Efficiency Considerations in EFM

Ajay Gummalla, Dolors Sala (Broadcom)
Kent McKammon (SBC)
Frank Effenberger (Quantum Bridge)
Mark Sankey (Calix)

Overhead Components

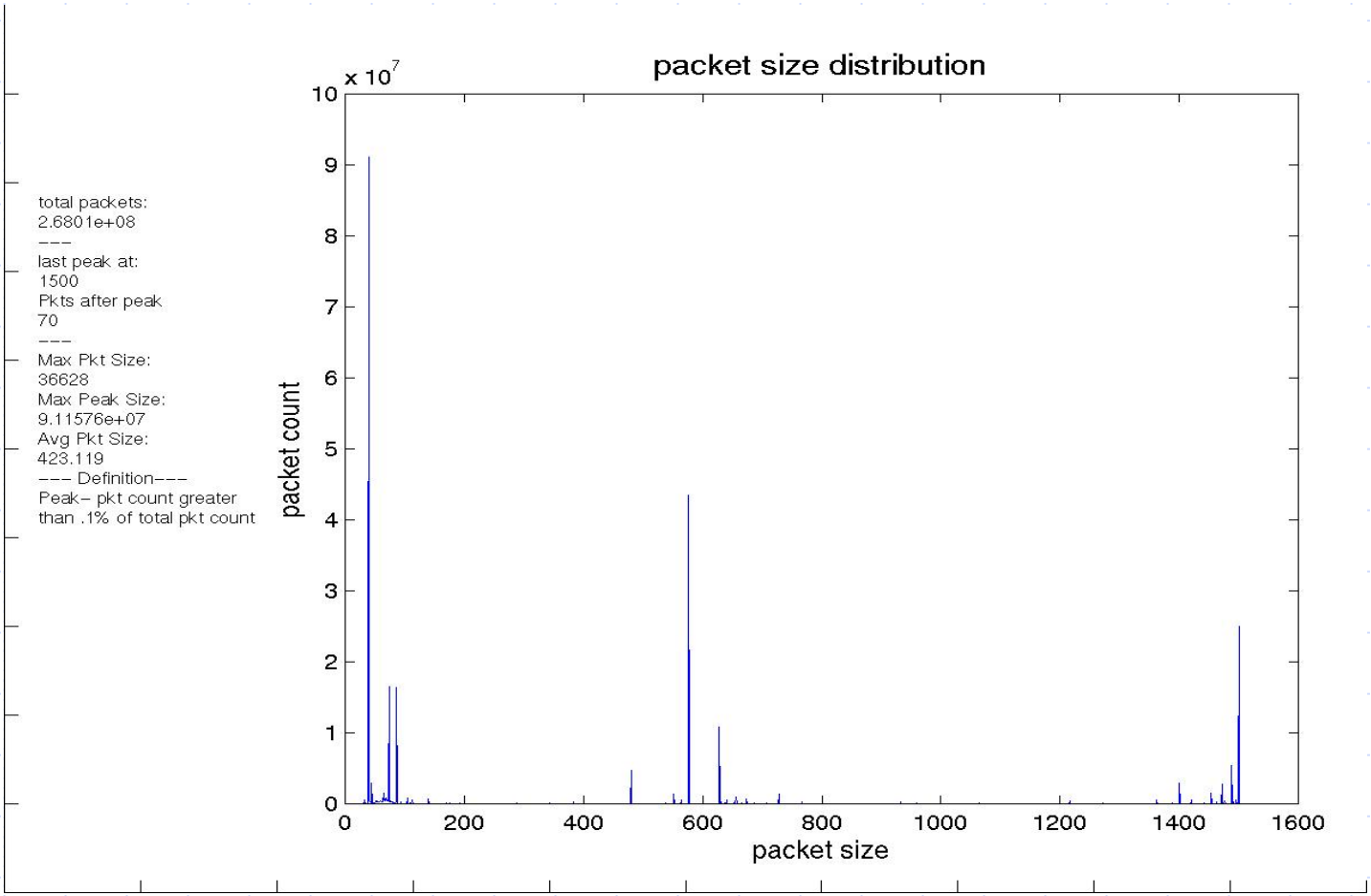
- Ethernet
  - Line Code 8B/10B
  - MAC: Start/Stop, IPG, Preamble
  - FEC
- EPON
  - No_Fragmentation
  - Burst Overhead

