Fundamentals of Passive Optical LAN

2018 BICSI WINTER CONFERENCE & EXHIBITION
Orlando, FL | February 4-8

Brought to you by the Association for Passive Optical LAN (APOLAN)

Founding Members:

www.apolanglobal.org

Course Agenda

- Day 1
  - Passive Optical LAN: 101 – Tom Ruvarac
  - Passive Optical LAN: 102 – Dustin Bateman
  - Introduction to POL Components – Matt Miller
  - Introduction to POL Design with Hands-On – Mike Watts & Chad Hines
- Day 2
  - Day 1 Review – Dustin Bateman
  - Power Survivability – Chad Hines
  - POL Testing Considerations – Mike Watts
  - POL Integration and Management – Matt Miller
  - POL Project Closeout Package Deliverables – Mike Watts

I am a…

A. Consultant
B. Designer
C. Contractor
D. Manufacturer
E. End User
F. Other

My experience with POL is…

A. I have installed one
B. I have turned one up
C. I have a project now
D. I have some knowledge
E. I am here to learn

Passive Optical LAN:101

Tom Ruvarac

President, APOLAN

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Section 1 Agenda

- Introduction to Passive Optical LAN
- Where did it originate
- Market adoption
- Knowledge Check

Let's Imagine…

Consumes twice the power!!

Promotes inefficient use of bandwidth!!

Costs 40 to 60% more!!

A Local Area Network that…

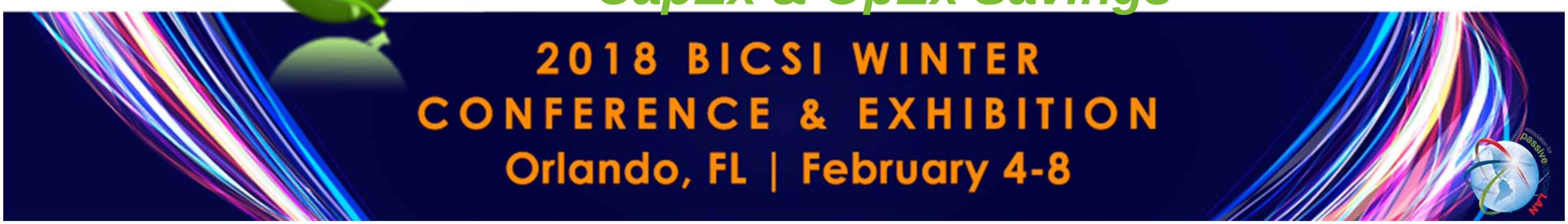
This describes a traditional LAN!

An exciting new way…

Passive Optical LAN

The infrastructure of tomorrow available today

"A Bandwidth Efficient LAN Architecture Providing Measurable CapEx & OpEx Savings"



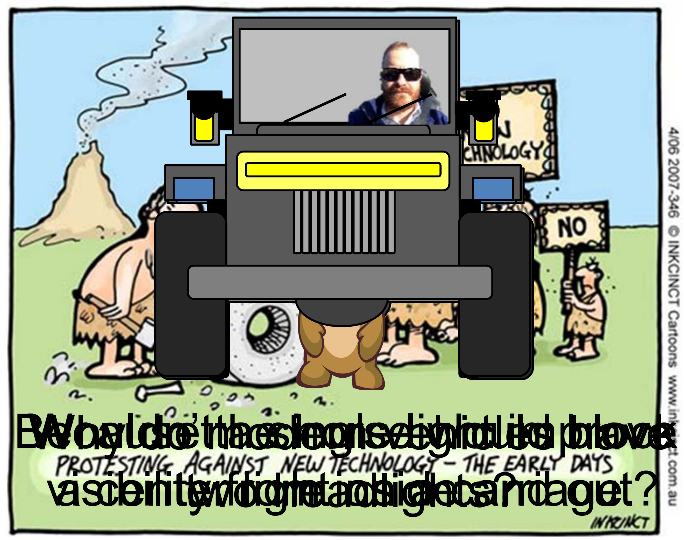
Thoughts…

Henry Ford Wisdom…

“If I’d asked customers what they wanted, they would have said “a faster horse.”

Steve Jobs Wisdom…

“Man is the creator of change in this world. As such he should be above systems and structures, and not subordinate to them.”



“There aren’t many horse and buggies on the road and most of us don’t have typewriters sitting on our desks. So why are copper networks still so widely used although they have been rendered obsolete by next-generation technologies?” *Scott Forbes, CEO Forbes Media*

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Key Acronyms

GPON

PON vs. POL

OLT and ONT

What is Passive Optical LAN?

Revolutionary

Economical

Efficient

What is Passive Optical LAN?

Standards based/recognized technology

- ITU G984, G987, G989
- ANSI/TIA 568C
- BICSI TDMM 13

Fiber Based Local Area Network

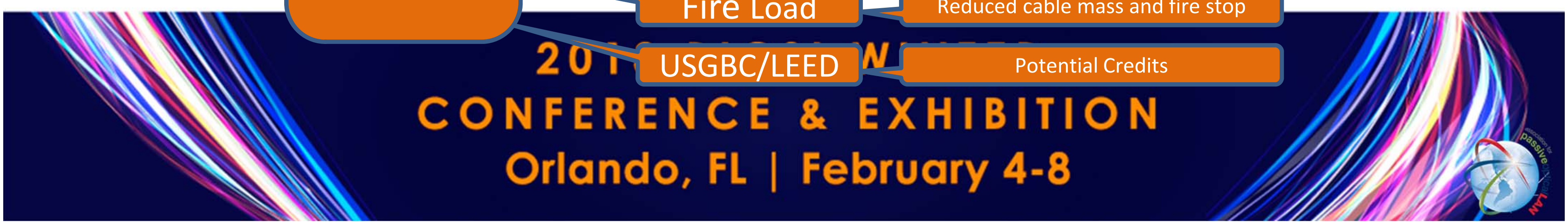
Point to Multipoint Topology

Why Passive Optical LAN?

- Reduced Costs
  - CapEx
    - ~40-60%
      - One Time
  - OpEx
    - ~50-75%
      - Every Year
  - Construction
    - Cable Tray, Conduit, and Pathways
    - Sleeving, Coring, and Fire Stopping
- Technically Future Proof
  - Singlemode
    - Unknown Bandwidth Capacity
  - Migration
    - Only upgrade users that need it
- Scale and Reach
  - Easy MACs
    - Can save 8-10 minutes per MAC
  - 20km/12.5mi
    - No 300m / 90+10m limitations

Why Passive Optical LAN?

- Security
  - AES 128 Encryption in the downstream
  - No crosstalk concerns with fiber
  - No EMI/RFI or Tempest Shielding
- Green IT
  - Power – Switches, UPS, HVAC
  - Floor Space – Reduce or eliminate TRs
  - Building Weight – Cable, Trays, Racks, CRACs, etc.
  - Waste – Less site waste and use of NRMs
  - Fire Load – Reduced cable mass and fire stop
  - USGBC/LEED – Potential Credits



Why Passive Optical LAN?

Carrier Grade Electronics

POL electronic components are designed and manufactured to have a service life greater than 25 years as required by carriers, compared to 5-8 years with Enterprise grade equipment

High Availability

Five 9s (99.999) with POL *vs.* Three 9s (99.9) with switches

Five 9s = 5.26 min/yr

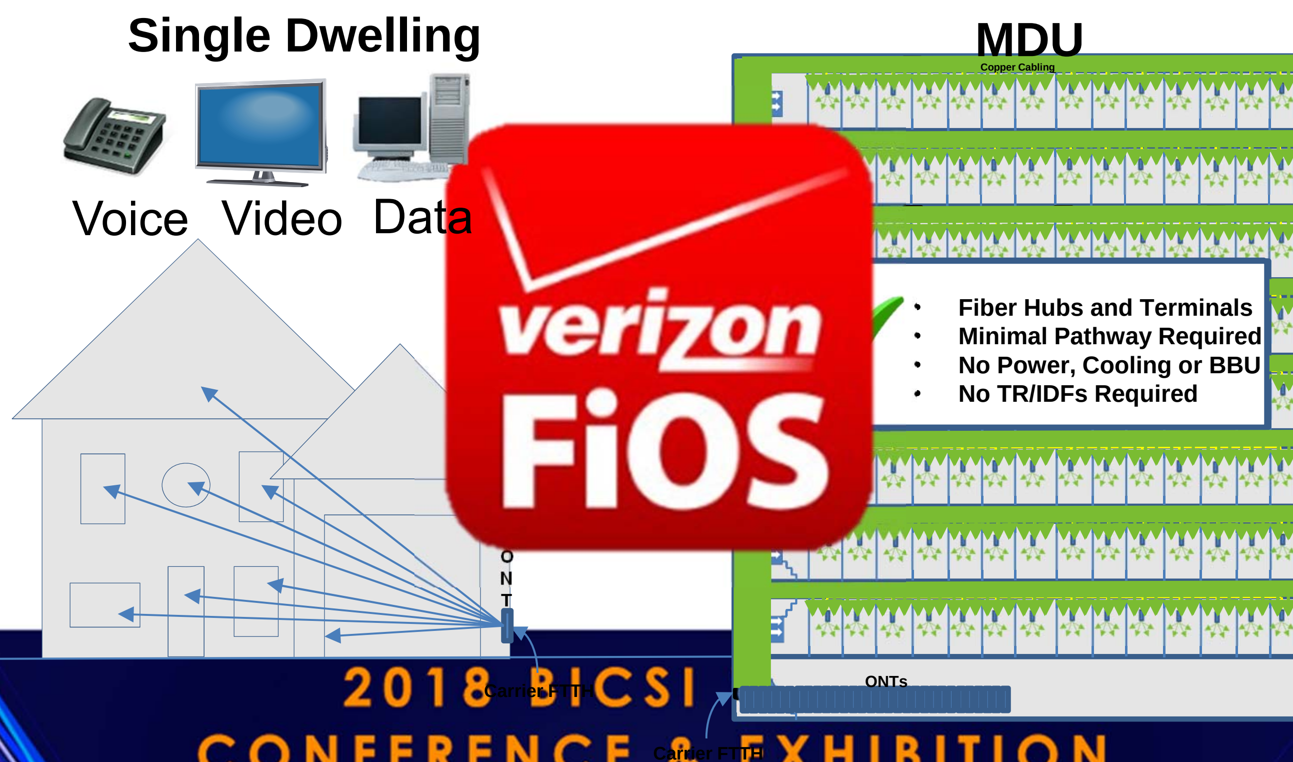
Three 9s = 8.76 **hr**/yr

Nearly six 9s (99.9999) of availability with POL *using FSAN-B Redundancy*

What should you know?

Similar	Different
Standards Based	Point to Multipoint
Local Area Network	Multiple Services
Enterprise Management	Guaranteed Bandwidth
Ethernet Frame Transport	Single Strand of SM Fiber
NAC Auth. – VLANs – PoE 802.1x – 802.1Q – 802.3at	No Access and Distribution

Where did it come from?



What's the difference between a…

30 Story Apartment Building and a 30 Story Office Building

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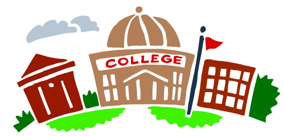
Target POL users

Healthcare

Hospitality



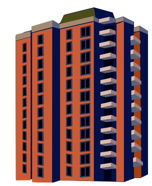
Education

(K-12 and Higher Ed.)

Campuses

High Occupancy Buildings

(Call Centers)

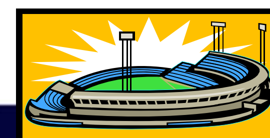


Multi-Tenant Units

(Commercial and Residential)

Casinos

Government and Military



Sporting Venues

Market Segment Adoption (Partial List)

Government and Military

- Department of Energy
- Department of Defense
- Department Homeland Security
- Health & Human Services
- Intelligence Agencies
- NASA
- State Department
- US Air Force
- US Air Guard
- US Army
- US Army Reserves
- USDA Forest Service
- US Marine Corps
- US Forest Service

Hospitality/Hotels/Resorts

- Marriott
- Mandarin
- Crown Plaza
- Buccament Bay Resort
- Ice Hotels
- Kittitian Hill Resort

Business Services

- Canon
- Google International HQ Sunnyvale
- Getty Images London HQ
- Verizon Business Offices
- GlaxoSmithKline
- Shearman & Sterling
- NiSource
- Center for Excellence in Wireless & IT
- Advanced Energy Center
- Simmons Building for Physics & Geometry
- Motorola Solutions Sweden AB
- Deltek
- Miles & Stockbridge Law firm
- Telecommunications Industry Association

MTU/MDU Residential and Commercial

- Empire State Building
- Dallas Fort Worth Airport
- Trump Tower Miami
- Trump Plaza NY
- Stuyvesant Town/Peter Cooper Village NY

Financial

- Russell Investments (AU)
- SouthEast Bank

Healthcare/Hospitals

- Erickson Living Retirement
- Pardubice Regional Hospital
- ArchCare/Cardinal Cooke Center
- Williamsburg Landing
- Camp Pendleton Hospital
- Western State Hospital
- Guthrie Corning NY Hospital

Education/K-12/Universities/Colleges

- Virginia Tech
- Howard Community College
- Stony Brook State University
- University of Mary Washington
- Bridgepoint Education
- Dalhousie University
- Amherst College
- Chilliwack School District (BC)
- Washington State University
- American College of Radiology
- Orangeburg Public Schools
- San Diego Public Library
- Santa Fe Public Schools

Example POL Implementation

Global Fortune® 225 Company – Americas Headquarters Melville, NY USA

Project Overview:

- Approximately 1 million sq. ft. (main building and 2 parking garages)
  - Planned growth for another 200,000 sq. ft.
- 1,500 employees
  - Planned growth for another 750
- Nearly 12,000 GPON Ethernet ports

Integrated Technologies over GPON:

- VoIP (PCs tethered through phone)
- Security
  - Access Control
  - Biometrics
  - Cameras (main building and parking)
  - Virtual turnstiles
  - Blue Phones in parking garage
- 480 WAPs
- Building automation
- Environmental controls
- IP Video content distribution
- Digital signage
- Point of Sale

association for passiveopticalLAN

Member Integration/Implementation

Project Highlights

$1 million in CAPEX savings

Approximately $250,000/yr in energy savings

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San Diego Downtown Central Library

Optical LAN

- Wireless Access Points
- Across library & courtyard
- Free access for patrons

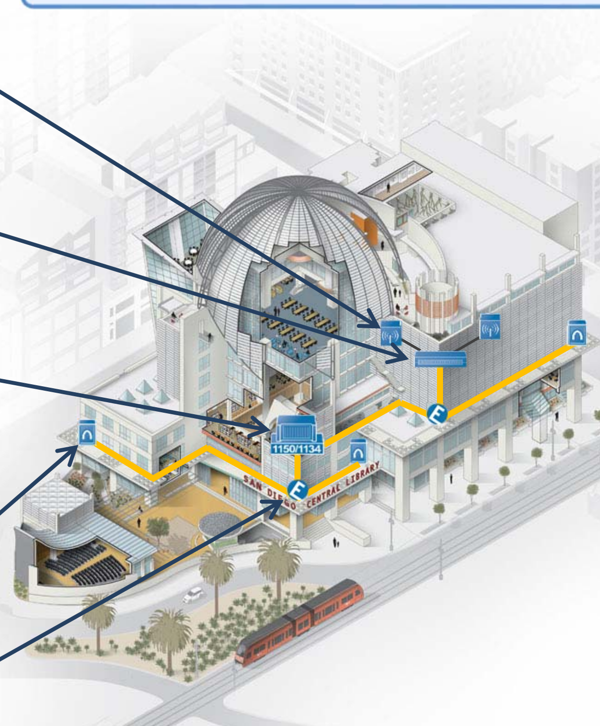
- Rack Mount ONT
- 24-ports GbE Ethernet
- Mainly serving WAPs

- Chassis Style OLT
- Located 4th floor data room
- Serves all ONTs with 18 miles

- Surface Mount ONTs
- 4-ports GbE Ethernet
- Mainly mounted under desks

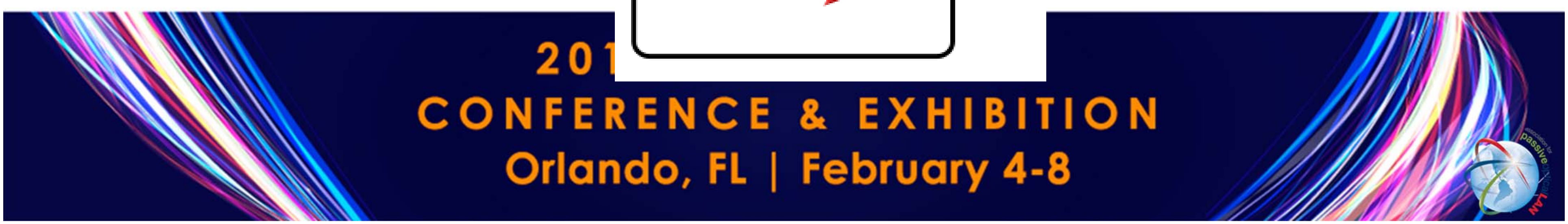
- Single Mode Fiber
- Passive Optical Splitters
- With Fiber Management

San Diego Downtown Central Library ~ modern smart and green building



- 9-story
- 3-story domed reading room
- 350-seat auditorium
- Technology center
- Outdoor plaza and café
- Coffee Bar
- LAN services Voice over IP, data & on-line video access
- Wi-Fi throughout the library and courtyard via 36 Meraki WAPs
- 3-D Printer Connectivity
- Nearly three hundred digital devices available
  - Workstations
  - iPads
  - iPad Minis
  - Chromebooks
  - Kindle
  - Sony eReaders
- Technology enable collaborative workspaces
- LEED Silver status

Knowledge Check



Passive Optical LAN is a standards based/recognized technology

A. True

B. False

Guaranteed bandwidth is possible with…

A. Passive Optical LAN

B. Switch Based

C. Both A and B

POL supports 802.1Q VLANs

A. True

B. False

AES 128 Encryption is present in __________ direction(s)

A. The upstream

✓ B. The downstream

C. Both upstream and downstream

Section 2 Agenda

- Verticals
- Bandwidth Requirements
- Dynamic Bandwidth Allocation
- Knowledge Check

Education Vertical

- **K-12**
  - Tight budgets vs. increased demand
  - Space constraints and non-traditional TRs/IDFs
  - Aging architecture vs. modern technology
    - Mondo Pads
    - AMX SchoolView
    - Smart Boards
    - Central content

- **Post Secondary / Higher Education**
  - Higher bandwidth demand
  - Increased BYOD
  - Valuable space lost with traditional
  - Lost revenue and added costs
    - Inefficient use of bandwidth
    - Inefficient use of space
    - Service providers profit

Hospitality Vertical

- **Hotels**
  - Industry groups driving POL advanced technology
    - HTNG – Hotel Technology Next Generation
    - HFTP – Hospitality Financial & Technology Professionals
      - HITEC – Hospitality Industry Technology Exposition and Conference
  - Higher port density in guest rooms and non administrative areas
    - Digital signage
    - Cameras
    - WAPs
    - IP card readers and locks
    - Four to eight data ports per guest room
  - Scalable solution with extended reach
    - Resort properties
    - Shared pilot properties (Fairfield Inn, Courtyard, and Residence Inn)
  - Future proof cabling infrastructure

Healthcare Vertical

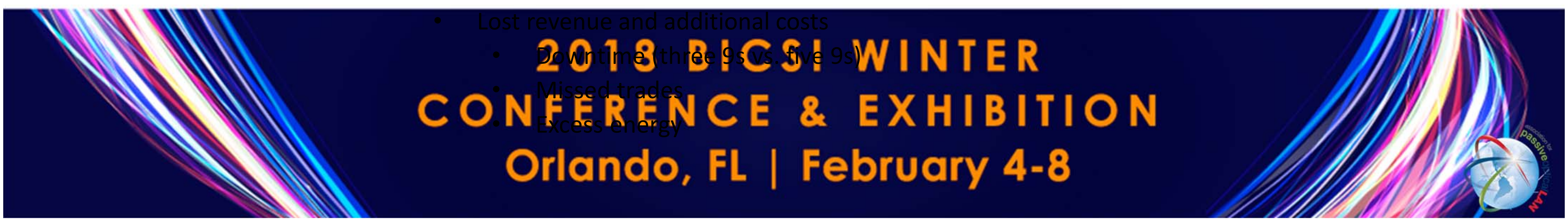
- **Assisted Living**
  - Patient wandering – WAP monitoring
    - In residence
    - Anywhere on the property
  - VoIP and Data needs in residence and administration
  - Security and Digital Communication

- **Critical Care**
  - Higher bandwidth demand
  - Higher port counts in patient rooms, nurse stations, and operating rooms
  - Building Automation and Intelligent Structures (converged networks)
    - Security
    - Monitoring
    - HVAC
    - Automated check-in / check out
    - Door sensors
  - No EMI/RFI concerns or Tempest shielding needed with fiber
  - Encrypted data pathways

Large Enterprise / Financial Verticals

- **Large Office Building**
  - Movement toward all BYOD
  - Converged networks (HVAC, Automation, Security, etc.)
  - Pathway and space constraints
  - Cost of traditional switch, cabling, and maintenance refresh
  - Increased technology
    - Pervasive wireless
    - Digital signage
    - Everything headed IP

- **Financial (Banks and Trading Floors)**
  - Higher bandwidth demand
  - Increased security
  - Increased port count
  - Redundancy, diversity, and automatic failover (FSAN-B)
  - Lost revenue and additional costs
    - Downtime (three 9s vs. five 9s)
    - Missed trades
    - Excess energy



Call Centers, Cities, and Retail

- **Call Centers**
  - High density areas
  - Low bandwidth requirements
    - IP Phones ~ 95Kb/s
    - Virtual “Dumb” terminals ~ 1Mb/s
    - Print/Scan/Fax ~ 500Kb/s

- **Cities, Towns, Neighborhoods, and MDUs**
  - Connect multiple buildings without distance limitations
  - Older buildings do not have pathways and spaces for traditional upgrades
  - Scalable solution for future expansion

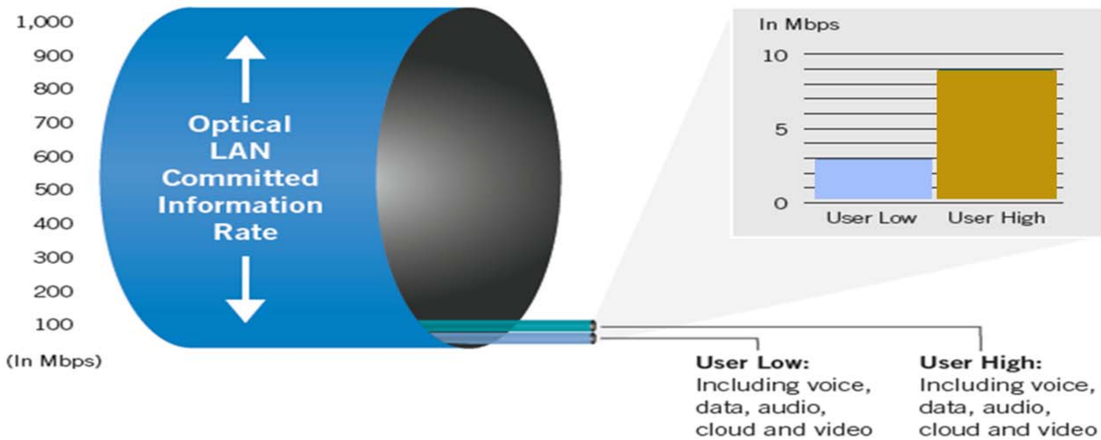
- **Retail**
  - Digital signage
  - Customer interactive Experience (pricing, web details, ordering, price compare)
  - Security, POS, multi-tenant service

You need how many "Gigs"?

Common LAN Services	Typical Required Bandwidth
Email and Web Browsing	500Kbps
Voice over IP	110Kbps
Cloud-based Services (data storage, enterprise s/w, collaboration, etc...) Low	50Kbps
Cloud-based Services (data storage, enterprise s/w, collaboration, etc…) High	100Kbps
Wireless Access Point Capacity (IEEE 802.11 a/b/g/n)	24Mbps
Wireless Access Point High Capacity (IEEE 802.11 ac/ad, dual radio)	300Mbps
IP Video Surveillance Standard Definition (MPEG4/H.264)	2Mbps
IP Video Surveillance High Definition (MPEG4/H.264)	6Mbps
IP Video Conferencing / Telepresence (720p-Good, includes primary/auxiliary)	2Mbps
IP Video Conferencing / Telepresence (1080p-Best, includes primary/auxiliary)	15Mbps

Gartner 2013 Estimates of Bandwidth needs through 2017 shows Super Users with a maximum requirement of sub-7Mbps

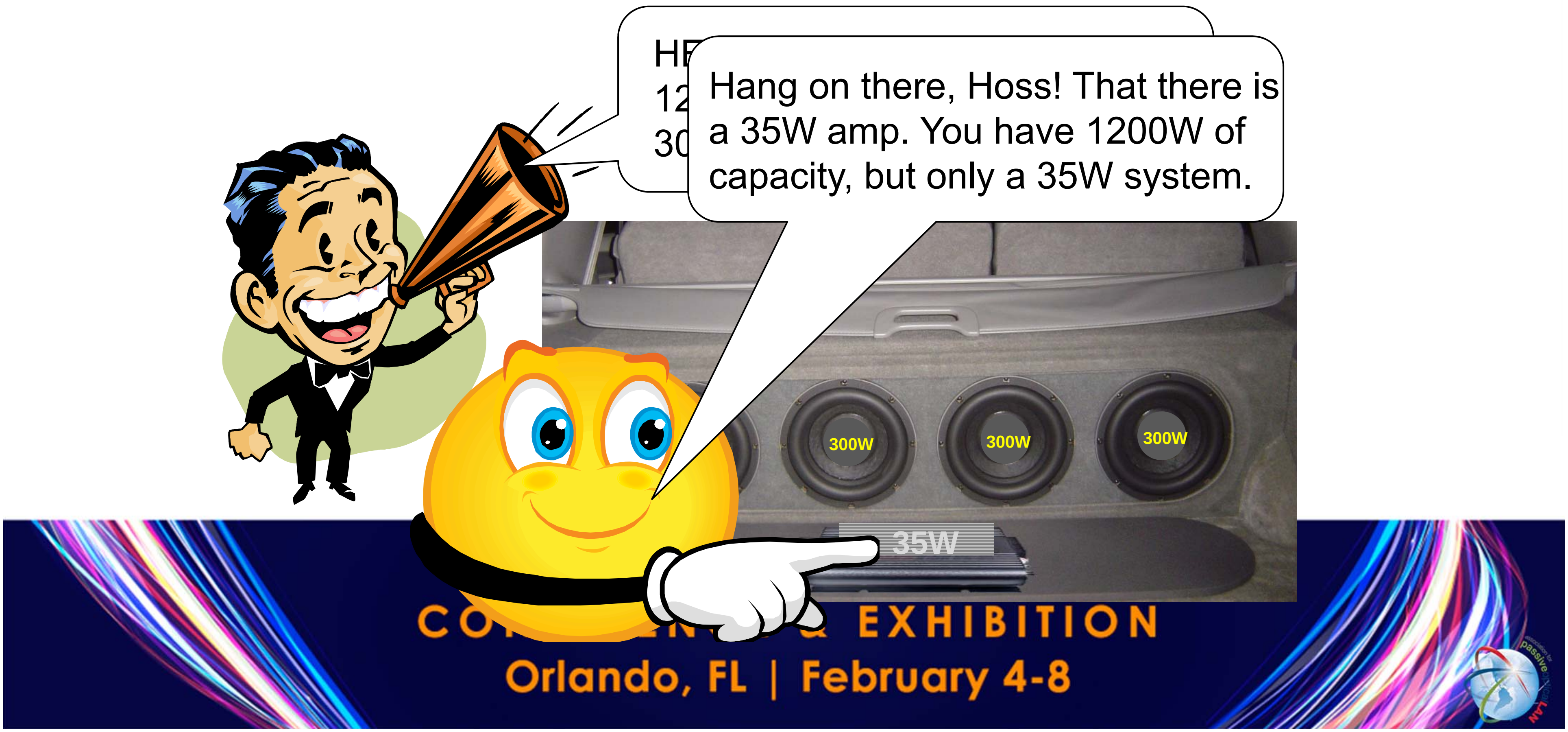
How much bandwidth is ***really*** needed?



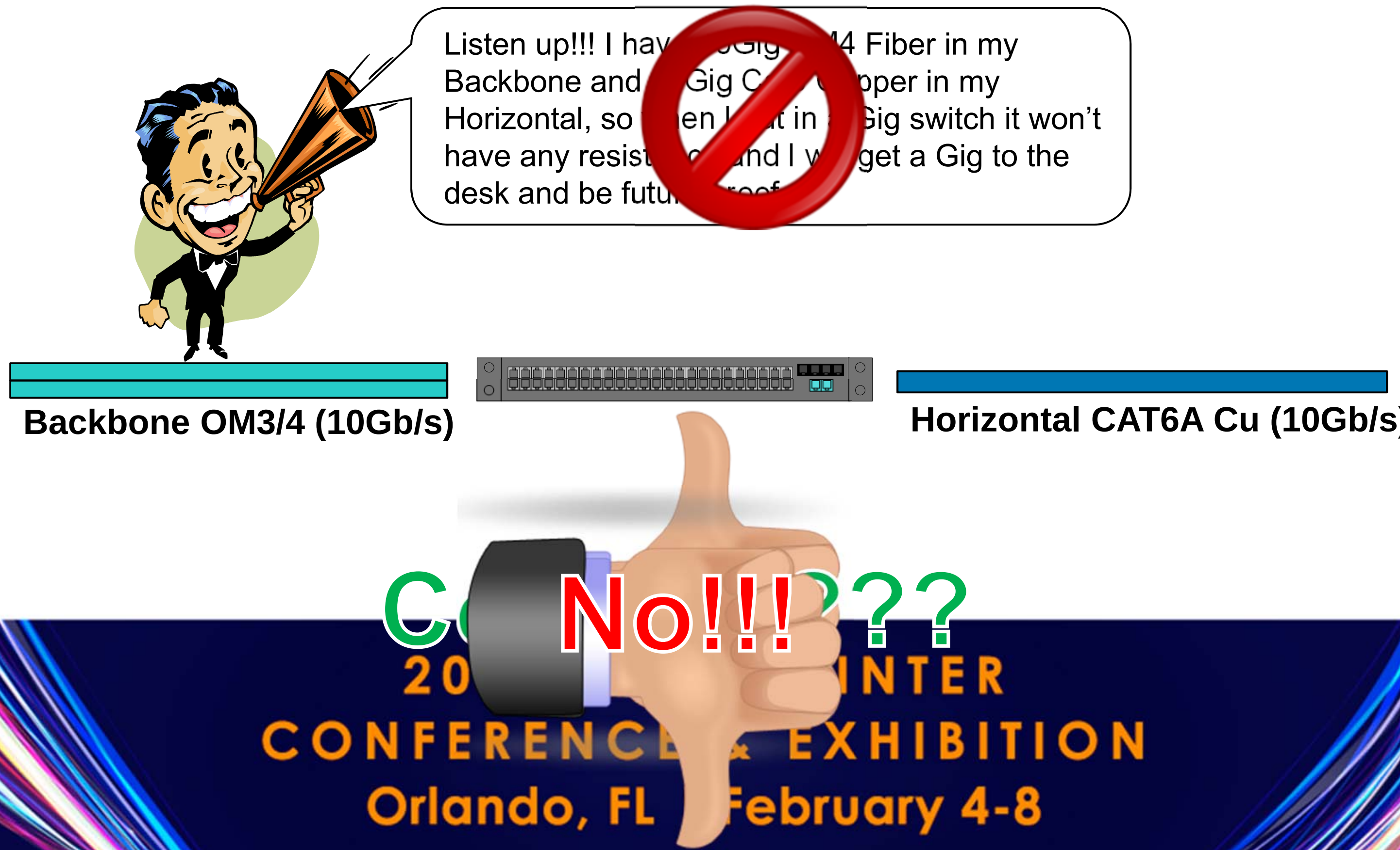
Optical LAN bandwidth compared to Peak bandwidth per User in 2017

- Blue represents symmetrical 1 gigabit bandwidth available at every ONT port
- Light Blue and Green represents Gartner Low User and High User bandwidth required 2017

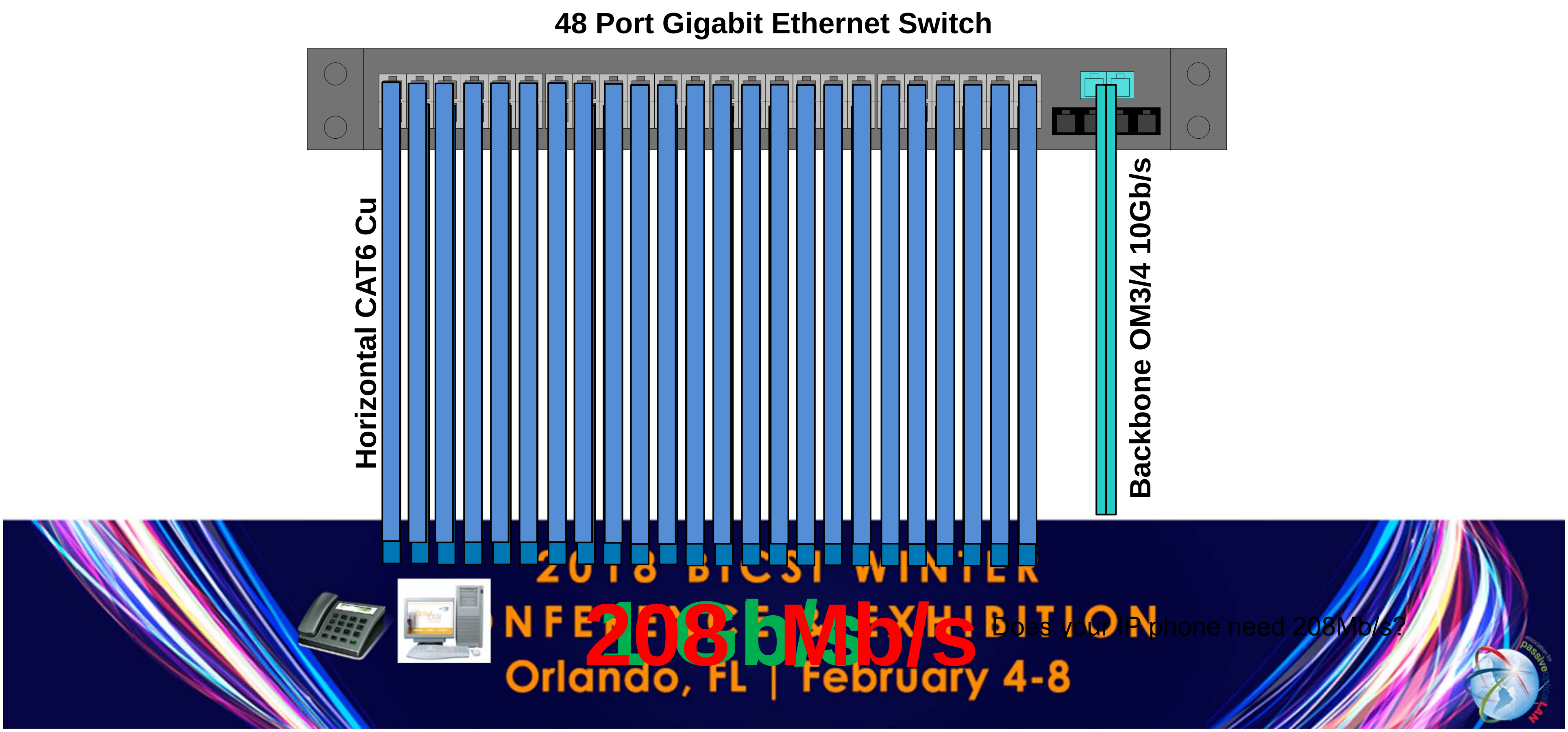
Bandwidth Capacity vs. Bandwidth Traffic



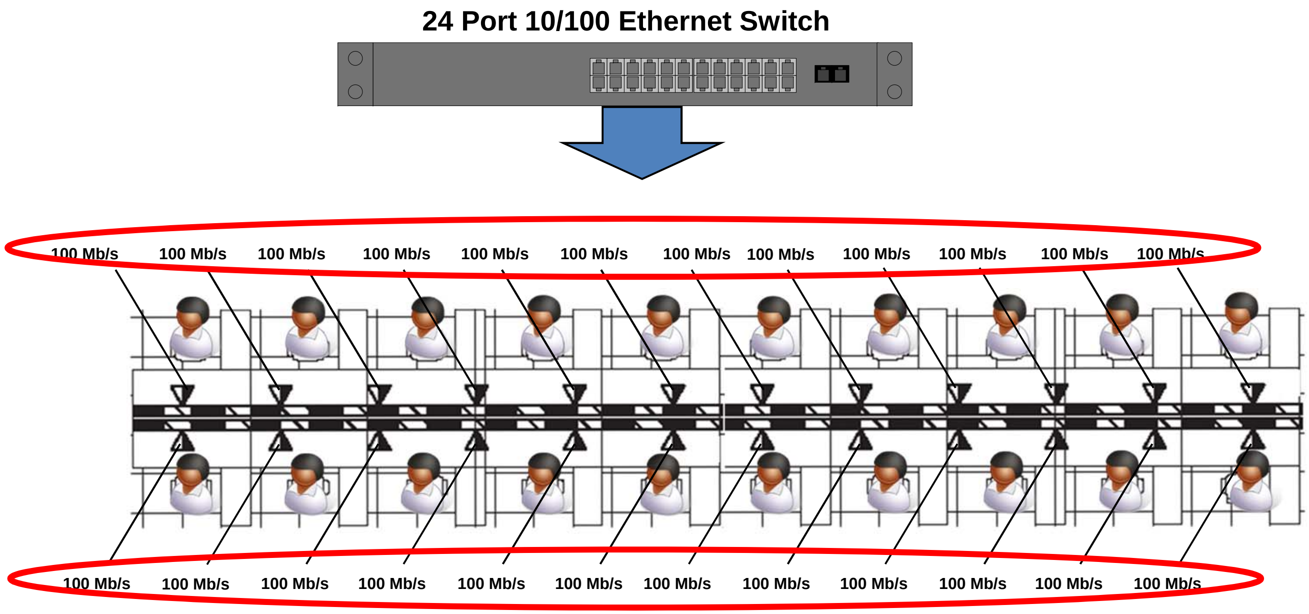
In traditional networks…



It is not a matter of resistance…



Switch Data vs. Dynamic Bandwidth Allocation



Most users use 0Mb/s over 98% of the workday.

Let's assume that half the people are away from the desk

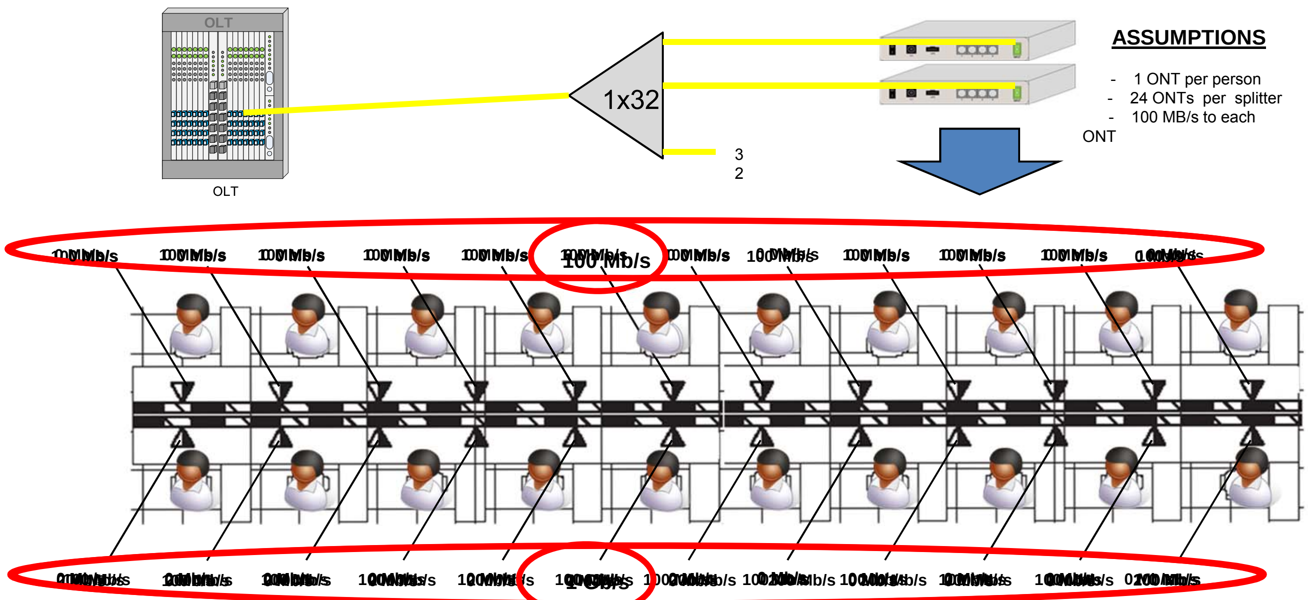
When all others are using 0Mb/s or are out of the office and a single user has to download a large file, they are limited to 100Mb/s.

Every data port still has a 100Mb/s Connection

Every data port has a 100Mb/s Connection

- A minimum of 100Mb/s
- A maximum of 100Mb/s

Switch Data vs. Dynamic Bandwidth Allocation



Most users use 0 Mb/s over 98% of the workday

- A maximum of 1 Gb/s

VLANS and Committed /Burst Rates

Knowledge Check

Gigabit switches provide 1Gb/s connections to each WAO

A. True

B. False

Most users consume bandwidth all day long

A. True

✓ B. False

This technology uses Dynamic Bandwidth Allocation

A. Switch Based

✓ B. Passive Optical LAN

Most users require a sustained GbE connection

A. True

B. False

Questions?

