Operating the EPON protocol over Coaxial Distribution Networks Call for Interest

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IEEE 802.3 Ethernet Working Group

Atlanta, GA

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Objectives for This Meeting

- To measure the interest in starting a study group to develop a standards project proposal (a PAR and 5 Criteria) for: Operating the EPON protocol over Coaxial Distribution Networks

- This meeting does not:
  - Fully explore the problem
  - Debate strengths and weaknesses of solutions
  - Choose any one solution
  - Create PAR or five criteria
  - Create a standard or specification

Agenda

- Introduction
- Market Potential
- High Level Concept
- Why Now?
- Q&A
- Straw Polls

The Brief History of EPON

2000

- EFM started

2004

- IEEE Std 802.3ah– 2004 is approved

2008

- China Telecom incorporates 802.3ah into Chinese standard
- China SARFT begins EPON assessment in two-way cable network upgrade

2009

- IEEE Std 802.3av-2009 is approved

2010

- IEEE P1904.1 SIEPON (ongoing)

….

EPON Today…

- **… is in commercial deployments:**
  - **Carriers: China Netcom, KDDI, K-Opticom,** Korea Telecom, NTT, SBB, ...
  - **Cable Operators: Bright House**,
  - **Deployed volume: 85M+ subscribers**
  - **2010 Global Market Share[1]: EPON/GEPON 56%, GPON 36%, BPON 3%, P2P 5%**

- **… has broad manufacturing base:**
  - **Optics/Transceivers/PHY: Delta Electronics, ETRI,** Fiberxon, Hitachi/Lightron, NEC, Sumitomo, Vitesse, Zenko
  - **ASIC: Broadcom, Centillium, Cortina, GW, Hisilicon, PMC-Sierra, Qualcomm, Vitesse**
  - **System: Alcatel-Lucent, Allied Telesyn, Alloptic, Corecess,** Dasan/Siemens, Enablence, Entrisphere, Fiberhome, Fujitsu, Furukawa, Hitachi, Huawei, Hyundai, Mitsubishi, Nayna, NEC, OKIFujikura, Salira, Samsung, Sumitomo, UTStarcom, ZTE, ZyXEL ...
  - **Test Equipment: Agilent, Fujitsu**

[1]**Ovum report:** ***Market Share: 4Q10 and 2010 FTTx, DSL, and CMTS,*** **(OT00061-022), 5/2011**

The Brief History of Data-Over-Cable

Pre-1997
- Many proprietary solutions

1994-1999
- IEEE 802.14 CATV MAC and PHY WG evaluates many proposals

1997
- DOCSIS®[1] 1.0
  - Max: 42 Mbps / 10 Mbps

1999
- DOCSIS 1.1
  - Adds initial QoS

2001
- DOCSIS 2.0
  - Enhanced upstream
  - 42 Mbps / 30 Mbps

2006
- DOCSIS 3.0
  - Channel bonding
  - D x 42 Mbps, U x 30 Mbps
    Typical: D is 4 or 8, U is 1 or 4

DOCSIS® is a trademark of Cable Television Laboratories
[1] Data-Over-Cable Service Interface Specification
[2] Cable Modem Termination System
[3] Quadrature Amplitude Modulation

High Speed Data-Over-Cable today:
- **… is in commercial deployments:**
  - **North American MSOs: All**
  - **European: KDG, UPC, Virgin Media, NumbericCable, UPC, …**
  - **China: Topway, OCN, BGC**
  - **North American Market: 75 M, Europe 13.4 M, China 5 M**
- **… has broad manufacturing base:**
  - ASIC: Broadcom, Conexant, TI
  - CMTS[2]: Cisco, ARRIS, Motorla, Casa
  - QAM[3]: Harmonic, BigBand Networks, Cisco, ARRIS
- **… CableLabs device evolution:**
  - Converged Cable Access Platform (CCAP)
    - Video QAM + DOCSIS 3.0 QAM + EPON
    - SP-CCAP-OSSI Rev I01 issued 9/30/11
    - http://www.cablelabs.com/cablemodem/specifications/ccap.html

Why a New CFI?

- **Cable operators are deploying EPON using DOCSIS® Provisioning of EPON (DPoE™) specifications**
- **Carriers and Operators are looking for a next generation solution**
  - Compatible with existing outside plant and inside coaxial cable services
  - Compatible with existing NMS and OAM
  - Where deployed by Cable Operators, compatible with DPoE specifications
- **Multiple Service Operators (MSOs) are looking for technical solutions to improve their customer offerings**
  - **e.g. Video over IP**

