Ethernet Passive Optical Networks
EPON

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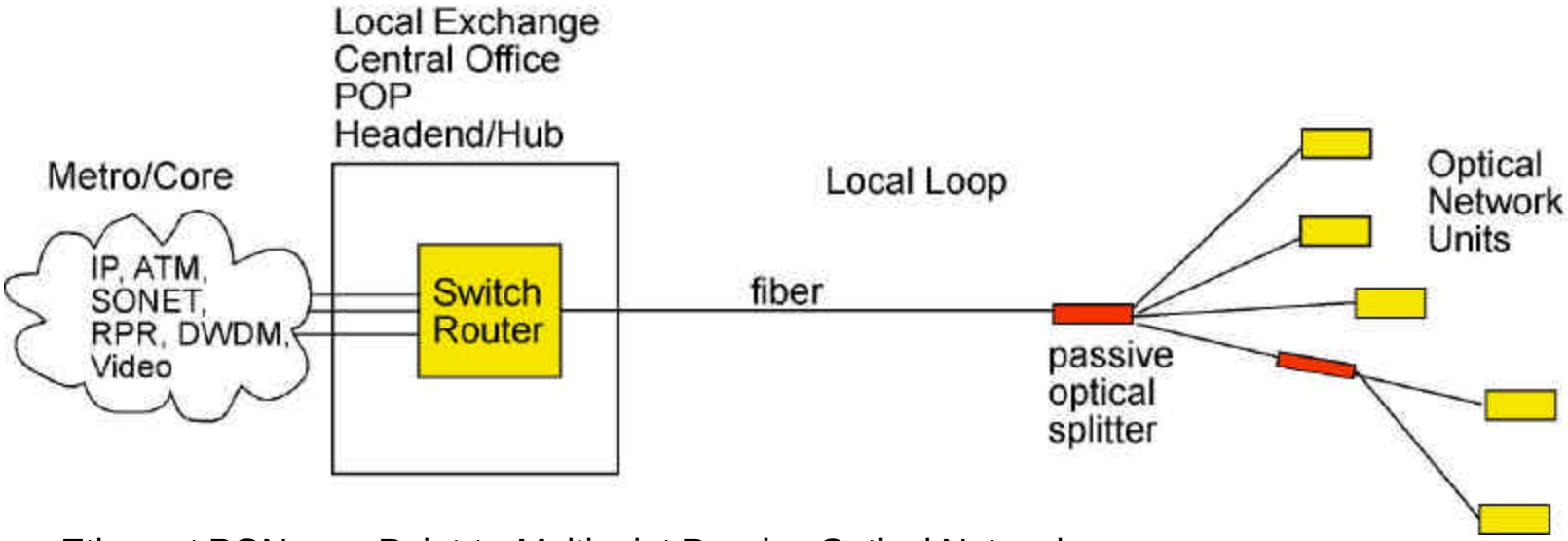
Discussion

1. What is an Ethernet Passive Optical Network (EPON)
2. Applications for Ethernet PONs
3. Ethernet PONs vs. ATM PONs
4. Can Ethernet PONs provide QoS
5. EPON Standard Discussion

What is an Ethernet PON?



- Ethernet PONs are Point-to-Multipoint Passive Optical Networks
- Used for FTTC, FTTB, FTTH, FTTN
- Provides voice, data and video services (POTs, Ethernet, T1/T3, etc)
- Provides dynamically allocated bandwidth (1 to 1000 Mbps) and service to each ONU
- Switch/Router interfaces to Metro/Core Equipment
- Passive Optical Splitters eliminate active electronics in the local loop
- Optical Network Units behave like DSL or Cable Modems, on speed
- Typical deployments have 4 to 32 Optical Network Units
- Single fiber deployments with 1550 (1510) nm downstream and 1310 nm upstream
- Downstream is a broadcast point to multipoint
- Upstream requires a multiple access protocol for multipoint to point