Passive Optical LAN: 101

Tom Ruvarac

APOLAN

Passive Optical LAN:102

Dustin Bateman

Director, Emerging Technologies, VT Group

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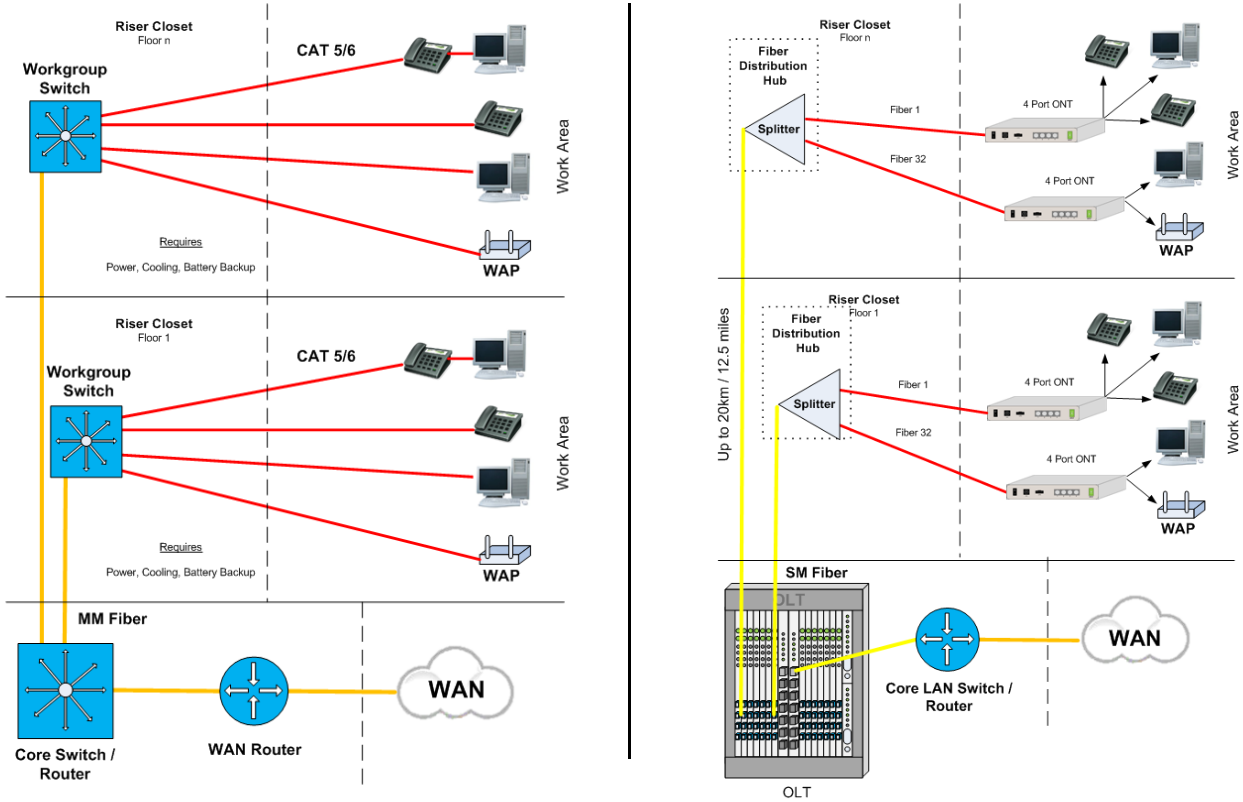
Section 3 Agenda

- Layout
- Primary Components
- Design Tips
- Support and Compatibility
- Knowledge Check
- Lunch

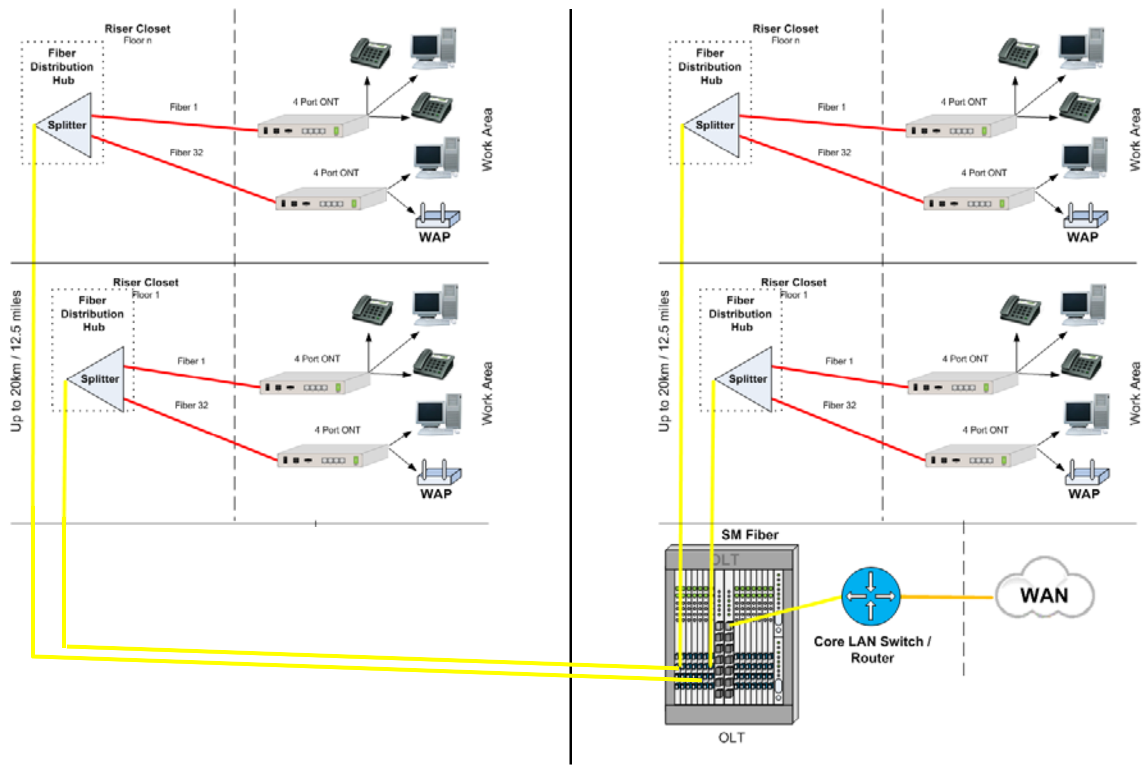
Traditional LAN vs. POL (GPON)



Traditional LAN

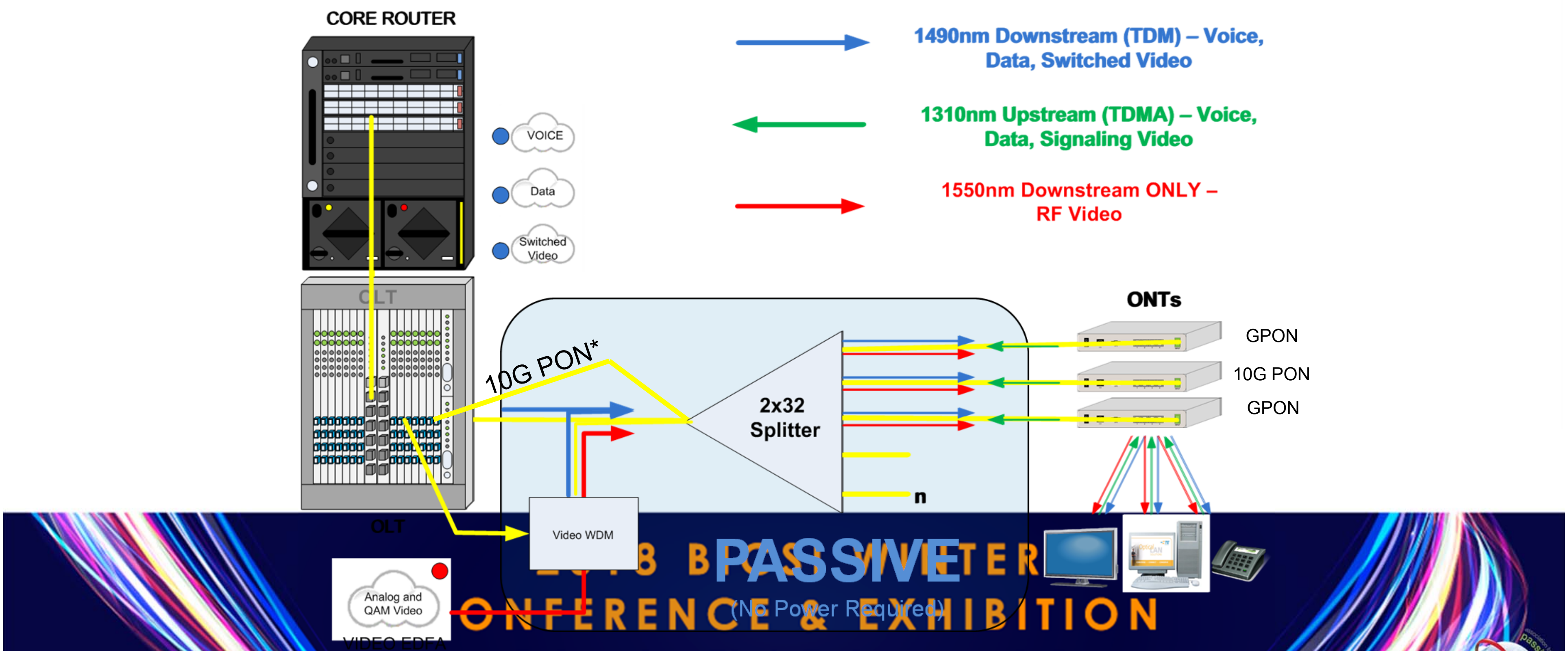
Passive Optical LAN

On a Campus



Optical LAN

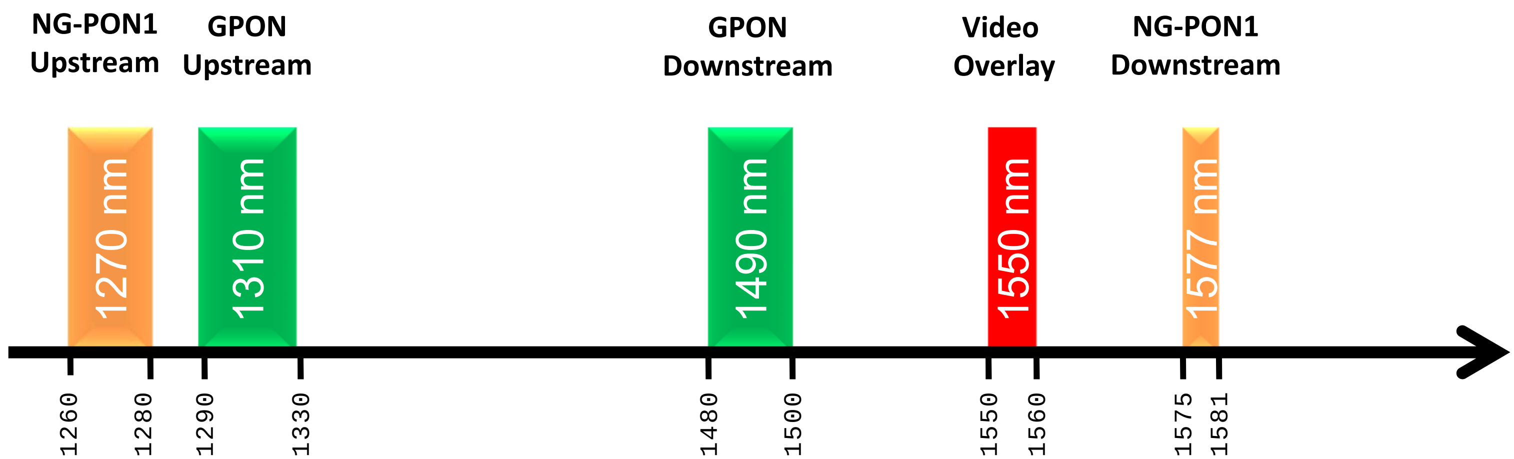
Basic POL Schematic



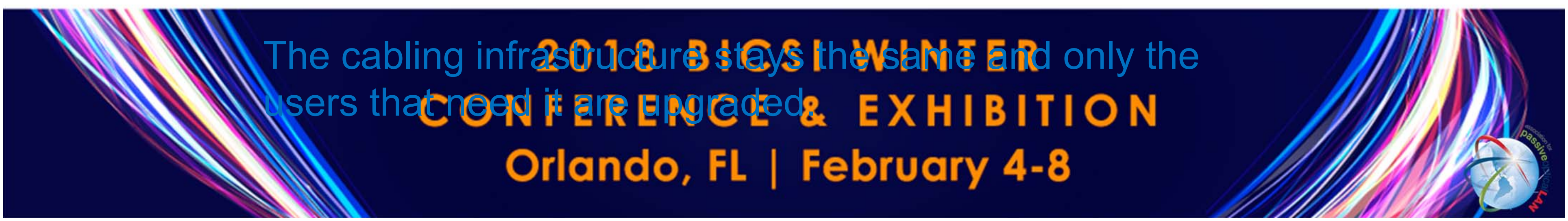
Only upgrade the users that <u>need</u> 10G PON

* Methods vary by electronics vendor.

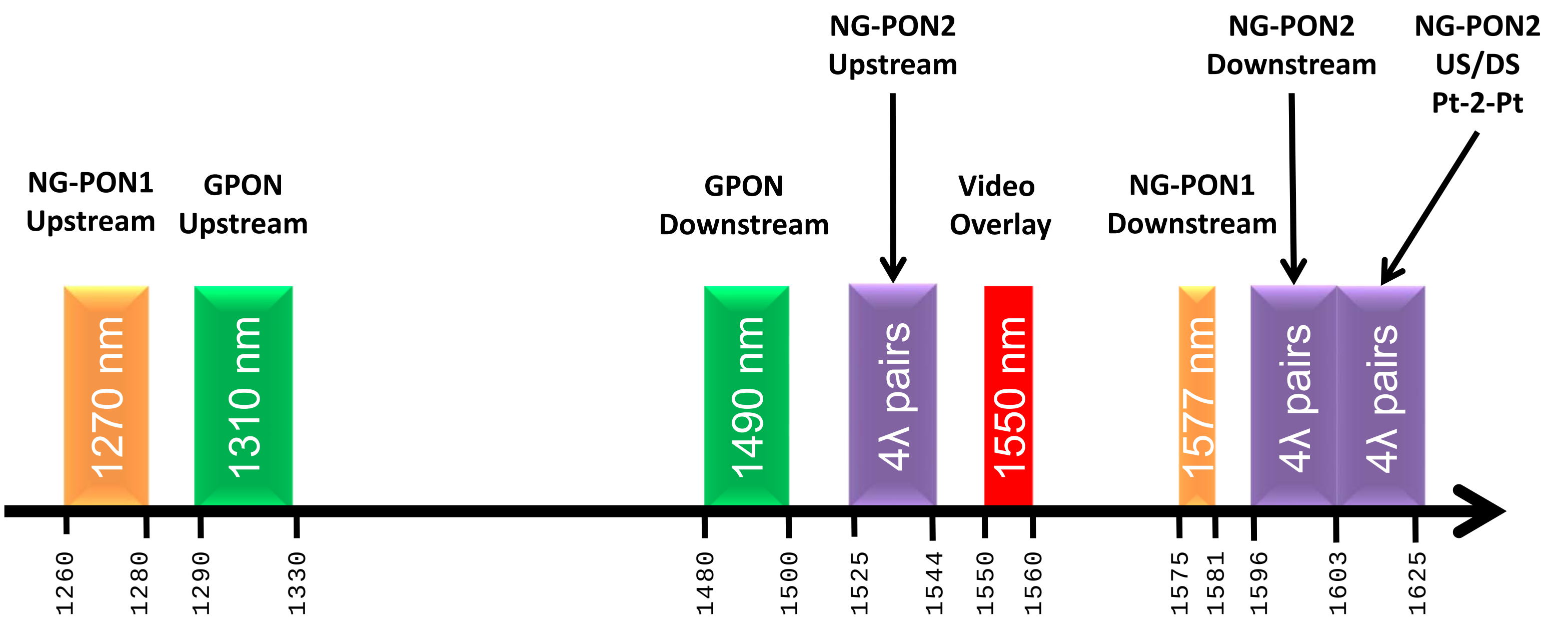
The Migration to 10G PON (NG-PON1)

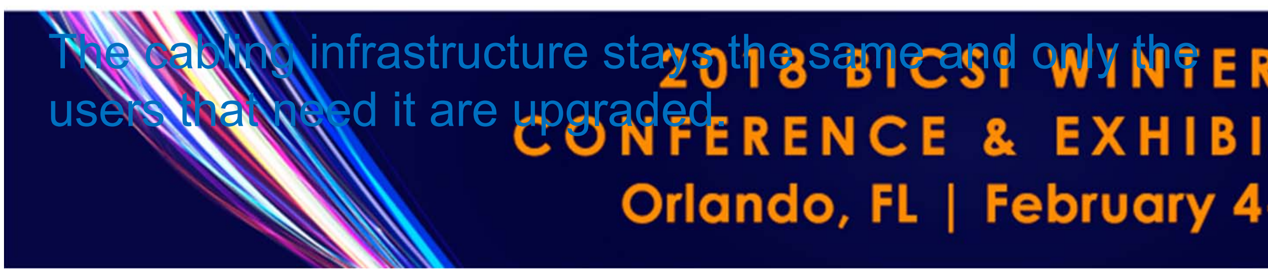


The cabling infrastructure stays the same and only the users that need it are upgraded.



The Migration to 40G PON (NG-PON2)





The cabling infrastructure stays the same and only the users that need it are upgraded.

PON Name	Version	DOWN (Gbps)	UP (Gbps)	Industry Standard
G-PON		2.5	1.25	ITU G.984
NG-PON1	XG-PON	10	2.5	ITU G.987
	XGS-PON	10	10	ITU G.9807
NG-PON2		40	40	ITU G.989

The Primary Components

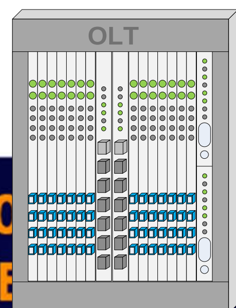
Optical Line Terminal (OLT)

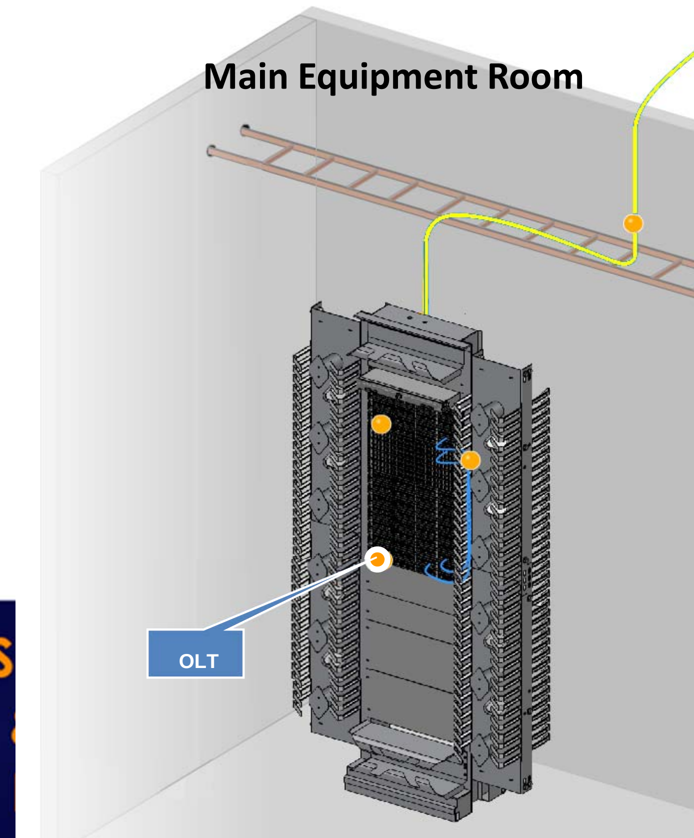
- -48VDC Carrier Grade Chassis
- After Layer 3
- Up to 14 Line cards
- Typically 4 singlemode output ports per card

  = 56 Outputs per chassis

  = 1792 ONTs (1x32 splitters)

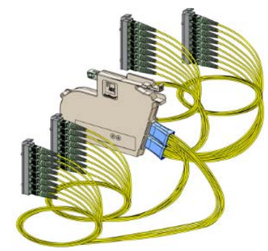
  = 7168 Ethernet Ports (ONT has
  4 copper output ports)





The Primary Components

Optical Splitters



Available Splits

1x2	
1x4	2x4
1x8	2x8
1x16	2x16
1x32	2x32

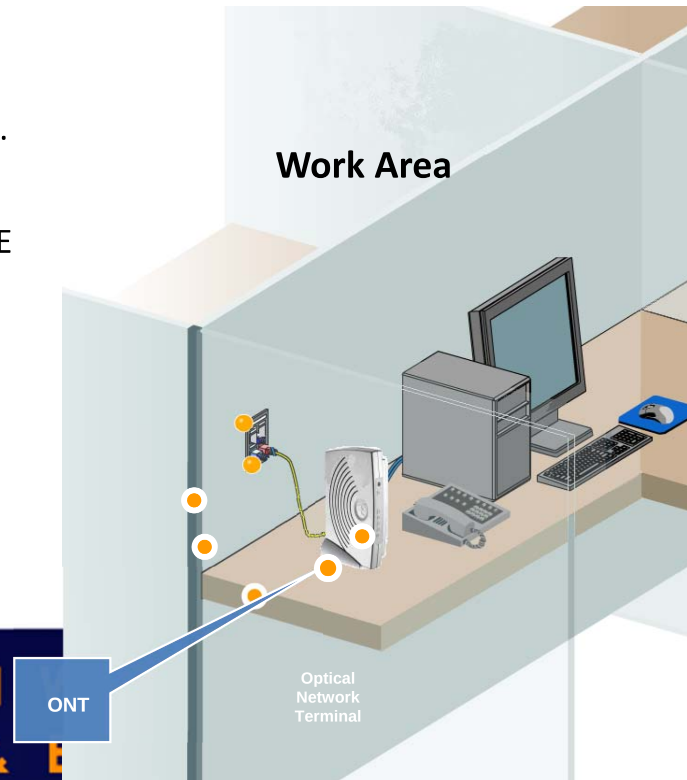
Traditional 1U Rack-Mount Splitter

The Primary Components

ONT – Optical Network Terminal

- Active equipment provided by electronics manufacturers.
- Located near the user or device
- Typically 4 RJ45 *(10/100/1000)* outputs with optional POE
- Up to 60W of available POE (vendor specific)
- Standard HVAC is adequate
- Optional internal or external battery back-up
- POTS and COAX ports available
- Establishes and maintains secure AES 128 Encryption
- Supports multiple VLANs on each port

ONT



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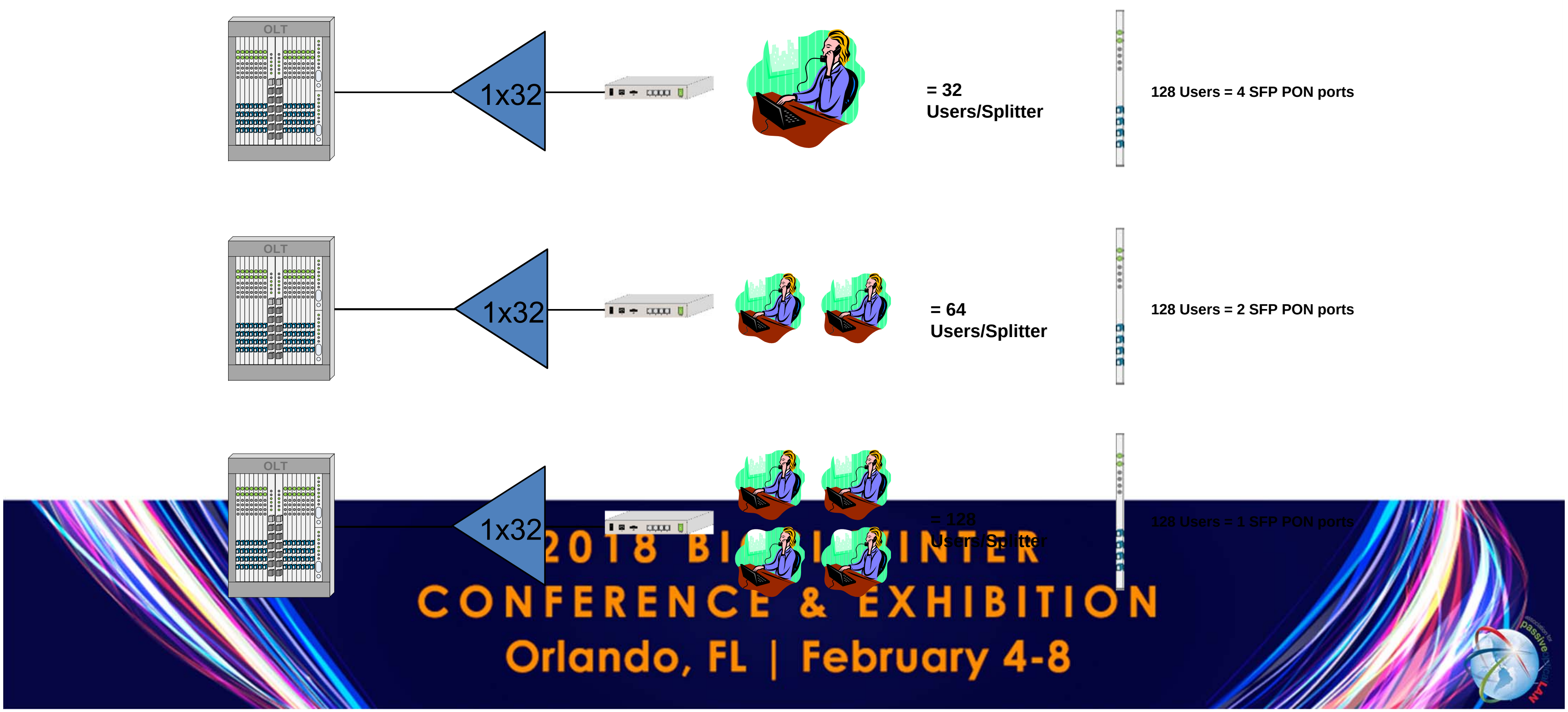
ONT Sharing


OLT
1x32
= 32
Users/Splitter
128 Users = 4 SFP PON ports
OLT
1x32
= 64
Users/Splitter
128 Users = 2 SFP PON ports
OLT
1x32
= 128
Users/Splitter
128 Users = 1 SFP PON ports
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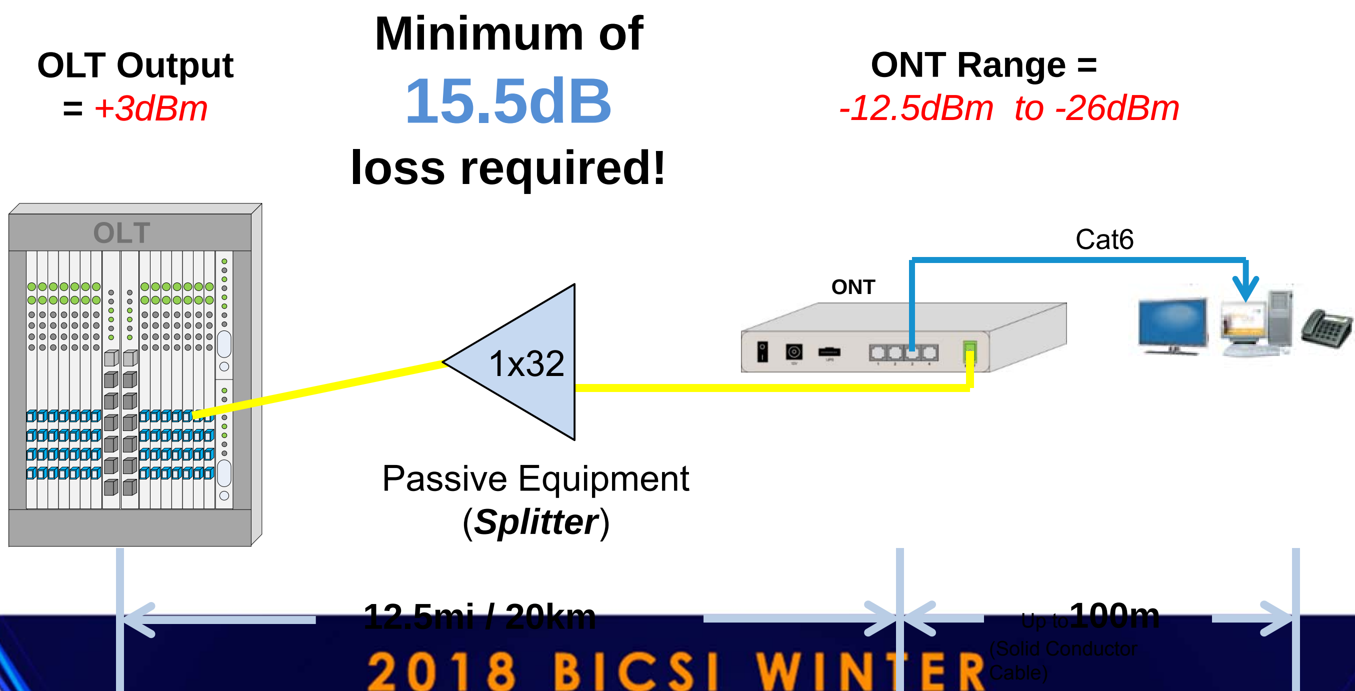
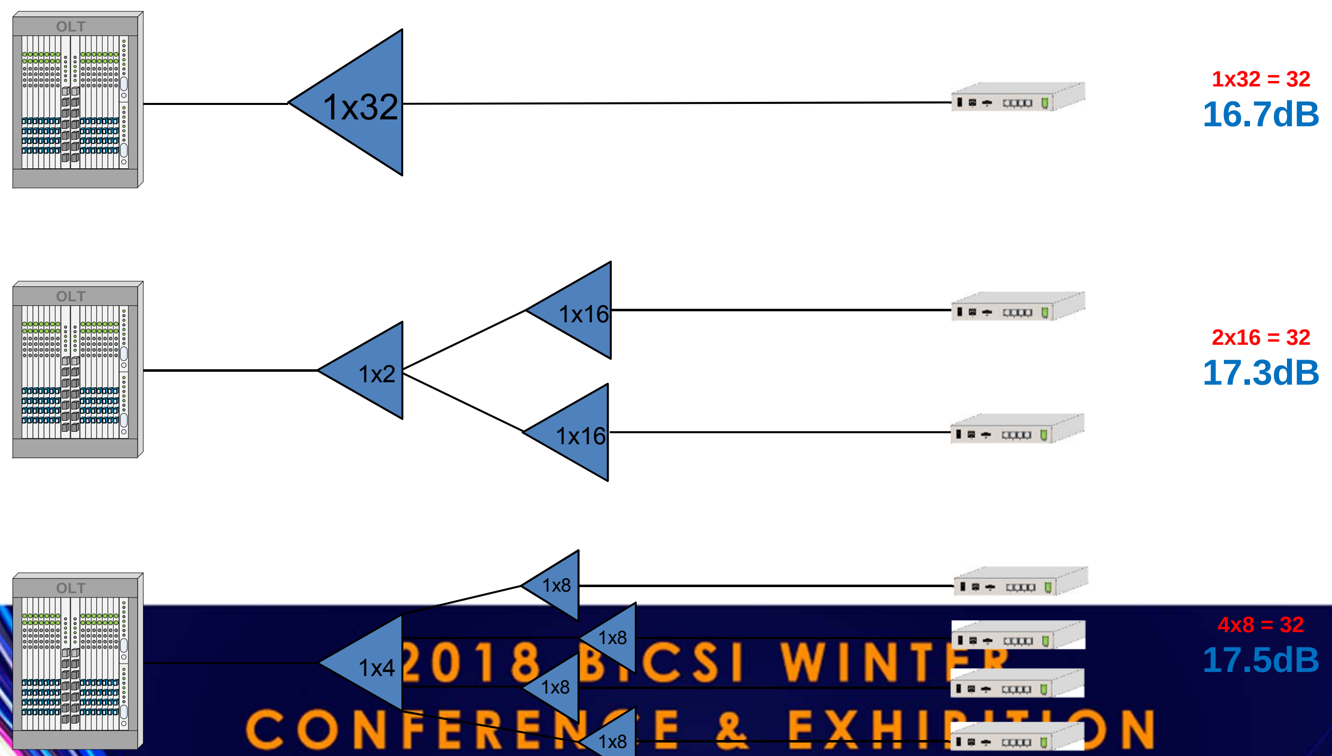
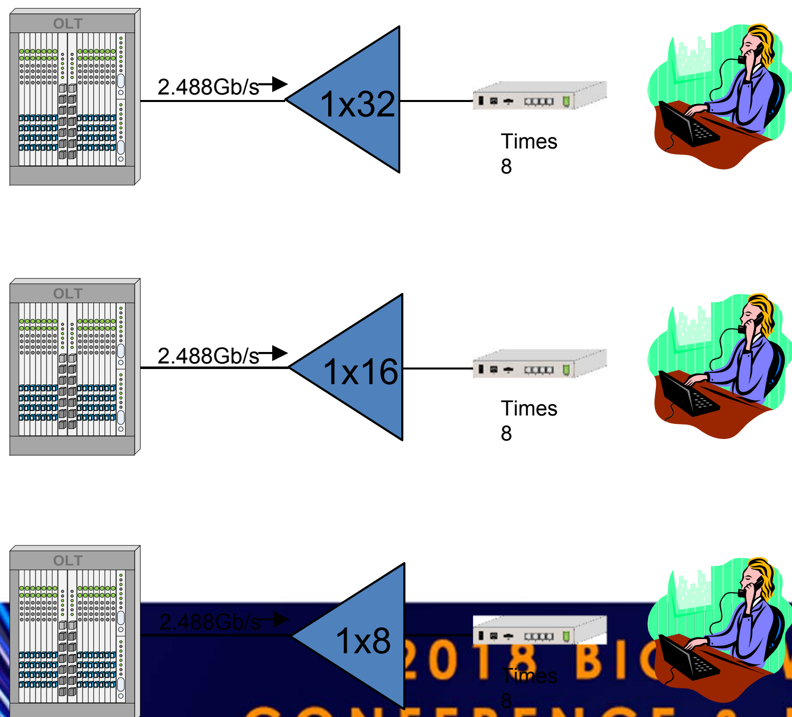
Distance and Loss



Cascade Splitting Loss



Split Ratios Do NOT “Change” Bandwidth

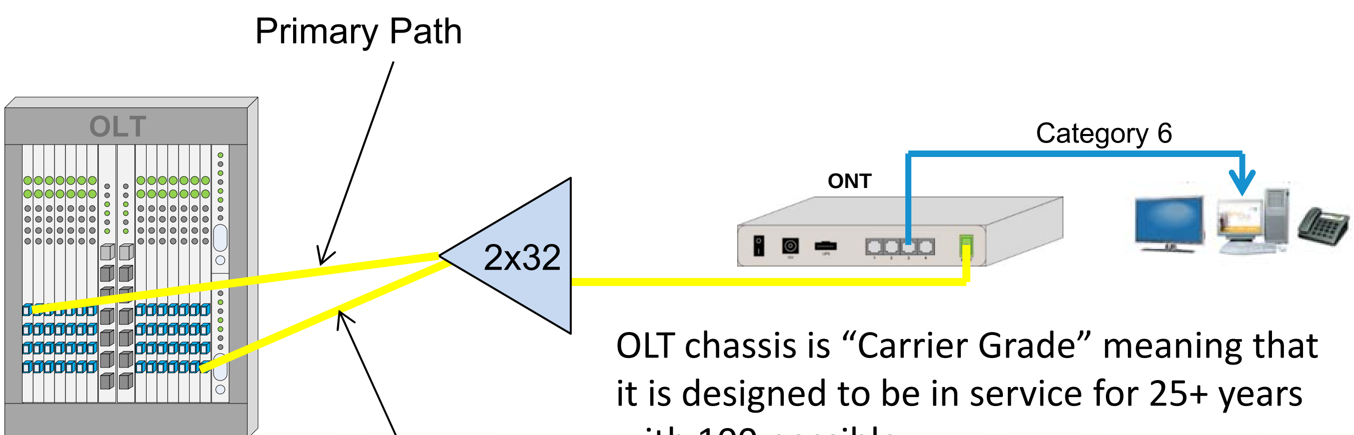


Bandwidth per ONT	Splitter Loss
311 Mb/s	17.3dB
311 Mb/s	13.5dB
311 Mb/s	10.3dB

Each ONT may require an Attenuator

Type B (FSAN-B) Redundancy

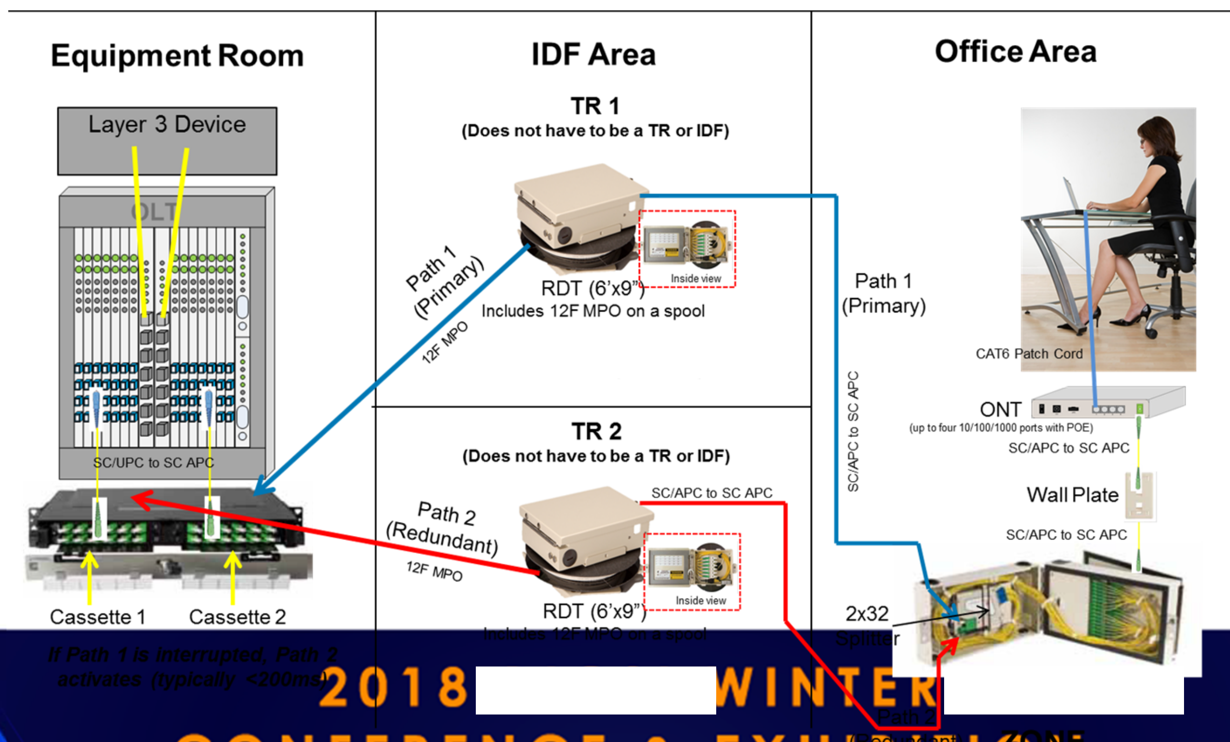
If any interruption is detected on the primary path (OLT to ONT), the OLT will switch to the redundant path instantaneously.



OLT chassis is “Carrier Grade” meaning that it is designed to be in service for 25+ years with 100 possible.

Type B Redundancy = Nearly Six 9s

Example Layout of Type B (FSAN-B) Redundancy



IP/Ethernet Protocol Support

Network Integration
Multiple 1G and 10G Ethernet Uplinks
IEEE 802.3ad Link Aggregation Control Protocol (LACP)
IEEE 802.1Q VLAN Encapsulation
IEEE 802.1w Rapid Spanning Tree (RSTP)
IEEE 802.1s Multiple Spanning Tree (MSTP)
Virtual Router-to-Router Redundancy (VRRP)
IPv4 / IPv6
IGMPv2 / IGMPv3
Network Access Control (NAC)
IEEE 802.1x (Port-based Authentication)
Dynamic Host Control Protocol (DHCP)
DHCP Snooping and Option 82 insertion
Port Security, Sticky MACs
RFC-2267 (Denial of Service)
Traffic Storm Control
Bridge Protocol Data Unit (BPDU) Guard

Service Delivery
802.1p: Class of Service
IP differentiated services code point (DSCP)
Quality of Service: Per-VLAN, Per-Port, Per-Service queuing / scheduling *
Sophisticated QoS and Traffic Management
Eight Queues per VLAN
Policing, Scheduling, Shaping per Queue
Congestion and Flow Control
Hardware Based ACLs: L2, L3, L4
Hardware Based Multicast Management
IEEE 802.3af, 802.3at (PoE)
Link Layer Discovery Protocol (LLDP)

Monitoring / Management
SNMP v1, v2, v3
CLI Console Port
Remote Monitoring (RMON) software agent
RMON I & II
Enhanced SNMP MIB support
RFC 1213-MIB (MIB II)
Extended MIB support
Network Timing Protocol (NTP)
RADIUS based authentication
SSH v1, v2
VMWare Support for EMS
OLT SysLog support (2014)
Y.1371 (2014)
802.1ag Fault Detection (2014)

This represents a partial list of supported IEEE and IP/Ethernet protocols

Knowledge Check

201

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Upstream (ONT to OLT) analog video utilizes which wavelength?

A. 1550nm

B. 1490nm

C. 1310nm

D. 1625nm

✓ E. None

A cascaded 1x4 + 1x16 split is a good practice?

A. True

B. False

GPON bandwidth can be increased by using a lower split ratio

A. True

B. False

The minimum loss required between the OLT and ONT is…

A. 13.5dB
B. 10.7dB
C. 15.5dB ✓
D. 17.2dB
E. None of these

PoE in a POL is administered at the…

A. OLT

✓ B. ONT

C. Injector

D. PoE is not possible

60 Minute Lunch Break

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Please respect others and return on time.

