SOFTWARE-DEFINED NETWORKING AND OPENFLOW

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Software-Defined Networking (SDN): Fundamental Control Plane Paradigm Shift

• Decouples the integrated control plane in routers to improve network flexibility and manageability

• External controllers augment the control plane and make forwarding decisions for a set of flows

• A group of technologies that open the data, control, and management planes of the network through APIs
# SDN Network Architecture: The Big Picture

<table>
<thead>
<tr>
<th>Cloud-Optimized Network Stack</th>
<th>Key Benefits</th>
<th>Enabling Technologies</th>
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</thead>
<tbody>
<tr>
<td>Cloud Management Layer</td>
<td>Automation and Orchestration</td>
<td>Cloud APIs: OpenStack, VMware, Microsoft, CloudStack</td>
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<tr>
<td>Services Layer</td>
<td>Personalization and Monetization</td>
<td>Programmatic Control: OpenFlow: OpenScript</td>
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<tr>
<td>Network Virtualization Layer</td>
<td>Flexibility and Efficient Asset Utilization</td>
<td>Overlay Networking: VXLAN, NVGRE, STT; MPLS</td>
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<tr>
<td>Network Fabric Layer</td>
<td>Reliability and Simplicity</td>
<td>Any-to-Any Connectivity: Ethernet Fabrics; IP Routing</td>
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Who is behind OpenFlow: Open Networking Foundation (ONF)

- ONF launched publicly in March, 2011
- The ONF defines OpenFlow and API specifications
- Founding members of ONF are network operators:
  - Deutsche Telekom
  - Microsoft
  - Facebook
  - Verizon Wireless
  - Google
  - Yahoo!
- Support from more than 70 major companies since the launch
- Recent interest from the IETF in provisioning protocols
OpenFlow Overview

• Protocol that enables communication between an OpenFlow controller and an OpenFlow router
  • Control plane decisions for a defined set of flows are made by the controller, which typically runs on a server
  • Other control plane decisions and all data plane forwarding is still done by the router
• Router and controller communicate via the OpenFlow protocol, which defines messages
• Router maintains flow tables, which are maintained by the controller using APIs
OpenFlow Router Operation

- Flow table contains entries that define a flow based on the packet header.
- Flows are sorted by priority as defined by the controller, highest priority flows match first.

<table>
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<th>Flow Table</th>
<th>Flow</th>
<th>Action</th>
<th>Counters</th>
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</tbody>
</table>

- Does the packet belong to this flow?

Layer 2

<table>
<thead>
<tr>
<th>Ingress Port</th>
<th>MAC DA</th>
<th>MAC SA</th>
<th>Ether Type</th>
<th>VLAN ID</th>
<th>802.1p Bits</th>
<th>IP Src</th>
<th>IP Dst</th>
<th>IP Protocol</th>
<th>IP DSCP</th>
<th>TCP/UDP Src Port</th>
<th>TCP/UDP Dst Port</th>
</tr>
</thead>
</table>

Layer 3

- Add, Remove, Modify VLAN Tag
- Forward to a Port List
- Drop
- Send Packet to Controller
- Forward Via Control Plane
OpenFlow Applications: What can you do with OpenFlow?

- OpenFlow itself does not define or mandate any specific application, it’s just an interface into the control plane.
- Enables a large set of applications due to its flexibility to program the network based on any external criteria:
  - Cost
  - Time of day
  - Latency
  - Security
  - Traffic policy
  - Load
- Ideal for automation in highly orchestrated environments where you want to precisely control network behavior.
Network Virtualization
Hybrid Port Mode: OpenFlow Overlay

- OpenFlow used as an overlay in an existing network to add exception rules to create new services
- Hybrid port mode: OpenFlow does not affect other traffic on the same port, enforced in hardware
- Allows for OpenFlow service development without risk on top of the existing production network
Data Center Network Virtualization

Scalable Cloud Services

- vSwitches connect virtual machines, ToR switches connect physical machines
- Tunnels enable physical network abstraction
- SDN gateways enable scalable connectivity into the logical network
- Programmatic interface to server infrastructure with OpenFlow
Network Analytics Application and SDN Controller

SDN Approach to Network Analytics

- SDN/OpenFlow Controller uses north bound APIs for application development
- SDN/OF Controller provisions network using OpenFlow
- OpenFlow to networks
  - For traffic replication from WAN to Analytics Network
  - For traffic replication from Analytics Network to Analytic tools
- Analytic tools provide for reporting and analytics
Extending Clouds Across Data Centers

Data Center A
- Servers
- Fibre Channel SAN
- SAN Extension
- Openflow Router

Data Center B
- SAN Extension
- Fibre Channel SAN
- Servers
- Storage

Openflow Controller
GSLB Controller
On Demand Tunnel w/VLAN Rewrite

WAN
Interconnected through Internet

Openflow Controller

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Extending Clouds Across Data Centers, contd
Where is the ONF and OpenFlow headed?

• OpenFlow 1.3 received preliminary approval in April
  • Post review approval in June, and work on 1.3.1 (clean up)
  • 1.4 was originally planned for late summer, but delayed

• ONF would like to see more adoption of 1.3
  • Stabilize the specification at a good version
  • Go back to original approach of OpenFlow 1.0 which requires working code before a new feature is standardized

• Need open reference implementations to help promote adoption and testing

• Forwarding Abstractions Working Group (FAWG) is working to make OpenFlow support on more hardware platforms easier
Further Information

• Open Networking Foundation
  https://www.opennetworking.org/index.php

• Intro to OpenFlow
  https://www.opennetworking.org/standards/intro-to-openflow

• Brocade OpenFlow Page
Questions?