Cisco MPLS-TP Solutions

Moustafa Kattan
Consulting Systems Engineer, Emerging
Dec 5, 2011
Agenda

- MPLS-TP Fundamentals
- Carrier Packet Transport (CPT)
- Control Plane
- MPLS-TP Scenarios
Circuit to Packet Migration

- Massive change in SP traffic make-up in next 5 years*
- SP revenue shifting from circuits to packet services**
  5 yrs → ~80% revenue derived from packet services
  Packet traffic increasing at 34% CAGR***

*ACG Research 2011, **Cisco Research 2010, ***Cisco VNI 2011
• POS and SDH R&D / Innovation caps 1995 / 2004
• Ethernet has undergone continual innovation since standardization
• OTN transitions in 2004/5 from SDH hierarchy to Ethernet payloads

SPs are making transition from SDH / POS to Ethernet
Worldwide Ethernet Services Market

> 80% of Ethernet services will still be < 1GE by 2014

Wholesale and retail Ethernet services: E-Line, E-Tree and E-LAN

Source: Infonetics, Dec'2010
Why is Transport Moving Toward Packet?

• **Market drivers:**
  Fast deployment of new packet applications and services in recent years
  - *IP Video, Mobile data (smart phone apps)*
  - *Triple play, IP and Ethernet VPNs*
  - Creates new revenue opportunities for service providers

• **Infrastructure drivers:**
  Transport moving to packet becomes inevitable
  - Replacing aging legacy networks, end of life devices
  - Consolidating networks onto common infrastructure
  - Flexible data rates and statistical Multiplexing for efficiency
  - Goal: Support growing new services with lower cost
## MPLS Options

### Industry Direction

#### Core
- Edge & Aggregation

#### Edge & Aggregation

<table>
<thead>
<tr>
<th>Static</th>
<th>Hybrid (Static/Dynamic)</th>
<th>Dynamic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forwarding Plane</td>
<td>MPLS Label</td>
<td>MPLS Label</td>
</tr>
<tr>
<td></td>
<td>Dynamic NMS</td>
<td>Agg/Core – Dynamic IP</td>
</tr>
<tr>
<td>Protection</td>
<td>Manual or NMS Calc and provisioning</td>
<td>Dynamic—core Manual—Agg/Acc</td>
</tr>
<tr>
<td>OAM</td>
<td>MPLS-OAM</td>
<td>MPLS-OAM</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>TDM Transport</th>
<th>Packet Data Network</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Connection mode</strong></td>
<td>Connection oriented</td>
<td>Connectionless (except TE)</td>
</tr>
<tr>
<td><strong>OAM</strong></td>
<td>In-band OAM</td>
<td>Out-of-band (except PW, TE)</td>
</tr>
<tr>
<td><strong>Protection Switching</strong></td>
<td>Data Plane Switching</td>
<td>Control plane dependency</td>
</tr>
<tr>
<td><strong>BW efficiency</strong></td>
<td>Fixed Bandwidth</td>
<td>Statistical multiplexing</td>
</tr>
<tr>
<td><strong>Data Rate Granularity</strong></td>
<td>Rigid SONET hierarchy</td>
<td>Flexible data rate</td>
</tr>
<tr>
<td><strong>QoS</strong></td>
<td>One class only</td>
<td>QoS treatment</td>
</tr>
</tbody>
</table>
Poll Response

The properties of MPLS-TP make it most suitable for deployments in what part of the network?

