Cisco optical solution overview and update

Jaromír Pilař

Consulting System Engineer, CCIE #2910

Enable Your Network
Empower Your Business

Cisco footprint in optical networking

- Market entrance in 1999 through Pirelli, Cerent and Monterey acquisition
- Cisco continues in investment into advanced optical technology
  - ✓ CoreOptics acquisition to obtain coherent optical technology (CP-QPSK) and MLSE
  - ✓ Massive investment Cisco ONS 15454 MSTP future functionality including 100 Gbps technology and beyond
- Flexible, zero-touch optical networking
  - ✓ Market leader in two degree and multi degree ROADM technology and packet optical transport
  - ✓ Support for omni-directional and colorless ROADM available
  - ✓ Automated optical control plane in the roadmap
- Tight integration with core routing, Metro Ethernet and TDM technology
  - ✓ IPoDWDM technology for close integration of core routing with Cisco ONS 15454 MSTP or 3rd party optical transport system
  - ✓ Xponder technology for Metro Ethernet integration
  - ✓ MSPP on the Blade for integrated TDM solution
- High quality planning and management tool
  - ✓ Comprehensive design and validation tool available to customers (Cisco Transport Planner)
  - ✓ Enhanced craft terminal for initial setup and deployment (Cisco Transport Controller)
  - ✓ Advanced management suite (Cisco Transport Manager)

Cisco ONS 15454 MSTP

Platform introduction and overview

Cisco ONS 15454 MSTP
Fully reconfigurable, intelligent DWDM platform

- **Carrier Class DWDM Transport**
  - **Combines TDM, Ethernet, SAN and video services (fully integrated with Cisco ONS 15454 MSPP)**
  - **Originally introduced in 2003 as advanced metropolitan DWDM platform (broad services range, 800 km reach)**
  - **Through several releases evolves into platform covering all requirements for enterprise BC/DR solutions, metropolitan DWDM networks and LH applications (2300 km in release 9.2)**

- **Flexible optical networking platform**
  - **Cost effective Reconfigurable Optical Add/Drop Multiplexers (ROADM) with support for optical mesh**
  - **Full band Tunable 10G Lasers, modular client interfaces**
  - **Tight integration with IP core routers (IPoDWDM strategy)**

- **Future proof extensible platform**
  - **Up to 112 wavelengths available for the platform today**
  - **Support for 40 Gbps transport, 100 Gbps demonstrated in public**
  - **Further developed to extend the reach and functionality**
  - **High level of investment protection**

Cisco ONS 15454 MSTP

Examples of installations in Central and Eastern Europe

•Hansapank Estonia

•KPSI – Regional Government Poland

•Hungarian PTT National backbone

•Czech Republic (NREN)

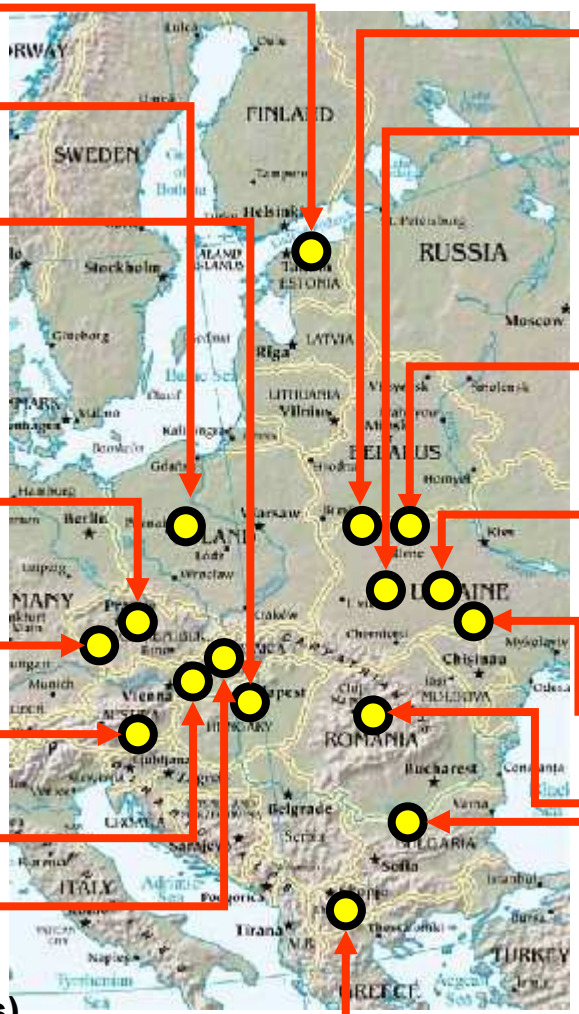
•Sloane Park Czech Republic

•Elekto Maribor Slovenia

•Slovanet Slovakia

•Energotel Slovakia

OSE (Greek Railways) National Backbone



UMC – Mobile SP National Backbone

UComLine - Ukrainian Challenger National Backbone

KievStar - Mobile SP National Backbone

Datacom - Ukrainian Challenger National Backbone

• UkrTelecom - Ukrainian PTT National Backbone

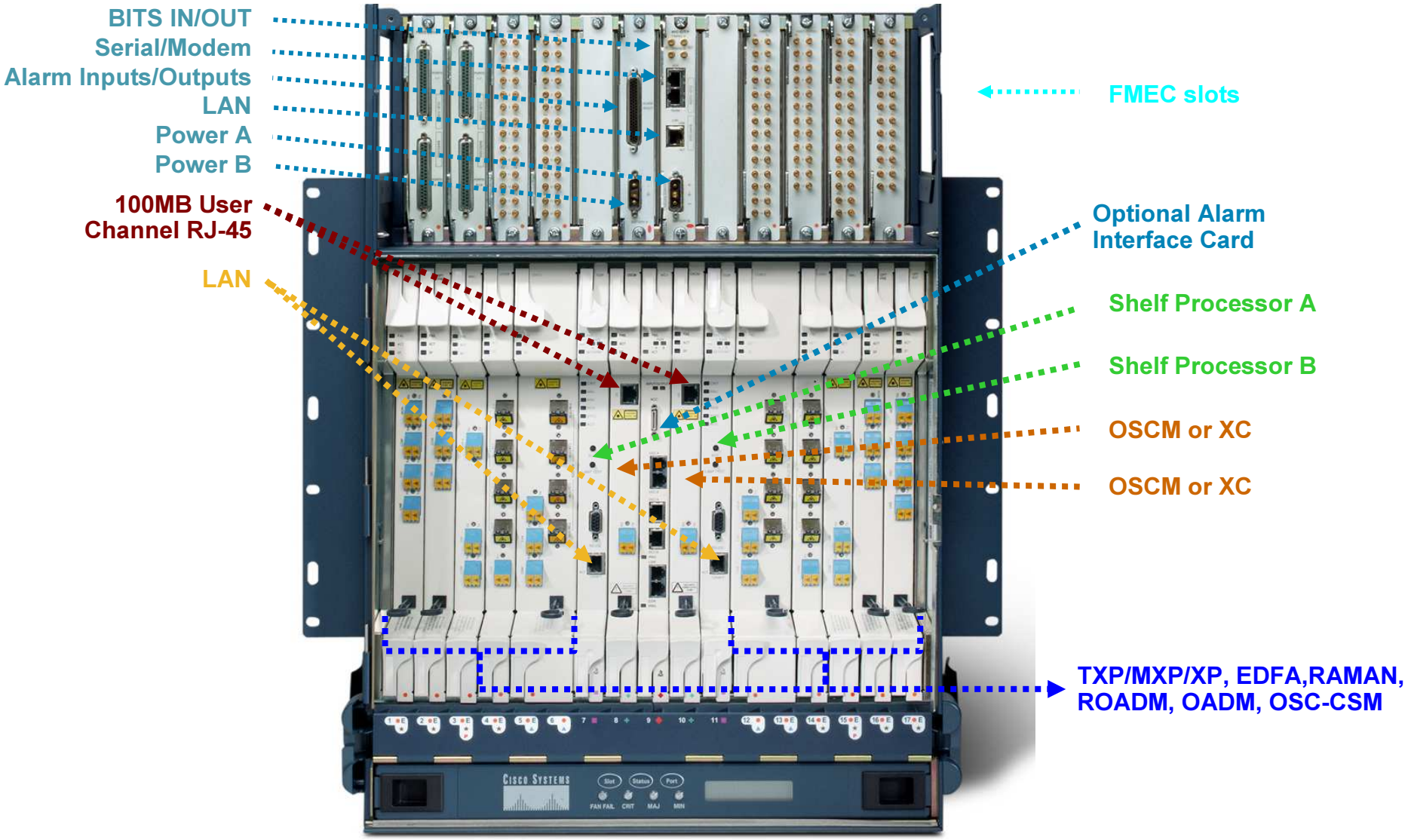
• ComBridge - Romania

Bulgarian Telecom (BTC) National Backbone

Cisco ONS 15454 MSTP

System performance, topologies and supported interfaces

Cisco ONS 15454 MSTP Chassis (ETSI) - M12



New smaller chassis - M6 and M2

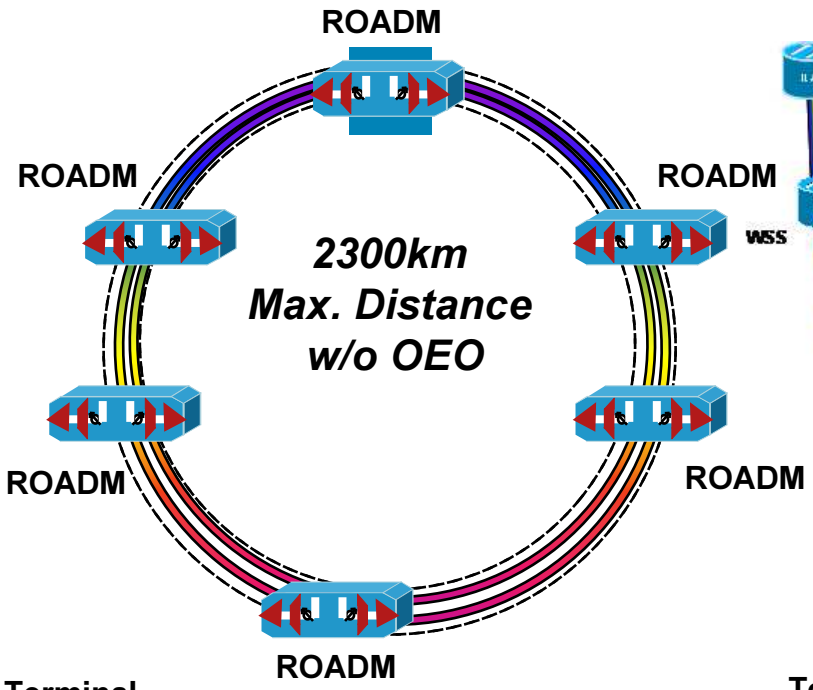
New MSTP Chassis - R9.2

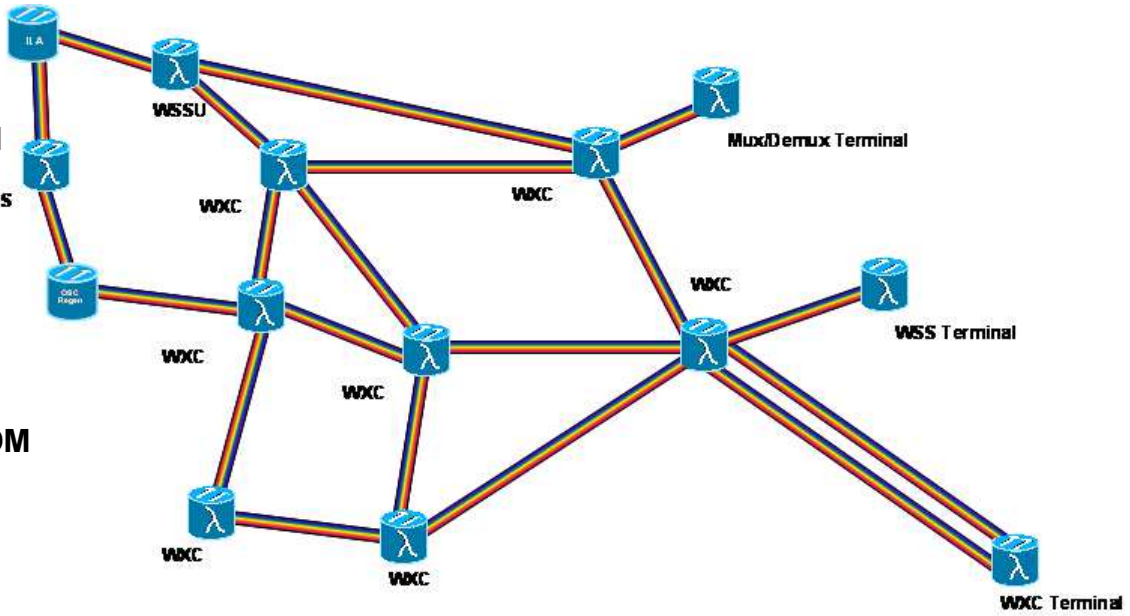
- MSTP Line card Backward Compatibility (SM-ROADM, OTU2-XP, 10G DME, Ethernet-XP, etc...)
- Improved Cooling
- Integrated OSC
- Integrated Multi-Shelf Management
- Integrated Database Back-Up
- Both ANSI & ETSI compliant
- Both AC & DC Power Options
- >50% Footprint Reduction

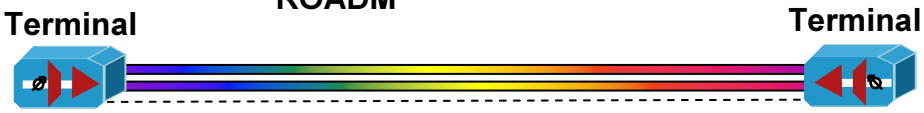
6 Slot ONS 15454 MSTP

2 Slot ONS 15454 MSTP

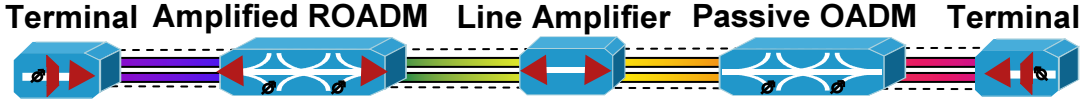
Cisco ONS 15454 MSTP release 9.2:
Network Topologies (examples w/o RAMAN)







Single Span: 42dB max w/OSC
44 dB max w/o OSC (w/o RAMAN)



Point-to-Point 2300 km w/o OEO

- ***Ring***
- ***Single span point to point***
- ***Multi span point to point*** **(bus)**
- ***Optical mesh*** **- manually patched (OIC) or using WXC (OXC)**

