

Ethernet in the First Mile

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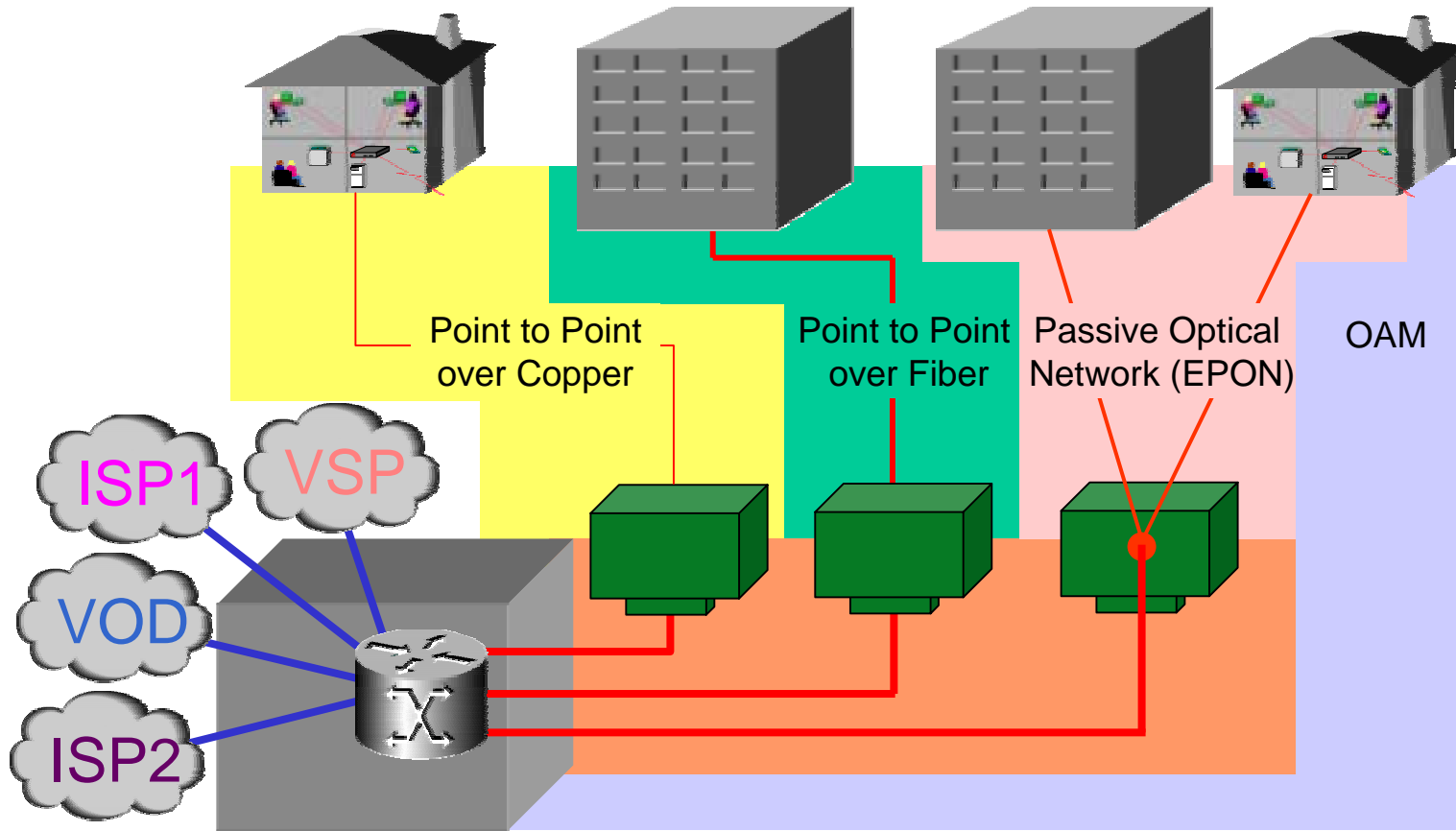
IEEE Oakland/East Bay Communications Society

Thursday, October 17, 2003

Agenda

- **Overview**
- **Technology**
- **IEEE Draft Standard P802.3ah**
- **User/Vendor/Customer Perspectives**
- **Deployment Scenarios**
- **Summary**
- **Q&A**

