

Flexible and Extensible Architecture for Multiple Generations of NG-EPON

Glen Kramer,
glen.kramer@broadcom.com

Why are we here?

- ❑ Observed Usage Growth Rate: 40-60% YoY
 - Successive generations of access technology are required every 3-5 years.

- ❑ It is no longer efficient to develop a standard for a single generation at a time.

- ❑ The goal of this group must be:
 1. Define a single standard for multiple generations of EPON.
 2. Ensure that deployments can commence one generation at a time.
 3. Ensure that multiple generations of devices can coexist on the same network.
 4. Ensure that earlier generations do not incur cost penalty for future extensibility.

Keep your eyes on the prize

- ❑ Must keep 100G-EPON simple
- ❑ Must keep the cost low. Given the choice, always defer the cost to a later generation.
- ❑ If 100G-EPON technology fails, it won't be because of low performance. It will be because of high cost and/or being too late.

Rushed
standard
development

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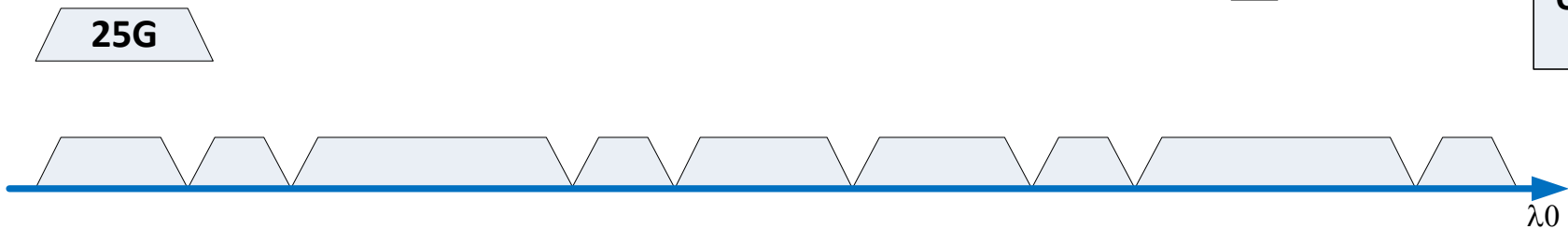
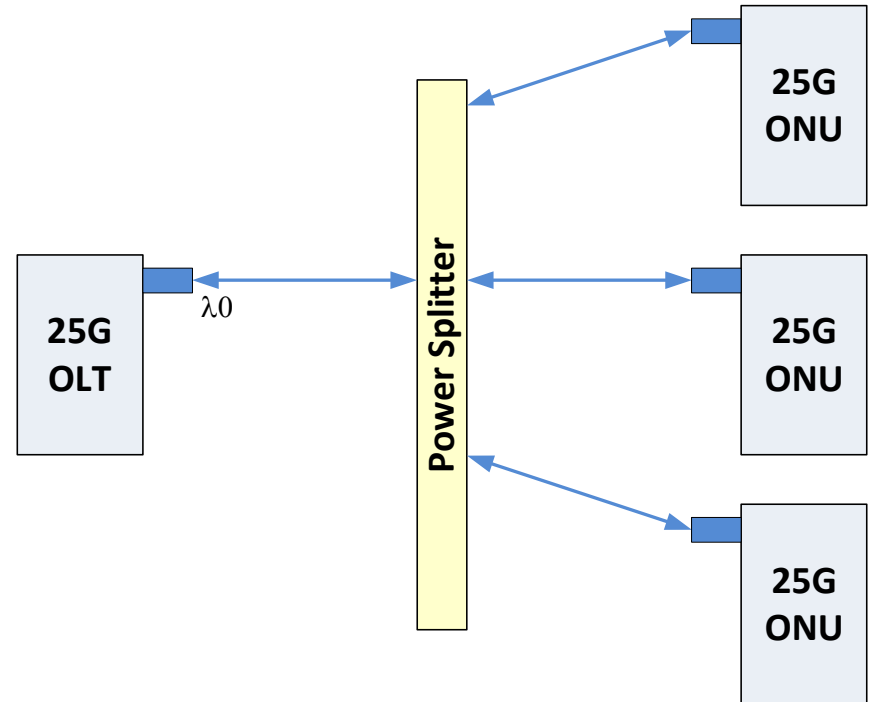
- Reliable technology
- Cost-efficient product
- Fast time to market

