IP / DWDM Innovations for Ethernet Services Delivery

Cisco Expo Tunisia – April '08

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Agenda

- Cisco in the Optical Market

- IP over DWDM

- Reconfigurable Optical Add-Drop

- Integrated Switching Capability

- References

Cisco in the Optical Market

- SONET and DWDM Player since 1999

- Development based on Innovation:

  Multi Service SONET / SDH since 1999

  Reconfigurable Optical Add-Drop since 2004

  Integration of DWDM Optics with G.709 in Routers since 2005

  Ethernet Aggregation integrated in DWDM since 2007

  Multi-Degree Optical Add-Drop Available NOW

Consistent Market Leadership

- Reconfigurable Optical Add-Drop
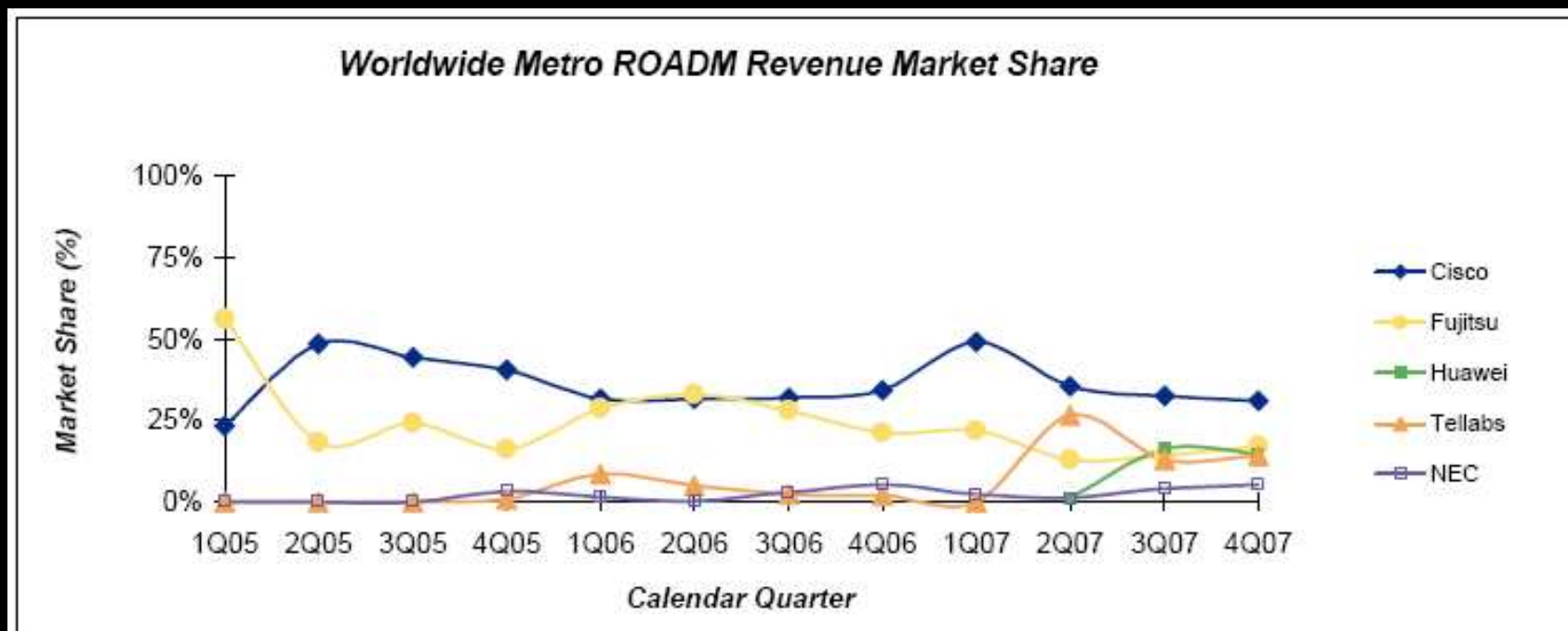
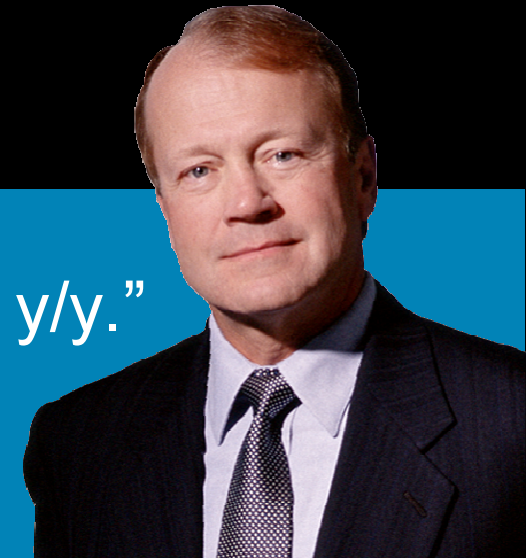*Infonetics, 4QCY07 Market Data, revised Feb. 08*

Cisco IP NGN Transport Momentum and Customers

- 75,000+ systems shipped/in-service
- 5,000+ ROADMs sold—market leader
- 1,000+ MSPP and 500+ MSTP customers

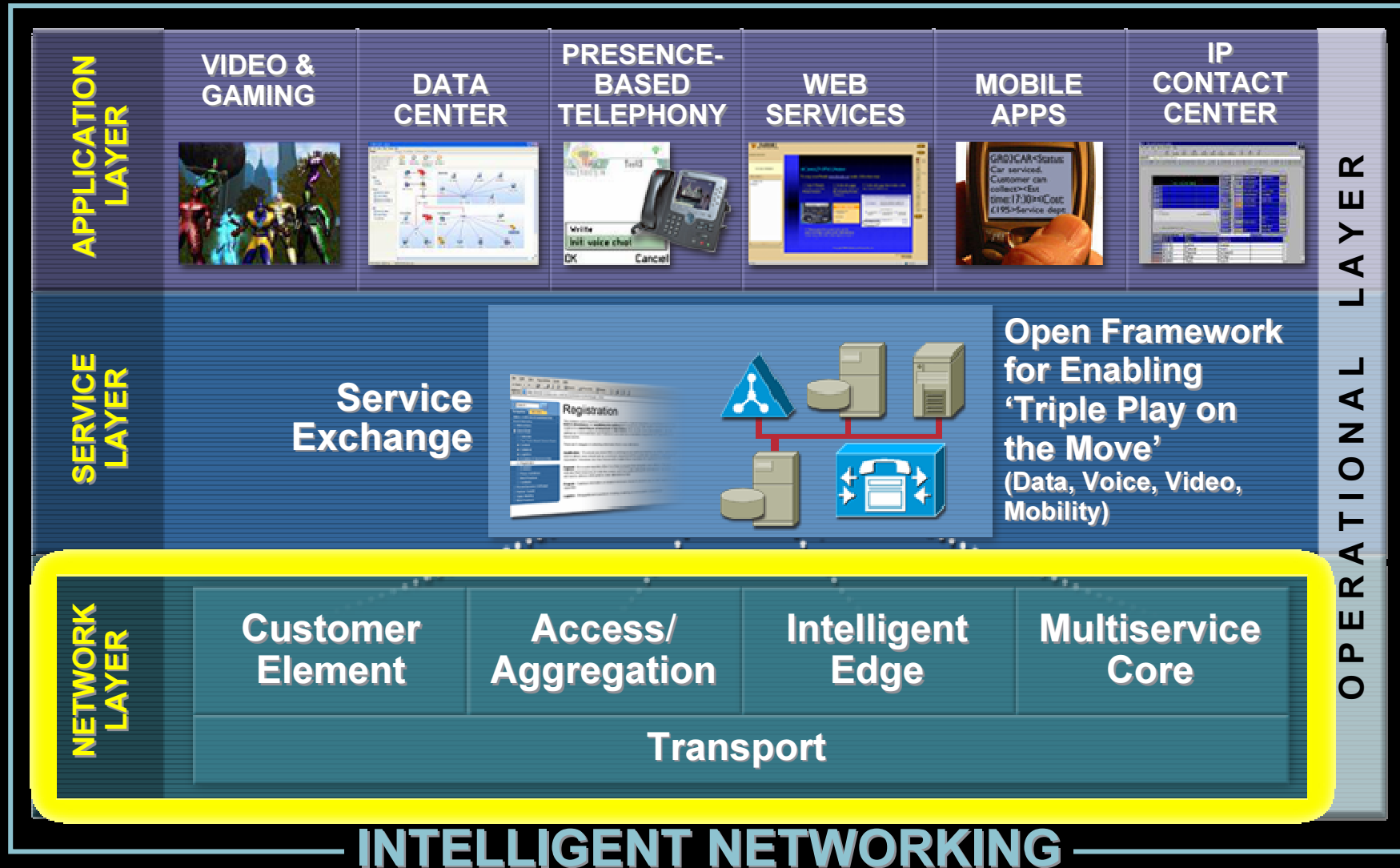**Q2 FY 2007 Quarterly Update**

"Optical business grew 40% y/y."

