Application Delivery Using Software Defined Networking

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GITPro World 2013, Palo Alto, CA, April 13, 2013

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

Overview

1. Cloud Computing $\Rightarrow$ Network Virtualization $\Rightarrow$ SDN

2. SDN defined by Five Innovations

3. Open Application Delivery Using SDN

Virtualization of Life

❑ Internet $\Rightarrow$ 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

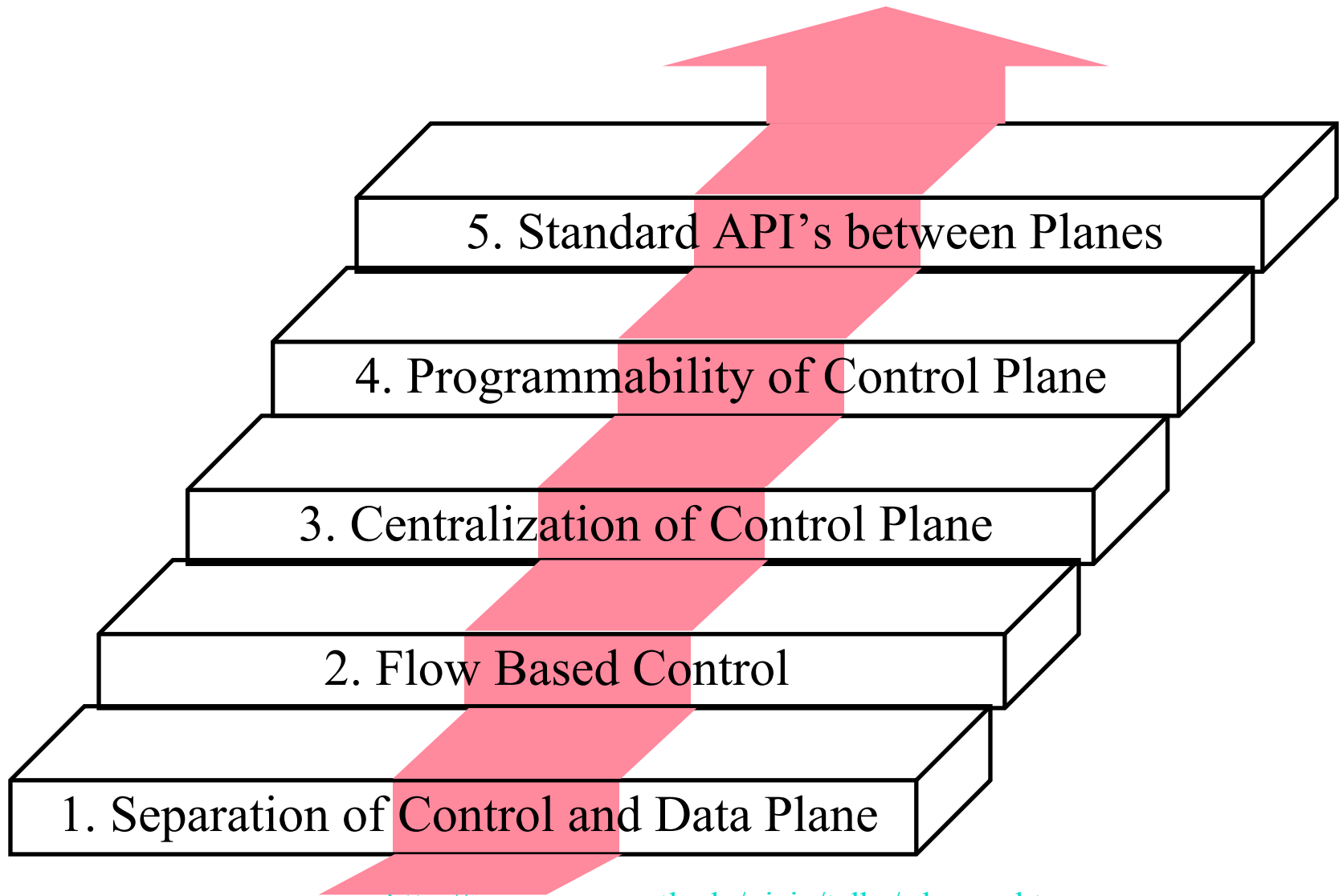**Networks need to support efficient cloud computing**
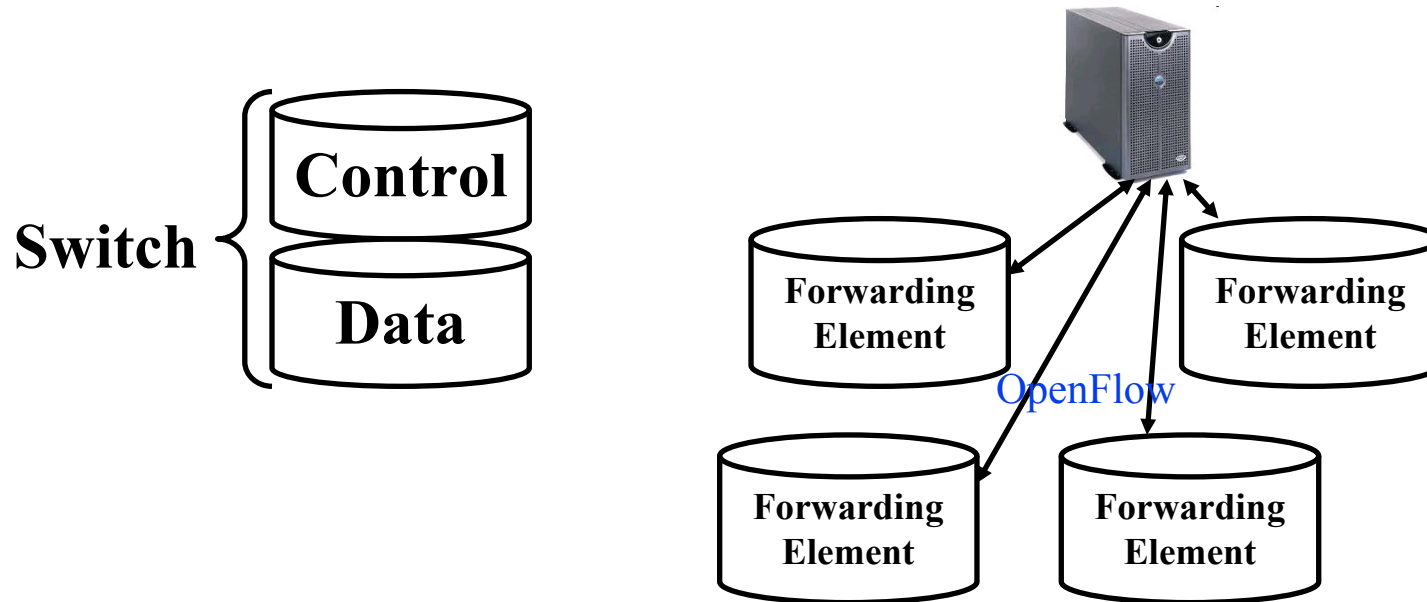
Network Virtualization

