Passive Optical Networking

Greg Dawes
Zhone Technologies Sr. Sales Engineer
Fiber to the Room Workgroup Chair

Agenda

- What is Passive Optical Networking

- Types of PON

- PON Components

- Copper to PON Comparison
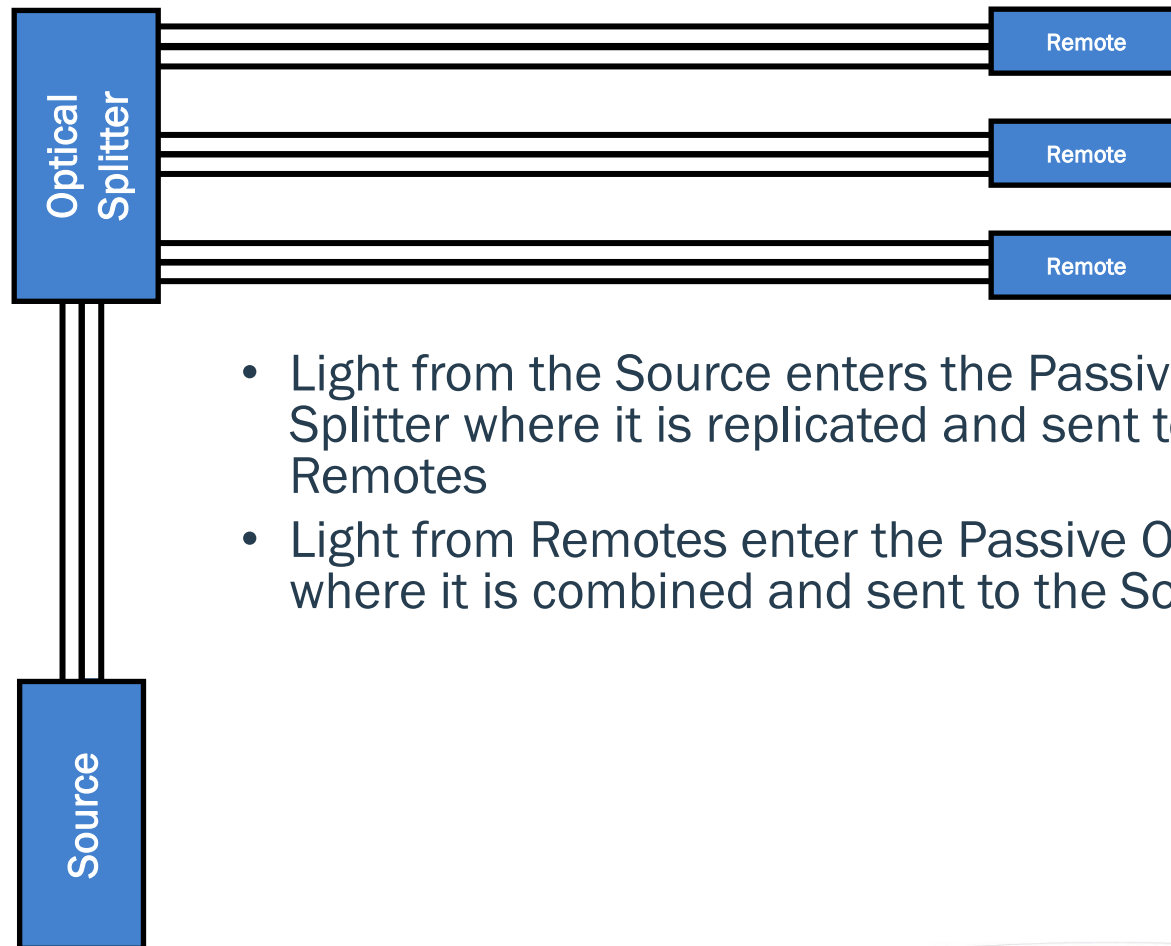
- PON Installation

- Why PON

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Passive Optical Networking

- A Passive Optical Network provides a shared common Single Mode Fiber optic network infrastructure to multiple endpoints that is completely passive.
  - Passive – No powered equipment between endpoints
- Passive Optical Networks were developed:
  - To remove the cost of intermediate electronics in both copper and fiber networks.
    - Optical Splitters instead of Active Electronics
    - Single-mode Fiber for extended distances
  - To reduce the amount of fiber required for the network
    - Transmit and Receive over a Single fiber
    - Single fiber to the optical splitter located close to the endpoints

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Passive Optical Network

Optical Splitter

Remote

Remote

Remote

Source

- Light from the Source enters the Passive Optical Splitter where it is replicated and sent to all the Remotes
- Light from Remotes enter the Passive Optical Splitter where it is combined and sent to the Source

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PON Applications

- Integrate all Guest Room services onto a single optical infrastructure
- High Speed Internet Access
- Voice Services
  - Analog Telephones
  - VoIP (w/ PoE) Telephones
- Video Services
  - RF (QAM) Video
  - IP Video (IPTV)
- WiFi Access Point
- Monitoring Services
  - Building Automation Systems
  - Security Cameras and Systems
  - Sensors and Monitoring

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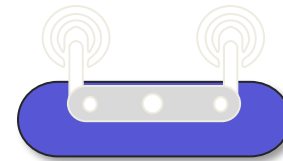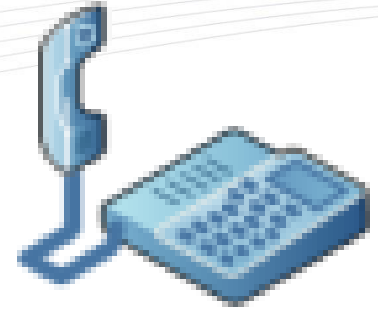
Who's Installing PON

- Hospitality (Hotels/Resorts)
- MDU – Residential and Office
- Hospital/Health Care Facilities
- Federal Agencies
  - Department of Defense (DoD)
  - Joint Interoperability Test Certification (JITC)
- Universities
- Manufacturing Facilities
- Data Centers

Virtually Any Local Area Network

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Types of PON

- GPON – Gigabit PON (ITU G.984)
  - 2.5 Gbps Downstream / 1.25 Gbps Upstream today
  - 10GPON (ITU G.987) products out in 2014
    - 10 Gbps Downstream / 2.5 Gbps Upstream
  - WDM PON on the roadmap
    - Point-to-Point over a shared medium with 1 Gbps dedicated per channel

