Application Delivery Using Software Defined Networking

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These slides and audio/video recordings are available at:
http://www.cse.wustl.edu/~jain/talks/sdn_gw.htm

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Overview

1. Cloud Computing ⇒ Network Virtualization ⇒ SDN
2. SDN defined by Five Innovations
3. Open Application Delivery Using SDN
Virtualization of Life

- Internet ⇒ Virtualization

- No need to get out for
  - Office
  - Shopping
  - Entertainment
  - Education

- Virtual Workplace
- Virtual Shopping
- Virtual Education
- Virtual Sex
- Virtual Computing
Virtualization of Computing

- August 25, 2006: Amazon announced EC2
  ⇒ Birth of Cloud Computing in reality
  (Prior theoretical concepts of computing as a utility)

- *Web Services To Drive Future Growth For Amazon* ($2B in 2012, $7B in 2019)
  - Forbes, Aug 12, 2012

- **Networking**: Plumbing of computing
  - Virtual Channels, Virtual LANs,
    Virtual Private Networks

Networks need to support efficient cloud computing
Network Virtualization

- Each VM needs its own network interface card (NIC)
- Each tenant needs its own Virtual LAN

Need to be able to re-program networks quickly
SDN Definition: 5 Innovations

1. Separation of Control and Data Plane
2. Flow Based Control
3. Centralization of Control Plane
4. Programmability of Control Plane
5. Standard API’s between Planes
1. Separation of Control and Data Plane

- Control Plane = Making forwarding tables
- Data Plane = Using forwarding tables
- Once vs. Billion times per second, Complex vs. fast
- One expensive controller with lots of cheap switches
2. Flow-based control

- Data/disk/Memory sizes are going up by Moore’s Law
- Packet size has remained 1518 bytes since 1980
- Multimedia, big data ⇒ Packet Trains
- Flow is defined by L2-L4 headers
- Decide once, use many times ⇒ Execution performance

<table>
<thead>
<tr>
<th>Match Fields</th>
<th>Priority</th>
<th>Counters</th>
<th>Instructions</th>
<th>Timeouts</th>
<th>Cookie</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Packet + Byte Counters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward to Port n</td>
</tr>
<tr>
<td>Encapsulate and forward to controller</td>
</tr>
<tr>
<td>Drop</td>
</tr>
<tr>
<td>Send to normal processing pipeline</td>
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<tr>
<td>Modify fields</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>In Port</th>
<th>VLAN ID</th>
<th>Ethernet</th>
<th>IP</th>
<th>TCP &amp; Mask</th>
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<td>SA</td>
<td>DA</td>
<td>Type</td>
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<tr>
<td></td>
<td></td>
<td>Src</td>
<td>Dst</td>
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</tbody>
</table>
3. Centralization of Control Plane

- Consistency
- Fast Response to changes
- Easy management of lots of devices

Centralized vs. Distributed
4. Programmable Control Plane

- Policies can be changed on the fly
  ⇒ Software Defined
5. Standardized API between planes

- Independent development of hw/control/applications
- Commodityization of HW/Control/Application
- South-Bound API: OpenFlow

Network Controller Software

Northbound API

Southbound API
SDN Impact

- Why so much industry interest?
  - Commodity hardware
    - Lots of cheap forwarding engines ➔ Low cost
  - Programmability ➔ Customization
  - Those who buy routers, e.g., Google, Amazon, Docomo, DT will benefit significantly

- Tsunami of software defined devices:
  - Software defined wireless base stations
  - Software defined optical switches
  - Software defined routers
After
Life Cycles of Technologies

Potential

MPLS

ATM

Research Hype Dis illusionment Success or Failure

Time
Industry Growth: Formula for Success

Paradigm Shifts $\Rightarrow$ Leadership Shift  
Old market leaders stick to old paradigm and loose  
Mini Computers $\rightarrow$ PC, Phone $\rightarrow$ Smart Phone, PC $\rightarrow$ Smart Phone
Application Delivery in a Data Center

- **Replication**: Performance and Fault Tolerance
  - If Load on S1 > 0.5, send to S2
  - If link to US broken, send to UK

- **Content-Based Partitioning**:
  - Video messages to Server S1
  - Accounting to Server S2

- **Context Based Partitioning**:
  - Application Context: Different API calls
    - Reads to S1, Writes to S2
  - User Context:
    - If Windows Phone user, send to S1
    - If laptop user, send to HD, send to S2

- **Multi-Segment**: User-ISP Proxy-Load Balancer-Firewall-Server
- Google appliances in Tier 3 ISPs
- Details of Google WAN are not public
- ISPs can not use it: L7 proxies require data visibility
Our Solution: OpenADN

- Open Application Delivery Networking Platform
  Platform = OpenADN aware clients, servers, switches, and middle-boxes

- Allows Application Service Providers (ASPs) to quickly setup services on Internet using cloud computing ⇒ Global datacenter

Diagram:

- OpenADN aware clients
- Servers A1, B1
- Servers A2
- OpenADN middle-box
- Access ISP
- Internet
- Legacy
- Clients

[Diagram of network topology with clients, servers, and middle-boxes connected through OpenADN]
OpenADN in SDN’s Layered Abstractions

- SDN provides standardized mechanisms for distribution of control information
- OpenADN aware devices use enhanced OpenFlow

Northbound API

Southbound API

DATA PLANE  CONTROL PLANE  APPLICATIONS

OpenFlow

OpenFlow

Forwarding HW

Forwarding HW

Forwarding HW

Network Controller Software

ASP1
OpenADN Controller

ASP1
ISP's Controller

ASP1
OpenADN Aware

ASP1
Legacy
(OpenADN Unaware)

ASP2
OpenADN Controller

ASP2
OpenADN Controller

ISP
Policies

ISP
Policies

ISP's Controller

ISP's Controller

Middle-boxes

White Paper:
http://www.cse.wustl.edu/~jain/talks/sdn_gw.htm

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Key Features of OpenADN

1. Edge devices only. Core network can be current TCP/IP based, OpenFlow or future SDN based
2. Coexistence (Backward compatibility): Old on New. New on Old
3. Incremental Deployment
4. Economic Incentive for first adopters
5. Resource owners (ISPs) keep complete control over their resources

Most versions of Ethernet followed these principles. Many versions of IP did not.
Summary

1. Cloud computing ⇒ Virtualization of computing, storage, and networking
   ⇒ Numerous recent standards related to networking virtualization both in IEEE and IETF

2. Recent Networking Architecture Trends:
   1. Centralization of Control plane
   2. Standardization of networking abstractions
      ⇒ Software Defined Networking (SDN)
   3. Most networking devices will be software defined

3. OpenADN enables delivery of applications using North-bound SDN API