p = Physical
v = Virtual
M = Machine
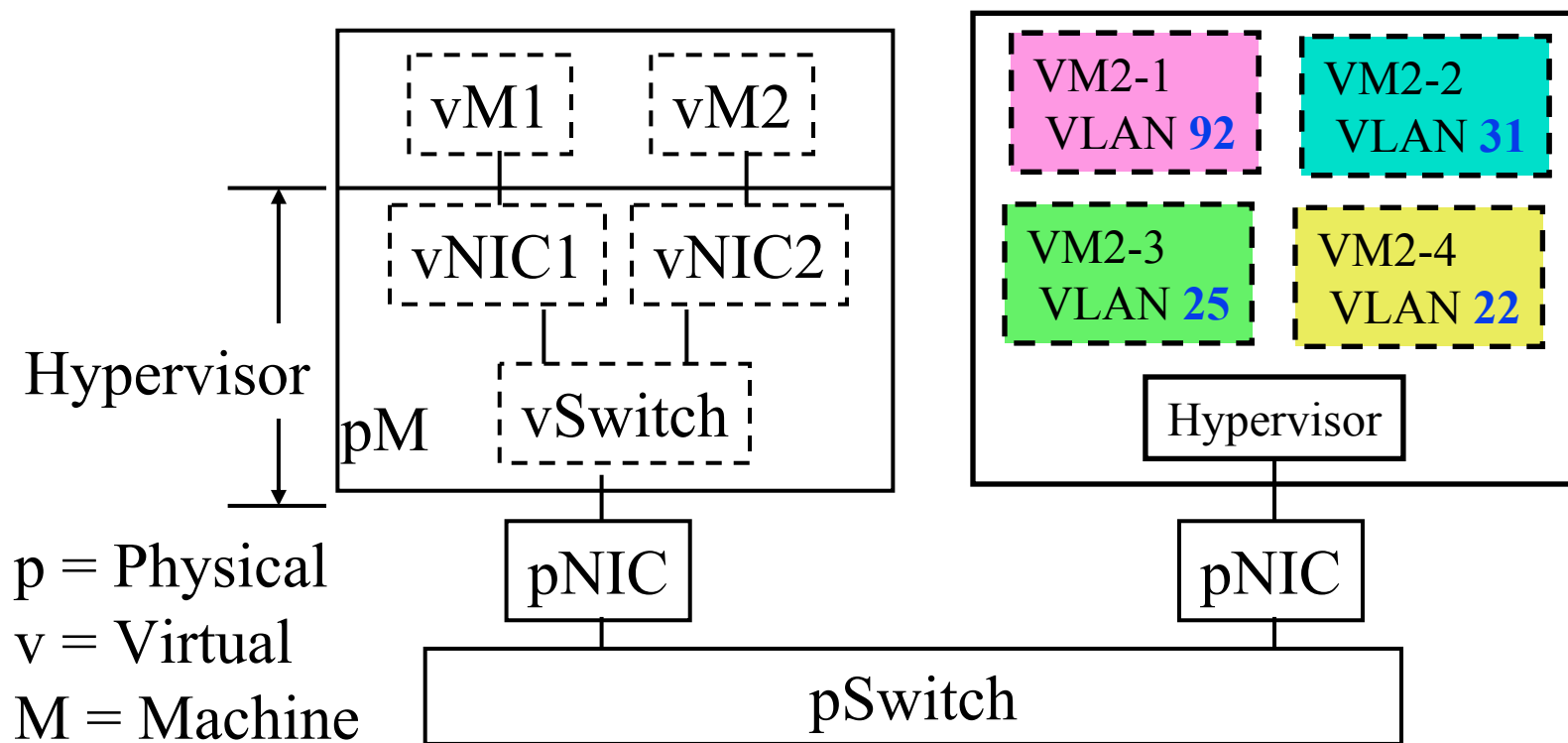
❑ Each VM needs its own network interface card (NIC)

❑ Each tenant needs its own Virtual LAN

Need to be able to re-program networks quickly

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SDN Definition: 5 Innovations

5. Standard API's between Planes

4. Programmability of Control Plane

3. Centralization of Control Plane

2. Flow Based Control

1. Separation of Control and Data Plane

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1. Separation of Control and Data Plane

