



OpenADN: Service Chaining of Globally Distributed VNFs



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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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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?



http://www.cse.wustl.edu/~jain/talks/adn_stl.htm

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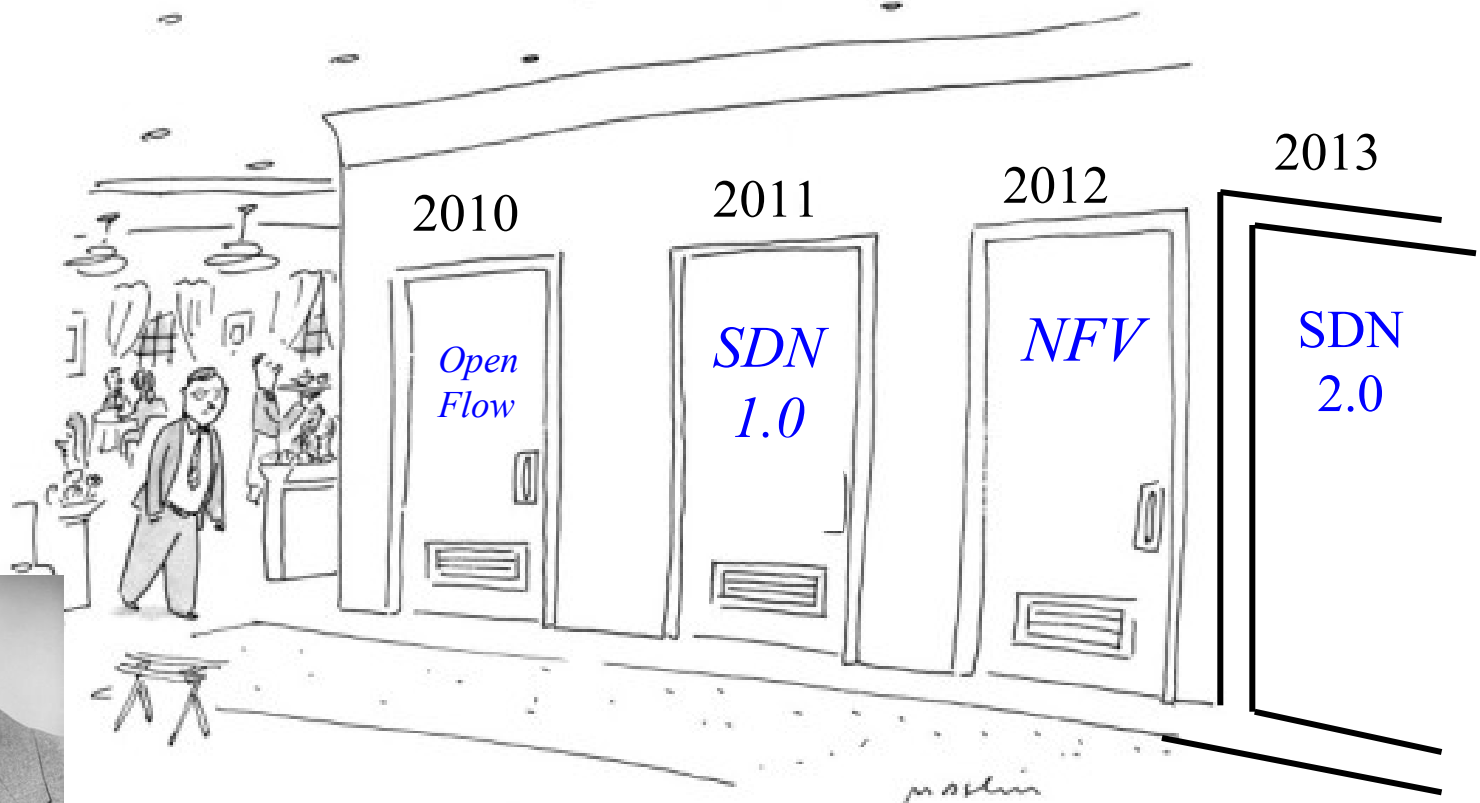
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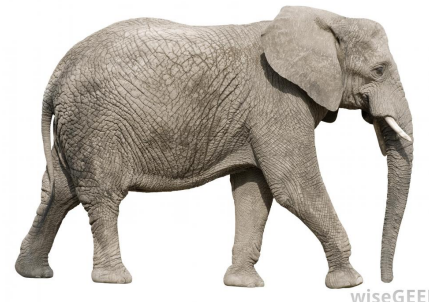
What have Telcos seen in the last 3 Years?

- A new future every year...



