EPoC Channel Bonding

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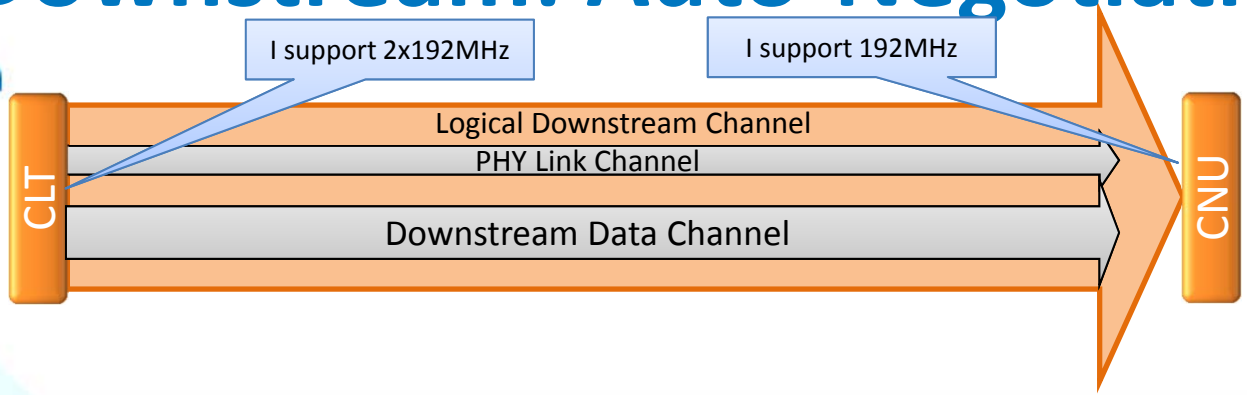
Overview

- The channel size has been a challenging topic in EPoC.
  - Some have argued for a smaller channel (100MHz, 125MHz, or 192MHz) to provide low cost solutions.
  - Some have argued for a larger channel (2x192MHz or 4x192MHz) to provide high bandwidth future proof solutions.
- The specification of a single channel size will prevent EPoC from addressing both markets.
  - This presentation does not argue for or against a particle channel size.
  - This presentation attempts to show that multiple channel are possible.
- Channel Bonding in the MAC is a significant challenge
  - A single logic PHY channel is simple, low cost, and has the best performance
  - Adding MAC bonding to the EPON standard will delay the standard and lower performance.
  - Do we really need channel bonding in the MAC?
- This presentation will look at a possible solution using existing standards…
  - Auto-negotiation of the channel size via the PHY Link Channel (PLC)
  - EPON 1G/10G rate support
  - 802.1 Link Aggregation for mixing multiple generations of products

