READY TO GIVE UP ON TDM?

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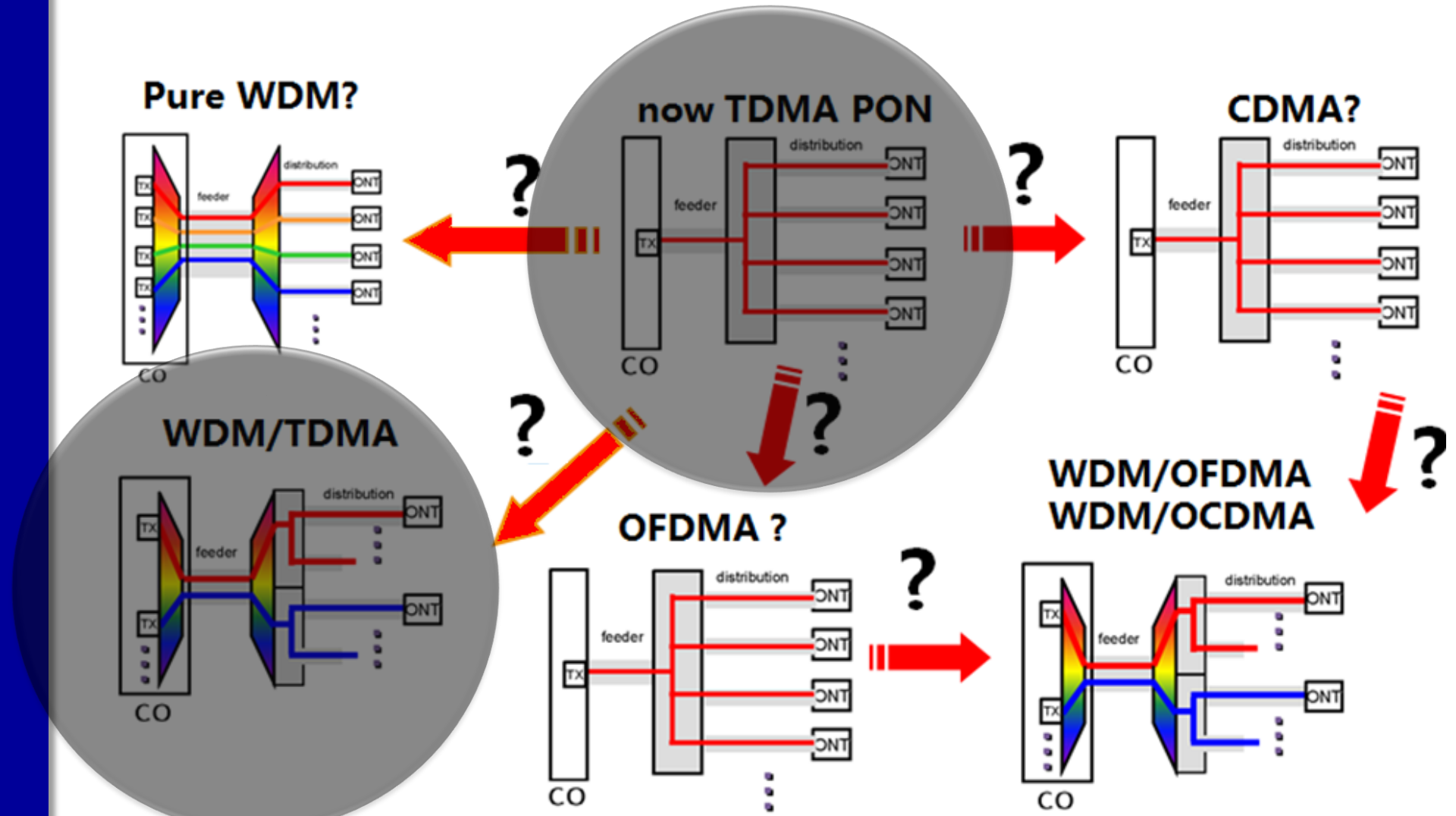
NG-EPON Options



Why we like TDM-PON?

- TDM-PON has proven to be flexible
  - When paired with strong QoS mechanisms, controlled over-subscription can be used to share a single OLT port among multiple subscribers.
    This is ideal for residential deployment.
  - The same QoS mechanisms can be applied to business deployment, where no over-subscription is used. Each customer gets dedicated circuit into the transport network.
    This is ideal for business deployment.
  - With proper network engineering, residential and business customers can be also served off the same OLT port.
  - Advanced QoS mechanisms guarantee latency, throughput, jitter comparable with dedicated P2P solutions at a fraction of a cost of such a dedicated circuit.

Why we like TDM-PON?