Telco = LARGE Infrastructure

- 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)
- WiMAX started in 2001. Became LTE in 2005. Deployed in 2010
- Analog + Digital



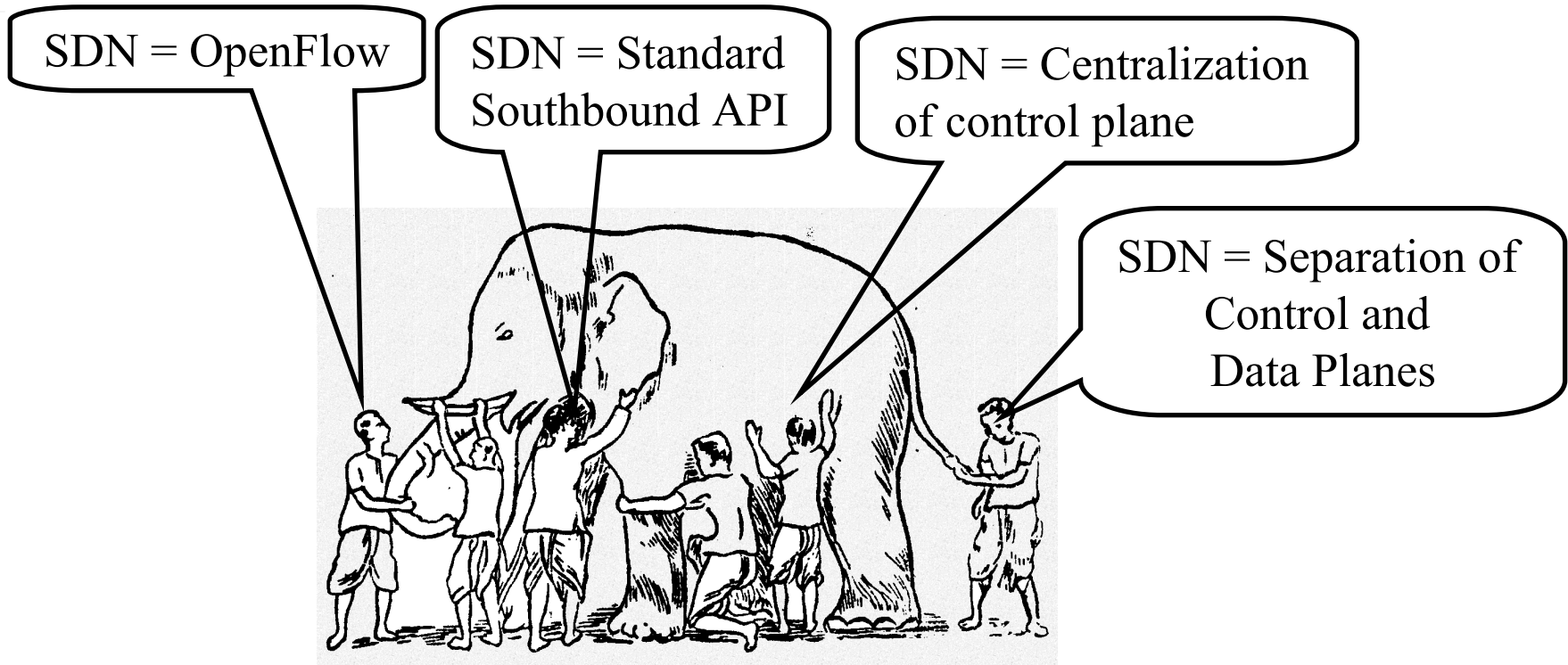
Technology is Changing Too Fast

- 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**

Ref: ONF, "The OpenFlow Timeline," http://openflownetworks.com/of_timeline.php

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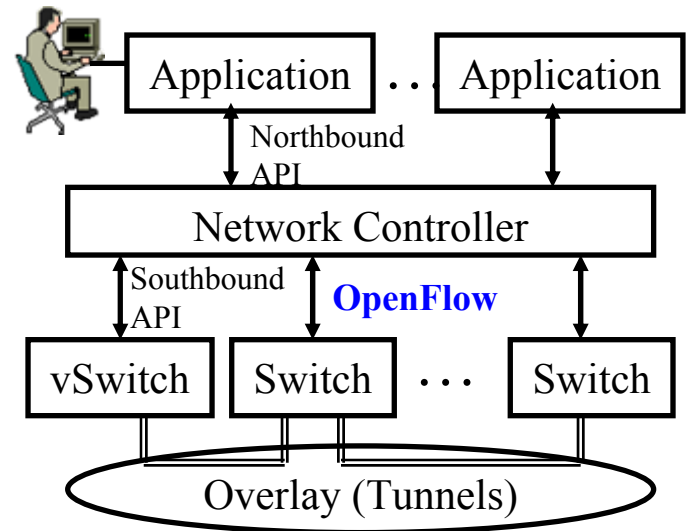
What is SDN?



- All of these are mechanisms.
- SDN is *not* about a mechanism.
- It is a framework to solve a set of problems ⇒ Many solutions

SDN 1.0: SDN Based on OpenFlow

- 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.