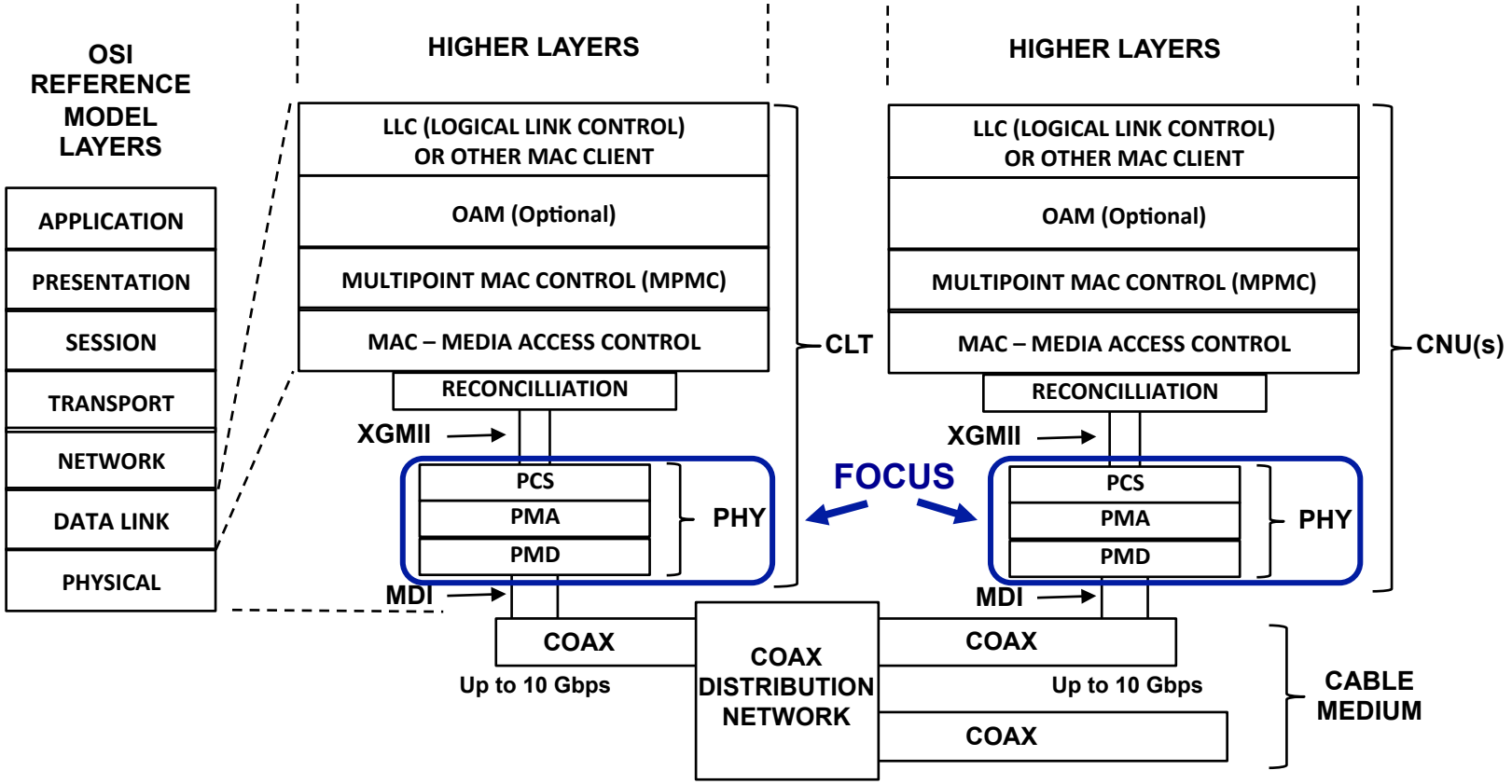
Next Step: Extend EPON over Coax

- Proposed scope of study:

  A new PHY for operating the EPON protocol over Coaxial Distribution Networks ("EPoC")

  - Up to 10 Gbps downstream / Up to 10 Gbps upstream
    - Support symmetric and asymmetric full-duplex deployments
- Focused project
- No substantive changes to other EPON sublayers
  - Anticipate additional OAM messages for configuration, monitoring, etc.

Project Focus – Layer Diagram



CLT – COAX LINE TERMINAL
CNU – COAX NETWORK UNIT
MDI – MEDIUM DEPENDENT INTERFACE
OAM – OPERATIONS, ADMINISTRATION, & MAINTENANCE

PCS – PHYSICAL CODING SUBLAYER
PHY – PHYSICAL LAYER DEVICE
PMA – PHYSICAL MEDIUM ATTACHMENT
PMD – PHYSICAL MEDIUM DEPENDENT
XGMII – GIGABIT MEDIA INDEPENDENT INTERFACE

