# Expanding Fiber Capacity with CWDM and DWDM

Presented by

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Omnitron Systems

# Agenda

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CWDM vs. DWDM

Active vs. Passive WDM

DWDM in the Enterprise

Summary

# About Omnitron Systems

- Omnitron Provides Fiber Connectivity Solutions for Enterprise, Government and Telecom networks
  - Managed and Unmanaged Media Converters
  - PoE Injector Media Converters
  - Carrier Ethernet Network Interface Devices
  - T1/Ethernet and CWDM Multiplexers
- Headquarters in Irvine, California
- All Products Made in the USA

# Omnitron Systems and BICSI

- Omnitron is an official BICSI CEC Provider
  - First company offering BICSI CECs with free online videos at www.omnitron-systems.com
- Providing White Papers on BICSI.org
- Contributing Articles to BICSI News
- Delivering BICSI Conference Presentations
- Exhibiting at BICSI Events for 15+ Years

# Introduction

## WDM relieves Fiber exhaust from…

### Video

- Internet/Streaming Video
- IP Security & Traffic Video

### Wi-Fi and DAS

- Demand for Hot-Spots
- Offloading data backhaul for Wireless Operators
- Connectivity high-capacity DAS

### Data Center Connectivity

- Data Center Interconnect
- Cloud Computing, XaaS, Backup

### Service Provider Access Networks

- Carrier Ethernet
- Video and Cable
- Mobile Backhaul

# Introduction

**Wavelength Division Multiplexing (WDM)**

- A reliable and cost-effective solution for increasing capacity of fiber optic networks for over a decade
- Enables multiple wavelengths (channels) over fiber
  - Independent and simultaneous data channels
- Inexpensive when compared to alternatives
  - Installing new fiber (costly and time consuming)
  - Circuit Emulation (costly and complex – training and support)

# Introduction

**Wavelength Division Multiplexing**

- Equipment agnostic – supports switches, routers, servers
- Protocol agnostic – supports any network protocol
- Recent advancements in WDM manufacturing, economies of scale, and lower prices bring more optical networking options to the enterprise

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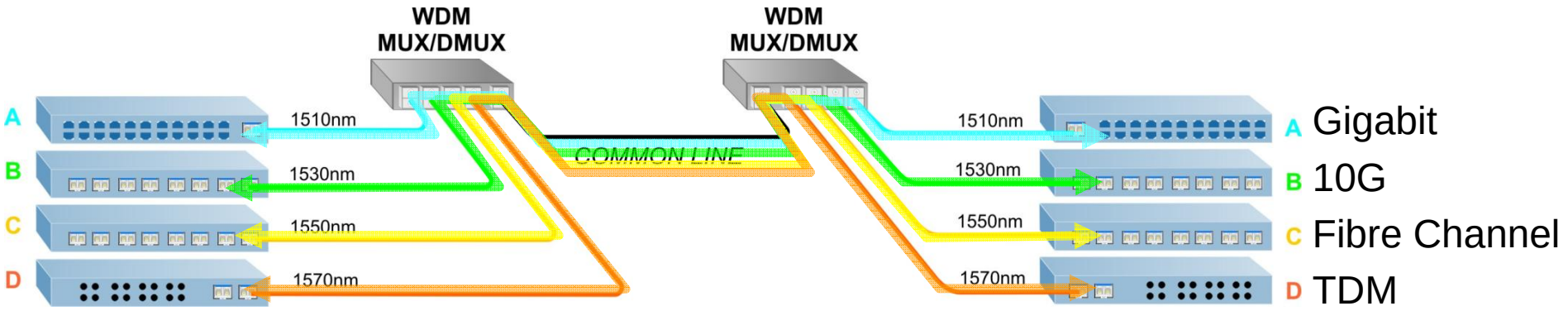
# Multiplexing Equipment

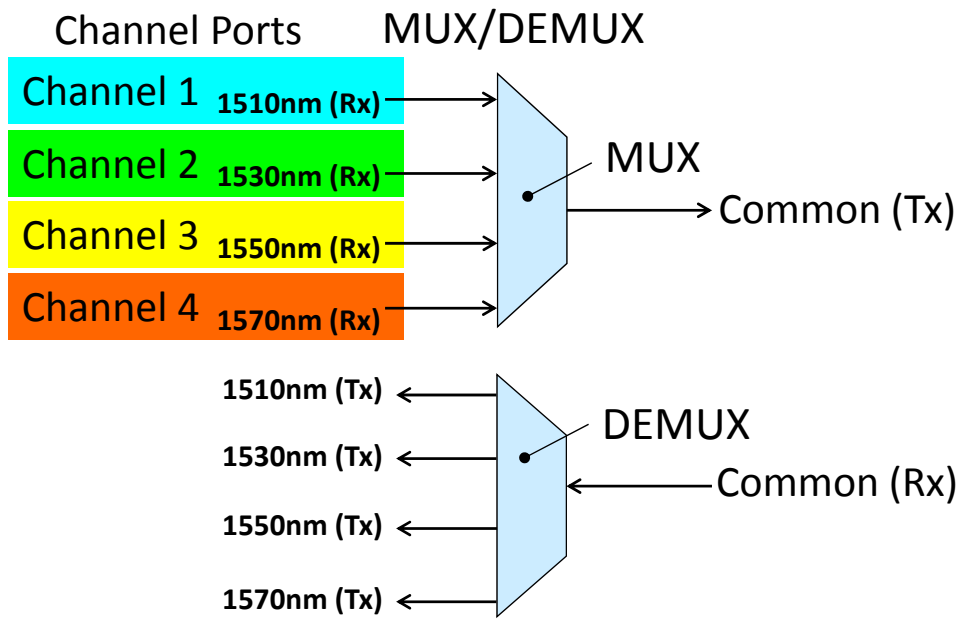
- WDM Multiplexer (MUX) combines unique wavelengths from different networking equipment
- Each Wavelength is an independent data channel that can transport different network protocols and data rates



