Cisco Packet Transport Network – MPLS-TP
The Challenge

Packet is Growing…
Grow SONET/SDH? 
Transport Reliability

OpEx
Revenue
Expenses

ARPU

Financials

Need Services
IPTV
EPL
VoD
EPL
Business Ethernet
Mobile Backhaul
HSI
E-LAN

Which Technology?
IP/MPLS
SONET/SDH
OTN
MPLS-TP
ASON
T-MPLS
PBB
WDM
PBB-TE

Transport Reliability
Services
Packet is Growing…
Need
Which Technology?
Packet Optical Transport System (P-OTS)

Metro P-OTS Keys
- Predictable, Deterministic
- Resiliency – 50-msec
- Bandwidth Efficiency
- Legacy Support (TDM)
- Integrated ROADM
- Service Scalability
- Granular Service Differentiation
- Network Management
- Higher BW (Tbps), Lower Cost/bit
Why MPLS-TP?
Bringing proven technology to Transport

MPLS-TP leverages flexibility of scale of MPLS and adapts it to transport space:
• Transport operational model
• Addresses growth in packet traffic and services
• Service flexibility - P2P private lines, Video transport, Multipoint, best effort traffic as well as legacy services
• SONET/SDH like SLA and OAM with granular BW provisioning
• High network utilization of transport network
• Capex/Opex Savings as Bandwidth increases
• Efficient Access & Aggregation saves $$$$ in Core
# MPLS Transport Profile (TP)

- Converge Data/Transport

<table>
<thead>
<tr>
<th>Attribute</th>
<th>TDM Transport</th>
<th>Packet Data Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection Mode</td>
<td>Connection Oriented</td>
<td>Connectionless (Except TE)</td>
</tr>
<tr>
<td>OAM</td>
<td>In-Band OAM</td>
<td>Out-of-Band (Except PW, TE)</td>
</tr>
<tr>
<td>Protection Switching</td>
<td>Data Plane Switching</td>
<td>Control Plane Dependency</td>
</tr>
<tr>
<td>BW Efficiency</td>
<td>Fixed Bandwidth</td>
<td>Statistical Multiplexing</td>
</tr>
<tr>
<td>Data Rate Granularity</td>
<td>Rigid SONET Hierarchy</td>
<td>Flexible Data Rate</td>
</tr>
<tr>
<td>QoS</td>
<td>One Class Only</td>
<td>QoS Treatment</td>
</tr>
</tbody>
</table>

Packet Transport
## MPLS Transport Profile (TP)

### Components

<table>
<thead>
<tr>
<th>Data Plane</th>
<th>Control Plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>– MPLS Forwarding</td>
<td>– NMS provisioning option</td>
</tr>
<tr>
<td>– Bidirectional P2P and</td>
<td>– GMPLS control plane option</td>
</tr>
<tr>
<td>– Unidirectional P2MP LSPs</td>
<td></td>
</tr>
<tr>
<td>– No LSP merging</td>
<td></td>
</tr>
<tr>
<td>– No Penultimate hop popping (PHP)</td>
<td></td>
</tr>
<tr>
<td>– PW (SS-PW, MS-PW)</td>
<td></td>
</tr>
<tr>
<td>– No Routing Required</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OAM</th>
<th>Resiliency</th>
</tr>
</thead>
<tbody>
<tr>
<td>– In-band OAM channel (GACH)</td>
<td>– Sub-50ms protection switch over without IGP</td>
</tr>
<tr>
<td>– Connectivity Check (CC): proactive (ext. BFD)</td>
<td>– 1:1, 1+1, 1:N path protection</td>
</tr>
<tr>
<td>– Connectivity verification (CV): reactive (ext. LSP Ping)</td>
<td>– Linear protection</td>
</tr>
<tr>
<td>– Alarm Suppression and Fault Indication with AIS (new</td>
<td>– Ring protection</td>
</tr>
<tr>
<td>tool), RDI (ext. BFD), and Client Fault Indication (CFI)</td>
<td></td>
</tr>
<tr>
<td>– Performance monitoring, proactive and reactive (new</td>
<td></td>
</tr>
<tr>
<td>tools)</td>
<td></td>
</tr>
</tbody>
</table>
MPLS Transport Profile (TP)

