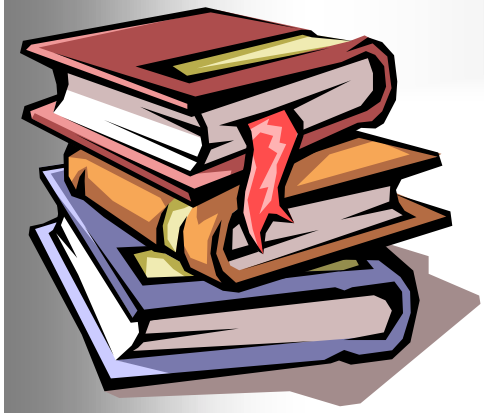

IEEE 802.3 EFM

Ethernet PON timing Considerations

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Scope

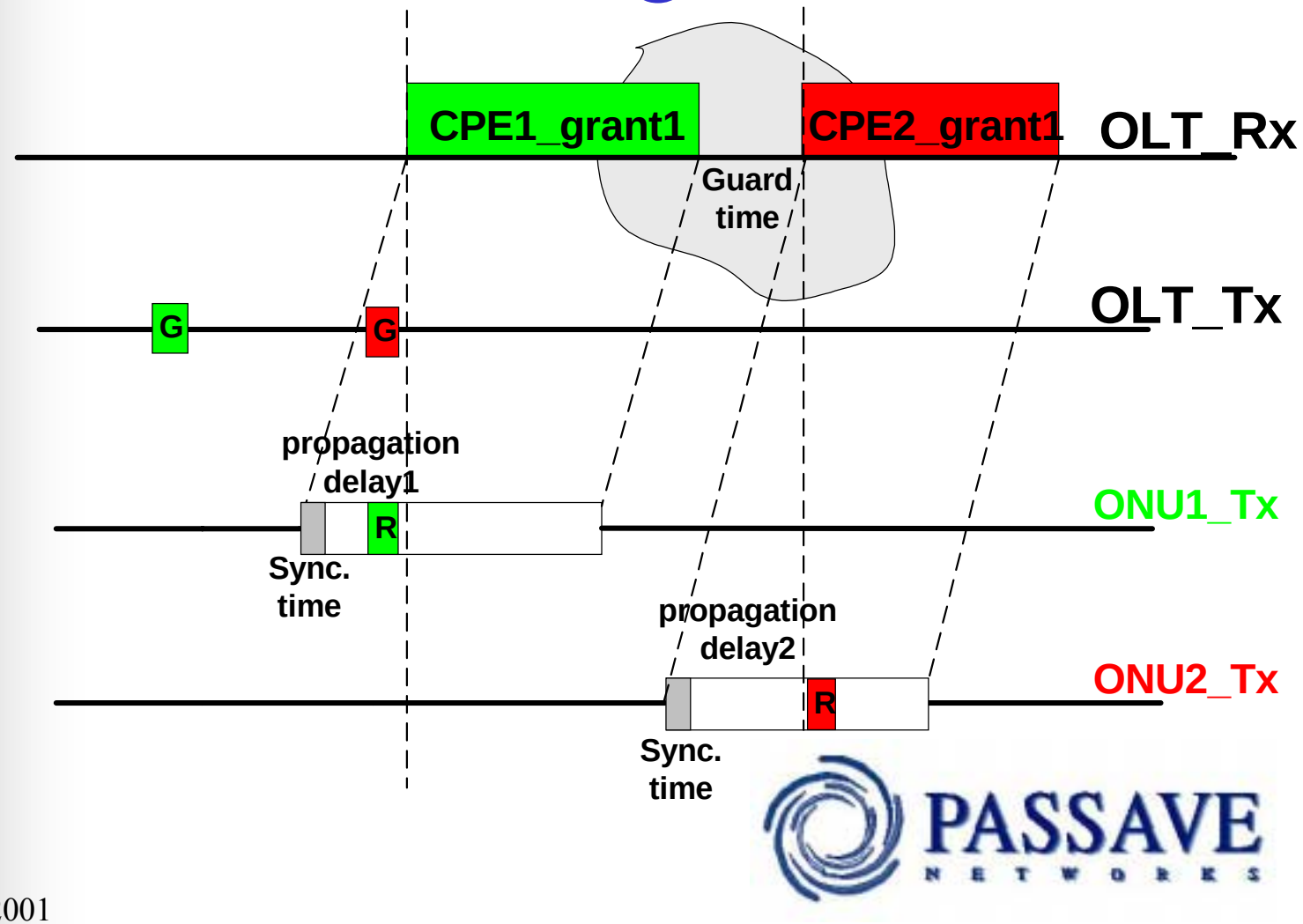
- Timing considerations in several implementation aspects of the Ethernet PON protocol
- Optical Timing Considerations
- Frequency Considerations
- Guard Time Calculation
- Phase Lock Considerations
- Packets at Grant Tail
- Bandwidth Utilization

