Ethernet PON (EPON) Protocol

By Edward Beili
<ebeili@onopathnet.com>

12 March 2001
Outline

- FTTx Services
- PON Network
- Point to Multipoint EPON Protocol
- EPONP building blocks
- Ranging
- Bandwidth Allocation
- PON Network Discovery
- Conclusion
FTTx services

- **Data**
  - Speed: 100/1000Mbps; Symmetric/Asymmetric
  - QoS: Latency, Min/Max Rate
  - Security

- **Video**
  - Analog/Digital streaming

- **Voice**
  - Low jitter & latency
  - Constant delay
  - Business vs. Residential (Life-line)
Passive Optical Network (PON)

CO | PON | CP

OLT | Passive Optical Splitter/Combiner | ONT | ONU

ONU | ONU | ONU
PON Challenge

- Only the OLT is able to detect collisions
- Upstream channel separation methods:
  - TDMA
  - WDM
  - RF sub-carrier
  - Phase etc.
- TDMA issues:
  - Burst-mode Transceiver
  - Downstream traffic isolation (privacy)
  - Frame Segmentation to achieve small latency
TDMA PON Protocols

- **FSAN ATM-PON – ITU-T G.983**
  - Well defined, Field tried, Industry Standard
    - Accepted by major ILECs: BT, FT, NTT, BellSouth, GTE, SBC, QUEST
    - Supporting Vendors: Alcatel, Lucent, Terawave, QuantumBridge, Nortel...
  - Inherent 8Khz clock, QoS, Bandwidth allocation
    - Expensive & Complicated (Intermediate ATM layer)
    - Off-the-shelf components are scarce

- **Ethernet PON**
  - Native IP
  - Simple & Cheap off-the-shelf components
    - Non-standard technology
    - Complicated Telephony, QoS, Bandwidth allocation
EPON – The need for standard

Goals:

- Multi-vendor interoperability between OLT & ONU
- Standard solutions acceptance by service providers
- Cost reduction due to availability of standard components (larger volumes, broader deployment)
- More bandwidth to the end user for less $$
Ethernet PON (EPON) Protocol

- Using standard Ethernet frames
- OLT “broadcasts” Ethernet Frames to its ONUs
- Each ONU transmits in turn using grants issued by the OLT
- OLT regulates the amount of up-stream B/W given to each ONU by controlling the window size
- EPONP control frames are exchanged in-band
- Ranging is used to minimize inter-window gaps
EPON transport – Requirements

- Reliable & Secure transport
- Voice requirements:
  - Constant delay
  - Low latency
  - Low jitter
  - Life-line
- Bandwidth Allocation (Static/Dynamic)
EPON transport – Main functions

- Transmission grants
- ONU discovery/ID assignment
- Periodic sanity check (who is alive)
- Bandwidth allocation
- Security
- Error handling
EPONP - Overview

- 100/1000BaseFX Phy is used at both ends
- Full duplex, 100/1000Mbps statically configured
- Flow-control (back-pressure) is turned off at both ends
- Frames are not segmented
- Short (64 byte) control frames (grants and messages) are periodically exchanged between LC and ONUs
EPONP – Overview (2)

- **Downstream**
  - Ethernet traffic is broadcasted from OLT to all of its ONUs
  - OLT periodically sends a Start message containing grants for 1..N full cycles to its subtending ONUs
  - Each grant contains:
    - Window_Size and Window_Offset per ONU
    - Cycle_Size
    - Number_of_Cycles

- **Upstream**
  - Each ONU buffers the upstream LAN traffic and sends it to the OLT when its window is open.
  - Upstream B/W is controlled by the window size per ONU
EPONP – Parameters

- Window_Size_ONU1
- Window_Offset_ONU1
- Start_of_Cycle
- Cycle_Size
- ONU1
- ONU2
- ONU3
- ONU4
- IWG - Inter Window Gap
- Number_of_Cycles

EPON tutorial
EPONP - Parameter Limitations

EXAMPLE (100Mbps symmetric, 16 ONUs, no segmentation):

- \((\text{voice\_frame} + \text{ctrl\_frame} + \text{max\_frame}) \leq \text{Window\_Size} \leq \text{max Cycle\_Size}/16\)
- \(2.5\text{ms} \leq \text{Cycle\_Size} \leq 20\text{ms} \leq \text{max (max latency, max Voice\_Delay)}\)
- \(0.96\mu\text{s} \leq \text{IWG} \leq 4\mu\text{s}\)
EPONP – Ranging

- Ranging procedure to minimize the guard time, using echo messages sent from OLT to ONUs:
  - OLT measures round trip delay for each ONU
  - OLT notifies each ONU of equalization delay: $T_e$
  - ONU adjusts transmission phase to $T_e$

- Adjust the delay periodically to compensate for temperature changes, component aging etc.
Bandwidth Allocation (BA)

- **Upstream**
  - Controlled by the OLT protocol state machine
  - Window size based – equal delay
  - Window rate based – variable delay

- **Downstream**
  - Rate limiting in the OLT or ONU
EPON tutorial

BA – Upstream

Upstream Static BA (window size based)

Upstream Dynamic BA

ONU1
ONU2
ONU3
ONU4

Start

ONU1
ONU2
ONU3
ONU4

ONU4 -> LifeLine
ONU discovery & ID assignment

- **Static assignment**
  - E.g. manual provisioning during ONU installation
  - ...

- **Auto-discovery**
  - Binary Tree
  - Hashing (MAC) + Mask
  - Raffle
  - ...

IEEE 802.3 EFM working group 12 March 2001
Conclusion

- Topics to work on:
  - Building blocks / Parameters
  - Ranging
  - BA
  - PON discovery
Acronyms

- CO: Central Office
- FTTB/C/Cab/H: Fiber-To-The-Business/Curb/Cabinet/Home
- FSAN: Full-Service Access Network
- OLT: Optical Line Terminal
- ONT: Optical Network Terminator
- ONU: Optical Network Unit
- PON: Passive Optical Network
- POTS: Plain Old Telephone Service
References

- ITU-T G.983.1, “High Speed optical access systems based on Passive Optical Network (PON) techniques”
- ITU-T G.983.3, “A broadband optical access system with increased service capability by wavelength allocation“
- ITU-T G.959.1, “Optical transport network physical layer interfaces”.