A Flexible Architecture for EPON

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Goals

- Agree on a common architecture
- Minimal augmentation to operate 802.3 in PTMP topology
- Maximize commonality with point-to-point topology
- An architecture is proposed together with examples of algorithms.
- Recommendation of specific algorithms is next step

Highlights of the Architecture

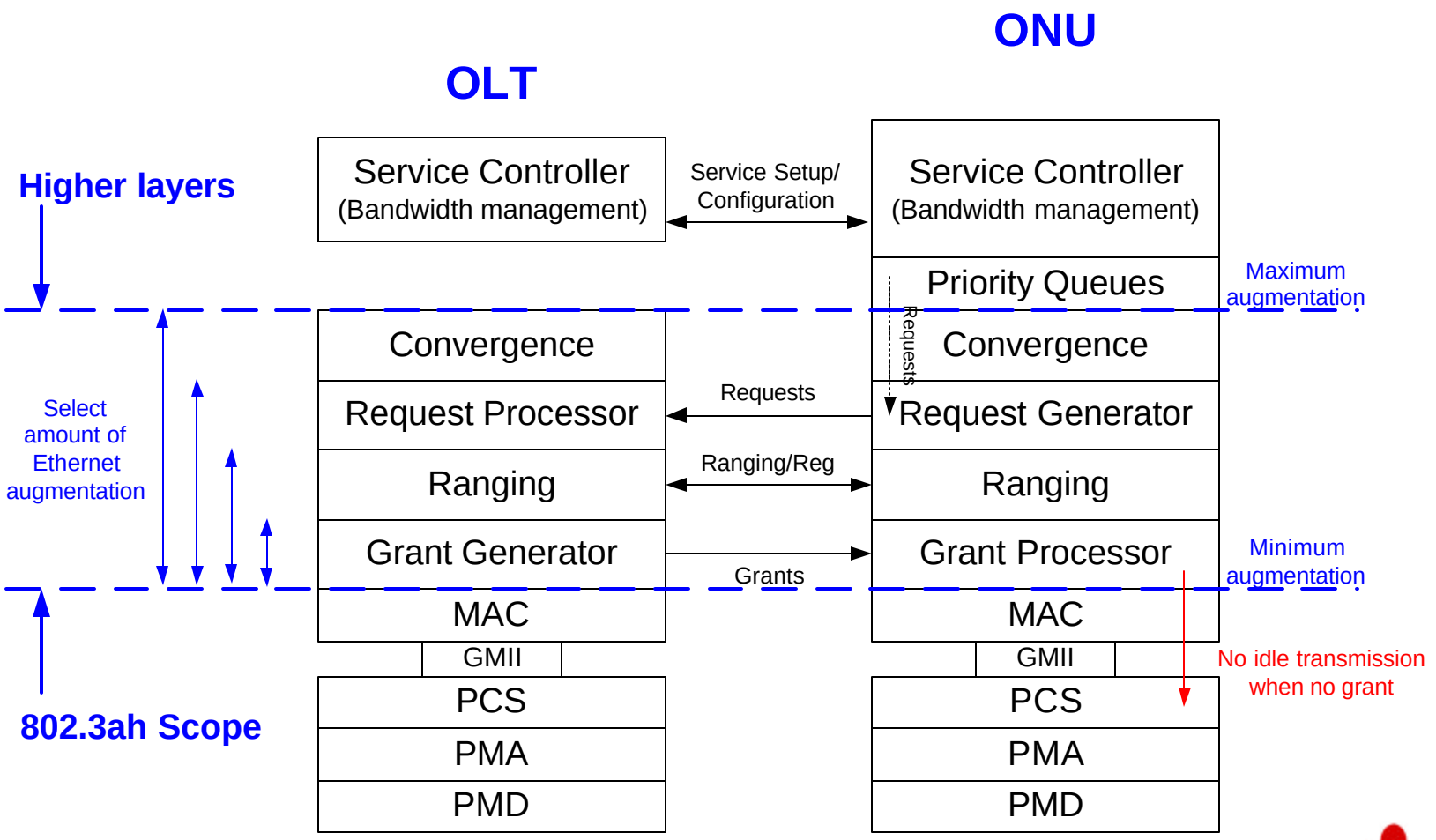
- **Defines a centralized sharing system on top of Ethernet MAC**
  - Defines a gating mechanism between MAC and MAC client that controls how and when frames are presented to the MAC layer for transmission
    - Adds functionality at or above MAC-control layer
    - Amount of augmentation is flexible and can be decided based on desired interoperability level
  - Adds hooks to gate PHY transmission of idles to control the burst mode operation
  - No need of any new timing unit (I.e., slot, cycle,..) in PHY
  - Solves compatibility issues by filtering frames
- **Minimum augmentation of PHY**
- **Allows a unified PON and PTP transceiver ***

