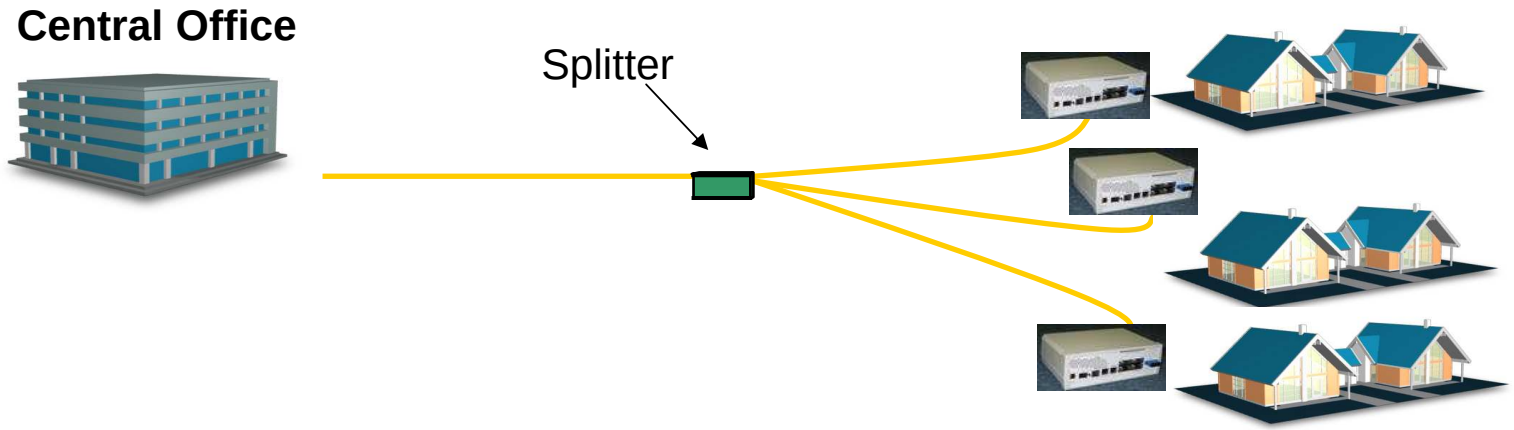
Energy-Efficient Ethernet and PON links



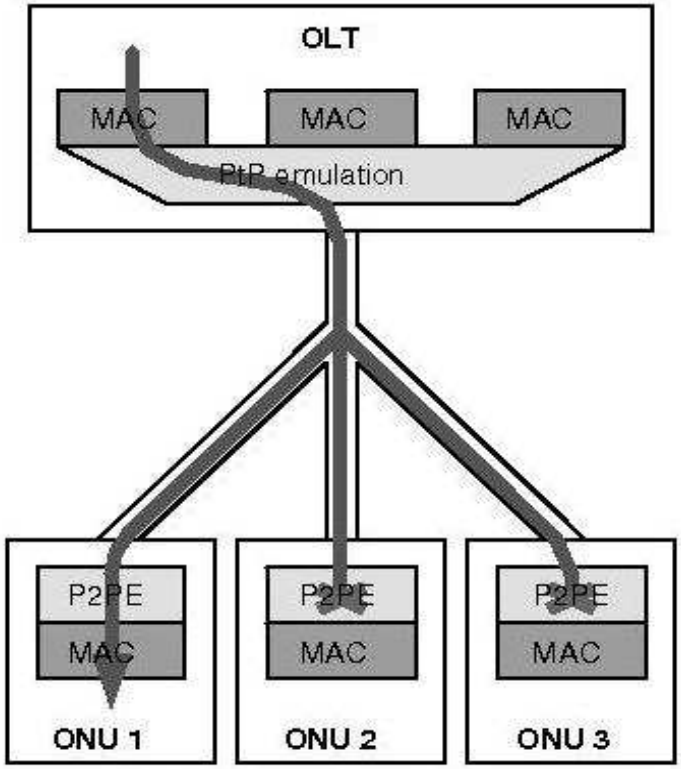
802.3av/802.3az Joint Session
Denver – July 2008

Ethernet Passive Optical Network (EPON)

1. Extends Ethernet to a point-to-multipoint topology. Bandwidth is time-divided among subscriber nodes (ie. “ONUs”).

2. Enables existence of multiple MACs associated with a single PHY at the head-end (ie. “OLT”)

3. Reconcilation sublayer includes point-to-point emulation – so that each MAC instance sees a regular full-duplex ethernet link