John Chambers
Cisco Systems, CEO

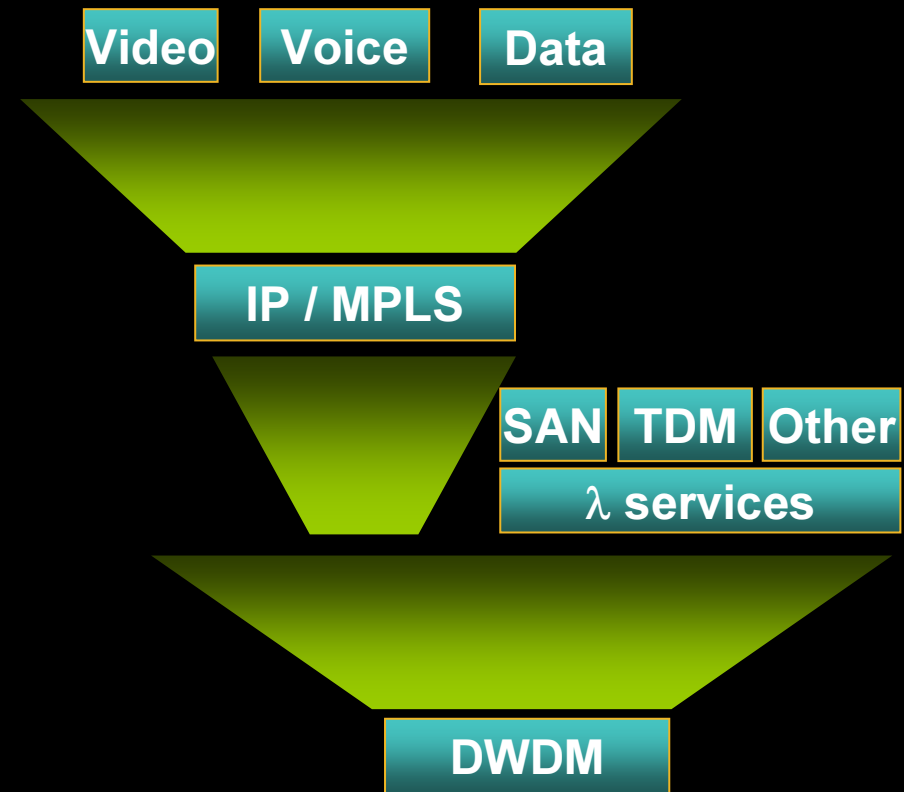## Expanding Global Customer and User Base

at&t	verizon	Comcast	TIME WARNER CABLE THE POWER OF YOU	Sprint Together with Nextel.	Qwest Spirit of Service
TELMEX	BT	COX	CABLEVISION	KT "The Value Networking Company"	ALLTEL You got that right.
veroxity	cogent COMMUNICATIONS Optical Internet	TIME WARNER TELECOM	US SIGNAL	cablecom	香港寬頻 HONGKONG BROADBAND NETWORK

Next-Generation Network Architecture

APPLICATION LAYER

VIDEO & GAMING	DATA CENTER	PRESENCE-BASED TELEPHONY	WEB SERVICES	MOBILE APPS	IP CONTACT CENTER

SERVICE LAYER

Service Exchange

Registration

Open Framework for Enabling 'Triple Play on the Move'
(Data, Voice, Video, Mobility)

NETWORK LAYER

Customer Element	Access/ Aggregation	Intelligent Edge	Multiservice Core

Transport
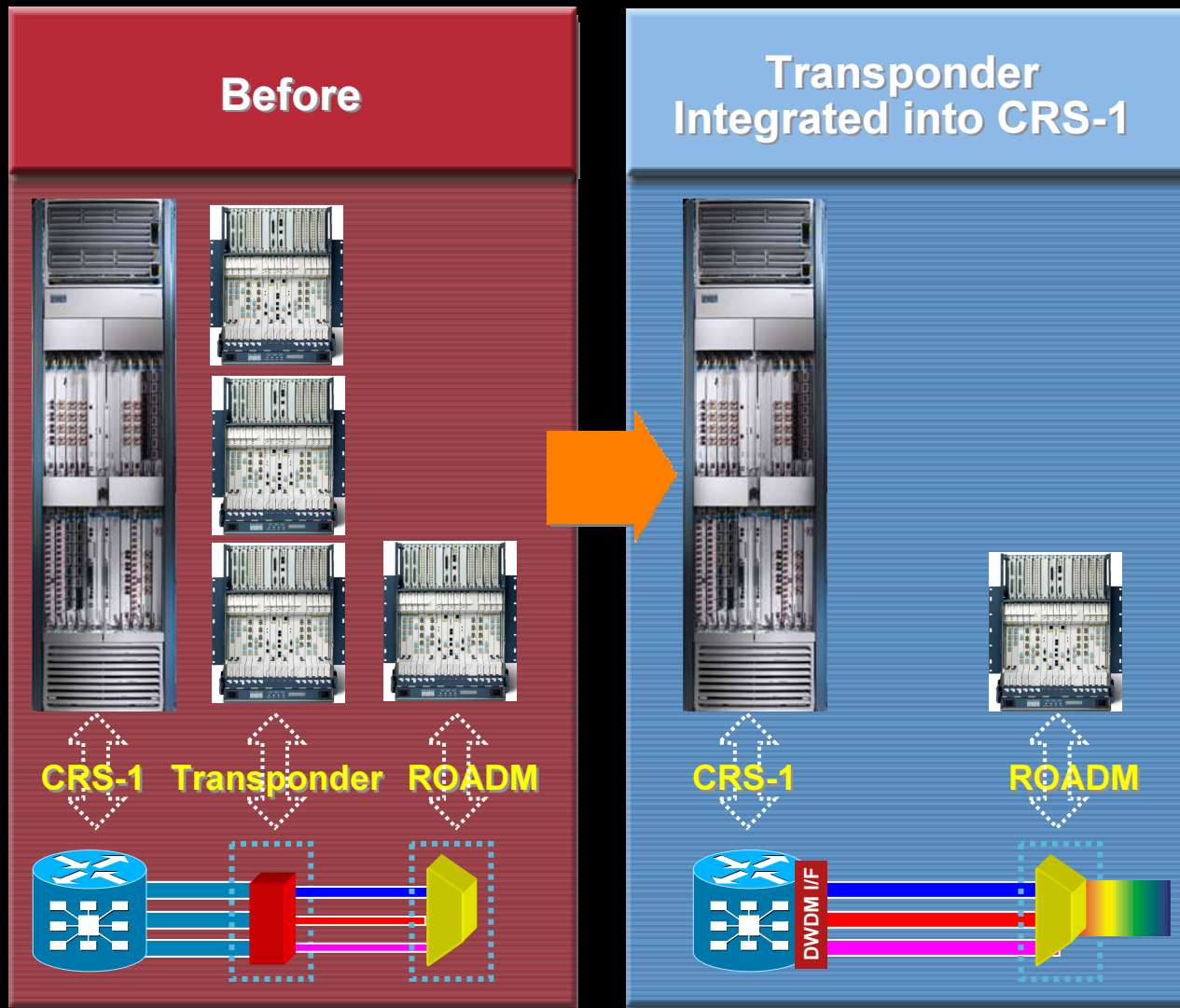
OPERATIONAL LAYER

INTELLIGENT NETWORKING

IP-over-DWDM 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!*

Video	Voice	Data

IP / MPLS

SAN	TDM	Other

λ **services**

DWDM

IPoDWDM - Strategy

Before

Transponder Integrated into CRS-1

CRS-1   Transponder   ROADM

CRS-1   ROADM

DWDM I/F

- **Increased Performance**

  4x increase in throughput for *existing* 10G DWDM systems

- **Lower CapEx**

  50% optics reduction

- **Lower OpEx**

  Fewer shelves (space, cooling, power, management), fewer interconnects

- **Enhanced resiliency**

  Fewer devices, fewer active components, fewer interconnects

IPoDWDM: ITU Optics on Routers over DWDM

Cisco CRS-1 (16/8/4)

1x OC-768c ITU PLIM
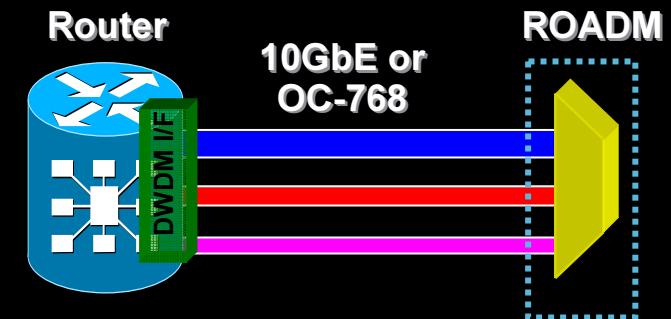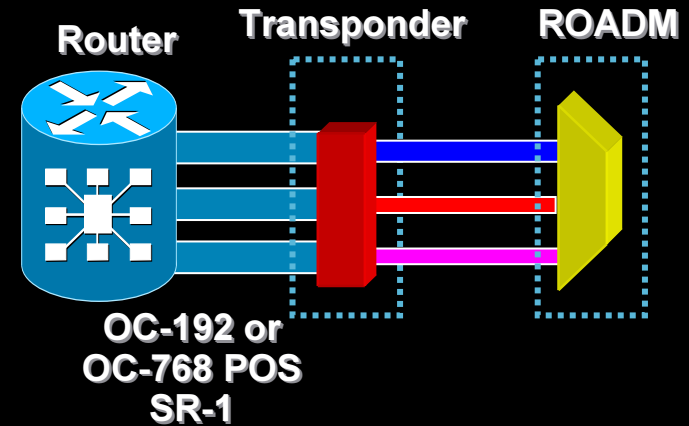
4 x 10GbE ITU PLIM

