# MPCP-Timing Model

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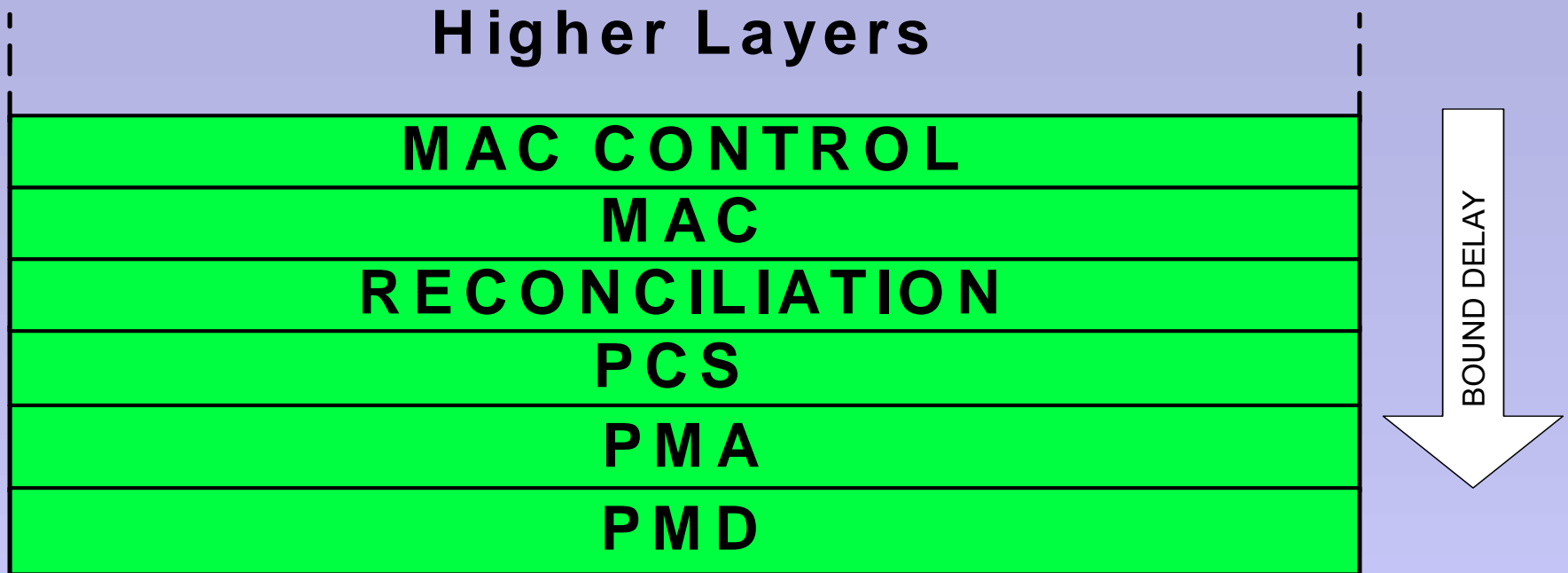
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# Introduction

- **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

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# Layering Behavior

| Higher Layers |
|:---:|
| **MAC CONTROL** |
| **MAC** |
| **RECONCILIATION** |
| **PCS** |
| **PMA** |
| **PMD** |