EPoC
Market Potential

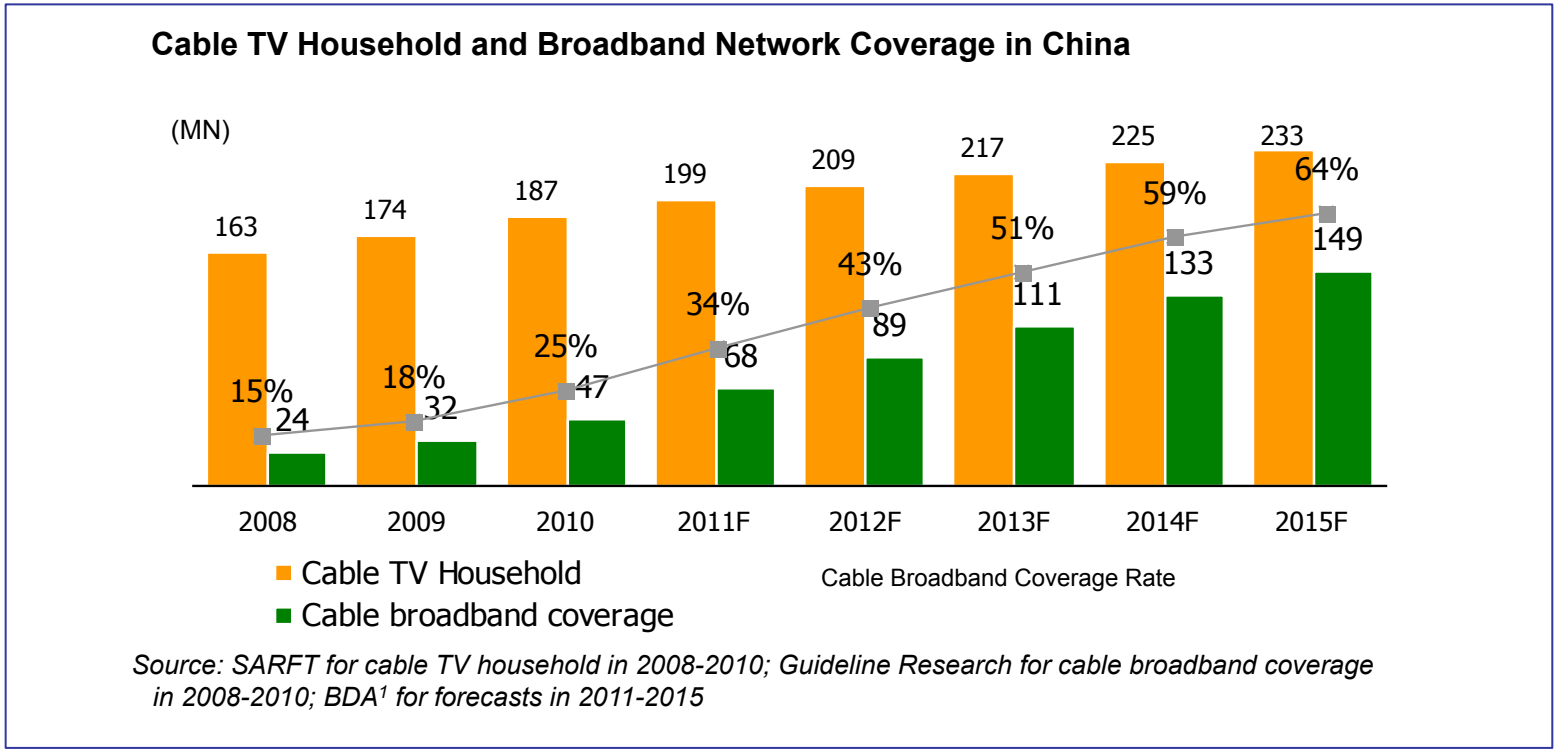
Alex Liu, Qualcomm

The MxU EPoC Opportunity

- It has become common for fiber to be pulled “in the street” stopping at the edge of a multi-tenant building or in the neighborhood
- Pulling new fiber is very expensive
- A significant percentage of the subscribers are in Multiple Dwelling/Tenant Units (MxUs)
  - MSO or MxU owner own the coaxial network
- Coaxial cable is the medium of choice for MSOs
- Leveraging the success of EPON in US and China onto coax is the opportunity

China Market Potential For EPoC

- Over 190M coax connected users today
- 233M connected by coax in 2015, 149M with broadband + video
- 300M "homes-passed" by coax in 2019



Source: SARFT for cable TV household in 2008-2010; Guideline Research for cable broadband coverage in 2008-2010; BDA[1] for forecasts in 2011-2015

[1]BDA China Ltd., www.bda.com

US Cable Market

- US 129.3 million homes passed with cable video service (coax)
  - 45.4M digital video subs, 45.7M high speed Internet subs, 24.7M telephony subs*
- Any multiservice customer is a target for an Ethernet service
  - IPTV deployments will accelerate the need
  - New fiber construction can be 4-5 times the cost of upgrading the coax
- North American MSOs have adopted EPON for next-generation FTTx
  - CableLabs DOCSIS Provisioning of EPON (DPoE) specifications have been published
  - 3M lines for business services by 2015
- The impact of EPoC on the DPoE/EPON market
  - EPoC eliminates much of the need for fiber upgrades to deploy “PON Speed” services
  - EPoC expands the addressable DPoE/EPON market by opening up areas where pulling new fiber is prohibitively expensive
  - EPoC facilitates migration to a unified Ethernet-based architecture

* SNL Kagan & NCTA www.ncta.com

EPoC in other markets

- Japan
  - Approximately 15M MSO subscribers in Japan live in MxUs
  - The MSOs do not have access to the existing fiber or twisted pair in the MxUs.
  - The telcos and other competitors offer "Gigabit speed" service over PON, much faster than what the MSOs can offer with their existing HFC networks

- Other Areas of Study
  - Canada
    - Canadian MSOs have adopted EPON and DPoE for business and residential services. EPoC will expand the areas where DPoE can be offered
  - Europe
    - European Telco's are starting FTTx deployments (British Telecom, France Telecom, Portugal Telecom) and the MSOs will need to respond. EPoC preserves the coax drop while offering FTTx speed service.
  - South East Asia
    - Hong Kong, India, Korea, Taiwan, Vietnam, and others have Cable markets where preserving the coax drop will allow them to offer FTTx speed technology at a without requiring a complete fiber upgrade.

Path Forward

- IEEE 802.3 EPON is in mass deployment

- To meet the growing needs of carriers and cable operators, the EPON protocol must transparently operate over coaxial distribution networks

We recommend that IEEE 802.3 charter a Study Group for a new PHY for operating the EPON protocol over Coaxial Distribution Networks ("EPoC")

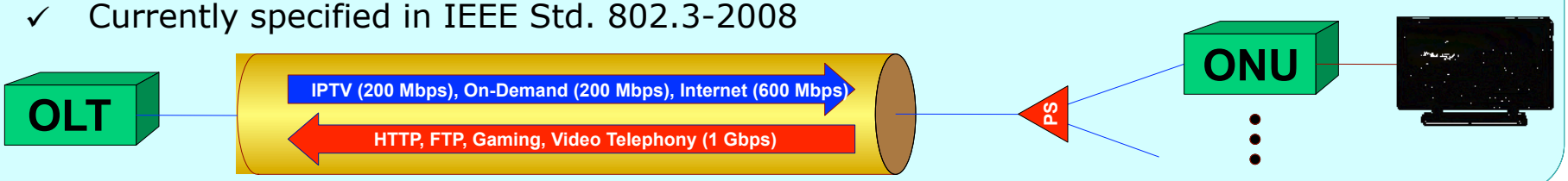
EPoC
High Level Concept

Kevin A. Noll, Time Warner Cable

Review of Existing EPON Speeds

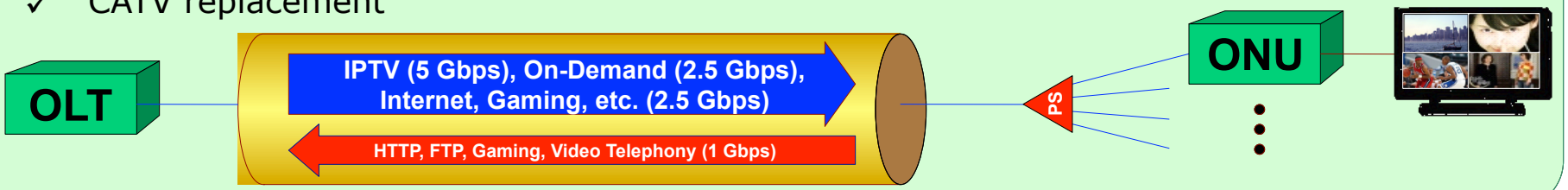
802.3ah: 1 Gbps downstream / 1 Gbps upstream

