The challenges of supporting 25G/10G operation
(A system-level view)

Glen Kramer, Broadcom

802.3ca Objective

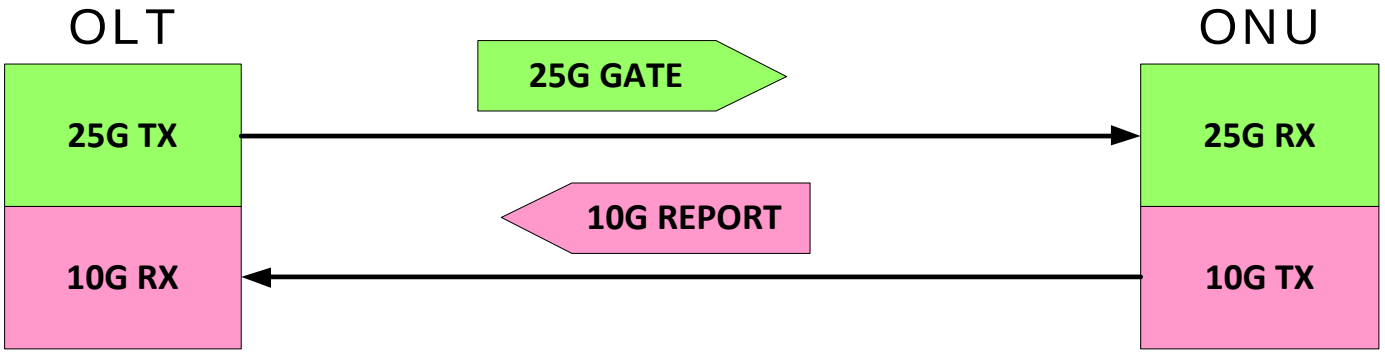
- **Provide specifications for physical layers operating over a single SMF strand and supporting symmetric and/or asymmetric MAC data rates of:**
  - **25 Gb/s in downstream and less than or equal to 25 Gb/s in upstream**

- Without much discussion, the TF always assumed that using 10G upstream, as defined in 802.3av, will allow
  - Less standards work – point to an existing specification
  - Reuse of existing 10G US IP blocks
  - Reuse of existing 10G upstream optical components
  - Reuse of software (maybe?)
  - One solution to one problem (i.e., only one way to implement 10G upstream)

- **But does this assumption hold true?**

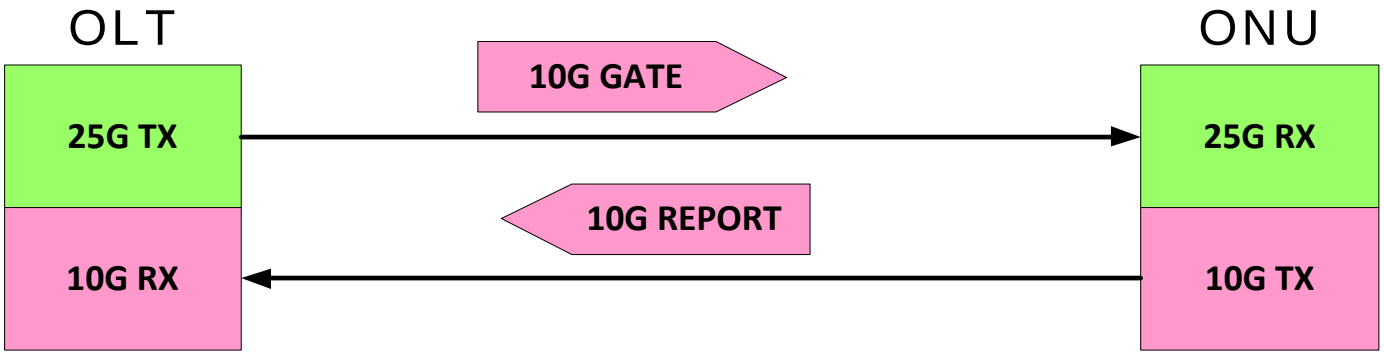
MPCP Issues

- If we use 25G GATEs and 10G REPORTs
  - ONU can never obtain the absolute value of MPCP time in TQ to use in REPORT timestamp.
  - Each upstream LLID needs its own MAC address to use in REPORT SA, but downstream, there is only one MAC address per PLID.



