



Migration Paths to 25G EPON, 50G, 100G EPON and Wavelength Plans



Eugene (Yuxin) Dai
Cox Communications
IEEE 802.3ca TF, IEEE Plenary Meeting
November, 2017
Orlando, FL, USA

Outline

- Coexistence and access network migration
- PON rate hierarchy
- 50Gbps EPON with PAM4
- 25Gbps, 50Gbps and 100Gbps EPON wavelength plans

PMD status of 802.3ca

- Slow progress in PMD
 - We spent > 2 years on a 4x25G wavelength plan. Main difficulties are
 - Spectra resource limitations in O band and other constraints such as FWM, cost, etc.
 - Coexistence requirements with 10Gbps PON and 2.5 Gbps PON make the situation worse
 - Unless we are open to other bands, consider less channels, and reconsider coexistence requirements, the difficulty will not go away
- Power budget gap is difficult to fill
 - FEC alone cannot compensate the loss of WDM mux/dmux
 - SOA is needed; channelized SOA may be needed because of the 20nm width in channel 0. The cost is a serious concern.

The paths for higher capacities

- Channel bounding, advanced modulations such as PAM4 and coherent are ways to achieve higher capacities for PON
- As far as channel bounding is concerned, the rule of thumb is to consider WDM only after TDM meets the bottleneck under current technology
- Today, optical PAM4 has been used in several high-speed Ethernet standards
- Today, 50Gbps DWDM PAM4 system with 80km reach is available
- There are challenges for PAM4 in PON, although details are out of the scope of this contribution, the author believes they are solvable
 - One example is the 4-5 dB power penalty of PAM4. It is compatible with the WDM filter loss in channel bounding which can be compensated with SOA
- PAM 4 is assumed to have a 50G rate in this contribution

Reconsider coexistence requirements

- We have been treated coexistence as an isolated requirement
 - We first required coexistence with 10G EPON
 - Implicitly assuming coexistence with XGS-PON as well
 - Then coexistence with GPON was added
- The “brownfield” and “greenfield” coexistence is another way to view the above coexistence requirements, ie, coexist with 10G PON and GPON
- However, meaningful coexistence is closely linked with practical migration paths in access network

Consider coexistence and network migration together may open new views

... A Big Step for PON

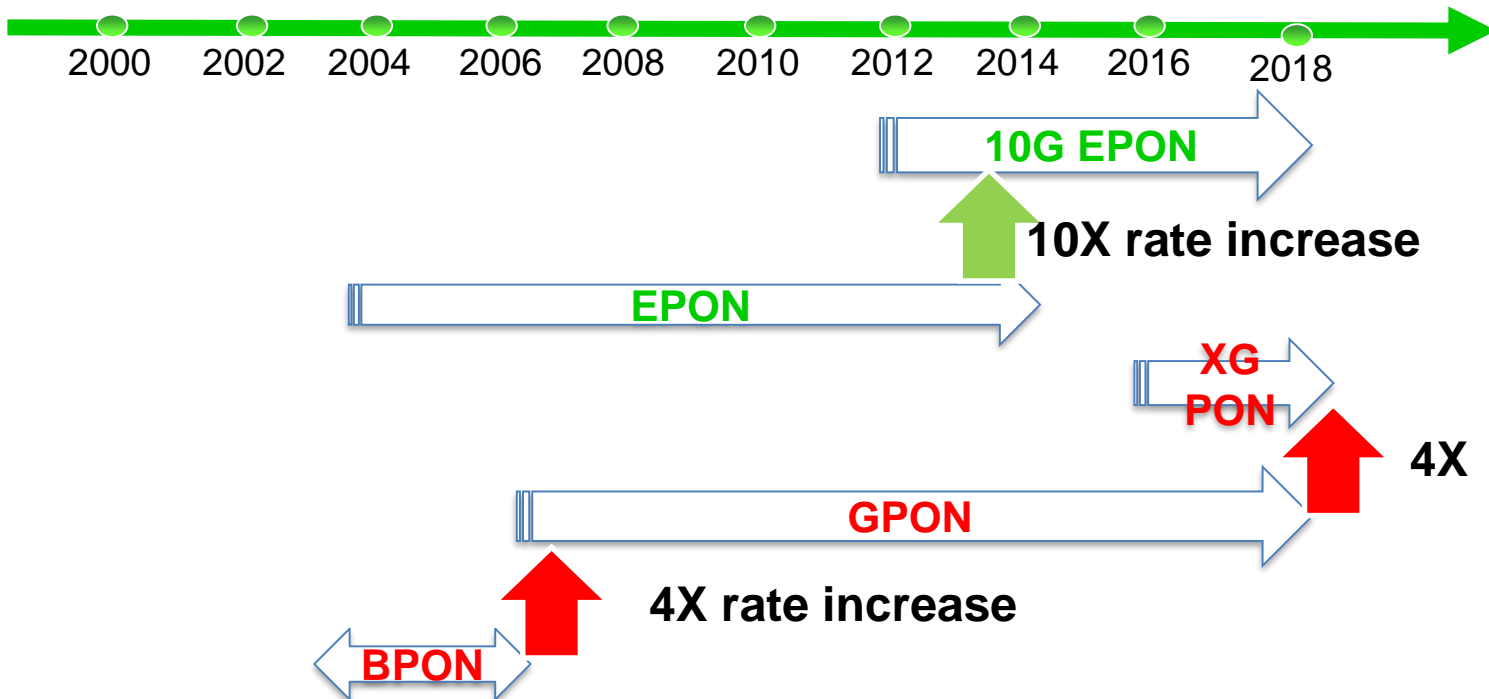
- Access network infrastructure migration takes a long time
- Access network rate migration normally involves CPE replacement, and may need touch OSP.
- PON rate upgrade results replacing ONTs at end-user location.