EPON Standards

1. 802.3ah-2005 (1 Gb/s)
   - PCS based on 1000BASE-X (ie. with 8b/10b coding)
   - ONUs transmit in upstream in burst mode
   - MAC Control extensions for coordination of ONU's network entry and TDM (ie. MPCP)
   - Extensions to MAC Control functions for managing TDM in the upstream channel and the entry of new ONUs into the network (ie. MPCP)

2. 802.3av (10 Gb/s)
   - Soon entering WG ballot
   - Based on 802.3ah-2005 architecture (including MPCP, Burst Mode)
   - PCS based on 10GBASE-R (64b/66b coding/synchronization) with extensions for FEC

EPON Interest in Energy Efficiency

1. Subscriber Devices (ONUs) are “always-on” devices, but spend a lot of time sitting idle.

   - An idle ONU might consume around 3-8 Watts
   - EPON is technology for “Fiber-to-the-Home” – when every home has one the energy requirements are enormous
   - Carriers have significant interest in meeting aggressive targets for power-saving

2. Components with significant power consumption during idle time:
   - Analog components (Receiver/Transmitter)
   - SERDES
   - Baseband processing and packet forwarding engines
   - Device peripherals

3. Powersaving mode for an ONU:
   - Power off these components periodically (while leaving a minimal number of components active)
   - Low cost, but enables Service Providers to reach battery and standby consumption targets

Service Providers and ITU-T

1. PON Service Providers have been quite interested in powersaving in general and sleep mode in particular
   - In recent forums, some of the largest providers have specifically identified these technologies as priorities for their next generation networks.

2. ITU-T
   - SG15 has formed a group to study powersavings in DSL and PON access networks

   - FSAN NGOA plans include powersaving, G984.4 includes "power shedding". As well, an optional appendix for G984.3 is currently being discussed in SG15/Q2

Suitability for 802.3az *Low Power Idle* in an EPON

1. The Low Power Idle[1] (LPI) approach is attractive as a powersaving mechanism for EPON

2. LPI facilitates complete (periodic) disabling of the subscriber device while maintaining active link status:

   - enables the high level of power saving that can be achieved by putting the ONU hardware to sleep

3. Entry and exit from idle mode is simple and can be adapted to the multipoint topology:

   - Sleep signal is sent from OLT to particular ONU
   - ONU wakes up at predefined time

4. With 802.3az, device support of LPI is optional and full interoperability between powersaving and non-powersaving devices is facilitated

[1] http://www.ieee802.org/3/az/public/may08/hays_02_0508.pdf

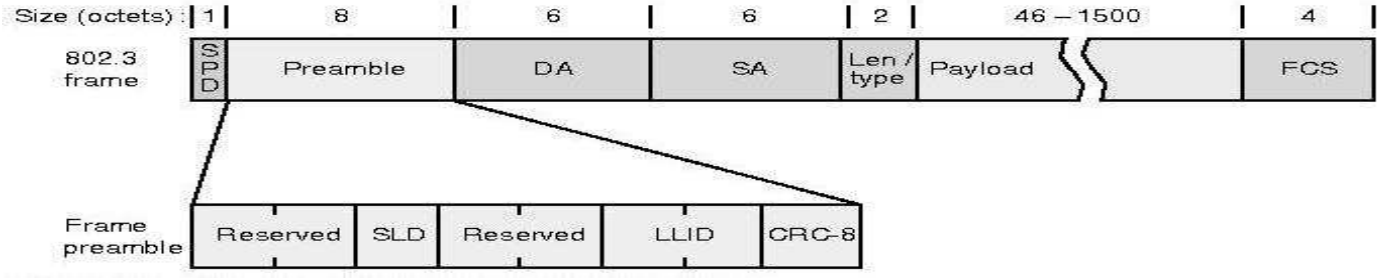
Relevant PON differences

- In an EPON, ONUs enter low-power mode independently of each other
  - The receiver and transmitter in the “sleeping” ONUs are in powerdown
  - OLT continues transmission to other ONUs

- EPON does not support auto-configuration
  - Must rely exclusively on LLDP for capabilities and parameter exchange

Backup

Point to Point Emulation



1. Logical Link ID (“LLID”) is a field in the frame preamble which identifies the ONU that is the destination (or source) of a particular frame

2. In the downstream direction, the LLID field is inserted by the Reconciliation Sublayer (RS) in the transmitting OLT and removed by the RS in the receiving ONU

3. Each ONU has its own LLID and discards frames addressed to other ONUs

4. Broadcast LLID is received by all ONUs

Low Power Idle