OpenADN: Mobile Apps on Global Clouds Using Software Defined Networking



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

Top Networking Trends of 2012

1. Cloud Computing and Mobile Apps
2. Software Defined Networking
3. Centralization of Control Pane
4. Virtualization

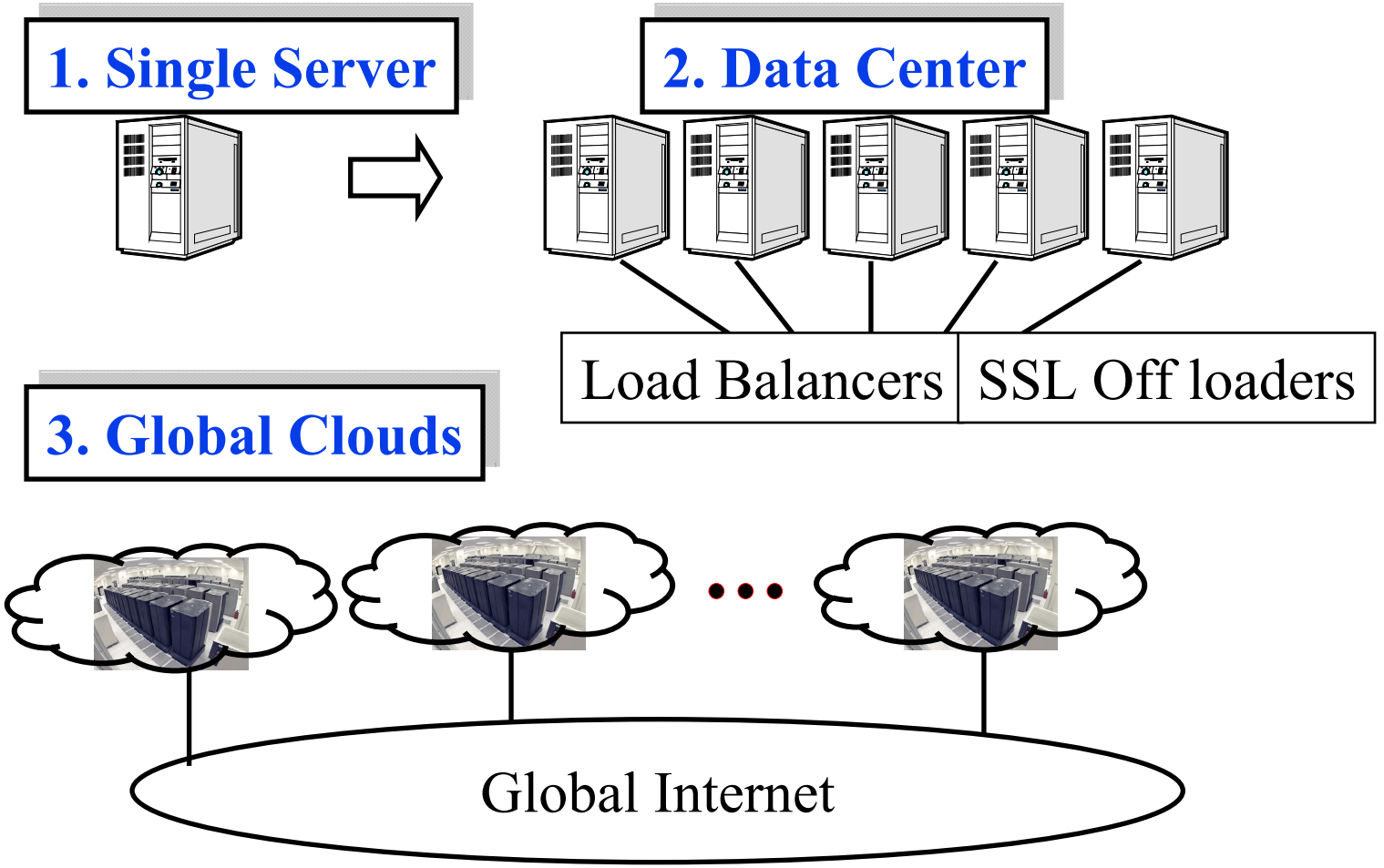
Clouds and Mobile Apps

- 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

- June 29, 2007: Apple announced iPhone
  ⇒ Birth of Mobile Internet, Mobile Apps
  - Almost all services are now mobile apps: Google, Facebook, Bank of America, …
  - Almost all services need to be global (World is flat)
  - Almost all services use cloud computing