- EPON/GEPON – Ethernet PON (IEEE 802.3ah)
  - 1.25 Gbps symmetrical today
  - 10G EPON (IEEE 802.3av) products out in 2014
    - 10 Gbps Symmetrical
    - 10 Gbps Downstream / 1.25 Gbps Upstream

- Main differences are speed and the type of data traffic supported
  - EPON supports Ethernet traffic only
  - GPON supports Ethernet, TDM, and ATM traffic
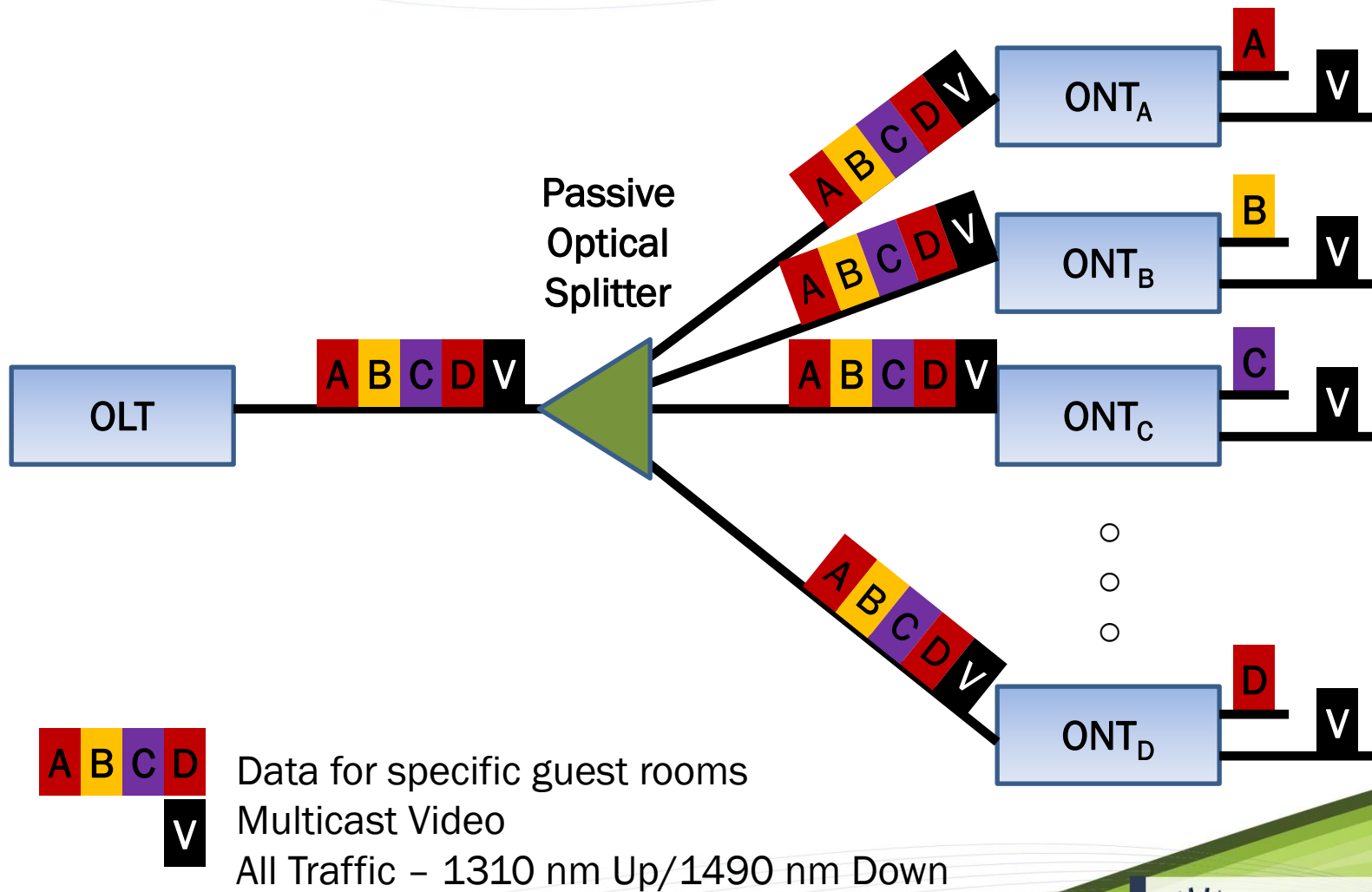 - Both types are used globally for FTTx deployments