MPCP Issues

- If we use 10G GATEs and 10G REPORTs
  - ONU locked on 25G downstream clock, but timestamps arrive in TQs.
  - In 25G architecture, only PLID has MPCP function and can process GATEs. But in 10G, GATEs are addressed to individual LLIDs. How to reconcile?



TQ and EQ clock shift

- Very hard for the OLT scheduler to schedule 25G and 10G in the same time domain

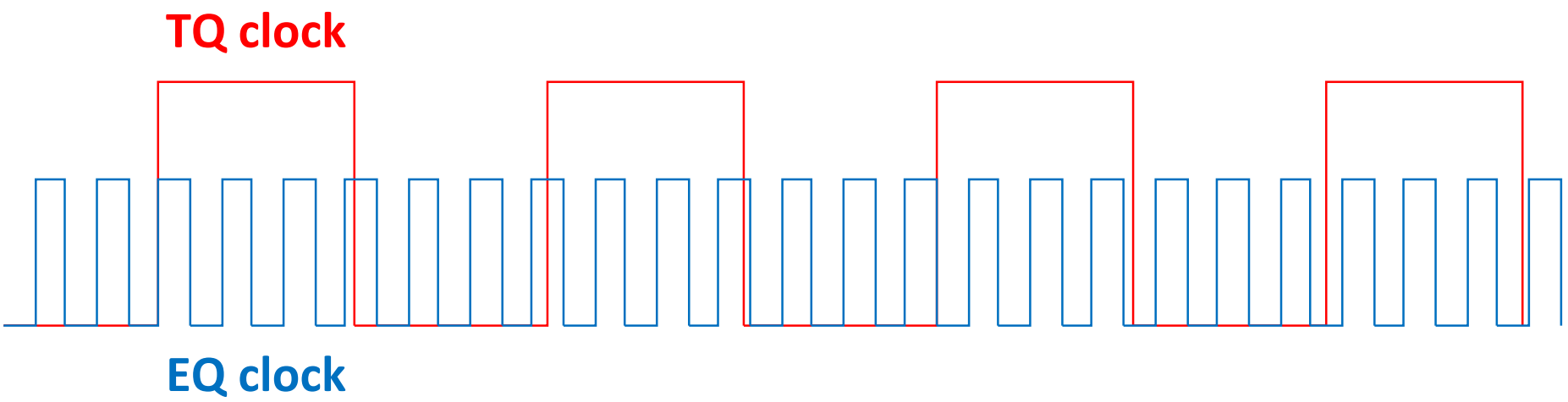
- **10G clock base (all values in units of TQ)**
  - GATE Timestamp = OLT local_time
  - ONU local_time = OLT local_time - DS_delay
  - OLT receive_time = grant_start_time + RTT

- **25G clock base (all values in units of EQ)**
  - GATE Timestamp = OLT local_time + RTT
  - ONU local_time = OLT local_time + US_delay
  - OLT receive_time = grant_start_time

Loop timing is hard

- 25.78125 GBd downstream
- 10.3125 GBd upstream

- Downstream MPCP is locked to EQ clock
- Upstream MPCP needs to use TQ clock
- TQ clock = 0.16×EQ clock (i.e., $\times {}^{4}/_{25}$)



Problem with 25G/10G option

- **A lot of extra standards work**
  - Control and Data paths need to be completely redesigned to support 25G/10G operation.
    - Need new MPCP and MPRS state diagrams.
    - Much more work than what we had to do to design 25G MPCP from scratch.
  - Also OAM needs to be redesigned.
    - In 25G downstream, there is one OAM connection per ONU (PLID). In 10G upstream, there is one OAM connection per each LLID