In brownfield PON upgrades to the next rate is costly
After a PON upgrade to a new rate it is expected the it will operate at that rate for a reasonably long time

It is not economical to increase PON rate at small steps

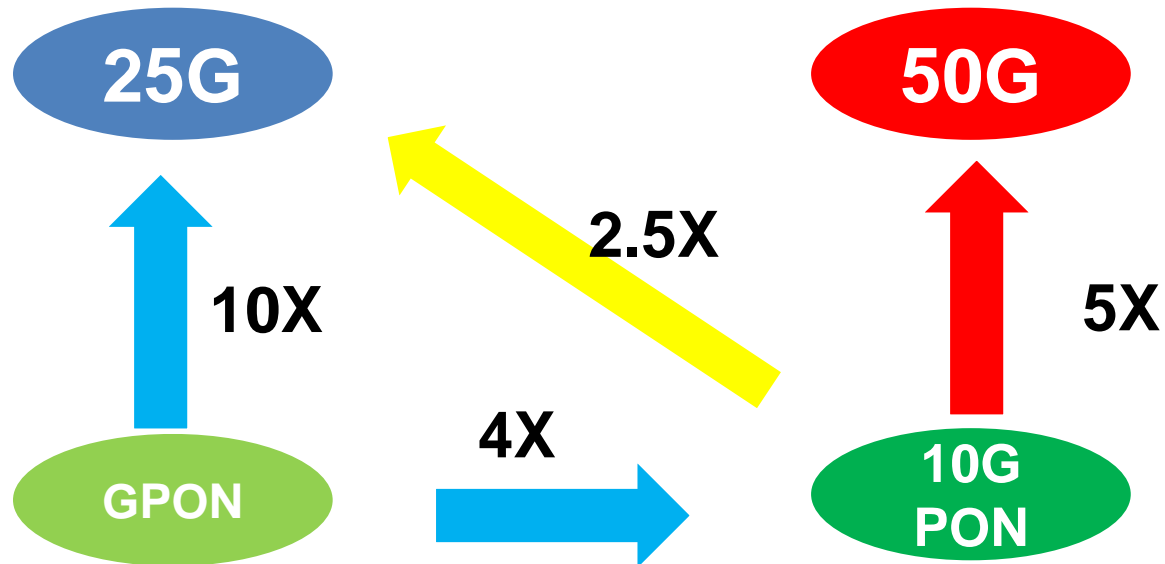
PON deployment rate hierarchy

Historic PON Field Deployment and Rates



- 4X to 10X rate increase seems to be reasonable steps for a reasonable life span of a PON rate