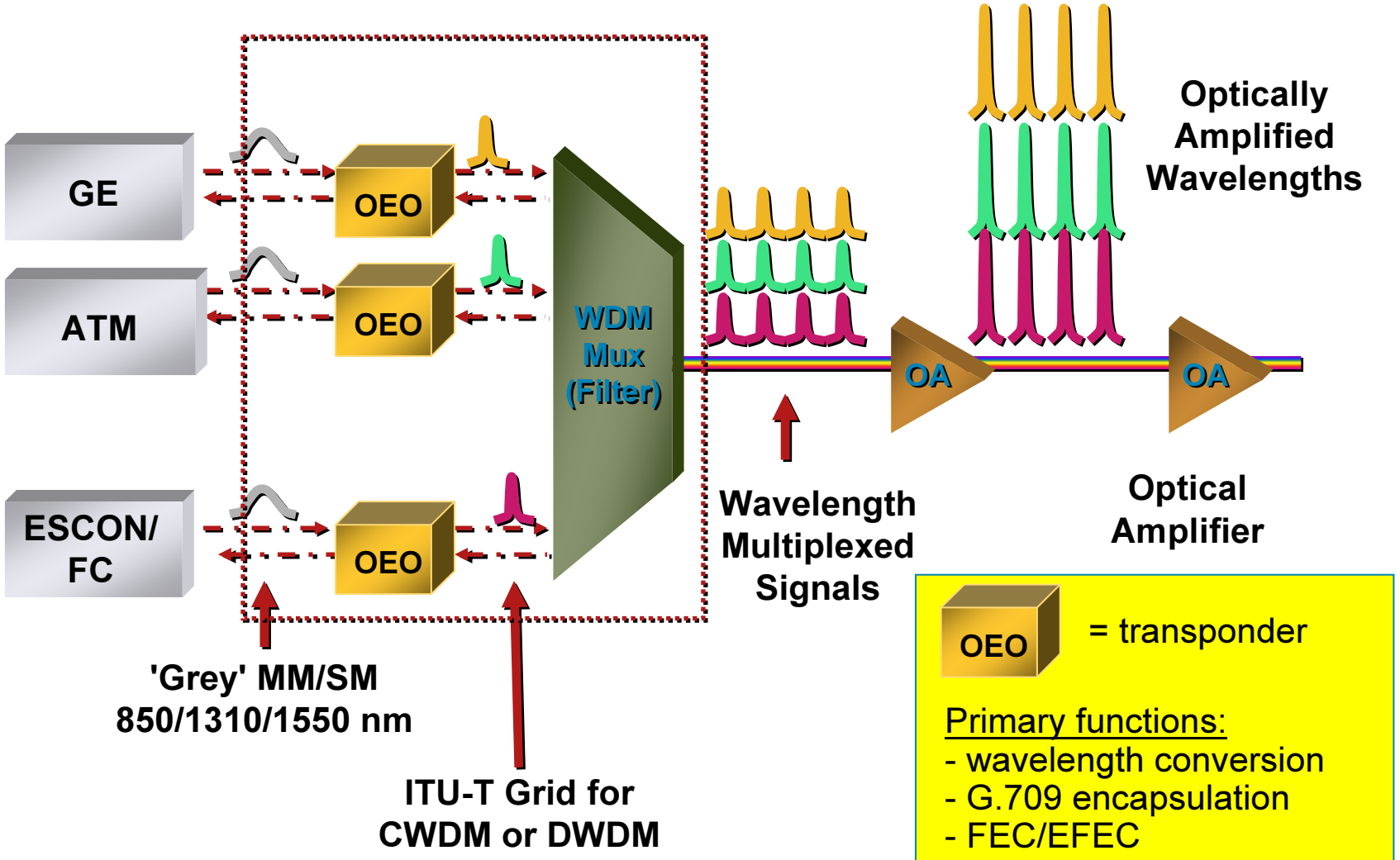
Cisco ONS 15454 MSTP - native client support

Wide range of telco and enterprise client interfaces

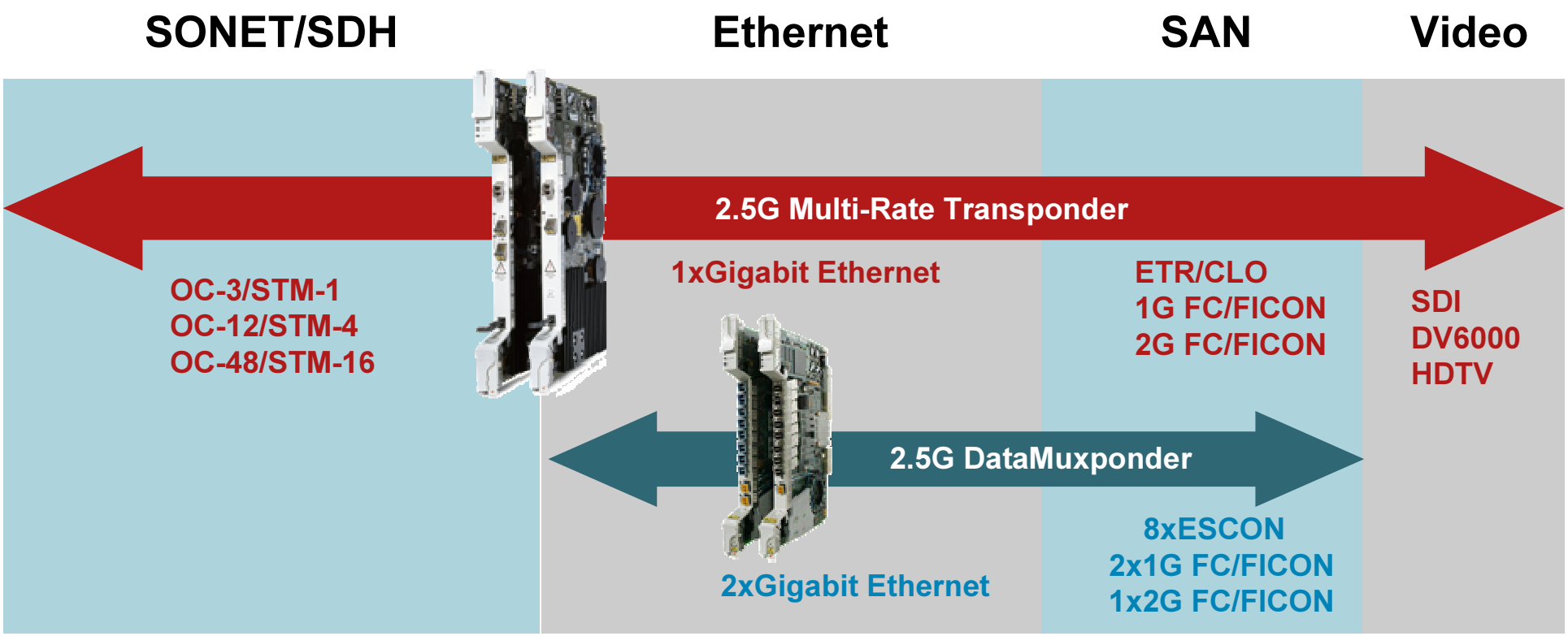
TDM	***Data***	***Storage***	***Video***	***2R***
• STM-1 • STM-4 • STM-16 • STM-64 • STM-256 • OTU-2 • OTU-2e • OTU-3 • E1 • E3	• E • FE • GE • 10 GE LAN PHY • 10 GE WAN PHY • 40 GE	• 1G FC/FICON • 2G FC/FICON • 4G FC/FICON • 8G FC/FICON • 10G FC/FICON • ESCON • ISC 1 • ISC 3 • Sysplex CLO • Sysplex ETR • STP • 5G Infiniband	•DV-6000 •HDTV •SDI •D1 video •DVB ASI	•Any rate from 100 Mbps to 2.5 Gbps

- *BENEFIT: High flexibility in system deployment, most of applications covered*
- *BENEFIT: Broad range of potential service offerings*
- *BENEFIT: 40Gbps support allows for further bandwidth scaling*

WDM system anatomy – transponder based system

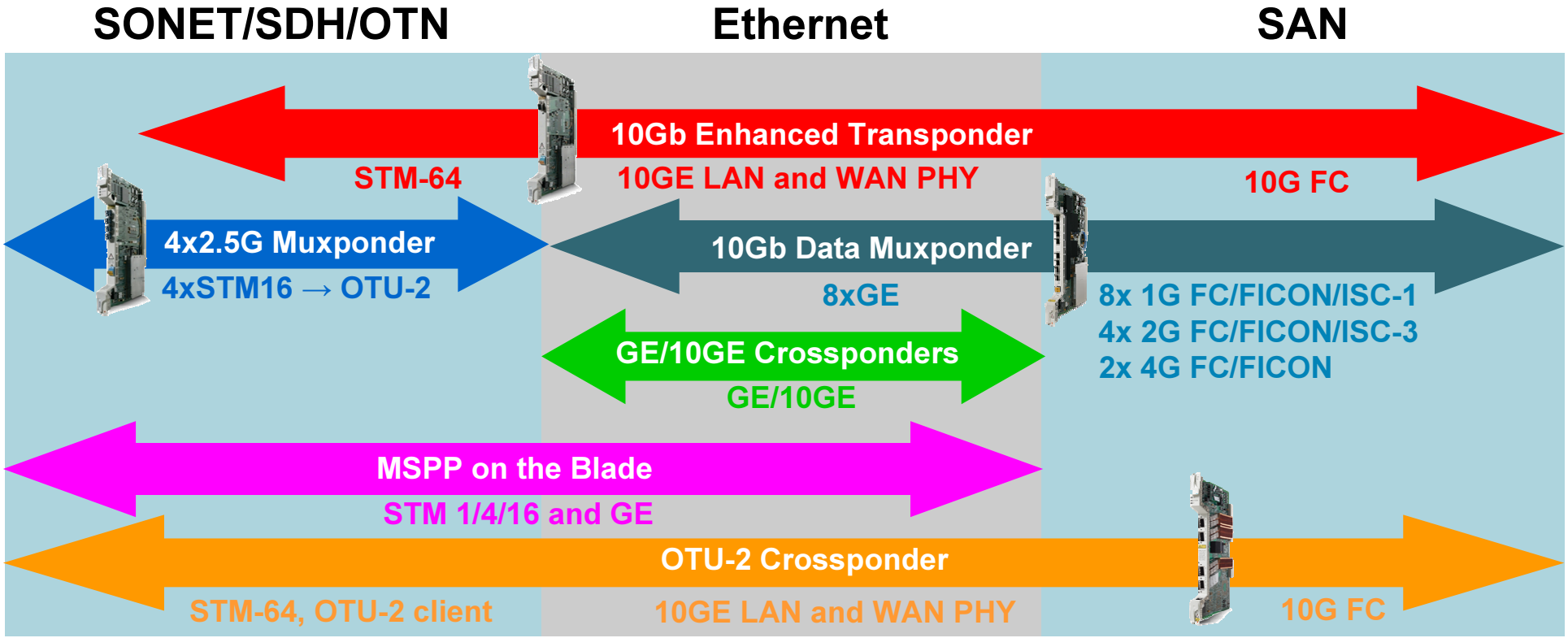


Cisco ONS 15454 MSTP
2.5Gbps Service Cards



- Simple planning, sparing, and ordering with multi-rate, multiprotocol and pluggable optics
- Optical, G.709 and payload monitoring
- FEC support at 2.5Gbps transponder
- G.709 support, trunk lasers 400GHz tunable in 100GHz grid
- Client 1+1, Y-cable and splitter protection

Cisco ONS 15454 MSTP
10*Gbps Service Cards*



- All 10G applications covered by 1 transponder,
- Aggregation cards reduce the cost of service delivery
- Full C-band or L-band tunability - 80 channels @ 50GHz spacing
- FEC and EFEC support (G.975, G.975.1), G.709 support
- Optical, G.709 and payload monitoring, Client 1+1, Y-cable protection and 'splitter' (XP)
- MLSE support for PMD challenged fiber

Pluggable client interfaces
Integrating flexible core with cost effective edge

Type/category	Example
Grey optics 850 nm SFP	1000BaseSX, MMF FC clients
Grey optics 1310 nm SFP	1000BaseLX, SDH SR/IR clients, FC SMF clients
Grey optics 1550 nm SFP	1000BaseZX, SDH LR clients
Grey optics 850 nm XFP	10GE, 10G FC
Grey optics 1310 nm XFP	10GBaseLR, 10G FC, STM-64
Grey optics 1550 nm XFP	10GBaseER/EW, STM-64 LR
CWDM client optics	GE, 1/2G FC, STM-16
DWDM client optics	GE, 1/2G FC, STM-16, 10GE, 10G FC, STM-64, OTU-2
Electrical client SFP	10/100/1000BaseT for GE Xponder

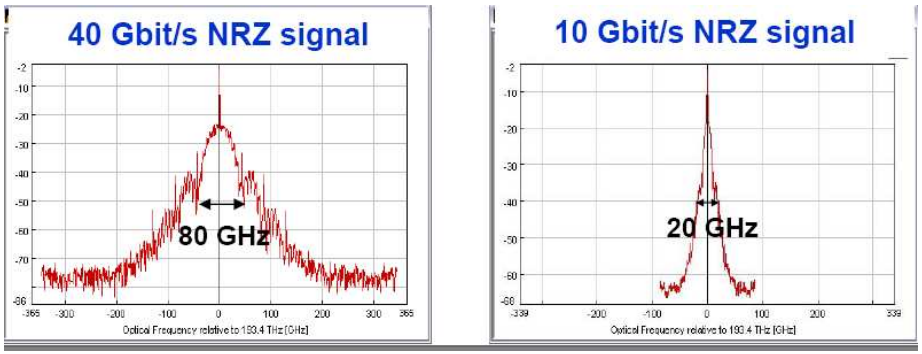
- *BENEFIT: Lower opex through common sparing with other Cisco products*
- *BENEFIT: Per port reach and rate selection*
- *BENEFIT: Tight integration of CWDM and DWDM from network perimeter*
- *BENEFIT: High transponder reusability for different services*

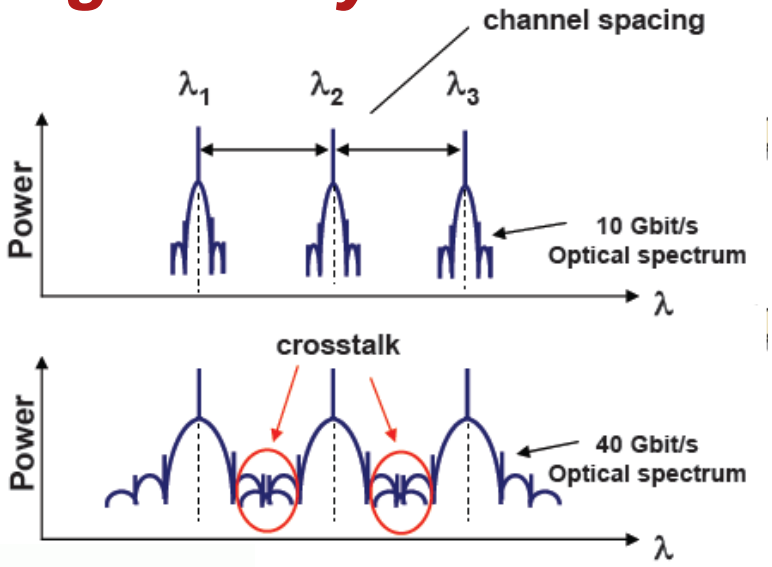
http://www.cisco.com/en/US/prod/collateral/optical/ps5724/ps2006/brochure_c02-452560.html

40Gbps transport

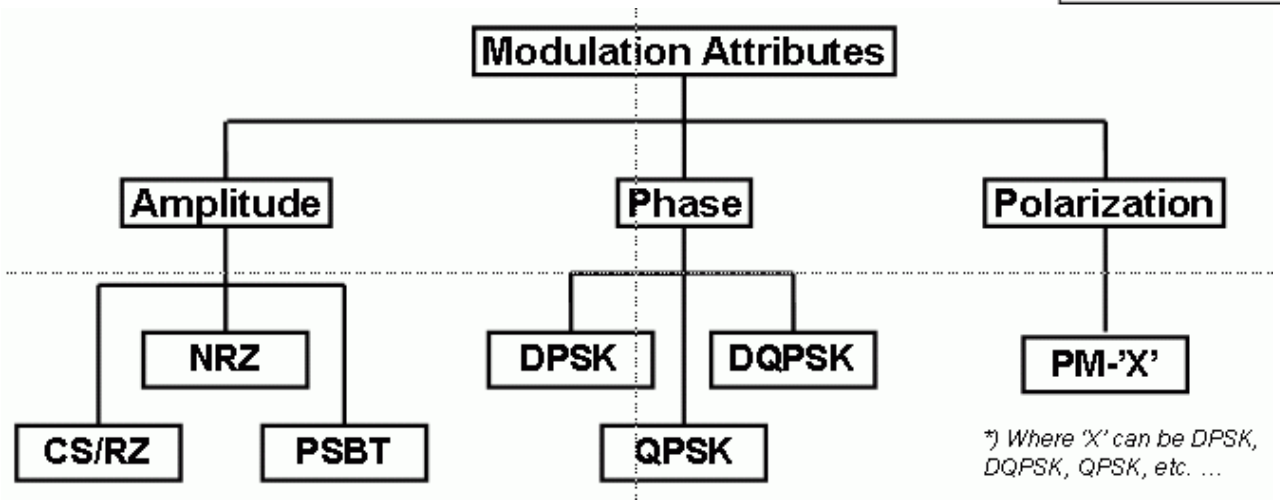
What is the market demand?

Compatibility with existing 10G systems.





New modulation formats are needed!

