EPOC Upstream TDMA Slot Mapping

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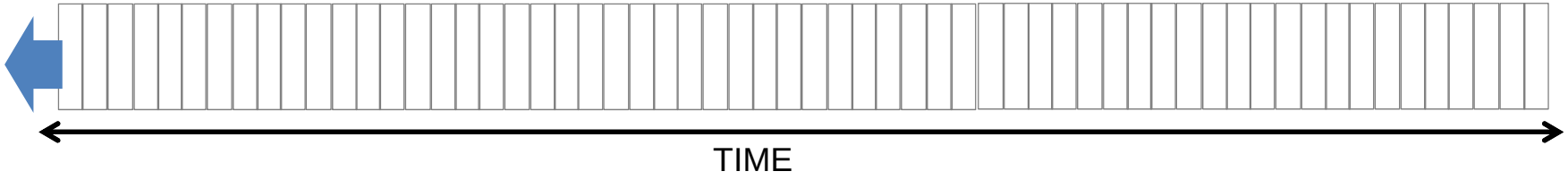
Overview

- There was concern that the EPON MAC with a one-dimensional TDMA Scheduler is not feasible for EPoC.
- These slides show that a simple mapping from the EPON TDMA scheduler to a multiple carrier RF PHY is possible.
- The EPON Scheduler and Ethernet MAC are not required to change to support the EPoC PHY.
- This is not a technical proposal. It is an example of a solution to show technical feasibility.

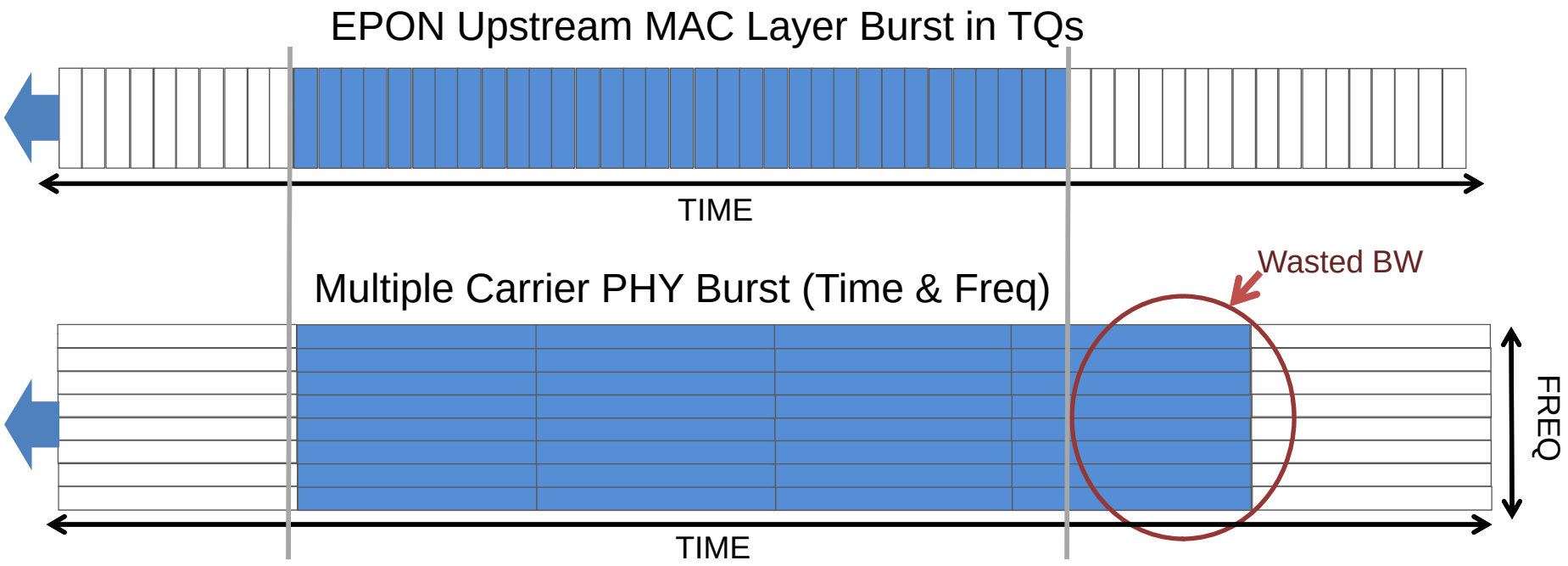
EPON TDMA & Multi-Carrier Transport



- EPON MPCP MAC Layer (TDMA)
  - Grant value of Time Quanta (TQ) 16ns, One transmitter at a time
  - A CNU will only see his Grant. (no full MAP)
  - Conversion of Bytes to TQ is done outside of the MAC layer and is open to modification.

