MPCP-Timing Model

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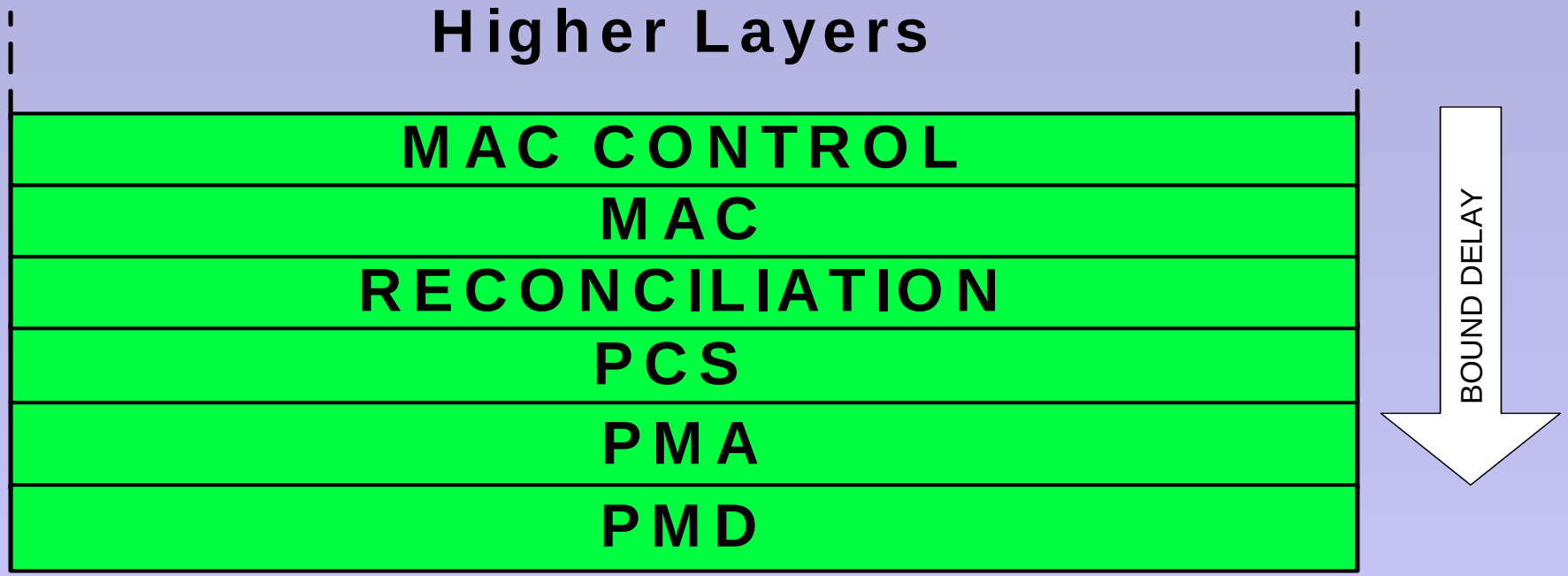
Introduction

- The essence of MPCP is scheduling future transmission opportunities to avoid collisions
- A derived requirement is the ability to synchronize distributed events to a central counter
- Synchronization is performed using timestamps

Absolute Timing Model

- A global counter exists in the OLT
- Events are synchronized to arrive at the OLT
- The OLT sets the ONUs counters based on it's local counter
- A Timestamp is added when message is transmitted by the MAC Control layer
- Timestamp granularity is 16 bit-times, 32 bit resolution

Layering Behavior



- Delay through MAC and PHY is relatively constant
- Accumulated variable delay is accounted for as guard band throughout protocol