- ✓ The first commercial FTTH technology with Gigabit bandwidth deployed in the world
- ✓ Currently specified in IEEE Std. 802.3-2008



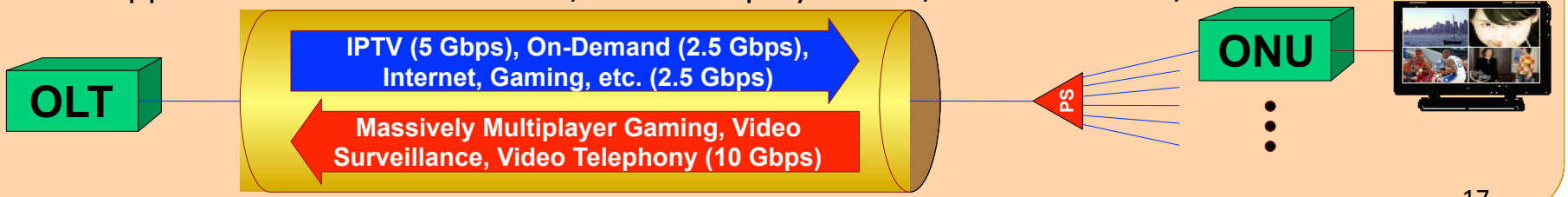
802.3av: 10 Gbps downstream / 1 Gbps upstream

- ✓ Providing more downstream bandwidth to support advanced digital TV services
- ✓ CATV replacement

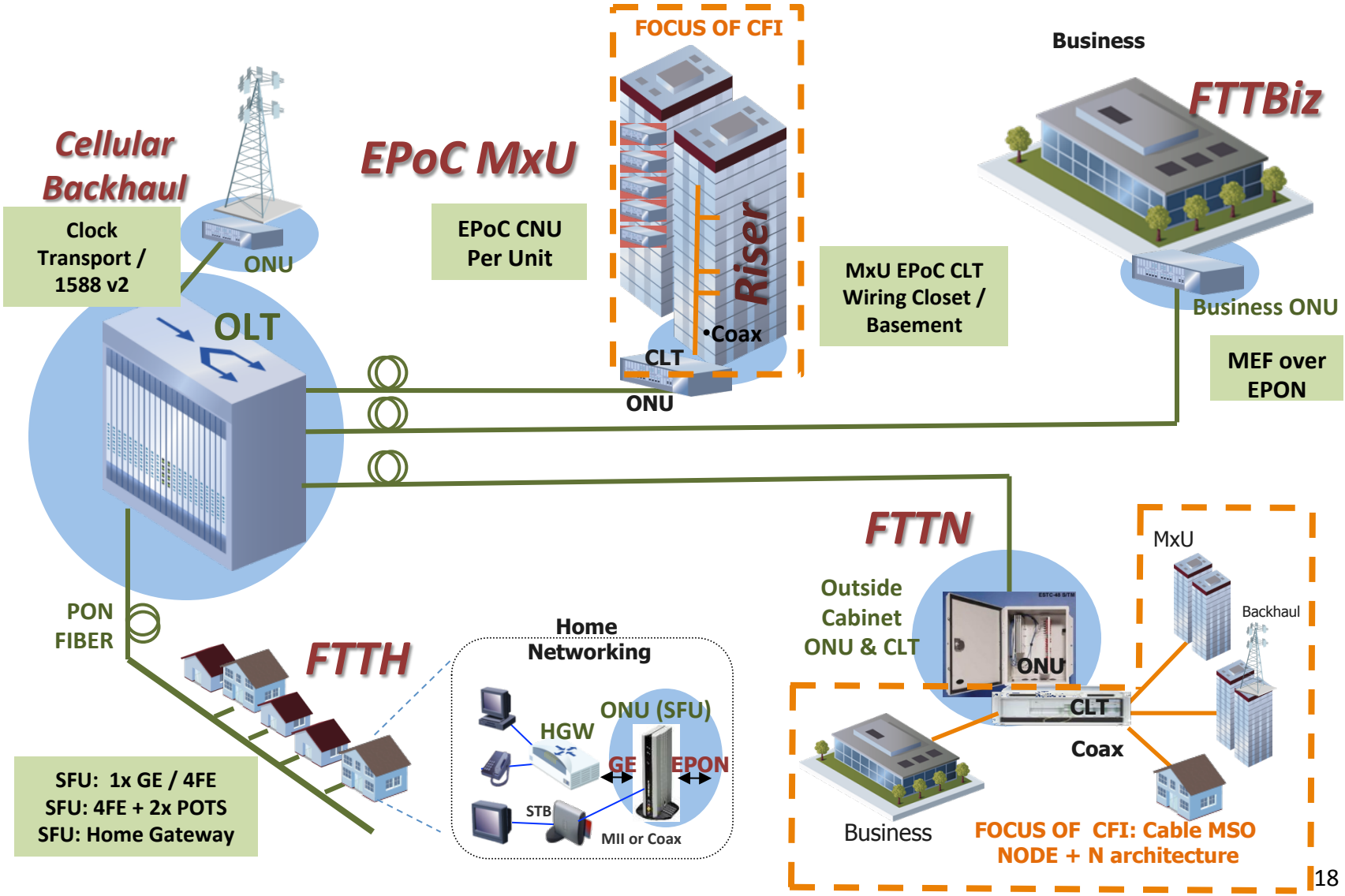


802.3av: 10 Gbps downstream / 10 Gbps upstream

- ✓ Support for advanced, bandwidth-intensive upstream and downstream services
- ✓ Support for more subscribers / dense deployments / MxU markets / Backhaul