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

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

- 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	64.000	512.000	1518.000	417.188
% distribution	0.563	0.281	0.156	
Without FEC	86.000	534.000	1540.000	439.188
Efficiency	0.744	0.959	0.986	0.950

Model2

Pkt	64.000	512.000	1518.000	354.800
% distribution	0.800	0.000	0.200	
Without FEC	86.000	534.000	1540.000	376.800
Efficiency	0.744	0.959	0.986	0.942

Model1

  - We get ~950 Mbps good throughput

Impact of Frame based FEC

Pkt	64.000	512.000	1518.000	417.188
% distribution	0.563	0.281	0.156	
Without FEC	86.000	534.000	1540.000	439.188
Efficiency	0.744	0.959	0.986	0.950
With FEC	113.000	593.000	1663.000	490.188
Efficiency	0.566	0.863	0.913	0.851

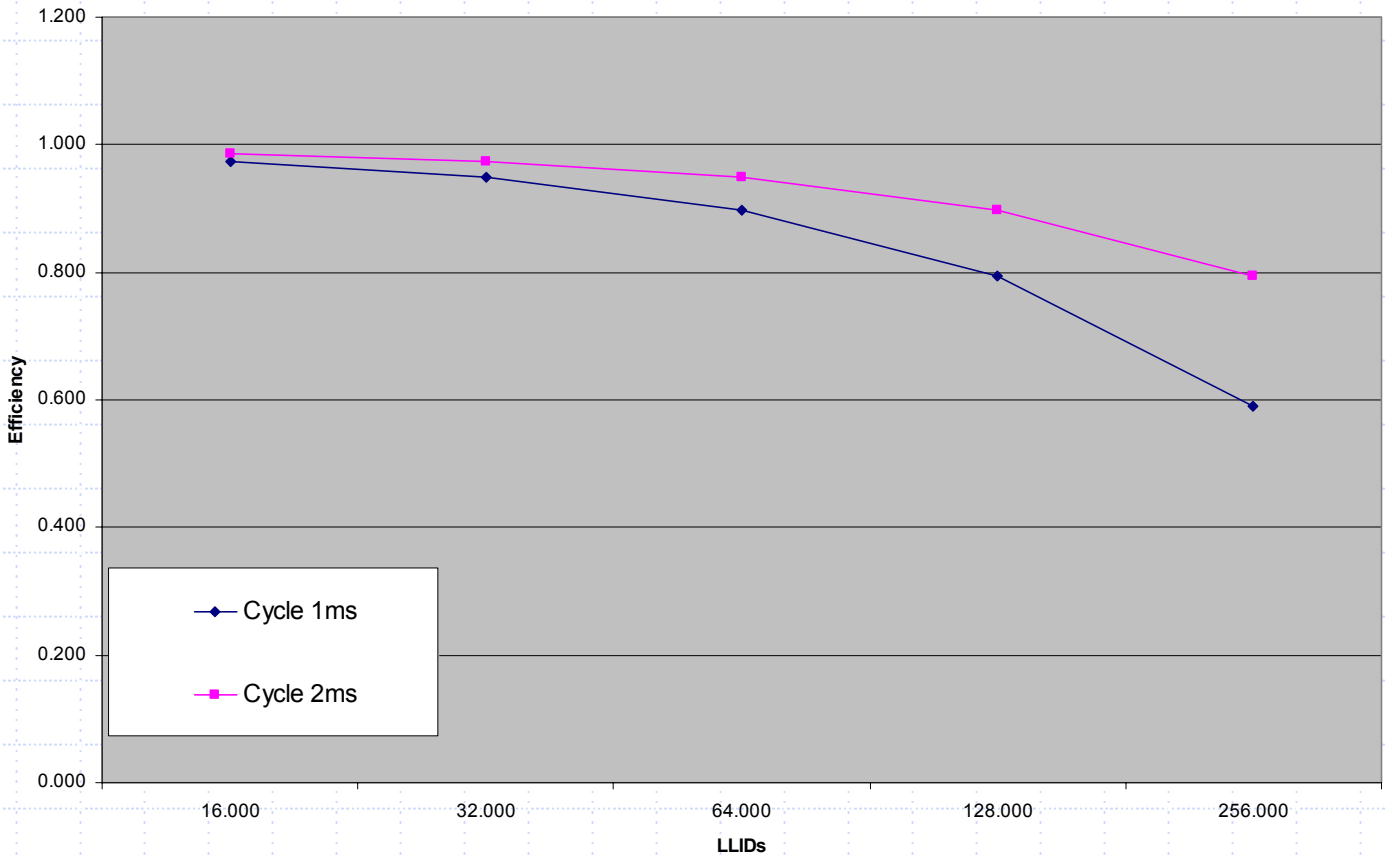
Model2

Pkt	64.000	512.000	1518.000	354.800
% distribution	0.800	0.000	0.200	
Without FEC	86.000	534.000	1540.000	376.800
Efficiency	0.744	0.959	0.986	0.942
With FEC	113.000	593.000	1663.000	423.000
Efficiency	0.566	0.863	0.913	0.839

