Ethernet PON (EPON) Protocol

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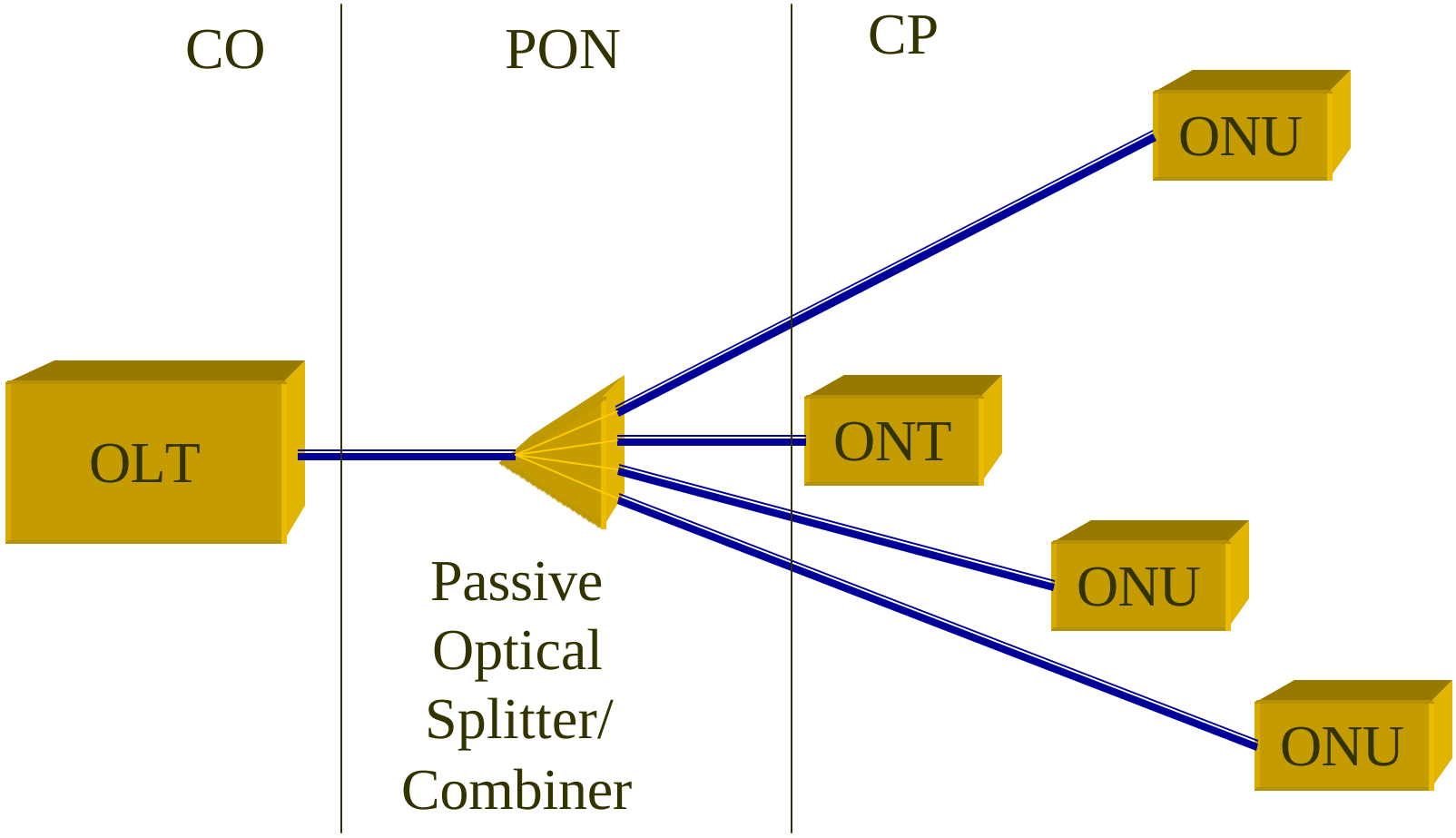
Outline

- 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)



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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 $$

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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)

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EPON transport – Main functions

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

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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

