EPOC Upstream Mapping

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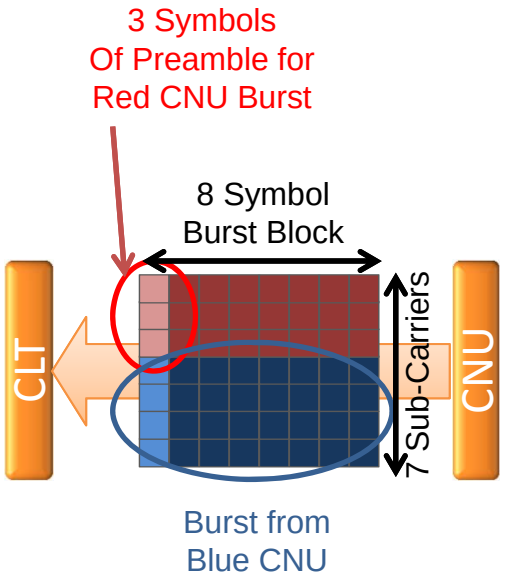
Overview

- This presentation is a baseline proposal for mapping the EPON's one dimensional GATE times to EPoC's two dimensional OFDMA Upstream.
- This presentation is a continuation of the subject from the EPoC study group presentations for technical feasibility.
- This solution provides a fixed delay and fixed efficiency for the upstream.
- This solution does not require the EPoC PHY to make modifications to the REPORT or GATE frames currently used by the EPON MAC.

Disclaimer

- The drawings in this presentation show upstream bursts carried in fixed sized blocks with multiple symbols.
  - The burst blocks contain multiple data carrying symbols with 1 or more preamble symbols.
  - This is the most challenging scenario to describe and it makes a colorful picture.

