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2013 China-America Frontiers of Engineering

Software defined networking

Does SDN qualify as a "frontier" of engineering?

What is software defined networking (SDN)?

NETWORKWORLD

August 2012

Searching for an SDN Definition: What Is Software-Defined Networking?

Network Computing For IT By IT

May 2012

Understanding Software Defined Networking

"If you aren't intimately familiar with Software Defined Networking, don't fret. Only 10% of 450 IT practitioners at a recent Network World event raised their hands when asked if they understand SDN .."

NETWORKWORLD

May 2013

Agenda

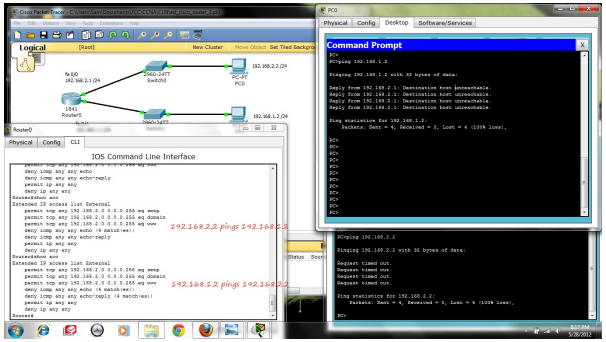
- Understanding the shift to software in networking
- Why do engineers and operators care about SDN?
- SDN technology progression: OpenFlow, network virtualization, and controller platforms
- SDN in practice
  - SDN and cloud computing
  - SDN deployments in some of the largest networks
  - SDN Research focus areas
- Summary and references

Collaboration with Mohammad Banikazemi, Jack Kouloheris, David Olshefski, John Tracey, Guohui Wang, IBM TJ Watson Research Center

Realities of traditional networking

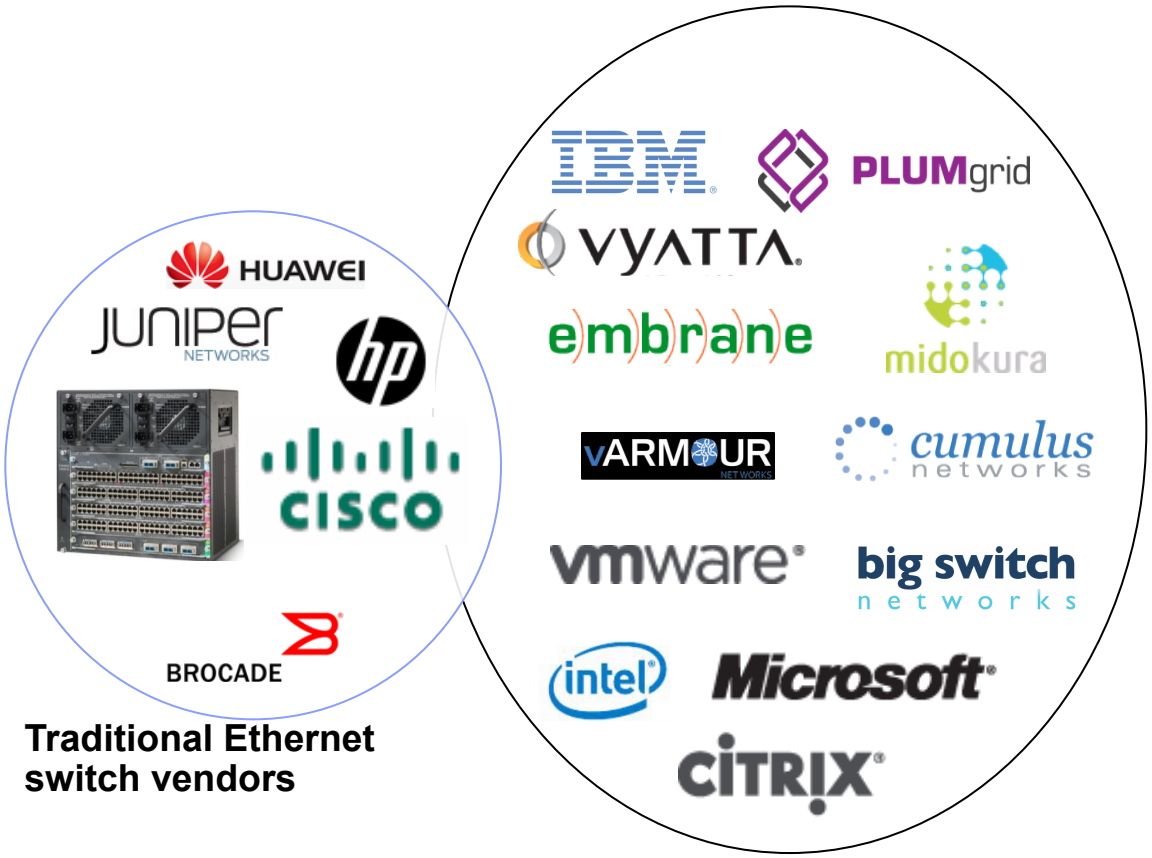
- network functions embedded in hardware appliances
  - high-speed packet switching, protocols, and services all residing on devices
- proprietary from various vendors