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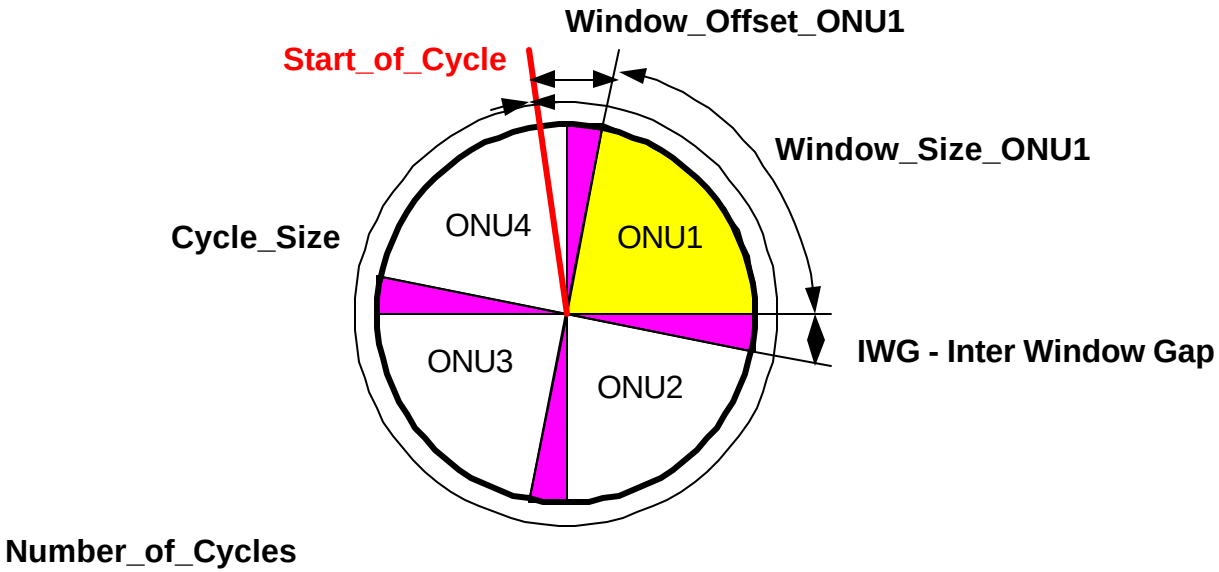
EPONP – Overview (2)

- 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



EPONP - Parameter Limitations

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

- (voice_frame + ctrl_frame + max_frame) <= Window_Size <= max Cycle_Size/16
- 2.5ms (16 x min Window_Size) <= Cycle_Size <= 20ms (max (max latency, max Voice_Delay)
- 0.96μs (IFG) <= IWG <= 4μs

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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.

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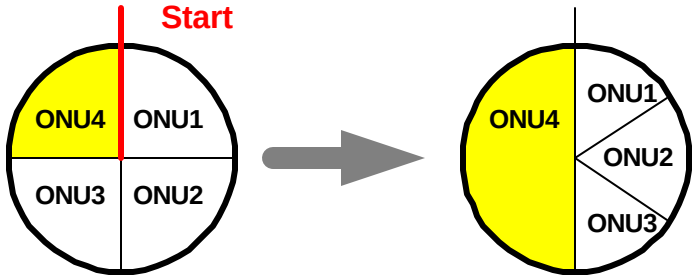
Bandwidth Allocation (BA)

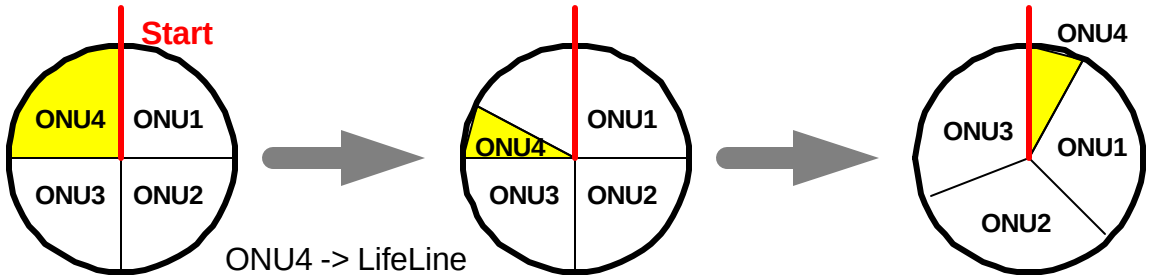
- Upstream
  - Controlled by the OLT protocol state machine
  - Window size based – equal delay
  - Window rate based – variable delay
- Downstream
  - Rate limiting in the OLT or ONU

BA – Upstream

Upstream Static BA (window size based)



Upstream Dynamic BA



ONU4 -> LifeLine

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ONU discovery & ID assignment

- Static assignment
  - E.g. manual provisioning during ONU installation
  - …
- Auto-discovery
  - Binary Tree
  - Hashing (MAC) + Mask
  - Raffle
  - …

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.983.2, “The ONT Management and Control Interface Specification”
- 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”.