



10GE PON

Loop-timing

Overview

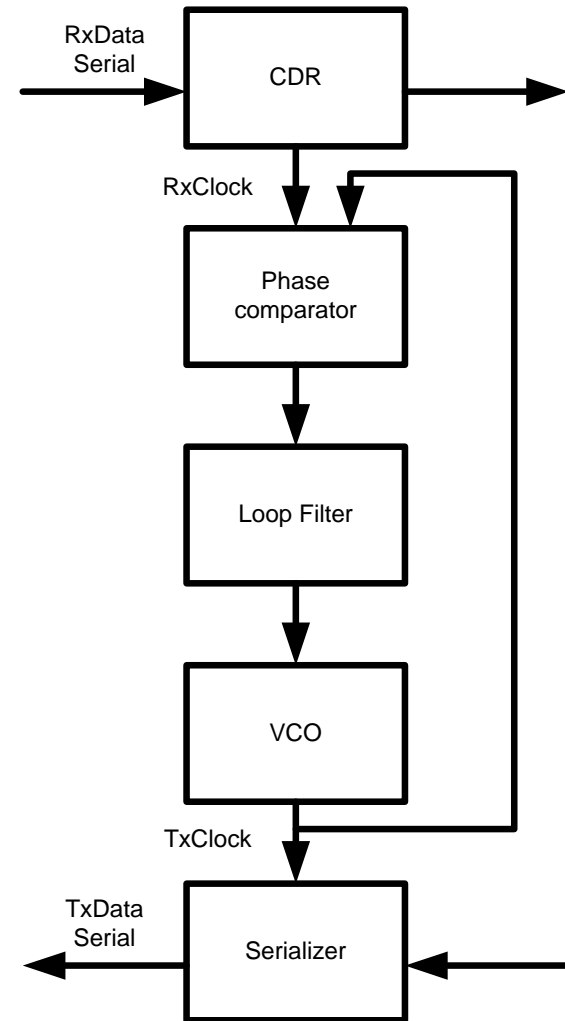
- 10G jitter budget is extremely tight!
 - Total UI is less than 97ps

All measures must be taken to
reduce jitter

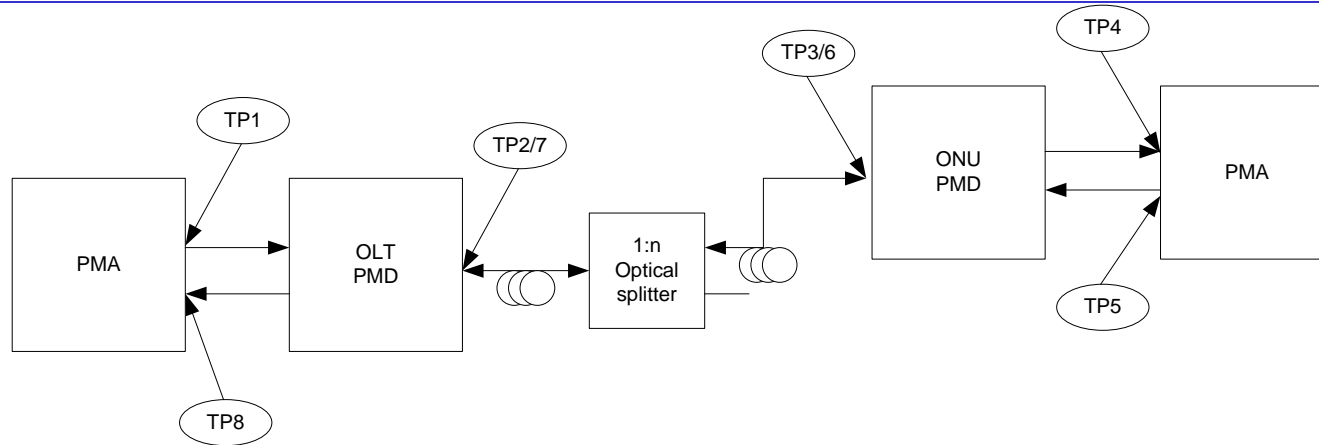
Problems with loop-timing

ONU loop-time PLL

- The ONU requires a de-jitter PLL to attenuate receive jitter
 - At 10Gpbs conventional PLLs couple too much noise in the loop filter increasing random jitter.
 - Many solutions use expensive VCXOs
- Jitter attenuation
 - Jitter peaking can result in higher output jitter at some frequencies.
- **A local oscillator will have less output jitter**
 - for a given cost point