- **Implementation will be very hard and costly**

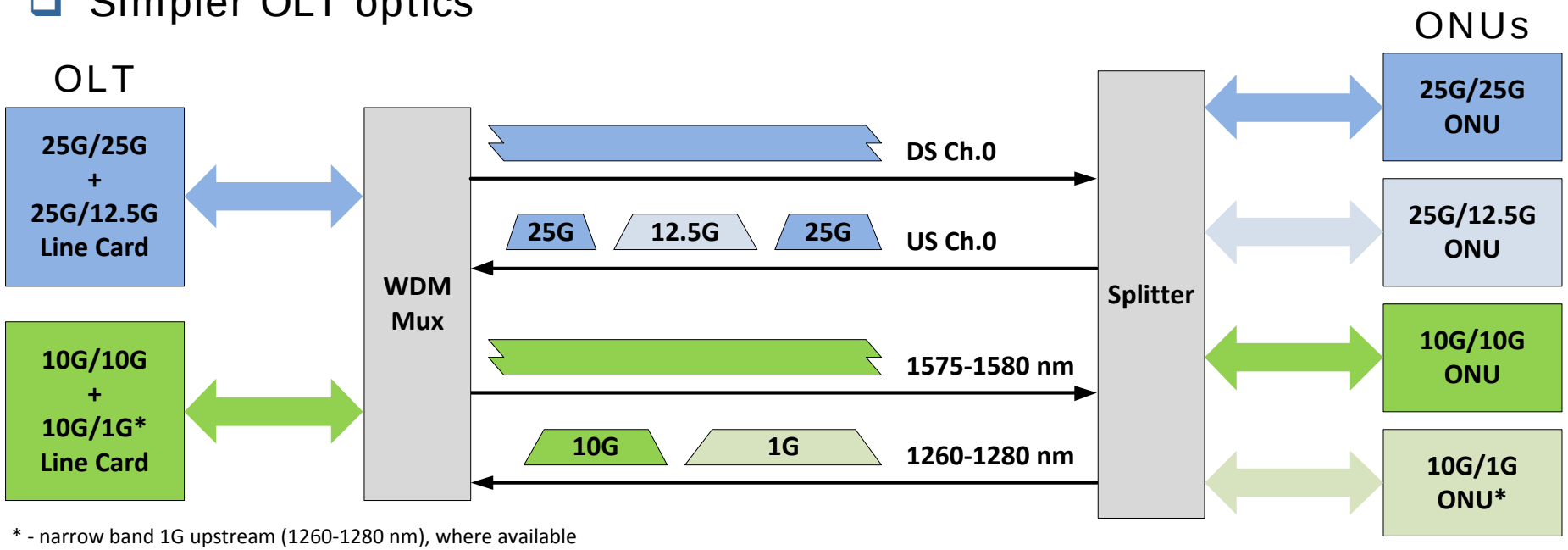
Proposal

- Instead of 10Gb/s upstream, asymmetric 25G-ONU should use **12.5Gb/s**
- 802.3ca Generation-1 shall consist of two options:
  - Symmetric: 25G/25G (25.78125 GBd)
  - Asymmetric: 25G/12.5G (12.890625 GBd)
- 12.5G upstream data path
  - Framing is identical to 25G Upstream
  - EQ clock is the same; loop-timing is easy (1:2)
  - Instead of one 25GMII transfer on rising and falling edges of the TX_CLK and RX_CLK clocks, only use rising edge.
  - All layer interfaces are the same as in 25G case
  - No changes to MPRS state diagrams, except the definition of IN_CLK and OUT_CLK (half clock rate of 25G).

Proposal – Wavelength Plan

- **Downstream:**
  - All channels -- WDM Coexistence
- **Upstream:**
  - 10G vs. (25G or 12.5G) – WDM Coexistence
  - 25G vs. 12.5G – Same wavelength; TDM Coexistence

- Old line cards can be left in place and 25G added on new line cards
- External WDM Mux between 10G and 25G line cards
- Simpler OLT optics



* - narrow band 1G upstream (1260-1280 nm), where available

Thoughts on 12.5G

- The 12.5G Upstream enjoys all the architectural benefits of 25G:

1. **Clean separation between user and operator's control traffic**
   - All control messages are exchanged on PLID and are never mixed with user traffic on ULIDs.
2. **Simpler design**
   - The MPCP is not in the Data Path, as in 10G-EPON. MPCP is simpler – does not need to emulate PHY behavior.
3. **Improved Discovery/Registration**
   - Only ONUs (PLIDs) are discovered/registered via the normal MPCP discovery process.
   - Multiple ULIDs are assigned via eOAM → no time/bandwidth is wasted for discovery.
4. **Improved PON Efficiency**
   - Reduced number of GATE/REPORT transmissions.
   - Redundant OAM connections are eliminated.

- As we are targeting 20 Gb/s total sustained throughput per 25G channel, we would also get 10 Gb/s total sustained throughput per 12.5G channel.