  * Transceiver includes layers above PMD to MAC-control

Terminology

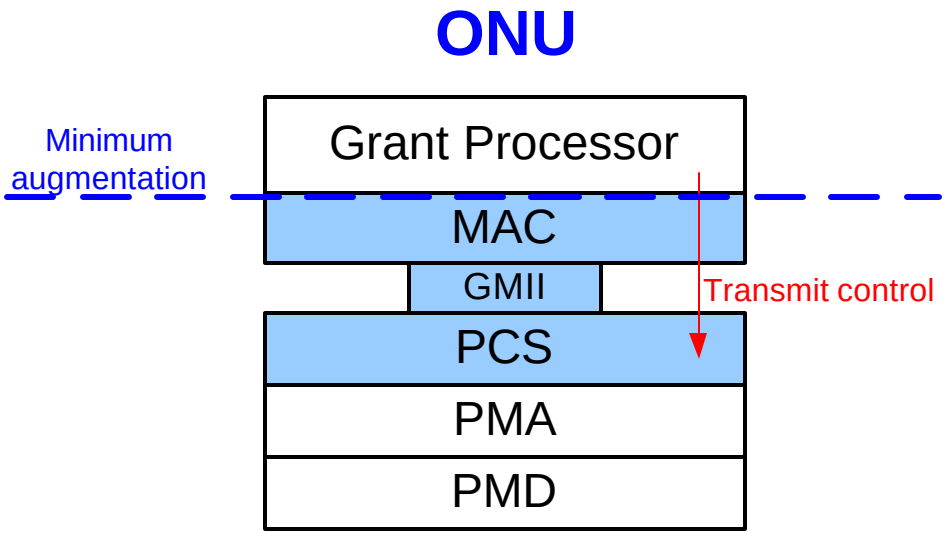
- OLT (Optical Line Terminator): Controller device at the central office of the EPON
- ONU (Optical Network Unit): Subscriber device in an EPON
- Allocator: OLT function that assigns bandwidth to ONUs in the EPON
- Service controller: Function to manage, monitor and control the services provided at the link level of the EFM network.
- Grant: Specifies an interval during which an ONU may transmit
- Grant request: Request for a grant sent by an ONU to OLT