Backbone/core
- 46%

Metro
- 56%

Access
- 51%

None of the above, MPLS-TP deployments will be minimal
- 3%
MPLS-TP is a Subset of MPLS
Bridging the Gaps of IP and Transport

- OAM Enhancements
- Static Provisioning
- Evolved control-plane
- MPLS Forwarding
- PW
- GMPLS

IP Centric
Multi-Services
MP2MP
MPLS-TP Concept

NMS for Network Management or Control Plane

- Working LSP
- MPLS-TP LSP (Static or Dynamic)
- Pseudowire
- Section
- Client Signal
- Protect LSP

Connection Oriented, pre-determined working path and protect path. Transport Tunnel 1:1 protection, switching triggered by in-band OAM, Option with NMS for static provisioning.
IETF and ITU-T agreed to work together and bring transport requirements into the IETF and extend IETF MPLS forwarding, OAM, survivability, network management, and control plane protocols to meet those requirements through the IETF Standards Process.[RFC5317]¹


Definition of MPLS “Transport Profile” (MPLS-TP) protocols, based on ITU-T requirements

Note: IETF decided to support single MPLS-TP OAM solution. IETF Chair stated at IETF 79 (11/2010) and IETF 80 (3/2011)

Derive packet transport requirements

Integration of IETF MPLS-TP definition into transport network recommendations

MPLS-TP OAM Standards Status

- Core protocols are under WG last calls to become RFCs
- IETF Chair Russ Housley stated at IETF 79 and IETF 80 meetings: IETF only supports single OAM solution for MPLS-TP

ITU-T determined in Feb. 2011 for G.8113.1 to enter Traditional Approval Process, contingent on IETF Code Point assignment; and continue work with IETF to standardize MPLS based MPLS-TP OAM.

• Standardizing by IETF and ITU-T
• Pending to approval in ITU-T
• Contingent on IETF Code Point assignment
• Not supported by IETF
## Support for MPLS-TP Standard Specifications – Nov 2011

<table>
<thead>
<tr>
<th>Document</th>
<th>Cisco</th>
<th>Ericsson</th>
<th>Hitachi</th>
<th>NEC</th>
<th>Meta switch</th>
<th>Alcatel-Lucent</th>
<th>Huawei</th>
</tr>
</thead>
<tbody>
<tr>
<td>Released product</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Bidirectional, co-routed Forwarding (RFC 5960)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>GAL/GACh (RFC 5966)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>E-LINE Services (RFC 4448)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>E-LAN Services (RFC 4664)</td>
<td>Yes*</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>ATM Services (RFC 4717)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>CC/NDI (draft-ietf-mpls-tp-cc-cc-cv-rd)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<tr>
<td>LSP Ping/Trace</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Fault CAM (draft-ietf-mpls-tp-fault)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>1:1 Linear Protection (draft-ietf-mpls-tp-linear-protection)</td>
<td>Yes*</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>MPLS-TP Integration with IP/MPLS (RFC 5639)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Static PW Status</td>
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<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</tbody>
</table>

* Pre-standard lockout

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## Transport Services Offerings Comparison

### P-OTS Migration from Metro SDH/SONET to MPLS-TP

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SONET SDH</th>
<th>MPLS-TP</th>
<th>IP/MPLS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ethernet</strong></td>
<td></td>
<td></td>
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<tr>
<td>Eline (10GE)</td>
<td></td>
<td></td>
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<tr>
<td>Eline (GE)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Eline (any gran. Sub GE/10GE)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-Tree</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>E-LAN</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Legacy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F/R</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>TDM</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td><strong>IP</strong></td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>L3VPN</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>L3 Unicast</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>L3 Multicast</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
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<tr>
<td>Traffic Engineering</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>50ms restoration</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Multiplexing Technology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNI processing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granularity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology Maturity</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- **SONET SDH**: Limited, VC-4, MPLS w/ OAM & 50ms Protection
- **MPLS-TP**: Typically rich, Variable
- **IP/MPLS**: Typically rich, Variable

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Agenda

- MPLS-TP Fundamentals
- Carrier Packet Transport (CPT)
- Control Plane
- MPLS-TP Scenarios
Design Considerations – when to use MPLS-TP?