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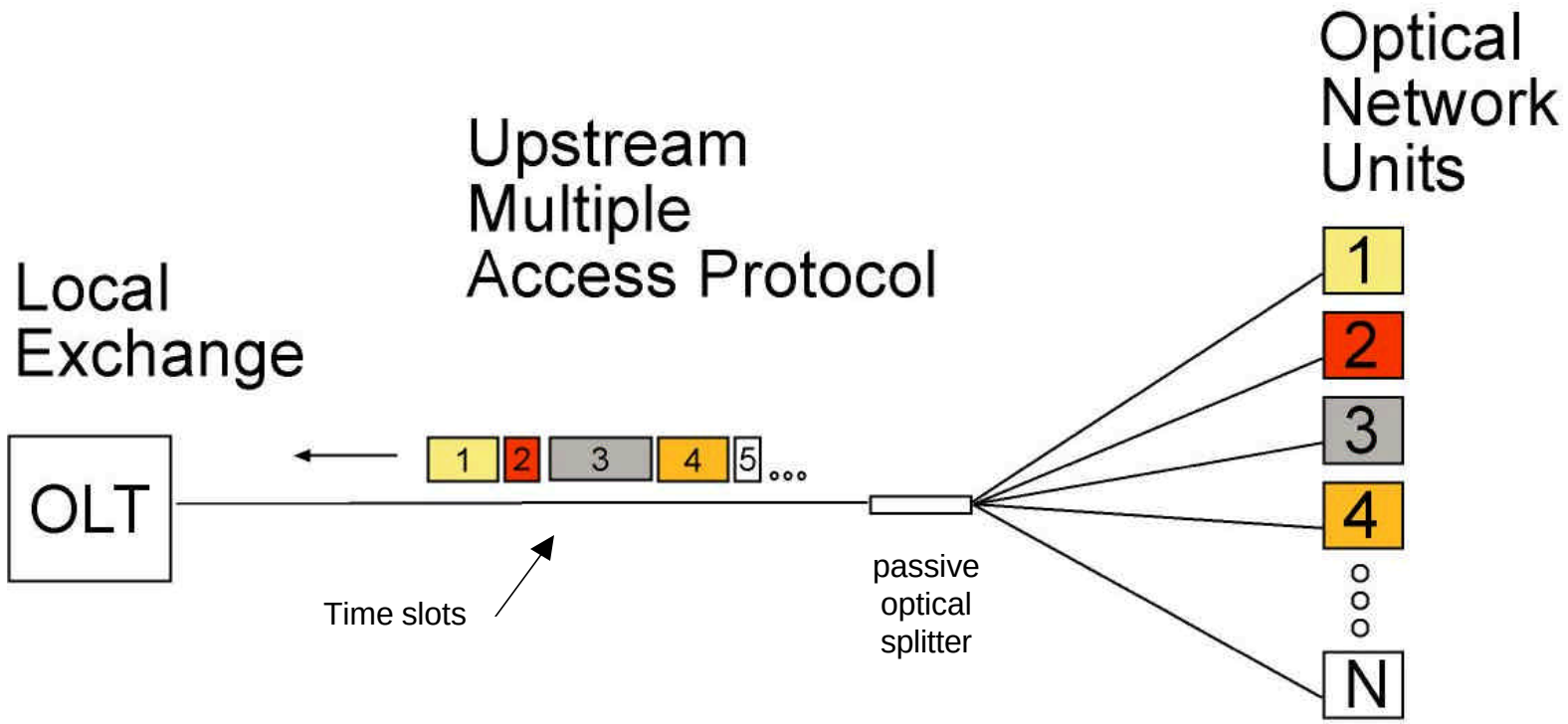
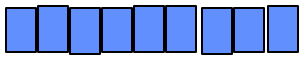
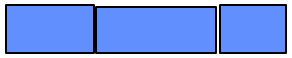
Ethernet PON Frames, Time Slots



EPONs
PONs are point-to-multipoint optical network using optical splitters
Downstream → Ethernet frames are broadcast and extracted based on MAC address of frames
Upstream ← Multiple access protocol; variable time slots, variable frame size



ATM PON – fixed 56 byte (53 byte cell + 3 byte dead zone)