EPoC Channel Bonding for Continuous Mode

FDD DOWNSTREAM

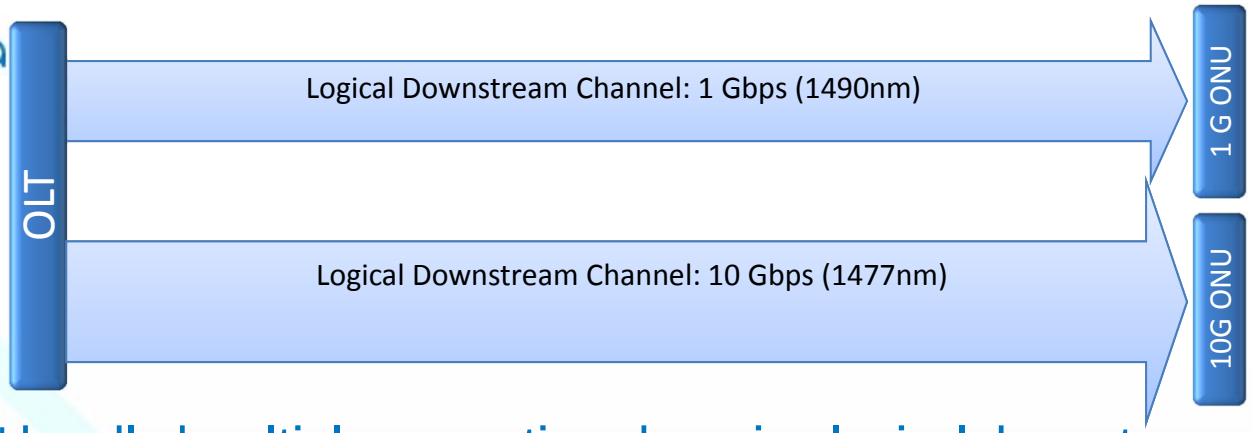
Downstream: Auto-Negotiation



- The amount of spectrum supported by a device is a product specification.
  - For Example: 96MHz, 192MHz, 2x192MHz, or 4x192MHz could be allowed in the standard. (Exact #'s TBD)
- Operators specify the minimum requirements for CNUs on their network.
  - For Example: 192MHz or better CNUs only.
- During PHY Link Up, the CLT retrieves the capabilities of the CNU
- If the CNU supports a narrower channel than the CLT, the CLT can….
  - Reduce the downstream channel size for all CNUs to the lower capabilities
  - Reject the Link Up and report the incompatibility at the CLT and CNU.
  - Redirect the CNU to another PHY Link Channel associated with another Logical downstream channel.

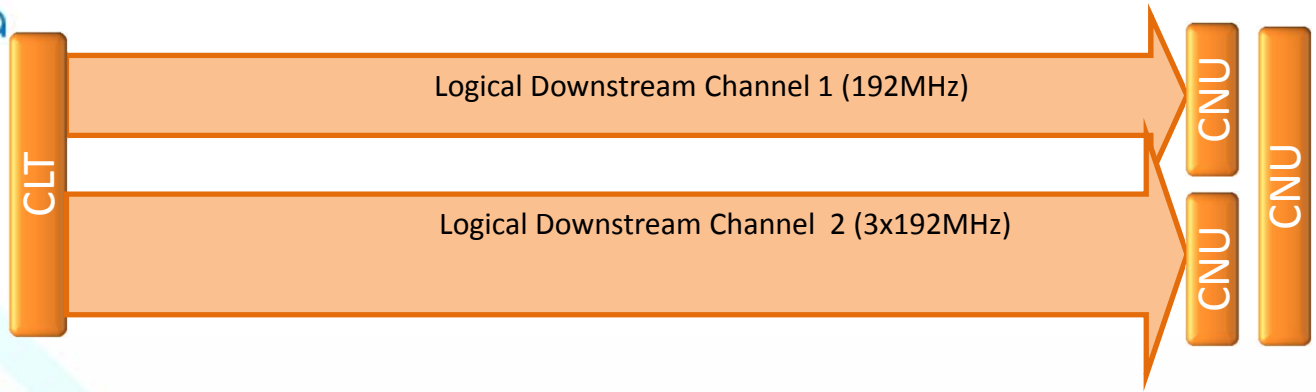
This procedure is similar to other Ethernet devices

Downstream: EPON Multiple Generations



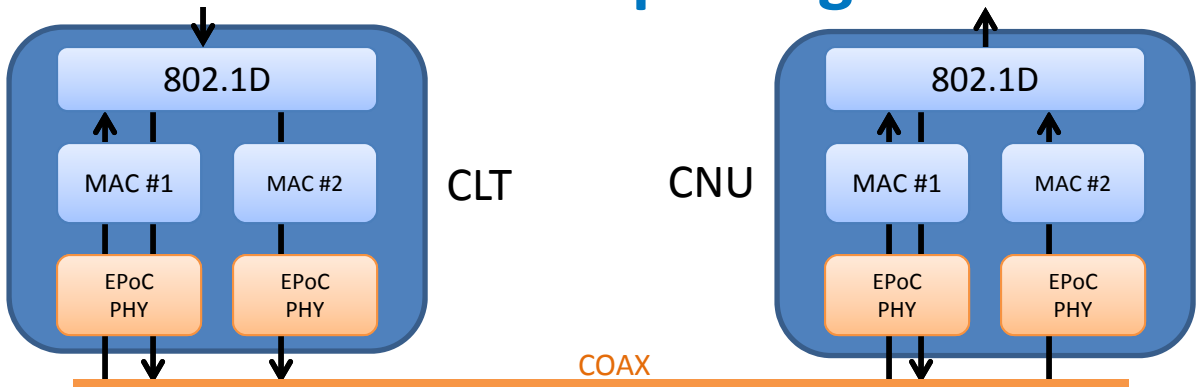
- EPON handled multiple generations by using logical downstream channels in 2 wavelengths
  - 1Gbps uses 1490nm and 10Gbps uses 1477nm
- EPON can share the upstream for both logical downstreams
  - 1Gbps/10Gbps ONU uses same upstream as 1Gbps/1Gbps ONU
- An EPON ONU receives one of the two downstream channel
- EPoC could use a similar method but….
  - Multiple wavelengths don't exist on coax
  - Isolated blocks of frequency will strand capacity
  - Each channel would need to be able to auto-negotiate to a different speed (more flexible than 1 Gbps and 10 Gbps)

