NGN Transport Solutions

Cisco Expo Maroc, 30 juin / 1er juillet 2009
Louis-Vincent Perrinel – Consulting System Engineer
Agenda

1. Service Provider Network Evolution Background

2. IPoDWDM Solutions

3. Scaling Bandwidth: per-channel 40G, 100G and beyond

4. Enhancing Agility: towards the Zero-Touch Network

5. References
Global IP Traffic Growth
Internet in 2012 Will Be 75x What It Was in 2002

Source: Cisco Visual Networking Index — Forecast, 2007–2012
Growth...Fueled by Video

1995: Web Overtakes Gopher, FTP
2000: Peer-to-Peer Overtakes Web
2013: Video Content Overtakes Peer-to-Peer
2025: Video Communication Overtakes Video Content

Video Communication

Video Content

P2P

WWW

Gopher, FTP

1993-1995

1995-2000

2000-2013

2013-2025

2025+
Industry Trends: Service Provider

**Economic Pressure on SP Spending**
- Traffic increasing capex faster than revenue growth
- Profitable models for IP / MPLS investment

**Video over IP Network Growth**
- SP offerings: new profit opportunities
- Specialized offerings: need shared business model

**Mobile Internet Acceleration**
- New radios delivering broadband IP
- Developed markets: Mobile supplanting fixed
- Emerging markets: Mobile only choice
Network “Table Stakes”

**Optical / IP Integration**
- IP+WDM key from metro to core applications
- Network Architecture approach saves OpEx & CapEx

**Evolved Transport Layer**
- ROADM has redefined transport layer
- MSTP Platform must scale from Edge to Core applications

**Service Integration**
- MPLS will play an expanding role in handling customer requirements across all applications
IP NGN Convergence — Transport Layer

Common Network Management and Control

Router / SAN

Mesh ROADM

Integrated Transponders

Features
- Flexible Network Configuration
- WDM Interfaces on Router
- Rapid Service Turn-up
- Dynamic Network

Mesh ROADM

- Omni-Directional
- Colorless
Economic Benefits

- Integration
  Decreases CapEx

- Automated Provisioning
  Decreases OpEx

- Advanced ROADM
  Improved ROI

- Control Plane Signaling
  Increases Revenue & Decreases OpEx
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What Is IPoDWDM?

1. IPoDWDM is a new network model which integrates the Transponder within the Router Blade

2. This reduces both Cap as well as OP Ex while increasing network scalability, flexibility and time to market

3. Integration of the DWDM transponder onto the Router blade allows for a robust, intelligent network
Why IPoDWDM

Traditional Model: External Transponder

OC768-SR

Transponder

40G DWDM

OC768-SR

Next Gen.: IPoDWDM

OC768-ITU

40G DWDM
# IPoDWDM leadership – More than the Sum of its Optical & IP parts

<table>
<thead>
<tr>
<th>2-Degree ROADM</th>
<th>IPoDWDM Introduction</th>
<th>2-8 Degree (Mesh) ROADM</th>
<th>CRS-1 40G WDM PHY with 2000 km reach</th>
<th>Cisco IP NGN IPoDWDM Vision</th>
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<tr>
<td><strong>2-Degree ROADM Solution</strong></td>
<td><strong>IP over DWDM</strong></td>
<td><strong>Mesh ROADM (WXC)</strong></td>
<td><strong>2000 km +</strong></td>
<td><strong>Combine Multi-Degree ROADM and IPoDWDM Reach Innovations to Optimize Service Availability, Scalability and Acceleration</strong></td>
</tr>
<tr>
<td>ONS 15454 MSTP</td>
<td>CRS-1 ONS 15454 MSTP</td>
<td>ONS 15454 MSTP</td>
<td>CRS-1 ONS 15454 MSTP</td>
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</tr>
</tbody>
</table>

**Cisco IP NGN IPoDWDM Vision**

- **2003–2004**: Flexibile Wavelength Management: Reconfigurable Optical Add/Drop Multiplexer (ROADM)
- **2005–2006**: ITU Lambdas on Core Routers: True integration of IP & DWDM improves Management, OpEx & CapEx
- **Spring 2007**: Automation of mesh networks: Breaking the Ring Barrier - Remotely provisioning Wavelengths across entire networks
- **Summer 2008**: Extending reach of 40G: Enabling automated mesh transport for 40G signals
- **2009+**: Continuous Innovation
  - Directionless & Colorless
  - 40G X-Ponder
  - 100G…
Cisco Variety of IPoDWDM Interfaces

1. Cisco CRS-1 1-Port OC-768C/STM-256C Tunable WDMPOS.
2. Cisco CRS-1 1-Port OC-768C/STM-256C DPSK+ Tunable WDMPOS Interface Module.
3. Cisco CRS-1 4-Port 10GE Tunable WDMPHY Interface Module.
4. Cisco 1-Port 10 Gigabit Ethernet (10GE) Tunable WDM-PHY Shared Port Adapter on the Cisco 12000 and CRS-1
5. Cisco 2-Ports and 4-Ports 10 Gigabit Ethernet (10GE) with G.709 on the Cisco 7600 using XFPs.
6. Tunable XFPs on MSTP (Q3 2009)
Intelligent Transport Layer
G.709 OAMP Functionality