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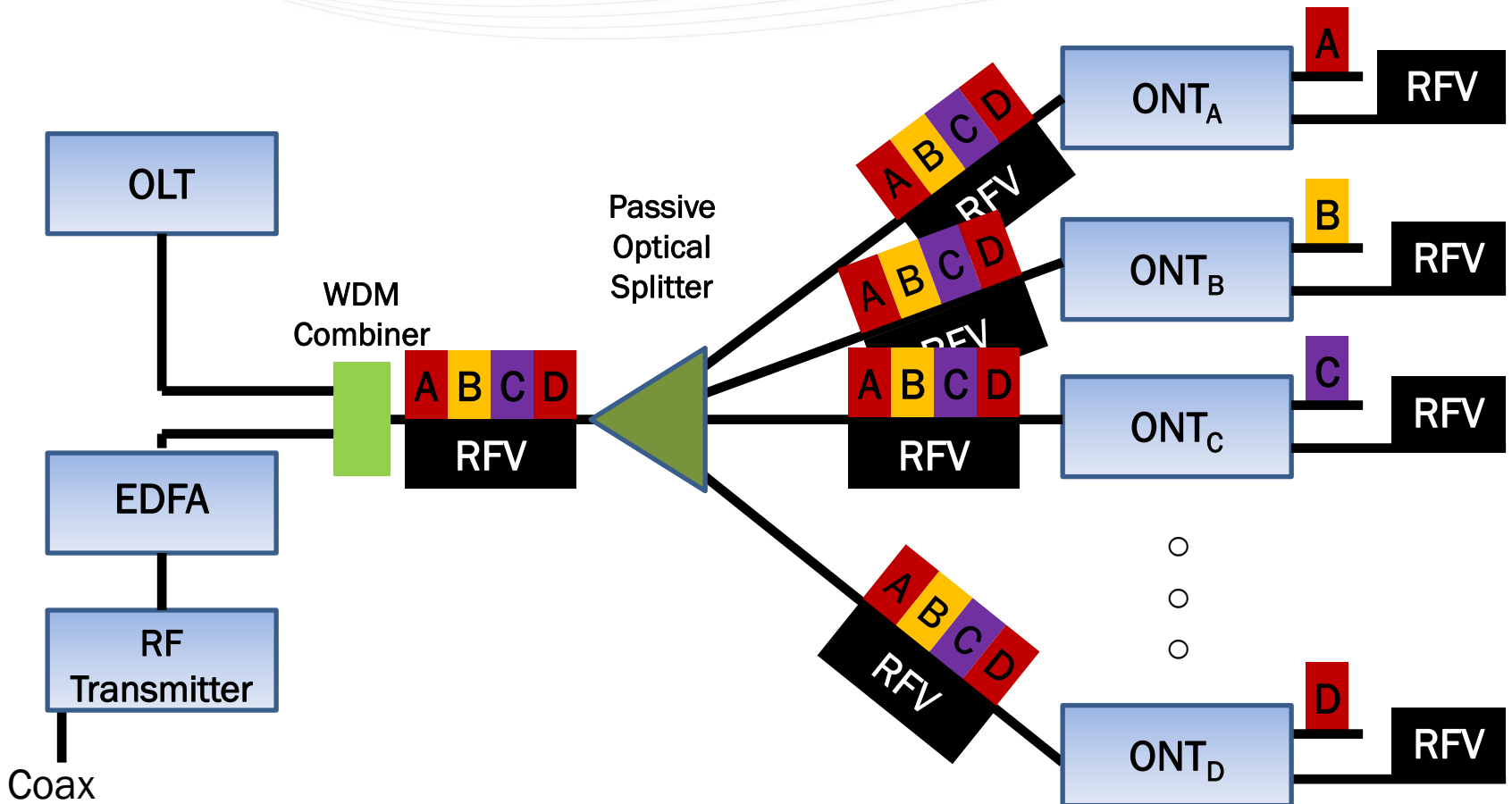
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PON Components

- In the Main Distribution Frame (MDF)
  - Optical Line Terminal (OLT)
    - A modular chassis or multiport fixed box
    - Performs as a L2/L3 switch
- In the Intermediate Distribution Frame (IDF)
  - Passive optical splitters
    - Splits the optical signals up to 64 ways
    - Passive so no electricity is required
- In the Guest Room
  - Optical Network Terminal (ONT)
    - Also known as Optical Network Unit (ONU)
    - Provides connectivity for:
      - HSIA, Phones, TVs, Mini-Bar, Door Locks, CCTV...

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PON Diagram – IPTV

Passive Optical Splitter

OLT

ONT_A

ONT_B

ONT_C

ONT_D

Data for specific guest rooms
Multicast Video
All Traffic – 1310 nm Up/1490 nm Down

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PON Diagram – RF Video

OLT

WDM Combiner

EDFA

RF Transmitter

Coax

Passive Optical Splitter

A B C D
RFV

ONT_A — A — RFV
ONT_B — B — RFV
ONT_C — C — RFV
ONT_D — D — RFV

A B C D — Data for specific guest rooms (1310 nm Up/1490 nm Down)
RFV — RF Video (1550 nm Down)

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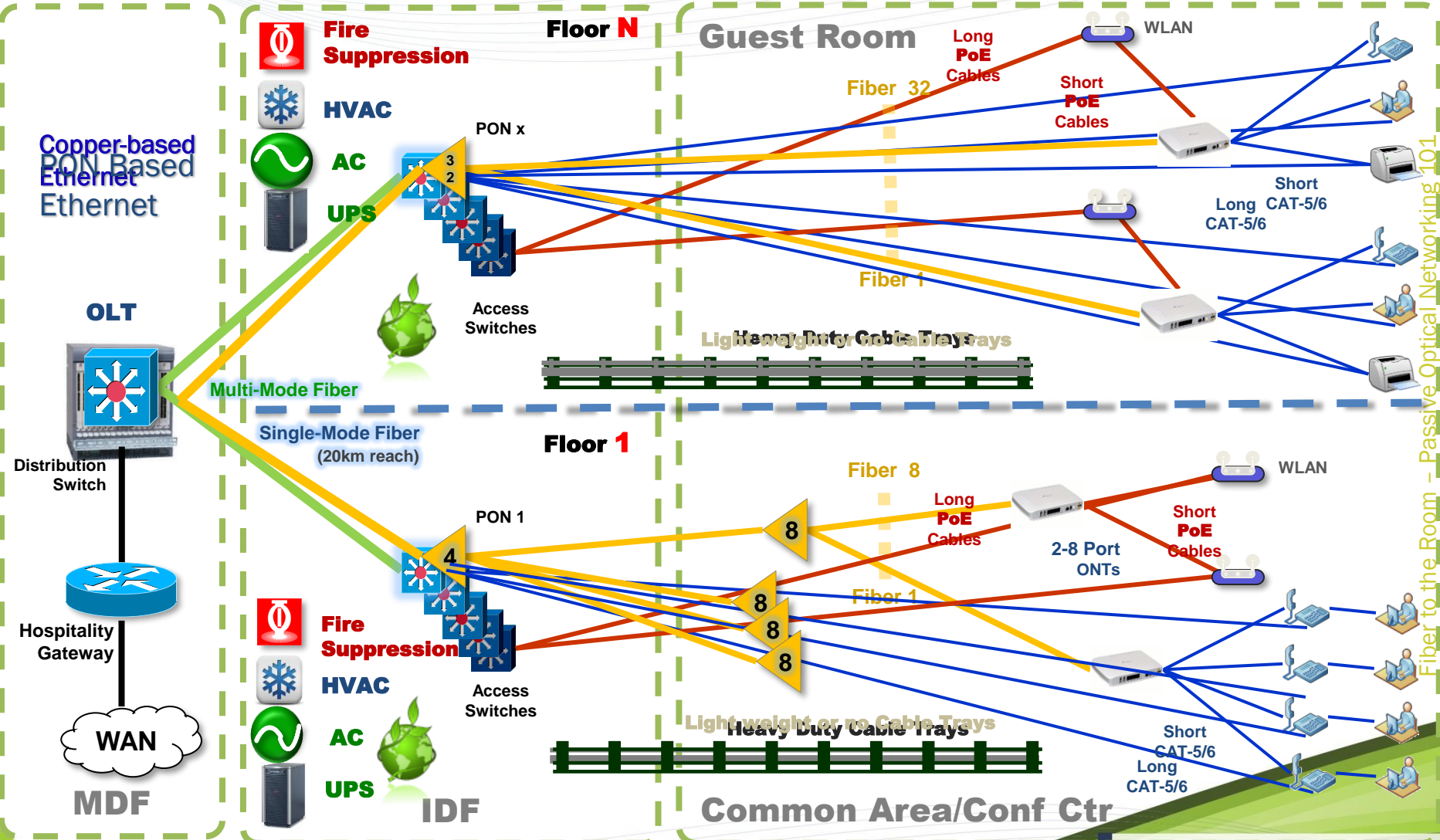
Optical Splitters

