Cloud Computing, Software Defined Networking, Network Function Virtualization

Aryan TaheriMonfared

Department of Electrical Engineering and Computer Science
University of Stavanger

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Outline

1. Introduction
   - Problem? & Solution
   - IaaS Cloud Networking
   - Software Defined Networking
   - Network Function Virtualization

2. Solutions
   - Backbone Monitoring
   - SDN Controlled Cloud Platform
   - Tenant Virtual Network Monitoring
   - Virtual Network Flavor
   - Monitoring Service Orchestration and Transport
   - Tenant Controlled Virtual Networks
   - Uninet Network Emulation

3. Evaluation
   - Overview

4. Summary
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4 Summary
Cloud computing characteristics introduce new challenges to well studied network functions.

Network operation and maintenance has scalability and efficiency challenges.

- Traditional network functions should be implemented using new mechanisms.
- New functions should be introduced to fulfill requirements of the new computing model.
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Virtual Networks in Cloud

- VNs connect VMs/containers and higher level services
- VNs are overlays on top of providers’ infrastructure
- Providers establish and maintain VNs
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Software Defined Networking

SDN

- New methods for network management and configuration
- Abstractions between different layers of networking mechanisms
- e.g. Control plane abstractions: *distributed state*, *specification*, *forwarding*
### OpenFlow
- An approach for forwarding abstraction
- Separate forwarding plane from control plane physically
- One control plane can manage multiple forwarding planes

### OpenFlow Switch Spec (+ OpenFlow Wire protocol)
- OF switch has a set of flow tables, and a group table
- OF controller add/update/delete flow entries
- Flow entry has a matching pattern, ordered actions, priority, counters

### OpenFlow Config Protocol
- Configure an OpenFlow Capable Switch
OpenFlow Rules

OFPST_FLOW reply (OF1.3) (xid=0x2):
  in_port=1, dl_src=fa:16:3e:1a:26:5c
    actions=set_field:0x1->tun_id, goto_table:10
  in_port=2, dl_src=fa:16:3e:90:c1:19
    actions=set_field:0x1->tun_id, goto_table:10
  dl_type=0x88cc
    actions=CONTROLLER:65535
  priority=8192, tun_id=0x1
    actions=goto_table:20
  tun_id=0x1, dl_dst=fa:16:3e:6a:3e:13
    actions=output:3, goto_table:20
  priority=8192, tun_id=0x1
    actions=drop
Management Plane

**OVSDDB**
- Don’t forget the management plane!
- As important as OpenFlow
- Controlling several devices with single management plane
- OF-Config can be implemented on top it
- More than virtual entities (Pica8, HP)
- "OVSDDB is a database. You can use it to configure a switch or track your stamp collection" Ben Pfaff

**OF-Config**

**NETCONF**
OVS Configuration

```
[root@uninett-os-control fedora]# ovs-vsctl show
f0f8bd25-ca36-4629-96cf-8180304f04aa
 Manager "tcp:192.168.10.15:6640"
   is_connected: true
 Bridge br-ex
 Controller "tcp:192.168.10.15:6633"
   is_connected: true
 Port "qg-5fc23168-7a"
   Interface "qg-5fc23168-7a"
     type: internal
 Port br-ex
   Interface br-ex
     type: internal
 Bridge br-int
 Controller "tcp:192.168.10.15:6633"
   is_connected: true
 fail_mode: secure
 Port "tap1lab83c46-9b"
   Interface "tap1lab83c46-9b"
```
**Software Defined Networking**

**Traditional vs SDN**

**Proprietary Interfaces**

**Management**

**Control**

**Forwarding**

**SDN Controller** (Network Operating System)

**Control**

**Management**

**Proprietary Interfaces**

- OpenFlow
- OF-CONFIG/OVSDB

**SDN**

**Management**

**Control**

**Forwarding**
Network Function Virtualization

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Network Function Virtualization

**NFV**

- Network architecture
- Utilizes virtualization for delivering network functions
- Functions realized in software
- Deployed on standard hardware
- Decoupled from proprietary hardware
- Evolve beyond HW lifecycles
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Simplified Network
Monitoring Components
Monitoring Data Processing using Data-Intensive Frameworks

- Support various query types: ad-hoc, exploratory, long-term planned, trend discovery
- 3-OM faster than traditional tools (e.g. nfdump)
SDN Controlled Cloud Platform

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High-Level Data Center Architecture
Cloud Networking Details (Isolation Techniques)
So what?