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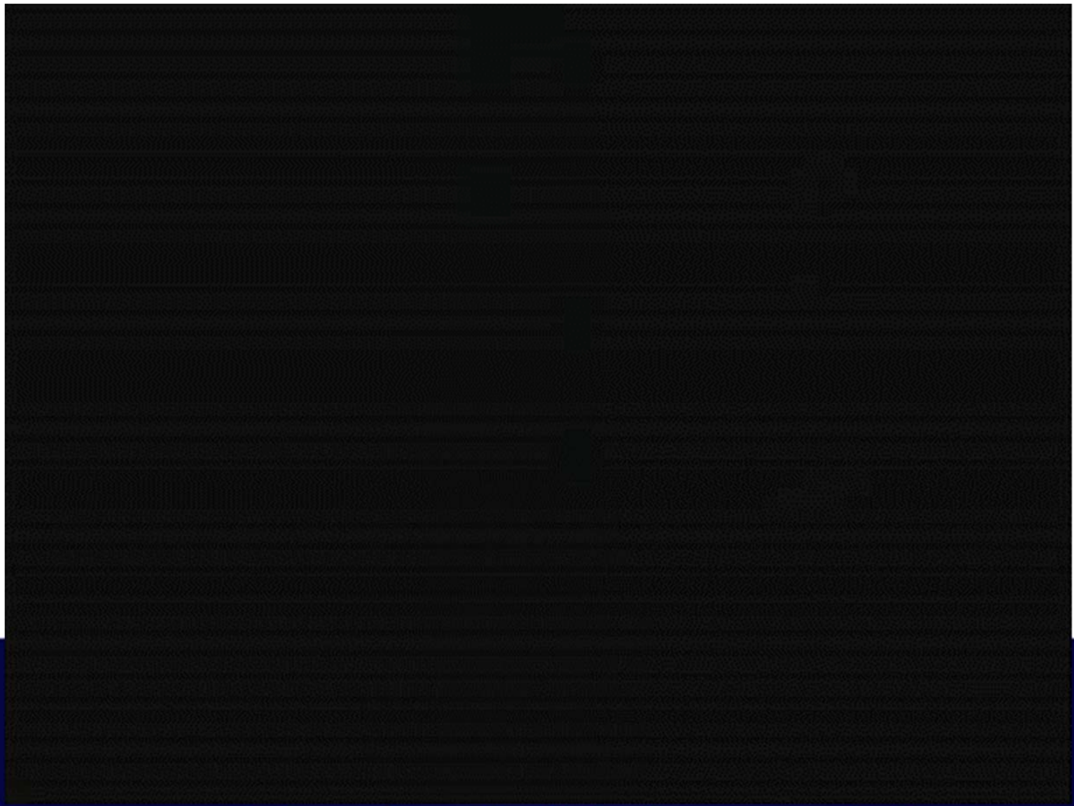
Section 4 Agenda

- Savings
- LEED and Environmental Benefits
- Largest POL deployment in the world
- Knowledge Check
- 15 Minute Break

Savings



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POL: Total Cost of Ownership Savings

Expense	250 Users	500 Users	1000 Users	Campus 5000 Users	Campus 10,000 Users
TCO	32%	46%	57%	68%	68%
CapEx	31%	41%	48%	55%	55%
OpEx	40%	50%	65%	70%	70%
• Power	48%	61%	68%	75%	75%
• Cooling	48%	61%	68%	75%	75%

POL: Power Consumption Comparison

Regional Medical Center
4000 drops

Price per kw hour	$0.082	W/HR	Annual $
Total POL Budget		14,050	$10,081
Total Traditional Budget		37,171	$26,670
Difference		*(23,121)*	*($16,589)*
Total Savings Percentage		-62.20%	

Traditional LAN

Main Distribution Frame				
Description	Quantity	Rated Power	Total Power	Notes
Cisco WS-C3750X-48P-S(715W)	7	134	937	
UPS	1	937	187	UPS overhead
HVAC	1	1,125	1,350	Draw to cool UPS & Cisco *1.2
Total			2,474	

Intermediate Distribution Frames				
Description	Quantity	Rated Power	Total Power	Notes
Cisco WS-C3750X-48P-S(715W)	96	134	12,854	
UPS	1	12,854	2,571	UPS overhead
HVAC	1	15,425	18,510	Draw to cool UPS & Cisco *1.2
Total			33,936	

Desktop/Work Area				
Description	Quantity	Rated Power	Total Power	Notes
N/A				
Total			0	

Power over Ethernet				
Description	Quantity	Attenuation	Total Power	Notes
Copper drops	1,463			
Average length of drop	200			
Total feet	292,600	0.0026	761	Total loss via PoE
Total			761	

Passive Optical LAN

Main Distribution Frame				
Description	Quantity	Rated Power	Total Power	Notes
AXS1800	2	516	1,032	2-SW, 2-SYS, 8-PON
UPS	1	1,032	206	UPS overhead
HVAC	1	1,238	1,486	Draw to cool UPS & AXS *1.2
Total			2,724	

Intermediate Distribution Frames				
Description	Quantity	Rated Power	Total Power	Notes
N/A	N/A	N/A	N/A	
Total			0	

Desktop/Work Area				
Description	Quantity	Rated Power	Total Power	Notes
WT21004	1,255	9	11,295	Admin areas
Total			11,295	

Power over Ethernet				
Description	Quantity	Attenuation	Total Power	Notes
Copper drops	1,463			
Average length of drop	8			
Total feet	11,704	0.0026	30	Total loss via PoE
Total			30	

Potential LEED Credits*

- Energy and Atmosphere Credit 1 (1-3 pts).
  - Reduction in TRs, HVAC equipment, switch equipment, UPS, lighting and other energy needs.
  - The PON system helps the overall efficiency of the energy systems.

- Innovation in Design Credit 1 (1-4 pts).
  - The PON system utilizes less equipment, resulting in less raw materials, less garbage, less transportation and reduced time for implementation and commissioning.
  - In addition, utilizing a fiber system ensures the life of the system extends beyond the life of a conventional “switched” system.

*not guaranteed or implied

"Eco-Friendly"

- **Reduced Power Requirements**
  - Savings between 40% to 60%
- **Reduced HVAC Requirement**
  - A Fortune 500 company saved about $450K on the Power distribution network (HVAC, backup etc) for a building project with 2000 Ethernet ports
- **Reduction in Non-renewable materials**
  - Reduction of up to 8000 pounds of plastic and copper versus a Cat 6 install for building of 4000 Ethernet ports
- **Floor Space Savings**
  - Traditional layer-2 solutions are bound by the 300ft Ethernet limitation
- **Fire Load Savings**
  - Savings in Sprinkler Systems
  - Fire Load and ceiling space savings

Green Benefits

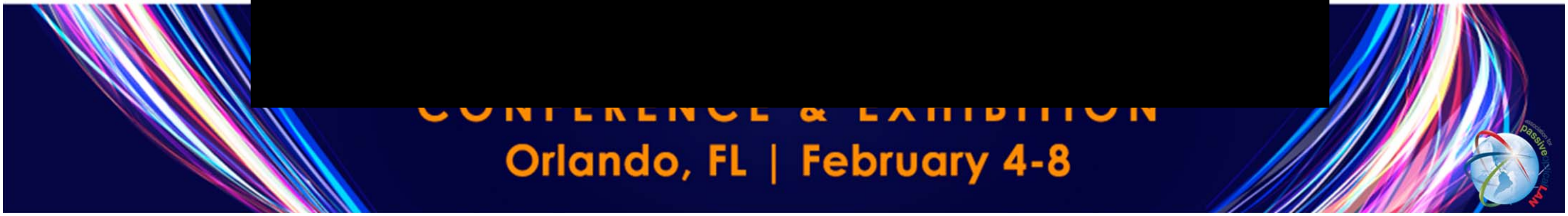
Reduction in power consumption
Reduction in non-renewable materials
Ceiling space and fire load savings
Reduction in cabling costs
Floor space savings

Cabling Comparison

Riser Rated Cables	Reduced Bend Radius Single-Mode	Category 5e UTP	Category 6a UTP
10G Distance	40km	45m	100m
Cable OD	3mm	5.7mm	7.5mm
Weight	4lb / 1000’	22lb / 1000’	39lb / 1000’
Minimum Bend Radius	5mm	22.8mm	30mm
Tensile Strength	48lbf	25lbf	25lbf
Cost	Low	Medium	High

Largest Enterprise POL Deployment

[redacted]



Knowledge Check

Which of these are a benefit of POL?

A. Reduction in power
B. Reduction of fire load
C. Reduction of non-renewable materials
D. All of these are benefits

LEED Credits are

✓ A. Possible with POL
B. Automatic with POL
C. Guaranteed with POL
D. Not Possible with POL

So far, my knowledge depth of Passive Optical LAN increased so far today by…

A. A little
B. A lot
C. What is Passive Optical LAN?
D. None

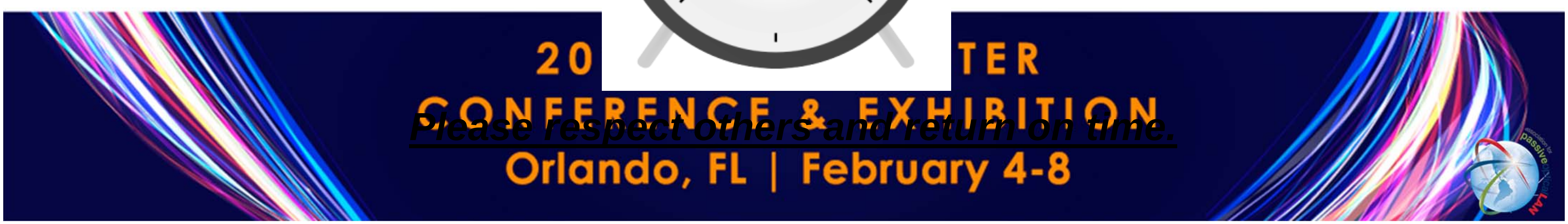
Questions?

Passive Optical LAN: 102

Dustin Bateman

VT Group

15 Minute Break



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Introduction to POL Components

Matt Miller

Associate Vice President, CallisonRTKL

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Agenda

- Components
  - OLT
  - ONT
  - Video
  - DC Power
- Power Considerations
- Management
  - Centralized Management
  - Management Systems
  - Bandwidth Management
  - VLANs, QoS, LLDP and other Standards

Objectives

- Identify the various types of optical splitters and their principles of operation
- Identify the active electronic components in a Passive Optical LAN
- Understand the management principles for a POL

Components - OLT

- OLT is head-end component
- Typically located in MDF or Data Center
- Manages connected ONTs
- Typically consist of:
  - Management
  - Switch Fabric
  - Uplink Interfaces
  - PON Interfaces
- Out-of-band Management

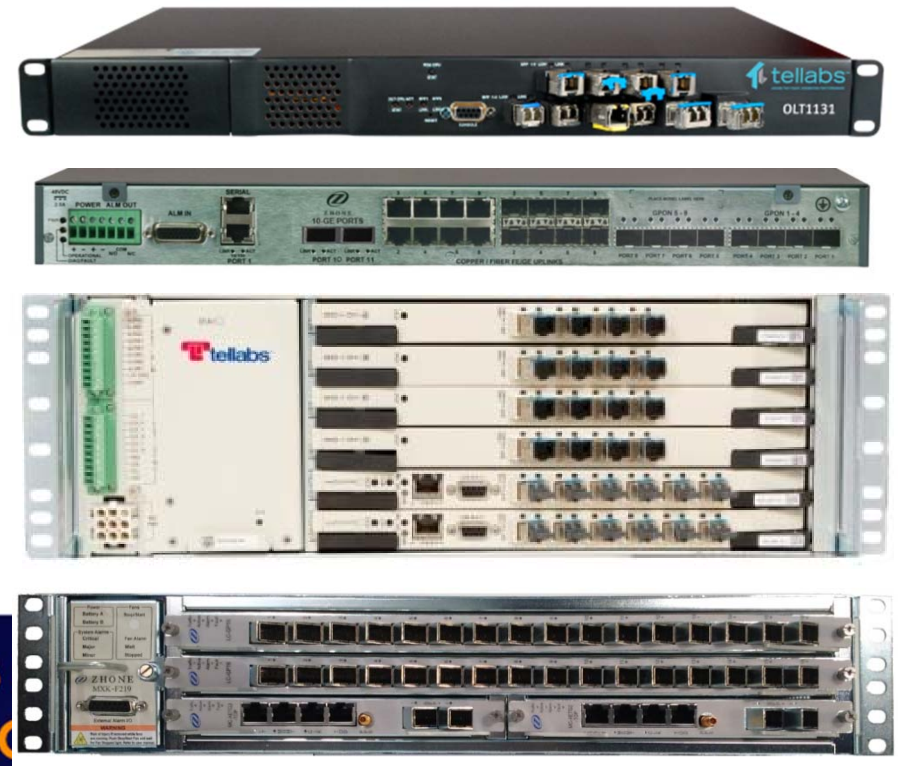
Components – Large OLT Models

- Chassis-Based
- Fully Redundant
- Up to 224 PON Ports
- Thousands of ONTs
- DC Powered

Components – Small OLT Models

Small OLTs

- AC and DC Power
- Small Chassis and Standalone
- Small Office/Field Office
- 4 to 16 PON Ports
- Hundreds of ONTs



Components – OLT Uplinks

- Standard Ethernet uplinks to core
- Uplinks typically 1G or 10G pluggable optics
- VLANs trunked into uplink ports
- Uplinks can be combined into LAGs

Components – OLT PON Ports

- From 4 to 224 PON ports per OLT
- Each PON port typically supports 32 ONTs
  = Thousands of ONTs per OLT!
- Typically SFP based
- Class C+ optics feature 32dB loss budget

Components – OLT Redundancy

<u>Typically Redundant</u>

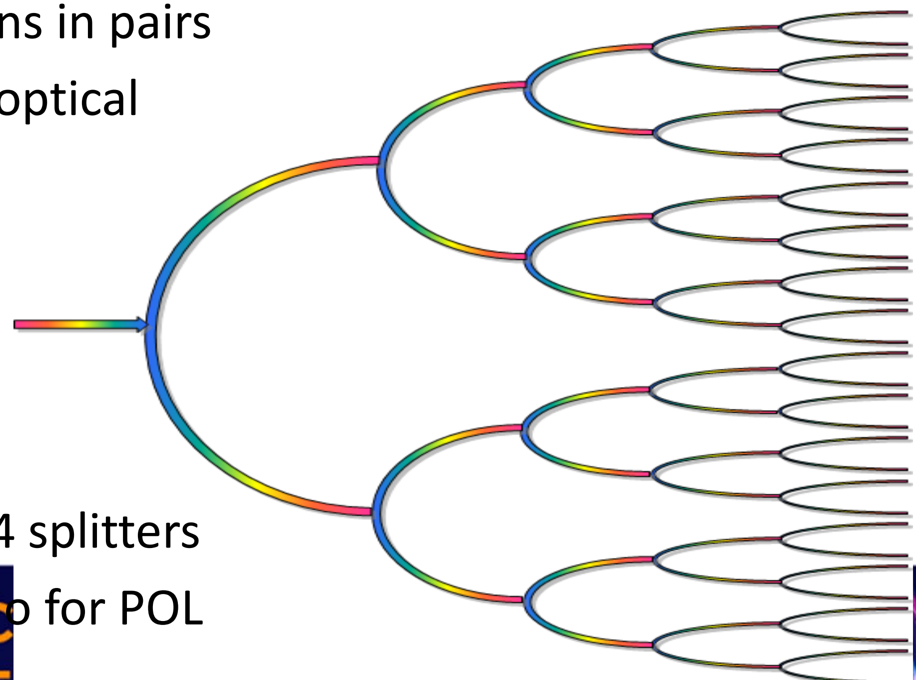
- Power
- Backplane
- Management
- Switch fabric
- Uplinks

<u>Sometimes Redundant</u>

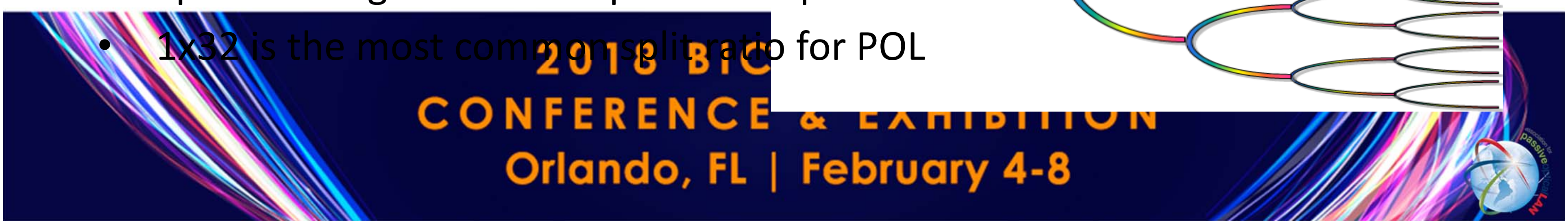
- PON Ports
- PON Cards
- Entire OLT

Optical Splitters

- Splitters provide optical connections in pairs
- Each 1x2 split equates to ½ of the optical power
  - ~3dB loss



- Splitters range from 1x2 up to 1x64 splitters
- 1x32 is the most common split ratio for POL



Splitter Loss

Splitter	Max Loss*	Typical Loss*	Wavelength Range
1x2	3.8dB	3.1dB	1260-1360nm and 1480 -1580nm**
2x2	4.3dB	3.2dB	1260 - 1635nm
1x4	7.2dB	6.6dB	1260 - 1635nm
2x4	7.8dB	6.7dB	1260 - 1635nm
1x8	10.3dB	9.7dB	1260 - 1635nm
2x8	10.9dB	9.8dB	1260 - 1635nm
1x16	13.5dB	12.8dB	1260 - 1635nm
2x16	14.1dB	12.9dB	1260 - 1635nm
1x32	16.7dB	16.0dB	1260 - 1635nm
2x32	17.4dB	16.2dB	1260 - 1635nm
1x64	20.4dB	19.7dB	1260 - 1635nm
1x2 + 1x16	17.3dB	15.9dB	1260 - 1635nm
1x4 + 1x8	17.5dB	16.3dB	1260 - 1635nm

* Includes PDL, WDL and TDL. Does not include connector loss

** May not be compatible with NG PON1 or NG PON2

Optical Splitter

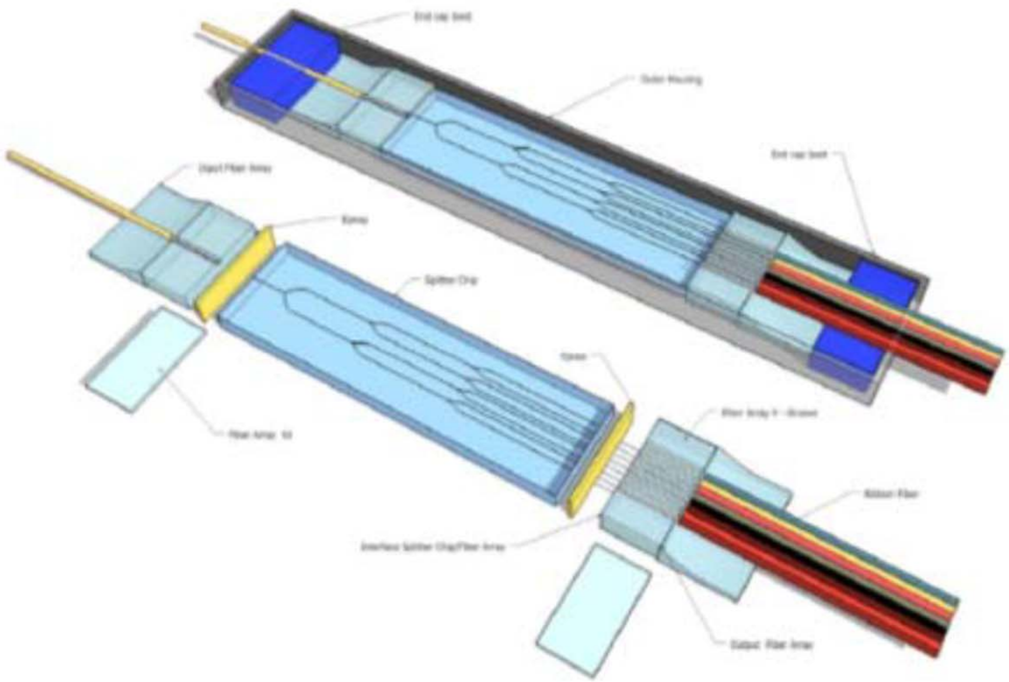
The term "passive" in Passive Optical Network refers to the fact that the splitter requires no power as opposed to an "active" device like the OLT or switches an a traditional network. The splitter serves to optically replicate upstream signals to a number of downstream fibers. The typical number of fibers served in a PON network is 32. As the splitter provides a replicated optical signal to all 32 subscribers downstream, it is simultaneously combining those 32 fibers into a single feeder fiber in the upstream direction. Consequently the optical splitter is sometimes referred to as a splitter/combiner. The splitter will be housed in a number of form factors.

PLC Splitter

Planar Lightwave Circuit (PLC) Splitter

- More Expensive
- Uniform Output
- Most appropriate for outdoor use
- Manufacturing
    1. Waveguide used to split the optical signal is fabricated using a silicon dioxide chip.
    2. Involves a lithographic process similar to that used in the manufacture of silicon computer chips. PLC splitters provide the most uniformity between fiber outputs (the downstream fibers) with respect to the amount of optical loss measured on each fiber.
- Best choice when loss is critical

Planar Light Circuit/Planar Waveguide



FBT Splitter

Fused Biconical Taper (FBT) splitter

- Lower Cost
- Typically less uniform from fiber to fiber.
- Manufacturing
  1. Thermally fused two overlapping fibers together under tension
  2. The resulting fusion splice creates a two by two splitter.
  3. Typically, one of these fiber connections is trimmed off and the result is a single fiber subtending to two fibers.
  4. These two fiber outputs can then be fused to additional one-by-two splitters until the desired number of splits is achieved.
- Used where extreme temperature variations or other environmental factors are not likely to cause the optics connected at the ends of the fiber to drift from their optimum wavelength specifications.

2xN Splitters

- 2 Inputs
- 2 to 64 Outputs
- Second Input Allows
  - Redundant feeders/PON Ports/PON Cards/OLTs
  - Easier Migration to 10G
  - Flexibility for the Future

ONTs

- ONT located close to the end user
- Fiber input
- Variety of user interfaces available
- Provide PoE
- Consume ~7W power + PoE draw

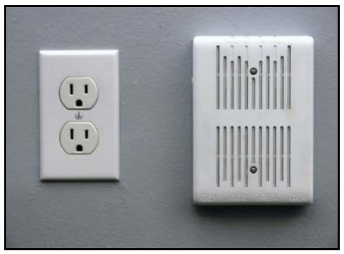
ONT Models - Traditional

- Large variety of ONTs available
- AC and DC power options
- Desk-mount, In-wall, and Rack-mount
- Battery backup

- Match interfaces to user needs:
  - Ethernet Ports with PoE
  - POTS Ports
  - Coaxial Television
  - Wi-Fi

ONT Models - Unique

In-Wall



Rack-Mount

Industrial/Outdoor

ONT Connections

What Can I Connect?

- PCs
- Thin Clients
- VoIP Phones
- POTS Phones
- Wireless Access Points
- Coaxial Cable TV
- IPTV

- Access Control
- Security Cameras
- Building Management Systems
- Biometric Sensors

- Anything with an Ethernet, POTS, or Coax Interface!

ONT Compatibility

- EPON and GPON are not compatible
- Different manufactures *typically* choose not interoperate
- Beyond the standards, some manufacturers implement additional features – especially true in EPON

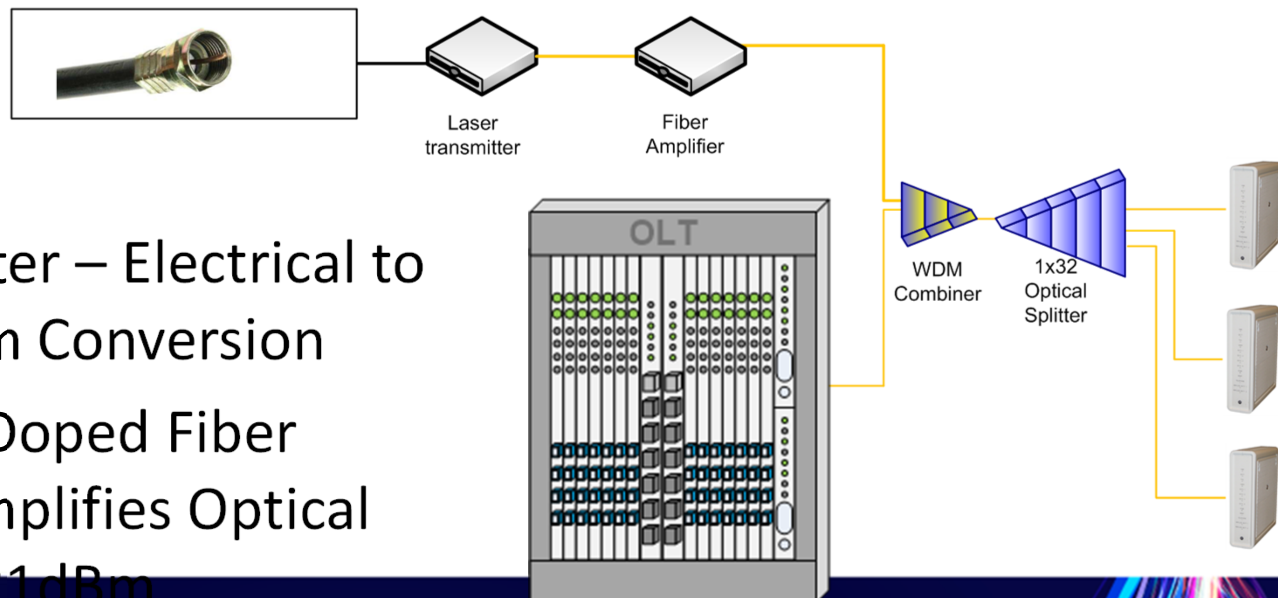
ONT Security

- ONT security designed to assume the ONT is in the hands of the adversary
- ONT does not function without OLT
- Usually no management ports on ONT
- ONT receives all programming from OLT

Power Considerations

- ONTs report a loss of power or loss of service
- ONTs can be powered via AC or DC
- Battery backups for high availability
- PoE and PoE+ available

Components - Video



- Laser Transmitter – Electrical to Optical 1550nm Conversion
- EDFA (Erbium Doped Fiber Amplifier) – Amplifies Optical Signal to 18 – 21dBm
- WDM – Combines Wavelengths

Components - Video

- Laser Transmitter
- EDFA
- RF Nodes
- RFoG/two-way

Components – DC Power

- Most OLTs use -48V DC Power
- Same power used in telco central offices
- Rectifiers required to convert AC to DC
- Properly ground your equipment!

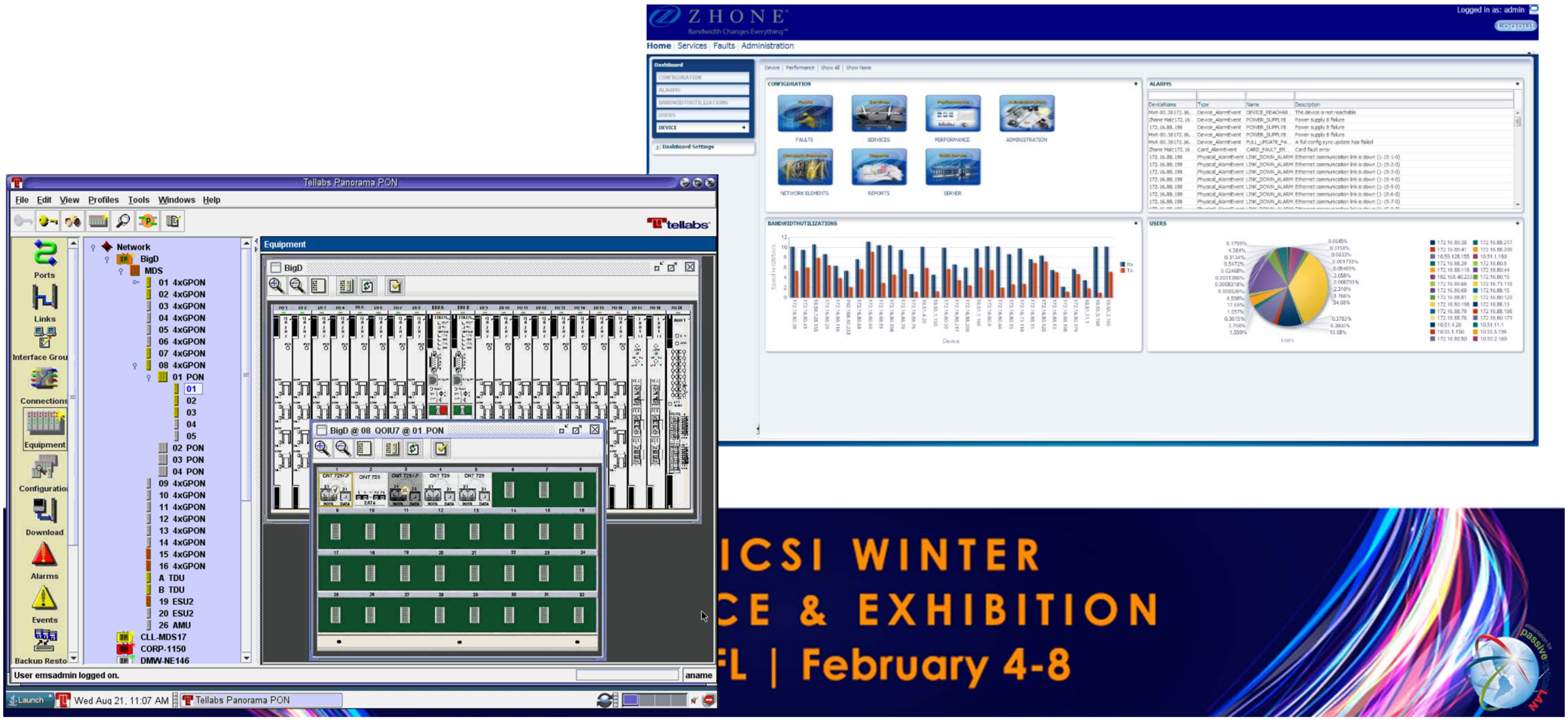
Components – DC Power

- Redundant Inputs
- Redundant Outputs
- Redundant Rectifiers
- Fuse or Circuit Breaker Protection
- Network Management
- Basically an external power supply!

Centralized Management

- ONTs Centrally Managed
- No physical ONT management ports
- Same concepts as traditional network
  - VLANs
  - PoE
  - QoS

Centralized Management



Management Systems

- Systems included standard CLI and EMS
- OLT runs without management server
- Application and Web/Mobile
- GUI is more important in PON than legacy networks
  - Density is far greater!
- ONTs are an extension of the OLT

Profiles & Templates

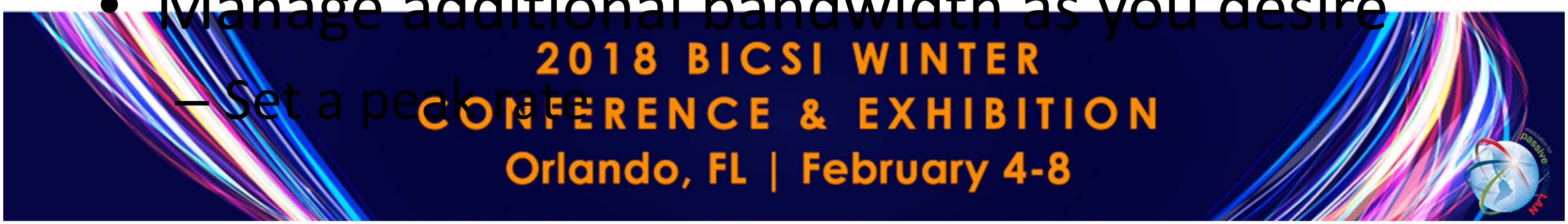
- Create a standard profile or template for your services
- Apply that profile or template to many ONTs at once!

Management Systems Features

- Alarming and Notification
- Bandwidth Monitoring
- Central OLT & ONT Upgrades
- MAC Searches
- VLAN Member Reports

Bandwidth Management

- Bandwidth Management is Built-in!
- Guarantee every user bandwidth
  - Set a committed rate
  - Committed rates cannot exceed capacity of any link in the system
- Manage additional bandwidth as you desire
  - Set a peak rate



Managing All The Same Things

The same things you manage today…

- VLANs
- PoE
- QoS
- LLDP
- Network Access Control

What makes PON a POL?

1. Indoor ONTs
2. Power over Ethernet
3. Internal Packet Switching
4. Enterprise Ethernet Features

Questions?

Introduction to POL Components

Matt Miller

CallisonRTKL

Introduction to POL Design

Mike Watts & Chad Hines

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Section 9 Agenda

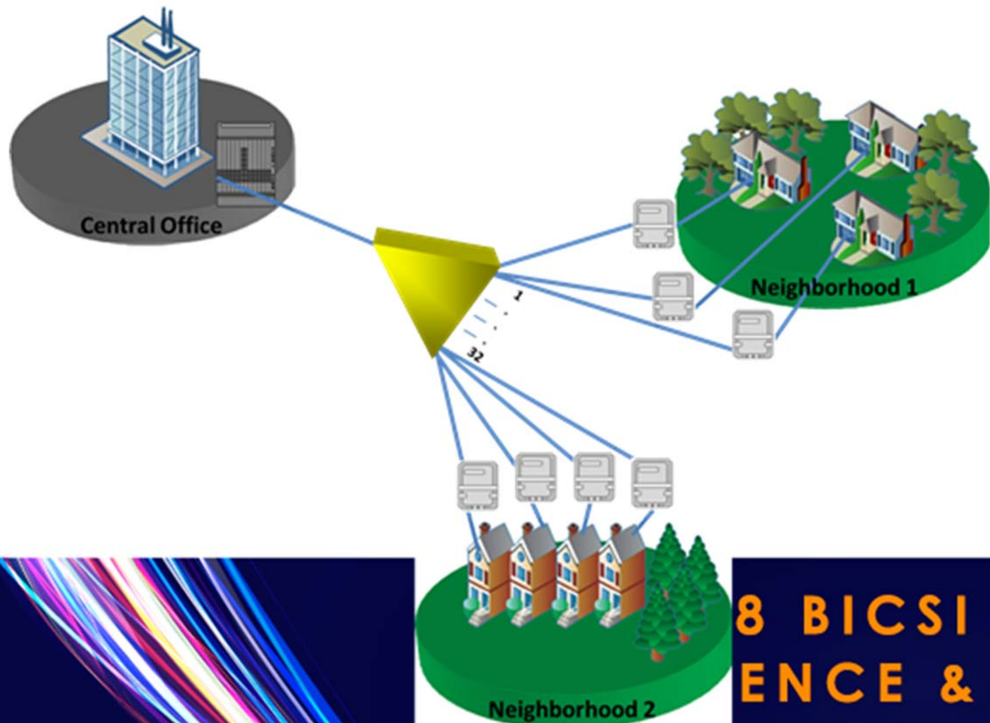
- POL Component and Budget Review
- POL Cable Design Options Overview
- Design Challenge Exercise
- Knowledge Check

APC and UPC

- Ultra Physical Contact Connectors (UPC)
  - Blue

- Angled Physical Connectors (APC)
  - Green

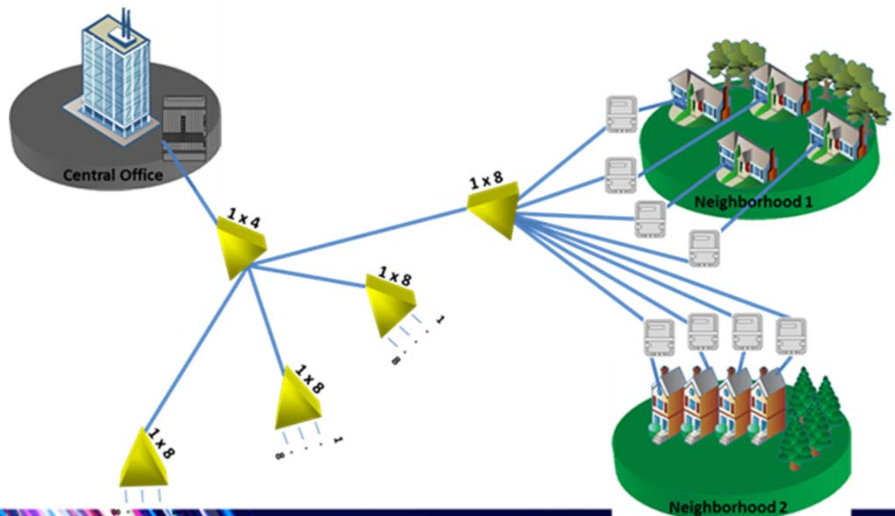
Splitter Deployment



Single Splitter

- One splitter in the Optical Distribution Network
- All splitter loss is at one location
- Works for 99% of POL deployments

Splitter Deployment



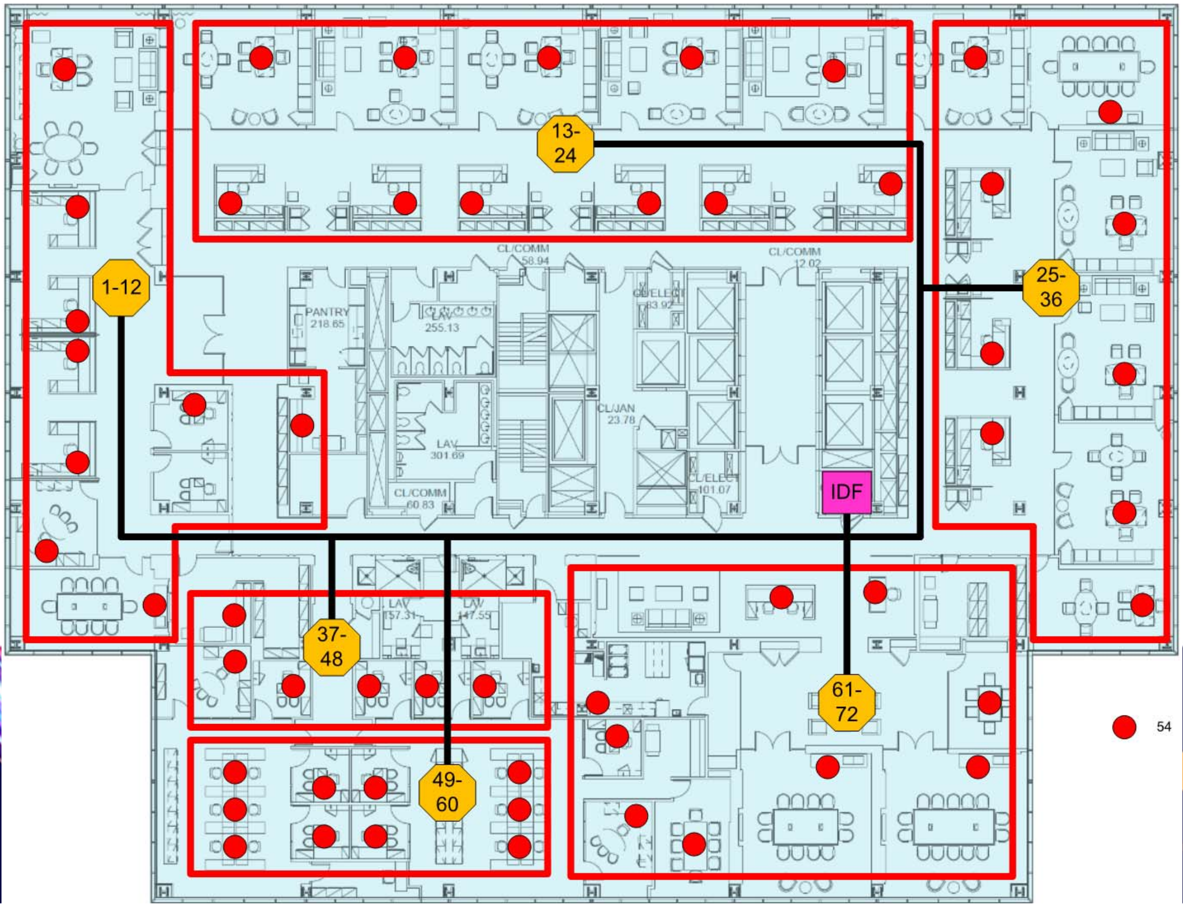
Cascaded Splits

- Used when end users are geographically dispersed
- Campus out-buildings
- Loss from splitters in path must be summed

Engineered Splits

- Loss may favor a particular output

Centralized Split Overview



FDH
Houses Splitters

Consolidation Point
Zone Cabling

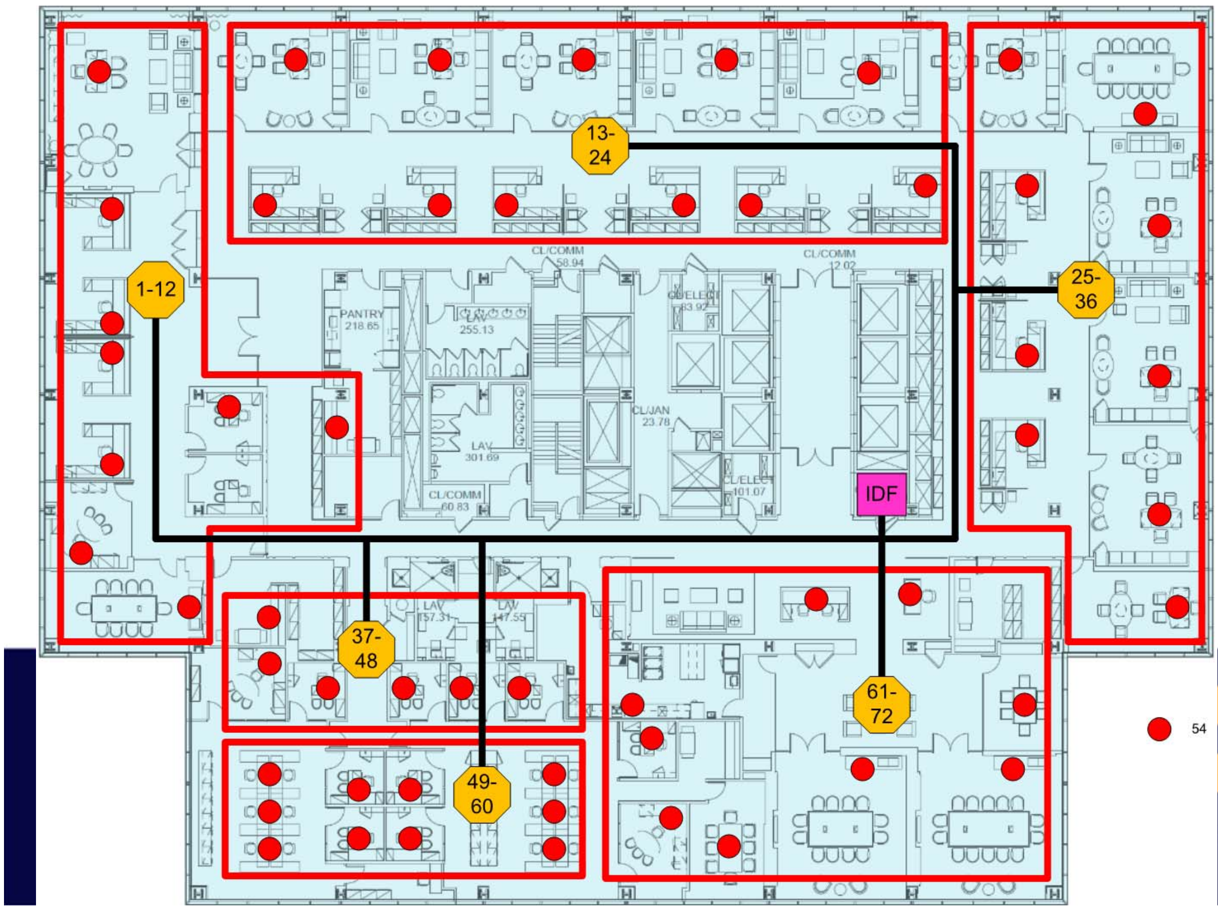
Centralized Splitting

- Provides maximum ROI for POL
- Houses splitters in one location per floor
- Installation Labor hours are reduced
- Connection between Riser and Horizontal

Centralized BoM

Area	Product Description	Total Qty
MDF	Rack Mount Fiber Enclosure, 1U, holds 3 MPO Fiber cassettes	
MDF	MPO Fiber Cassette	
IDF	1 x 32 splitter used with FDH	
IDF	288-Port capacity FDH accommodating 18 splitters and 24 MPO outputs	
Horizontal	24 port Consolidation Point w/300 foot Plenum MPO Cable	
ONT Fiber	SCAPC-SCAPC Plenum Yellow 3 (10')	
OLT Fiber	SCUPC-SCAPC Plenum Yellow 8 (25')	
Horizontal	SCAPC-SCAPC Plenum Yellow 23 (75')	
Horizontal	SCAPC-SCAPC Plenum Yellow 31 (100')	
Horizontal	SCAPC-SCAPC Plenum Yellow 38 (125')	
Horizontal	SCAPC-SCAPC Plenum Yellow 46 (150')	
WAO	4-port White Faceplate	
WAO	SCAPC Singlemode adapter	
WAO	Category 6 modular jack	
WAO	RJ45 plug to RJ45 plug, T568B Blue	

Zone Split Overview



Zone Splitter Housing

Zone Splitting

- Eliminates the need for the IDF
- Places Splitter closer to user
- Location for cross-connects
- Termination for horizontal and feeder fiber
- Moves redundancy closer to the user in Type B applications.