Model1

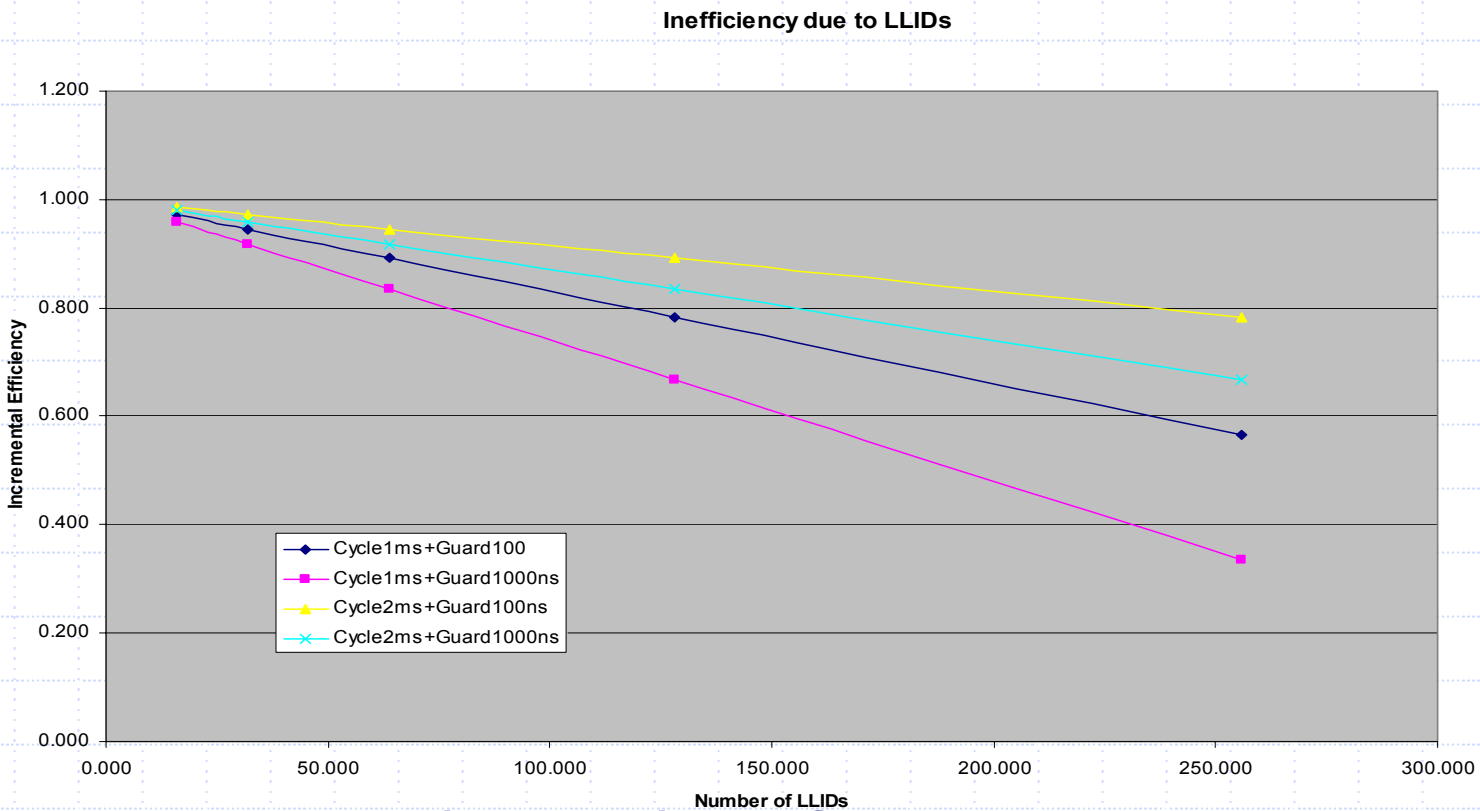
- We get ~850 Mbps good throughput

Incremental Overhead No_Fragmentation



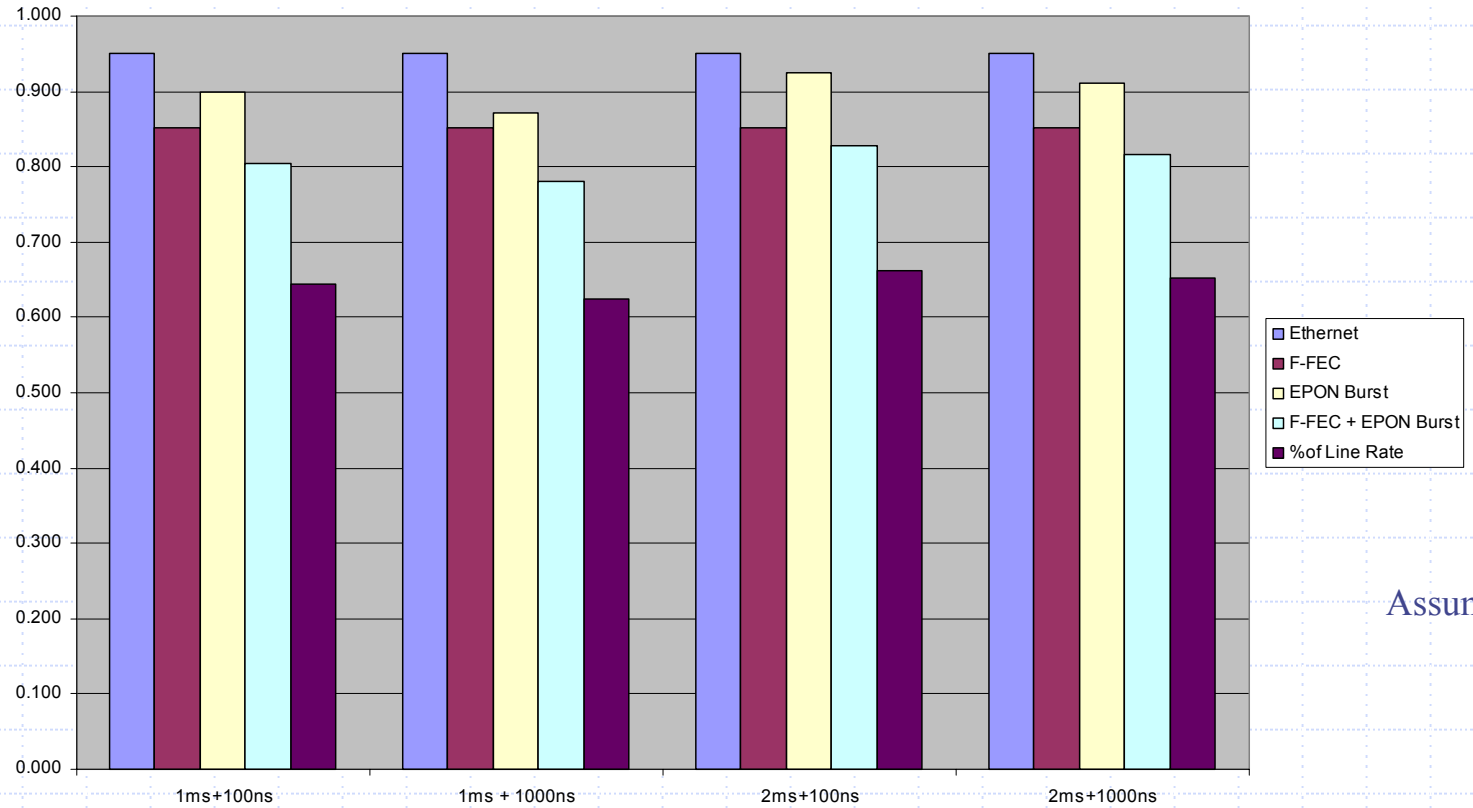
We waste bandwidth equivalent of half an average packet size at the end of each burst

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.
  - 5% for Ethernet framing (IPG+Start+Stop)
  - 7% for FEC
  - 3% for FEC framing in Frame based FEC
  - 5-10% for burst overhead and no_fragmentation
- Throughput of Ethernet system with everything included is ~780 Mbps