Current SP Architecture
Span of G.709 OAMP

POS

Span of SDH OAM&P

Rely on SDH OAMP for Monitoring and Fast Protection

Router

No Transponders

IPoDWDM NGN SP Architecture
Span of G.709 OAMP

Router

Can Rely on G.709 OAMP
E.g. MPLS FRR – but Trigger much Earlier than SDH LOS

10GE LANPHY Inside G.709 on a Wavelength

Transponders

Can Rely on G.709 OAMP
E.g. MPLS FRR – but Trigger much Earlier than SDH LOS
Proactive FRR based on pre-FEC errors

Today’s protection

Proactive protection
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## Improved 40G Optical Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NRZ</th>
<th>ODB</th>
<th>DPSK</th>
<th>DPSK+</th>
<th>DQPSK</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 GHz Compatible</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Worst Case Reach (km)*</td>
<td>500</td>
<td>500</td>
<td>&gt;1000</td>
<td>&gt;1000</td>
<td>~1000</td>
</tr>
<tr>
<td>Chromatic Dispersion Robustness (ps/nm)</td>
<td>+/- 50</td>
<td>+/- 150</td>
<td>+/- 50</td>
<td>+/- 650</td>
<td>+/- 650</td>
</tr>
<tr>
<td>PMD Robustness (ps)</td>
<td>2.5</td>
<td>2-3</td>
<td>2.5</td>
<td>2.5–3.5</td>
<td>5-8</td>
</tr>
<tr>
<td>Complexity</td>
<td>Med</td>
<td>Med</td>
<td>Med+</td>
<td>Med+</td>
<td>High</td>
</tr>
</tbody>
</table>

* Distance depends on link specifics. 2x worst case is possible.
* Additional reach (~2x) possible with Raman amplification
100Gig E in the IEEE 802.3ba Objectives

- Support full-duplex operation only
- Preserve the 802.3 / Ethernet frame format utilizing the 802.3 MAC
- Preserve minimum and maximum FrameSize of current 802.3 standard
- Support a BER better than or equal to $10^{-12}$ at the MAC/PLS service interface
- Provide appropriate support for OTN
- Support a MAC data rate of 40 Gb/s
  - Provide Physical Layer specifications which support: 40 Gb/s
    - at least 100m on OM3 MMF
    - at least 10m over a copper cable assembly
    - at least 1m over a backplane
- Support a MAC data rate of 100 Gb/s
- Provide Physical Layer specifications which support:
  - at least 40km on SMF
  - at least 10km on SMF (likely to become 2-4km)
  - at least 100m on OM3 MMF
  - at least 10m over a copper cable assembly
IEEE 802.3ba Timeline
100GE and the ITU

1. ITU agreed to optimize new OTU4 rate for 100GE transport

2. Industry appears to have learnt its lesson from 10GE (i.e. LAN/WAN PHY)
   Ideally want one mapping, one FEC and one modulation scheme !!!
   some resistance from traditional transport vendors

3. Transmission requirements are the same as 40G:
   Must work over existing, installed DWDM common equipment;
   Support 50GHz DWDM channel spacing;
   Full band tunable lasers on 50GHz ITU grid
   Optical reach of ≥ 1,500km;
   Chromatic dispersion tolerance of ≥±800ps/nm;
   Polarization Mode Dispersion tolerance of > 10ps (mean DGD);
   Must be “plug and play” and installable by existing field technicians

4. 40G was the first commercial application for advanced modulation:
   100G will build on similar approaches
100G Development Efforts

1. Leading standardization effort within OIF (eco-system)
   - Strong supplier base and supply continuity (multiple vendor soln)
   - Compatibility among system vendors
   - Share development costs and reduce risks

2. Structure/architecture of the solution
   - Separate cards for client and trunk
   - Regenerator uses 2 trunk cards

3. Target Data rates / standards supported
   - OTU4 trunk as per ITU-T G.709 standard
   - Multiplexing of 10x10G (10GE, OC192, FC-1200, OTU2)
   - Multiplexing of 2x40G (OC768, 40GE, OTU3) plus 2x10G (10GE, OC192, FC-1200, OTU2)
   - 100GE Native
Cisco 100GbE demo – June08

1. Cisco demonstrated world’s first operational 100GbE MAC and router interface

2. Demo included DWDM transmission over production network in Comcast’s network

3. 100GbE MAC was based on Cisco’s MLD architecture which is baseline for IEEE 802.3ba
   - implemented in FPGA
   - very robust architecture
Cisco 100GbE demo – June08

100GE DEMO Network

Cisco CRS8

Stratalight OTS4000

Grp2, Ch8 = 1537.00

Nortel CPL (~317 km)