Switch { **Control** / **Data** }

Forwarding Element

Forwarding Element

Forwarding Element

Forwarding Element

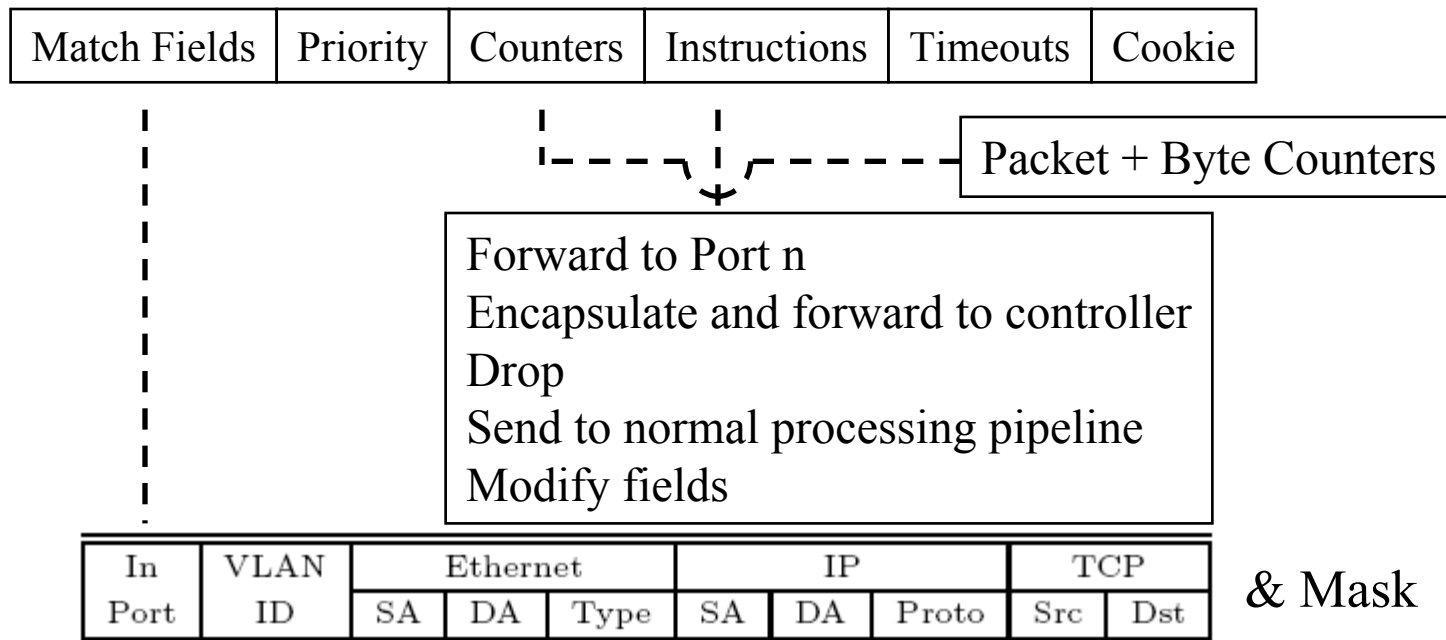OpenFlow

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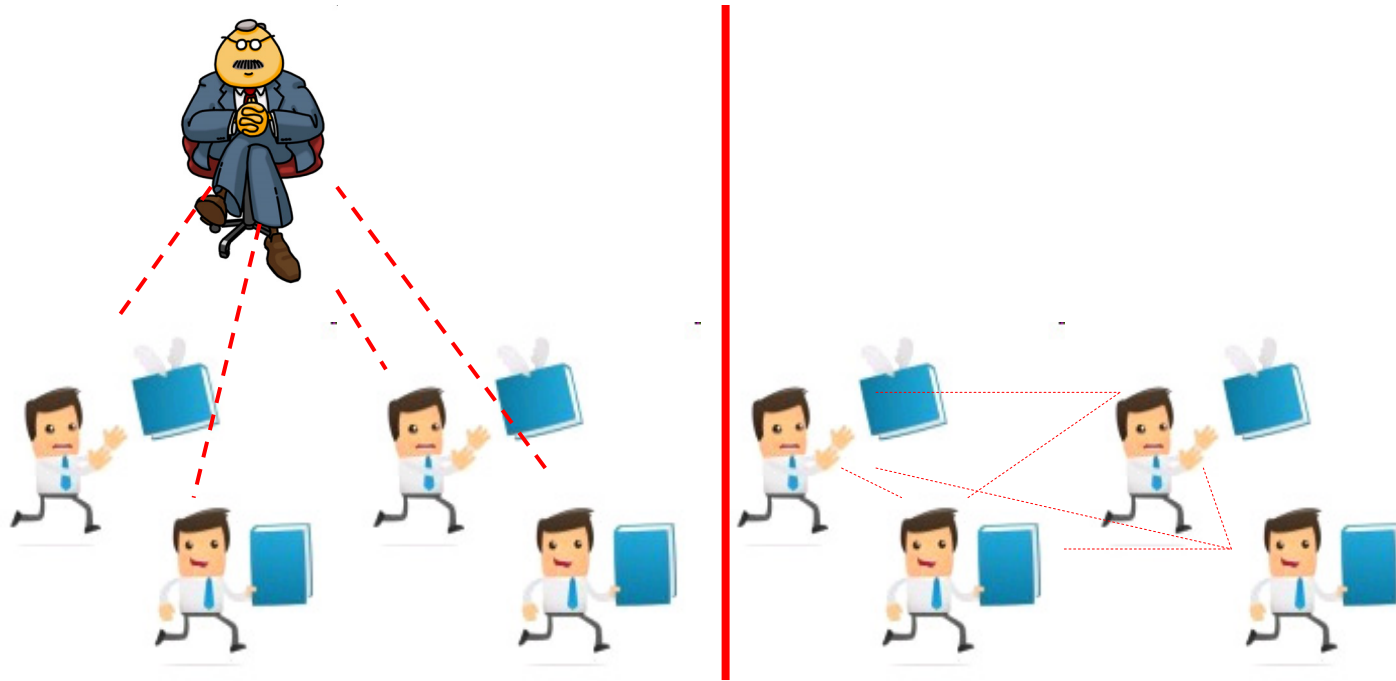- ❑ One expensive controller with lots of cheap switches

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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

Match Fields	Priority	Counters	Instructions	Timeouts	Cookie

Packet + Byte Counters

Forward to Port n
Encapsulate and forward to controller
Drop
Send to normal processing pipeline
Modify fields

