Optical Considerations for the First Mile

IEEE 802.3 Ethernet in the First Mile (EFM) Study Group
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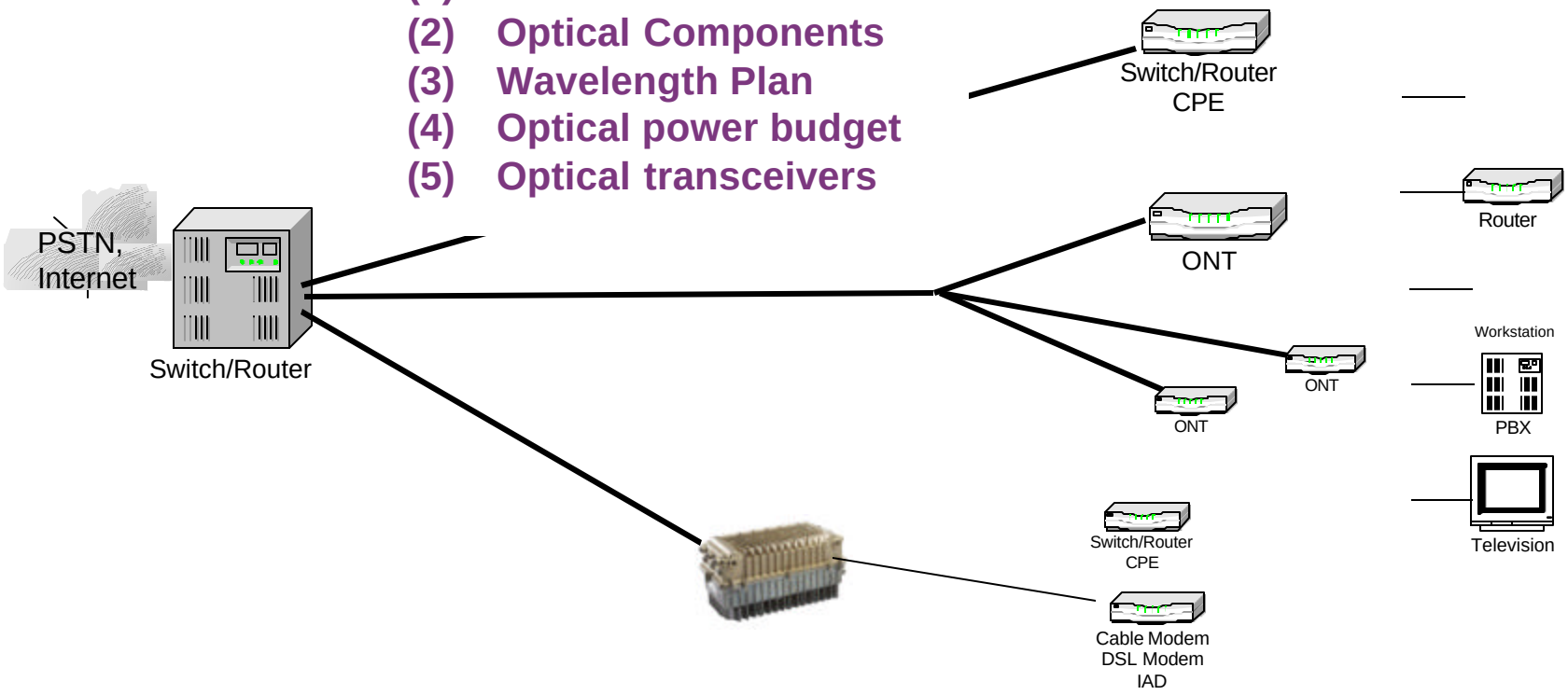
First Mile optical plant requirements are **different** from those in LAN/Campus.

