# MPCP
# A Timing Approach

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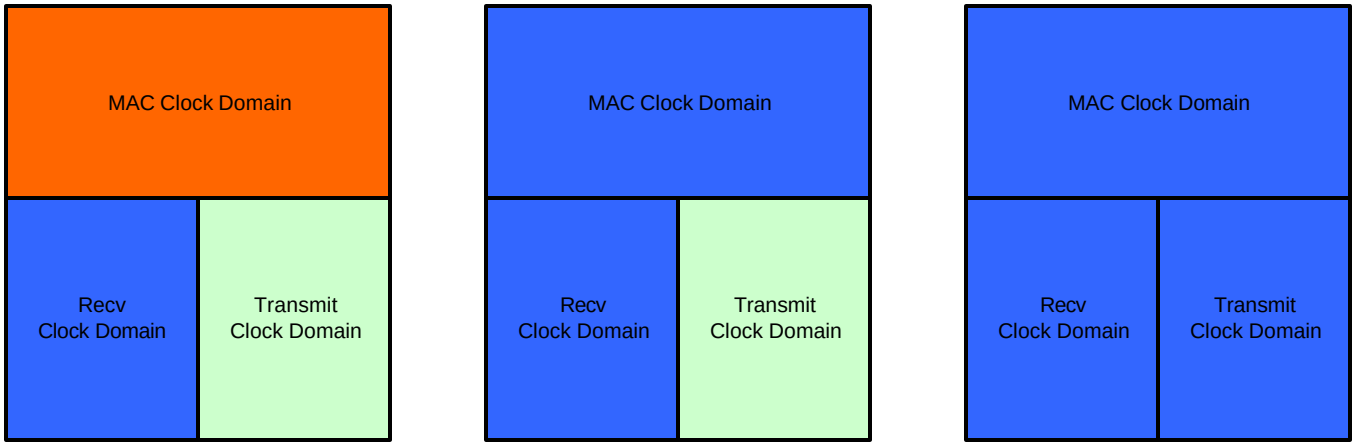
# Timing Function

- **Timing establishes a common notion of when ONUs may transmit**
- **Uncertainty in timing needs to be accounted for in the guard band**
  - Jitter from clock domain shifts
  - Jitter from worst case clock offset
    - Worst case clock offset: 200 ppm (200 KHz)
  - Jitter (not delay) from the time message is transmitted to when it is received
  - Jitter in message processing time

**Only protocol component of the guard time described here**

# Clock Domains



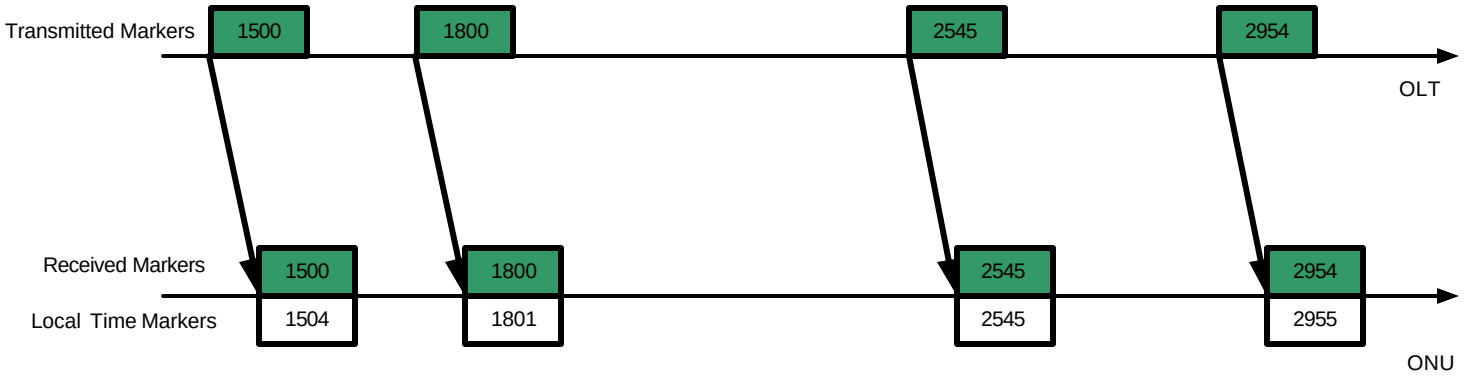

**Asynchronous Clock Domain**

**Downstream Clock Domain**

**Synchronous Clock Domain**

- **Asynchronous Clock Domain: MAC, receive and transmit clocks are asynchronous**
- **Downstream Clock Domain: MAC operation is locked to the OLT transmit clock**
- **Synchronous Clock Domain: MAC operation and transmit clock are locked to the recovered downstream clock**
- **System performance increases from Asynchronous- to Synchronous-clock domains**