EPON Communication Basics

- Separated Uplink and Downlink
  - Fiber or λ separation
- Downlink – OLT transmits continuously. ONUs are referred by Ethernet addresses.
- Uplink – Time division multiplexing among ONUs ≡ **Granting.**

PASSAVE NETWORKS

Granting Scheme



Frequency Considerations

- Each ONUs has a different clock
  - Ethernet defines ±100ppm accuracy → 400nsec drift in 2msec - requires fast calibration
- Frequency locking
  - ONUs Rx clock locked on OLT transmission
  - ONUs Tx. clock lock on Rx. clock

Optical Timing Considerations

- Standard Ethernet GBIC: Extinction ratio of only **9dB**. Required Off level $> 10 \cdot \log(\mathbf{No}_{\mathbf{CPE}}) + \mathbf{S}/\mathbf{N} = 35\text{dB}$
- Laser switching time: Off ~10µsec, On ~1msec
- Optical switching time is covered by guard time ⇒ **must be reduced** for **EPON** (<100nsec).
- Dedicated EPON GBIC.

PASSAVE NETWORKS

Optical Timing Considerations

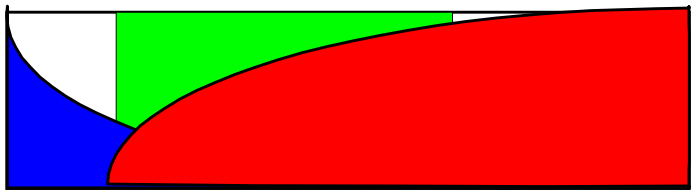
- Laser diode switching time < 10nsec
- Fast laser driver is required
- APON – Laser switching time is 3 bits
- APON devices have achieved non-modulation isolation > 40dB

PASSAVE NETWORKS

Guard Time Calculation

- A guard time at grant end →
  - Ethernet guarantees 96 bits Interframe Gap for processing – Lower bound for guard time.
  - Laser switching time
  - All processes may overlap

