Framing for Forward Error Correction in 10G EPON

Jeff Mandin

802.3 10G EPON study group
San Diego - July 2006

Agenda

1. Problem Statement
2. Line code/FEC interaction
3. Proposal for 10G FEC framing

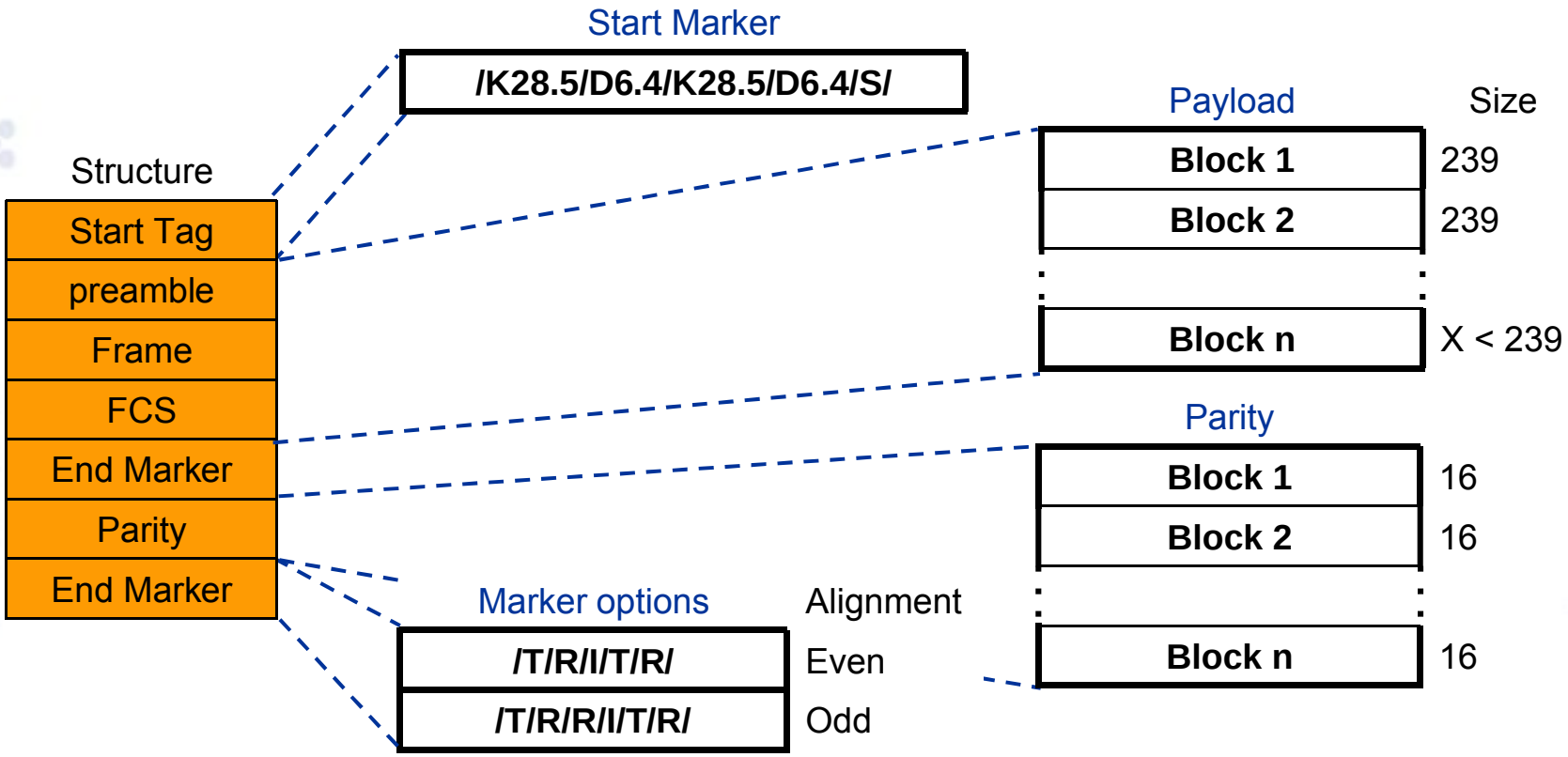
Work items for FEC in 10GEPON

- Analysis of the optical system indicates that employment of FEC is highly beneficial (or even essential) to attain 10Gbps downstream in an economically feasible way
- Work to do for 10GEPON FEC includes:
  - Code selection
  - Signaling
  - Framing (cf. 802.3ah section 65.2)

