

# Network Virtualization



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[http://www.cse.wustl.edu/~jain/talks/nv\\_ant.htm](http://www.cse.wustl.edu/~jain/talks/nv_ant.htm)



1. Why Virtualize?
2. OTV: Overlay Transport Virtualization
3. VXLAN: Virtual Extensible LAN
4. OpenFlow
5. Software Defined Networks

# Virtualization Trend

- ❑ Virtual Memory  $\Rightarrow$  L1, L2, L3, ...  $\Rightarrow$  Recursive
- ❑ Virtual Desktop  $\Rightarrow$  Virtual Server  $\Rightarrow$  Virtual Datacenter  
Thin Client  $\Rightarrow$  VMs  $\Rightarrow$  Cloud
- ❑ 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 virtualized
- ❑ This presentation is limited to L2 Network (LAN) and L3 (WAN) virtualization

# Why Virtualize?

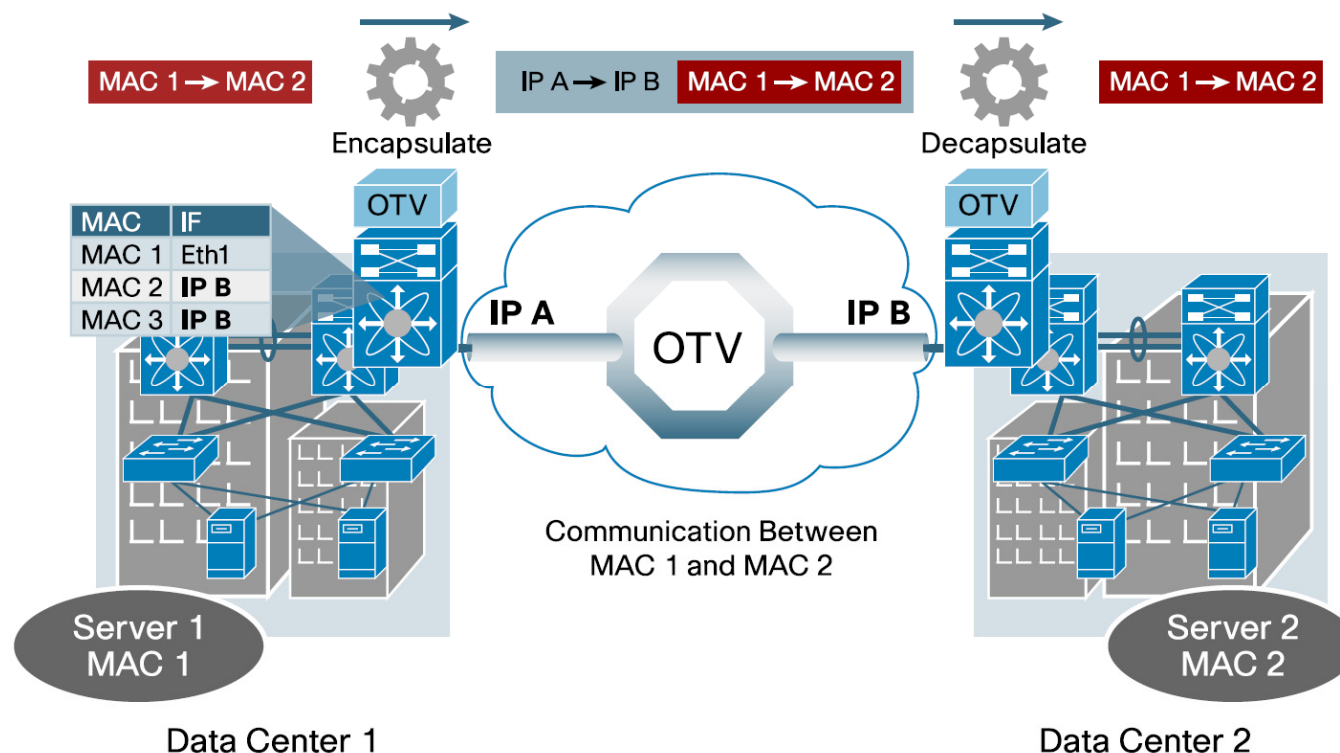
- ❑ Ease of Management  $\Rightarrow$  Centralization
- ❑ Sharing  $\Rightarrow$  Carrier Hotels = Sharing buildings
- ❑ Cost Savings
- ❑ Isolation  $\Rightarrow$  Protection
- ❑ Dynamics: Replication, load balancing
- ❑ Mobility for fault tolerance