EFM Elements



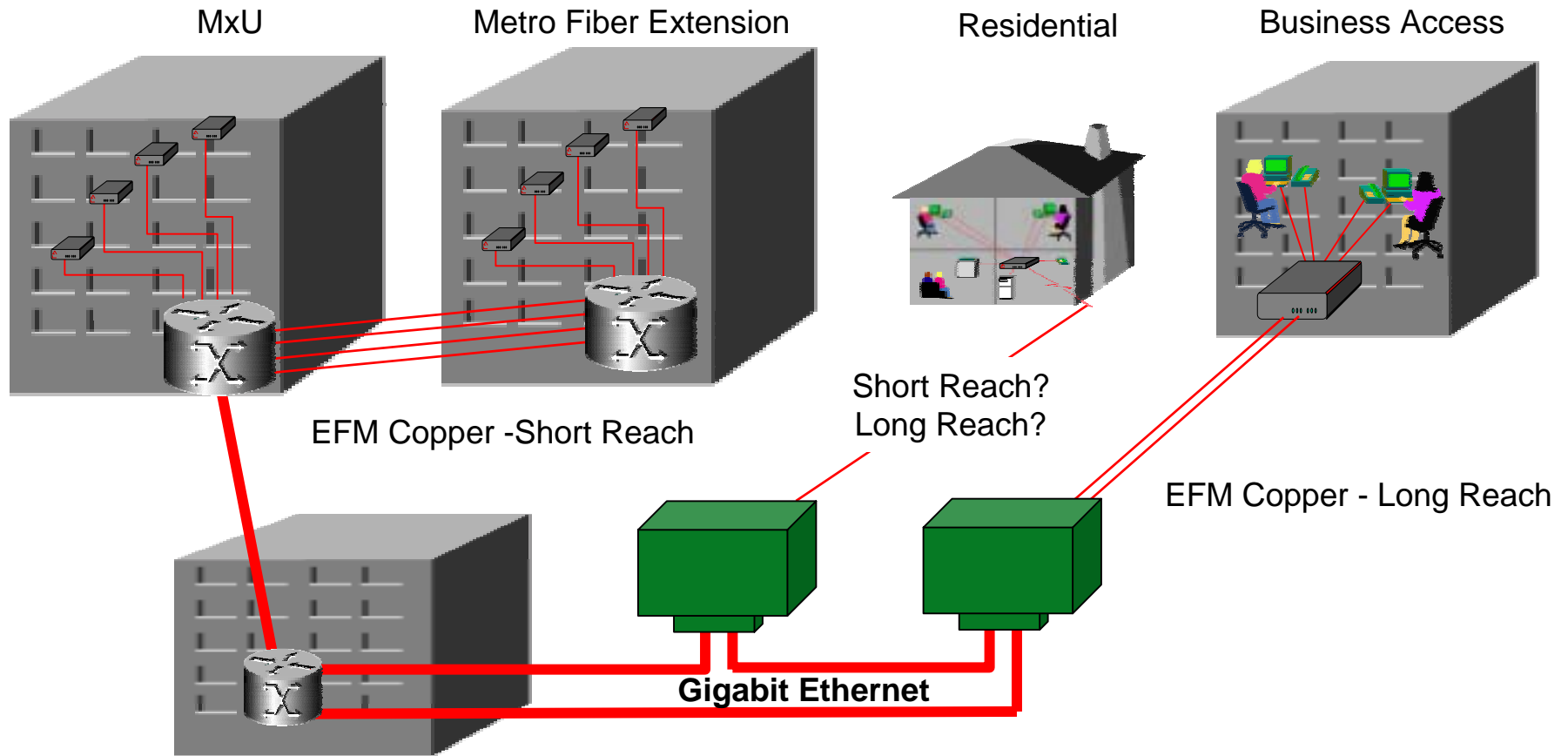
Terminology

- MxU - Multi-Tenant/Dwelling/Company Unit
- Downstream - Data to the subscriber
- Upstream - Data from the subscriber
- OLT - Optical Line Termination
- ONU - Optical Network Unit
- Port names for EFM, e.g. 10PASS-T, are being debated - not discussed herein

EFM Copper - Objectives

- Two objectives (two copper PHYs):
 - PHY for single pair non-loaded voice grade copper distance $\geq 750\text{m}$ and speed $\geq 10\text{Mbps}$ full-duplex [*aka Short Reach*]
 - PHY for single pair non-loaded voice grade copper distance $\geq 2700\text{m}$ and speed $\geq 2\text{Mbps}$ full-duplex [*aka Long Reach*]

EFM Copper - Applications



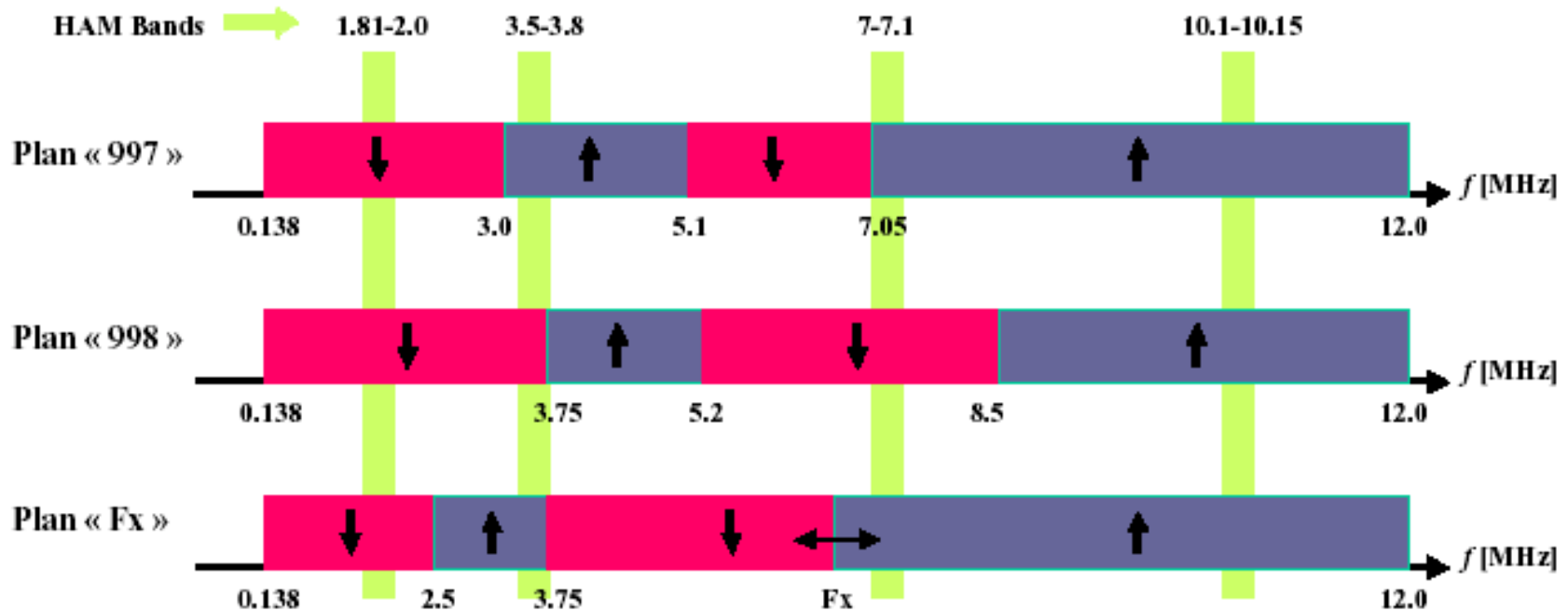
EFM Copper - Proposals

- Two proposals for each objective:
 - Ethernet over VDSL (T1.424), either QAM or DMT for Short Reach
 - Ethernet over SHDSL (ITU-T G.991.2) or Ethernet over Annex J ADSL (ITU-T G.992.3) for Long Reach

EFM Copper - Short Reach

- Passband Frequency Division Duplexing
- Quadrature Amplitude Modulation
 - aka Single Carrier Modulation
 - Actually one carrier per passband
 - Early lead in market share, mostly for MxU applications
- Discrete Multi-Tone
 - aka Multiple Carrier Modulation
 - Tones spaced at 4.3125 kHz
 - Dominant market share for ADSL deployments

EFM Copper - Short Reach



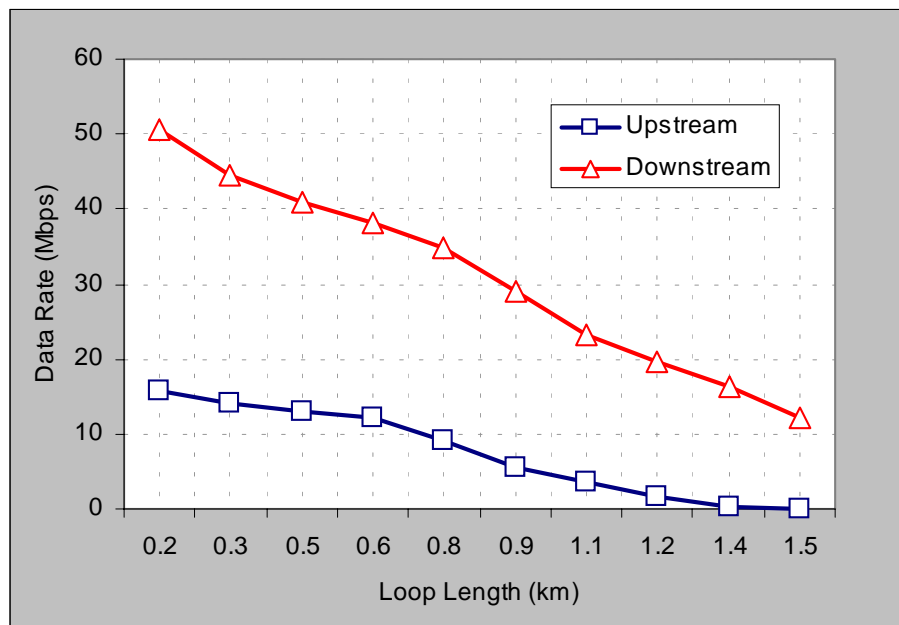
Plan 998 approved for ANSI T1 (North America, Japan)