Guard time

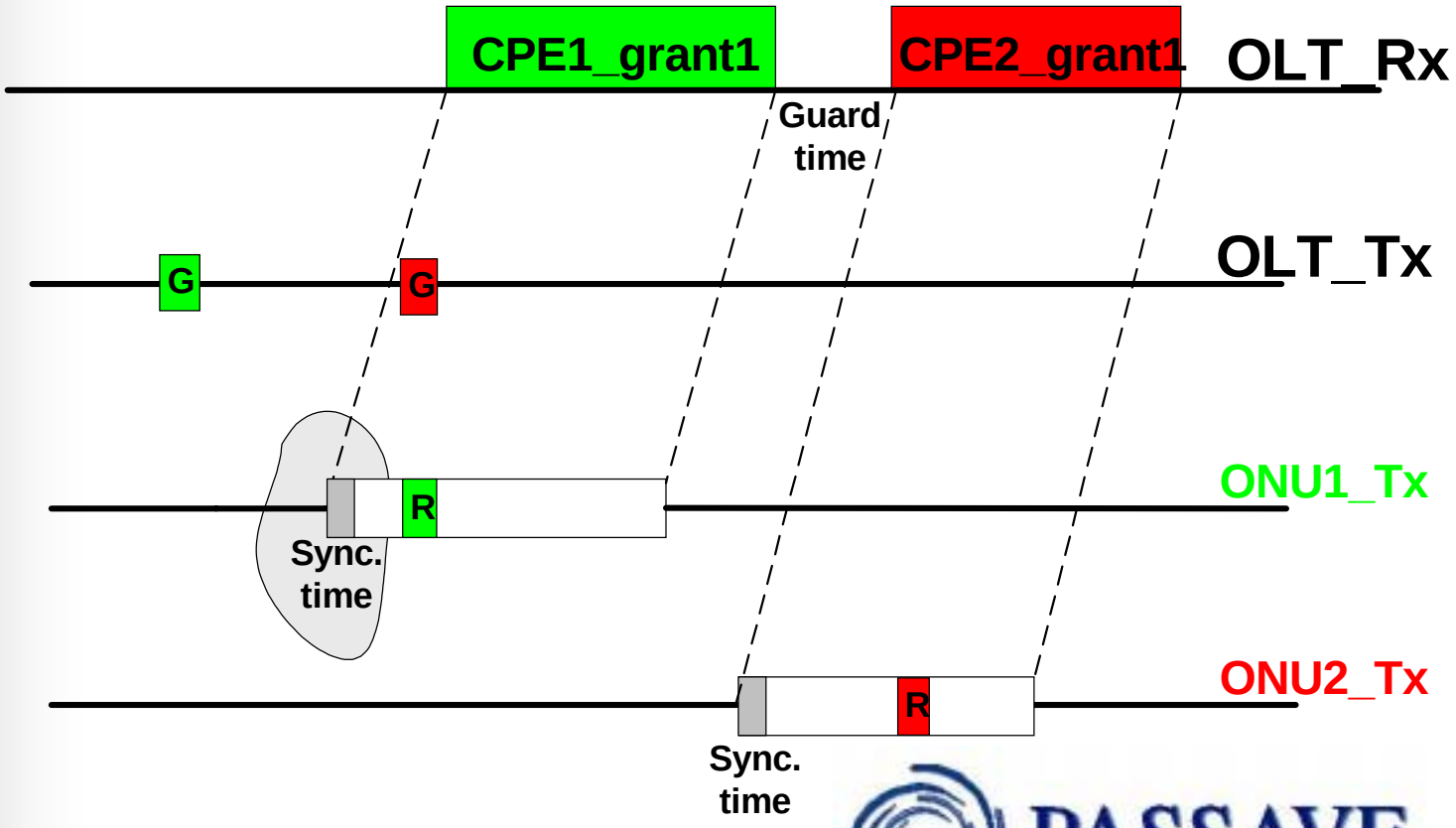


Laser_off time **Interframe gap** **Laser_on time**

Ranging

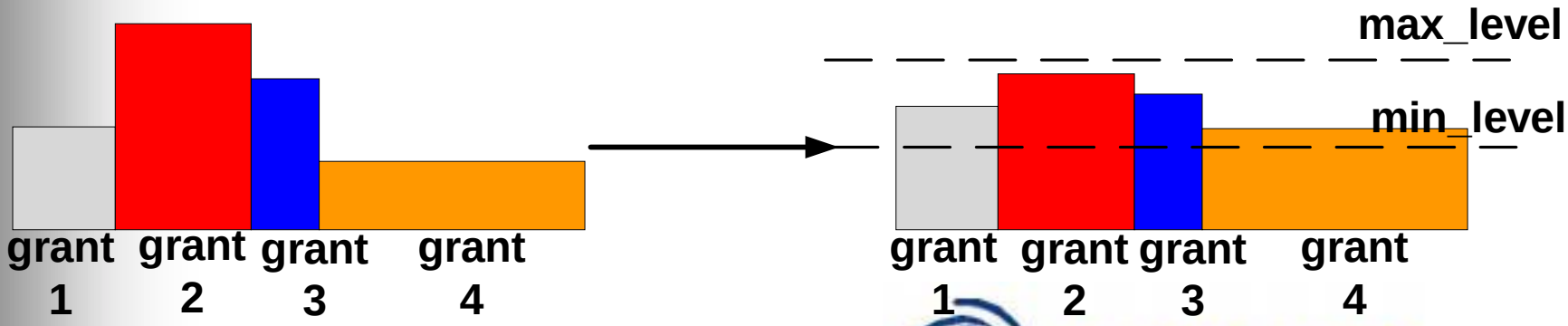
- Unknown variable round trip delay
  - Topology not guaranteed.
  - Total delay - 20km = 200µsec, can be limited to path variance.
  - Round Trip Delay drifts with temperature changes ≈7ppm/C°
- Ranging process resolves the round trip delay of each ONU and initiate the granting mechanism.

