Current Trends in Internet Evolution and a Framework for Application Delivery

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

Overview

1. Networking Application Trends
2. OpenFlow and SDN
3. OpenADN Vision and Extensions
4. Key Features

2012: Where are we now?

- At the knee of Mobile Internet age (paradigm shift)
  - Computing (IBM 360) ⇒ Mini-computing (PDP11) ⇒ Personal Computing (Desktop, PC+MAC) ⇒ Laptops ⇒ Netbooks ⇒ Smart Phones + Tablets
    Shift started on June 29, 2007 when iPhone was released.
- Most valued companies in the stock market are generally those that lead the paradigm shift
  - Automotive (General Motors) ⇒ Electrical (GE, Edison Electric) ⇒ Networking (Cisco + 3Com in 80's) ⇒ Internet (Netscape + Yahoo in 90's) ⇒ Mobile Internet (Apple +MS+ Google, 2010's)
- Note: Apple ≠ PC (MAC) company (mobile device company)
  - Google ≠ search engine (mobile device company)
- Also Social Networking (Facebook), Internet Retail (Amazon)

Trend: Explosion of Mobile Apps and Clouds

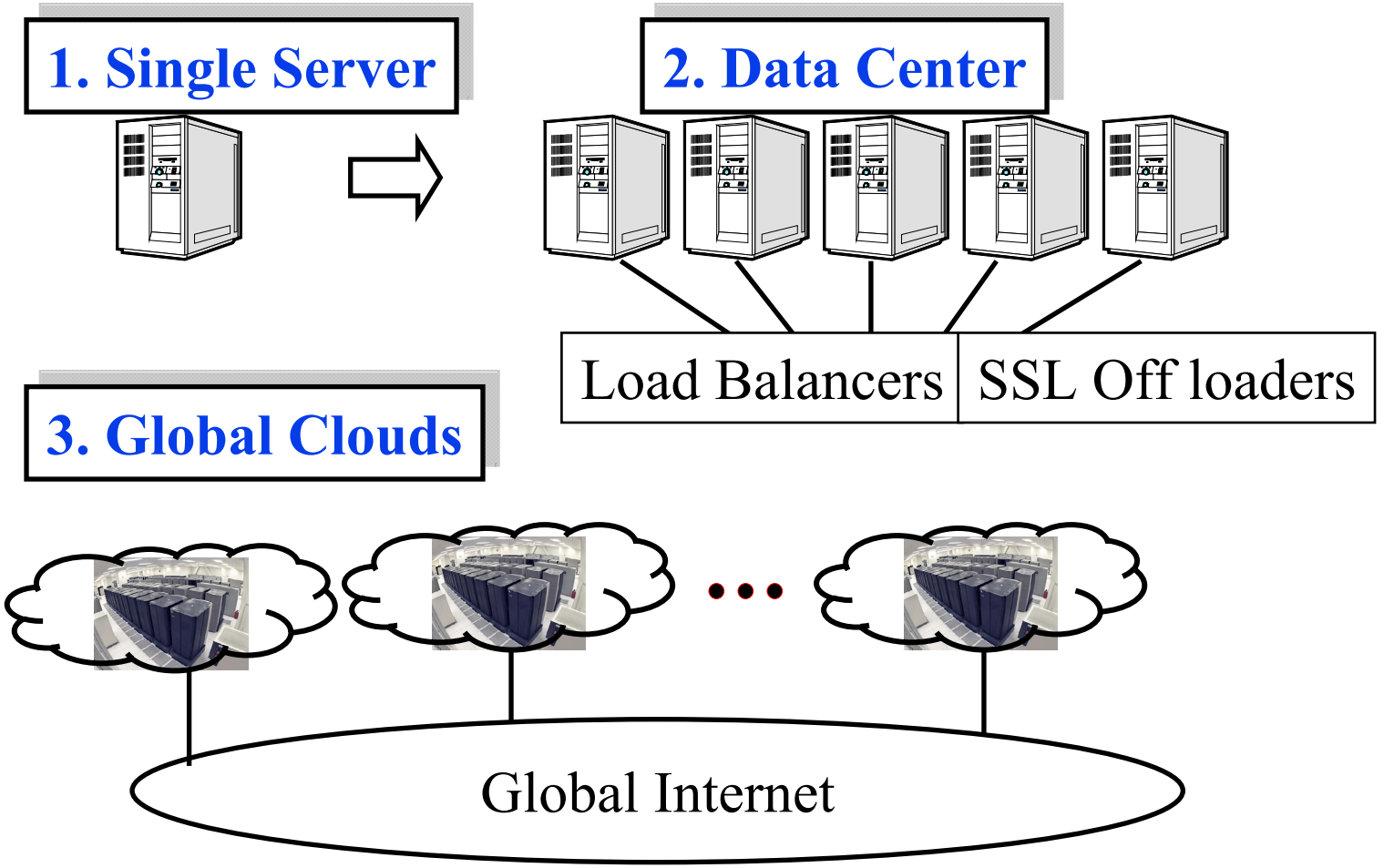



- All top 50 Internet sites are services [Alexa]
- Almost all services are now mobile apps: Google, Facebook, Bank of America, …
- Almost all services need to be global (World is flat)
- Almost all services use cloud computing (Easy management)