Networks need to support efficient service setup and delivery

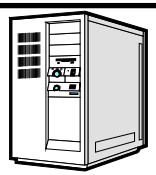
Service Center Evolution



Need to make the global Internet look like a data center

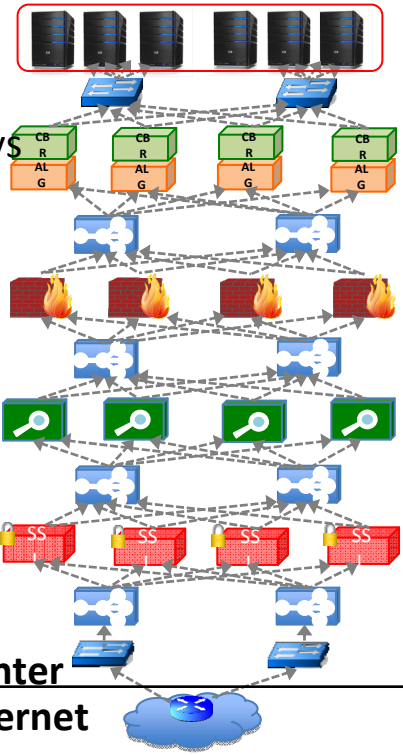
Service Center Evolution

1. Single Server



2. Datacenter

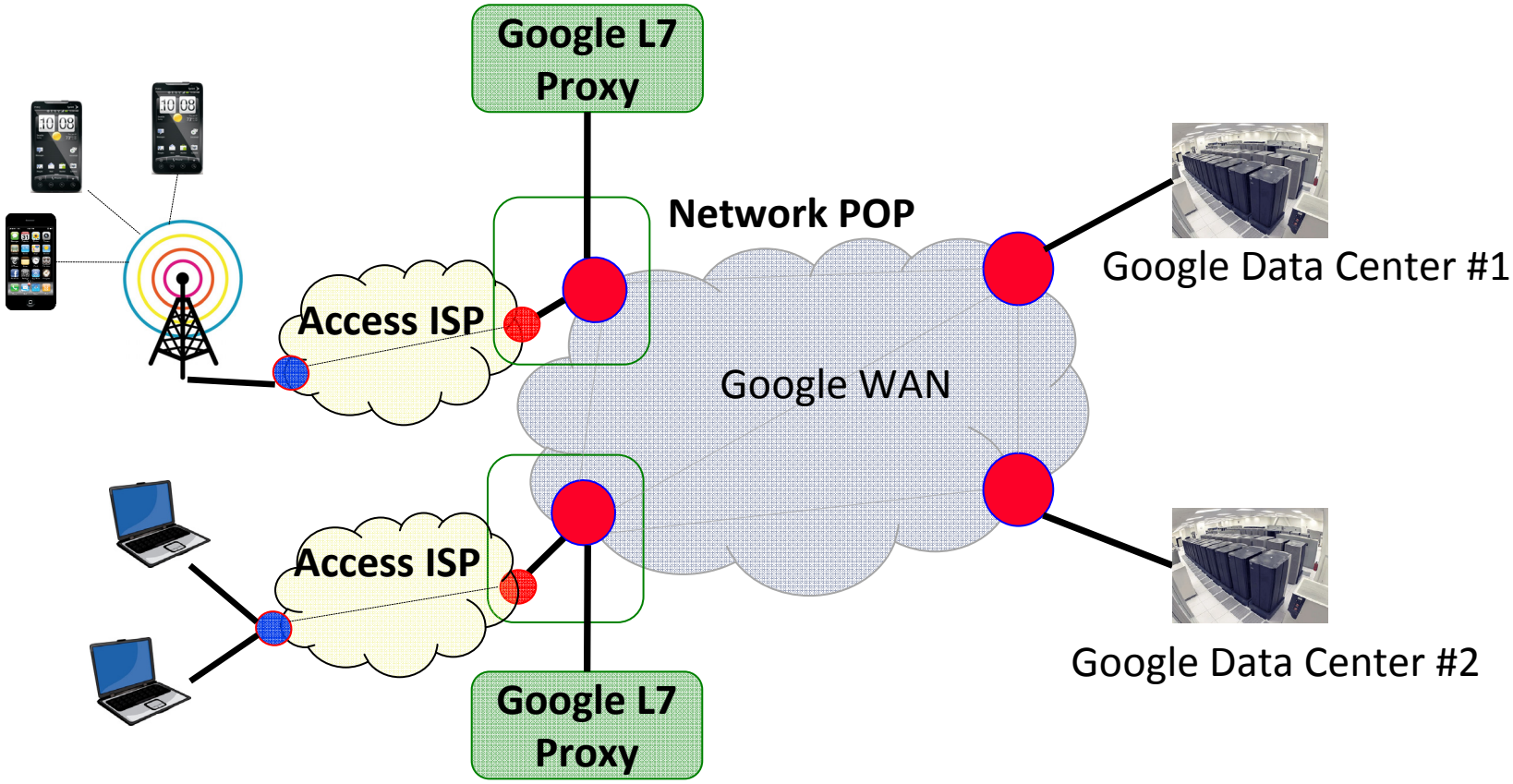
Application Servers
L2 Switches
Application Level Gateways & Content-Based Routers
Load Balancers
Application Firewalls
Load Balancers
Intrusion Detection and Prevention Systems
Load Balancers
SSL Offloaders
Load Balancers
L2 Switches