Downstream: EPoC Multiple Generations



- Follow the EPON model of 2 logical downstream channels for a single upstream channel.
- Allow CNUs to listen to one or both of the downstream channels.
- A Downstream PLC will exist in both of the logical channels.
  - Single Upstream PLC is shared. CLT should only request information on one downstream PLC at a time.
- CNUs would advertise the number of logic channels supported and the maximum size of the logical channel during auto-negotiation.
- Auto-negotiation can determine the size of each logical downstream channel and force CNUs to the appropriate channel.

Downstream: Splitting Traffic



- Bringing up the LLIDs
  - Bidirectional Link is established on MAC #1
    - Note that only MAC #1's broadcast LLID would be used by the CNU to avoid duplicated broadcast.
  - Downstream only Link is established on MAC #2
    - The process of establishing a downstream only multicast LLID was done for SIEPON.
    - In this case, it is essentially a multicast LLID with a single CNU.
- 802.1 Link Aggregation splits the traffic
  - Algorithm for load balancing is vendor specific and out of scope for 802.3bn.
  - Since Link Aggregation doesn't split conversations (DA/SA pairs), there is no need to time stamp or re-order packets.
  - No additional delay or jitter added to MPCP control packets since traffic split is above the MAC.

Channel Bonding can be achieved following EPON and 802.1 Standards

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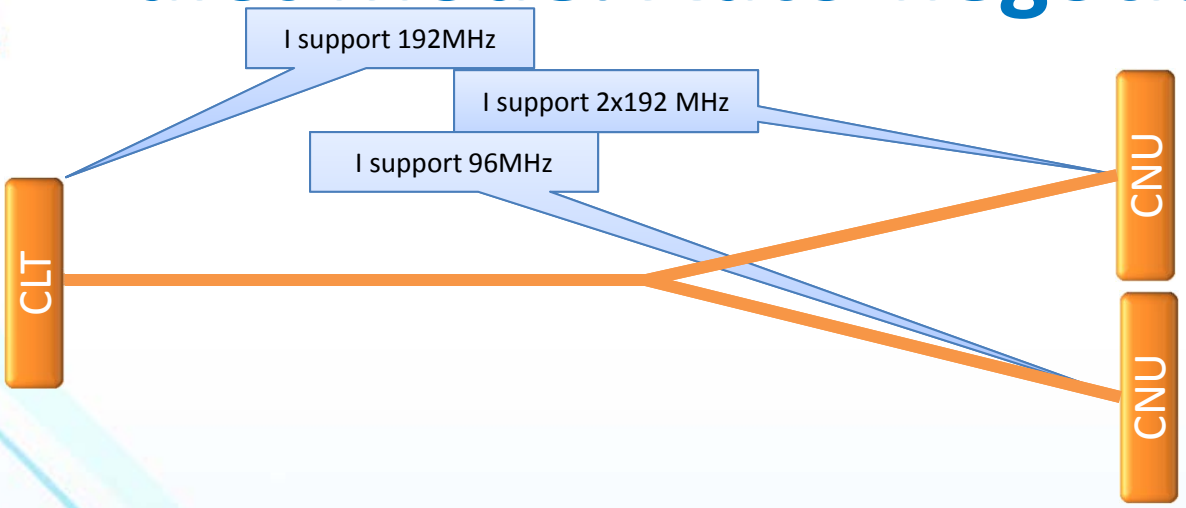
EPoC Channel Bonding for Burst Mode