Ethernet PON – variable time slot and frame size

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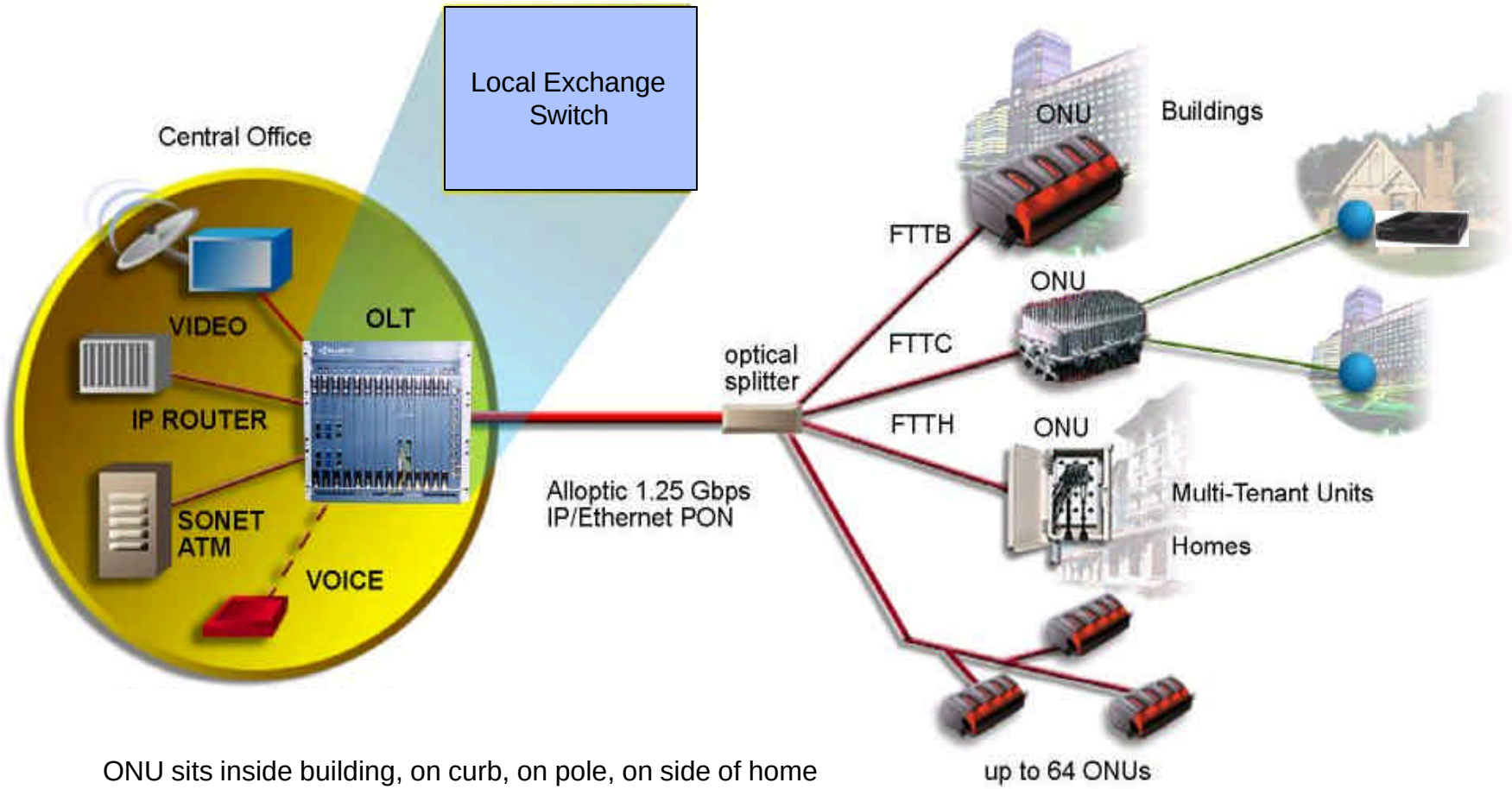
Ethernet PONs - Visual



ONU sits inside building, on curb, on pole, on side of home
OLT bridges to Metro/Core

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EPON – Covers many bases as an optical feeder

Fiber Feeder

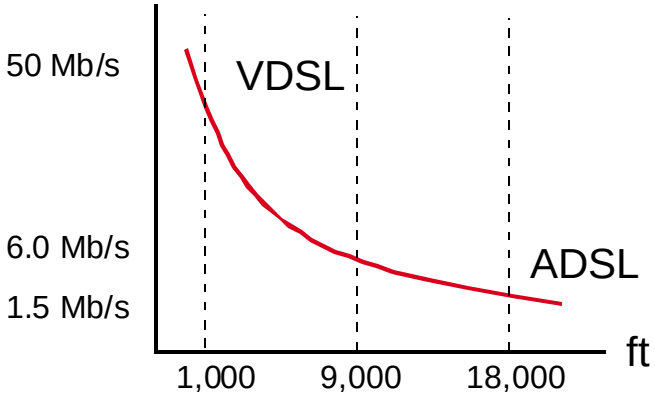
Coax (HFC)

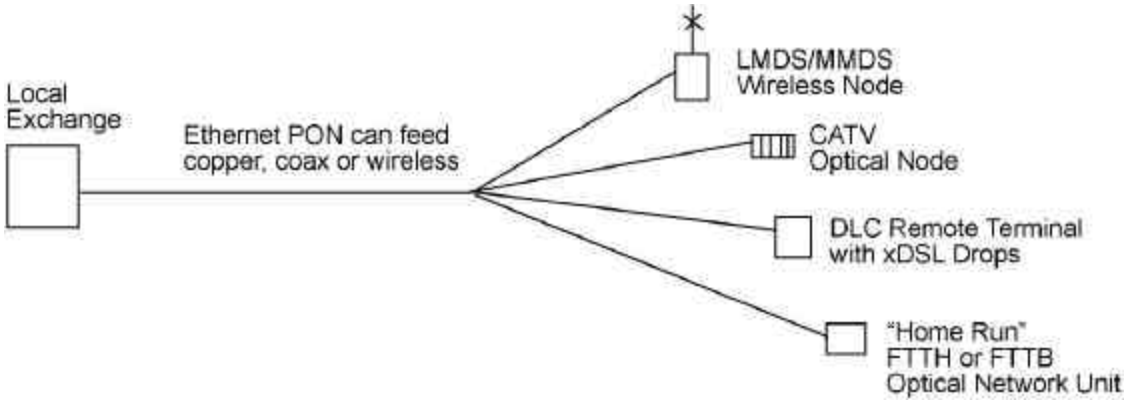
Fiber Feeder

Wireless (LMDS)