- **When to consider MPLS-TP?**
  - Most common use case: replacing SONET/SDH with MPLS-TP
  - Typical applications:
    - Metro aggregation/access
    - Mobile back-haul

- **Which MPLS-TP Model?**
  - Depending on the operational model and long term planning
    - Dynamic with GMPLS control plane is preferred if ops model allows
    - Static provisioning model may provide easy adaption for the transport ops – most commonly adopted practice today

- **Can MPLS-TP be used to replace IP/MPLS?**
  - No. MPLS-TP is MPLS focused on transport-only features, it does not provide L2/L3 services functions as IP/MPLS does
Standards-based Unified MPLS Architecture

End to End Cisco PRIME Management

Access

MPLS-TP Aggregation
Pre-Aggregation

Metro

Packet Transport Aggregation

Core

IP/MPLS Core and Service Edge

Unified MPLS

Pre-Aggregation Packet Transport Aggregation

Unified MPLS

Light Reading Webinar June 17, 2011
Carrier Packet Transport (CPT) System

Feature Rich, Carrier Class and Manageability
- Advanced Standard Based MPLS-TP
- Innovative Distributed Satellite Architecture
- Fully CE and IP/MPLS support (Unified-MPLS)
- Common Packet + Optical Network Management
CPT Satellite Architecture Key Benefits:

- Managed as a Single Network Element (≥35% lower TCO)
- Automatic Satellite Discovery (like inserting a linecard)
- Flexible Topologies (Hub & Spoke or Rings (R9.6))
- Scalable Port Density / ≤880GE
- Supports flexible oversubscription models 4:1 / 3:1 / 2:1 / 1:1
- Single CTC & Prime Management Interface
### Simplifying Access and Aggregation
Unprecedented Capacity and Scale in a Small Footprint

<table>
<thead>
<tr>
<th></th>
<th>Today</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CPT 600</td>
</tr>
<tr>
<td>Rack Units</td>
<td>6</td>
</tr>
<tr>
<td># of Slots</td>
<td>8 Slot</td>
</tr>
<tr>
<td>Max. Linecards per Chassis</td>
<td>6 LC</td>
</tr>
<tr>
<td>Max. Linecard Bandwidth (Today)</td>
<td>80 Gbps</td>
</tr>
<tr>
<td>Max. Slot Bandwidth (Future)</td>
<td>240 Gbps</td>
</tr>
<tr>
<td>Chassis Bandwidth</td>
<td>1.4 Tbps</td>
</tr>
</tbody>
</table>

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CPT Service and Resiliency Key Benefits:

- Superior MPLS Service Flexibility
  MEF 9 & 14 Certified
- Strict Service SLA <50ms
  All MEF Service Type
- Integrated G.709 Interfaces
  Extended Interfaces Reach over DWDM and Protocol Resiliency
Cisco Transport Controller (CTC) Key Benefits:

- GUI based Node and Network Craft Provisioning Tool
- Node and Network Alarm Management and Correlation
- A to Z Circuit Provisioning (EVC, MPLS-TP, & IP/MPLS)
- Multi-Segment MPLS Provisioning (MS-PW between MPLS-TP & IP/MPLS)
- Full Node Maintenance: Software Upgrade/Downgrade & Database Backup/Restore
Poll Question

In what timeframe are you considering deployment of MPLS-TP?

- Within the next 12 Months
- Within 12-18 Months
- Later
- Never
- Undecided
### Poll Response

**When do you expect to see significant strategic deployment of MPLS-TP by numerous operators?**

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the end of 2011</td>
<td>2%</td>
</tr>
<tr>
<td>In 2012</td>
<td>30%</td>
</tr>
<tr>
<td>In 2013</td>
<td>32%</td>
</tr>
<tr>
<td>In 2014</td>
<td>19%</td>
</tr>
<tr>
<td>Unsure / do not expect to see significant deployments of MPLS-TP</td>
<td>16%</td>
</tr>
</tbody>
</table>
Agenda