High Level Architecture

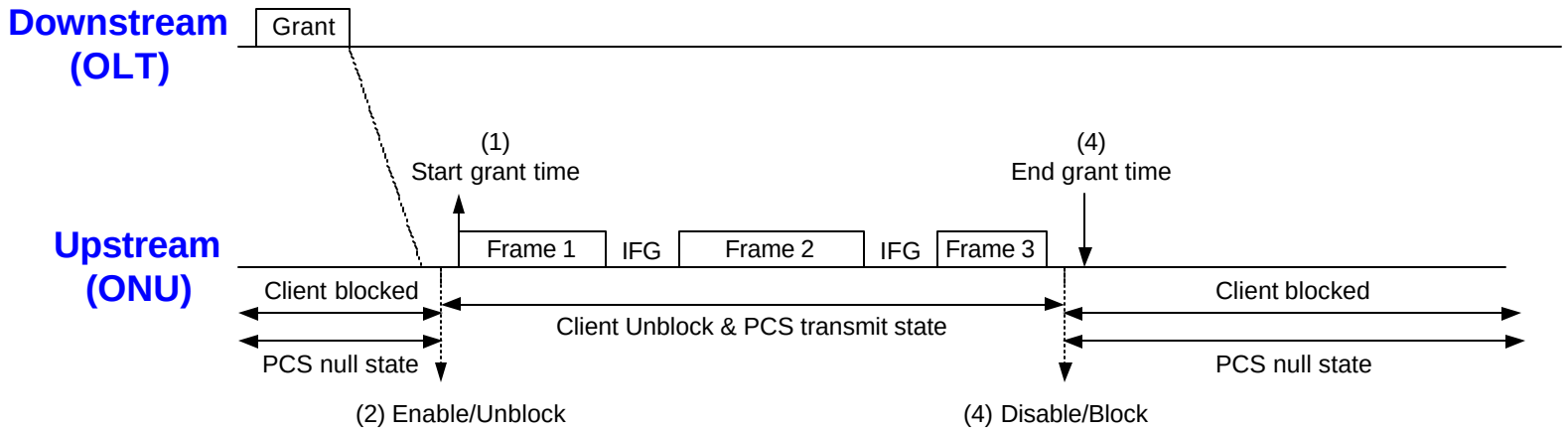


Minimum Augmentation

- **Define a burst mode operation to control ONU transmission (i.e., stop idle transmission when not allowed to transmit)**
  - PCS is configured in null state (no idle transmission)
  - PCS moves to transmit state during transmit period
    - Idles are transmitted between frames within a burst