(1) Environmental issues
(2) Optical Components
(3) Wavelength Plan
(4) Optical power budget
(5) Optical transceivers



Optical Ethernet Outdoors

Objective: Study Environmental Requirements for Ethernet in the First Mile

TELCORDIA
ITU-T SG 6 (Outside Plant)
ITU-T SG 15 (Optical Access)
ANSI
IEC/FCC/UL/ETSI/CSA

ITU-T examples :
G.652, G.671, G.957,
G.983, G.959, etc…

Telcordia examples :

GR-63	NEBS
GR-326	Singlemode Optical Fiber Connectors
GR-487	Electronic equipment and cabinets
GR-765	Optical splices and splicing systems
GR-909	Fiber in the Loop Systems
GR-910	Fiber Optic Attenuators
GR-950	Optical Network Units
GR-1221	Passive optical components
GR-1380	Fusion Splice protectors
GR-2883	Fiber Optic Filters

POWERING ISSUES
- Network Feed +/- 130 VDC
- CATV Loop 90 VAC
- Local Utility 90-240 VAC
- Optional Battery Backup

FTTC Switch !?

OUTSIDE PLANT REQUIREMENTS
Damp Heat 85C, 85% RH for 500 Hrs
Temperature -40 to +85 C
Water and dust sealed

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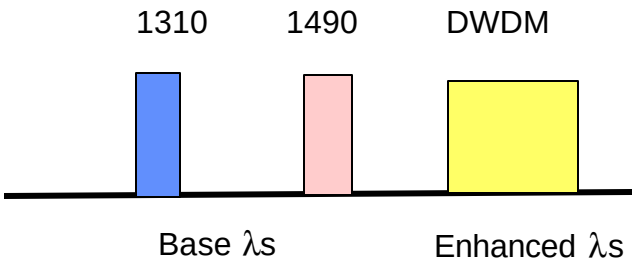
Wavelength Plan

- **Single fiber - 1490/1310 nm**
  - ITU-T G.983.WDM
  - Upstream 1260-1360 nm (1310 nm nominal)
  - Downstream 1480-1500 nm (1490 nm nominal)
  - DWDM Enhancement Band 1540-1565 nm (ITU G.959.1, G.692)



- **Single fiber – 1310/1310 nm**
  - 1310 nm Upstream and Downstream
  - Upgradeable to CWDM (1470, 1490, 1510, 1530, 1550, 1570, 1590, 1610)
  - Upgradeable to ITU DWDM
  - Concern: Additional 3.5 x 2 = 7 dB loss, and requires low back reflection connections
- **Two fiber – 1310/1310 nm**
  - 1310 nm Upstream and Downstream, no WDM
  - Concern: 2x the Cable plant (splices, connectors, etc).

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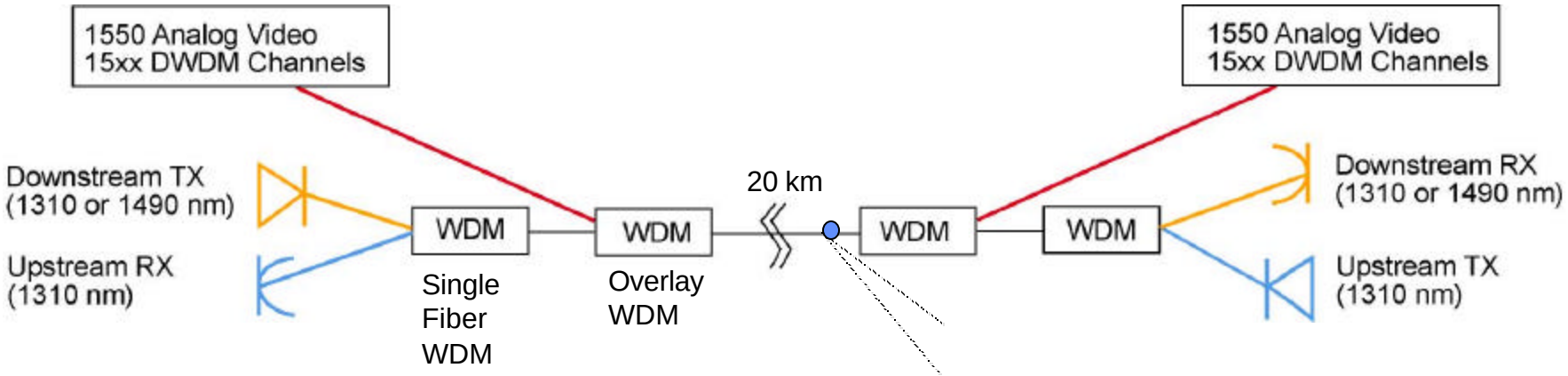
Wavelength Plan