3. Global Clouds

Need to make the global Internet look like a data center

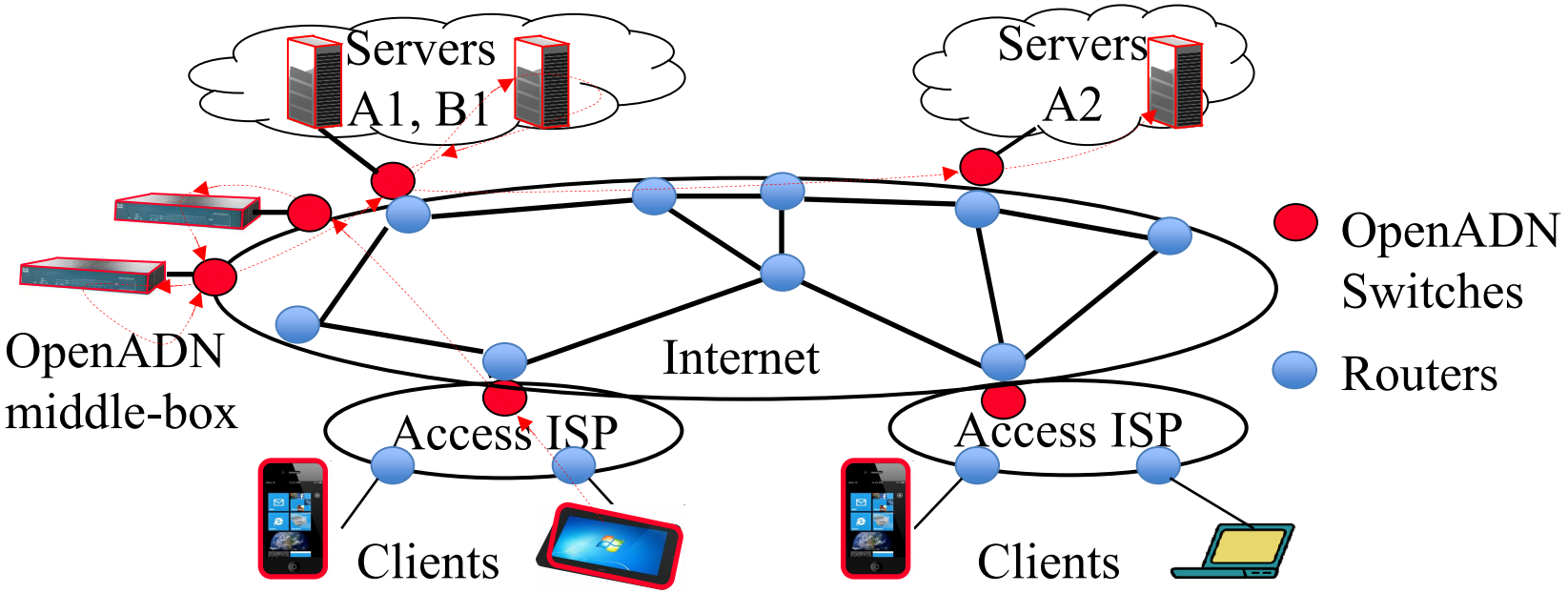
Google WAN



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

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

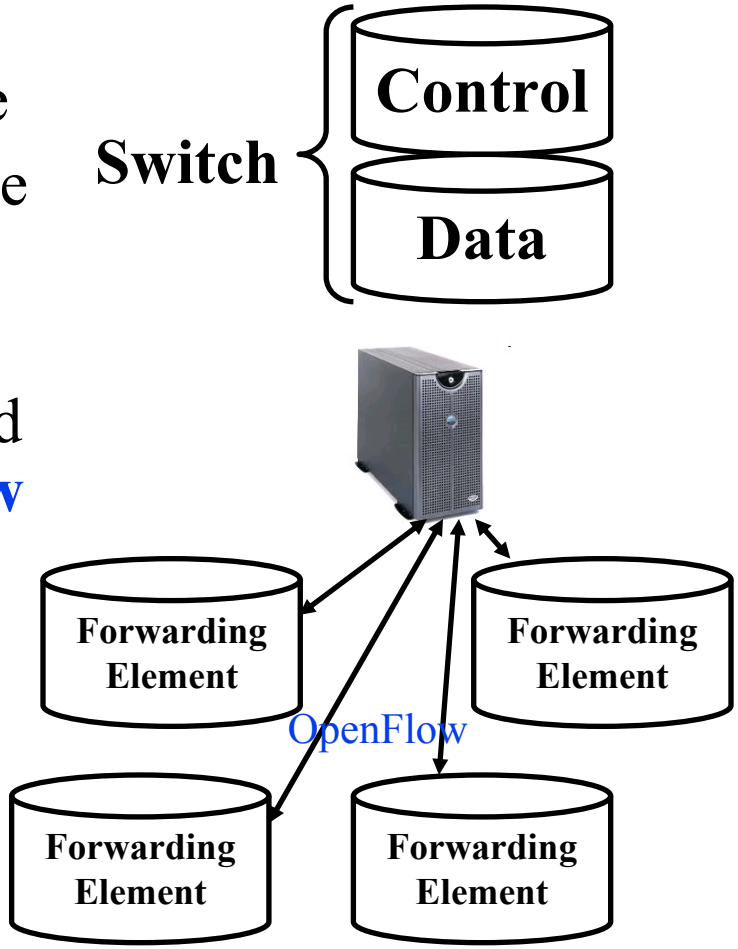


OpenADN Innovations

1. Cross-Layer Communication
2. MPLS like Labels
3. Extended OpenFlow flow-based handling, centralized policy control
4. Software Defined Networking: Standardized abstractions, Multi-Tenants, Control Plane programming for data plane
5. ID/Locator Split
6. Layer 7 Proxies without layer 7 visibility

Step 1: Centralization of Control Plane

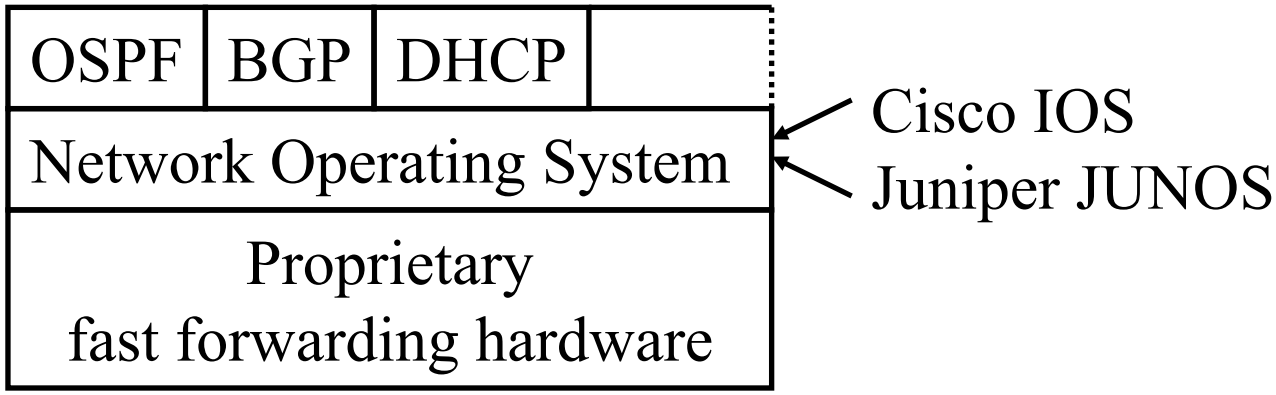
- Control = Prepare forwarding table
- Data Plane: Forward using the table
- Forwarding table is prepared by a central controller
- Protocol between the controller and the forwarding element: **OpenFlow**
- Centralized control of policies
- Switches are simple.
  Controller can be complex
  Can use powerful CPUs
- Lots of cheap switches
  = Good for large datacenters



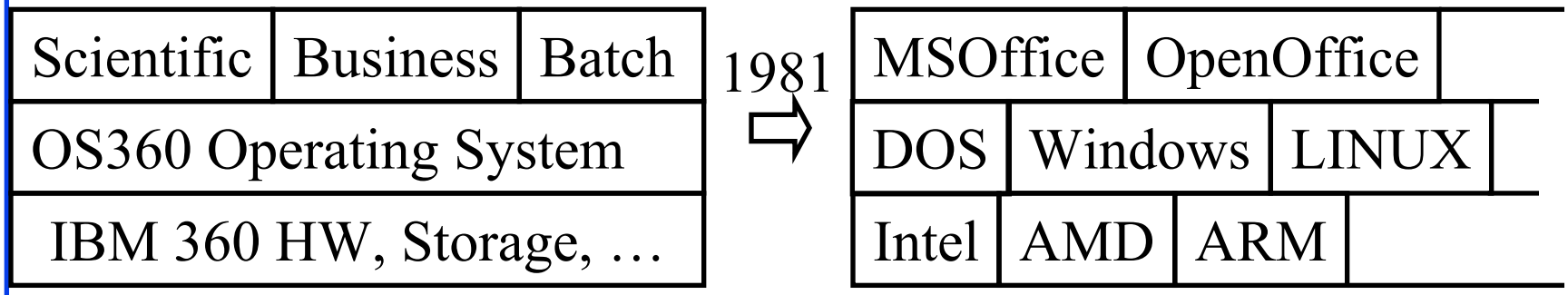
Ref: [MCK08] ``OpenFlow: Enabling Innovation in Campus Networks," OpenFlow Whitepaper, March 2008
http://www.openflow.org/documents/openflow-wp-latest.pdf

Step 2: Standardized Abstractions

- The routers are expensive because there is no standard implementation.