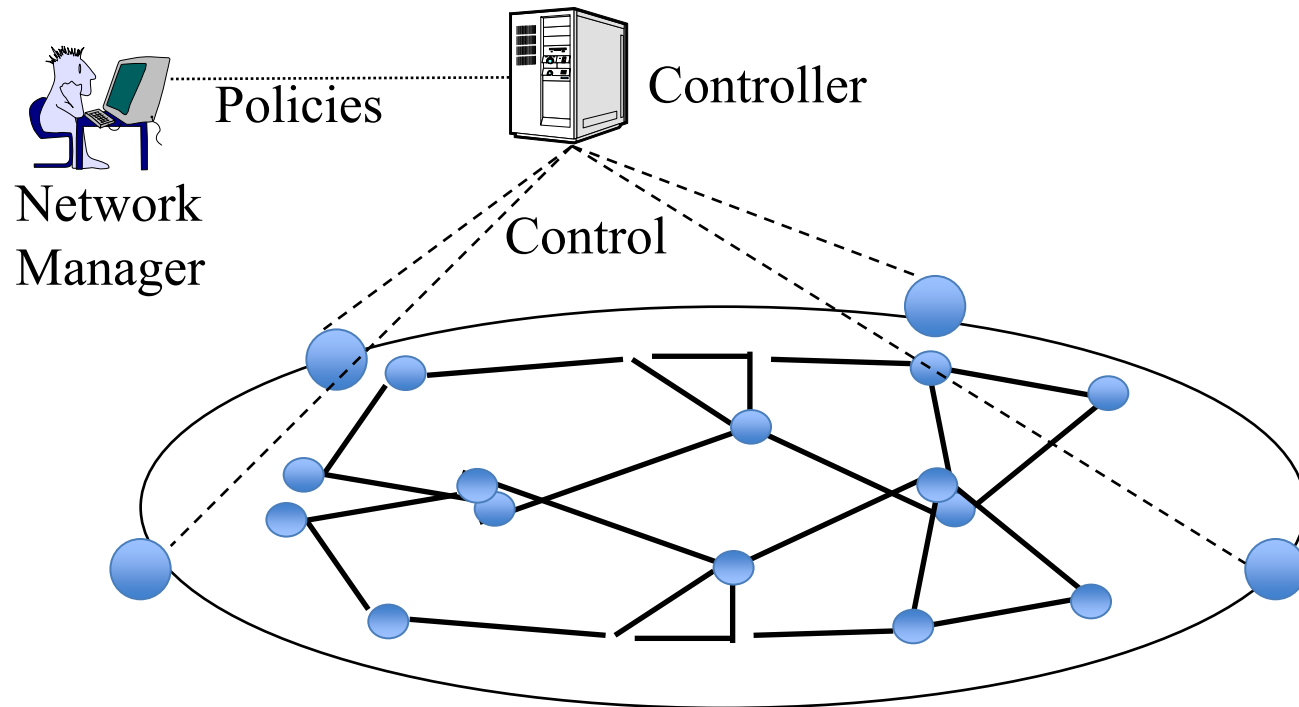| In Port	VLAN ID	Ethernet			IP			TCP	
		SA	DA	Type	SA	DA	Proto	Src	Dst

& Mask

3. Centralization of Control Plane

Centralized vs. **Distributed**

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

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4. Programmable Control Plane

❑ Policies can be changed on the fly
⇒Software Defined

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5. Standardized API between planes

