IEEE 802.3 EFM

Voice Services over PON

It's more than possible

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History

- Legacy Enterprise Ethernet suffered from low QoS due to:
  - CSMA/CD – no minimal delay guarantees
  - Best Effort switching – no queuing delay guarantees
- Not relevant in EPON

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Scope

- Delay requirements summary
- QoS parameters
- Bearer mechanism
- Signaling method

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Sample Delay Requirements

- International end to end delay (ITU G.114) < 150ms
- National lag (ITU G.114) < 50ms
- Access system delay (GR303) < 25ms
- Caller ID type 2 spec. delay (GR30) < 12.5ms
- Network-wide to avoid echo-canceling < 30ms
- Access to avoid echo-canceling (T1.508) < 5ms
- Switching hierarchy might impose more queuing delays

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QoS Consideration

- Bounds on end-to-end delay
  - Packetization delay f(packet size)
  - Queuing delay f(grant cycle, system load)
  - Jitter buffer f(grant cycle)
  - Transmission delay f(packet size, line rate)
  - Propagation delay f(span)

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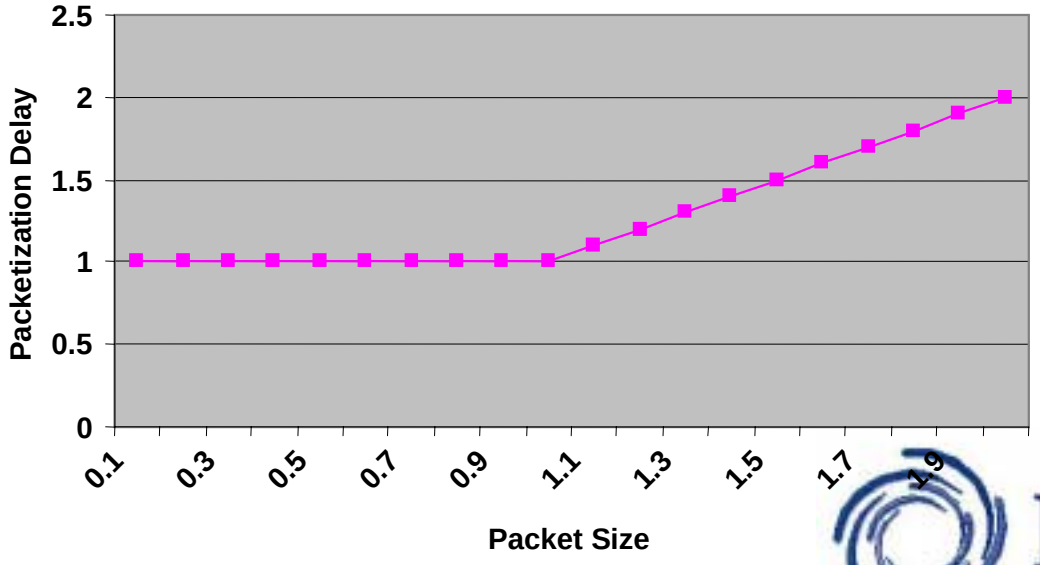
Packetization Delay

- Suffered once when packet is same length as Grant Cycle
- Smaller packets have no benefit, requiring higher overhead as well as serialization delay



Queuing Delay

- Function of load offered to system.
  - CBR traffic source model (not Poissonic)
  - Priority based scheduling
  - No Oversubscription
- Queuing delay equals space between grants
- Susceptible to clock disparities

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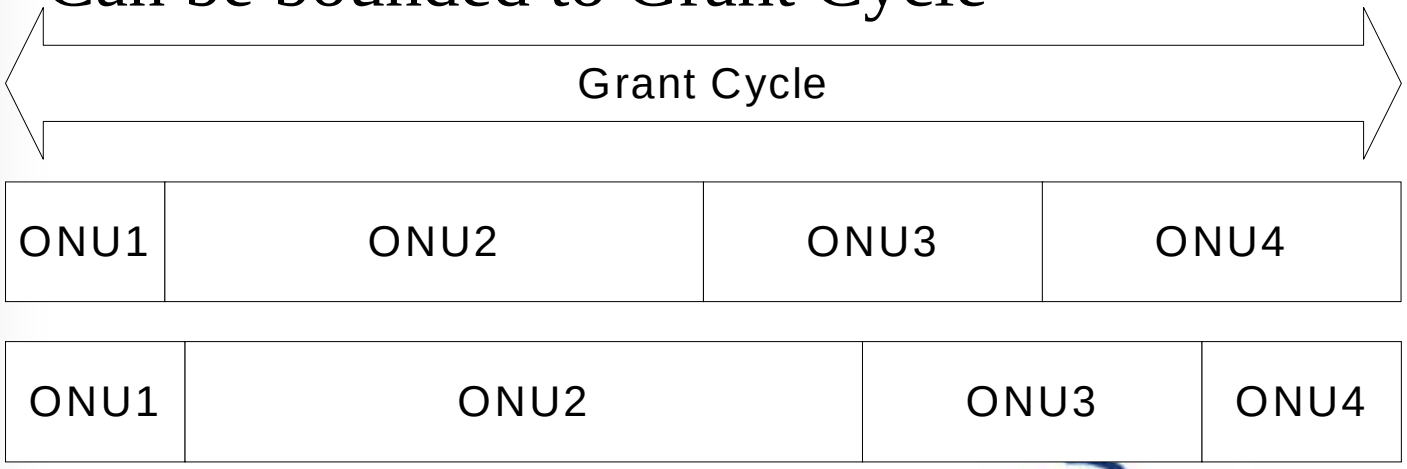
Jitter Buffer

- Several sources for unexpected delay:
  - Control messages stealing bandwidth
  - Drift of clock domains – sampling frequency error
  - ‘Breathing’ of phase inside grant space
- Can be bounded to Grant Cycle



Jitter Management

- Variable length frames can eliminate most buffering
  - Bounded by variance of phase-jitter in grant cycle
  - Similar effect gained by using very small packets with overhead penalty
- Two stage granting can reduce phase-jitter to zero.

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Bearer Mechanism

- Application over RTP / IP
- Fixed size packets containing stream of samples and RTP header
- Variable length packets require synchronization between grant mechanism and packet generator

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Clock Recovery

- Ethernet clock is 100ppm accuracy
- E1s require 50ppm
- Recommendations:
  - 8KHz clock not recovered from 125Mhz carrier
  - RTP mechanism for clock recovery from PDU required

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Bandwidth Requirements

- RTP framing mechanism has 256 bit header
- Ethernet header (tagged) is 240 bit

➔Overhead of 25% for 1ms E1 traffic

➔Overhead of 155% for 5ms Voice traffic (although only 9.5Mbit for 96 phone lines)

- Susceptible to packet size
- Extremely susceptible to guard time and grand cycle – through overhead at switching ONUs

➔16% bandwidth waste for 32 ONUs @ 5usec guard and 1msec cycle

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Signaling

- Not really in scope of IEEE 802.3 EFM

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Conclusion

- Voice services are more than possible!
- Empirical results show 250+ E1s easily accommodated in 1G PON
  - Delay approximates 3*Grant Space

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Recommendations

- Fixed size packets for simplicity
- Granting schedule of 1ms for reasonable E1 delays
- Small guard band required for high utilization
- Priority based queuing required

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