Networks need to support efficient service setup and delivery

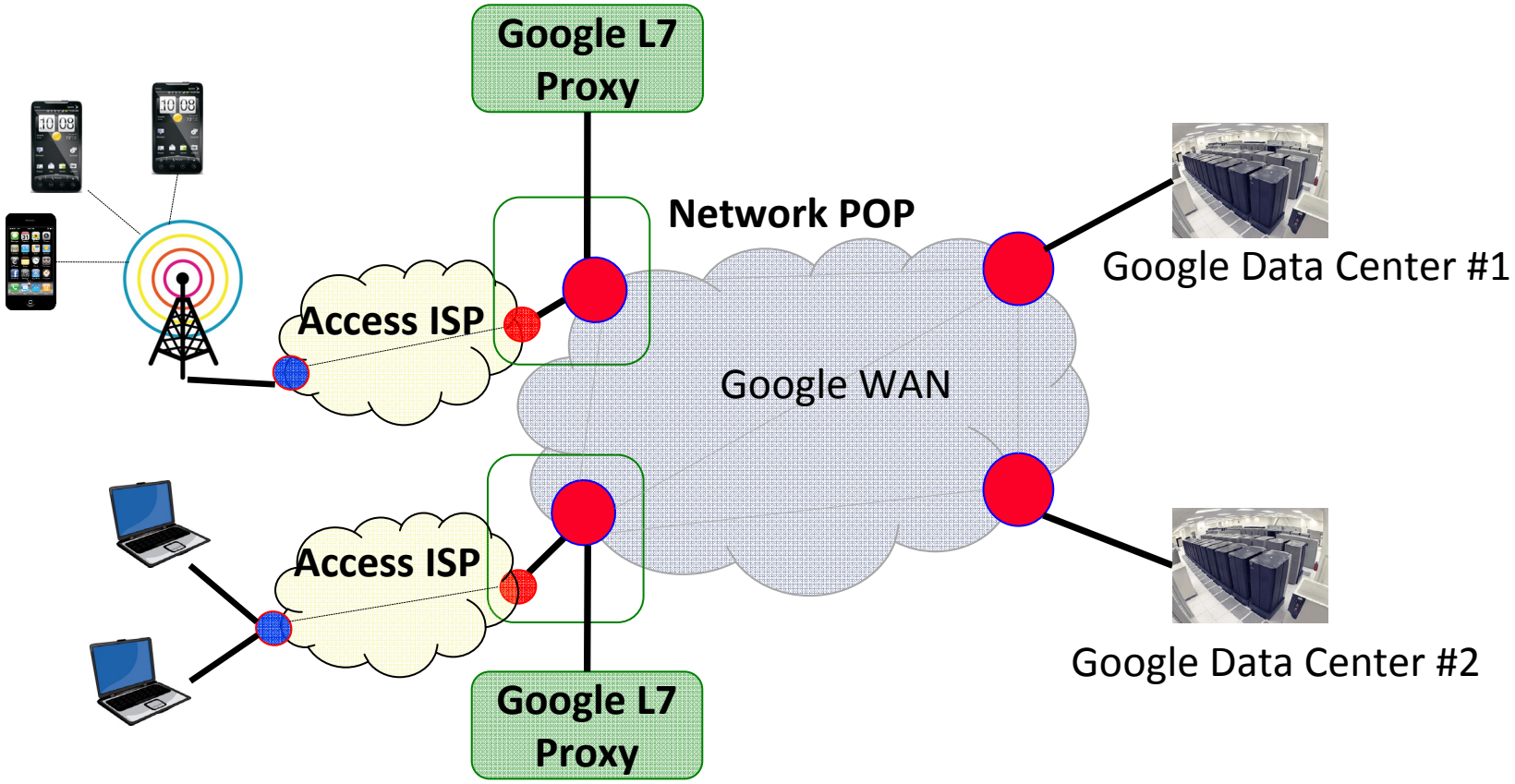
Ref: Top 500 sites on the web, http://www.alexa.com/topsites

Service Center Evolution



Need to make the global Internet look like a data center

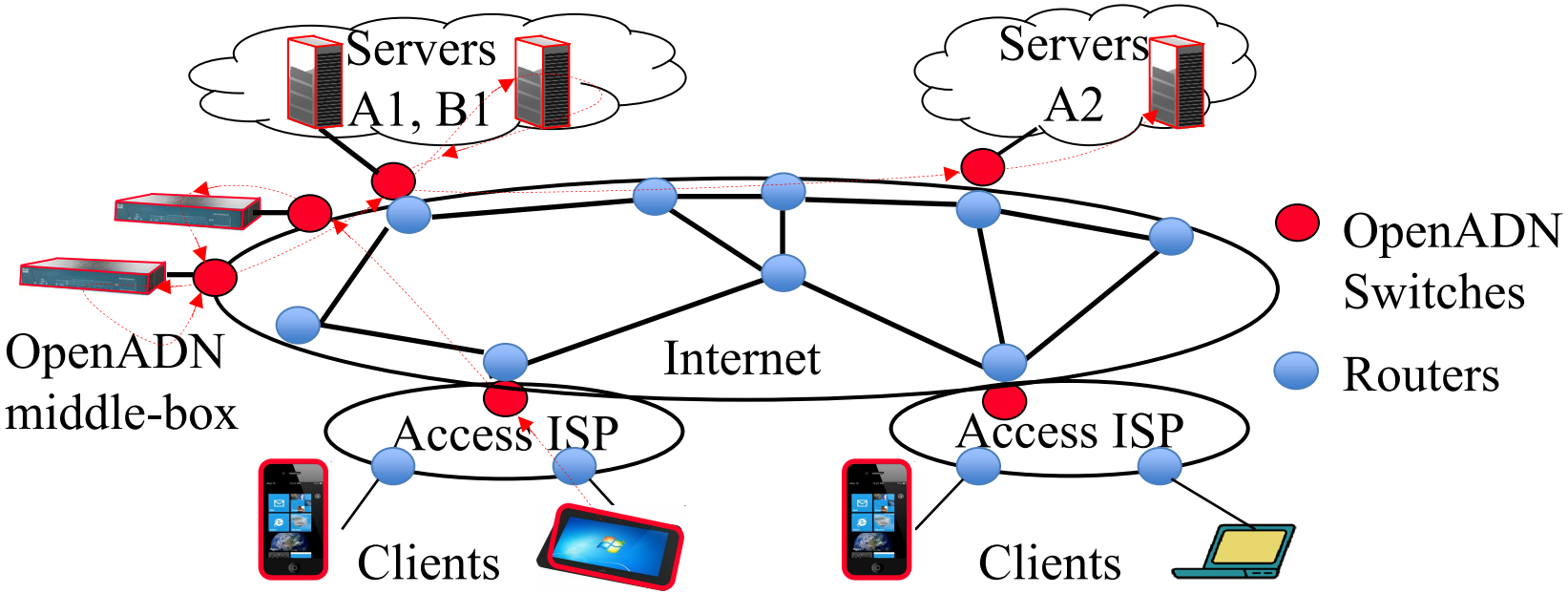
Google WAN



- OpenADN appliances are like 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