Cisco 12000

1 x 10GbE ITU SPA

Cisco 7600

4 x 10GbE ITU DWDM XENPAK

DWDM XFP w/EFEC

ONS 15454 MSTP

Router — **Transponder** — **ROADM**

OC-192 or
OC-768 POS
SR-1

Router — **ROADM**

DWDM I/F

10GbE or
OC-768

55% CapEx Reduction due to 10GbE versus 10G POS and no TxPs

70% OpEx Reduction (Less Power, Space, and Fewer Active Devices)

IP Over DWDM Value Proposition

Aggregation	Edge		Edge	Aggregation
Edge Routers		**IP Over DWDM Network Convergence**		Edge Routers

Increase Service Flexibility
Faster service provisioning
New revenue generating services

Increase Reliability
Meet SLAs for customer loyalty

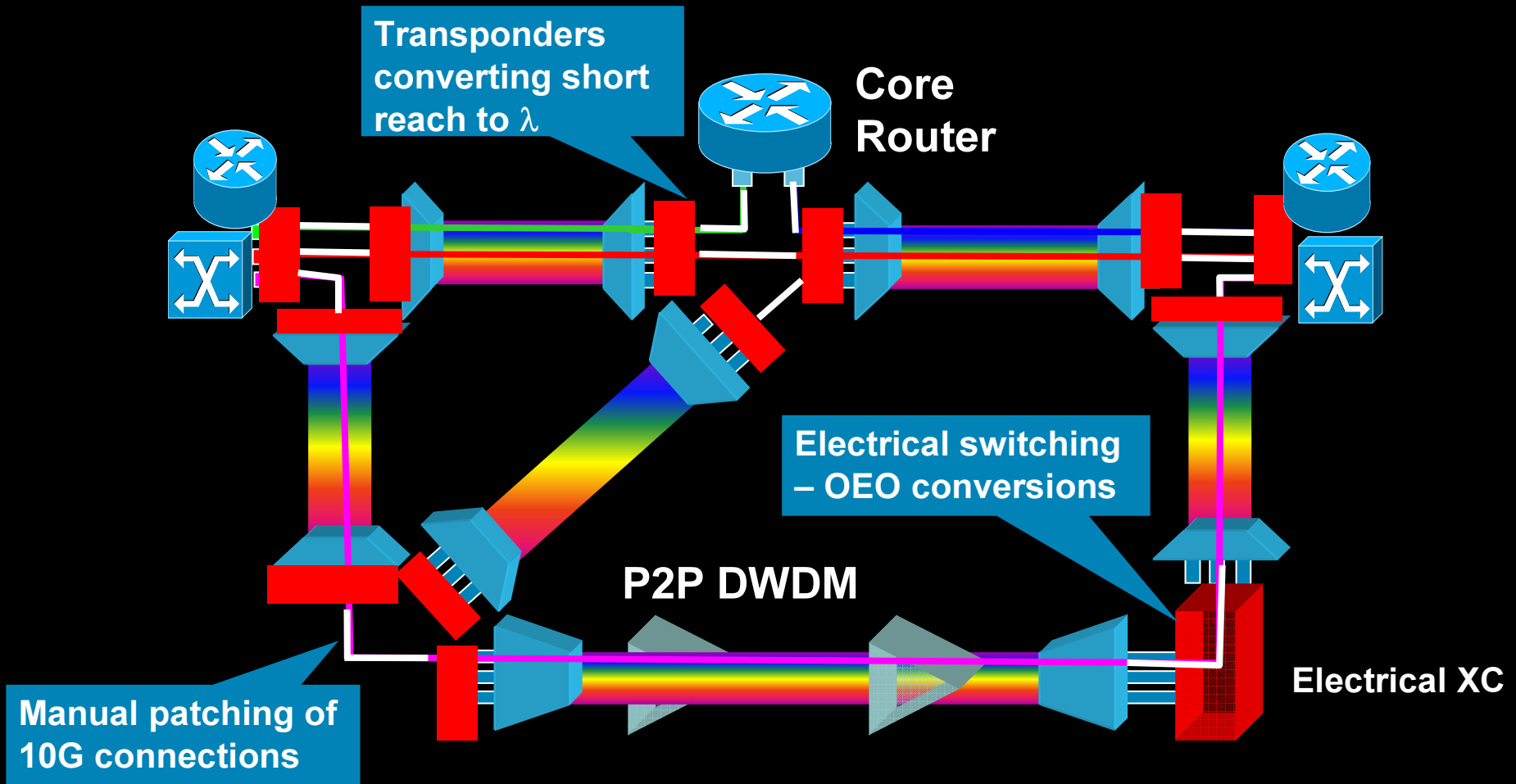**Manage Traffic Growth Efficiently**
Video/Rich IP Media growth

Lower opex
Simplify network & management

Lower capex
Increase profitability & ROI

Traditional IP Network + Optical Network are not Optimized around IP Transport
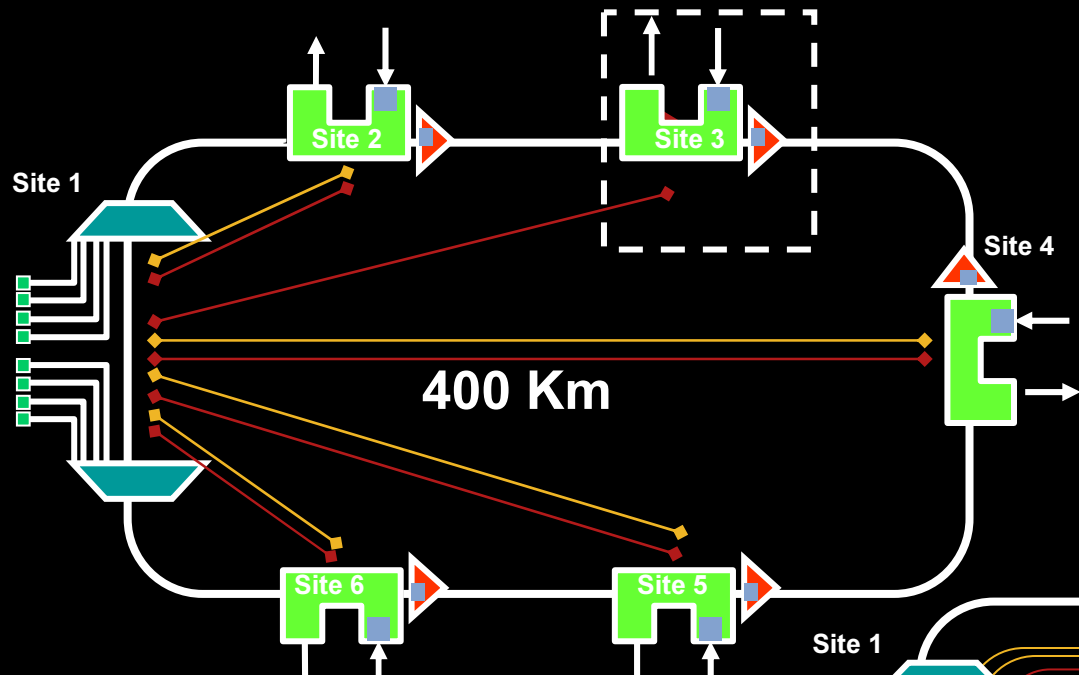
IP Layer Management