BOUND DELAY

- 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

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# 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
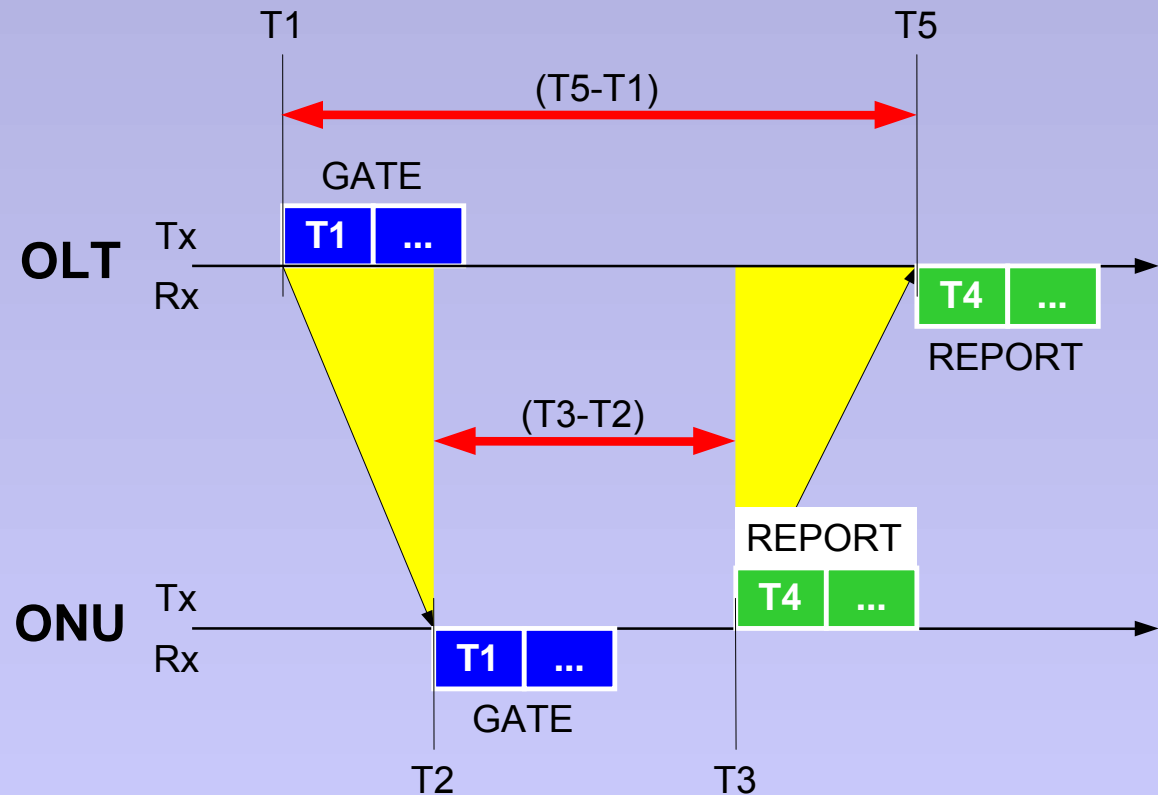


$$RTT = T2\text{-}T1 + T5\text{-}T3 = T5\text{-}T4$$
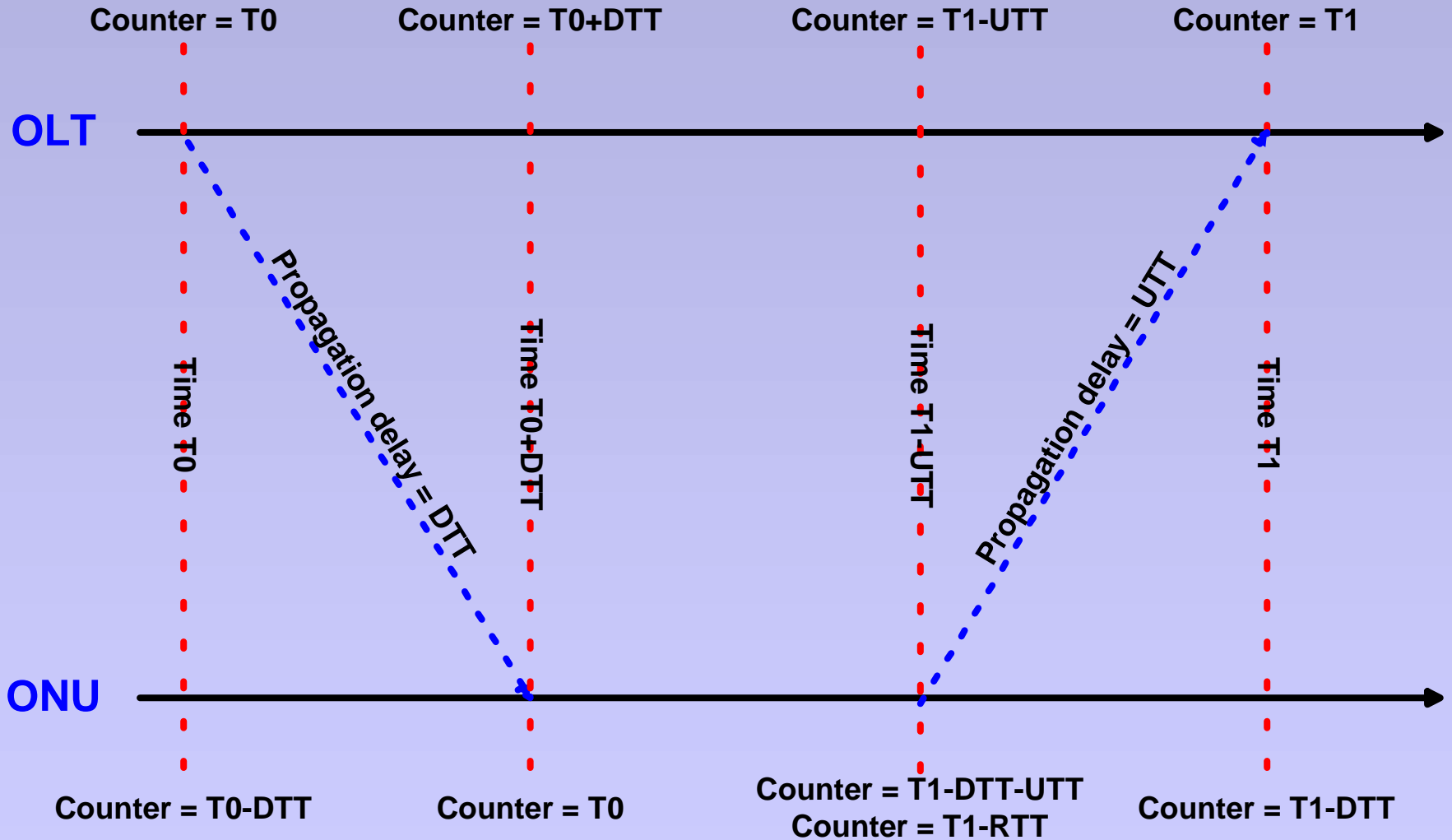
$$T3\text{-}T2 = T4\text{-}T1$$