2/7/17in
2/7/17in

2/7/18out
2/7/18out

Stratalight OTS4000

Cisco CRS4

OM3 MMF
100GE

OM3 MMF
100GE

Cisco CRS8

Stratalight OTS4000

Grp2, Ch8 = 1537.00

Nortel CPL (~317 km)

2/7/17in
2/7/17in

2/7/18out
2/7/18out

Stratalight OTS4000

Cisco CRS4

OM3 MMF
100GE

OM3 MMF
100GE

100G DEMO Network

40G
Philadelphia

40G
McLean

Comcast Production Network

40G PLIM
Slot5

40G PLIM
LCC1 Slot5

PHL IBONE CRS16

McLean IBONE CRS MC 2+1
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Putting the Pieces of the Zero-Touch DWDM Network Together
Tunable Optics

- Full C-band Tunable
- 50GHz Stable
- G.709/FEC/EFEC Enabled
- 10Gb, 40Gb, 100Gb

Tunable XFP

TxP/MxP/XP

Router ITU Optics

Tunable XFP
Putting the Pieces of the Zero-Touch DWDM Network Together
Directional and Omni-Directional DWDM

- In an Add/Drop Node normally every channel is tied to a direction
  - Adding a channel West requires to plug the DWDM interface into the West-facing ROADM
  - This is applicable to both Degree-2 and Multi-Degree Nodes

- Omni-Directional capability allows the selection of the direction for the wavelength independently
Putting the Pieces of the Zero-Touch DWDM Network Together
Colored and Colorless ROADM

1. Currently every channel is tied to a specific port on the filters
2. Only channel 1 can work on Port 1 / Only channel 2 can work on Port 2
3. Colorless allows use of different wavelengths for different sections of optical path to avoid congestion
Colorless Multi-Degree Mux and Demux WSS

1. Supports any wavelength from any degree to any degree
2. Drop port count limitations due to port sharing with inter-degree connections
3. Add/drop ports are colorless
   Add port filtering rejects rogue wavelengths and noise
4. Supports drop and continue
5. Add and express channel equalization provided by Mux WSS
   Demux WSS provides drop channel power control
Multi-Degree Colorless Mux and Demux WSS Node
Colorless Considerations

1. Maximum # of Colorless Ports in 2009 = 8
2. >8 Ports Requires Cascading of 9x1 WSS
3. Suppliers are working on High-Port Count Colorless ROADM (2010-2011)
4. Most Providers will combine Colorless and Colored ROADM
Putting the Pieces of the Zero-Touch DWDM Network Together
Dynamic Service Activation with GMPLS

- Auto provisioning on demand via GMPLS
- Supports IPoDWDM and Transponders
- Calculates Photonic Path (Linear and NLE, Amp NF, and CD)
- Auto patching via Colorless/Omni-Direcional ROADM
- Coordinates SRLG with Layer 3 and Layer 1
- No truck rolls for Service Creation or Maintenance
Optical Mesh Restoration

- How Fast?
- 1:N?
- DWDM-Aware
- Speed of Tunable Optics
- Is IP Layer Aware?
Strategically Placed OEO

10G/40G/100G
Transparent
Fully Tunable
Connected to Colorless/O-D ROADMcisco Expo © 2009 Cisco Systems, Inc. All rights reserved. Cisco Confidential
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First and Longest IPoDWDM Deployed Customer Application

CRS-1 w/ Integrated 40Gig DWDM Optics
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 Momentum
Increasing Customer Success

6 of top 20 SPs globally
Over 20 customers worldwide
40% of 40G ports shipped are IPoDWDM

Comcast Cable, USA
TeliaSonera, Sweden
Free (ISP), France
Netia, Poland
Sprint, USA
CESNET2, Czech

Largest IPoDWDM, 40G global deployment
Triple-play services core backbone
Interoperating with Nortel DWDM
100G piloted

World’s largest gaming festival with 40G
IPoDWDM on CRS-1
http://www.world-television.se/world_television.se/mnr_stat/mnr/TeliaSonera/294/

Converging all types of business apps (voice, video, data) on a flexible 40G IPoDWDM core
network interoperating with Ciena optical system

Using IPoDWDM to reduce points of failure for extreme
bandwidth demanding apps
CRS-1 and ONS 15454 MSTP

10GE IPoDWDM on
CRS-1 over legacy
Huawei DWDM for
Internet and IPTV

Compared capex & opex of various solutions with
IPoDWDM. Also ease of integration with existing
non-Cisco optical gear.

Using IPoDWDM to cost-effectively increase
throughput of existing fiber for IPTV/video
services

T-Com, Germany
Deutsche Telekom
IPoDWDM
Further Info

Video
Proactive Protection with IPoDWDM: http://www.cisco.com/go/IPoDWDM

Website
IPoDWDM- http://www.cisco.com/go/IPoDWDM

Press Releases
Dreamhack- http://blogs.cisco.com/sp/comments/the_gaming_explosion/
Breakout Session Evaluation Form

Your session feedback is valuable

Please take the time to complete the breakout evaluation form and hand it to the member of staff by the door on your way out

Thank you!