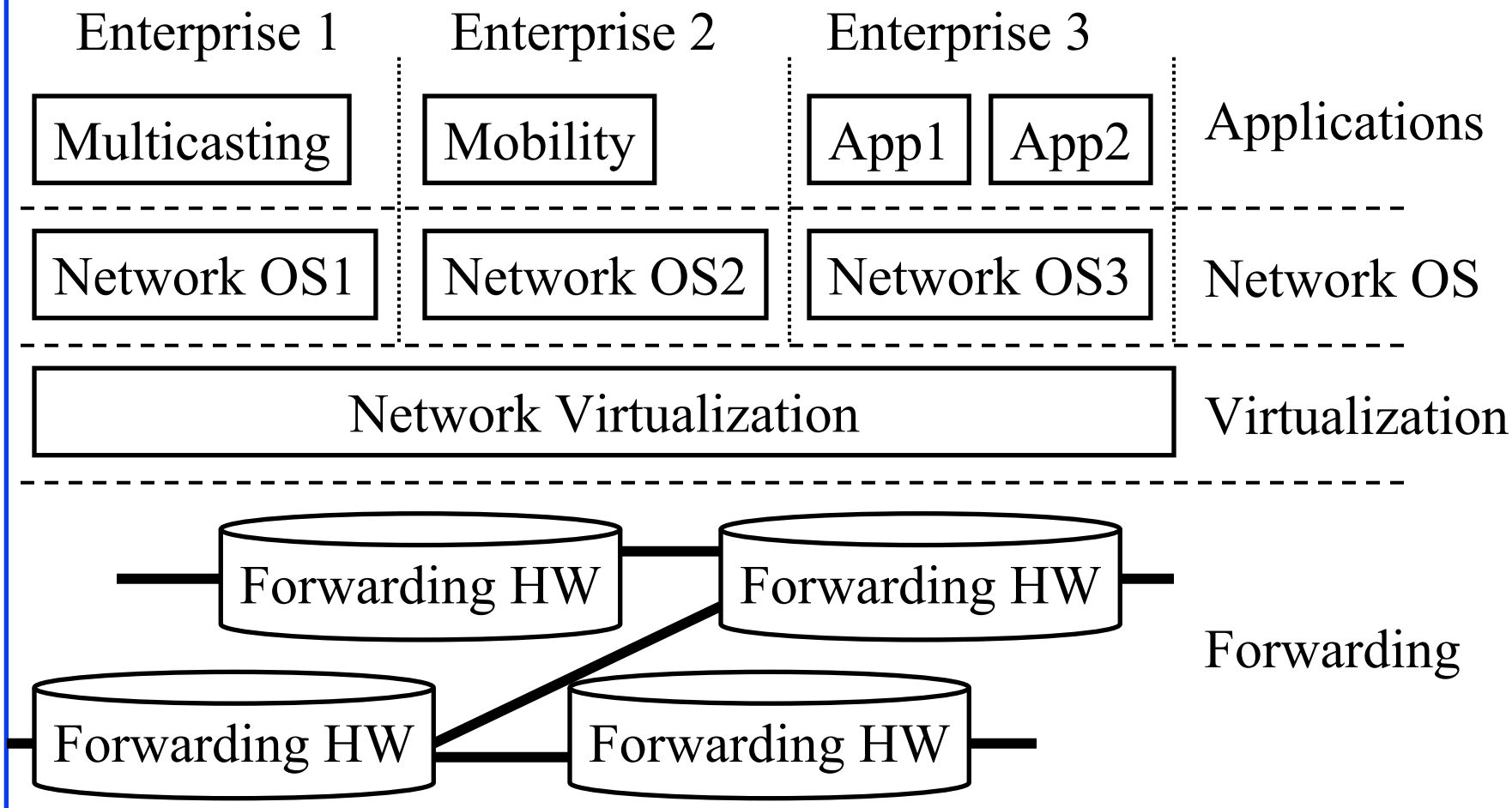


- Similar to Mainframe era computers.



Software Defined Networking

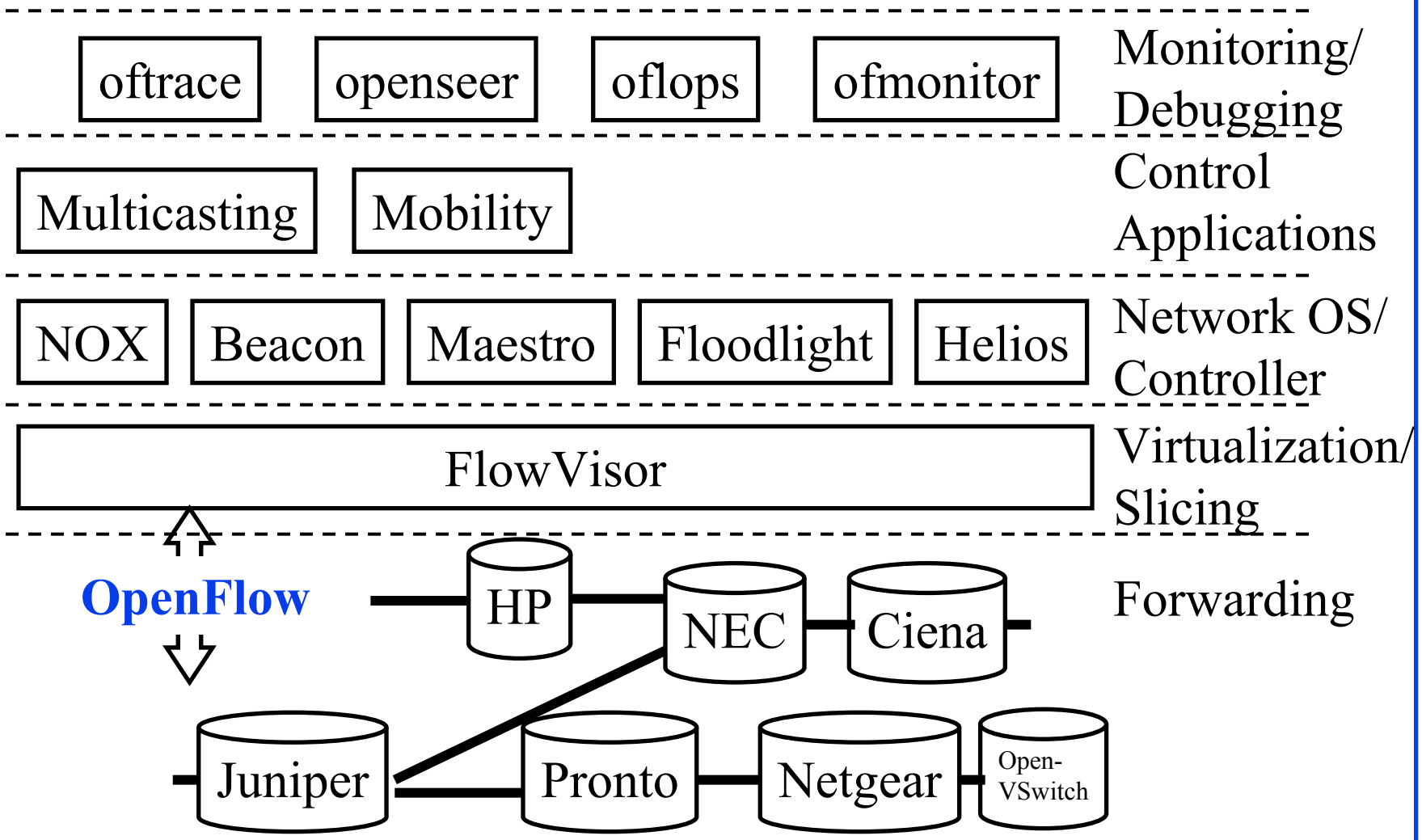
- Layered abstractions with standardized APIs