# MUX and DEMUX

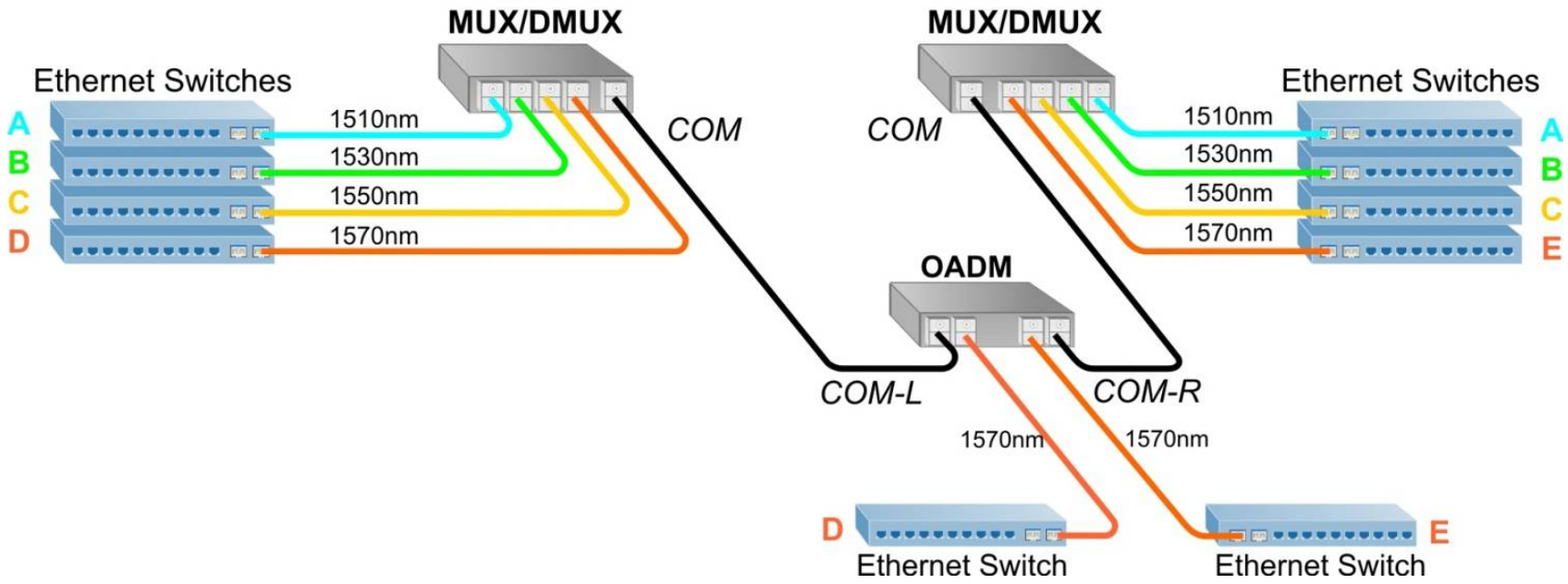
**Multiplexer (MUX)** combines wavelengths, and the **Demultiplexer (DEMUX)** separates the individual wavelengths.

- Individual MUX or DEMUX devices for uni-directional networks
- MUX and DEMUX in the same device simplifies deployments



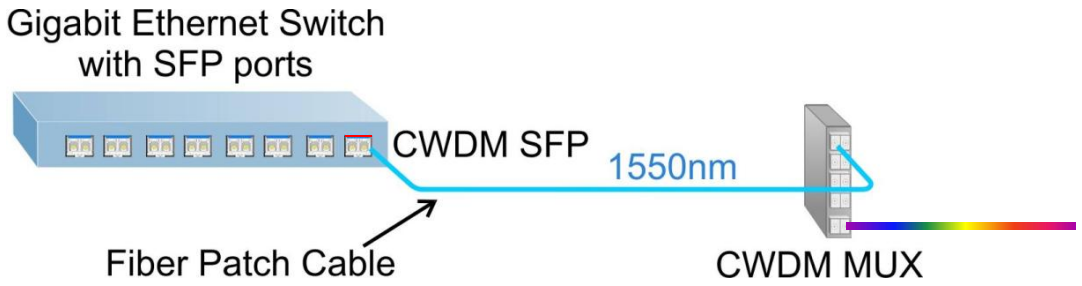
# OADM

**Optical Add+Drop Multiplexers (OADM)** are used to insert (add) and remove (drop) wavelengths anywhere along a WDM Common Line



# Connectivity to Multiplexers

- **WDM Transceivers** are used with SFP/SFP+/XFP capable switches to convert standard wavelengths to WDM wavelengths



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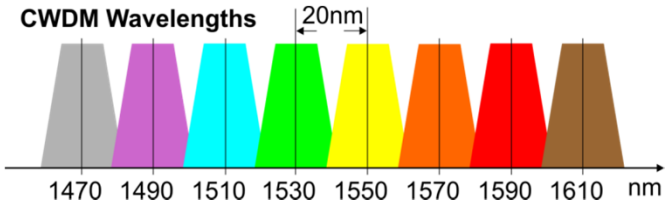
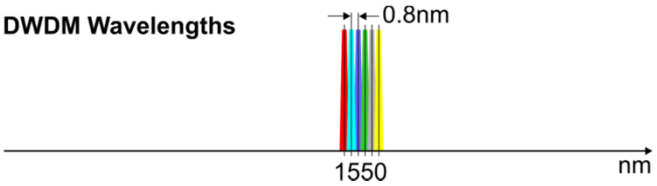
# CWDM & DWDM

**Coarse** Wavelength Division Multiplexing




**Dense** Wavelength Division Multiplexing




**Key Differences:**

- Number of wavelengths
- Grouping of wavelengths within the spectrum
- Bandwidth supported per wavelength
- Transmission distance

