OpenADN: Service Chaining of Globally Distributed VNFs

RAJ JAIN
Project Leader: Subharthi Paul
Washington University in Saint Louis
Saint Louis, MO 63130
Jain@cse.wustl.edu

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These slides and audio/video recordings of this talk are at:
http://www.cse.wustl.edu/~jain/talks/adn_stl.htm

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Overview

1. What will Telco look like in 3 years?
2. SDN 1.0 and SDN 2.0
3. Network Function Virtualization and Service Chaining
4. Function Virtualization and Service Chaining
5. OpenADN – How to do it with no content visibility

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What will Telco Look like in 3 Years?

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What have Telcos seen in the last 3 Years?

• A new future every year...

2010 - Open Flow
2011 - SDN 1.0
2012 - NFV
2013 - SDN 2.0
• Telco’s need a lot of infrastructure: Hardware, cable, spectrum, operators

• It used to take 10 years to change: 1G (1980), 2G (1990), 3G (2000), 4G (2010)


• Analog + Digital
Technology is Changing Too Fast

- April 2008: OpenFlow paper in ACM SIGCOMM CCR
  Separation of research traffic from production network
  (No SDN in the paper)
- 2009: OpenFlow V1.0.0 specs
- **March 2011**: Open Networking Foundation is formed
- **Oct 2011**: First Open Networking Summit
  ⇒ Multi-tenant networks
  ⇒ Software Defined Networking (**SDN 1.0**) = OpenFlow
- **Nov 2012**: Network Function Virtualization (**NFV**)
- **April 2013**: Second Open Networking Summit
  ⇒ OpenDaylight (Bring your own Plug-In) style **SDN 2.0**

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What is SDN?

- All of these are mechanisms.
- SDN is *not* about a mechanism.
- It is a framework to solve a set of problems ⇒ Many solutions
• SDN originated from OpenFlow
• Centralized Controller
  ⇒ Easy to program
  ⇒ Change routing policies on the fly
  ⇒ Software Defined Network (SDN)
• Initially, SDN =
  – Separation of Control and Data Plane
  – Centralization of Control
  – OpenFlow to talk to the data plane
• Now the definition has changed significantly.
“What is SDN?
The physical separation of the network control plane from the forwarding plane, and where a control plane controls several devices.”

1. Directly programmable
2. Agile: Abstracting control from forwarding
3. Centrally managed
4. Programmatically configured
5. Open standards-based vendor neutral

The above definition includes How.
Now many different opinions about How.
⇒SDN has become more general.
Need to define by What?

What do We need SDN for?

1. **Virtualization**: Use network resource without worrying about where it is physically located, how much it is, how it is organized, etc.
2. **Orchestration**: Manage thousands of devices
3. **Programmable**: Should be able to change behavior on the fly.
4. **Dynamic Scaling**: Should be able to change size, quantity
5. **Automation**: Lower OpEx
6. **Visibility**: Monitor resources, connectivity
7. **Performance**: Optimize network device utilization
8. **Multi-tenancy**: Sharing expensive infrastructure
9. **Service Integration**
10. **Openness**: Full choice of Modular plug-ins

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**SDN 2.0: OpenDaylight Style SDN**

- **NO-OpenFlow (Not Only OpenFlow)** Multi-Protocol
- New work in IETF XMPP, ALTO, I2RS, PCEP, ...

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What do We need NFV for?

1. **Virtualization**: Use network resource without worrying about where it is physically located, how much it is, how it is organized, etc.

2. **Orchestration**: Manage thousands of devices

3. **Programmable**: Should be able to change behavior on the fly.

4. **Dynamic Scaling**: Should be able to change size, quantity

5. **Automation**

6. **Visibility**: Monitor resources, connectivity

7. **Performance**: Optimize network device utilization

8. **Multi-tenancy**

9. **Service Integration**

10. **Openness**: Full choice of Modular plug-ins

Note: These are exactly the same reasons why we need SDN.

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Virtual Network Functions (VNFs)

- Virtual Network Functions (VNFs) are generally replicated for performance and fault tolerance
- **Service chaining** is based on **content** and **context**
VNF Service Chaining in A Data Center

- **Content-Based Partitioning**:  
  - SD Video from S1  
  - HD Video from S2

- **Context Based Partitioning**:  
  - Network Context:  
    - If link to S1 broken, send to S2  
  - Application Context:  
    - Reads to S1, Writes to S2  
    - If Load on S1 >0.5, send to S2  
  - User Context:  
    - If Phone user, send to S1  
    - If laptop user, send to S2

- You can statically program the forwarding or SDN can help **dynamically** program the forwarding

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With cloud computing, anyone can super-compute on demand.