EPON/EPoC APPLICATIONS



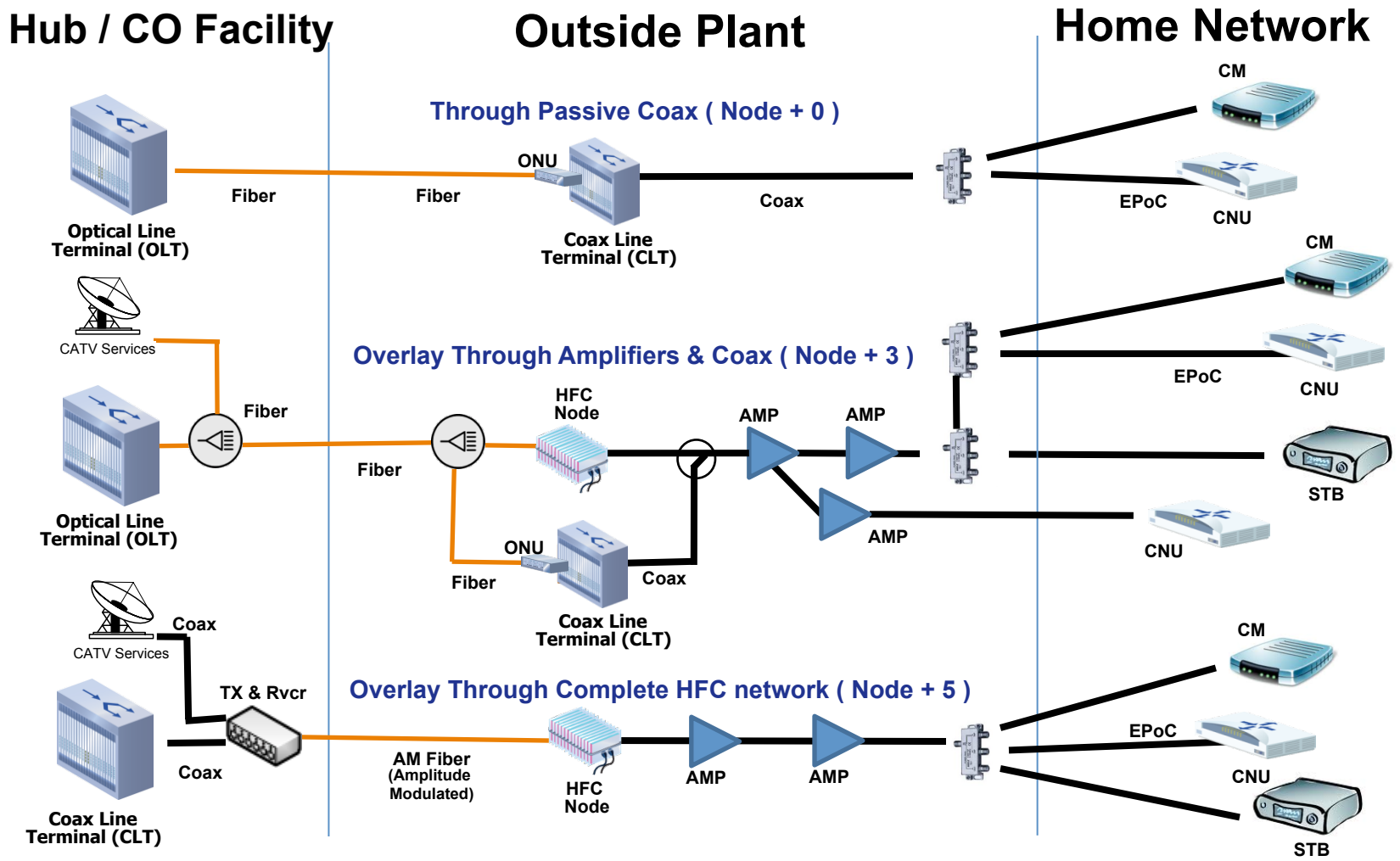
Coaxial Network Compatibility

Developing an EPON coaxial PHY standard would require:

1. Considering common coaxial cable topologies and architectures
2. Following standard and local cable operator provisioning
   - Use spectrum where allocated (and available)
   - No interference to existing services
3. Incorporating flexibility with evolving cable standards and local provisioning
   - China: State Administration for Radio Film and TV (SARFT)
   - U.S.: Cable Television Laboratories (CableLabs), Society of Cable Telecommunications Engineers (SCTE)