ONF Definition of SDN

“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?*

Ref: https://www.opennetworking.org/index.php?option=com_content&view=article&id=686&Itemid=272&lang=en

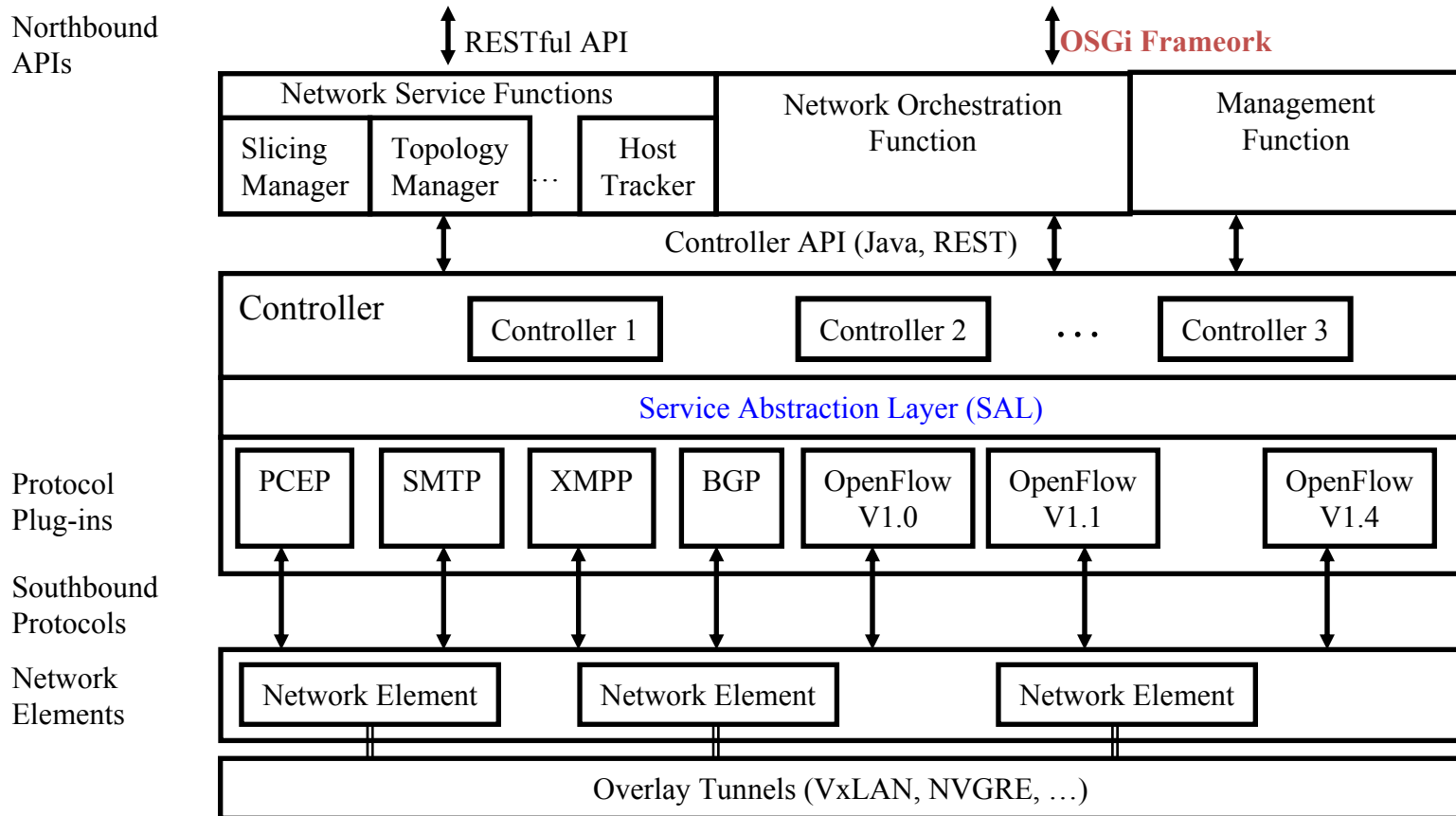
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What do We need SDN for?

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

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?

