EPOC Technical Feasibility, Part 2

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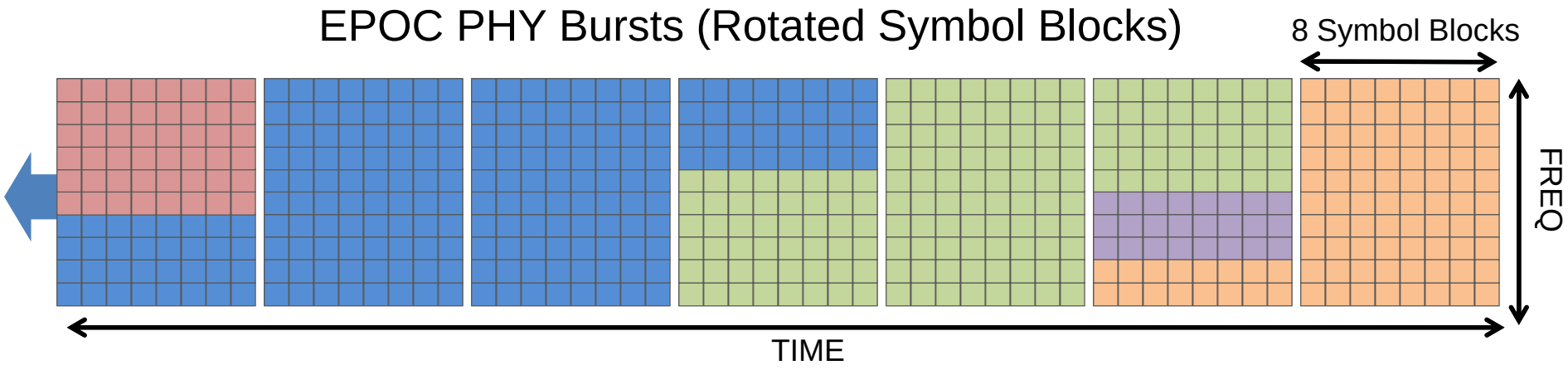
Overview

- There was concern that the EPON MAC with a one-dimensional TDMA Scheduler is not feasible for EPoC.
- At the last meeting, we presented a simple mapping from TDMA to longer symbol multiple carrier solutions.
- Issues were raised on the feasibility of the solution based on limits to the number of multiple transmitters and the ability to sub-rate the MAC.
- As promised at the last meeting, this presentation will continue the OFDMA example with analysis on the multiple transmitters and examples of sub-rating solutions in earlier standards.

This is not a technical proposal. It is an example of a possible solution to show the technical feasibility of EPoC.