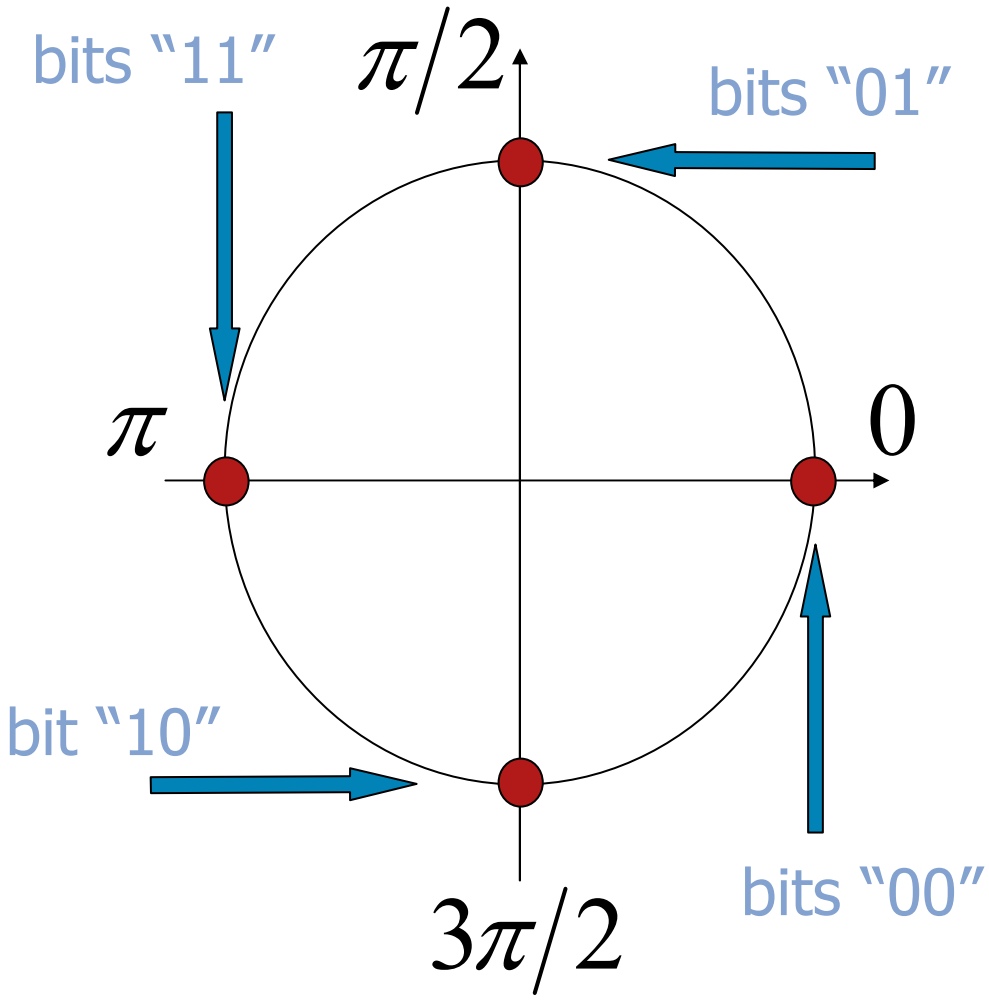


40Gbps transport
Technology options

Parameter	10G NRZ		ODB	DPSK	DQPSK	CP-DQPSK
Required OSNR B2B (dB)	5		13	8.5	8	4
Reach (km)	>2000		>500	>1000	>1000	>2000
50 GHz Compatible	Y		Y	Y	Y	Y
Chromatic Dispersion Robustness with 1 / 2 dB of OSNR margin (+/-ps/nm)	500/800		250	650	750	20,000
PMD Robustness with 1 / 2 dB of OSNR margin (ps)	10 / 14		2.5	2.5 / 3.5	5 / 8	> 25
Complexity	LOW		LOW	LOW	MEDIUM	HIGH

DQPSK – 4-Level Phase Modulation

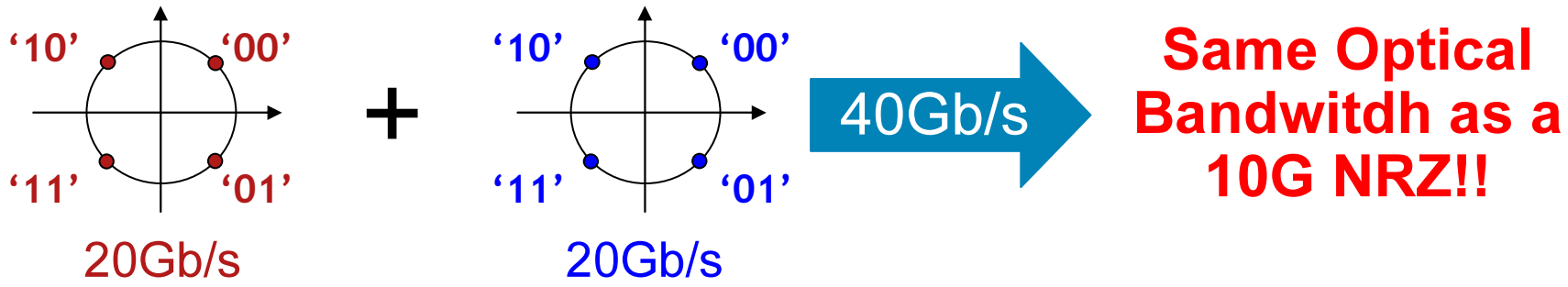
- Four “signal points” are used
- This way, each “phase”, or “signal point”, carries two bits

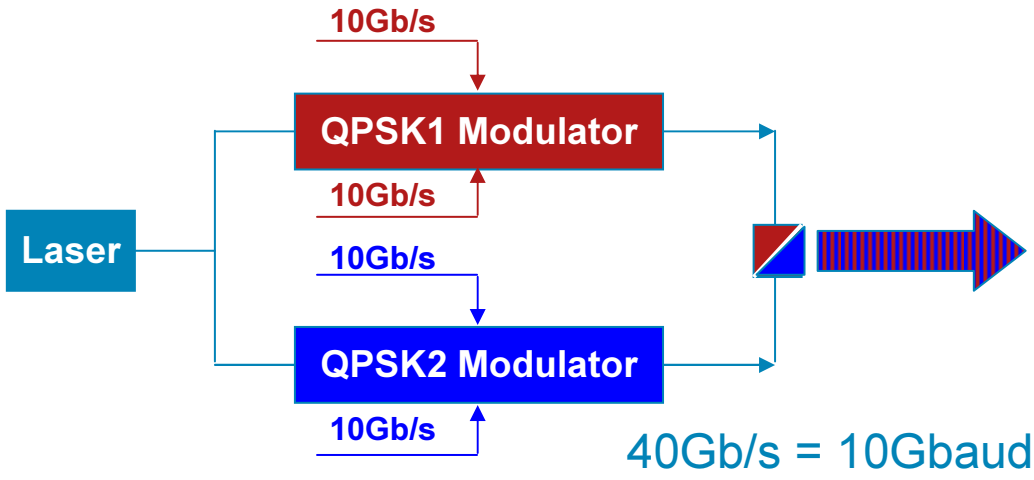


CP-DQPSK Solution

Dual Polarization DQPSK with Coherent Detection

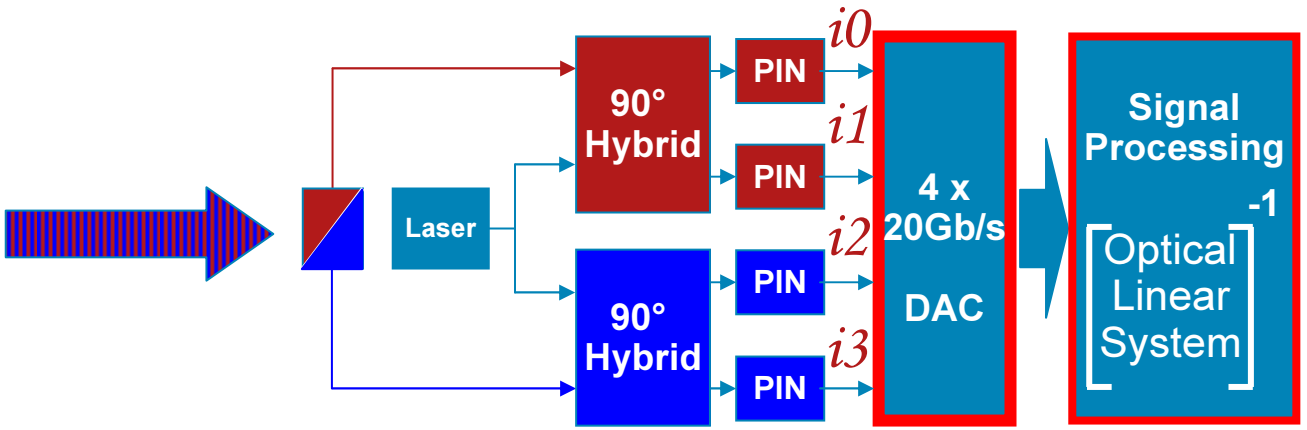
Transmitter: Two QPSK signals are muxed in polarization





10Gbaud signal propagate into the fiber as a 10Gb/s signal

Coherent Detection and Post Processing

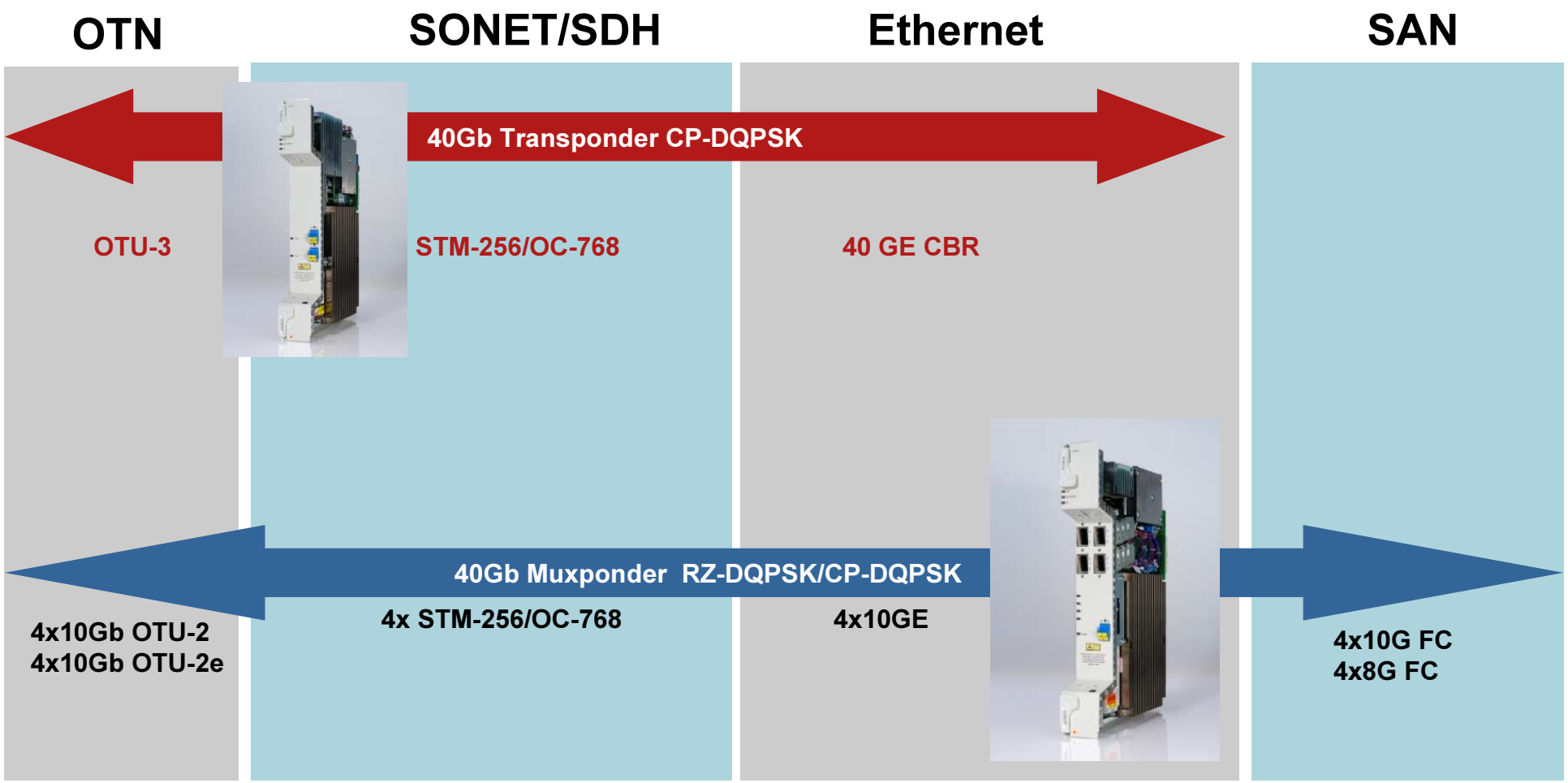


- RX Laser serves as Local Oscillator to provide a polarization and phase
- 90° Hybrid converts phase modulation in amplitude modulation
- Coherent receiver with Digital Signal Processing (DSP):
  - Synchronizes to carrier frequency and phase electronically
  - Recovers Polarization electronically
  - Compensates CD and PMD electronically

Key Benefits:

- ~3dB better noise tolerance vs. conventional (~2x distance)
- Can compensate huge amounts of dispersion (>200x more than conventional)
- Usable for 40Gbps and 100Gbps, can scale to higher speeds

Cisco ONS 15454 MSTP
40 Gbps Service Cards

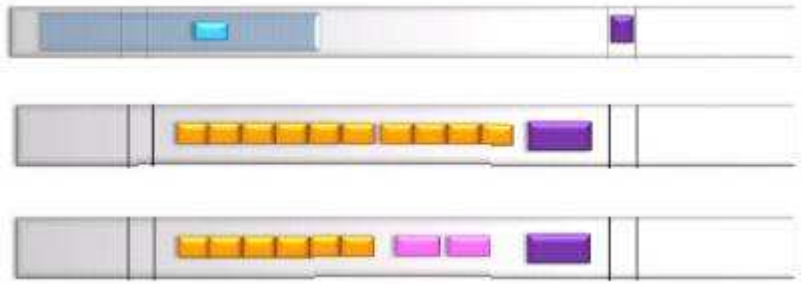


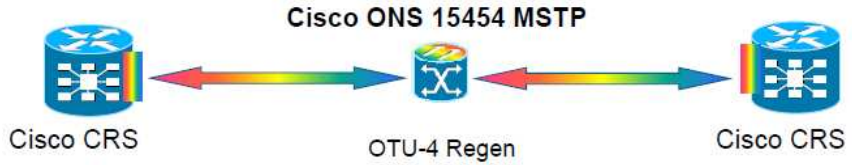
Journey towards 100Gbps

- 100GE commercial availability expected ~ 2010
- 100G DWDM interface expected within following 12 months
- Initial deployment will be limited to Core IP backbone network
- Customer can anticipate the deployment for other applications only if pricing will provide better trade off respect 40G
- Same requirements for interoperability with existing systems built for 10G transmission
- Standardization effort in IEEE and ITU-T