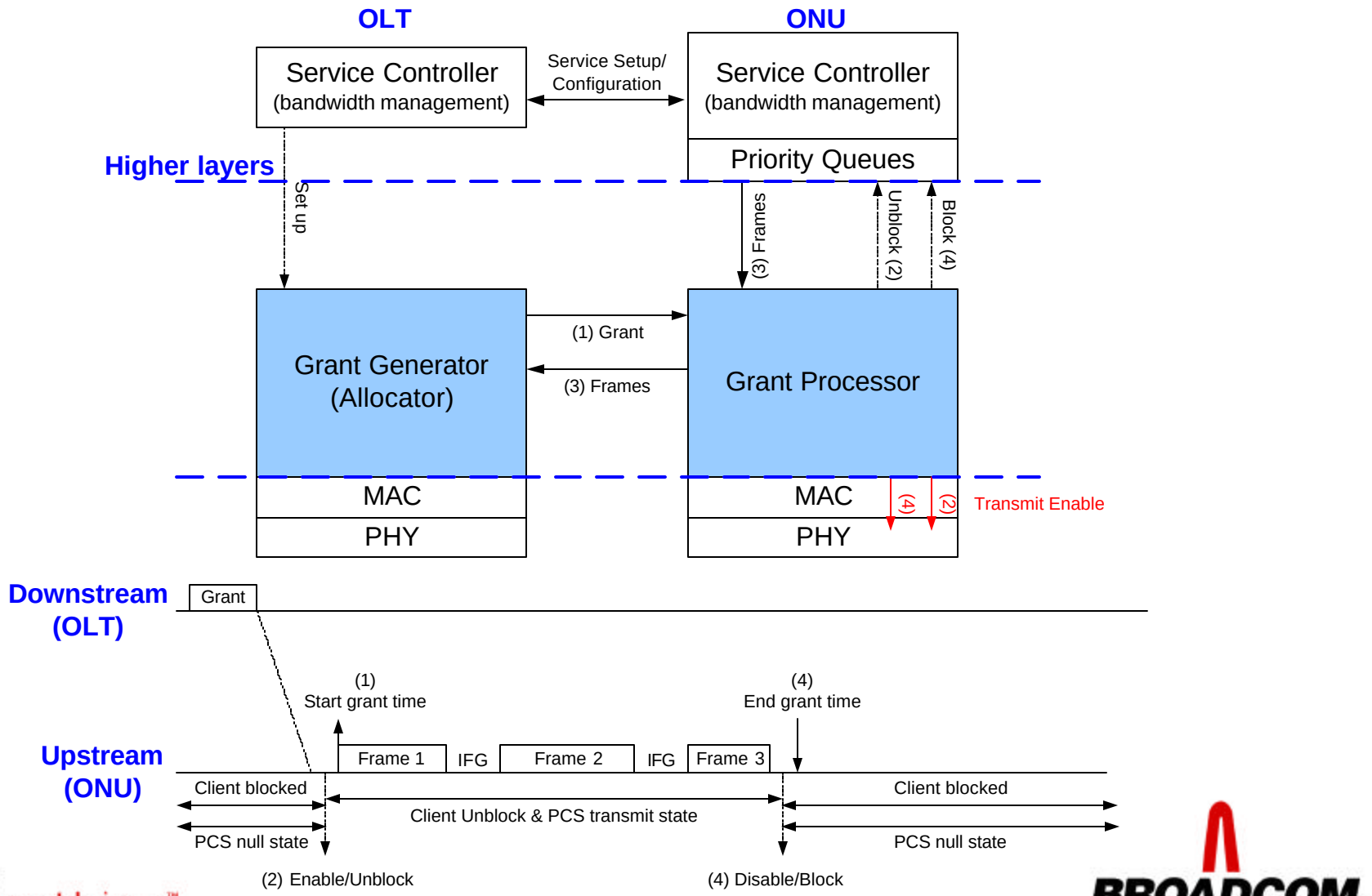


Upstream Burst Mode Operation



- **Implementation example:**
  - Propagation of transmit time from MAC-control to PCS
    - Start of transmit
      - Set Tx_enable signal, maps to
      - Wait signal in MAC, maps to
      - TX_EN, TX_ER reserved configuration
      - Change state of PCS to transmit state
    - End of transmit
      - Reset Tx_enable signal, maps to
      - Reset wait signal in MAC, maps to
      - TX_EN, TX_ER reserved configuration
      - Change state of PCS to null state