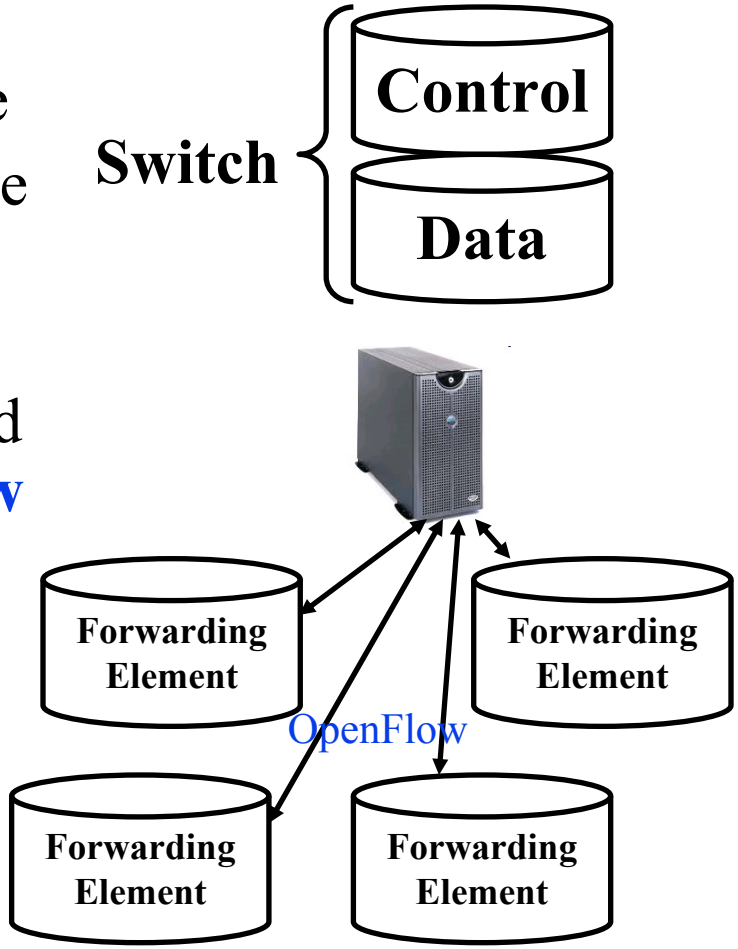


OpenADN Innovations

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

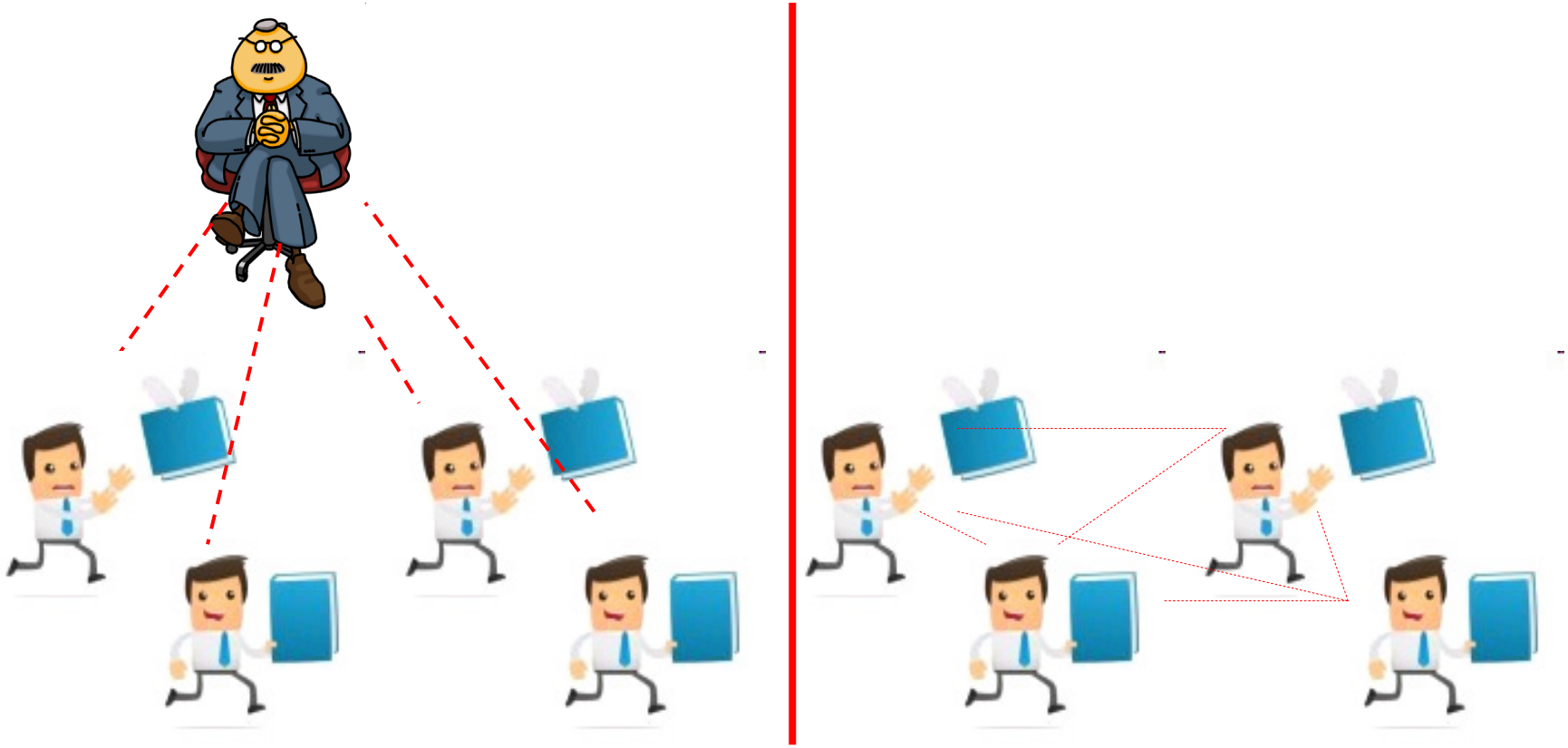
Step 1: Separation of Control and Data Planes