Zone BoM

Area	Product Description	Total Qty
MDF	Rack Mount Fiber Enclosure, 2U, holds 6 MPO Fiber cassettes	
MDF	MPO Fiber Cassette	
IDF	MPO Fiber Trunk 12 Strand Singlemode Plenum (100 foot)	
IDF	MPO Fiber Trunk 12 Strand Singlemode Plenum (200 foot)	
IDF	MPO Fiber Trunk 12 Strand Singlemode Plenum (300 foot)	
Horizontal	1 x 32	
Horizontal	Fiber Zone Box	
Horizontal	Fiber Zone Box Installation Kit	
ONT Fiber	SCAPC-SCAPC Plenum Yellow 3 (10')	
OLT Fiber	SCUPC-SCAPC Plenum Yellow 8 (25')	
Horizontal	SCAPC-SCAPC Plenum Yellow 23 (75')	
Horizontal	SCAPC-SCAPC Plenum Yellow 31 (100')	
Horizontal	SCAPC-SCAPC Plenum Yellow 38 (125')	
Horizontal	SCAPC-SCAPC Plenum Yellow 46 (150')	
WAO	Faceplates 4-port White Alpine	
WAO	SCAPC Singlemode adapter	
WAO	Category 6 modular jack	
WAO	RJ45 plug to RJ45 plug, T568B Blue	

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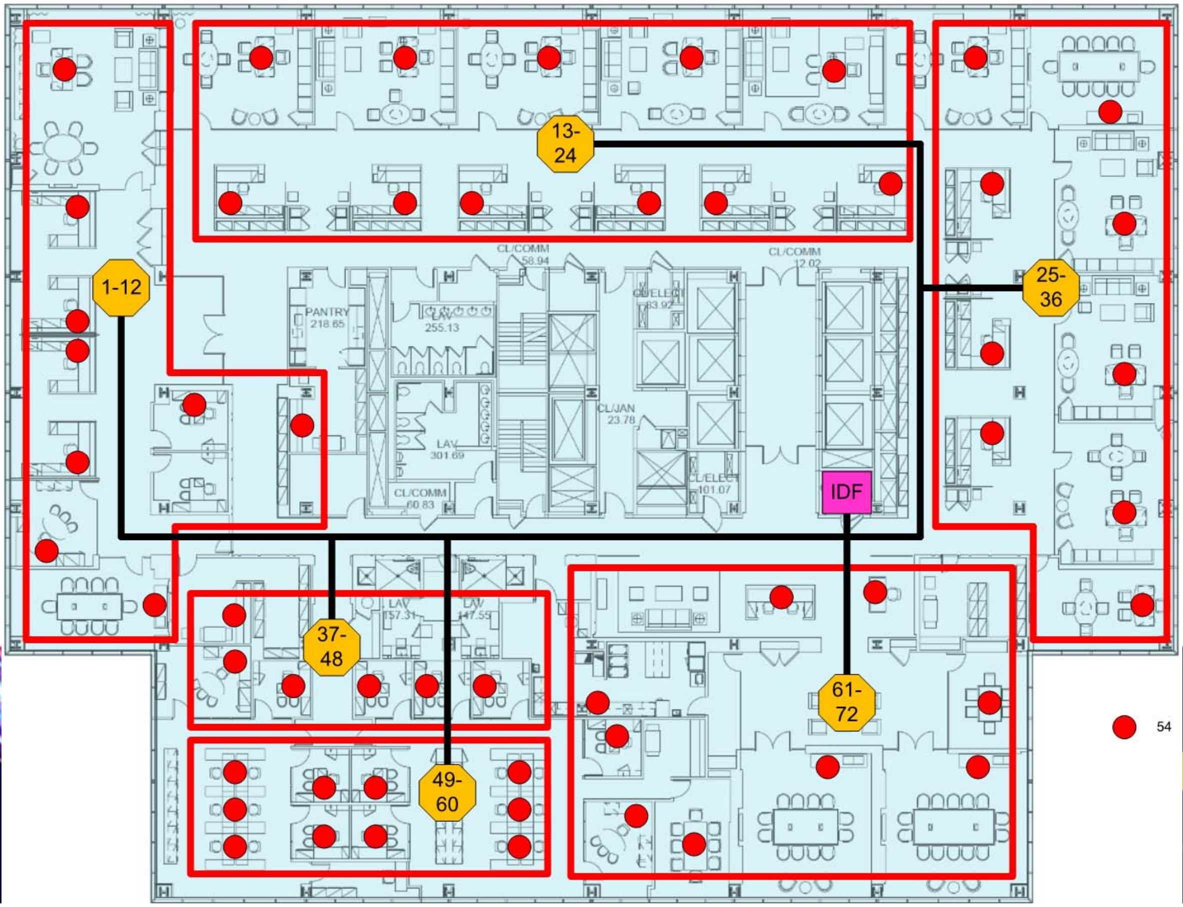
Rack Mount Split Overview



Rack Mount Splitting

- Customer used to look and feel
- Splitters are rack-mounted or installed in fiber housing modules
- Fiber is terminated on patch panels
- Can use Pre-terminated or field connectorized cable

Rack BoM

Area	Product Description	Total Qty
MDF	Rack Mount Fiber Enclosure, 2U, holds 6 MPO Fiber cassettes	
MDF/IDF	MPO Fiber Cassette	
IDF	Wall Mount 2-Post Open Frame Rack Cabinet 8U	
IDF	Rack Mount Fiber Enclosure, 1U, holds 2 MPO Fiber cassettes	
IDF	Rack Mount Fiber Enclosure, 2U, holds 6 Panels	
IDF	SC Adapters, Simplex, APC, 12 F, Single-mode	
Riser	MPO Fiber Trunk 12 Strand Singlemode Plenum (100 foot)	
Riser	MPO Fiber Trunk 12 Strand Singlemode Plenum (200 foot)	
Riser	MPO Fiber Trunk 12 Strand Singlemode Plenum (300 foot)	
IDF	Rack Mounted 1 x 32 splitter	
ONT Fiber	SCAPC-SCAPC Plenum Yellow 3 (10')	
OLT Fiber	SCUPC-SCAPC Plenum Yellow 8 (25')	
Horizontal	SCAPC-SCAPC Plenum Yellow 23 (75')	
Horizontal	SCAPC-SCAPC Plenum Yellow 31 (100')	
Horizontal	SCAPC-SCAPC Plenum Yellow 38 (125')	
Horizontal	SCAPC-SCAPC Plenum Yellow 46 (150')	
WAO	Faceplates 4-port White Alpine	
WAO	SCAPC Singlemode adapter	
WAO	Category 6 modular jack	
WAO	RJ45 plug to RJ45 plug, T568B Blue	

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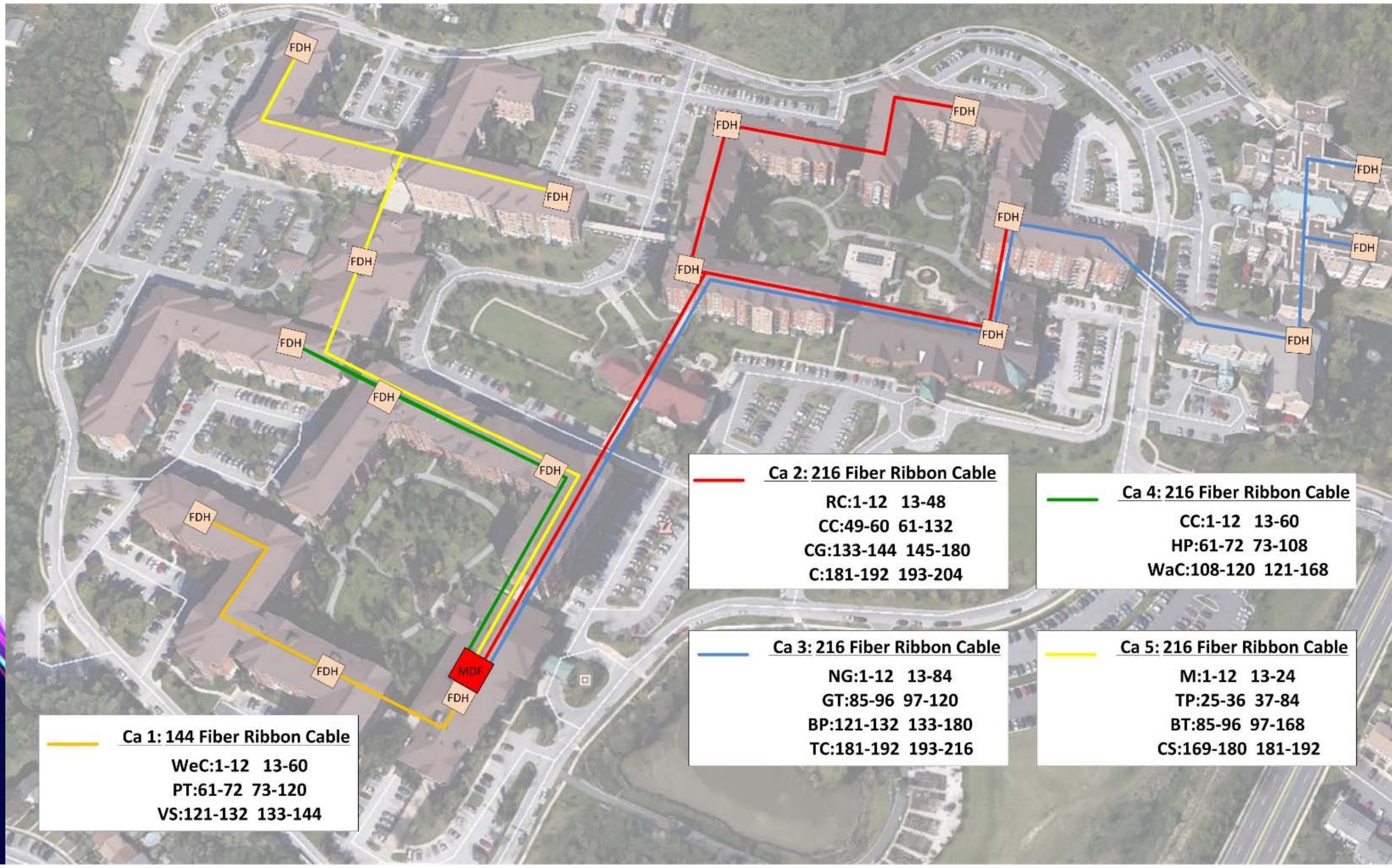
Hybrid Deployments

- Some deployments choosing hybrid deployments
- Hybrid Ideas
  - Keep IDFs for rack-mount ONTs, but use fiber zone hubs
  - Put ONTs in active zone box and run category cabling to user
  - Use 100% rack-mount ONTs in retrofit scenario

Campus Overview



OSP Deployment

- OSP options can be mixed with LAN options
- Be careful of mixing manufacturer product lines due to incompatibility issues
- Many options due to PON history in telecommunications

Good Design Practices

- ✓ Meets customer requirements
- ✓ Provides a value to the customer:
  - ✓ Reduced Cost
  - ✓ Power/Space/Cooling
  - ✓ Performance
  - ✓ Longevity
- ✓ Is not overly complex
- ✓ Makes customer happy!

End of Day One

Founding Members:

www.apolanglobal.org

Day 1 Review

Dustin Bateman

Director, Emerging Technologies, VT Group

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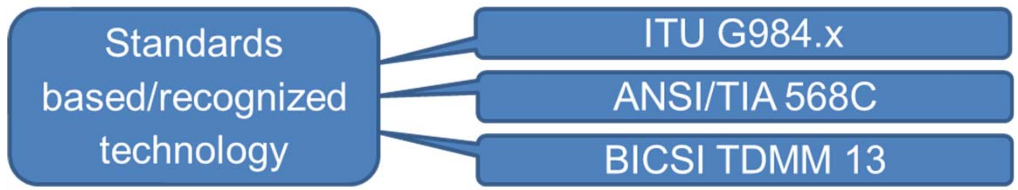
Passive Optical LAN is a standards based/recognized technology

- ✓ A. True
- B. False



Guaranteed bandwidth is possible with…

- ✔ A. Passive Optical LAN
- B. Switch Based
- C. Both A and B

Similar	Different
Standards Based	Point to Multipoint
Local Area Network	Multiple Services
Enterprise Management	Guaranteed Bandwidth
Ethernet Frame Transport	Single Strand of SM Fiber
802.1x – 802.1Q – PoE	No Access and Distribution

POL supports 802.1Q VLANs

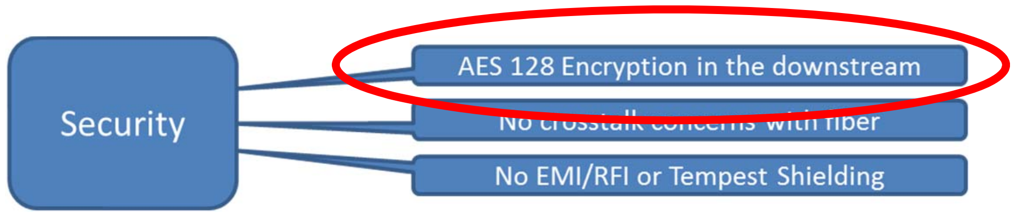
✓ A. True

B. False

Similar	Different
Standards Based	Point to Multipoint
Local Area Network	Multiple Services
Enterprise Management	Guaranteed Bandwidth
Ethernet Frame Transport	Single Strand of SM Fiber
802.1x – 802.1Q – PoE	No Access and Distribution

AES 128 Encryption is present in __________ direction(s)

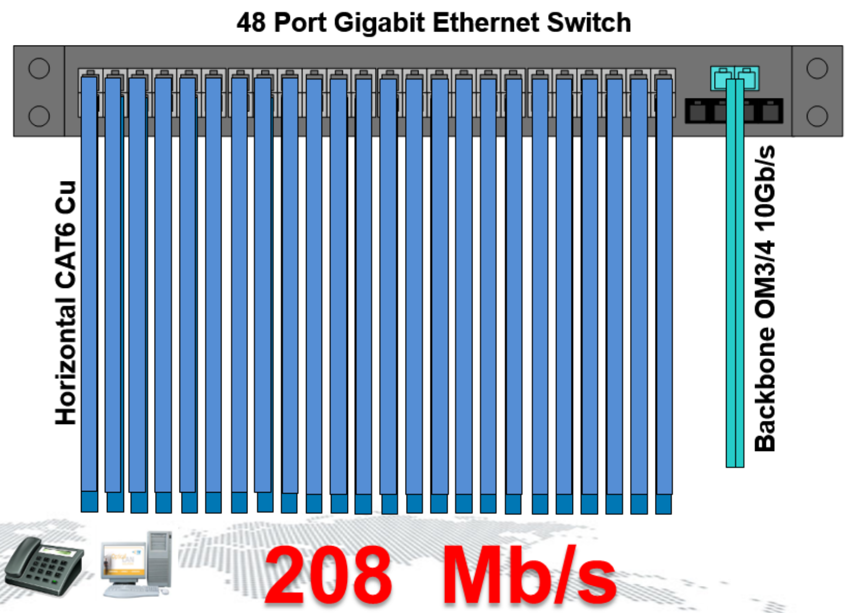
A. The upstream
B. The downstream
C. Both upstream and downstream



Gigabit switches provide 1Gb/s connections to every WAO

A. True

B. False



Most users consume bandwidth all day long

A. True

B. False

Most users use **0**Mb/s over 98% of the workday

Apps (7)				
Microsoft Lync (32 bit)	0%	55.8 MB	0 MB/s	0.1 Mbps
Microsoft Outlook (32 bit) (2)	0%	92.6 MB	0 MB/s	0 Mbps
Microsoft PowerPoint (32 bit)	2.3%	192.5 MB	0 MB/s	0 Mbps
Photos	0%	0.1 MB	0 MB/s	0 Mbps
Snipping Tool	0%	2.2 MB	0 MB/s	0 Mbps
Task Manager	1.6%	10.8 MB	0 MB/s	0 Mbps
Windows Explorer	1.4%	147.3 MB	0 MB/s	0 Mbps

This technology uses Dynamic Bandwidth Allocation

A. Switch Based
B. Passive Optical LAN

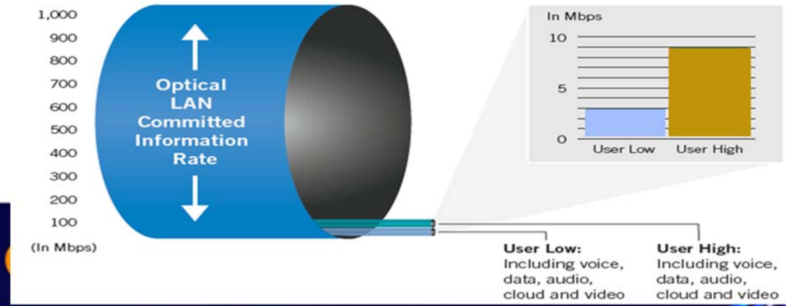
Switch Data vs. Dynamic Bandwidth Allocation

Most users require a sustained GbE connection

A. True

B. False

Common LAN Services	Typical Required Bandwidth
Email and Web Browsing	500Kbps
Voice over IP	110Kbps
Cloud-based Services (data storage, enterprise s/w, collaboration, etc...) Low	50Kbps
Cloud-based Services (data storage, enterprise s/w, collaboration, etc…) High	100Kbps
Wireless Access Point Capacity (IEEE 802.11 a/b/g/n)	24Mbps
Wireless Access Point High Capacity (IEEE 802.11 ac/ad, dual radio)	300Mbps
IP Video Surveillance Standard Definition (MPEG4/H.264)	2Mbps
IP Video Surveillance High Definition (MPEG4/H.264)	6Mbps
IP Video Conferencing / Telepresence (720p-Good, includes primary/auxiliary)	2Mbps
IP Video Conferencing / Telepresence (1080p-Best, includes primary/auxiliary)	15Mbps



Upstream (ONT to OLT) analog video utilizes which wavelength?

A. 1550nm
B. 1490nm
C. 1310nm
D. 1625nm
E. None

1550nm Downstream ONLY – RF Video

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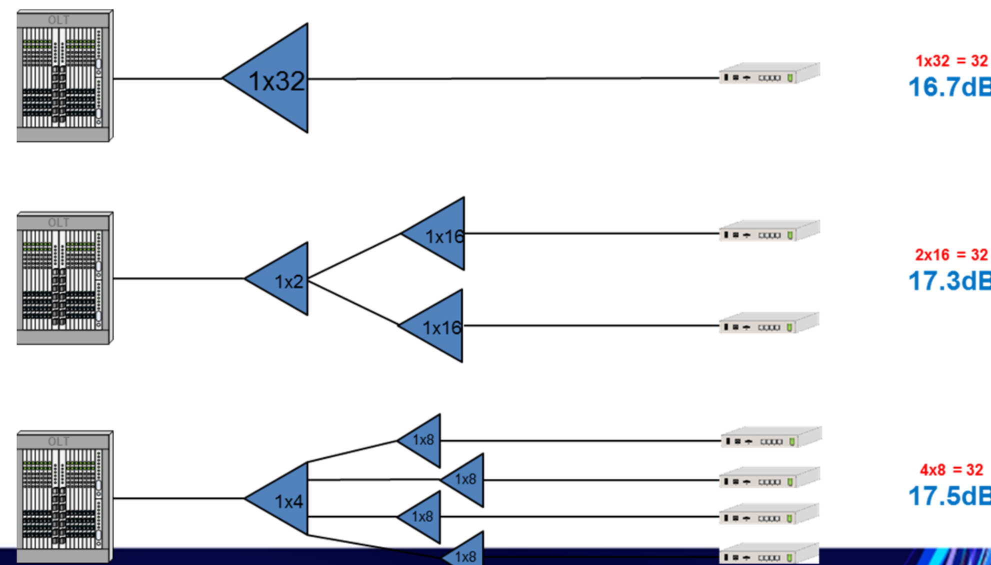
A cascaded 1x4 + 1x16 split is a good practice?

A. True

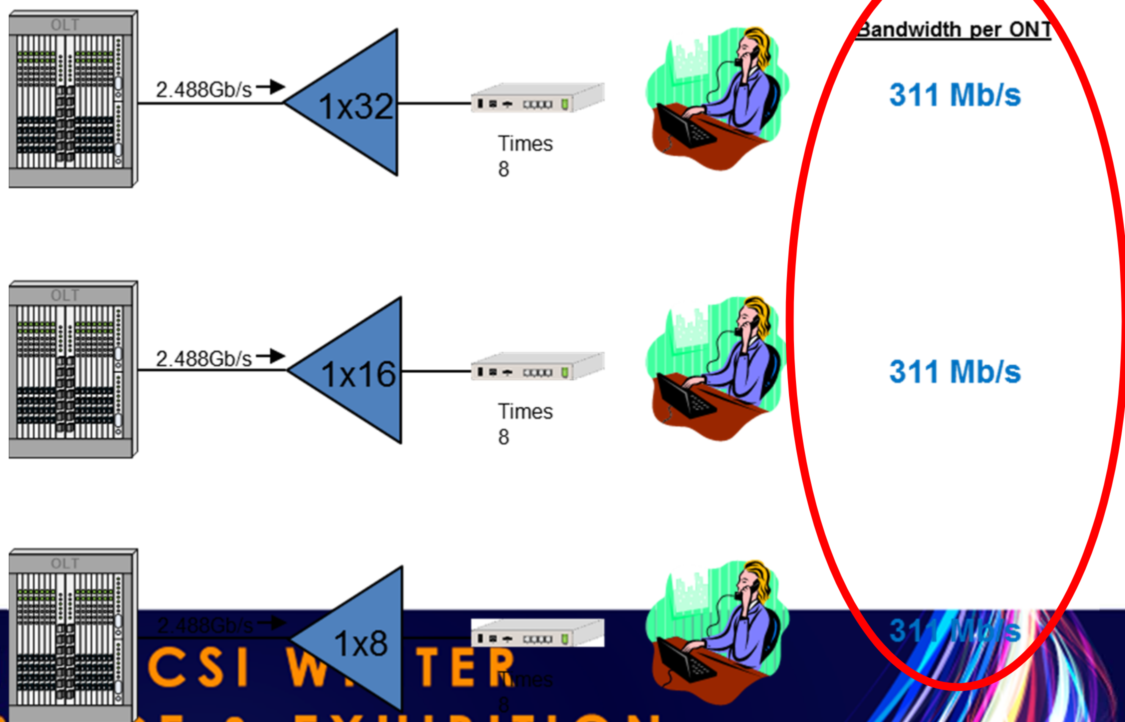
B. False



GPON bandwidth can be increased by using a lower split ratio

A. True

B. False



The minimum loss required between the OLT and ONT is…

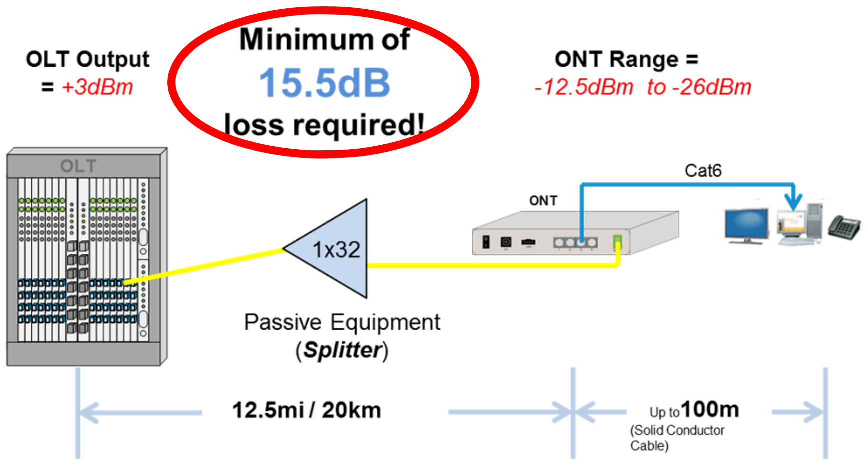
A. 13.5dB

B. 10.7dB

C. 15.5dB

D. 17.2dB

E. None of these

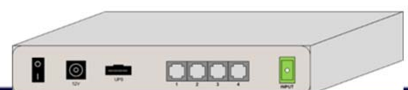


PoE in a POL is administered at the…

A. OLT
B. ONT
C. Injector
D. PoE is not possible

ONT – Optical Network Terminal

- Active equipment provided by suppliers such as Tellabs and Zhone.
- Located near the user or device
- Typically 4 RJ45 *(10/100/1000)* outputs with optional POE
- Up to 60W of available POE (vendor specific)
- Standard HVAC is adequate
- Optional internal or external battery back-up
- POTS and COAX ports available
- Establishes and maintains secure AES 128 Encryption
- Supports multiple VLANs on each port



ONT

Which of these are a benefit of POL?

A. Reduction in power
B. Reduction of fire load
C. Reduction of non-renewable materials
D. All of these are benefits

Green Benefits

Reduction in power consumption
Reduction in non-renewable materials
Ceiling space and fire load savings
Reduction in cabling costs
Floor space savings

LEED Credits are

A. Possible with POL
B. Automatic with POL
C. Guaranteed with POL
D. Not Possible with POL

- Energy and Atmosphere Credit 1 (1-3 pts).
  - Reduction in TRs, HVAC equipment, switch equipment, UPS, lighting and other energy needs.
  - The PON system helps the overall efficiency of the energy systems.
- Innovation in Design Credit 1 (1-4 pts).
  - The PON system utilizes less equipment, resulting in less raw materials, less garbage, less transportation and reduced time for implementation and commissioning.
  - In addition, utilizing a fiber system ensures the life of the system extends beyond the life of a conventional "switched" system.

*not guaranteed or implied

My retained knowledge of Passive Optical LAN from yesterday was…

A. A little
B. A lot
C. What is Passive Optical LAN?
D. None

Questions?

Day 1 Review

Dustin Bateman

VT Group

Design Scenario Challenge

Challenge – Determine the quantity of each component required for Passive Optical LAN design

Assumptions:

1. Using pre-terminated fiber throughout
2. ONTs will be shared at Cubicles
3. ONTs will be mounted under the desks
4. ONTs will be locally AC powered
5. OLT is located in MDF
6. Raised floor throughout building

OLT	1
ONT's	107
WAP's	26
Printers	9

Assumptions

1. Using pre-terminated fiber throughout
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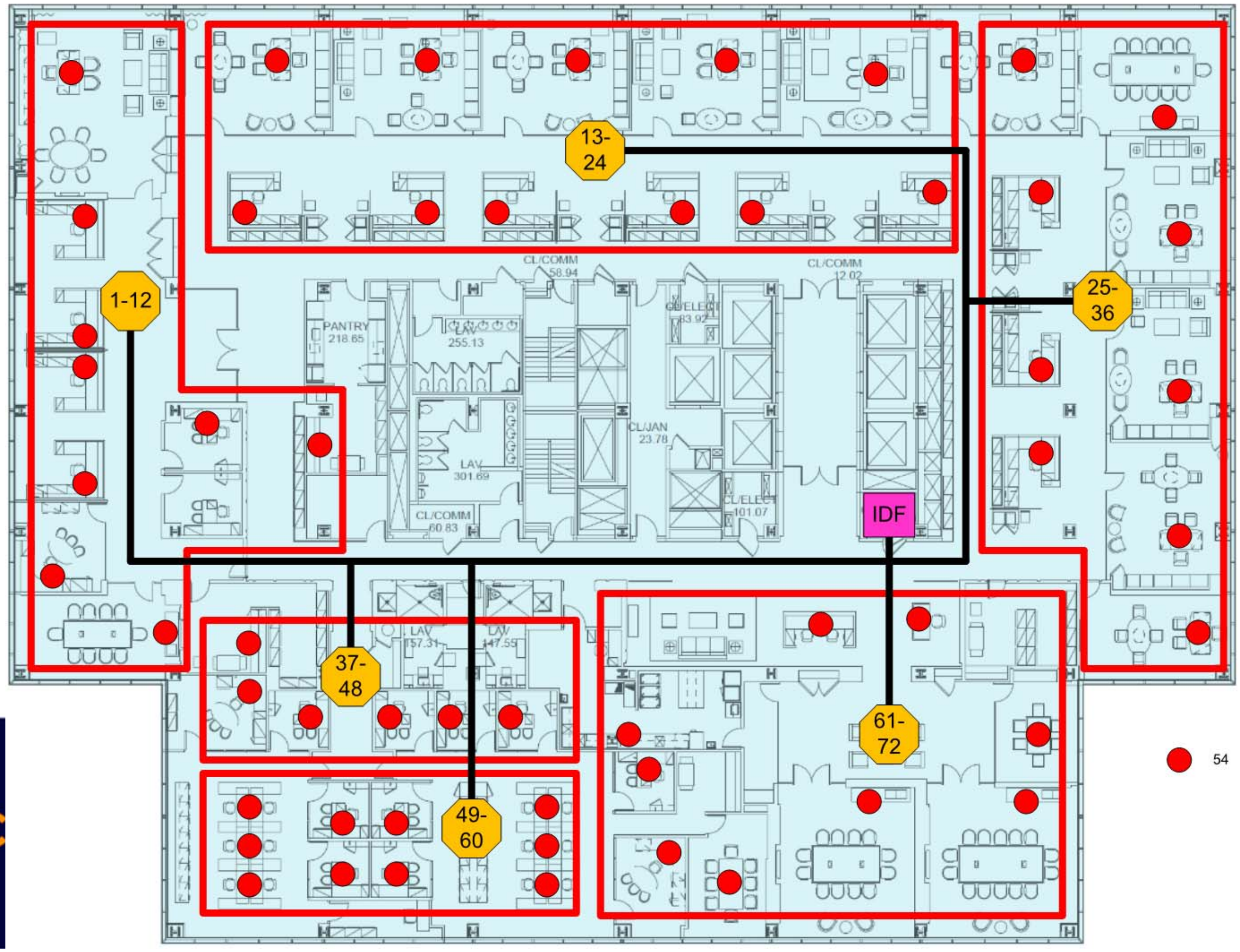
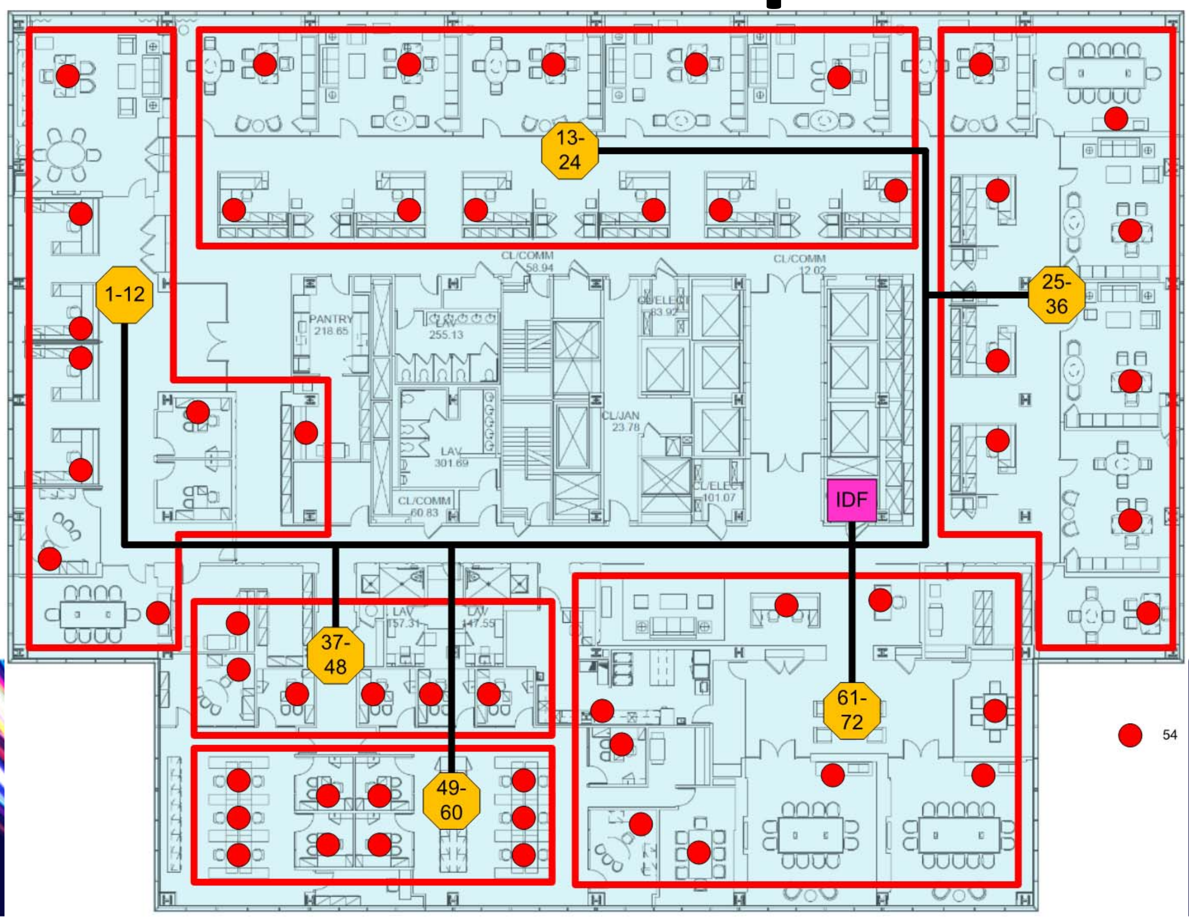


Centralized Split Overview



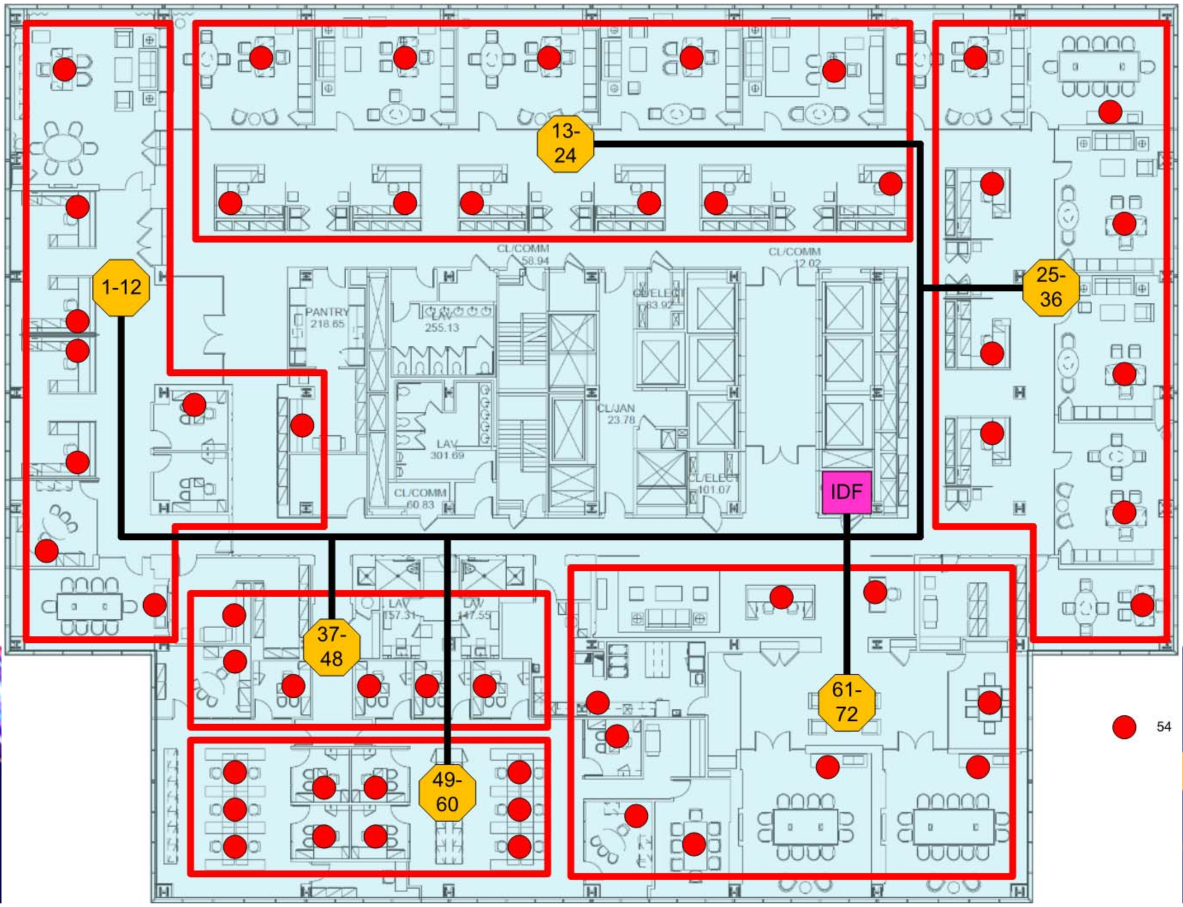
FDH
Houses Splitters

Consolidation Point
Zone Cabling

Centralized Scenario Answers

Area	Product Description	Total Qty
MDF	Rack Mount Fiber Enclosure, 1U, holds 3 MPO Fiber cassettes	1
MDF	MPO Fiber Cassette	2
IDF	1 x 32 splitter used with FDH	4
IDF	288-Port with 18 splitter ports 500’ 24 MPO adapters	1
Horizontal	24 port Fiber Terminals w/300 foot Plenum Cable w/MPO	10
ONT Fiber	SCAPC-SCAPC Plenum Yellow 3 (10')	107
OLT Fiber	SCUPC-SCAPC Plenum Yellow 8 (25')	4
Horizontal	SCAPC-SCAPC Plenum Yellow 23 (75')	30
Horizontal	SCAPC-SCAPC Plenum Yellow 31 (100')	40
Horizontal	SCAPC-SCAPC Plenum Yellow 38 (125')	30
Horizontal	SCAPC-SCAPC Plenum Yellow 46 (150')	10
WAO	4-port White Faceplate	107
WAO	SCAPC Singlemode adapter	107
WAO	Category 6 modular jack	37
WAO	RJ45 plug to RJ45 plug, T568B Blue	251

Zone Split Overview

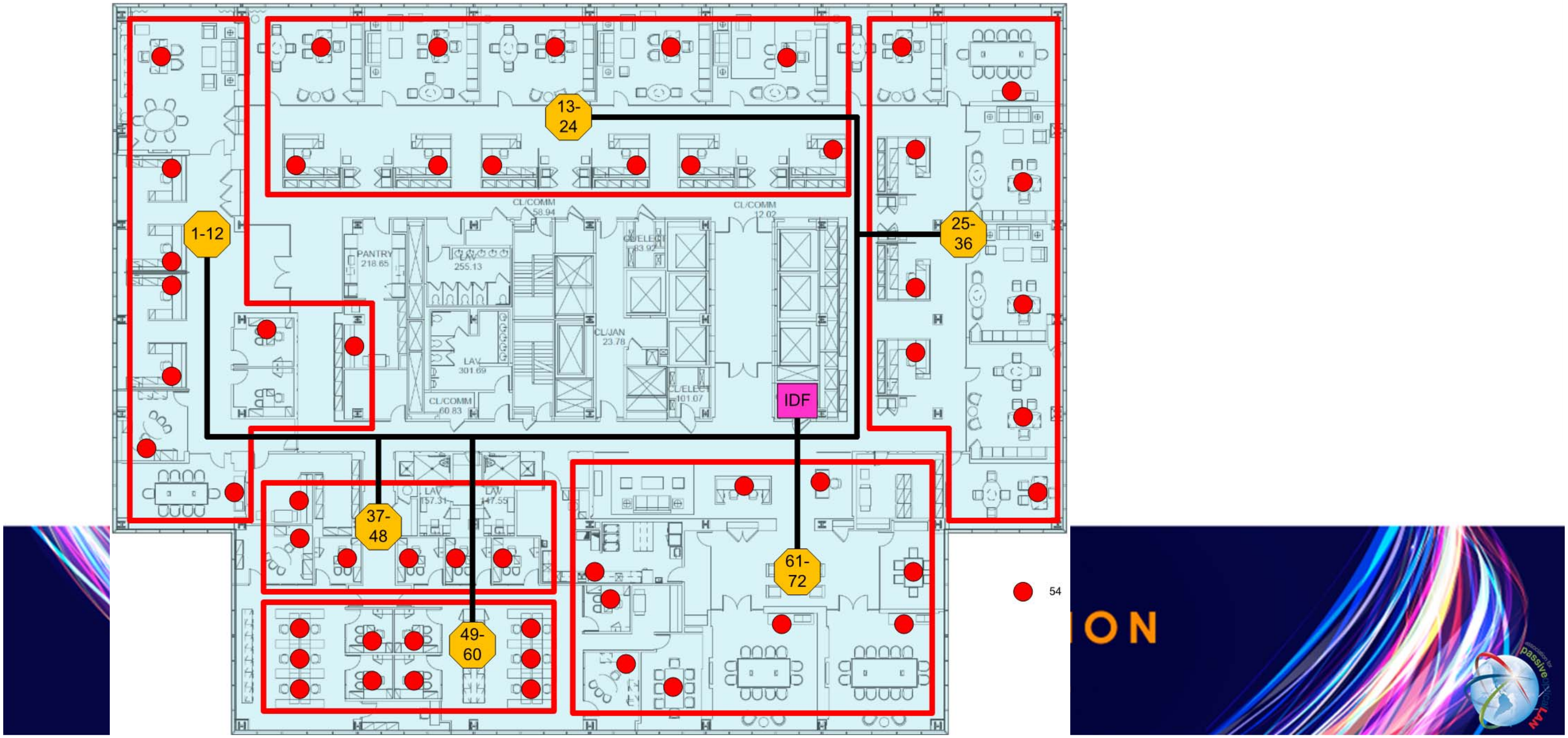


Zone Splitter Housing

Zone Scenario Answers

Area	Product Description	Total Qty
MDF	Rack Mount Fiber Enclosure, 2U, holds 6 MPO Fiber cassettes	1
MDF	MPO Fiber Cassette	5
IDF	MPO Fiber Trunk 12 Strand Singlemode Plenum (100 foot)	1
IDF	MPO Fiber Trunk 12 Strand Singlemode Plenum (200 foot)	2
Horizontal	MPO Fiber Trunk 12 Strand Singlemode Plenum (300 foot)	2
Horizontal	1 x 32 Splitter	5
Horizontal	Fiber Zone Box	5
Horizontal	Fiber Zone Box Installation Kit	5
ONT Fiber	SCAPC-SCAPC Plenum Yellow 3 (10')	107
OLT Fiber	SCUPC-SCAPC Plenum Yellow 8 (25')	5
Horizontal	SCAPC-SCAPC Plenum Yellow 23 (75')	10
Horizontal	SCAPC-SCAPC Plenum Yellow 31 (100')	40
Horizontal	SCAPC-SCAPC Plenum Yellow 38 (125')	30
Horizontal	SCAPC-SCAPC Plenum Yellow 46 (150')	30
WAO	Faceplates 4-port White Alpine	107
WAO	SCAPC Singlemode adapter	107
WAO	Category 6 modular jack	37
WAO	RJ45 plug to RJ45 plug, T568B Blue	251

Rack Mount Split Overview



Rack Scenario Answers

Area	Product Description	Total Qty
MDF	Rack Mount Fiber Enclosure, 2U, holds 6 MPO Fiber cassettes	1
MDF/IDF	MPO Fiber Cassette	8
IDF	Wall Mount 2-Post Open Frame Rack Cabinet 8U	4
IDF	Rack Mount Fiber Enclosure, 1U, holds 2 MPO Fiber cassettes	4
IDF	Rack Mount Fiber Enclosure, 2U, holds 6 Panels	4
IDF	SC Adapters, Simplex, APC, 12 F, Single-mode	10
Riser	MPO Fiber Trunk 12 Strand Singlemode Plenum (100 foot)	1
Riser	MPO Fiber Trunk 12 Strand Singlemode Plenum (200 foot)	1
Riser	MPO Fiber Trunk 12 Strand Singlemode Plenum (300 foot)	2
IDF	Rack Mounted 1 x 32 splitter	6
ONT Fiber	SCAPC-SCAPC Plenum Yellow 3 (10')	107
OLT Fiber	SCUPC-SCAPC Plenum Yellow 8 (25')	6
Horizontal	SCAPC-SCAPC Plenum Yellow 23 (75')	30
Horizontal	SCAPC-SCAPC Plenum Yellow 31 (100')	40
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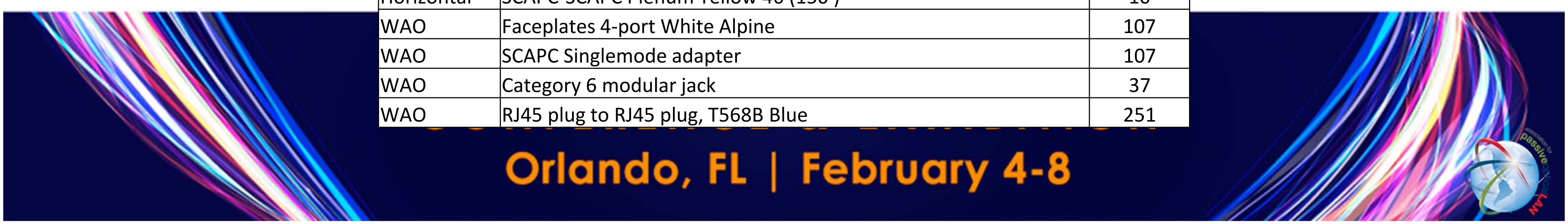


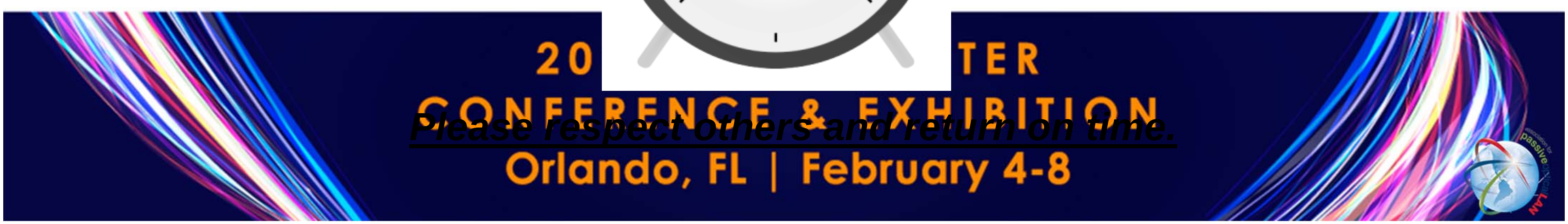
Design Questions

- What design challenges do you see?
- What problems do you see POL solving?
- What problems do you see POL causing?