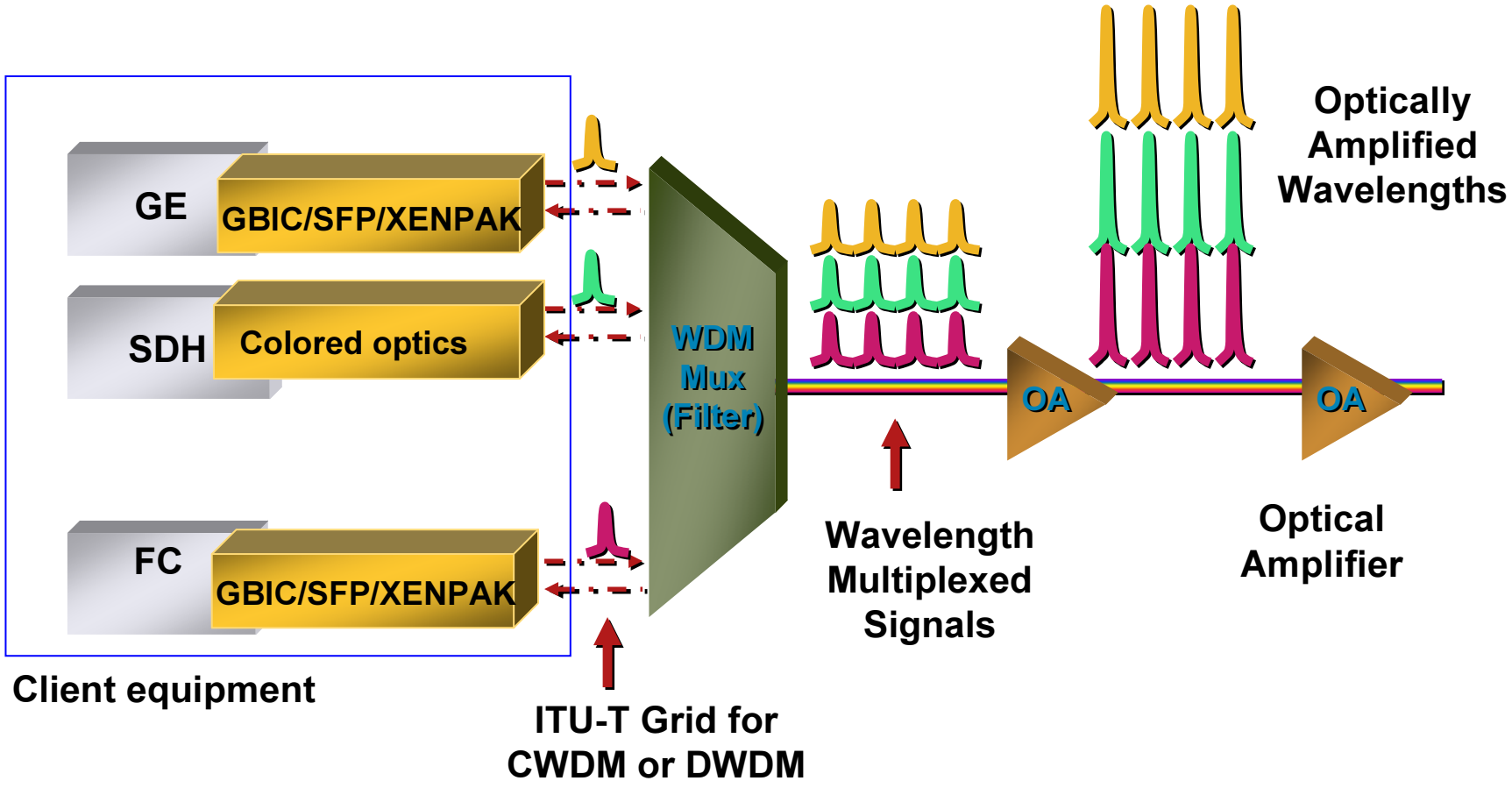
Cisco ONS 15454 - 100Gbps program

- CP-DQPSK Modulation, 50,000ps/nm CD robustness, 30ps PMD robustness
- 100Gbps transmission will leverage on 3 cards that can be differently combined:
  - 100GE/OTU-4 Full C band tunable Line Card
  - 10x10G Client Line Card
  - Mixed 40G/10G Client Line Card
- Common development between DWDM Optical team (ONS), ASR and CRS
- The 3 units can be placed in M2 or M6 and chassis





WDM system anatomy – colored client signals



Cisco ONS 15454MSTP multivendor interoperability
Alien wavelength support

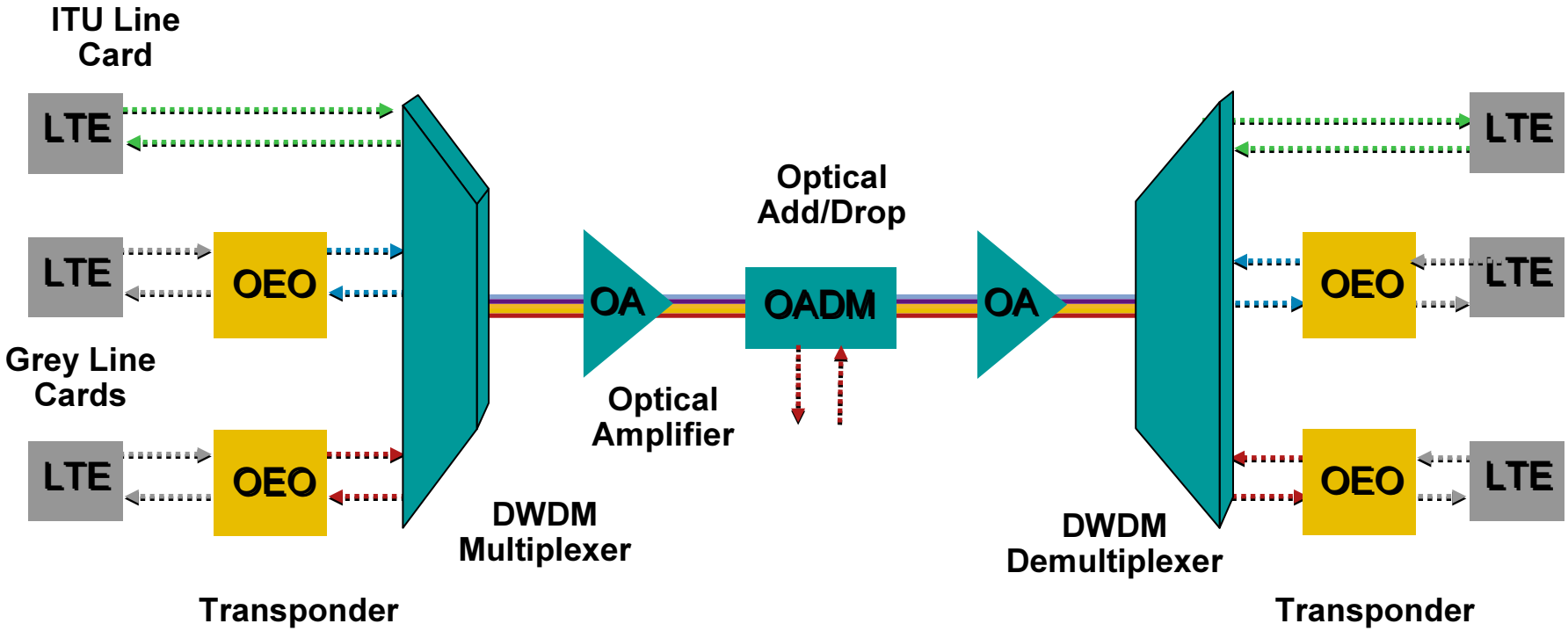
Available options:

- **Colored pluggables:**
  - **DWDM XENPAK, X2, XFP**
  - **DWDM GBIC, SFP**
- **DWDM line cards (e.g. from MSPP)**
- **IPoverDWDM interfaces**
- **Generic signal (e.g. from 3rd party)**

1. **Technology:**
   - **Transmitter characteristics:**
     - **Modulation format: NRZ / ODB**
     - **Transmitter type: MZ / DML / EML**
   - **Receiver characteristics:**
     - **Receiver Threshold: Opt / Avg**
     - **no-FEC / FEC / E-FEC**
     - **2R / 3R**
2. **Bit Rate**
3. **Sensitivity Back-to-Back**
4. **TX Optical Output Power Range: Pmin ÷ Pmax [dBm]**
5. **TX Wavelength Stability: [±pm]**
6. **Chromatic Dispersion Robustness**
7. **Scale Factors: F-PPL, F-POL, F-OSNRPL, F-OSNROL**
8. **Gaussian X-Talk-penalties**
9. **Single-interfering X-Talk penalties**

- *BENEFIT: High degree of interoperability with 3rd party equipment*
- *BENEFIT: Lower cost per channel where transponder is not needed*

Cisco ONS 15454 MSTP - support for both options

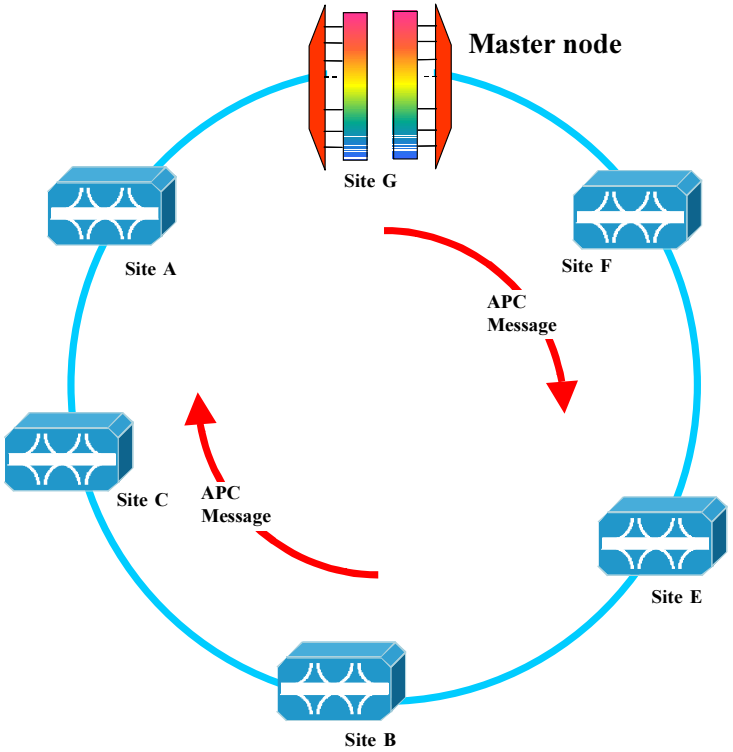


Advanced monitoring functionalities
Monitoring of multiple levels of communication

- Optical parameters
  - signal levels
  - laser bias
- OTN
  - G.709
  - FEC/EFEC statistics
- Payload specific
  - RMON like information for ethernet
  - 8B/10B, running disparity for FC
  - SDH specific
  - others (ESCON, ...)

Automatic Power Control

The tool for keeping the network operational and stable



- Keep either power or gain constant on each amplifier
- Avoid BER or non linear effect
- APC automatically starts when network detects needs for a gain correction
- No human intervention required
- Correct amplifier power/gain
  - whenever the # of channels changes
  - to compensate ageing effects
  - To compensate changing in operating conditions (e.g. temperature increase)

BENEFIT: Automatic reaction of network to fast and slow changes in the network

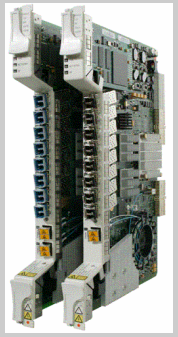
Cisco ONS 15454 MSTP

Muxponding, crossponding and MSPP integration

Flexible muxponding

Effective use of bandwidth by Cisco ONS 15454 MSTP

2.5G DM
- 8 ports
- GE
- 1/2G FC
- 1/2G FICON
- ESCON
- signal mix supported



10G DME(X)
- 8 ports
- GE
- 1/2/4G FC
- 1/2/4G FICON
- ISC-1, ISC-3
- signal mix supported

40G MXP
- 4 ports
- 10GE
- 8/10G FC
- 8/10G FICON
- STM-64
- OTU-2, OTU-2e
- signal mix supported

4xSTM-16 ->OTU2 Muxponder
- 4 ports
- STM-16 clients
- ODU1 into OTU2

- *BENEFIT: Better lambda capacity utilization*
- *BENEFIT: Higher service density and flexibility*

Ethernet enabled DWDM

Solution components - GE/10GE XP/XPE

GE crossponder

- 20x GE ports (UNI)
- 2x 10GE ports (NNI)

10GE crossponder

- 2x 10GE ports (UNI)
- 2x 10GE ports (NNI)

Features

- Smart optical ring protection based on G.709 overhead (sub 50 ms)
- Configurable as muxponder, transponder, 10GE regenerator and in L2 switch mode
- SFP for GE ports
- XFP for 10GE ports (DWDM or 'grey')
- Can interoperate with IPoDWDM card in routers
- Enhanced version available in release 9

CARRIER ETHERNET MEF Certified Compliant

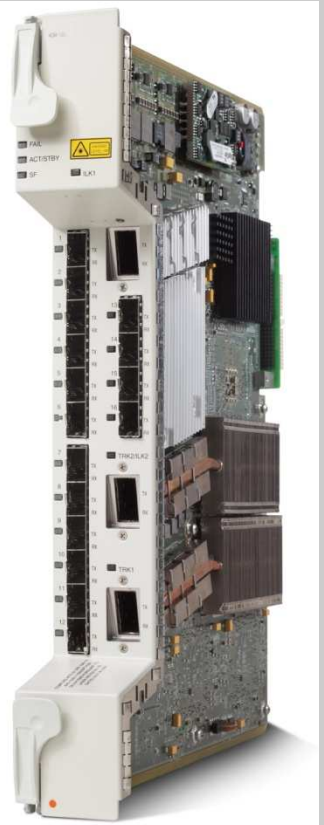
Cisco ONS 15454 MSTP flexible optical networking
MSPP on the blade

HW features

- 16 SFP Based Client (Grey and CWDM optics available)
- Support of OC-3/OC-12/OC-48 and GE client signals
- 1 Trunks XFP Based supporting E-FEC/FEC and G.709
- 2 SR XFP supporting redundancy connection with protection board and Pass-through Traffic
- GFP-F Mapping

SW features

- OTN PM on Trunk
- A to Z Circuit provisioning (STS layer)
- SONET PM (B1, B2 on Trunk and aggregate) and Alarm Management (Line, Section and Path)
- Ethernet RMON statistics
- UPSR Protection on Trunk
- 1+1 APS on Client



- *BENEFIT: Better lambda capacity utilization*
- *BENEFIT: Higher service density and flexibility*
- *BENEFIT: Compact MSPP integration*

Cisco ONS 15454 MSTP

Reconfigurable OADM

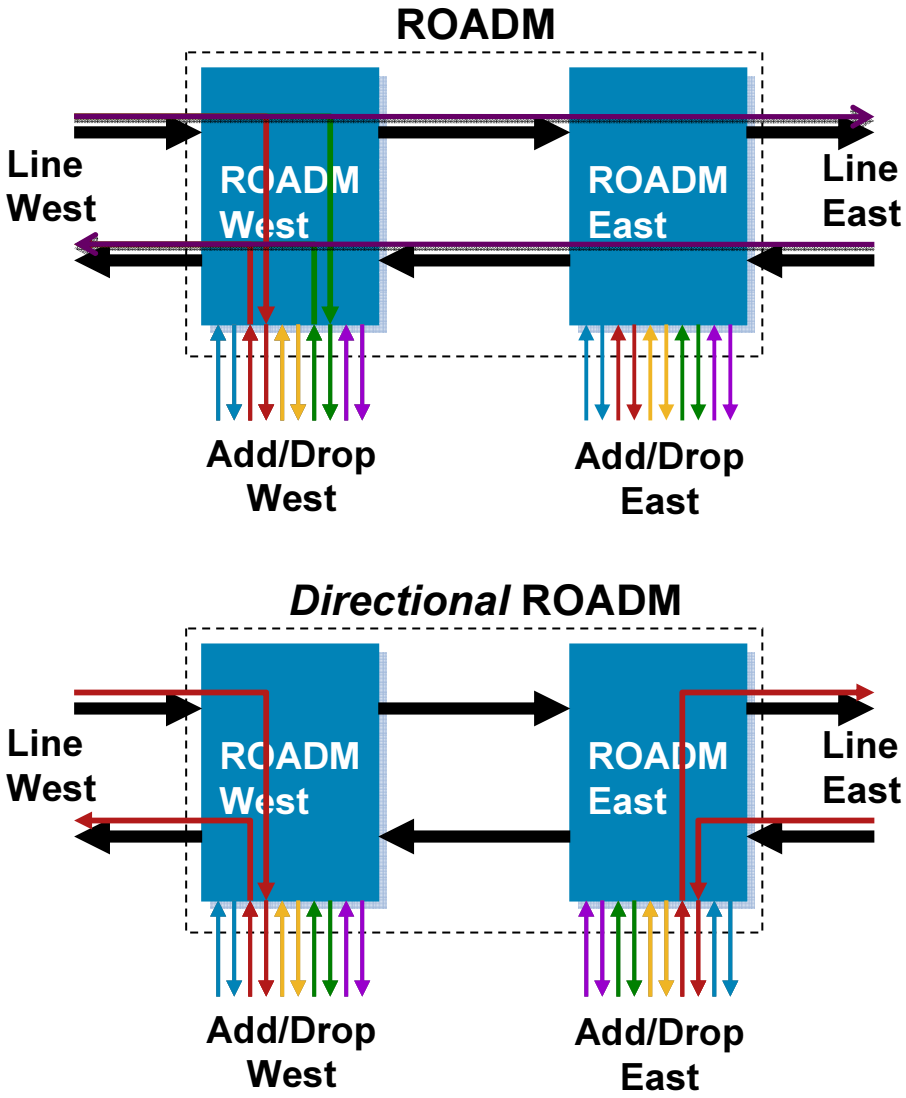
Reconfigurable optical add/drop multiplexers
Evolution steps

- Basic implementation
  - 2° ROADM
  - Multidegree ROADM (optical mesh)
- Enhanced functionality
  - Omnidirectional
  - Colourless
  - DWDM aware control plane
- Integration and space/power efficiency
  - Single module ROADM

NEW

Increasing flexibility of optical networks
What is a ROADM?

