MPCP and TDM Services

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Two Service Models...one protocol

FTTH

1. TDM (POTS)
2. Static BW Allocation
3. High BW Data (no sharing)
4. 1GBps; e.g., 64 users @ 15Mbps

- Cost/simplicity Critical

ILECS

FTTB

1. High BW Data
2. Dynamic BW Allocation
3. TDM (T1/E1, DS3)
4. 1GBps; e.g., 16 users @ 100Mbps

- QOS/SLA Critical

CLECS

Let's make it a flexible protocol!

P2MP Ethernet realities

- Very low number of ONUs (~64) sharing 1Gbps
- Expect vast majority of deployments to use:
  - Low cost optics
  - Multi-service ONUs including legacy TDM
  - ONU doing ‘fine scheduling’ within fixed timeslot

- BER $\leq 10^{-12}$

- Ethernet is bursty by nature
- TDM is not ‘automatically’ supported

- MPCP requires special considerations for TDM

TDM Requirements

- Absolute requirements:
  - Cyclic nature
  - Low latency
  - Low jitter
- True TDM voice & data
  - PCM voice emulation and T1/E1 transport
  - not 'TDM-like', as in VoIP
- Maximum latency specified in the standards:
  - GR909: **1.0 ms** one way
  - ITU G.982/FSAN: **1.5 ms** one way

Latency requirements

GR-909:

R7-1 [345] The **round trip** delay through an integrated FITL system consisting of an HDT and ONUs connected by an ODN optical path **shall not** exceed **2.0 ms**. The round trip delay is equal to the time it takes for a voice frequency signal to travel from a voice service interface of an ONU to the switch-side interface of its master HDT, loop-back through the HDT and reach a voice service interface at another ONU.

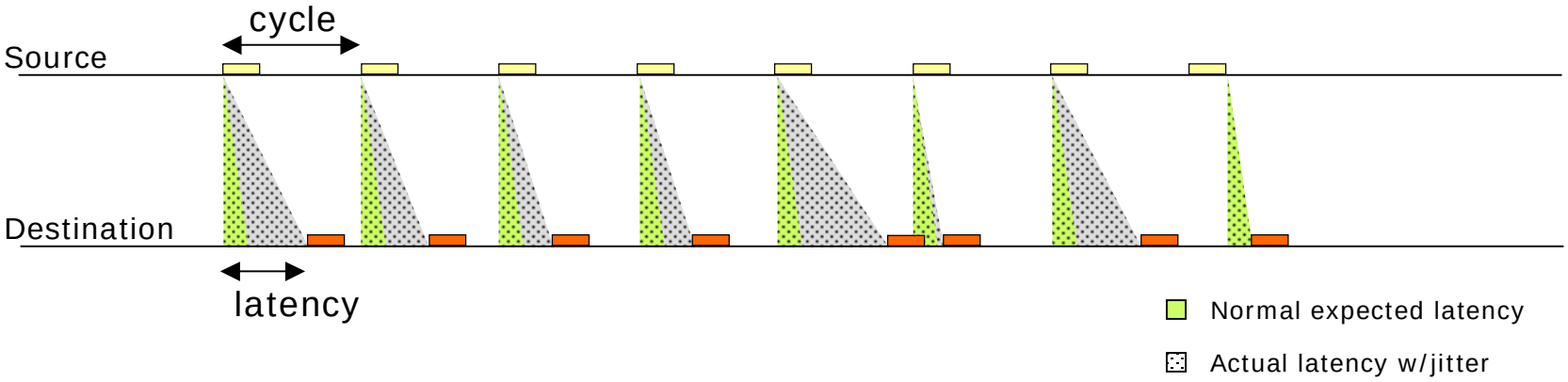
O7-2 [346] The **round trip** delay through an integrated FITL system consisting of an HDT and ONUs connected by an ODN optical path **should not** exceed **1.4 ms.**

Transport delay requirements are driven by the service requirements of voice services.