Timestamps

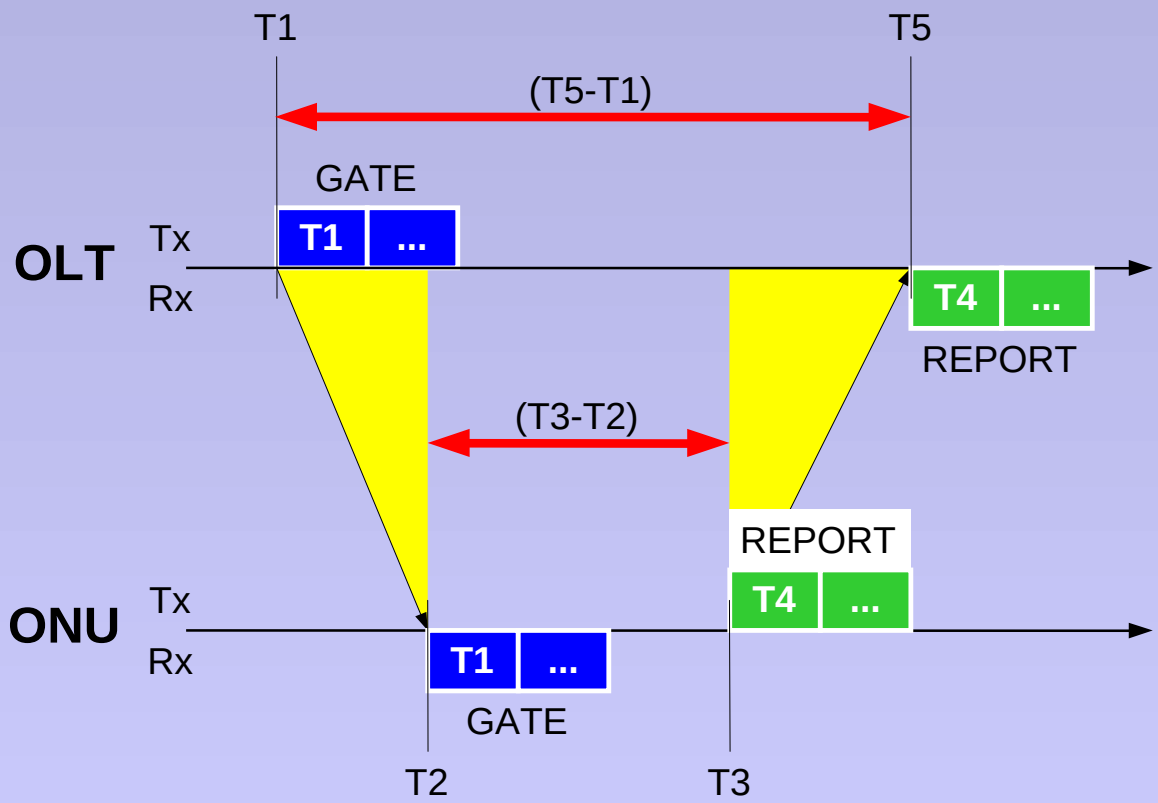
- **OLT inserts timestamps based on it's local counter**
- **ONU inserts timestamps based on it's local counter**

- **ONU updates local counter to reflect incoming timestamp**
  - Drift detection at ONU can be used for local fault detection

- **OLT monitors difference with incoming timestamp**
  - Drift detection at OLT can be used for passive ranging

Ranging - RTT Measurement

1. OLT sends GATE at absolute T1
2. ONU receives GATE at T2, and resets local counter to show T1
3. ONU sends REPORT at time T3, showing timestamp T4
4. OLT receives REPORT at absoluteT5