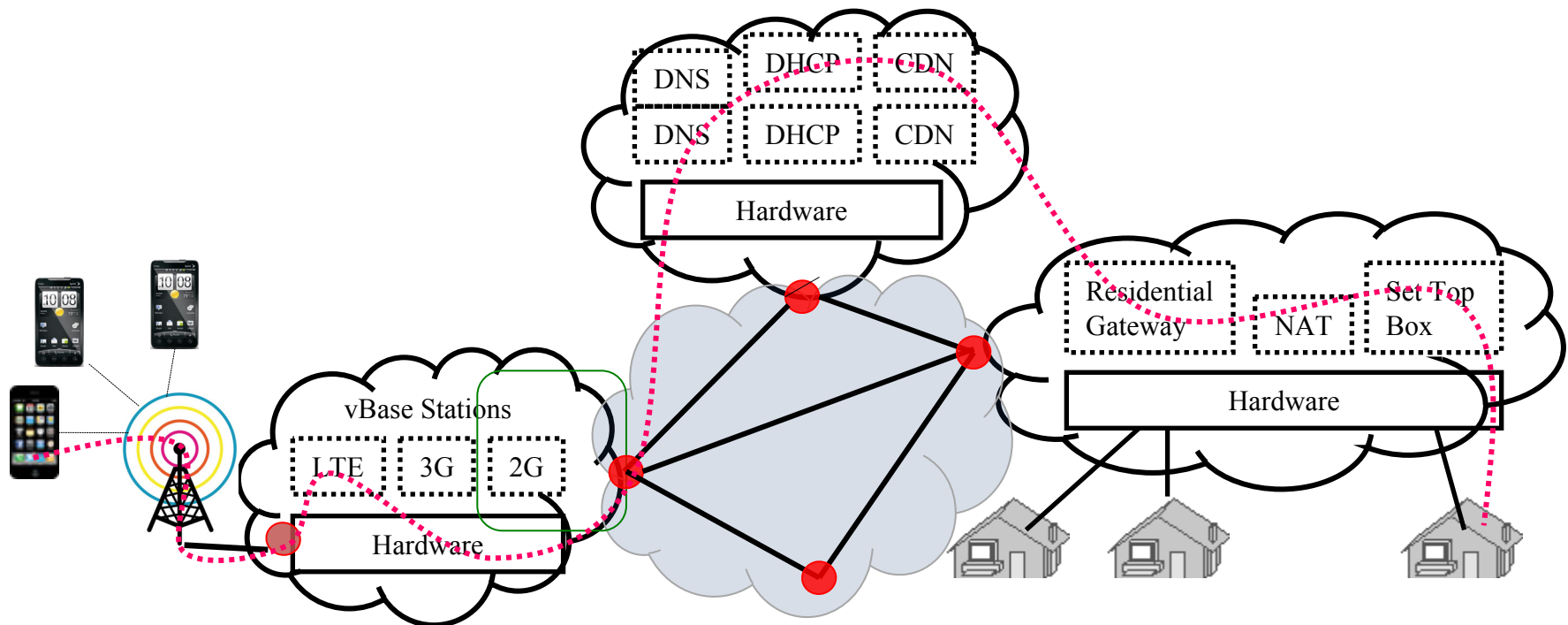
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Note: These are exactly the **same** reasons why we need SDN.

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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