- TDM-PON has proven to be cost-effective
  - Initial CAPEX can be offset by connecting larger number of customers.
  - As bandwidth needs grow, additional ports can be activated on OLT. Extra CAPEX is then based on customer demand.
  - With smart ODN design, customers can be relocated between OLT ports without requiring changes in the field.
- TDM-PON has proven to be versatile
  - We use it for residential FTTH, business (FTTB, FTTBp), cell tower backhaul (FTTCell), and other applications.
  - The Ethernet roots of EPON make it easily adaptable to any application, as long as data is packetized and can be forwarded over L2 links.

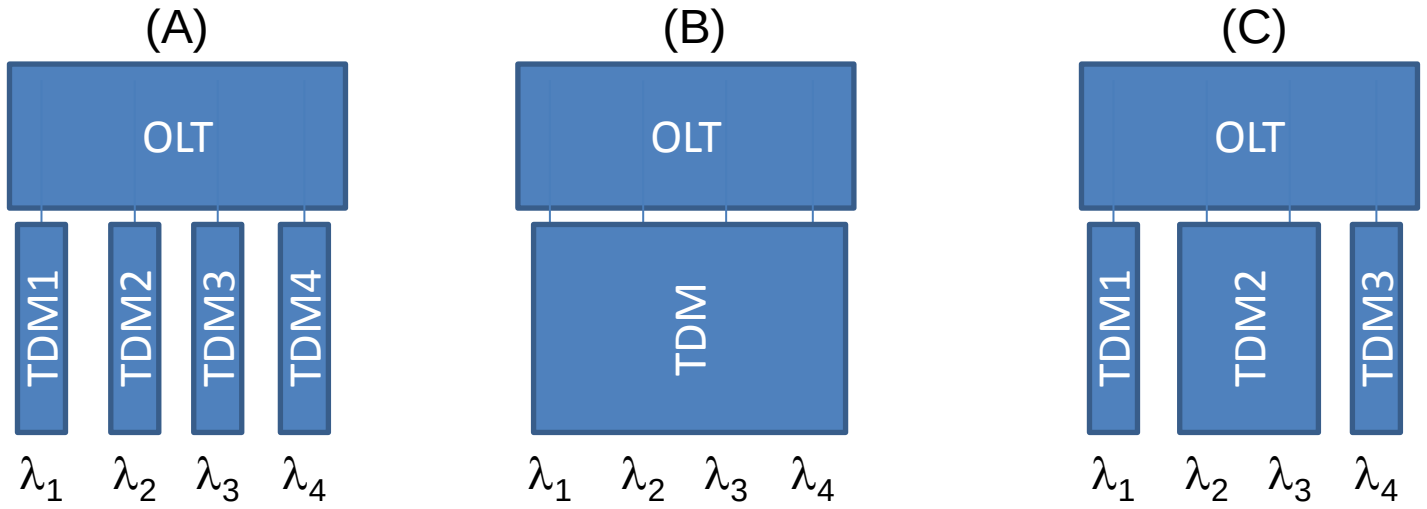
Where do we go in NG-EPON?

- NG-EPON needs to address the three key aspects for any “next-generation” IT technology:
  - Lower cost (per bit/s, per customer, etc.)
  - Higher speed (more bit/s per port)
  - Higher capacity (more connected customers)
- If it is not competitive to existing 1G-EPON and 10G-EPON solutions, it will never be adopted. It will also need to compete on cost and features with CWDM P2P Ethernet access (1+G links), especially for business applications.
- Flexibility of bandwidth assignment, and ability to share bandwidth effectively among multiple subscribers are key to making it cost-effective for operators to deploy.

Can we get rid of TDM in NG-EPON?

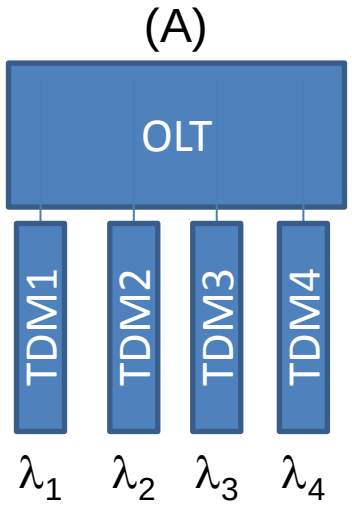
- I believe the answer is simple: No!
- There is no reason NOT to support TDM in NG-EPON
  - Ability to share a channel with X Mb/s among a number of connected users is critical in making NG-EPON a flexible and versatile technology
  - A very small share of end-applications requires big dedicated pipes. They can be supported off NG-EPON or moved to CWDM P2P solutions.
  - In most cases, what matters is ability to send instantaneous high data rate burst rather than long-term sustained throughput. This is where TDM-PON solutions excel.
- For NG-EPON to succeed on the market needs to build on TDM-PON legacy and ability to share data channel among subscribers.
- There are, however, various ways to get TDM-PON work in NG-EPON framework. The following slides assume multi-λ system.