- 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

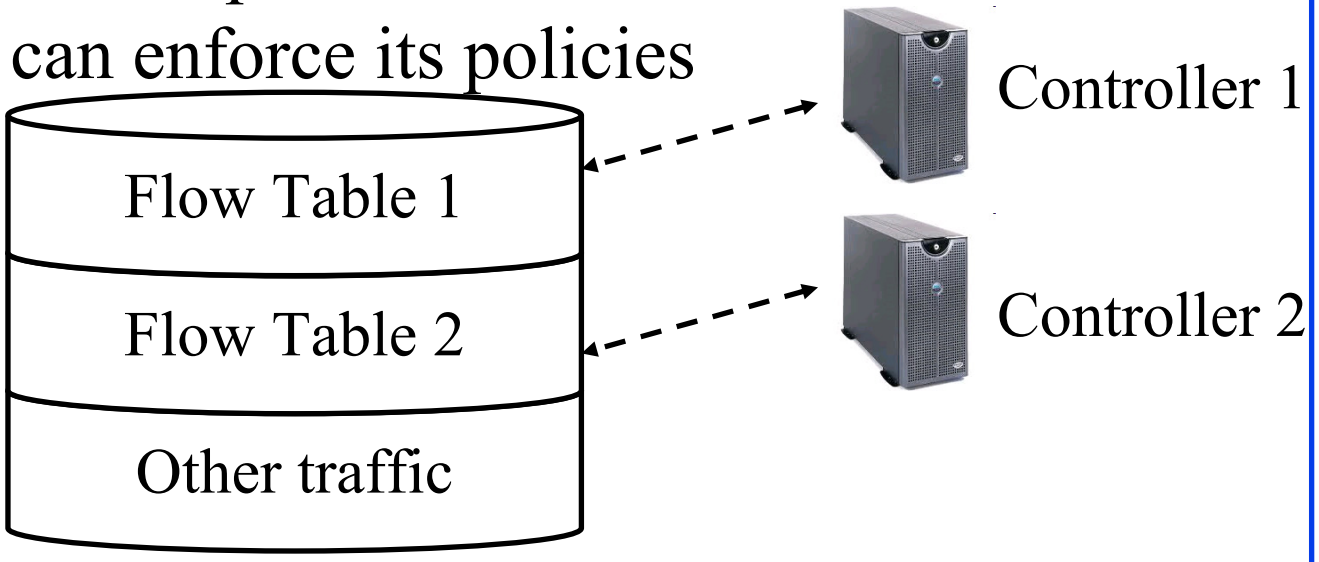
Centralized vs. Distributed



- Fully centralized is not scalable.
  Fully distributed is not manageable.
  ⇒ Hierarchy

Step 2: Multi-Tenants Clouds

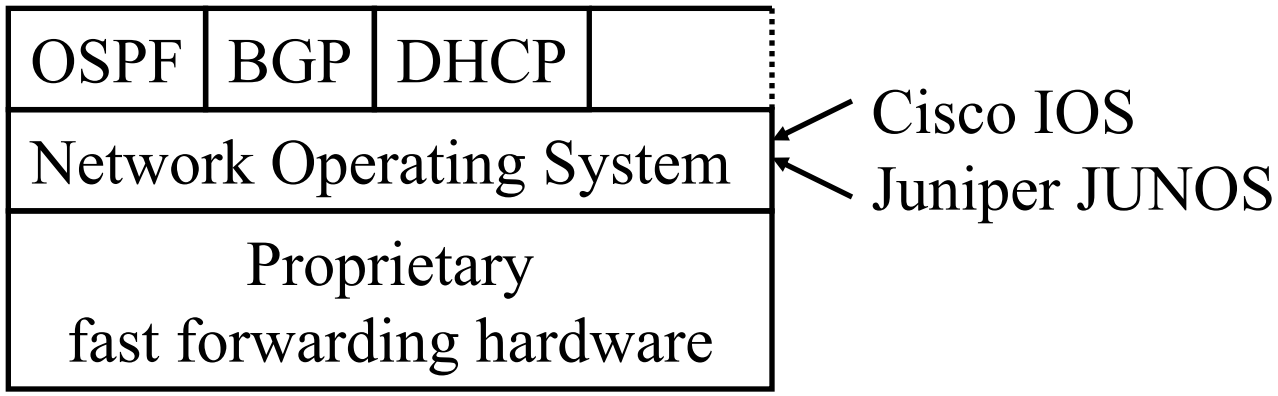
- Problem: Multiple tenants in the datacenter
- Solution: Use multiple controllers.
  Each tenant can enforce its policies



- Significant industry interest ⇒ Open Networking Foundation, https://www.opennetworking.org/

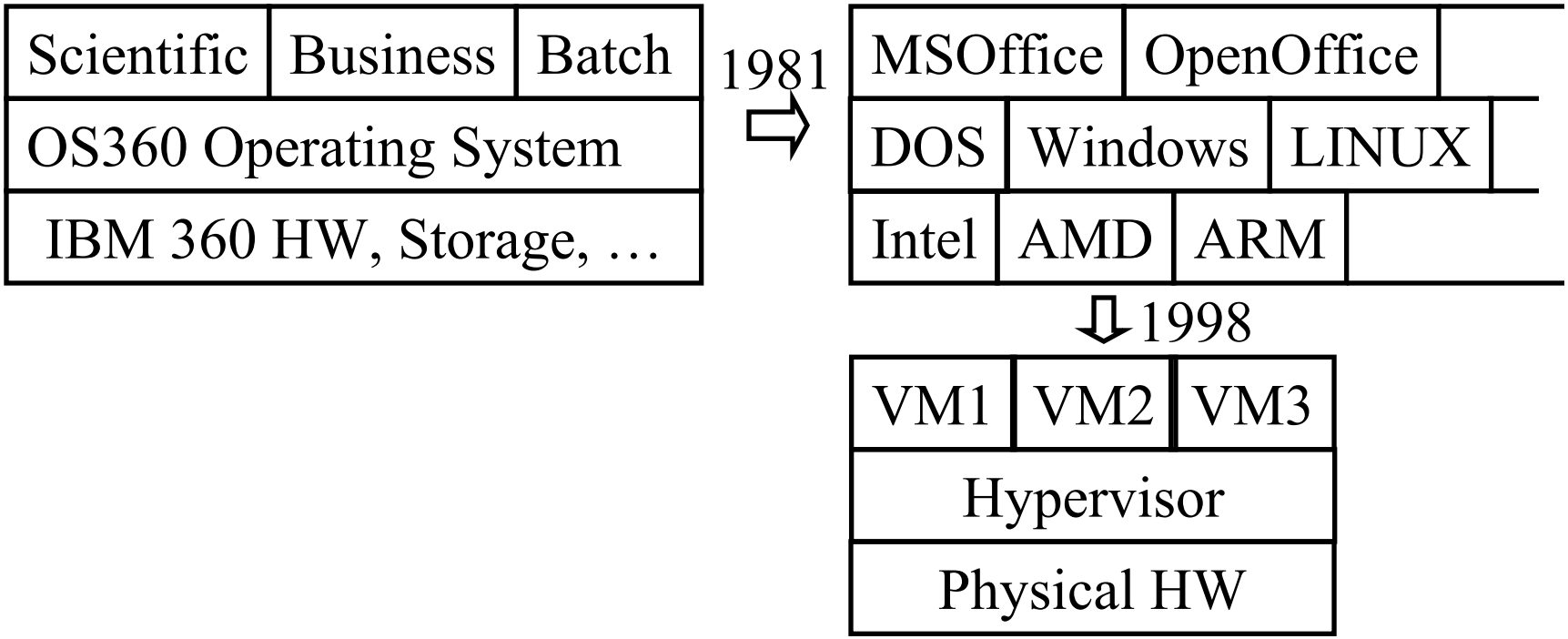
Step 3: Standardized Abstractions

- The routers are expensive because there is no standard implementation.
- Every vendor has its own hardware, operating/ management system, and proprietary protocol implementations.
- Similar to Mainframe era computers.
  No cross platform operating systems (e.g., Windows) or cross platform applications (java programs).