Fiber Feeder

Fiber (FTTX)





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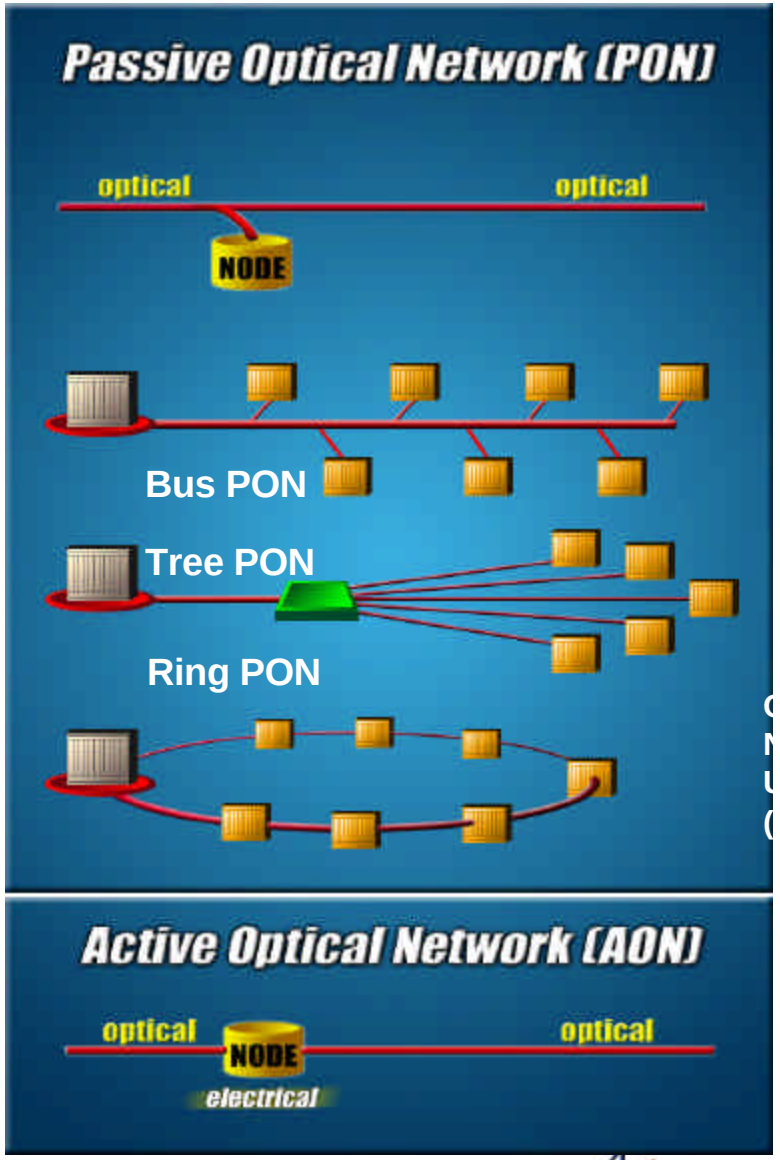
Why PON as an Optical Fiber Feeder

- Minimum fiber deployment
  - in the local loop
  - in the Central Office
- Lowest initial deployment cost
- Eliminate loop electronics
- Low maintenance requirements
- High bandwidth (WDM overlay)
- Voice, Data and Video
- Asymmetric or symmetric traffic
- Fault tolerant: power loss
- Broadcasts downstream (video)