- Physical infrastructure is owned by Cloud Service Provider (CSP). Tenants get virtual infrastructure
  - **Win-Win** combination

With virtualization, an ISP can set up all virtual resources on demand

- Physical Infrastructure owned by NFV infrastructure service provider (NSP) and tenant ISPs get virtual NFVI services
  - **Win-Win** combination
Service Chaining in a Multi-Cloud Multi-Tenant Environment

- VNFs belong to tenants. Multiple tenants.
- Each Cloud belongs to a different Cloud Service Provider (CSP)
- Internet infrastructure belongs to an NFVI service provider (NSP)
- Need to provide L7 forwarding without L7 visibility
Challenges in Service Chaining

• **Dynamic:**
  – Forwarding changes with state of the servers, links, ...

• **Content sensitive:**
  – Different for different types of videos, read-writes, ...

• **Distributed Control:**
  – Equipment belongs to infrastructure provider
  – Data belongs to Tentants

• **Massive Scale:**
  – Billions of Users with different user context

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Any Function Virtualization (FV)

• Network function virtualization of interest to Network service providers

• But the same concept can be used by any other industry, e.g., financial industry, banks, stock brokers, retailers, mobile games, ...

• Everyone can benefit from:
  – Functional decomposition of their industry
  – Virtualization of those functions
  – Service chaining those virtual functions (VFs)

  ⇒ A service provided by the next gen ISPs
VF Chaining in a Multi-Cloud Multi-Tenant Environment

- Multiple tenants share computing and networking resources
- Google and Akamai already use this kind of service chaining
• Google appliances in Tier 3 ISPs
• Details of Google WAN are not public
• ISPs cannot use it: L7 proxies require data visibility

[Diagram showing network topology with Google L7 Proxies, Network POPs, and Google Data Centers]
Our Solution: OpenADN

- Open Application Delivery Networking Platform
  = OpenADN aware clients, VNFs, switches, and middle-boxes
- Allows Tenant ISPs to quickly setup services using cloud computing and Infrastructure ISPs

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OpenADN Innovations

1. Software defined networking: Centralized policy control
2. OpenFlow extensions for south bound communication between controller and forwarding elements
3. Cross-Layer Communication
4. OpenADN tags: Layer 7 Proxies without layer 7 visibility
5. MPLS like Labels
6. ID/Locator Split
7. Late Multi-stage binding
8. Rule-Based Delegation

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Rule-Based Delegation

Only a few OpenADN modules in the edges are necessary.

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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
   → Can be done now.

2. Coexistence (Backward compatibility):
   Old on New. New on Old

3. Incremental Deployment

4. Economic Incentive for first adopters

5. Resource owners (NSPs/CSPs) keep complete control over their resources

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

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Resource Control

- Tenants keep complete control of their data. NSP does not have to look at the application data to enforce application level policies.
- NSPs keep complete control of their equipment. Tenants communicate their policies to NSP’s control plane.
- VFs and Middle boxes can be located anywhere on the global Internet. (Of course, performance is best when they are close by.)
- Tenants or NSPs can own OpenADN modules. NSPs can offer “Service Chaining” service.
- No changes to the core Internet
Beneficiaries of This Technology

- **Equipment/Software vendors**: Sell openADN appliances,
- **Tenants**: Deploy virtual functions anywhere and move them anytime
- **Network Service Providers (NSPs)**: Offer new services
- **Cloud Service Providers (CSPs)**: Freedom to move VMs, Less impact of downtime

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Summary

1. **Technology Thrashing**: Technology changing faster than deployment.

2. Virtual Networking Functions (VNFs) will be replicated and deployed globally
   ⇒ Need **dynamic** service chaining based on user, network, and application context

3. Virtual functions useful not only for networking but also for **all other global enterprises** and games
   ⇒ New business opportunity for NFV Infrastructure service

4. **Tenants can share** wide area network infrastructure and specify their policies

5. NSPs keep complete **control** over their resources. Tenants keep complete control over their traffic.

6. Can be implemented incrementally **now**.