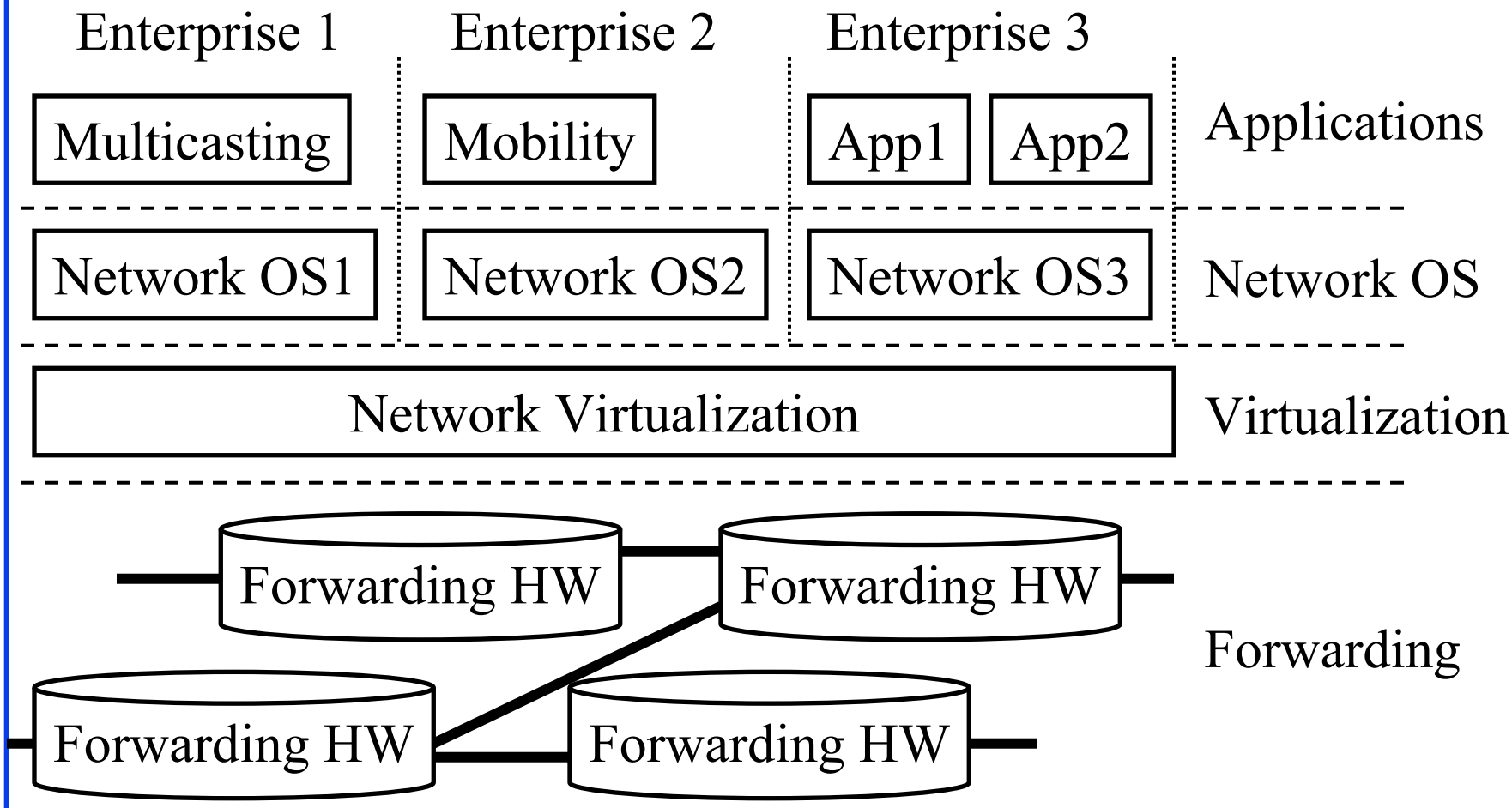
Example: PC Paradigm Shift

- Computing became cheaper because of clear division of hardware, operating system, and application boundaries with well defined APIs between them
- Virtualization ⇒ simple management + multi-tenant isolation