- Multi-Carrier Transport
  - Bonded 6/8MHz QAM channels, OFDMA, SDM (Wavelet), etc
  - Symbol time is many times longer than TQ
  - Multiple transmitters per symbol time are possible
  - Different Bit capacity possible for each carrier
  - Single Symbol Rate for all channels for this proposal, different symbol rates could work but it is a more complicated.

True TDMA (Direct Mapping)



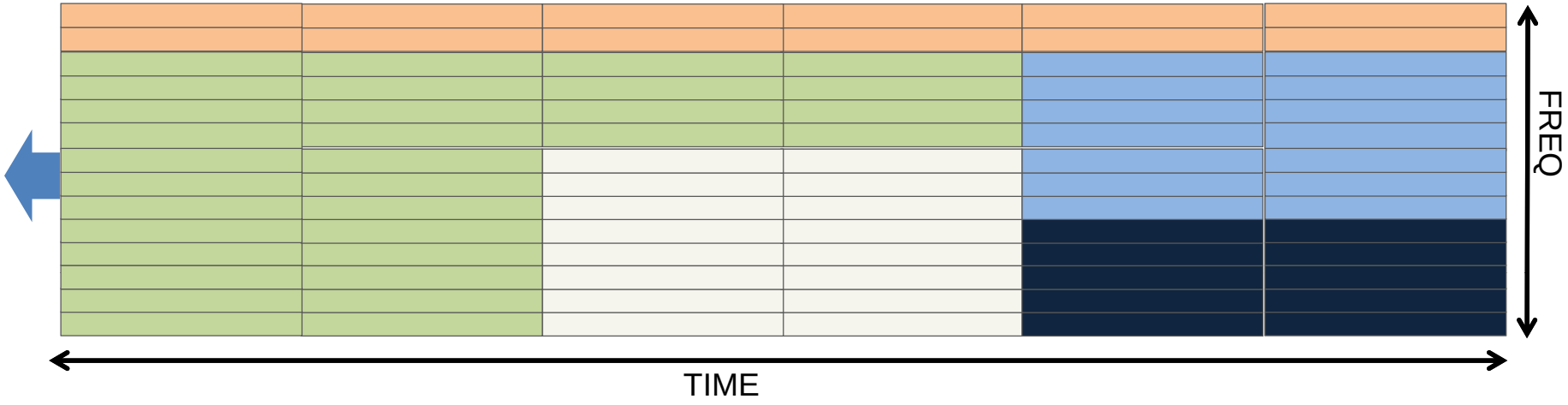
Why Can't we directly map TDMA onto the RF PHY?

- 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. 10us @ 1Gbps = 1250 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 Carrier PHY Bursts from 5 CNUs



- 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.

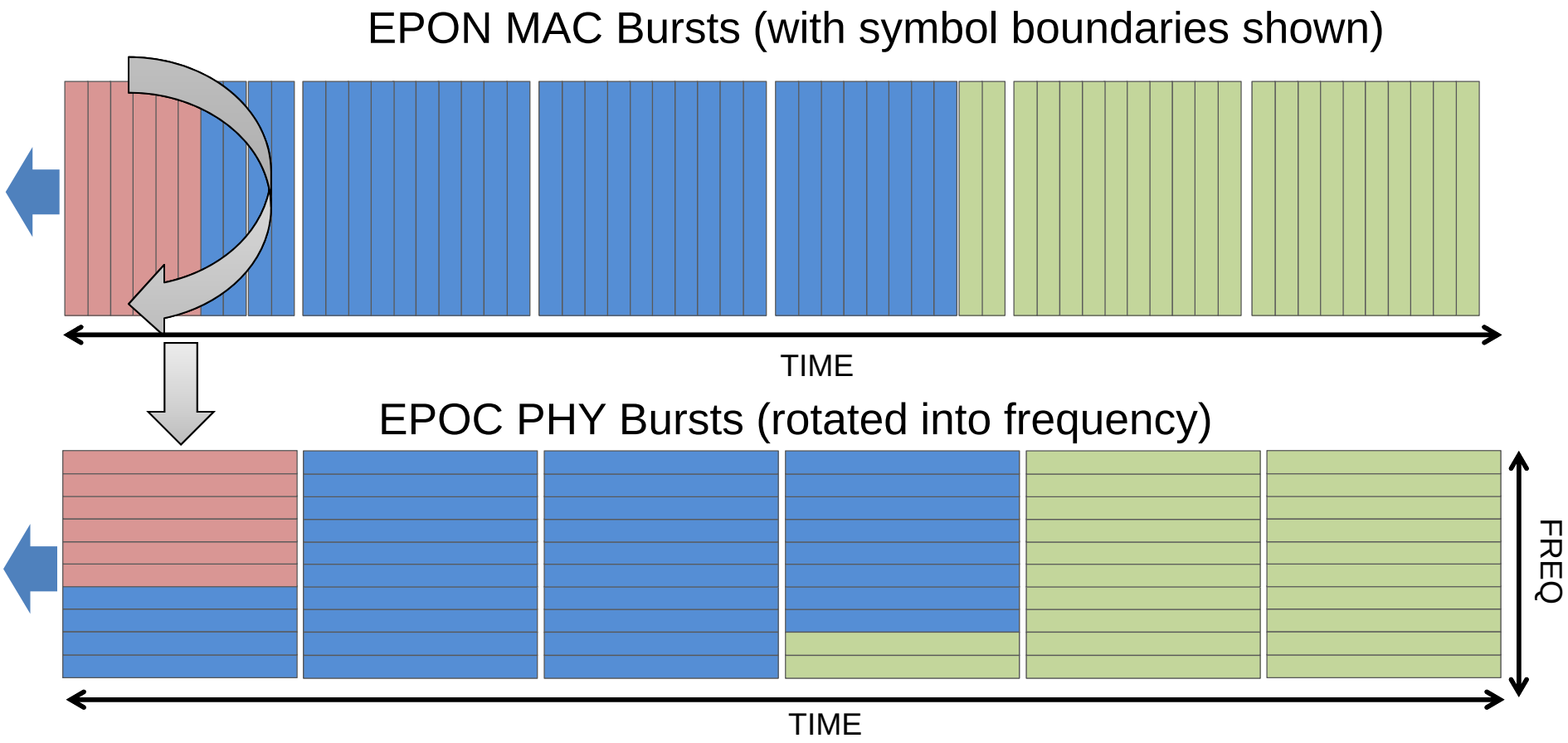
X The Ethernet MAC doesn't support a multiple path PHY layer. (e.g. Orange starts before white and finishes after it)