Why a 1.25 Gbps GBIC is not always suitable for the First Mile

- Distances up to **20 km** (ITU-T G.983 specification)
- **Single fiber** solutions often required by local network operators
- 1550 nm **analog video** overlay requirement – more TVs than PCs
- 15xx **CWDM or DWDM** Channel requirements for FTTB
- FTTH networks using **integrated optics**
- Isolation between wavelengths should be >30 dB (>40 dB for analog video)

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Fiber, Connectors, Couplers

FIBER AND CONNECTOR ISSUES

- **Single mode fiber (SMF) only**
- **Single fiber and dual fiber solutions**
- **Connector standard: SC, LC with UPC/APC**
- **Cable: Trunk Feeder, Distribution, Drop**
- **Standard SMF-28 OK, Wideband fibers OK too**

Fiber and connectors are not easy to deal with, keep them away from consumers

COUPLERS (EPON)

- **Dual window - 1310nm & 1550 nm center wavelength**
- **Wideband +/- 60nm pass band**
- **Low loss - 3.5 dB max per 1:2 junction**
- **Reliability meets Telcordia standard**
- **Two types: Fusion, Planar Waveguide**

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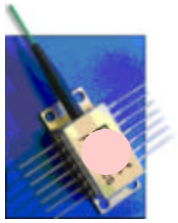
Optical Transceivers, WDMs

OPTICAL TRANSCEIVERS

- **Gigabit Ethernet EFM – 20 Km reach**
- **Single and Dual Fiber Solutions**



WDMs

- **WDM upgrade path needs to be considered**
- **Thin Film Filters, Arrayed Waveguide, Bragg Grating**
- **CWDM vs. DWDM overlay for First Mile – a good debate**
- **An EFM solution will need to interface with Metro DWDM**

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Upstream EPON Transmitter and Receiver issues

UPSTREAM TRANSMITTER (EPON)

- **Background optical noise – light leakage from idle ONU**
- **Laser turn on and turn off time (minimize guard band between timeslots)**
- **Burst mode feedback control of laser diode's temperature drift**

UPSTREAM RECEIVER (EPON)

- **Optical power step change between packet trains (caused by the difference of splitting point, fiber distance and laser power)**
- **Clock recovery**
- **Guard band margin considerations**
  - At 1.25 Gb/s one bit is about 6" long in fiber, 1uS = 200m
  - In FTTH application, customer may move ONU and add fiber length

Optical Line Rate and Power Budget

EFM OPTICAL LINE RATE

- **1.25 Gbps – 1 Gigabit Ethernet**

OPTICAL POWER BUDGET

- **20km service range → ~ 8 dB loss in fiber at 1310 nm**
- **EPON up to 32 splitting → ~ 17.5 dB loss in coupler, Splitting ratio is tradeoffs between bandwidth and number of ONU. Power budget is tradeoffs between splitting ratio and distance**
- **Connector, splice, CWDM loss ~ 4 dB**
- **Additional system margin required: 3 dB margin + 3 dB aging**
- **Bit Error Rate 10^{-10} (ITU), 10^{-12}**

Conclusion

- **EFM should study environmental requirements; resources for published specs include Telcordia, ITU-T, ANSI, etc.**
- **A base wavelength plan is a critical decision:**
  - **Single fiber 1550/1310**
  - **Single fiber 1490/1310 – ITU-T; chosen by several incumbents**
  - **Single fiber 1310/1310**
  - **Dual fiber 1310/1310**
- **An overlay wavelength plan is also critical. It is not clear as to whether CWDM or DWDM will be used in the first mile. See ITU G.983.WDM**
- **Ethernet PONs optimize infrastructure, but require burst mode transceivers.**
- **Other optical issues include security, fiber plant integrity, fiber diagnostics and plant management, and optical safety and protection.**
- **OBJECTIVES SUMMARY**
  - **Study environmental issues**
  - **Optical requirements for PTP and PTMP network need to be defined**
  - **Let's hear from more local network operators**

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