Distributed End-to-End Service-Enabled Flow-Path Management over Multi-domain SDN

A. Murat Tekalp
Koç University (KU), ARGELA

Contributors:
Seyhan Civanlar (ARGELA), Tolga Bağcı (KU), Selin Yılmaz (KU)
Outline

- Problem Statement – Multi-Domain SDN
- Proposed Architectural Elements
- How Different Domain Controllers Talk
- What Different Domain Controllers Talk
- State of the Art
- Koç University Simulation Environment and Testbed
Multi-Domain SDN

- SDN domains consist of different content-provider and ISP networks, each managed by their own controller according to their specific policies.
Distributed End-to-End Service-Enabled Flow-Path Management

- Each SDN domain abstracts its network as a set of service-enabled paths, bundled with service-properties and advertises these to other domains.
- SDN domains are connected by inter-domain links.
- Each domain controller has full control over traffic over its internal links.
- Each domain controller initiates QoS-enabled e2e path requests, based on the shared inter-domain virtual topology, and monitors the negotiated service guarantees.
- There is no external entity that manages e2e stitching of slices or service-enabled paths that the SDN domains provide.
Proposed Architectural Elements

- Services Apps
- Network Functions Apps
- New Controller Functions Apps

- Inter-domain Video Services Apps
- New Distributed Inter-domain Flow-Path Management App
- New Inter-domain Controller Discovery and Communication Functions
- SDN Controller
- Hypervisor Layer Functions
How different SDN domain controllers talk?

Approach 1: Out-of band Controller Discovery and Messaging using East-Westbound API

Approach 2: In-band Controller Discovery + Messaging (ARGELA Patent Application)
Control plane network

Data plane network
What different SDN domain controllers talk?

- They share aggregated topology and link state/cost information
- They engage in SLA vs. cost negotiations

Internal topology is available at Topology Manager (base services of the Controller)

Aggregated topology is stored at Global Topology Manager

ARGELA Patent Application: METHOD AND SYSTEM FOR DELIVERING SERVICE-ENABLED FLOW PATHS ACROSS MULTIPLE DOMAINS IN SDN NETWORKS
Full multi-domain topology (not seen by any entity)

Summarized multi-domain topology as seen by controller 1

Each controller sees only its own full topology
Step 1: Domain 1 calculates E2E path given the latest aggregated network map
Step 2: Domain 1 starts SLA vs. cost negotiations with domains along the desired path
Step 3: Each domain along the final negotiated path makes own intra-domain routing decisions to satisfy the negotiated SLA parameters.
State-of-the-Art

Software Defined Internet Exchange (SDX)

- Today’s networks can only forward traffic based on the destination IP prefix, BGP
- Deploying SDN at IXP could revolutionize wide-area traffic delivery
- Application-specific peering
- Scalability can be a problem

Control Exchange Points (CXP)

- A CXP is external to an ISP entity that manages e2e stitching of slices that the ISPs provide.
- A CXP manages slices of multiple ISPs and provides inter-domain routing coordination.
- An ISP abstracts its network as a set of pathlets, bundled with ISP-provided properties, connecting the network edges and advertises these to the CXP.
- Slices are connected by inter-domain links.
- CXP admits QoS-enabled e2e path requests, embed paths in the inter-domain virtual topology and monitors the provided service guarantees.

Orchestrator

Uses Network Services Framework (NSF) and NSI messages

Distributed Multi-Domain SDN Controllers (DISCO)

Koç University Simulation Environment for Multi-Domain SDN

Controller: - Floodlight

Hypervisor-Layer:

Switch-Layer: - MiniNet Cluster

MiniNet
- Rapid prototyping tool for experimenting with OF
- Creates realistic virtual network
- Simulation environment limited to single domain

MiniNet Cluster
- Recent extension of Mininet for large scale networks
- Each domain has its own file system
- Domains/nodes can be distributed to different servers, connected by SSH.
### Table: Number of messages for three different size network scenarios

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<th>Total Domains</th>
<th>Total Switches</th>
<th>Total Border Gateways</th>
<th>Total Intra Links</th>
<th>Total Inter Links</th>
<th>Total Discovery Messages</th>
<th>Total Topology Sharing Messages</th>
<th>Total Link Bandwidth Sharing Messages</th>
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Real Test-bed for Multi-Domain SDN
Evaluation: Video QoE vs. Network QoS

End-User QoE
(Video quality, Mean Opinion Score)

Service Application QoS
(number and avg. duration of rebuffering)

Network QoS
(throughput, delay jitter, RTT)
More to come…
Thank you