



Next Generation Transport Solutions

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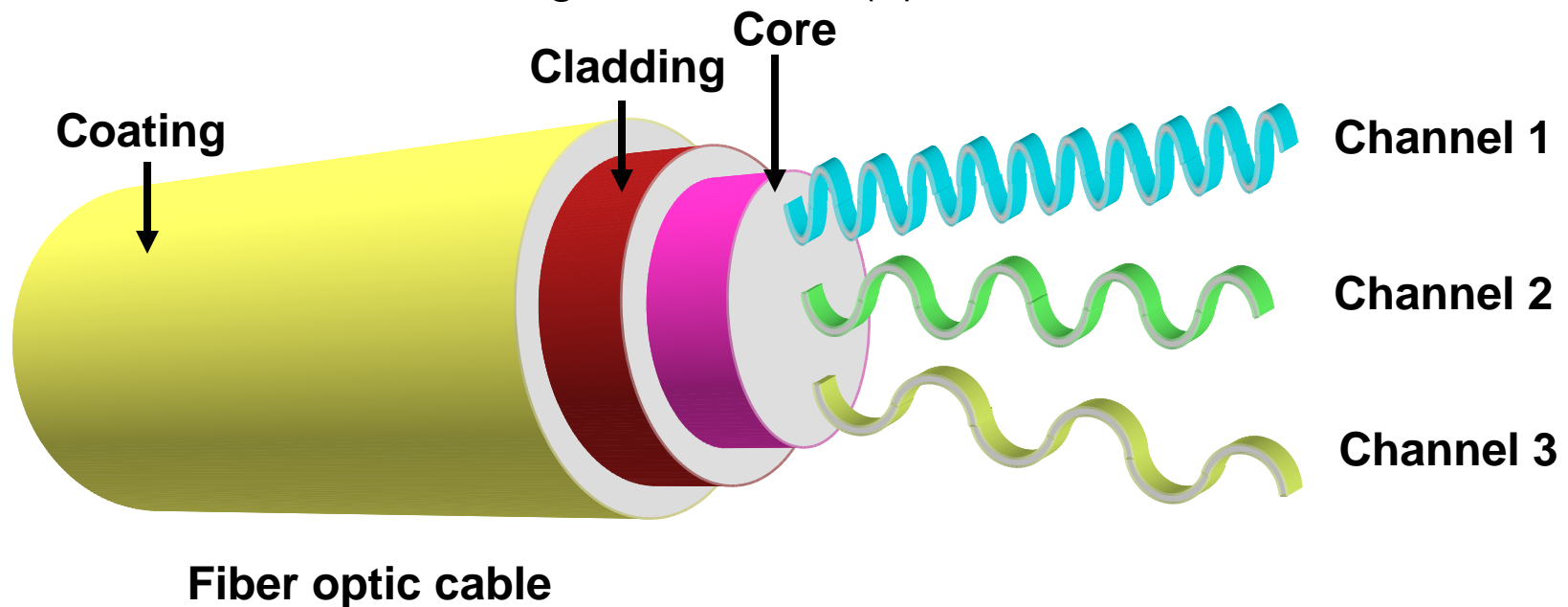
Agenda

- DWDM Introduction
- ONS 15454 Solutions
- IPoDWDM Architectures
- Future Trends

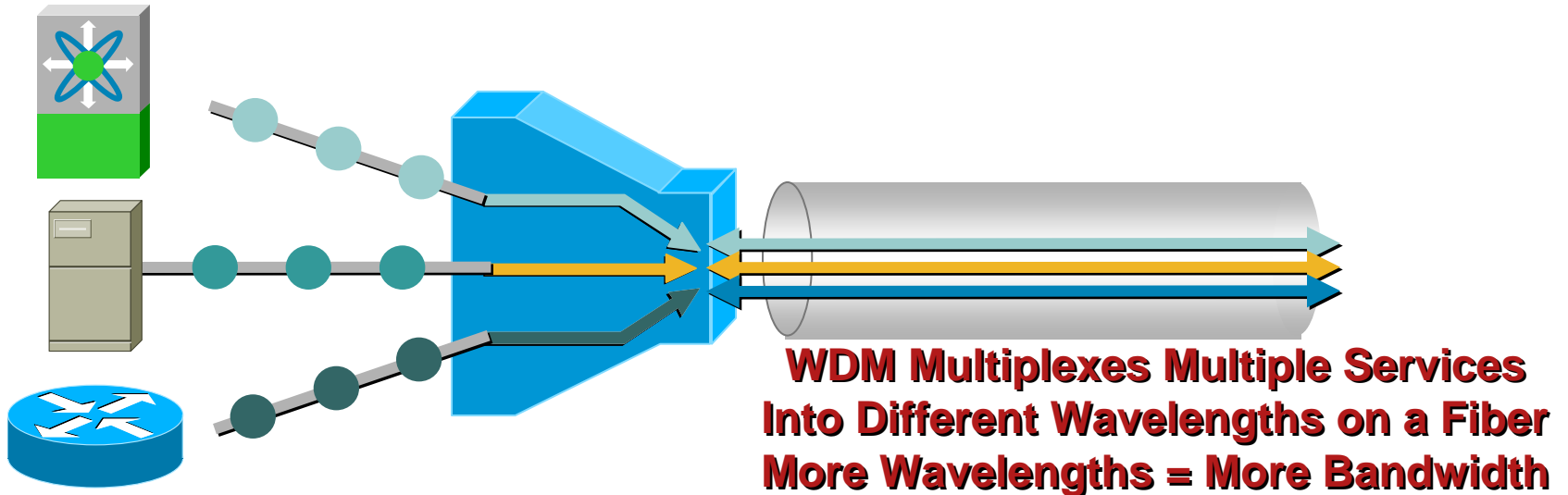
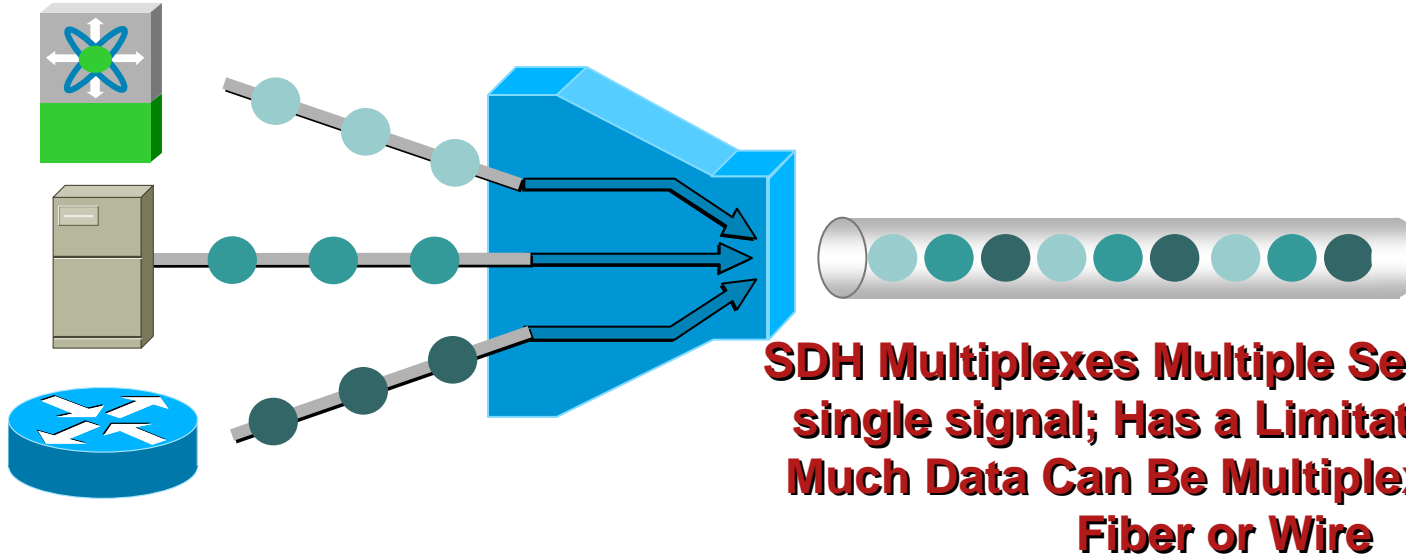
What is WDM?

Defined

- Wave Division Multiplexing
- Optical (light) signals of different wavelengths travel on the same fiber.
- Each wavelength represents an independent optical channel.
- Optical channel = wavelength = lambda (λ)

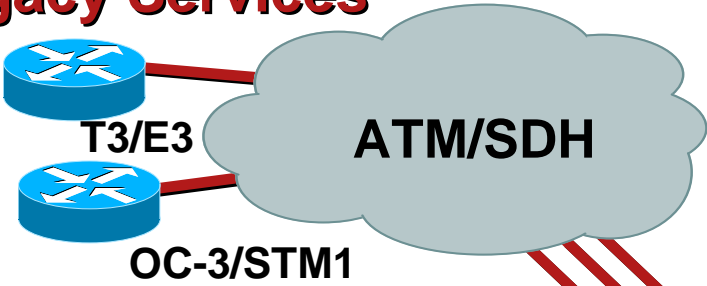


SDH and WDM Comparison

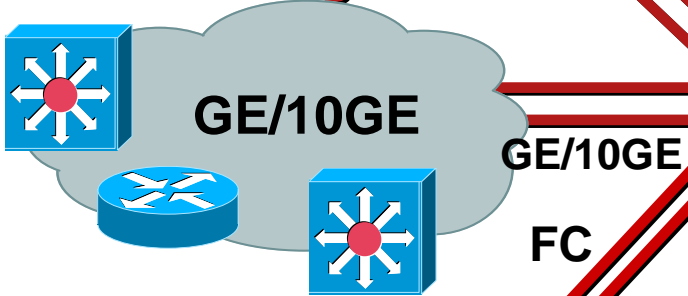


When Do We Use DWDM ?

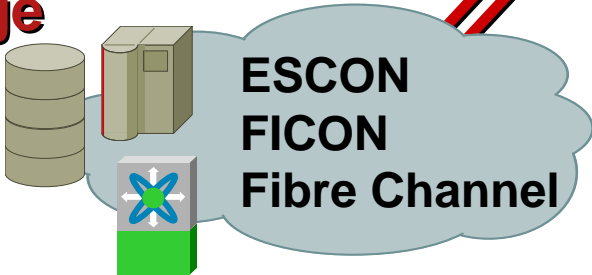
Legacy Services



Data Networking



Storage



OC-12c
OC-48c
OC-192c

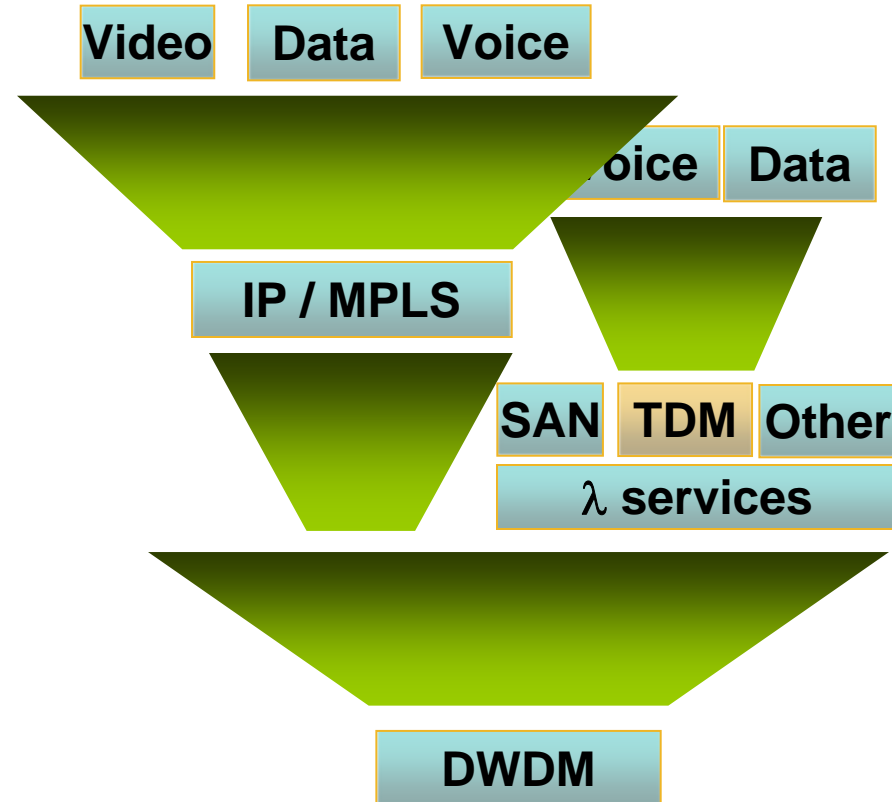
Single Fiber Pair

DWDM

- Integrate data networking, storage and legacy services

Converged NGN Transport

- Packet layer convergence to IP/MPLS has delivered CapEx & OpEx savings in core networks
- WDM layer convergence has enabled CapEx & OpEx savings in multi-service metro networks
- *Significant additional CapEx/OpEx saving can be delivered by converging the IP and optical layers!*