Plans 997, 998 approved for ETSI (Europe)

Plans 997, 998, Fx accepted in ITU-T

EFM Copper - Short Reach

Rate vs Reach Curve



**Minimum required performance
24 SM class 6 disturbers**

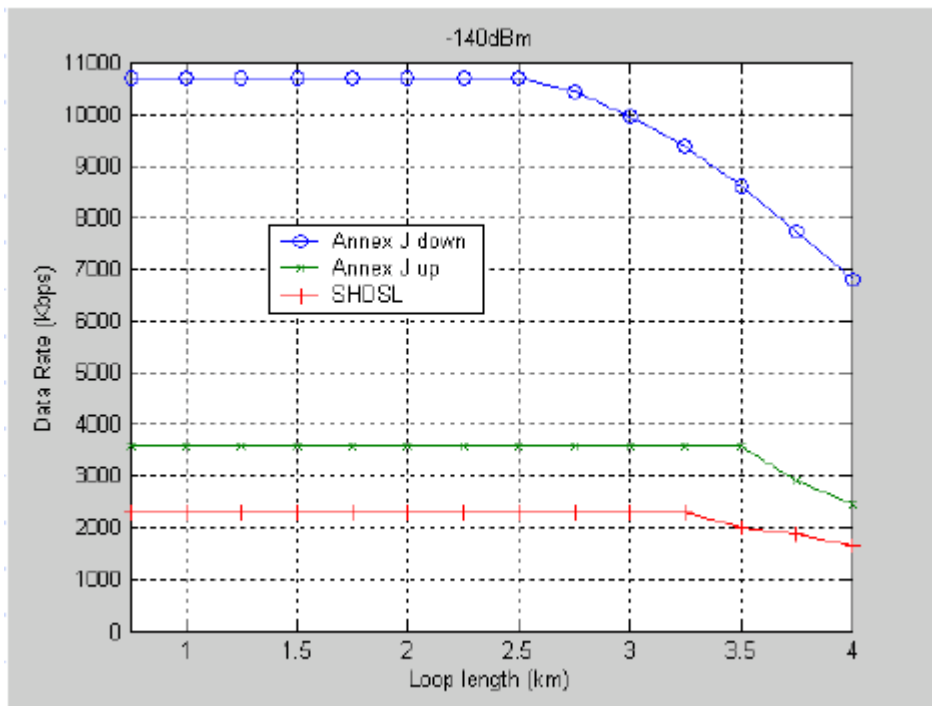
Source: T1E1.4/2002-125

EFM Copper - Long Reach

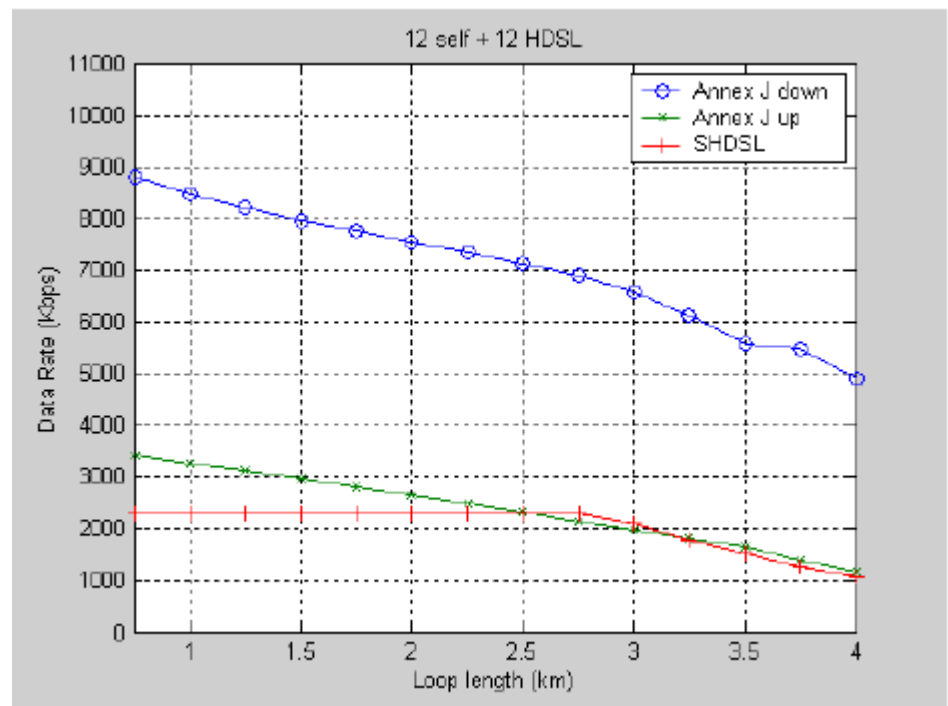
- SHDSL
 - Existing ANSI and ITU-T standards
 - Constant, symmetric rate
 - Baseband, no line sharing with POTS
- Annex J ADSL
 - Existing ITU-T standard, no ANSI standard
 - Asymmetric rate, usually higher than SHDSL
 - Passband, allows line sharing with POTS