# CWDM Overview

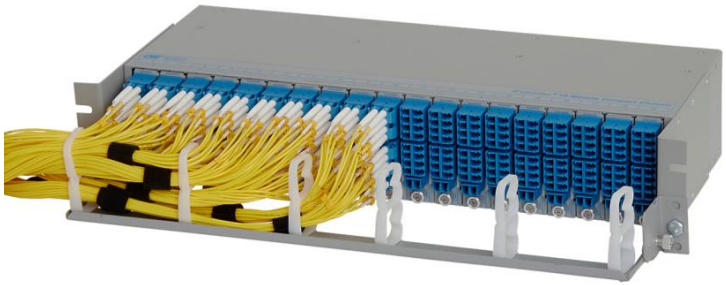
- CWDM is typically deployed in point-to-point topologies in enterprise networks and telecom access networks
- Can be used to add a limited number of channels to ring networks with OADMs
- CWDM can transport 40 to 80 kilometers depending on the power of the transceivers and the data rate

# CWDM Overview

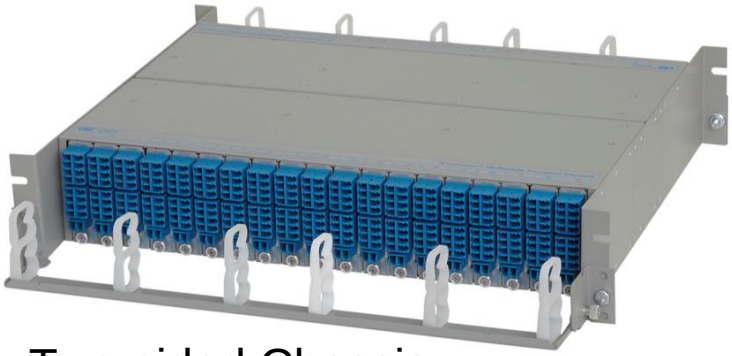
- CWDM is a flexible technology that can be deployed on most types of fiber networks
- Can be deployed over single-mode dual fiber, single-fiber and multimode fiber.
  - CWDM over multimode enables deployments over short distances inside buildings  where regulatory or economical limitations make it difficult to replace existing  fiber
  - Single-fiber CWDM uses two wavelengths per channel (similar to BIDI 1310/1550 single-fiber), and supports up to 8 channels

# CWDM Overview

- CWDM is deployed as a single point to point or as multiple Common Fiber runs in a star configuration
- CWDM Multiplexers are available in high-density modules and chassis configurations
  - Up to 304 channels distributed from 2U of rack space