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

X EPON OLT schedulers and EPON PHYs are one-dimensional

We need a simpler solution that fits with Ethernet

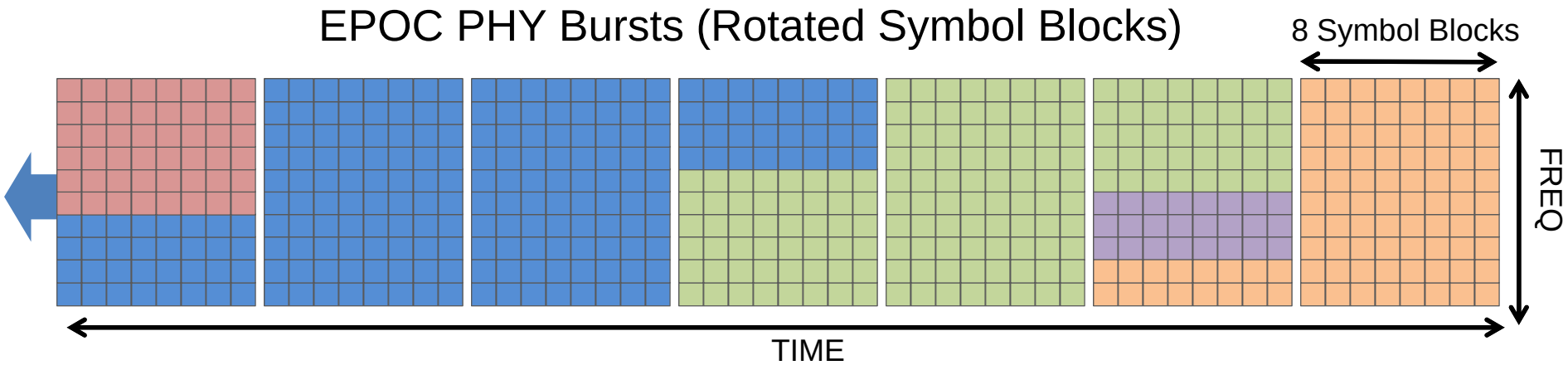
TDMA to Two Dimensional Mapping



- Multiple transmitters will share a symbol time.
- Granularity is achieved by sharing symbol in frequency.
- Constant overhead and delay at PHY layer
  - No preference for one packet/burst over another.
  - Same Average Delay and Efficiency for all