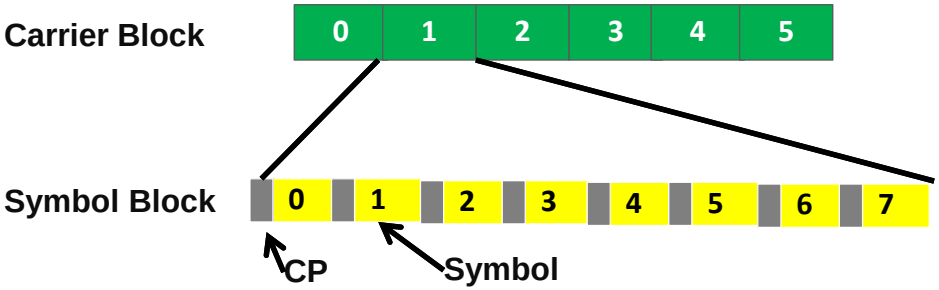
Burst Blocks



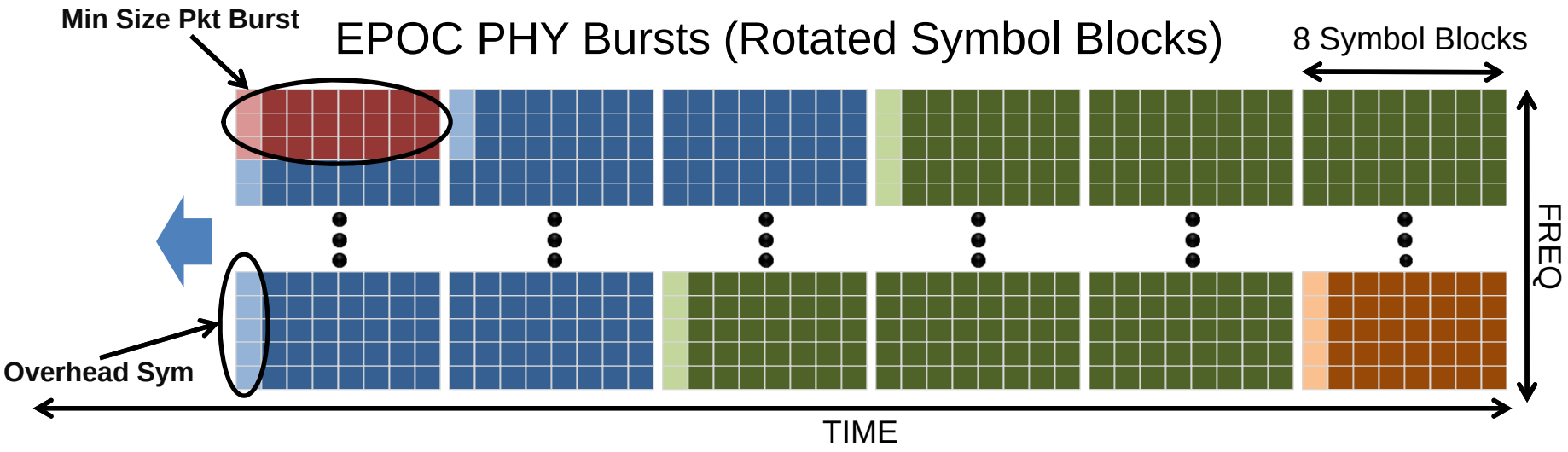
- Bursts of a single symbol are not usable in most modulation schemes.
- To create valid bursts in a rotated block of time, a block of multiple symbols could be rotated.
  - 8 symbols are grouped in the example above.
- Example
  - 2 Symbol burst overhead, 2 to 6 bits per carrier symbol.
  - 8 symbol 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



Why have Transmitter Limits? (1)

- The output power of a wideband transmitter is proportional to the occupied bandwidth. If the TX has to change output power without reconfiguration time, the change must be done in the digital domain, prior to the wideband DAC.

- DACs have a finite dynamic range. ENoB (Effective number of bits) define the dynamic range of DACs. SNR = 6.02*ENoB + 1.76 dB

- When a wide band transmitter only transmits part of the allocated channel, it will generate noise outside of its allocated frequencies (spurious emission) that may interfere with other CNU's upstream transmissions.

Why have Transmitter Limits? (2)

- DOCSIS Downstream RFI (DRFI) has a spec for the downstream spurious emissions of wideband modulators. Equipment built around this spec can generate multiple channels of 256-QAM signals.
  - Spurious < -73 + 10*log10(N),
    for N=32 or 192 MHz, the spurious level should be less than -58 dBc
- DRFI also has a spec for the downstream spurious emissions of wideband modulators when transmitting 1/16th of full bandwidth.
  - For this case DRFI requires the spurious emissions noise floor at -57 dBc (compared to power per channel with full bandwidth transmission)
  - For 16 such transmitters the combined spurious emissions is -45 dBc.
- For minimal degradation of the EPoC signal using higher constellation, the spurious emission contribution from multiple TX should be less than -40 dBc.
- DRFI provides 16 simultaneous transmitters with 5 dB better spurious emissions performance than required by EPoC
  - Extension one more step, to 32 transmitters, is technically feasible today, compared to DRFI initial release containing these requirements in 2010, and with today's DRFI providing 5 dB margin over EPoC requirement
- DRFI 2010 shows technical feasibility for EPoC with 32 simultaneous TX

