Discussion of service requirements for PON channel bonding

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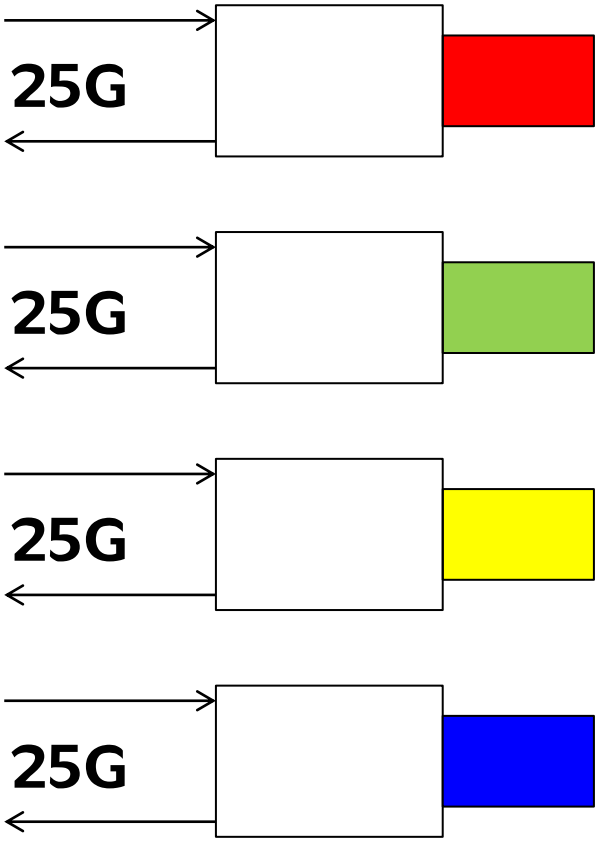
Service requirements

- PON bonding is desired to achieve higher “peak rates” than is possible with a single channel system
- Peak rate in this context means that rate can be maintained for an indefinite period of time if there is no congestion
  - Since PON is a shared medium, total traffic load does matter
- Note that real ONU and OLT equipments may suffer from other bottlenecks (packet processing) - but out of scope
- Fundamentally, this requires that OLT’s and ONU’s with multiple optical transceivers are used

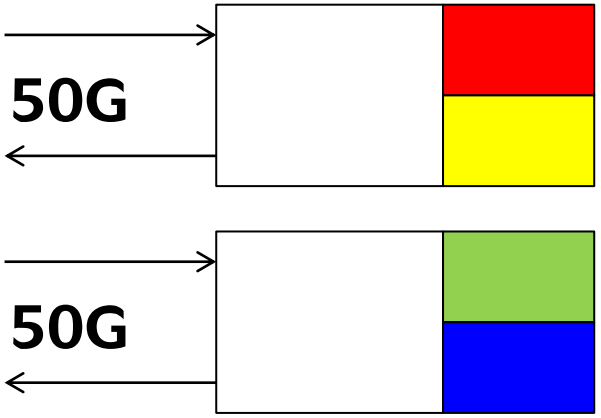
Possible OLT and ONU

Unbonded



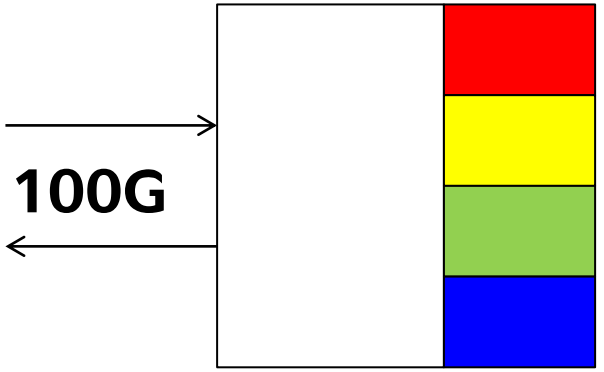
ONU: Maybe tunable?

Dual-bonded



ONU: Maybe tunable?
Plus 4 other combinations?