Questions?

Passive Optical LAN Design

15 Minute Break



Please respect others and return on time.

Passive Optical LAN Power Survivability

Chad Hines

ITConnect, Inc.

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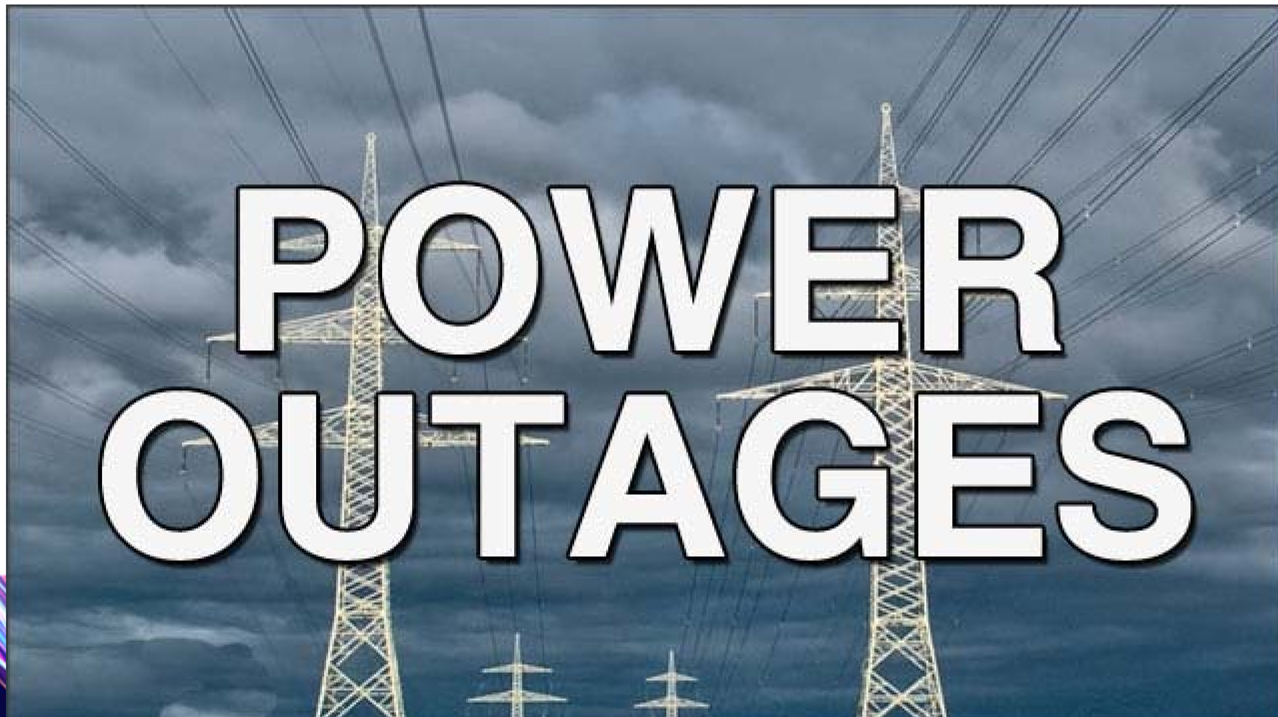
Section 6 Agenda

- Survivability
- Verticals
- Types
- Hardware and Cabling
- When, Where, and How
- Knowledge Check

What is survivability

- Survivability: the capability of a system or organization to withstand a disaster or hostile environment, without significant impairment of its normal operations.

Why Would We Need Survivability



Power Over Ethernet Requirements

Non-PoE Requirements

What’s The Impact

ONT Placement Can Define Powering

AC = Local

DC = Remote

Wall-mount

Ceiling tile mount

Secure Wall Box

Wall Plate ONT

Wall Plate ONT

Under-desk mount

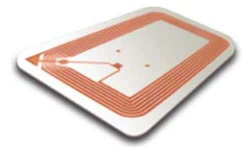
Desktop

What Needs to Survive

VoIP Handsets

VTC

RFID



PTZ Camera

AV Control
Systems

Wireless

Access Control

Call Centers/ DoD/ Financial

Healthcare


CODE BLUE
Patient: Rogers, Alex
MRN: 65077
Unit: Cardiac Care Unit
Room: 313-1
Accept
Decline
Options
CODE
EMERG
CANCEL

Hospitality

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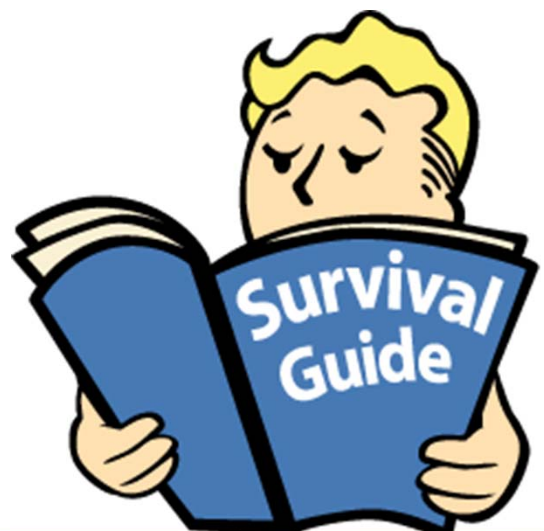
Commercial Business and Education

Different Ways to Survive

- Local battery
- Remote:
  - Powered
  - Battery
  - Generator
- AC power on generator
  - “Emergency power”



Local Batteries

Local Batteries

- PROs
  - Place them only where needed
  - Low cost/ commitment
  - May already be using UPS at desk
- CONs
  - Replacement after several years
  - More items to manage
  - Limited uptime
  - Battery failure

Remote Power

- Remote power means to power multiple devices from a DC power station which can be either distributed or centralized.
  - Distributed remote power is typically located in an IDF or zone distribution box and can be remotely powered from a DC power plant from the MDF
  - Centralized remote power is typically in the MDF feeding localized power distribution units to feed ONT's
  - Voltage options: 48vdc – 54vdc

Why Remote Line Power?

AC access not required at each ONT

Reduces CapEx and OpEx

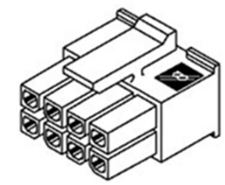
Uses low cost copper cables

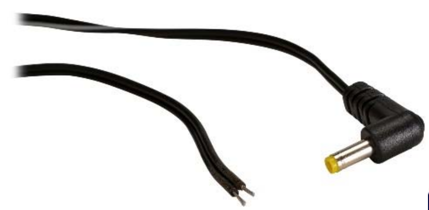
Battery backup provided in centralized location rather than at each ONT

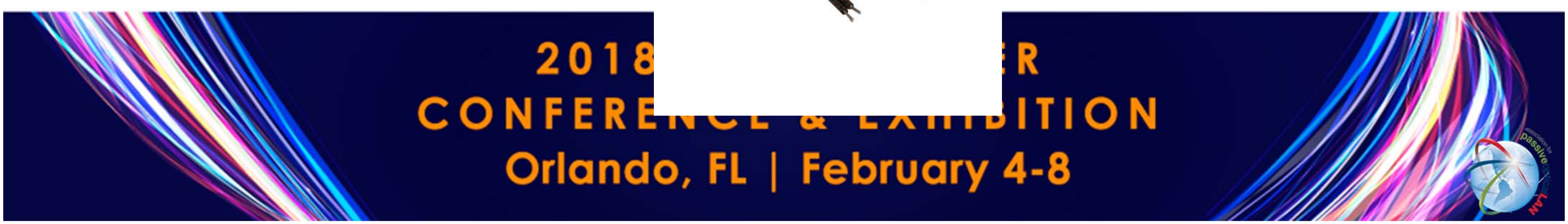
Reduces time to market & enables rapid deployment

Power Connectors

Locking preferred for remote power applications







Power Connectors

Non-locking connector
introduces risk

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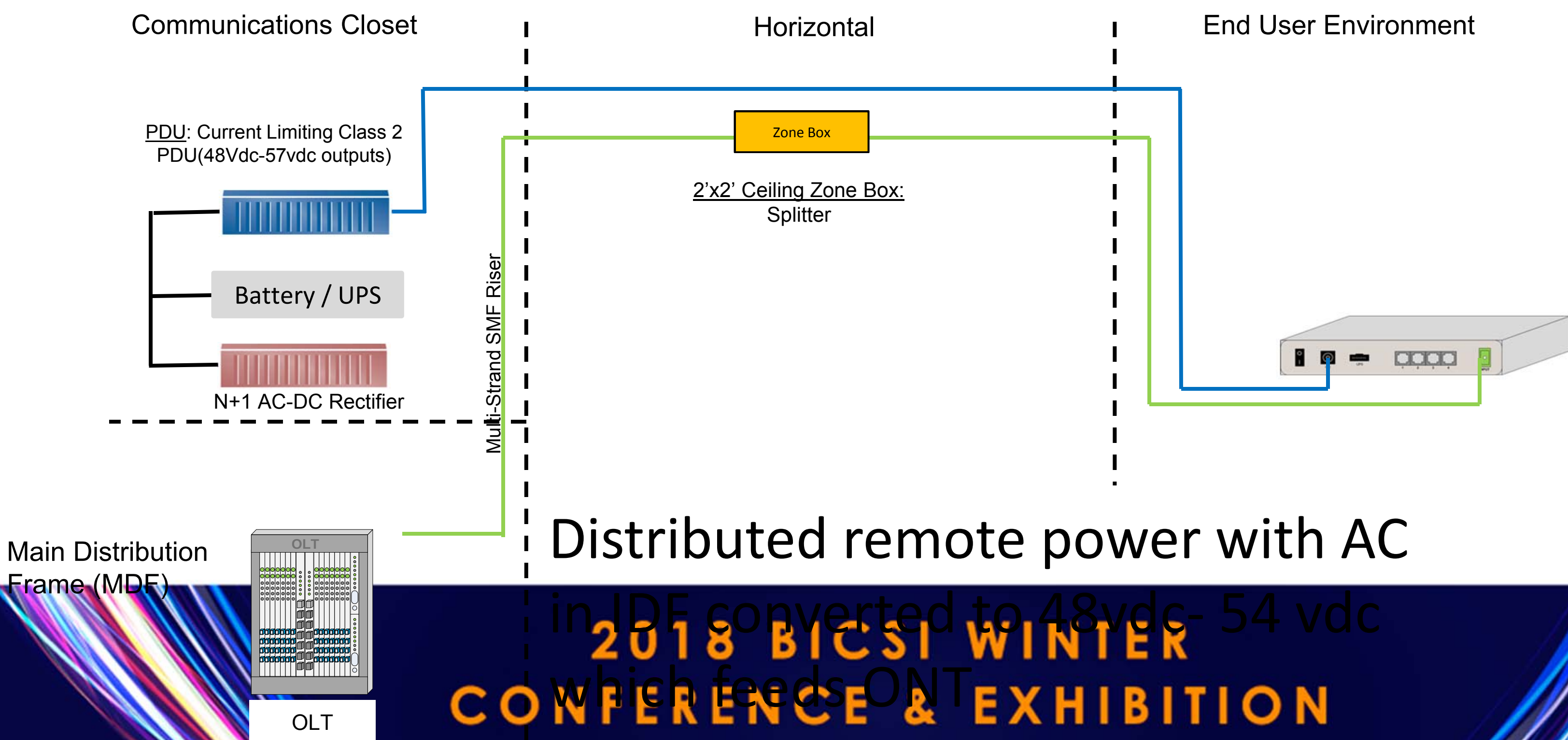
Power Connectors

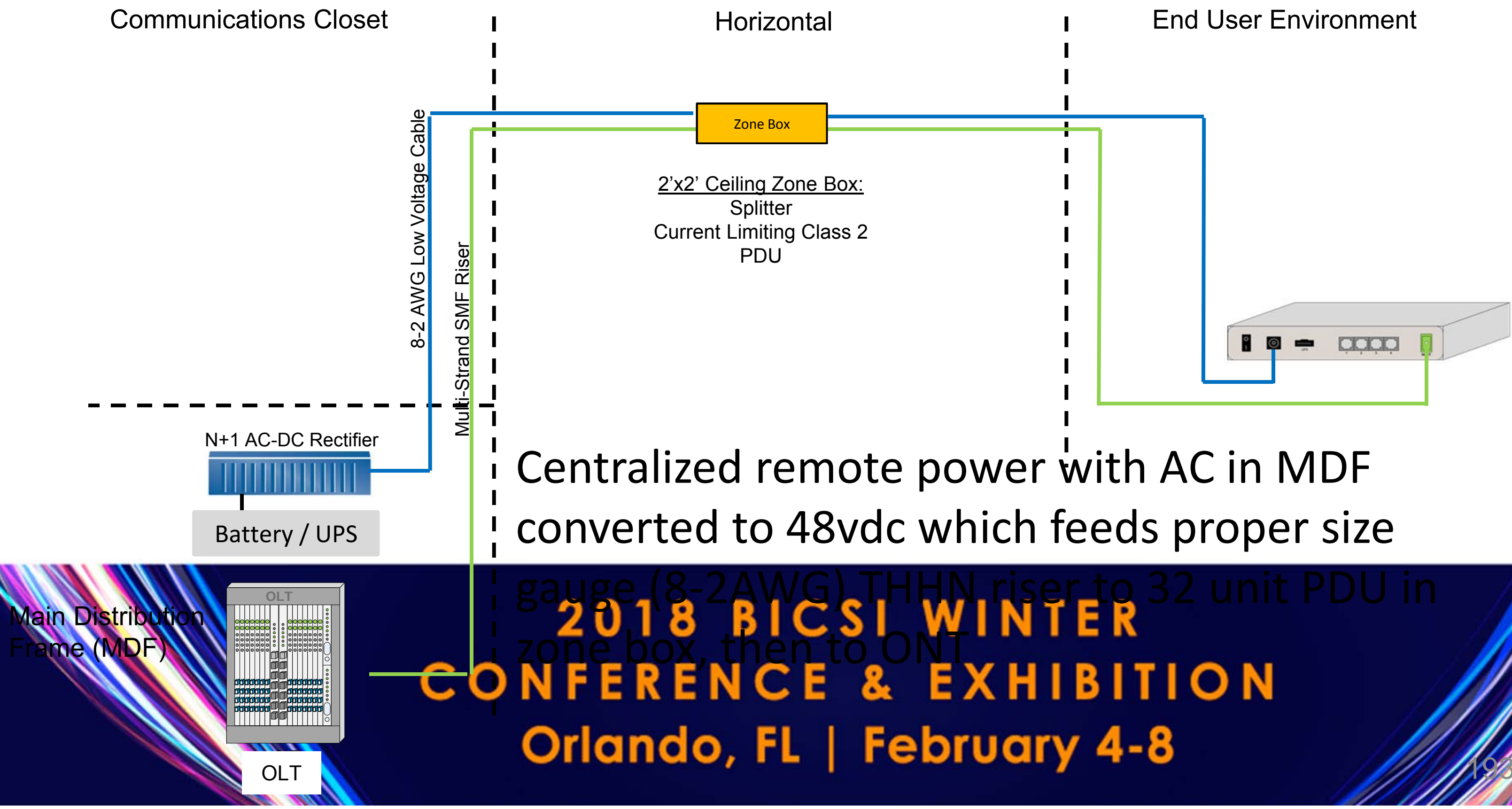
Be
creative
but not
sloppy

48vdc Centralized



Distributed remote power with AC in IDF converted to 48vdc- 54 vdc which feeds ONT

48vdc Distributed



Centralized remote power with AC in MDF converted to 48vdc which feeds proper size gauge (8-2AWG) THHN riser to 32 unit PDU in zone box, then to ONT

Remote Power

- PROs
  - Survivability, battery back up can be sized to any customer requirement
  - Eliminates AC plug and wall wart at ONT
  - Centralizes battery backup
  - Remote power reset of an ONT and device
- CONs
  - Level 4 DC Technician
  - Power Engineer is required
  - Requires additional power in MDF
  - Electrical contractor will take a loss

Cost Savings Summary

Capex Savings

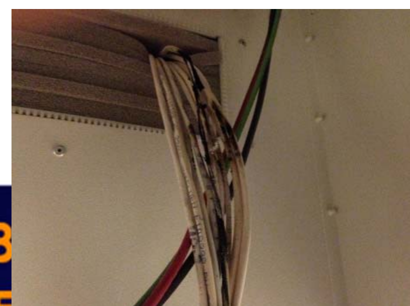
- Eliminating need to run AC power to each ONT location **reduces cost for cabling, conduits, and electricians**
- **Reduced space** required at each ONT
- NEC Class 2 system eliminates cost of using **armored cable** to comply with standards

Opex Savings

- Eliminating batteries at remote sites reduces ongoing **battery maintenance** cost
- Remotely accessible system minimizes need for **site visits** for troubleshooting & alarming
- **Reduction in power consumption** through improved power conversion efficiency and lower HVAC requirements

Remote Power Caution

- What happens when you have a coil of copper cable and send constant DC voltage through it?
- Trimming to avoid the coil means you've limited future flexibility
- Not all ONTs are 48vdc
- Certified UL/CSA Listed and NEBS class 2 certified product
- Consult a Certified DC Engineer for proper design



AC Generator Power

- Alternating Current (AC) power
  - Installed on dedicated “emergency” circuits
  - Circuits fed from dedicated panels
  - Panels powered with dedicated feeders from generator power

AC Generator Power

- PROs
  - Survivability
  - Not limited to run time of battery
- CONs
  - Added cost / complexity
  - Requires licensed electrician to install vs. low voltage contractor
  - Requires space outside of facility to house

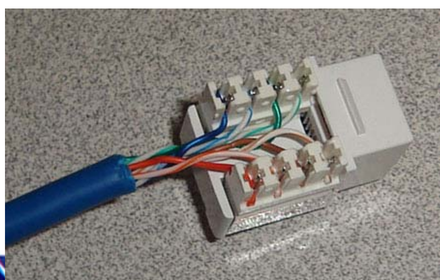
Rectifier Hardware Options

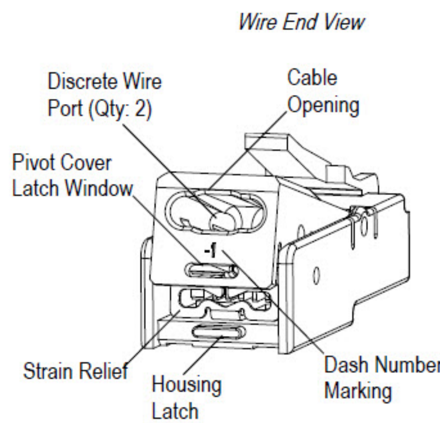
PDU Hardware Options

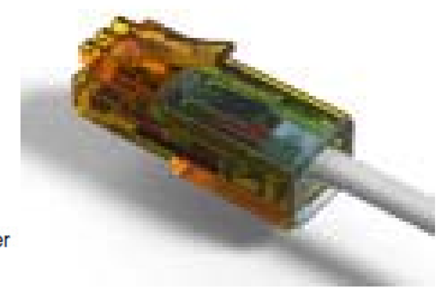
Cabling Options

- Solid vs. Stranded
- Hybrid composite cable
- Separate cables
- Use existing copper

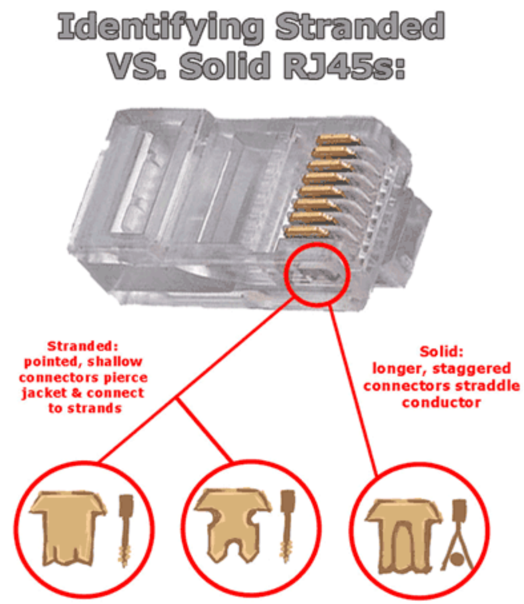
Solid vs. Stranded Conductor



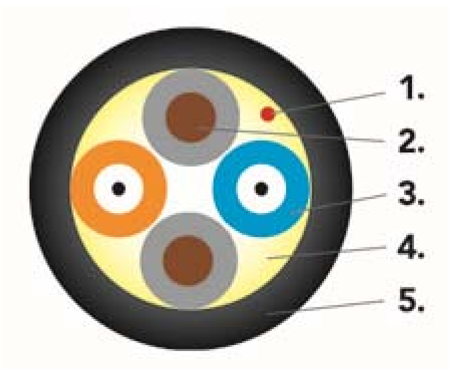


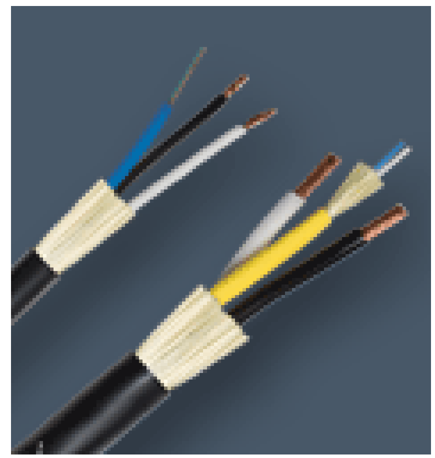


Solid vs. Stranded Conductor

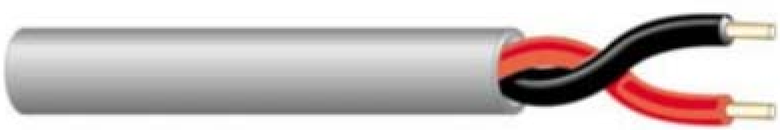


Composite Cable





Separate Cables



Considerations for Cabling

- Will the copper and fiber originate in the same location? This will significantly impact your decision for Composite or Separate cables.
- Repurposing existing Cat-X cable as your power carrier is a benefit and reduces costs for cable and installation.

Power System Design Process

Step 1: Get the Numbers

- How many ONTs are required?
  - Per floor?
  - Per building?
  - Per sector?
- What is the rated power consumption of the ONTs?
- Will PoE+ be supplied by the ONT?

Step 2: Follow the Fiber Plan

- Where are the distribution points?
- Are IDF closets or electrical rooms available for power?
- What is the maximum distance from a distribution point to an ONT?

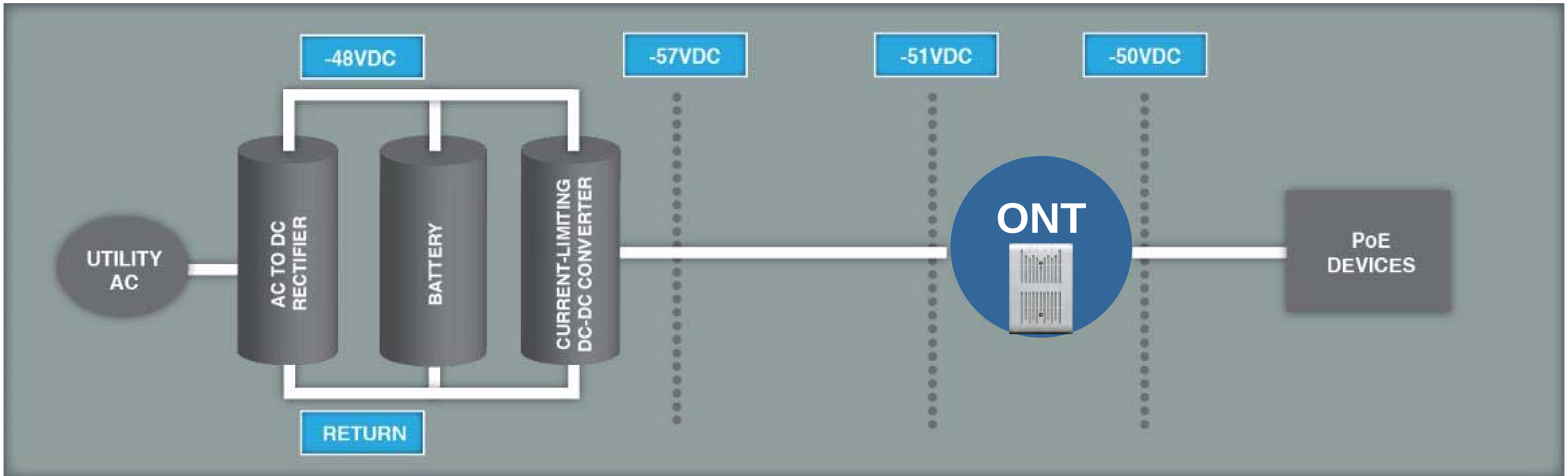
Step 3: Consider Other Factors

- What is the desired runtime?
- Which circuits are considered Emergency circuits?
- What are future growth and expansion expectations?

Step 4: Determine Power Architecture

- Distributed DC Plants
- Centralized DC Plants

How Far Can It Reach?

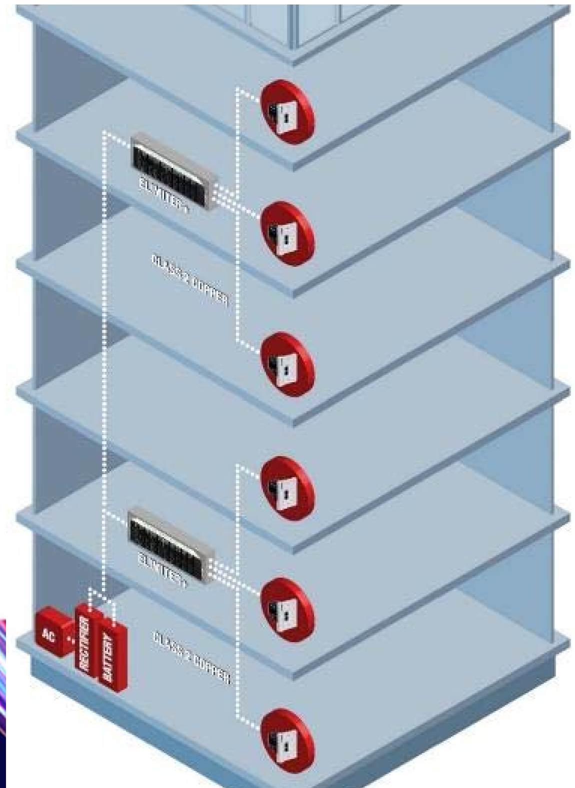


- **6Vdc** allowable voltage drop in cable to meet PoE+ standard at ONT
- 1Vdc drop across ONT

Max Distance to ONT Supporting PoE+

Load (Watts)	Cable Gauge (AWG) 20	18	16	14	12
90	100	160	250	400	640
80	150	250	400	625	1000
70	175	275	450	725	1150
60	200	325	525	850	1350
50	250	400	625	1000	1600
40	300	500	800	1250	2050
30	400	650	1050	1700	2700

Design Architecture: Centralized DC Plants



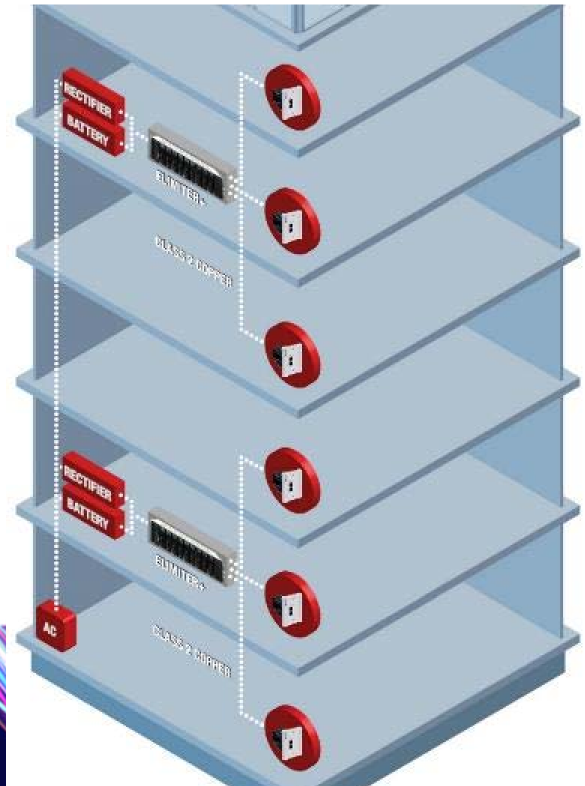
Pros

- Single DC plant and batteries to maintain
- Less space per floor required for power equipment

Cons

- Cabling cost to run Class 1 circuits to each Zone
  - Conduit
  - Electrician
  - Large AWG cable
- 48Vdc Plant and Battery must be larger to offset cable losses

Design Architecture: Distributed DC Plants



Pros

- All DC cabling will be NEC Class 2 compliant
- Installation cost
- Equipment cost

Cons

- Space must be found for power equipment in IDFs
- Distributed batteries are more difficult to maintain
- Additional AC circuits required to each rectifier location

Design Example

ONT Count by IDF	1-2 Port ONT	DC WATTS	4 Port ONT	DC WATTS	8 Port ONT	DC WATTS	24 Port ONT (AC)	500W 120VAC	Total ONT	Total DC load	DC Power system Load	Total AC load (W)	# of Ch
IDF 3D	47	30	3	80	0	80	1	500	51	1650	2145	500	50
IDF MDF	47	30	7	80	0	80	1	500	55	1970	2561	500	54
IDF 3A	45	30	12	80	0	80	1	500	58	2310	3003	500	57
IDF 2F	48	30	10	80	2	80	1	500	61	2400	3120	500	60
IDF 2E	50	30	11	80	7	80	1	500	69	2940	3822	500	68
IDF 1A	58	30	21	80	0	80	1	500	80	3420	4446	500	79
IDF 2A	56	30	18	80	5	80	1	500	80	3520	4576	500	79
IDF 4A	62	30	24	80	0	80	1	500	87	3780	4914	500	86
IDF 2C	77	30	18	80	3	80	1	500	99	3990	5187	500	98
IDF 1Z	61	30	36	80	1	80	1	500	99	4790	6227	500	98
IDF 3C	76	30	34	80	1	80	1	500	112	5080	6604	500	111
IDF 5A	87	30	28	80	7	80	1	500	123	5410	7033	500	122
Total ON	714		222		26		12		974	41260	53638	6000	962

Deployment Methodologies

- What is the design architecture?
- What is the end user survivability requirement?
- Cabling and infrastructure approach
- Maintaining flexibility and future management in your network.

Knowledge Check

Does a 48VDC remote power system fed by an AC plug in require a licensed electrician for installation?

A. Yes

B. No

C. Sometimes

Can a class 2 circuit be installed in plenum space without the use of conduit?

✓ A. Yes

B. No

C. Sometimes

Questions?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90 Minute Lunch Break

CONFERENCE & EXHIBITION

Please respect others and return on time.

Orlando, FL | February 4-8

POL Testing Considerations

Mike Watts

Vice President of Noovis

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Fiber Connectors

SC/APC is default standard in PON networks

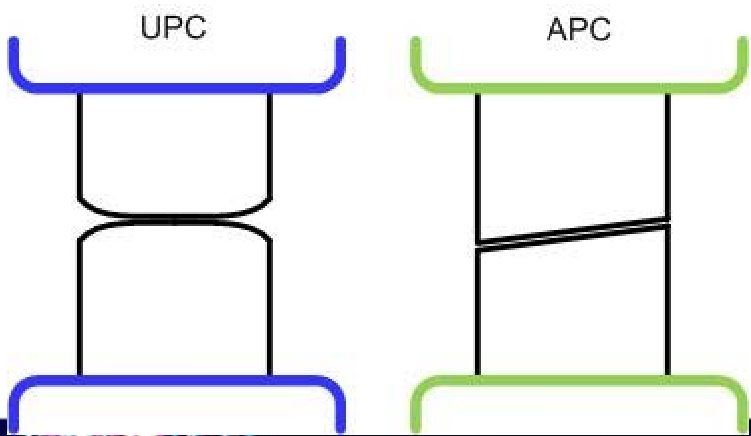
- APC connectors reduce reflectance
- Reduce damage to transmitters and amplifiers
- Allow injection of Analog Video

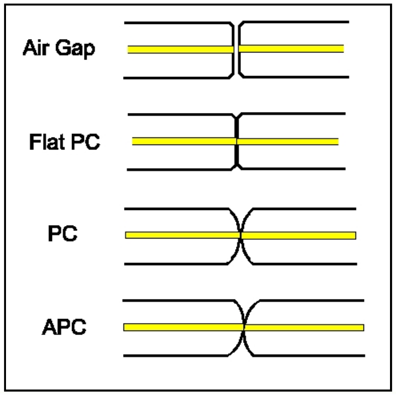
APC and UPC

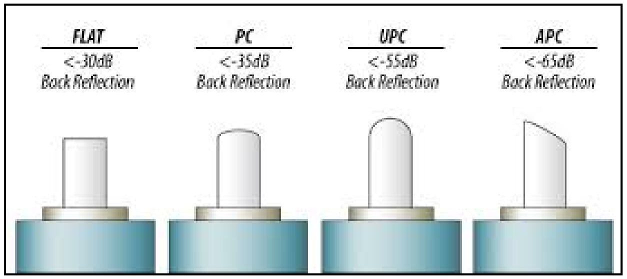
- Ultra Physical Contact Connectors (UPC)
  - Blue

- Angled Physical Connectors (APC)
  - Green

Endface Comparison







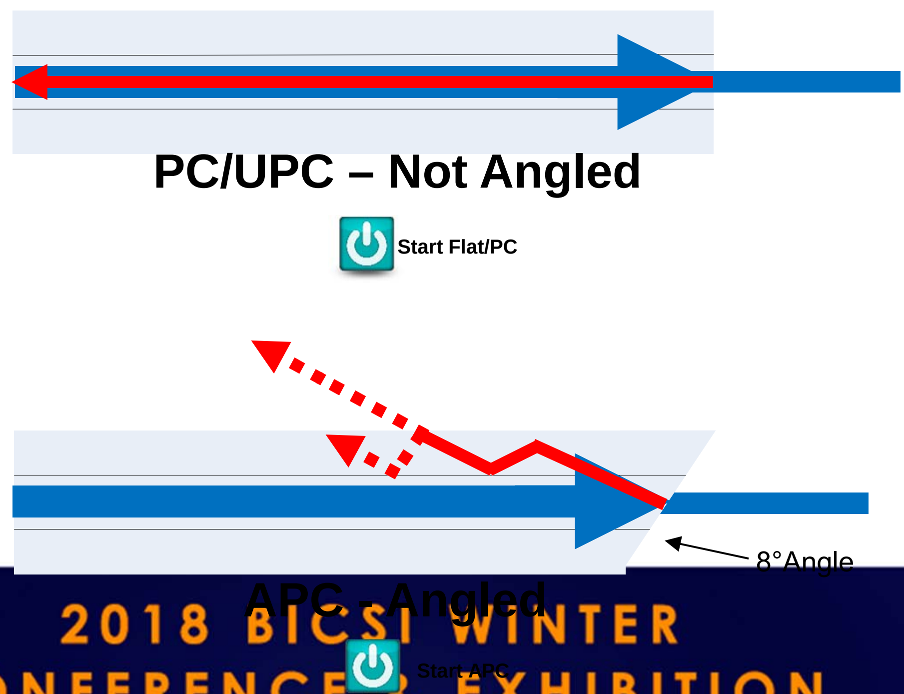
Source: FOA.ORG

APC vs. PC (un-mated)

RL = ~14.7dB

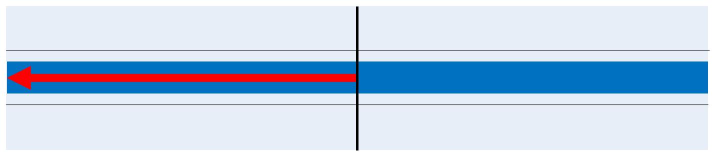
RL = Return Loss

RL = >60dB



APC vs. PC (mated)

RL = ~ 50-55dB

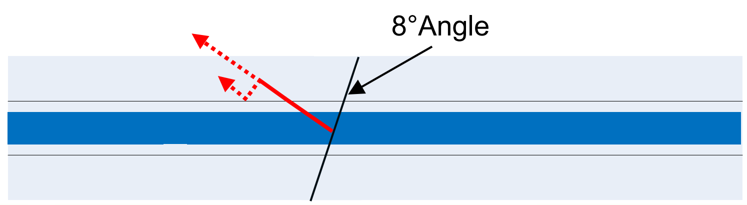


PC/UPC – Not Angled

Start PC

RL = Return Loss

RL = >60dB



APC - Angled

Start APC

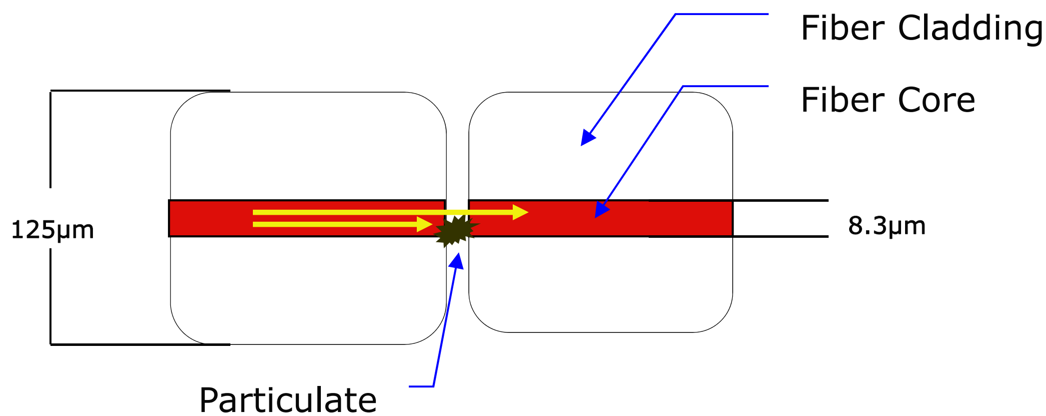
Importance of Cleaning

No. 1 cause of fiber network failures is contaminated connectors

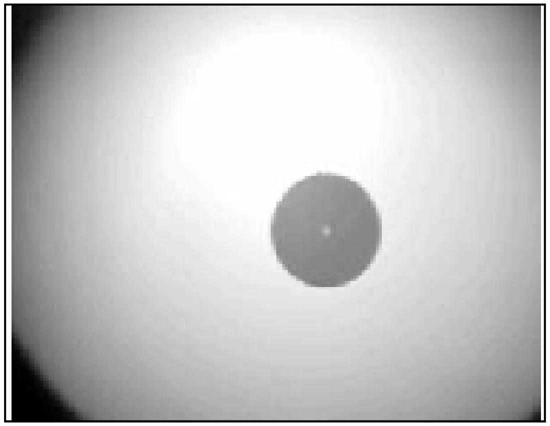
- *NTT-Advanced Technology Research, 2010*

80% of network problems are due to dirty connectors!