- device-centric configuration and management
- proprietary CLIs and APIs
- limited automation with custom scripts



- provisioning of network services manual, slow, and prone to errors
- limited agility

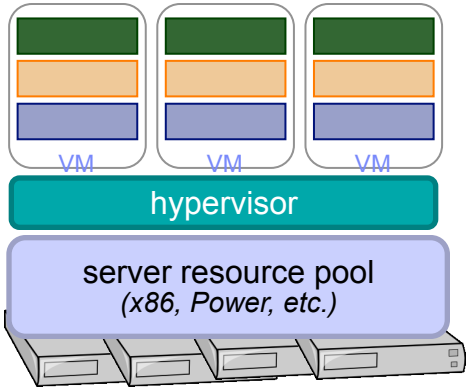
Accelerating shift to software in networking



Traditional Ethernet switch vendors

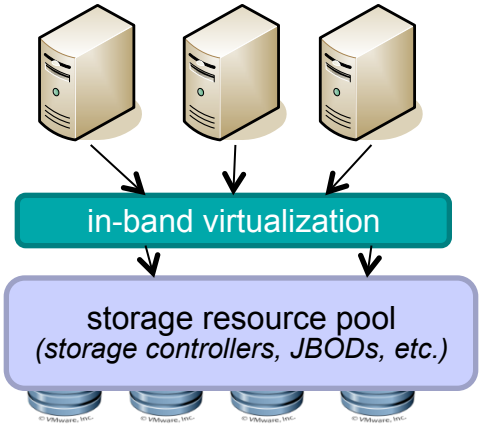
software providers moving the control point toward software functions and virtual switching

Networks are the new virtualization focus



server virtualization

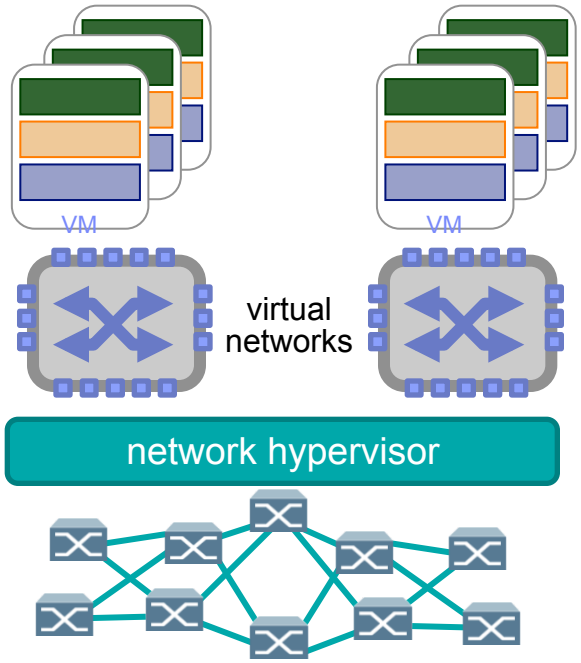
- efficiency (consolidation)
- multi-tenancy (isolation)
- flexibility (scaling, migration)
- hw independence (emulation)



storage virtualization

- efficiency (thin provisioning)
- multi-tenancy (isolation)
- flexibility (scaling, mapping)