# 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**
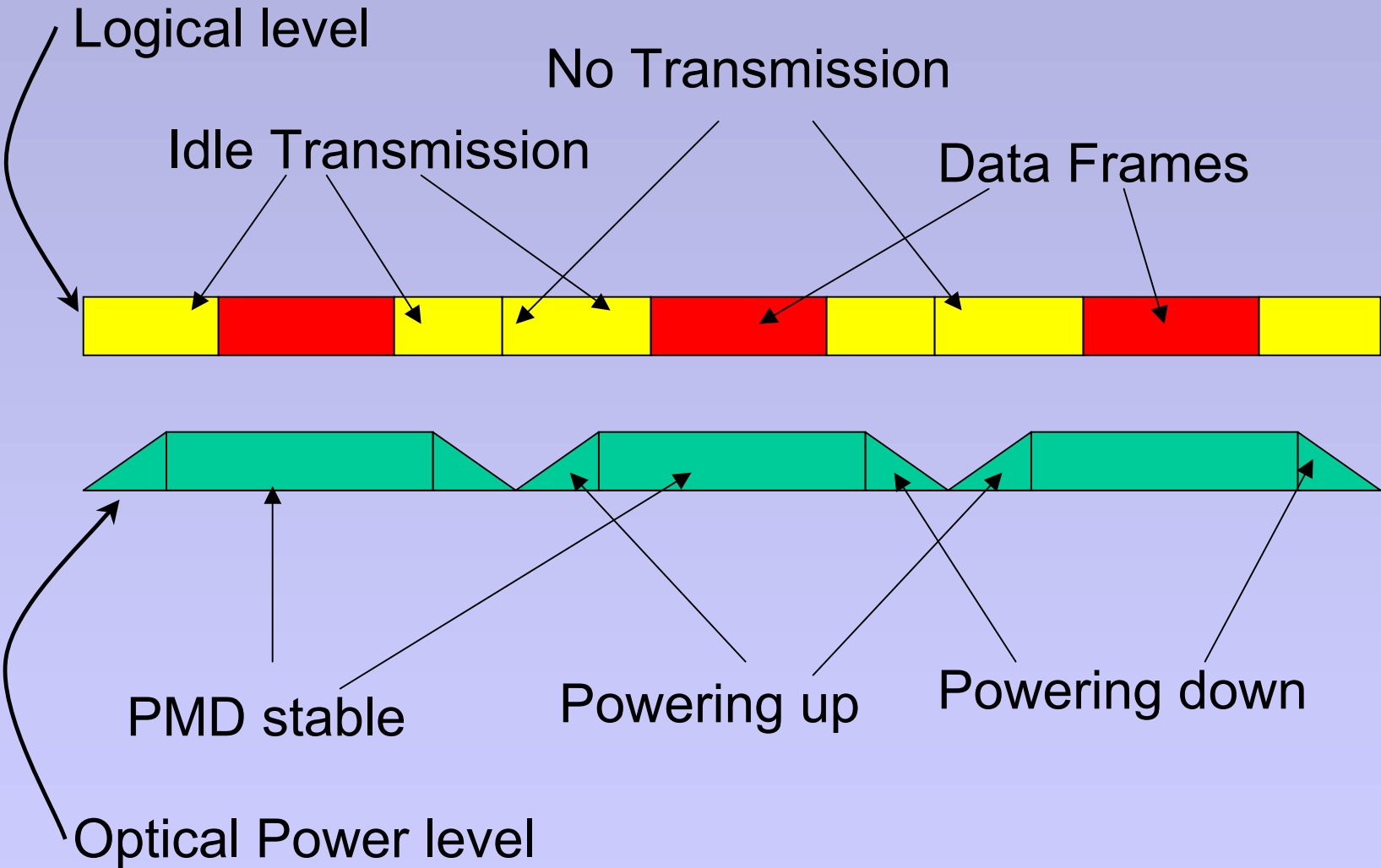
# RTT Compensation Illustrated