Granting Scheme



Near – Far Problem

- Different transmission paths → Variance in received power.
- Classes for optical path loss at ONU → Low Rx. power range and Low interference at OLT.
  Similar to G.982/G.983



Phase Lock Considerations

- A phase slip at every grant.
- Phase slip → synchronization header.
  - Bit slip.
  - Byte slip.
- **Standard Ethernet**
- Bit Sync. – Commercial CDRs take 250 bits.
- Octet sync.
  - **Comma** encounters immediate Sync.
  - Comma not present in Ethernet preamble.
- Ethernet packet – 8 bytes preamble → 64 transitions.

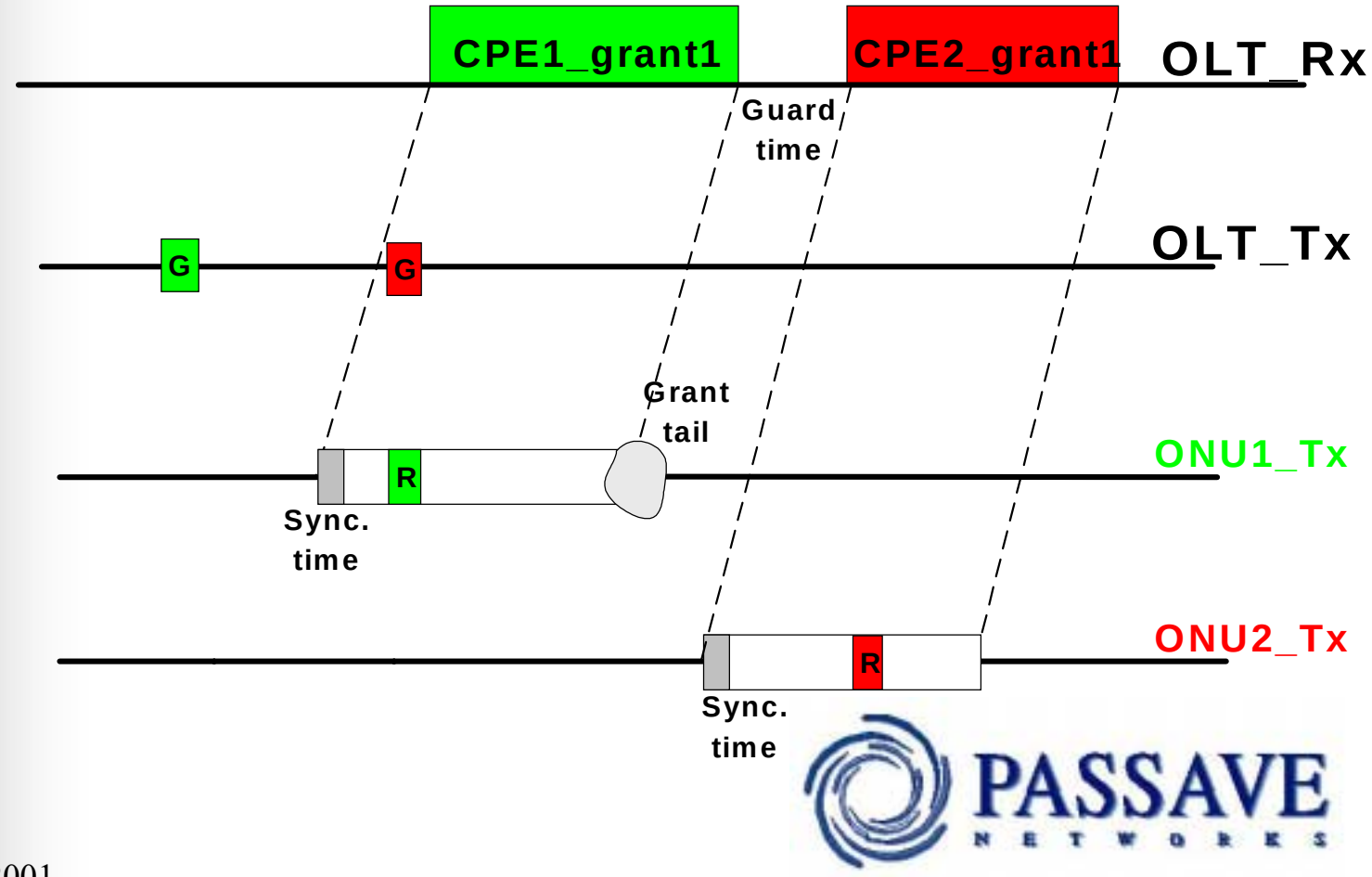
PASSAVE NETWORKS

APON Phase Lock

- APON
  - Single Clock domain.
  - Holding state for each ONU Phase.
  - 1 Byte for phase sync. check.