Ref: http://*www.itc23.com/.../K1_McKeown-ITC_Keynote_Sept_2011.pdf*

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

SDN Architecture Component Examples

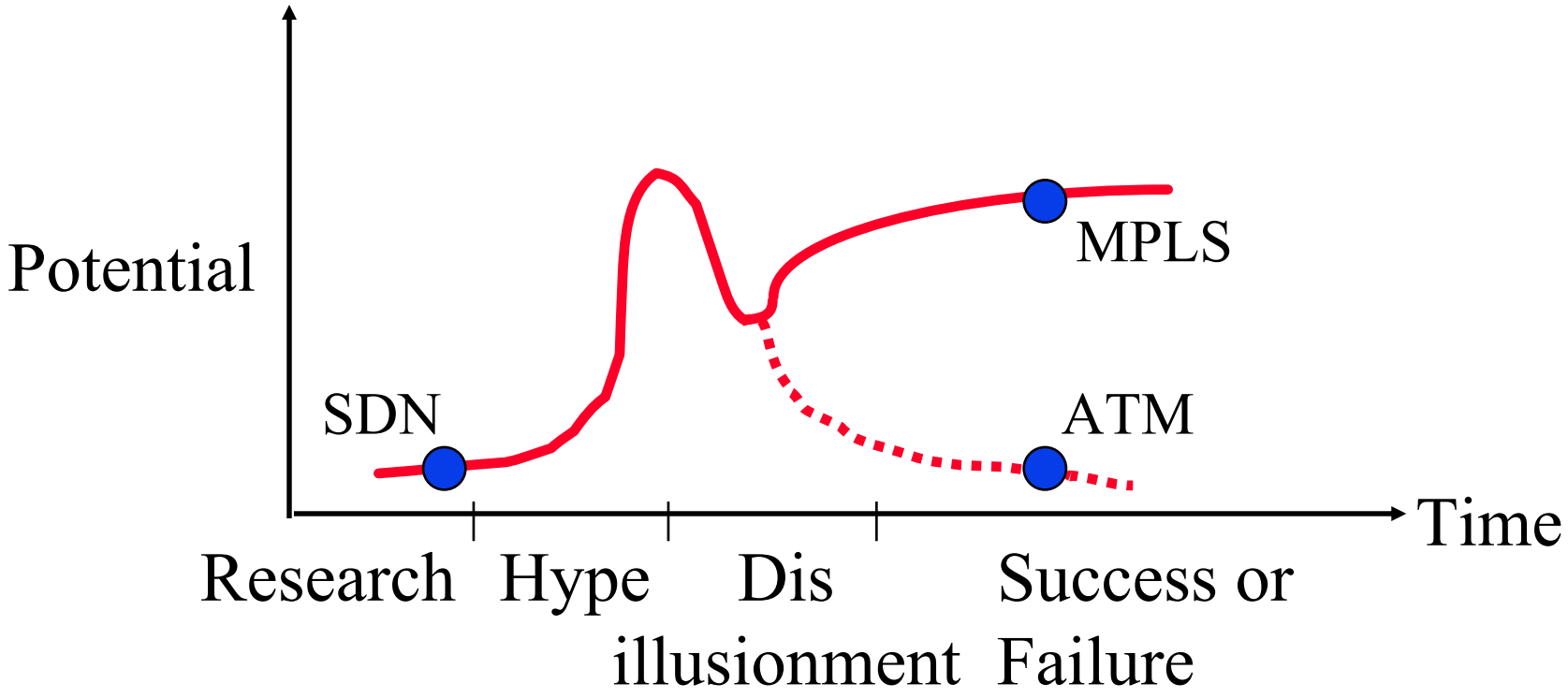


Ref: https://courses.soe.ucsc.edu/courses/cmpe259/Fall11/01/pages/lectures/srini-sdn.pdf
http://www.cse.wustl.edu/~jain/talks/adn_wpr.htm

SDN Impact

- Why so much industry interest?
  - Commodity hardware
    $\Rightarrow$ Lots of cheap forwarding engines $\Rightarrow$ Low cost
  - Programmability $\Rightarrow$ 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

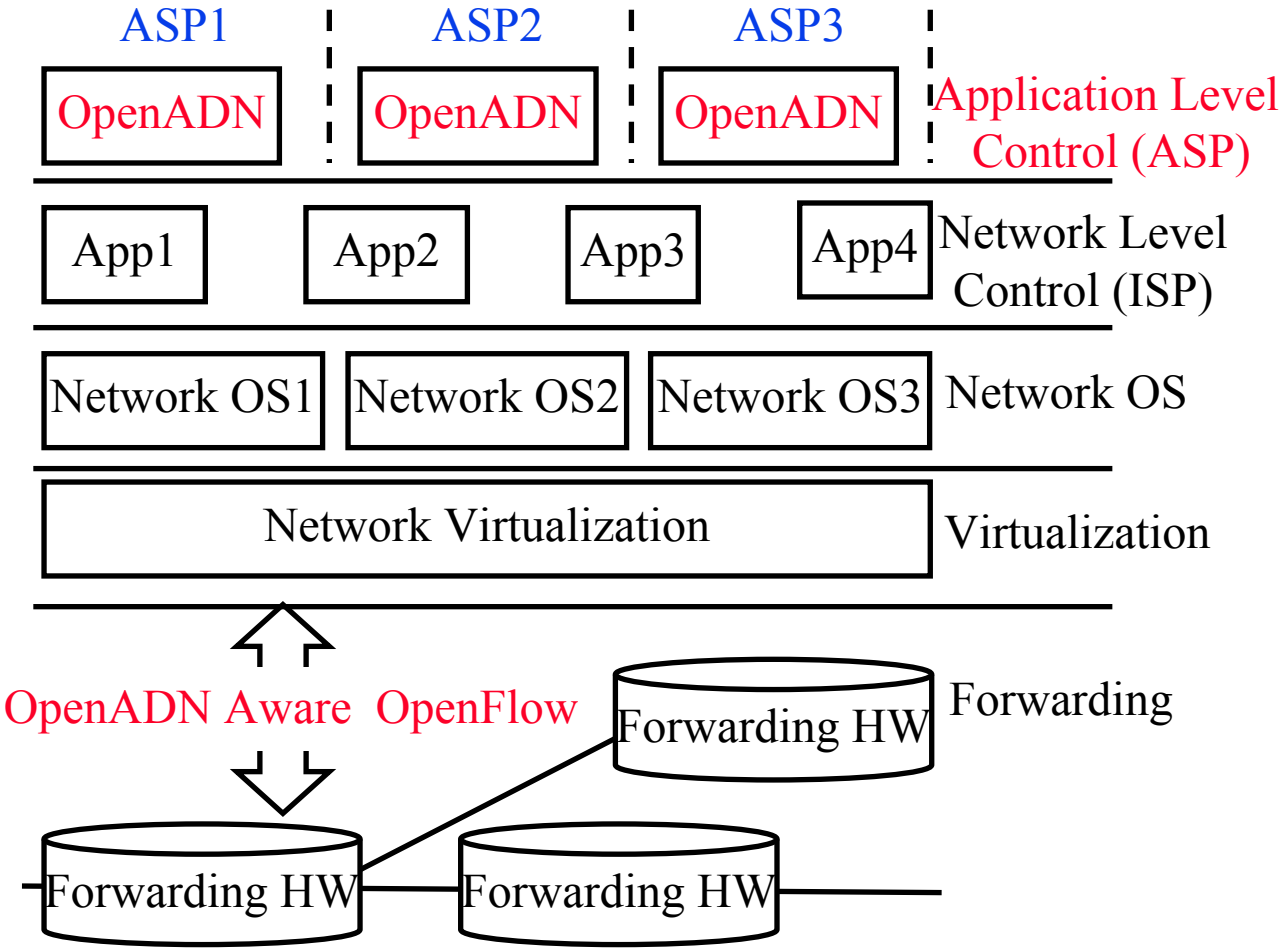
Life Cycles of Technologies



Industry Growth: Formula for Success

- Paradigm Shifts ⇒ Leadership Shift
- Old market leaders stick to old paradigm and loose
- Mini Computers→PC, Phone→Smart Phone, PC→Smart Phone