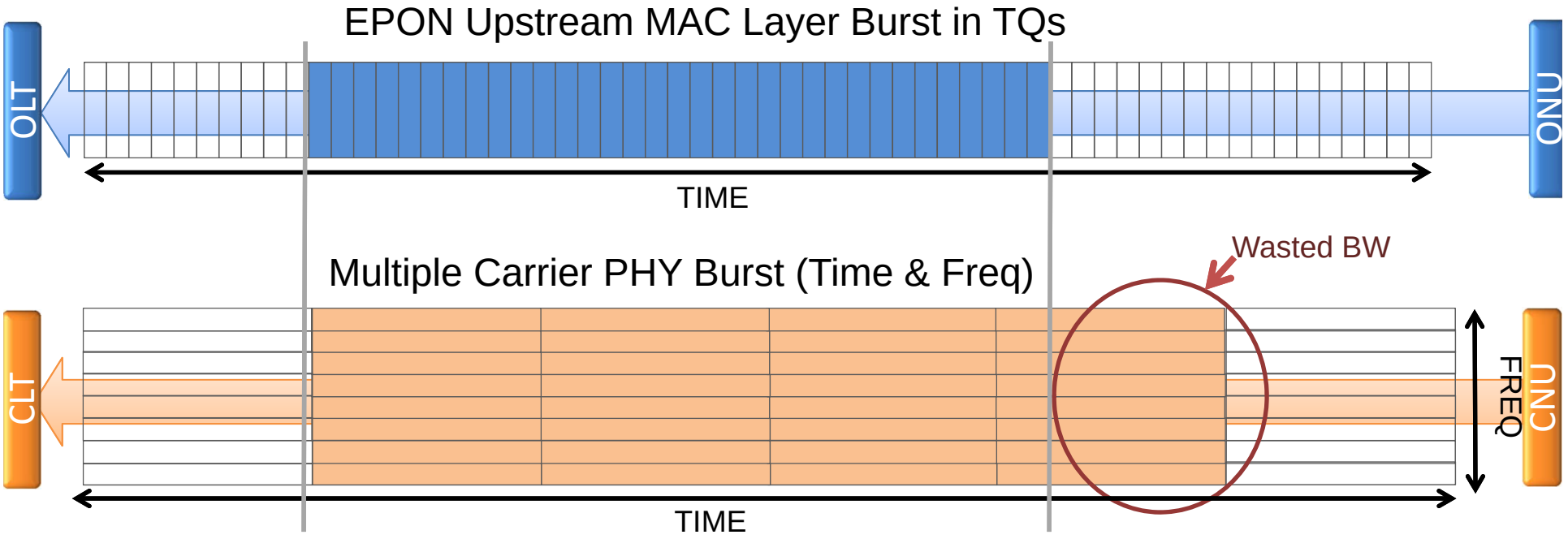


- The need for preamble symbols, the number of symbols in a burst block, and the size of the upstream symbols are not discussed in this presentation.

- This methodology described can be used with single symbol blocks, multiple symbol blocks, or any number of preamble symbols (including 0).

This presentation does not attempt to advocate or justify any particular PHY layer parameters.

True TDMA (Direct Mapping)

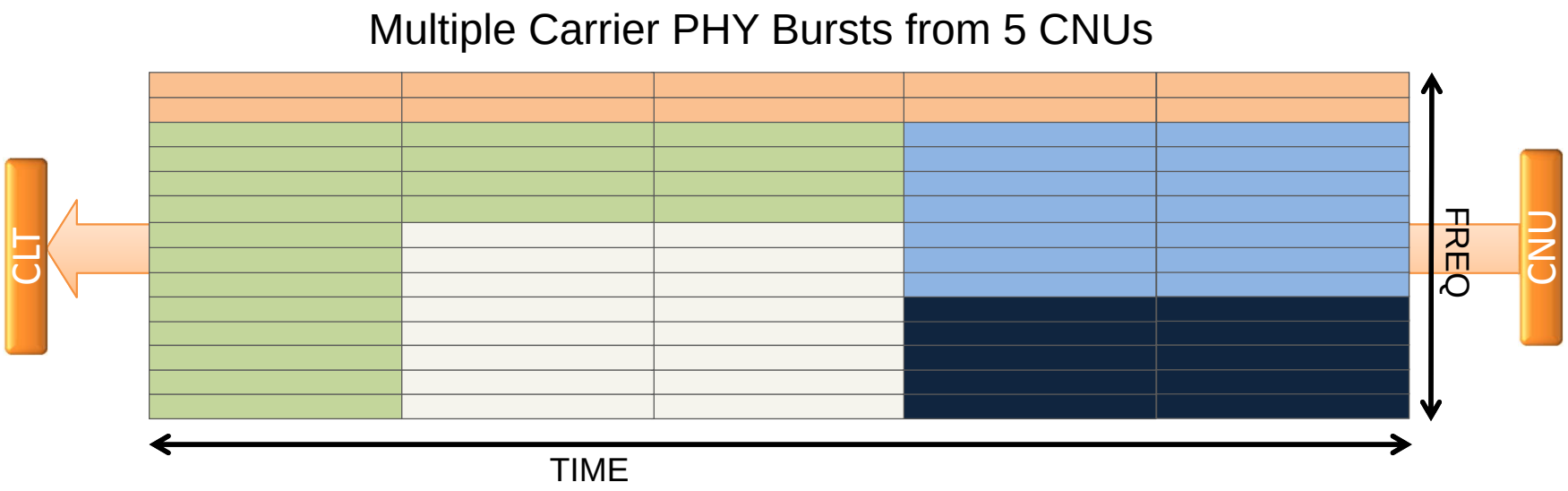


Why Can't we directly map TDMA onto the RF PHY?