EFM Copper - Long Reach

Rate vs Reach Curves



No Disturbers



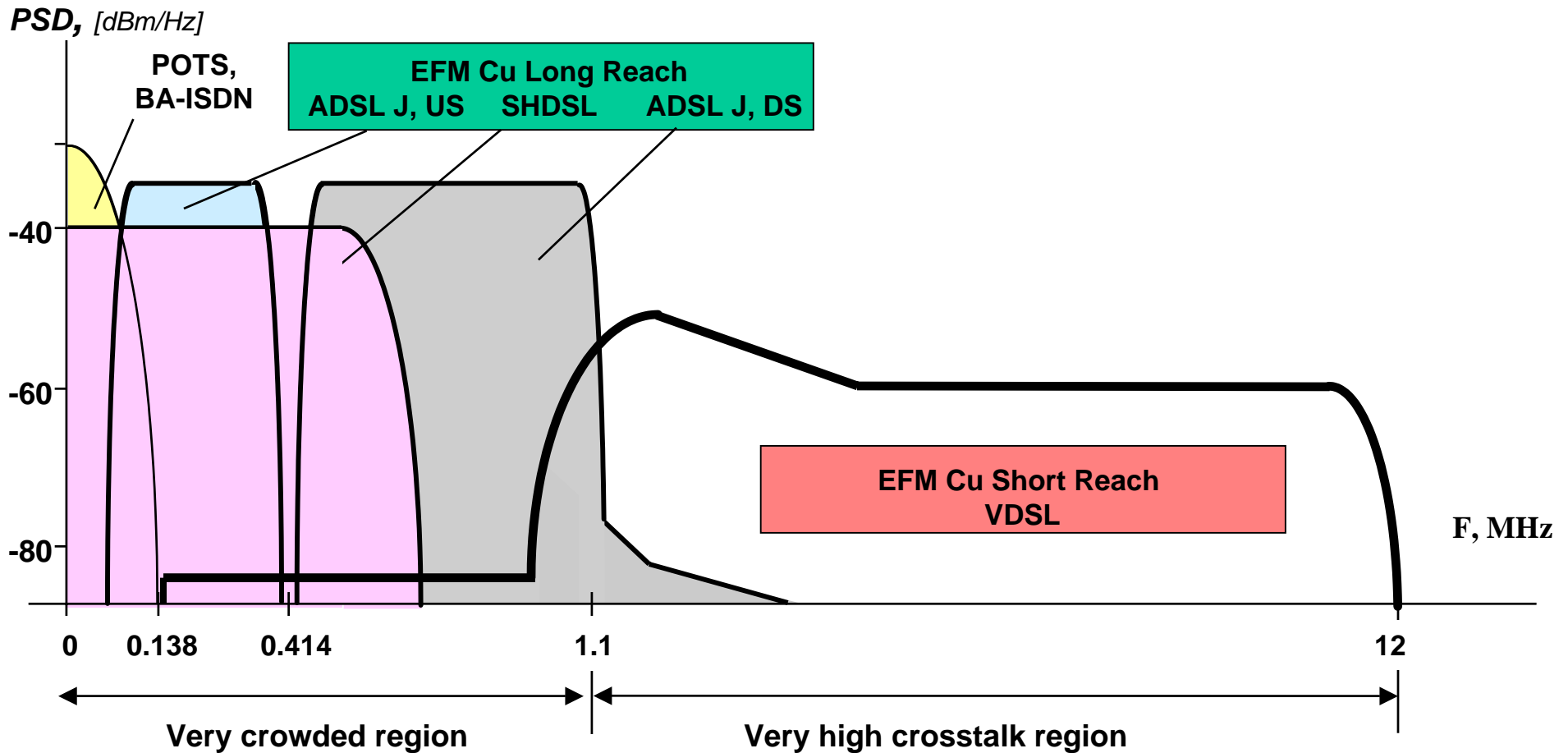
12 self + 12 HDSL Disturbers

Source: http://www.ieee802.org/3/efm/public/jul02/copper/artman_copper_1_0702.pdf

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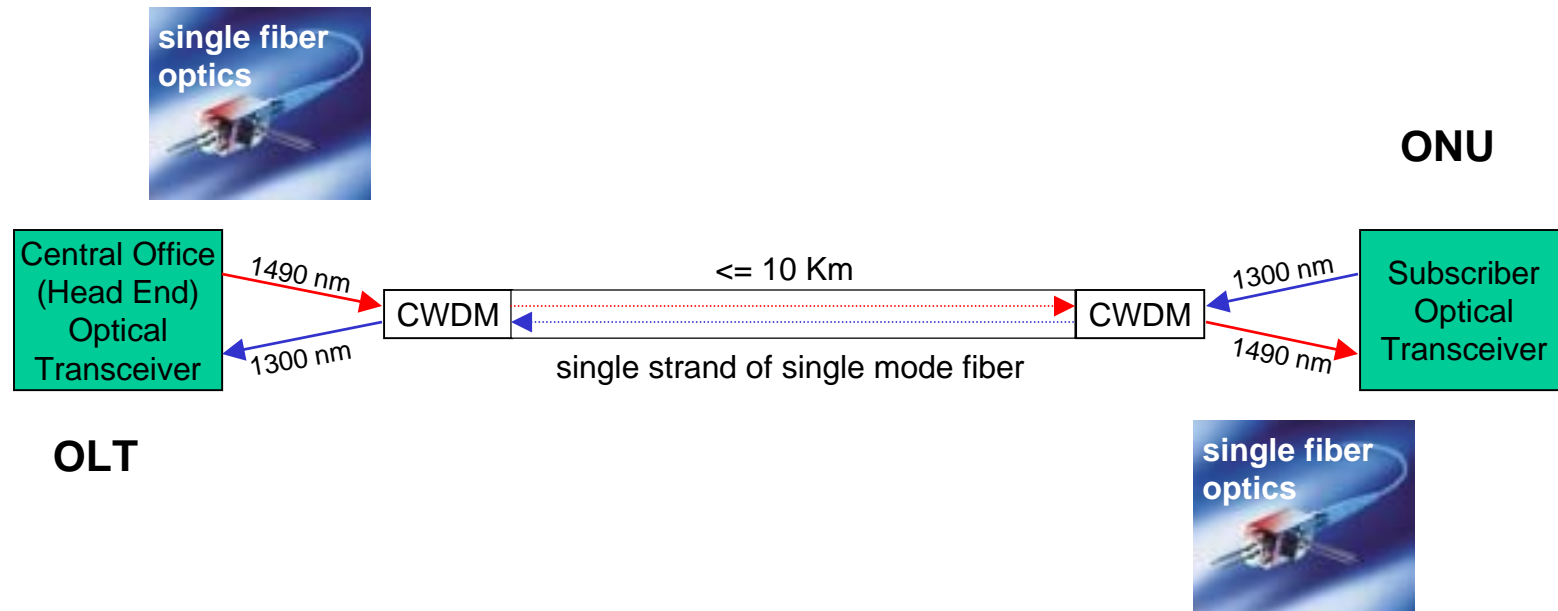
EFM Copper - DSL Spectra



Point to Point Fiber

- Four Optical Transceiver Options
 - 100 Mbps dual strand single mode fiber
 - 100 Mbps single strand single mode fiber
 - 1000 Mbps dual strand single mode fiber
 - 1000 Mbps single strand single mode fiber

Single Fiber BiDi links



P2P Fiber - 100 Mbps Dual Strand

4B/5B coding - 125 Mbps signaling rate

Transmitter Characteristics

| Parameter | Value | Units |
|-------------------------|-----------------------|-------|
| Transmitter Type | Long wavelength laser | |
| RMS Spectral Width | 7.7 | nm |
| Wavelength | 1260 to 1360 | nm |
| Launch Power (Max/Min) | -8/-15 | dBm |
| Extinction Ration (Min) | 6 | dB |

Receiver Characteristics

| Parameter | Value | Units |
|------------------------|--------------|-------|
| Receiver Type | PIN Diode | |
| Wavelength | 1260 to 1360 | nm |
| Average Rx Power (Max) | -8 | dBm |
| Sensitivity | -25 | dBm |
| Return Loss | 12 | dB |

P2P Fiber - 100 Mbps Single Strand

4B/5B coding - 125 Mbps signaling rate

Transmitter Characteristics

| Parameter | Value | Units |
|-------------------------|--|-------|
| Transmitter Type | Long wavelength laser | |
| RMS Spectral Width | 7 (ONU) 4 (OLT) | nm |
| Wavelength | 1260 to 1360 (ONU) 1480 to 1580 (OLT) | nm |
| Launch Power (Max/Min) | -8/-14 | dBm |
| Extinction Ration (Min) | 8.2 | dB |

Receiver Characteristics

| Parameter | Value | Units |
|------------------------|--|-------|
| Receiver Type | PIN Diode | |
| Wavelength | 1260 to 1360 (OLT) 1480 to 1600 (ONU) | nm |
| Average Rx Power (Max) | -8 | dBm |
| Sensitivity | -30 | dBm |
| Return Loss | 12 | dB |

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P2P Fiber - 1000 Mbps Dual Strand