APPLICATIONS

ASP1
Application

ASP2
Application

ASP3
Application

Northbound API

CONTROL PLANE

| NOX | Beacon | Maestro | Floodlight | Helios |

Network Controller Software

Southbound API

DATA PLANE

OpenFlow
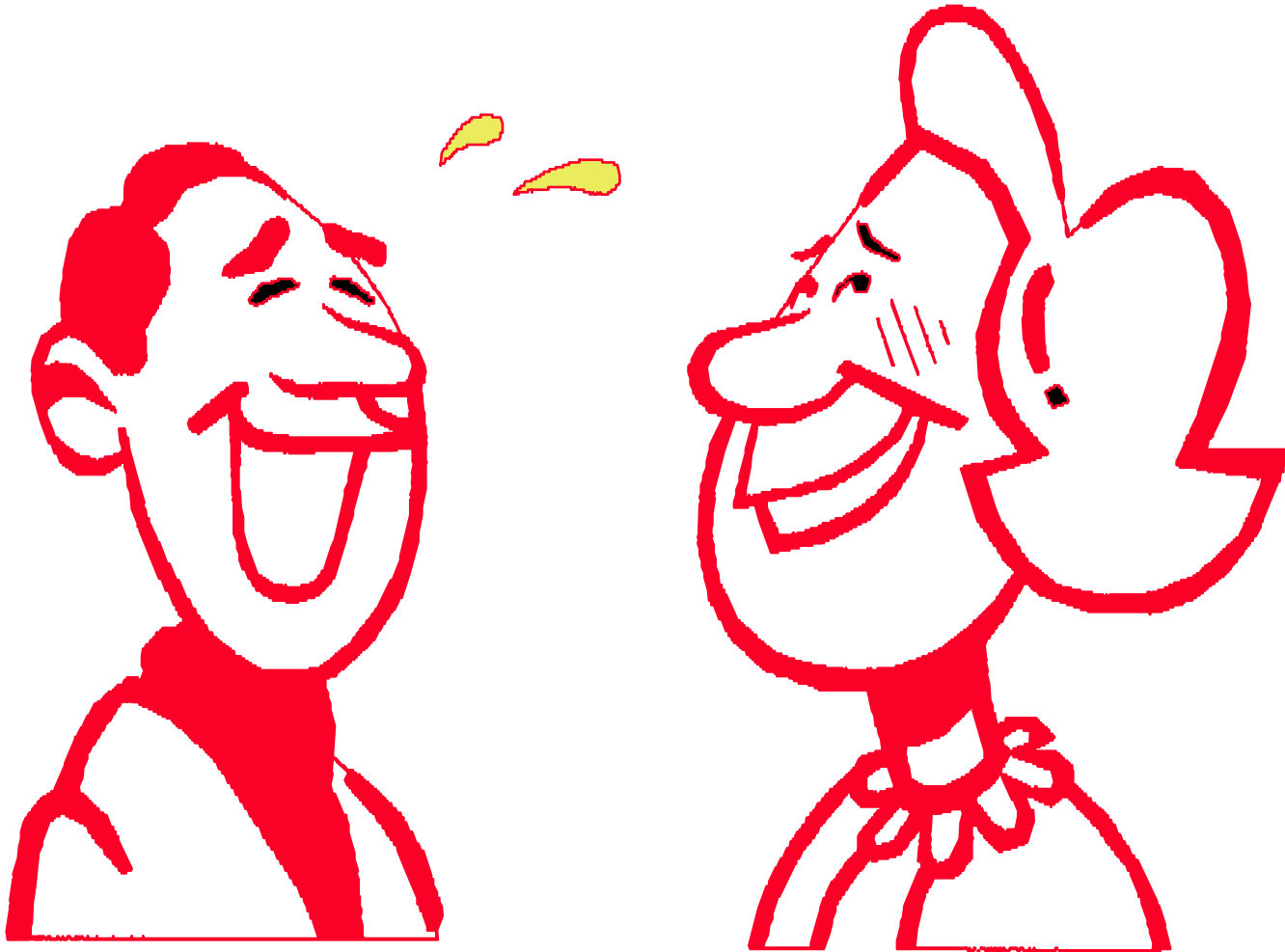
Forwarding HW

Forwarding HW

Forwarding HW

Forwarding HW
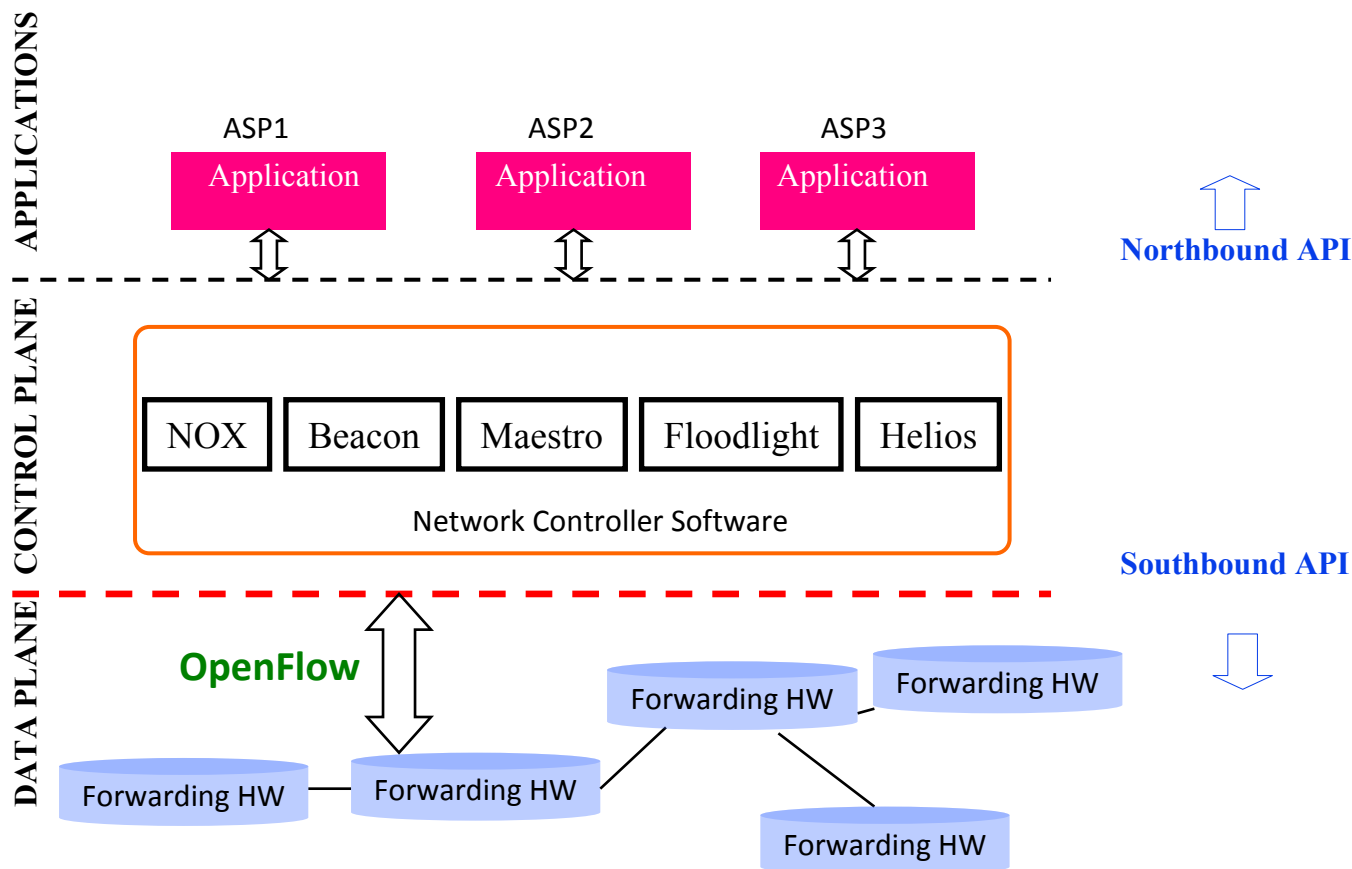
Forwarding HW

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

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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