Counter = T0    Counter = T0+DTT    Counter = T1-UTT    Counter = T1

OLT

Time T0

Propagation delay = DTT

Time T0+DTT

Time T1-UTT

Propagation delay = UTT

Time T1

ONU

Counter = T0-DTT    Counter = T0    Counter = T1-DTT-UTT
Counter = T1-RTT    Counter = T1-DTT

# 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**
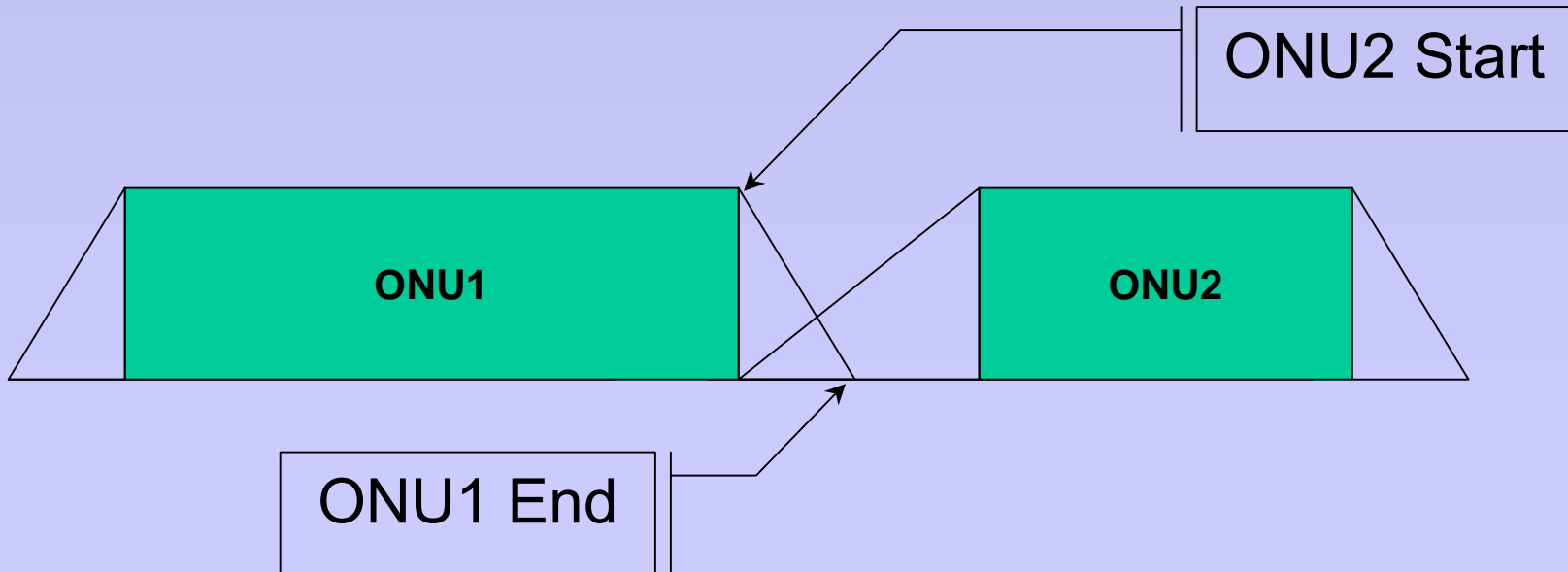
# Transmission Burst

Logical level

Idle Transmission

No Transmission

Data Frames



PMD stable

Powering up

Powering down

Optical Power level

# Reference Points

□ **Start of transmission**

   – Point in time where Laser is turned <span style="color:green">ON</span>

□ **End of transmission**

   – Point in time where Laser is <span style="color:red">OFF</span>

**OLT may overlap transmission windows:**

ONU2 Start

ONU1

ONU2

ONU1 End

# 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**

# P2MP Motion: MPCP Timing

P2MP Track Motion:

Use proposal <haran_1_0302.pdf> as a basis for the first P2MP draft, with the exception of:

- page 13, add bullet: Complete Frames shall be transmitted in a given Grant (no fragmentation)
- page 10, remove "No Transmission"

Motion: Onn Haran

Second: Tom Dineen

Y: __41

N: __0

A: __1