Problem Statement for FEC Framing

- How should the parity data be interspersed with the codeword data before transmission to PMA?
  - Unlike some standards (eg 802.3an, 802.16), 10GEPON does not have the ability to dedicate a channel in the PMD layer to the parity data
- Since in 10GEPON we must include the codeword data and parity bytes in a single datastream, how do we facilitate correct identitification and efficient reconstruction of PCS data at the receiver?
  - Must have immunity to noisy channel
- Why is framing important? Impacts:
  - Effectiveness of error protection
  - Byte overhead of FEC
  - Complexity of FEC implementation
- Broadly speaking – there are 2 approaches to FEC framing:
  - **Ethernet frame oriented** (ie. “packet-oriented” used by GEPON)
  - **Codeword oriented** (10G Cu, 10G backplane)

Packet-oriented FEC Framing (GEPON solution)



Packet-oriented FEC Framing (GEPON solution cont.)

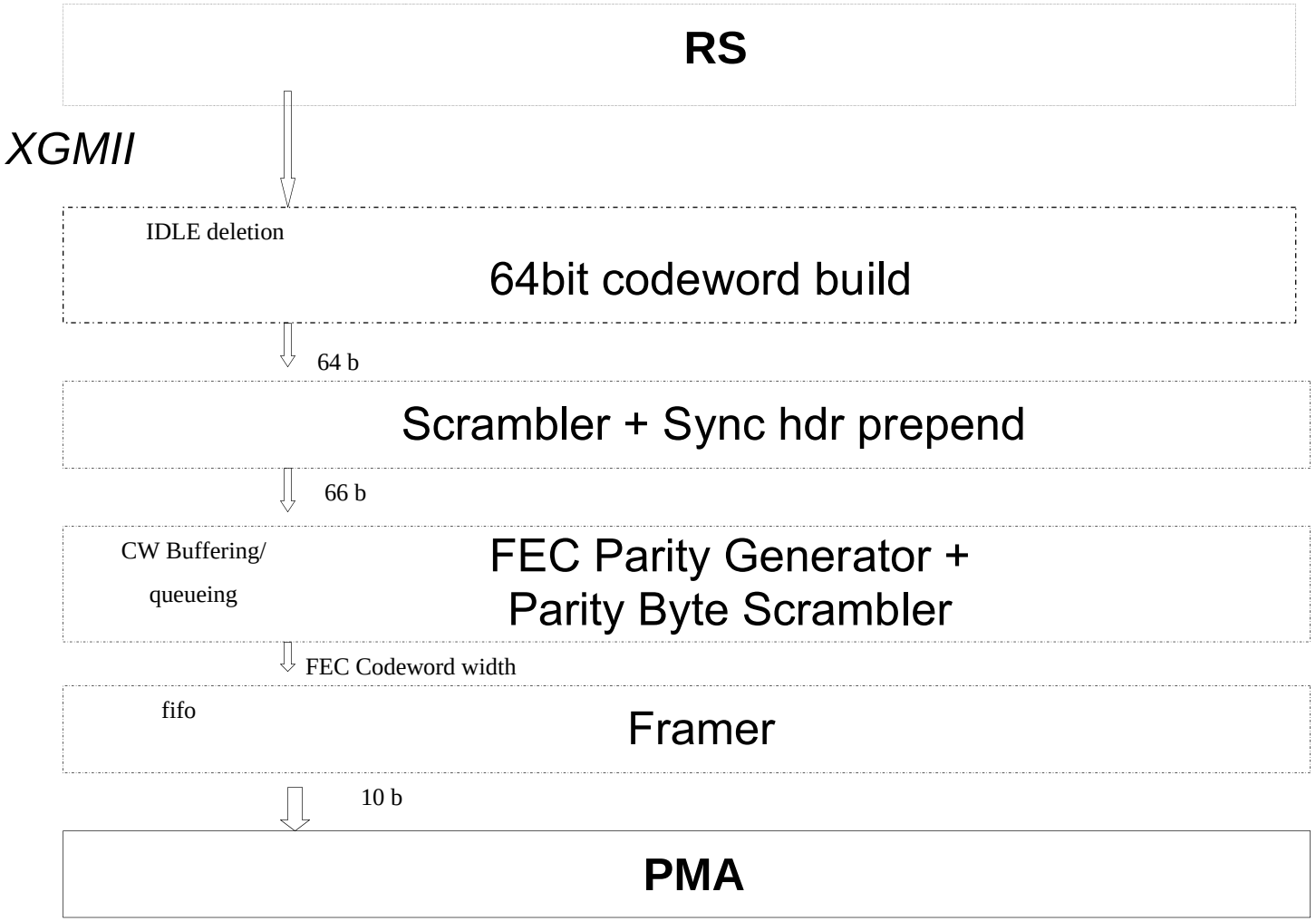
- Based on frame delimiters built from 10b codewords
  - 8b/10b provides channel noise resistance due to its coding overhead and error detection capabilities
  - Delimiters add to the bandwidth overhead of FEC (ie. in addition to parity data itself)
- Designed for compatibility w/ 802.3z
- Integrated with 8b/10b coding scheme