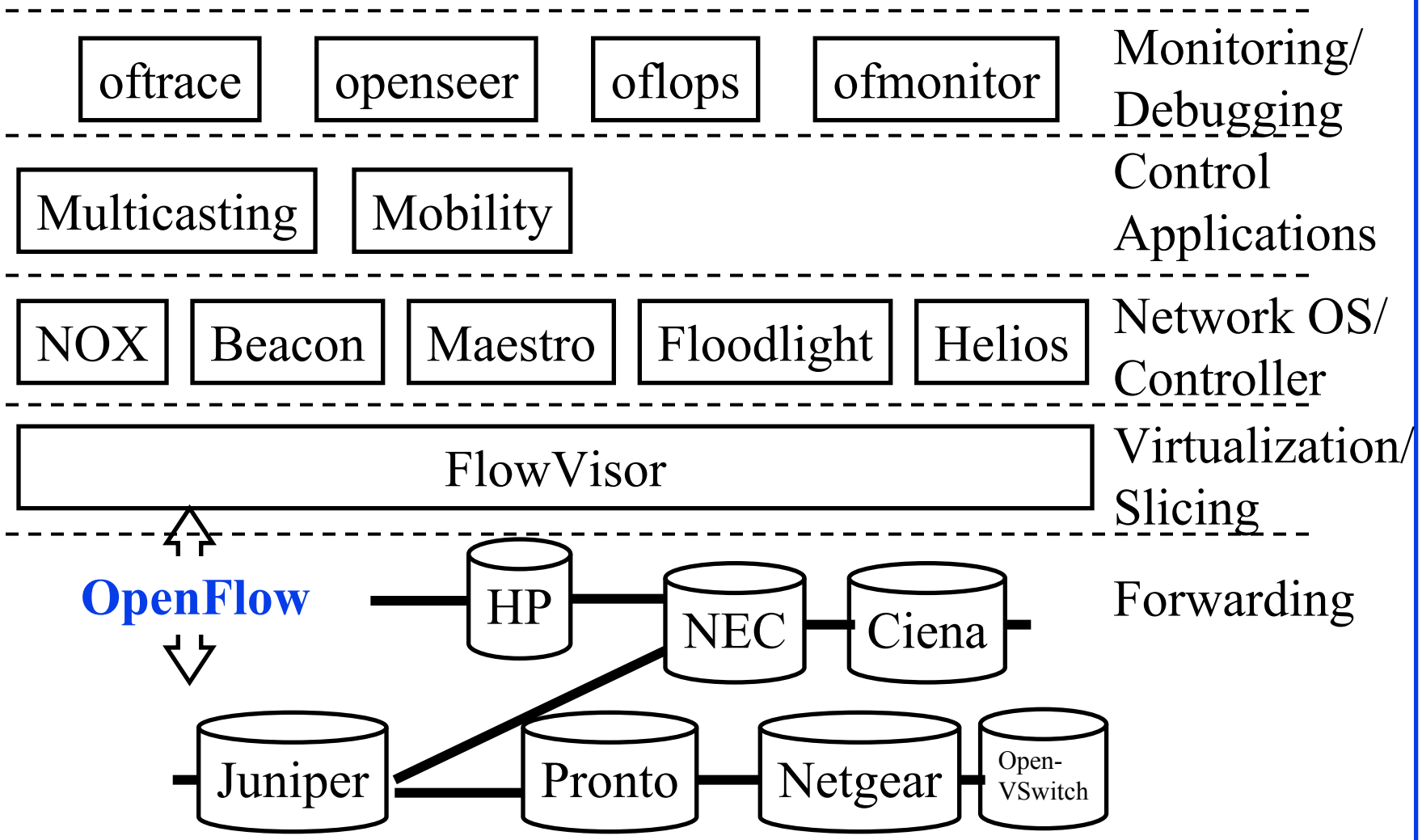
Software Defined Networking

- Layered abstractions with standardized APIs



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

SDN Architecture Component Examples

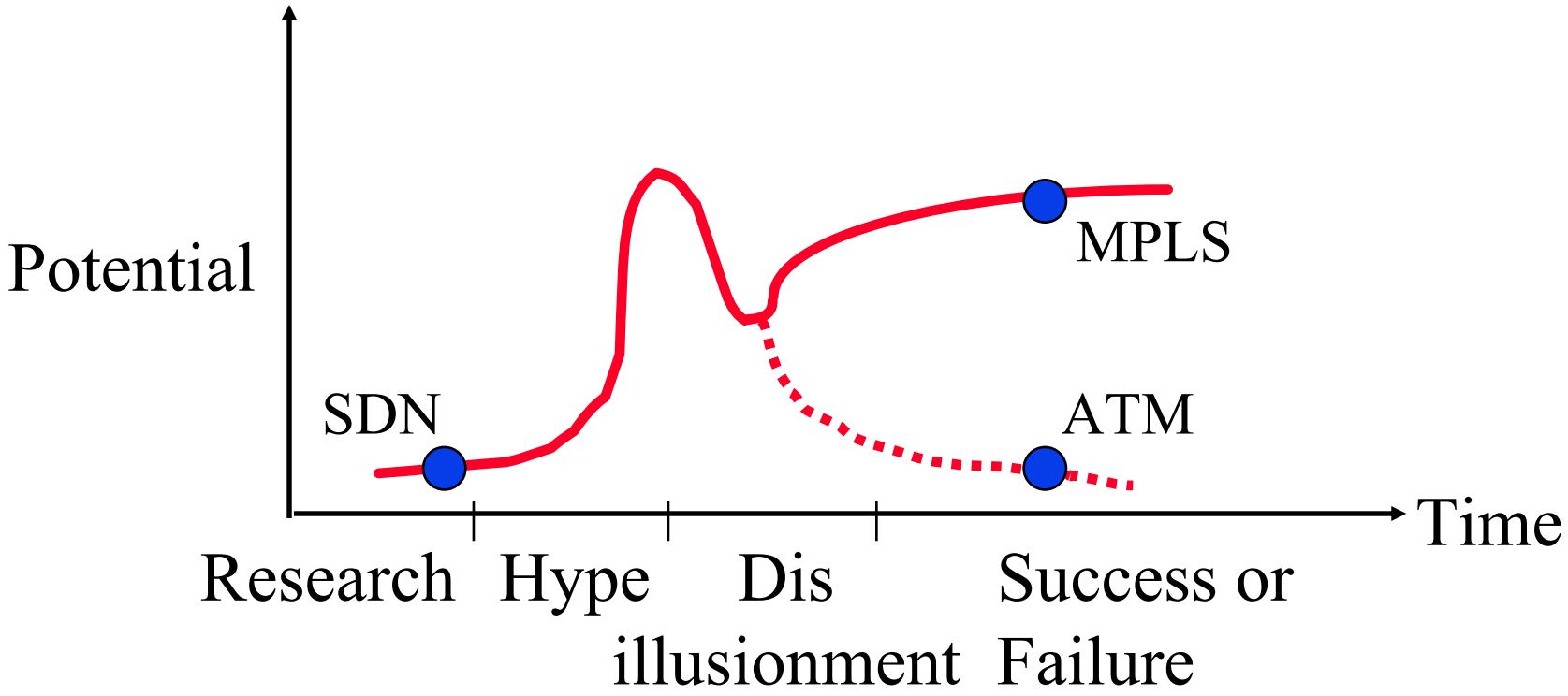


Ref: https://courses.soe.ucsc.edu/courses/cmpe259/Fall11/01/pages/lectures/srini-sdn.pdf
http://www.cse.wustl.edu/~jain/talks/adn_iuc.htm

SDN Impact

- Why so much industry interest?
  - Commodity hardware
    ⇒ Lots of cheap forwarding engines ⇒ Low cost
  - Programmability ⇒ Customization
  - Sharing with Isolation ⇒ Networking utility
  - Those who buy routers, e.g., Google, Amazon, Docomo, DT will benefit significantly
- Opens up ways for new innovations
  - Dynamic topology control: Turn switches on/off depending upon the load and traffic locality
    ⇒"Energy proportional networking"