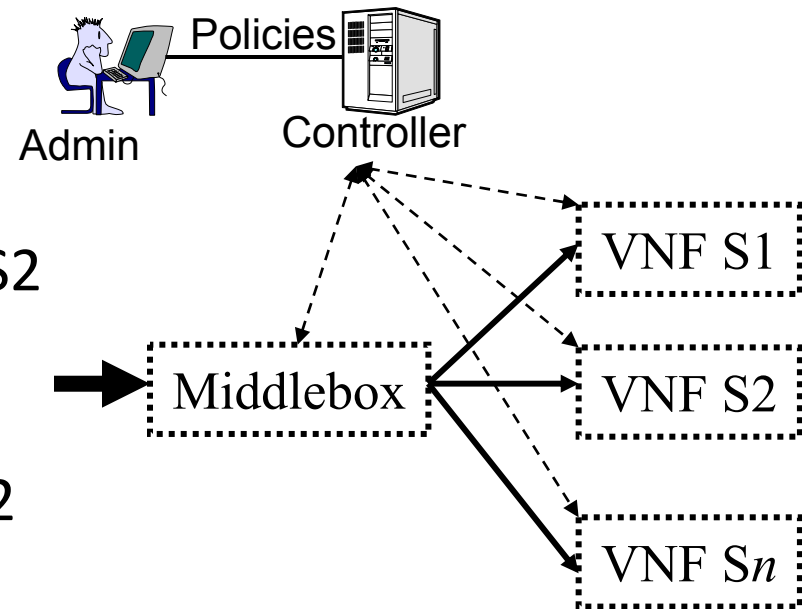
- **Content-Based Partitioning:**

- 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



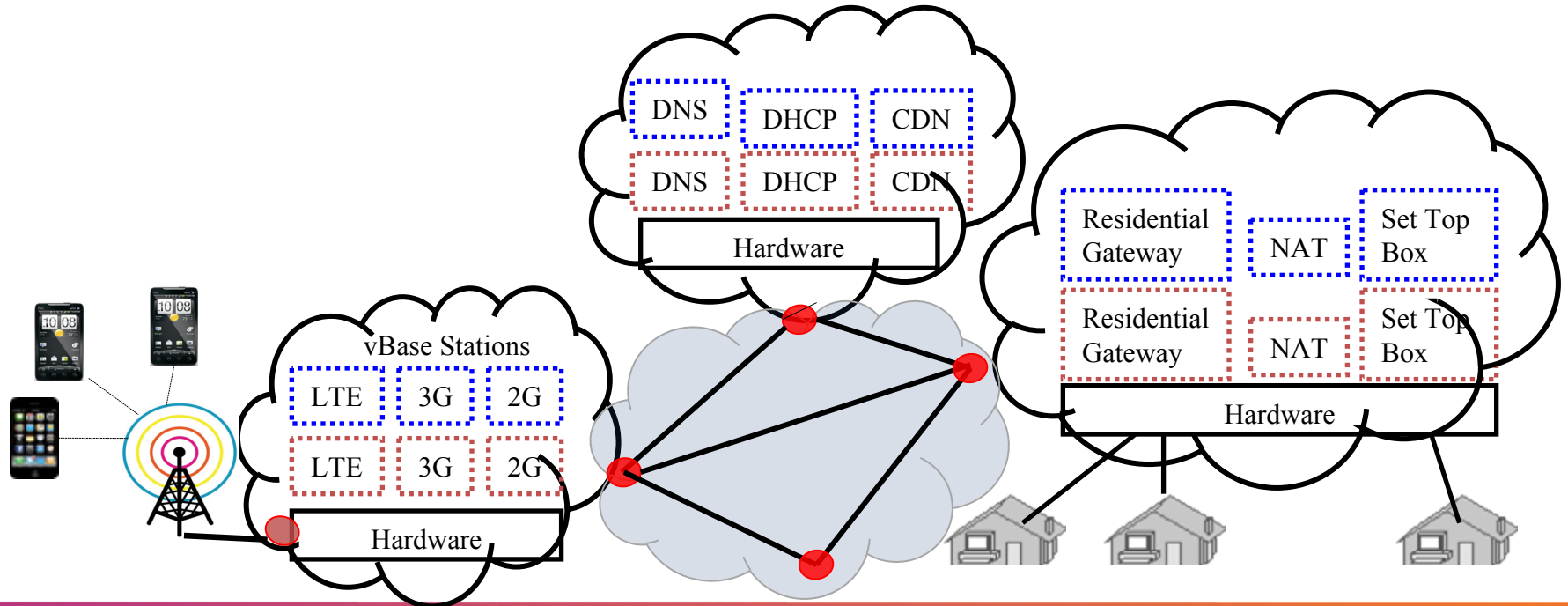
Service-Infrastructure Separation

- 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



http://www.cse.wustl.edu/~jain/talks/adn_stl.htm

Challenges in Service Chaining

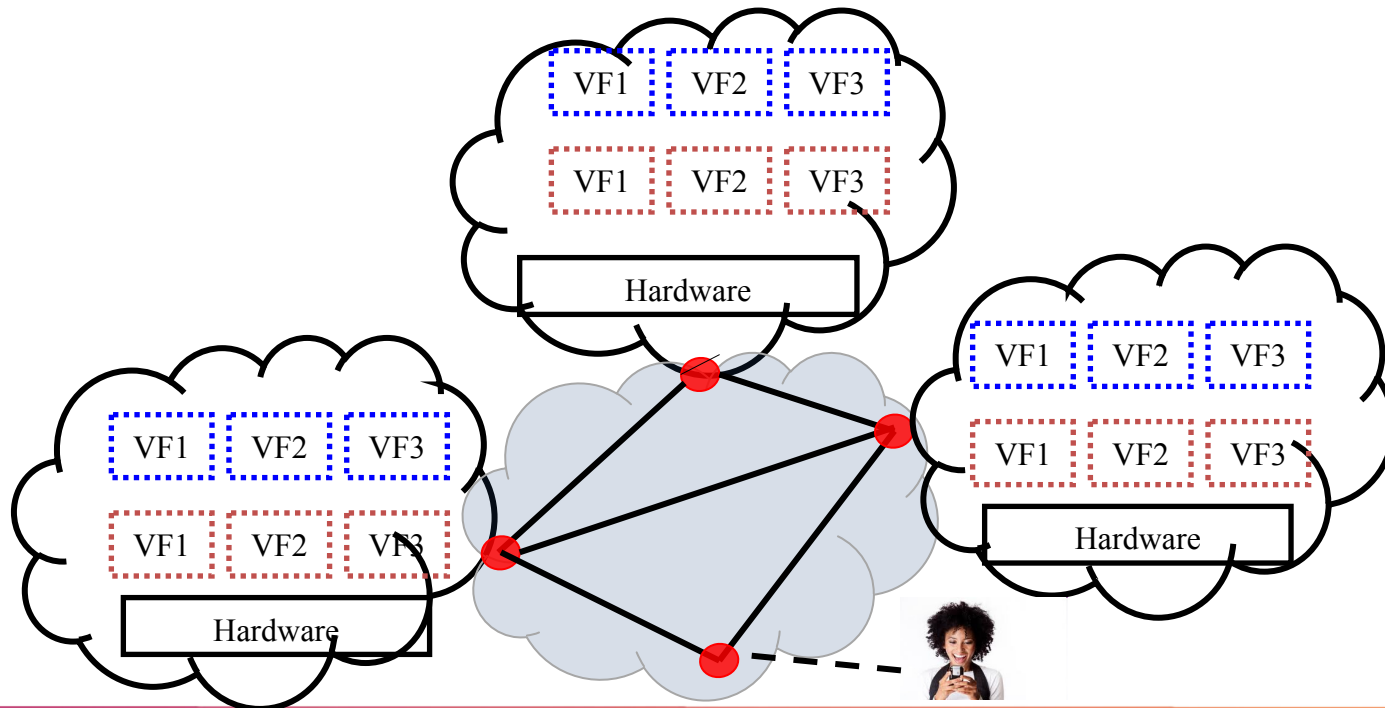
- **Dynamic:**
 - Forwarding changes with state of the servers, links, ...
- **Content sensitive:**
 - Different for different types of videos, read-writes, ...
- **Distributed Control:**
 - Equipment belongs to infrastructure provider
 - Data belongs to Tentants
- **Massive Scale:**
 - Billions of Users with different user context