One-sided Chassis

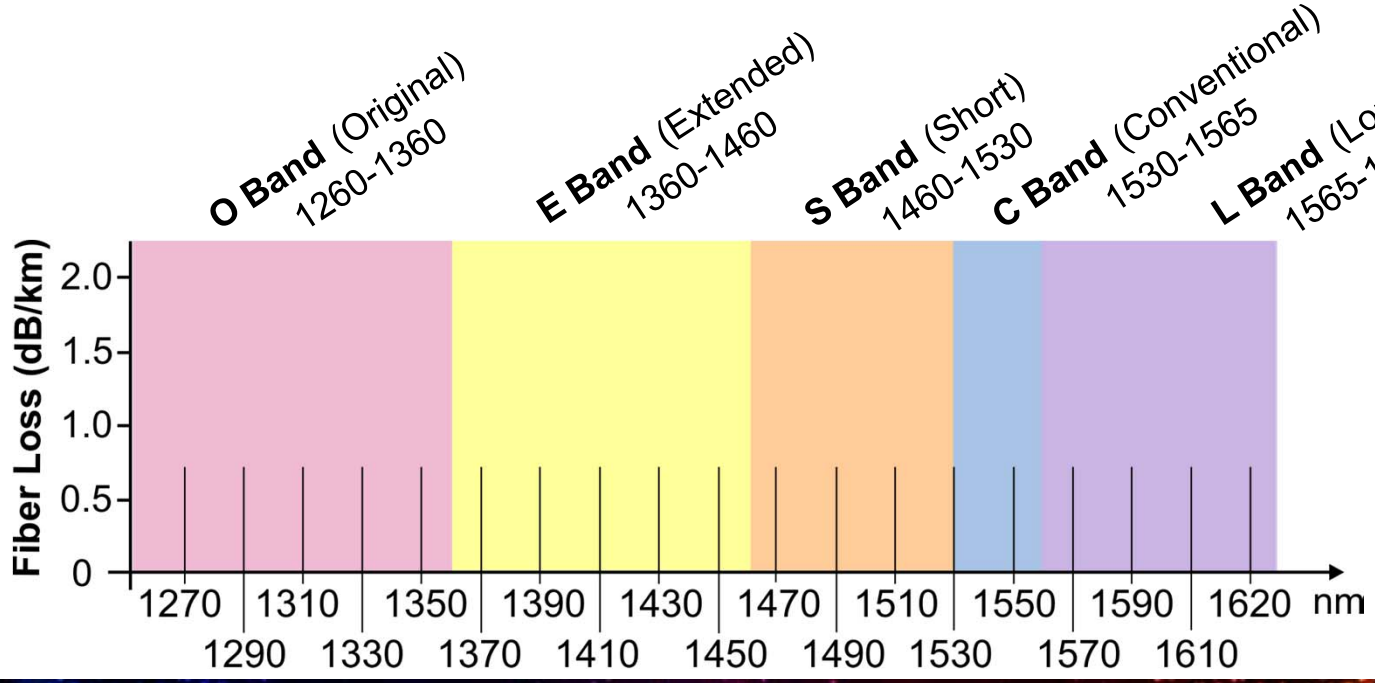


Two-sided Chassis

# xWDM Wavelengths

ITU-T Defines 5 Different “Bands” or groupings of wavelengths

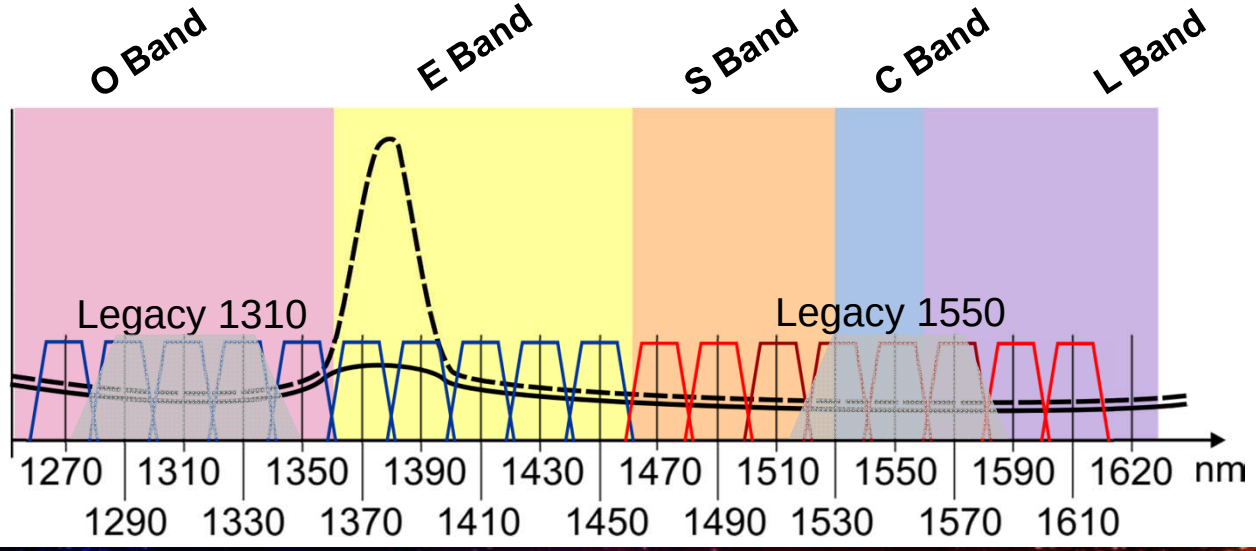
- Optimizes wavelengths for legacy 1310 and 1550 services, and attenuation characteristics for different types of fiber.



# **CWDM** Wavelengths

CWDM Wavelengths are grouped by **Lower Band** and **Upper Band**

- **Lower Band** not typically used due to Water Peak and legacy 1310
- **Upper Band** split between **Upper 1** (most common 4-Channel MUX) and **Upper 2** (straddles the Upper 1 and enables legacy 1550)



# **CWDM** Transceivers

- CWDM Small Form Pluggable (SFP) transceivers are available for all 18 CWDM wavelengths
- CWDM SFPs are inexpensive and can be used with any networking equipment that supports SFPs

# **DWDM** Overview

- Baby Bell companies used DWDM in long haul networks to help alleviate fiber exhaustion and the costs involved in running new fiber from one city to another
- Telecoms and Enterprises have begun to view DWDM as an option for the metropolitan network, which had predominantly been SONET based.
- Today DWDM is also used for interconnecting data centers and for financial services networks, and is often deployed in ring topologies

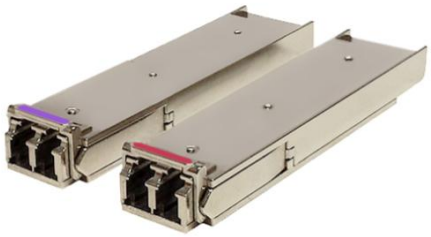
# **DWDM** Overview

- Each DWDM channel can transport up to 100G, and distances over 1,000 kilometers can be achieved with the use of optical amplifiers
- DWDM requires modern single-mode dual fiber, and is not used on single-fiber or multimode fiber

# **DWDM** Transceivers

- Uses Erbuim doped lasers for narrow wavelength spacing
- SFP+ transceivers support up to 10G data rates, and distances of 80 km in passive systems
  - Can be installed in standard SFP sockets

- XFP transceivers are an older technology, and also support 10G data rates.
  - XFPs are more expensive than SFP+ transceivers
  - But can achieve longer distances of 120 km with high-power level 4 and 5 transceivers

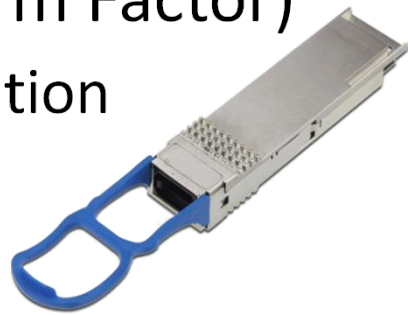


# **DWDM** Transceivers

- **Tunable** DWDM Transceivers
- Configurable to support a specific channel in a DWDM optical network
- Enables network operators to remotely change wavelengths (channel paths) in software
  - Redistribute bandwidth
  - Bypass network faults
  - reconfigure/upgrade traffic patterns and services
- Deployed in transponders, optical switches and ROADMs