- ROADM (Reconfigurable Optical Add & Drop Multiplexer) is an optical Network Element able to Add/Drop or Pass through any wavelength composing the DWDM spectrum
  - A ROADM is typically composed by 2 line interfaces and 2 Add/Drop interfaces
- Typical ROADM implementations have Add/Drop interfaces dedicated to a direction
  - As a side-effect, if it is required to reconfigure the connection to drop the channel from a different side the new channel is sent to a different physical port: this would require to manually change the cabling of any connected client equipment



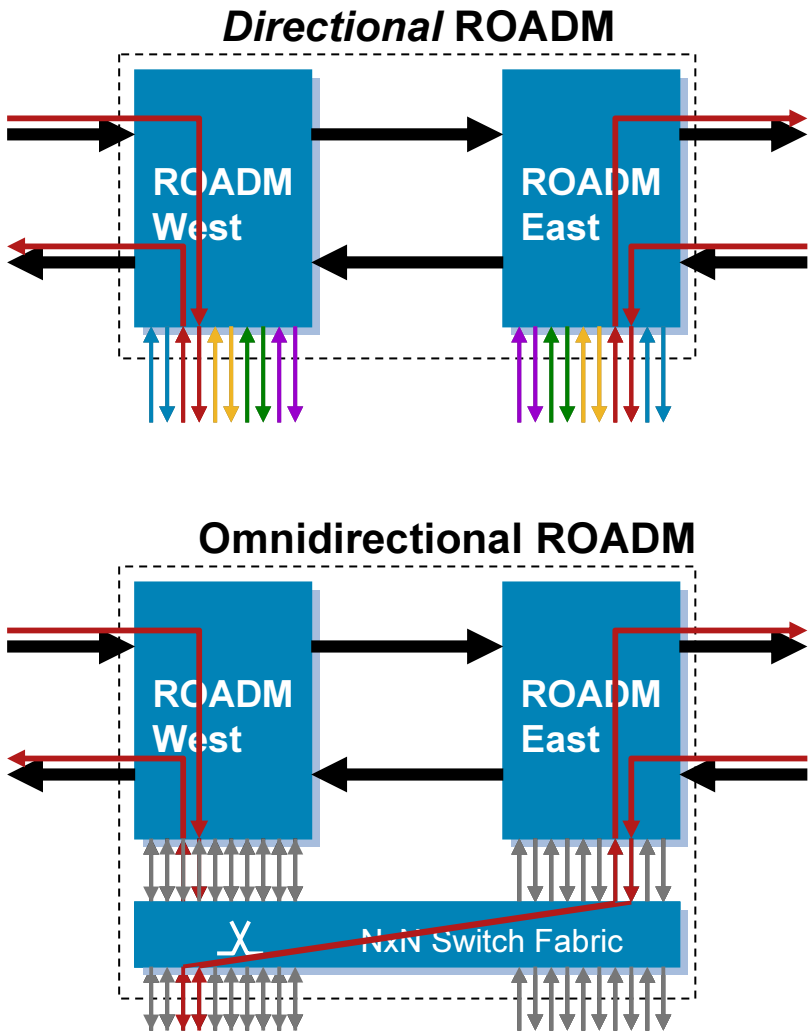
What is an Omnidirectional ROADM?

Omnidirectional ROADM functionalities can, again, be understood comparing it with a *Directional* ROADM

- A *Directional* ROADM always add/drop a given wavelength from/to a given Line Side: channel #1 is always dropped from West Side
- If it is required to reconfigure the connection to drop the channel from a different side the new channel is sent to a different physical port: this would require to manually change the cabling of any connected client equipment

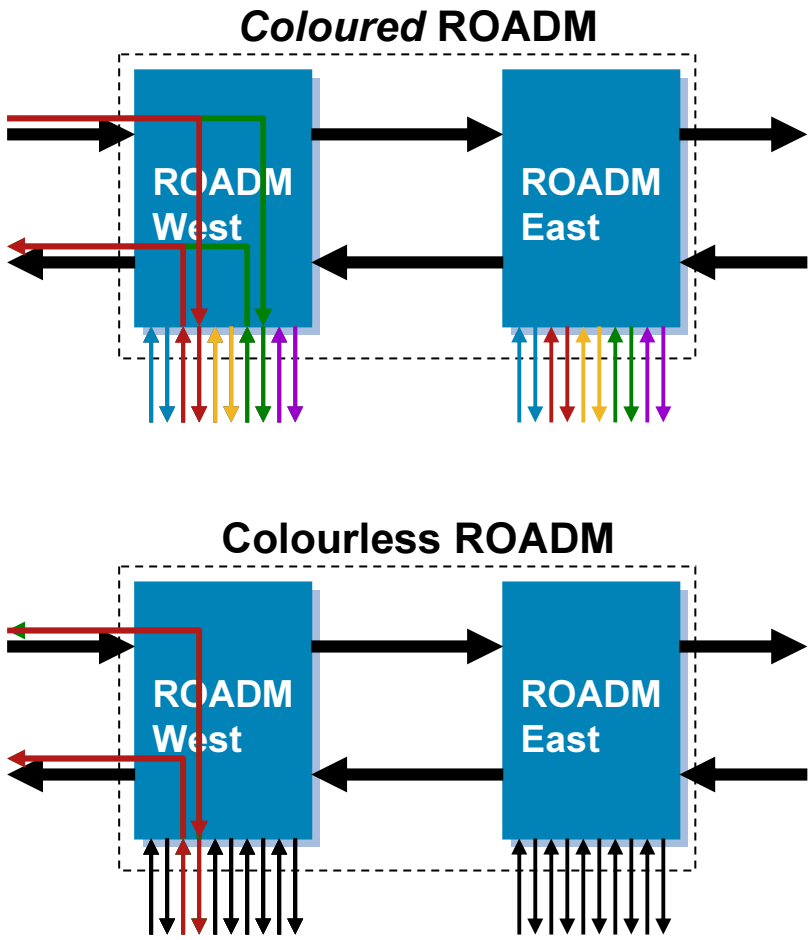
A Omnidirectional ROADM, on the contrary, can be reconfigured to drop ANY wavelength from ANY Line Side:

- For instance we can start dropping the red wavelength from the West Side
- and reconfigure the ROADM to drop the red wavelength from the East Side on the same port
- No re-cabling is required



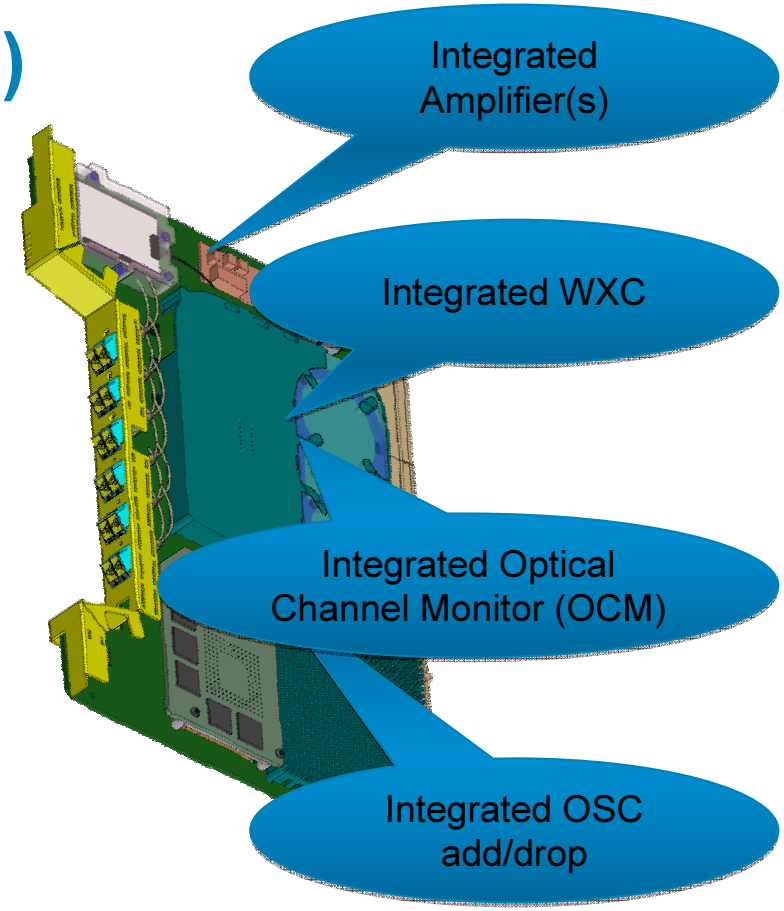
What is a Colourless ROADM?

- Colourless ROADM functionalities can be understood comparing it with a Coloured ROADM
  - A *Coloured* ROADM always add/drop a given wavelength from/to a given port: channel #1 is always dropped on port #1
  - If it is required to reconfigure the connection to drop a different wavelength (i.e. channel) the new channel is sent to a different physical port: this would require to manually change the cabling of any connected client equipment
- A colourless ROADM, on the contrary, can be reconfigured to drop ANY wavelength on ANY port:
  - For instance we can start dropping the green wavelength
  - and reconfigure the ROADM to drop the red one on the same port
  - No re-cabling is required

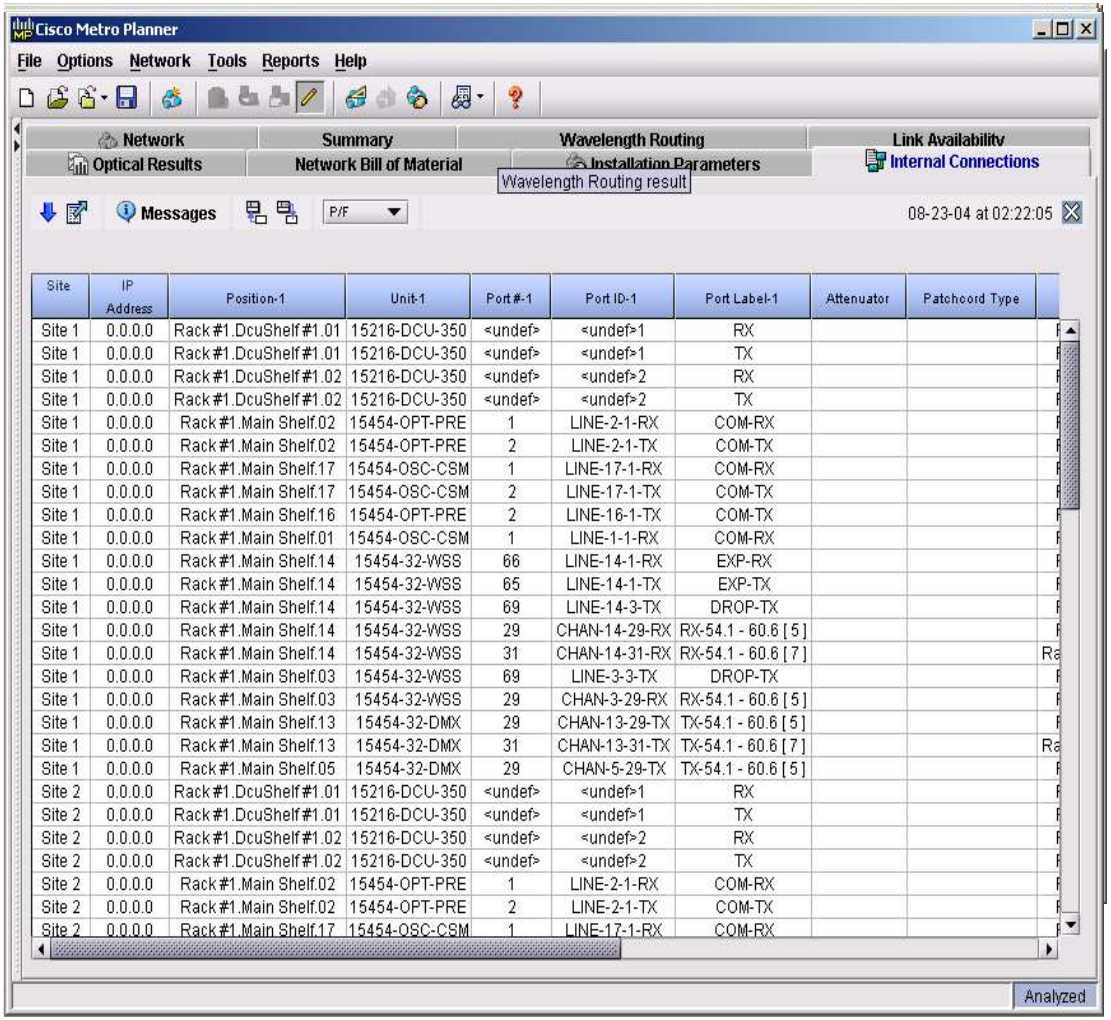


Single Module ROADM (SMR)

- **Next Generation ROADM Technology**
  - Hyper Integration:
    - Booster
    - Preamplifier
    - Wavelength crossconnect
    - OSC add/drop
    - Integrated Optical Channel Monitoring
  - Consumes ~40% less Power
  - Address terminal, 2^0, 3^0 and 4^0 ROADM applications
  - 15454-40-SMR1-C=
    - 40chs Degree-2 ROADM with integrated Pre-Amplifier.
  - 15454-40-SMR2-C=
    - 40chs Degree-4 ROADM with integrated Booster & Pre Amplifier
- Attractive pricing with PAYG bundles



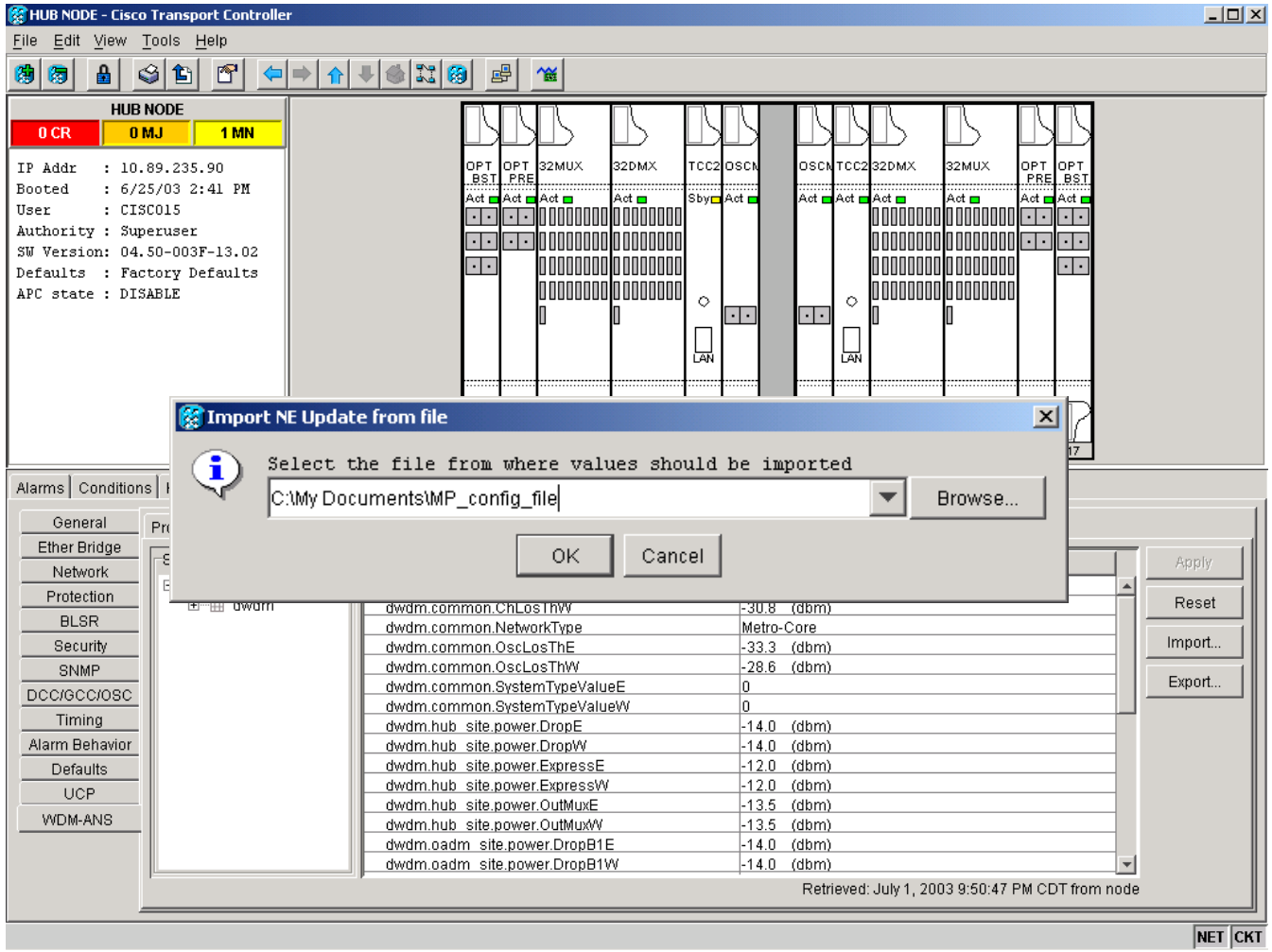
Cisco ONS 15454 MSTP:
Comprehensive design tool - Cisco Transport Planner