8B/10B coding - 1250 Mbps signaling rate

Transmitter Characteristics

| Parameter | Value | Units |
|-------------------------|-----------------------|-------|
| Transmitter Type | Long wavelength laser | |
| RMS Spectral Width | $f(\lambda)$ | nm |
| Wavelength | 1260 to 1360 | nm |
| Launch Power (Max/Min) | -3/-11 | dBm |
| Extinction Ration (Min) | 6 | dB |

Receiver Characteristics

| Parameter | Value | Units |
|------------------------|--------------|-------|
| Receiver Type | PIN Diode | |
| Wavelength | 1260 to 1360 | nm |
| Average Rx Power (Max) | -3 | dBm |
| Sensitivity | -20 | dBm |
| Return Loss | 12 | dB |

P2P Fiber - 1000 Mbps Single Strand

8B/10B coding - 1250 Mbps signaling rate

Transmitter Characteristics

| Parameter | Value | Units |
|-------------------------|--|-------|
| Transmitter Type | Long wavelength laser | |
| RMS Spectral Width | 2 (ONU) 0.4 (OLT) | nm |
| Wavelength | 1260 to 1360 (ONU) 1480 to 1500 (OLT) | nm |
| Launch Power (Max/Min) | -3/-9 | dBm |
| Extinction Ration (Min) | 6 | dB |

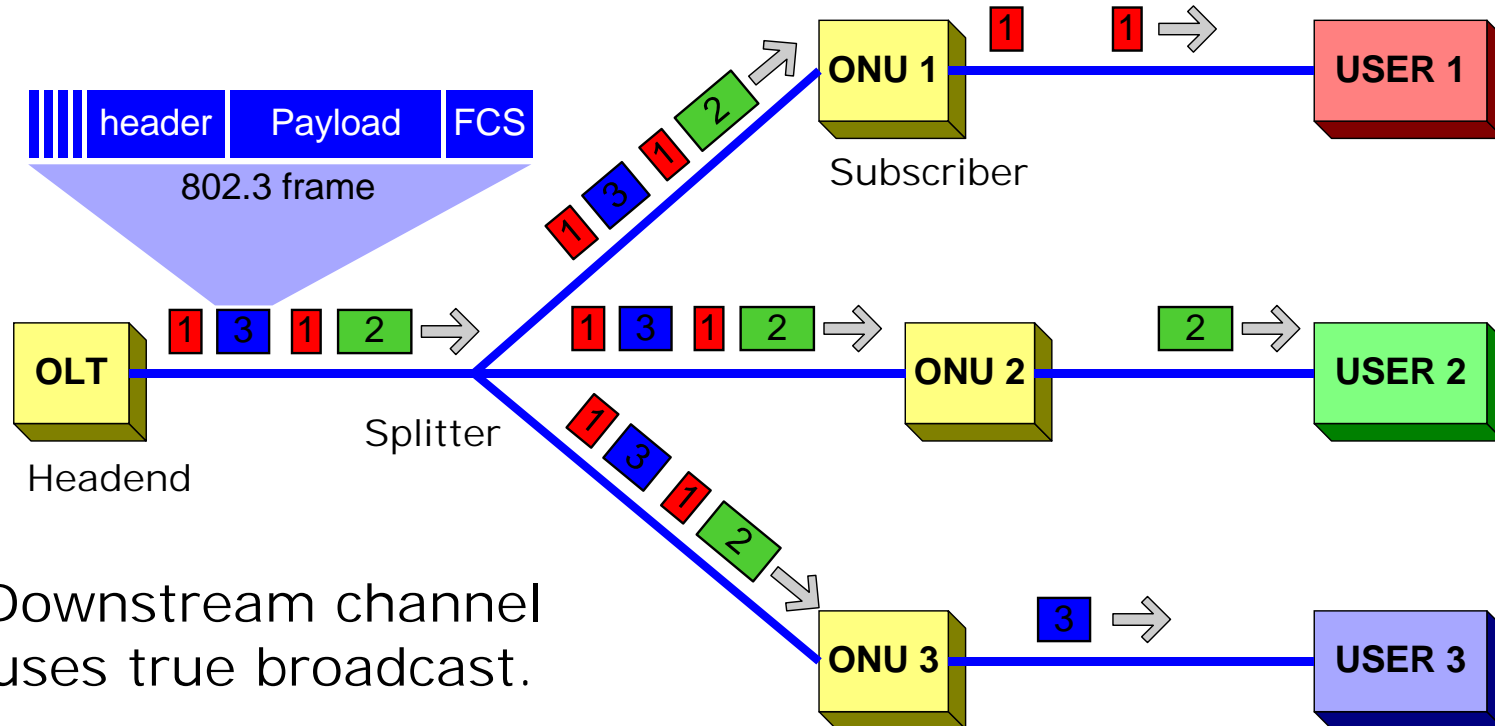
Receiver Characteristics

| Parameter | Value | Units |
|------------------------|--|-------|
| Receiver Type | PIN Diode | |
| Wavelength | 1260 to 1360 (OLT) 1480 to 1500 (ONU) | nm |
| Average Rx Power (Max) | -3 | dBm |
| Sensitivity | -20 | dBm |
| Return Loss | 12 | dB |

Ethernet in the First Mile

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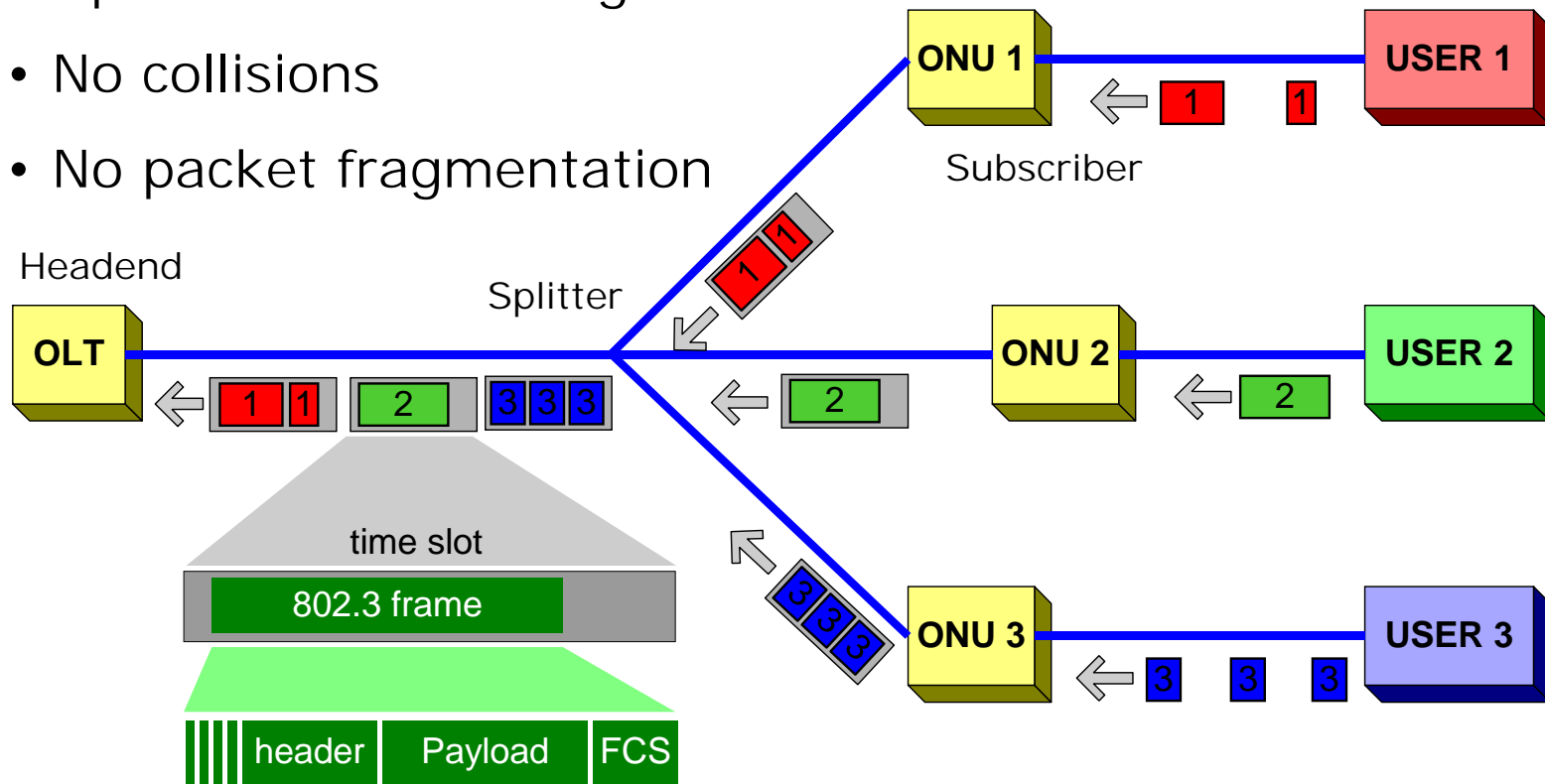
EPON Downstream