Granting Mechanism



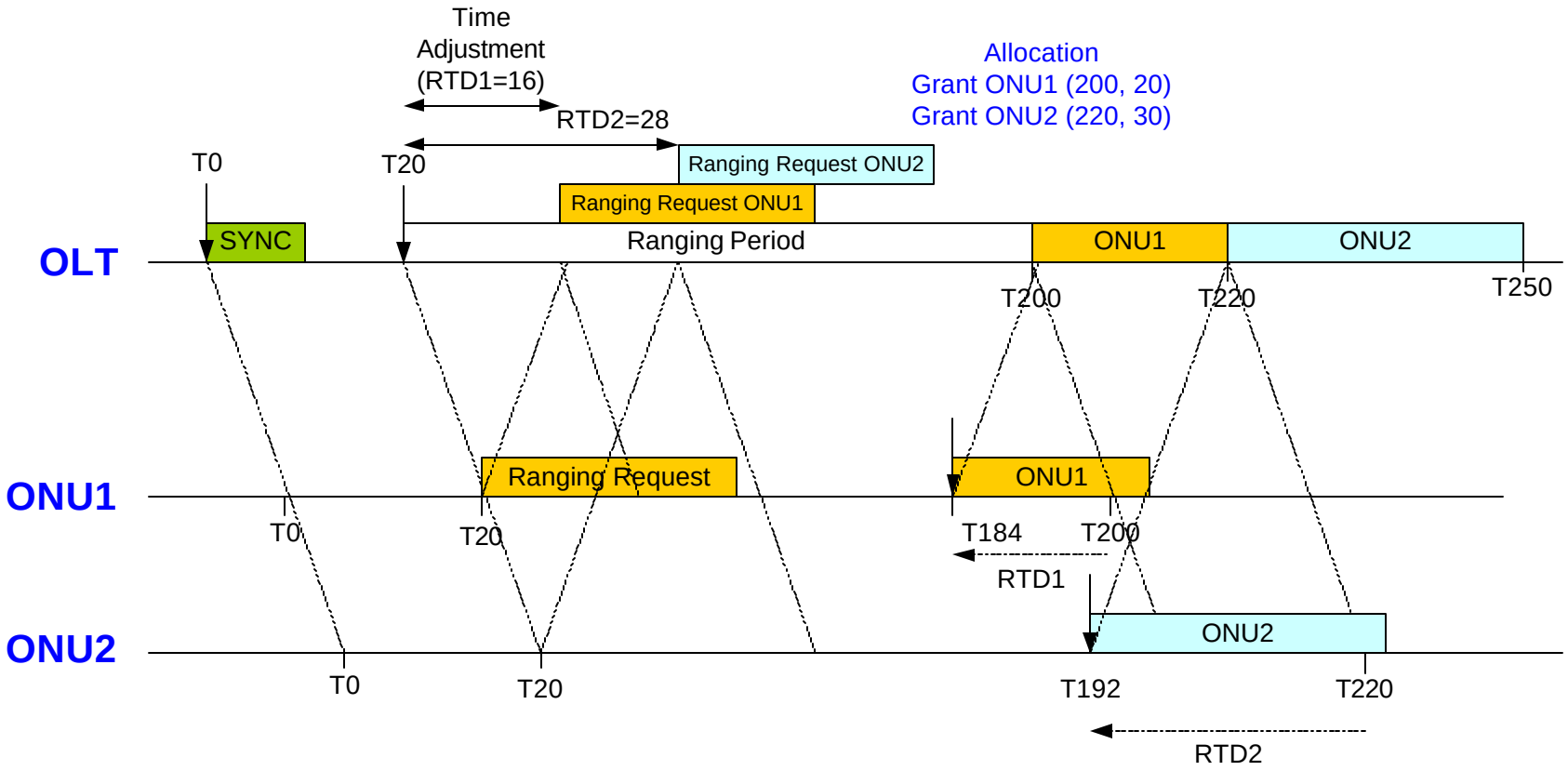
Basic Operation

- **OLT arbitrates access by assigning bandwidth**
  - The OLT informs the ONUs of grant assignments
    - A grant specifies the size of a region.
    - Regions dedicated to a particular ONU are specified with unicast grants
    - Ranging can be specified with broadcast grants (I.e., contention-based region) in order to allow plug-and-play of unknown ONUs
  - The allocator is the OLT algorithm that decides the grant assignments
    - It must guarantee that grants assigned to individual ONUs do not overlap
    - It must reserve ranging regions to allow new ONUs to join
    - The particular algorithm is vendor specific and does not need to be standardized
- **ONUs transmit in assigned regions as specified in the grants**
  - ONU gates transmission (frames as well as idles) based on grants:
    - All transmission is blocked when no grant
    - All transmission is open during grant periods (idles occur during IFG)
  - For robustness, the ONU does not transmit unless it receives the explicit grant for the region
  - ONU MAC client decides what frames to transmit in each particular assigned grant
  - ONU can request more grants as needed

Ranging

- **Ranging is the process of measuring the differences in round-trip delay between ONUs and OLT to prevent overlapping transmissions**
- **All devices (OLT and ONUs) in the network are synchronized to a common time reference**
- **The OLT clock is the common time reference.**
  - OLT periodically broadcasts the clock timing (SYNC)
  - ONUs take this time as local time and adjust for round-trip delay (RTD)
  - Ranging process is used to estimate the time offset
- **Example of Ranging Operation:**
  - OLT allocates grants for ranging
  - ONU initiates ranging, sends a ranging request
  - OLT computes round trip delay (RTD) based on arrival time of request within grant
  - OLT sends to the ONU a response indicating the compensation time

