CISCO ONS 15454 MSTP OVERVIEW

OPTICAL TECHNOLOGY GROUP
Agenda

Cisco® DWDM Strategy
- Primary motivators
- Customers/network benefits
- Carrier-class design/customer acceptance

LH/metro vs. fully reconfigurable networking
- Basic DWDM architectures & attributes
- Cisco ONS 15454 MSTP Operational Efficiencies

Cisco ONS 15454 MSTP Solution Overview
- Reconfigurable OADM (ROADM)
- Services
- Transmission
Primary Motivators for Metro Regional DWDM

Priority on density & performance
- Simple, low cost

SONET/SDH, DWDM

Fiber Exhaust
32-64 Lambda, 2.5-Gbps/10-Gbps, 80- to 320-km Networks

Inter-POP Transport
High Capacity, Flexible Service Mix
FEC, G.709, End-to-End Management

Deliver Services
150-Mbps/600-Mbps/2.5-Gbps/10-Gbps
SONET/SDH, GE/10GE, SAN

Priority on service access
- Multiple service types
- Multiple services per lambda
- Multiple destinations
- 1 to 4 to 8 lambda/site
- 4 to 16 nodes/ring
Cisco Metro Regional DWDM Strategy: Eliminating Complexity

Taking advantage of ‘Simple, Fast, Easy’ Multiservice Provisioning Platform (MSPP) Architecture Pioneered by Cisco

- Easy channel and capacity planning
- Reliable network design and management of analog network elements
Cisco ONS 15454 MSTP
Target Customer Networks

Enterprise Networks
• Enterprise managed network
• Service provider, managed service

Carrier Networks
• MON – metro optical networks
• Span exhaust / fiber relief
• International metro, regional & long haul
• Core/IOF – metro regional WDM networks
Data-Center Networking: Transport Convergence

Aggregate disparate protocols and applications onto a scalable, fully managed, and protected optical network across a metropolitan or wide-area environment.
Storage Services that Influence Metro DWDM

Assumes Synchronous Mirroring Plus a Complete Application Environment

Server or Storage Disk Based

Geographically Dispersed Cluster with mirroring

Network $$$+
Host $$$+
Disk $$$$+
Software $$$$+

Synchronous Mirroring

Asynchronous Mirroring

Local Tape Backup
Remote Tape Backup

Database or File or Object back-up

COST

Recovery Times

Source: Gartner

Business Continuity Technologies
(storage/SAN, data replication, optical transport network)
Cisco ONS 15454
Multiservice Architecture

Three Core Functions…
1. SONET/SDH Transport with TDM aggregation
2. Native Ethernet and IP switching and aggregation
3. MSTP … Intelligent DWDM transmission and wavelength transport

...Streamlining Capital and Operating Expenses
One Platform, One Management System
Multiservice Architecture Economic Benefits

Reduced Cost per Incremental Service

Greater Revenue Services Per Fiber: Service Density = Services per $\lambda \times \lambda$ per Fiber

Superior Revenue-to-Capital Ratio: Revenue-Services per Fiber/Reduced Cost per Incremental Service

- High service density
- Aggregated TDM, Ethernet, IP, $\lambda$ services in a single platform
- Low first-service cost
- Efficient use of fiber/infrastructure
- Scalable design
- Simple, fast, and easy service turn-up and maintenance

Increased Traffic per Fiber Pair

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Cisco ONS 15454 MSPP Acceptance

- Customers: 1500+ across all segments
  - Independent LECs
  - Competitive Carriers
  - International
  - National Carriers
  - Cable TV
  - Incumbent LECs
- 50,000+ Systems Shipped/In-Service
- All Network Topologies and Configurations Deployed
- First-Cost and Life-Cost Leader

Certification Status

- Telcordia Standards
  - NEBS Level 3
  - GR-253-CORE
  - GR-1400-CORE
  - GR-1230-CORE
- Osmine Testing
  - TIRKS, NMA, TEMS
- UL 1950
- CE Mark
- CSA, ICES-003
- FCC Part 15 Approval
- IEEE 802.3
- RUS Approved
Cisco ONS 15454 MSTP
Customer/Industry Acceptance

