NGN and MPLS

Monique Morrow
mmorrow@cisco.com
Distinguished Consulting Engineer
November 22 2005
AGENDA

• Why NGN: The Problem
• MPLS Technology Set as an NGN Service Enabler
• NGN Service Architecture with GMPLS
• NGN and Future Direction with GriD
• Conclusions
Why NGN: The Problem
Converging the Networks

- Business
- L1/L2
- IP/MPLS
- Consumer
- Voice
Converge services onto one network

- Virtualization
- Service flexibility
- Scalability
- Continuous operation
- Management
- Investment protection
- Security

One Network, Many Services
Convergence to Single Network?

Public IP

Private IP

IPTV

Optical

Core

Peering

Distribution

Services Edge

Access / Aggregation

Transponder

Peer

Transponder

Peer

Transponder

Peer

Transponder

Peer
Traditional Multi-Layer PoP Design: Operational Complexity, Limited Flexibility & Scale

- Multiple systems to provision, manage, & upgrade
- Inefficient use of capital: Empty slots, unused capacity
- Many intra-PoP links to implement & maintain
- Multiple software streams to qualify
- Difficult to scale, add new services
- Industry moving towards Core/Edge convergence
MPLS Technology Set as an NGN Service Enabler
MPLS-Related Standards and Alignment with NGN

- RFC2547bis (BGP/MPLS VPN)
- Pseudowires and Pseudowire Multi-hop constructs
- MPLS Interworking (ATM, FR, Ethernet...)
- Interprovider QoS
- MPLS NM/OAM/MIBs
- Multicast VPN
- MPLS Security
- DiffServ enabled MPLS Traffic Engineering
- Fast Network Protection with MPLS TE fast Reroute
- MPLS Performance/Reliability/QoS
- GMPLS Protection/Restoration
MPLS Services and Transport Network Management for NGN

Layer 2/3 Management Essentials:
IP/MPLS Routing, QoS, TE, OAM, HA
# Multicast in NGN Architecture

<table>
<thead>
<tr>
<th>Three Key Service Trends</th>
<th>Multicast Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadband Consumer Service Enablement</td>
<td>YES</td>
</tr>
<tr>
<td>Triple-play, gaming, content delivery</td>
<td>Video component in Triple Play service is 90% Multicast Video</td>
</tr>
<tr>
<td>Peer-to-Peer Applications</td>
<td></td>
</tr>
<tr>
<td>Mass delivery of customized services</td>
<td>Multicast Games: Half-Life, Counter-Strike</td>
</tr>
<tr>
<td>Flexible Service bundling</td>
<td>Peer-to-Peer: Multicast Kazaa, BitTorrent</td>
</tr>
<tr>
<td>Evolution of current SP offerings to Enterprises</td>
<td>YES</td>
</tr>
<tr>
<td>L1 bandwidth, L2VPN, L3VPN with value-added services</td>
<td>Multicast VPN as a L3VPN Service for IPv4 and IPv6</td>
</tr>
<tr>
<td>Improving OPEX associated with delivery of ATM, FR ..</td>
<td>Multicast over ATOM, VPLS, PWS</td>
</tr>
<tr>
<td>Customized Service delivery and bundling</td>
<td></td>
</tr>
<tr>
<td>Converged Wireless and Wire line Services</td>
<td>YES</td>
</tr>
<tr>
<td>Enhanced mobility between fixed and wireless services</td>
<td>Multicast and Mobile IP Integration: Department of Defense, Emergency Services, Hospitals</td>
</tr>
<tr>
<td>IMS, 2G transition to 3G &amp; Integration of Fixed &amp; Mobile</td>
<td>Multicast support for 3G chipset in CDMA</td>
</tr>
</tbody>
</table>
Bringing MPLS-TE to Multicast

- P2MP RSVP-TE replaces PIM for constructing and maintaining “MPLS Multicast” states in the core.
- Fast ReRoute can be combined with P2MP LSP to minimize packet loss during link failure.
Pseudo-Wire Emulation Edge to Edge and NGN

L2 transport over IP = L2TPext / L2TP-eth
L2 transport over MPLS = pwe3-ethernet / pwe3-mpls-cp
NGN Service Architecture with GMPLS
IP+Optical NGN Evolution

Drivers:
- Service Virtualization using LR/VR
- BW Guarantee, BW protection
- Multi-layer TE for IP+Optical
- P2MP TE
- MPLS/GMPLS Interworking
- IPv4, IPv6 unicast and multicast Services
Next Generation IP+Optical Networks: A Vision

- LR/VR: Service Virtualization
- Border Model: Logical separation of IP & Optical admin. Boundaries
- 6PE/6VPE for IPv6 over GMPLS

Key Features:

- PCE for:
  - Area Path Computation
  - MPLS/GMPLS Interworking
  - Multi Layer TE
  - P2MP path calculation

- LSM for: v4/v6 Multicast over (G)MPLS

PCE / Border Router

Service Network 1
(e.g., L2VPN)

Service Network 2
(e.g., L3VPN)

Service Network 3
(e.g., L3VPN)

