Efficiency Considerations in EFM

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Overhead Components

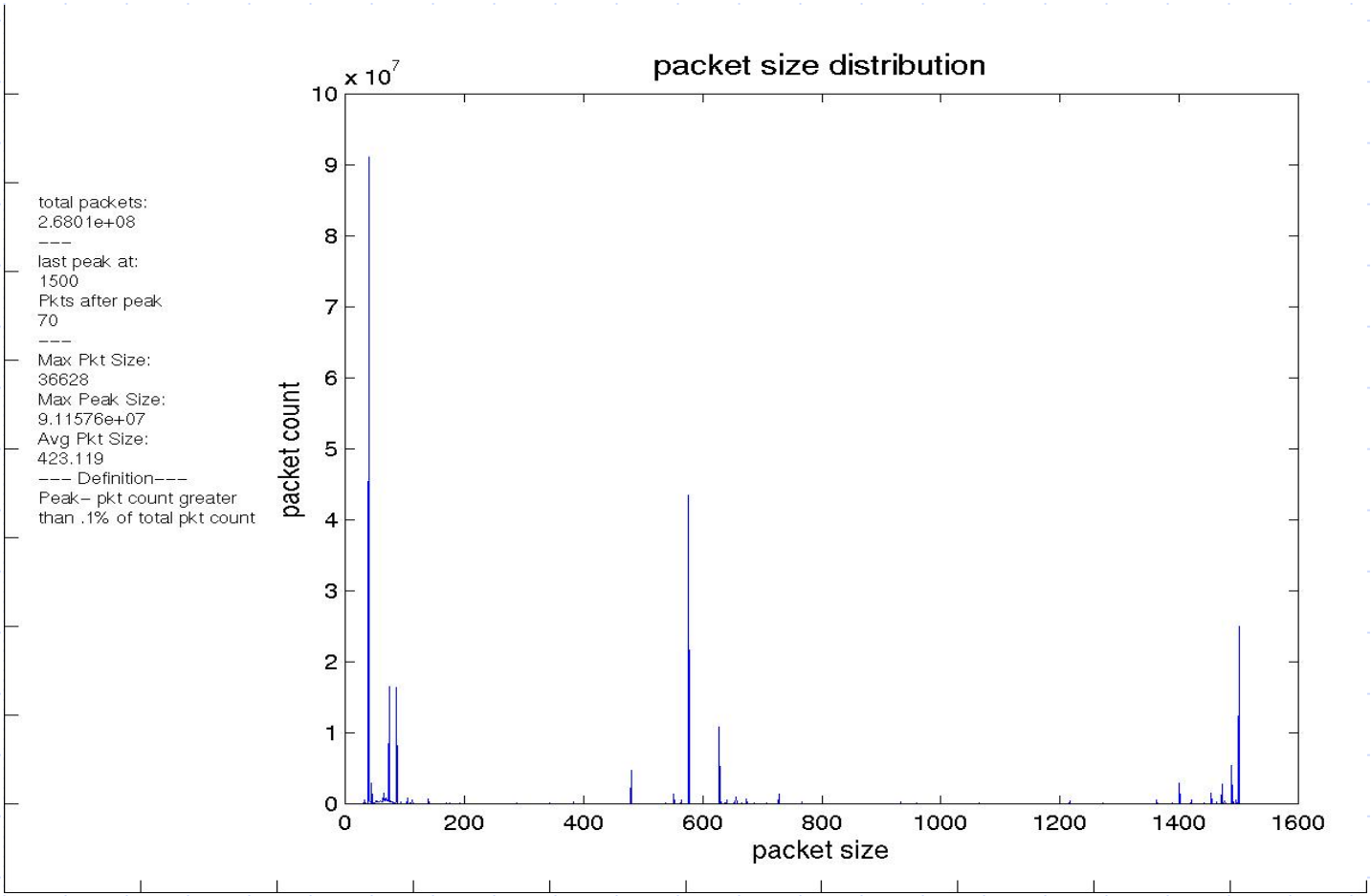
- Ethernet
  - Line Code 8B/10B
  - MAC: Start/Stop, IPG, Preamble
  - FEC
- EPON
  - No_Fragmentation
  - Burst Overhead

Note: All calculations are normalized to 1 Gbps MAC rate except when it says line rate explicitly.