Achievements since FCS: August 2003

Metro DWDM Market Share Growth

- Cisco is #2 in WW Metro DWDM Market Share: 17.2% mkt share in Q1 ‘04 (independent analysts) +4.1% quarter/quarter market share gain

- >75 New Customer Wins Within 3 Quarters: SP, Enterprise (Managed/Private), Cable & Federal Global: Americas, EMEA and Asia-Pac

- Current Year Network Deployments: >750 wavelengths shipped over last 3 quarters 2-4 wavelengths to 32-wavelength systems in-service today

Certifications
- Storage
  EMC (SRDF) – done
  HP (DRM) – done
  IBM – upcoming
- OSMINE
  TIRKS/NMA/TEMS

Announced MSTP Customers Since SuperComm 2003
- Dansk Bredbaand
- networx
- Cablecom
- illinoisbell
Cisco ONG: WDM Core Competencies

- Solid history of building innovative carrier-class WDM solutions
- Acquired 30 fundamental WDM patents through Pirelli acquisition and continue to develop/patent new technology

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Source: Cisco Legal (up to Q1 of 2003).
Cisco DWDM: World Class Facilities

25000 sq ft of Labs, WDM Headquarters Monza Italy:

- Fully automated Labs with SW tools supporting 24 hours/day testing of:
  - DWDM OSNR and equalization
  - Q factor measurement
  - APD multi-BER test
  - Dispersion robustness
- Test of components and subsystem vendors specifications
- Systems and networks design rules verification
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Basic DWDM Architectures

Metro Ring 120 km

Linear (Pt- Pt) 600–1000 km

Regional Ring 600–1000 km
Attributes of Traditional LH DWDM

- Designed for point-to-point transport
  Cannot be deployed in ring topology
- Fixed OADM (usually 10–20% of total traffic)
- Cost model is for >40 channels
  High first cost for amplifiers and filters
- Expensive Raman amplification to go >1000 km
- Large footprint and power consumption
- Cumbersome new wavelength provisioning
- Inability to support line-rate 10 GE LAN PHY (no G.709)
  Constrained by older, proprietary FEC coding
Attributes of Traditional Metro DWDM

- Primarily designed for 2.5-Gbps networks
  - Growth to 10-Gbps requires more amplifiers or OEO Regen
- Typically deployed in >200-km applications
  - Growth to >200-km requires more amplification or OEO Regen
  - No FEC on transponders
- Fixed OADM (usually up to 100% of total traffic)
- Very low-cost model
  - Very few amplifiers required
  - Channel or band-based architectures
  - No FEC or tunability
  - OSC and controllers are not redundant
- Small/medium footprint and low power consumption
- Cumbersome new wavelength provisioning
  - Manual attenuators and no automatic power control
  - No drop and continue because of band architectures
Cisco ONS 15454 MSTP Features

- 32 channels @ 100-GHz channel spacing in C-band
- Hardware ready for 64 channels @ 50-GHz spacing in C-band
- 1000-km nonregenerated optical performance
- Transparent transport of any service from 8 MB to 10 GB
- Muxponding of OC-n and data interfaces
- SFP and XFP-based transponders
- Tunable transponders over multiple channels
- G.709-based transponders with full performance monitoring
- Complete wavelength reuse with drop and continue
- Automatic configuration, setup, and maintenance
- Low power consumption and footprint
- Lowest first cost and lowest total cost
Traditional DWDM Metro Solution

- Fixed channel filters require specific part numbers.
- Current functions do not support dynamic traffic management.
- Systems use passive DWDM components for signal aggregation.
- Optical span power management is a manual process.
- Channel balancing is a manual process.
- Adding nonengineered λ services is intrusive
- Sparring is inefficient
Cisco ONS 15454 MSTP—DWDM Solution

ROADM
- Provides drop/port tunability and lambda blocking
- Enables dynamic allocation of ITU paths.
- Scales from 1 to 32 lambda services
- Enables ability to predeploy ITU interfaces without predetermined lambda path (source to destination)
- Lessens transponder-ROADM recabling
- Offers automated bridge and role for churn
- Reduces sparing costs
- Enhances flexibility (any \( \lambda \) to any drop)