ITU-T G.982:

A maximum of **1.5 ms** is recommended for the mean signal transfer delay between [the SNI] and [UNI] for fibre-to-the-home applications.

Latency & jitter



- Jitter = variability of latency of individual packets
- Directly affects QOS of isochronous services
- P2MP TDMA Cycle should be within TDM latency budget

- Challenge: **keep bounded within standard specified limits**

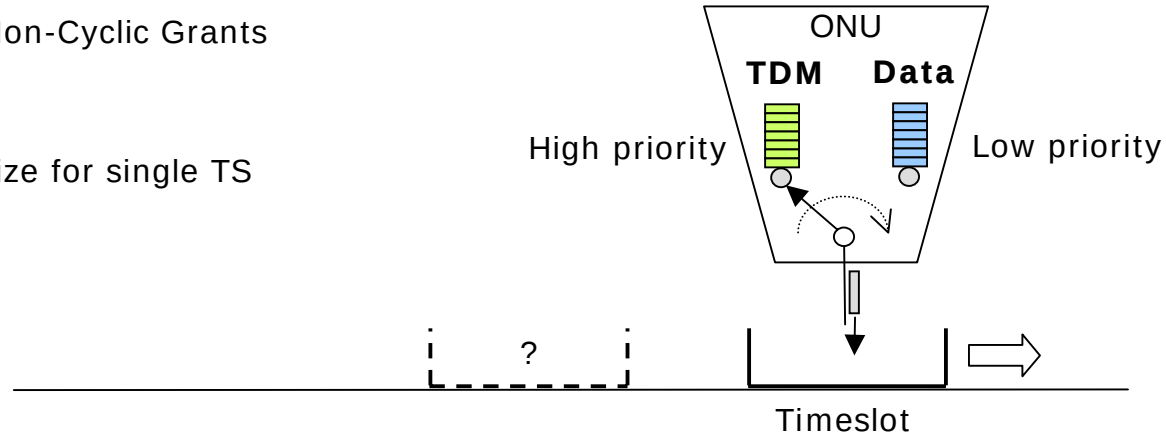
MPCP approach to TDM

- 2 modes to consider:
  - **Non-Cyclic** (in the proposed baseline today)
    - OLT explicitly grants individual timeslots
    - GATE includes short list (1-4) of absolute Timeslot times
  - **Cyclic** (Proposed enhancement)
    - ONU is granted to transmit cyclically
    - ONU can precisely predict next timeslot…. and schedule time-critical transmissions
    - Two options:
      - Limited – one GATE schedules up to N cycles, or
      - Perpetual – one GATE schedules perpetually