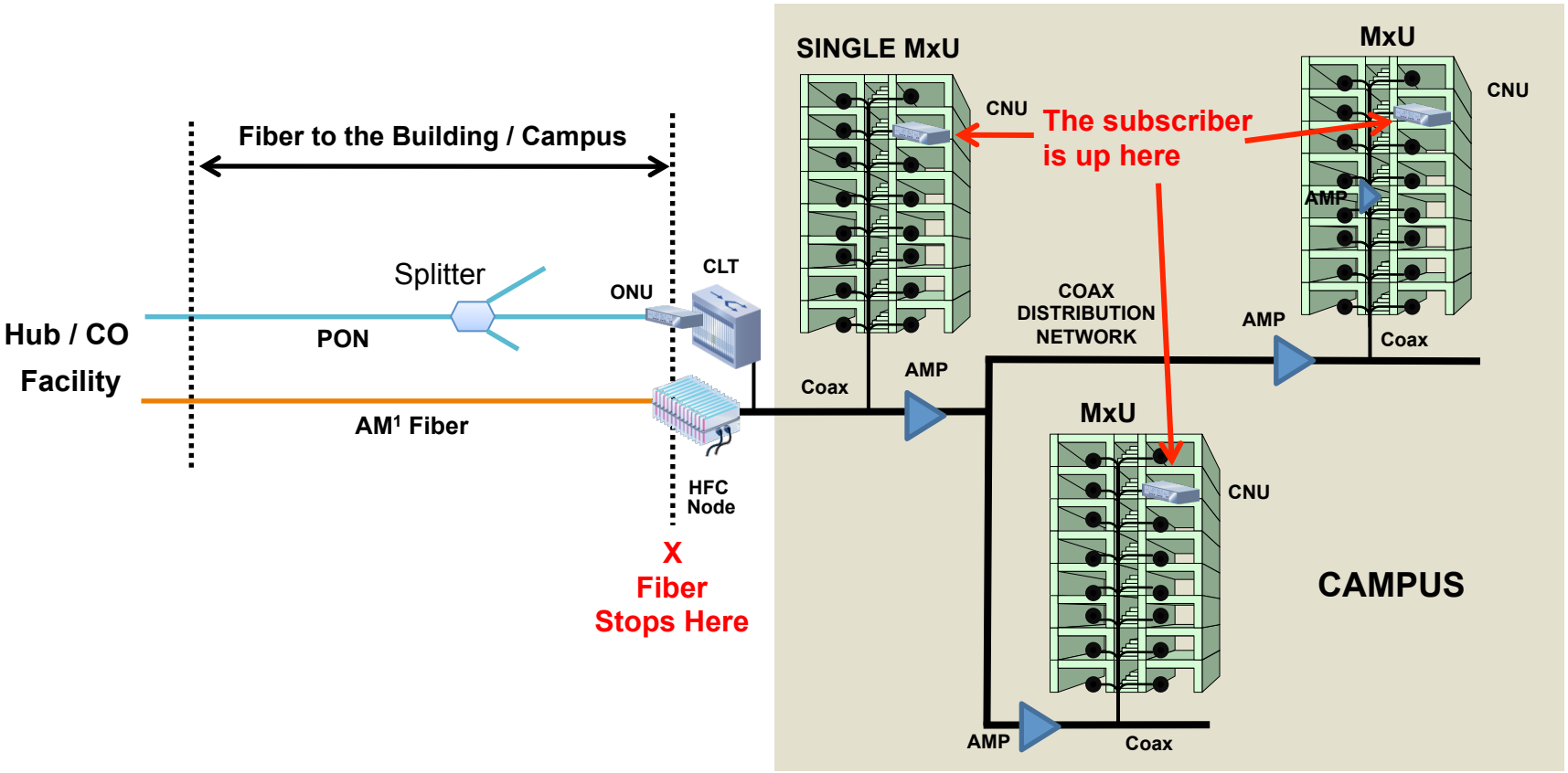
1. Considering common coaxial cable topologies and architectures

MSO Deployment Options over Coax



The MxU Fiber – Coax Gap

- Fiber stops outside the building / campus, remainder of run is coaxial cable



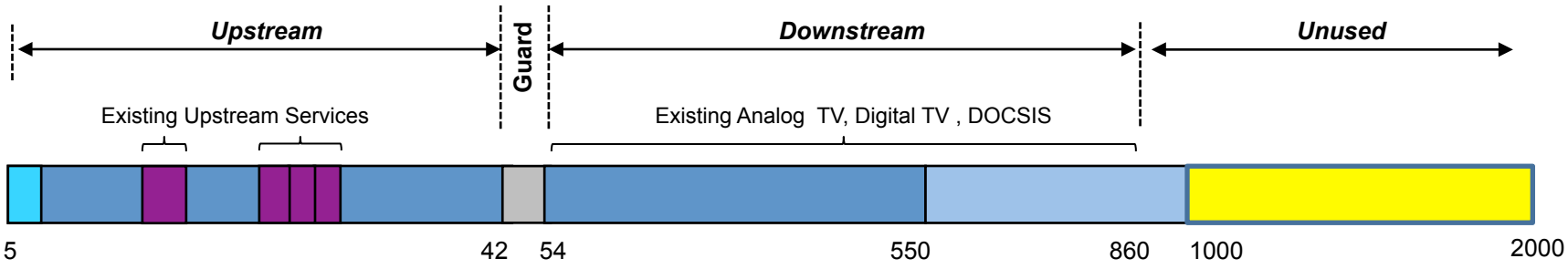
[1]Amplitude Modulated

2. Follow Cable Operator Provisioning

- Use spectrum where allocated by cable operator
  - Requires precise configuration and configurable options
    - Example: downstream use likely needed to be agile from 54MHz to 2000MHz
    - Example: upstream use: 5Mhz to 250MHz and also 900+Mhz to 2000MHz
  - Expect use to vary widely by operator and cable distribution network
- Flexible provisioning
  - Work around existing services
  - Analog TV, Digital TV, DOCSIS high speed data services, Voice, Etc.

Spectrum Usage Varies by Operator

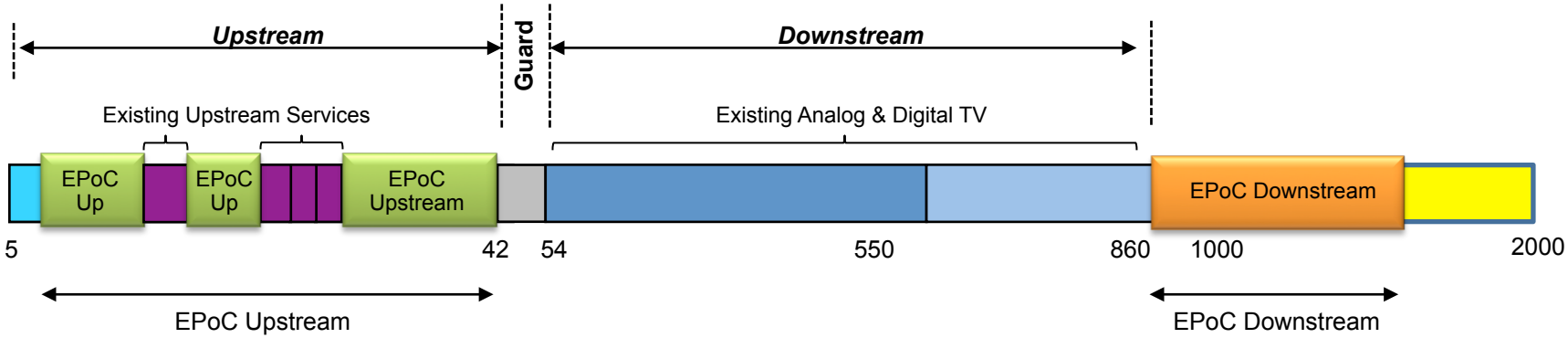
- What is in use now? (example based on North American cable)
  - Analog TV: 54+MHz to 550MHz
  - Digital TV, DOCSIS uses 550MHz up to 750MHz (or 860MHz)
  - Upstream generally from 5MHz to 42MHz
- International use is similar with different boundaries, varies with operator and country