# Absolute Timing - Operation

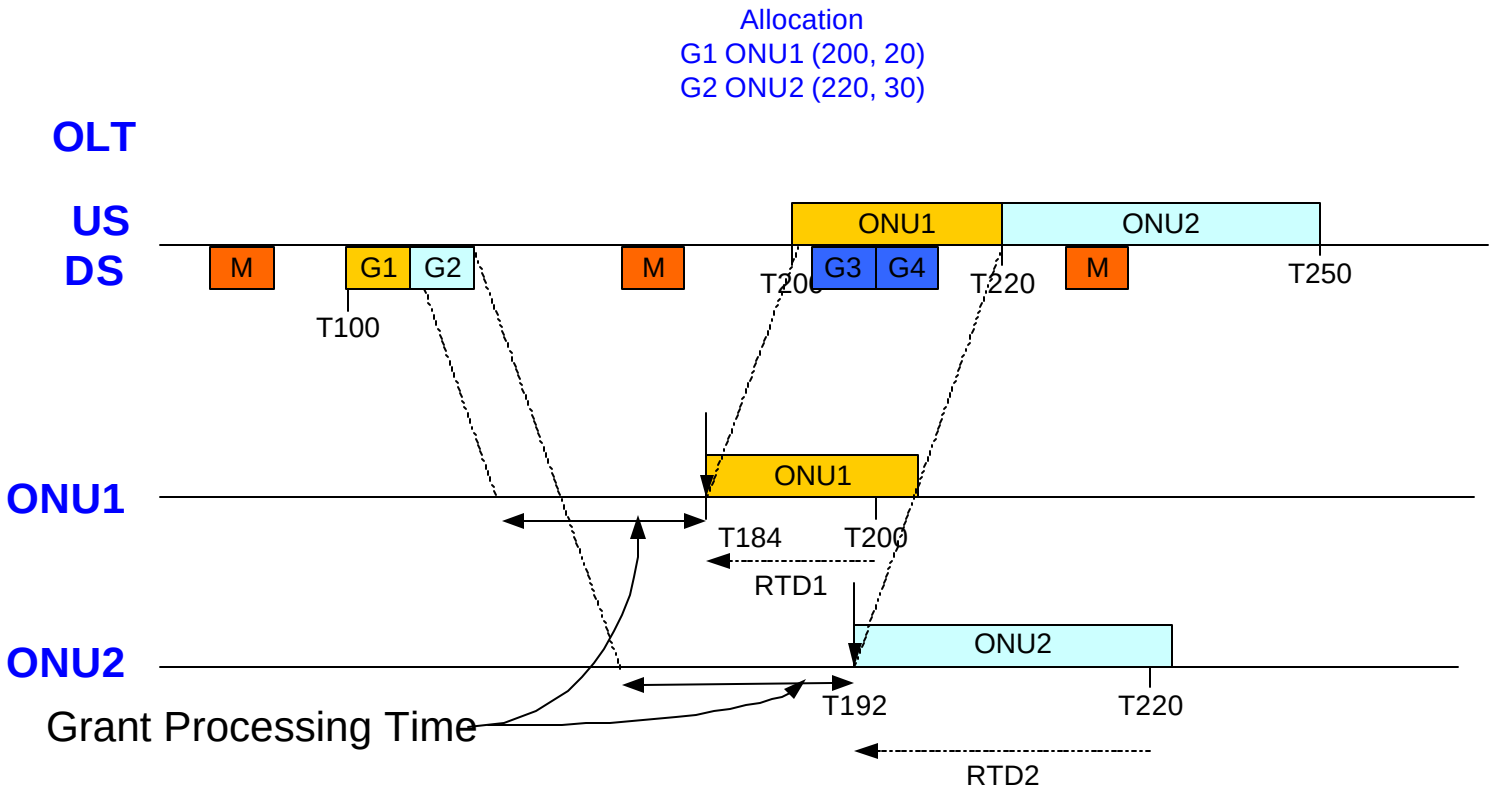



- **OLT periodically transmits a marker**
  - Marker could be a special 10B code word or MAC Control Frame
  - Marker could contain the timestamp of the OLT clock
- **ONU adjusts its local clock to the marker**
  - ONU can update the counter with the received timestamp

# Absolute Timing – Operation (2)

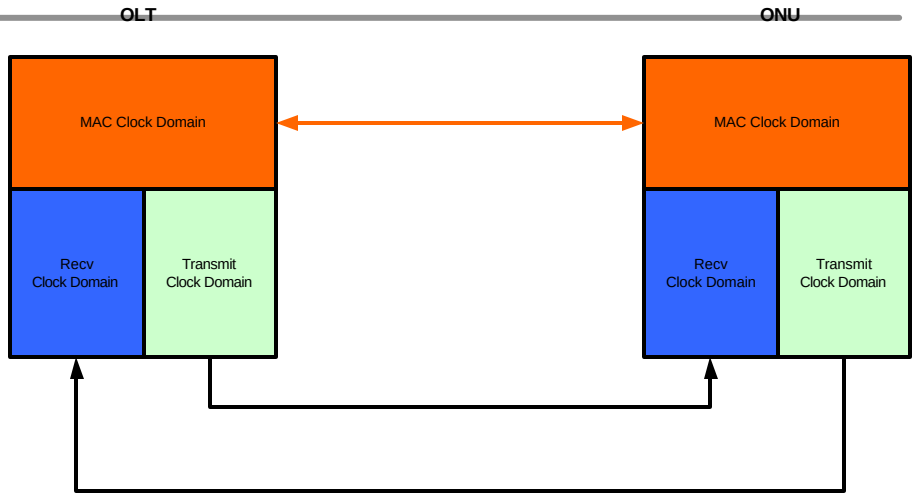
- **The markers are sent frequently**
  - The time between two markers need not be constant
- **Gate messages are transmitted independent of markers**
  - Gate message contains the start time according to clock counter in the markers