ONU's scheduling dilemma

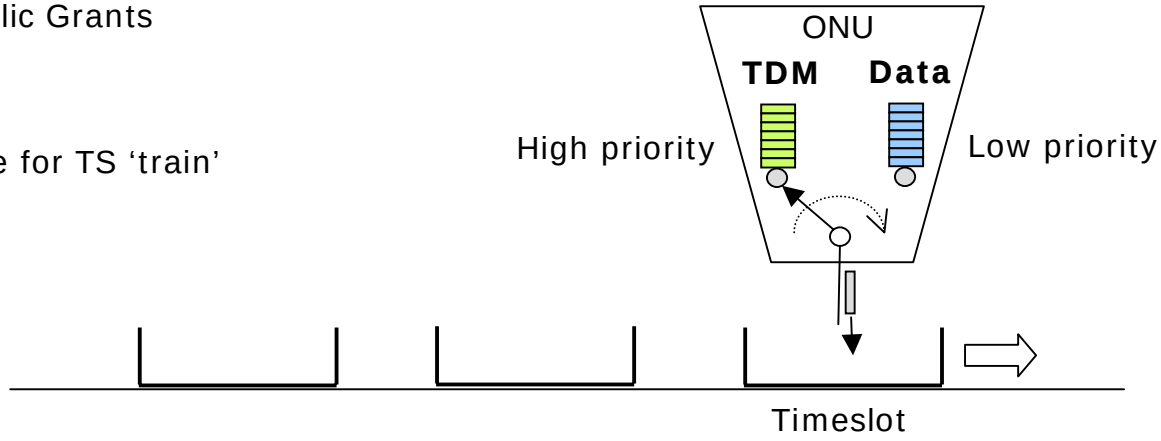
With Non-Cyclic Grants

Optimize for single TS

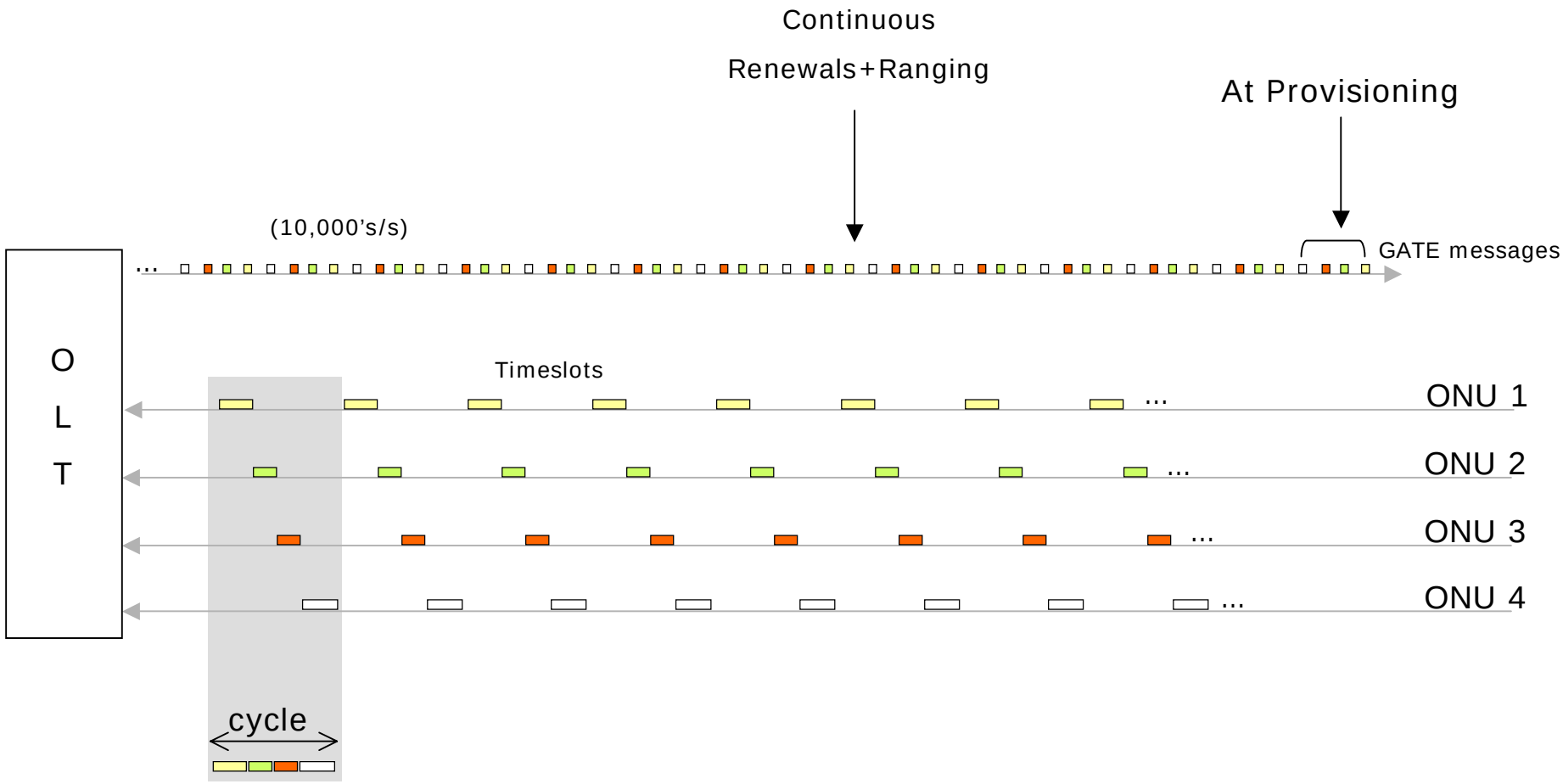


With Cyclic Grants

Optimize for TS 'train'