120 - 1000 km
Operational Efficiency in Terms of Work Hours: Initial 8 Channels

- **MSTP Traditional DWDM**
  - Equipment: $1,049
  - Work Hours: 200

- **OpEx**
  - Equipment: $32
  - Work Hours: 3%

- **Traditional DWDM**
  - Equipment: $1,014
  - Work Hours: 5%

**54% Fewer Touches**

42% Fewer Touches

54% Operational Efficiency (work hours)
Operational Efficiency in terms of Work Hours: Additional 4 Channels

<table>
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<tr>
<th>MSTP</th>
<th>Traditional DWDM</th>
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<td>OpEx</td>
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Cisco ONS 15454 MSTP

Add OADM

Initial Install/Adj.
Readjustments
MSTP ANS

Automated Adjustments

Cisco.com
Scalability: OpEx Comparisons From 8 Channels to 32 Channels

Initial Install/Adj. Readjustments MSTP ANS

Initial Install/Adj.

OpEx Equipment Total Work Hours

MSTP Traditional DWDM

OpEx $47 4% $86 6%
Equipment Total $1,307 $1,549
Work Hours 296 534

Operational Work Hours
Shelf Efficiency: MSTP vs. Traditional DWDM (terminal sites) 32-Channel Configuration
Example: Regional DWDM System

32-Channel Reconfigurable Multiplexer (32-WSS)
- Software selectable between add and pass path
- Per-channel equalization and power monitoring
- Low insertion loss
- Hardware switching in < 10 ms
- Single multiplexed fiber to connect east and west
- Connectors: 4 x 8 MPO ribbon; 5 LC-PC-II optical

Traditional DWDM Products
- Span designs must account for future traffic patterns at all sites.
- Unanticipated growth will require additional OADM or EDFA equipment.
- Adding OADM or EDFA equipment to a ring impacts all existing traffic.
- TDM services require separate equipment and management.
Cisco ONS 15454 Chassis Design

- **12 Universal Slots**
  - TDM electrical cards
  - DWDM cards
  - OC-N optical cards
  - Ethernet/FE/GE cards
  - Each provisionable for network and drop side

- **5 Common Slots**
  - Redundant processors (TCC)
  - Redundant cross-connects (X-conn)
  - Optional alarm card (AIC)

- **Compact Chassis**
  - Installs in 19- or 23-in. bay
  - Up to 4 chassis per 7-ft. bay
  - (incl. 1.75-in. fuse and alarm panel)

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622M/2.5-Gbps TDM  2.5-Gbps/10-Gbps TDM
Addressing Applications: Supporting Access to Regional Networks

- **IOF Chain (same reach as ring)**
- **IOF Ring**
  - (300 km for 3 nodes - 600 km for 8 nodes)
- **Single Span (120 km)**
- **Point-to-Point Line (600 km)**
- **Metro Core**
  - (900 km, 15 nodes)
- **Access Ring**
  - (50 km for 5 nodes)
- **Passive OADM**
- **Amplified OADM**
- **Line Amplifier**

Customer Value: Optimized for many applications → CapEx, Single technology → OpEx
Reference Optical Performances: Open and Closed Rings/Linear

• Assumptions:
  OADM insertion loss = 16 dB
  Equal span losses

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Cisco ONS 15454 MSTP: Management

- **Cisco Transport Controller**: Craft system for installation, setup, and node and network management
- **Cisco Transport Manager**: EMS / NMS layer applications for advanced optical management
- **Cisco MetroPlanner**: Network design tool application
- **Intelligent Optical Transmission**: Automatic manual free regulation and setup
- **Full FCAPS for DWDM, OTN, and SONET/SDH**
- **TL-1 and SNMP interface to OOS; CORBA NBI available from Cisco Transport Manager**
- **Carrier-class future proof, scalable architecture**
- **End-to-end wavelength management**
- **Optical protection management**

Cisco ONS 15454 MSTP

Cisco Transport Controller

Cisco Transport Manager

Cisco MetroPlanner
ONS 15454 MSTP: Intelligent Optical Transmission

- Network topology auto-discovery
- TDM-like A-Z wavelength path provisioning
- Network automatic power control
  - Fully automated wavelength additions
  - No truck rolls
  - Auto power control algorithm
  - Addresses fiber aging
  - Fast transient suppression
  - No service impact with fiber cut
- Node and Network point-and-click setup and regulation
- Fast Ethernet user data channel available
- Wavelengths also support in-band G.709 GCC
Intelligent DWDM: Automatic Network Setup

Automatic Network Setup from Design to Deployment

• MSTP design tool is used to design, verify and order MSTP networks.