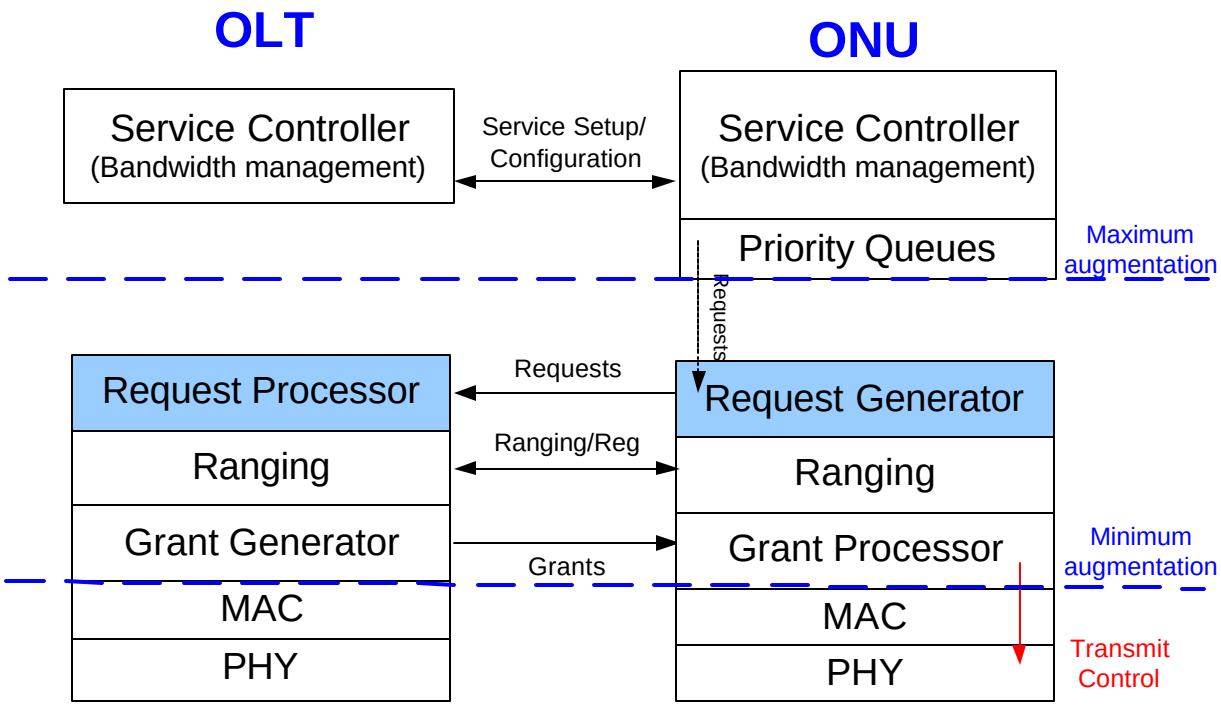
Ranging Example



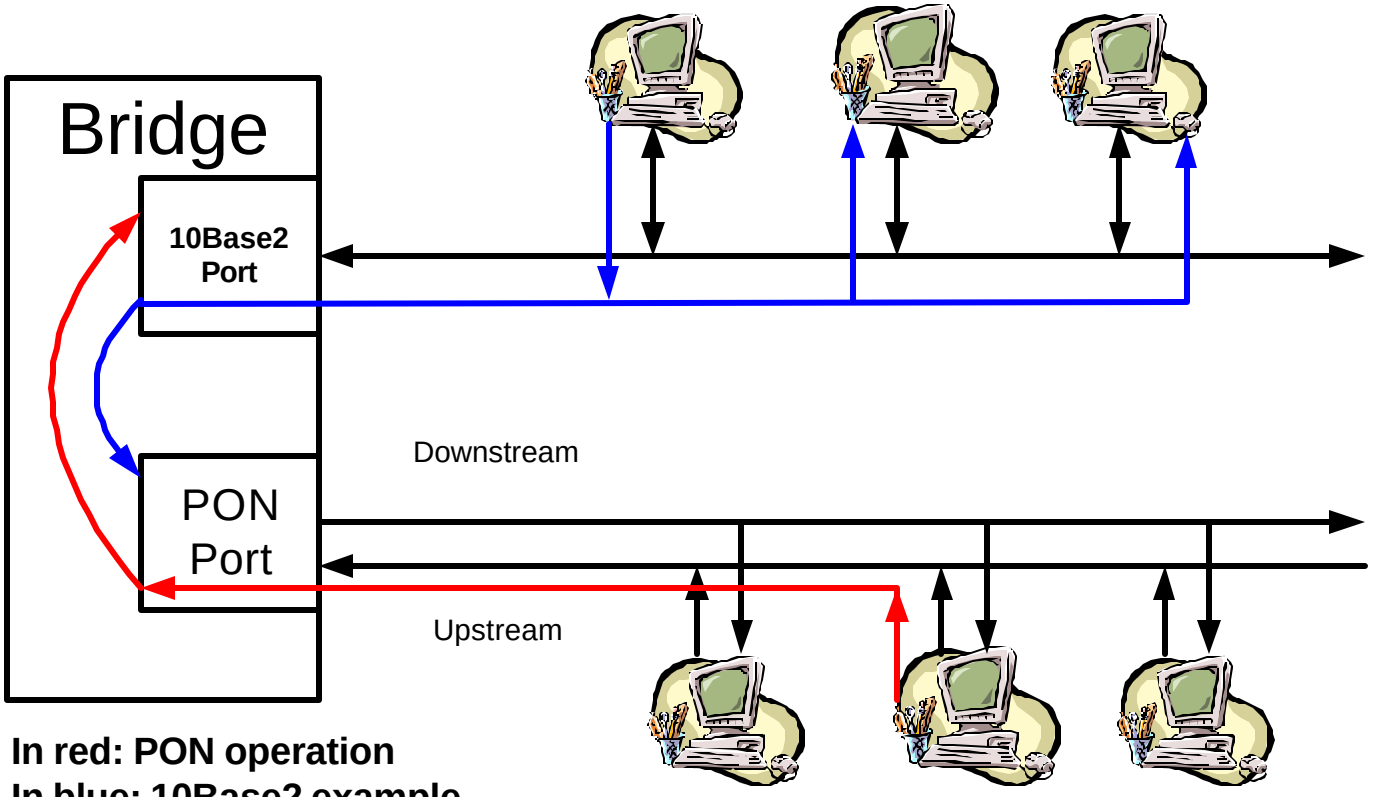
Note: SYNC and ranging request can be done at the same time

Request Mechanism

- **The request mechanism is used to timely update the OLT of the ONU state so that OLT can dynamically adapt the bandwidth assignment**
  - Request messages are generated by ONU and used by the OLT allocator



Convergence Issues



In red: PON operation
In blue: 10Base2 example

Convergence Layer

Convergence is supported by filtering mechanisms:

- **Upstream broadcast frames**
  - OLT filtering layer mirrors back the broadcast frames received on the upstream to the downstream
  - ONU filtering layer checks source address of broadcast frames and forwards only those with unknown address
- **Peer-to-peer communication**
  - OLT filtering layer forwards frames with destination address on the PON side to the downstream
- **Flow control:**
  - PAUSE of an ONU on the upstream is done through the allocation of grants
  - PAUSE of the OLT downstream transmission to an ONU
    - OLT must interpret PAUSE as unicast and must only PAUSE the ONU indicated in the source address