Failure Isolation



- Loop-timing makes isolating the source of jitter difficult.
 - Jitter from TP1-TP8 can result in upstream bit errors
 - OLT Transmit jitter results in upstream bit errors
 - Poor optical receive signal at ONU results in upstream bit errors
 - Difficult to isolate an upstream jitter problem from a downstream jitter problem in the field
- Non-loop-timed links are simpler to debug
 - Only jitter from TP5-TP8 can result in upstream bit errors
 - Upstream errors are due to upstream signal path
 - Very minor dependence to the downstream signal

Requirements of loop-timing

MPCP protocol

- Loop-timing is not required for MPCP protocol to function properly
 - Sec 65.3.1.2 is a PHY requirement
- OLT MPCP operates on Tx clock
- ONU MPCP operates on Rx clock
 - Same clock with or without loop-timing!

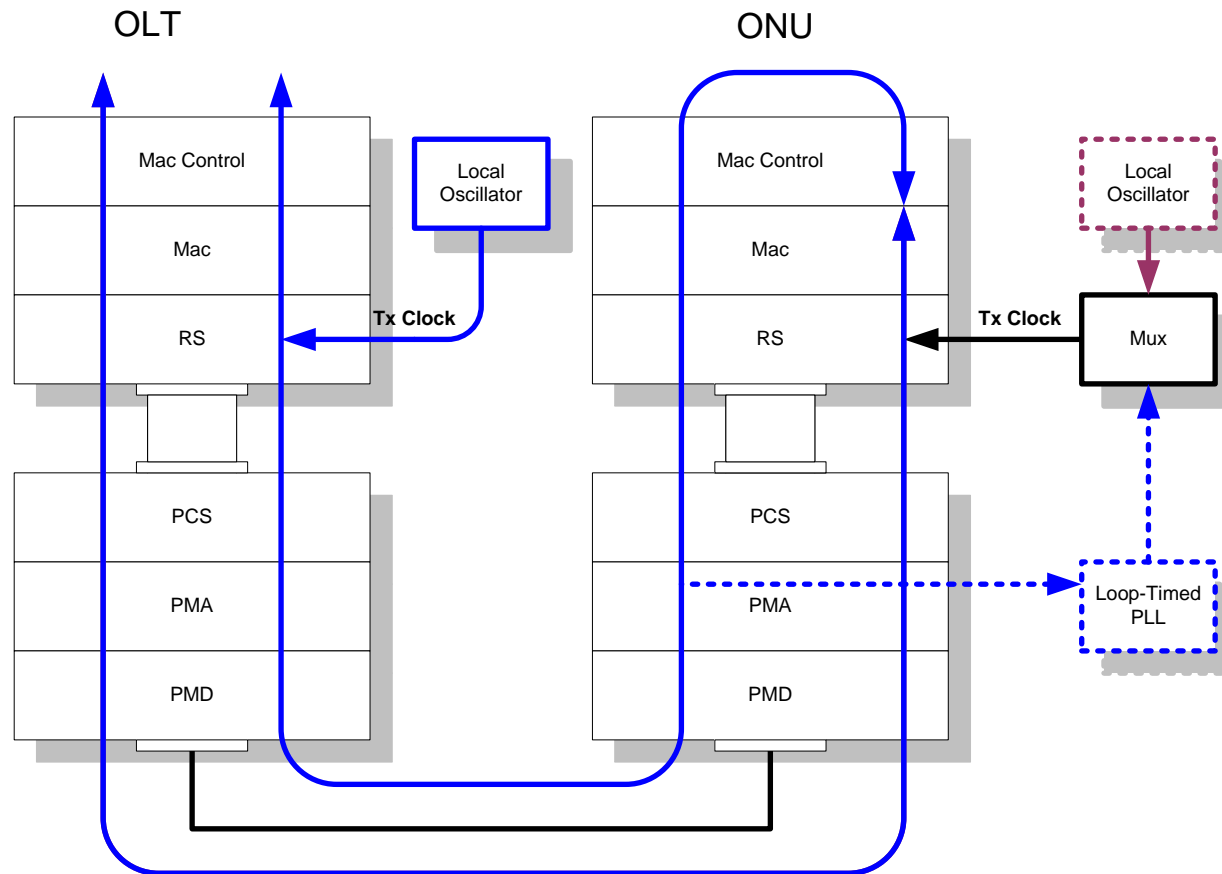
Sec 64.2.2.2

localTime

This variable holds the value of the local timer used to control MPCP operation. This variable is advanced by a timer at 62.5MHz, and counts in time_quanta. At the OLT the counter shall track the transmit clock, while at the ONU the counter shall track the receive clock. For accuracy of receive clock see 65.3.1.2. It is reloaded with the received timestamp value (from the OLT) by the Control Parser (see Figure 64–11). Changing the value of this variable while running using Layer Management is highly undesirable and is unspecified.