• Output of MSTP design tool is used to automatically set up network.
  MSTP design tool configuration file used to:
  • Automatically set all eVOA and amplifiers
  • Identify card names and slot assignments for technicians
  • Give port-to-port fiber connections to technicians

• 1510-nm OSC is used to establish “DCC-like” link to all nodes.
  OSC gives full automatic topology discovery.
  OSC allows user to provision and monitor all cards and circuits.
Intelligent DWDM: Automatic Power Control

Automatic Power Control (APC)

• Automatically monitors and adjusts the optical power of amplifiers
• Automatically corrects gain as needed without manual intervention
• Maintain power levels to avoid nonlinear effects
• Manages fast effects directly at amplifier level
• Manages aging at network level through information exchange between nodes
• Equalizes power on a per-channel basis at network ingress
Intelligent DWDM: Wavelength Path Provisioning

Wavelength Path Provisioning

• Optical circuits are managed in the same way as SONET/SDH circuits.

• Element management system is used to provision A–Z SONET/SDH and wavelengths.

• Transponders are tuned to the correct wavelength.

• Incorrect circuits are not allowed if wavelength is unavailable.

• Wavelength performance monitoring is provided by G.709.
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Existing ROADM Technology: Blocker with Port Tunability

Description: WSS provides blocking and drop port tunability.

• Scaling from 8 to 32 is accomplished by adding units, 8 channels at a time.

• WSS offers the ability to predeploy ITU interfaces without knowledge of where that wavelength will originate and terminate, thereby lessening Txpdr-ROADM recabling.

• WSS offers automated bridge and role for churn.
Cisco ONS 15454 – R-OADM Architecture

- Complete flexibility to manage network growth
  
  Scalability: 32chs solution deployed day 1, Add Service Interfaces Only

- Wavelength path provisioning
  
  Dynamic: Software controlled, Never break composite line, OchSPRing capable

- Increased service velocity
  
  Easier to provision wavelength than a dark fiber

- Ability to target cost-effectiveness from 6 Channels
Cisco ONS 15454 ROADM

32-Channel reconfigurable multiplexer (32-WSS)
- Dual slot card
- Software selectable between add and pass path
- Per-channel equalization and power monitoring
- Optical connectors
  - 4 x 8 MPO ribbon connectors
  - 5 LC-PC-II optical connectors

32-Channel reconfigurable demultiplexer (32-DMX)
- Single slot card
- Integrated VOA and power monitoring
- Optical connectors
  - 4 x 8 MPO ribbon connectors
  - 1 LC-PC-II optical connector

Any of the 12 general-purpose slots
Cisco ONS 15454 9-Port FC/GE Muxponder

- Protocol support:
  - 9 ports 1G FC/GE/ISC-1 to 10G
  - 5 ports 2G FC/ISC-3 to 10G
  - 4G FC ready
- Oversubscription allowed
- Aggregation of IBM coupling facility links
- Buffer-to-buffer credits
  - Up to 1600 km (1G FC)
  - Up to 800 km (2G FC)

Two Versions
- Full C-band tunability 10G ITU (32ch), with EFEC
- Full L-band tunability 10G ITU (32ch), with EFEC
Cisco ONS 15454 1-Port 10G FC Transponder

• 10G Fibre Channel client

• Industry-leading Cisco end-to-end solution: Full support for VSANs (EISL, TE port) from Cisco MDS 9000 10G FC card

Enhancements over 10G MR Transponder

• Full C-band tunability 10G ITU (32 ch), with EFEC

• Buffer-to-buffer credit support for extended distance support

• Detailed performance monitoring for 10G FC for enhanced troubleshooting and SLAs
10G ITU EFEC