Problems

- Current solutions are not scalable
- Not flexible
- No knowledge of multi-tenancy

Solution

- Incorporate SDN controller
- Use Cloud controller knowledge
High-Level Data Center Architecture with an SDN Controller
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4 Summary
Case: Monitoring Each Tenant
Monitoring Components

- Monitoring Data Generation
- Data Collection/Storage
- Data Processing

Orchestration
Case: Monitoring Each Tenant
Virtual Network Flavors

Virtual Networks (Overlays)

Tenant 1

 Tenant 2

 Tenant 3

Virtual Network Flavors
Virtual Network Flavor

Underlay and Overlays Controlled by an SDN Controller
Virtual Network Flavors

- Core
- Agg.
- Edge

Virtual Networks (VN):
- VN1
- VN2
- VN3

Virtual Switches (VS):
- VS1
- VS2
- VS3
- VS4
Virtual Network Flavor

Specifies:

- Coarse-grained traffic classes
- End-to-end priority
- Maximum throughput
Programming Endpoints

- Classifying Overlays
- Marking Tunnel Packets
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Monitoring Service Orchestration and Transport
Monitoring Components

- Monitoring Data Generation
- Transport
- Data Collection/Storage
- Transport
- Data Processing
Monitoring Service Design
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4. Summary
Tenant Controlled Virtual Networks

Virtual Network Control Mechanisms
Internal Structure
Tenant Controlled Virtual Networks

Internal Structure

Compute Node $i$
- br-int
- brtun-xy
- brint-xy

Compute Node $j$
- br-int
- brtun-xy
- brint-xy

VM1, VM2, VM3

Physical Transport Network
- eth1

Tenant Transport Network
- ex-xy

Tenant Tunnels
- GRE

Tenant Virtual Network
- GRE

Tenant Controlled Virtual Network
Tenant Controlled Virtual Networks

Tenant Controlled Virtual Network
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Uninett Network Emulation

- **Topology:** https://drift.uninett.no/nett/ip-nett/isis-uninett.net
- **Current load:** https://drift.uninett.no/nett/ip-nett/load-now
Benefits

- Emulate the whole network
- Real (virtual/physical) switches/routers
- Testing new ideas, policies, TE
- etc.
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Evaluation

SDN Controllers*
- Pox
- Ryu
- Floodlight
- OpenDaylight
- ONOS
- OVX

Cloud Platforms
- OpenStack
- DevStack (*Development environment*)
Overview

Setup

Cluster 1 - Production
- 10x physical machine (2U)
- Production
- Test workloads

Cluster 2 - Solution evaluation
- 9x physical machine (1U)
- Physical OpenFlow capable switch (HP)

Cluster 3 - Fast prototyping
- 5x physical machine (NUC)
- Different DC network topology
- Physical OpenFlow capable switch (Pica8)
### Implementation

- 6 modules for OpenDaylight SDN controller
- Topology automation (Pica8, Mininet)
- 1 extensive evaluation framework for OpenStack (Java)
- 1 evaluation framework for OpenStack (Bash)
- Open Source

### Keep your infrastructure healthy

- Monitor: Graphite, Collectd, Statd, nfcapd,
- Configure: Puppet, SaltStack
- Deploy: PXE, Clobber
Testbed
Thank you!

- Code: https://github.com/aryantaheri