OpenADN in SDN's Layered Abstraction

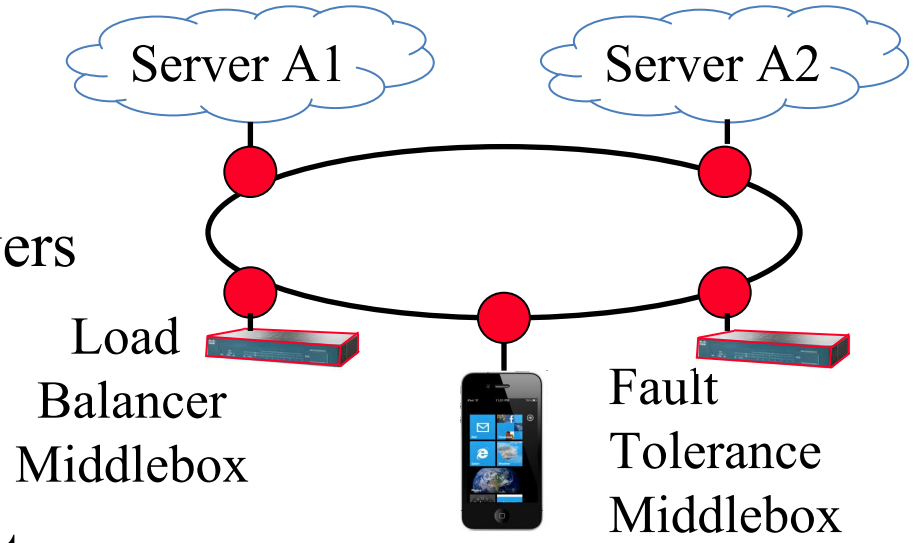


- SDN provides standardized mechanisms for distribution of control information

OpenADN Features

Message level:

- Server selection
- Load balancing between servers
- Fault tolerance
- Server mobility
- User Mobility
- Secure L5-L7 headers and data
- Middlebox services: Intrusion detection, Content based routers, application firewalls, …
  - Control plane and data plane MBs
- Middlebox traversal sequence
- Message level policies
- TCP Splicing



Networking: Failures vs Successes

- 1986: MAP/TOP (vs Ethernet)
- 1988: OSI (vs TCP/IP)
- 1991: DQDB
- 1994: CMIP (vs SNMP)
- 1995: FDDI (vs Ethernet)
- 1996: 100BASE-VG or AnyLan (vs Ethernet)
- 1997: ATM to Desktop (vs Ethernet)
- 1998: ATM Switches (vs IP routers)
- 1998: MPOA (vs MPLS)
- 1999: Token Rings (vs Ethernet)
- 2003: HomeRF (vs WiFi)
- 2007: Resilient Packet Ring (vs Carrier Ethernet)
- IntServ, DiffServ, …

Technology alone does not mean success.

Key Features of OpenADN

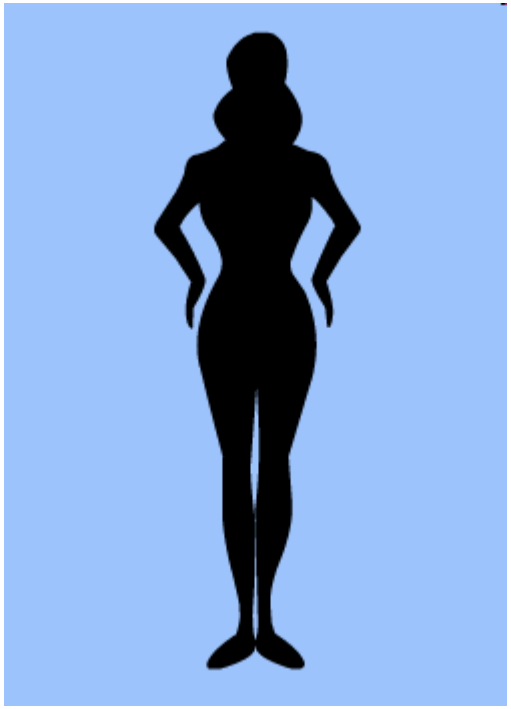
1. Edge devices only.
   Core network can be current TCP/IP based, OpenFlow or future SDN based
2. Coexistence (Backward compatibility):
   Old on New. New on Old
3. Incremental Deployment
4. Economic Incentive for first adopters
5. Resource owners (ISPs) keep complete control over their resources

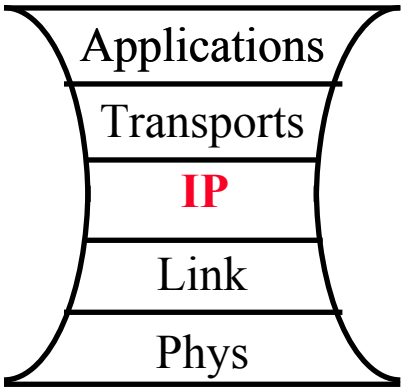
Most versions of Ethernet followed these principles.
Many versions of IP did not.