Various TDM/WDM-PON approaches



- Assume OLT with 4 wavelength channels (λ_1, λ_2, λ_3, λ_4). Data can be striped across individual λs in many ways:
  - (A) Each λ is an independent TDM domain. This is an approach to stacking a number of existing EPON systems in WDM domain.
  - (B) All λs are combined to create one big TDM domain. This is an approach to adopted by 40+GE systems.
  - (C) Flexible approach, where selected λs are combined to create a TDM domain, but there is more than one TDM domain on OLT.

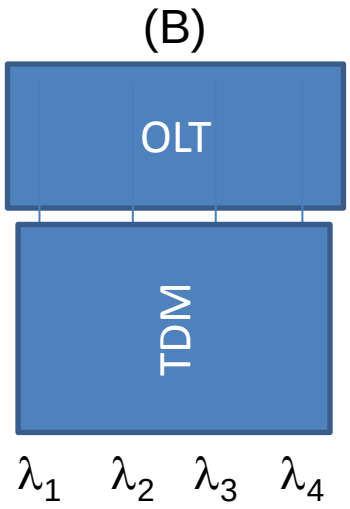
(A) TDM/WDM-PON



- Each λ is an independent TDM domain.
- In this approach, we only need to specify the wavelength grid for NG-EPON and add some management parameters / registers.
- Coloured ONUs with fixed downstream / upstream optics could be used.

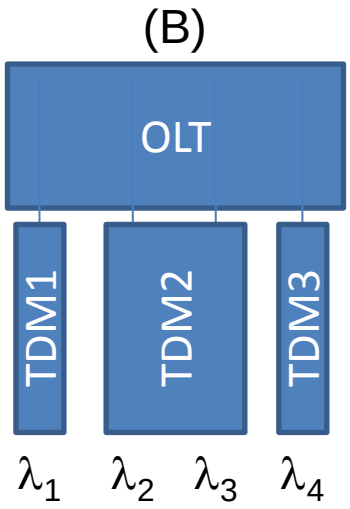
- Alternatively, single-channel tunable ONUs could be used and a protocol to bring them up and tune to a specific target channel will need to be developed.
- Single channel ONU should have cost and complexity comparable to existing 1G-EPON/10G-EPON devices
- Putting multiple 1G-EPON/10G-EPON transceivers into a single physical port on OLT does not require standardization.

(B) TDM/WDM-PON



- A single TDM domain across all λs.
- Similar to (A), we need to specify the wavelength grid for NG-EPON and add some management parameters / registers.
- ONUs with fixed downstream / upstream optics can be used. There is no tuning needed.
- Each ONU would receive data transmitted across all channels, and need to be able to process it. This might drive the cost of ONUs up (faster electronics, larger and more complex optics).
- OLT MAC would need to handle much higher aggregate data rate when compared with current 10G-EPON systems.
- Similar to (A), integration of multiple 1G-EPON/10G-EPON transceivers into a single physical port on OLT does not require standardization.

(C) TDM/WDM-PON



- Flexible allocation of λs to multiple TDM domains supported on the OLT.
- Each λ belongs to only one TDM domain at the time. At least two λs per OLT.
- Similar to (A) and (B), we need to specify the wavelength grid for NG-EPON and add some management parameters / registers.

- Lower cost ONUs could support only one λ (either fixed or tunable optics). These could be used for lower profile customers with limited bandwidth needs (e.g., residential users).
- More flexible ONUs would support more than one λ (either fixed or tunable optics). These would be used for customers needing more bandwidth than a single wavelength channel could provide.
- For ONUs with tunable optics, a new control protocol will be needed to control ONU tunability and convergence to specific target λ(s).

Challenges for TDM/WDM-PON

- There is a number of challenges common to all scenarios:
  - For tunable ONUs, a protocol controlling target λ(s) the ONU will be receiving / transmitting. Some sort of MPCP extensions would be required in this case (part of MPCP Discovery process?)
  - For ONUs with fixed optics, we need to guarantee proper operation in the absence of ability to change Rx/Tx λ(s).
  - For both ONU and OLT, we need to define the wavelength grid, number of λs to be used, their location, tolerances, etc.
- There are some challenges specific to given scenario:
  - For (B), all ONUs receive all λs, allowing them to support high aggregate data rates, but increasing their complexity.
  - For (C), more flexible ONUs supporting multiple λs need to coexist on the same ODN with single λ ONUs, without causing collisions.

THANKS !