# **DWDM** Transceivers

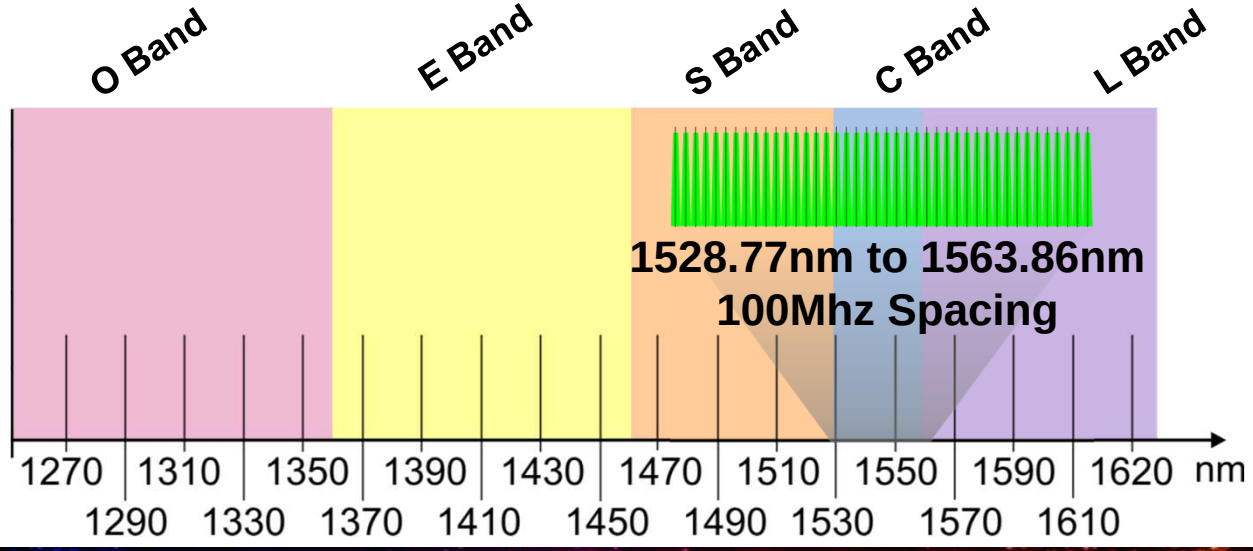
- The latest generation of 40G and 100G DWDM transceivers
- QSFP-DD (double density) and QSFP28 (Small Form Factor)
  - PAM4 with amplification and dispersion compensation for distances of 5 km to 6 km



- Coherent CFPx
  - Supports 40G and 100G multi-channel data transmission for distances that reach 1000s of Km

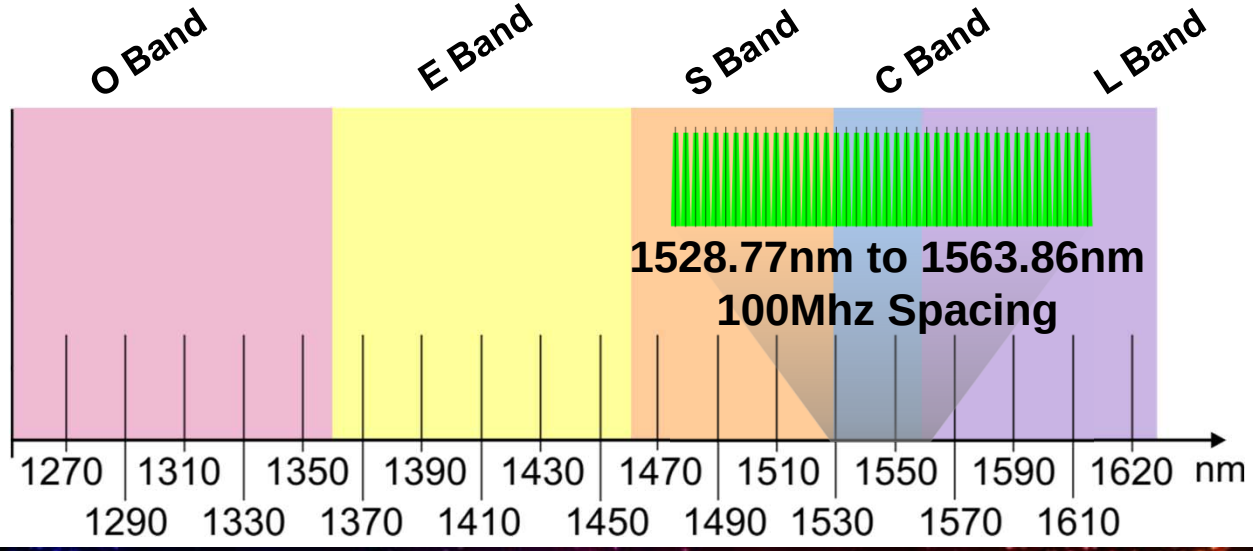
# **DWDM** Wavelengths

- ITU standard DWDM region is from 1528.77nm to 1563.86nm
  - Resides mostly within the C Band
  - Lower attenuation and dispersion
  - Erbium Doped Fiber Amplifiers (EDFA) operate in this region



# **DWDM** Wavelengths

- DWDM Wavelengths are most commonly available transceivers
  - Channels 21 (1560.61nm) through 59 (1530.33nm)
- 100GHz (0.8nm) wavelength spacing for 40 channels, or 50GHz (0.4nm) spacing for 80 channels



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# Passive vs. Active WDM Systems

CWDM and DWDM are deployed with passive or active systems

- Most **CWDM** equipment is passive, and requires transceivers from active equipment to transport data
  - CWDM amplification is performed on each wavelength, and typically done with transponders
- **DWDM** equipment can be active or passive
  - Distances greater than 120km requires active DWDM
  - Deployed with optical amplifiers on the common line

# Passive CWDM and DWDM Systems

**Advantages of Passive Systems**

- Inexpensive, require no power, and are easy to deploy
  - Can reduce costs by up to 50% compared to active systems
- Transceivers are managed by network equipment
- Fewer active elements = higher reliability and less latency

**Disadvantages of Passive Systems**

- Shorter distances
- Limited management, so as more channels are added, managing passive WDM becomes more complicated

# Active CWDM and DWDM Systems

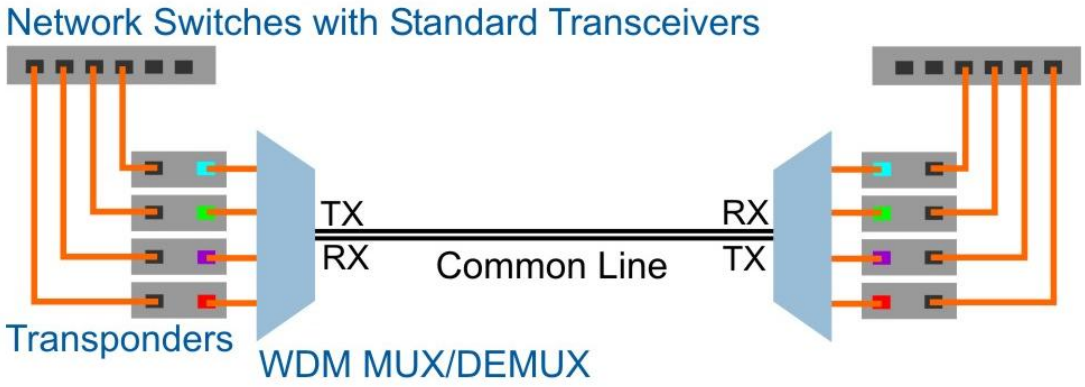
- Active WDM systems have standalone AC or DC powered devices separate from the routers or switches with embedded WDM transceivers
- Active WDM devices include
  - Transponders
  - Muxponders
  - Amplifiers
  - Powered DWDM multiplexers and optical switches