$$RTT = T2-T1+T5-T3 = T5-T4$$

$$T3-T2 = T4-T1$$

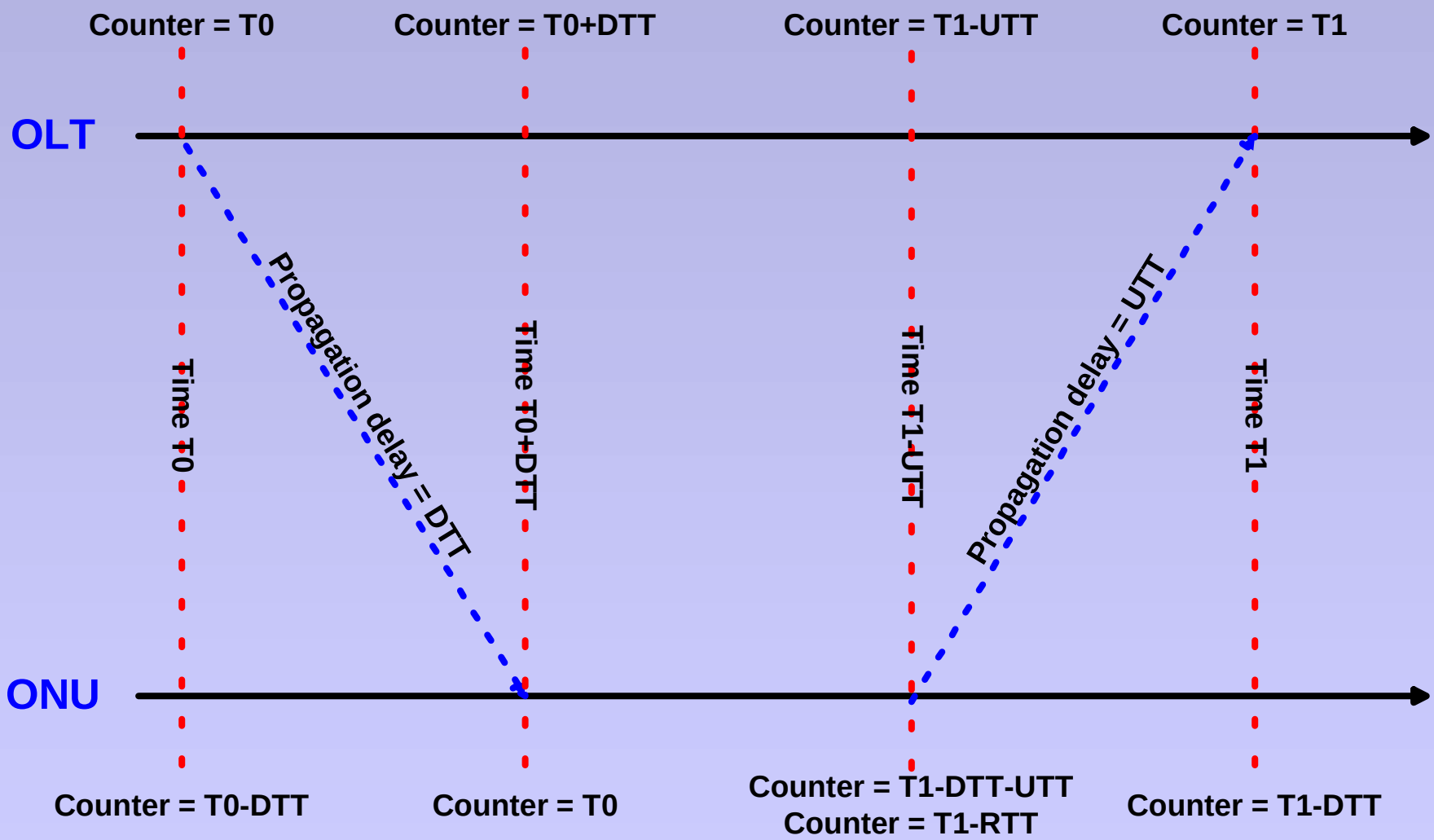
RTT Compensation

- **Delay compensation is performed at OLT**
- **Grants to ONU reflect arrival time that is compensated for RTT**

- **Example:**
  - If OLT is to receive data from an ONU at time *T*, it will send GATE containing Slot Start = *T*-RTT

- **Minimal delay defined between the timestamp and start-time, to allow for processing time**
- **Maximal delay defined between the timestamp and start-time, to keep the network synchronized**