TDM via non-Cyclic MPCP



Non-Cyclic MPCP – observations

Advantages:

- 'Stateless' ONU
- Granting is explicit
  - no extra mechanisms to modify, terminate

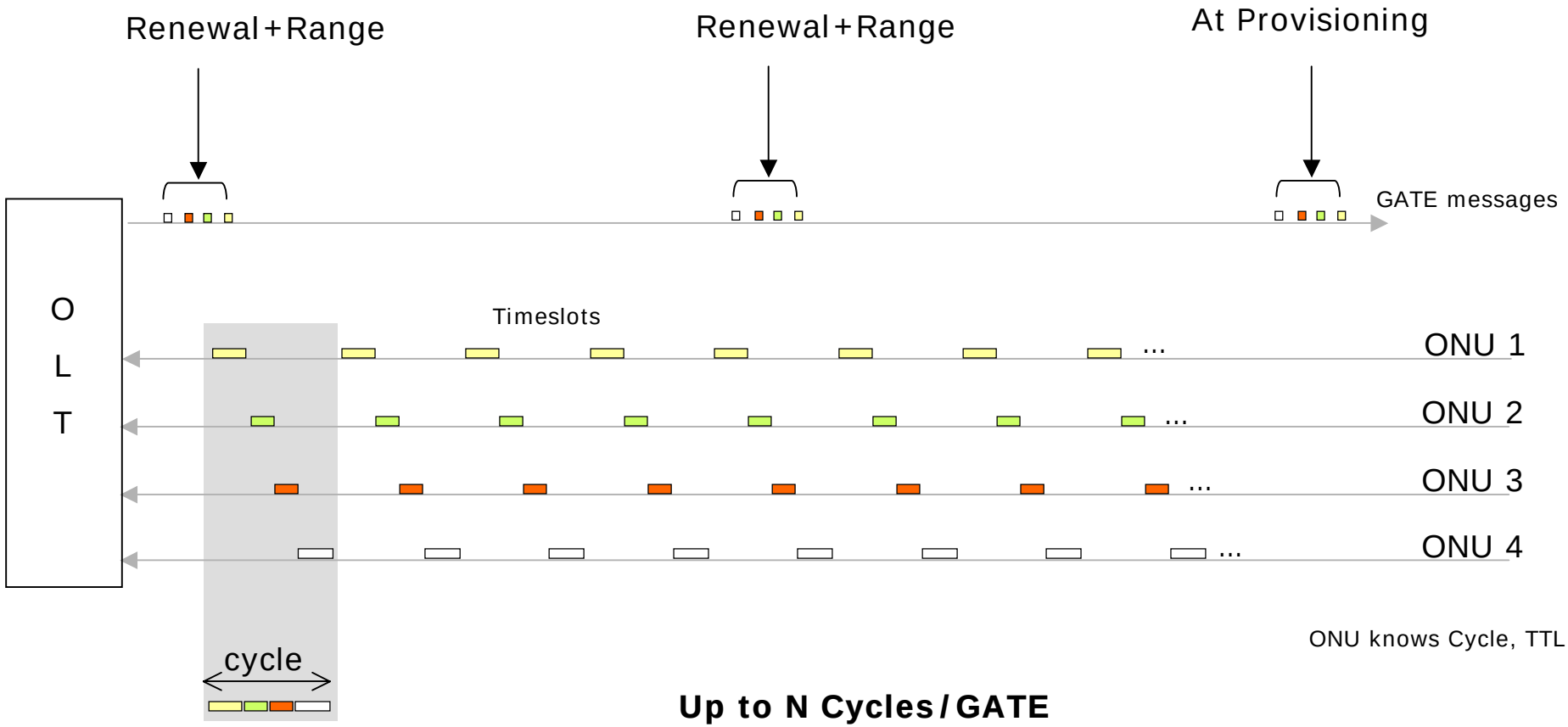
Issues:

- Continuous GATE stream not very natural to static BW model
- ONU cannot predict next timeslot – limits scheduling
- OLT scheduling complexity = F(# ONUs, cycle)
- BW overhead
  - Downstream: inserted GATEs
  - Upstream: inserted REPORT for every GATE? (ranging loop)
- Jitter/latency prone
  - Downstream: inserting GATEs
  - Upstream: late GATEs

MPCP side-effects!

- **Appropriate for TDM??**

TDM via Limited Cyclic MPCP



Limited Cyclic MPCP – observations

Advantages:

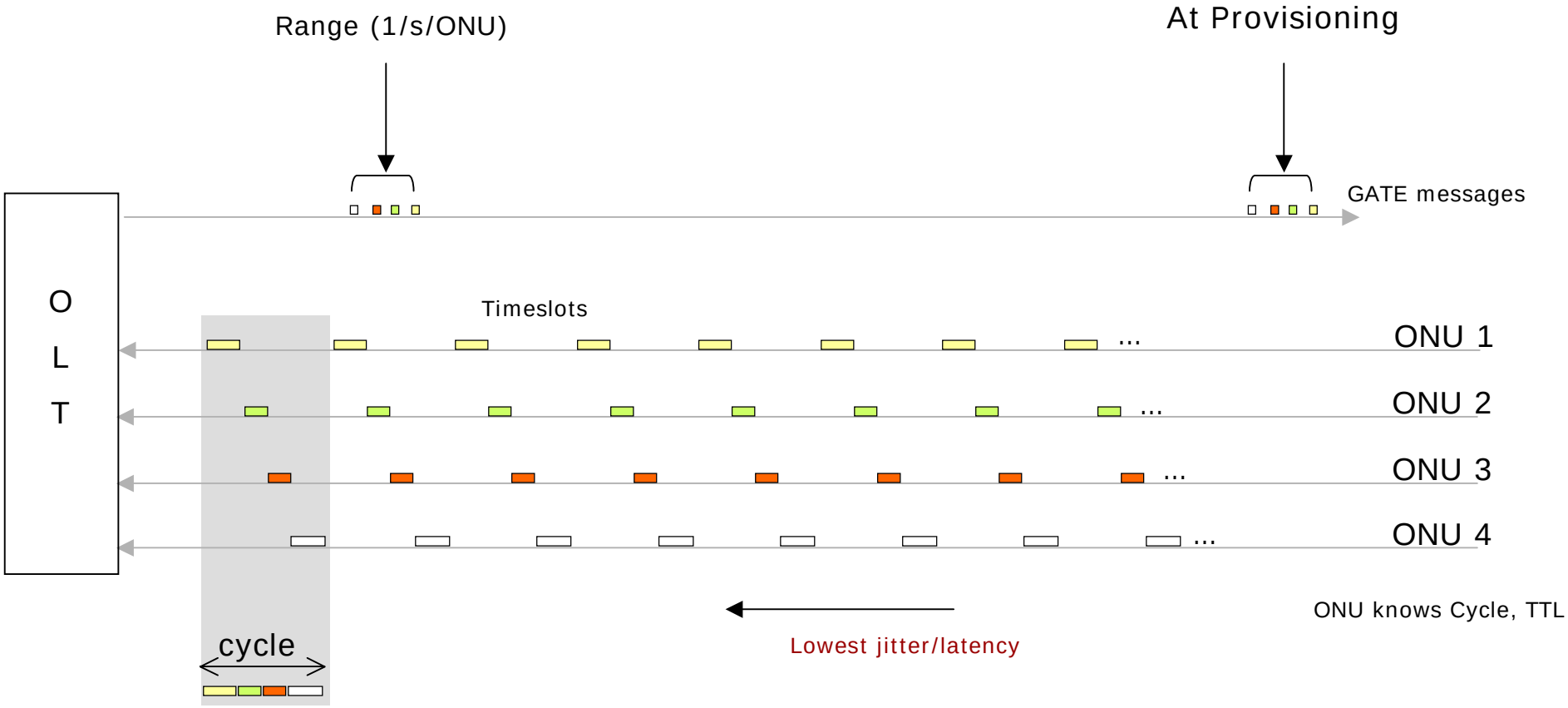
- Improvement over single-GATE scheme = F(#cycles)
- Reduces continuous GATE/REPORT BW; jitter/latency
- ONU can precisely predict next timeslot (sometimes)