NOTE: example only, not to scale

Example: EPoC Provisioning

- EPoC provisioning needs to be flexible
  - No interference with existing services
  - Analog and Digital TV, DOCSIS high speed data services, Voice, Etc.
- Cable operator can control provisioning details
  - Customize for individual cable networks



NOTE: This is one illustrative example of spectrum provisioning. There are many other examples including EPoC UP in portion of 1000MHz to 2000MHz region instead in 5 - 42MHz region

3. Incorporate flexibility with evolving cable standards and local provisioning

- Cable networks may undergo several architectural changes over next several to many years:
  - Upstream split may move higher, dependent on standards, local operator
    - e.g., moves from 42MHz to 85MHz (or higher)
  - Analog TV channels going away
    - e.g., replaced with Digital TV channels or IPTV over High Speed Data
  - MPEG TV transport migrating to all IP TV transport
    - e.g., digital TV channels migrating to IP
- The EPoC PHY would need to be flexible and permit re-provisioning to make use of more RF spectrum as it is made available by the cable operator

High Level Summary

- EPON being deployed with increasing penetration rates internationally
- In many locations, fiber stops on the street/basement/curb with coaxial cable remaining as the network to the subscriber
- An EPON PHY for coax could allow the access network to serve subscribers on existing coaxial network topologies
- There is sufficient initial RF spectrum to permit EPoC without interfering with existing cable operators' services
- As cable operators change their services, EPoC should accommodate and grow with the changes

EPoC
Why Now?

Why Now and Why in IEEE 802.3?

- There are cable operators that are asking for this.
- Value to do this in IEEE 802.3
  - Recognized as the international standard for Ethernet
    - Responsible for EPON Protocol and physical layers
  - An IEEE 802.3 standard for EPoC would be viewed as a worldwide standard
- The original IEEE standard for Ethernet in the First Mile (EFM), IEEE Std 802.3ah-2004, supported twisted pair, point to point fiber, and point to multi-point fiber
  - Also considered coaxial cable, but there was no demand at the time
- A PHY for point to multi-point coaxial cable will round out the set of media supported by EFM.

EPoC Q&A

15 minutes

EPoC is Go

Summary and Straw Polls

Straw Polls

_____ Number of people in the room

____ Individuals who would attend and contribute to an **EPON over Coax PHY Study Group**

____ Companies support the formation of the **EPON over Coax PHY Study Group**

Straw Polls

- Request that IEEE 802.3 WG form a study group to develop a PAR & 5 Criteria for
  EPON over Coax PHY

  - **Y: _____**
  - **N: _____**
  - **A: _____**

Acronyms

AM	Amplitude Modulation
AMP	Amplifier
ASIC	Application Specific Integrated Circuit
BPON	Broadband Passive Optical Network
CATV	Community Access Television
CCAP	Converged Cable Access Platform
CFI	Call For Interest
CLT	Coax Line Terminal
CM	Cable Modem
CMTS	Cable Modem Termination System
CNU	Coax Network Unit
DOCSIS	Data-Over-Cable Service Interface Specification
DPoE	DOCSIS Provisioning of EPON
DSL	Digital Subscriber Line
EFM	Ethernet in the First Mile
EoC	Ethernet over Cable
EPoC	EPON Protocol over Coaxial Distribution Network
EPON	Ethernet Passive Optical Network
FE	Fast Ethernet
FTTx	Fiber-To-The-x, where x can be Home, Business, Curb, Neighborhood, Last Amp, etc.
GEPON	1.0 Gbps EPON
GE	Gigabit Ethernet
GPON	Gigabit-Per-Second Passive Optical Network
HFC	Hybrid Fiber-Coax
HGW	Home Gateway
IEEE	Institute of Electrical and Electronic Engineers
IPTV	Internet Protocol Television
IP	Internet Protocol
LAN	Local Area Network
LLC	Logical Link Control
MAC	Media Access Control
MAN	Metropolitan Area Network
MDI	Medium Dependent Interface
MEF	Metro Ethernet Forum
MII	Media Independent Interface
MOCA	Multi-media Over Coax Alliance
MPMC	Multipoint MAC Control
MSO	Multiple Service Operator
MxU	Multiple Dwelling/Tenant Unit
NCTA	National Cable Television Association
NMS	Network Management System
NODE + N	Hybrid Fiber “Node” plus “N” amplifiers; where N can be from “0” to many. “Node + 0” also known as “all passive”
OAM	Operation, Administration, Maintenance
OLT	Optical Line Terminal
ONU	Optical Network Unit
OSI	Open Systems Interconnect
OSS	Operation Support System(s)
P2P	Point-to-Point
PCS	Physical Coding Sublayer
PHY	Physical Layer
PMA	Physical Medium Attachment
PMD	Physical Medium Dependent
PON	Passive Optical Network
POTS	Plain Old Telephone Service
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
Rcvr	Receiver
SARFT	State Administration for Radio, Film, and Television
SCTE	Society of Cable Telecommunications Engineers
SFU	Single Family Unit
SIEPON	Service Interoperability in Ethernet Passive Optical Networks, IEEE P1904.1
STB	Set Top Box
TV	Television
TX	Transmiter
VoIP	Voice over IP
XGMII	Gigabit Media Independent Interface