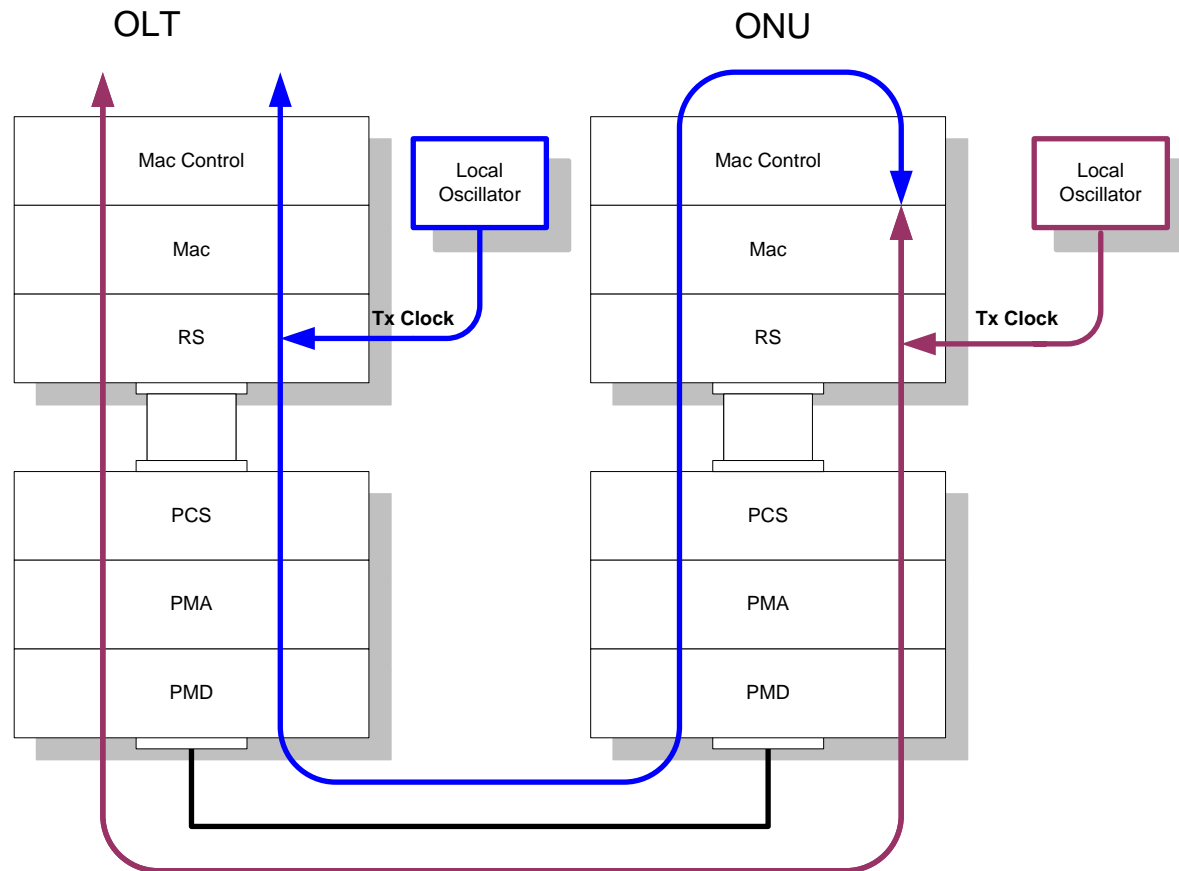
TYPE: 32 bit unsigned

Layering with clocks – loop-timed



- Clock is sourced from the PHY
- The MAC is speed agnostic

Layering with clocks – non-loop-timed



- Cross clock domain occurs between Mac Control and Mac in ONU

MPCP guard time compliance

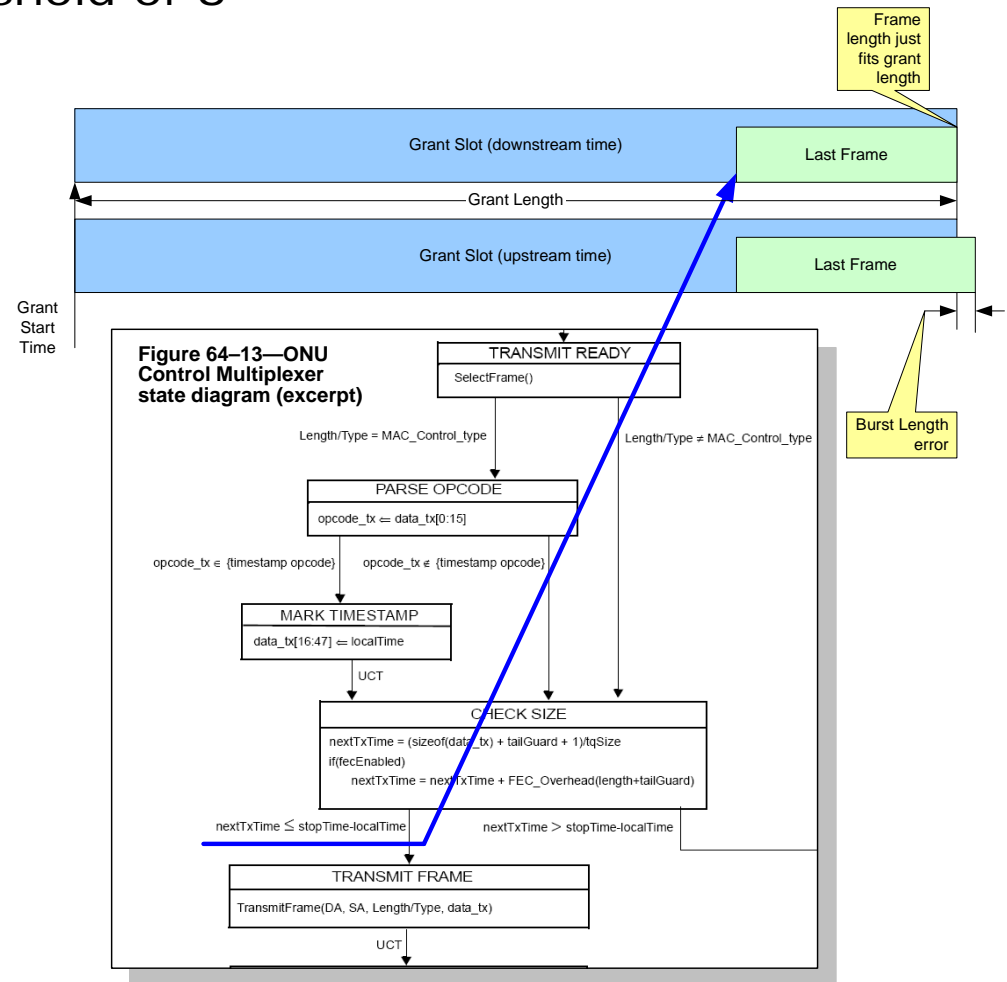
- MPCP timers have a guardThreshold of 8 at the ONU and 12 at the OLT
 - Sec 64.2.2.1

- Burst Length error (maximum)
 - OLT and ONU oscillators differ by 200ppm
 - A maximum length upstream frame just fits in grant

$$(1522 \text{ bytes} + 224 \text{ FEC OH}) \times 200\text{ppm} = 2.79 \text{ bits}$$

- Burst Length error < 1 TQ

- guardThreshold is met with a local time reference
 - 1TQ easily can fit in the 12 TQ guardThreshold at OLT



Impact on DBA

- Reports contain the queue length in ONU clocks, OLT grants in OLT clocks
 - Clock differences may result in an OLT grant not equal to Queue Report
 - 16-bit grant length * 200ppm = 13.1TQ peak difference
 - Does not result in Grant out of slot
 - No requirement for Grant Length to equal Queue Report value
 - Grant length may be aligned to frame boundaries to increase efficiency
 - OLT DBA may adjust for clock differences by adjusting grant length
 - ONU Report may adjust for clock differences by adjusting report value

Impact on FEC

- Alignment of the MAC Control to the PCS inserting FEC parity is not maintained due to different clocks.
- The PCS may be required to send an extra FEC codeword in order to complete burst.
- Guard time may need to be increased.
 - guardTime is not a specified value and is a function of the DBA

Summary

10GE PON PMA

- EPON should leverage the technology of point-to-point solutions.
 - Leverage existing SERDES technology
 - Utilize existing test equipment for jitter
 - Loop-timed jitter transfer cannot be analyzed easily

Conclusion

- Loop-timing is not required for MPCP
 - Loop-timing adds cost and increases jitter
 - **Loop-timing should be dropped for 10G ONUs**
- Jitter transfer specifications are unnecessarily difficult to implement
 - Small supply of loop-timed SERDES
 - Loop-timing unnecessarily increases ONU's transmit jitter