Any Transport of DWDM

- Many (multiservice) ITU clients:

MSA modules:

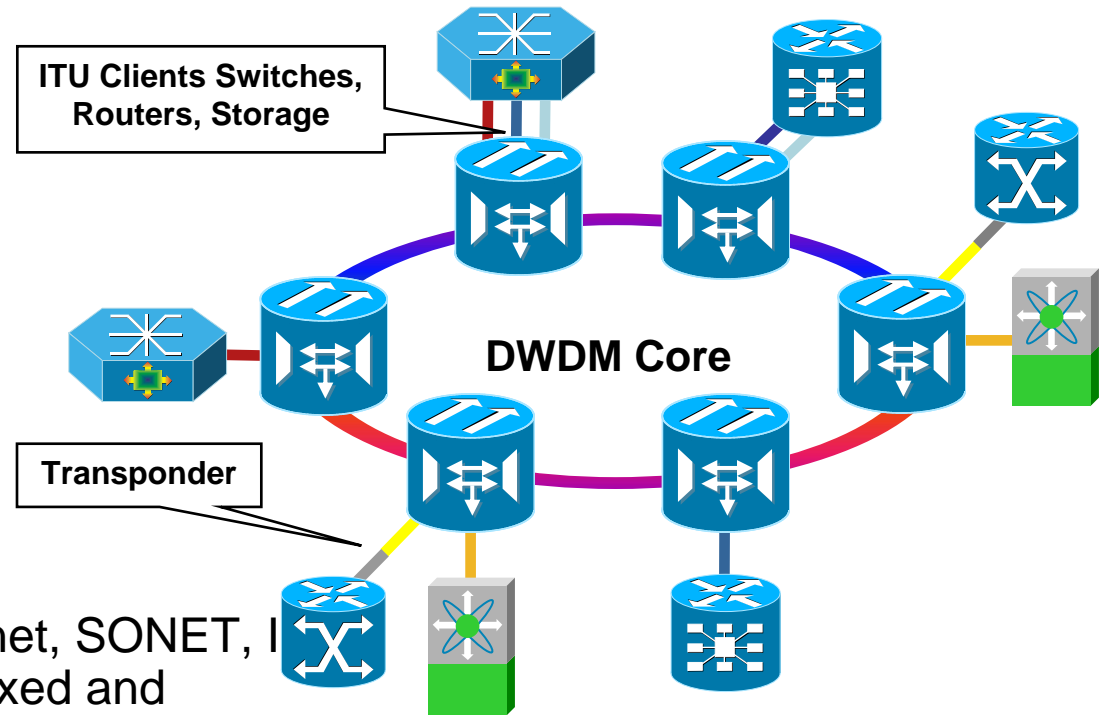
ITU—SFP, GBIC,
XENPAK, XFP

Next-gen 10G:

PLIM ODB, DPSK,
50GHz, tunability,

40G

- Enabling scalable cost-effective converged WDM architectures (Ethernet, SONET, I storage over WDM) with fixed and pluggable optics
- Third optics—alien wavelength support
- Transponder support for current architectures



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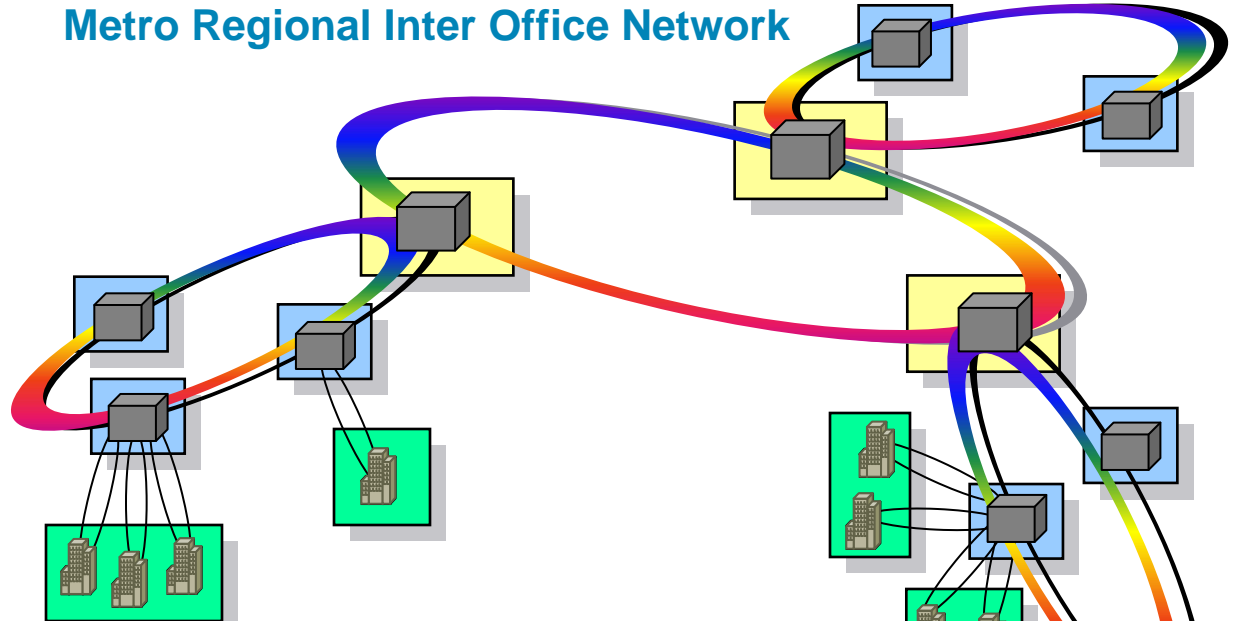
Cisco Optical Product Portfolio

Large Multi-Ring Hub



ONS 15600 SDH

Metro Regional Inter Office Network



Medium-Large Exchanges



ONS15454E MSPP

DWDM



ONS15454MSTP

Small Hubs
redundant CPE



ONS 15310 MA

Passive DWDM



ONS 15216

Key Platform Benefits

- **IPOverDWDM** – DWDM as the converge layer for IP and other services (bit rate and protocol independent)
- **Mesh/Multi-Ring** - Cope with network expansion and avoid 3R regen cost
- **ROADM** - Traffic patterns flexibility
- **XPonder** – Layer2 and Layer1 converged to optimize Ethernet over DWDM
- **CTP** - Optimize the network against required flexibility, avoiding network over-engineering
- **MSPP-on-a-Blade** – 10G ADM functionalities in a single blade with Ethernet support
- **End-to-End Provisioning** – Implemented in “Local Craft” and EMS and extended to Routers / Switches
- **Alarm Correlation** – Simplified management & troubleshooting at Node and Network level



Consolidating TDM and Packet

- **MSPP-on-a-blade installed in DWDM shelf**
- **Method for migrating from SDH to Ethernet**
- **Similar density and flexibility to XPonder plus SDH**
 - 16-User Definable SFP-based Client Ports
 - Supports STM-1/4/16/GE Client Signals
 - 1-XFP-based Trunk Supporting E-FEC/FEC and OTN G.709
 - 2-SR XFP-based interconnect ports supporting redundancy connection with protection board and Pass-through Traffic
 - GFP-F Mapping
- **Enables providers to cap investment in stand alone MSPP shelves, focus investment on MSTP**



MSPP-On-A-Blade: Unit Details

2x STM-64 InterLink Ports for Protection

Supported XFP Types

- STM-64 I1 (ONS-XC-10G-S1=)

16x Client STM-1 / STM-4 / STM-16 / GE Ports

Supported SFP Types

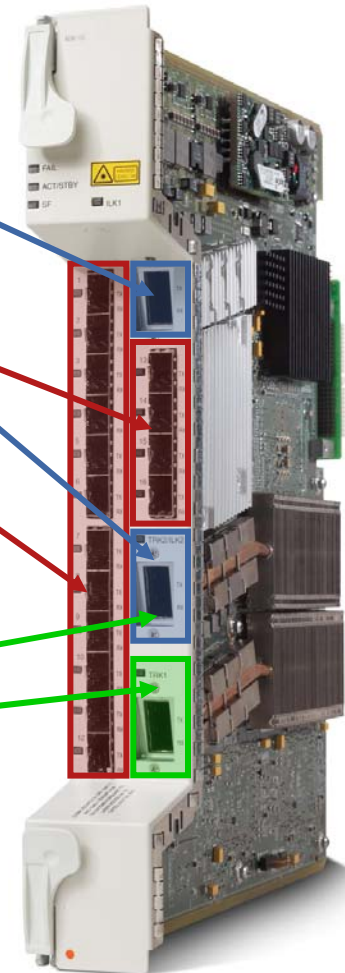
- 1000Base-SX (ONS-SE-G2F-SX=)
- 1000Base-LX (ONS-SE-G2F-LX=)
- 1000Base-ZX (ONS-SI-GE-ZX=)
- STM-16 I1/ STM-4 I1 / STM-1 I1 / GE-LX Multi-rate SFP (ONS-SE-Z1=)
- STM-1 LH2 SFP (ONS-SI-155-L2=)
- STM-1 SH1 / STM-4 SH1 Multi-rate SFP (ONS-SI-622-I1=)
- STM-16 I1 SFP (ONS-SI-2G-S1=)
- STM-16 SH1 SFP (ONS-SI-2G-I1=)
- STM-16 LH2 SFP (ONS-SI-2G-L2=)

2x STM-64 Ports

STM-64, G.709, FEC/E-FEC SW Provisionable

Supported XFP Types

- 10G DWDM (ONS-XC-10G-xx.x=)
- OC-192 SR1 (ONS-XC-10G-S1=)

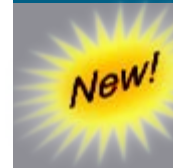


Industry First Ethernet Aggregation Integrated into DWDM

- Introducing Ethernet XPonder
- Single card for Ethernet ADM function, muxponder, transponder
- Innovations:
 - Circuit-Like Provisioning
 - Layer-2 Ethernet aggregation of NxGE into 10GE
 - Sub-wavelength add/drop and drop and continue
 - 50 ms resiliency
 - G.709 (WDMPHY): reach & SONET-like monitoring