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 there industry
 - Virtualization of those functions
 - Service chaining those virtual functions (VFs)
⇒ A service provided by the next gen ISPs

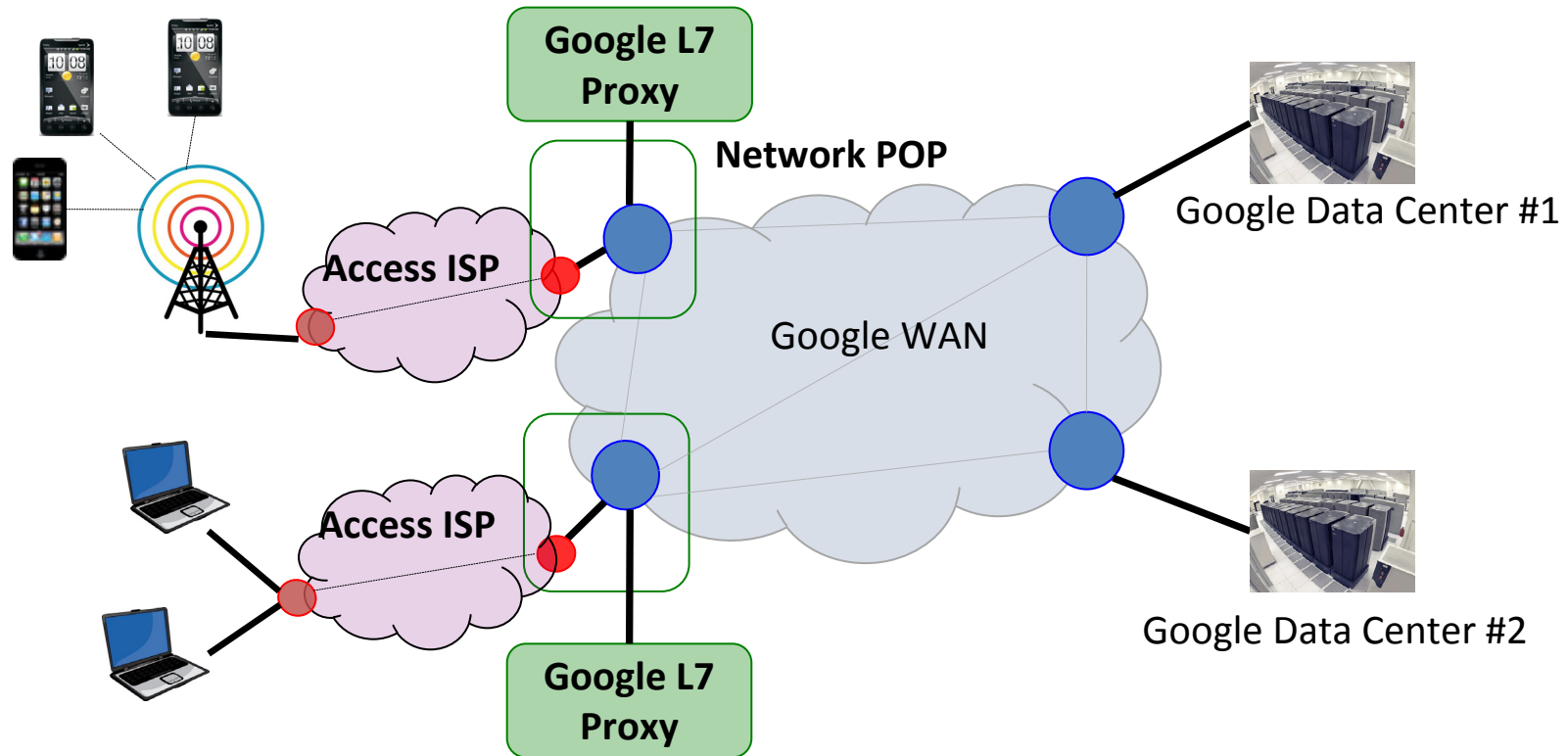
VF Chaining in a Multi-Cloud Multi-Tenant Environment

- Multiple tenants share computing and networking resources
- Google and Akamai already use this kind of service chaining