- **GUI-based Network Design Entry**
- **Traffic requirements:**
  - **Any-to-Any Demand provided by ROADM**
  - **Point-to-point demands**
- **Comprehensive Analysis checks for:**
  - **wavelength routing and selection**
  - **optical budget and OSNR**
  - **CD, PMD, amplifier tilt etc.**
- **Smooth Transition from Design to Implementation**
  - **Bill of Materials**
  - **Rack Diagrams**
  - **Step-by-Step Interconnect**

BENEFIT: Fast and comprehensive network design

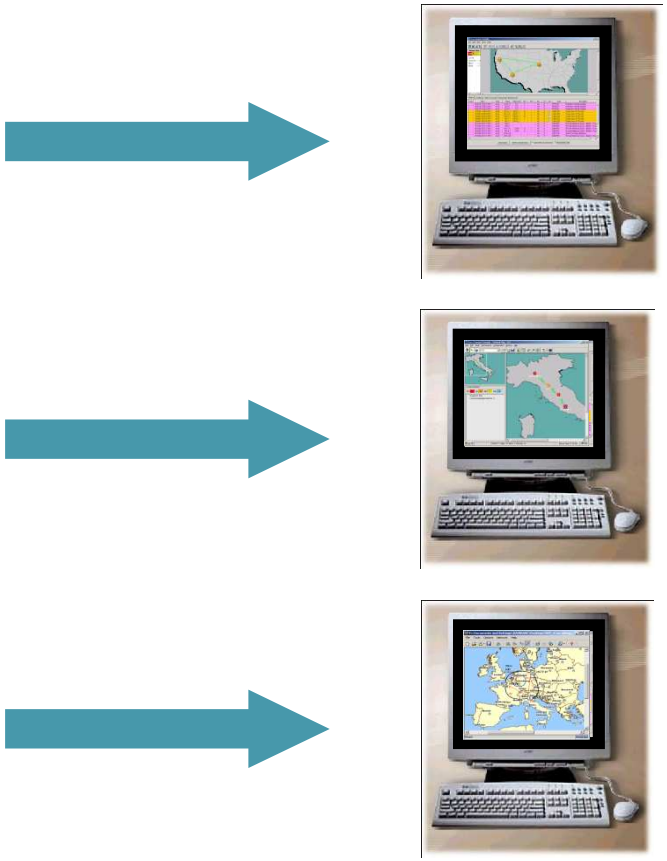
Cisco ONS 15454 MSTP flexible optical networking
Automatic Node Setup



BENEFIT: Fast network deployment and setup

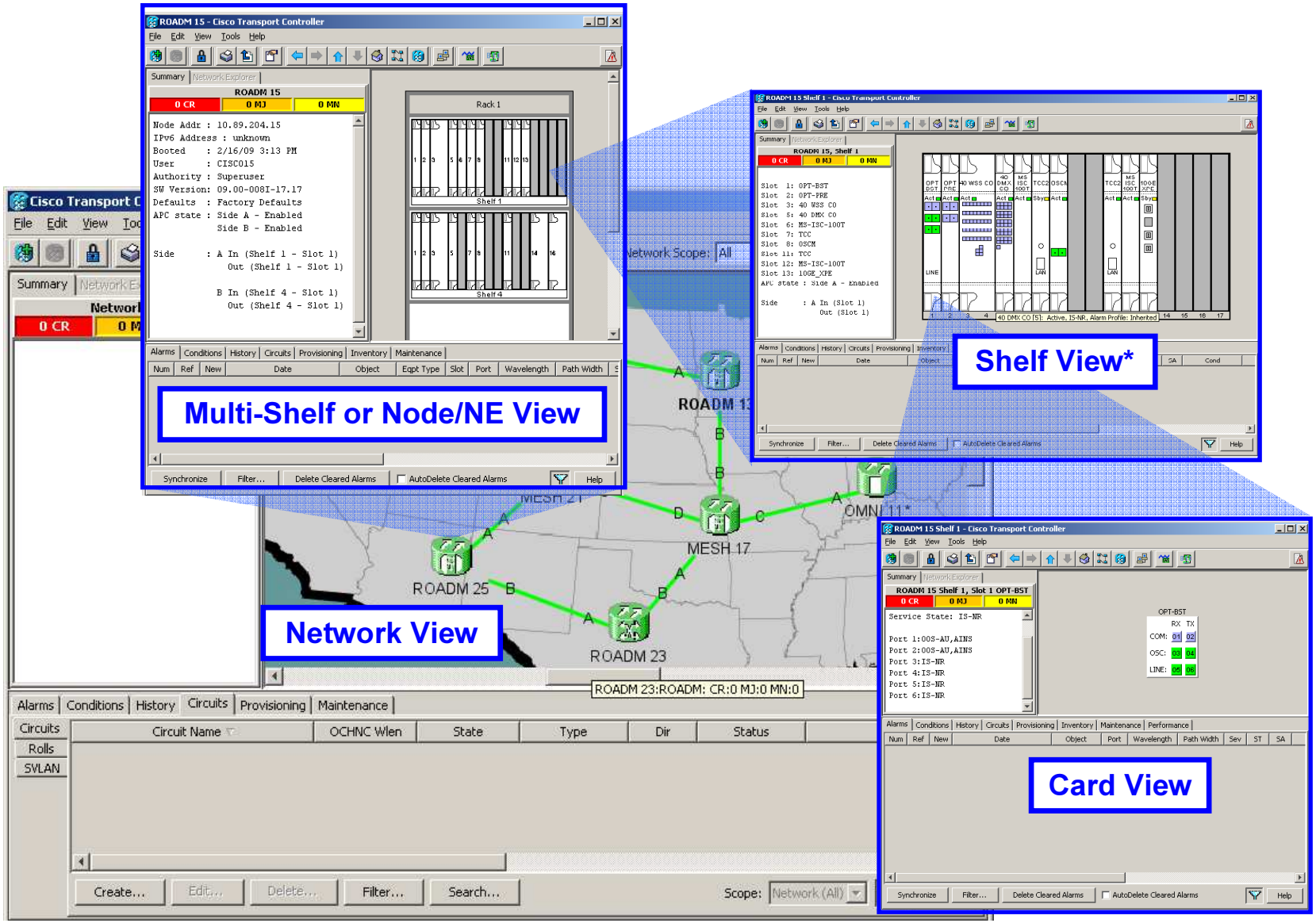
Cisco ONS 15454 MSTP:
Management Applications Options

- ***Cisco Transport Controller (CTC)***
  - Installation and setup
  - Full node/ring management capability
- ***Cisco Transport Manager (CTM)***
  - EMS/NMS layer applications for advanced optical management
  - CORBA/TL1 and SNMP NBI available for OOS integration
- ***Cisco Transport Planner***
  - Network design
  - Network modelling
  - Computer-aided installation: from network design straight to installation
- ***OSMINE completed***
  - TIRKS, NMA and TEMS



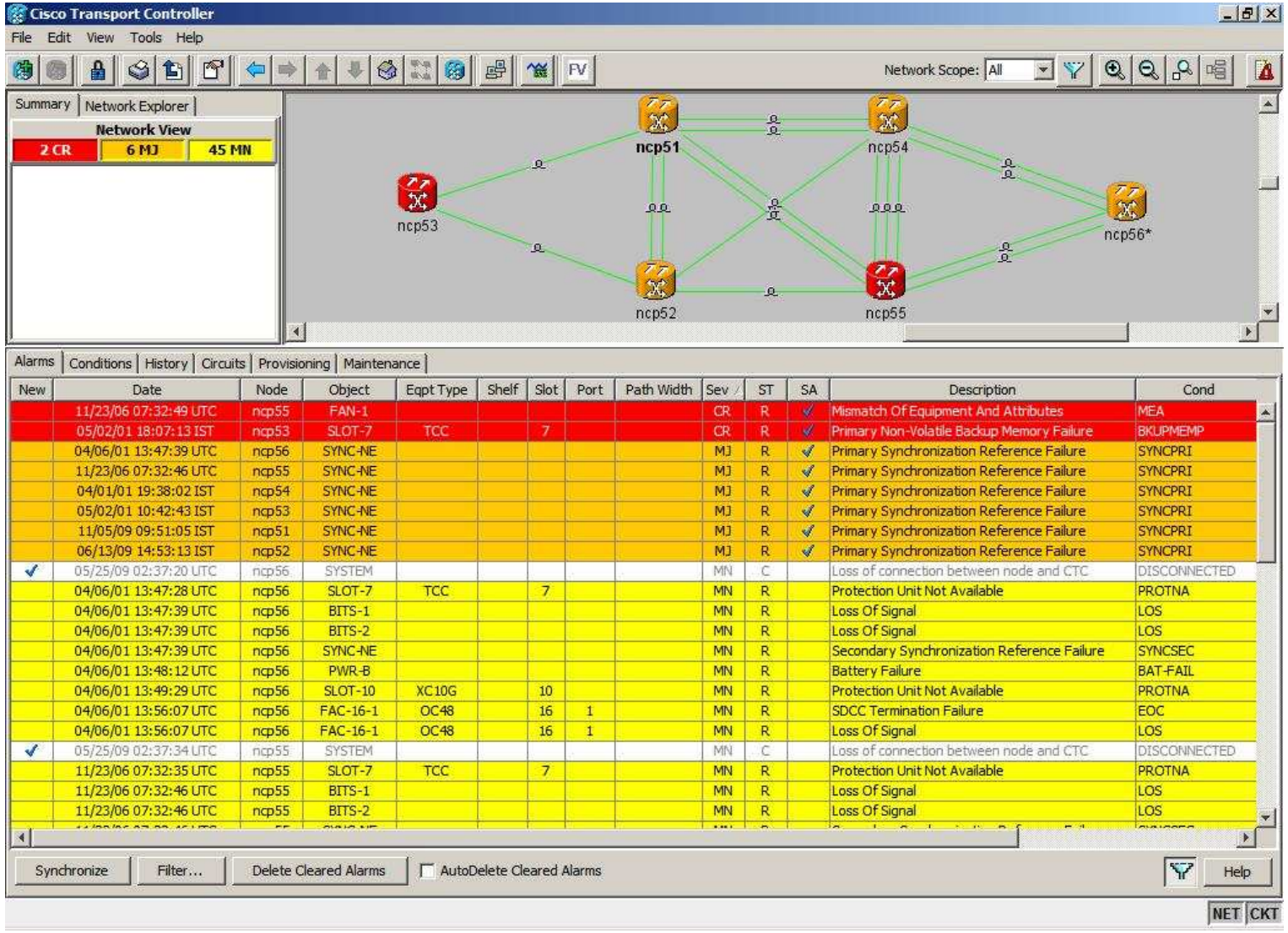
Cisco Transport Controler

Views & Navigation

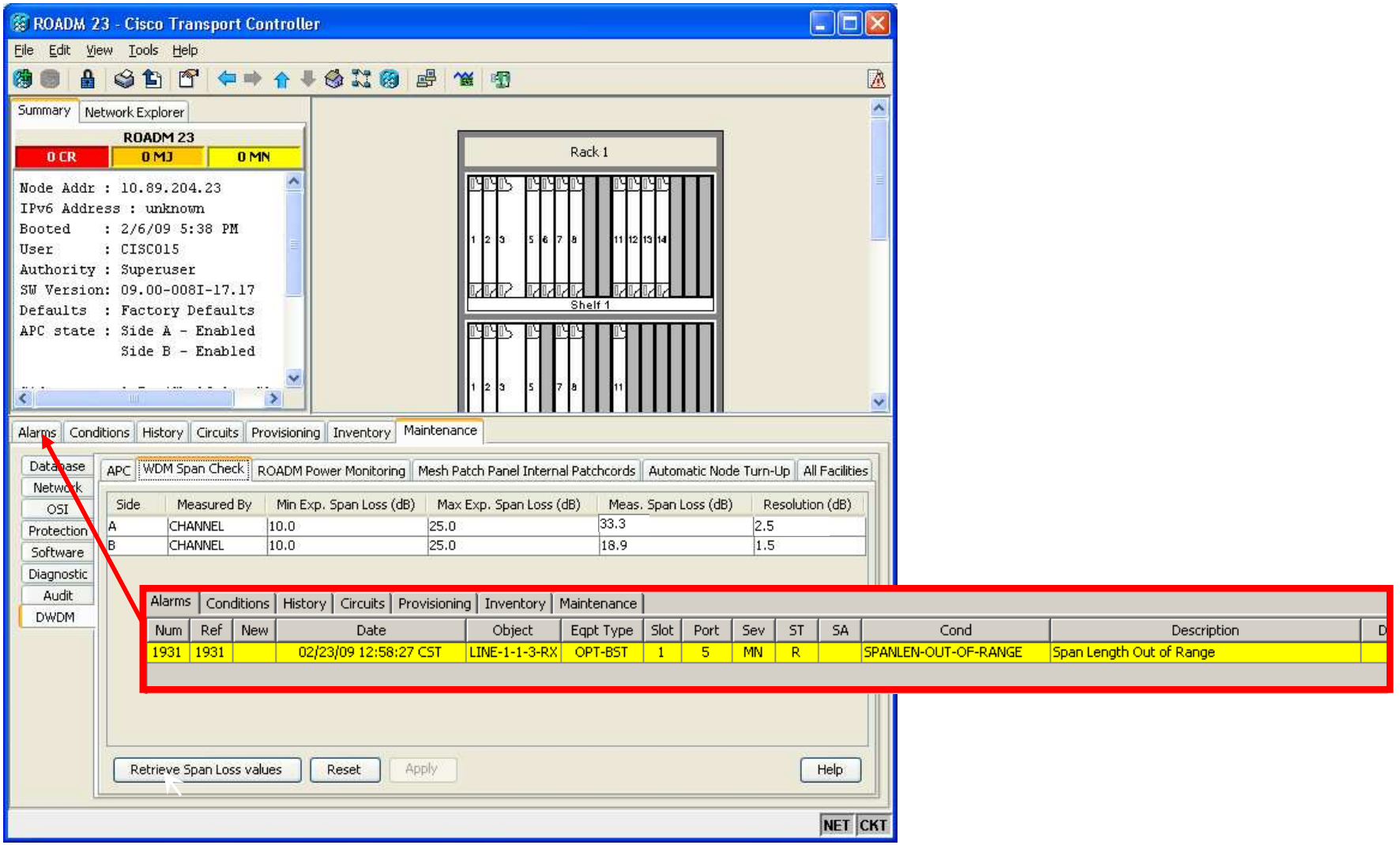


* If the top-level node view is a single shelf (not multi-shelf) this is referred to as Node/NE View