MEF 9 and 14 Certified



*20xGbE and
2x10GE XPonder*



*4x10GbE
XPonder*

Ethernet X-Ponder 9.0 Features

Xponder Release 8.0 Hardware

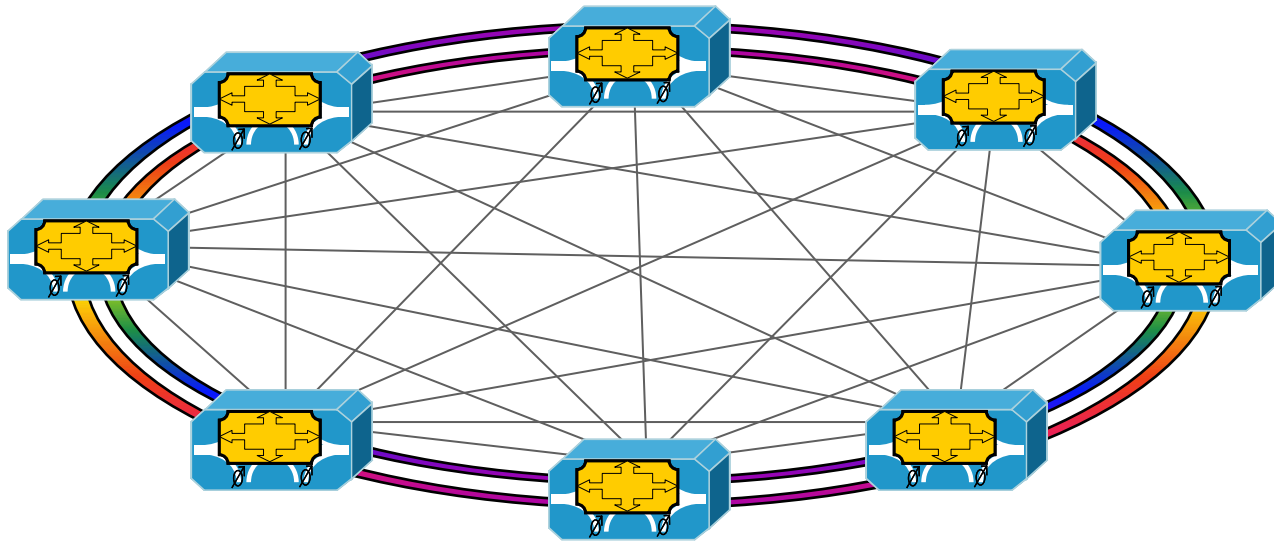
- Link integrity using Y.1731 Ethernet OAM-AIS message per SVLAN
- 1+1 Protection in either same or different shelf in the same MSN
- VLAN Profiling
- IGMP Version 2 with report suppression and automatic router i/f identification
- Multicast VLAN Registration (MVR)
- End to End circuit/SVLAN provisioning for point-to-point, multipoint and protection scenario
- XFP MM that supports also 10GE+G.709 for board interconnection in the same location
- Per SVLAN ingress rate limit
- Pseudo CLI
- Per VLAN MAC address enable-disable

Enhanced Xponder Release 9.0 Hardware (Includes all R8.0 XP Features)

- 32K MAC address*
- Add of double tag and Add+Translation*
- Add SVLAN +Translate CVLAN*
- Per CVLAN to SVLAN ingress COS*

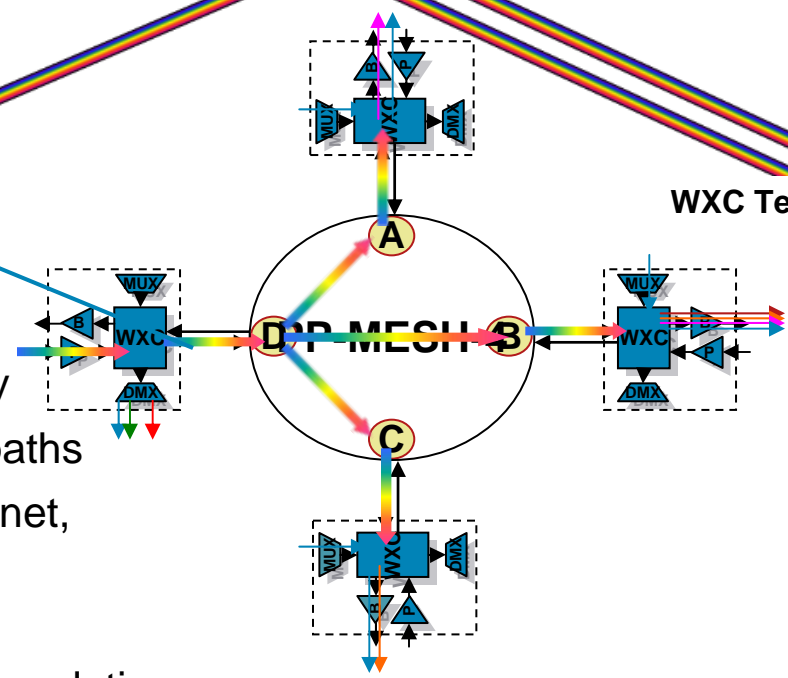
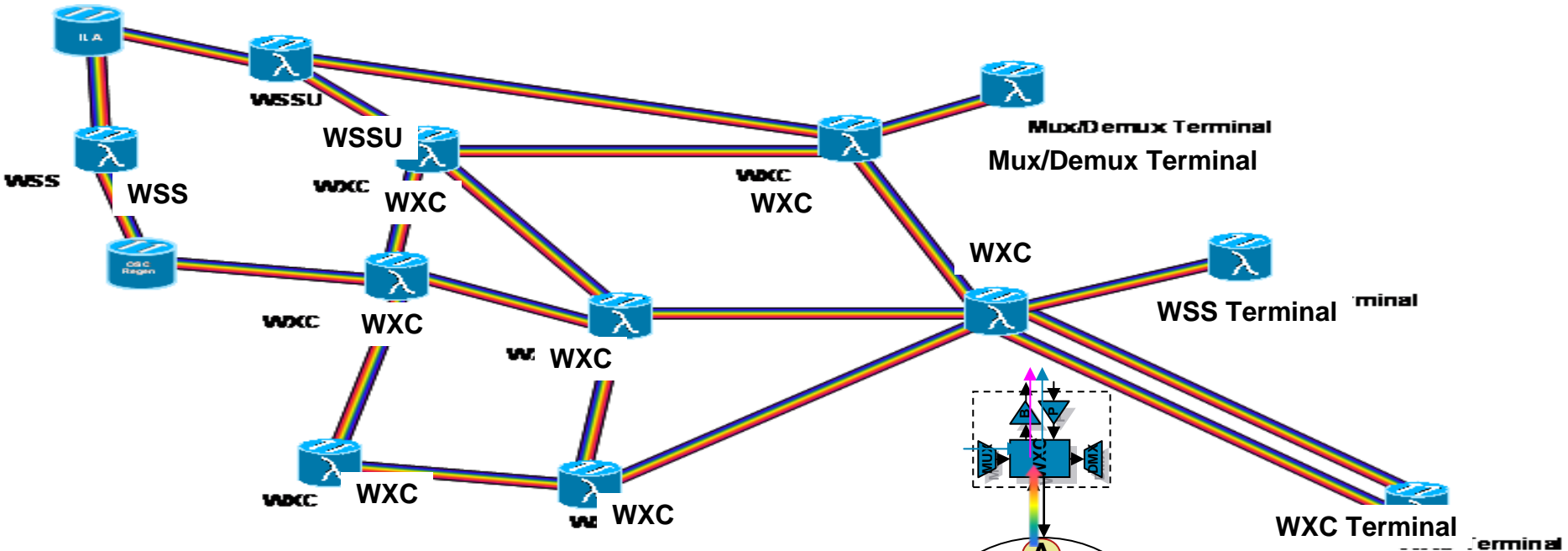


ROADM and Intelligent DWDM Network



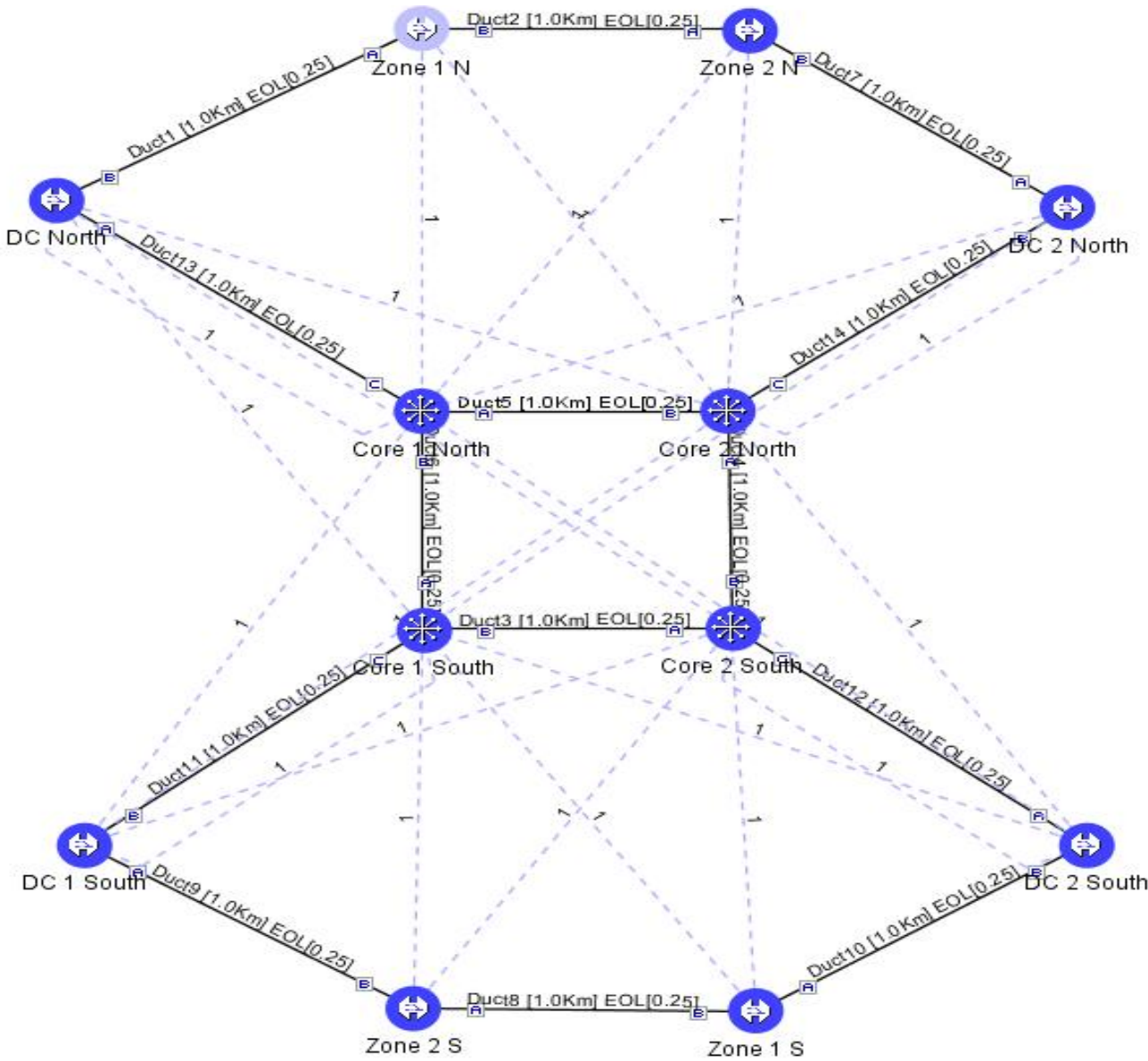
- Any-to-Any Wavelength connectivity
- Software Provisioned Wavelength Paths
- Protocol Agnostics (SONET, IP, Ethernet and Storage)
- Transport Layer Protection
- Dynamic and Intelligent Transport Foundation

Extend Same Concept to Mesh Architecture



- Any-to-any wavelength connectivity
- Software provisioned wavelength paths
- Protocol agnostics (TDM, IP, Ethernet, and storage)
- Transport layer protection
- Dynamic and intelligent transport foundation

End to End ROADM



Agenda

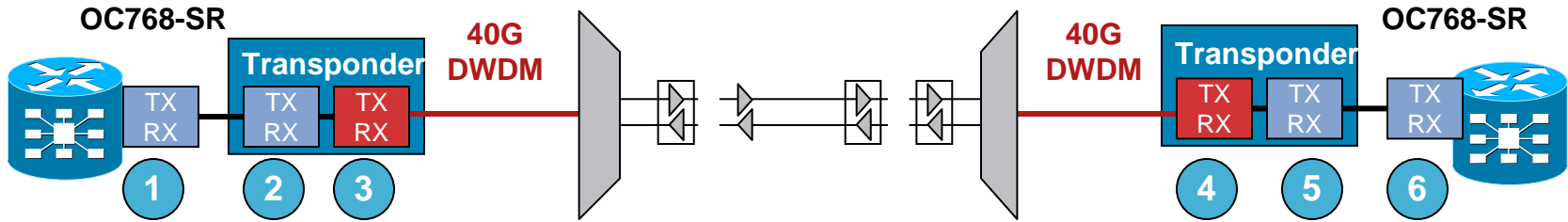
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What Is IPoDWDM?