- MPLS-TP Fundamentals
- Carrier Packet Transport (CPT)
- Control Plane
- MPLS-TP Scenarios
Control Plane - iOverlay

- iOverlay can provide the network knowledge of peering while providing greater scale
- Provide Multi Layer Support while Respecting Organizational Boundaries
- Leverage Expertise across layers
- Share and leverage information across layers
iOverlay: Solving the Multi-layer Control Plane Problem

- Phase 1: Deliver WSON capability in Optical Layer
- Phase 2: Enable interfaces between packet layer and optical layer using G-MPLS UNI
- Phase 3: Extend interfaces to add new capabilities
- Phase 4: In-line fully automated decision making
The Interaction

- Restoration – L3 Protect -> L0 Restores
  Today:
  Protection is provided via L0 Team
  1+1, Fiber protection, etc…
  Does not efficiently utilize available BW
  Increases Cost per Bit
  Protection is provided via L3 team
  Decrease Interface Utilization based on WC BW
  Does not efficiently Utilize BW
  Increase Cost per Bit

iOverlay:
L3 detects Circuit degradation and initiates Proactive Protection
L0 Restores capacity back to network and signals existing router port to change if needed
No SRLG data is propagated and recorded
WSON in the Standards Bodies
(Wavelength Switched Optical Networks)

- **WSON Optical Impairment Unaware**

- **WSON Optical Impairment Aware Work Group Document**
  http://www.ietf.org/id/draft-ietf-ccamp-wson-impairments-06.txt
Why Do We Need WSON?

- WSON is an Impairment aware DWDM control plane (ASON is not)

- **Client interface registration**
  - Alien wavelength (open network)
  - Transponder (closed network)
  - ITU-T interfaces

- **Wavelength on demand**
  - Bandwidth addition between existing S & D Nes (CLI)

- **Optical restoration-NOT protection**
  - Automatic Network failure reaction
  - Multiple SLA options (Bronze 0+1, Super Bronze 0+1+R, Platinum 1+1, Super Platinum 1+1+R)
WSON Restoration Example for AToDWDM

• Impairment Aware DWDM Control Plane
• Switch when you can & regenerate when you must (Lambda Switching)
• Minimize TDM XC/OEO
• Minimize Latency and cost
Agenda

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- Control Plane
- MPLS-TP Scenarios
Use Case 1: MPLS-TP For Metro Aggregation and Access

City X MPLS-TP Metro

City Y MPLS-TP Metro

City Z MPLS-TP Metro

MPLS-TP Agg. & Access

MPLS Core & Service Edge

Core router CRS

Muti-Service Edge ASR9K

Aggregation Node CPT 600

Access Node – CPT 5x

Upto 100G IPoDWDM

MPLS-TP over 10G WDM Ring

MPLS-TP Access Ring

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POTS Use Case
Tier 2 US

Business Driver

• Growth in Ethernet Services leads to Packet Transport migration

Cisco Solution and Value Solution:

• CPT Provides compact, scalable and pay as you grow architecture
• Strict transport SLAs for L1/L2 services with MPLS-TP
• Unified MPLS w/ CPT & PW Head-End on ASR9K Simplifies Network Design and Enables L3 Services in ETN

Cisco differentiation

Unified MPLS approach with common management and standards based MPLS-TP Solution
## North America Mobile Backhaul

### Tier 2

Business Driver

- Growth in Ethernet Services leads to Packet Transport migration.