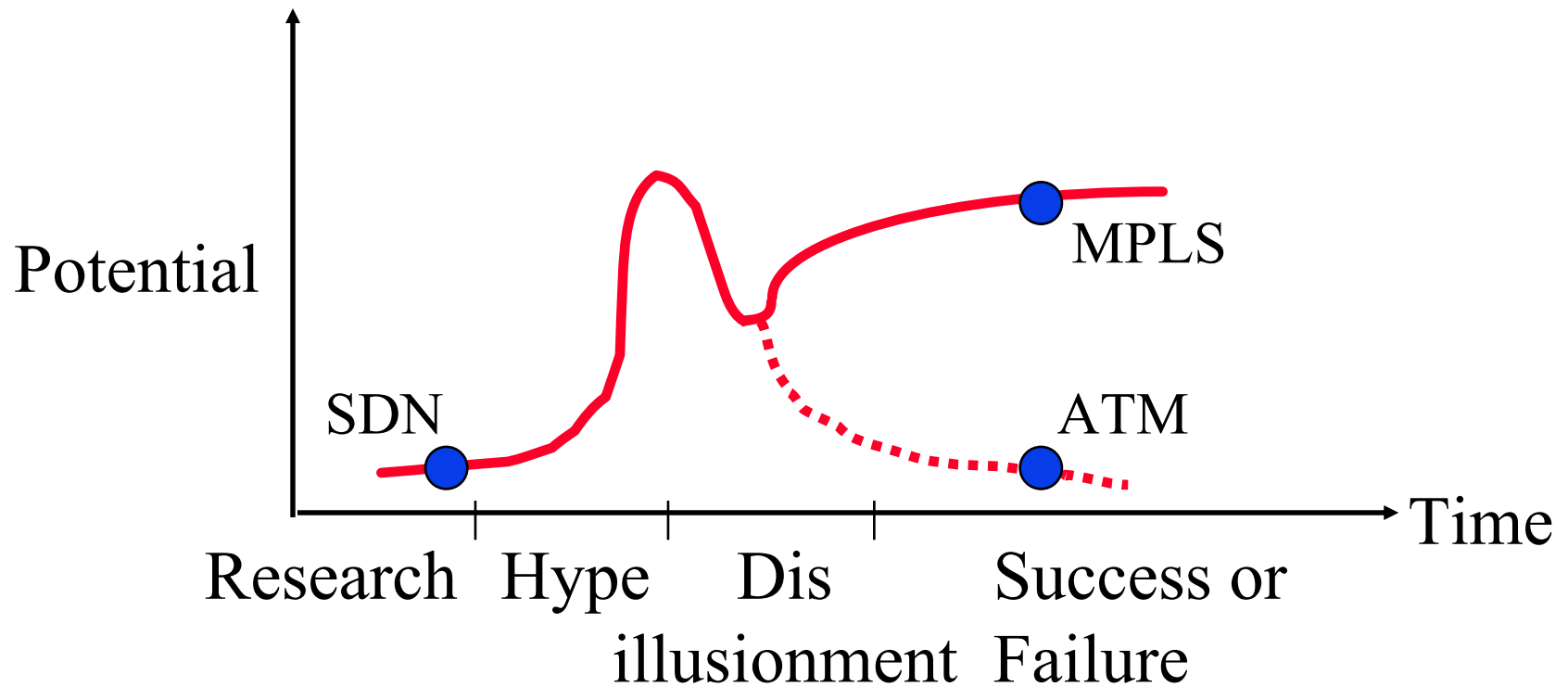 ➢ Software defined optical switches

  ➢ Software defined routers

Before

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After

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

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Life Cycles of Technologies

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Industry Growth: Formula for Success

Number of Companies

Innovators
⇒ Startups
⇒ Technology Differentiation

Big Companies Manufacturing
⇒ Price differentiation

New Entrants | Consoli-dation | Stable Growth — Time
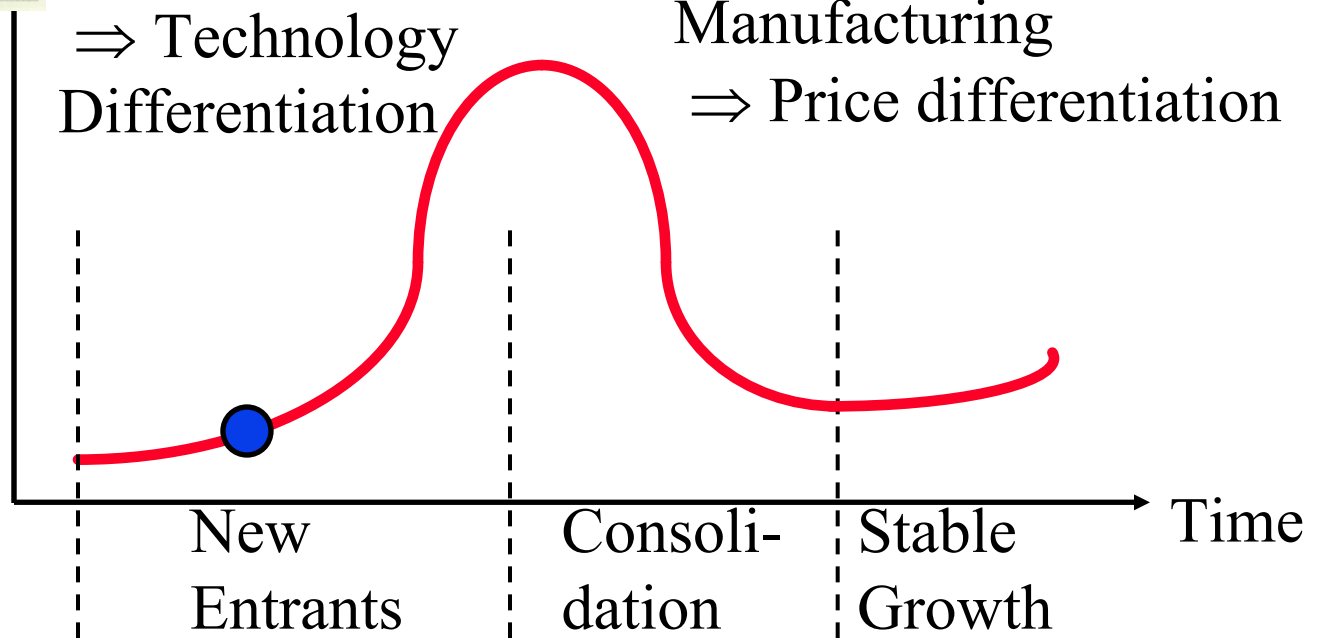
❏ Paradigm Shifts ⇒ Leadership Shift
❏ Old market leaders stick to old paradigm and loose
❏ Mini Computers→PC, Phone→Smart Phone, PC→Smart Phone

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Application Delivery in a Data Center

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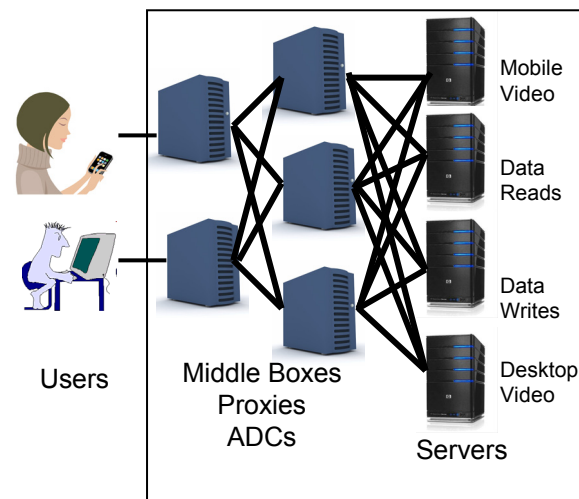   - ✓ If Load on S1 >0.5, send to S2
   - ✓ If link to US broken, send to UK