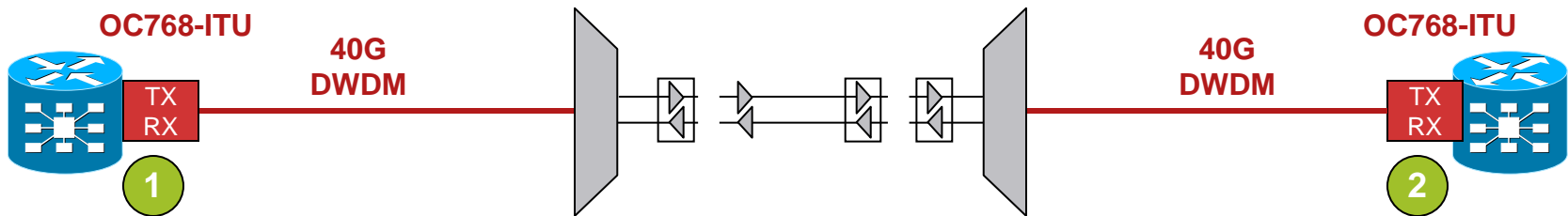
- IPoDWDM is a new network model which integrates the Transponder within the Router Blade
- This reduces both Cap as well as OP Ex while increasing network scalability, flexibility and time to market
- Integration of the DWDM transponder onto the Router blade allows for a robust, intelligent network

Why IPoDWDM

Traditional Model: External Transponder



Next Gen.: IPoDWDM

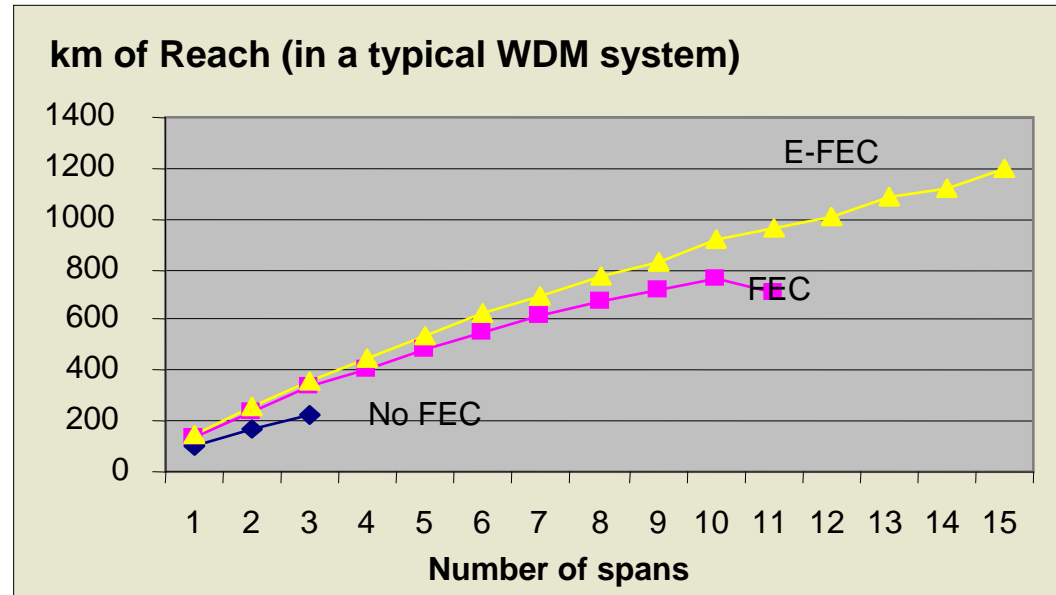
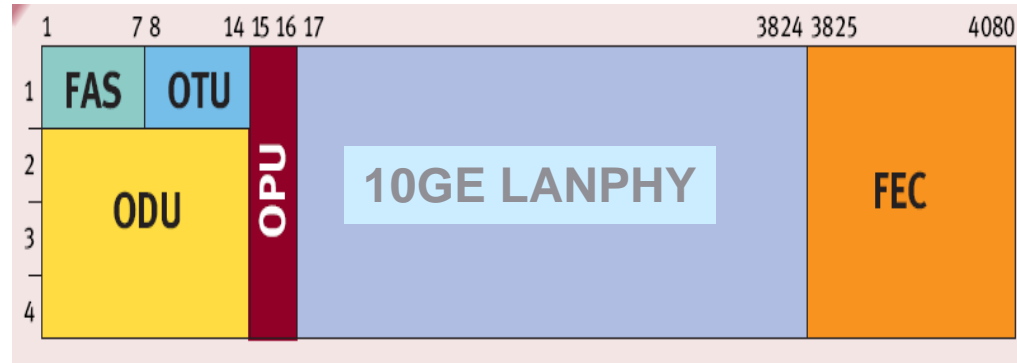


OTN- G.709 Digital Wrapper

- **10GE LANPHY payload over G.709 payload (over-clocked)**
- **OAM&P based G.709 Standard (SDH-like)**
- **FEC enabled transmission G.709 Standard modes, and Enhanced-FEC >1500 km**

ITU standard references:

- **G.709**
- Overclocking: G.sup43, sub-clause 7.1
- Enhanced FEC: G.975.1 Appendix I.7



IPoDWDM leadership – More than the Sum of its Optical & IP parts

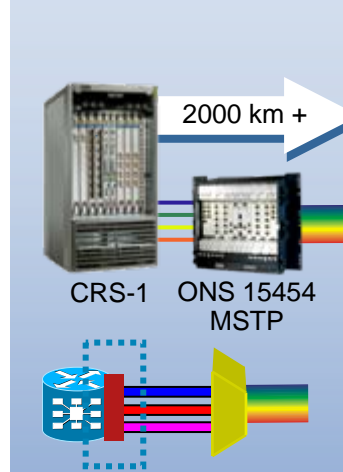
2-Degree ROADM

IPoDWDM Introduction

2- 8 Degree (Mesh) ROADM

CRS-1 40G WDMPHY with 2000 km reach

Cisco IP NGN IPoDWDM Vision



Combine Multi-Degree ROADM and IPoDWDM Reach Innovations to Optimize Service Availability, Scalability and Acceleration

2003–2004

2005–2006

Spring 2007

Summer 2008

2008+

Flexible Wavelength Management:
Reconfigurable Optical Add/Drop Multiplexer (ROADM)

ITU Lambdas on Core Routers:
True integration of IP & DWDM improves Management, OpEx & CapEx

Automation of mesh networks:
Breaking the Ring Barrier - Remotely provisioning Wavelengths across entire networks

Extending reach of 40G:
Enabling automated mesh transport for 40G signals

Future Innovation
Fiber Optimization by expanding the application for IPoWDM

Cisco IPoDWDM

CRS-1



Introducing:

- 40G IPoDWDM PLIM w/DPSK modulation
- Doubling reach (to 2000KM) w/o regen

XR 12000/12000



Introducing:

- 10GE SPA w/NRZ modulation
- IPoDWDM to the Edge, 2000 km w/o regen

7600



Introducing:

- 10GE XFP
- IPoDWDM to the Aggregation

ONS 15454 MSTP



Introducing:

- Omni-directional and colorless ROADM
- Zero touch provisioning on all nodes

IPoDWDM Enhancements

2000 KM reach:
Deployable in virtually any geography; further reductions in power, space, cooling & capex

Zero touch: Speeds provisioning, reduces opex & carbon emission from truck rolls

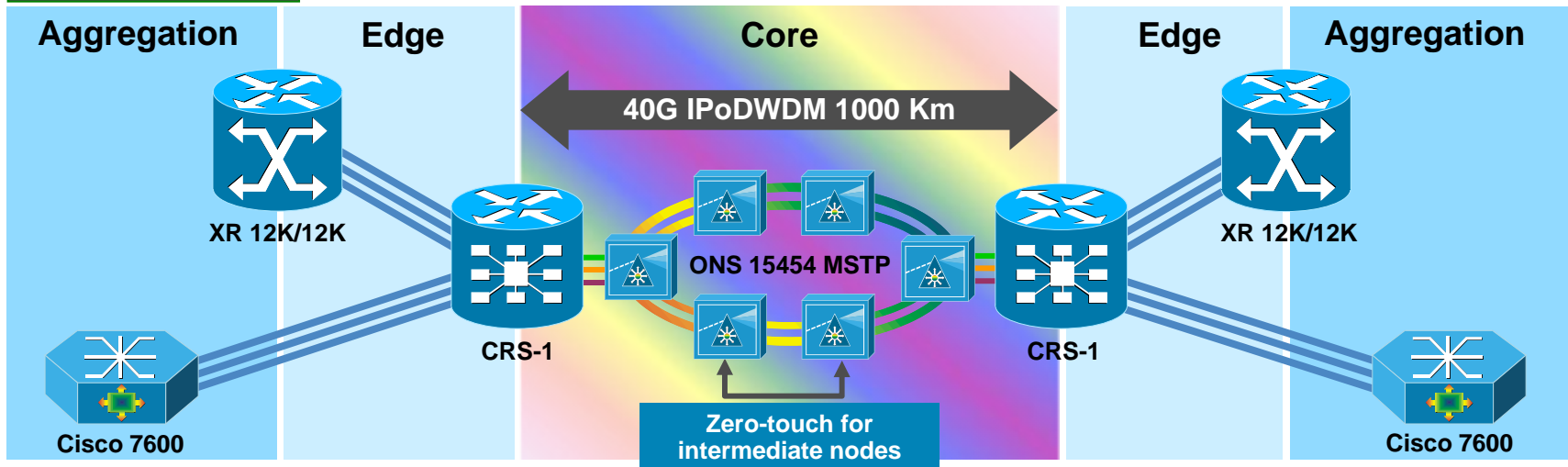
Proactive Protection: Link recovery tested at <15ms, increasing quality of experience

Virtual Transponder:
Deployable by carriers with transport data depts.

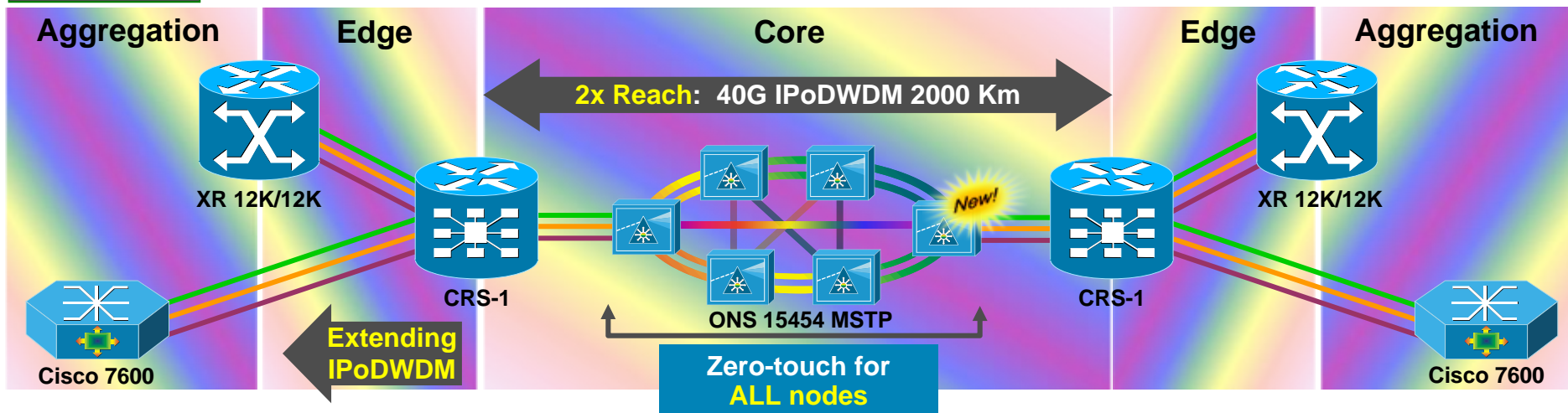
Introducing: IPoDWDM for the approaching Zettabyte Era

Doubling Reach, Extending beyond Core, Zero Touch

December 2005



Today



Improved 40G Optical Performance

Parameter	NRZ	ODB	DPSK	DPSK+	DQPSK
50 GHz Compatible	N	Y	N	Y	Y
Worst Case Reach (km)*	500	500	>1000	>1000	~1000
Chromatic Dispersion Robustness (ps/nm) **	+/- 50	+/- 150	+/- 50	+/- 700	+/- 200
PMD Robustness (ps) **	2.5	2-3	2.5	2.5	5
Cost/Complexity	Med	Med	Med+	Med +	Very High