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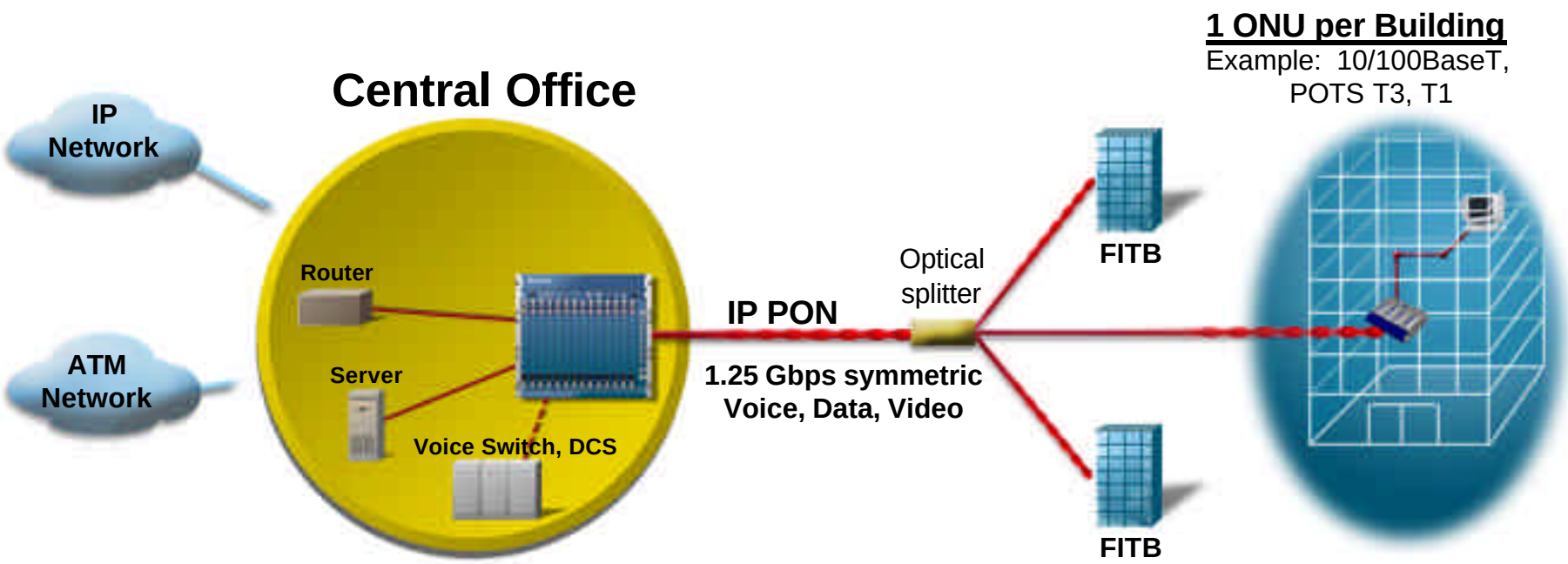
FTTB



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EPON Optical Network Units

Optical Modem

Ethernet
Optical

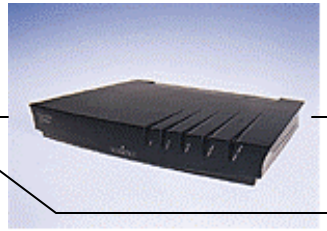
Ethernet

IP/Ethernet (1000 Mbps)
(POTS, Video)

Dumb or Smart?
Firewall, Routing, Switching,
Dynamic Bandwidth Allocation

DSL Modem

ATM
Copper



Ethernet

Ethernet (1-10 Mbps)
(POTS)

Cable Modem

Analog
Coax

Ethernet

Ethernet (1-10 Mbps)
(Video)

TDM

T1

T1 (1.5 Mbps) - legacy

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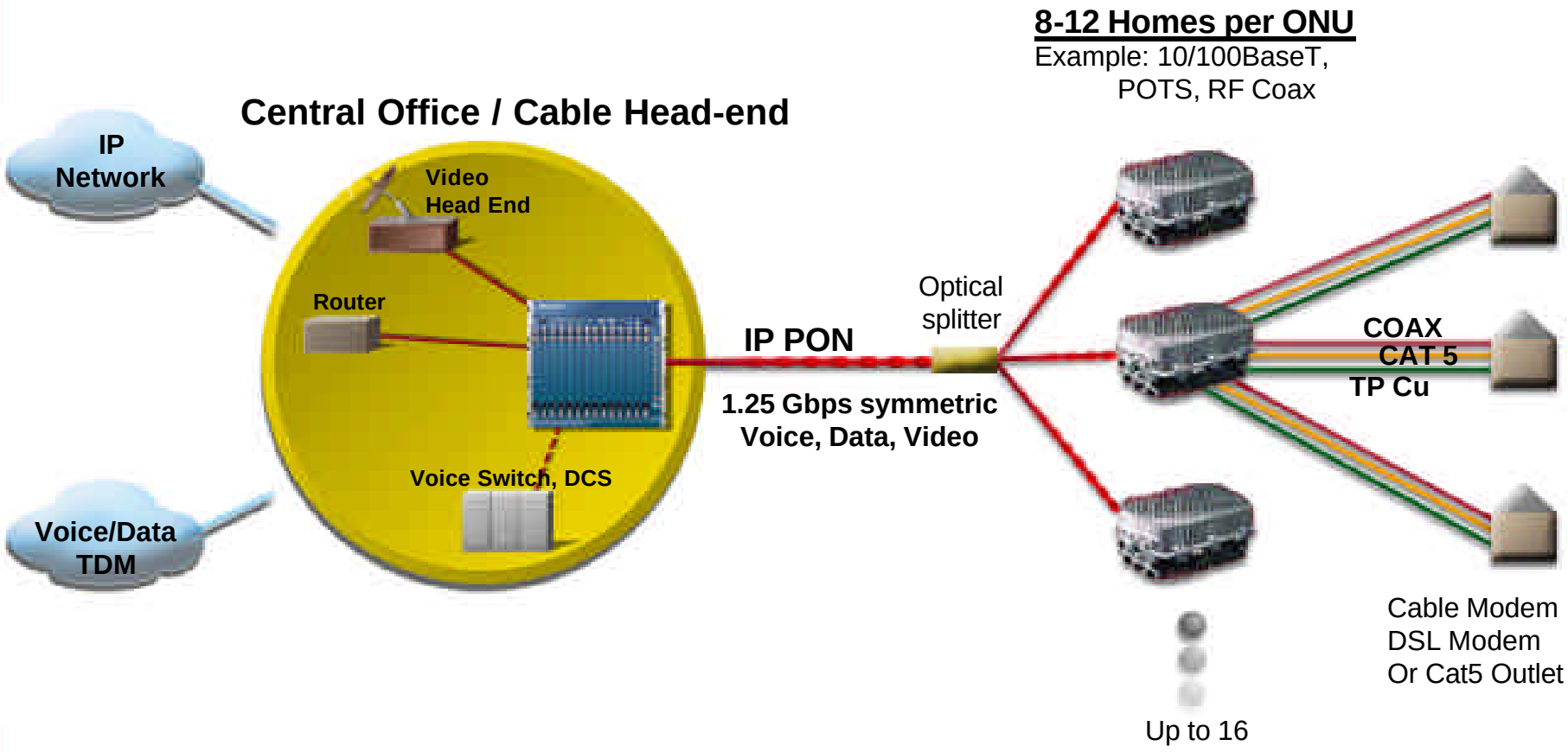
FTTC