Optical Layer Management

Transponders converting short reach to λ

Core Router

Electrical switching – OEO conversions

P2P DWDM

Electrical XC

Manual patching of 10G connections

The IP-over-DWDM Architecture Streamlines the Transport of IP packets

Common Network Management and Control

Integrated transponders

Core Router

Photonic switching – no OEO conversions

Mesh ROADM
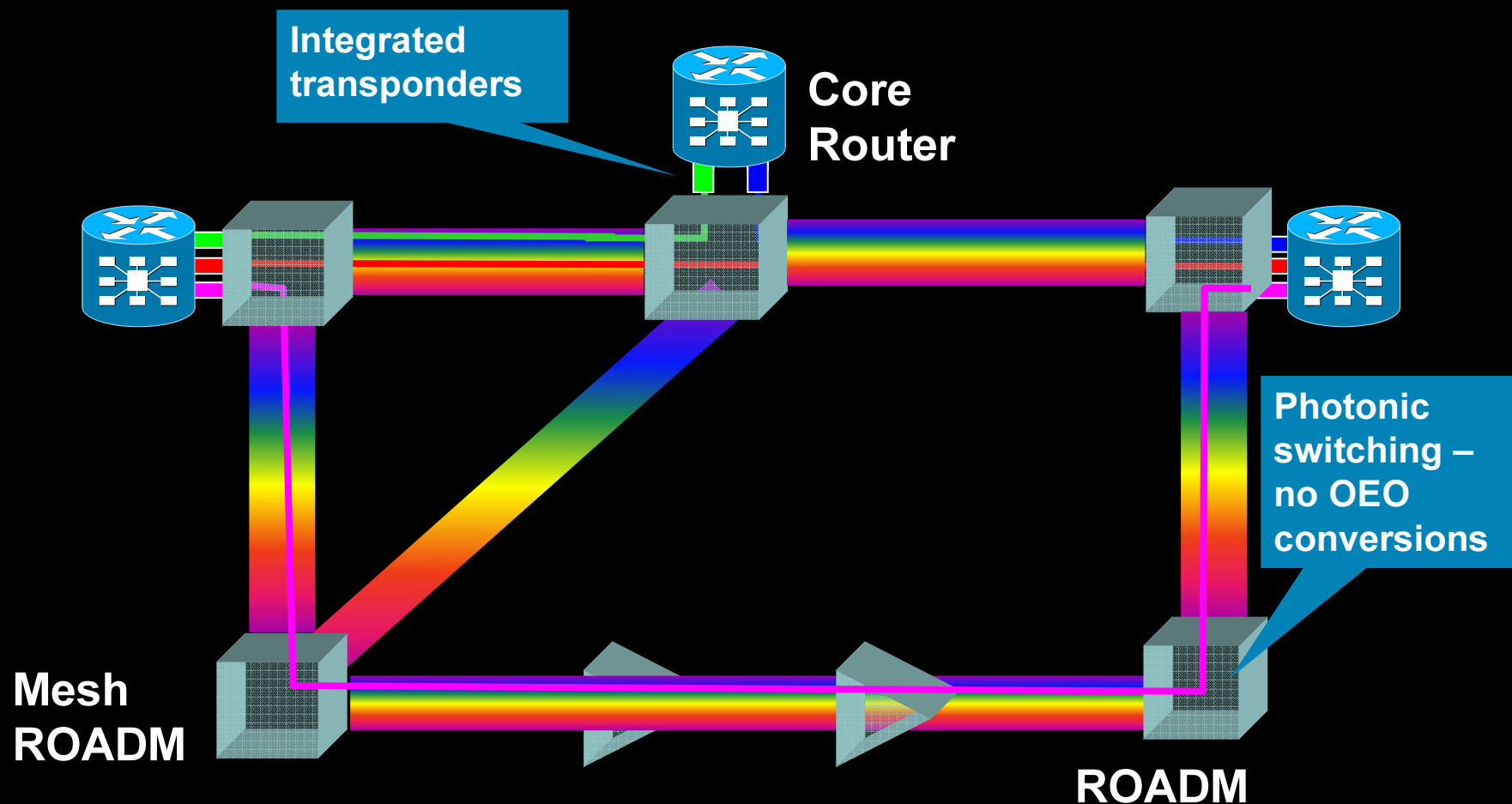
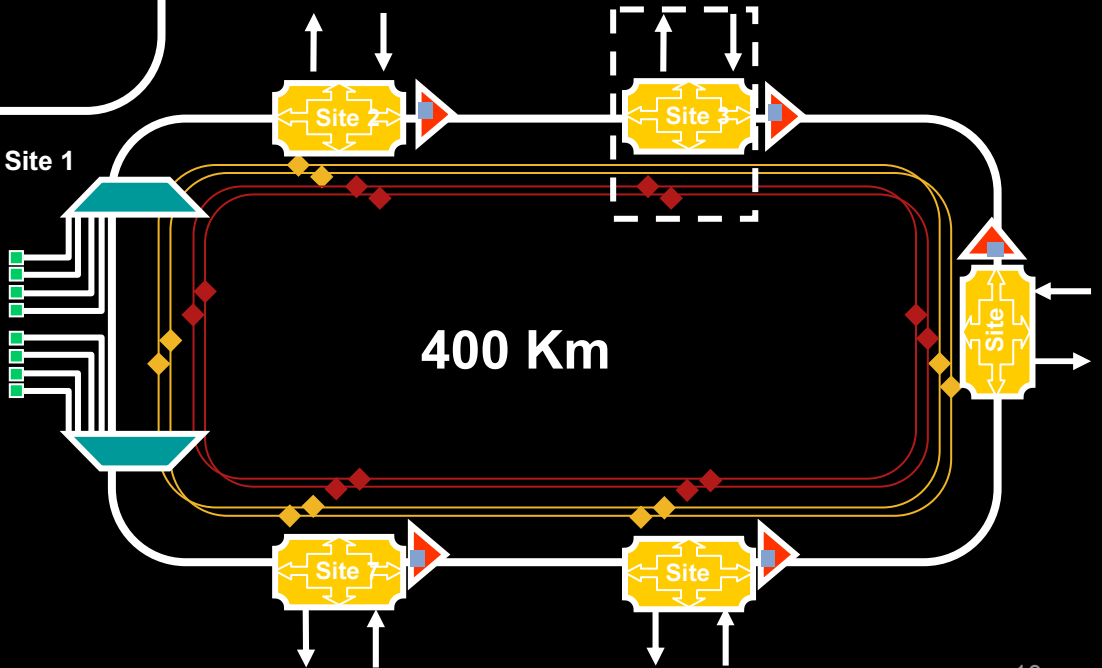**ROADM**

Reconfigurable Networking

Site 1

Site 2

Site 3

Site 4

400 Km

Site 6

Site 5

- **Fixed OADM Solutions cause enormous Operational Hurdles which inhibit network growth**
- **TDM / IP / SAN / WDM often from multiple vendors**

- **ROADM - Operational simplicity…**

  Single Node scalable from 1-40 ch

  Simple cabling

- **…at the right price!**

  Price curve to drive toward the elimination of fixed OADMs

- **TDM/IP/WDM Convergence!**

Site 1

Site 2

Site 3

Site

400 Km

Site

Site

Industry's most comprehensive ROADM Portfolio

- Right-sized ROADM solutions Supports 2° Through 8° Deployments
- Current Metro DWDM customer requirements*

85%	2°
12%	3°–4°
3%	5°–8°

- Mesh will grow over time
- New 8° ROADM Scales in-service from 2°–8°

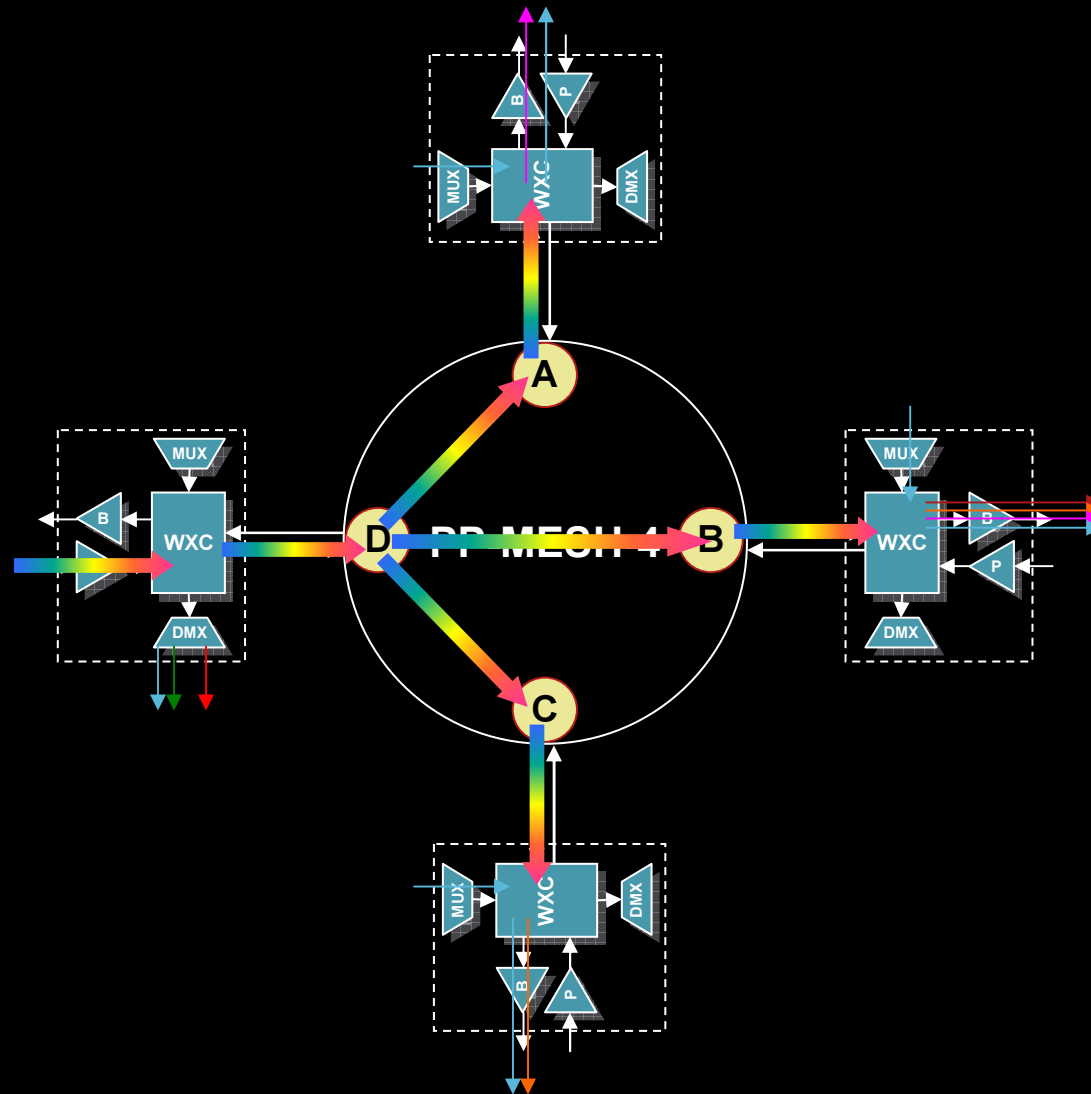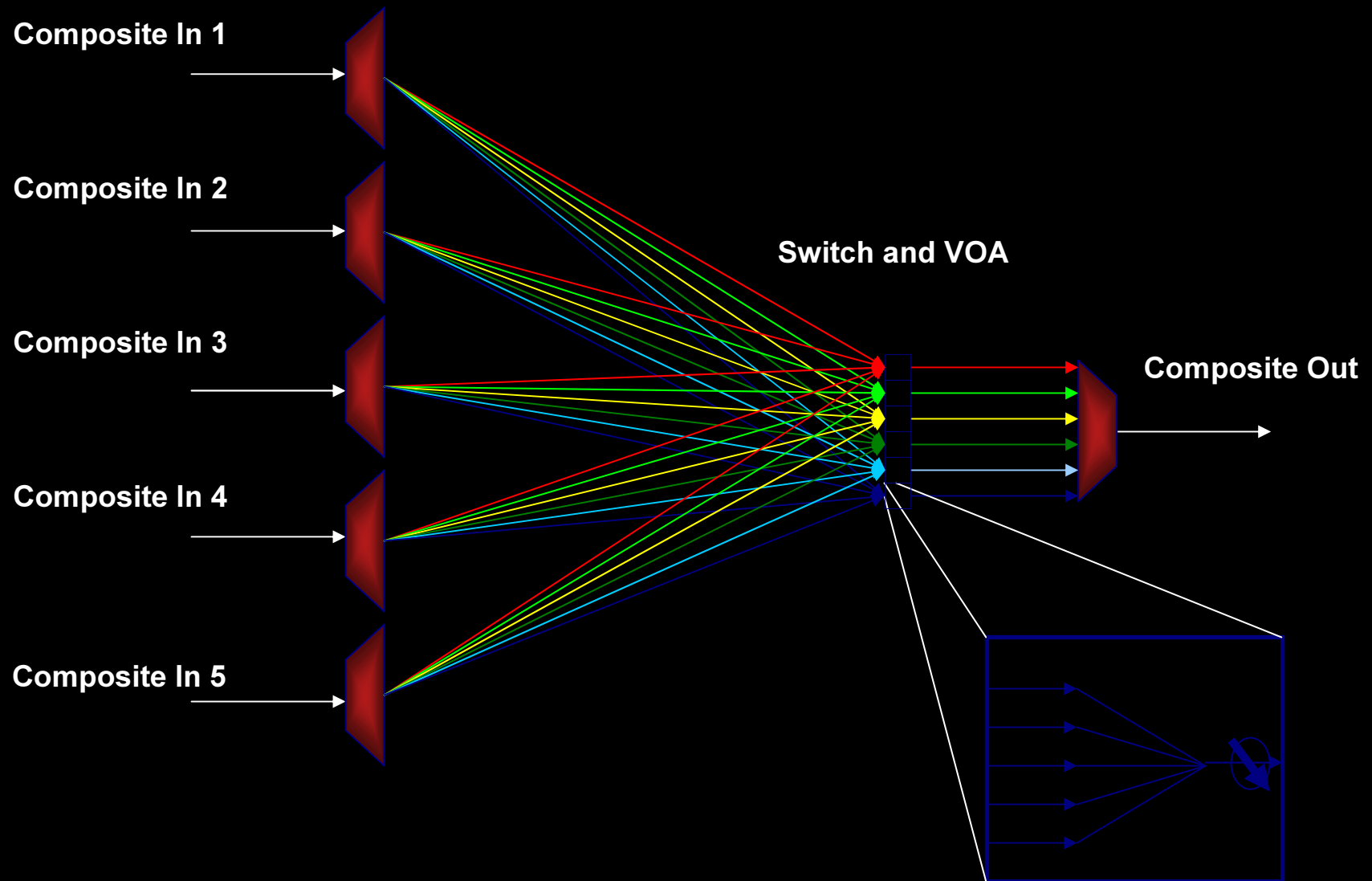*Based on Cisco Internal Study of Customer Requirements