# LAN Virtualization Technologies

- ❑ Problem: LANs were **not** designed for:
  1. Long distances
  2. Dynamic on-demand connectivity
  3. Very large number of nodes
  4. Multiple tenants
  
- ❑ Solutions:
  1. Overlay Transport Virtualization
  2. VXLAN
  3. Software defined networks

# Overlay Transport Virtualization (OTV)

- ❑ Cisco technology to allow a single LAN to span multiple datacenters located far apart
- ❑ Encapsulates L2 frames and sends using L3



Ref: [Cisco-OTV] Cisco, "Enhance Business Continuity with Application Mobility Across Data Centers,"

[http://www.cisco.com/en/US/prod/collateral/switches/ps9441/ps9402/white\\_paper\\_c11-591960.pdf](http://www.cisco.com/en/US/prod/collateral/switches/ps9441/ps9402/white_paper_c11-591960.pdf)

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[http://www.cse.wustl.edu/~jain/talks/nv\\_ant.htm](http://www.cse.wustl.edu/~jain/talks/nv_ant.htm)

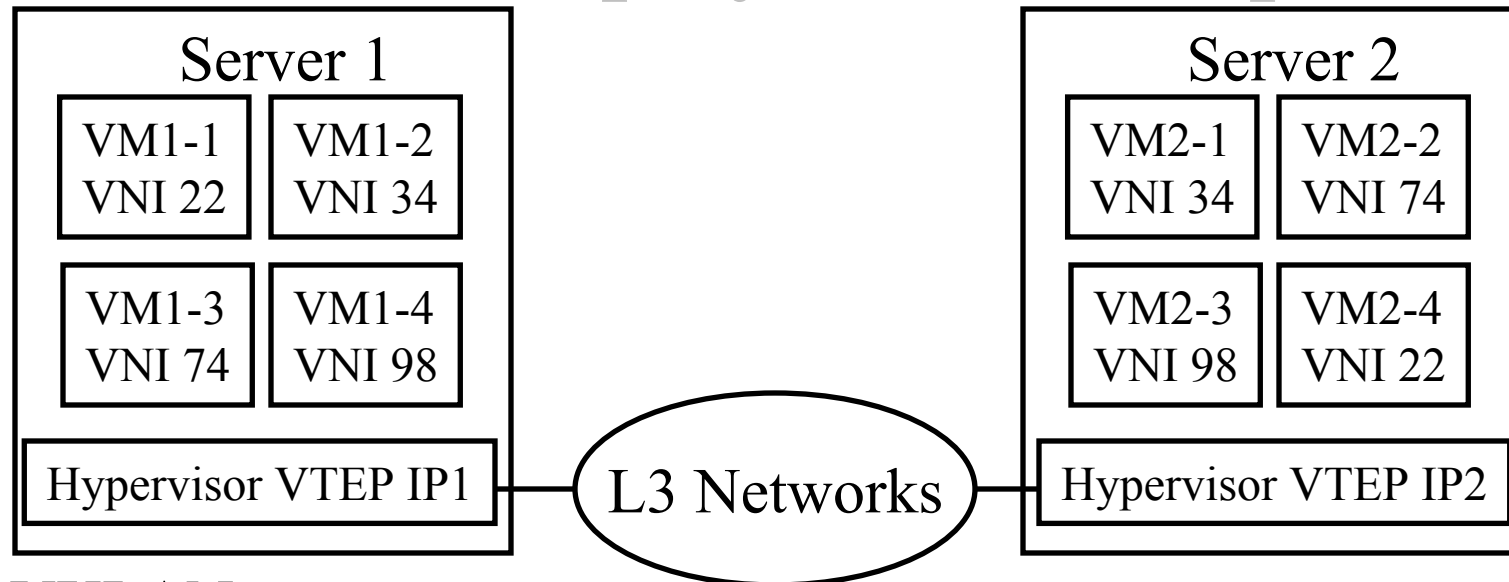
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# VXLAN

- ❑ Virtual Extensible Local Area Networks
- ❑ Developed by VMware
- ❑ Supported by many companies for standardization in IETF
- ❑ VXLAN solves the problem of multiple tenants in a cloud environment.
- ❑ A server may have VMs belonging to different tenants
- ❑ Allows each tenant to have their own VLANs that connect their VMs