↑↑
**CRS 40G
(1st Gen)**

↑↑
**CRS 40G
(2nd Gen)**

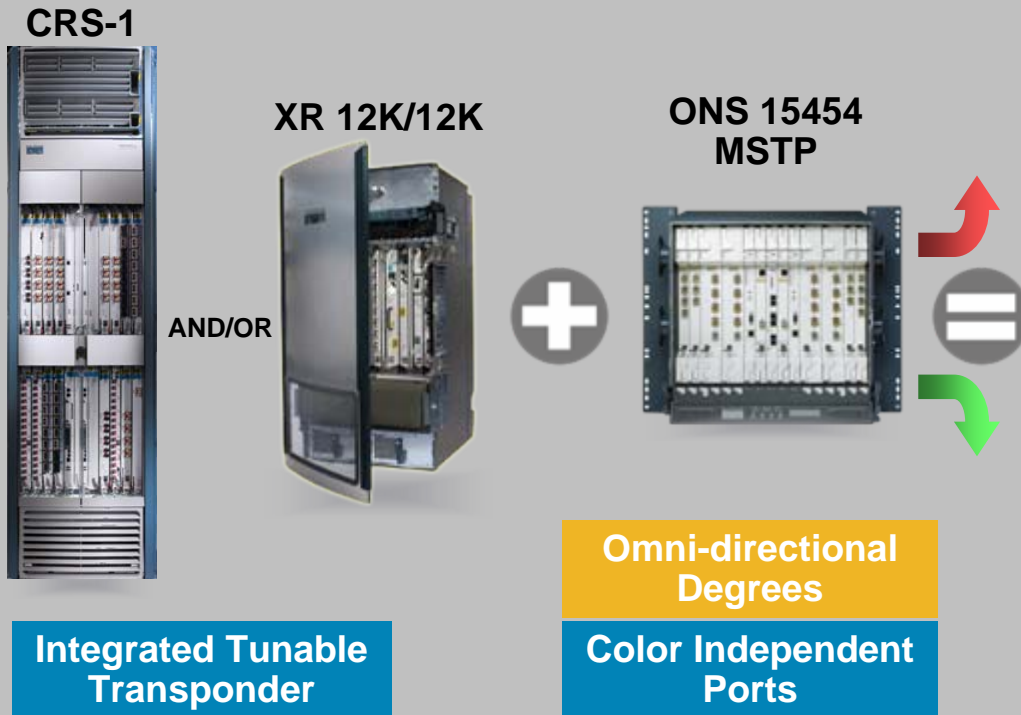
* Distance depends on link specifics. 2x worst case is possible.

* Additional reach (~2x) possible with Raman amplification

** Integrated TDC will increase this

Introducing: ONS 15454 Industry Firsts

Omni-directional and Colorless ROADM



Zero Touch Provisioning

- Remotely re-configure wavelengths in any color and any direction on ALL nodes without re-wiring fiber
- Rapidly reconfigurable bandwidth; capitalize on changes in network demand and transitory events

Winner

Cisco ONS 15454



Worldwide ROADM
Leadership
Frost & Sullivan
Best Practices Award

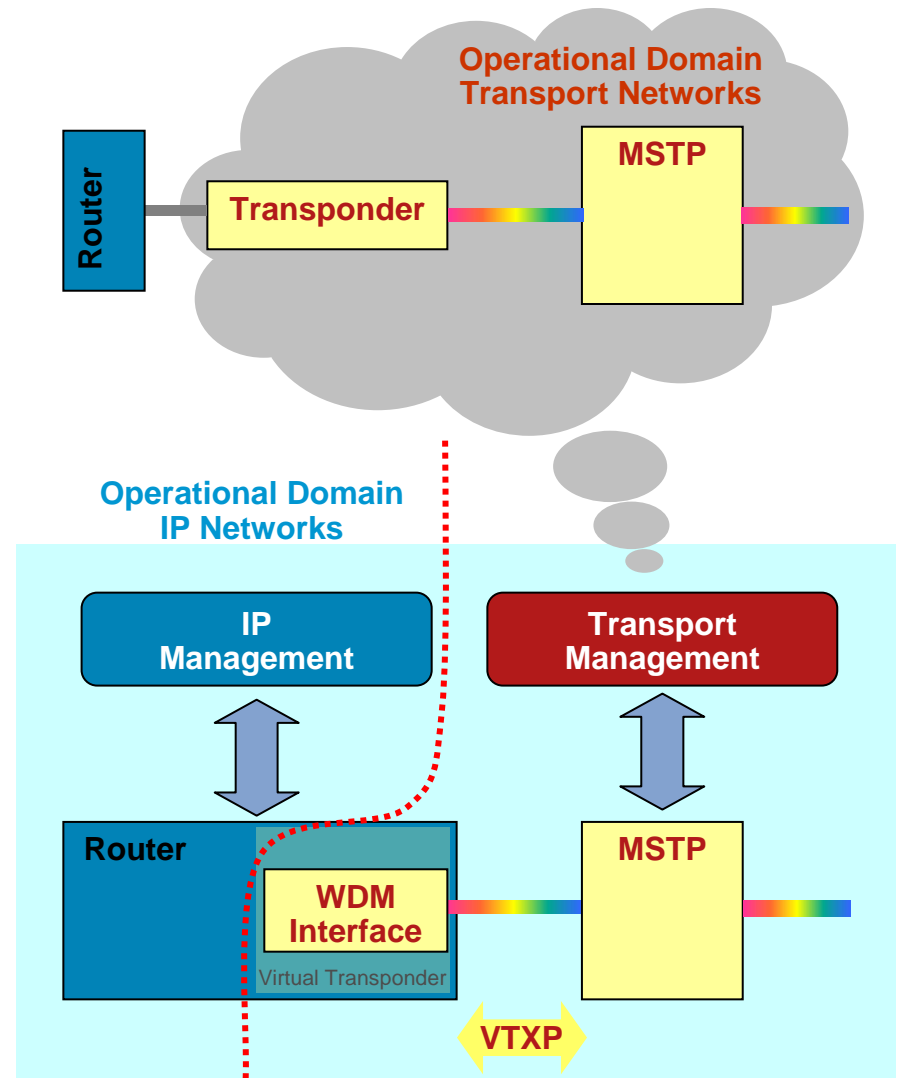
IPoDWDM Innovations

Virtual Transponder Management

- **Pioneering** feature: Virtual Transponder Protocol (VTXP)
- **Open standards** (XML) based interoperating with 3rd party MSTP
- Full FCAPS Management for Router WDM interfaces

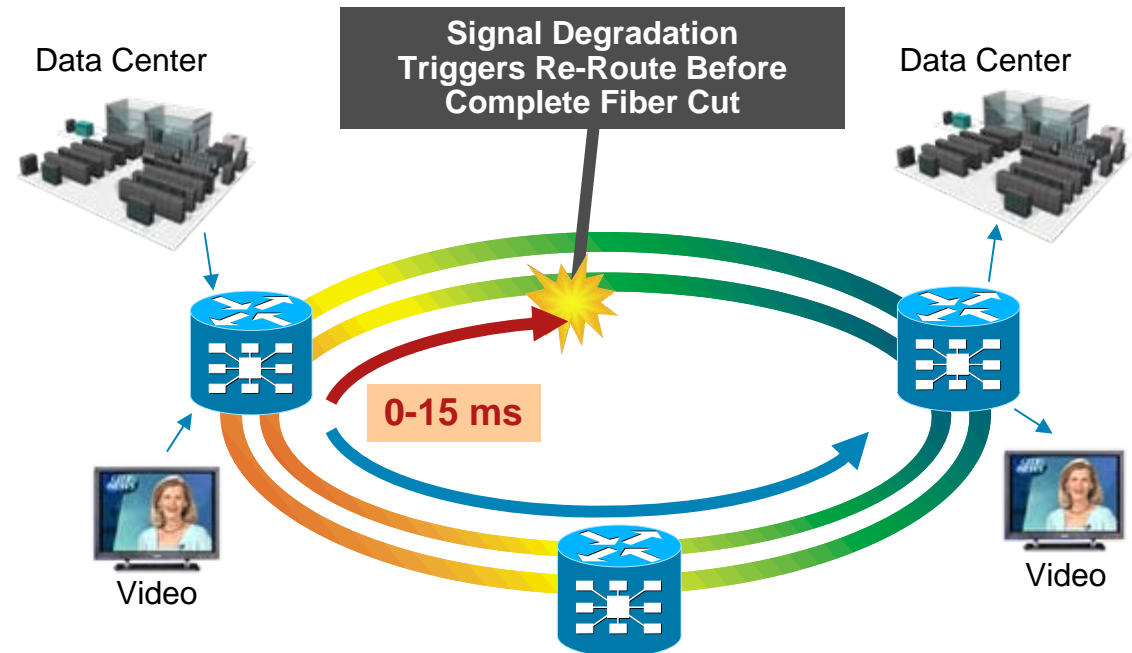
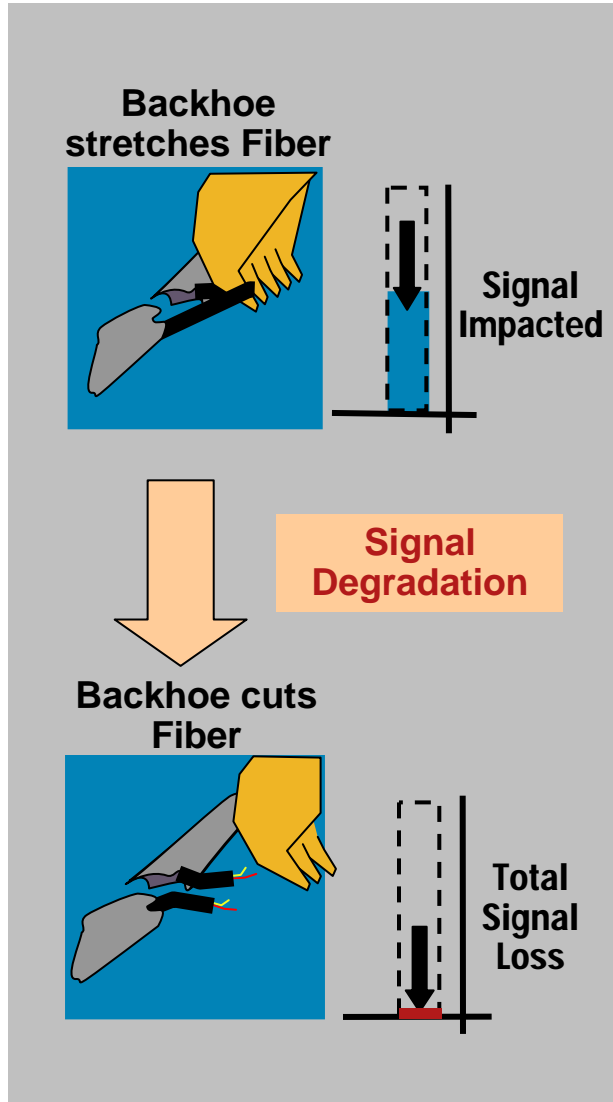
Flexible Management

- Segmented: No change to existing NMS/OSS, operational models
- Integrated Management