Up to 8°

Shipping

40-Channel Wavelength Cross Connect (WXC)

2°

Shipping

40-Channel ROADM

Over 5,000 In-Service

32-Channel ROADM

Fully Interoperable

Investment Protection

Degree-2 ROADM Node using WSS/DMX

ADD (W)

1 ... 32

DROP (E)

1 ... 32

32-DMX

32-WSS

Splitter

32-WSS

Splitter

32-DMX

1 ... 32

DROP (W)

1 ... 32

ADD (E)
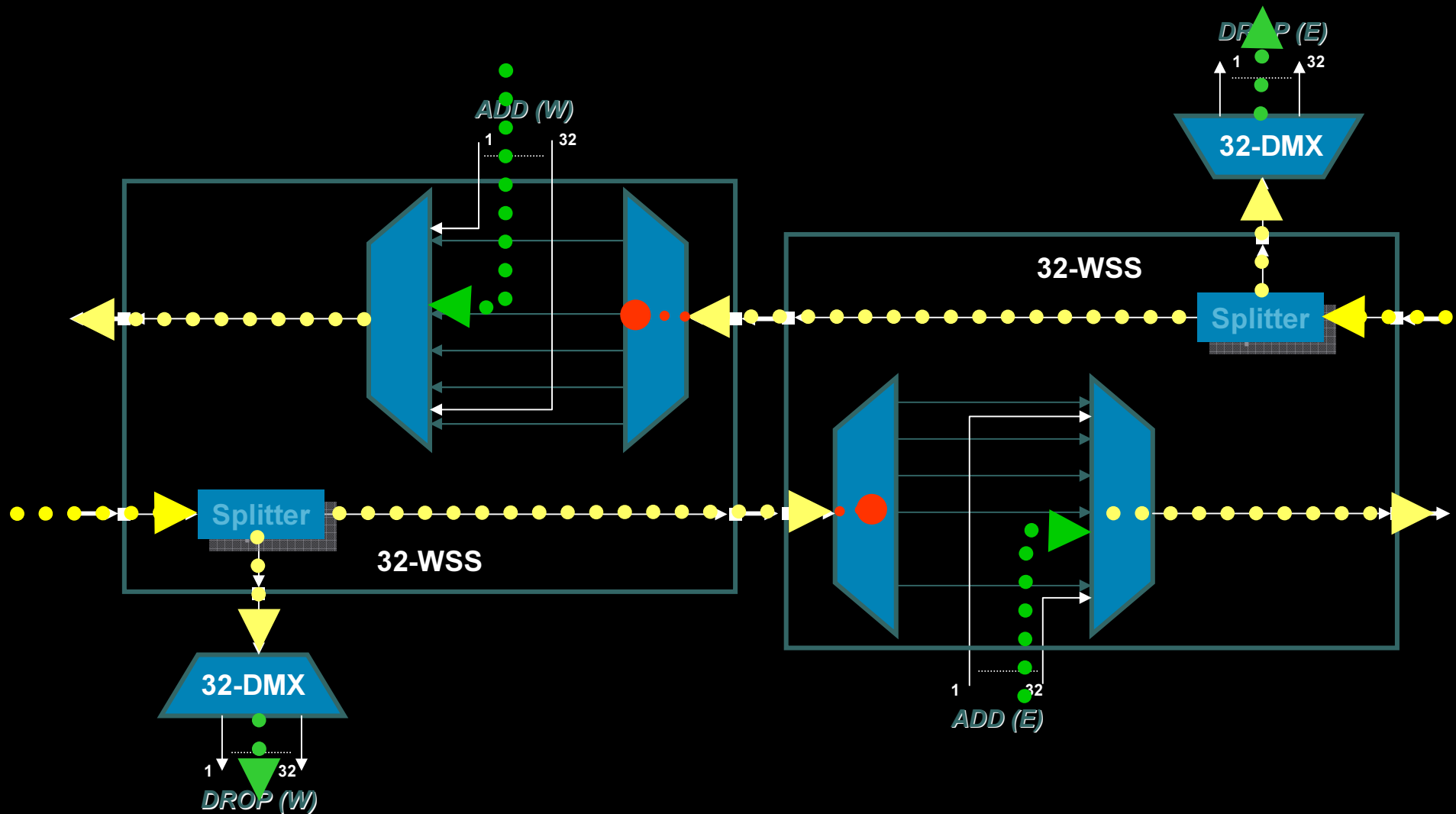
Degree-4 ROADM Optical Signal Flow