- Optical splitters are critical to the Passive Optical Network
    - Splits an incoming light source into two separate paths
    - Repeating this split multiplies the number of devices that can be connected to a single port
- Optical Splitters come in a number of configurations
    - 1x2, 1x4, 1x8, 1x16, 1x32, 1x64
    - 2x2, 2x4, 2x8, 2x16, 2x32, 2x64
- Ports are all equal
    - The light is replicated
    - Has no affect on bandwidth
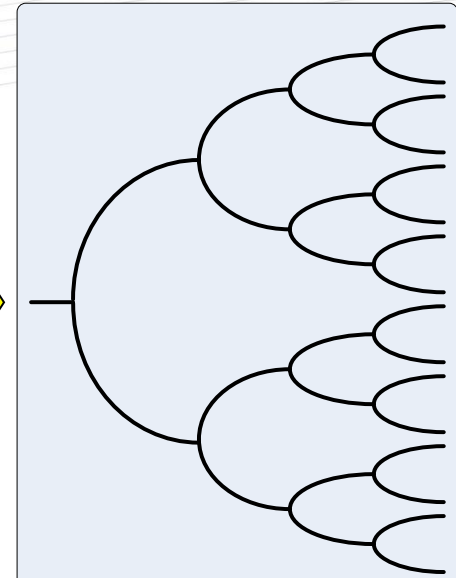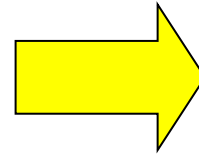
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Copper Verses Fiber Network

Copper-based Ethernet / PON Based Ethernet

MDF — OLT, Distribution Switch, Hospitality Gateway, WAN

IDF — Fire Suppression, HVAC, AC, UPS, Access Switches, PON x, PON 1

Guest Room / Common Area/Conf Ctr — WLAN, Long PoE Cables, Short PoE Cables, Fiber 32, Fiber 1, Fiber 8, Short CAT-5/6, Long CAT-5/6, 2-8 Port ONTs

Multi-Mode Fiber / Single-Mode Fiber (20km reach)

Heavy Duty Cable Trays / Light-weight or no Cable Trays

Floor N / Floor 1

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Copper Solution Limitations

- Ethernet services have been delivered the same way for over 15 years (stacking Ethernet switches)

- Each new Ethernet Switch generation is:
  - More Expensive
  - Requires More Power
  - Requires More Space
  - Requires Copper infrastructure upgrades
    - Cat3, Cat5, Cat5e, Cat6, Cat6a, Cat7, Cat8 …
    - Replacing copper is extremely expensive
    - Copper is inherently insecure

- Power and Carbon Footprint Reduction Mandates
 - US Gov – Exec Order 13423 → 30% energy reduction by 2015

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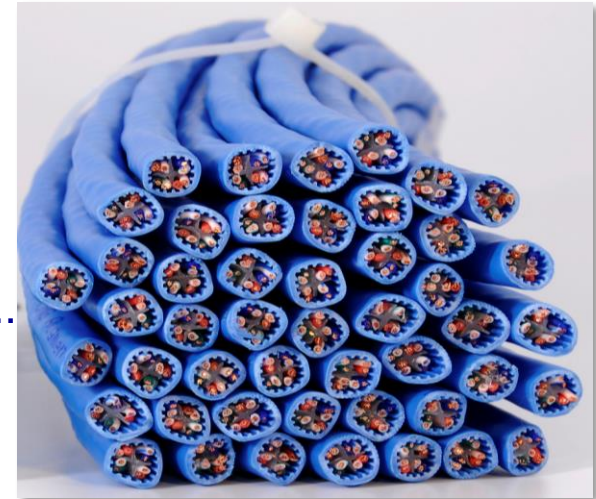
Fiber Cable Vs. Copper Cable

Riser Rated Cables	Fiber Optic Cable	Tier 1 Vendor Category 5e UTP	Tier 1 Vendor Category 6a UTP
10G Distance	40 km	45 m	100 m
Cable OD	2.9 mm	5.7 mm	7.5 mm
Weight	4 lb / 1000 ft	22 lb / 1000 ft	39 lb / 1000 ft
Minimum Bend Radius	5 mm	22.8 mm	30 mm
Tensile Strength (Installation)	48 lbf	25 lbf	25 lbf