Characteristics

- **Connection-oriented** packet switching model
- **No** modifications to **MPLS** data plane
- **No** IPv4/v6 needed for **packet forwarding**
- Interoperates/interworks with **existing MPLS** and pseudowire control and data planes
- **No** LSP merging
- LSPs may be point to point (unidirectional, co-routed **bidirectional** or associated bidirectional)
- LSPs may be point to multipoint (unidirectional)
- **Networks** can be created and maintained using **static provisioning** or a **dynamic** control plane: LDP for PWs and RSVP-TE (GMPLS) for LSPs
- **In-band OAM** (fate sharing)
- **Protection** options: 1:1, 1+1,1:N, Ring-Protection (Achieve GR-253 detection and switching times)
- Network operation equivalent to existing transport networks
MPLS Transport Profile (TP)

- Encapsulation

SONET/SDH

- VT1.5 SPE
- STS-1/Nc SPE
- VC-11/12

VT1.5 Muxed Into STS-1

VT1.5 approximately Equivalent to Pseudowire

MPLS-TP

- SAToP
- CEoP
- PWE3
- MPLS Label Switched Path (LSP)

SAToP Circuit Emulation
1588v2
Generic Associated Channel (G-Ach)
for Inband MPLS-TP OAM

Pseudowire Muxing Function

- Ethernet Service
- 802.1Q
- .1ad
- VC-3/4

PWE3 Encap

MPLS Label Switched Path (LSP)

Network Identifier
STS/VC number

MPLS Transport Profile (TP) over DWDM

SONET/SDH over DWDM

802.1Q
802.1.ad

Ethernet Mapping

- GFP-F/HDLC

MPLS Label

Network Identifier
STS/VC number

802.1Q
802.1.ad

Ethernet Service

G-Ach

G-Ach
MPLS Transport Profile (TP)

- SONET/SDH Analogy

SONET/SDH
- Ethernet Service
  - Ethernet Mapping
  - GFP-F/HDL
  - STS-1/Nc SPE
  - VC-3/4 SPE
  - SONET/SDH over DWDM

MPLS-TP
- Ethernet Service
  - MPLS Label Switched Path (LSP)
  - MPLS-TP over DWDM
  - Service Granularity (PW) @ 1 Mbps

- SONET/SDH Analogy
- MPLS
- MPLS-TP over DWDM
- MPLS Label Switched Path (LSP)
- MPLS TP over DWDM
- Service Granularity (PW) @ 1 Mbps

OC-192
STM-64

192 STS-1/VC-3 @ 51 Mbps
Fixed SPE
Capped at 10 Gig

192 LSP’s @ 51 Mbps CIR
Bandwidth Efficient
Service Scalability & Flexibility
Statistical Multiplexing
MPLS-TP Resiliency

1:1 LSP Protection

- Working LSP provisioned as Active Path between two TPE’s
- Protect LSP provisioned as Standby Path between two TPE’s
- Active/Standby home in on same node but different interfaces – Network redundancy
- MIP’s are agnostic to Active/Standby Designations
- LSP Fault Detection via BFD, LDI, & Manual APS Switching
- In 1:1 Protection the Standby Path is idle until APS
**MPLS-TP Resiliency**

**Link Down Indication (LDI) Fault Detection & AIS**

- LSP LDI Generated from MIP
- LSP MEP/TPE receives LDI and triggers protection switching
- MPLS-TP LDI Packet will have GAL Label, GE-ACH Header
- LDI is equivalent to SONET/SDH AIS

- LSP AIS Generated from MEP or MIP
- AIS is a transient, If persistent BFD will detect failure, IF LDI is disabled or between MPLS-TP domains
- MPLS-TP AIS Packet will have GAL Label, GE-ACH Header
- AIS is transient with no consequent APS actions. This is different from SONET/SDH AIS. MPLS-TP LDI is equivalent to SONET/SDH AIS
**MPLS-TP OAM**

