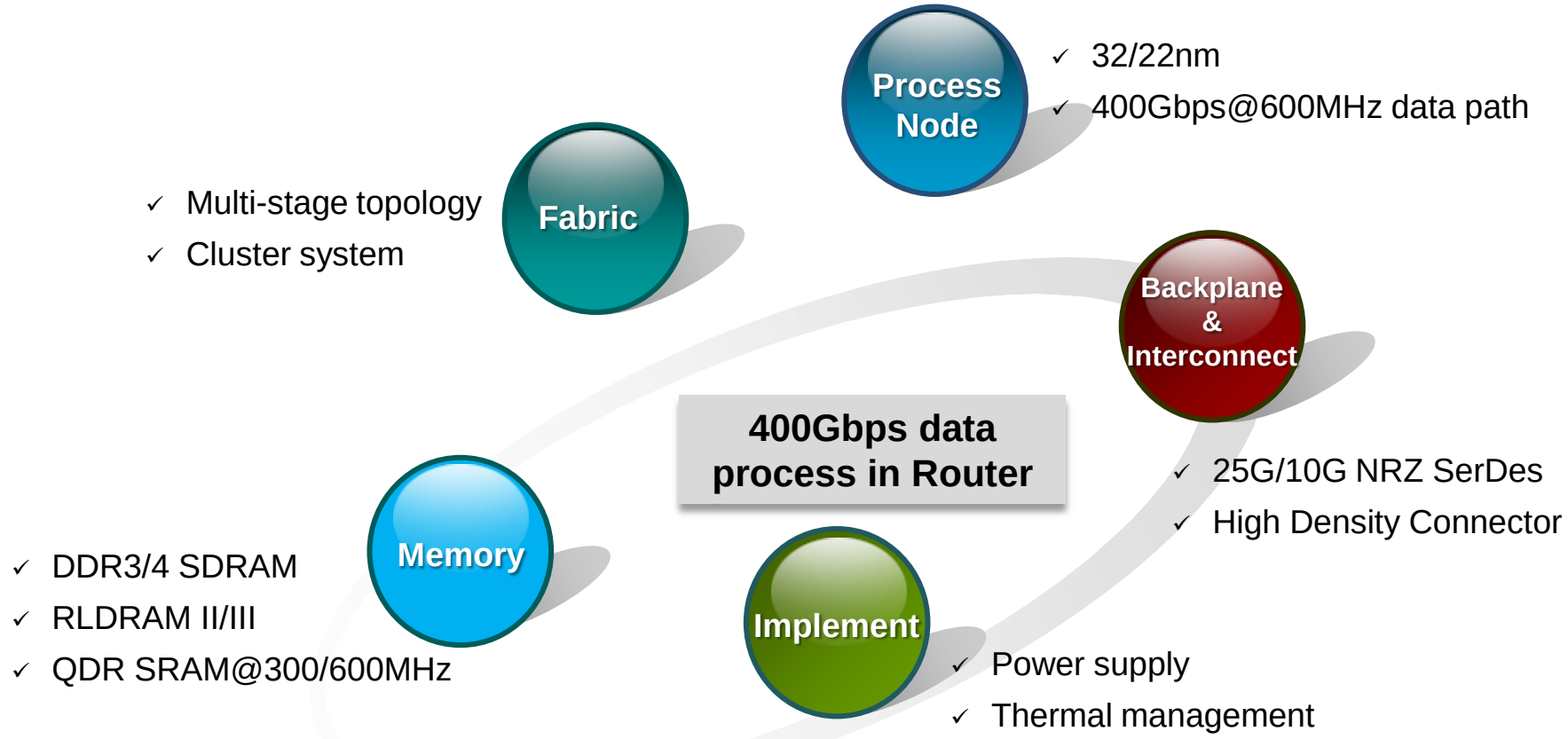
Scenario 3: Optical Interconnection of Intra Data Center



- <10km optics is typically deployed for the application between Core Router and Core Switch.
- Market demand from Intra-DC is a cost-effective solution and the 500m SMF objective from BM satisfied the needs from data centers.