Service Network 4
(e.g., L2VPN)
NGN and Future Direction with GriD
The GRID Network

- Where is the GRID?
- How do we build it? Own, lease, share,
  - Multiple Fiber bundles, Lambdas......big BW !!
- Fast provisioning
- High flexibility
- Scalable
- BW on demand
- Large investment - what is the business case?
• NBI: An EMS or a device (routers, switches) may provide north-bound management interfaces to be used by NMS/OSS or other applications

C&P: Configuration & Provisioning
P&F: Performance & Fault Management
NM NBI: Network Management North-Bound Interfaces
GM-GA: Grid Middleware (OGSA/WSRF based) Serving Grid Applications
Abstracted Interfaces, Resources: OGSA/WSRF based; Needed to hide network details from GM-GA

• While the NBI exposes much more information, the information exposed via the abstract interfaces (A-I) are abstracted and restricted
• Example, NBI may provide detail interfaces for MPLS VPN configuration, such as VRF, MP-BGP, hub-and-spoke configurations, but A-I will provide only interfaces like “join/leave vpn”
• NBI may provide routing related interfaces, such as for configuring OSPF, but A-I will not

Grid based EMS/NMS/OSS and Abstract Interfaces
Abstraction Example: Path and QoS Abstraction

- **Path** (in Operator/SP/Carrier domains): Concatenation of any combination of following:
  - Segments on Edge links
  - Tunnel/Circuit/LSP in the core

- **QoS**: Example, Platinum QoS, which can be any of (depending on support)
  - DiffServ EF
  - Relevant IntServ QoS
  - Priority queue + DS-TE tunnel + FRR protection
• Grid Middleware components serving typical Grid Applications should not be dependent on underlying wide varieties of networking technologies

• Either abstract or hide details

• For example, Abstract or hide details of
  • Path: ATM PVC, MPLS LSP, GMPLS LSP, Sonet/SDH Circuit or a Lightpath
  • VPN: L2VPN, L3VPN
  • QoS: DiffServ, IntServ, MPLS, etc.
Conceptual View of Grid Infrastructures

http://forge.gridforum.org/projects/ogsa-wg
Some Grid Applications

• **HEP**
  Today 1 PetaByte per sec
  Tens of PetaByte 2008
  1 ExaByte 2015

• **Distributed Visualization**
  [GeoWall2 (NSF) - GeoScience Advanced Visualization](http://www.evl.uic.edu/cavern/optiputer/)
  [Continuum - Enhanced Distributed Collaboration](http://www.evl.uic.edu/cavern/continuum/indexmain.html)

• **3D visualization tools are used**

• **Key tools needed to process & analyze approximately 64 Tbyte of data by 2008**

• **Remote screening - Mammography**
  Digitized image results 75MB
  Radiologist performs 100 patient readings per day
  (1 image every 30sec)
  16 images per patient results in 16 * 75MByte = 1.2GByte
  100 patients screened remotely means 1.2 Gbyte data every 30 sec
Future Needs

• Change form processor centric to BW dominated computing
  Around 2010 Grid applications will require an International Distributed Cyber Infrastructure based on
  Petascale computing, exabyte storage, and terabit networks

• Terabit challenge
  http://www.cmf.nrl.navy.mil/CCS/
  Terabit global Large Data SOA
  Integrate federated, distributed computational grids, realtime sensors, and digital historical information
  Scalable to support exponentially increasing data
  Privacy, authenticity and security demands: InfoAssured
  Affordable ... highly available ... E2E QoS/QoP flows
  Legacy and rapidly evolving technology integration
  Perf, NetOps, Information Assurance tools/sensors
GMPLS control plane supports multiple switching and forwarding planes

Introduces new functions to accommodate circuit-oriented optical network regimes

GMPLS = MPLS + MP\(\lambda\)S + N

- where N is MPLS control of new switching planes
- draft-ietf-ccamp-gmpls-architecture-07.txt
ITU-T G.ASON / Overlay
http://www.itu.int/ITU-T/

**Client Data**
- e.g. IP, ATM, TDM

**Connection Controller Interface (CCI)**
- Instructs switches to make connections across ports
- Some topology information may be carried

**Internal Network-Node Interface (I-NNI)**
- Carries signaling messages between OCCs within a single domain
- Either single operator or subnetwork

**User Network Interface (UNI)**
- Carries signaling between the User and the OCC (Control Plane)

**External Network-Node Interface (E-NNI)**
- Carries signaling information between separate domains

**Network Management Interfaces (NMI-A & NMI-T)**
- NMI-A between Management System and Control Plane
- NMI-T between Management System and Transport Plane

**OCC – Optical Connection Controller**

**Network Management Interfaces**
- **NMI-A**
  - Between Management System and Control Plane
  - **NMI-T**
  - Between Management System and Transport Plane

**Connection Controller Interface (CCI)**
- Instructs switches to make connections across ports
- Some topology information may be carried

**Internal Network-Node Interface (I-NNI)**
- Carries signaling messages between OCCs within a single domain
- Either single operator or subnetwork