Packet-oriented FEC Framing in a noisy channel using 64b/66b code (cont.)

What if we defined delimiters using an ordered set in 64b/66b code?

- 2-bit error in the sync header received from PMA (ie. 01 shows up as 10) will cause control bytes to be interpreted as data by PCS (and the converse error will cause data to be interpreted as control)
  - Real concern since BER at PMA can be as high as 10^{-3} or 10^{-4}
  - No distance between control bytes and data bytes in 64b/66b
- Hence: 64/66b code does not lend itself to operation is a noisy channel environment.
- Consequently: FEC must protect the codewords themselves – not the data in the codewords

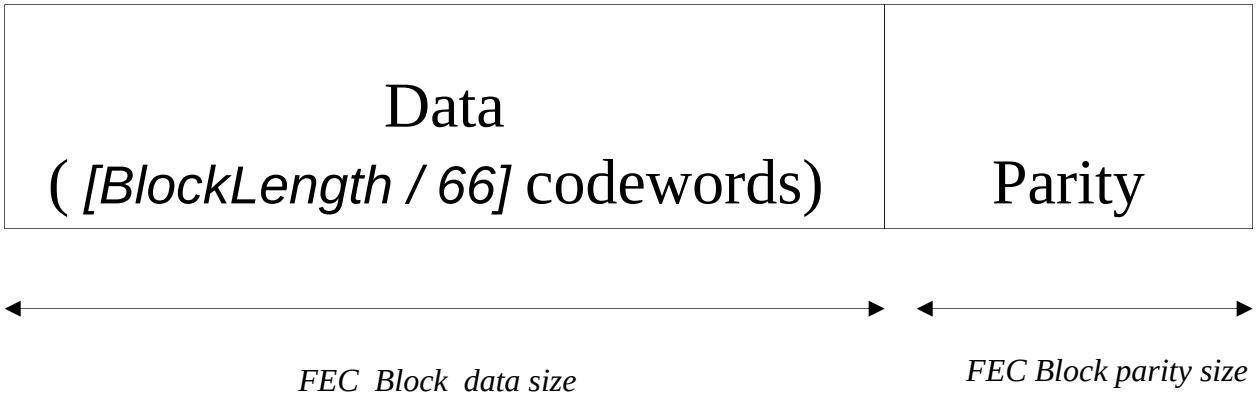
10GEPON: Sublayers for codeword - oriented FEC



10G EPON: PCS and FEC sublayers (cont.)

- Some FEC algorithm such as LDPC (*BlockLength*, *ParityOutputLength*) is in effect
- Scrambled 66b codewords are accumulated at FEC sublayer until there enough data to apply the FEC (*BlockLength*, *ParityOutputLength*) code
- For every (*BlockLength / 66)* codewords transmitted, there will be a FEC output of *ParityOutputLength* parity bits.

10G EPON: Proposed FEC Frame Format



10G EPON: Proposed FEC Frame Format (cont.)

- Since the frame is a FEC codeword, the frame length will depend the specific FEC code chosen
  - Place the maximum number of 66bit codewords into the data portion of the FEC block

- Parity bytes are scrambled but not 64/66 encoded.

Summary

1. **Benefits of FEC can be simply realized in 10GEPON by protecting the 66b codewords (including sync header)**

2. **Sender and receiver must previously agree on the FEC algorithm and hence the frame format**

3. **Parity data is a bit stream and does not contain codewords**

PMC-SIERRA

Thank you