Ref: VXLAN: A Framework for Overlaying Virtualized Layer 2 Networks over Layer 3 Networks, draft-mahalingam-dutt-dcops-vxlan-00, 2011-08-27

# VXLAN Deployment Example



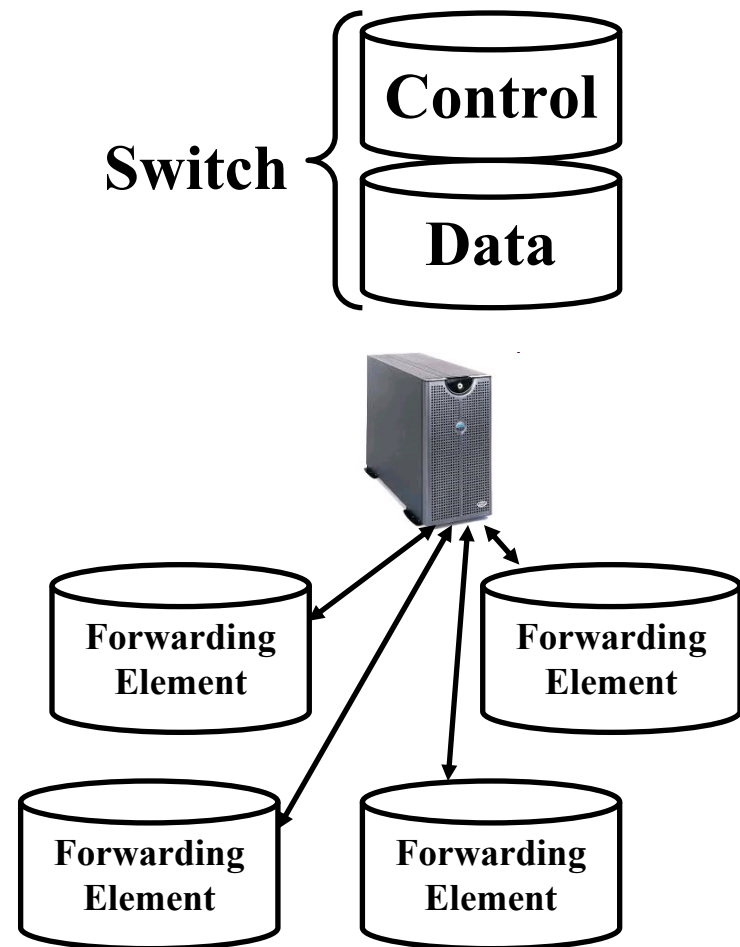
- ❑ 4 VXLAN segments
- ❑ Uses tunneling to overlay Segments over L3  
Tunnels end points (VTEP) in hypervisors