Relative Cable Diameter Comparison

2.9 mm

Fiber

5.7mm

7.5 mm
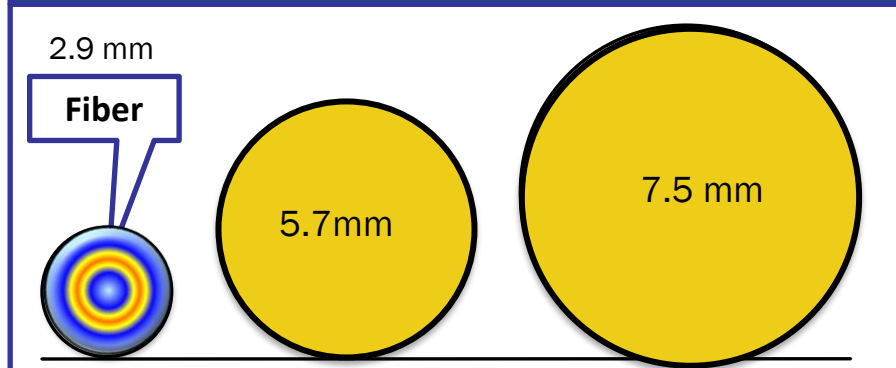
Relative Bend Radius Comparison
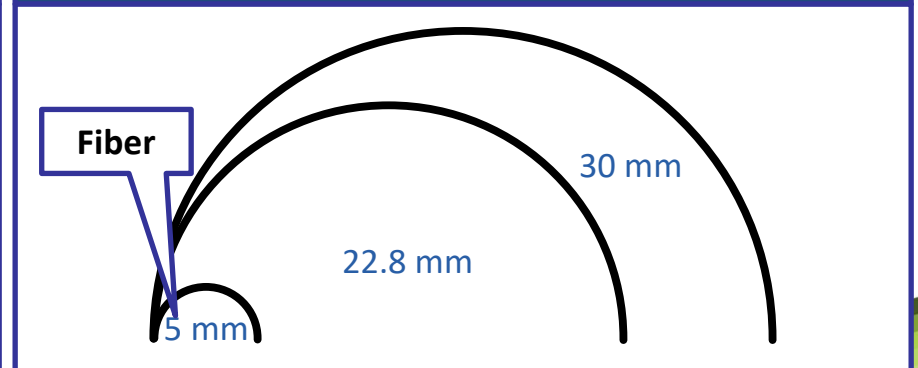
Fiber

5 mm

22.8 mm

30 mm

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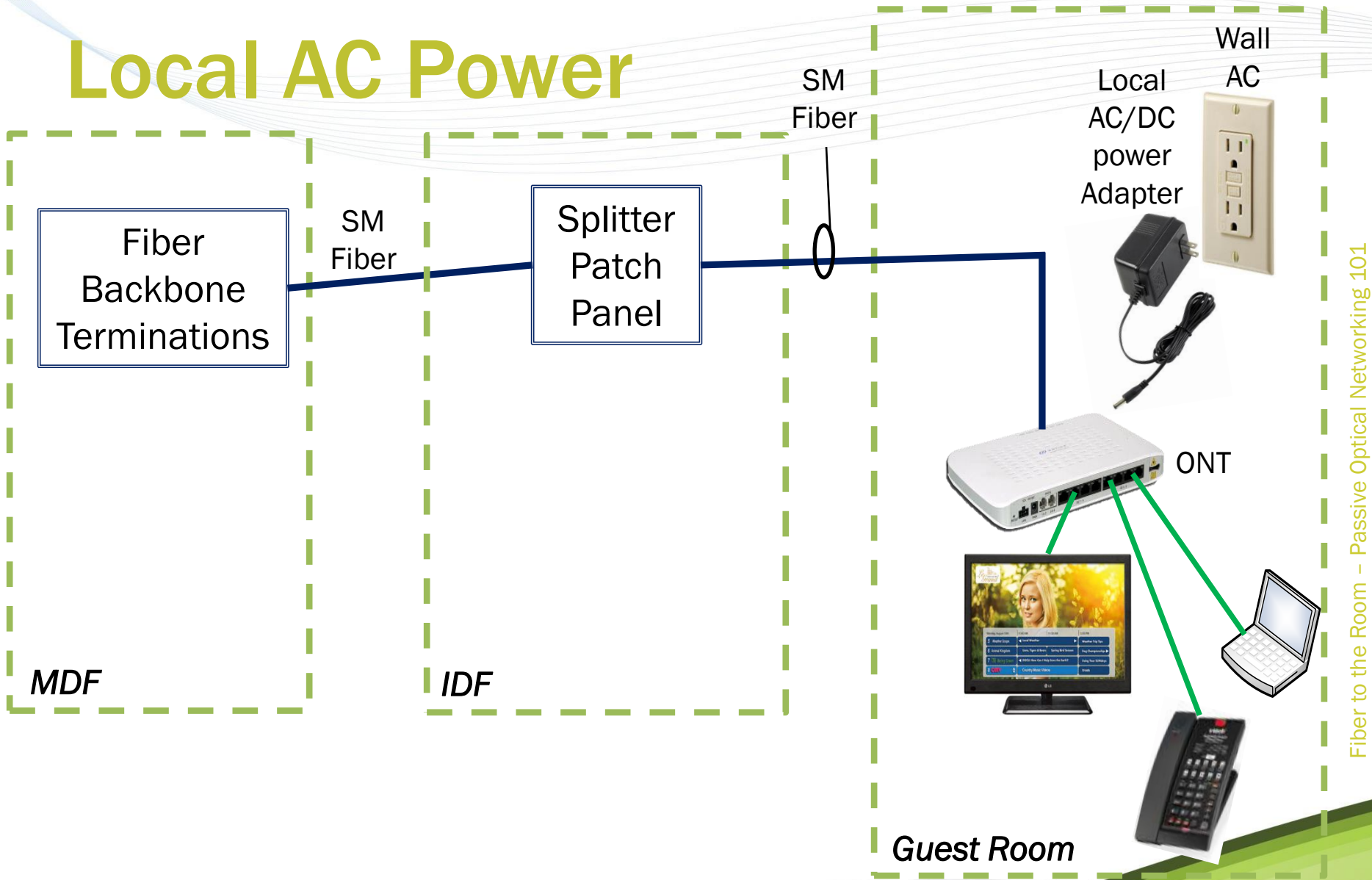
ONT Installation Options

- ONT should be mounted in or near the guest room
  - Wall Plate Form Factor ONT
  - Standalone Form Factor ONT
    - Structured Cabling Box
    - Hidden (soffit or behind furniture)
- Must be readily accessible by maintenance personnel
- Must NOT be readily accessible by guests
- Cable Connections
  - PON Connection
  - HSIA Connections
  - Phone Connections
  - TV Connections
- Power