  - Requires a coherence bandwidth of the order 0.1bit/round_trip_delay = 3ppm for APON, 0.5ppm for EPON.
- Ethernet jitter tolerance is 0.75UI.
- APON – Tighter Jitter spec. – 0.02UI

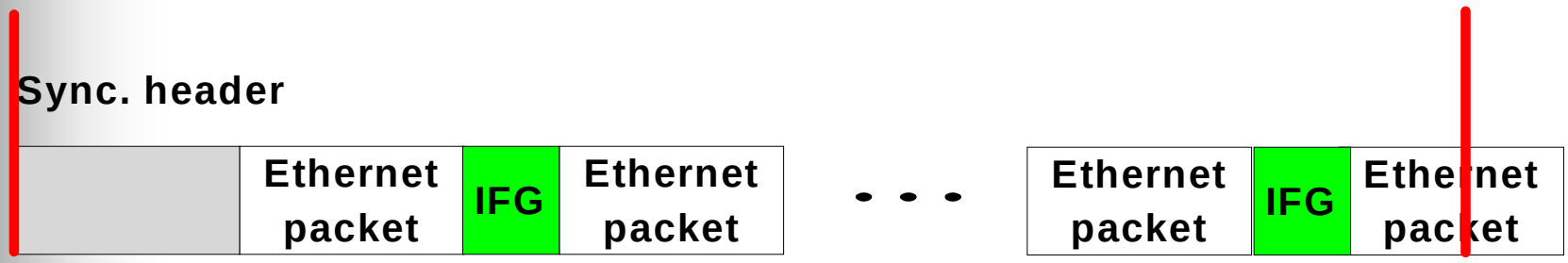
PASSAVE NETWORKS

Granting Scheme



Packets at Grant Tail

- Internal Fragmentation.
- Last packet does not fit the grant tail. (may add an unused time one packet – up to 1517 bytes).
- Unexploited bandwidth of $\mathbf{0.5 \cdot L_{mean\_packet}}$
- Smart queuing may reduce end of grant loss.



Total Unexploited Grant Time

- **Total unexploited grant time :**

$$T_{Sync\_header} + \underbrace{0.1\mu}_{Interframe\_gap} + T_{optic\_switching} + \underbrace{\{0 \rightarrow 12\mu\}}_{Last\_unsent\_packet}$$