- EPON MAC Layer bursts are mapped across ALL sub-carriers.
- Symbol is unit of granularity for PHY.
- Short Symbols can have reasonable granularity and efficiency. (e.g. 1us @ 1Gbps = 125 Byte granularity)
- Long Symbols will have poor granularity and efficiency. (e.g. 20us @ 1Gbps = 2500 Byte granularity)
- Since Longer Symbols maybe required to achieve BER or provide narrower frequency control, a more complicated mapping will be considered. (The symbol size is a discussion for another presentation)

Direct TDMA will be too wasteful for Long Symbol PHYs

Two Dimensional Scheduling



- Multiple transmitters share a symbol but occupy different carriers.
- Different delays and efficiencies can be achieved by allocating different shapes
  - High Latency, High Efficiency (Orange Burst) has burst overhead for 2 carriers but longer delay
  - Low Latency, Low Efficiency (Blue Burst) has burst overhead for many carriers but data burst completes much sooner.
- Significant complexity is added to the PHY layer and MAC layer to support a fully flexible 2 dimensional scheduler.
- Bursts will arrive with different delays; Filling complex shapes is more difficult for the transmitter; The receiver must handle a complex mapping; The receiver must buffer data from multiple streams as they come in.

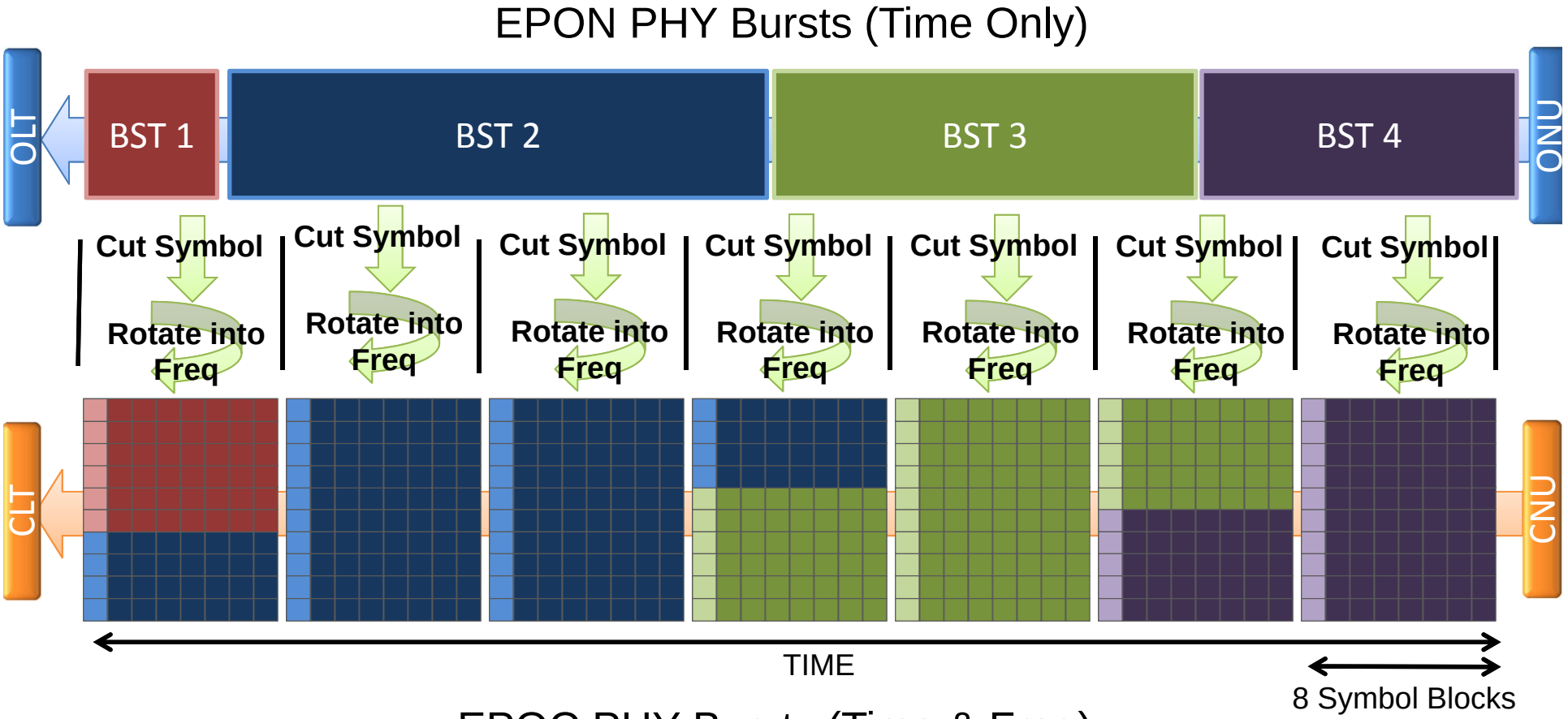
X The Ethernet MAC doesn't support a multiple path PHY layer. (e.g. Orange starts before white and finishes after it)