network virtualization now emerging

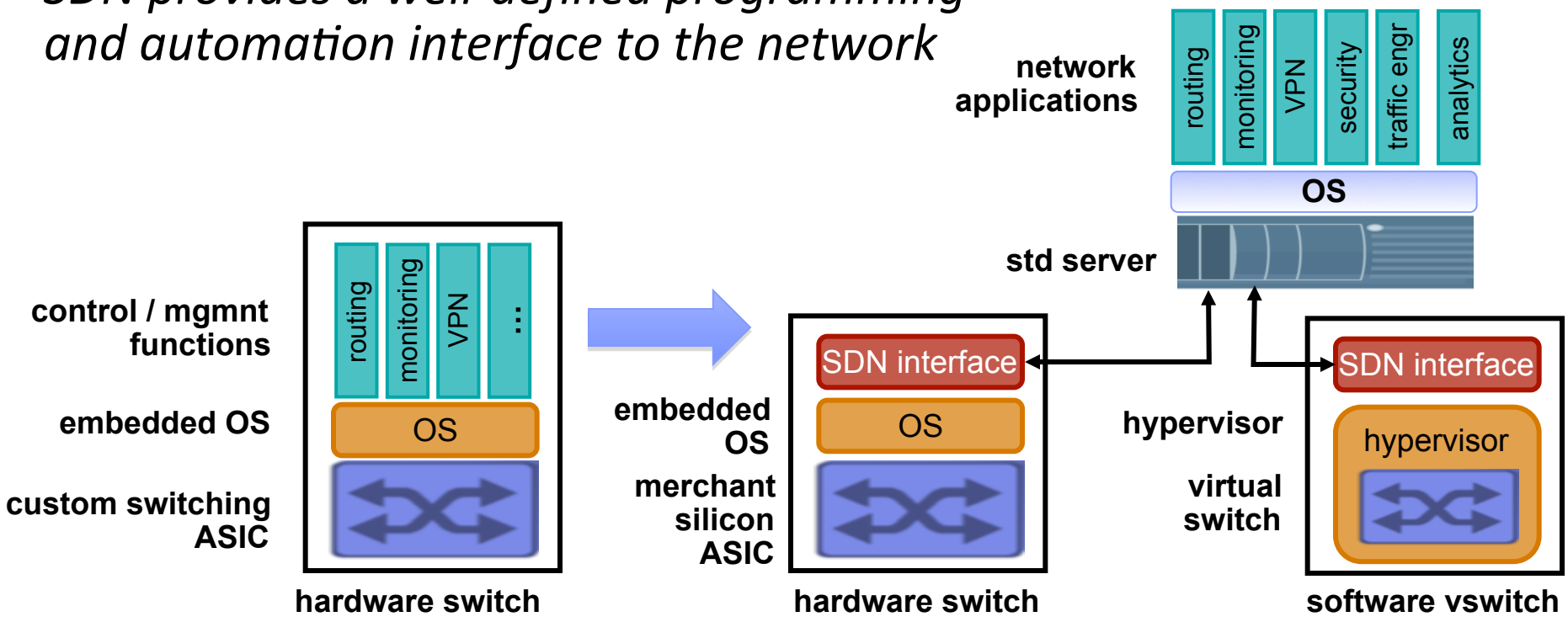


network virtualization

- efficiency (multiplexing)
- multi-tenancy (isolation)
- flexibility (loc independence)
- hw independence (encap)

Software-defined networking : the new paradigm

SDN provides a well-defined programming and automation interface to the network



Traditional, vertically integrated model

- distributed control with forwarding
- localized decision making
- embedded, fixed function

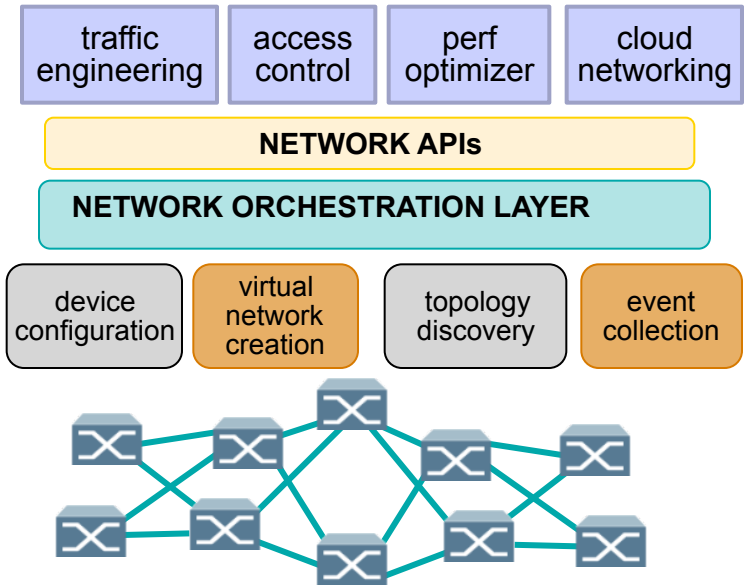
SDN, horizontal model

- decouple control and management from forwarding
- end-to-end decision making
- programmable function

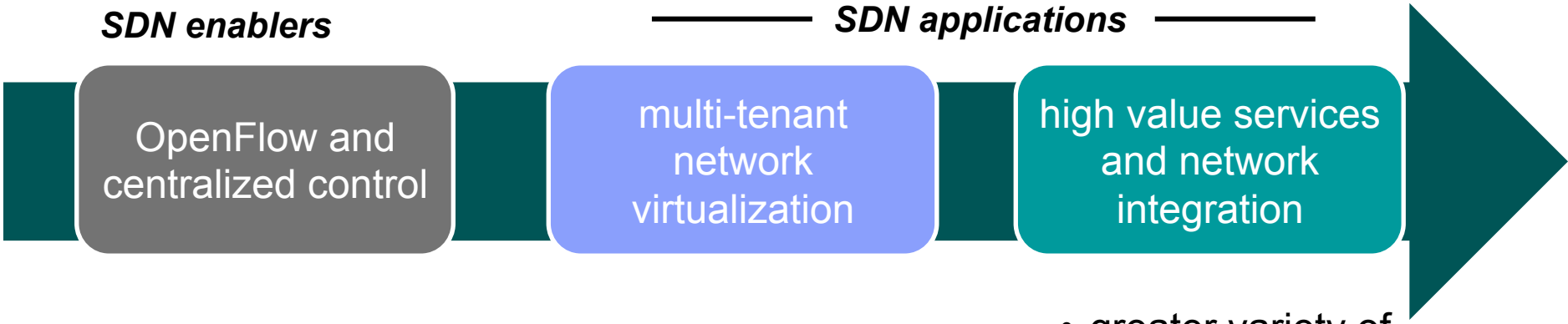
Software-defined networking – the promise