**OAM Architecture**

- Based on Maintenance Entities
  - Maintenance End Points (MEPs) and Maintenance Intermediate Points (MIPs)
  - Multiple levels
- Maintenance Entities
  - Association of two MEPs
  - Zero or more intermediate MIPs
  - MEPs source and sink OAM flow
  - MIPs can only sink or respond to an OAM flow
MPLS-TP OAM

- MPLS-TP LSP/PW G-ACh Packet Structure

<table>
<thead>
<tr>
<th>13</th>
<th>TC</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0 0 Version Reserved</td>
<td>Channel Type</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td>TLV Type</td>
<td>Length</td>
<td></td>
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<tr>
<td>Value</td>
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<td>LSP Label</td>
<td>TC</td>
<td>S</td>
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<tr>
<td>PW Label</td>
<td>TC</td>
<td>1</td>
</tr>
<tr>
<td>0 0 0 1 Version</td>
<td>Reserved</td>
<td></td>
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G-ACH Message

MPLS-TP section defined as link connecting two adjacent T-PE
GAL as label stack
Same ACH structure

Existing VCCV ACH (RFC)
Use of GAL not required, but allowed
ACH TLV header defines length of ACH TLV list
ACH TLVs provide additional context for processing of G-ACH message
G-ACH message may not require ACH TLVs
MPLS-TP OAM

Associated Channel (A-CH) Processing

- Pseudo-Wire (PW) OAM in MPLS-TP is exactly the same as PW OAM in IP/MPLS
- PW OAM is only processed between MEP’s
- PW OAM is defined by the 1st nibble 0001 in the PW control word

- LSP OAM in-band designated by label 13
- LSP OAM can be processed between MEP’s and MIP’s
MPLS-TP OAM

LSP Continuity Check (CC) Bidirectional Forwarding Detection (BFD)

LSP OAM - GAL Label = 13
G-ACH Control Word = 0x01
CC Type = 0x1
Channel Type = 0x7 – BFD

MAC Header | L1 | GAL/BoS | Generic ACH | Channel Payload

0001 | Ver | Resv | CC, BFD
MPLS-TP OAM

BFD Remote Down Indication (RDI)

- Failure indication sent by local end point to remote end point
- Sent on direction opposite to failure
- Uses existing BFD diagnostics field
  - 0 - No Diagnostic
  - 1 - Control Detection Time Expired
  - 3 - Neighbor Signaled Session Down
  - 4 - Forwarding Plane Reset
  - 5 - Path Down
  - 7 - Administratively Down
- Diagnostics field indicates reason for last change in session state on an end point
MPLS-TP OAM

LSP Continuity Verification (CV) LSP-Ping

LSP OAM - GAL Label = 13
G-ACH Control Word = 0x01
CC Type = 0x1
Channel Type = 0x1 – MPLS LSP Ping

MAC Header | L1 | GAL/BoS | Generic ACH | Channel Payload
0001 | Ver | Resv | C, LSP-Ping Type
MPLS-TP OAM

LSP Continuity Verification (CV) – Fault Isolation

LSP OAM - GAL Label = 13
G-ACH Control Word = 0x01
CC Type = 0x1
Channel Type = 0x4 – MPLS LSP Echo Request
MPLS-TP OAM

Pseudowire Maintenance Entity (PME) – VCCV RFC 5085

CPT Supports In-Band VCCV

Ethernet PW-ACH (IPv4) = 0x21
Ethernet PW-ACH (IPv6) = 0x57

PWE3 Control Word (1st nibbles) = 0x1
Channel Type = 0x21 or 0x57
MPLS LSP Ping Payload

On-Demand Continuity Check Between MEPS and MIPs
NMS Retrieval of PW Path to Populate the Global ID of MIPs/MEPs
MPLS-TP OAM

Static Pseudowire Status Notification

- Static PWs require in-band status notification (no LDP notification)
- Existing PW Status TLV sent over G-ACh
- Three messages sent at 1 per sec to set/clear fault then continuous messages sent at a longer interval
- Native service OAM or port shutdown can propagate failure to remote CE
For LM, each “counterstamp” records the count of packets or octets sent or received over the channel prior to the time this message is sent or received.