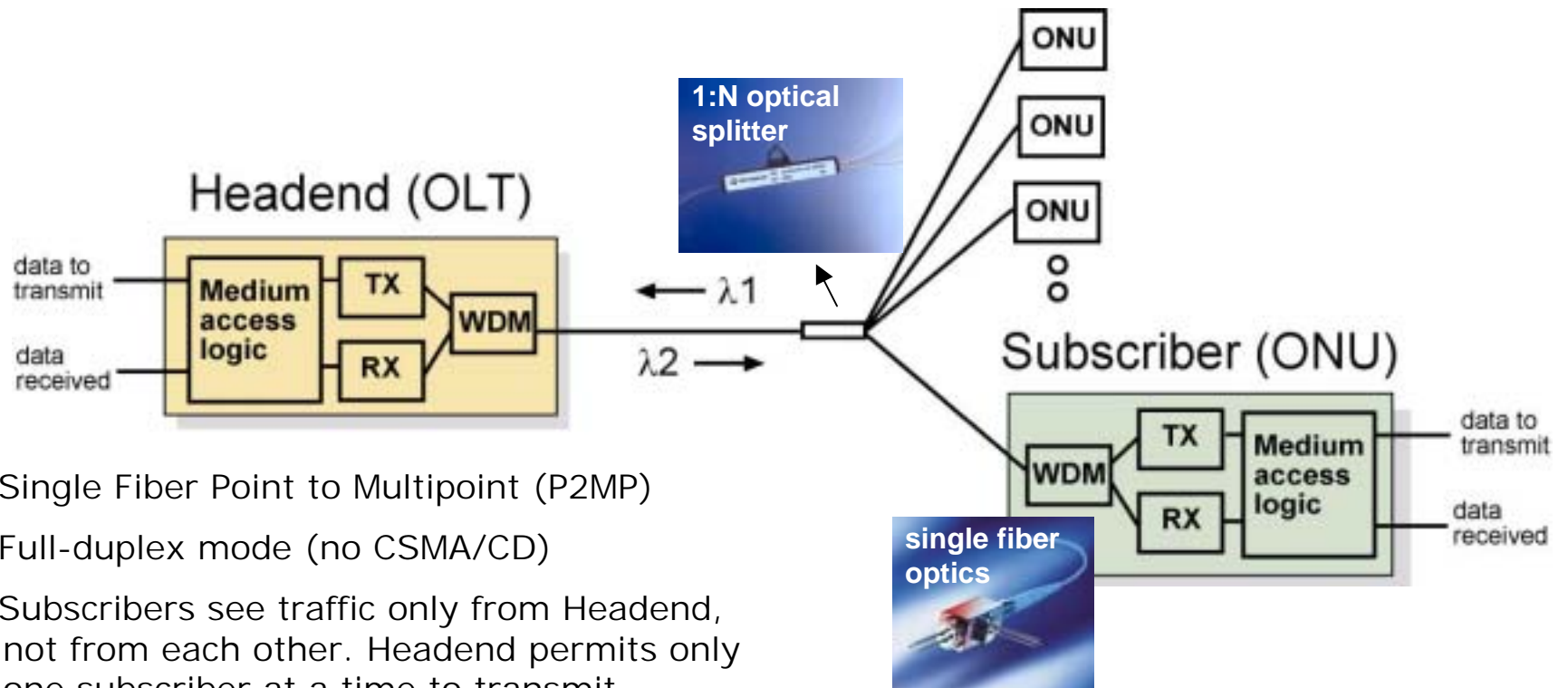
- Downstream channel uses true broadcast.
- 802.3 Frames extracted by MAC addresses.

EPON Upstream

- Upstream time slicing
- No collisions
- No packet fragmentation



EPON Configuration



- Single Fiber Point to Multipoint (P2MP)
- Full-duplex mode (no CSMA/CD)
- Subscribers see traffic only from Headend, not from each other. Headend permits only one subscriber at a time to transmit.
- Flexible optical splitter architectures

EPON - 1000 Mbps single strand (A)

8B/10B coding - 1250 Mbps signaling rate

Transmitter Characteristics

| Parameter | Value | Units |
|-------------------------|--|-------|
| Transmitter Type | Long wavelength laser | |
| RMS Spectral Width | $f(\lambda)$ | nm |
| Wavelength | 1270 to 1360 (ONU) 1480 to 1500 (OLT) | nm |
| Launch Power (Max/Min) | +2/-3 (ONU) 0/-4 (OLT) | dBm |
| Extinction Ration (Min) | 6 | dB |

Receiver Characteristics

| Parameter | Value | Units |
|------------------------|--|-------|
| Receiver Type | PIN Diode | |
| Wavelength | 1270 to 1360 (OLT) 1480 to 1500 (ONU) | nm |
| Average Rx Power (Max) | -3 (OLT) -5 (ONU) | dBm |
| Sensitivity | -26 (OLT) -25 (ONU) | dBm |
| Return Loss | 20 | dB |

EPON - 1000 Mbps single strand (B)

8B/10B coding - 1250 Mbps signaling rate

Transmitter Characteristics

| Parameter | Value | Units |
|-------------------------|--|-------|
| Transmitter Type | Long wavelength laser | |
| RMS Spectral Width | $f(\lambda)$ | nm |
| Wavelength | 1270 to 1360 (ONU) 1480 to 1500 (OLT) | nm |
| Launch Power (Max/Min) | +2/-3 (ONU) +5/+1 (OLT) | dBm |
| Extinction Ration (Min) | 6 | dB |