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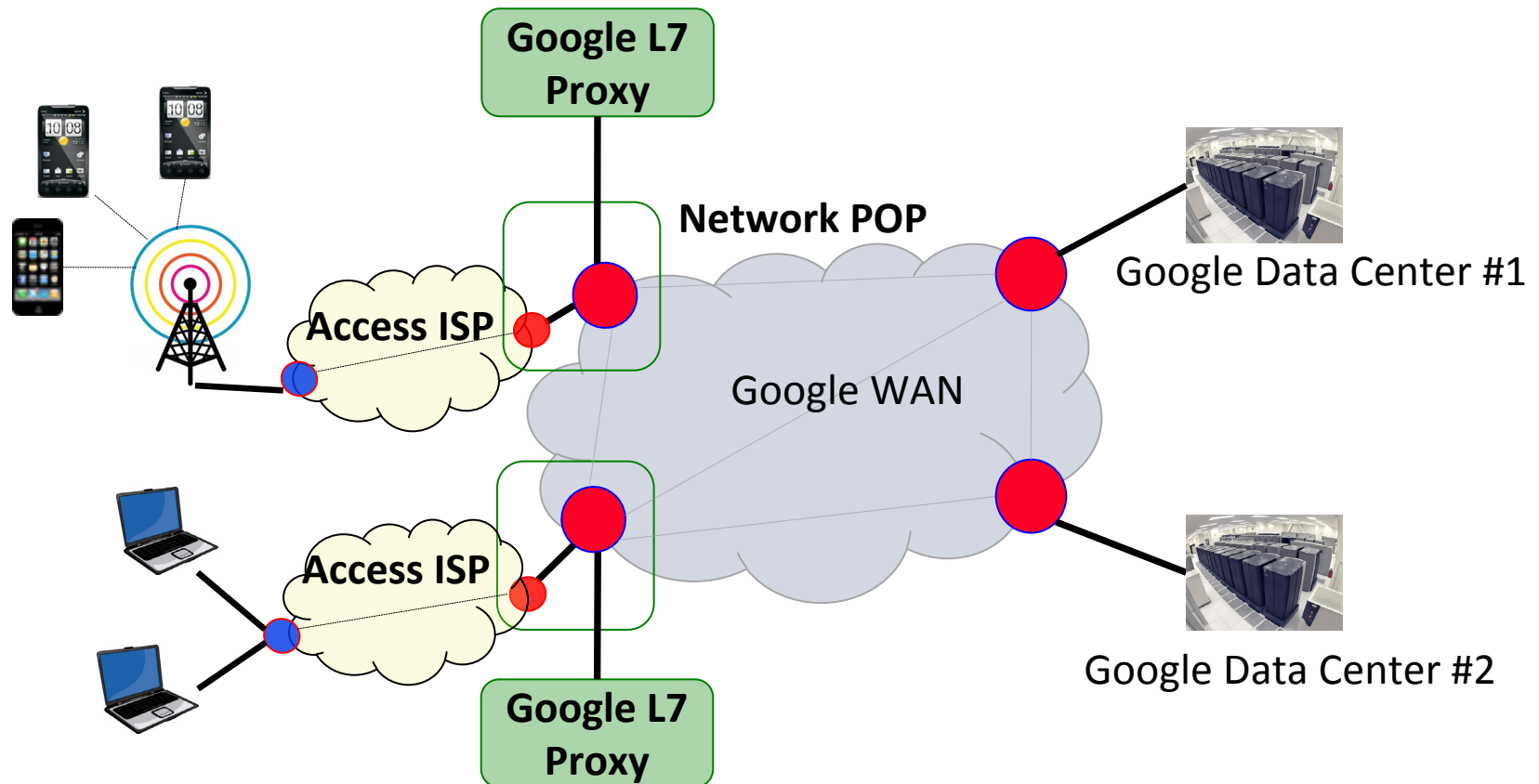   ➢ Accounting to Server S2