X Constant overhead and delay in the PHY layer is expected by higher layer protocols.

X EPON OLT schedulers and EPON MACs are one-dimensional

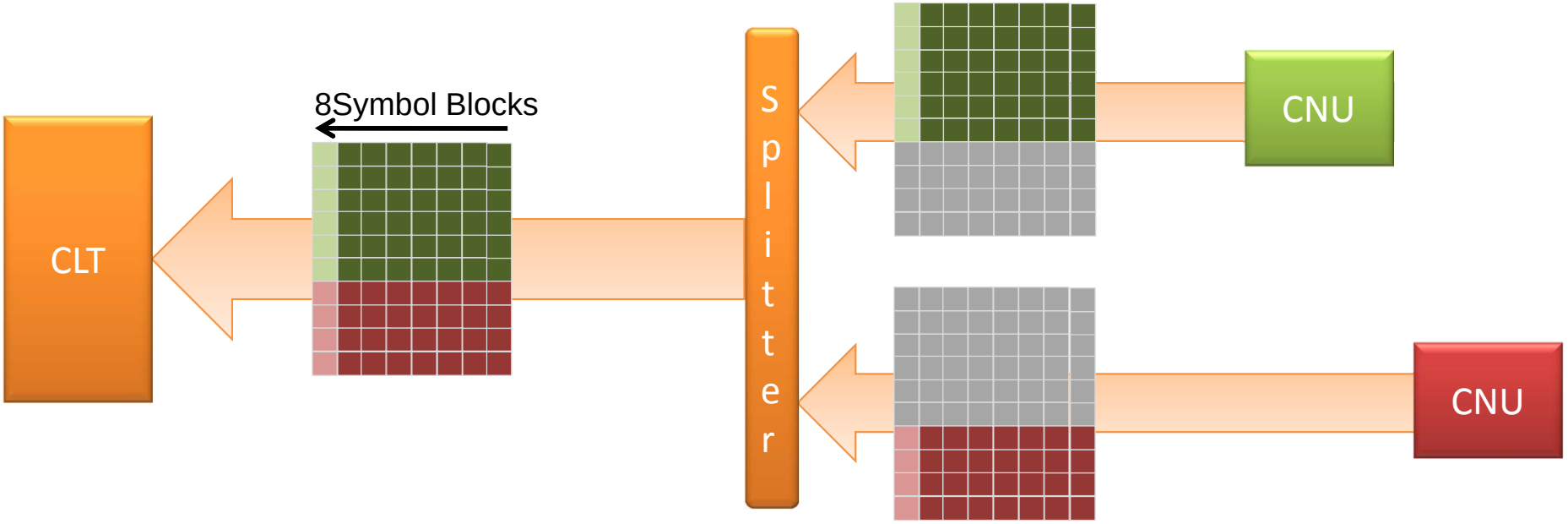
We need a simpler solution that fits with Ethernet