Quad-bonded



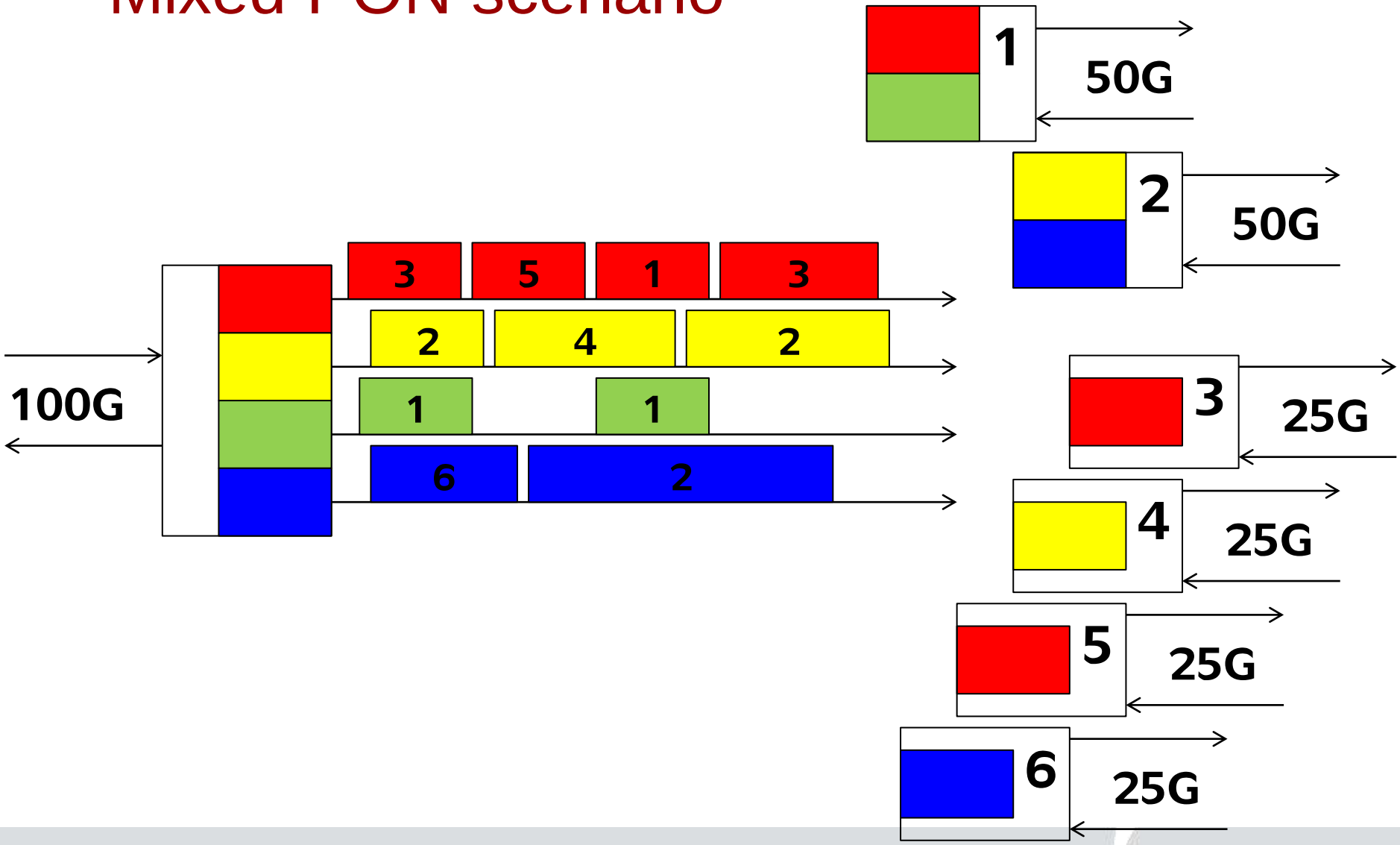
Operational issues on OLT side

- **OLT represents large up-front investment during deployment**
  - **This should be deferred as much as possible**
  - **“Pay as you grow” adds channels one by one as demand grows**
- **This implies that the bonding scheme needs to accommodate any number of PHY channels (Quasi-static)**
- **It also suggests that the OLT will be a 100G MAC based, unless one wants to replace the line card at upgrade**
- **OLT power saving is of growing importance**
  - **Central office power is effectively very expensive**
  - **Most of the time, the PON is not busy!**
- **This suggests that the number of active channels in a given OLT will change during operation (More dynamic)**

Operational issues on ONU side

- **ONU is expensive part of the network, since not shared**
  - **Requiring maxi ONU for every customer is going to cost too much**
  - **However, high rate customers need the wider ONUs**
- **The bonding scheme must support a PON with a mix of ONUs**
- **Manual operations on ONUs are even more expensive**
  - **Colorless ONUs to avoid swapping colored transceivers?**
  - **Pre-placing more capable ONU to avoid the upgrade?**
- **ONU power saving was always important**
- **Just like the OLT, the number of active channels in a given ONU can change during operation**

Mixed PON scenario



Downstream transmission

- If single channel ONUs exist on a channel, then the signal on that channel has to look like a 25G MAC signal
  - Packets need to be kept together, NOT striped across the channels
- Segregation of ONU types across channels is problematic
  - Increasing the number of channels one needs (1+2+4=7?)
  - Increases bandwidth wastage, since sharing groups are restricted
- The best policy is that any ONU type can be found on any channel assignment
  - And so all the channels will look like a 25G MAC signal
- This leads us toward something that is frame-based (each frame goes down one channel)
  - Care must be taken to maintain the order of packets

Upstream transmission

- The ONU can transmit on any or all of its equipped channels
- To achieve the required peak rate, multi-channel ONUs must be able to transmit on multiple channels at the same time
- However, simultaneous transmission is not needed always
  - Use cases: power saving, uneven channel loading, unequal start-time from the last transmissions on each channel
- To best utilize the multiple channels, the MPCP gating process should be capable of independent control and transmission on each channel
  - Coordination of the grants can be done, but it is out of scope
- Again, this leads us towards a frame-based bonding solution
  - Same frame ordering rule applies

Conclusions

- Channel bonding in PON networks brings several challenges
  - Support of mixed PON operation, varying number of deployed channels, and varying usage of those channels
- Previous low-level methods of combining channels (e.g., striping) will not work, as striped data does not look like frames to single channel ONU
- A frame-based (each channel is quasi-independent) works

- Last thought: PON is a precisely timed network… solution could use that to advantage