Life Cycles of Technologies



Industry Growth: Formula for Success

Innovators
⇒ Startups
⇒ Technology Differentiation

Big Companies
Manufacturing
⇒ Price differentiation

Number of Companies

New Entrants

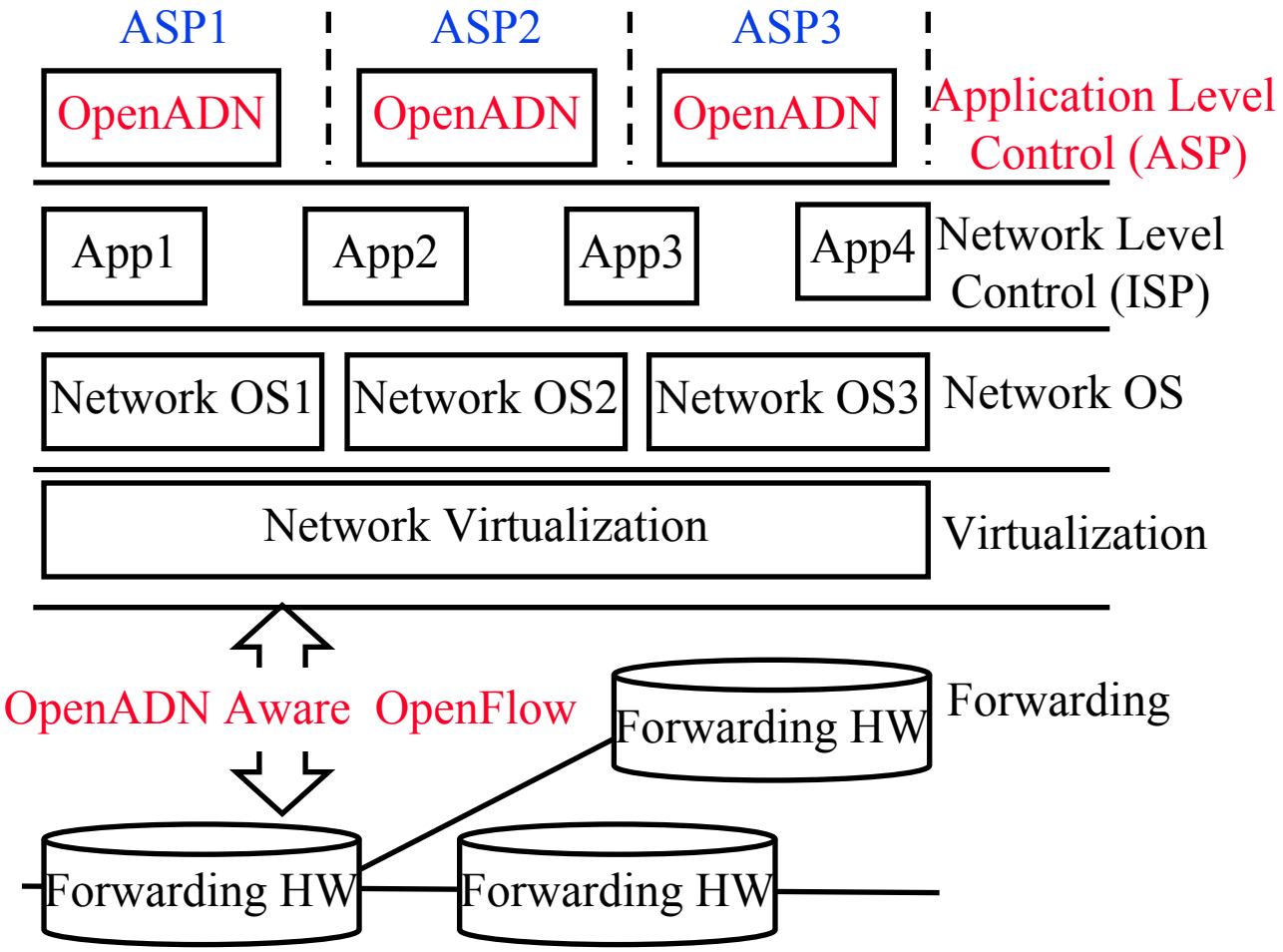
Consoli-dation

Stable Growth

Time

- 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

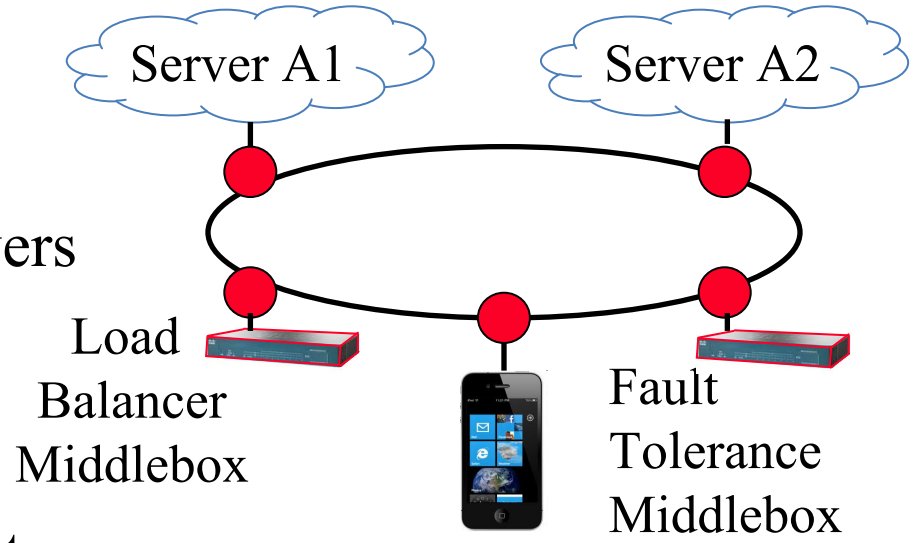


- SDN provides standardized mechanisms for distribution of control information

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

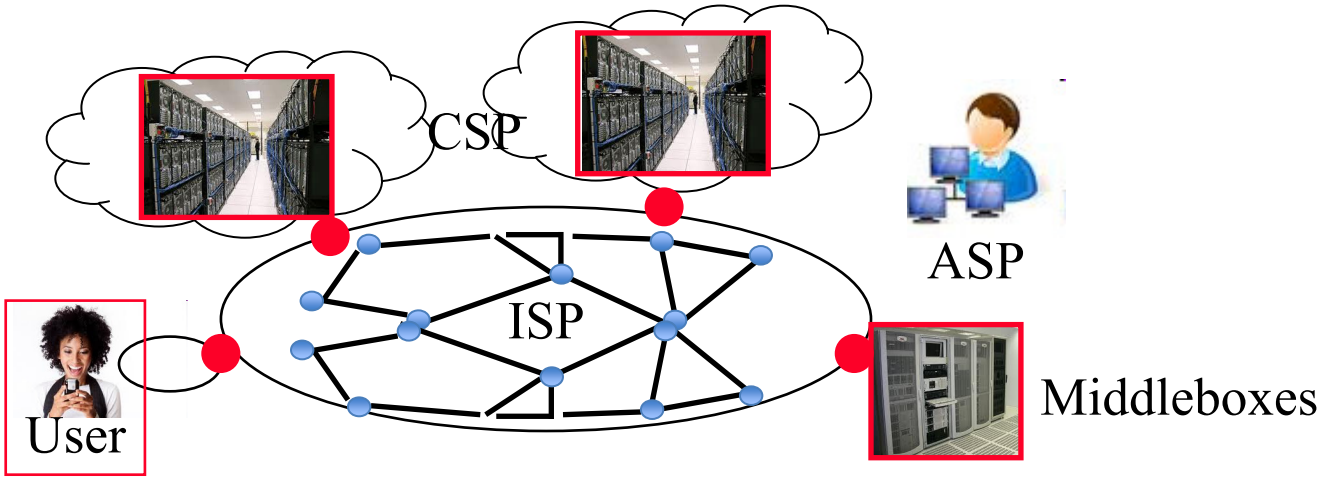
Most versions of Ethernet followed these principles.
Many versions of IP did not.

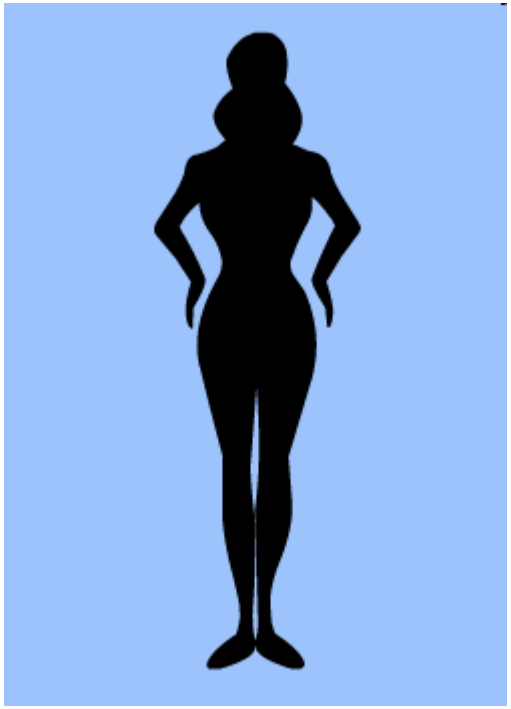
Resource Control

- 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

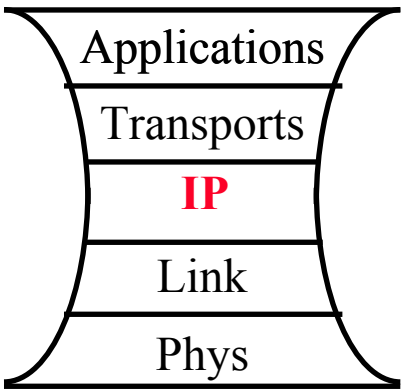
Beneficiaries of This Technology

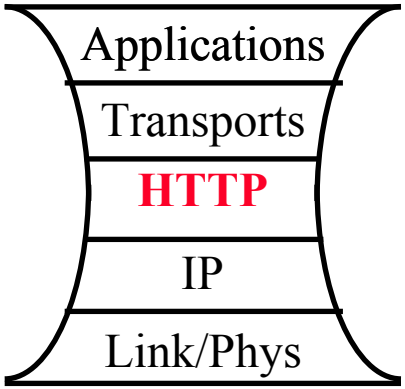
- Equipment/Software vendors: OpenADN-aware appliances