Traffic Models

- Model 1: 80/20 Traditional Ethernet traffic model
  - 80% 64 byte frames
  - 20% 1518 byte frames
- Model 2: Packet Distribution from collected traffic traces in a cable headend
  - 56.3% 64 byte packets
  - 28.1% 512 byte packets
  - 15.6% 1518 byte packets

Packet Size Distribution from Traffic Traces



Efficiency Equations

- Ethernet Framing + FEC

$$\sum_i \frac{\text{Length of Frame}_i}{\text{Length of Frame}_i + \text{Overhead of Frame}_i}(\text{Probability of frame}_i)$$

- Per Burst Calculations

$$\text{Slot Length Per ONU} = \frac{\text{Cycle Period}}{\text{Number of LLIDs}}$$

$$\text{Efficiency} = 1 - \frac{\text{Average Fragment at end of Burst} + \text{Burst overhead}}{\text{Slot Length in Bytes}}$$

P2P Ethernet Efficiency

- Good throughput of the system depends on the traffic characteristics
  - Efficiency is a function of packet distribution.

Pkt	64	512	1518	417.1875
% distribution	0.563	0.281	0.156	
Without FEC	86	534	1540	
Efficiency	0.744186	0.958801	0.985714	0.842285

Model2

Pkt	64	512	1518	354.8
% distribution	0.8	0	0.2	
Without FEC	86	534	1540	
Efficiency	0.744186	0.958801	0.985714	0.792492

Model1

  - We get ~840 Mbps good throughput

Impact of Frame based FEC

Pkt	64	512	1518	417.1875
% distribution	0.563	0.281	0.156	
Without FEC	86	534	1540	
Efficiency	0.744186	0.958801	0.985714	0.842285
With FEC	113	593	1663	
Efficiency	0.566372	0.863406	0.912808	0.704043
				0.138242