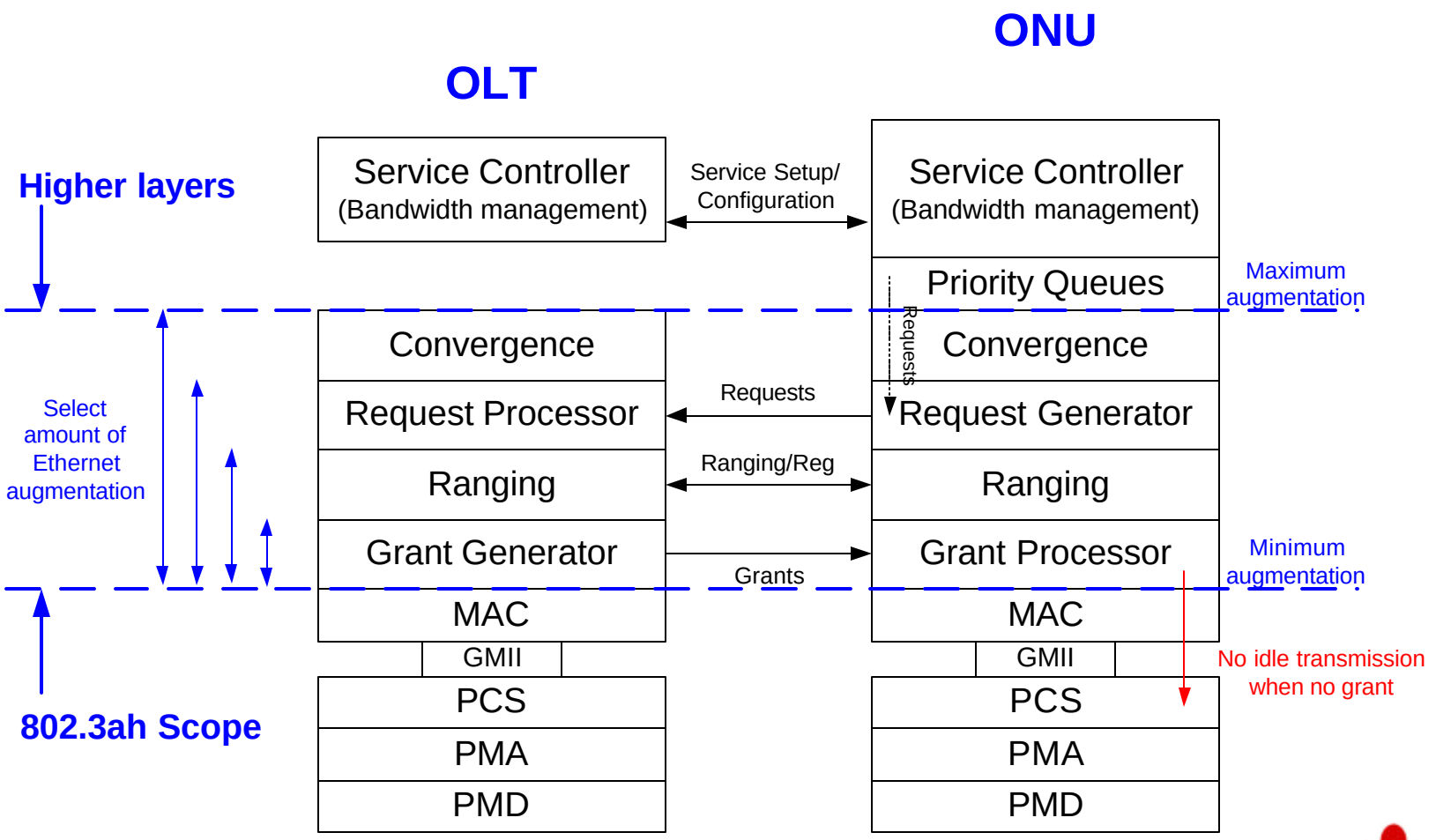
Properties of Proposed Compatibility Solution

- **Compatibility is not a physical layer problem**
  - No need for new concepts like physical layer addresses
- **Retains 802.3 frame format on the wire**
- **Buffering frames in physical layer is not needed**
- **It can share filtering tables with 802.1 bridging tables if 802.1 is implemented**

Specification

- At this stage, agreement on architecture is most important
- However, some example descriptions are available

High Level Architecture



Summary

- **A flexible architecture with minimal augmentation of MAC and PHY is proposed**
- **It enables a single transceiver for PTP and PTMP topologies**
  - No additional PHY headers nor additional framing
- **Extended functionality added on top of existing 802.3 framework**
  - Amount of augmentation added to be decided by 802.3ah committee based on level of interoperability desired.
    - Minimum augmentation specifies the upstream burst mode operation
  - Additional functionality can include:
    - Grant mechanism
    - Request mechanism
    - Ranging
    - Compatibility Layer
    - Link Security (not discussed here)

Recommendation

- **Agree on high level architecture first**
- **Specify the following functions**
  - Request/Grant mechanism
  - Ranging
  - 802 Convergence
- **Define a PON control layer with the above functions**
- **PON control layer should be placed above the MAC**