Rotating Bursts from Time to Time & Freq



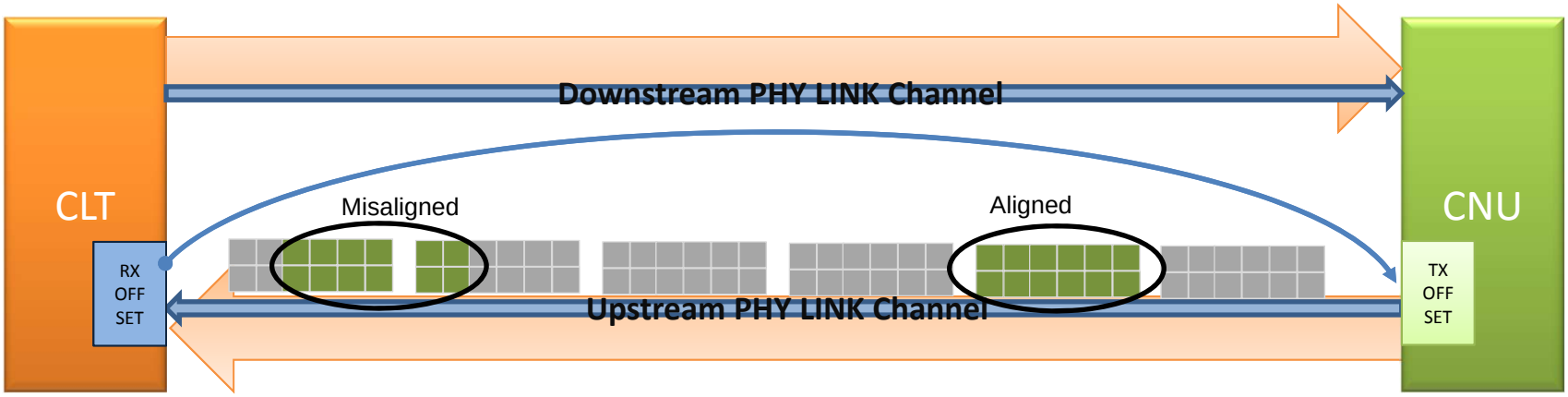
- TDMA EPON GATEs are mapped into time and frequency at symbol block boundaries.
- Symbol blocks are divided in frequency by allocating a subset of sub-carriers to bursts sharing the symbol time.

Upstream Symbol/Burst Alignment



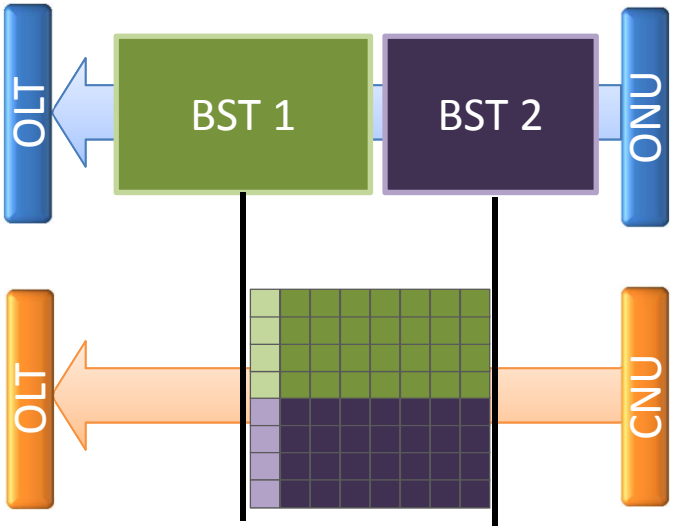
- CNUs must transmit in different symbols or sub-carriers in a symbols to avoid collisions. [Small # of guard band carriers assumed but not shown]
- The CLT PHY must receive all symbol blocks with common alignment.
- CNU PHYs need frequency & phase alignment so symbol blocks are aligned at the CLT PHY. (within EPON 8 TQ jitter limit should be fine)
- MPCP Discovery will provide delay compensation to guarantee unique time slots but it will not align the symbol blocks.
- The CNU PHY must be aware of symbol block boundaries.