How to keep the cost low

- ❑ Keep the number of wavelengths to a minimum
 - 1st gen: 1 wavelength
 - 2nd gen: 2 wavelengths, not 1+2
 - 3rd gen: 4 wavelengths, not 1+4, not 1+2+4
- ❑ For economies of scale, share the components among generations
- ❑ No Rx/Tx tunability required
- ❑ Backward-compatibility (may not be necessary for lower cost)
 - 2nd gen ONU can pretend to be the 1st gen ONU
 - 3rd gen ONU can pretend to be either 1st gen or 2nd gen ONU
- ❑ Coexistence
 - 2nd gen OLT can serve 1st gen and 2nd gen ONUs
 - 3rd gen OLT can serve 1st, 2nd, and 3rd gen ONUs

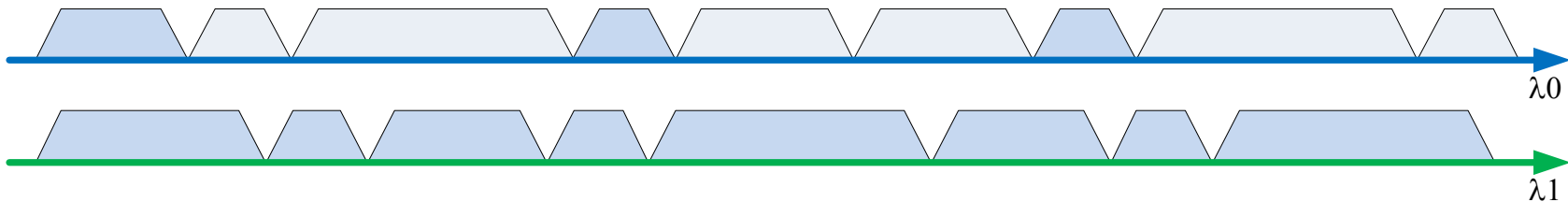
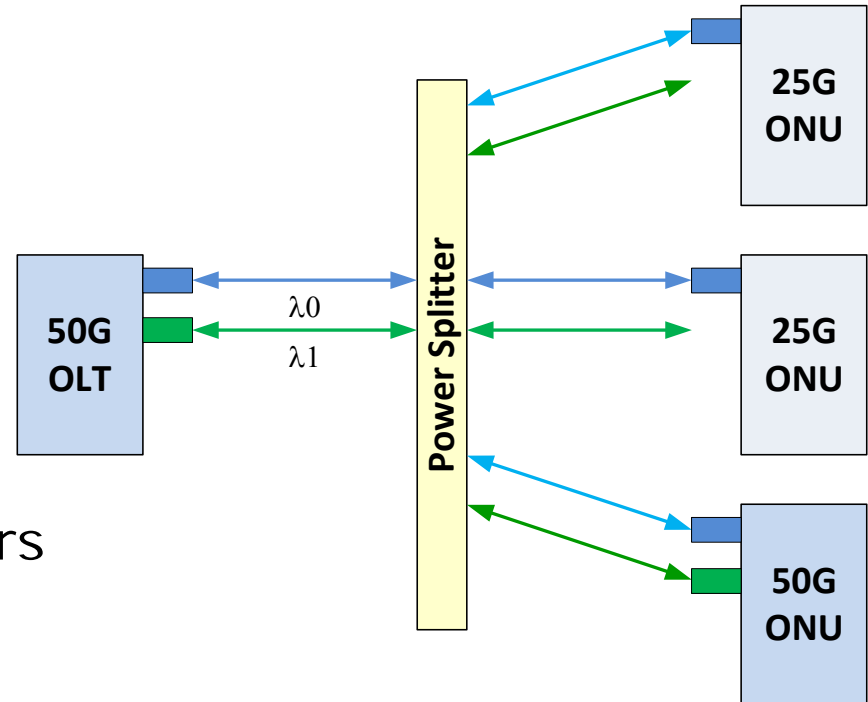
Deployment of 1st Generation