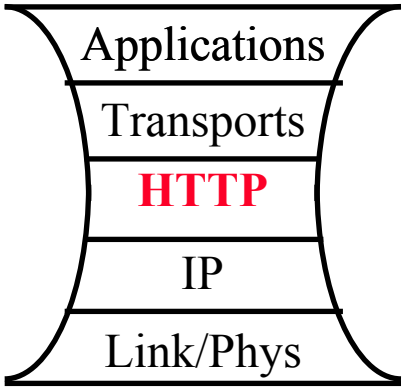
Resource Control

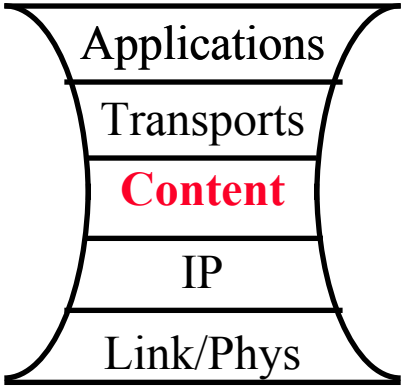
- ASPs keep complete control of their data.
  ISP does not have to look at the application headers or data to enforce application level policies
- ISPs keep complete control of their equipment.
  ASPs communicate their policies to ISP's control plane
- Middle boxes can be located anywhere on the global Internet
  (Of course, performance is best when they are close by)
- ISPs own OpenADN switches and offer them as a service
- ASPs or ISPs can own OpenADN middle boxes
- No changes to the core Internet

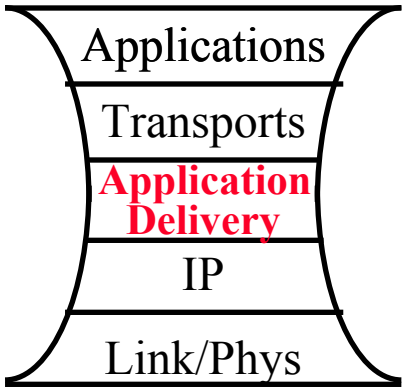
The Narrow Waist





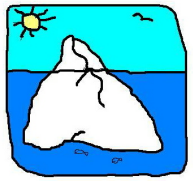






Network Virtualization

- OpenADN is per-application virtual global Internet
- Virtualization is the key enabler of cloud computing.
- Compute virtualization, storage virtualization, networking virtualization
- **Networking**: Plumbing
  - Past: Virtual Channels, Virtual LANs, VPN
  - Networks consist of: Hosts - L2 Links - L2 Bridges - L2 Networks - L3 Links - L3 Routers - L3 Networks – L4 Transports – L5 Applications
  - Each of these can be/need to be virtualized
  - Quick review of re[illegible]hnologies for network virtualization



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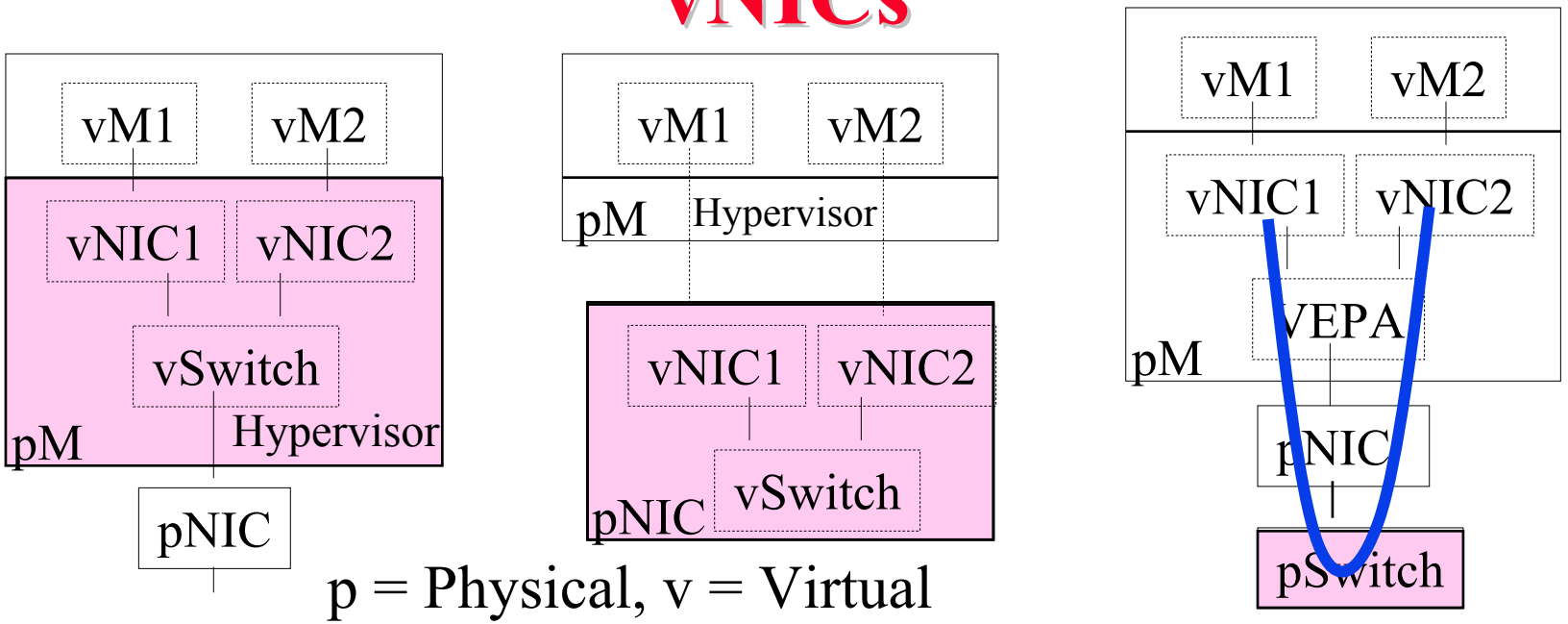
vNICs

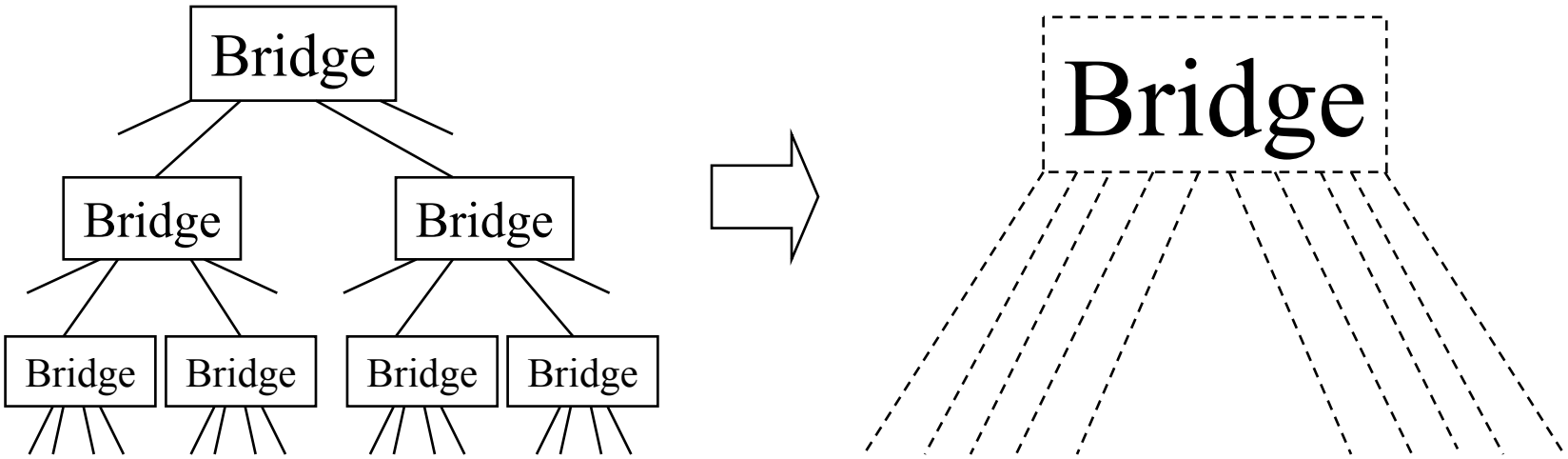


p = Physical, v = Virtual

1. Hypervisor vendors: S/W NICs in w Virtual Ethernet Bridge (**VEB**)(overhead, not ext manageable, not all features)
2. NIC Vendors: NIC provides virtual ports using Single-Route I/O virtualization (**SR-IOV**) on PCI bus
3. Switch Vendors: Switch provides virtual channels for inter-VM Communications using virtual Ethernet port aggregator (**VEPA**): **802.1Qbg** (s/w upgrade), **802.1Qbh** (new switches)