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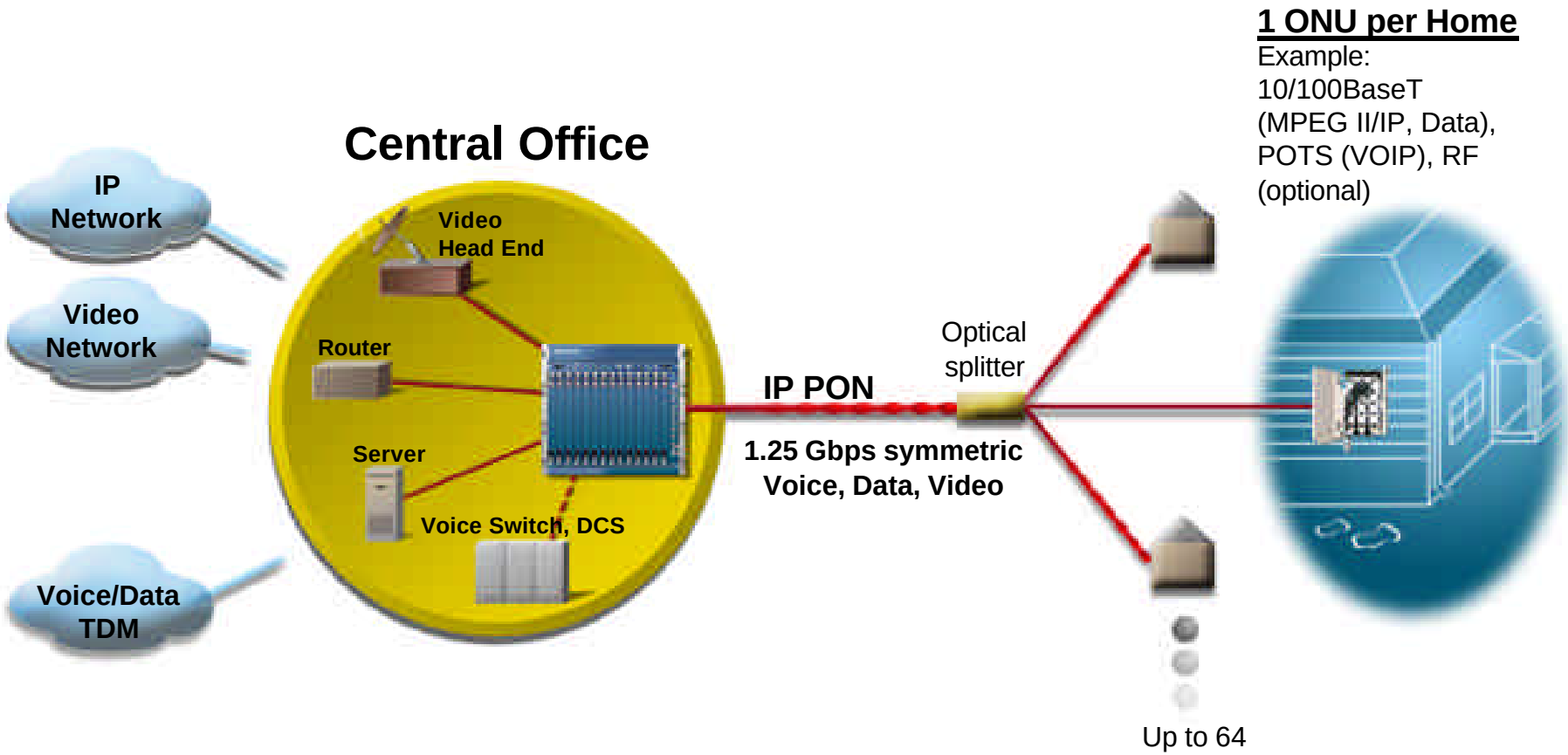
FTTH