- ❑ 25G OLT serves 25G ONUs
- ❑ One DS and one US wavelength
- ❑ One scheduler
- ❑ Architecture is similar to 10G-EPON, just 2.5x faster



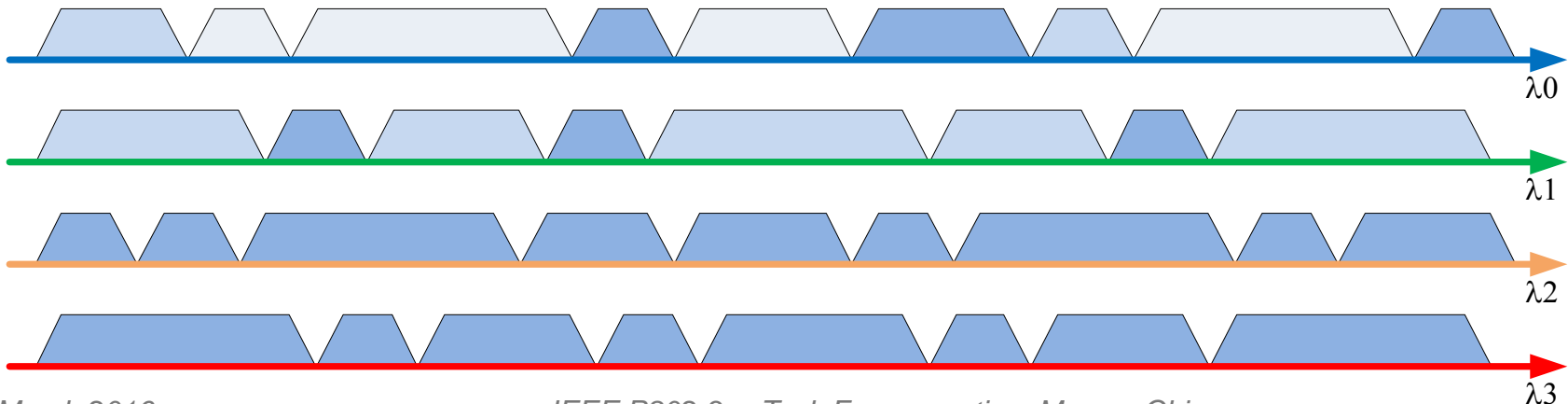
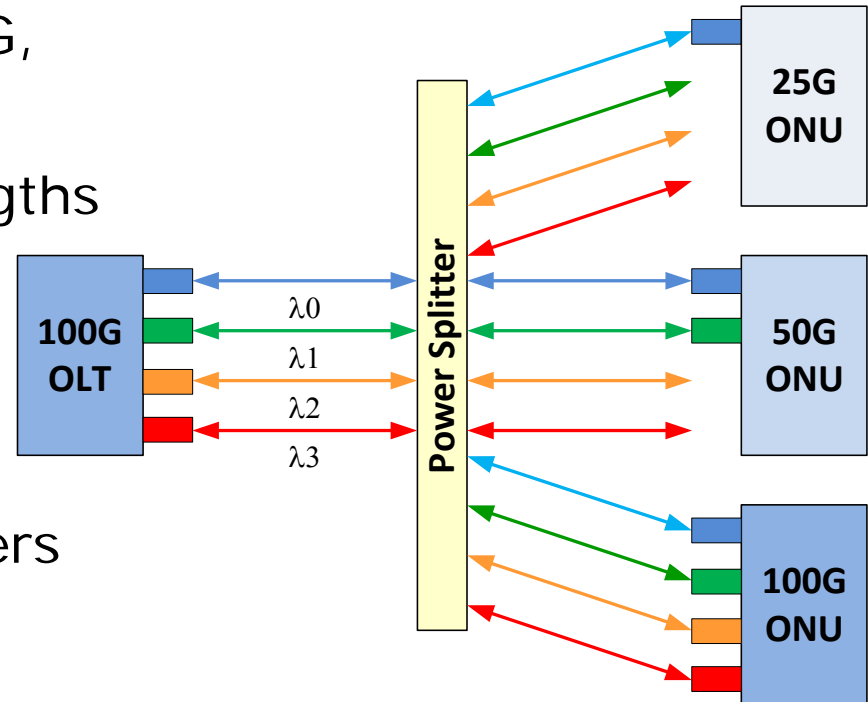
Deployment of 2nd Generation