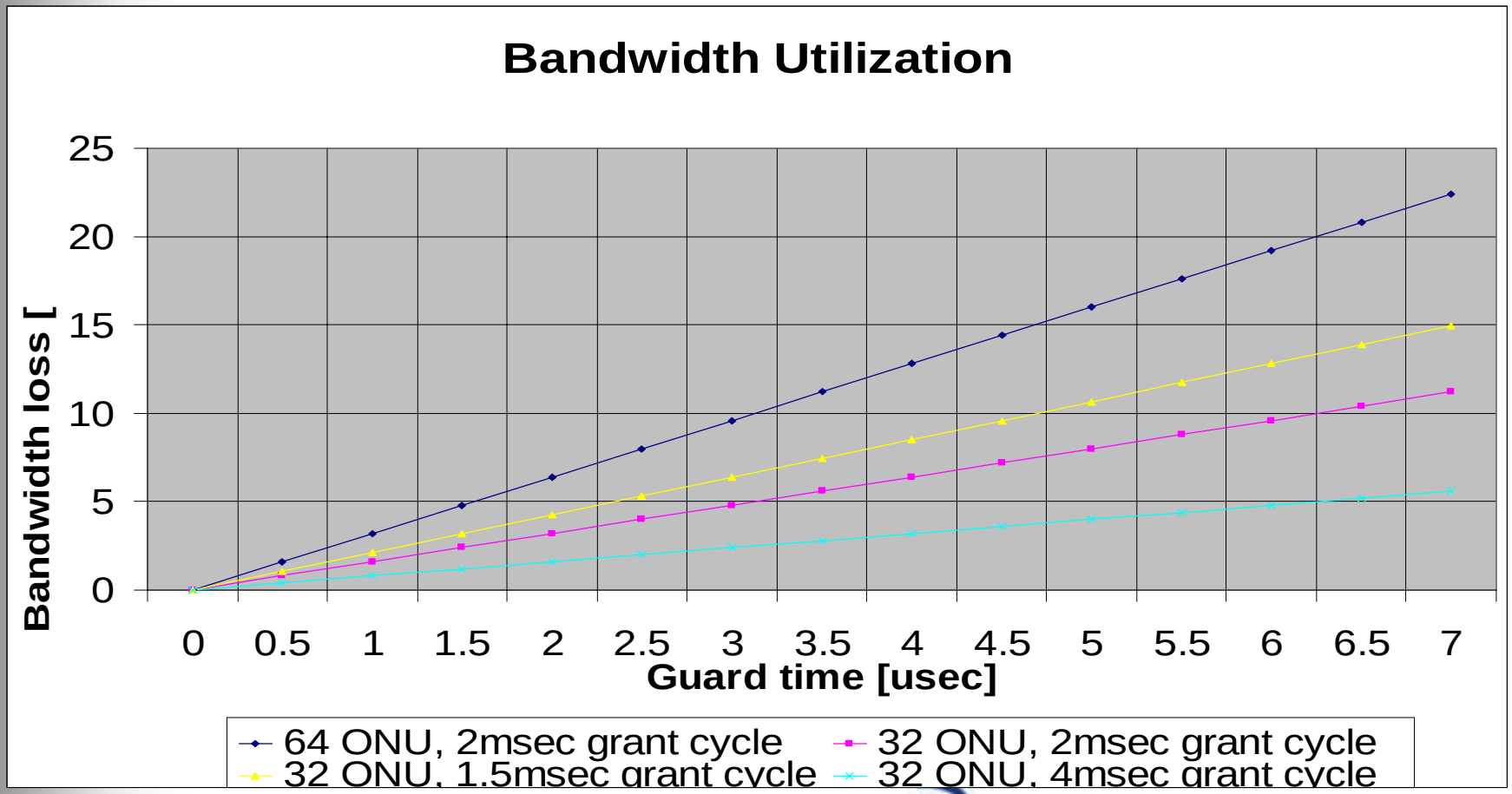
- Average utilization (@ average packet of 400byte) :
- 3.3µsec + switching time + header time

Scheduling Cycle tradeoffs

- Large Cycle – Better utilization, Large buffer size.
- Small Cycle – Low delay, Large overhead.

- Some traffics types require minimal delay.
  - Voice: delay < order of tens of msec
  - E1: delay < order of msec

Bandwidth Utilization



PASSAVE NETWORKS

Conclusions

- Single clock domain - OLT clock.
- Define Sync. header.
- Define minimal guard time.
- Define power classes.
- Short guard time → High utilization.