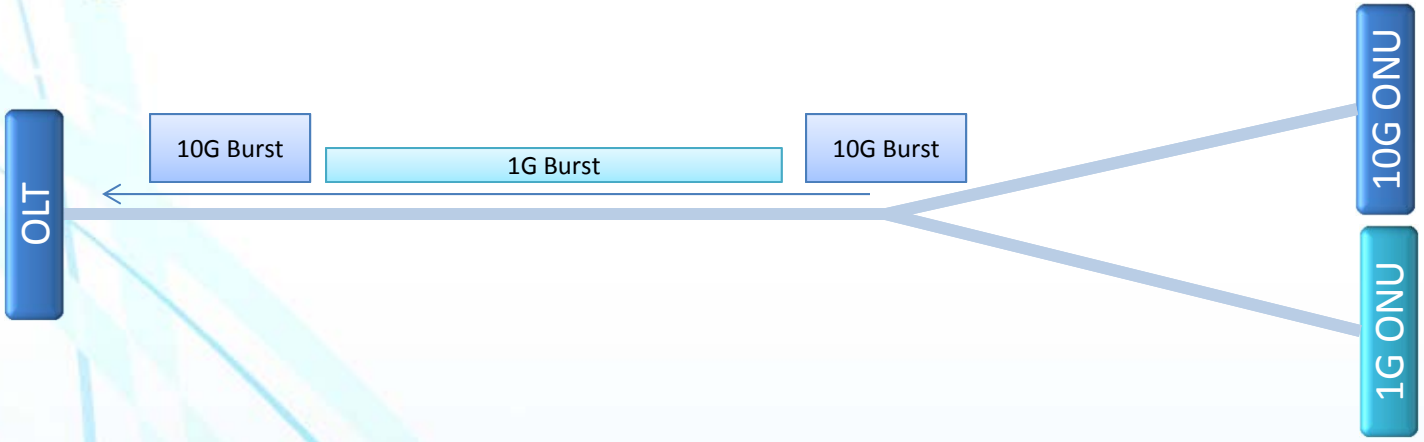
TDD & FDD UPSTREAM

Burst Mode: Auto-negotiation



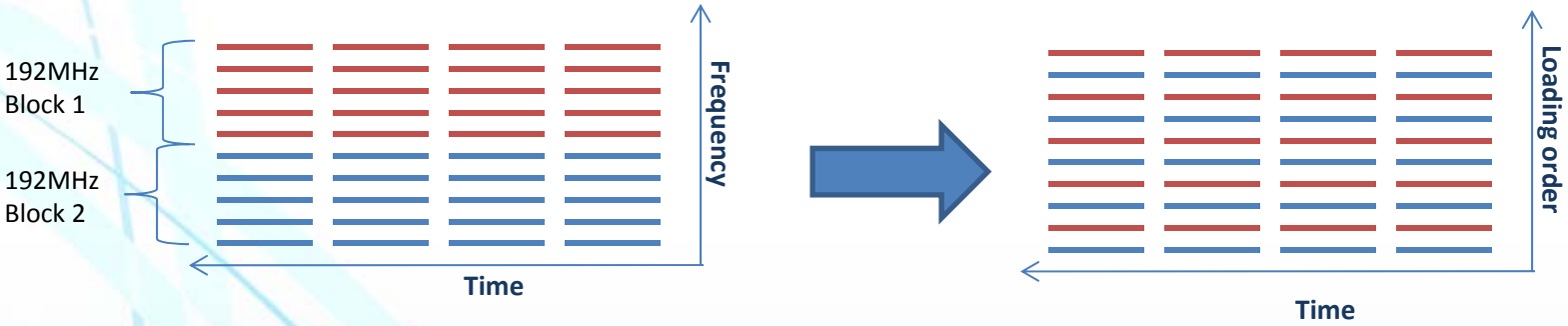
- Like the downstream continuous mode, the burst mode can determine the size of the upstream channel through auto-negotiation.
- The IEEE specification can list allowed channel sizes (e.g. 192MHz, 2x192MHz, etc).
- The operators and system vendors would select use appropriate device.
- If the CNU supports a narrower channel than the CLT, the CLT can….
  - Reduce the downstream channel size for all CNUs to the lower capabilities –OR-
  - Reject the Link Up and report the incompatibility at the CLT and CNU –OR-
  - Grant narrower slots to that CNU (Considered in next slides)