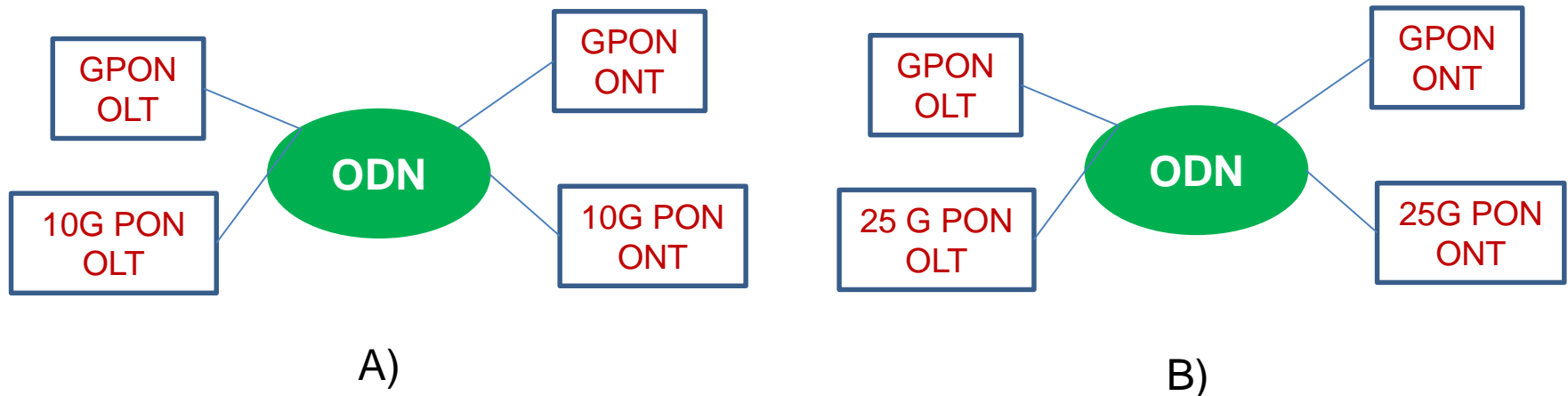
Migration paths to 25G and 50G



- 10G PON to 25G PON migration is too small a step
 - Reducing 10G PON splitting ratio to $\frac{1}{2}$ is roughly equivalent to migrating to 25G PON
- 10G PON should migrate to 50G PON (5X rate increase)

2.5G PON Migration & Coexist Scenarios

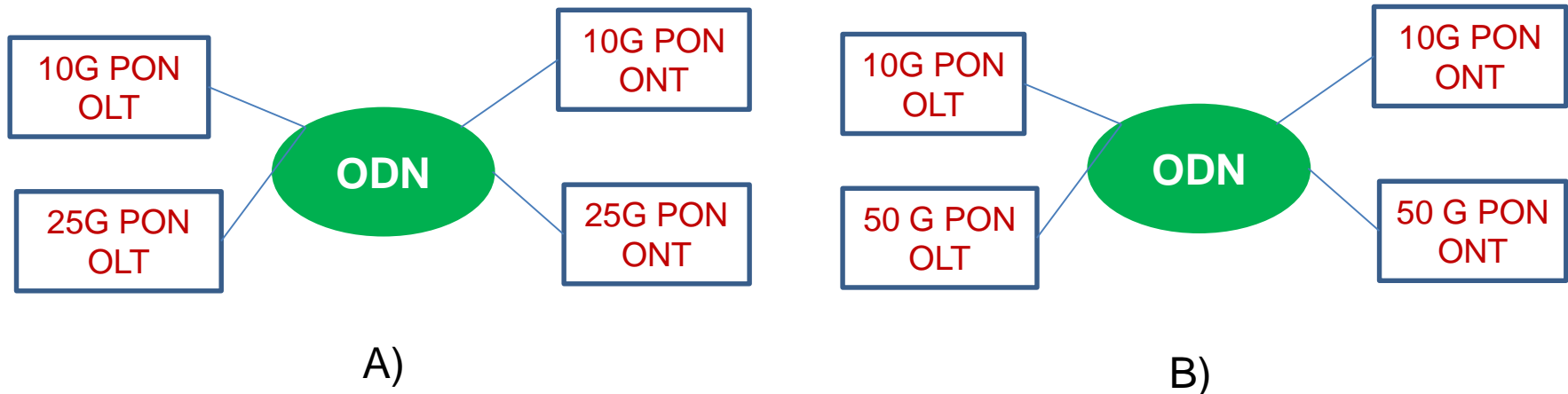
- GPON is the most deployed PON technology, however, bandwidth is already under constraints in offering Gigabit services
- There are two migration paths for GPON:
 - Either migrates to 10G PON (10G EPON, XGS-PON) with 4X rate increase
 - Or, migrates to 25G PON with 10X rate increase (ITU-T is working on 25G PON as well).