Importance of Cleaning

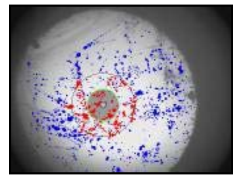


Common Contaminants

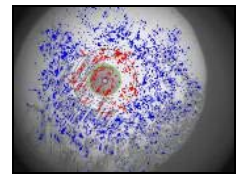


SINGLEMODE FIBER

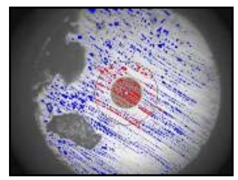
End face should be free of any contamination or defects,



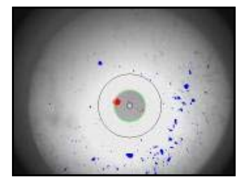
Dust Particles



Hand Lotion



Finger Prints

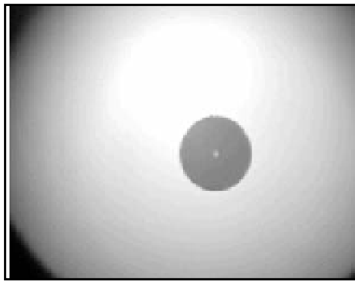


Alcohol Residue

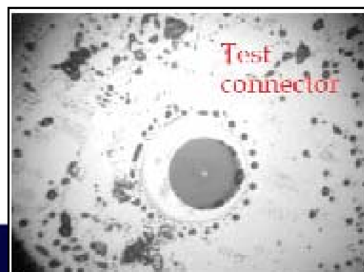
- Dust
- Skin oil
- Alcohol residue
- Distilled water residue
- Vegetable oil
- Hand lotion
- Dryer lint
- Saltwater residue
- Graphite

Information courtesy of USCONEC and EXFO. Used with permission.

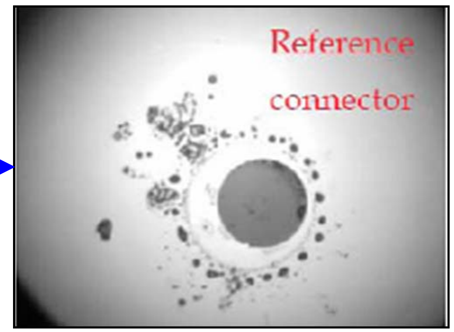
Contaminate Transfers



Clean ferrule



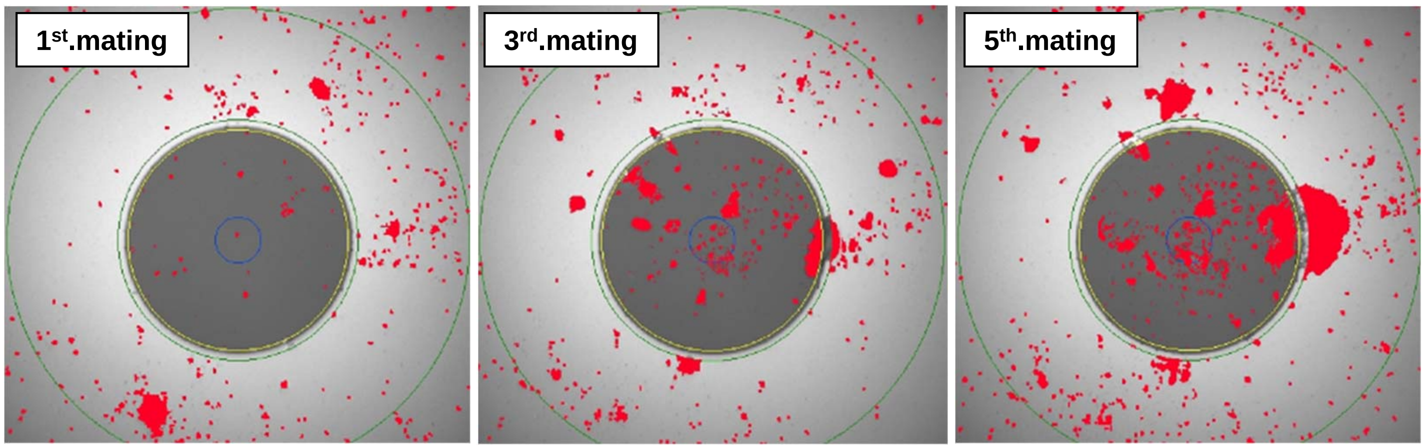
Contaminated ferrule



Contamination transfers from the contaminated to the clean ferrule reducing optical performance.

Information courtesy of USCONEC, Hickory, NC. Used with permission.

And Migrates



Dirt on connectors moves to the middle of the ferrule!!!

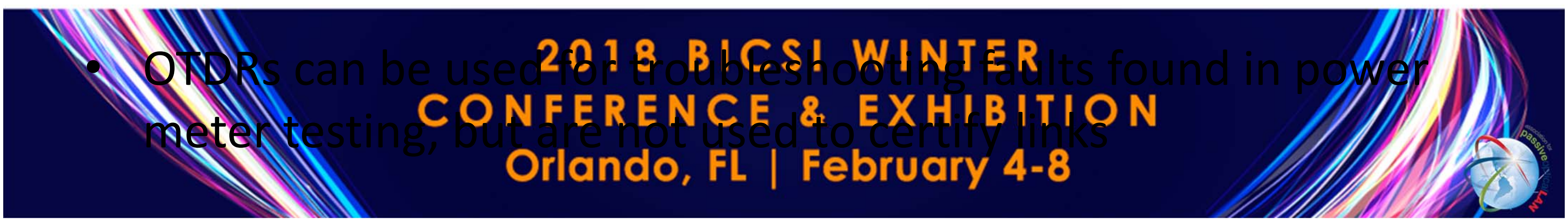
Source: IEC standard committee

Testing

- Key is to verify cable plant performance and connectivity
- Splitters are passive, usually trouble free
- Look for issues at connectors and jumpers
- Be aware if disconnecting before a splitter, a number of users on the channel will lose service

Testing

- Test in one direction. Light source at the OLT and power meter at the ONT locations.
- Ideally use a PON specific Light Source/Power Meter set to test 1310/1490/1550nm
- An alternate option is to use a standard Light Source/Power Meter at 1310nm and 1550nm
- OTDRs can be used for troubleshooting faults found in power meter testing, but are not used to certify links



Testing

- Testing with splitters: 3dB loss for each 1:2 split (excludes connections)
- ANSI/TIA 568C.3 = max .75dB per mated pair
- Singlemode cable = 0.5dB/km
- Bend insensitive cable can be helpful

Optical LAN Link Budget

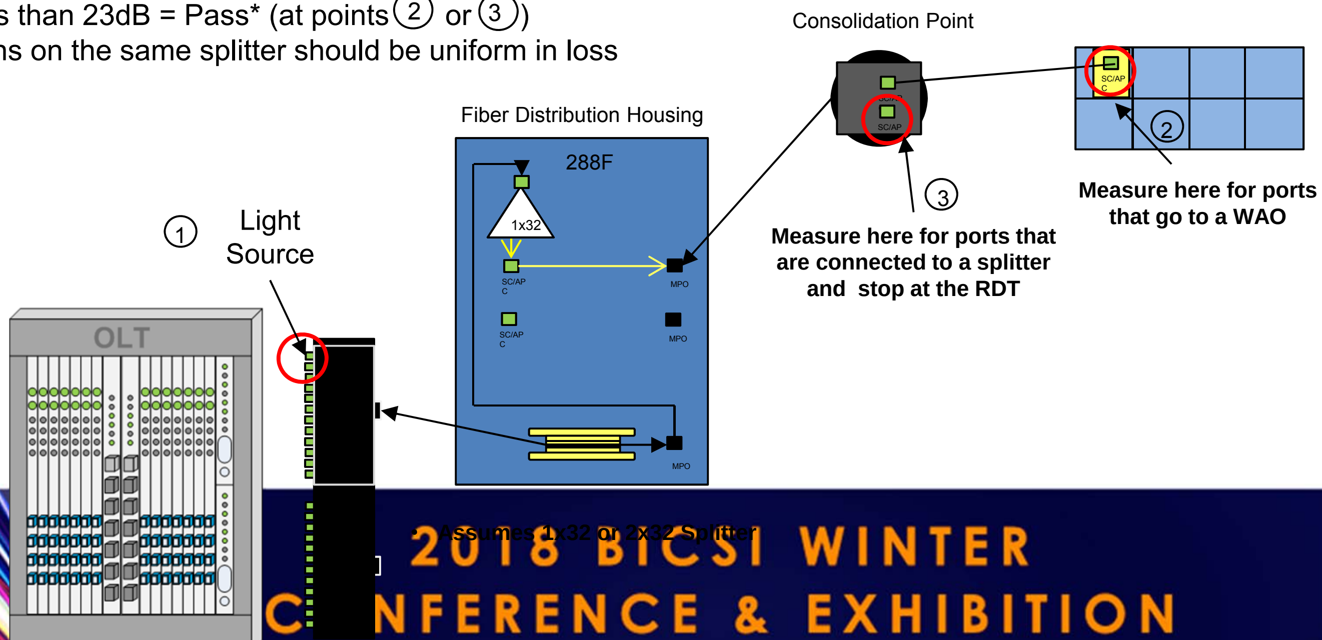
- Max distance limited by attenuation, fiber loss. Splitters and connections contribute.
- Most budgets between 15.5 & 28dB; smaller splits and shorter cables require attenuators

Loss Contributor	GPON Budget
Splitter (1:32) =	16.7dB
Fiber Loss 10Km=	5dB
Conn/Splice Loss=	3.6dB
	25.3dB

Attenuation	Loss (Maximum)	Unit
Optical Loss 1310 nm	0.5	dB/Km
Optical Loss 1490 nm	0.5	dB/Km
Optical Loss 1550 nm	0.5	dB/Km
Splice Loss per unit	0.3	dB
Connector Loss	0.75	dB
1x32 PON Splitter	16.7	dB
1x16 PON Splitter	13.5	dB
1x8 PON Splitter	10.3	dB
1x4 PON Splitter	7.2	dB

Centralized Split Test Layout (Downstream)

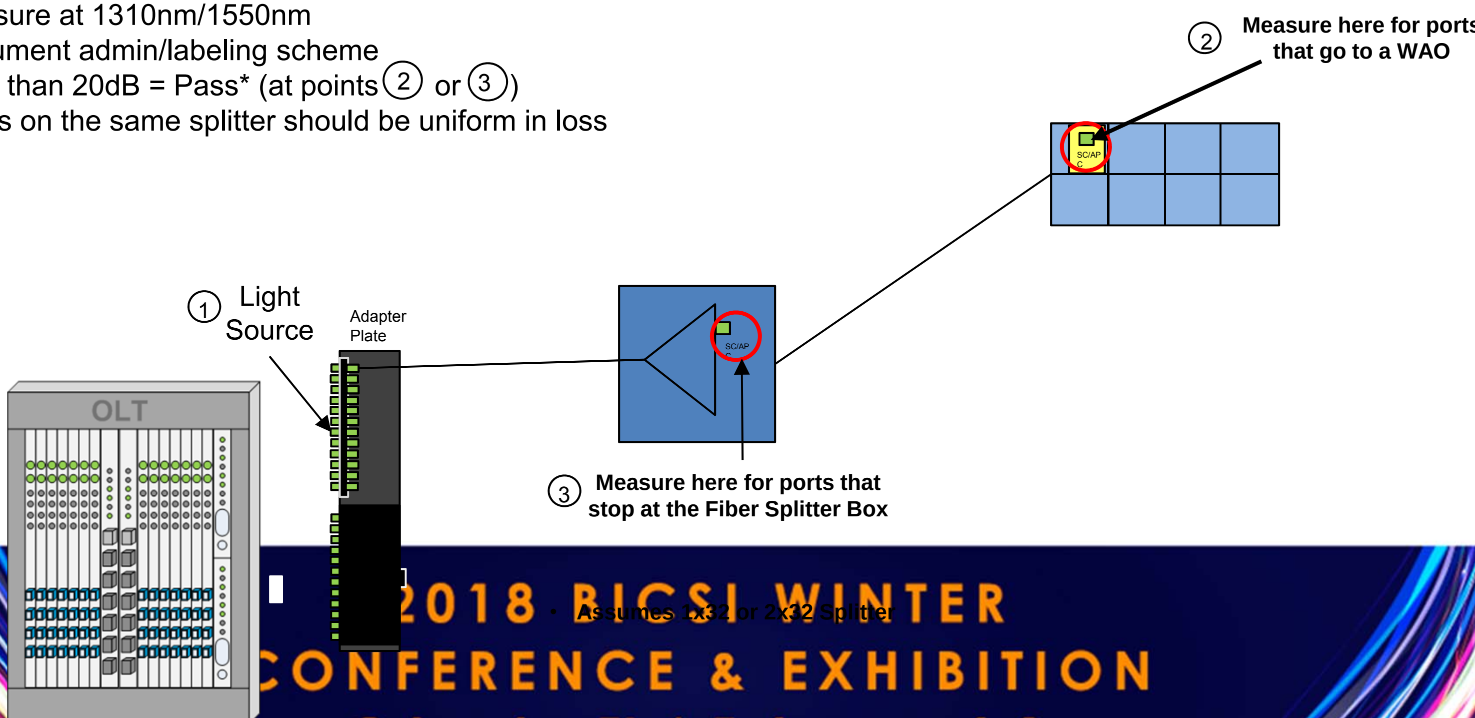
- Measure at 1310nm/1550nm
- Document admin/labeling scheme
- Less than 23dB = Pass* (at points 2 or 3)
- Paths on the same splitter should be uniform in loss



- Assumes 1x32 or 2x32 Splitter

Zone Split Test Layout (Downstream)

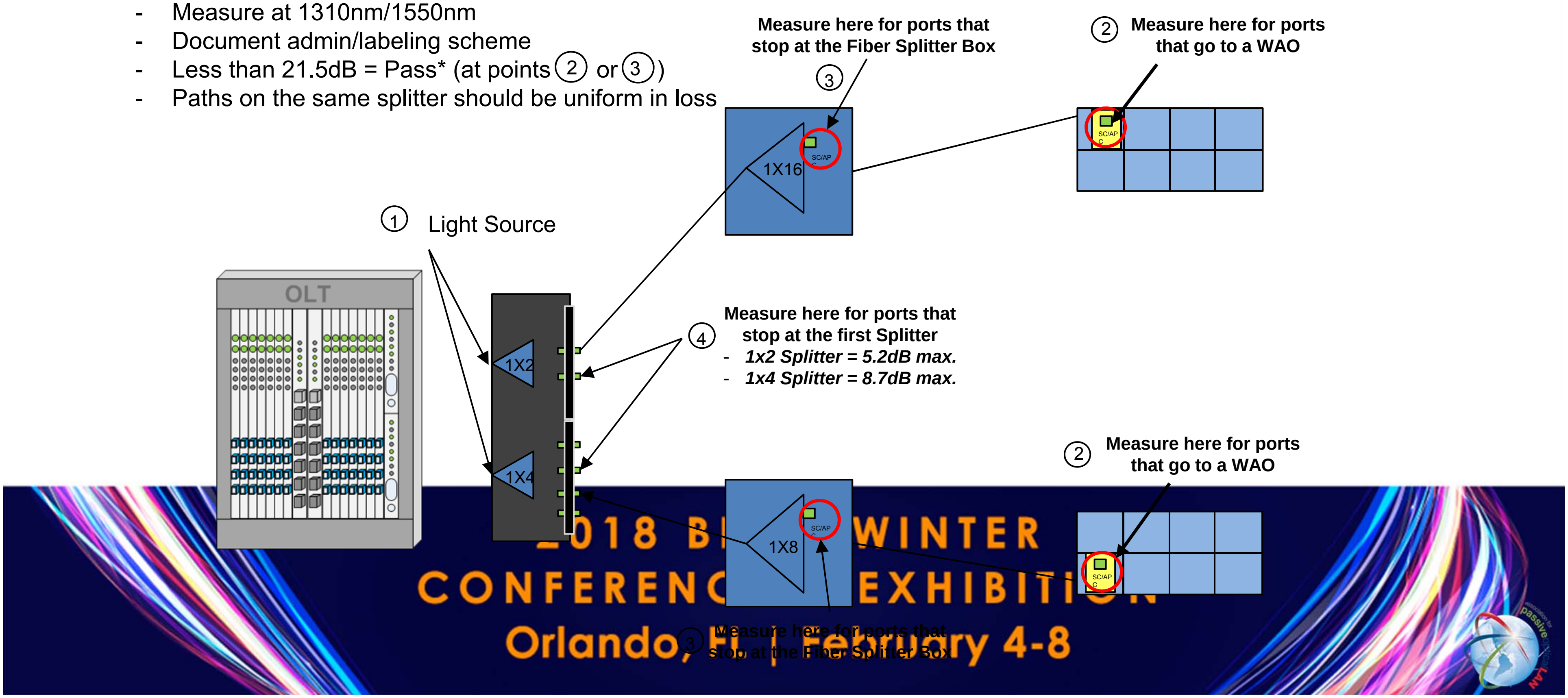
- Measure at 1310nm/1550nm
- Document admin/labeling scheme
- Less than 20dB = Pass* (at points 2 or 3)
- Paths on the same splitter should be uniform in loss



• Assumes 1x32 or 2x32 Splitter

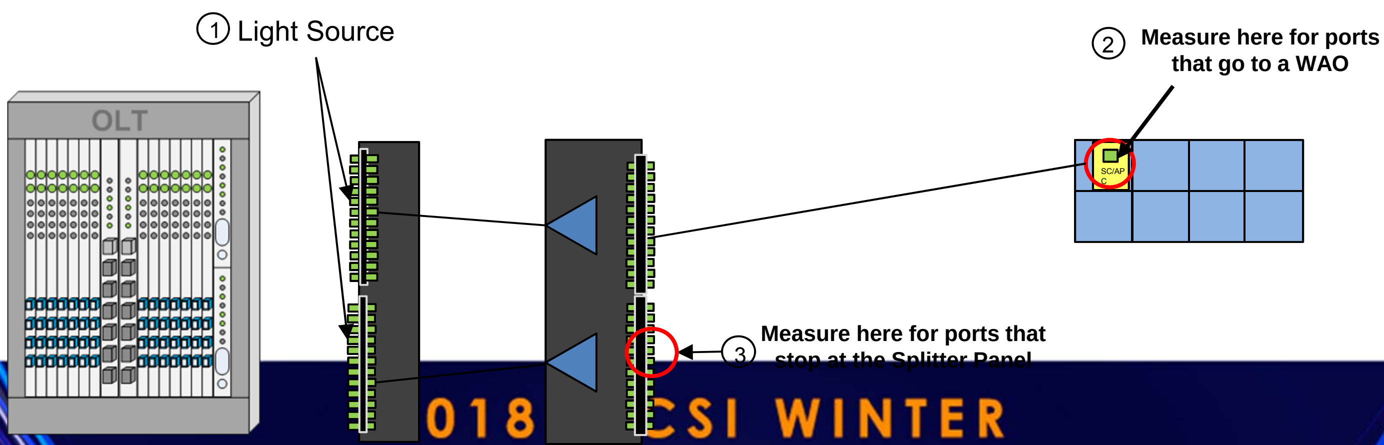
Zone Split (Cascaded) Test Layout (Downstream)

- Measure at 1310nm/1550nm
- Document admin/labeling scheme
- Less than 21.5dB = Pass* (at points 2 or 3)
- Paths on the same splitter should be uniform in loss



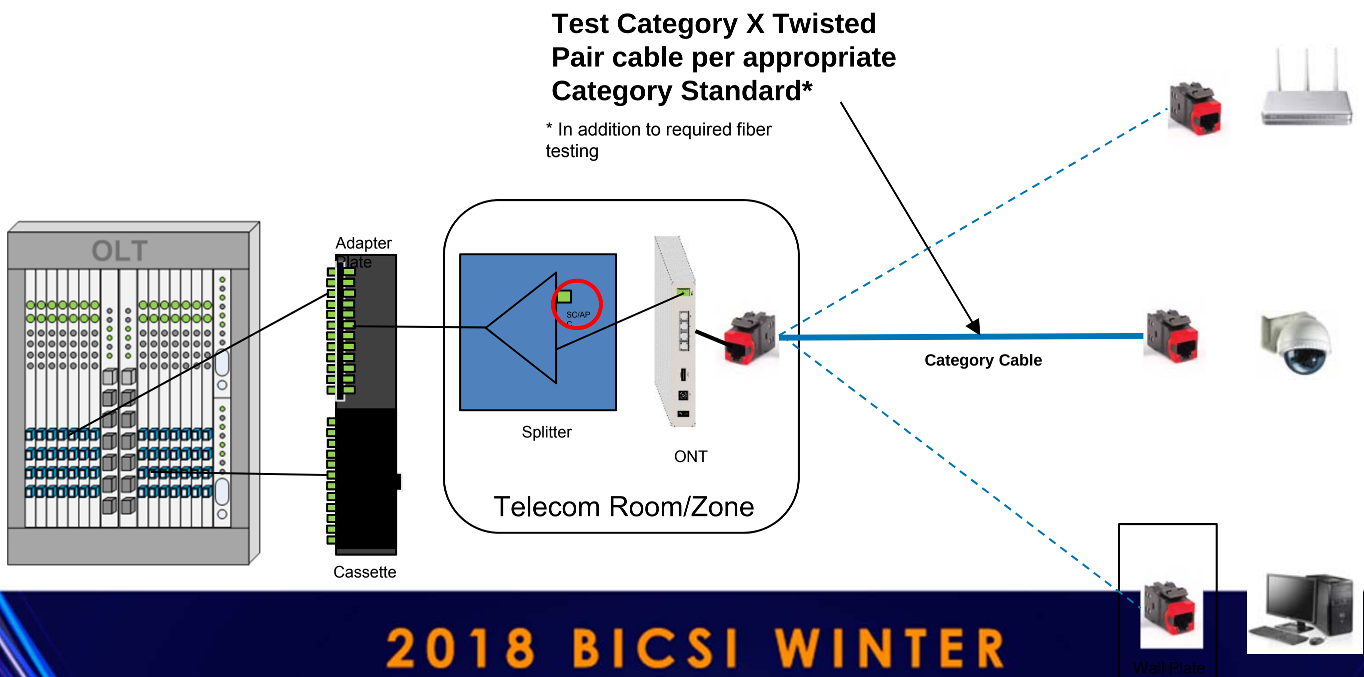
Rack Mount Split Test Layout (Downstream)

- Measure at 1310nm/1550nm
- Document admin/labeling scheme
- Less than 19.75dB = Pass* (at points 2 or 3)
- Paths on the same splitter should be uniform in loss



- Assumes 1x32 or 2x32 Splitter

Hybrid PON/Traditional Test Layout (Downstream/Upstream)



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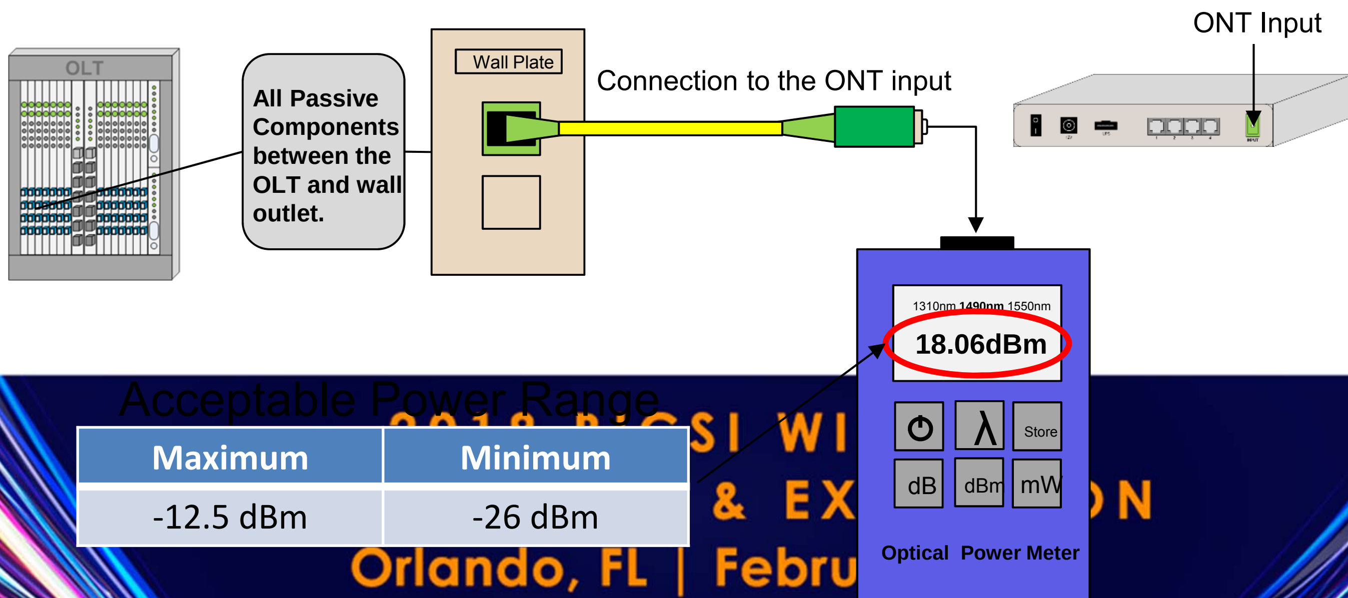
Move, Add, Change (MAC) Testing

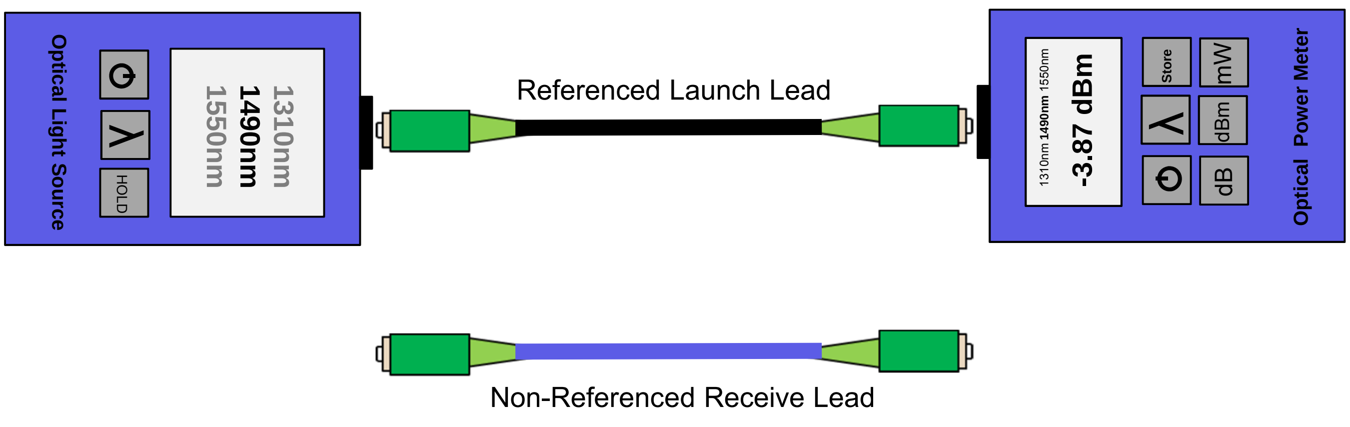
Once the splitter input is connection is made to the OLT, it cannot be disconnected for testing of MACs without disruption to the other users. When a move, add, or change is made on an active PON circuit, verification must be made to ensure that the proper range of power in dBm will be fed to the ONT. There is a minimum and a maximum value that is acceptable per ITU G.984X. This is verified by placing the connector that will connect to the input of the ONT into an Optical Power Meter and measuring the power in dBm to verify that it is between the minimum and maximum level.



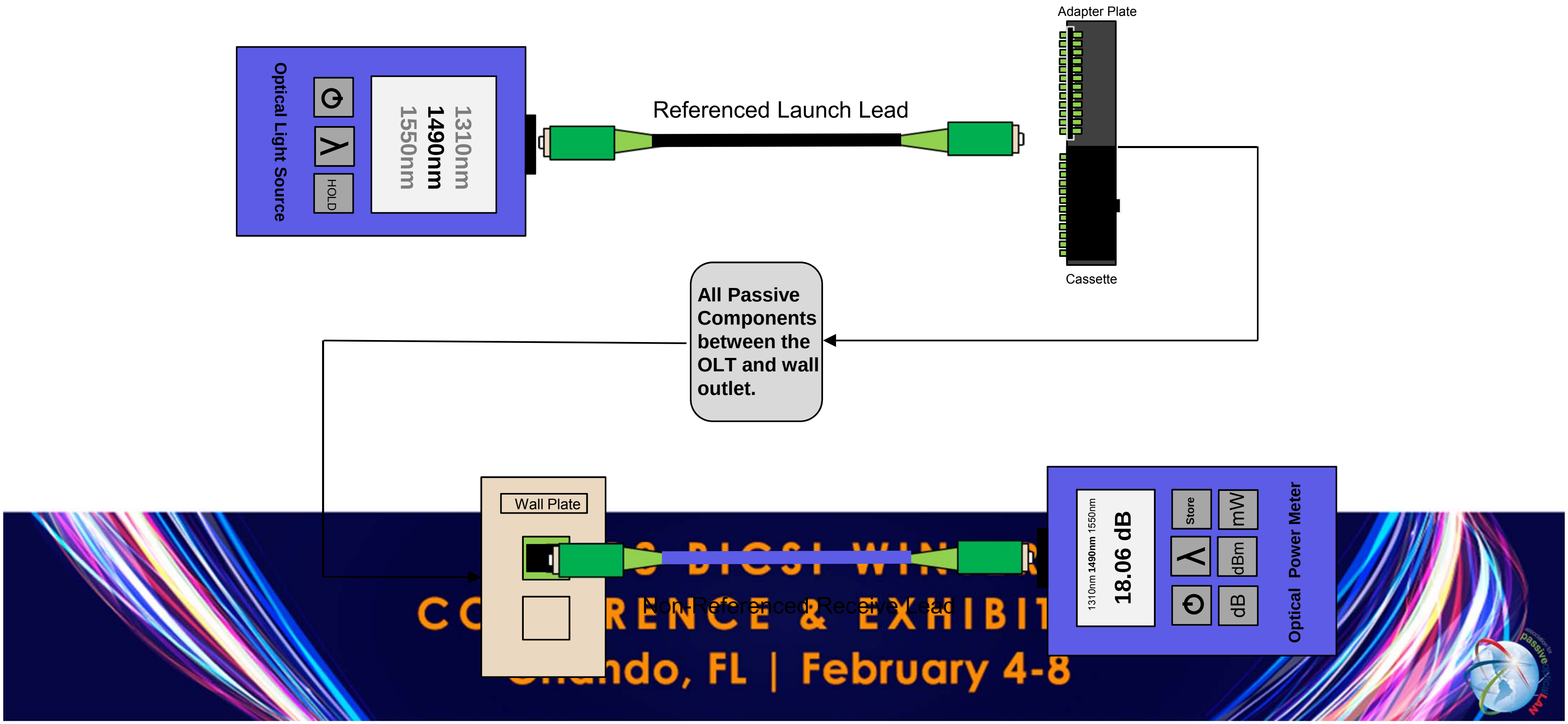
Acceptable Power Range

Maximum	Minimum
-12.5 dBm	-26 dBm

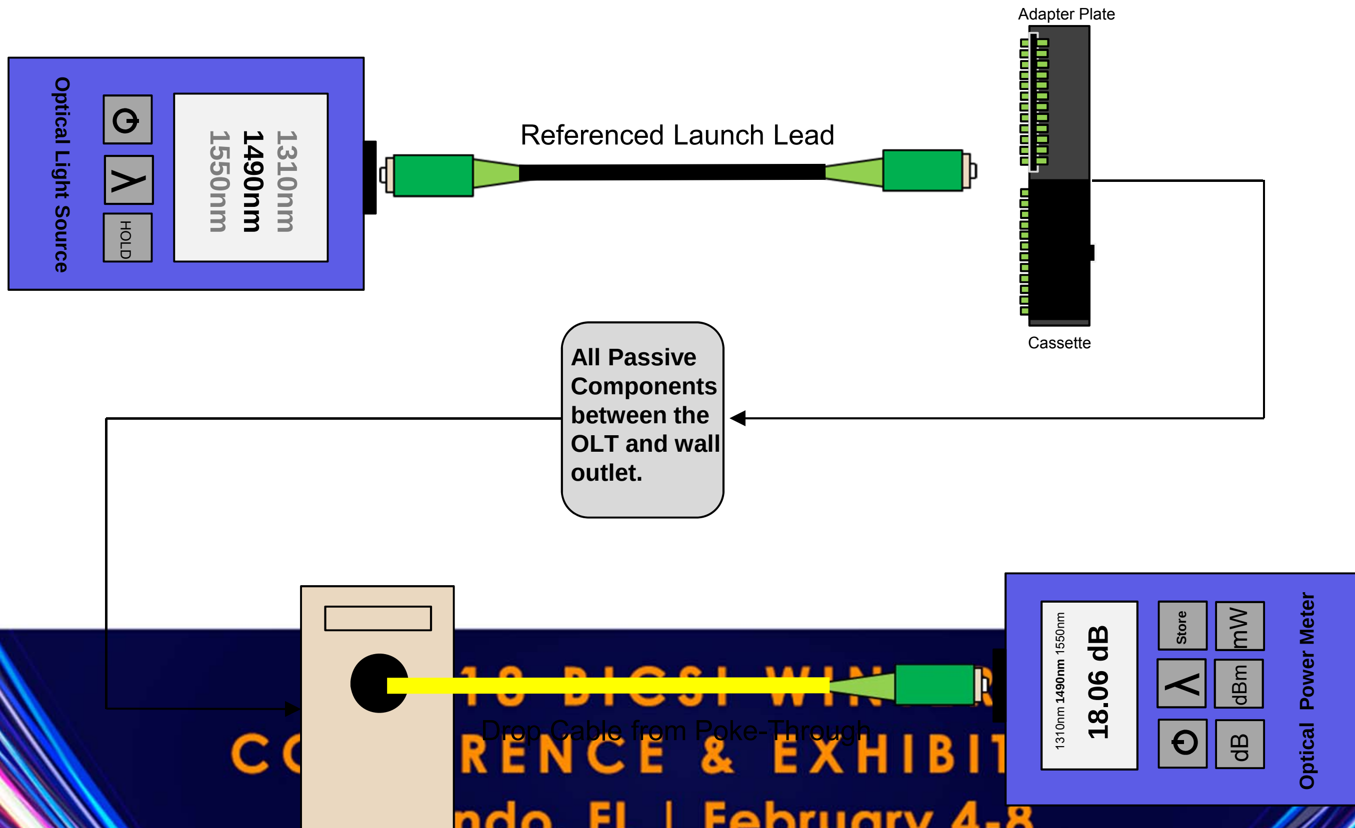
Referencing the meter



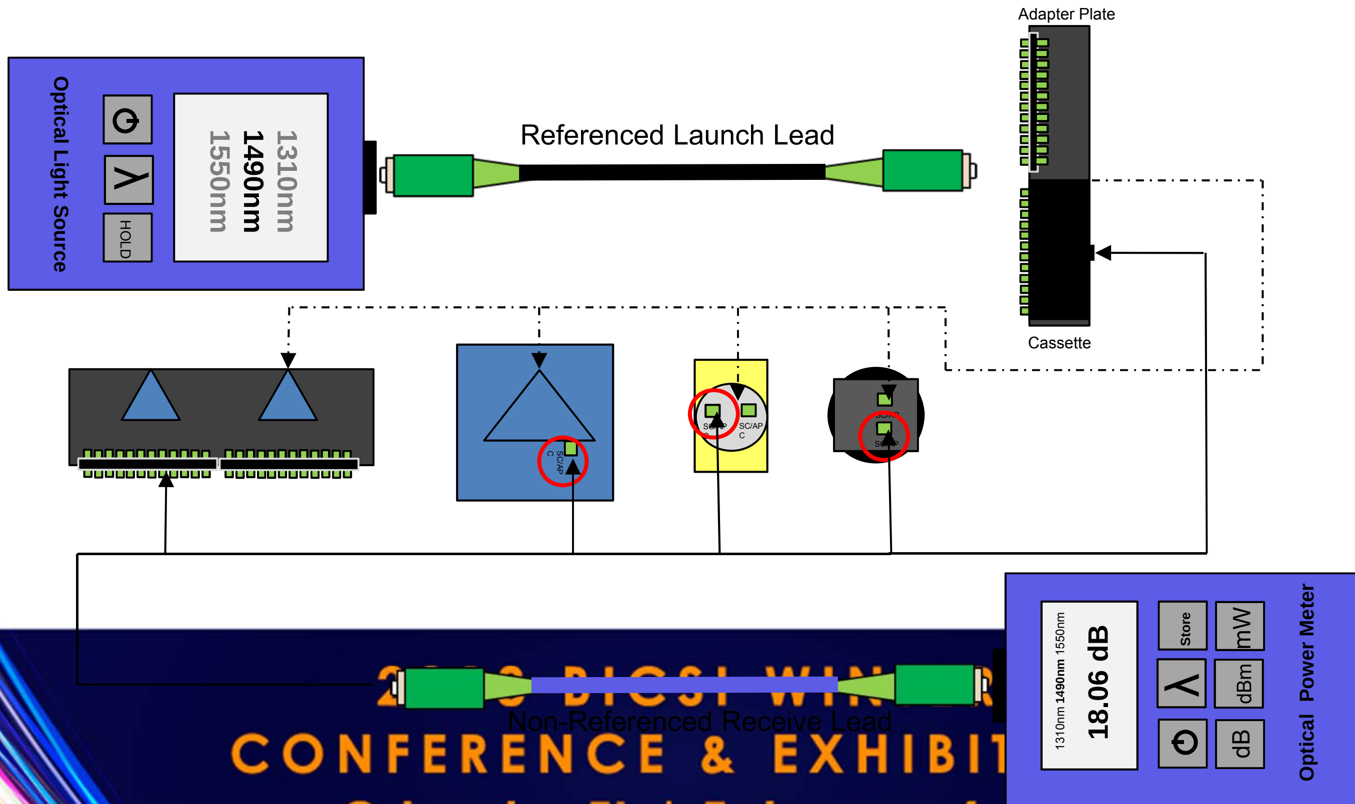
Link Test with WAO



Poke Through



Mid-Point Verification



Knowledge Check

This is the common POL connector

- ✓ A. SC/APC
- B. ST
- C. MT-RJ
- D. FC

POL Networks use this fiber…

A. Multimode
B. Singlemode
C. Unimode
D. OM3

It is important to ensure connector endfaces are clean prior to mating

✓ A. True

B. False

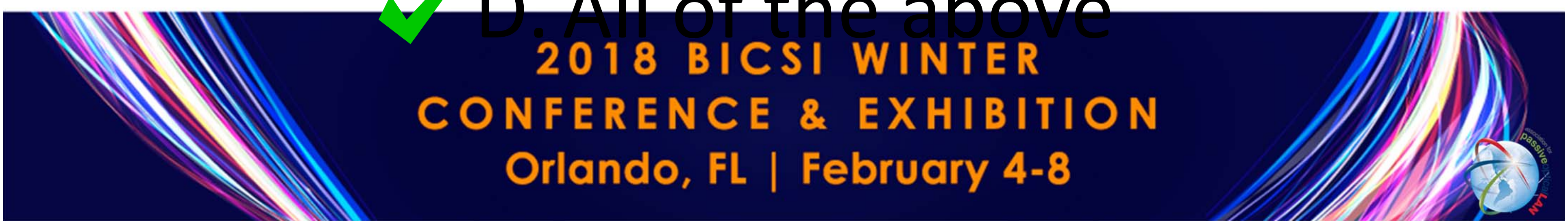
Contaminate on fiber connectors can

A. Transfer

B. Migrate

C. Block light

D. All of the above



You should always use a wet cleaning method to remove contamination

A. True

B. False

A reduction of 3dB of light signal reduces the received power by…

A. 10%

B. Half

C. 12 Volts

When testing a POL with an OTDR, you should test in this direction…

A. Upstream

B. Downstream

C. Sideways

Loss budgets should be determined by advertised "<u>Typical</u>" performance values

A. True

B. False

Questions?