1 ONU per Home

Example:
10/100BaseT
(MPEG II/IP, Data),
POTS (VOIP), RF
(optional)

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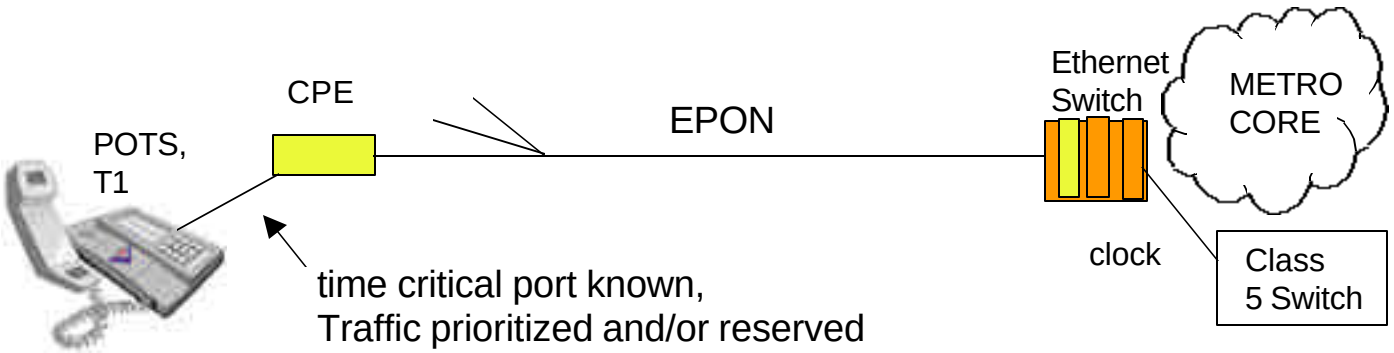
Quality of Service (QoS) for EPONs

How is real time traffic (POTs, T1s, etc) provided over an Optical Ethernet last mile ?



PONs operate in a “closed loop” last mile
Routers at OLT and ONU (CPE)
Use central office clock; guarantee low latency
Bandwidth: Over provision and manage
Prioritization: Layer 3 DiffServ/TOS
Layer 2 802.1p, 802.1q
RSVP
Queuing techniques, Bandwidth assignments
Video buffering

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EPONs and APONs

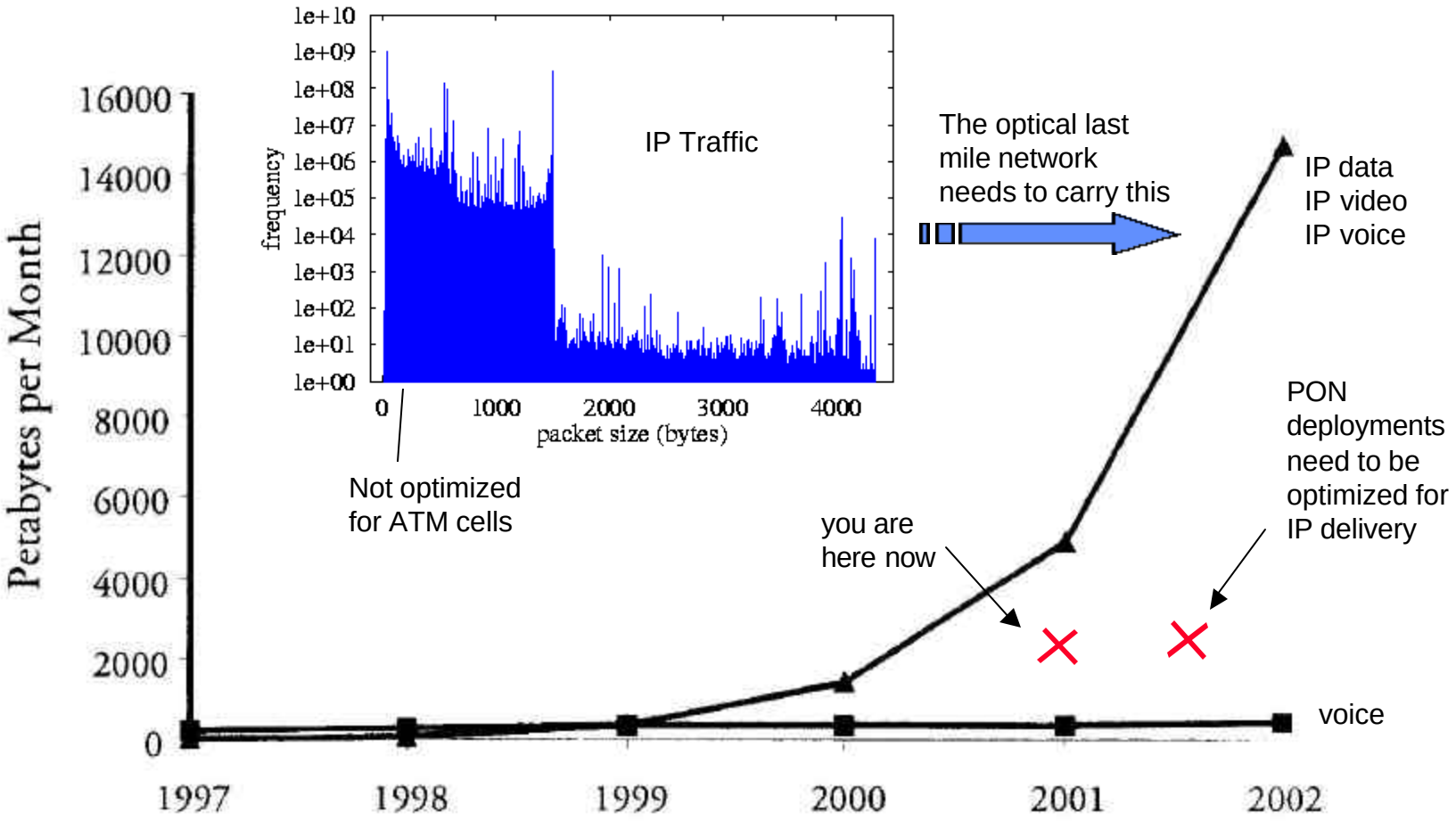
ATM PON Standard: ITU G.983 (FSAN)
Initialized in 1995, when ATM was a logical choice for the last mile
APON standard lacks interoperability