- ❑ 50G OLT serves a mix of 25G and 50G ONUs
- ❑ Two DS and two US wavelengths
 - λ_0 : 25G and 50G ONUs, all broadcast traffic
 - λ_1 : 50G ONUs
- ❑ Two independent US schedulers



Deployment of 3rd Generation

- ❑ 100G OLT serves a mix of 25G, 50G, and 100G ONUs
- ❑ Four DS and four US wavelengths
 - λ_0 : 25G, 50G, and 100G ONUs, all broadcast traffic
 - λ_1 : 50G and 100G ONUs
 - λ_2, λ_3 : 100G ONUs
- ❑ Four independent US schedulers



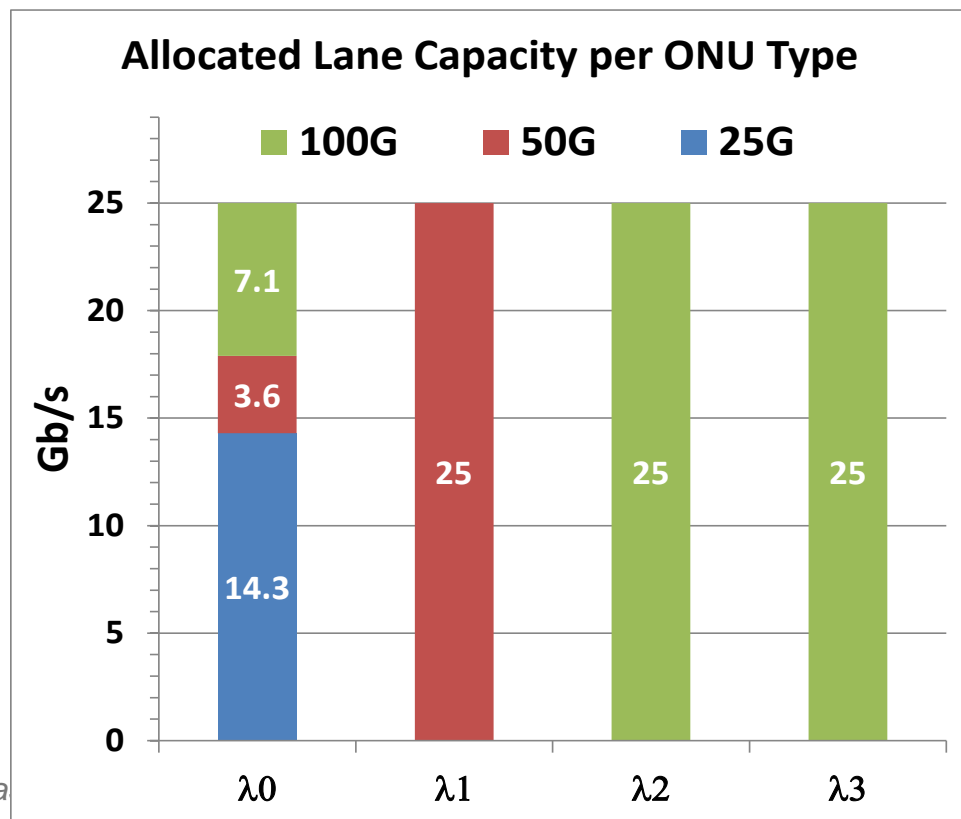
Notes on Bandwidth Distribution

□ In the shown scheme, any distribution of bandwidth is feasible, subject to the following constraints:

- Total throughput of all 25G ONUs is ≤ 25 Gb/s
- Total throughput of all 25G and 50G ONUs is ≤ 50 Gb/s
- Total throughput of all ONUs is ≤ 100 Gb/s

□ An example of allocation targets:

- Capacity allocated to all 50G ONUs shall be 2x of the capacity allocated to all 25G ONUs
- Capacity allocated to all 100G ONUs shall be 2x of the capacity allocated to all 50G ONUs