40-WXC Functional Block Diagram

Composite In 1

Composite In 2

Composite In 3

Composite In 4

Composite In 5
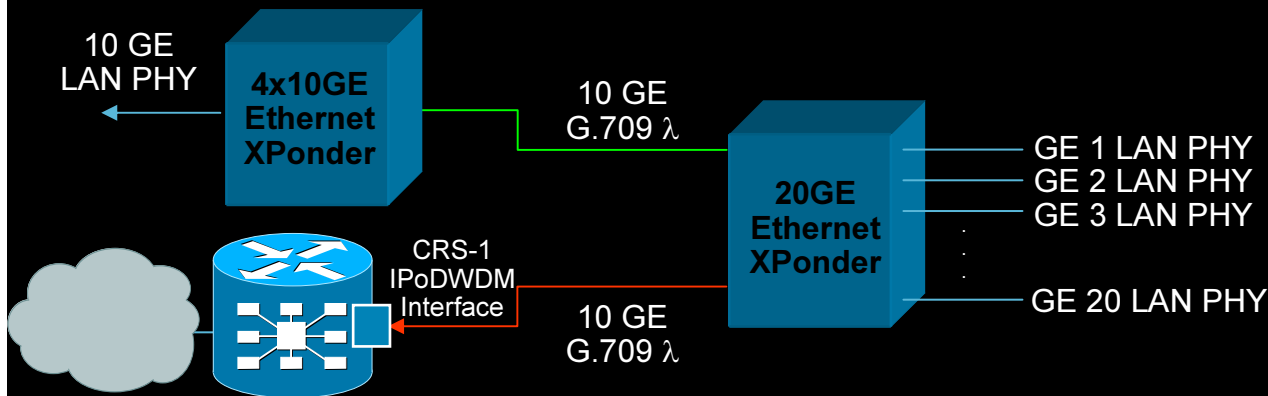
Switch and VOA

Composite Out
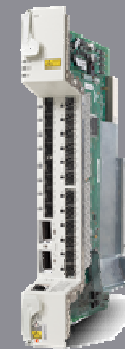
40-WXC Capabilities
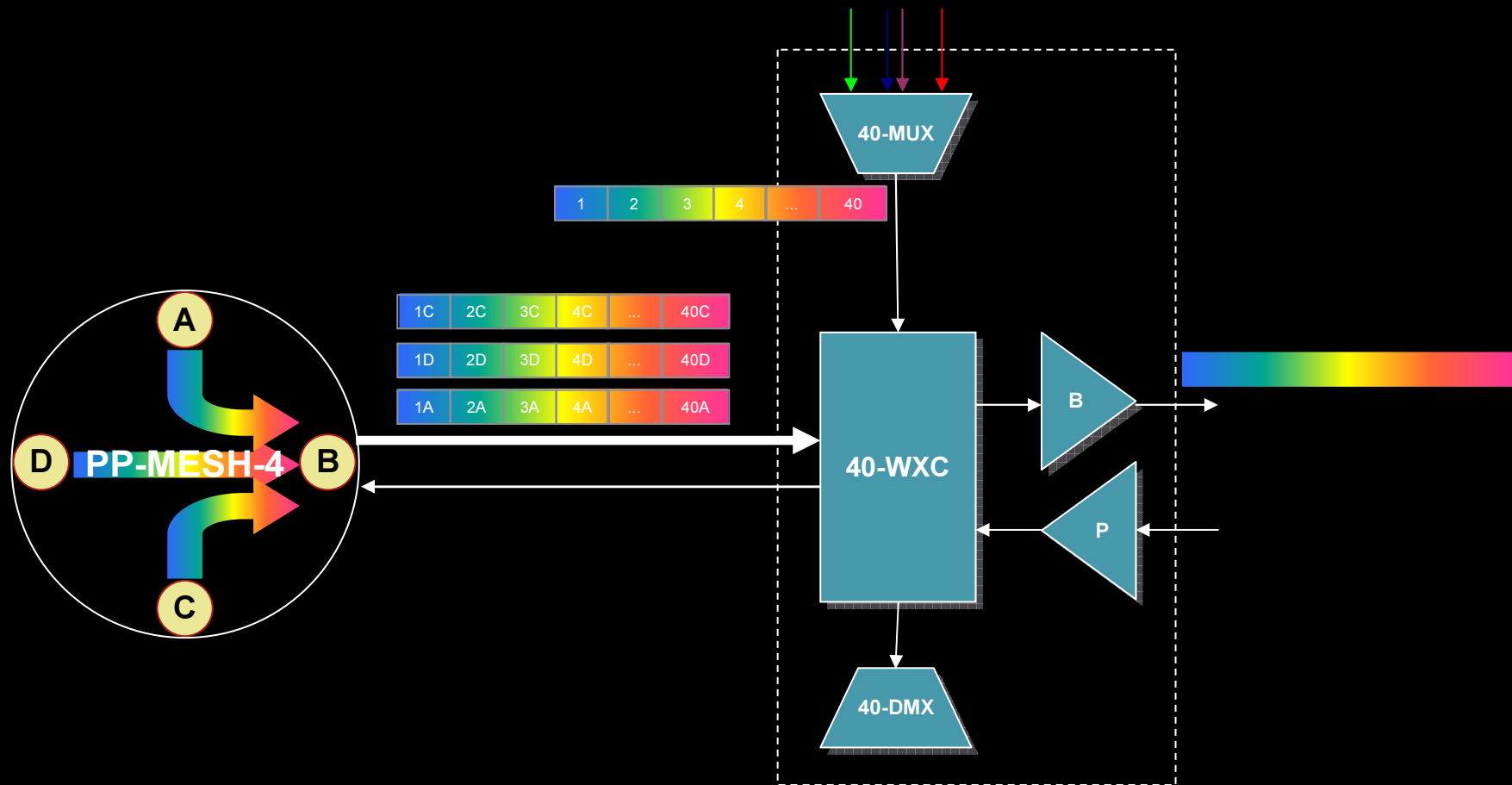
Industry First Ethernet Aggregation Integrated into DWDM

- Introducing Ethernet XPonder (Pronounced Cross-Ponder)

- Single card for Ethernet ADM function, muxponder, transponder

- Innovations:

  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

  SONET clocking synchronization over Ethernet

MEF 9 and 14 Certified

20xGbE and 2x10GE XPonder

4x10GbE XPonder

10 GE LAN PHY

4x10GE Ethernet XPonder

10 GE G.709 λ

20GE Ethernet XPonder

GE 1 LAN PHY
GE 2 LAN PHY
GE 3 LAN PHY
GE 20 LAN PHY

CRS-1 IPoDWDM Interface

10 GE G.709 λ

GE XPonder Operating Modes

- **Fixed Configurations**
  - **20x GE Muxponder**

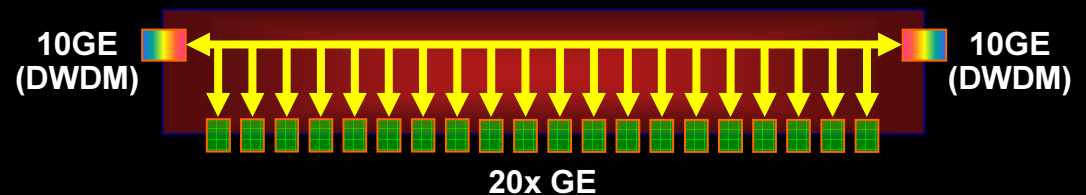   Default Per-port Traffic Load is 50% (configurable - w/ or w/o Flow Control)

10GE (DWDM)

20x GE
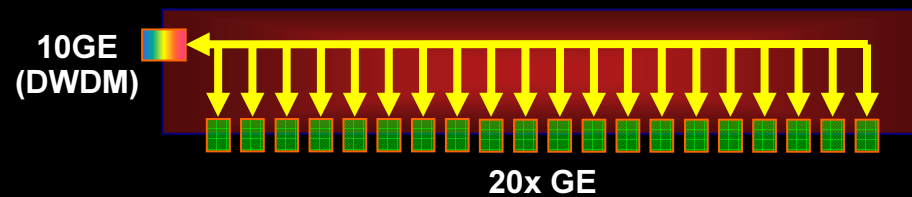
  - **2x 10x GE Muxponder**

    Full GE rate multiplexing of Clients to independent Trunks (10th port @ 99%)

10GE (DWDM)   **10GE (DWDM)**

10x GE   **10x GE**
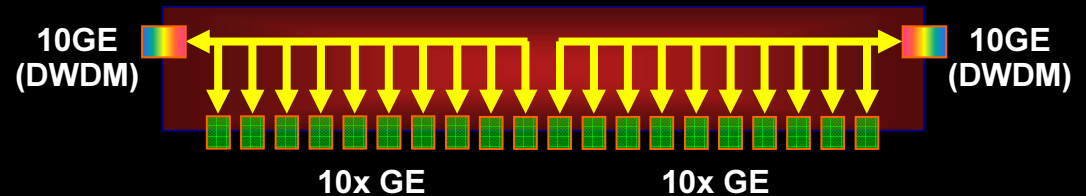
- **Layer2 Switch**
  - **Possible to map any port to any port (GE or 10GE) leveraging on Layer2 VLAN**

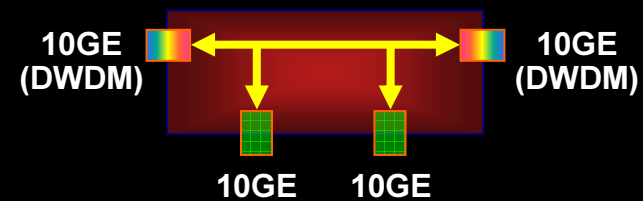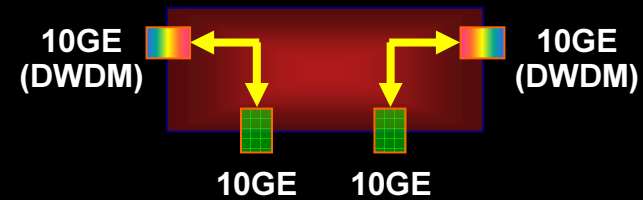**10GE (DWDM)**   **10GE (DWDM)**

20x GE

10GE XPonder Operating Modes

- **Fixed Configuration**
  - **2x 10GE Transponder**

    Supports 10GE LAN PHY

- **Layer2 Switch**
  - **Possible to map any port to any port leveraging on Layer2 VLAN**

  - **10GE LAN PHY DWDM Regenerator**

10GE (DWDM)   10GE (DWDM)

10GE   10GE

10GE (DWDM)   10GE (DWDM)