Both scenarios are possible and practical

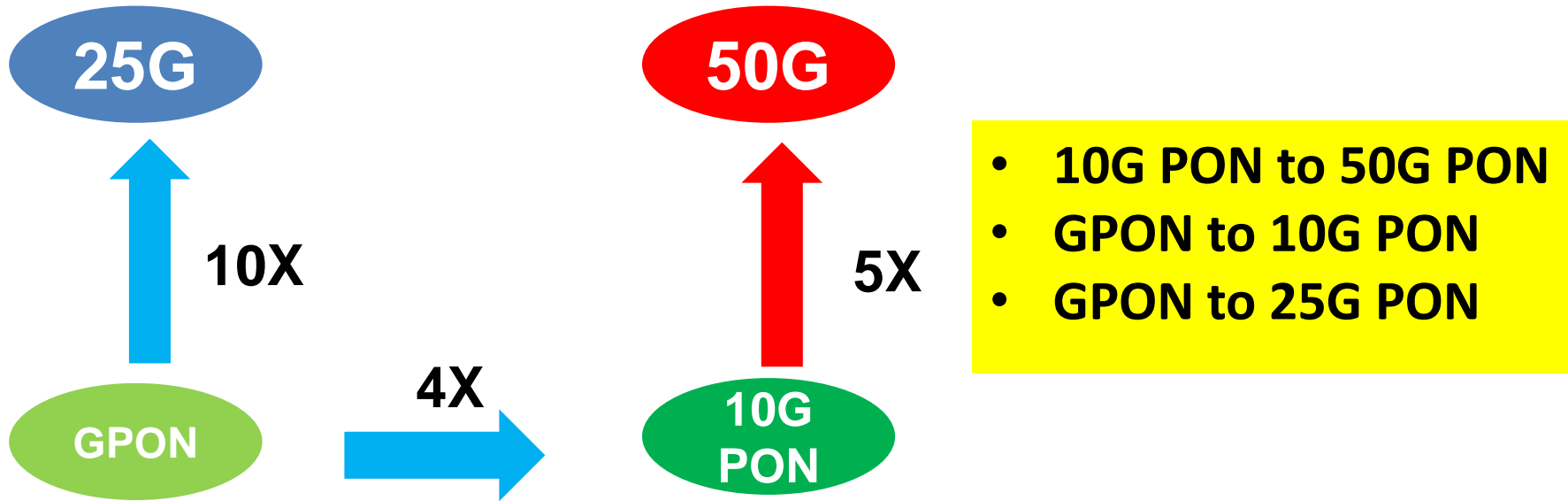
10G PON Migration & Coexist Scenarios

- 10Gbps PON, ie. 10G EPON, XGS-PON, are starting to be deployed
- In principle, there are two migration paths to higher rates PON
 - A, migrates to 25G PON with 2.5X rate increase
 - B, migrates to 50G PON with 4X rate increase



- **Scenario A is too small a step ...**
- **Scenario B is practical migration path**

