OpenFlow-based Hybrid Control Plane within the CTTC ADRENALINE Testbed

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OpenFlow Extensions Towards Multi-Layer and Multi-Domain Networks: OFELIA
Outline

• Introduction
• Distributed GMPLS vs. centralized OpenFlow-based Unified Control Plane
• OpenFlow-based Hybrid Unified Control Plane
• The ADRENALINE Testbed: next steps
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Introduction

• Internet Packet traffic volume growth will continue in the future
  • Services: video over IP, cloud computing, etc.

• Carriers require solutions to aggregate and transport these ever-increasing Bw demands
  • Solution: Multi-Layer (MLN) infrastructure converging packets and circuits
  • The aim: Enhance the scalability through reducing network cost (offloading higher layer), complexity and power consumption

• MLN combines the advantages:
  • Statistical multiplexing and Bw flexibility of packet networks (e.g., IP/MPLS)
  • High transport capacity and deterministic performance of circuit networks (WSON)
Introduction

• Adopt a Unified Control Plane (UCP) and management paradigm to fully exploit MLN advantages
  • A single control plane instance automatically governs all the layers
  • Favoring cooperation between layers -> enhance network resource usage (MLN TE decisions)

• Technologies to deploy UCP for MLN:
  • Distributed GMPLS
  • Centralized OpenFlow
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Distributed GMPLS UCP for MLN

- **GMPLS** provides **distributed control** for packet / circuit networks:
  - Set of common interconnection functions and distributed protocols (routing, signaling, link management)
- Each node has a controller performing automatic provisioning / routing of LSPs
Distributed GMPLS UCP for MLN

• GMPLS architecture allows decoupling data and control planes
  • HAL uses data plane protocols (SNMP, TL1, etc.) for the switch configuration

• Link state routing protocol (OSPF-TE) collects TE link and node attributes into the TE Database (TED)

• On-line path computation strategies (source/PCE)
  • In MLN, the aim: to enhance the network scalability through efficient use of network resources

• Signaling protocol (RSVP-TE) provides automatic establishment of LSPs within a MLN (distributed coordination)
Logically centralized OpenFlow-based UCP for MLN

- OpenFlow assumes a decoupled and logically centralized control plane with a network-wide operating system (NOX)
  - NOX Controller/s configures the data plane using the OpenFlow protocol
- Applications running on top of the NOX decide flow routing, admission control, etc.
Logically centralized OpenFlow-based UCP for MLN

- **Discovery control** application collects the network topology and connectivity information
  - Monitors the available Bw

- **Path computation** application computes the route for each flow
  - MLN TE decisions are applied to efficiently group/merge independent (Packet) flows throughout lower-layer (Optical) circuits

- **Flow processing** application processes new flows: creates flow rules and updates the flow tables in switches
GMPLS- vs. OpenFlow-based UCP: scalability problem

- **Distributed GMPLS routing** (TED synchronization) works well for a low number of nodes
  - For large TE domains and/or highly dynamic traffic, it presents important limitations: convergence / stability issues

- **Centralized OpenFlow-based UCP** better addresses the traffic dynamicity (i.e., unique network view at NOX Controller)
  - The processing power of the NOX Controller may be a scalability issue if the network size (number of switches) becomes large --> NOX becomes the “bottleneck”
  - **Problem**: high amount of control traffic, long flow setup latencies
OpenFlow-based UCP: scalability solutions

• Increase the processing power (parallelism technique / multi-thread batching sending messages), e.g., Maestro[^1]

• Decrease interactions between OpenFlow switches and controllers, e.g., DevoFlow[^2]

• Migrate towards a distributed control plane, e.g., HyperFlow[^3]

• **Our proposal:** OpenFlow-based Hybrid Unified Control plane
  • Distributed NOX Controllers interworking through extended GMPLS protocols

[^3]: A. Tootoonchian and Y. Ganjali, HyperFlow: A Distributed Control Plane for OpenFlow, INM/WREN 2010
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OpenFlow-based Hybrid UCP

- **To favor scalability:** partition the network in different domains
  - Reduce NOX Controller traffic processing (path comp., accesses to network view, OpenFlow messages, etc.)
  - Each domain is controlled by a NOX with a lower number of switches
- **At a single domain:** the simplicity of centralized OpenFlow NOX Controller is kept
- **Among domains:** exploit GMPLS/PCEP distributed protocols to enable the interconnection among NOX Controllers
OpenFlow-based Hybrid UCP

- Exchange of either full or selected (e.g., multi-carrier) segment information using extended OSPF-TE
- PCE/PCEP to compute routes encompassing multiple segments
  - Use of static/OSPF-TE information collected in the TED
- Coordination to set up flows using extended RSVP-TE
  - Configuration of flow tables at each domain according to OpenFlow protocol
• **Additional advantage**: interoperability between OpenFlow-controlled domains and legacy GMPLS-enabled transport networks
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ADRENALINE Testbed

• A GMPLS/PCE UCP has been designed / developed to govern both switching technologies in an integrated way
  • Based on the architecture defined in the ICT IP STRONGEST project

• Next steps:
  • Design / development of the OpenFlow Hybrid Control Plane application for the interworking among separated NOX Controllers

• Validation/evaluation through ADRENALINE Control Plane Emulator
  • Up to 74 servers for NOX Controllers and OpenFlow switches
Experimental Facilities: OpenFlow Hybrid Control Plane

- OpenFlow Switches on PC
- OpenFlow Control Plane Servers
- External Control Plane Connectivity
- IPSec Gateway
- Experimental Facilities:
  - OpenFlow Hybrid Control Plane
  - NOX A
  - NOX B
  - OpenFlow Protocol
  - OpenFlow-controlled domain
  - GMPLS CP
  - GMPLS-controlled domain
  - GMPLS CP
  - Apps
  - HCP

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Thanks for your kind attention!

• Questions?

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