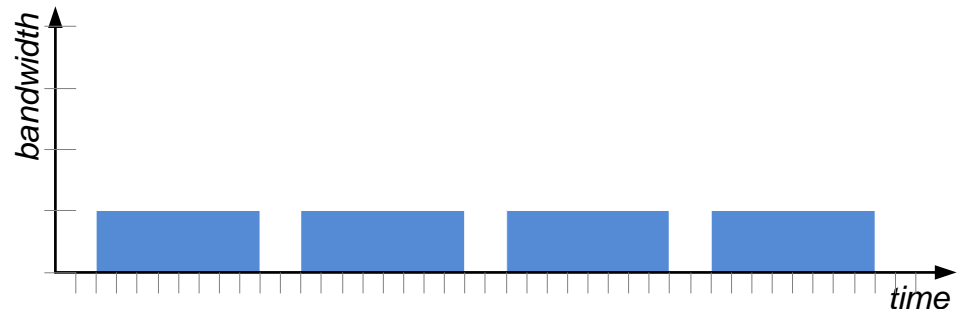
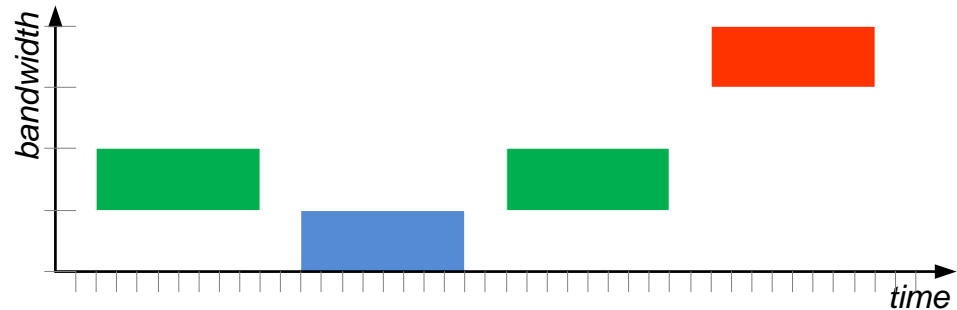
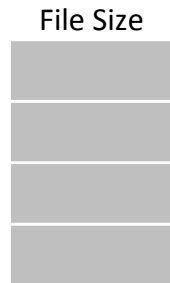
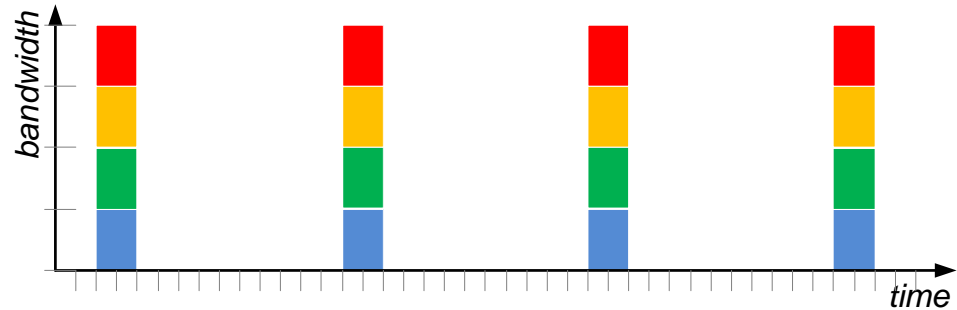
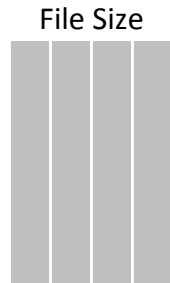
Notes on Bandwidth Distribution

□ To reach their throughput targets, 50G and 100G ONUs don't necessarily need to transmit simultaneously on all wavelengths available to them.