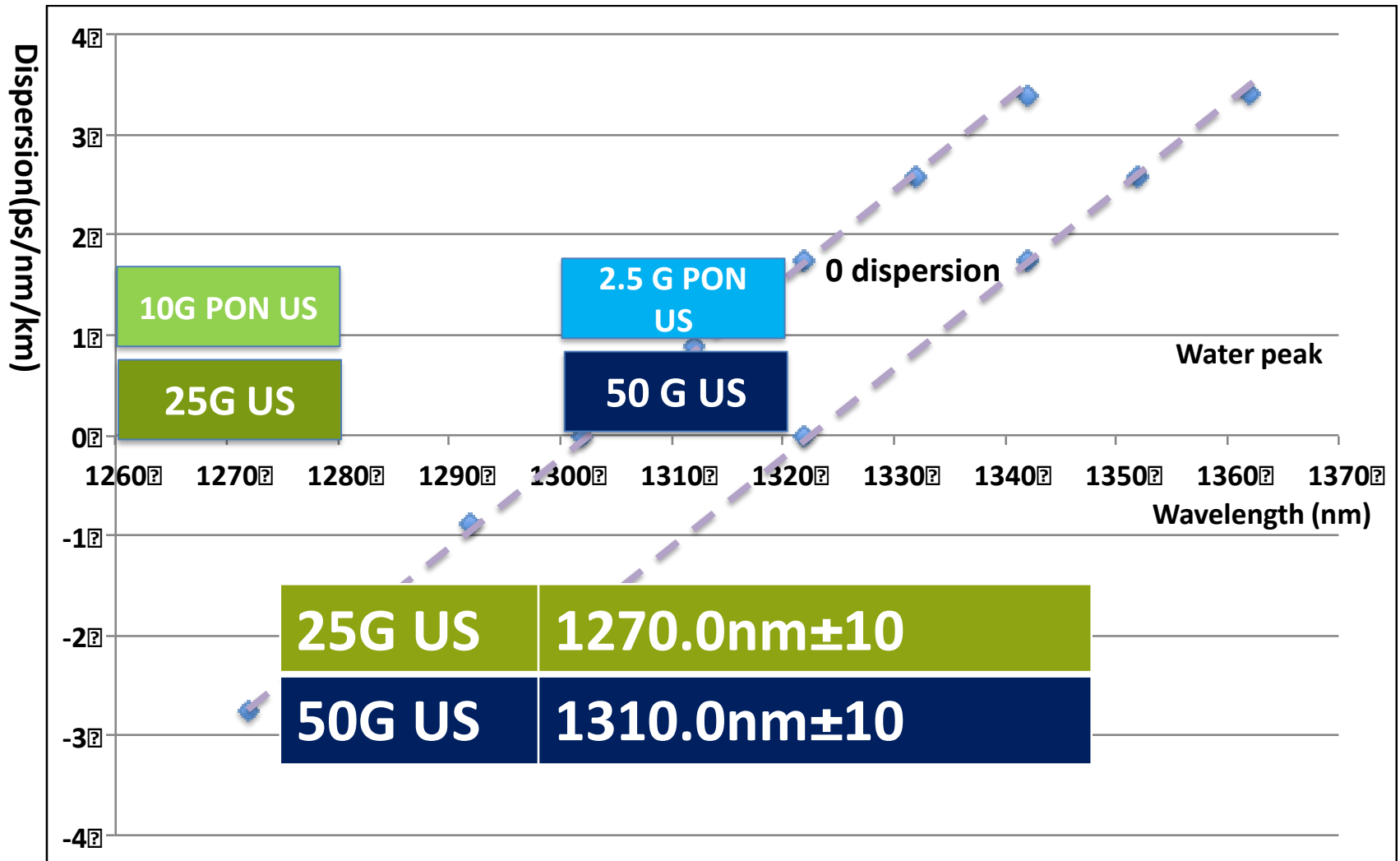
Practical migration paths and coexistence