# Active CWDM and DWDM Systems

- **Transponders** are fiber-to-fiber media converters that support two or more pluggable transceivers
- Convert standard 850nm, 1310nm or 1550nm wavelengths to CWDM or DWDM wavelengths
  - Can also provide MM to SM conversion
  - Support the 3 Rs
- Used as a cost-effective alternative to proprietary Ethernet and Fibre Channel WDM transceivers

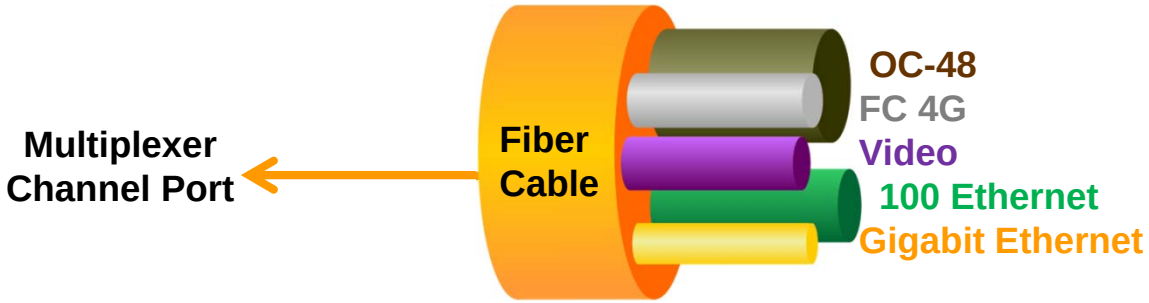
# Active CWDM and DWDM Systems

- **Transponders** convert individual CWDM or DWDM wavelengths and add optical power
- Each transponder connects to a Channel Port on a Multiplexer



# Active CWDM and DWDM Systems

- **Muxponders** digitally aggregate the data streams from different network equipment onto a single wavelength
- Typically aggregates up to 16 sub-10G services onto one fiber that is connected to a Channel Port on a WDM Multiplexer
- Enables multiple data streams over each WDM wavelength for transport along with other wavelengths

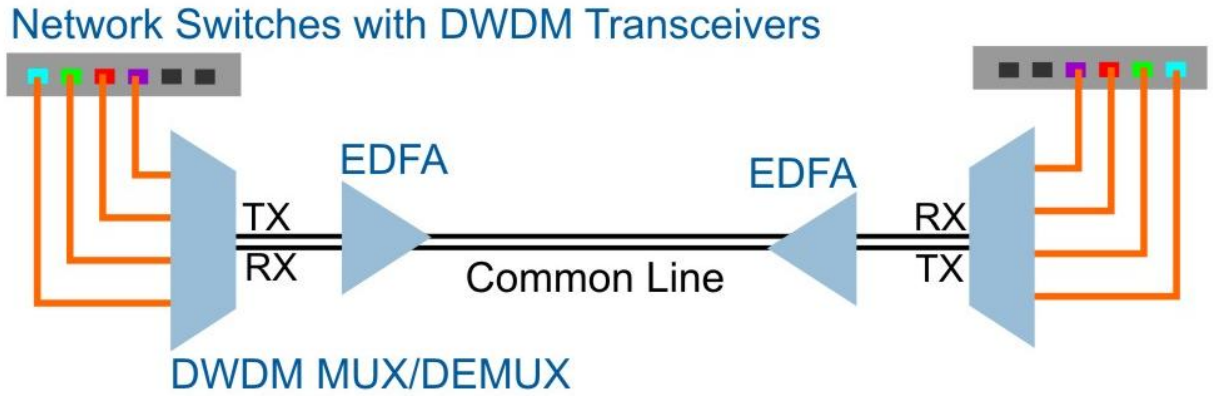


# Active DWDM Systems

- **DWDM Optical Amplifiers (OA)** are deployed at different locations along the common line
- Amplifies (boosts) all DWDM wavelengths
- Several types of amplifiers are available, some use fiber pumps, some use Optical-Electrical-Optical (OEO) conversion
- Extend DWDM networks over long distances, but they are very expensive