	EPON	APON
Layer 2 Protocol	**Ethernet**	**ATM**
Transport	**Frame**	**Fixed Cell**
Speed	**100 Mbps, 1.25 GBE 10 GBE**	**155 622 Mbps**
Service Providers	**CLECs, ELECs, DLECs, MSOs, ILECs**	**FSAN ILECs**
Standard	**IEEE ??**	**FSAN**
Upstream	**TDMA, Other**	**TDMA**
Cost	**Ethernet Switch**	**ATM Switch**
Delivery	**POTS, Data VOIP, IP Video**	**POTS, Data**

Advantages of Optical Ethernet (EPON) vs. ATM (APON) in the First Mile

- Low cost due to economies of scale
- ~320,000,000 Ethernet Ports deployed worldwide
- LANs are ~90% Ethernet today
- Byte life begins and ends as IP/Ethernet
- Ease of Scalability, Management
- Cable Modems and DSL Modems have Ethernet Interfaces
- Many IP/Ethernet chipset solutions to chose from
- Future cost curve of components (electrical, optical) steep for Ethernet
- Ethernet is a Universal standard, no variations
- CLECs (ELECs) can start with IP centric networks
- Carriers are now offering Ethernet WAN Services
- Ethernet beat FDDI, Token Ring, Fibre Channel, ATM in the LAN
- Work force Solution: Many LAN technicians comfortable with Ethernet

PON should be Packet based



Standards Issues: CSMA/CD vs. TDMA

Ethernet CSMA/CD – Layer 2 Protocol

- Contention based random access protocol
- Distance limited
- Timing not critical
- Point to point transceiver in both directions

Ethernet PON Broadcasting Downstream – Ethernet Framed

- Broadcast and select multiple access protocol
- No distance limitation and timing is not critical
- Single point to multipoint transmission

Ethernet PON Upstream TDMA – Ethernet Frames in Time Slots

- Managed collision free multiple access protocol
- No distance limitation but timing is critical
- Multiple point to single point transmission
- Upstream is sliced to multiple data slots, each time slot assigned to one node
- Upstream node is assigned to supply timing information and manage upstream collision
- Optical delay must be pre-measured to calculate the right timing assignment

Howard's Questions: A Summary

EPON scope, propose….

- ….define a point-to-multipoint Ethernet Passive Optical Network (EPON) protocol for use in optical access networks at rates scalable to multiple gigabits per second.
- …. define a high speed protocol that is optimized for Ethernet transmission in point-to-multipoint networks for Fiber-to-the-Building/Home/Curb applications, reaching several kilometers. Current PON standard is based on ATM or TDM transport. There is no existing high-speed Ethernet-based standard for passive optical point-to-multipoint deployments optimized for packet transmission.

Justification in terms of market potential

- PON market $2B cumulative in 4 years (Yankee Group)

Compatibility with 802 standards

- Yes

Technical Feasibility

- Demonstrated by multiple companies

Thank you

IEEE Ethernet in the First Mile (EFM) Study Group
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