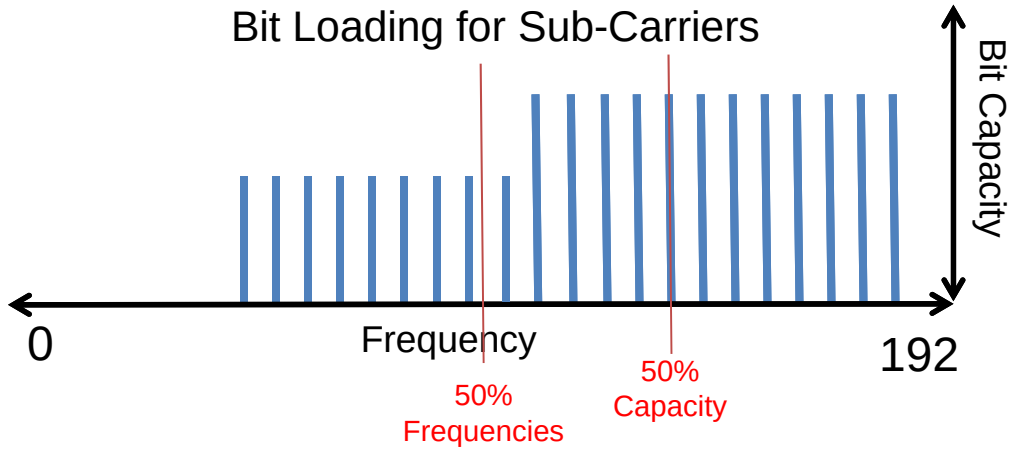
PHY Link for Symbol Alignment



- CNUs find and receive the downstream PLC.
- All CNUs have frequency lock for upstream symbol block timing from downstream PLC.
- CNU is configured with size of upstream symbol block from PLC.
- CNU delineates upstream symbol blocks without random phase at startup.
- CNU responds to Broadcast PHY Link on Upstream PLC aligned with CNU symbol burst boundary.
- CLT measures phase offset of Broadcast PHY Link response and sets offset for CNU to correct alignment.
- All CNUs have a common symbol block boundary after PHY Link completes.