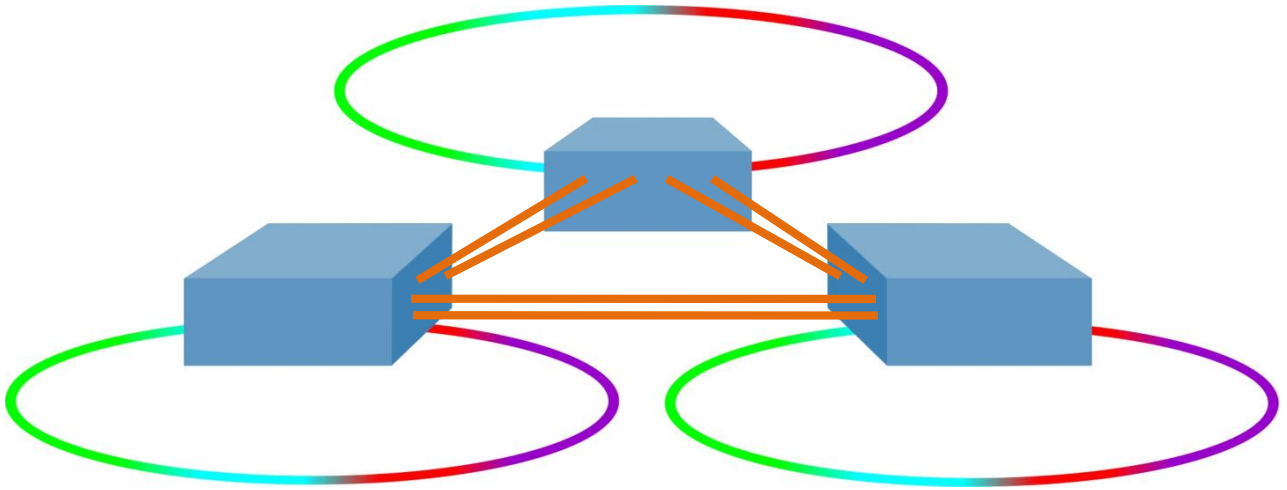
# Active DWDM Systems

- **DWDM Optical Amplifiers** enable long-haul optical transport
- Amplifies all the DWDM wavelengths on the Common Line
- Two common types of optical amplifiers are **EDFA** and **Raman**



# Active DWDM Systems

- **Reconfigurable Optical Add/Drop Multiplexer (ROADM)** enables redirecting wavelengths on a network with software
- A “tunable OADM” that controls which channels are dropped and which channels are passed through a DWDM common line.



# Active DWDM Systems

- **Optical Switches** enables the redirection of light channels between ports without doing O-E-O conversion.
- Optical switches are built using an array of microscopic mirrors, which direct channels and connect fibers optically using software
- These capabilities are making them popular in optical cross-connect and fiber protection networks

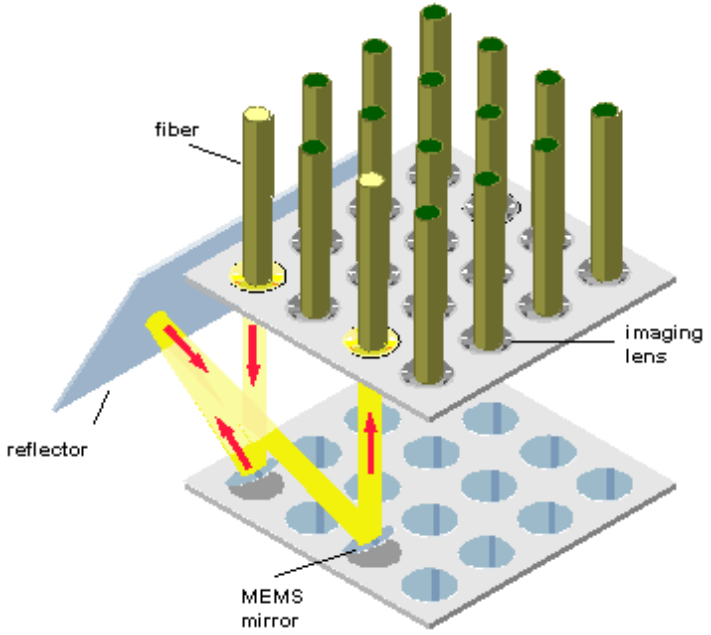
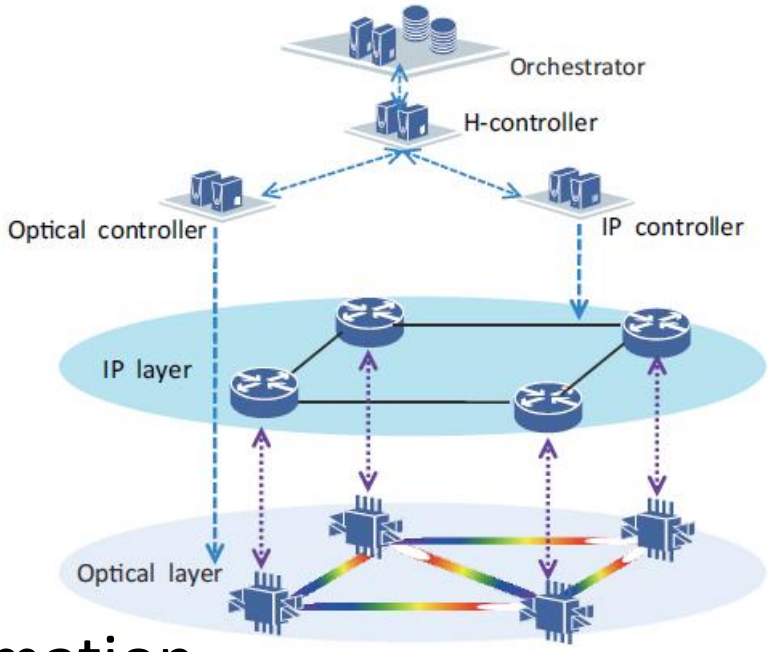



Image credit: PC Magazine

# Optical SDN

- Software Defined Networking (SDN) is the latest development in optical WDM networks.
- SDN is a network architecture approach that enables the separation of the control plane and data plane, and through virtualization makes routing and forwarding decisions based on multi-layer network availability information.



# Optical SDN

- SDN brings new capabilities to optical networking, particularly high-capacity telecom transport networks.
  - Control of optical port speeds, protocols, and wavelengths
  - Re-route fiber paths in case of link failures
  - Advanced modulation and detection schemes, especially at 100 Gb/s and higher speeds
  - A flexible wavelength grid rather than a fixed 50 GHz grid
  - Configurable wavelength routing via dynamic ROADMs

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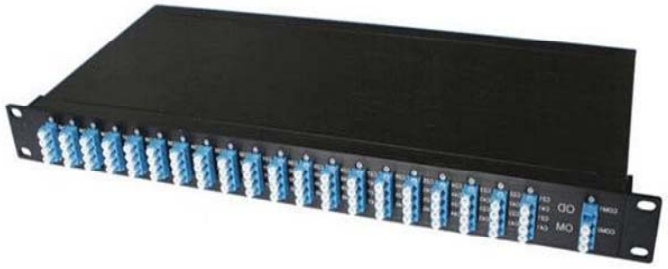
# DWDM in the Enterprise

- Today, the need for longer distances and more bandwidth, combined with the lower prices of passive DWDM equipment, makes DWDM a viable solution for high-capacity Enterprise and Data Center networks.
- **Passive** DWDM systems can transport 40+ channels over distances up to 80 Km.

