Scalable and Reliable control and Management for SDN-based Large-scale Networks

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Traditional Control & Network Management Architecture

NETWORK MANAGEMENT SERVERS

OSS ... NMS

NETWORK DEVICE

CONTROL PLANE

CLI SNMP

MANAGEMENT PLANE

DATA PLANE

PACKETS IN PACKETS OUT

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Traditional Control & Network Management Architecture

- Network functionalities such as data, control, and management planes
  - Distributed and embedded within the vendor specific networking devices

- Remote management through provisioning and configuration

- Closed, inflexible, complex, error-prone, and hard-to-manage production network problems
SDN has changed the way to manage Nets

- Enables direct programming and centralized management by decoupling the network control and forwarding functions

- Centralized control of multi-vendor environments (standard)
  - Devices from any vendor, including switches and routers
  - Quick deployment, configuration and updating devices across the entire network

- Reduced complexity through automation (deployment)
  - Flexible network automation and management framework
  - Possibility of developing tools that automate many management tasks that are done manually today

- Higher rate of innovation (new network functionality)
  - Network in real time to meet specific business needs and user requirements as they arise
Ambiguous SDN Control & Management?

**NETWORK MANAGEMENT SERVERS**

- OSS
- . . .
- NMS

**CONTROL PLANE**

- SDN Controller

**DATA PLANE**

- OpenFlow
- SNMP

1. Fully integrated management
2. SDN controller agnostic management
Open Daylight Control & Management Arch.

NETWORK MANAGEMENT SERVERS

OSS       ...       vNMS

CONTROL PLANE

SDN Controllers

APP₁        APP₂        ...        SVC₁        ...

DATA PLANE

PACKETS IN ——> PACKETS OUT

NETWORK DEVICE

Open Flow  OVSDB  ...  BGP-LS  PCEP  LISP  SNMP
Control and measurement

- Control: access control, routing, etc.
- Measurement:
  - Traffic engineering: flow size (elephant flows to route), traffic distribution (estimate rack-to-rack traffic matrix)
  - Accounting
    - Billing based upon network usage
  - Troubleshooting
    - Find performance bottlenecks
    - Attacks
    - Failures

SDN focuses on control of traffic engineering (so far)

Scalability, Availability, and Accuracy issues
Major Issues

❖ Scalability
  ▪ Control messages priority differentiate (annotation)
  ▪ Kind of best-efforts for control traffic
  ▪ Solutions so far: extension of SW(DevFlow, etc.) and Controller (clustering, hierarchy)

❖ Availability
  ▪ 99.999% availability for carrier networks

❖ Inaccurate and Unreliable Management
  ▪ Management practice takes mainly remote approaches
  ▪ Network events should be inferred by the remote management systems
    → Potential network problems are often accumulated and enlarged
    → Diagnosis is delayed, inaccurate, unreliable, and not scalable
  ▪ SDN remote/centralized control tends to extend legacy network mgmt problems into the control plane
Existing SDN Scalability Solutions

Enhancing controller techniques

Recent controllers support methods of parallelism

Distributing some control functions to the switches (DevoFlow, DIFANE) to reduce control messages.

Clustering multiple controllers (HyperFlow, ONIX).
IRIS<CoMan> Architecture

NETWORK MANAGEMENT SERVERS

- OSS
- vNMS

CONTROL PLANE

SDN Controllers with Scalability & Reliability

- APP₁
- APP₂
- SVC₁

SuVMF
- Classification services
- Filtering redundant events
- Integrating applications and services

DATA PLANE

- OpenFlow
- OVSDB
- SNMP
- BGP-LS
- PCEP
- LISP

NETWORK DEVICE

PACKETS IN

PACKETS OUT
IRIS-Controller

- A Spin-off project from Floodlight

- Floodlight
  - Openflow-based SDN Controller from BigSwitch (Open Source)
  - Supports Openflow 1.0 (and soon will announce 1.3 support)
  - Adopted widely by research communities