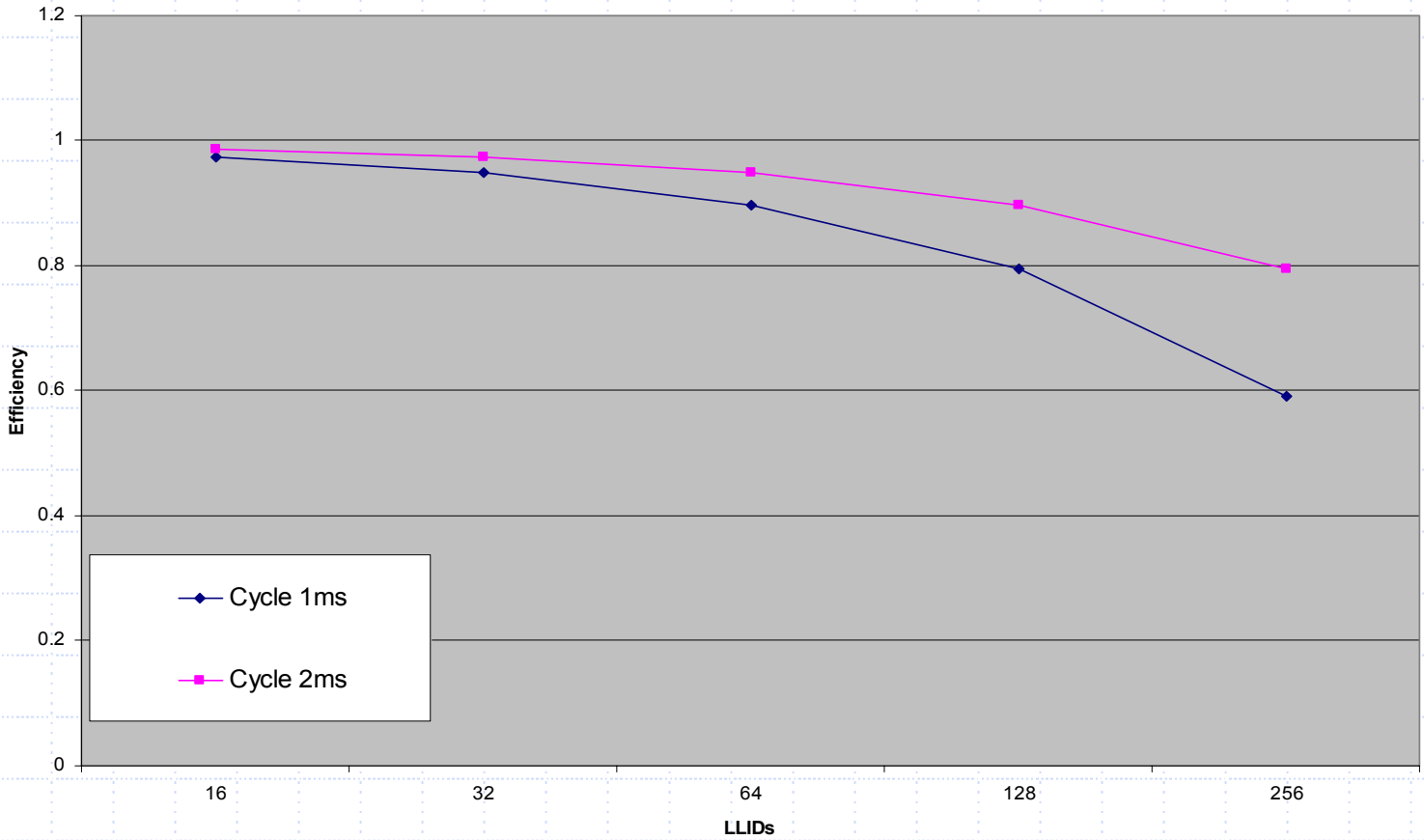
Model2

Pkt	64	512	1518	354.8
% distribution	0.8	0	0.2	
Without FEC	86	534	1540	
Efficiency	0.744186	0.958801	0.985714	0.792492
With FEC	113	593	1663	
Efficiency	0.566372	0.863406	0.912808	0.635659
				0.156833