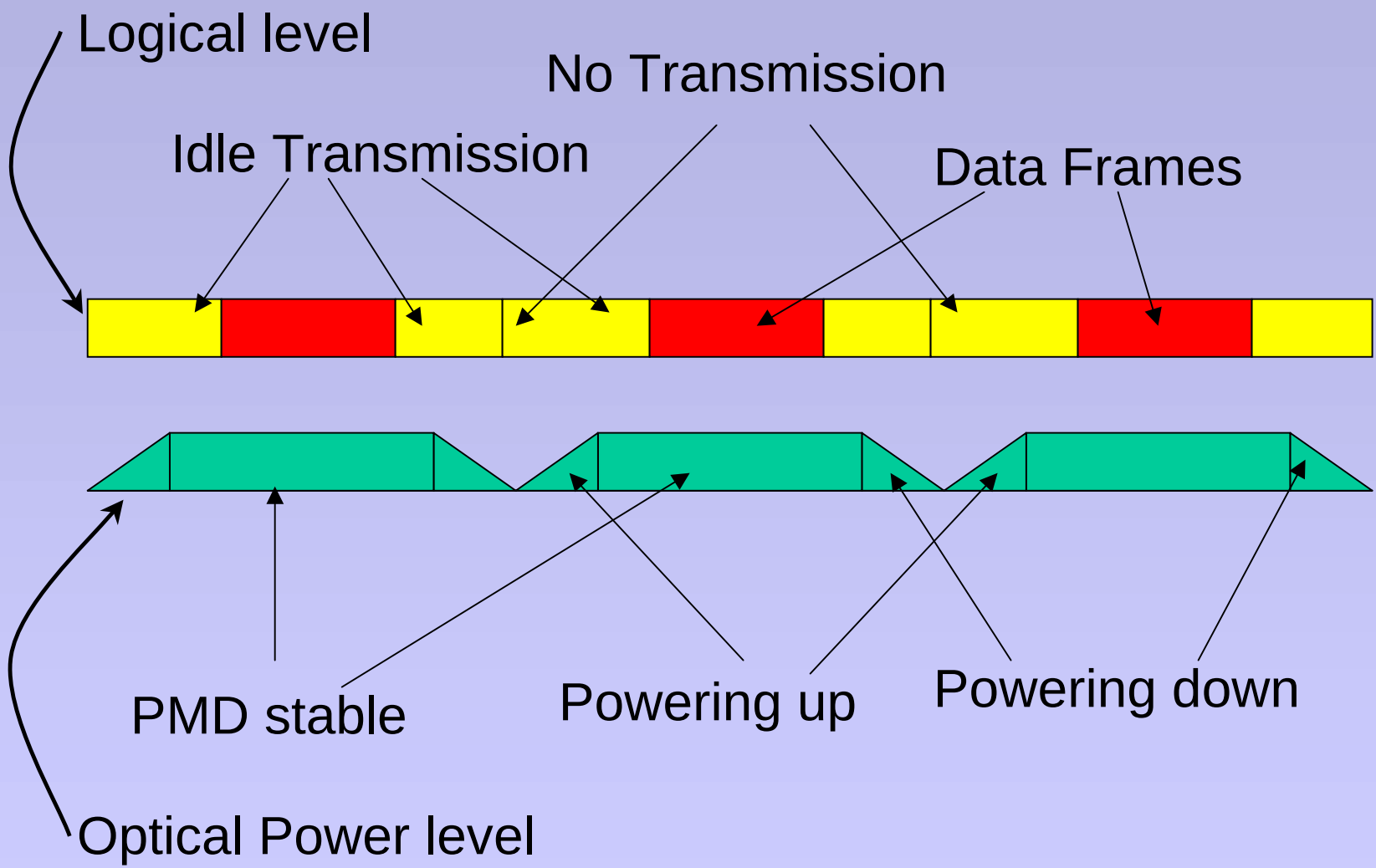
RTT Compensation Illustrated



Implementation Delay

- **Implementation delay in MAC and PHY is formed of:**
  - Fixed delay – always there
  - Variable delay – varies with MAC and state
- **RTT measurement compensates for fixed delay portion**
- **Variable delay portion can not be deterministically compensated and is accounted for in Guard band**