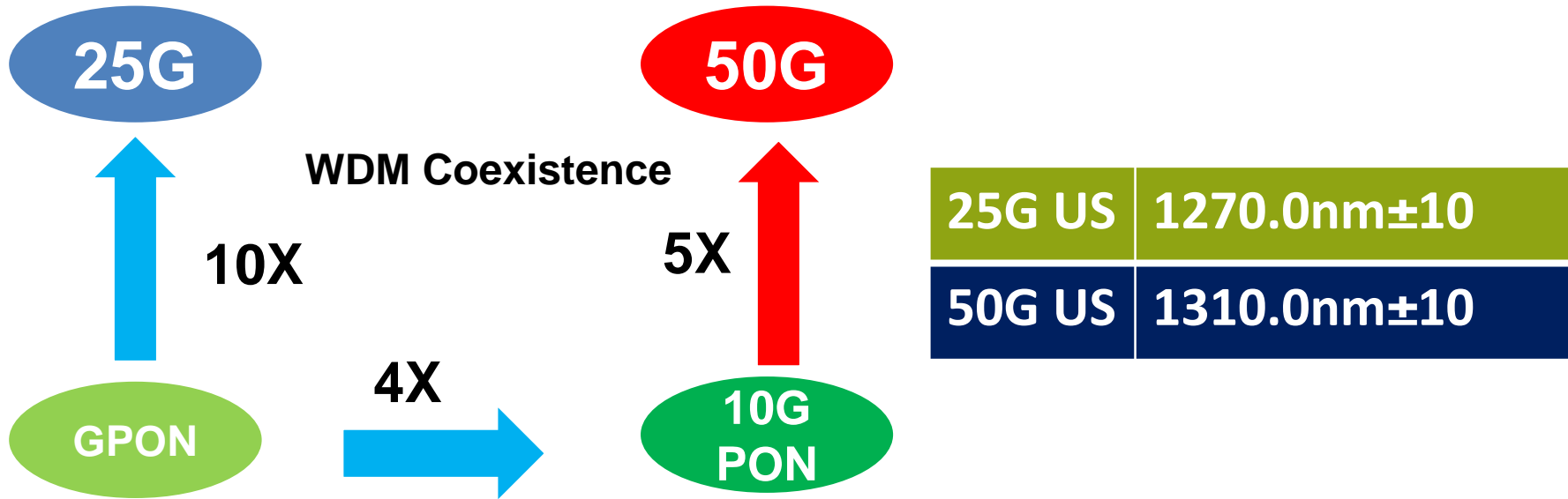
New coexistence requirements

- 25G PON only needs to coexist with GPON
- 50G PON only needs to coexist with 10G PON (10G EPON, XGS-PON)