The Perspective of 400GbE from System Vendor

- The performance of packet process in LPU is based on ASIC technology and Moore law.
- The technologies or platform of 400Gbps/Slot of the core Router are near-ready, and waiting for the solution of 400GbE Interface.
- Several system vendors released ASIC/LPU solution related to 400Gbps.



Lessons Learned from Previous Works: Cost and Density

- **In BA project 100GBASE-LR4 was defined enabling a CFP package with 10*10 Gb/s CAUI-10 electrical interface and 4*25 Gb/s optical interface:**
  - Very soon solutions, but big, “hot”, and expensive.
  - BM initiated to provide lower cost solutions with higher density by defining CAUI-4 electrical interface.
- **For 400GbE optical transceiver:**
  - **Power dispersion:** the limitation of early adopter is according to CFP baseline.
  - **Density:** initial 400GbE deployment evolves first at the core network, the LPU could support 4*CFPs at most in the core Router.
  - **Cost:** 100GbE bit/sec cost parity is desirable for 400GbE.

Lessons Learned from Previous Works: Timing of Versions

- **At 10GE (and lower rates) many package generations exist:**
  - No problem in field because PMD didn't change over time.
  - Continuous backwards compatibility.
  - 2km and 10km solutions merged into a single solution to maximize volume and reduce cost.
- **At 100GE many package generations are expected as well:**
  - BM solution will only be backwards compatible if it doesn't define a new PMD for 500m with an incompatible optical interface.
  - Further improvement in reduction of number of optical / electrical lanes is expected in the future, e.g. 2*50Gb/s or serial 1*100Gb/s.
  - Number of incompatible generations should be carefully managed to minimize incompatibility. Only consider if a significant cost reduction can be achieved which will be used for some significant amount of time.
- **Several 400GE package generations are expected as well.**

400GbE SMF PMD Observations

16*25Gbps WDM (duplex SMF)

- To enable quick time to the market, mainstream 100GbE 25Gb/s NRZ technology can be reused, by simply increasing the number of channels from 4 to 16.
- Because 100GBASE-LR4 works well at 10km reach over SMF, thus 400GBASE-LR16 will also work at 10km over SMF (w/ SOA? w/ FEC?).

8*50Gbps PAM4 (duplex SMF)

- In this case the electrical and optical interfaces can remain at 25GBd, reusing similar components of 100GbE.
- 8*50G PAM4 will be a potential candidate of 2km (w/ FEC) and 10km (w/ FEC & SOA?).

8*50Gbps NRZ (duplex SMF)

- For this architecture, the performance of optical components is challenging (especially the sensitivity of receiver). The link loss and the transmission penalty might be an issue for electrical lanes.

4*100Gbps PAM4 (duplex SMF)

- Based on the previous investigation, 100Gbps NRZ will not be practical and therefore multi-level modulation is a promising way for single channel 100Gbps.
- Move complexity into the electronics to simplify the optics (using ~30GHz even 22GHz O/E components) is a promising way to make a balance between the application demand and the cost.

The Perspective on 400GbE SMF PMD Objectives

- **Taking into consideration the “lessons learned” from previous standards:**
  - Define a 400 Gb/s PHY for operation up to at least 10km of SMF.
  - Define a 400 Gb/s PHY for operation up to at least 2km of SMF, with the note “if it can be shown that a SMF PMD with a shorter reach than 100GBASE-LR4 has sufficient cost, density, or power difference to justify an additional SMF PMD type”.
- **In this way there is an opportunity to investigate potentially different solutions for 2km and 10km, one being a “quick” solution, e.g. for 10km, and a lower cost solution, e.g. for 2km, operating with fewer optical lanes than 16.**
- **In this way it may be possible to avoid waiting for 400GE modules enabling a higher density.**

Summary

- To provide the perspective of a networking equipment vendor with considerations for application space and objectives for 400Gb/s PMDs.
- To enable quick time to market, to define a near term solution by scaling up mature 100Gb/s PMD, in order to address the emerging needs for initial 400GbE applications.
- Define an improved medium term solution enabling lower cost and a higher port density by reducing the number optical lanes based upon advanced modulation.
- **Proposed Objectives for SMF PMDs for the 400GbE Study Group**
  - At least 10km over duplex SMF
  - At least 2km over duplex SMF

Thank you