# DWDM in the Enterprise

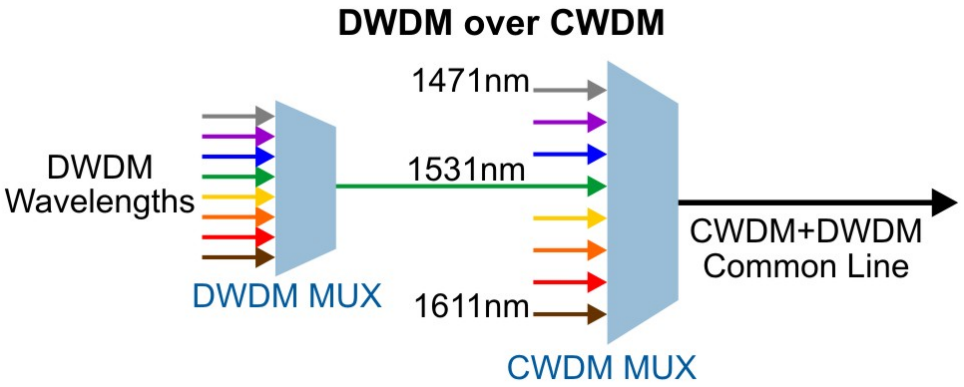
- 1U rack mount “Pizza Box” passive DWDM MUX/DEMUX equipment supports 40 or more DWDM channels



- Modular passive DWDM MUX/DEMUX equipment supports 8 or more channels per module with expansion ports enable “pay as you grow” flexibility
- LGX 3RU high density form factor

# DWDM in the Enterprise

- New DWDM over CWDM multiplexers transport up to ten DWDM channels over the 1530 section of the CWDM spectrum
- Add 8 to 10 DWDM channels to an existing CWDM network without replacing the existing CWDM equipment



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# Summary

- Increasing bandwidth requirements are stretching the capabilities of enterprise fiber networks
- Multiplexers and OADM provide scalable, flexible and cost effective solutions to expand fiber capacity
- Transceivers support WDM wavelengths to connect network equipment to Multiplexers

# Summary

Wavelengths in the WDM spectrum are organized in groups

- Enables combining WDM with legacy 1310 and 1550 services,
- Addresses attenuation for different types of fiber
- **CWDM** in Upper and Lower Bands across entire spectrum
  - Deployed mostly in Upper 8 Wavelengths
- **DWDM** mostly in the C-Band Region
  - Due to low attenuation and operation of EDFA in this region

# Summary

| | CWDM | DWDM |
|---|---|---|
| **Fiber type** | Dual Fiber, Single-Fiber, Single-mode, and Multimode | Single-mode Dual Fiber |
| **Wavelengths** | 18 wavelengths at 20nm Spacing | 80 -100 wavelengths at 100GHz (0.8nm) spacing for 40 channels, or 50GHz (0.4nm) spacing for 80 channels |
| **Bandwidth** | 10G per channel | 10G, 40G and 100G per channel, depending on active equipment |
| **Distance** | 80 to 120km depending on transceivers and transponders | Passive 10G: 80km, Passive 40G/100G: 6km Active 10G, 40G and 100G: 1000s km |
| **Active Amplification** | Per channel with transponders | Active for all channels (common fiber) with a variety of types of amplifiers |

# Summary

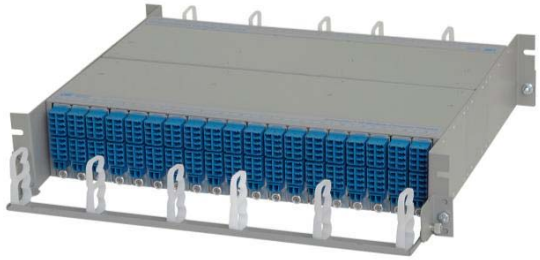
- WDM Network Equipment can be Active or Passive
  - Active CWDM Transponders amplify each wavelength
  - Active DWDM Amplifiers amplify all wavelengths on the Common Line
  - ROADM and Optical Switches enable Optical SDN
- Passive DWDM equipment now at a cost-effective price point for enterprise deployments
  - Available as 40 or 80 channel rack mount multiplexers
  - or scalable modular multiplexers in rack mount chassis
  - Also available in CWDM/DWDM combination multiplexers

# Summary

- CWDM and DWDM are technologies that provide a compelling reduction in bandwidth costs that can dramatically change how networks are upgraded to continually meet the ever changing needs of users.

# Omnitron Modular Multiplexers

- iConverter CWDM Multiplexers and OADM
  - 2RU High-Density 19 and 38-Module Chassis
  - Supports Dual Fiber, Single-Fiber and Multimode Fiber



- OmniLight LGX CWDM and DWDM Multiplexers
  - 3RU LGX Chassis Supports 14 Full Size or 28 Half Size LGX Modules
  - Can install iConverters in LGX chassis with adapter bracket

# Omnitron Transceivers and Transponders

- SFP, SFP+ and XFP Transceivers
  - Available with CWDM and DWDM Wavelengths
  - Tunable DWDM XFP Transceivers
  - Compliant with MSA SFF-8472 and INF-8077i standards
  - Works with iConverter Transponders and 3rd Party Equipment

- iConverter Transponders
  - Protocol transparent up to 11.32 Gbps
  - Convert wavelengths and amplify optical signals
  - Deploy transponders and MUX modules in same chassis

# www.omnitron-systems.com/resources

# Thank You

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