POL Testing Considerations

Mike Watts

Noovis

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Passive Optical LAN Integration & Management

Matt Miller

Associate Vice President, CallisonRTKL

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Agenda

- PON Communications
- ONT Ranging Process
- RF Video Injection
- Centralized Administration
  - Management Server vs CLI
- Templates & Profiles
- VLAN Creation
- Uplink Provisioning
  - Link Aggregation Groups
- ONT Deployment & Discovery
- ONT Provisioning
  - FSAN Type B Protection
- Bandwidth Calculations & Assignment
- Traffic Flow
- Tagging, LLDP, PoE, QoS
- STP & Loop Detection
- Multicast

Objectives

After successfully completing this course, you should be able to:

- Understand the differences between ITU and IEEE PON Standards
- Describe the ONT ranging and provisioning process
- Understand the basic steps for deploying a POL
- Understand the future PON standards

Standards – IEEE vs. ITU

- ITU and IEEE have separate standards for PON
- Both standards use the same passive infrastructure (fiber & splitters)
- The primary difference is the electronics

Popular Standards Comparison

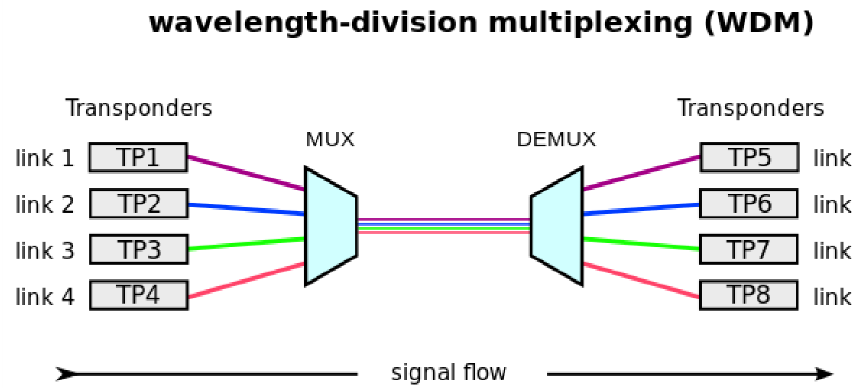
	EPON	GPON
Standard	IEEE 802.3ah	ITU G.984
Speed	1Gbps Symmetrical	2.4Gbps Down / 1.2 Gbps Up
Framing	Ethernet (mostly native)	GEMS Encapsulation
Wavelengths	1490nm/1310nm	1490nm/1310nm
Dynamic Bandwidth	Optional Vendor Specific	Built-in
Encryption	Optional Vendor Specific	AES-128 Downstream

Standards Timeline

IEEE	Year	ITU
	1995	1995 – APON Standard Introduced (155M)
	1996	
	1997	
	1998	
	1999	1999 – BPON Standard Approved (622M/155M)
	2000	
	2001	
	2002	
	2003	2003 – GPON Standard Approved (2.4G/1.2G)
2004 – EPON Standard Approved (1G)	2004	
	2005	
	2006	
	2007	
	2008	
2009 – 10G EPON Standard Approved (10G)	2009	
	2010	2010 – XGPON1 Standard Approved (10G/2.5G)
	2011	
	2012	
2012 – Extended EPON Task Force Formed	2013	2013 – NGPON2 (40G TWDM)
	2014	

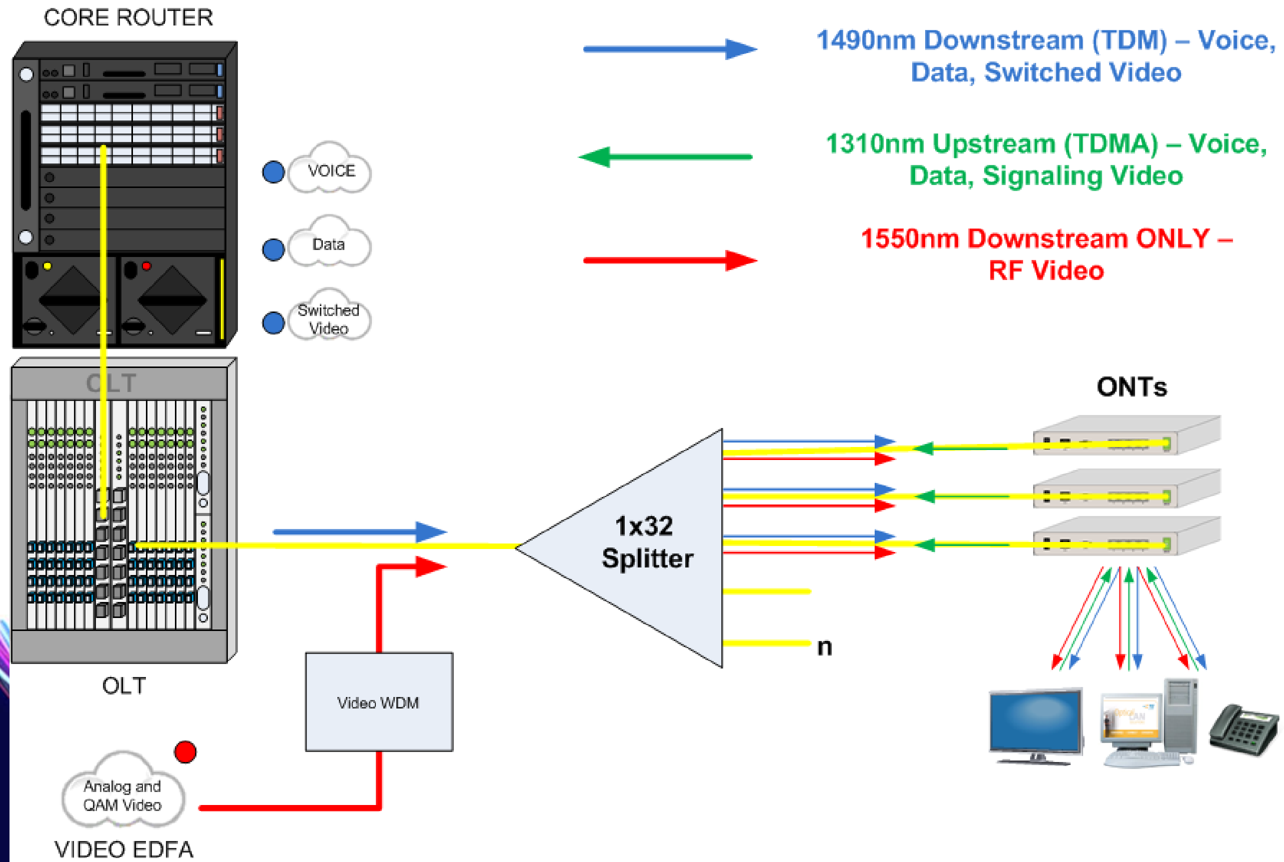
WDM Methodology

- Multiple wavelengths over the same physical strand of glass
- Wavelengths do not interfere with each other
- Allows multiple discreet communications



"WDM operating principle" by Xens - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:WDM_operating_principle.svg#mediaviewer/File:WDM_operating_principle.svg

WDM in PON

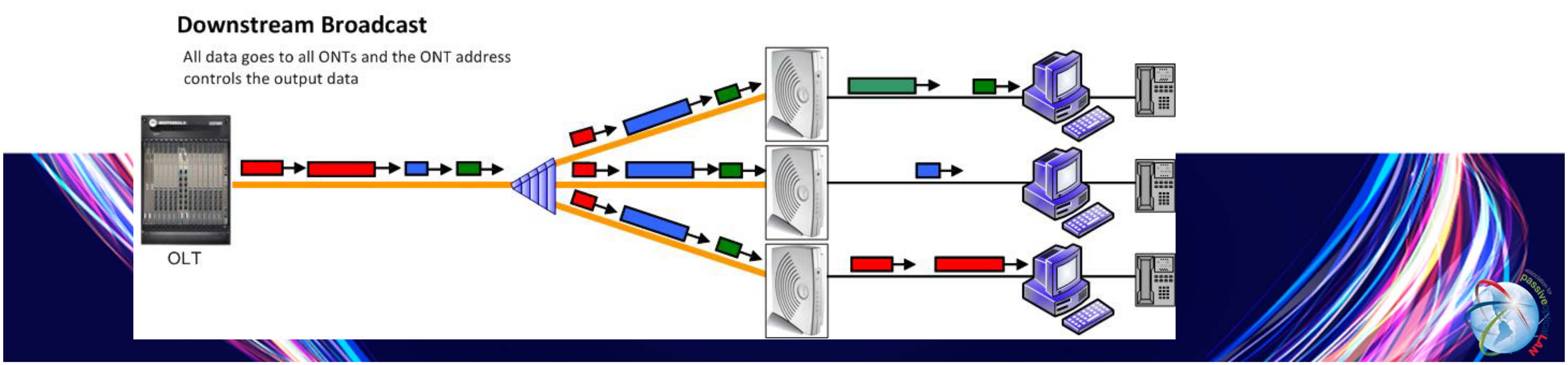

CORE ROUTER
VOICE
Data
Switched Video
1490nm Downstream (TDM) – Voice, Data, Switched Video
1310nm Upstream (TDMA) – Voice, Data, Signaling Video
1550nm Downstream ONLY – RF Video
OLT
ONTs
1x32 Splitter
n
OLT
Video WDM
Analog and QAM Video
VIDEO EDFA

PON Types

- **BPON – (Broadband PON)** is an older version of PON technology which is based on ITU specifications and is characterized by an asymmetrical 622 Mbps downstream and a 155 Mpbs upstream optical line rate. Earlier versions of Verizon's FiOS™ offering in the U.S. are based on BPON but more recent implementations of FiOS use GPON technology.
- **GPON – (Gigabit PON)** is the latest ITU specified PON network and is characterized by a 2.4 Gbps downstream and a 1.25 Gbps upstream optical line rate. The first significant commercial deployments of GPON began in early 2008. Most carrier implementations of GPON are in the U.S. however it is beginning to proliferate in European markets as well.
- **EPON – (Gigabit Ethernet PON or GEPON)** is an IEEE standards based PON system characterized by a symmetrical 1.25 Gbps optical line rate. EPON is the predominant PON solution since it has been commercially available since 2001. GEPON has been primarily deployed in Asian Pacific markets. Recently, 10Gbit/s EPON or 10G-EPON was ratified as an amendment (IEEE 802.3av) in the IEEE 802.3 standard and provides for an asymmetrical 10 Gbps downstream/1 Gbps upstream rate as well as a symmetrical 10 Gbps rate.
- **WDM PON – (Wave Division Multiplexing PON)** is an emerging technology which leverages the optical advances of dense wave division multiplexing (DWDM) to provide a dedicated wavelength to a single ONT. Implementations range from "tunable" optics which must be matched to the ONT's optics to a dynamic optical locking capability which automatically assigns a wavelength to the ONT at the ranging phase. WDM PONs utilize an arrayed waveguide grating (AWG) to multiplex up to 32 wavelengths of light onto a single fiber in the same way a passive optical splitter does. Unlike a typical optical splitter however, an AWG utilizes a phase shift in the optical light to provide an output on each fiber that only receives a certain wavelength of light.

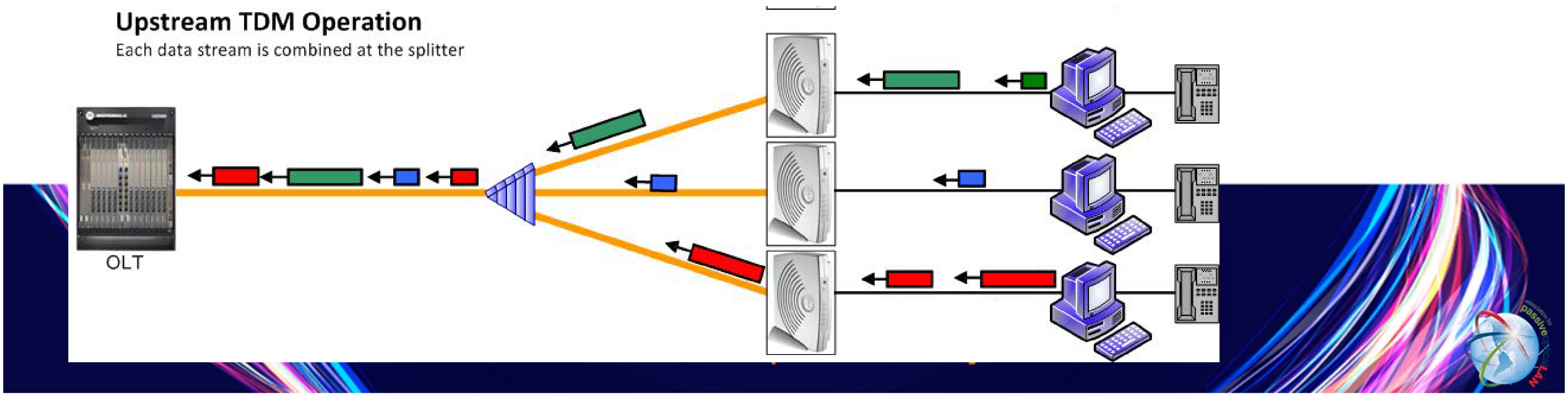
Downstream Communication

The OLT transmits a signal downstream that all of the ONTs receive (point-to-multipoint). In the downstream direction, the information is broadcast on a specific color (wavelength) of laser light. The information is encoded into digital form and given a specific address that matches a specific ONT. The ONT that matches the address receives the signal and forwards the information to the end-user Ethernet port as depicted below.



Upstream Communication

Since many ONTs are placed on the same fiber, each with their own laser, upstream communications must be coordinated so that they do not interfere with each other. This is done by synchronizing the ONTs and requiring each to send information to the OLT (Upstream) in a specific time window (TDM). The upstream laser color is different from the downstream laser, so the upstream signal will not interfere with other ONTs on the PON. Using the WDM technique, ONTs do not interfere with each other; the upstream signals do not interfere with downstream signals, and the upstream and downstream signals can communicate at the same time (full duplex). This mechanism for converged, duplex communication is depicted below.



GPON Bandwidth

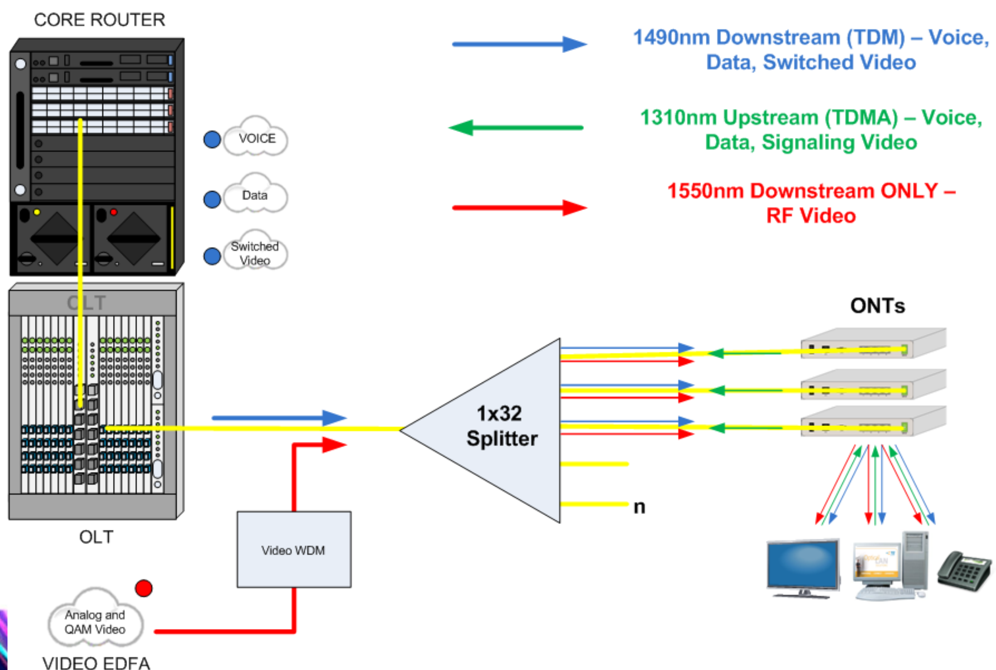
- GPON upstream bandwidth is directly correlated to TDMA time slot
- Each ONT will get a number of timeslots allocated. Each frame is 125µs in length

- Static bandwidth management
- Dynamic Bandwidth Allocation (DBA)
  - DBA is specified in ITU 984.3. This feature is used to grant upstream bandwidth to ONUs based on their demand
  - Used for oversubscribing GPON links

ONT Ranging Process

1. Authorize ONT to be on the PON
2. Determine distance from OLT
3. Setup OMCI communications
4. Assign bandwidth timeslots
5. Upgrade ONT software
6. Assign VLANs, QoS, PoE, security, etc.

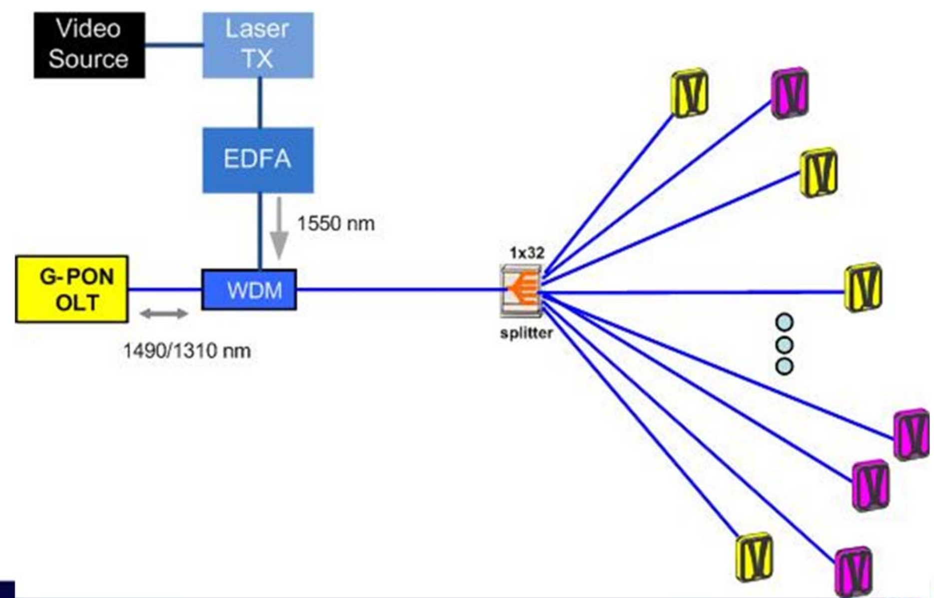
RF Video



Additionally, an analog signal can be injected onto the same PON fiber, using yet another color of light (WDM techniques). This is called an overlay and is generally used to carry broadcast TV to the user's location. As with data and voice propagation, the light is a different color and therefore does not interfere with the other signals being carried on the fiber cable.

RF Video

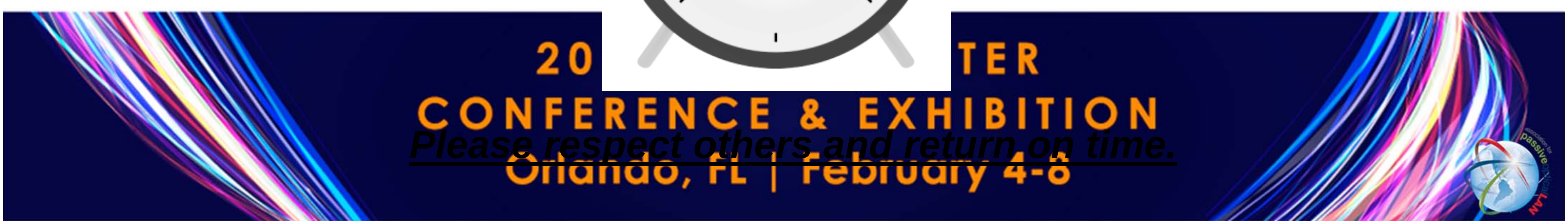
1. Video Source (Coax)
2. Laser Transmitter
3. Erbium Doped Fiber Amplifier (EDFA)
4. WDM



Centralized Administration

- Reduce Operations & Maintenance (O&M) by reduced the amount of equipment managed
  - ONTs are managed by the OLT
- No powered devices in the middle of the network
  - Same location as user
- Co-locate OLT with other IT gear
  - Same location as other gear
- OLT handles activation, administration, and provision
- No administration ports on ONTs

15 Minute Break



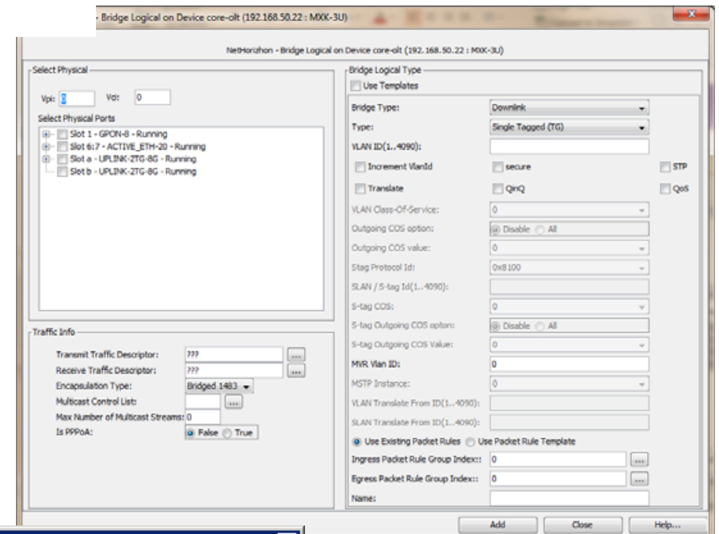
Please respect others and return on time.

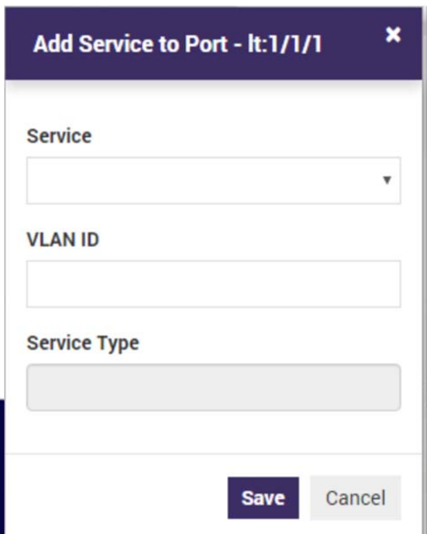
Knowledge Check

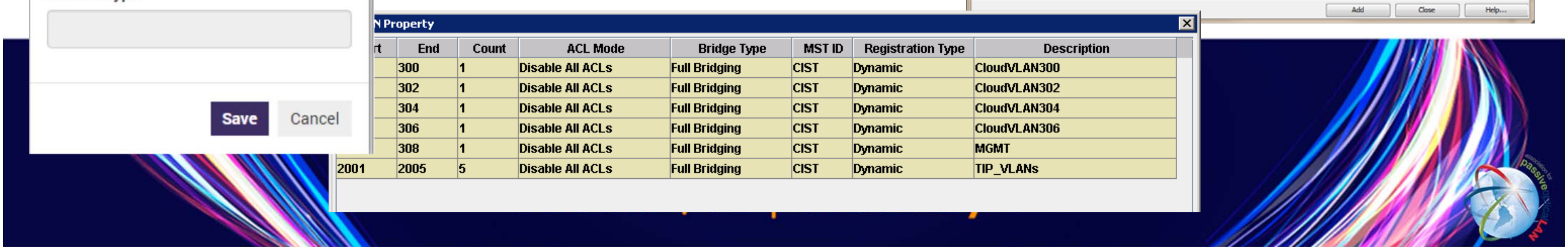
- What is a VLAN?
- Difference between Layers 1, 2 and 3
- Have you provisioned a Cisco/Brocade/Juniper switch?

VLAN Creation

- POL uses VLANs just like Ethernet switches



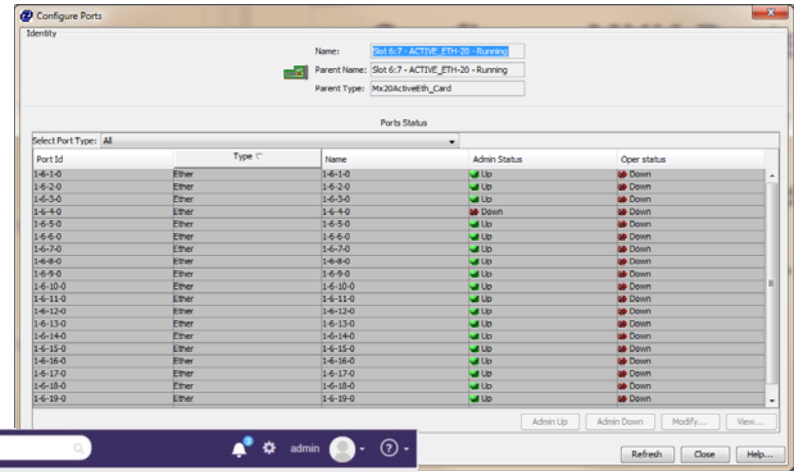


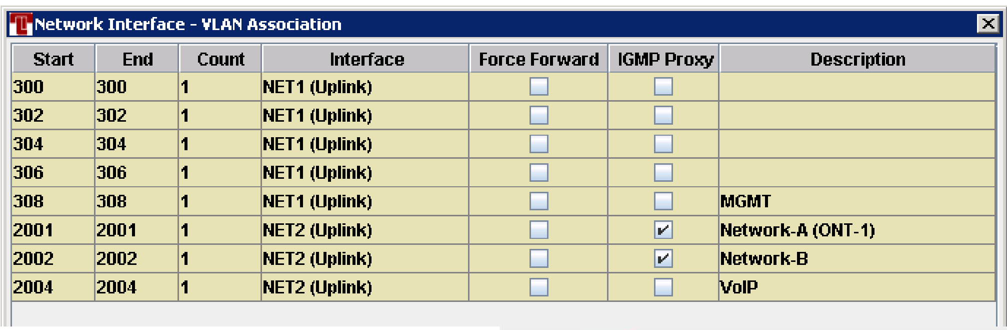


rt	End	Count	ACL Mode	Bridge Type	MST ID	Registration Type	Description
	300	1	Disable All ACLs	Full Bridging	CIST	Dynamic	CloudVLAN300
	302	1	Disable All ACLs	Full Bridging	CIST	Dynamic	CloudVLAN302
	304	1	Disable All ACLs	Full Bridging	CIST	Dynamic	CloudVLAN304
	306	1	Disable All ACLs	Full Bridging	CIST	Dynamic	CloudVLAN306
	308	1	Disable All ACLs	Full Bridging	CIST	Dynamic	MGMT
2001	2005	5	Disable All ACLs	Full Bridging	CIST	Dynamic	TIP_VLANs

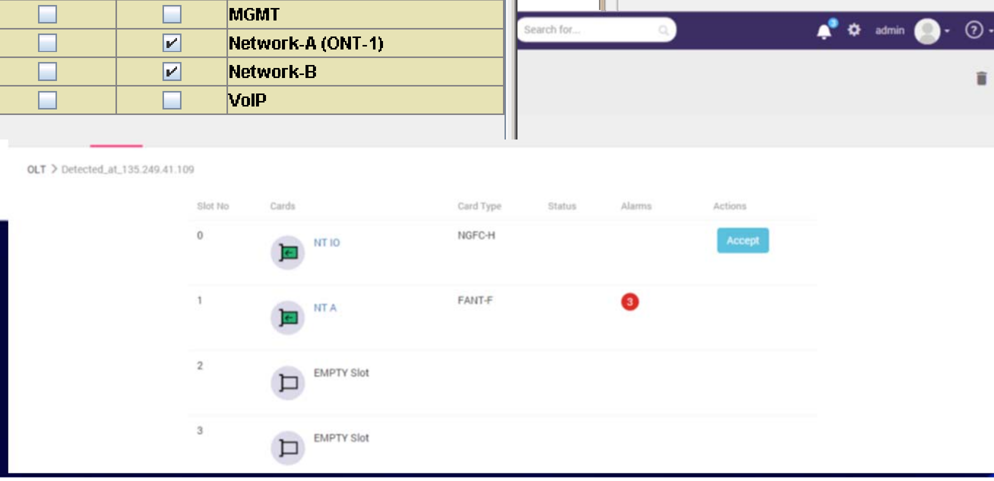
Uplink Provisioning

- Pick 1G and 10G Ethernet ports to connect to the core network



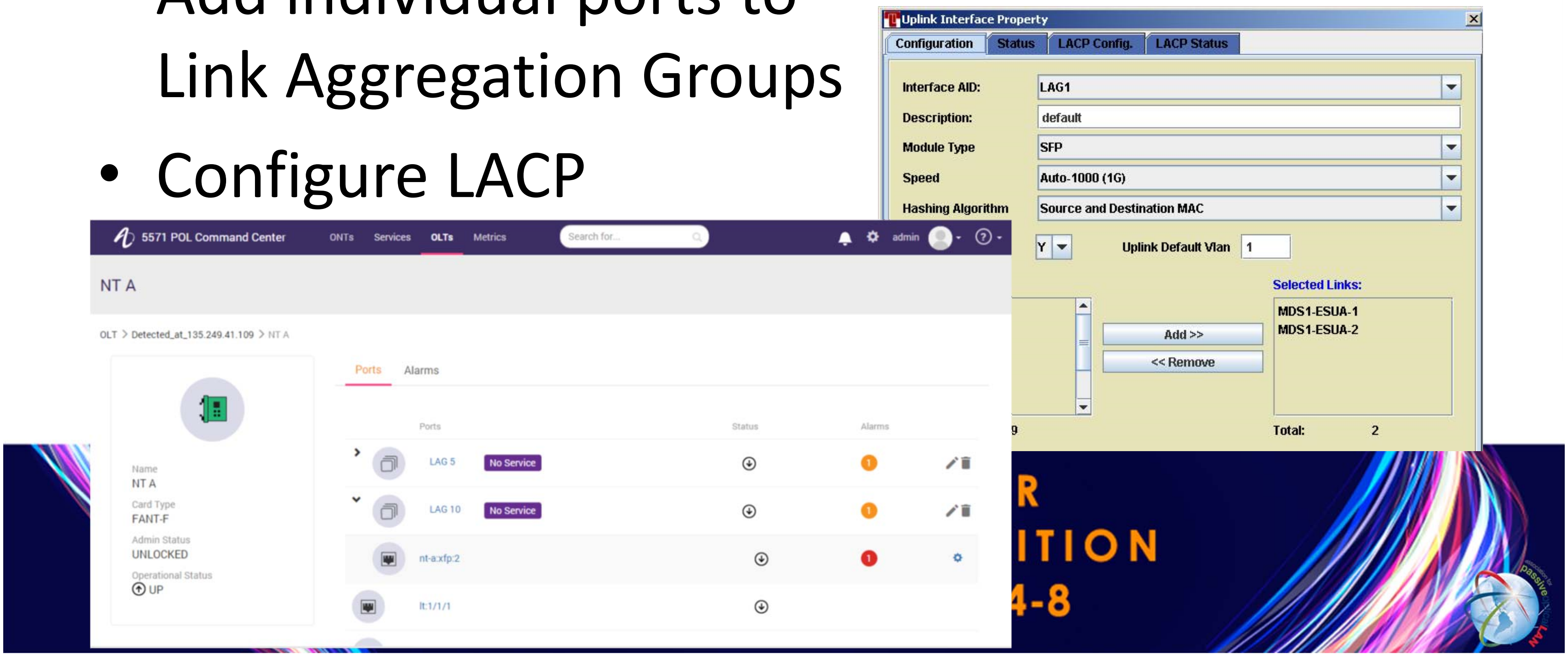

Network Interface - VLAN Association

Start	End	Count	Interface	Force Forward	IGMP Proxy	Description
300	300	1	NET1 (Uplink)	☐	☐	
302	302	1	NET1 (Uplink)	☐	☐	
304	304	1	NET1 (Uplink)	☐	☐	
306	306	1	NET1 (Uplink)	☐	☐	
308	308	1	NET1 (Uplink)	☐	☐	MGMT
2001	2001	1	NET2 (Uplink)	☐	☑	Network-A (ONT-1)
2002	2002	1	NET2 (Uplink)	☐	☑	Network-B
2004	2004	1	NET2 (Uplink)	☐	☐	VoIP



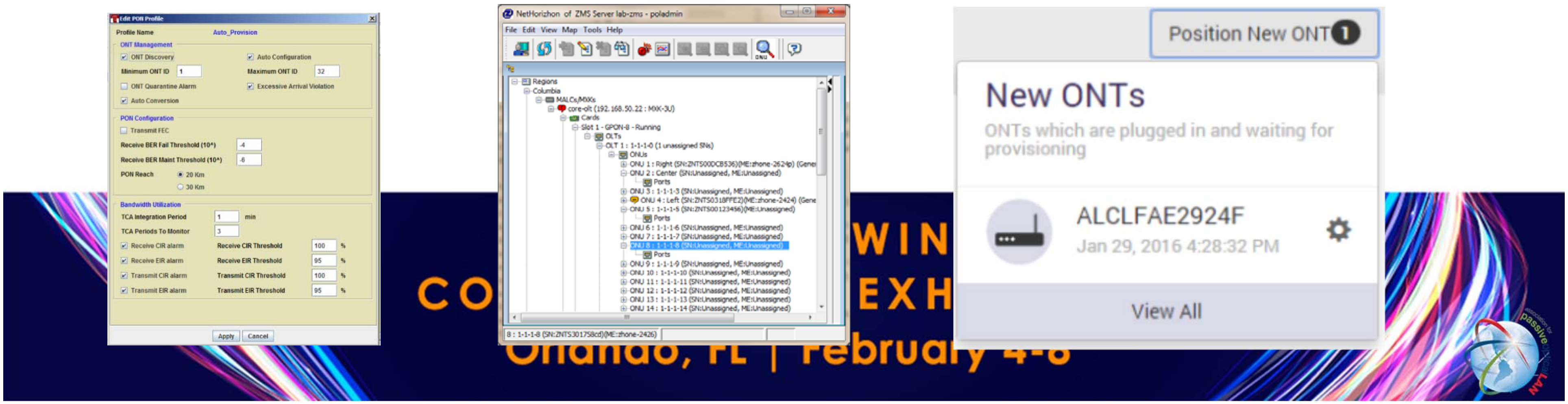
Uplink LAGs

- Add individual ports to Link Aggregation Groups
- Configure LACP



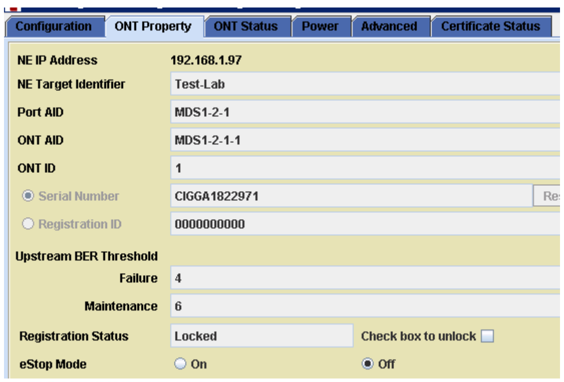
ONT Discovery

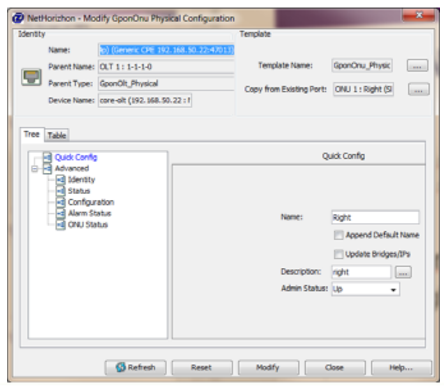
- ONTs will notify the OLT when they are connected
- Administrator determines next steps



ONT Ranging

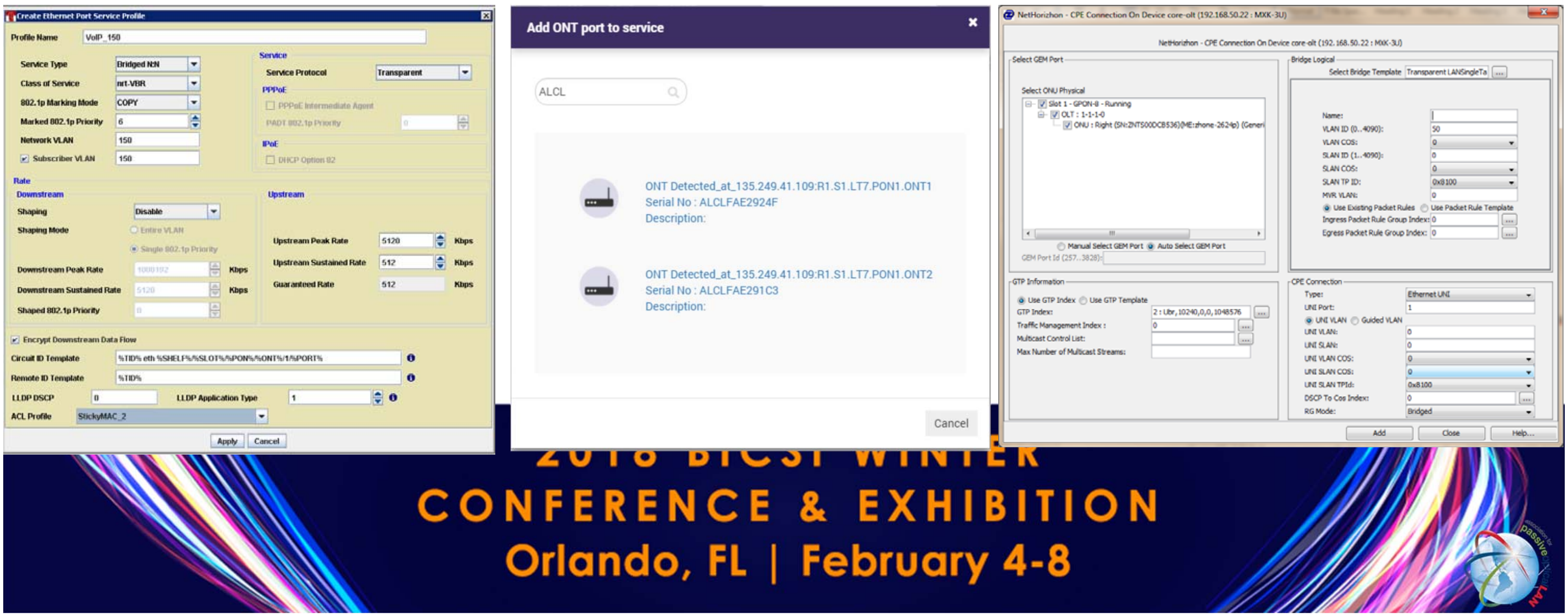
- Know your ONT locations before they are deployed
- Assign a name and location as they are ranged





ONT Provisioning

- Assign VLANs once ONTs are ranged



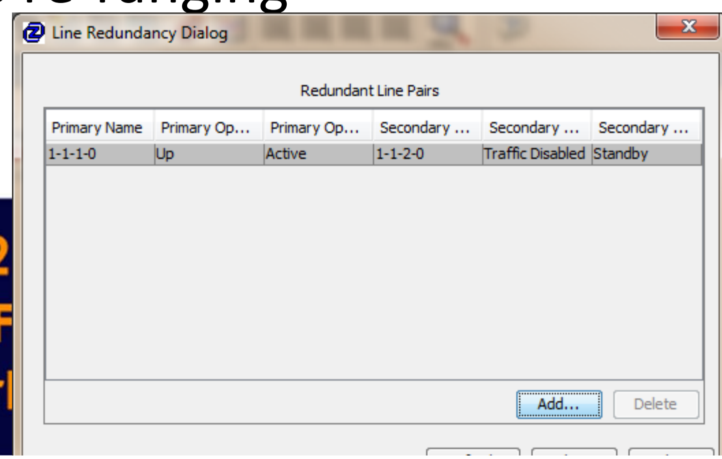
Optical Levels

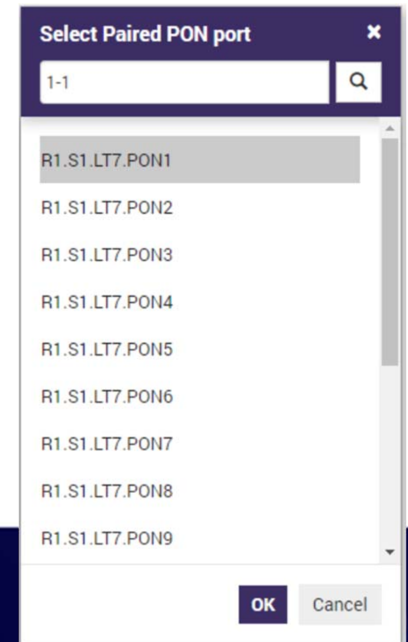
- OLTs and ONTs will report optical transmit and receive levels
- Provides basic indication of connection problems
- Not intended to replace cable plant certification

Type-B Protection

- Provides sub-80ms switchover protection between PON ports on same OLT
- Redundant OLTs an option
- Switchover between OLTs

  sometimes requires re-ranging



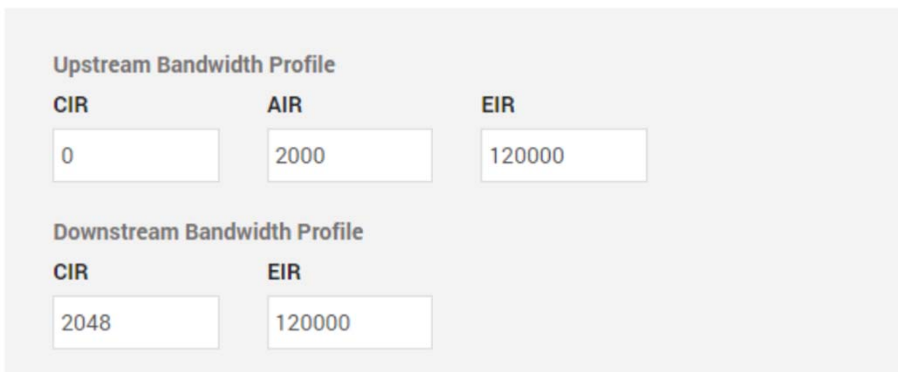


OMCI

- OLTs communicate with ONTs using ONT Management and Control Interface (OMCI)
- OMCI is part of the GPON standard and operating outside of GEM Ports
- OMCI is established after ONT is ranged