Upstream wavelength allocation



Coexistence and wavelength allocation

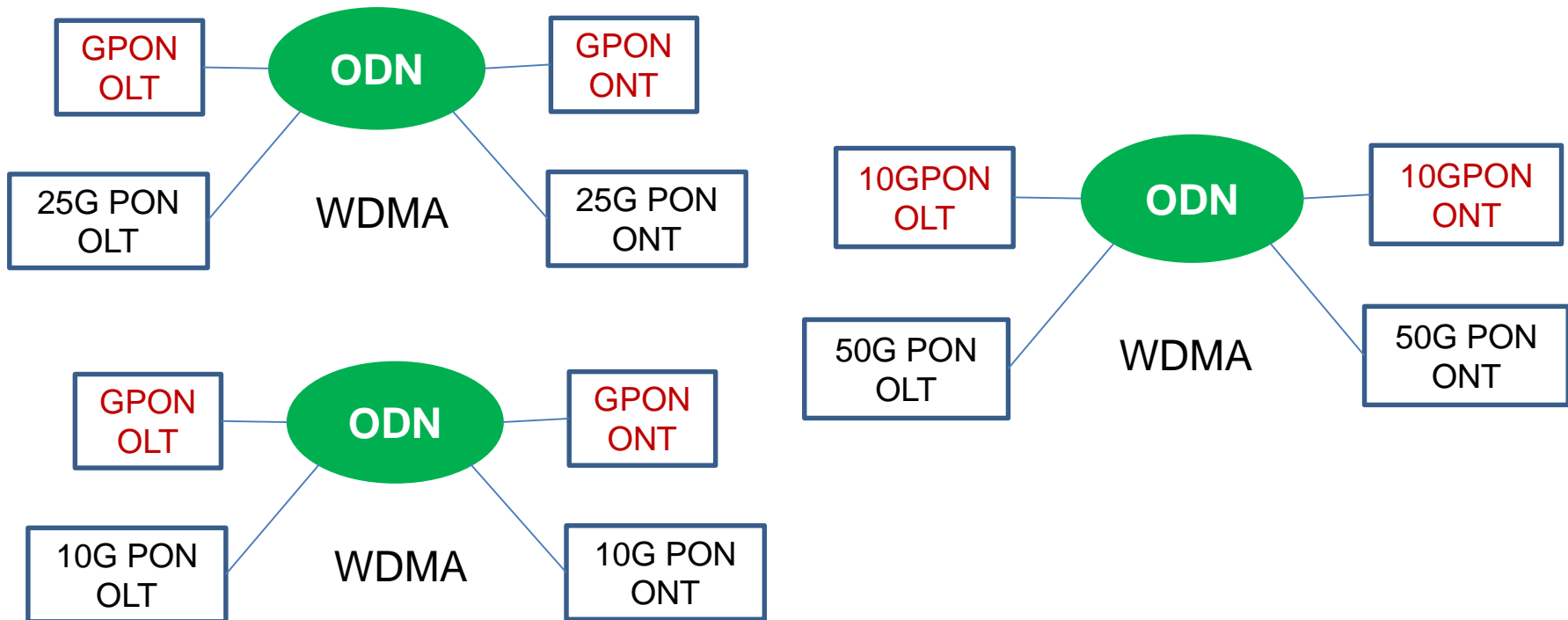


Coexistence

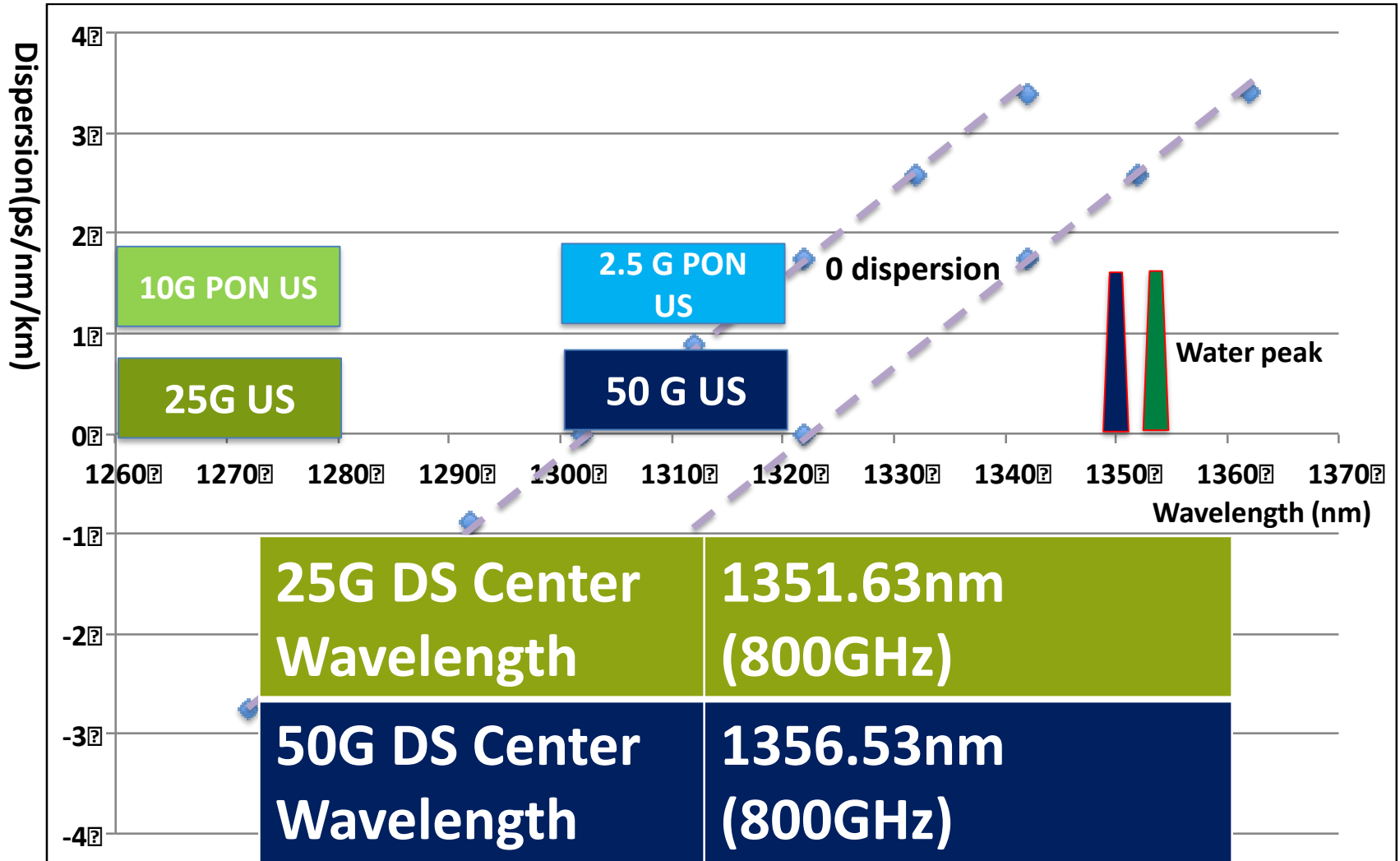
- 25G PON WDM coexist with GPON
- 50G PON WDM coexist with 10G PON (10G EPON, XGS-PON)