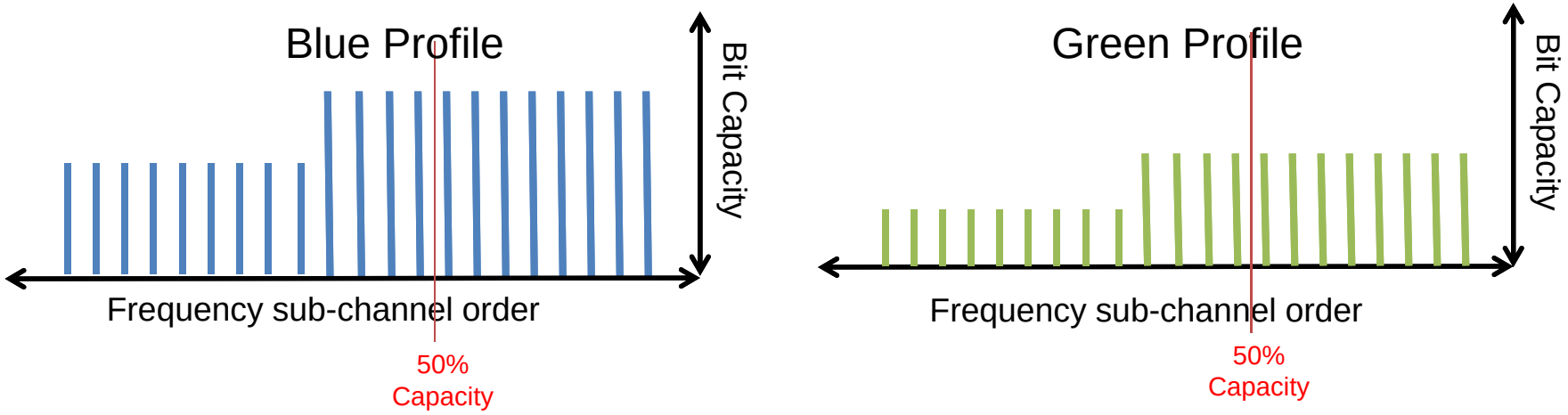
Time to Frequency Conversion





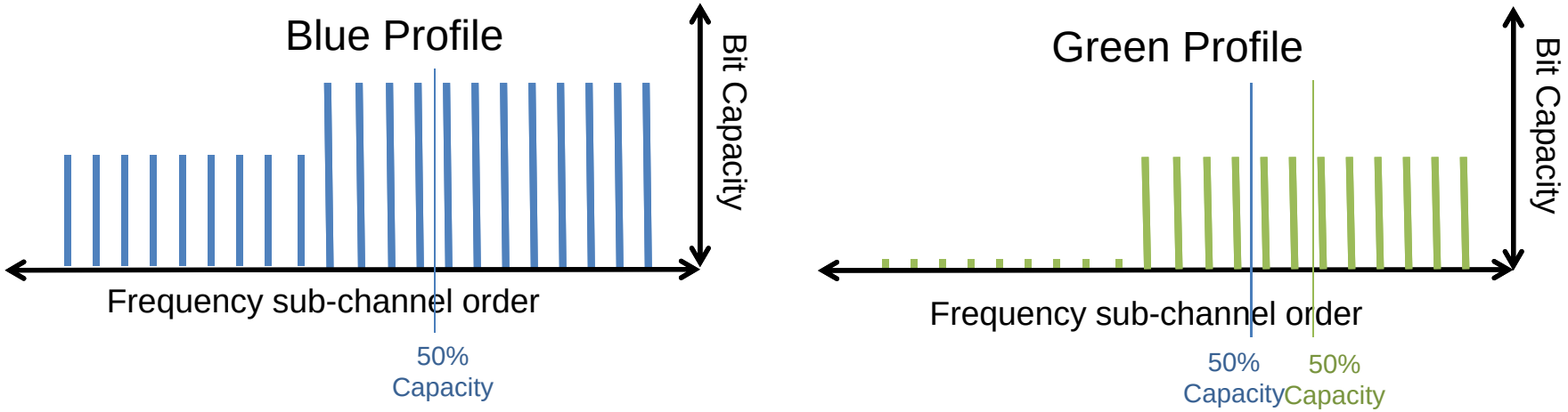
- Bursts boundaries not on symbols block boundaries will split sub-carriers within the symbol block.
- Directly splitting sub-carriers within the symbol block proportional to time will not equally split capacity.
  - For example, Burst 1 ending at 50% of symbol time is mapped to sub-carriers for 50% of the spectrum.
- Sub-carriers within the symbol block must be split based on the carrying capacity of symbol block.