IPoDWDM: Re-setting the Standard for QoE

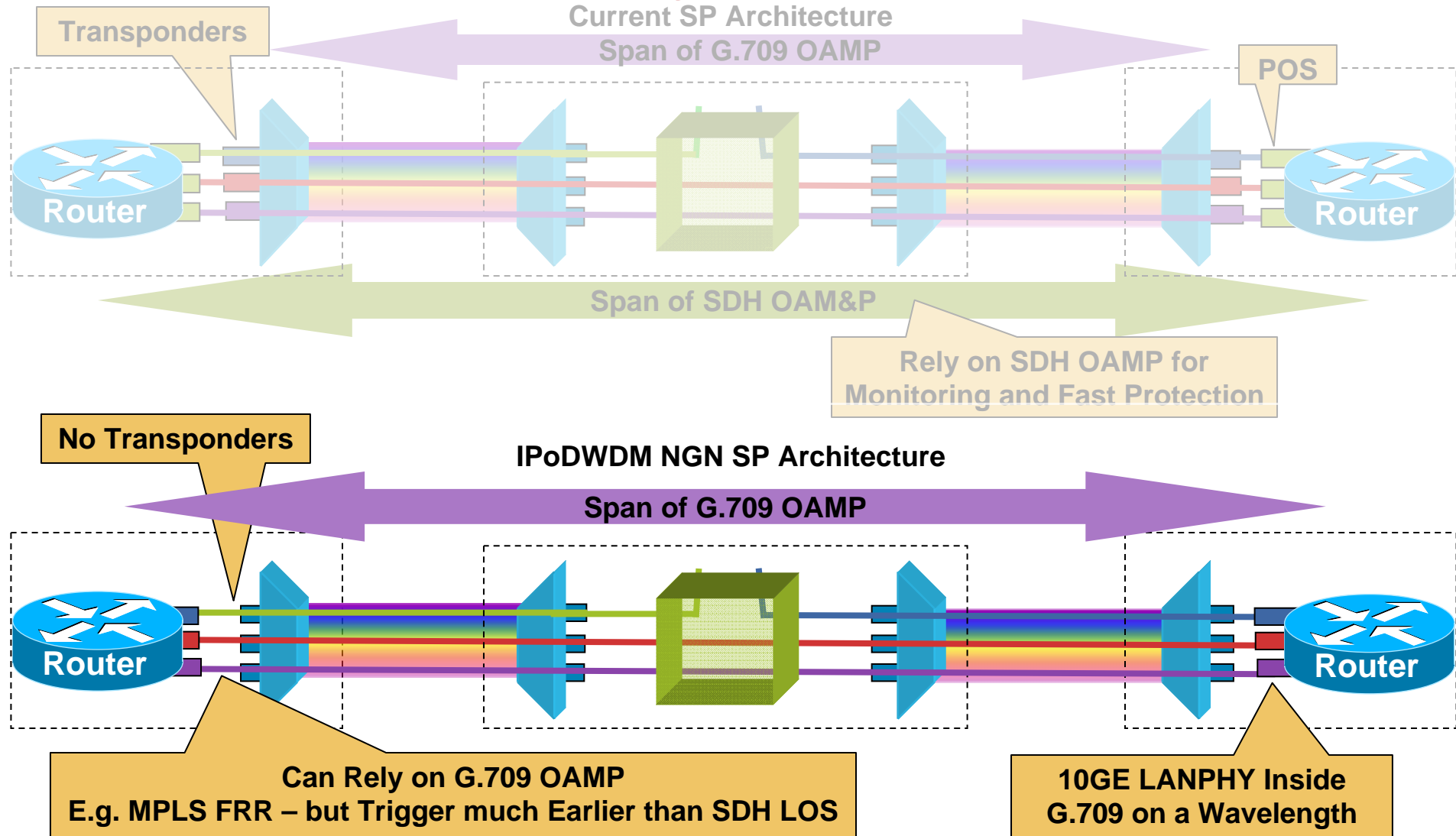
With Proactive Protection: IP Trumps SONET/SDH



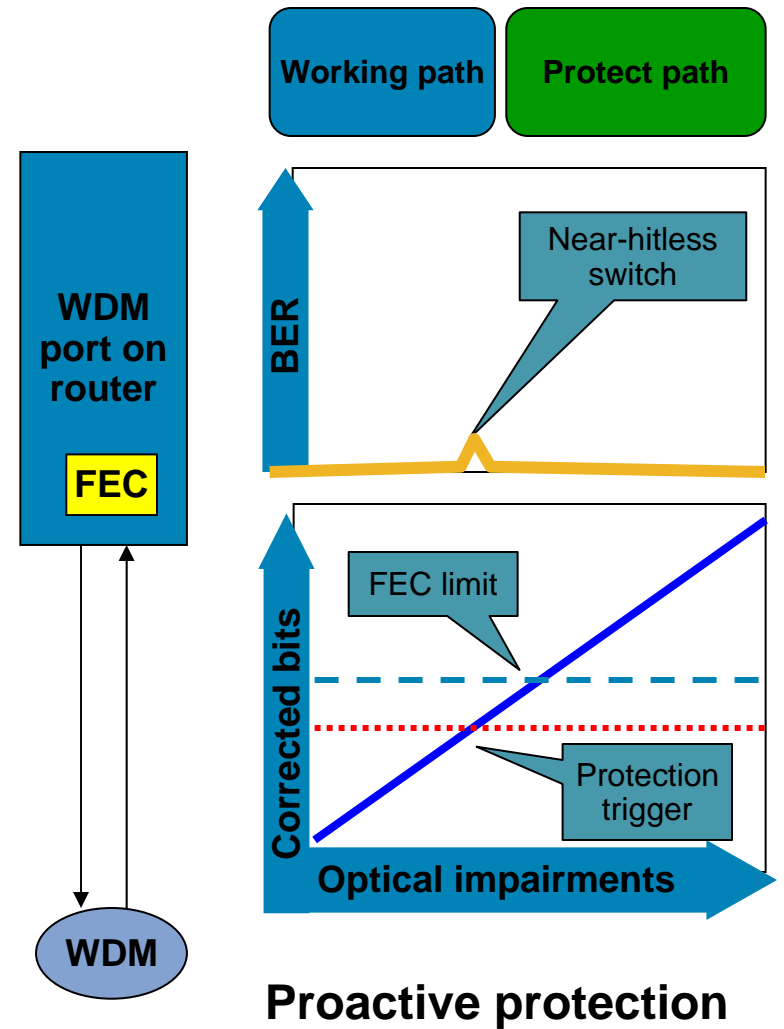
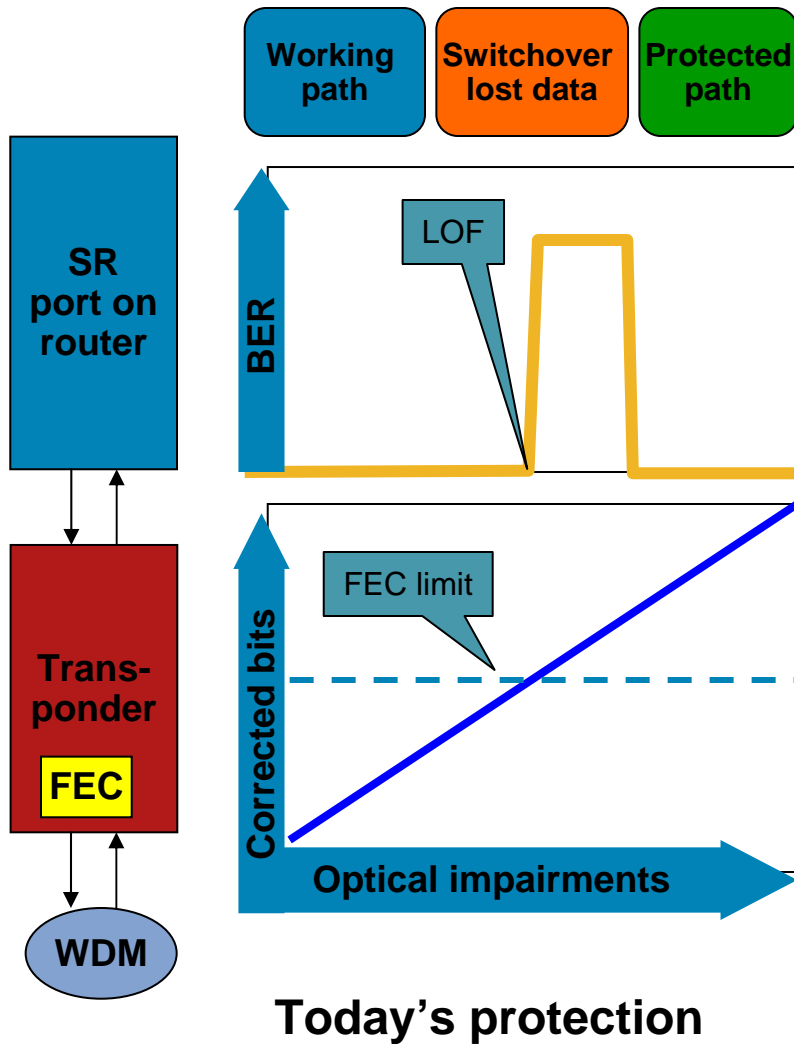
- Innovative early detection triggers failover on signal degradation, not loss
- 3x Faster recovery (<15ms) than SONET / SDH standards for near hitless video experience
- Unsurpassed reliability protects mission-critical data from loss

Intelligent Transport Layer

G.709 OAMP Functionality



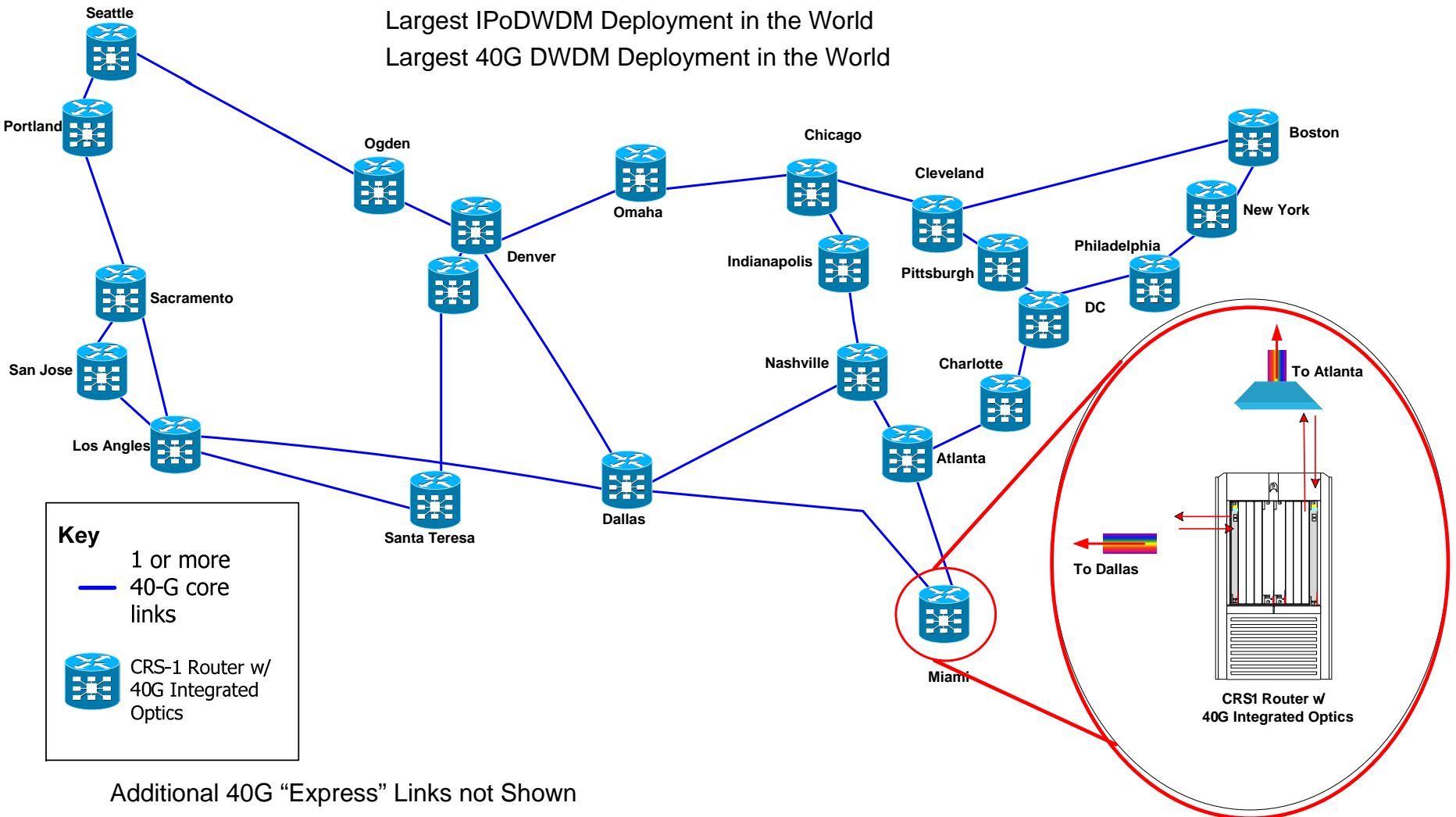
Proactive FRR based on pre-FEC errors



Network Architecture

First 40G IPoDWDM Network in the World

- This North American National Network is Currently:
 - Largest IPoDWDM Deployment in the World
 - Largest 40G DWDM Deployment in the World