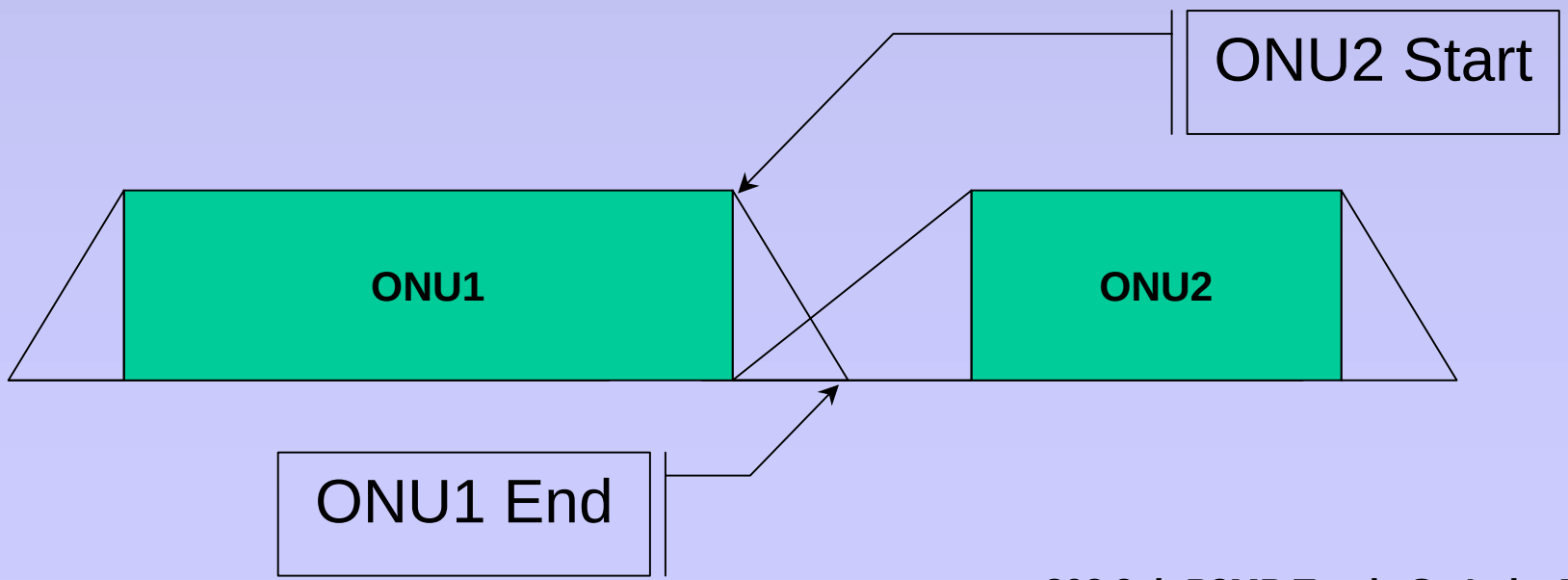
Transmission Burst



Reference Points

- **Start of transmission**
  - Point in time where Laser is turned ON
- **End of transmission**
  - Point in time where Laser is OFF

OLT may overlap transmission windows:



Decoupling of PMD Parameters

- **Three parameters isolated**
  - Laser on time
  - Laser off time
  - CDR lock time
- **Laser on/off parameters are specific to each ONU**
  - Propagated to the OLT at registration
- **CDR lock time is specific to each OLT**
  - Propagated to the ONUs at registration

- **Waiting for real numbers from PMD vendors**

MAC → PMD State-Machine @ ONU

1. **Wait until grant start time → ONU can now transmit**
2. **Signal PMD to turn laser on → Idles are transmitted**
    1. Wait “laser-on time” → laser modulation is now stable
    2. Wait “CDR lock time” → OLT can now receive frames
3. **MAC Control enables transmission → transmit frames**
    1. Wait until (grant end time - “laser-off time”)
4. **Signal PMD to turn laser off**