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Google WAN

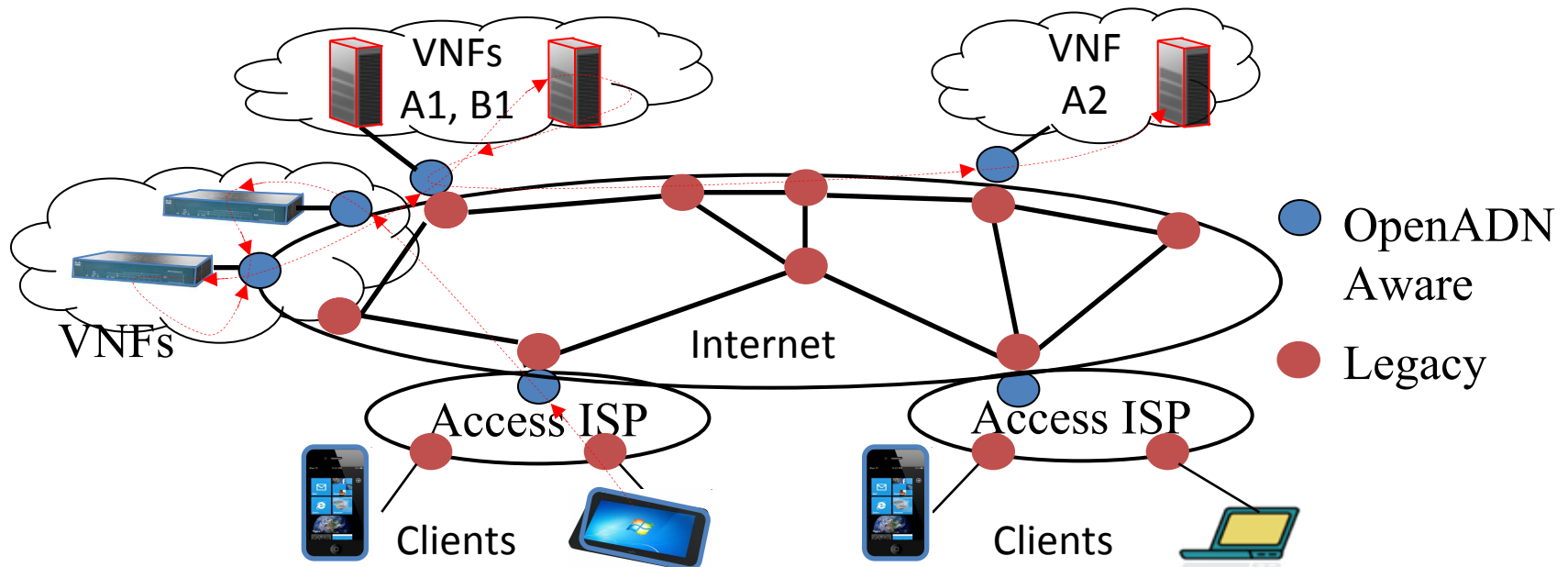


- Google appliances in Tier 3 ISPs
- Details of Google WAN are not public
- ISPs can not use it: L7 proxies require data visibility

