Outline

- **ASON/GMPLS control plane concepts**
- **Involved SDOs**
- **Architectural principles of control plane enabled transport networks**
- **Control plane enabled services**
- **Future transport network evolution**
- **Business impact of control planes**
- **Control plane deployments**
- **Summary**
Components of Control Plane enabled Network Domains

Management plane
CP MANAGEMENT

CONTROL PLANE

DCN

Data plane
Intelligent TN introduce ...

A distributed “Control Plane”

Signaling protocols for dynamic setup and teardown of connections

Routing protocols for automatic routing

Building on concepts/protocols from the data world
Key Concepts Derived from the Data World

- **Distributed processing/knowledge/storage**
  - Directory services
    - E.g., DNS, X.500
  - Open Distributed Processing

- **Standardized route determination and topology dissemination protocols**
  - Routing information exchange mechanisms
    - E.g., RIP, OSPF, BGP, IS-IS/ES-IS

- **Flexibility in binding time decisions**
  - Difference between provisioning and auto-discovery

- **Security based upon logical versus physical barriers**
  - E.g., authentication, integrity, encryption

- **Differentiate between provisioning and more dynamic connection management**

- **Survivability**
  - Distributed restoration using signaling
Leveraging Existing Protocol Solutions

Caveats

互联网服务社区的用户

- 传统互联网架构

当采用为传统互联网开发的协议解决方案时，它们会带来相关的基本原则和架构方面的内容。
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Control Plane Standards

- **Recommendations**
  - ITU-T
  - Interoperability results, IA: E-NNI, UNI
  - Carrier requirements
  - ASON architecture
  - Control plane management
  - Use cases

- **RFCs**
  - IETF
  - GMPLS protocols

- **Technical Specifications**
  - OIF
    - Ethernet service definitions
  - MEF
    - Technical Specifications
Protocols and Architectures

- **Control Plane capabilities are implemented in protocols, whose elements can be combined to support different architectures/implementations**
- **Different SDOs contribute various protocol elements and architectural components**
Control Plane Specifications - Example

ITU-T
- G.8080
- G.7714 → G.7714.1
- G.7713 → G.7713.2
- G.7715 → G.7715.1 → G.7715.2
- G.7712
- G.7718 → G.7718.1

IETF
- RFC 3495
- RFC 4204 → RFC 4207
- RFC 3474 → RFC 3473
- RFC 3946 → RFC 4208
- RFC 4202
- GMPLS MIB RFCs

TMF
- TMF 509
- ENNI 1.0 → ENNI 2.0
- UNI 1.0 → UNI 2.0
- E-NNI OSPF 1.0
- TMF 814

Requirements & Architecture
- Auto-Discovery
- Signaling
- Routing
- DCN/SCN
- Management

ITU-T, IETF, TMF, OIF, ITU-T IETF, RFC 3495, RFC 3473, RFC 4208, GMPLS MIB RFCs, TMF 509, ENNI 1.0, UNI 1.0, E-NNI OSPF 1.0, TMF 814, OIF
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Introduction of automated control doesn’t remove/change the attributes of transport resources

- Control Plane needs to be able to configure the same attributes

Introduction of automated control doesn’t modify the functional components that exist within the transport plane
Optical Control Plane
Fundamental Architecture Principles (1)

- Decouple services from service delivery mechanisms
  - Wide range of network infrastructure options
  - Network operator specific optimizations
- Decouple QoS from realization mechanisms
  - Wide range of survivability options
  - Network operator specific approaches

Introduce “call” construct, which reflects a service association that is distinct from infrastructure/realization mechanisms
Optical Control Plane
Fundamental Architecture Principles (2)

- **Provide boundaries of policy and information sharing**
  - Range of network operator business models
  - Varying trust relationships among users and providers, among users, among providers
  - Targeted solutions, scalability considerations (scope of information dissemination), etc.

Establish modular architecture with interfaces at policy decision points
Optical Control Plane
Fundamental Architecture Principles (3)

- Provide for various distributions of control functionality among physical platforms
  - Different distributions of routing and signaling control
  - Fully centralized to fully distributed system designs
- Decouple topology of the controlled network from that of the network supporting control plane communications (SCN)
  - The transmission medium may be different for control plane messages and transport plane data

Identifiers to distinguish transport resources from, and among, signaling and routing control entities, and SCN addresses
ITU-T ASON Architecture
Calls and Connections

- **Objective:** Support ability to offer enhanced/new types of transport services facilitated by:
  - Automatic provisioning of transport network connections
  - Span one or more managerial/administrative domains

- **Involves both a Service and Connection perspective**
  - **Call:** Support the provisioning of end-to-end services while preserving the independent nature of the various businesses involved
  - **Connection:** Automatically provision network connections (in support of a service) that span one or more managerial/administrative domains
ITU-T ASON Architecture

Domains

- ASON domains represent generalization of existing traditional concepts
  - Transport definitions of administrative/management domains
  - Internet administrative regions
- Domains may express differing:
  - Administrative and/or managerial responsibilities
  - Trust relationships, addressing schemes
  - Distributions of control functionality
  - Infrastructure capabilities, survivability techniques, etc.
- Domains are established by network operator policies
ITU-T ASON Architecture
Interfaces (1)

- Service demarcation points are where call control is provided
- Inter-domain interfaces are service demarcation points

- Design modularized around open interfaces at domain boundaries
  - **UNI, E-NNI, I-NNI**
UNI separates the concerns of the user and provider:
- “3.6 Modularity is good. If you can keep things separate, do so.” - RFC 1548
- Objects referenced are User objects, and are named in User terms