10GE   10GE

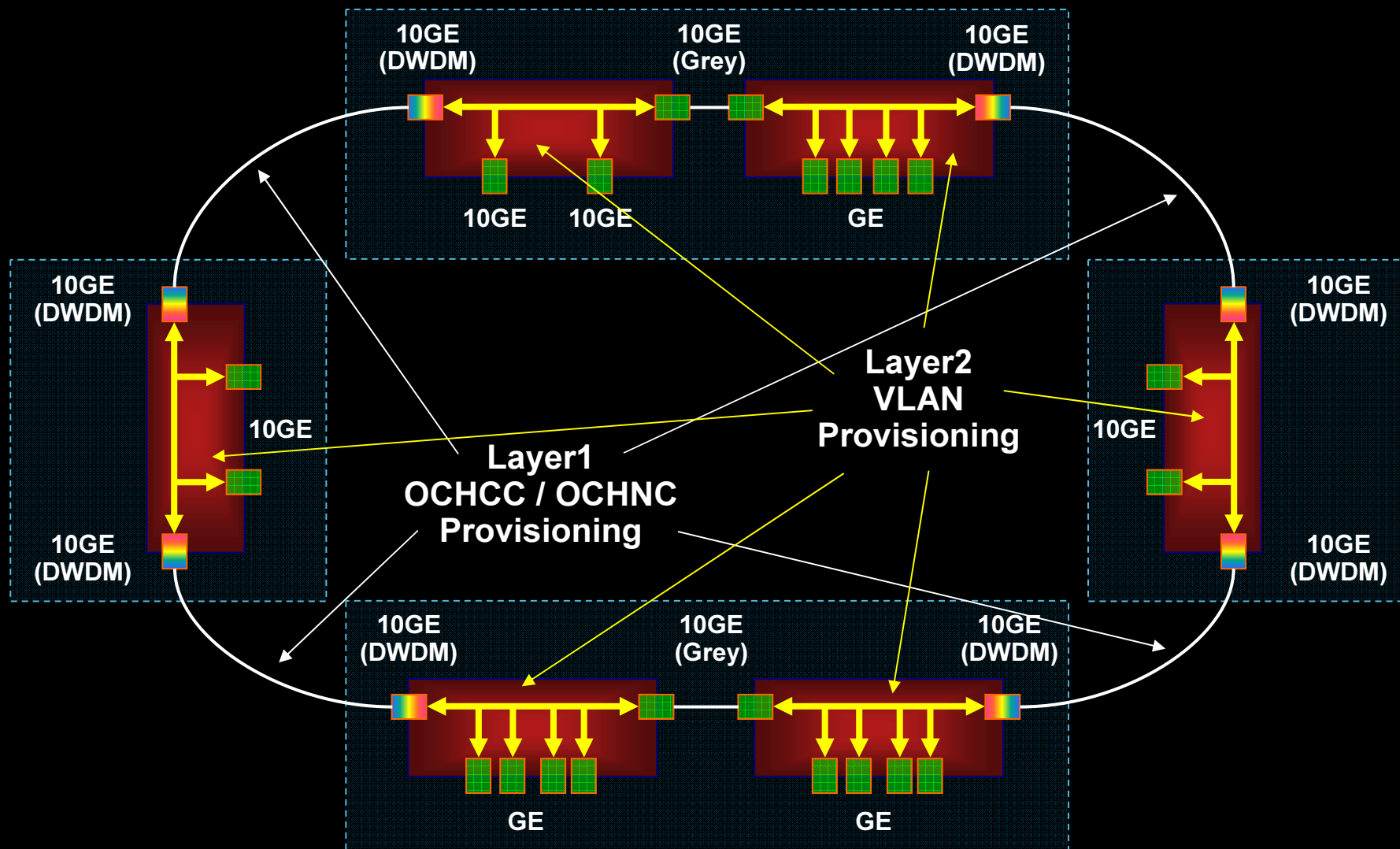10GE (DWDM)   10GE (DWDM)

L2 Switch features (1)

X-Ponder can be configured as a L2 switch supporting following feature set

- MAC Address
  - Support a MAC address table with up to 16k entries per card

- VLAN Management
  - Virtual Bridged LANs support according to the IEEE 802.1Q
  - VLAN tagging support according to IEEE 802.1Q standard
  - Up to 4096 VLAN-ids on all ports

- Spanning Tree*
  - Rapid-STP (RSTP) according to IEEE 802.1W standard support

- Multicast
  - Multicast replication based on Destination MAC Address. The replication shall happen within the same VLAN

- Security:
  - Per-port traffic block for a user provisionable pre-defined set of MAC addresses
  - "L2 Control Protocol Tunnelling" functionality Support
  - User provisioned L2 Control Protocols behaviour (Drop or Tunnel)

L2 Switch features (2)

- Provider bridges support as defined in IEEE 802.1ad standard
    - S-TAG (or Outer tag, or QinQ) support
    - "L2 Control Protocol Tunnelling" functionality Support
    - User provisioned L2 Control Protocols behaviour (Drop or Tunnel)
    - S-VLAN VID translation support through a provisionable VLAN translation table

- QoS
    - 7 egress queues per port scheduled with a Weighted Round Robin (WRR) algorithm.
    - Egress strict priority queue per port

- Policing
    - Single-Rate 3 colour marker (SrTCM). Marking will be based on the following parameters:
        - Committed Information Rate (CIR)
        - Committed Burst Size (CBS)
        - Excess Burst Size (EBS).

GE/10GE XPonder Layer2 Example

10GE (DWDM)   10GE (Grey)   10GE (DWDM)

10GE   10GE   GE

10GE (DWDM)

10GE

10GE (DWDM)

Layer2 VLAN Provisioning

Layer1 OCHCC / OCHNC Provisioning

10GE (DWDM)

10GE

10GE (DWDM)

10GE (DWDM)   10GE (Grey)   10GE (DWDM)

GE   GE

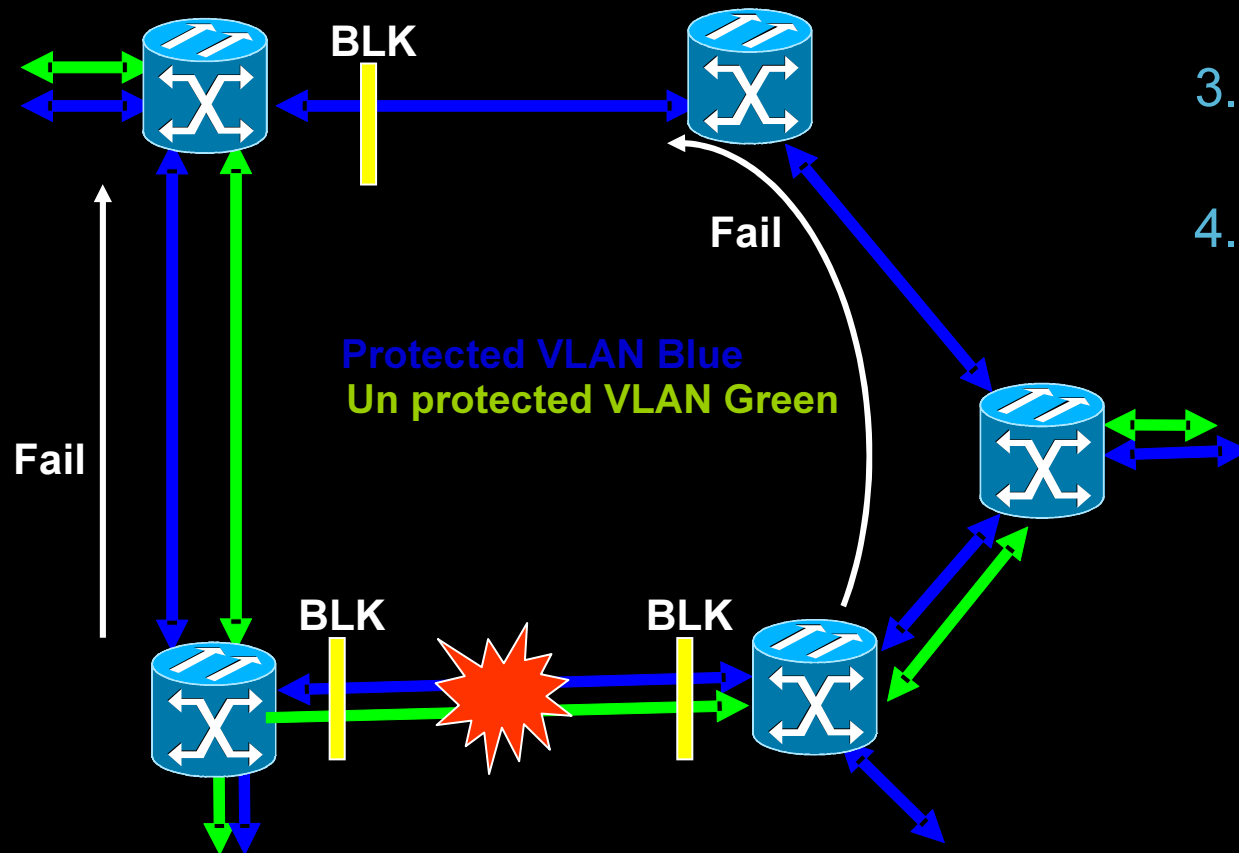# Smart Optical Packet Ring Protection Basic concept

- Revolutionary Protection Mechanism integrating G.709 messaging with Ethernet VLAN mechanism when configured as L2 switches
  - Protection mechanism is achieved using mix of Layer 1 and Layer 2 functionality
  - Fault detection and failure propagation is done via the G.709 bytes. Failure propagation is done at HW level
  - Traffic is flood for each protected VLAN around all 10GE WDM ring.
  - One node is identified (by user config) as master-designated node/port. This node/port is responsible for open-close L2 VLANs loop in case of failure
- Up to 256 protected VLAN can be configured
- Sub 50ms recovery time