Receiver Characteristics

| Parameter | Value | Units |
|------------------------|--|-------|
| Receiver Type | PIN Diode | |
| Wavelength | 1270 to 1360 (OLT) 1480 to 1500 (ONU) | nm |
| Average Rx Power (Max) | -8 (OLT) -5 (ONU) | dBm |
| Sensitivity | -29 (OLT) -25 (ONU) | dBm |
| Return Loss | 20 | dB |

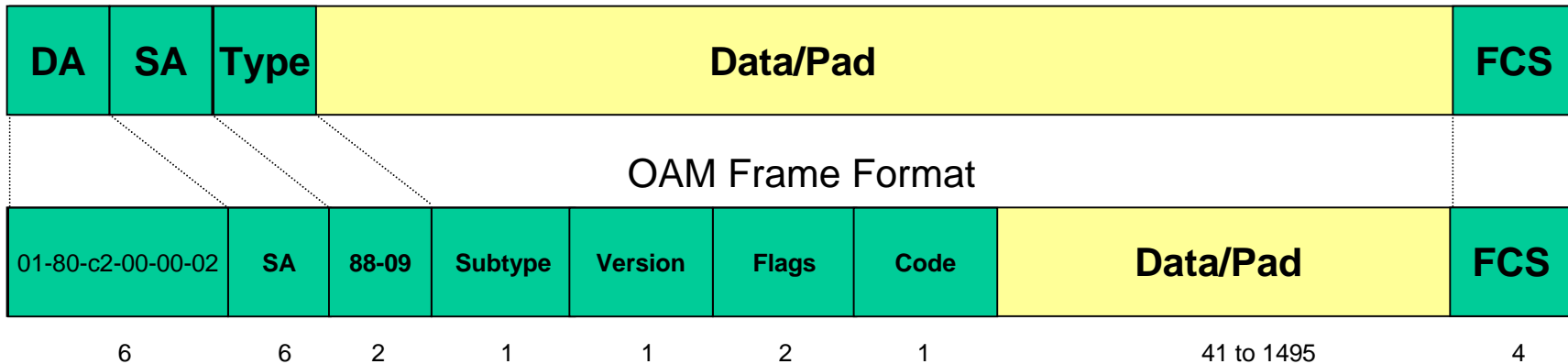
OAM

- Most enterprise networks are managed using SNMP - great for reading MIBs
- Subscriber access networks require additional management capabilities
 - Remote Failure Indication
 - Remote Loopback
 - Link Monitoring

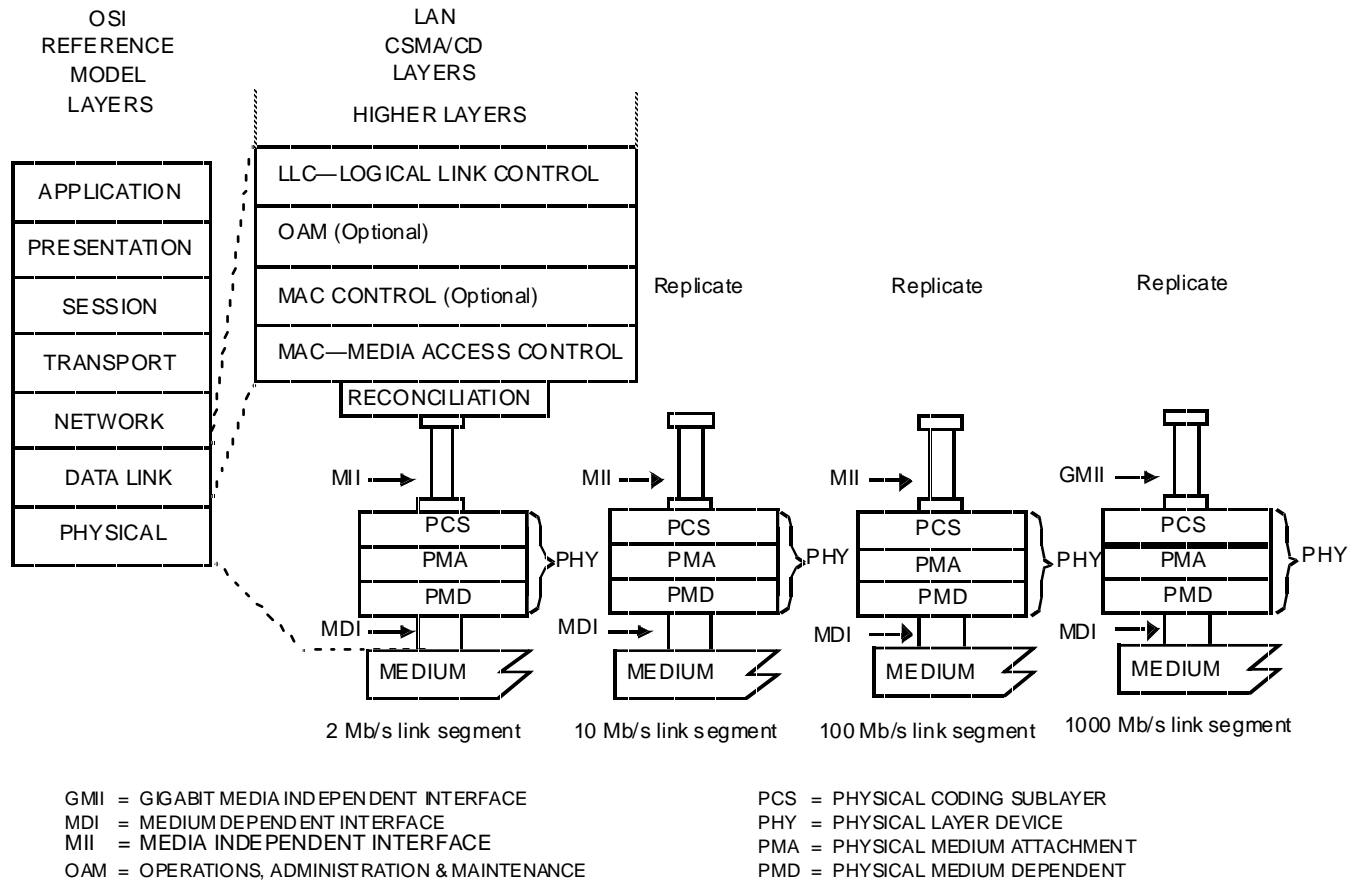
OAM

- EFM includes a frame-based transport mechanism for Operations, Administration and Maintenance