Mapping EPON can be achieved without a new scheduler or MPCP layer

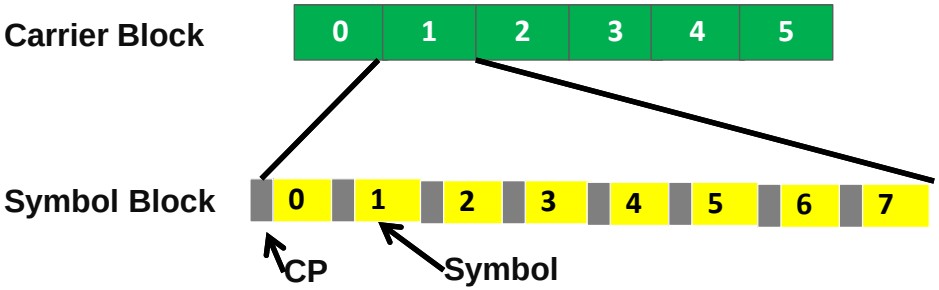
Burst Blocks



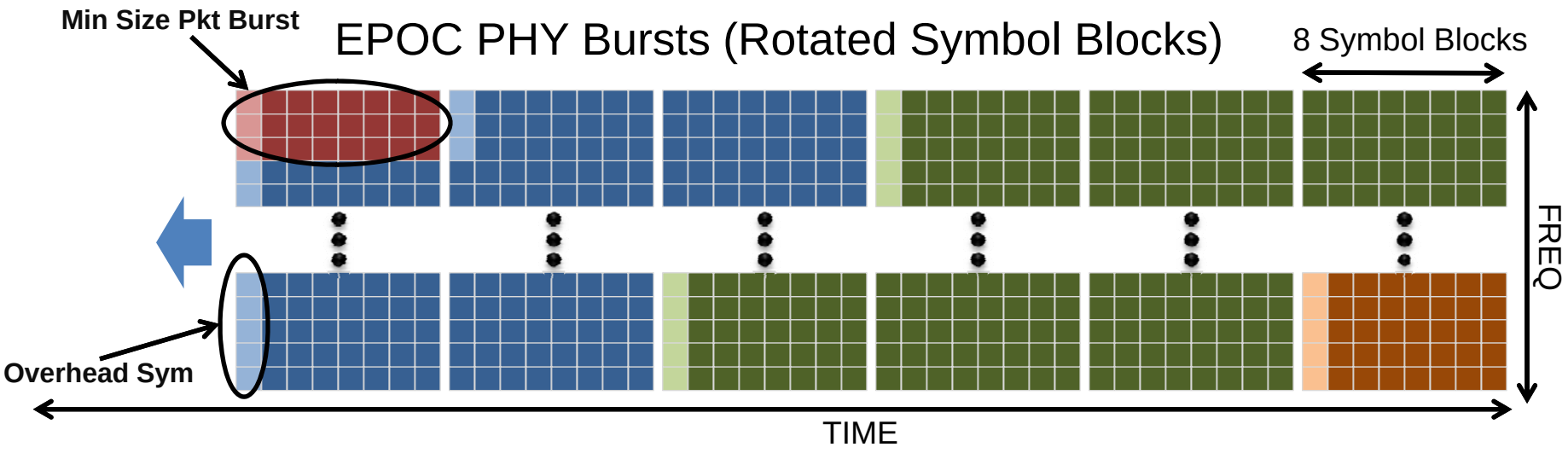
- Bursts of a single symbol are not usable in most modulation schemes.
- To create valid bursts in a rotated block of time, a block of multiple symbols could be rotated.
  - 8 symbols are grouped in the example above.
- Example
  - 2 Symbol burst overhead, 2 to 6 bits per carrier symbol.
  - 8 symbol block carrier would have 48 (8x6) bits of worst case granularity
  - Worst case small burst efficiency of 75% (6 of 8 sym have data)
- Larger symbol block will have better burst efficiency but coarser granularity.
- Larger symbol block will have increased delay.
- Note: In some modulation schemes, the adjacent carrier(s) between transmitters are not usable. This can be a constant overhead in the burst.

OFDMA Example

An example of OFDMA Burst



- Assume a 20us Symbol, 256 QAM
- 20% of Symbol is used for Cyclic Prefix
  - 4us multi-path
- OFDMA Block : 8 symbol blocks, 6 carriers each.
- Burst Overhead: 1 symbol
- 33 Bytes in burst start blocks, 38 Bytes in other blocks
- 38 Bytes worst case granularity vs 20 Bytes in 10G-EPON
- Minimum Packet Size Burst (3 Blocks - 99 Bytes Payload)
- 12.5% Burst Overhead for Minimum Size Burst
- 8x20us = 160us of Fixed Block Delay, All packets



Conclusions

- Short Symbols work well with TDMA but other factors may require long symbols.
- Pure TDMA won't work well with a long symbol time.
- Two Dimensional Scheduling would be very complex and wouldn't fit with the Ethernet MAC layer.
- A PHY layer with a fixed order, single packet flow, and constant delay is better for Ethernet and higher layers.
- A simple conversion layer can be created to allow long symbol PHYs to work with the existing Ethernet (EPON) MAC.
- More complex conversions layers can be considered when the modulation details are known to optimize performance.