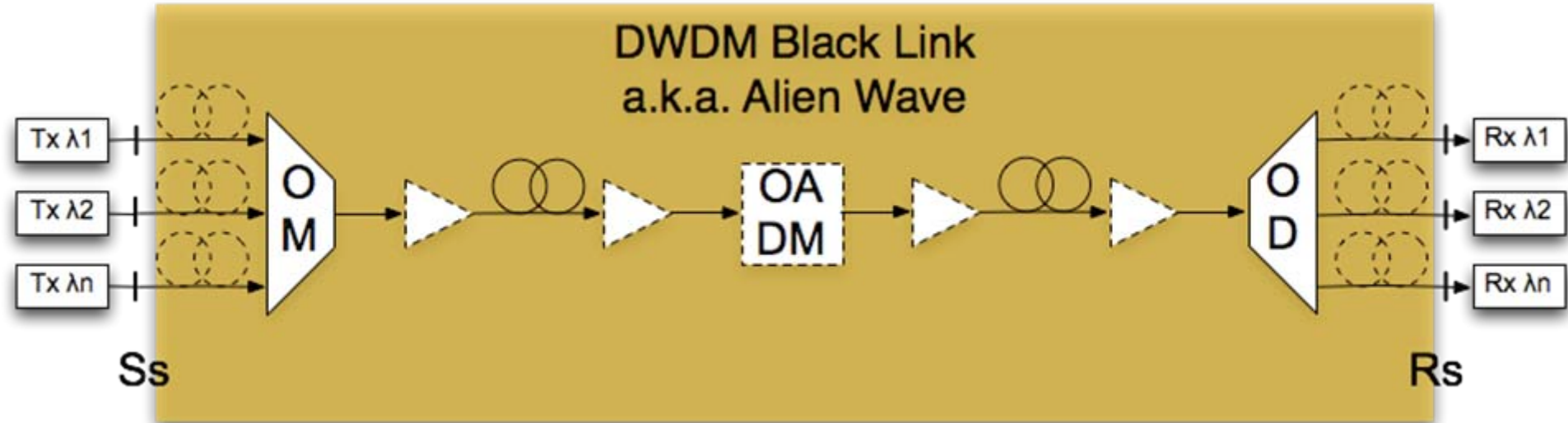


Additional 40G "Express" Links not Shown

IPoDWDM Testing Over Third-Party DWDM Systems

Manufacturer	Equipment Type	IPoDWDM Flavor and Test Network Type		
		10G	40G ODB	40G DPSK+
Alcatel	1626	Production	Production	Production
Ciena	CoreDirector		Test	
Ericsson	MHL3000		Test	
Fujitsu	Flashwave		Test	
Huawei			Production	
Lucent	OLS400		Production	
Nortel	CPL	Production	Production	Production
PadTec		Test		
Siemens	SURPASS hiT7550		Test	
Tellabs	TITAN 7100		Test	

ITU-T G.698.2 (Alien Wavelength)



- Linear unidirectional case shown
- Standard also defines ring and bidirectional cases
- Standard defines properties for Ss and Rs
- Standard defines properties for the “Black Link”

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2008-2012 Optical Strategy

Marketing Strategy

Best DWDM Platform taken to new heights

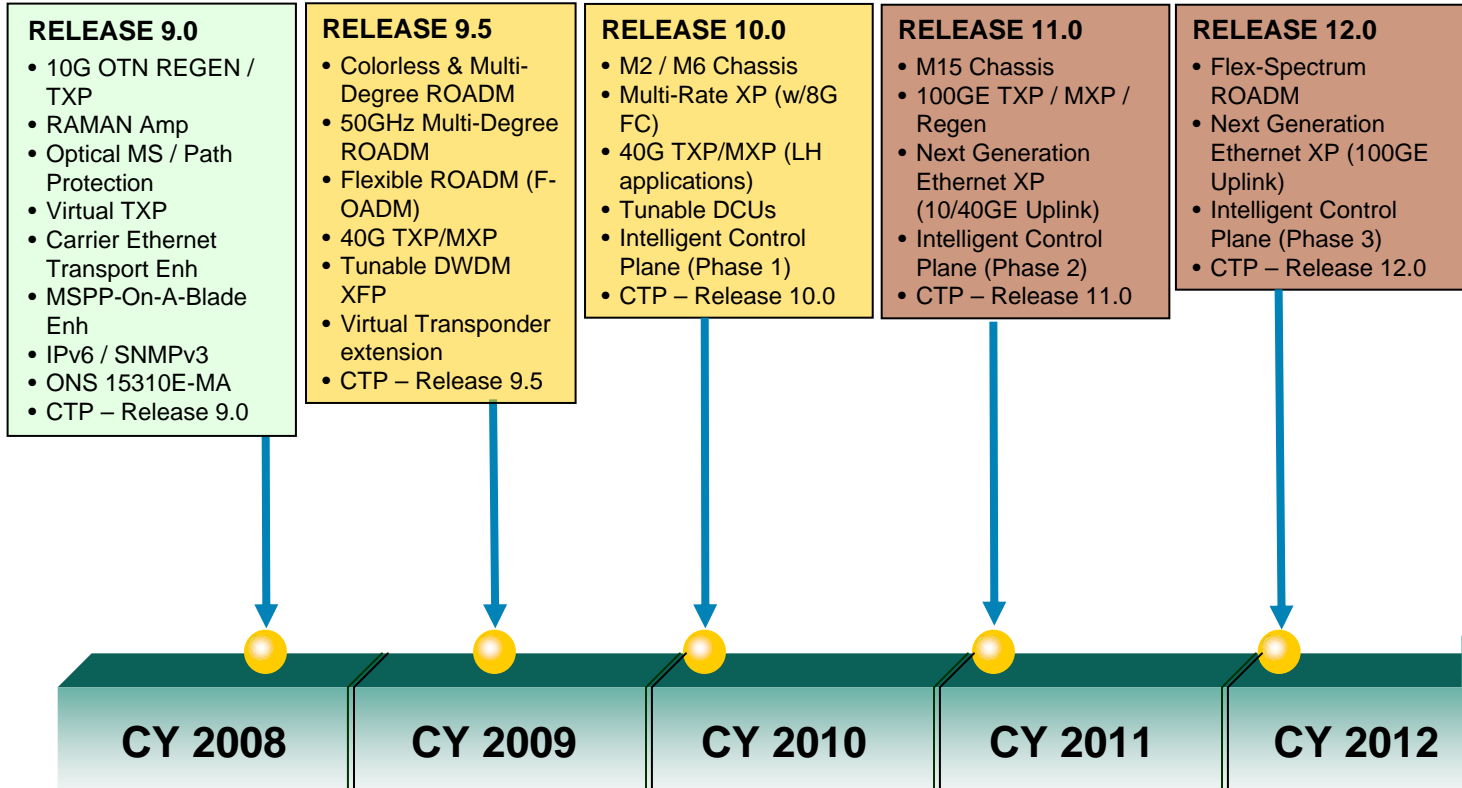
L0/L1/L2 Fully Integration

Technology Strategy

Convergence on DWDM Transport Layer

NG Multilayer convergence Network

OTBU Roadmap



- FCS
- Committed
- Planning
- Radar

Future 100GE Transmission

- Providers are asking for it today!
 - IEEE HSSG—kicked off and studying standards
 - ITU—kicked off and are also studying standards
- Requirements are the same as that of 40 Gig
 - Must meet reach of up to 1500 Km
 - Operate over third-Party DWDM
 - Must operate over existing systems built for 10 Gig
 - Etc
- Proper choice of Modulation Schemes will be imperative
 - Must be robust to linear and non linear impairments

Where is 100Gig

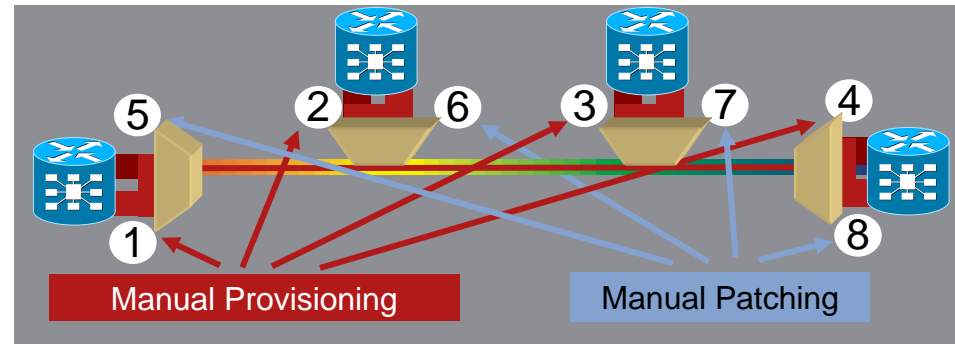


- Cisco is working closely with IEEE and ITU
- Cisco is also working in Parallel on a final product, not waiting for entire standard
- IEEE focused on 40Gig E and 100Gig E SR
Cisco will do the WDMPHY
- Target FCS 1HCY10

Control Plane Evolution (GMPLS)

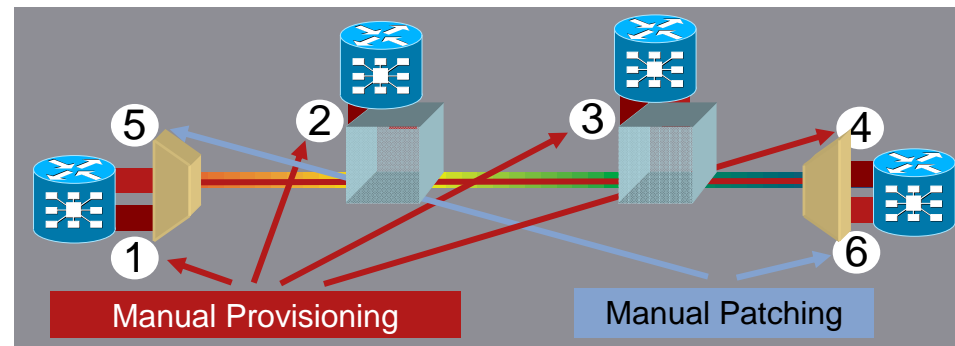
Manual Patching

- Manual provisioning of each node
- Manual patching of each node
- High OpEx
- Truck rolls to every node



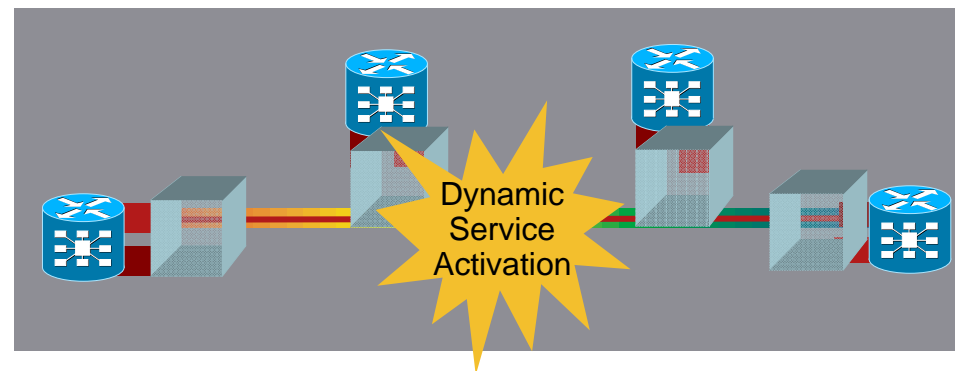
With ROADMs and WXC

- Manual provisioning via NMS
- Autopatching via intermediate ROADMs and WXC
- Lower OpEx
- More service flexibility
- Truck rolls to end points



Dynamic Service Activation with ROADMs and WXC and Control Plane

- Auto provisioning on demand
- Auto patching via ROADMs and WXC
- Lower OpEx even further
- No truck rolls





As the network grows...

...new challenges appear

- How to provide the core and metro bandwidth to the services in timely manner?
- Is the traffic pattern known and will it be known in the medium term ?
- And will my network be ok after all the changes ?
- Do we have to spend a fortune over-provisioning the transport network day one ?
- Can we properly react to catastrophic failure, not only with fast protection but with network optimization to safe status ?