# Absolute Timing - Gate Operation




- **ONU's adjust for the RTD and start transmission at time indicated in the GATE message**

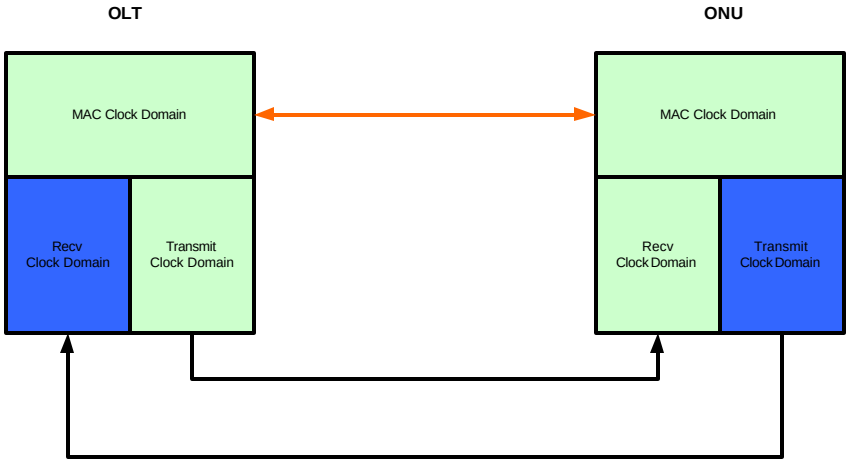
# Asynchronous Clock Domains




- **Synchronization at MAC level**
  - OLT and ONU clocks are synchronized by Marker messages
  - Marker frequency is determined by allowable guard band

# Downstream Clock Domain

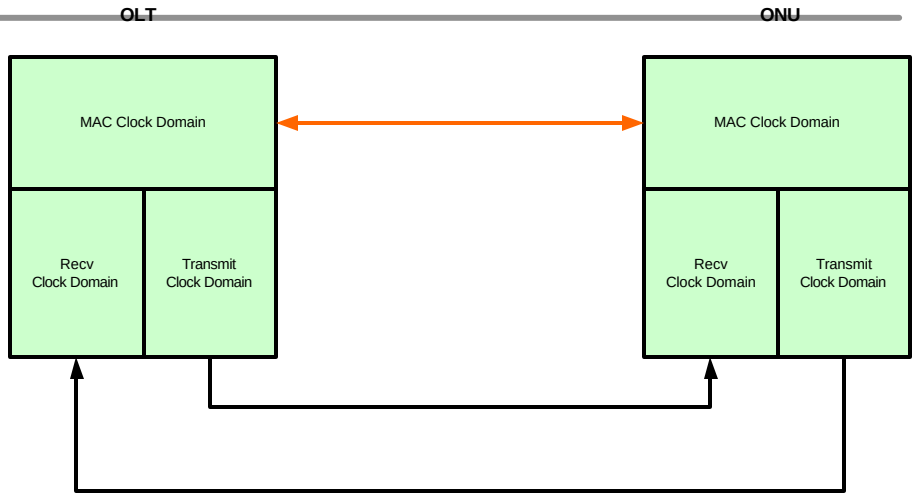
- **MAC Control operation in OLT is locked to transmit clock**
- **MAC Control operation in ONU is locked to receive clock**
- **OLT and ONU are synchronized through the receive clock**
- **Reduction in uncertainty leads to smaller guard band**




- **Absolute timing**
  - Marker message needed to match up counters once

# Synchronous Clock Domain

- **The complete system is locked to OLT transmit clock**




- **Operation of both options similar to downstream clock domain case**

- **Save a little more in guard band**

# Absolute Timing – Pros/Cons

- **Pros**
  - Simplifies system operation
    - Simplifies the OLT operation
      - It decouples the gate transmission and timing
      - Gate msgs pass through the MAC control without modifications
      - Gate msgs can reach the ONU much ahead of transmission time allowing software implementation
      - OLT does not maintain ONU state in MAC control
    - Adds two additional registers in ONU
  - Keeps the gate allocation mechanism independent of the protocol operation
  - MAC Control operation is independent of Phy clock

- **Cons**
  - Markers must be sent periodically
  - Generates a Marker frame in real time or interrupt downstream transmission to send Sync

# Summary

- **Three clock domain models presented**
  - Asynchronous clock domain
  - Downstream clock domain
  - Independent clock domain
- **Which clock domain model fits better in Ethernet architecture?**
- **Absolute timing approach simplifies the overall system operation**