□ **Scheduling larger grants on fewer wavelengths is more bandwidth-efficient!**

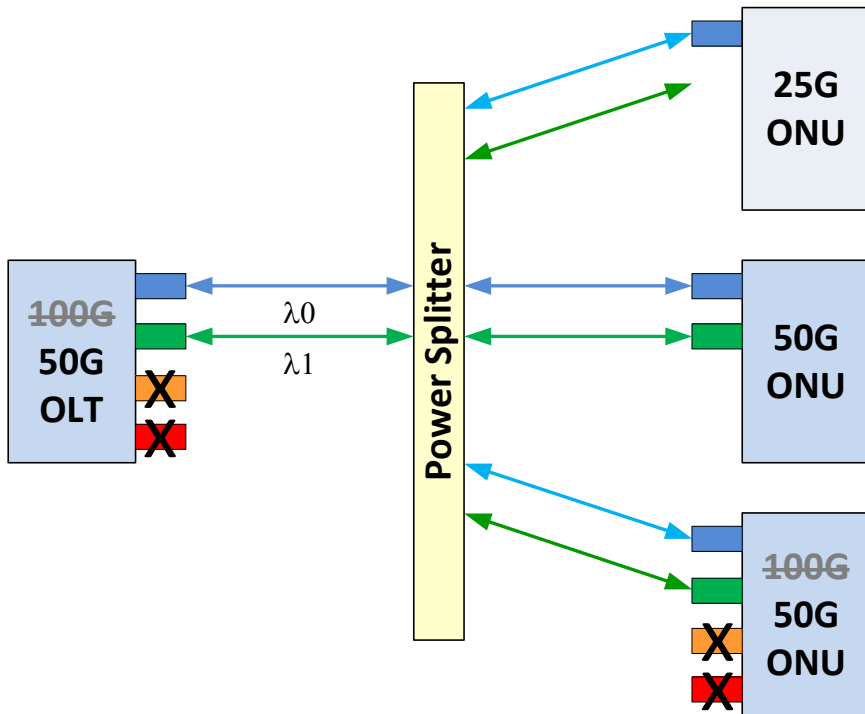
– $\text{BurstOverhead} / \text{BurstSize}$

Can a user tell a difference?

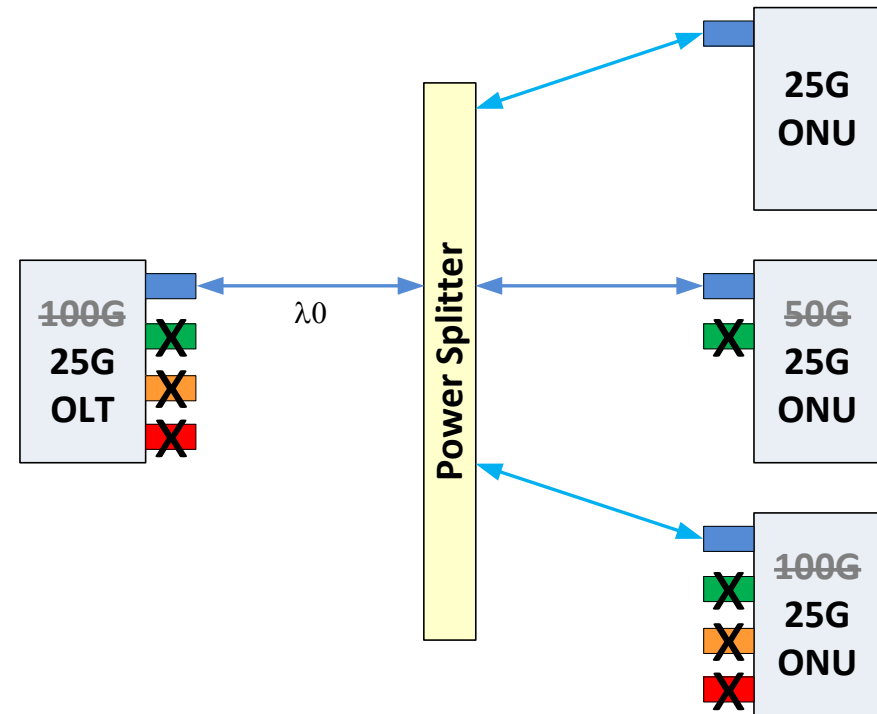


Reduced Capacity Mode

- Individual wavelengths may be turned off to save power or to perform maintenance



