NG-EPON Flexible Wavelengths

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Coexistence Discussion

- TF Objectives:
  - 25Gbps down/up
  - 50Gbps down/up
  - 100Gbps down/up
- Must these 3 types coexist on the same fiber?
  - I would say yes (Purpose of this contribution)
  - If not……..
- If Coexistence
  - Option A - WDM Coexistence
  - Option B – (W)TDM(A) Coexistence

Option A Architecture

- **Solution**: Utilize different wavelengths for each PHY implementation
- Wavelengths: 7 Down / 7 Up
- Benefits
  - Easiest to implement, leverage same concepts as 10G-EPON
  - Less complexity within standard
- Drawbacks
  - Utilizes a large amount of space in an already highly contentious spectrum
  - Less economies of scale with 14 wavelengths as opposed to 8
  - No Flexibility for robust configurations (i.e. channel changes/ balancing)

PHY	Wavelengths (Each Direction)
25G PHY	λ_1
50G PHY	λ_2, λ_3
100G PHY	λ_4, λ_5, λ_6, λ_7

Option B Architecture

- **Solution**: Utilize only 4 wavelengths for all 3 PHYs
- Wavelengths: 4 Down / 4 Up
- Benefits
  - Better Utilization of Spectrum
  - Wavelength Reuse
  - Flexibility
- Shortcomings
  - Added complexity to PCS
  - Additional Standards Work
  - May require tunable transmitters/receivers for additional features

PHY	Wavelengths (Each Direction)
25G PHY	λ_1
50G PHY	λ_1, λ_2
100G PHY	λ_1, λ_2, λ_3, λ_4

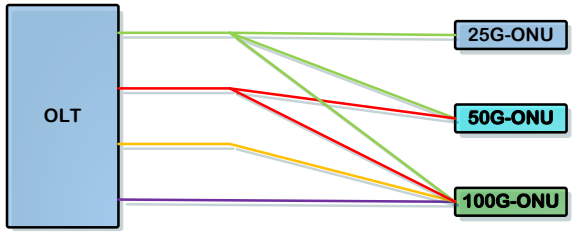
Exploring Option B Further

- Fixed Transmitter / Fixed Wavelengths
- Fixed Transmitters / Flexible Wavelengths
- Tunable Transmitters / Flexible Wavelengths

Fixed Transmitter / Fixed Wavelengths

- Attributes
  - Each PHY assigned to specific wavelengths
    - Only one specified wavelength for 25G and two for 50G
  - Fixed Transmitter/Receiver
  - TDM aware of its lane(s) (Multiple MAC domains)
  - No deviation from Standard assigned wavelengths
- Benefits
  - Simplest PHY implementation
- Shortcomings
  - Growth from 25G→50G→100G becomes difficult to manage
  - All 25G ONUs are limited to one lane only in mixed environment
  - Changing Wavelengths not possible
- Considerations
  - Need a mechanism to share lanes 1 and 2
  - 100G (and maybe 50G) could take away available bandwidth for 25G

Lane	25G	50G	100G
1	✓	✓	✓
2	✗	✓	✓
3	✗	✗	✓
4	✗	✗	✓



Fixed Transmitter / Flexible Wavelengths

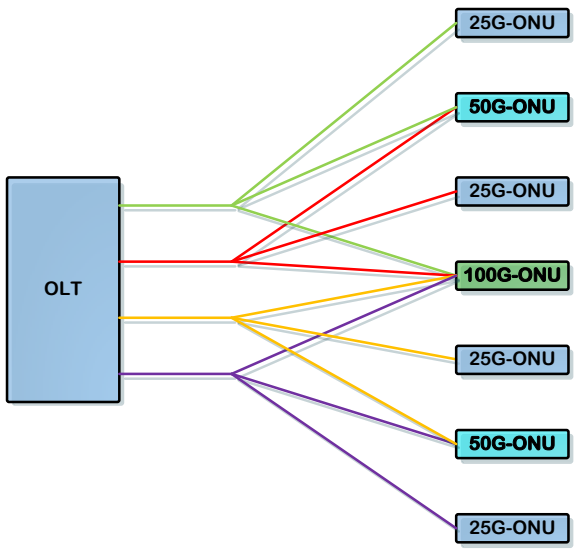
- Attributes
  - Standard allows any PHY to utilize any of the 4 wavelengths
  - Fixed Transmitter/Receiver
  - TDM aware of its lane(s) (Multiple MAC domains)
  - Wavelengths are fixed, but the standard allows the use of any wavelength for any PHY
- Benefits
  - Fixed lasers could be more cost effective
  - Allows WDM Filtering in the network to create segments if appropriate discovery process exists
- Shortcoming
  - In mixed environments scaling could become problematic
    - How to balance traffic load on different wavelengths?
  - Mixed environment still causes problems, although can be minimized via inventory control processes (not scalable)
  - Changing wavelengths possible, but requires truck roll
- Considerations
  - All Lanes must be TDM aware for coexistence
  - Discovery/Registration available on all lanes