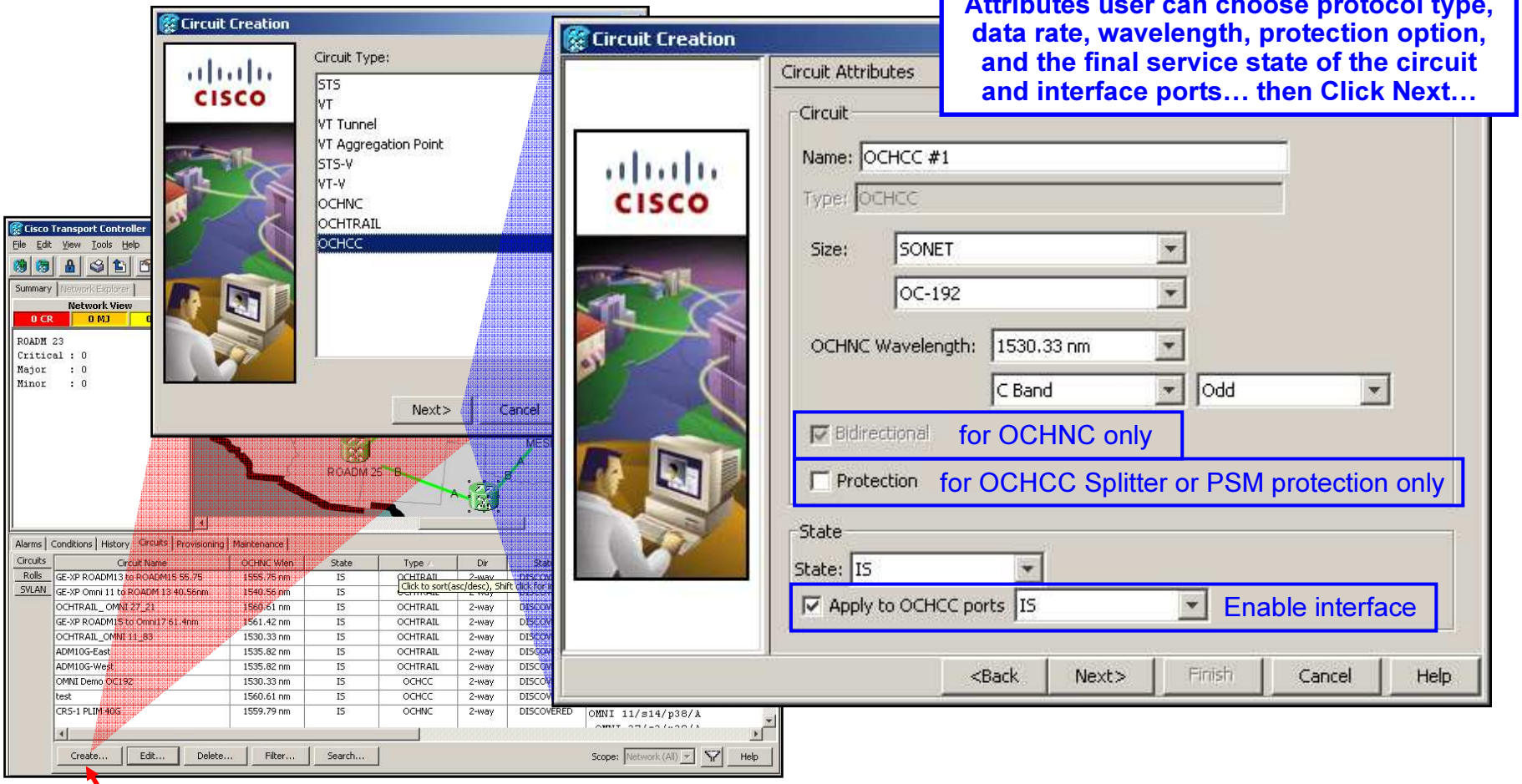
Cisco Transport Controler
Alarms Pane



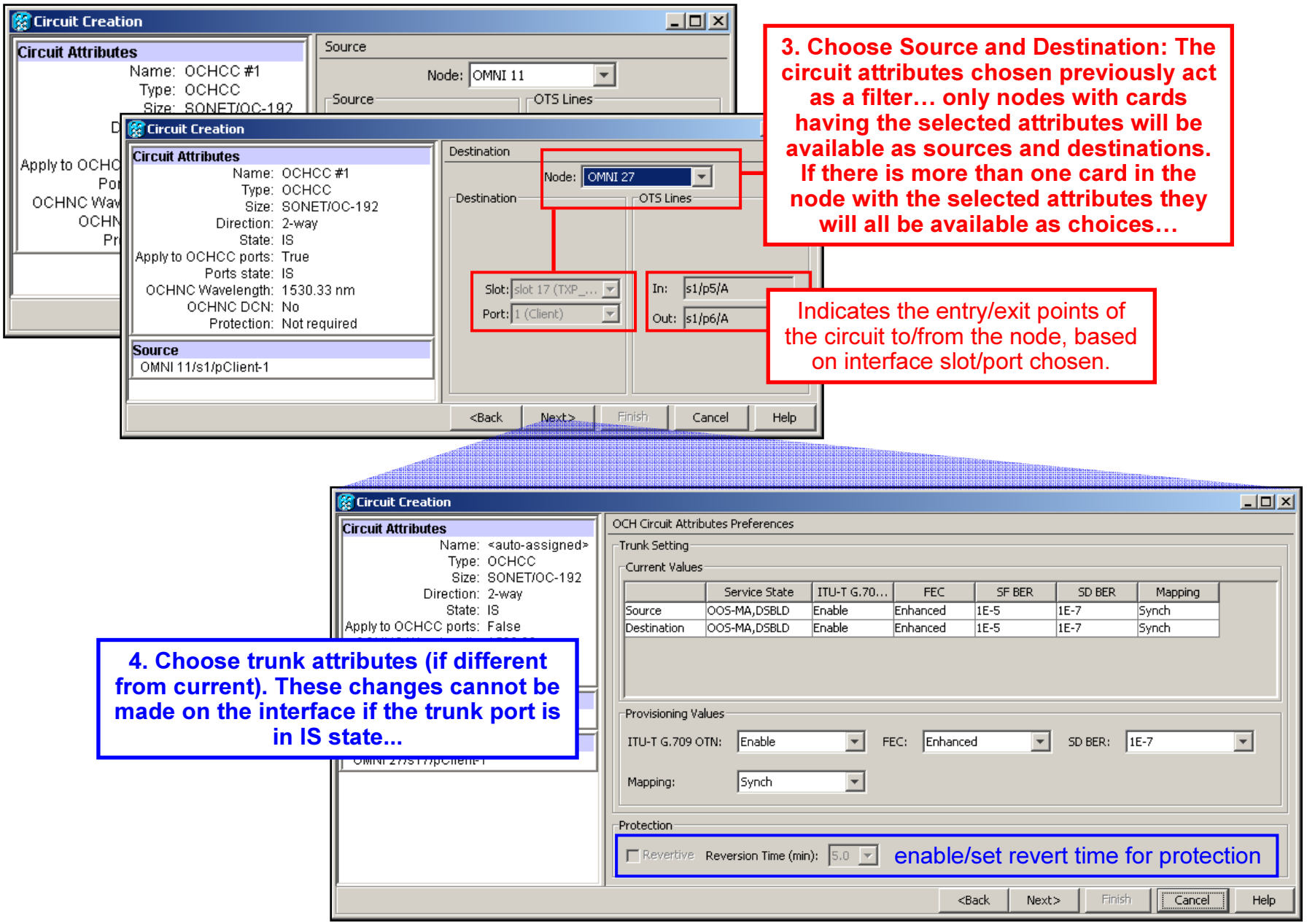
WDM Span Check (Non-Raman link)



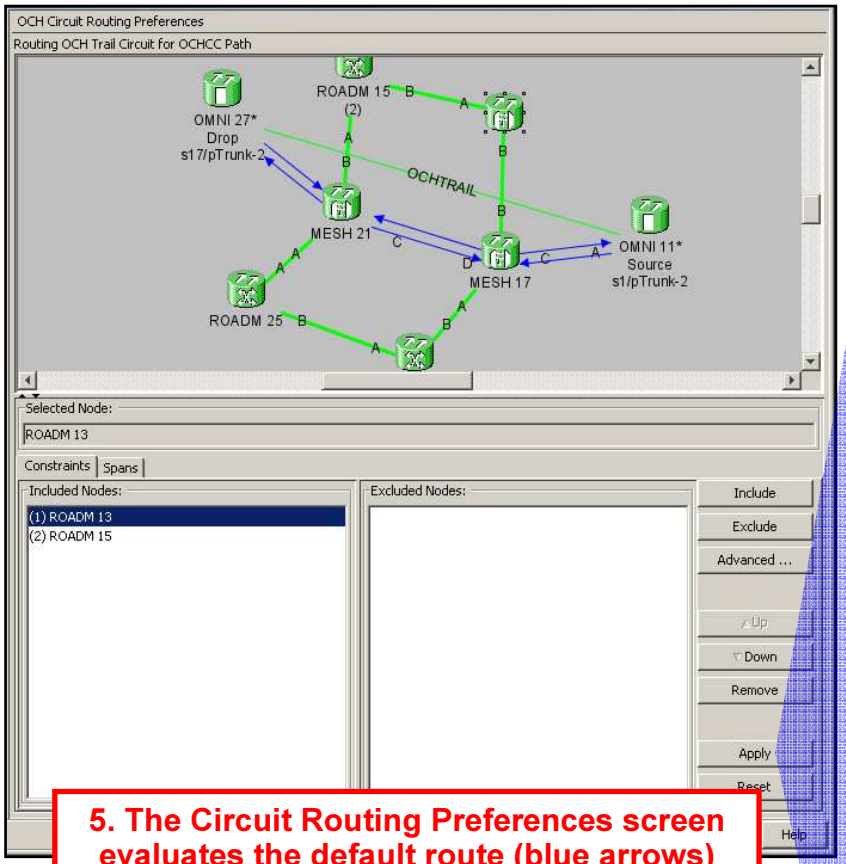
Circuit Provisioning / 1



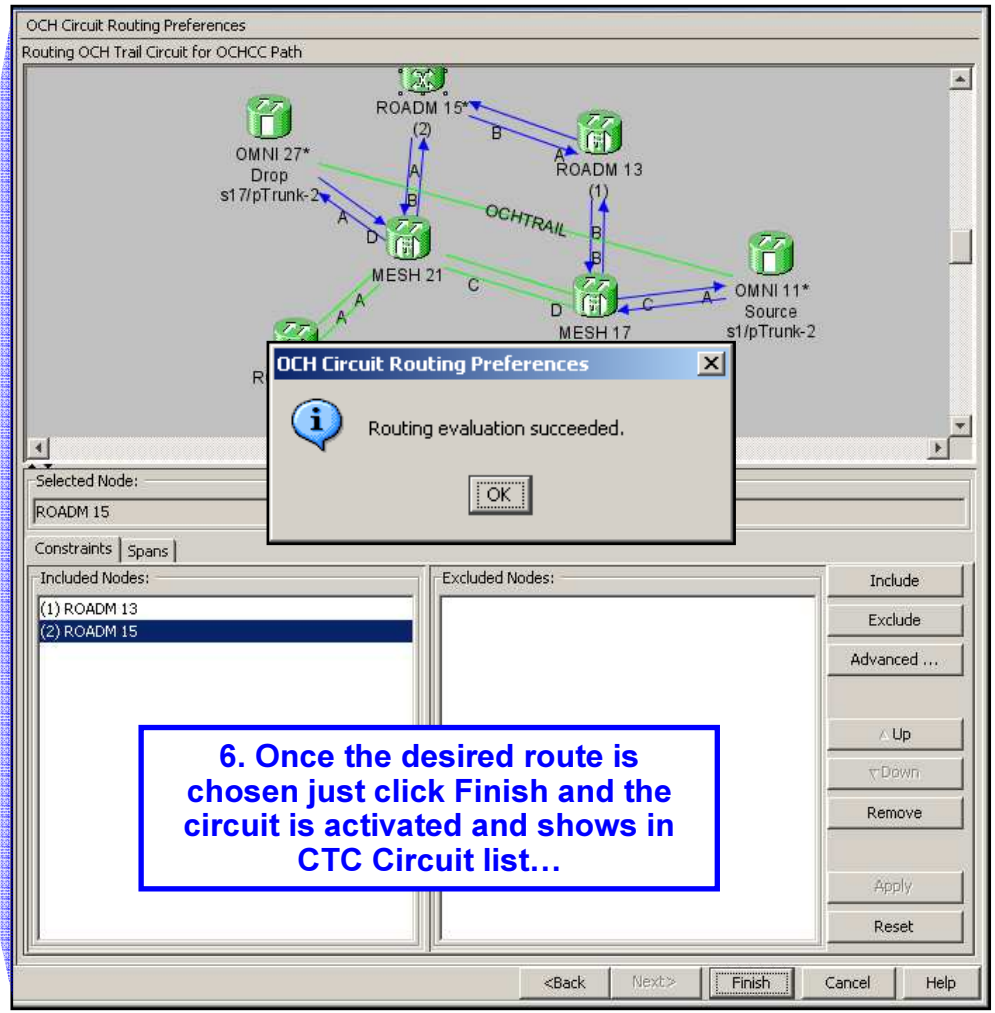
Circuit Provisioning / 2



Circuit Provisioning / 3



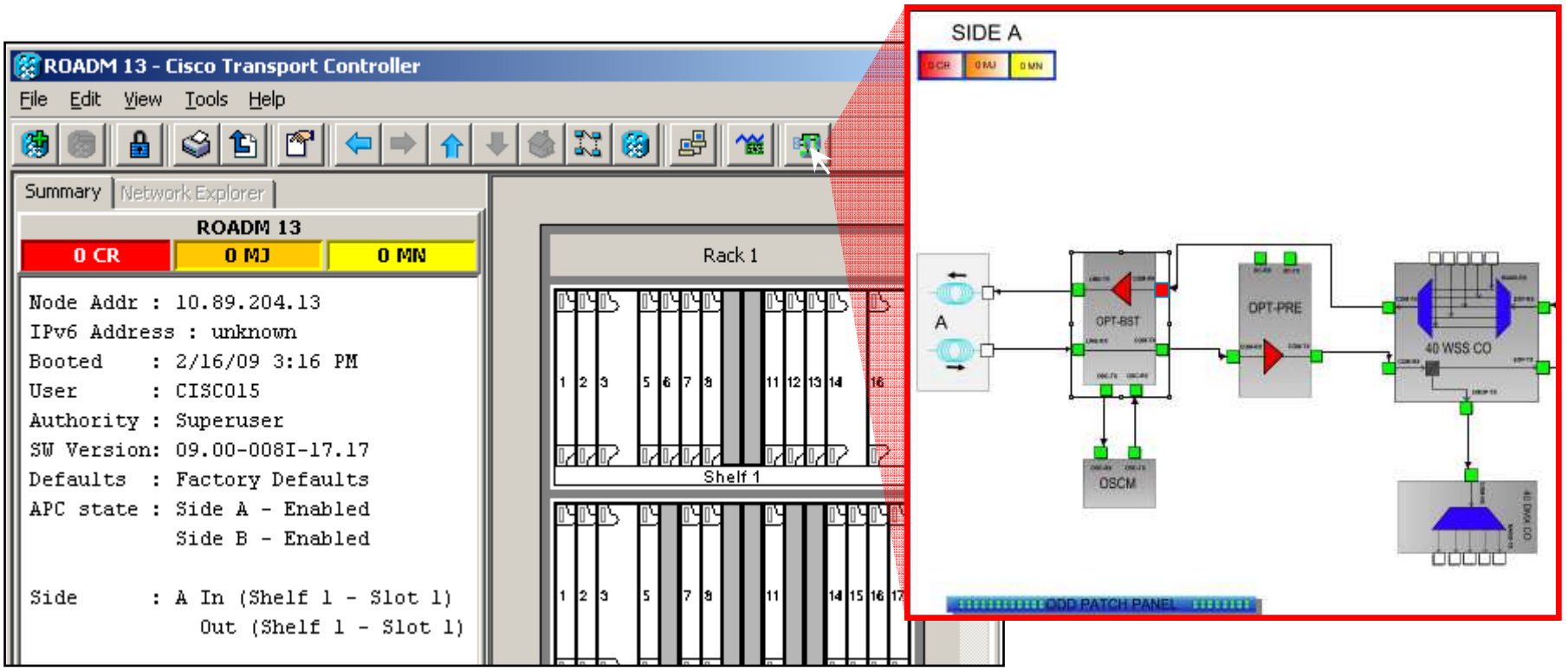
5. The Circuit Routing Preferences screen evaluates the default route (blue arrows) through the network based on the chosen source and destination and allows the user to choose an alternate route (mesh only) by including or excluding nodes. Once nodes are chosen the changes must be applied (Apply) and CTC will attempt to evaluate a new route…