Fiber to the Room – Passive Optical Networking 101

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ONT Powering Options

- The Optical Network Terminal is an active component and requires a power source.
- There are three basic powering options available.
    - Local AC power
        - ONT plugs into a wall outlet or is directly connected to the electrical line
    - Distributive DC Power
        - Power source is located in the IDF
        - Requires a copper pair to be run with the fiber cable
    - Centralized DC Power
        - Large DC power plant in the MDF
        - Requires a copper pair to be run to each ONT
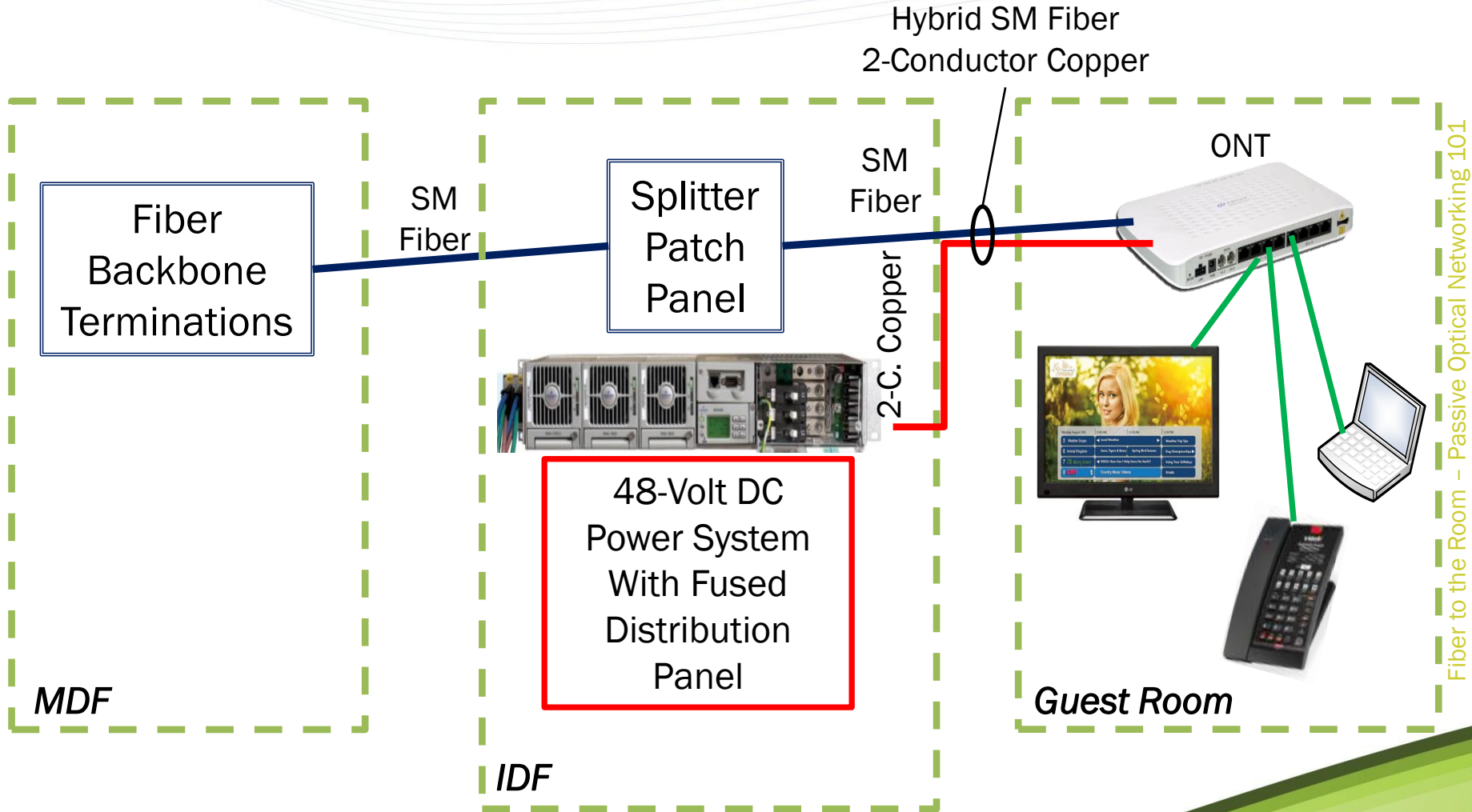
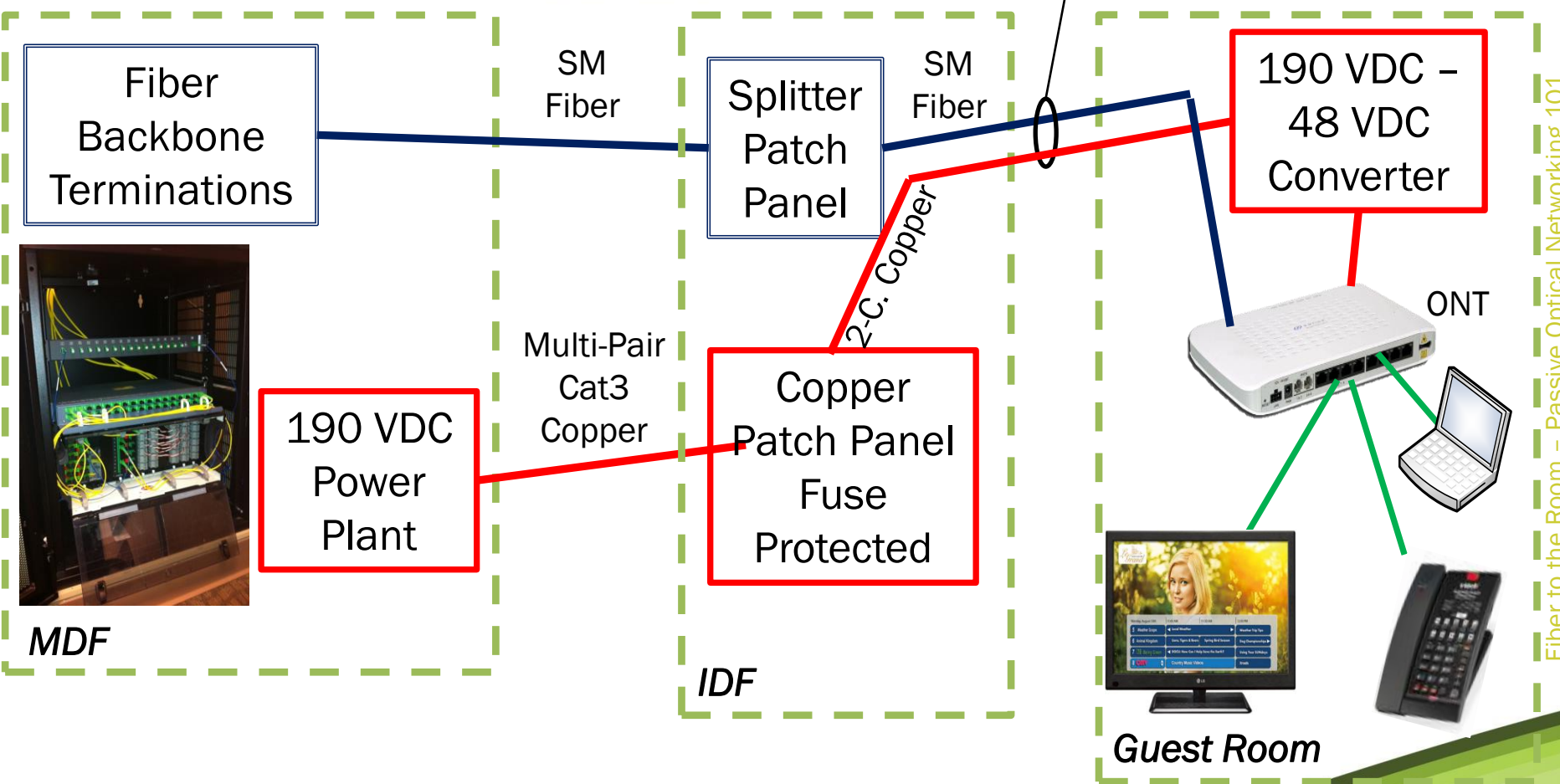Hotel Technology
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Local AC Power