**User Network Interface (UNI)**
- Carries signaling between the User and the OCC (Control Plane)

**External Network-Node Interface (E-NNI)**
- Carries signaling information between separate domains

**Network Management Interfaces (NMI-A & NMI-T)**
- NMI-A between Management System and Control Plane
- NMI-T between Management System and Transport Plane

**Signaling**

**Transport Plane**

**OCC – Optical Connection Controller**

**Client Data**
- e.g. IP, ATM, TDM

**Network Management Interfaces**
- **NMI-A**
  - Between Management System and Control Plane
- **NMI-T**
  - Between Management System and Transport Plane

**Connection Controller Interface (CCI)**
- Instructs switches to make connections across ports
- Some topology information may be carried

**Internal Network-Node Interface (I-NNI)**
- Carries signaling messages between OCCs within a single domain
- Either single operator or subnetwork

**User Network Interface (UNI)**
- Carries signaling between the User and the OCC (Control Plane)

**External Network-Node Interface (E-NNI)**
- Carries signaling information between separate domains

**Network Management Interfaces (NMI-A & NMI-T)**
- NMI-A between Management System and Control Plane
- NMI-T between Management System and Transport Plane

**Signaling**
<table>
<thead>
<tr>
<th>GUNI Functionality</th>
<th>Details</th>
</tr>
</thead>
</table>
| Direct service invocation                      | User/client requests a specific Grid service  
Client directly attached to the transport network and is member of the service signaling process.  
Client implements the signaling and the neighbor discovery functions                                                                                                                                                                                                 |
| Indirect service invocation                     | User/client requests a specific Grid service through an agent  
Client invokes transport network services using proxy signaling  
Integration of UNI based services without UNI based functionality in each client                                                                                                                                                                                                 |
| Optical transport format for control messages   | Circuit/wavelength/frame switching with out of band signaling  
Flow/burst/packet switching with signaling packets or control bursts  
Hybrid switching                                                                                                                                                                                                                                                                 |
| Flexible bandwidth allocation                   | Allows for wavelengths, sub-wavelengths, wavelengths bundle allocation  
Includes multi homing, dual homing, OVPN, Ethernet and G.709                                                                                                                                                                                                                                  |
| Claim of existing agreements                    | Allows for wavelengths, sub-wavelengths, wavelengths bundle allocation  
Includes multi homing, dual homing, OVPN, Ethernet and G.709                                                                                                                                                                                                                                  |
| Automatic, timely light-path setup             | Automatic neighbor discovery  
Automatic service discovery  
Might be related to agreement covering future time interval                                                                                                                                                                                                                     |
| Fault detection, protection, restoration       | Necessary to support variety of Grid service requirements and sensitivity levels  
Support of different protection and restoration signaling schemes                                                                                                                                                                                                                      |
| Propagation of service agreements and related events | Asynchronous event support for adaptive application services  
Ability to notify requester about events causing service provisioning problems                                                                                                                                                                                                                      |
| Traffic classification, grooming, shaping, transmission entity | Mapping of data traffic to transmission entities like bursts at physical (data) layer  
Mapping of control messages for in-band signaling                                                                                                                                                                                                                                           |
| Control and data plane security                | Control plane security credentials and policy information  
Data plane transport security                                                                                                                                                                                                                                                                                         |
## Network Scaling

<table>
<thead>
<tr>
<th></th>
<th>2005 Today</th>
<th>0 - 2 Years</th>
<th>3 - 5 Years</th>
<th>5 - 15 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optical Streams</strong></td>
<td>1- 10 Gbps</td>
<td>10- 40 Gbps</td>
<td>120- 640 Gbps</td>
<td>1- 10 Tbps</td>
</tr>
<tr>
<td><strong>Optical Ctrl Plane</strong></td>
<td>STATIC Provisioned</td>
<td>DYNAMIC GMPLS</td>
<td>DYNAMIC Burst/JIT GMPLS</td>
<td>DYNAMIC Burst/Flow GMPLS</td>
</tr>
<tr>
<td><strong>Control Plane</strong></td>
<td>STATIC Tunnel</td>
<td>DYNAMIC SIP</td>
<td>SIP QoS / QoP</td>
<td></td>
</tr>
<tr>
<td><strong>LAN / WAN Technology</strong></td>
<td>IPv4 10GE OC12 4xSDR IB</td>
<td>IPv6 10GE 4x/12x SDR/DDR IB</td>
<td>IPv6 100GE 12xQDR IB 64 128 IB</td>
<td>All Optical System Interconnect</td>
</tr>
<tr>
<td><strong>Security Devices</strong></td>
<td>1.0G IPv4 FW, K5, 3DES, CBs, KGs, NTAM</td>
<td>10G KGs HAIPEs, CAC, FEON, PKI, NTAM</td>
<td>40G HAIPE Scalable GFP Encrypter</td>
<td>640G HAIPE GFP Encrypter</td>
</tr>
</tbody>
</table>
Conclusions
Conclusions

- MPLS technology as innovative foundation for NGN
- Technology is evolving to facilitate convergence and service creation
- Optical and GMPLS can become key NGN service architecture foundation
- Moving to the future MPLS and Optical very relevant to Grid applications
Domo Arigato!