6. Once the desired route is chosen just click Finish and the circuit is activated and shows in CTC Circuit list…

DWDM Functional View

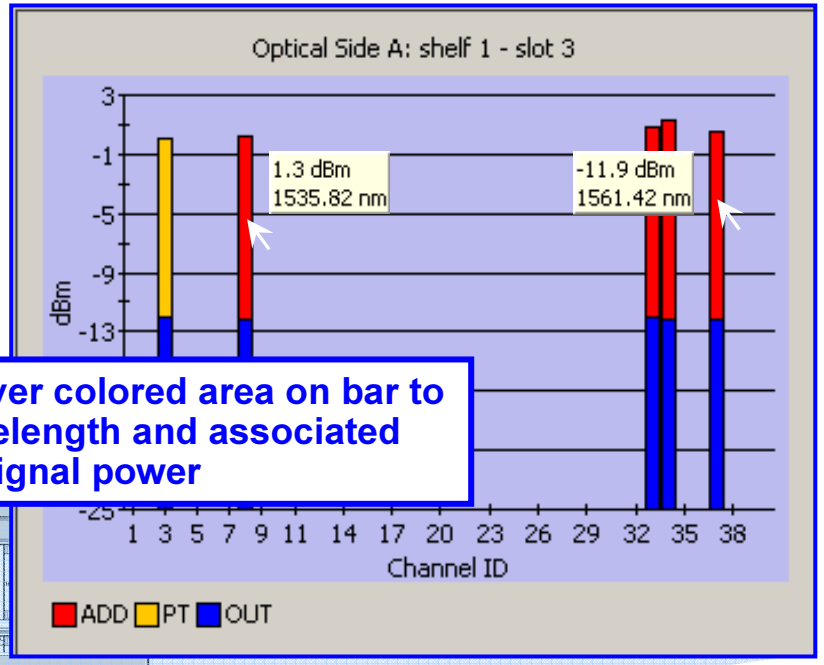
- Available since 8.5
- Displays logical port connections between Amp, Filter, and OSC units for all available optical sides, based on internal connections list
- Useful for understanding optical signal flow
- Show TX/RX power on a connection
- Rearrange card and link objects

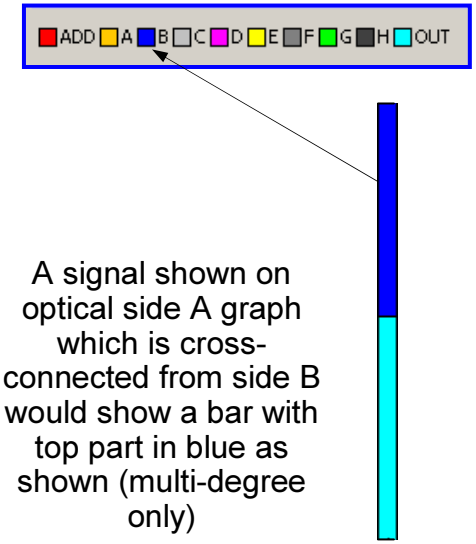


ROADM Power Monitoring

- Available since release 4.7. Accessed in NE View > *Maintenance* > *DWDM* > *ROADM Power Monitoring*
- In ROADM and Mesh nodes using 32/40-WSS or 40-WXC it provides capability to monitor the DWDM signal presence and equalization for each optical side separately
- Also available for TERM sites (later releases) and Dynamic Gain Equalization sites
- Color-coded to identify signal origin / optical side
- Color key for **multi-degree** indicates the cross-connected optical side…

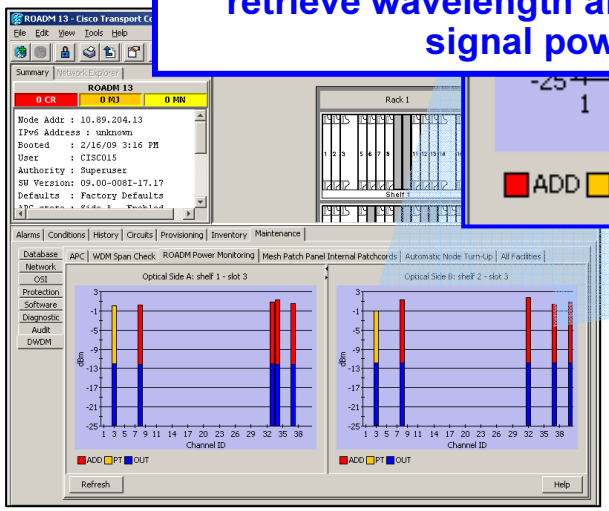
2-degree ROADM example





A signal shown on optical side A graph which is cross-connected from side B would show a bar with top part in blue as shown (multi-degree only)

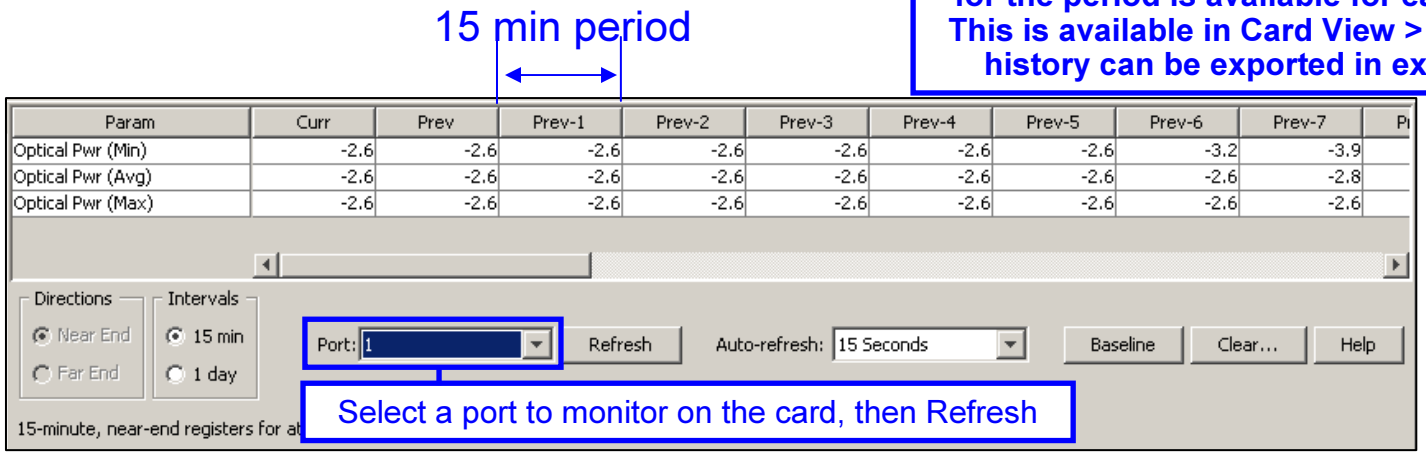
Place cursor over colored area on bar to retrieve wavelength and associated signal power



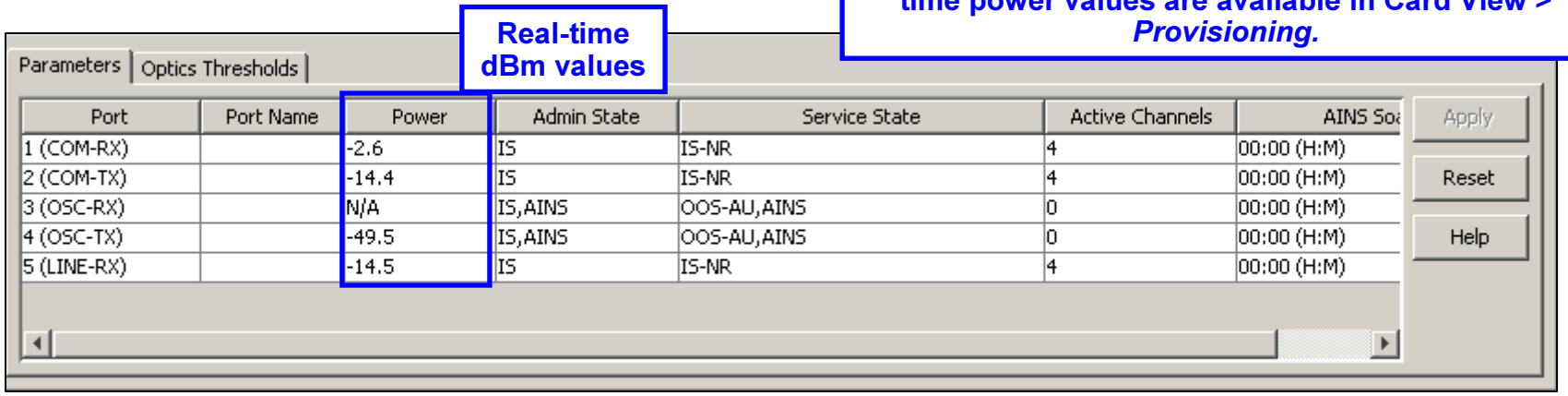
- Pass-through Wavelength Power
- Added Wavelength Power
- Output Wavelength Equalization

Performance Monitoring (PM) / Filters, Amps, OSC units

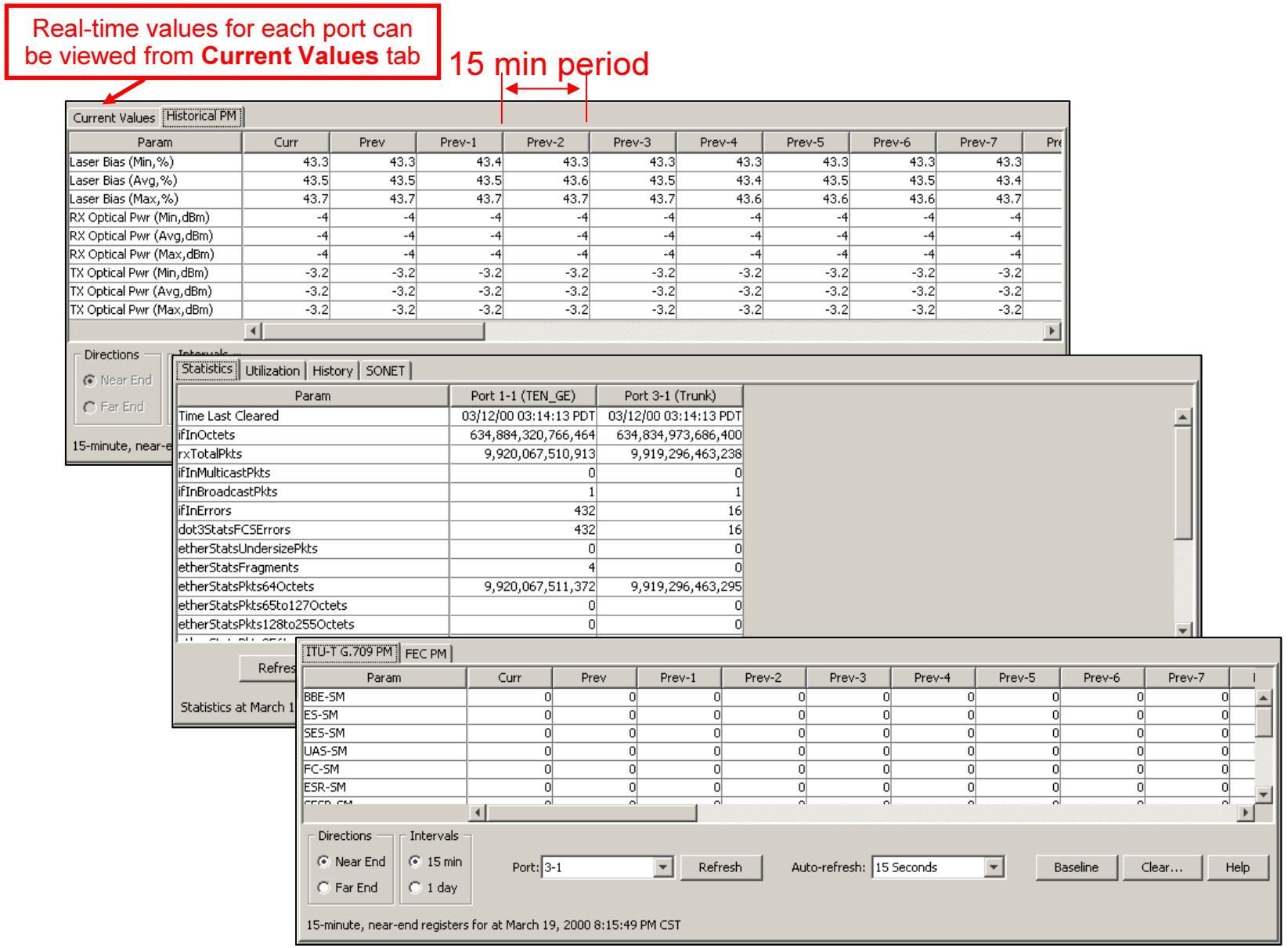
For DWDM filters, amplifiers, and OSC units an 8-hour (15 min intervals) / 2-day (1 day intervals) optical power history showing min/max/average power (dBm) for the period is available for each port on the card. This is available in Card View > *Performance.* All PM history can be exported in excel or html format.



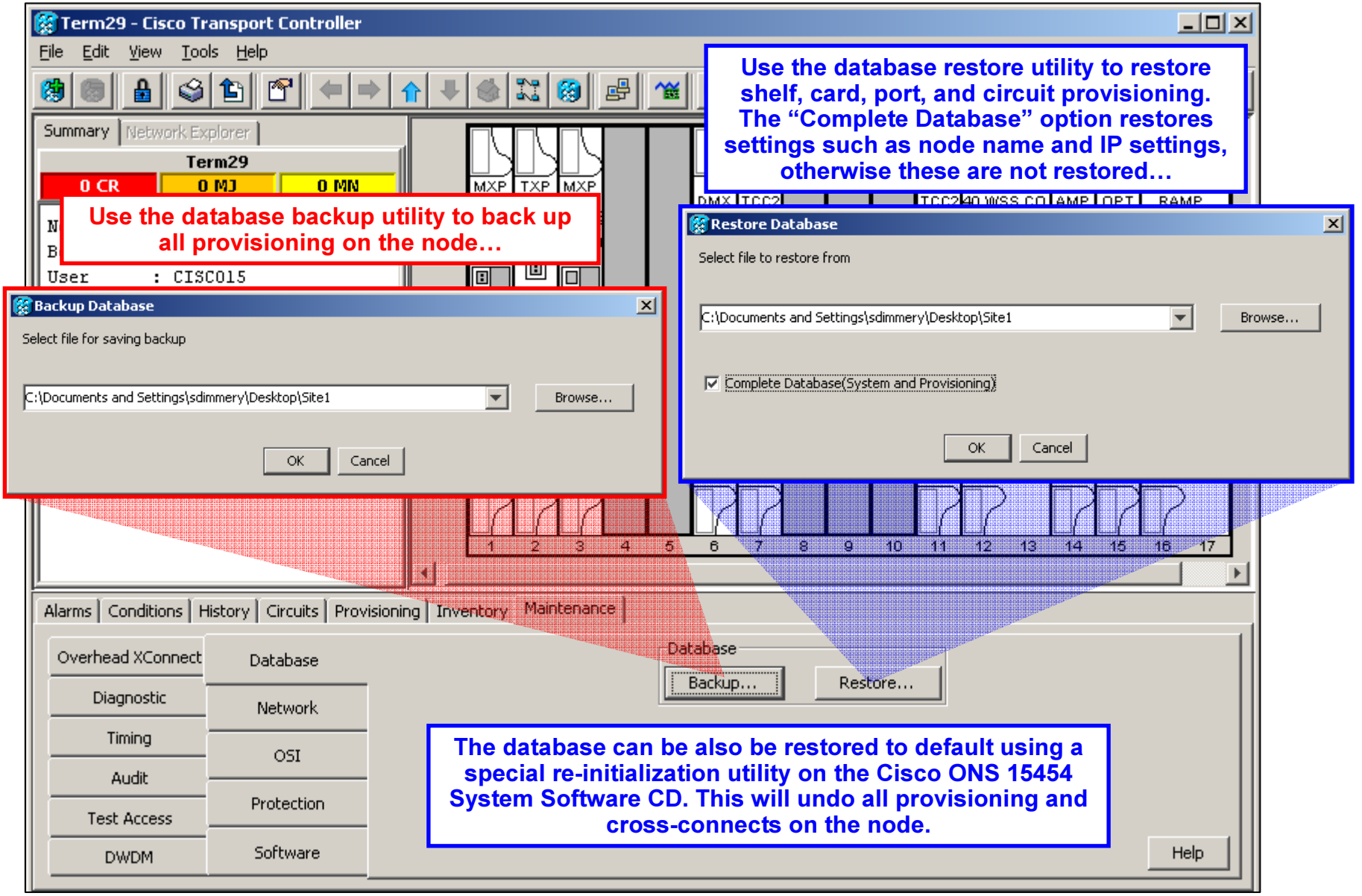
For DWDM filters, amplifiers, and OSC units real-time power values are available in Card View > *Provisioning.*



Performance Monitoring (PM) / Interfaces (TXP, MXP, etc)



Database Backup and Restore



Q & A