# Separation of Control and Data Planes

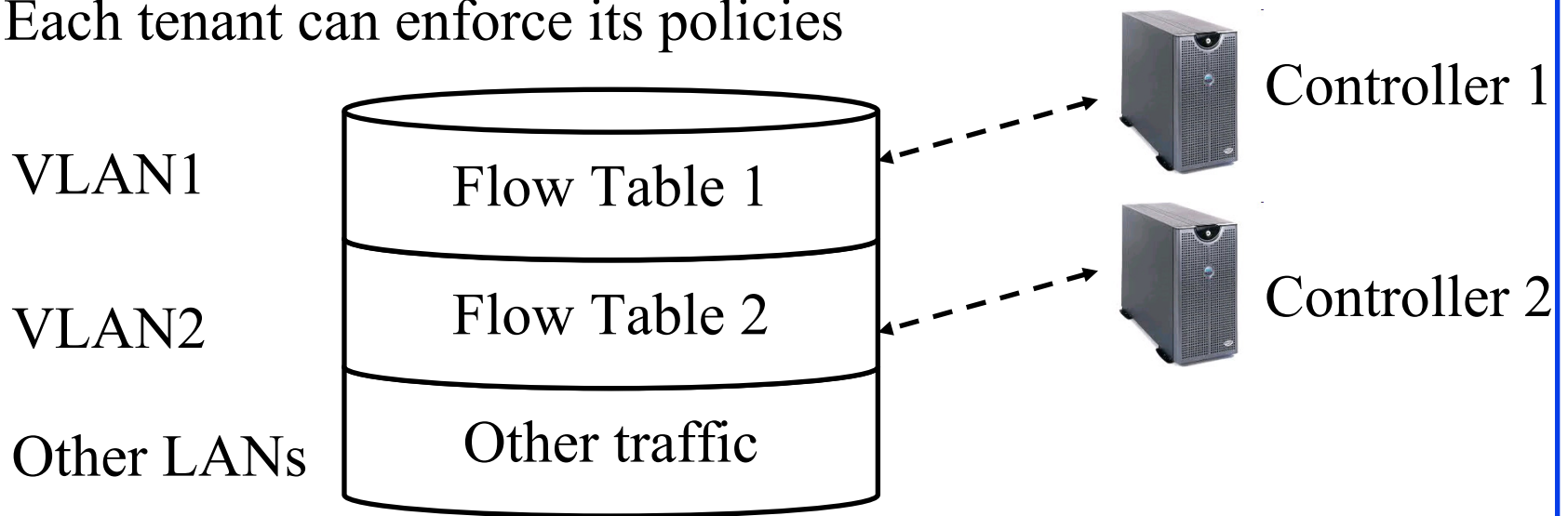
- ❑ Control = Prepare forwarding table
- ❑ Data Plane: Forward using the table
- ❑ Forwarding table is prepared by a central controller
- ❑ Protocol between the controller and the forwarding element:  
**OpenFlow**
- ❑ Centralized control of policies
- ❑ Switches are simple.  
Controller can be complex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



Ref: [MCK08] "OpenFlow: Enabling Innovation in Campus Networks," OpenFlow Whitepaper, March 2008

## 5. Software Defined Networks

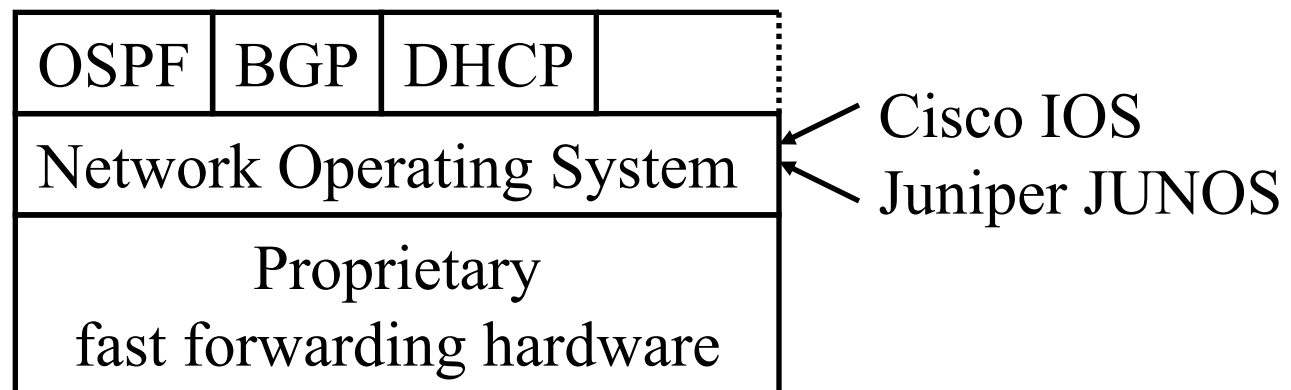
- ❑ Problem: Multiple tenants in the datacenter
- ❑ Solution: Use multiple controllers.  
Each tenant can enforce its policies



- ❑ Significant industry interest  $\Rightarrow$  Open Networking Foundation,  
<https://www.opennetworking.org/>

# Problem: Complex Routers

- ❑ 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).



# Solution: Divide, Simplify and Standardize

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

Scientific	Business	Batch
OS360 Operating System		
IBM 360 HW, Storage, ...		