Model1

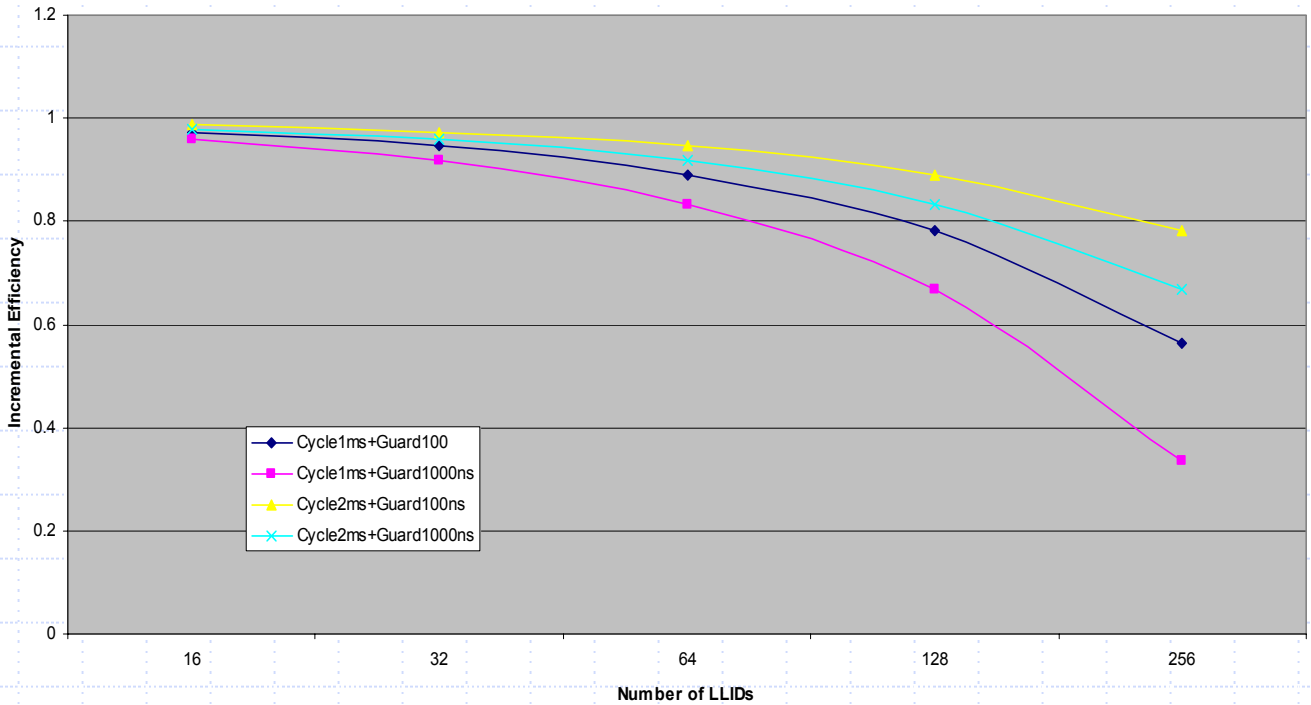
- We get ~700 Mbps good throughput

Incremental Overhead No_Fragmentation



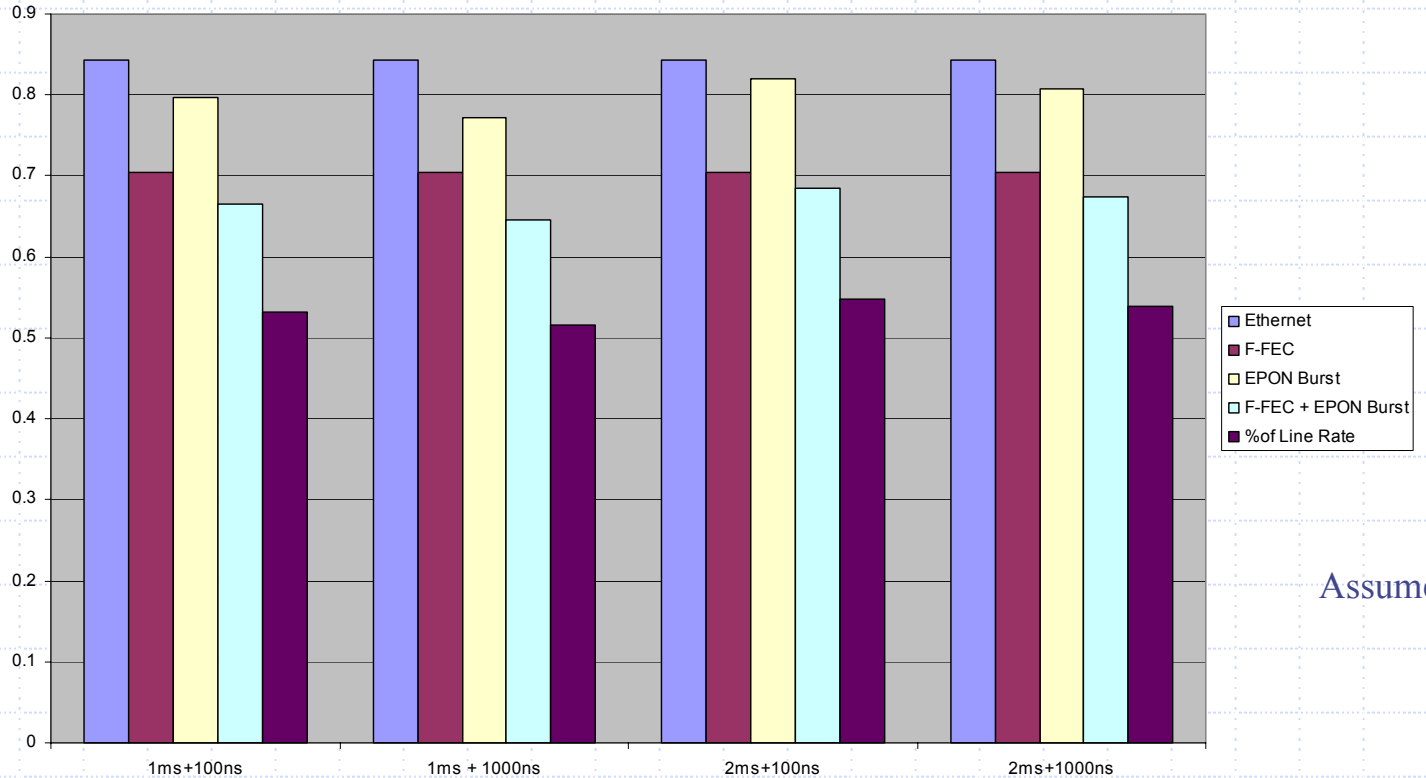
We waste bandwidth equivalent of half an average packet size at the end of each burst

Effect of LLIDs on Efficiency



- Minimize the number of LLIDs
  - One per ONU
- Increasing cycle times increases jitter and effects QoS

Impact of different components



Assumed 32 LLIDs

Every little bit adds up to make the system efficiency low

Comments

- Overhead in an FEC enabled Ethernet System
  - 20% for 8B/10B encoding.
  - 16% for Ethernet framing (IPG+Start+Stop)
  - 7% for FEC
  - 6+% for FEC framing in Frame based FEC
  - 5% for burst overhead and no_fragmentation
- Throughput of Ethernet system with everything included is ~650 Mbps (52% of line rate)
- Do we have a competitive standard?

Recommendations

- Choose stream based FEC
  - For backwards compatibility we are paying 6-8% additional penalty. Is it necessary?
- Choose to increase line rate to compensate for FEC overhead
  - Keeps the MAC rate same for FEC and non FEC systems
- Minimize the number of LLIDs (or grantable entities)