UNI enables:
- Client driven end-to-end service activation
- Multi-vendor inter-working
- Multi-client
  - IP, Ethernet, TDM, etc.
- Multi-service
  - SONET/SDH, Ethernet, etc.
- Service monitoring interface for SLA management
ITU-T ASON Architecture Interfaces (3)

E-NNI enables:
- End-to-end service activation
- Multi-vendor inter-working
- Multi-carrier inter-working
- Independence of survivability schemes for each domain

I-NNI supports:
- Intra-domain connection establishment
- Explicit connection operations on individual switches
ITU-T ASON Architecture
Call Control & Interfaces

- Call state is maintained at network access points, and at key network transit points where it is necessary or desirable to apply policy
  - Calls that span multiple domains are comprised of call segments, with call control provided at service demarcation points (UNI/E-NNI)
  - One or more connections are established in support of individual call segments, with scope of connection control typically limited to a single call segment
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- Data plane

DCN

CP MANAGEMENT
Optical Control Plane Service
Permanent Connection

- All intra-/inter-domain calls and connections are provisioned by Management Plane actions

C: Client network domain
TN: Transport Network provider domain
Management plane of a transport network provider domain is initiating a call/connection.

Soft Permanent Connection (SPC)

C: Client network domain
TN: Transport network provider domain
Management plane of a client domain is initiating a call/connection.

SC initiating domain

C: Client network domain
TN: Transport Network provider domain
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### Evolving Transport Network Standardization

#### Overview

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>OTN ODUk</th>
<th>Layer 2 PBB-TE</th>
<th>Layer 2 MPLS-TP</th>
<th>OTN All optical switching</th>
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<tr>
<td>TDM switching</td>
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<tr>
<td>Packet switching</td>
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<tr>
<td><strong>Data plane standards and specifications</strong></td>
<td>Done ITU-T G.709</td>
<td>2009 IEEE 802.1</td>
<td>2009 ITU-T/IETF</td>
<td>Various ITU-T</td>
</tr>
<tr>
<td><strong>Control plane standards and specifications</strong></td>
<td>Done RFC 4328 OIF UNI and E-NNI</td>
<td>In progress IETF, ITU-T, OIF</td>
<td>In progress IETF, ITU-T, OIF</td>
<td>Under study IETF, ITU-T, OIF</td>
</tr>
</tbody>
</table>
Evolving TN Standardization Activities
Multi-Layer Aspects #1

Client 1

UNI

Client layer call

1st server layer call

2nd server layer call

Client 2

Operator Domain

Client Domain #1

Client Domain #2
Evolving TN Standardization Activities
Multi-Layer Aspects #2

Two layer examples:
- SONET/SDH over OTN
- ...

Three layer examples
- Ethernet over VCAT over SONET/SDH
- Ethernet over VCAT over OTN
- Ethernet over VLAN over PBB
- Ethernet over VLAN over PBB-TE
- Ethernet over VLAN over T-MPLS (MPLS-TP tunnel)
Evolving TN Standardization Activities
Multi-Layer Aspects – Ethernet/VCAT/SDH

ECOC 2007
Berlin
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The Challenge - Complex Network Realities

Carriers are living in heterogeneous network environments

- Multi-domain
- Multi-layer
- Heterogeneous environment resulting from mergers and acquisitions, company splits, multi-vendor NEs

→ The need for interoperable solutions and seamless interworking even on global scale is increasing continuously!
The Promise - Save Money & Make Money
Lower Costs & Increased Revenues

- Enhanced Network Efficiency
- Operation Improvements
- Service Enhancements
- Bandwidth Services
Control Plane Enables - Service Enhancements

- **Improved customer satisfaction**
  - Faster provisioning

- **New revenue opportunities**
  - **New services:**
    - On-demand provisioning
    - Broadband Bandwidth on Demand services
    - Optical VPN
  - **SLA-based performance (QoS)**
  - Client self-service options
  - Provides service differentiators
Control Plane Enables - Operation Improvements

- Faster service provisioning
- Simplified network design
- Reduced fallout rates
- Integrated testing capabilities
- Higher quality databases (NE to OSSs)
- Increased automation in operation support
Control Plane Enables - Enhanced Network Efficiency

- Auto-discovery (auto-recognition)
- Mesh network topologies
- Improved network reliability and availability
- Flexible, robust protection and restoration
- Aligns with ‘convergence’ of multi-layer network evolution path
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Control plane is deployed across the globe in major carrier’s networks, enabling:

- Cost savings and faster provisioning through automation
- New services such as On-Demand-Bandwidth
- Mesh Restoration functionality for critical added reliability
Control Plane Deployments – Examples

Carrier Networks
- AT&T: Optical Mesh Services
- Verizon: JiT - Just in Time Services
- Trans-Atlantic/Pacific mesh optical networks, ...

Research Networks
- Internet 2, USA
- SINET3, Japan, ...

National and international field trials
- European projects: NOBEL, MUPBED, PHOSPHORUS, ...
- Kei-han-na Open Lab, Japan
- DRAGON, USA
- VIOLA, German project, ...
Summary

ASON/GMPLS control plane is
- Following basic principles of transport networks
- Becoming mature step by step
- Has a significant business impact
  - Supporting on-demand services over intelligent optical transport networks
  - Enables cost-effective end-to-end transport of high-speed data
- The most preferable, standard based solution for seamless interworking in complex network environments, comprising
  - Multi-vendor network elements
  - Multi-domain
  - Multi-layer
while maintaining the individual functionalities within network layers and domains
Thank You for your Kind Attention!

Acknowledgement:
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For more information please visit:
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IETF: www.ietf.org
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