- ASPs: Deploy servers anywhere and move them anytime
- ISPs: Offer new application delivery/middlebox services
- Cloud Service Providers (CSPs): Freedom to move VMs, Less impact of downtime
- CDNs, e.g., Akamai, can extend into application delivery

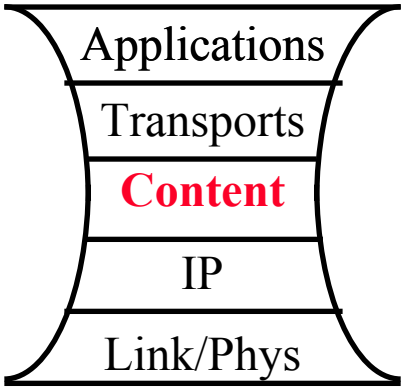


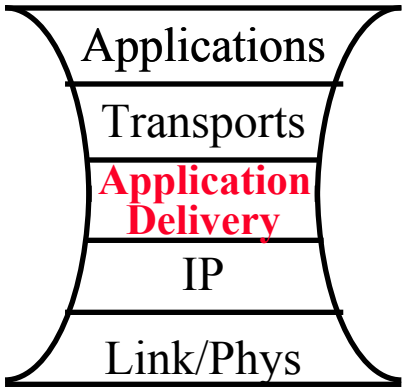


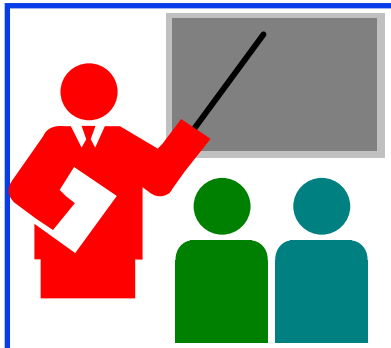
The Narrow Waist











Summary

1. Knee of **mobile internet** paradigm shift
   Explosion of Apps using cloud services
2. OpenADN appliances can provide ASPs networking services they need
3. OpenADN extends using best of OpenFlow, SDN, MPLS, ID/Locator Split, Cross-layer communications, middle box appliances
4. Keeps resource control under resource owners.
   Can be implemented incrementally now
5. Trend is towards simplifying and standardizing router interfaces ⇒ Software defined networking

Application Delivery: Opportunity for ISP's