Issues:

- Complexity at OLT still an issue
- Still at risk for jitter/latency
  - increases with higher # ONUs & smaller cycles
- New fields in GATE: ‘Cycle’ and ‘TTL’
- Mechanism to modify, terminate future grants:
  - To modify:
    - New GATE
  - To terminate:
    - New GATE w/ Length = 0 or TTL = 0, or
    - Let grant expire
- Detect lost GATEs
  - Time-out at OLT (using Ack REPORT)

TDM via Perpetual Cyclic MPCP

“Set it & Forget it”



“Set it and Forget it”

- Not a new concept…

Perpetual Cyclic MPCP – observations

Advantages:

- Eliminates jitter/latency & BW side-effects of non-cyclic MPCP
- Reduced OLT complexity
- ONU can precisely predict next timeslot (at any time)
- 'TTL' = "Perpetual" in provisioning GATE
  - Note: 'Cycle' could be distributed at initialization in simple system

Issues:

- Mechanism to modify, terminate future grants
  - Similar as Limited Cyclic MPCP
- Detect lost GATEs
  - Time-out at OLT (using Ack REPORT)

- Note: periodic Ranging GATE = implicit renewal

Risks of losing a GATE?

MPCP mode	Lost first GATE	Lost renewal GATE	Lost re-provisioning GATE	Lost Revoke
■ **Non-Cyclic (n<5)**	Starts w/next GATE (start late n cycles)	latency till next GATE (n cycles)	Changes after next GATE (n cycles)	N/A
■ **Limited Cyclic (N)**	■ Starts w/next GATE (start late N cycles) or ■ Starts after OLT timeout & re-issues GATE	■ latency N cycles or ■ latency till re-issue	■ Changes late N cycles or ■ Changes after OLT timeout & re-issue	■ Stops after N cycles or ■ Stops after OLT timeout & re-issue
■ **Perpetual**	Starts after OLT timeout & re-issues GATE	N/A	Starts after OLT timeout & re-issues GATE	Stops after OLT timeout & re-issue

- Perpetual GATE model:
  - Ack REPORT returned
  - OLT re-issues GATE if no REPORT detected (time-out)
- **Very, very low risk!!**
  - BER $\leq 10^{-12}$
  - MAC-Control messages are high priority

Summary

- TDM support is critical to success of P2MP

- Ethernet is bursty by nature
- TDM is not ‘automatically’ supported
- MPCP requires special considerations for TDM

- **Cyclic mode in MPCP**
  - Allows ONU to accurately predict next timeslot & optimize time-critical transmissions
  - Reduces/eliminates BW and Jitter/Latency overhead
  - Very appropriate for TDM
  - Accomplished via minor enhancements

- **Proposed to add to the Baseline**