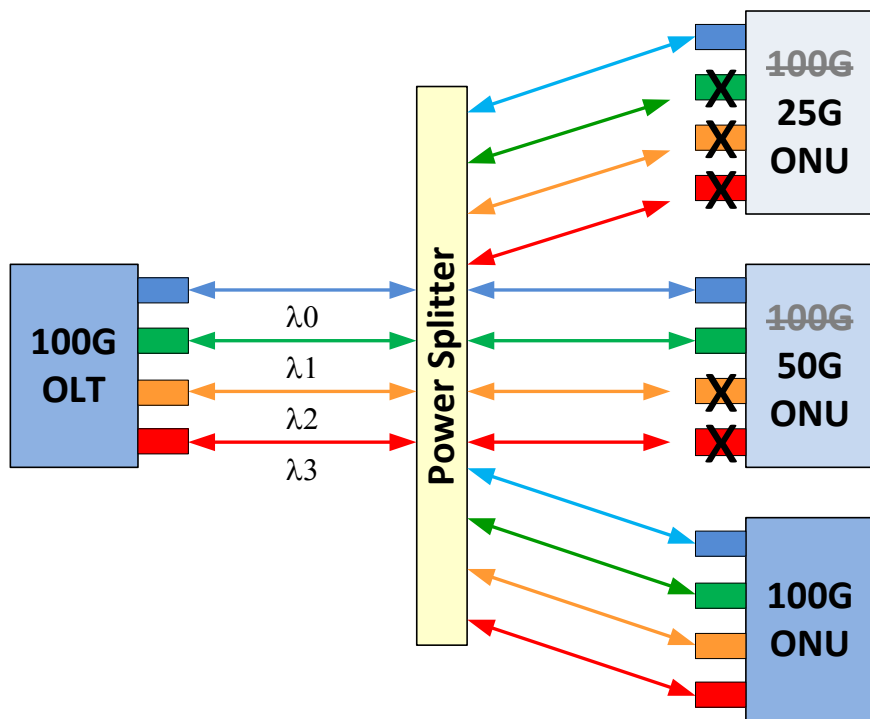
100G ONUs with 2 wavelengths turned off behave just like 50G ONUs



100G ONUs with 3 wavelengths turned off and 50G ONUs with 1 wavelength turned off behave just like 25G ONUs

Reduced Capacity Mode

- Wavelengths may be turned off for the entire PON or for individual ONUs



- Protocol to control individual wavelengths is required, but is easy.

- Upstream and downstream wavelengths may be turned off and on independently

		Number of upstream wavelengths enabled			
		1	2	3	4
Number of downstream wavelengths enabled	1	25G/ 25G	25G/ 50G	25G/ 75G	25G/ 100G
	2	50G/ 25G	50G/ 50G	50G/ 75G	50G/ 100G
	3	75G/ 25G	75G/ 50G	75G/ 75G	75G/ 100G
	4	100G/ 25G	100G/ 50G	100G/ 75G	100G/ 100G

ONU data rates (down/up) based on the number of enabled wavelengths

- ❑ **Faster ASIC (50G or 100G) can be deployed with slower optics (25G or 50G)**
 - The cost of 50G and 100G optics will be roughly 2x and 4x of 25G optics
 - It should be possible to deploy 100G OLT/ONU ASICs with 25G or 50G pluggable optics to offset the cost until the 100G capacity is required.

- ❑ **How about the opposite: slower ASIC with faster optics?**
 - **25G ASIC + 2x25G Optics:** ONU can send or receive on λ_0 **or** λ_1
 - **25G ASIC + 4x25G Optics:** ONU can send or receive on λ_0 **or** λ_1 **or** λ_2 **or** λ_3
 - **50G ASIC + 4x25G Optics:** ONU can send or receive on $\lambda_0+\lambda_1$ **or** $\lambda_0+\lambda_2$ **or** $\lambda_0+\lambda_3$ **or** $\lambda_1+\lambda_2$ **or** $\lambda_1+\lambda_3$ **or** $\lambda_2+\lambda_3$
 - Needs? Challenges? Cost/benefit analysis?
 - Discuss

Thank You