For LM, loss is measured as a delta between successive messages. For example, a loss measurement in the forward direction is computed as:

\[(Q_{TxCount}[n] - Q_{TxCount}[n-1]) - (R_{RxCount}[n] - R_{RxCount}[n-1])\]

Thus LM requires a small amount of state at the querier: it retains the counter values in the most recently received response.
1. The querier begins a measurement session by initiating a stream of query messages at a specific rate
2. Time T1: Query message exits the Querier TX port and is stamped with a time or counter value
3. Time T2: Query message enters the Responder RX port and is time- or counter-stamped
4. Responder inspects and processes the query and generates a response message, which is a copy of the Query with the Response flag set
5. Time T3: Response message exits the Responder TX port and is time- or counter-stamped
6. Time T4: Response message enters the Querier RX port and is time- or counter-stamped
7. Querier now has all four data values and can compute a measurement
Notes:
All E-OAM Sessions Will Transparently Traverse the MPLS-TP Network Domain
The E-OAM Session Will Start at the Attachment Circuit When the Services Starts on the MPLS-TP TPE
MPLS Interworking

Pseudo-Wires Form a Natural Bridge

- The MPLS PW works over both MPLS-TP and IP/MPLS-(TE).
- The PW OAM Header is replaced with the LDP Header when going from static to dynamic.
- This enables End to End Service Visibility and Management.
- MPLS-TP PW is a standard MPLS PW.

New IGP Label
Change VC ID symmetric
TTL Decremented by 1
EXP Bits copied
L2 Encapsulation

S-PE
Cisco Carrier Packet Transport
Cisco CPT 600, 200, & 50 System

Feature Rich, Carrier Class and Manageability
- Advanced Standard Based MPLS-TP
- Innovative Distributed Satellite Architecture
- Fully Carrier Ethernet and IP/MPLS supported
- Runs CTC, over 10 years of Network Management Experience

Based on over 10 years of Cisco Optical Transport Experience

Green Packet Transport
- Space & Power Optimized
- Standard Base MPLS-TP
- Rich Service Features (Video Optimization)
- DWDM = 10/40/100 Gig
- TDM – T1/T3, E1/E3, Oc1n/STMn

Carrier Class
- Fully Redundant Power Architecture
- Fully Redundant Software Architecture
- Fully Redundant Fan Architecture

Resiliency
- > 50ms Link Protection
- > 50ms Node Protection
- > 50ms Network Protection

End-to-End Manageability
- A to Z Point and Click Provisioning & Maintenance
- Industry standard CLI
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
Cisco POTS Architecture

Applications – TDM Lease Line, Ethernet Lease Line, Mobile Back-Haul, Residential, Smart Grid Utility, Data Center Interconnect & Cloud Based

Architectural Elements- Unified MPLS, E2E Management, Integrated Packet Transport, TDM, & DWDM

Cisco A-Z Management

Access
- ASR901
- ASR903
- ELINE, ELAN, TDM
- Transport Pre-Aggregation
  - CPT 50 w/Edge DWDM
- CPE
  - ASR901
  - ASR903

Aggregation
- CPT 200/600
- MPLS(TP) over 10/40/100 Gig DWDM
- Aggregation Node
- Unified MPLS
- Transport Aggregation
  - CPT 200 w/MSTP
  - CPT 600 w/MSTP

Core
- ASR 9K
- CRS 3 w/MSTP
- PE Edge
  - ASR9k w/MSTP
- Cloud
  - EOS
  - Umi
  - Webex

Cloud Service

Unified MPLS

Transport Aggregation
- CPT 200 w/MSTP
- CPT 600 w/MSTP
Enabling Next-Generation Transport

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Trust
Savings
Agility

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