- ITU-T Colored Line Interfaces
  OC-192 DWDM ITU-T
- Highly efficient transport of aggregated Ethernet, IP, and TDM services
- Support for all SONET network topologies, including UPSR, 2F and 4F BLSR, and PPMN
- 4 wavelengths per shelf
  Other universal slots may be used for wavelength, packet and TDM services
- Increased tuning range (4 chs at 100-GHz/8 chs at 50-GHz DWDM interface)
- EFEC : Increase of 2 dB of FEC gain (i.e., total ~8-dB total gain)
- Equivalent optical performance to 2.5-G ITU
Cisco ONS 15454 MSTP
Integrated, Intelligent DWDM

- 32 DWDM Transmission Elements
- 32 wavelengths today, with scalability to 64
- Multiplexer and demultiplexer
  - 32-I multiplexer
  - 32-I demultiplexer
  - 4-I multiplexer/demultiplexer
- Optical add/drop multiplexer
  - 1- and 4-band OADM (flexible OADM)
  - 1, 2 and 4I OADM
- Optical amplifier
  - Optical preamplifier (EDFA)
  - Optical booster-amplifier (EDFA)
- Optical service channel
  - Optical service channel module optical service Channel with combiner/separator
- Dispersion compensation modules
- Any slot installation, providing tremendous flexibility for building DWDM network elements
Cisco ONS 15454 MSTP Service Interfaces

- **ITU trunk interfaces**
  - 2.5-G/10-G (OC-48/192) ITU trunk
  - Use with 454 TDM/data/SAN interfaces + XC
  - Use with Cisco ONS 15600 Core Switching Platform

- **Colored GBIC interfaces**
  - Use with Cisco switches and routers

- **2.5-Gbps Multirate tunable transponder**
  - OC-3/12/48 GE, FC, ESCON
  - Transparent 2R (D1/SDI, DV6000)
  - G.709 trunk

- **10-Gbps Multirate tunable transponder**
  - OC-192, 10 GE LAN/WAN
  - G.709 trunk

- **10-Gbps tunable muxponder**
  - 4 x OC-48 on a wavelength

- **2.5-Gbps GE/FC tunable muxponder**
  - 2 x 1G FC, 2G FC, 2 x 1GE; ISC1/3, ETR/CLO

Customer Value: Streamlining CapEx and OpEx
Optical Add/Drop Multiplexer: Wavelength Plan and Structure

100-GHz 4 skip 1 C-Band Architecture

1530.33nm 1534.25nm 1538.19nm 1542.14nm 1546.12nm 1550.12nm 1554.13nm 1558.17nm
Flexible, Scalable DWDM Network Elements – Managing Cost and Growth

32-Channel Hub Node
- 32-\(\lambda\) multiplexer
- 32-\(\lambda\) demultiplexer
- Pre and boost optical amplifiers
- Optical service channel

2-Channel Amplified OADM
- 2-\(\lambda\) multiplexer/demultiplexer
- Pre optical amplifiers
- Optical service channel
- 6 universal slots for wavelength, TDM, and Ethernet/IP services

2-Channel Unamplified OADM
- 2-\(\lambda\) multiplexer/demultiplexer
- Optical service channel
- 8 universal slots for wavelength, TDM, and Ethernet/IP services
Multiple Options for Service Protection

Client Protected: Signaling Between Client Equipment

Y-Cable Protected: Transponder Protection Group

Fiber Protected: DWDM Wavelength Splitting
Network Planning Tool

- MetroPlanner Java-based DWDM only design tool
- Virtual photonics SONET layer design tool
- MetroPlanner next-generation integration of the design tools to complement the integration of the hardware platform

Features:
- Integrated design of DWDM and SONET
- Validation of optical performance
- SONET optimization
- Installation simplification support
- Ordering support

Partnering with Industry Leaders to Provide Best-in-Class Network Modelling
Cisco Intelligent Optical Transmission

**Summary**

**Traditional Vendors**

- Traditional solutions
  - Long-haul derivatives

**Cisco Optical**

- Next-generation metro regional solution designed from beginning

**Inflexible**

- Preplanning
- Limited application support

**Flexible**

- Minimizes need for preplanning
- Is configurable to meet cost-growth tradeoff
- Offers wide variety of applications

**Difficult to Manage**

Intelligent Software Enables Automated Network Setup and Management