Coexistence and migration

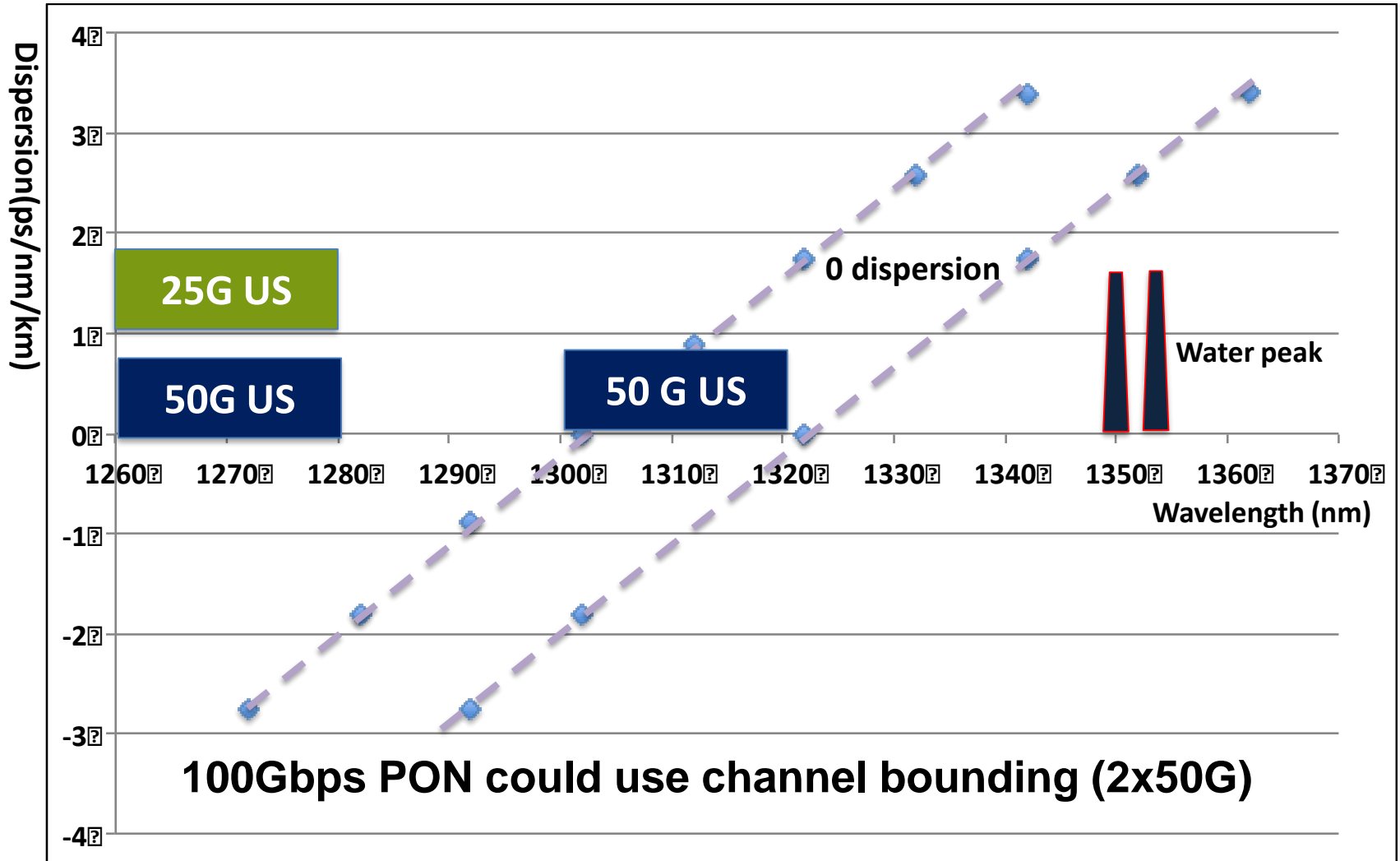
- 2.5Gbps PON migrates to 10G PON with WDMA coexistence
- 2.5Gbps PON migrates to 25G PON with WDMA coexistence
- 10Gbps PON migrates to 50G PON with WDMA coexistence



Downstream wavelength allocation



Towards 100 Gbps



Conclusions

- **The ~4x to 10X rate increase for PON upgrading works well from deployment experiences**
- **10G PON to 25G PON rate upgrade may be too small a step**
- **The practical PON rate upgrade scenarios to 25G and 50G are**
 - **2.5G PON to 10G PON; or 2.5G PON to 25G PON**
 - **10G PON to 50G PON**
- **Proposed wavelength plan meet the coexistence requirements and scales to 100G**



Thanks

Eugene.dai@cox.com