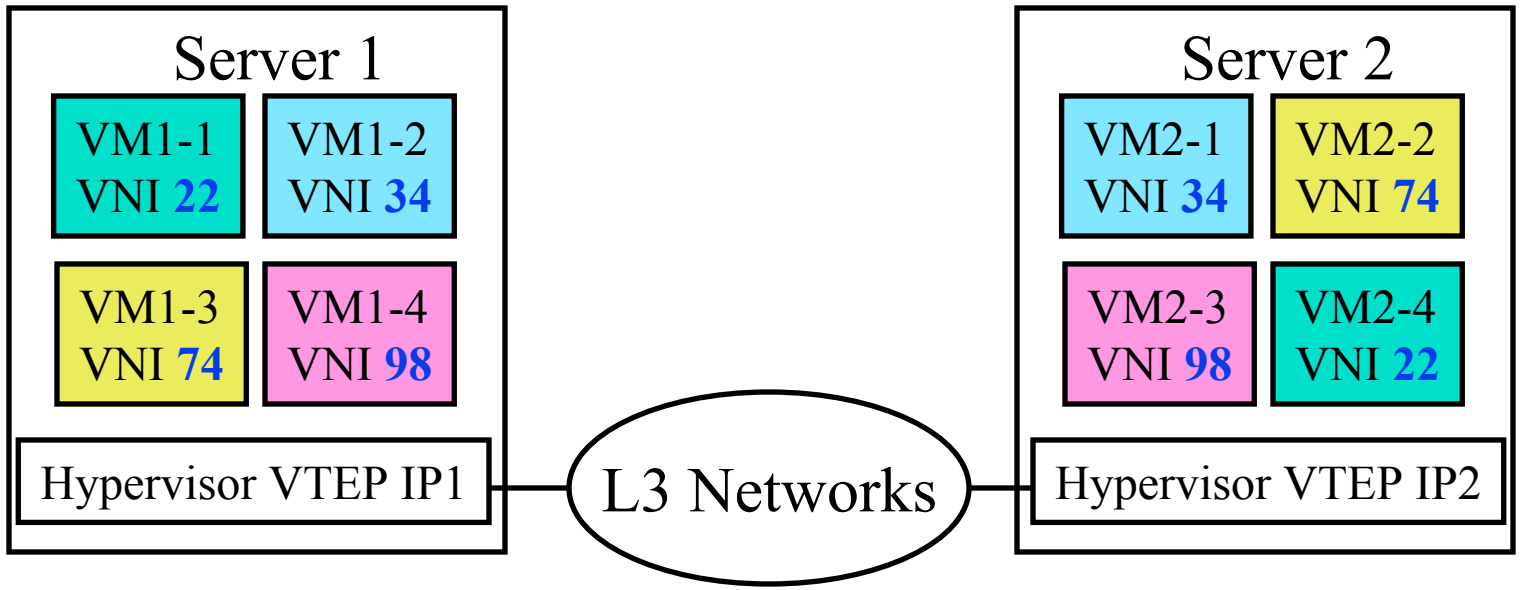
Bridge Port Extension

- Multiple physical bridges to make a single virtual bridge with a large number of ports
  ⇒ Easy to manage and configure
- **IEEE 802.1BR**



Multi-Tenants

- Each tenant needs its own networking domain with its VLAN IDs

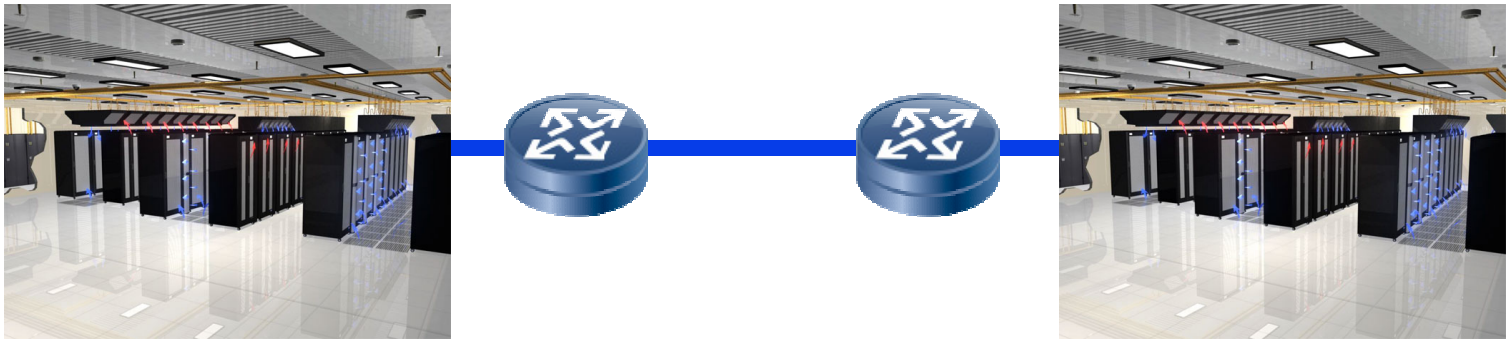


1. Virtual Extensible Local Area Networks (**VXLAN**)
2. Network Virtualization using Generic Routing Encapsulation (**NVGRE**)
3. Stateless Transport Tunneling Protocol (**STT**)

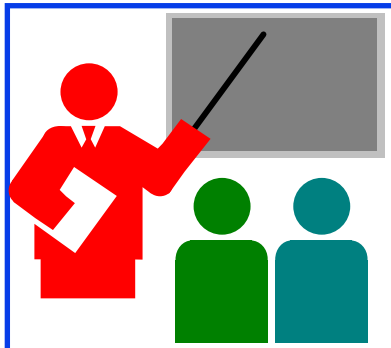
⇒ Network Virtualization over L3 (**NVO3**) group in IETF

Multi-Site

- Better to keep VM mobility in a LAN (IP address changes if subnet changes)



- Solution: IP encapsulation
- Transparent Interconnection of Lots of Links (**TRILL**)



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