Why have Transmitter Limits? (3)

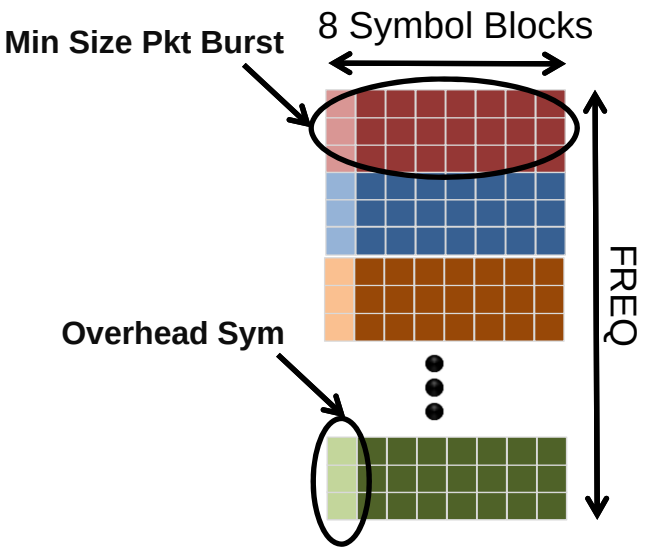
- A large number of transmitters could generate too much noise and cause bit errors.

- For this reason, the task force will need to specify the amount of spurious emissions from a single transmitter occupying a fraction of the full transmit band, and the maximum number of transmitters.

- A large number of transmitters will require a stricter limit on spurious emissions from a single transmitter.

Multiple Transmitter Limit Example

Single Symbol Block Bursts (Max Transmitters)



- **The number of transmitters can be limited by setting a minimum burst (grant) size on the OLT/CLT MAC.**
- **How much data in a block?**
  - **8 symbols in a block x 20us per symbol = 160us block**
  - **160us at 1 Gbps = 160,000 bits or 20K Bytes**
- **Minimum Burst Size**
  - **32 Transmitter Limit = 625 Bytes min per burst**
  - **64 Transmitter Limit = 313 Bytes min per burst**
- **Today's EPON Minimum Burst Size**
  - **Laser ON 64B, Laser OFF 64B**
  - **SyncTime 64B, Min Packet 84B**
  - **Total = 276 Bytes (72 transmitters)**
- **Early EPON Minimum Burst Size**
  - **SyncTime 400B (200TQ)**
  - **Total = 528 Bytes (38 transmitters)**

NOTE: This example only considers Full Duplex, a Half Duplex solution would be multiplied by Total (up+down) channel size. (e.g. 1G:3G system would have 4x min packet size)