BACKUP SLIDES

DOCSIS / EPON Cable Clarifications

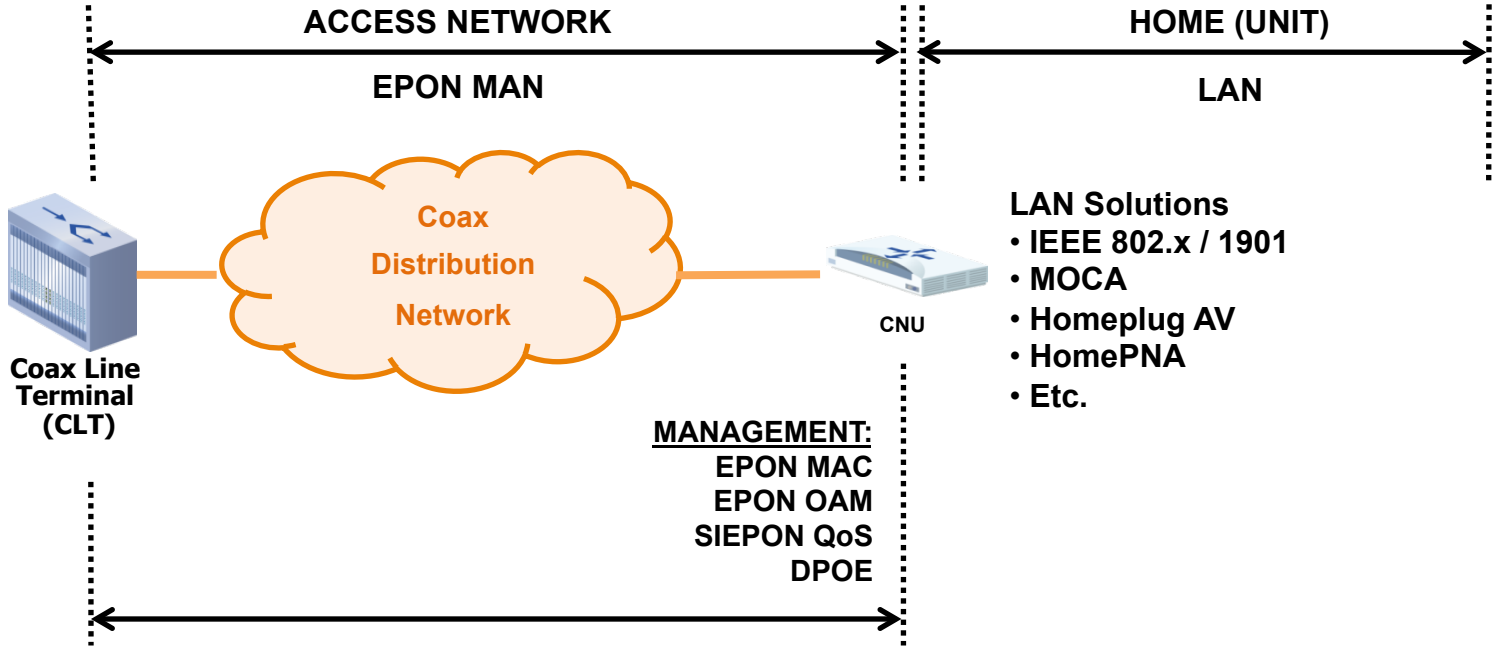
- DOCSIS
  - Family of specifications to deliver high speed data over cable
    - Including OSS, provisioning, QoS, security, MAC, physical layers, etc
  - Residential: if you have Internet access via cable, it's DOCSIS
    - Up to 8 * 42 Mbps now downstream (varies by operator and market)
      - Has been demonstrated to 1 Gbps with 32 bonded channels
    - Highly asymmetric (> 8-10 times downstream versus upstream)
      - Matches well to "in band" cable RF architecture
  - Business: cable IP services are being offered
    - Same DOCSIS over coax cable
    - Demand can exceed downstream and upstream availability
- EPON
  - Being deployed for commercial / backhaul in U.S.
    - Symmetric services can be offered
    - Business services expected to go above 1 Gbps

Futures

- Generalized realization by some cable operators
  - Commercial / business
    - EPON is preferred
  - All customers
    - Upgrading existing coax network to NODE + 0 is up to 5x more economical than pulling fiber "all the way" if EPoC existed
- Industry would like to have multiple options available
  - Includes DOCSIS, future DOCSIS, EPON, EPoC, etc.

Access Network vs. LAN

- EPON/EPoC MAN is the Access Network
  - Management directly to the Subscriber CNU



EPoC Can Be Built Today

- It is feasible to implement various data rates using today's silicon technology
  - i.e. not dependent on new or emerging silicon processes
- Examples: ideal minimum spectrum (MHz) per modulation rate for various data rates:

User Rate Mbps	Raw Rate Mbps	Example Modulation Rates		
		8 bits/sec/Hz	10 bits/sec/Hz	12 bits/sec/Hz
100	120	15	12	10
500	600	75	60	50
1000	1200	150	120	100
5000	6000	750	600	500
10000	12000	1500	1200	1000

  - Examples:
    - 1 Gbps downstream @ 10 b/s/Hz and 100 Mbps up @ 8 b/s/Hz
      - 120 MHz down and 15 MHz up
    - 5 Gbps downstream @ 10 b/s/Hz and 1 Gbps up @ 8 b/s/Hz
      - 600 MHz down and 150 MHz up
    - 10 Gbps downstream @ 12 b/s/Hz and 10 Gbps up @ 10 b/s/Hz
      - 1000 MHz down and 1200 MHz up

NOTE: rate options selected for Task Force requirements will be based the evaluation and consideration of the Study Group. These considerations should include: spectrum provisioning and flexibility options, noise conditions, maximum transmitter power, line losses, technology capability, other implementation attributes, cost feasibility, and etc.