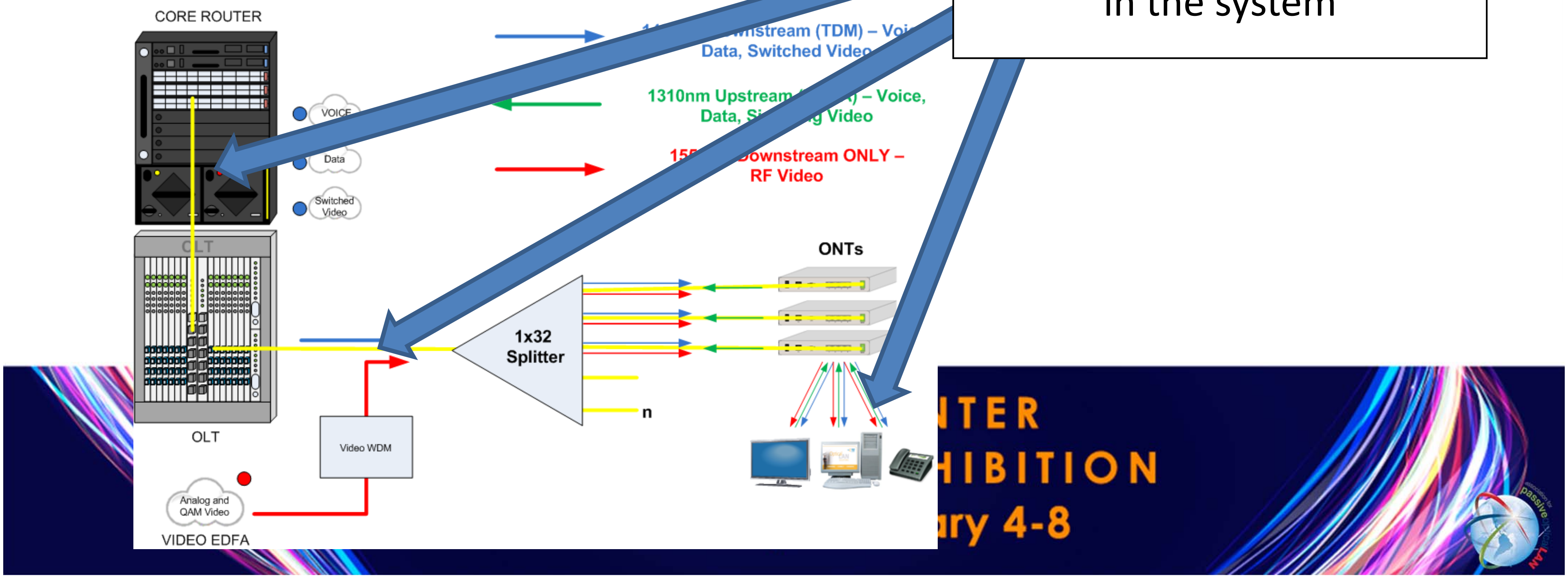
Bandwidth Assignment

- Bandwidth management is built-in to the GPON standard
- Required during provisioning



Bandwidth Management

Committed rates cannot exceed capacity of any link in the system

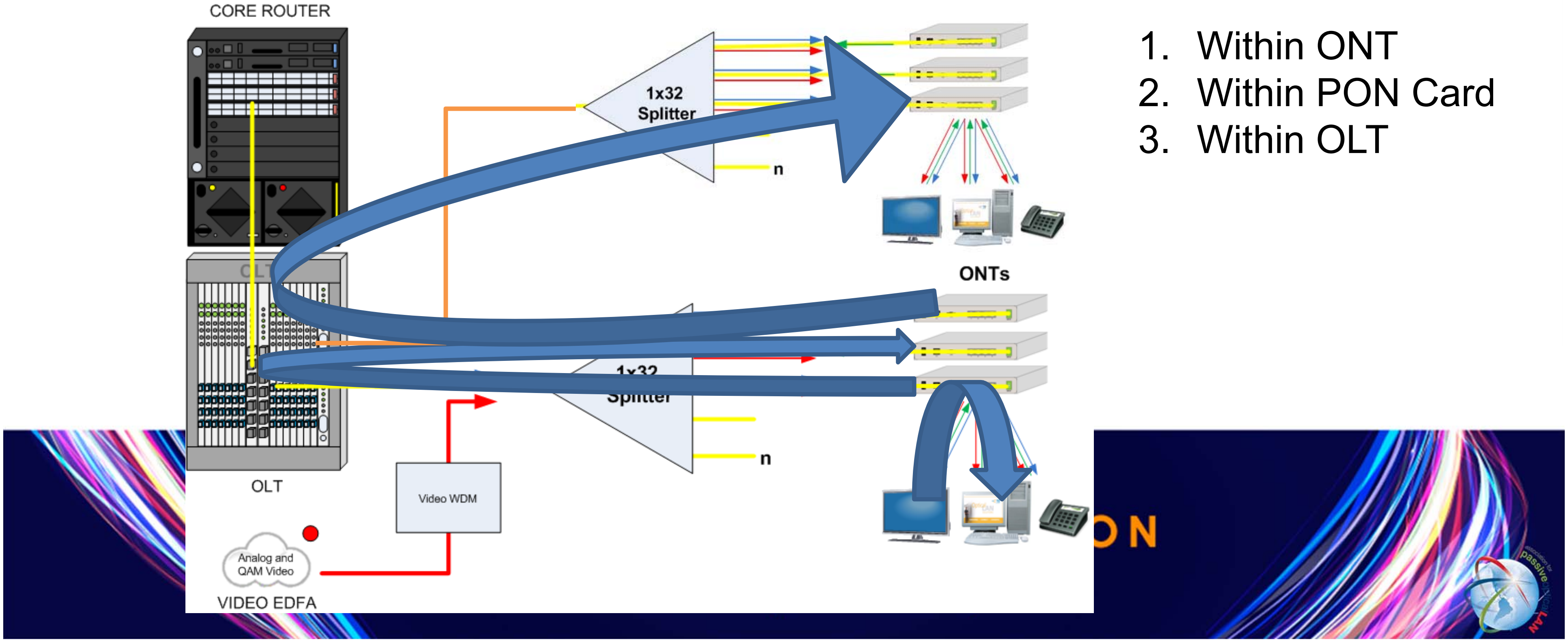


Upstream Granting

- The “Grant” is the permission sent from the OLT to the ONT to:
  - Allow the ONT to transmit traffic in its assigned timeslot on the Upstream data train
  - Control the flow of Upstream traffic from the ONTs to the OLT so collisions of traffic from different ONTs on the PON do not occur

Traffic Flow

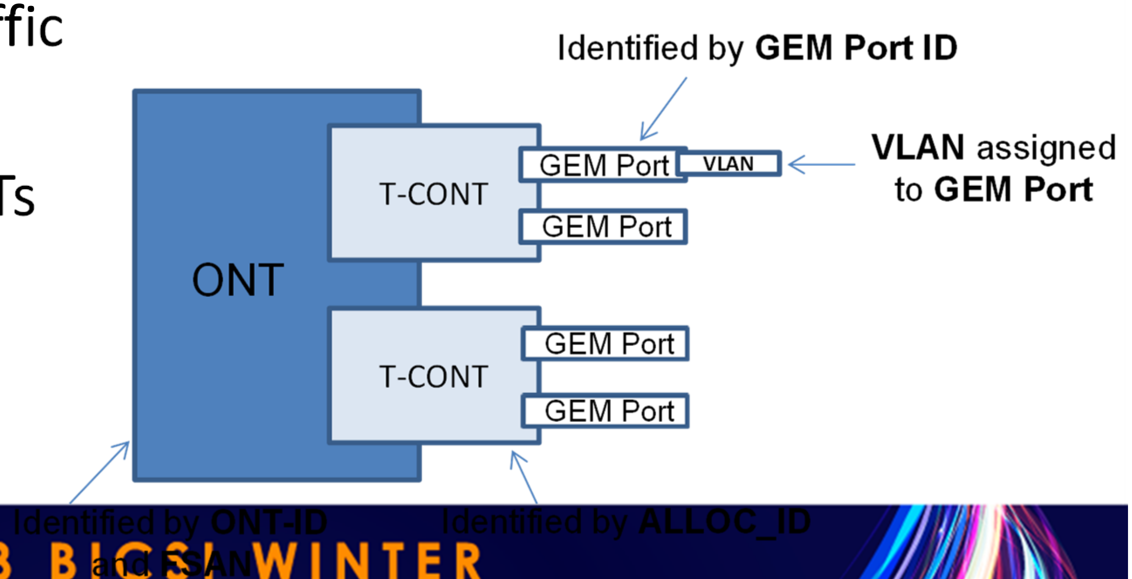
Internal switching separates POL from carrier PON vendors



1. Within ONT
2. Within PON Card
3. Within OLT

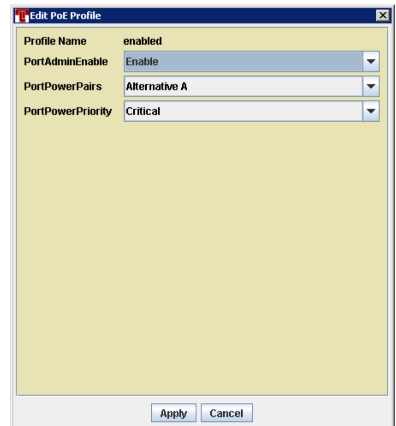
GPON Encapsulation

- VLANs mapped to GEM Ports
- GEM Ports assigned to traffic containers
- GEM Ports mapped to ONTs



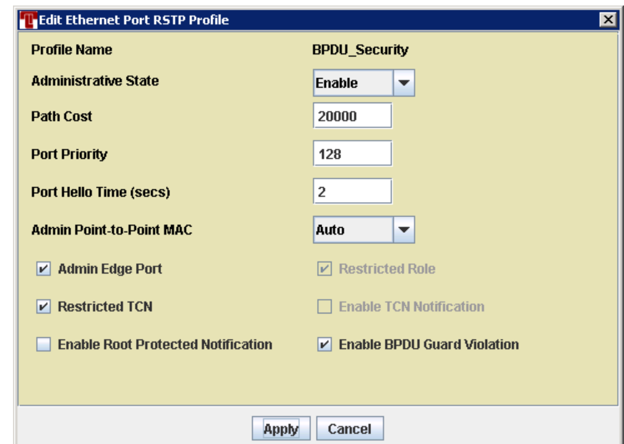
Tagging, LLDP, PoE, QoS

- Tag VLANs from ONT
- Deliver power
- Configure connected devices with LLDP
- Customize QoS



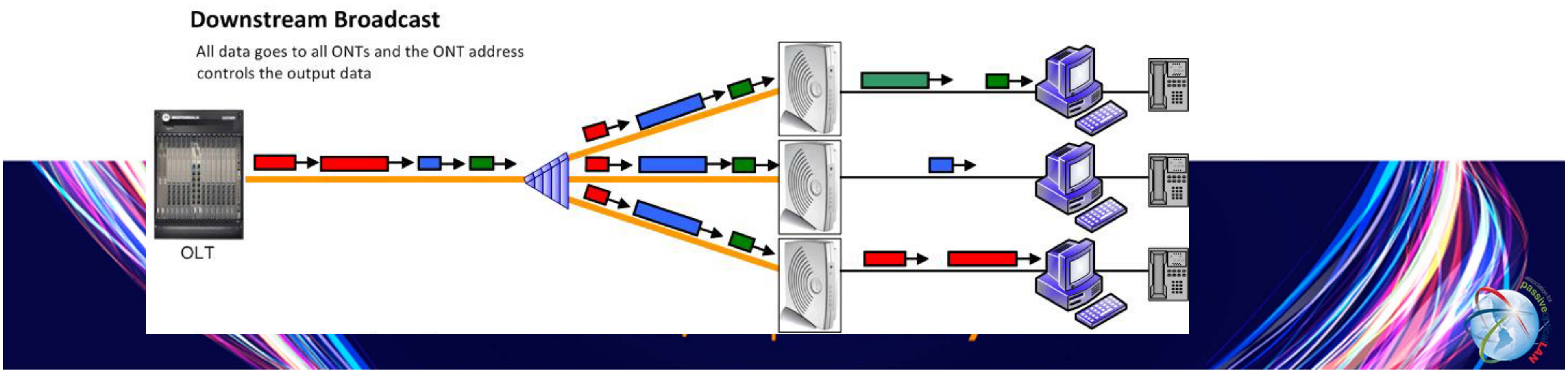
STP & Loop Detection

- Full STP is not required in POL networks
- Loop detection is important



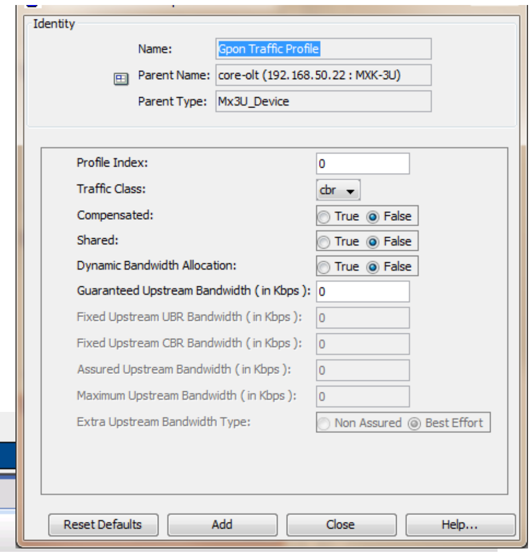
Multicast

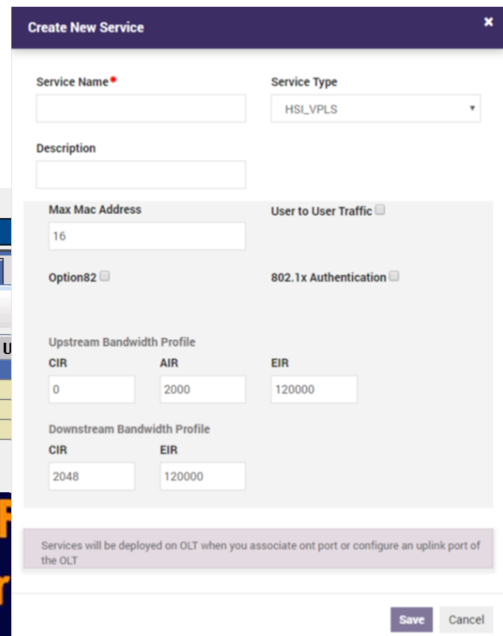
- Multicast compliments PON topology
- OLTs and ONTs feature IGMP snooping
- Specific multicast VLAN required

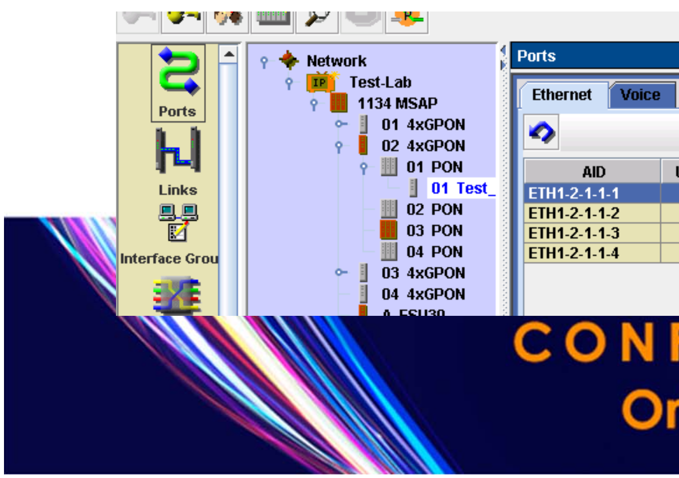


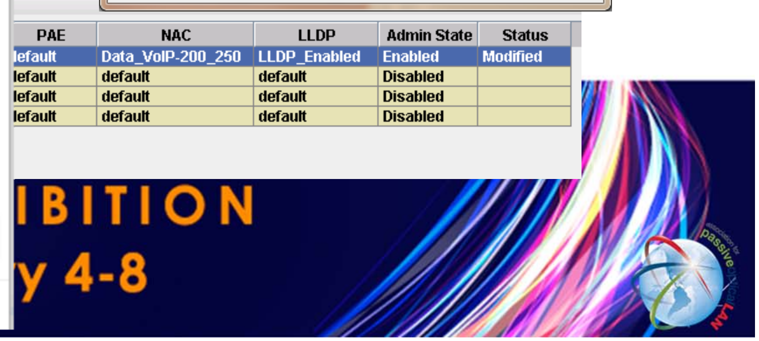
Templates & Profiles

- Templates and profiles allow admins to create common settings



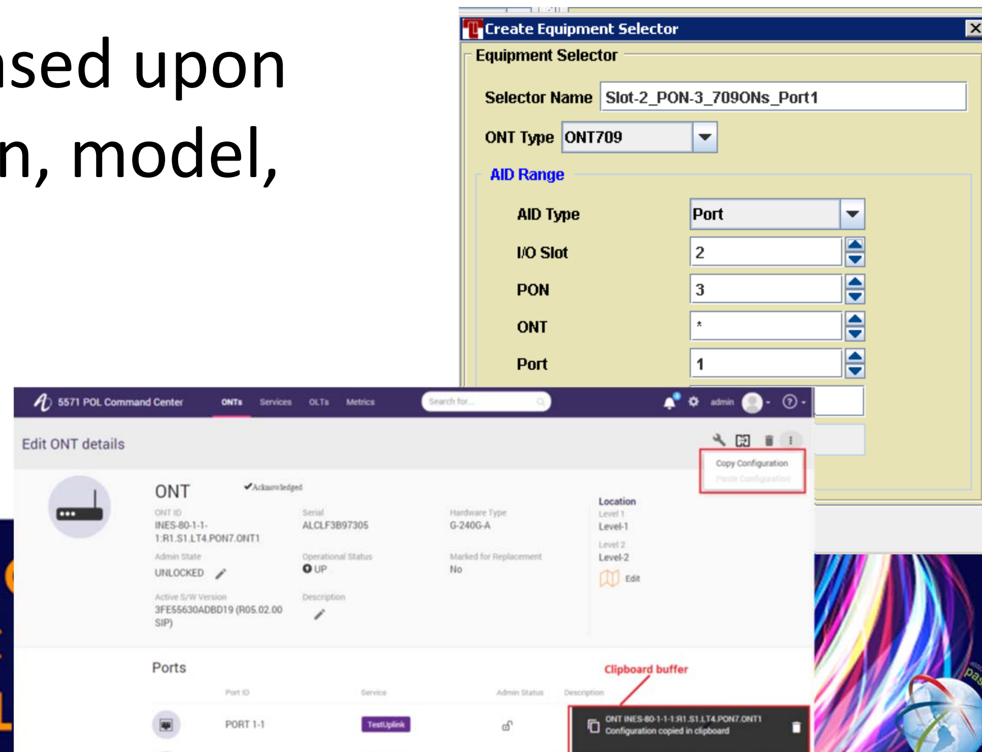


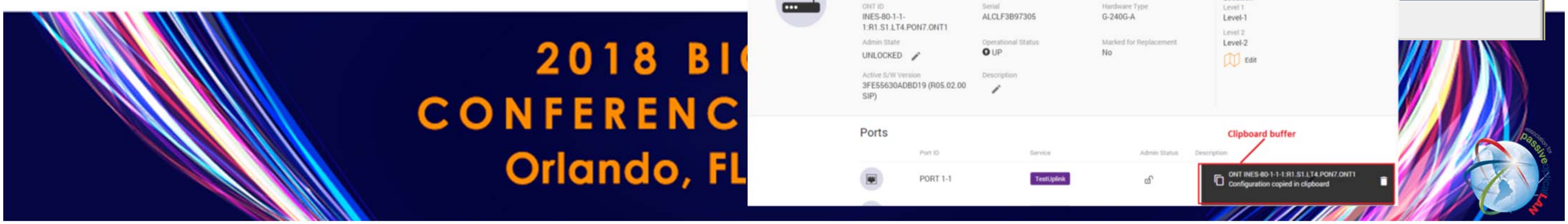




Rules & Auto-Port Provisioning

- Auto-provision ONTs upon detection
- Set rules or selectors based upon ONT properties (location, model, etc.)
- Copy Configurations





Converging Standards

- IEEE and ITU working to converge standards in future generations
- 10G EPON and XGPON use same PHYs

Future Standards

- EPON/GPON Networks can co-exist on the same fiber & splitters as 10G EPON/XGPON Networks
- 10G EPON and XGPON use same PHYs
- IEEE and ITU working to converge standards in future generations
- Next standards may combine multiple wavelengths in each direction for additional bandwidth

Complimentary Wavelengths

<u>EPON/GPON</u>

1490nm Down / 1310nm Up

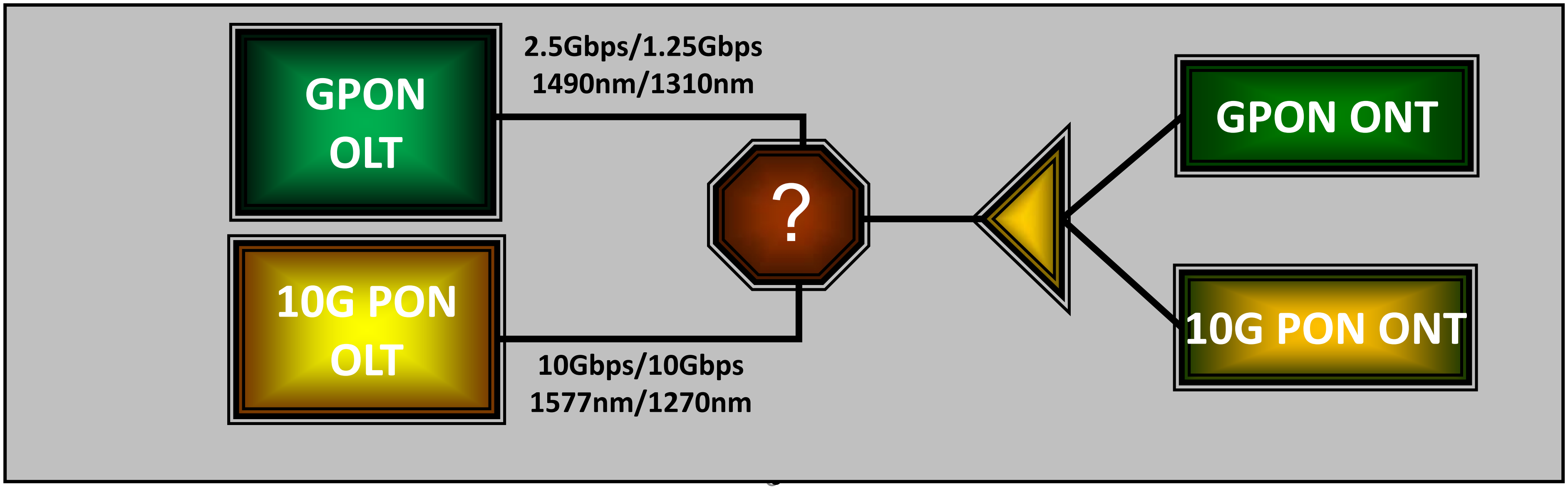
<u>10G EPON/XGPON</u>

1577nm Down / 1270nm Up

<u>RF Video</u>

1550nm Down

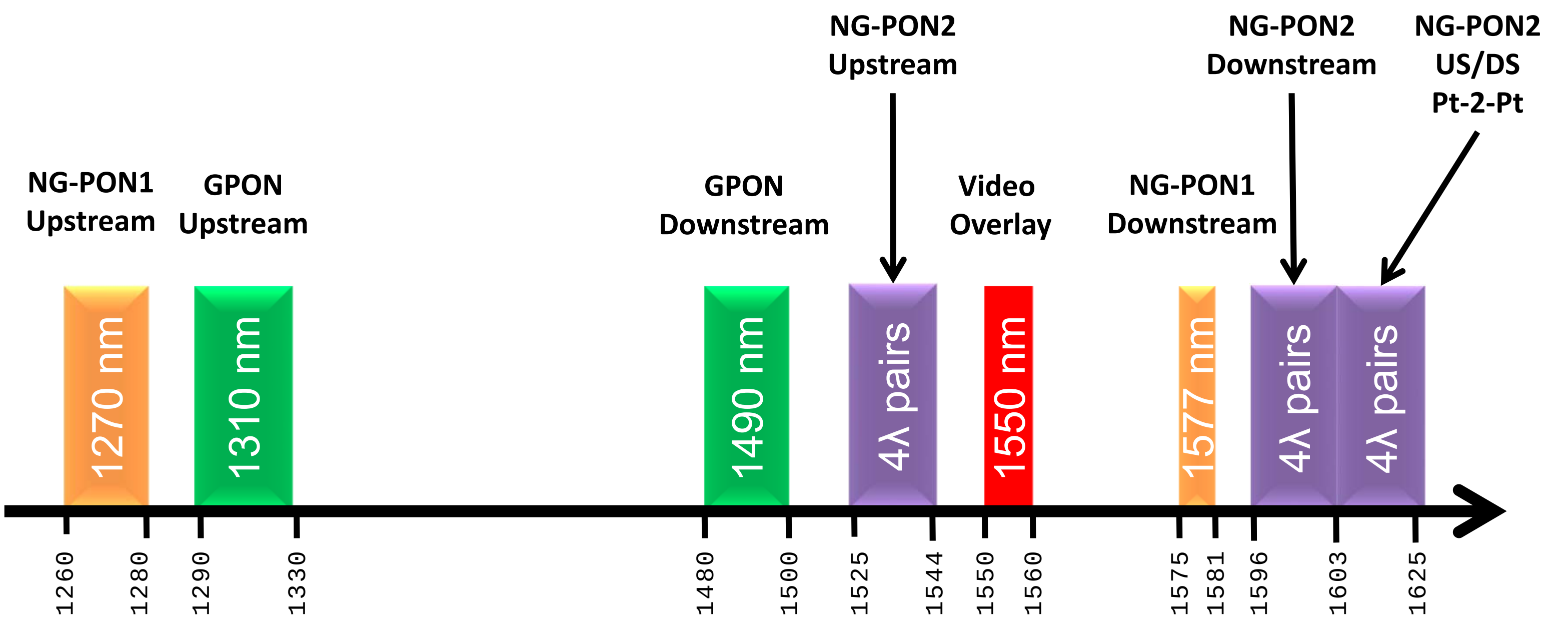
Migration to 10G



3

- 10G PON can coexist on the same fiber as GPON
- Bandwidths available as 10G Downstream and 10G/2.5G/1G Upstream
- Uses same infrastructure/splitters as GPON
- Casual migration – upgrade only the ONTs that you want

The Migration to 10 & 40G PON



The cabling infrastructure stays the same and only the users that need it are upgraded.

PON Name	Version	DOWN (Gbps)	UP (Gbps)	Industry Standard
G-PON		2.5	1.25	ITU G.984
NG-PON1	XG-PON	10	2.5	ITU G.987
	XGS-PON	10	10	ITU G.9807
NG-PON2		40	40	ITU G.989

Questions?

Passive Optical LAN

Integration & Management

Matt Miller

CallisonRTKL

POL Project Closeout Package

Mike Watts

Vice President of Noovis

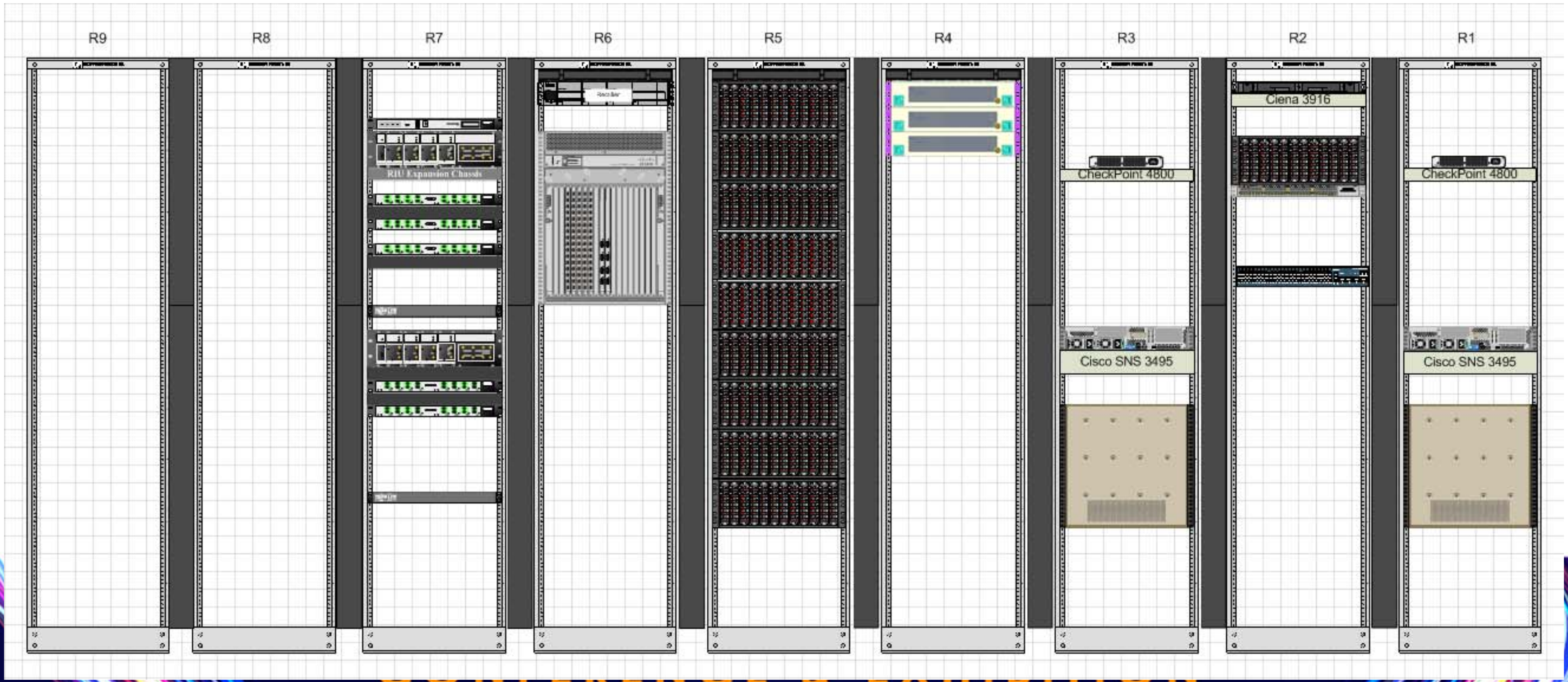
2018 BICSI WINTER CONFERENCE & EXHIBITION

Orlando, FL | February 4-8

Suggested Contents

- Rack Elevation Drawings
- As-Built Drawings
- Interconnect Documentation
- Test Results
- Datasheets and Documentation

Rack Elevation Drawings



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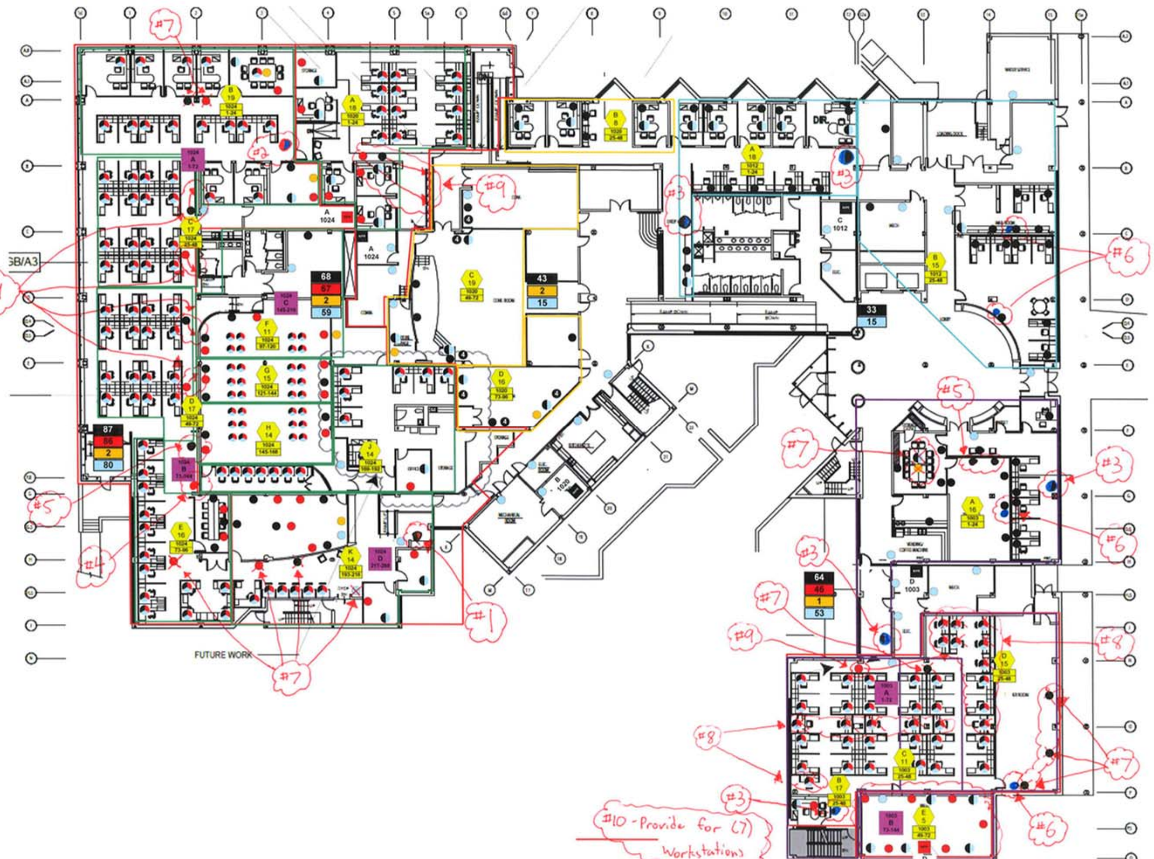
As-Built Drawings



Interconnect Documentation

Site	Building	OLT Rack	OLT Chassis	PON Card	PON Port	VAM Shelf	VAM Module	VAM Port	Backbone Shelf	Riser Cable	Backbone Port
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	MDF Rack 6	ManBay001	4	16	1	8	2	2	2	1
Las Vegas	Mandalay Bay	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Interconnect Documentation

FDH	FDH Location	Splitter	Splitter Fiber	FDH Port	RDT	RDT Port Count	RDT Location	RDT Port	Drop #	Room Number	ONT Model	ONT SN#
MB1	3rd floor mechanical room across from 313	1	1	1	1	1-12	Located in front of 115	1	1	GUEST RM 2	ONT 123	90D7B
MB1	3rd floor mechanical room across from 313	1	2	2	1	1-12	Located in front of 115	2	2	120	ONT 123	90F2F
MB1	3rd floor mechanical room across from 313	1	3	3	1	1-12	Located in front of 115	3	3	119	ONT 123	90D75
MB1	3rd floor mechanical room across from 313	1	4	4	1	1-12	Located in front of 115	4	4	116	ONT 123	910D4
MB1	3rd floor mechanical room across from 313	1	5	5	1	1-12	Located in front of 115	5	5	117	ONT 123	90F49
MB1	3rd floor mechanical room across from 313	1	6	6	1	1-12	Located in front of 115	6	6	114	ONT 123	90FCF
MB1	3rd floor mechanical room across from 313	1	7	7	1	1-12	Located in front of 115	7	7	115	ONT 123	9130E
MB1	3rd floor mechanical room across from 313	1	8	8	1	1-12	Located in front of 115	8	8	113	ONT 123	90D72
MB1	3rd floor mechanical room across from 313	1	9	9	1	1-12	Located in front of 115	9	9	112	ONT 123	910C6
MB1	3rd floor mechanical room across from 313	1	10	10	1	1-12	Located in front of 115	10	10	111	ONT 123	90E09
MB1	3rd floor mechanical room across from 313	1	11	11	1	1-12	Located in front of 115	11	11	118	ONT 123	90F08
MB1	3rd floor mechanical room across from 313	N/A	N/A	12	1	1-12	N/A	12	Spare	N/A	N/A	N/A

Interconnect Documentation

ONT GE Port 1 Device	ONT GE Port 1 MAC	ONT GE Port 2 Device	ONT GE Port 2 MAC	ONT GE Port 3 Device	ONT GE Port 3 MAC	ONT GE Port 4 Device	ONT GE Port 4 MAC	ONT POTS Port 1	ONT POTS Port 2	RF Port	WAP MACs	Notes
Active	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Active	N/A	N/A	N/A	N/A
Active	N/A	N/A	N/A	N/A	N/A	WAP	F40F1B7E0CF8	Active	N/A	N/A	F40F1B7E0CF8	N/A
Active	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Active	N/A	N/A	N/A	N/A
Active	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Active	N/A	N/A	N/A	N/A
Active	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Active	N/A	N/A	N/A	N/A
Active	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Active	N/A	N/A	N/A	N/A
Active	N/A	N/A	N/A	N/A	N/A	WAP	F40F1B7F2B34	Active	N/A	N/A	F40F1B7F2B34	N/A
Active	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Active	N/A	N/A	N/A	N/A
Active	N/A	N/A	N/A	N/A	N/A	WAP	F40F1B6373D8	Active	N/A	N/A	F40F1B6373D8	N/A
Active	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Active	N/A	N/A	N/A	N/A
Active	N/A	N/A	N/A	N/A	N/A	WAP	88F0316C59B4	Active	N/A	N/A	88F0316C59B4	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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Test Results

FasTesT Report

General Information

Filename:	MandalayBay2.olts	Cable ID:	AP 2.0 - Mandalay Bay
Test date:	3/30/2015	Fiber ID:	FIBER001; FIBER002; FIBER003; FIBER004; FIBER0(
Test time:	2:28 PM; 2:30 PM; 2:31 PM; 2:32 PM; 2:33 PM; 2:34 PM	Customer:	Mandalay Bay
Job ID:	AP 2.0 - Mandalay Bay	Company:	Sin City Cabling
Comments:			

Location A

Location:		Unit's model:	FOT-932
Operator:	Wayne Newton	Unit's s/n:	767843

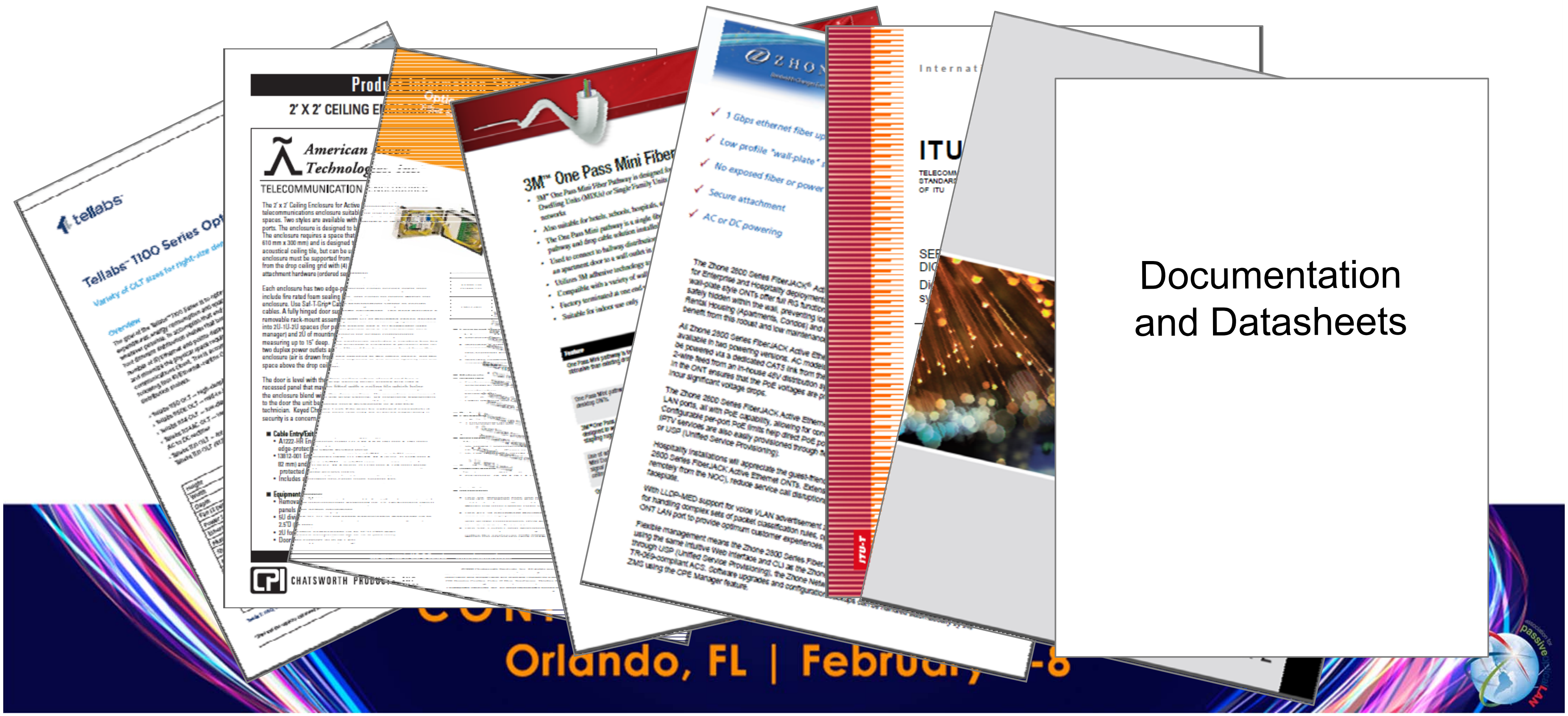
Location B

Location:		Unit's model:	FOT-932
Operator:	Celine Dion	Unit's s/n:	774536

FasTesT

Fiber ID	Wavelength (nm)	Loss A->B (dB)	Ref. A->B (dB)	Loss B->A (dB)	Ref. B->A (dB)	Average (dB)	ORL A->B (dB)	ORL B->A (dB)	Length (ft)
FIBER001	1310	0.39	N/A	1.30	N/A	0.82	42.59	40.05	N/A
FIBER002	1310	0.59	-1.26	0.63	0.87	0.61	42.30	41.61	2,112.7000
FIBER003	1310	0.52	-1.26	0.51	0.87	0.52	42.88	>42.52	2,111.3000
FIBER004	1310	0.37	-1.26	0.44	0.87	0.40	43.58	>42.37	2,115.6000
FIBER005	1310	0.34	-1.26	0.37	0.87	0.36	42.01	>42.25	2,113.2000
FIBER006	1310	1.74	-1.26	1.74	0.87	1.74	42.41	36.18	2,110.6000
FIBER007	1310	0.68	-1.26	0.81	0.87	0.75	38.39	34.97	2,109.1000
FIBER008	1310	0.54	-1.26	0.63	0.87	0.59	42.72	>42.76	2,105.7000
FIBER009	1310	1.51	-1.26	1.60	0.87	1.55	43.27	42.14	2,103.3000
FIBER010	1310	0.45	-1.26	0.56	0.87	0.51	43.54	>42.62	2,105.2000
FIBER011	1310	0.57	-1.26	0.61	0.87	0.59	43.38	42.61	2,107.7000
FIBER012	1310	1.24	-1.26	1.24	0.87	1.24	43.28	40.66	2,104.9000

Datasheets and Documentation



Questions?

POL Project Closeout Package

Mike Watts

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