Network example

Master-Node

Vlan blue is
in blocking

Protected VLAN Blue
Un protected VLAN Green
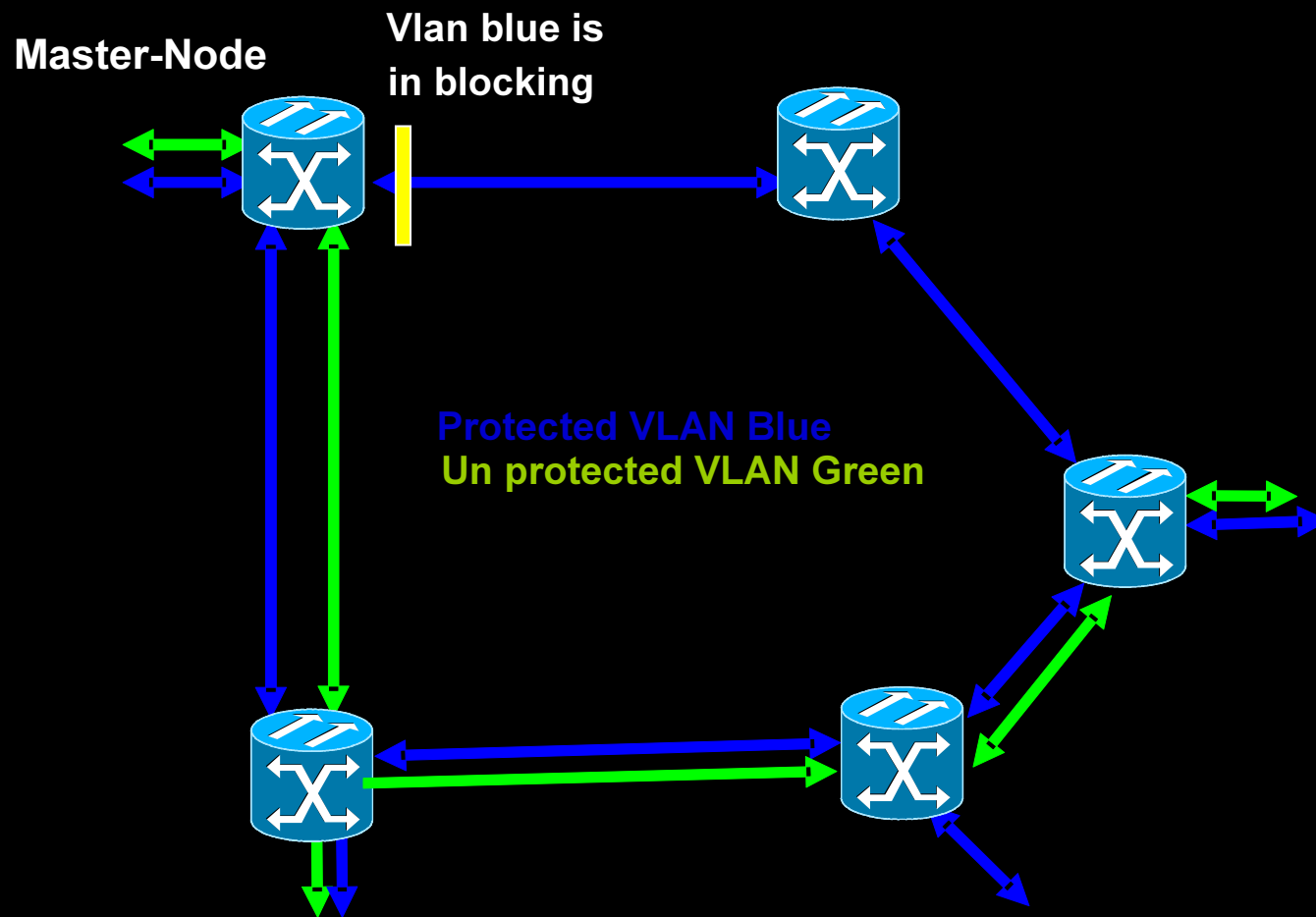
Network example: FAIL

Master-Node

BLK

Fail

Fail

Protected VLAN Blue
Un protected VLAN Green

BLK

BLK
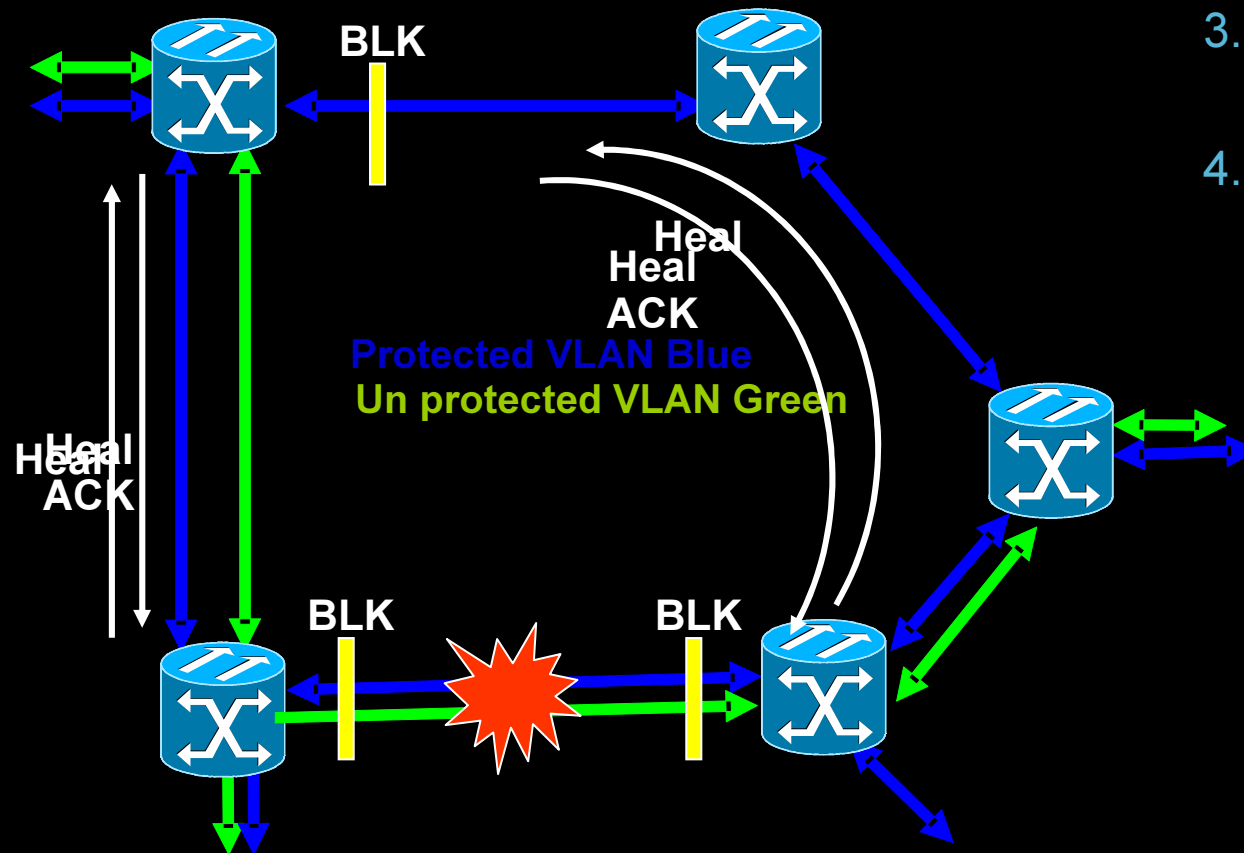
1. Fail detection
2. Port facing the fail in BLK
3. HW fdi/bdi propagation
4. Port on master node in FWD

Network example: Recovery

Master-Node

BLK

BLK   **BLK**

Heal
Heal
ACK

Protected VLAN Blue
Un protected VLAN Green

Heal
Heal
ACK

1. Recovery detection

2. HW Heal propagation

3. Port Port on master node in BLK

4. Heal ack received and BLK removed

Recent Public References

- **Shanghai's Oriental Cable Network Selects Cisco to Deploy First ROADM Optical Networking Technology in Mainland China**
  http://newsroom.cisco.com/dlls/2008/prod_011708.html - 17 January 2008, China

- **Saddleback Communications' XPonders Enable World Class Business Services**
  http://www.cisco.com/en/US/prod/collateral/optical/ps5724/ps2006/prod_case_study0900aecd8073eea2_ps2006_Products_Case_Study.html - 14 January 2008, USA

- **Cisco's MSTP Brings New Benefits to Hong Kong Businesses**
  http://newsroom.cisco.com/dlls/global/asiapac/news/2007/pr_07-12.html -12 July 2007, Hong Kong

- **Ukrtelecom Completes Second Phase of National Fiber Network With Cisco**
  http://newsroom.cisco.com/dlls/2007/prod_050707c.html - 7 May 2007, Ukraine

- **Bulgarian Telecommunications Company Expands Cisco IP Next Generation Network for Triple-Play Service Growth**
  http://newsroom.cisco.com/dlls/2007/prod_041207b.html - 12 Apr 2007, Bulgaria

- **Charter Communications Enhances Business and Residential Service Delivery with Cisco IP NGN Architecture**
  http://newsroom.cisco.com/dlls/2006/prod_101806.html - 18 Oct 2006, USA

- **New Jersey Turnpike Authority Upgrades Network with Cisco Optical Solution**
  http://newsroom.cisco.com/dlls/2006/prod_060606.html - 6 Jun 2006, USA

- **MobiCom Deploys State-of-the-Art Optical Network with Cisco Solution**
  http://newsroom.cisco.com/dlls/2006/prod_060206c.html - 2 Jun 2006, Mongolia