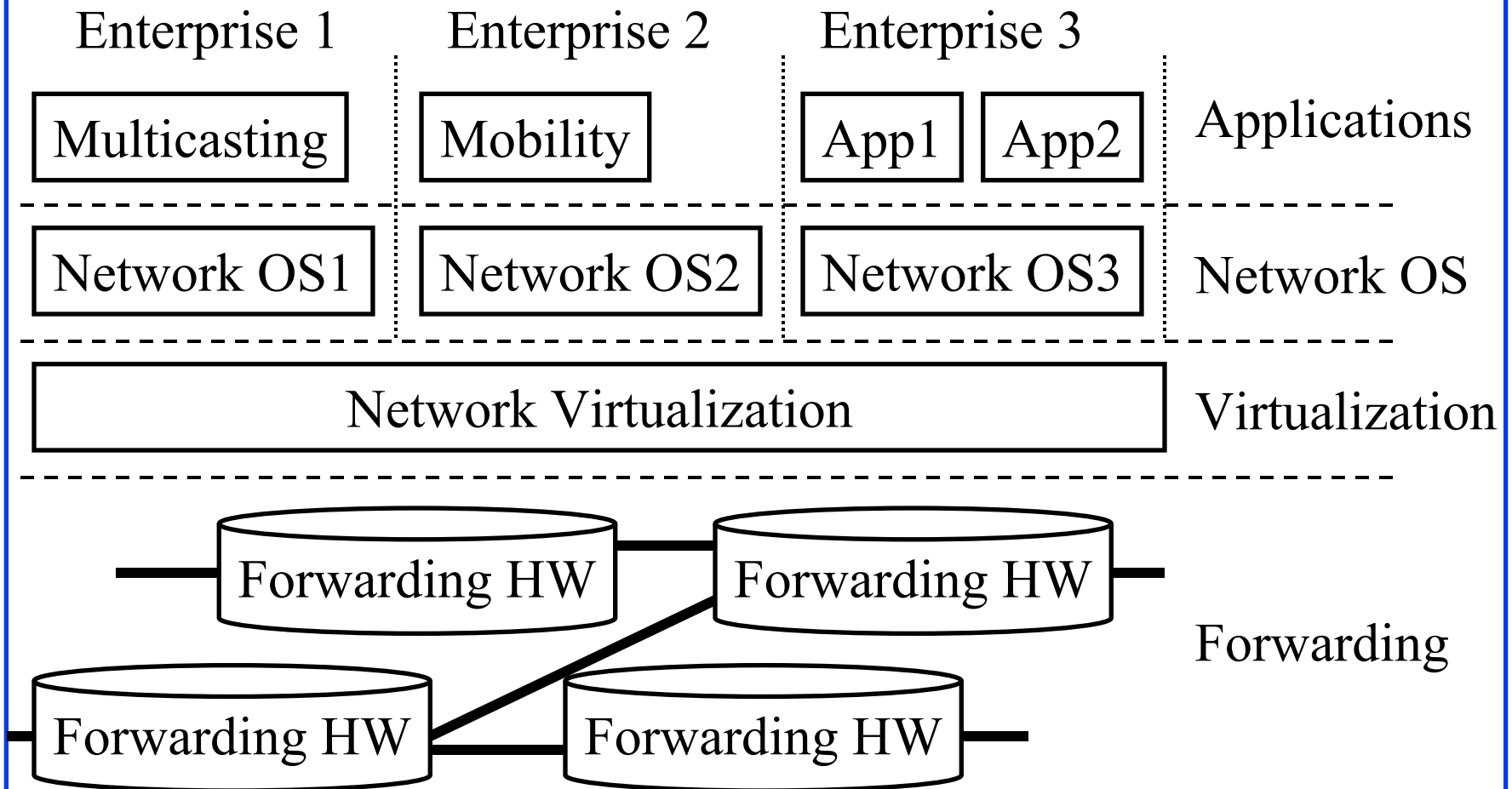


MSOffice	OpenOffice	
Windows	OS X	Chrome
Intel	AMD	ARM

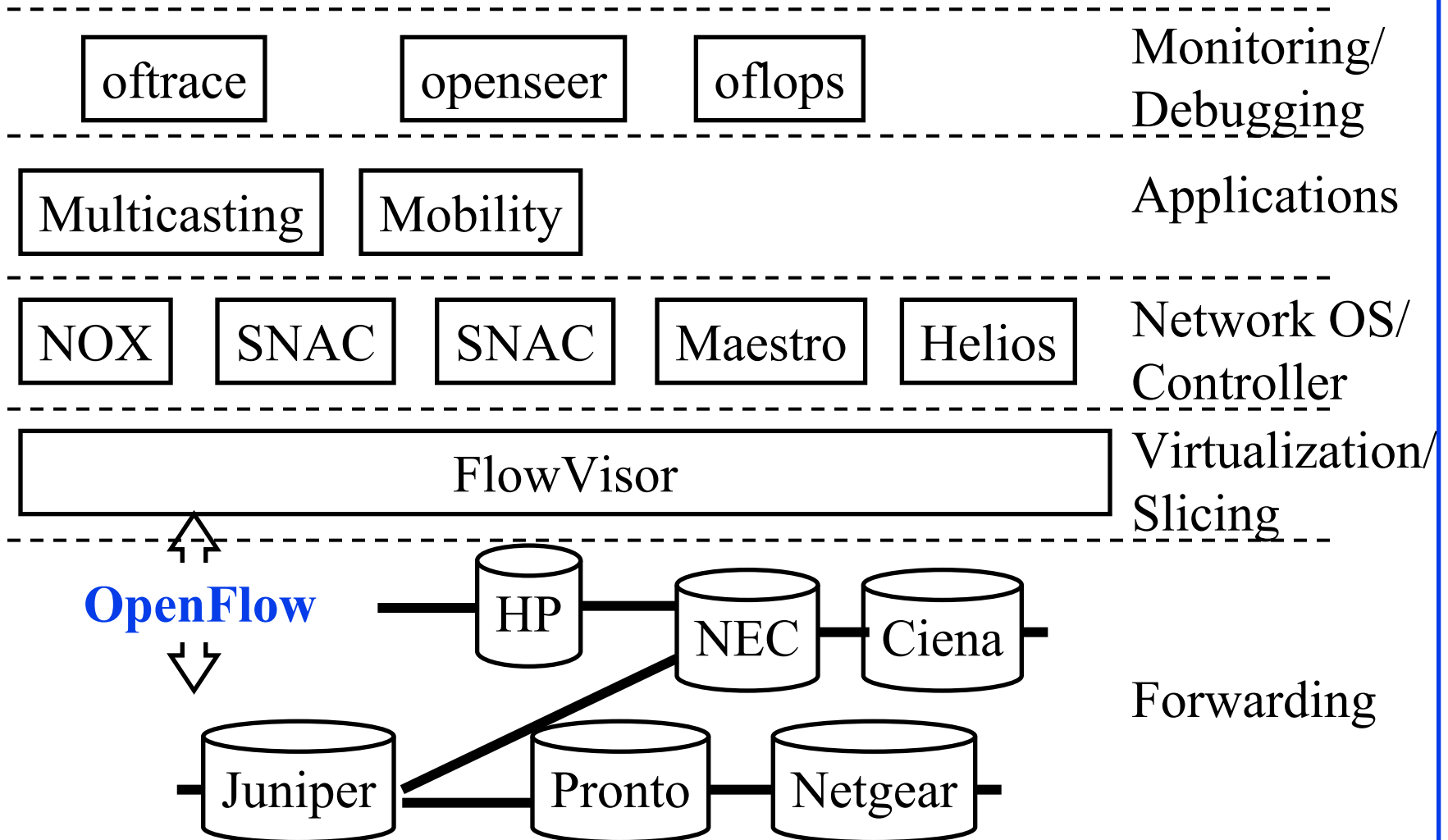


VM1	VM2	VM3
Hypervisor		
Physical HW		

# Multi-Tenant SDN Architecture

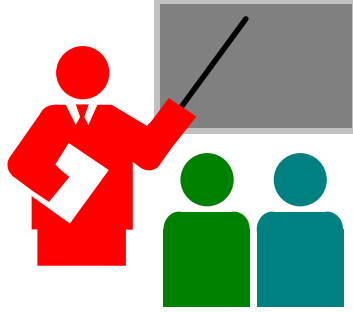


# SDN Architecture Component Examples



Ref: <https://courses.soe.ucsc.edu/courses/cmpe259/Fall11/01/pages/lectures/srini-sdn.pdf>

# Summary



1. Ethernet is being extended to cover multiple tenants in multiple data centers and large campuses
2. Most of these efforts encapsulate Ethernet frames and transport them using layer 3 protocols
3. OTV allows LANs covering multiple datacenters
4. VXLAN allows multiple tenants on the same server using their own VLANs
5. Software defined networks will allow cheap forwarding hardware to be used with multiple network operating systems and tenants.