Can 10G optics pull it off?

- 10G lasers should have sufficient BW.
  - Need new parts for new lambdas.
  - May need cooling if 25G upstream channel 0 is narrow.
- 10G APDs typically have ~8-10 GHz BW at high gain, which is going to cause some penalty at the Rx @ 12.9 GBd.
- Drivers and TIAs that were designed for 10.3 Gb/s may also have insufficient BW and add to the penalty.
- The optical penalty will increase due to extra 2.578 GBd.
- 25G transmission requires stronger FEC (+2 dB optical gain?).
- **Will the stronger FEC be enough to compensate the increased optical penalty to allow reuse of some 10G optical components in the upstream?**
- Alternatively, maybe 12.5 upstream should use optical components from 16G Fiber Channel (designed for 14.025 GBd)?

Conclusion

- Looking back at the initial reasons to reuse 10G upstream (see slide 2):
  - **Less standards work**
    - The same PMA/PCS/MPRS/MPCP specification as in 25G upstream
    - Only clock is different
    - Much less work compared to work needed to specify 25G/10G operation!
  - **Reuse of existing IP blocks**
    - Design once for 25G
    - Use the same data path for 12.5G (same FEC, envelope framing, GATE & REPORT MPCPDUs, etc.)
  - **Reuse of software**
    - Yes, everything between 25G and 12.5G is identical except the clock rate
  - **One solution to one problem**
    - Still one solution to get 10G upstream.
    - 12.5G upstream is a different problem, so a different solution is needed.

Thank You

Oh, Wait!
There is more

Marek Hajduczenia, Charter
Phil Miguelez, Comcast

No Good Deals

	Line Rate	10G	10G	10G	10G	12.5G	12.5G	12.5G	12.5G
	Upstream λ	1270 ±10nm	1270 ±10nm	25G Ch. 0	25G Ch. 0	1270 ±10nm	1270 ±10nm	25G Ch. 0	25G Ch. 0
	Data Format	TQ	EQ	TQ	EQ	TQ	EQ	TQ	EQ
Function	MPCP, DBA & Scheduling	EQ→TQ Conversion	EQ @ 10G	EQ→TQ Conversion	EQ @ 10G	EQ→TQ Conversion	Same clock	EQ→TQ Conversion	Same clock
	Coexistence w/ 10G/10G ONU	TDM	TDM	WDM	WDM	TDM	TDM	WDM	WDM
	RX → TX Loop Timing	$\times\frac{4}{25}$	$\times\frac{4}{25}$	$\times\frac{4}{25}$	$\times\frac{4}{25}$	$\div 2$	$\div 2$	$\div 2$	$\div 2$
	Laser	Reuse 10G	Reuse 10G	Cooled	Cooled	Uncooled	Uncooled	Cooled	Cooled
	LD & TIA	Reuse 10G	Reuse 10G	Reuse 10G	Reuse 10G	FEC+ for Extra Penalty	FEC+ for Extra Penalty	FEC+ for Extra Penalty	FEC+ for Extra Penalty
	APD	Reuse 10G	Reuse 10G	Reuse 10G	Reuse 10G	FEC+ for Extra Penalty	FEC+ for Extra Penalty	FEC+ for Extra Penalty	FEC+ for Extra Penalty

Plan B (AKA "Nuclear Option")

802.3ca Objective:

- **Provide specifications for physical layers operating over a single SMF strand and supporting symmetric and/or asymmetric MAC data rates of:**
  - **25 Gb/s in downstream and less than or equal to 25 Gb/s in upstream**

Proposal:

- **In "less than or equal", choose "equal", i.e., do not standardize asymmetric 25G**
  - These options will remain in scope for 802.3ca:
    ~~25/10~~, 25/25,
    50/25, 50/50,
    100/25, 100/50, 100/100
  - All 802.3ca options coexists with 10/10 via WDM

Discussion on Plan B

Pros:

- Operators want 25G-EPON for business applications, and that requires symmetric bandwidth.
- 12.5G upstream requires new optical components, thus splits the market. But it does not provide a significant step up from 10G upstream.
- 25G/25G ONUs will be able to coexists with 10G/10G ONUs via WDM.

Cons:

- Without the asymmetric option, deployments of 25G-EPON will be delayed, because there won't be any 25G burst mode TIAs for a while.