Ethernet Frame Format

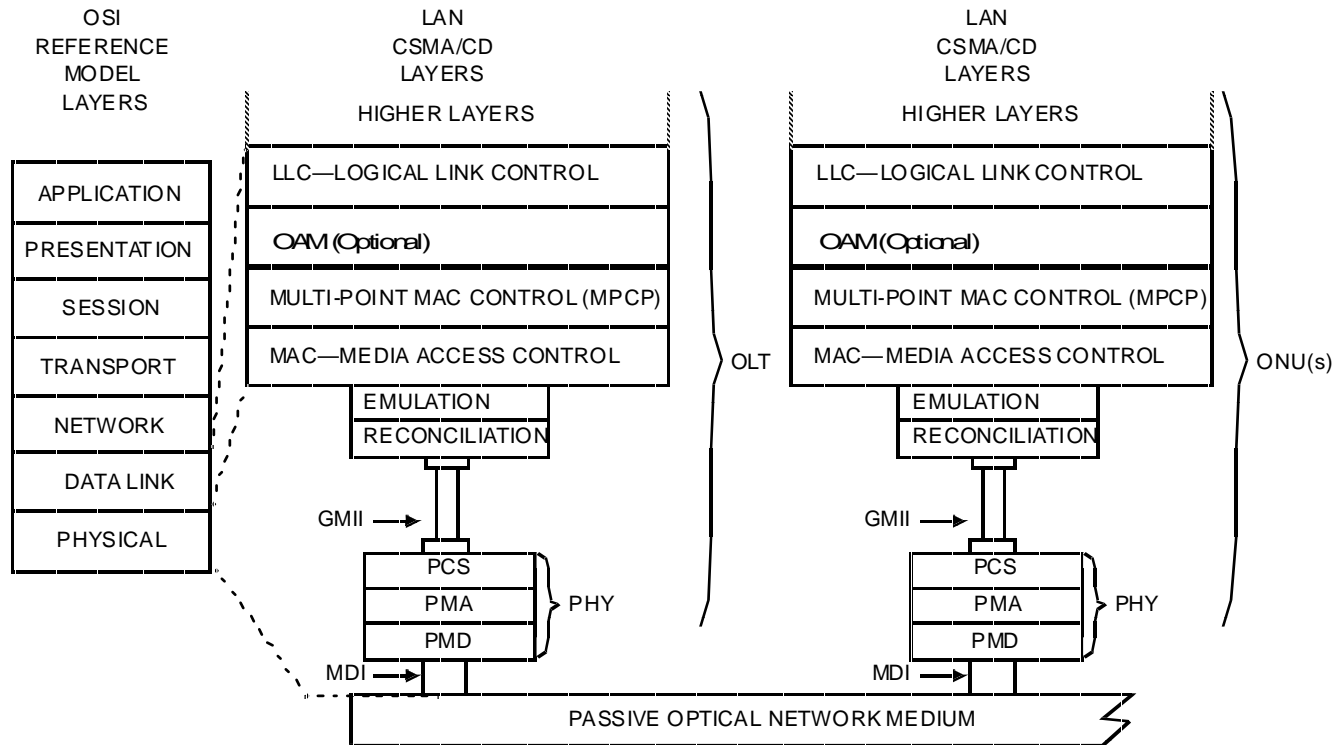


Layer Diagram - P2P



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Layer Diagram - EPON

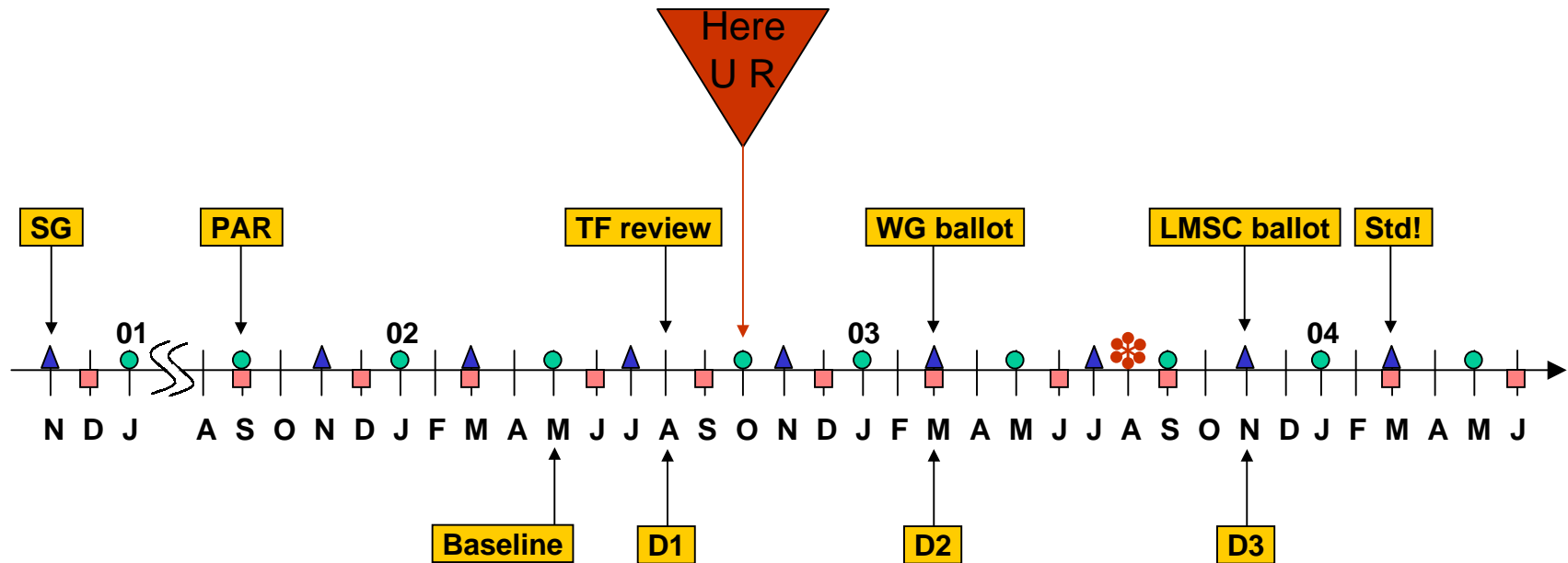






GMII = GIGABIT MEDIA INDEPENDENT INTERFACE
 MDI = MEDIUM DEPENDENT INTERFACE
 OAM = OPERATIONS, ADMINISTRATION & MAINTENANCE
 OLT = OPTICAL LINE TERMINATION

ONU = OPTICAL NETWORK UNIT
 PCS = PHYSICAL CODING SUBLAYER
 PHY = PHYSICAL LAYER DEVICE
 PMA = PHYSICAL MEDIUM ATTACHMENT
 PMD = PHYSICAL MEDIUM DEPENDENT

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Probable Timeline



-  T1E1 Decision
-  802 Plenary
-  802.3 Interim
-  IEEE-SA Standards Board

Requires a waiver of 802.3 operating rules to allow us to initiate a working group ballot before making a final decision on the Short Reach Copper line code

Future meetings

- **11-15 Nov, 2002, Kauai, HI - IEEE 802 Plenary meeting**
- **6-9 Jan, 2003, Vancouver, BC - Fairmont Hotel Vancouver**
hosted by the IEEE 802 LAN/MAN Standards Committee
- **10-13 March, 2003, Dallas, TX - IEEE 802 Plenary meeting**

For More Information

- IEEE 802.3ah EFM Task Force web site:
<http://www.ieee802.org/3/efm>
- Ethernet in the First Mile Alliance web site:
<http://www.efmalliance.org/>

Summary

- *Ethernet in the First Mile is:*
 - The Final Frontier*
 - The bridge (router) over the digital divide*
 - The optimal subscriber access network*
 - Faster, simpler, better, more profitable*
 - Coming soon to an IEEE Standard!*