Current TDM ASON Approach

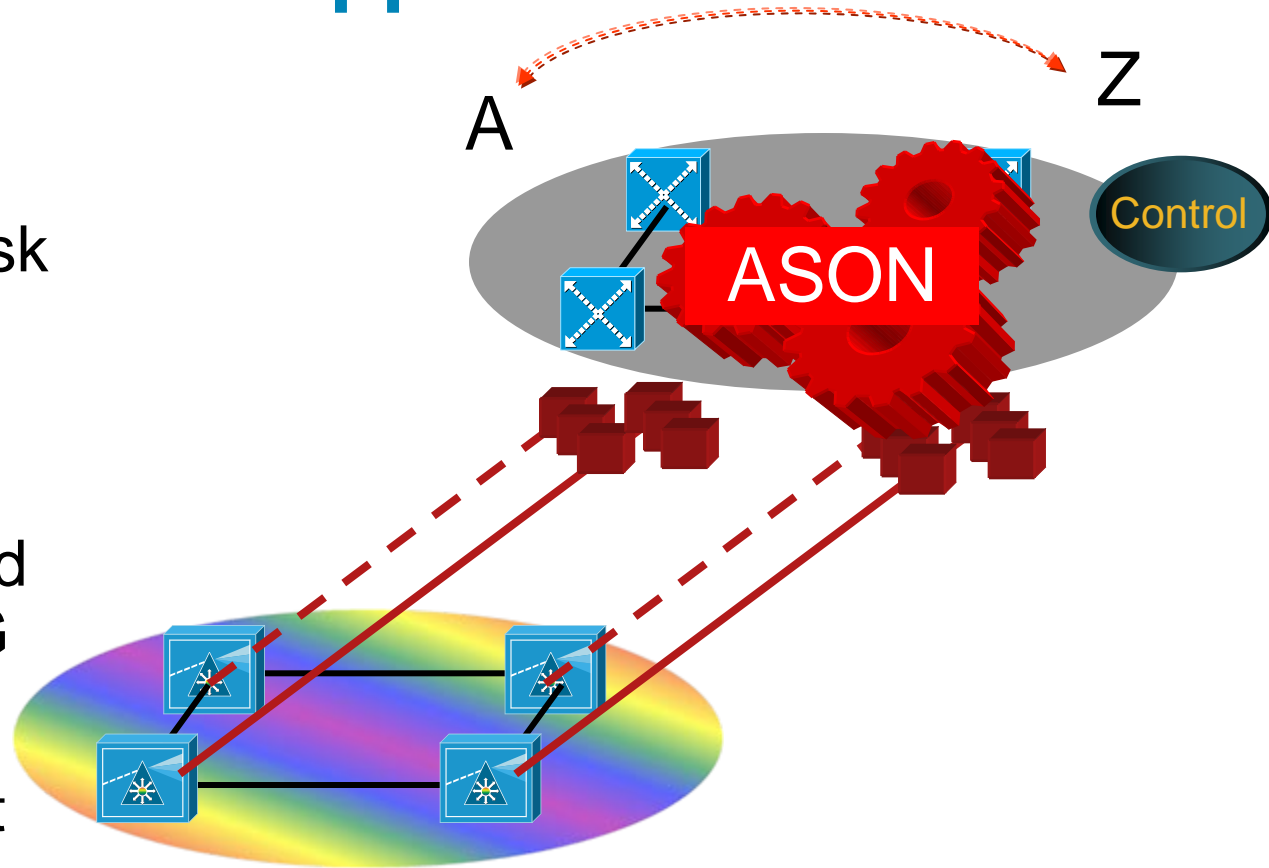
Q: Set up a GE service from A to Z

A: Sure now, just ask the bandwidth!
ASON will do in 1 min.

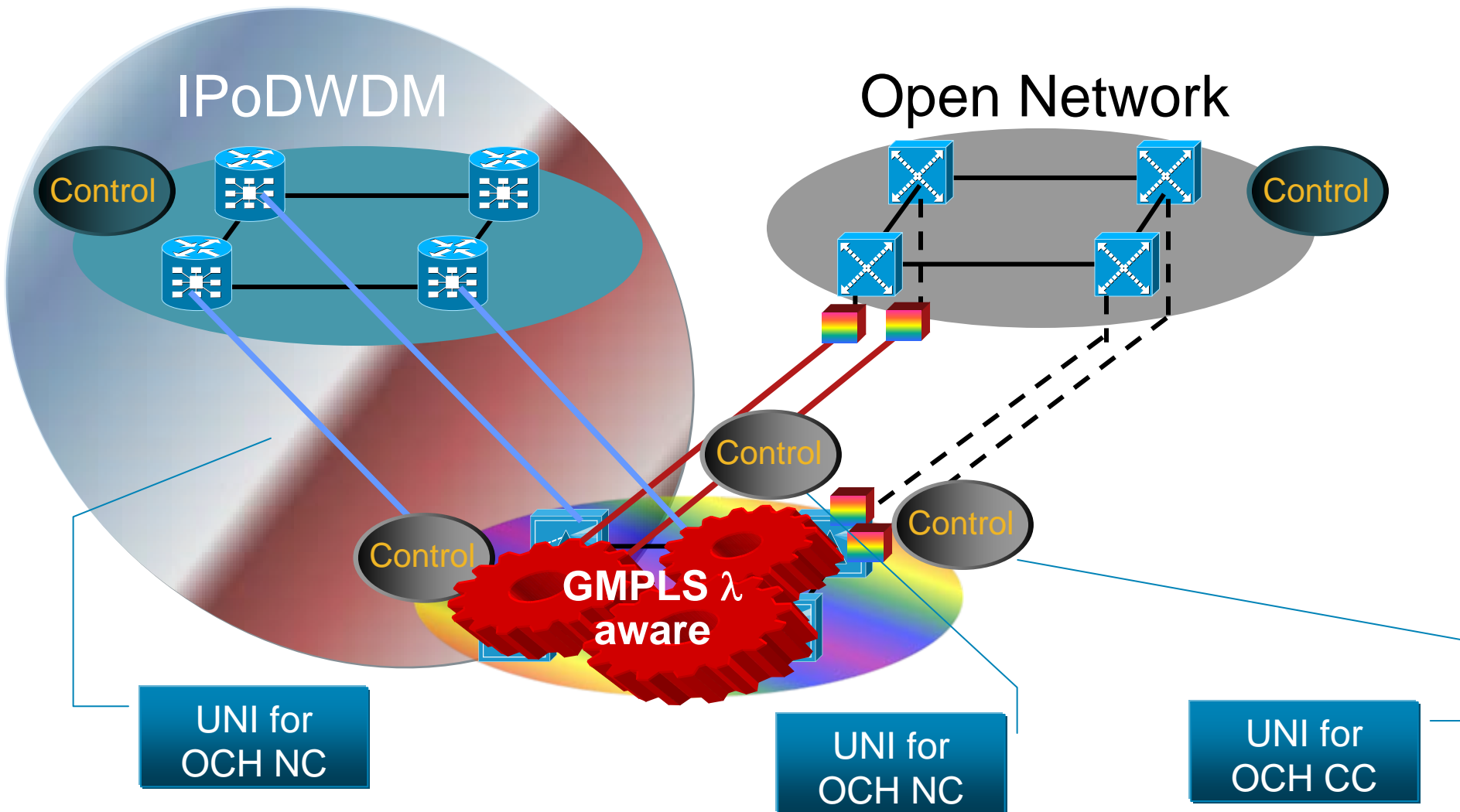
A:Uhm, oh, we need to light another 10G wavelength

Q: How long does it take?

A: uhm, oh... maybe 2 months ?!



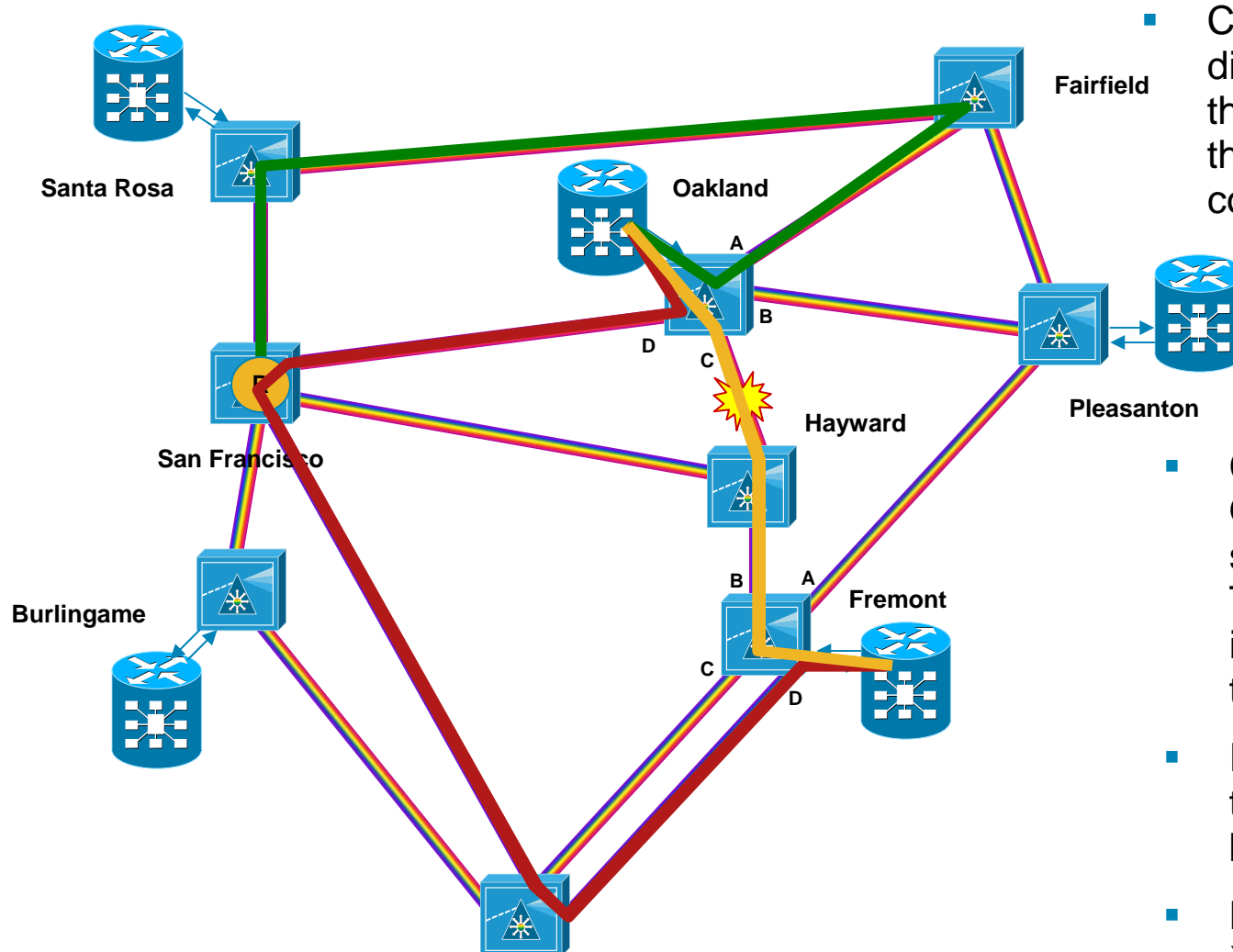
Cisco flexible approach



But it is not so simple... unluckily

- Standard GMPLS or ASON may not work!
- Optical impairment can prevent the optical channel to work
 - Is there enough power budget ? And what about OSNR ?
 - And CD, PMD, FWM ?
 - Is there any regenerator in the network ?
- GMPLS must be **DWDM aware** to assure its functionality. Network topology is not enough

Why Colourless Is Important: Zero pre-provisioning cost & Network Rerouting



- Colorless allows to use different wavelengths for the different sections of the optical path to avoid congestion situations
- Colorless ROADM OCH port enables small pull of TXPs / Tunable client interfaces connected to the DWDM network
- Pre-provisioning of the network interface becomes possible
- No need for photonics XC / flexible patch panel

Key Takeaways

- Predicting Network evolution and traffic requirements will not get easier than now in the future
- ONS 15454 is not just a great platform but provides the **Flexibility** and the **Service Richness** needed to cope with the unknowns
- Cisco Optical portfolio is fully integrated and a key element of the Cisco **NGN Strategy** and **Vision**
- **IPoverDWDM** provides more than just the combination of IP and DWDM benefits