- IRIS (2013~)
  - Yet another Openflow-based SDN Controller from ETRI
  - With an IO engine implemented from scratch on top of Java NIO
  - Supports Openflow 1.0~1.3
    - Floodlight/Loxigen-based Openflow API
  - Provides an Open-source version: OpenIRIS (http://openiris.etri.re.kr)
  - Provides a northbound API which is fully compliant with that of Floodlight
    (to support 3rd party applications from various research communities)
  - Focus on solving the scalability / availability issues of the centralized control
  - Current release is v2.0.8
### IRIS-C: Single-box performance

<table>
<thead>
<tr>
<th>System</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRIS 1.0.0</td>
<td>11,000,000 flows/sec</td>
</tr>
<tr>
<td>IRIS-Xen</td>
<td>10,500,000 flows/sec</td>
</tr>
<tr>
<td>IRIS-Loxi-1</td>
<td>2,500,000 flows/sec</td>
</tr>
<tr>
<td>IRIS-Loxi-2</td>
<td>5,000,000 flows/sec</td>
</tr>
<tr>
<td>IRIS-Loxi-3</td>
<td>10,000,000 flows/sec</td>
</tr>
</tbody>
</table>

**Testing environment**

- **Ubuntu 12.04 LTS 64bit (Kernel: 3.5.0-23-generic)**
- **CPU:** Intel Xeon E5-2690 v2 3.00GHz (20 physical core)
- **RAM:** 64G

**Benchmarking**

- **Cbench:** 1 core
- **Controller:** max 19 core
Controller Architecture for Scalability
A Network as a “Big Switch” :-P
Recursive Abstraction of Large Network into a single switch with many ports
IRIS-HiSA for Availability

- **Considerations**
  - Addresses exposed to data plane
  - Transparency
  - Horizontal scalability
  - High availability
  - State sharing

- **Functionalities**
  - Load balancing among physical controller instances
  - Switch migration
    - For failed controller instances
    - For newer controller instances
  - Security
    - Immune to attack such as DDoS

We believe OF-based brokering middleware will be one of the promising applications of Openflow.
Software-defined Unified Monitoring Agent for SDN

- A switch-side agent device providing control and management abstraction layer among SDN controllers, legacy NMS, and Openflow switches

- Functionalities:
  - Monitoring health of OpenFlow switches
  - Inspecting and verify the traffic (management sniffer)
  - Aggregation of verbose management information (syslog, SNMP, etc.)
  - Classification and prioritization of Openflow Asynchronous control messages
  - Filtering unnecessary messages
  - Identification of potential DoS attacks
SuVMF Architecture
MAC (Modify and Annotate Control)

- All the events should be inferred by a centralized remote SDN controller. As the underlying network is an inter-related complex system, it is not straightforward to identify a root cause of a problem or to chain policies.
- Provides algorithms, protocols, and facilities to modify and annotate control messages (e.g., adding sequence numbers in the control message) to assist remote network monitoring, control message differentiation, and resource isolation.

DMA (Detect and Mitigate Abnormality)

- Simple network status change (due to failure and attacks) may create various cascading critical network malfunctions.
- Detects and mitigates problems as near as the source of the problem.
SuVMF Arch. for Intra-System Scalability

FCP Throughput: 9 mpps, bps 5Gbps ~ 40 Gbps at 64 ~ 512 bytes

8 cores for FCP, 2x4 cores for BMS, 16 cores for UMS(sflow), 2 cores for VMM-agent, and 1 core for embedded Linux.
Test traffic is composed of 25% of 4 types OpenFlow msgs, 10% of sflow msgs, 5% of mgmt traffic, 60% of TCP dummy traffic in three different sizes (64, 256, and 512 bytes) out of a total of 10G traffic. The entire system throughput 3,296,000 pps/7.5 Gbps
SuVMF Arch. for IRIS Controller Scalability
SuVMF Arch. for Inter-System Scalability
Overall Architecture: Putting Them Together
Overall Project Overview
Thank You

Q & A

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