Fiber Backbone Terminations

SM Fiber

Splitter Patch Panel

SM Fiber

Wall AC

Local AC/DC power Adapter

ONT

MDF

IDF

Guest Room

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Distributive DC Power

MDF

Fiber Backbone Terminations

SM Fiber

IDF

Splitter Patch Panel

48-Volt DC Power System With Fused Distribution Panel

2-C. Copper

SM Fiber

Hybrid SM Fiber 2-Conductor Copper

Guest Room

ONT

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Centralized DC Power

Hybrid SM Fiber
2-Conductor Copper

Fiber Backbone Terminations

SM Fiber

Splitter Patch Panel

SM Fiber

190 VDC – 48 VDC Converter

ONT

190 VDC Power Plant

Multi-Pair Cat3 Copper

2-C. Copper

Copper Patch Panel Fuse Protected

MDF

IDF

Guest Room

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Key Value Advantages of PON

Advantages

Lower TCO (Total Cost of Ownership)

Green IT (Saves Power & Space/Reduces Carbon Footprint)

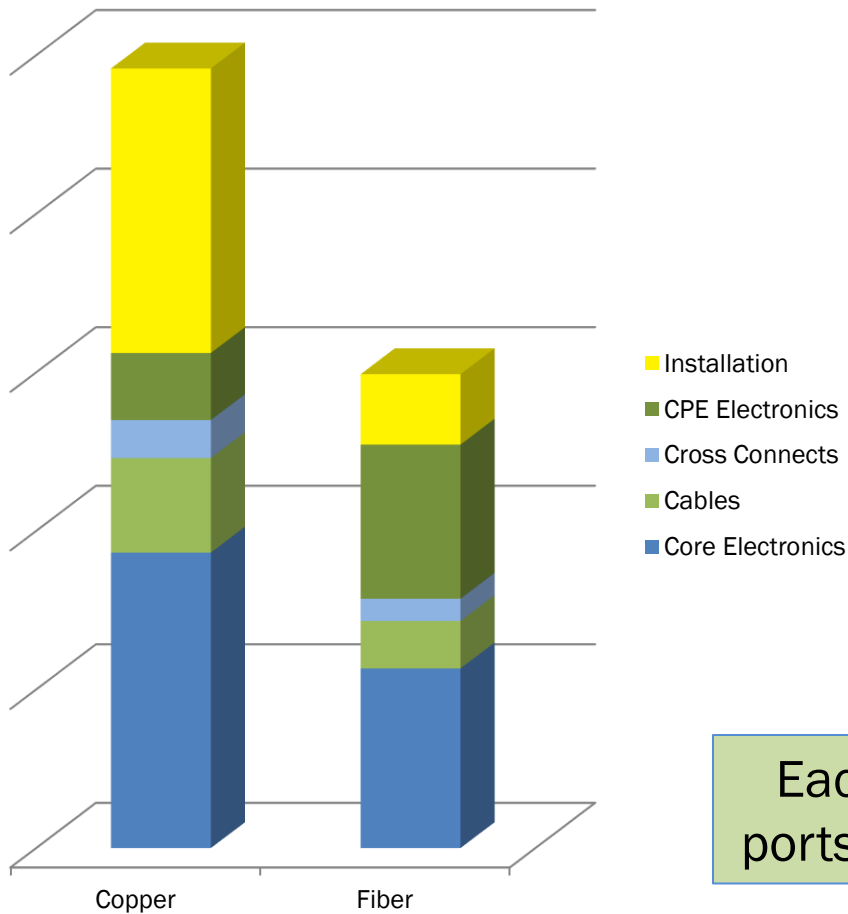High Availability and Security

Future-Proof Infrastructure

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215 Room CAPEX Comparison

Legend:
- Installation
- CPE Electronics
- Cross Connects
- Cables
- Core Electronics

Copper | Fiber

Fiber Savings	
Installation	75%
CPE Electronics	-130%
Cross Connects	41%
Cables	50%
Core Electronics	39%
Total Savings	39%

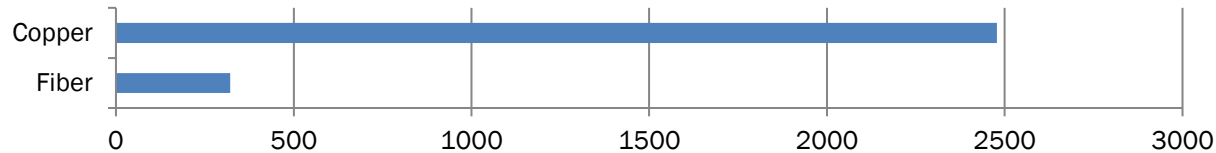Each guest room has 4 Ethernet ports plus a Wireless Access Point .