❑ **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

Users   Middle Boxes
        Proxies
        ADCs

Mobile Video
Data Reads
Data Writes
Desktop Video

Servers

Google WAN

Google L7 Proxy

Network POP

Google Data Center #1

Access ISP

Google WAN

**Access ISP**

Google L7 Proxy

Google Data Center #2

- ❑ 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
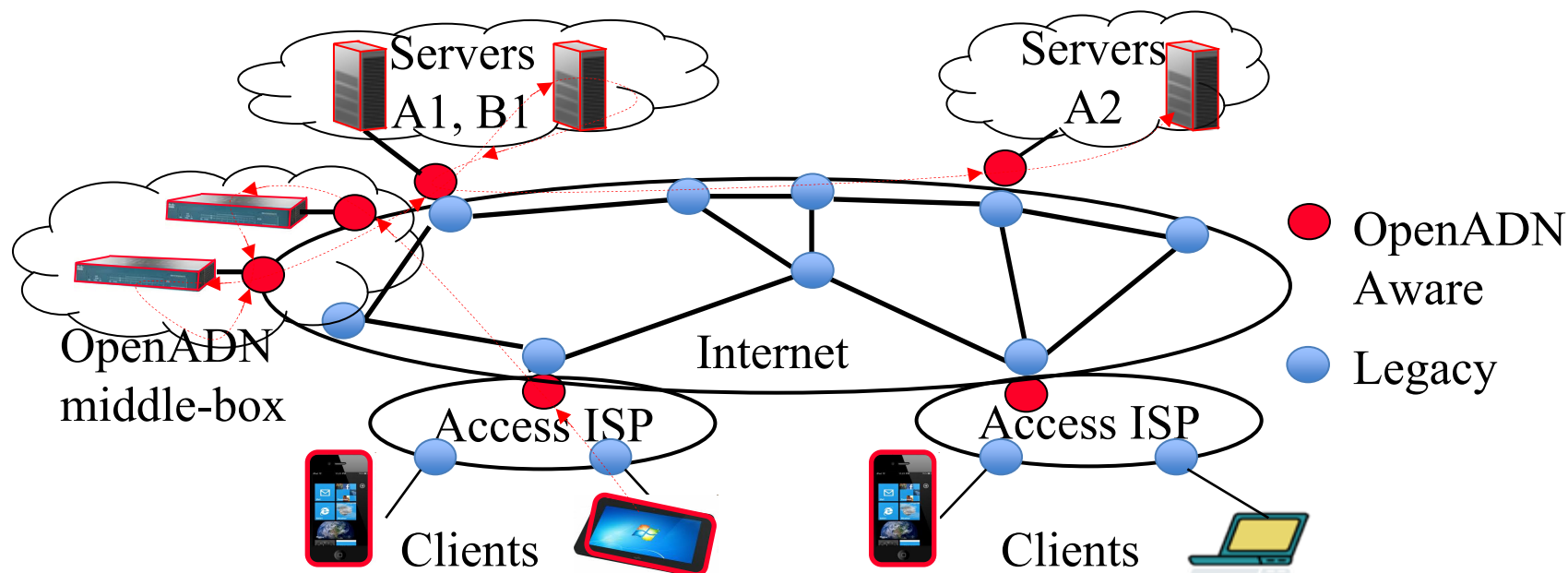
OpenADN in SDN's Layered Abstractions
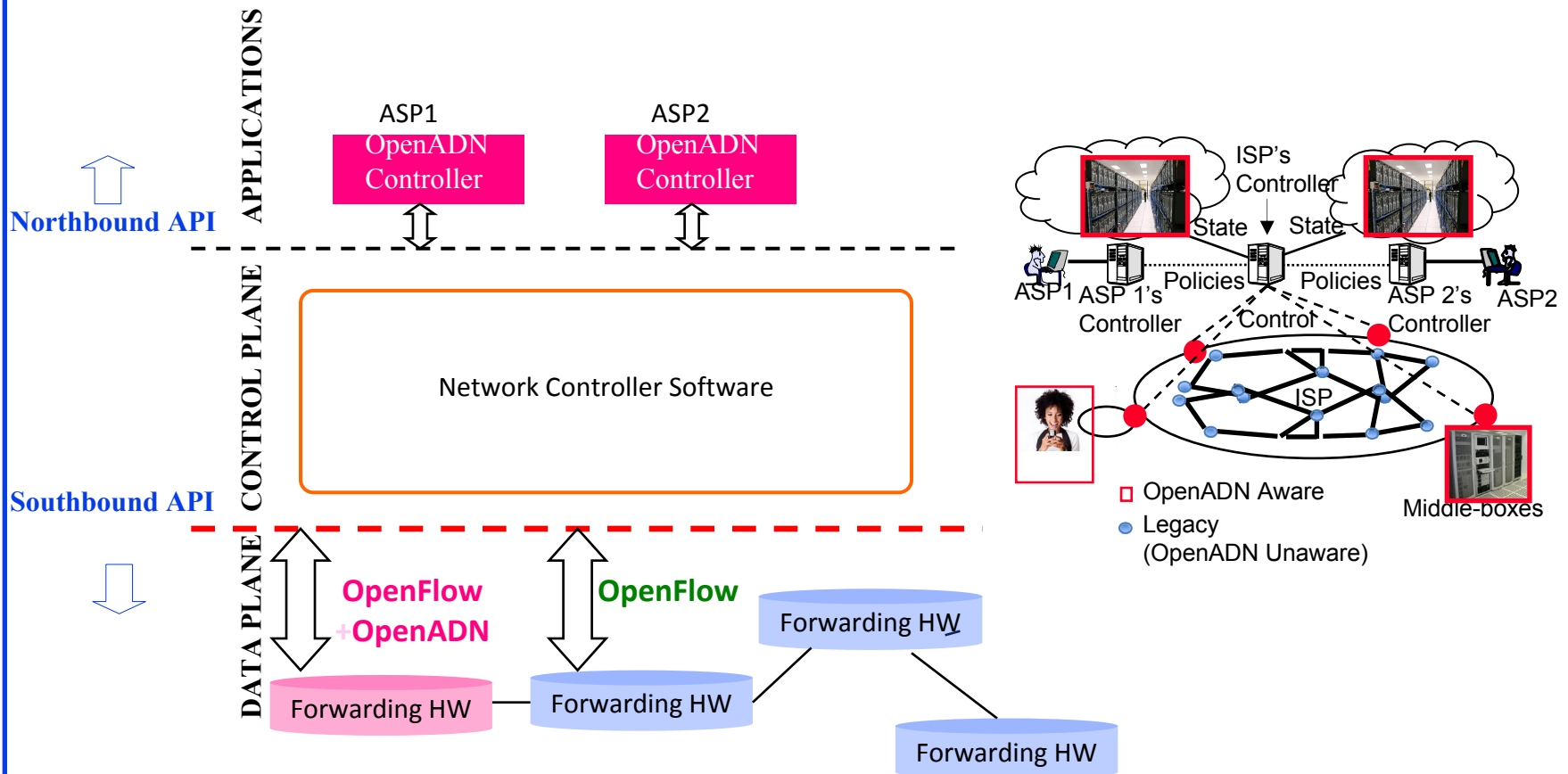
- SDN provides standardized mechanisms for distribution of control information
- OpenADN aware devices use enhanced OpenFlow

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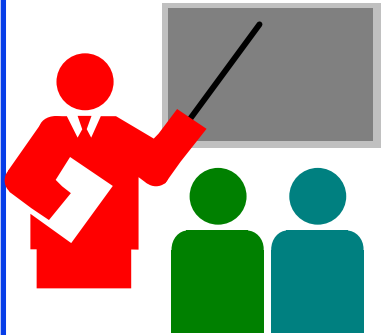
1. Cloud computing $\Rightarrow$ Virtualization of computing, storage, and networking
$\Rightarrow$ Numerous recent standards related to networking virtualization both in IEEE and IETF

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

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