Lane	25G	50G	100G
1	✓	✓	✓
2	✓	✓	✓
3	✓	✓	✓
4	✓	✓	✓

Tunable Transmitter/Wavelengths

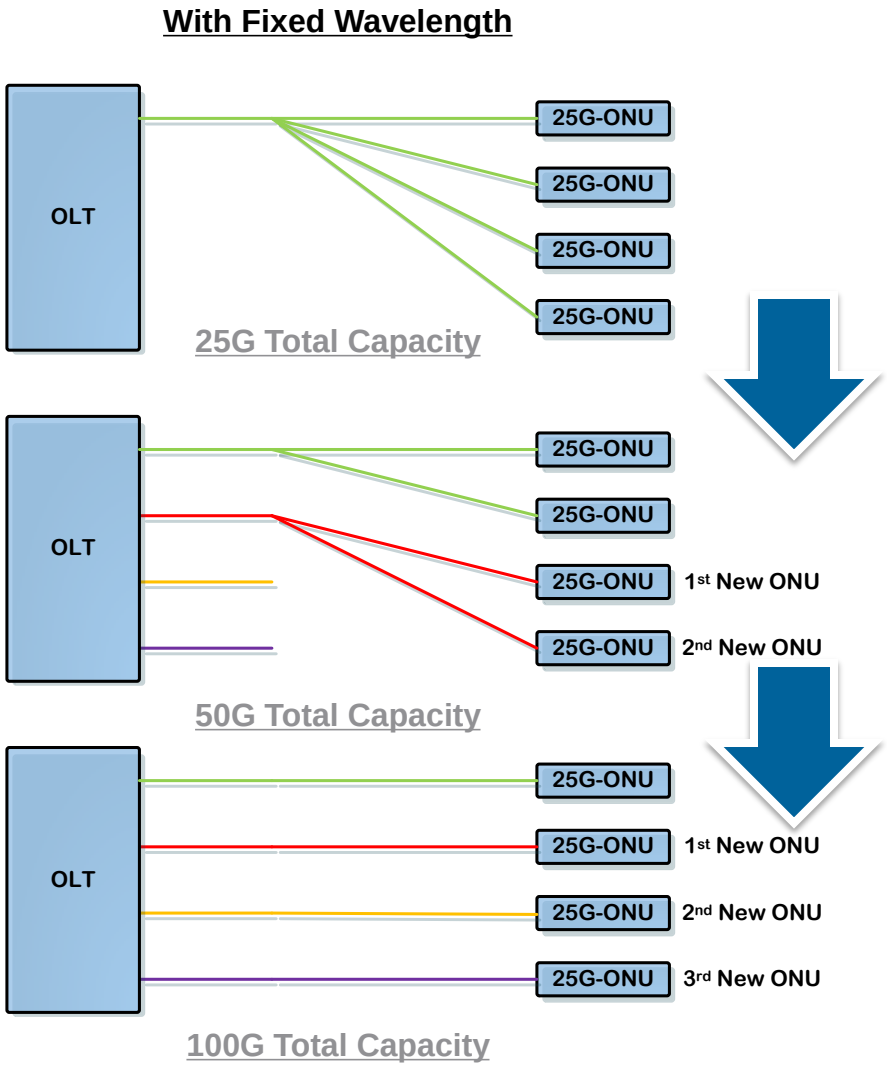
- Attributes
  - Each PHY speed allows utilization of any wavelength
  - ONU can tune and receive any wavelength or at least some number greater than 1
  - TDM aware of its lane(s) (Multiple MAC domains)
  - Fixed wavelengths may be utilized in addition, however would add some additional constraints to the specific ODN and lose the benefits of tunable ONUs
- Benefits
  - Flexible Solution
    - Automatic Load Balancing becomes possible
    - Channel Reassignment
  - Problematic wavelength(s) could be avoided (at reduced capacity)
  - Capacity can be added by moving ONUs to newly added wavelengths
- Shortcomings
  - Most complex implementation
  - Requires most standards work/updates
    - New Mechanism to discover channels, reassign channels, etc
  - Higher upfront implementation costs
    - Although allowing fixed implementations may help to reduce some costs at the expensive of additional operational complexity

Lane	25G	50G	100G
1	✓	✓	✓
2	✓	✓	✓
3	✓	✓	✓
4	✓	✓	✓



Lifecycle Management for Fixed (For 25G)

- When utilizing fixed transceivers, adding new wavelengths at the OLT requires:
  - Swap of existing ONUs to add capacity
  - Or Operational Management of adding different wavelengths from day 1
- A tunable feature could increase the usable lifespan of an ONU
  - Allows creating smaller aggregate groups as new wavelengths are added
    - For 25G ONUs, capacity could be doubled twice, by only swapping OLT hardware (card/optic) (smaller groups per wavelength)
  - Deploying 1 channel tunable ONUs allows the move to greater bandwidth without a truck roll to a customer



Channel Management Functions

- Traffic Management
  - Could allow ONUs to move to different channels to handle different traffic conditions
- Resiliency
  - Could allow moving from problematic channels (transmitter/receiver failure)
- Implementation
  - Capabilities (Tx/Rx)
    - # of Channels
    - Which Channels (if necessary)
  - Channel Assignments
  - Dynamic Channel Moves
  - Channel Quality Measurements

Considerations

- Ranging/Discovery
  - Should the tunable ONU scan multiple channels or just one?
    - One Channel could limit certain architecture scenarios (i.e. WDM splitting within the feeder portion of the network)
  - Device Reporting/Capabilities
    - OLT/ONU – 1, 2 or 4 channels?
- RS/PCS/PMD Architecture
- Multicast Replication
- EPON OAM/MPCP Updates
- Should 10G be accounted for in multiple channel scenarios?
- Should some of this work be handled in other groups such as SIEPON / DPoE?

Questions

Thank You