Burst Mode: EPON



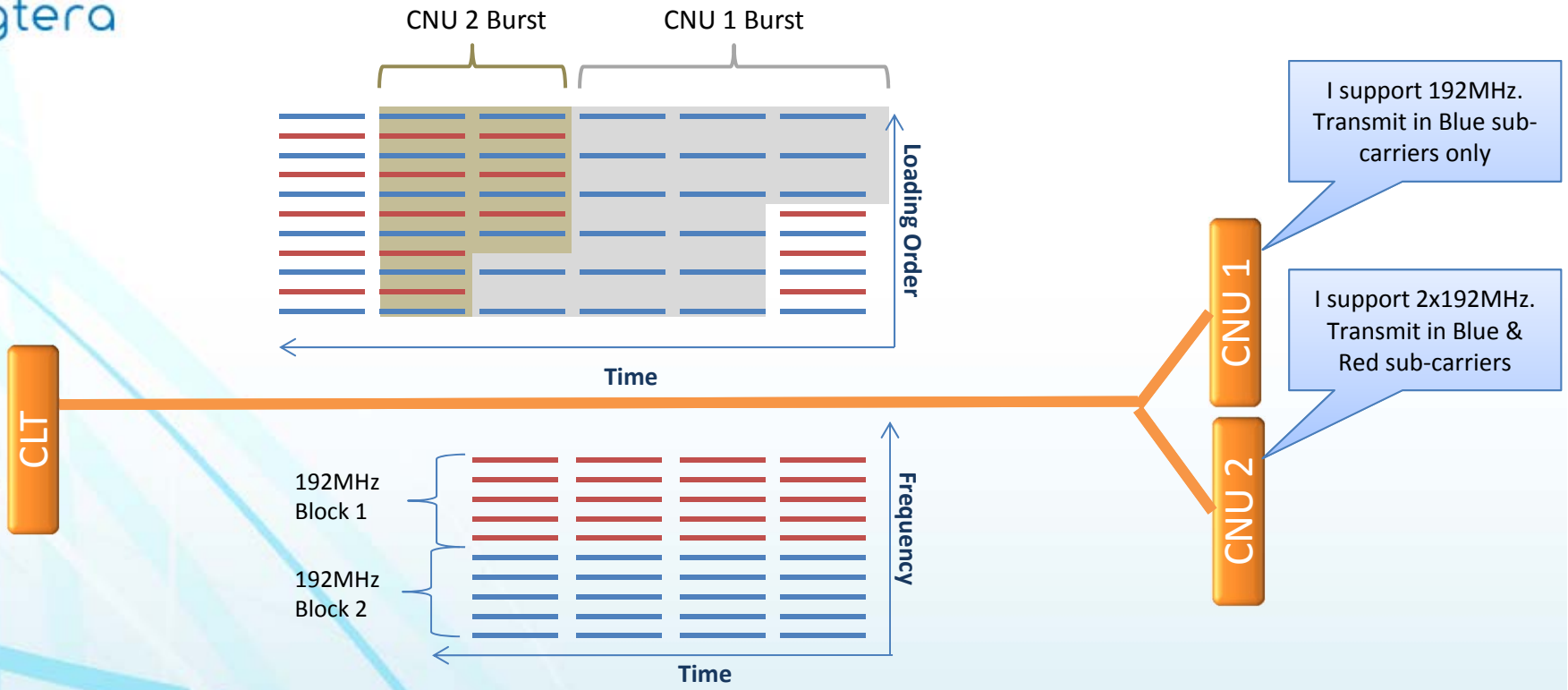
- EPON uses TDMA slot to mix data rates.
  - 1G ONUs burst at 1Gbps in their slot.
  - 10G ONUs burst at 10Gbps in their slot.
- EPON scheduler can support ONUs transmitting upstream in slots at different rates.
- EPoC could use a similar methodology to allow for mixed speeds for bursts.

Burst Mode: Multiple Spectrum Sizes



- For example, a CLT supporting a network with single 192MHz CNUs and 2x192 MHz CNUs could change the order of loading sub-carriers to support both burst rates.
- Frequency Interleaved (Shuffled loading order)
  - If the scheduler and data loading is interleaved between the 2 192MHz blocks, the data rate to any CNU becomes a linear relationship with time.
  - The capacity of a symbol is spread out evenly between the red and block 192MHz blocks above.

Burst Mode: Multiple Spectrum



EPON Like Multi-Rate Upstream

- Since CNU 2 has twice the carriers, it can burst at twice the rate of CNU 1 in it's time slot.
- Simple one dimensional scheduling with a different data rate based on source.
- This is simple for the scheduler and the same as 1G/10G EPON upstream.

Conclusion

- Auto-Negotiation will allow devices with different spectrum capabilities to co-exist on the same network.
- 1G/10G EPON's multiple logic downstream channels can be easily modified to support multiple generations of devices in an EPoC network.
- Traffic can be split into multiple logic downstream channels can using 802.1 Link Aggregation.
- Burst Mode can support multiple spectrum capacities using the 1G/10G methodology and interleaving the loading of the carriers.

EPoC can focus on a single logic channel and rely on EPON/802.1 for Channel Bonding