Cisco Solution and Value Proposition:

- CPT Provides compact, scalable and pay as you grow architecture.
- Strict transport SLAs for L1/L2 services with MPLS-TP.
- Unified MPLS w/ CPT & PW Head-End on ASR9K Simplifies Network Design and Enables L3 Services in ETN.
### MPLS-TP Roadmap

<table>
<thead>
<tr>
<th>Phase 2 Q4CY12</th>
<th>Phase 1 Q2CY12</th>
<th>FCS</th>
<th>FCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ATM/TDM AC</td>
<td>• Bandwidth Management (Make before Break)</td>
<td>• Bi-Directional Static LSP</td>
<td>• Alarm Reporting for LSP and PW</td>
</tr>
<tr>
<td>• LSP Delay &amp; Loss Management</td>
<td>• Dynamic (H)VPLS over MPLS-TP</td>
<td>• G-ACh/GPL</td>
<td>• Ethernet AC</td>
</tr>
<tr>
<td>• PW Delay and Loss Management</td>
<td>• VPWS Link Integrity</td>
<td>• Bandwidth Management (RSVP)</td>
<td>• IP-Less LSP Ping/Trace Route</td>
</tr>
<tr>
<td>• Static (H)VPLS over MPLS-TP</td>
<td>• MPLS-TP Node Addition</td>
<td></td>
<td>• IP Addressing for LSP End Points</td>
</tr>
<tr>
<td>• IP-Less PTP over MPLS-TP</td>
<td>• MPLS-TP MIB</td>
<td></td>
<td>• LSP BFD Offload</td>
</tr>
<tr>
<td></td>
<td>• SyncE over MPLS-TP</td>
<td></td>
<td>• Alarm Suppression/Correlation</td>
</tr>
<tr>
<td></td>
<td>• MPLS-TP LSP (H)QoS</td>
<td></td>
<td>• IP Addressing LSP Ping/Trace</td>
</tr>
<tr>
<td></td>
<td>• ISSU</td>
<td></td>
<td>• Static SS-PW</td>
</tr>
</tbody>
</table>

- **FCS**
  - Bi-Directional Static LSP
  - G-ACh/GAL
  - Bandwidth Management (RSVP)
  - IP-Less for LSP End Point
  - IP-Less for Physical Interfaces
  - BFD over G-ACh
  - 1:1 Protection
  - Alarming (AIS/RDI/LDI)
  - VCCV over Static PW
  - BFD over Static PW

- **Phase 2 Q4CY12**
  - OTN Pre FEC (SD, SF) Proactive 1:1 Protection
  - BFD LSP Delay and Loss Management Proactive 1:1 Protection
  - MPLS-TP Static PW HeadEnd (VFI)
  - Ethernet CRC Proactive 1:1 Protection
  - MPLS-TP LSP Bridge and Roll
Summary

- Transport is evolving toward packet
  - New services driving BW growth
  - Network convergence, technologies refreshes
  - lower OPEX by moving from SONET/SDH/ATM/TDM to MPLS-TP

- Standard status
  - Core set of MPLS-TP definitions are close to finish in IETF
  - IETF supports single, consistent OAM for MPLS and MPLS-TP
  - ITU-T G.7000 was not consented to become standards, it is pending to long approval process in ITU-T and code point allocation by IETF
  - Using Experimental code point in production network has the risk of code point collision

- Development
  - Cisco participated Inter-op events in 10/2011 and 2/2011.
  - CPT product family is available today with standards based MPLS-TP OAM

- MPLS-TP Use Case
  - End-to-end MPLS: IP/MPLS in the core, MPLS-TP for access
  - Applications of MPLS Based MPLS OAM
References

• Light Reading MPLS-TP Webinar, June 17, 2011 – *MPLS in Next-Generation Transport Networks*, by Heavy Reading, Cisco, CEI, Ericsson, IXIA

• Webinar, April 2011, *MPSL-TP Reality Check*, by VZ, Cisco and IXIA

• Cisco white pager

• Cisco Optical Networking Product Information:

• Cisco Carrier Packet Transport (CPT) System

• IETF RFC references:
  - MPLS-TP Requirements: http://datatracker.ietf.org/doc/rfc5654/
  - MPLS-TP OAM Requirements: http://datatracker.ietf.org/doc/rfc5860/
Please fill evaluation sheet and this nice Cisco-Linksys E4200 Dual-Band Wireless-N Router could be yours...