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215 Room OPEX Comparison

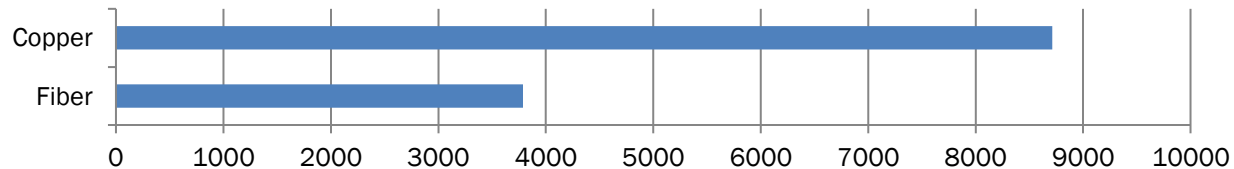## MDU Space Requirements (RU)
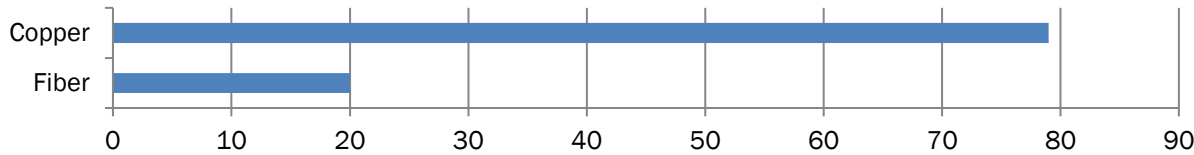
Total Cable Weight (Pounds)

Power Requirements (Watts)

Annual Maintenance ($)

Fiber to the Room – Passive Optical Networking 101

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Eco-Friendly Solution

Green Benefits

Reduction in Power Consumption
Savings of 40% to 60% in Electricity and Back-up Systems

Reduction in HVAC requirements
Up to $400k in HVAC for a 2000 port Ethernet solution

Reduction in Non-Renewable Materials
Up to 8000 lbs in Plastic & Copper (Cat-5/6) in a building with 4000 Ethernet ports

Reduction in Cabling Costs
Point to Multi-Point Fiber is Cheaper Than Copper Homeruns

Floor Space Savings
Reduce or eliminate IDF closets and reduce footprint in MDF room

Ceiling Space and Fire Load Savings
Savings in Fire Suppression Systems, and overhead Cable Tray Infrastructure

Conventional Cables

144 Multi-Mode Fibers
144 Copper Cat5 Cables



PON Fiber Cables

144 Single-Mode fibers

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Cable Congestion

PON Installation

- **Reduced Installation Costs**
- **Reduced Volume of Flammable materials**
- **Faster deployment**
- **Eliminate periodic Cable upgrades**
- **Eliminate power loss on PoE**
- **LEED Certification advantages**

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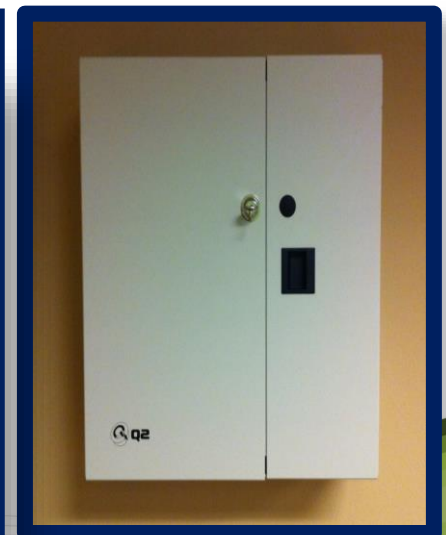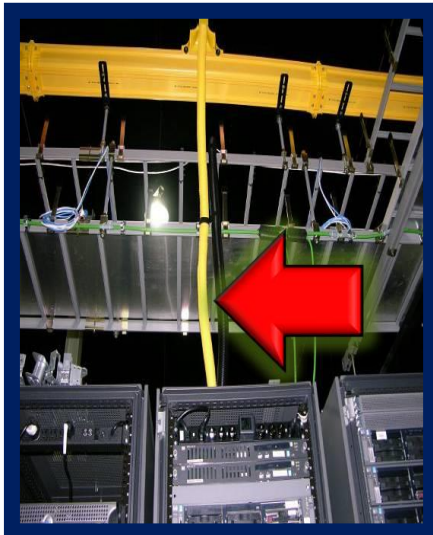
Secure and Reliable

Security / Reliability

Ultra Secure

- No Tempest Shielding Required

- AES 128-bit Encryption

- MAC & IP ACL's

- RADIUS Authentication (802.1x)

Highly Reliable

- Five-9's Availability on ALL Components

- Fiber Has A Better Bend Radius & Tensile Pull Strength Than Cat5/6 Cabling

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Scalable and Future-Proof

Future Proof

Single Mode Fiber supports future PON Technology advances
- (XGPON will work over a GPON)

LAN Electronic Upgrades do NOT require recurring *Cable* upgrades
- ANSI / TIA / EIA reviews cabling standards every 5 years
- Expected Copper Cabling Useful life is 7-10 years (*typical*)

Single Mode Fiber maximum line rate is unknown
- Current achievable rate is 108 Tbps (NEC)

* By NEC Laboratories America (using DWDM) 2011

Traditional Ethernet Solution Lifespan

[*CAT-3* (1991) ➔ *CAT-5* (199X) ➔ *CAT-5e* (2003) ➔ *CAT-6* (2008) ➔ *CAT-6a* (2008) ➔ *CAT-8* (2013)]

7-10 YEARS

Single Mode Fiber Lifespan

25+ YEARS

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Resources

- PON Webinar – 2012
- Fiber Design Guide – 2014
- Fiber 101 Webinar – 2013
  - http://collaboration.htng.org/inroom/protected/documents.php?prot=Y&gpid=376&action=show&dcat=24&gdid=25416
- Association of Passive Optical LANs (APOLAN)
  - http://www.apolanglobal.org/
- BICSI Documentation
  - http://www.bicsi.org/

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Questions?

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Thank You

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