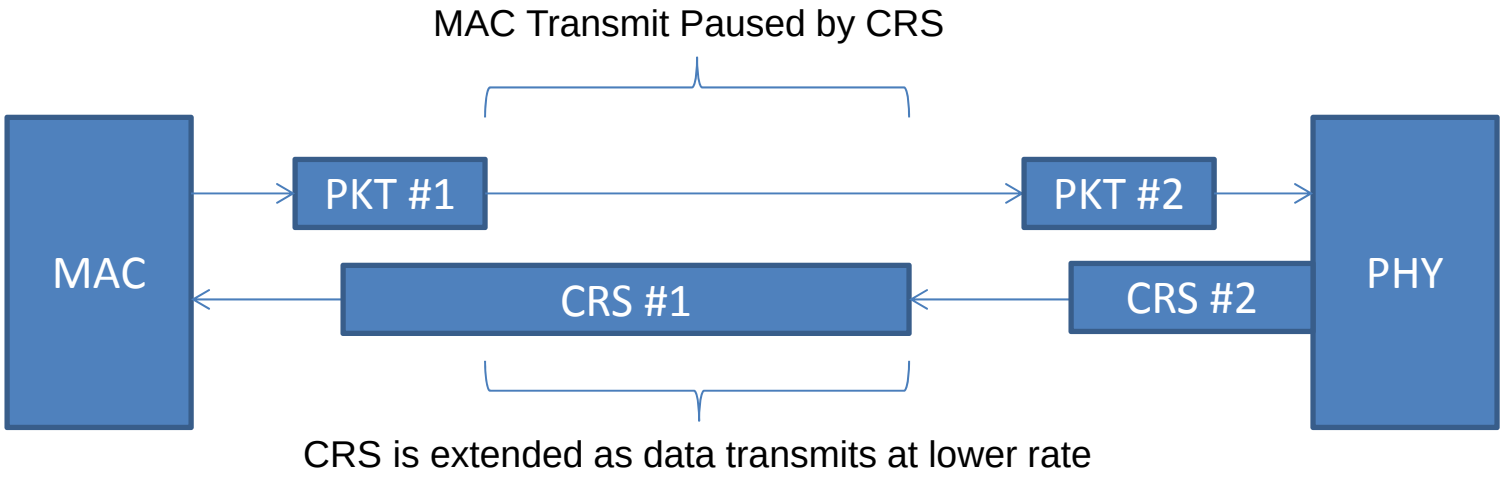
Multiple Transmitter Conclusions

- Any system with multiple transmitters will need to have limits on transmitters.
- Large symbol blocks will have require either a larger number of transmitters (lower spurious emissions) or a longer minimum burst size.
- Short Symbols or symbol blocks reduce the issue.
- In the simplest solution, EPoC could handle a multiple transmitters with a minimum burst size.
- The example OFDMA parameters show that min burst size is similar to early EPON transceivers.
- A scheduler aware of the limit could be made to optimize the upstream.

A Solution exists for EPoC with the current EPON MAC

Sub-rating Options (EFM)

- **IEEE 802.3 for Ethernet in the First Mile defined asymmetric non-power of 10 data rates.**
- **A set of data rates were defined for the PHY.**
- **The MII interface was used to connect the EFM PHY to the Ethernet MAC.**
- **To sub-rate, the MAC will defer to the "carrierSense" after sending a packet over the interface.**
- **While GMII has the CRS signal, XGMII removed the signal. To use this method, we would need to add the CRS to XGMII.**
- **Changes to the XGMII are a significant challenge**



Sub-rating Options (10G-EPON)

- **10G EPON does not support full 10 Gbps of Ethernet data and is therefore sub-rated.**
- **10G EPON introduced a streaming FEC that reduces the effective data rate by about 13%.**
- **The MAC Control paces the output data to the PHY by adding extra IDLEs between packets to reduce the data rate by the required 13%.**
- **The extra IDLEs are removed in the PHY below XGMII. XGMII and MAC run at nominal 10Gbps rate.**
- **Sub-rating PHYs are therefore already supported in the current 802.3 standard.**
- **In the case of EPoC, we could use this mechanism to provide a configured rate (not the fixed 13%) based on the result of the auto-negotiation at the PHY.**
- **Management channel (MDIO) can be used to read auto-negotiated rate from PHY and provision into MAC Control.**

Sub-rating Conclusion

- **EFM and 10G EPON provides two possible solutions for a lowering the data rate from the Ethernet MAC to the new EPoC PHY.**
- **The 10G EPON solution is probably a better solution since the XGMII interface is unchanged.**
- **The 10G EPON should easily work in a Media Converter Repeater application. It is not clear if the EFM method would work for this application.**
- **We need to decide if we should have a table of data rates like EFM or a more flexible solution.**
- **The task force can evaluate these solutions and other solutions to find the best solution with the minimum amount of change to the standard.**

It is technically feasible to use a sub-rate PHY with the Ethernet MAC