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Our Solution: OpenADN

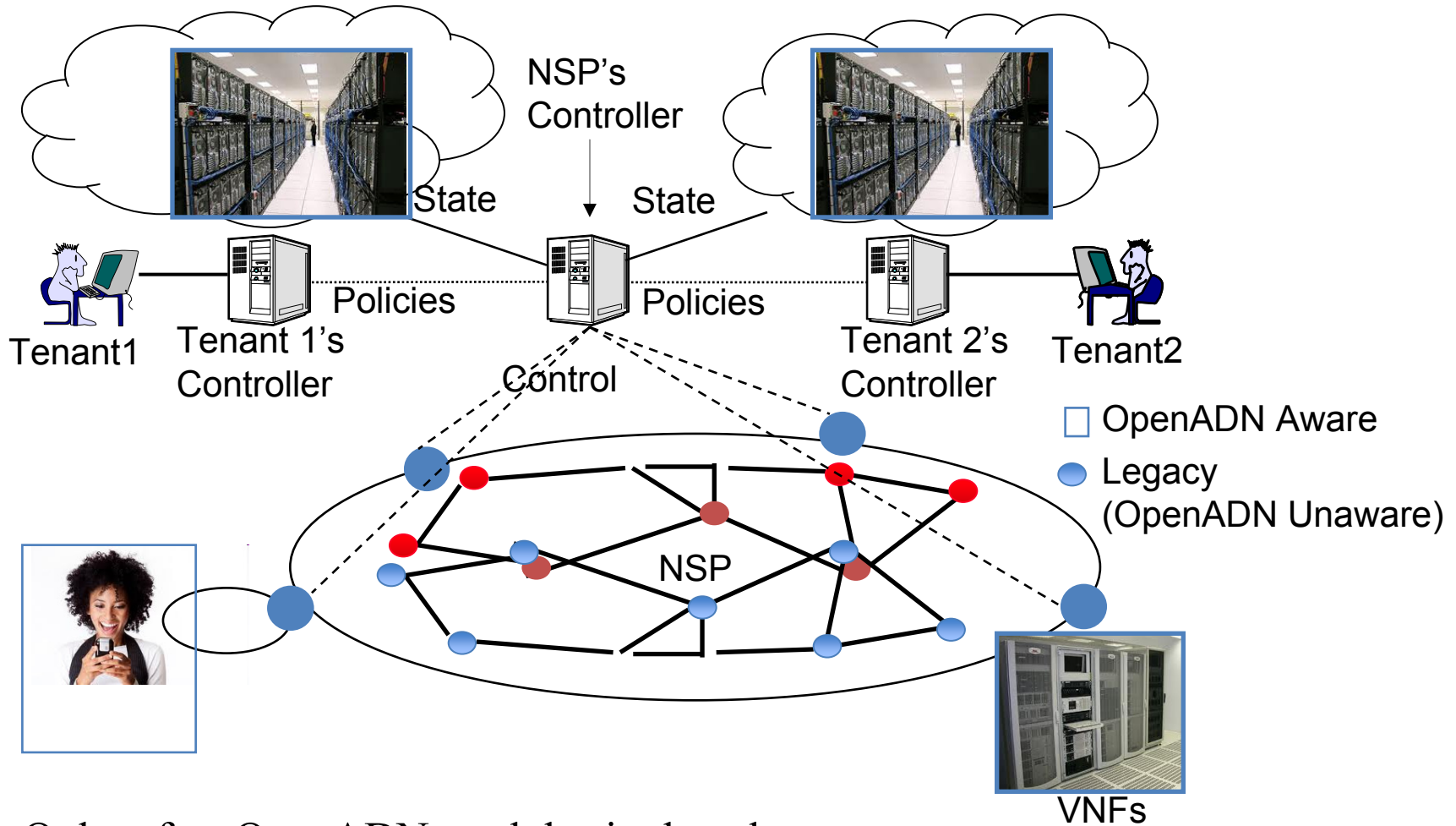
- Open Application Delivery Networking Platform
 = OpenADN aware clients, VNFs, switches, and middle-boxes
- Allows Tenant ISPs to quickly setup services using cloud computing and Infrastructure ISPs



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

Rule-Based Delegation



Only a few OpenADN modules in the edges are necessary.

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.

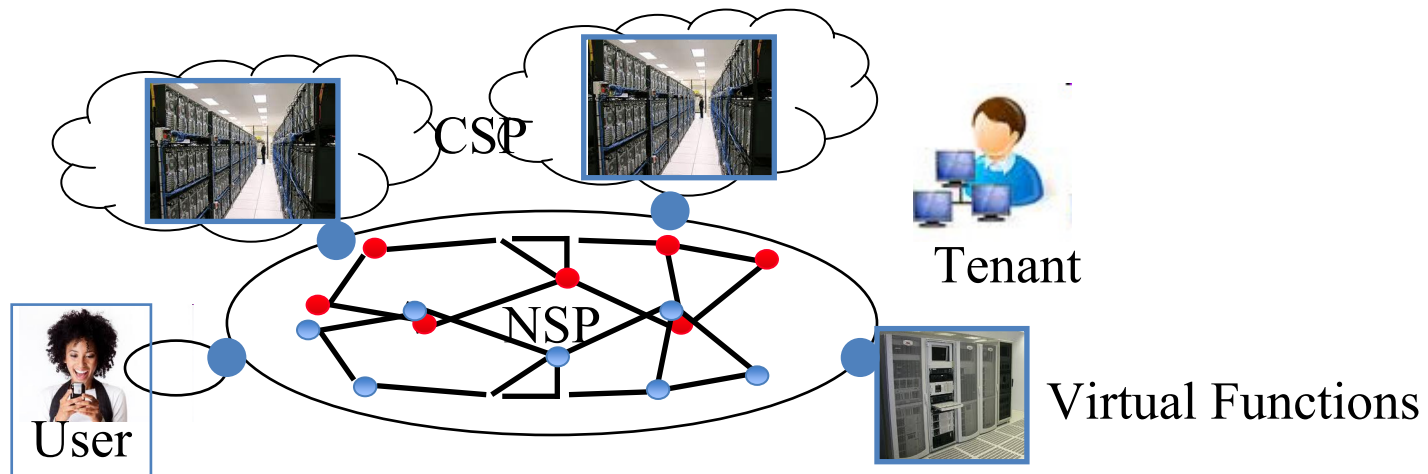
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Resource Control

- 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





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**.

http://www.cse.wustl.edu/~jain/talks/adn_stl.htm



References

- Raj Jain and Subharthi Paul, "**Network Virtualization and Software Defined Networking for Cloud Computing - A Survey**," IEEE Communications Magazine, Nov 2013, pp. 24-31, http://www.cse.wustl.edu/~jain/papers/net_virt.htm