Supporting Two Upstream Profiles



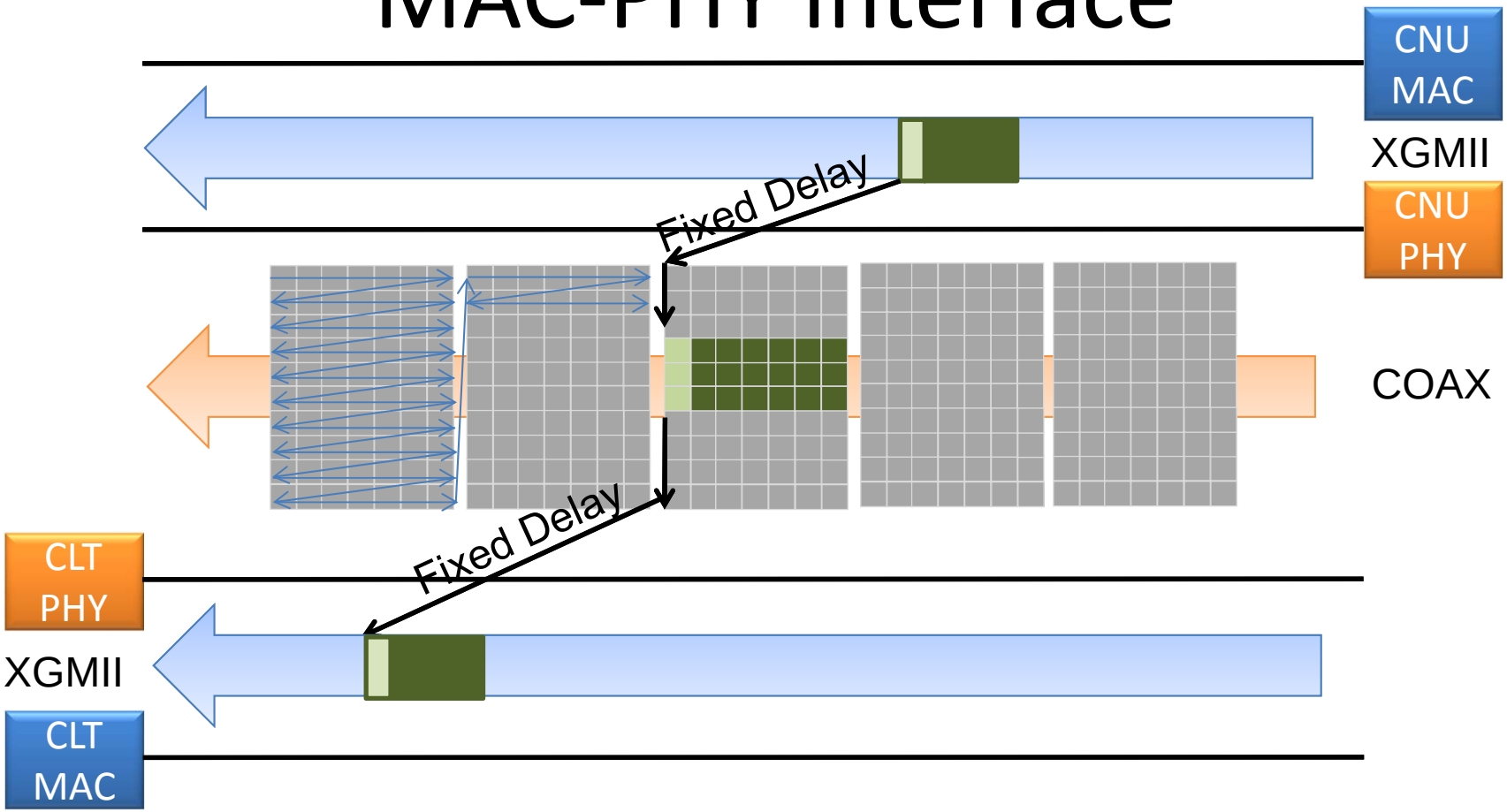
- CNUs determine their average data rate by dividing the total carrying capacity of the symbol burst block by the time of the symbol burst block.
- CNU use the average data rate to convert bytes to Time Quanta.
- If 2 CNUs have different modulation profiles due to different SNR, they will have different average data rates.
- These CNUs will request different time slot size from the OLT based on the average data rates.
- If the 2 profiles are only proportionally different, they will have the share the same carriers for a given percentage of capacity.
- In this scenario, only different average data rates per CNU are required to support different profiles.

Shuffling for Multiple Profile Support



- If the profiles have very different distributions, the percentage of capacity positions can be very different.
- Differences in the percentage capacity require additional overhead between bursts.
- To minimize the differences, the data loading/unloading order into the carriers can be modified to be better align the capacities.
- In the example above, the Green profile has nulled carriers at the lower frequencies.
- If the order of loading/unloading is changed to spread the nulled carriers, the percentage of capacity positions would better align so the overhead between bursts would be minimized.

MAC-PHY Interface



- CNU PHY fills or skips upstream sub-carriers at a fixed rate based on capacity.
- CNU PHY places frame into sub-carriers and symbols based on fixed delay from packet start on CNU XGMII from MAC.
- CLT PHY releases data to CLT MAC based on fixed delay from symbol and sub-carrier location to CLT.

Conclusions

- Translating TDMA Grants to long symbols or blocks of symbols can be accomplished in the EPoC PHY without changes to the EPON MAC.
- PHY Link can provide symbol block alignment for the EPoC PHYs.
- If required, solutions exist for supporting multiple upstream profiles.
- EPoC should adopt TDMA-to-2D Mapping