- rapid introduction of new functions at "software speed"
- better integration of the network with IT processes in the enterprise
- a new paradigm for applications to interact with the network
  - tell the network what you want
  - ask the network what you need to know
- a clean decoupling of the service API from the underlying implementation
- simplified, less expensive devices – drives commoditization
- provides a platform for network automation that can reduce operational cost

SDN architecture



Progression for software-defined networking



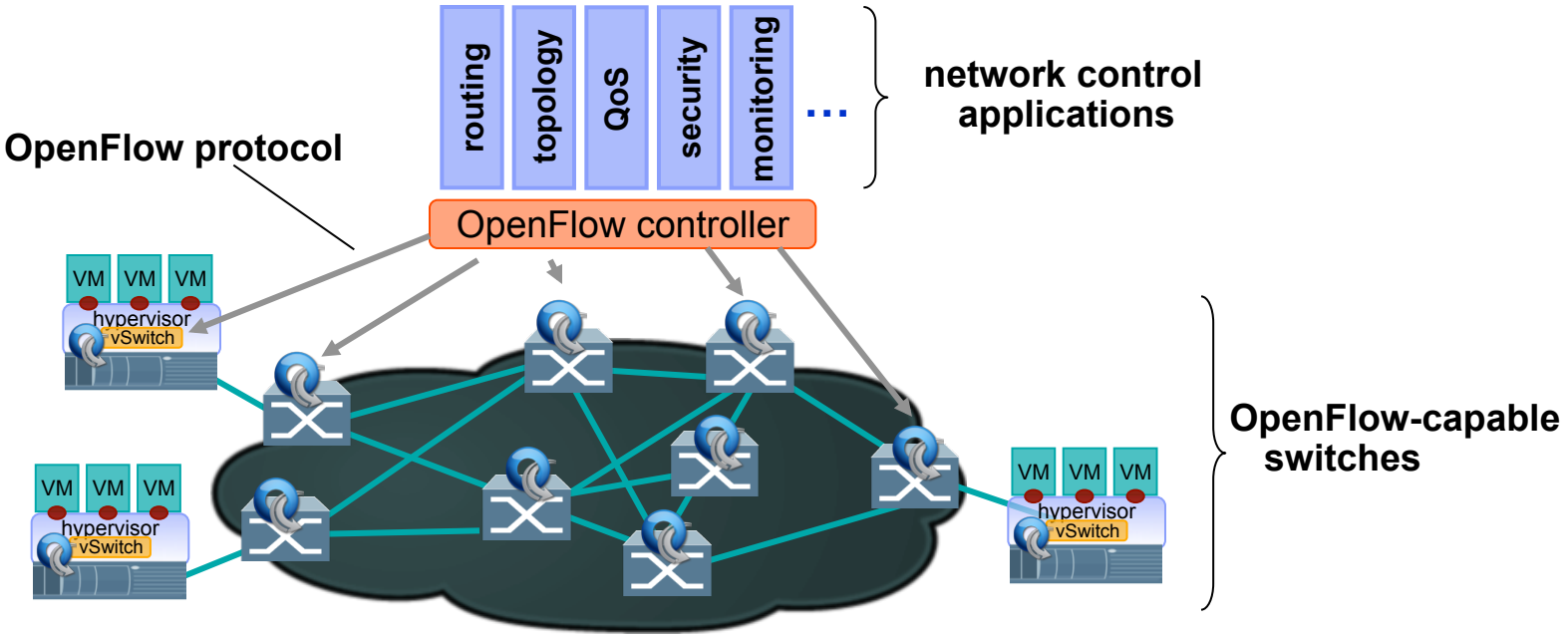
- industry standard protocol for SDN
- real deployments in campuses, large online SPs, and enterprises
- quickly becoming a standard feature on switches

- first production application for SDN
- multiple technical approaches
- vendor offerings already available or announced
- ultimately, a standard feature

- greater variety of network-level and application-level services
- integration with IT processes (security, provisioning, disaster recover, etc.)
- “app store” for SDN

OpenFlow : a standard protocol for SDN

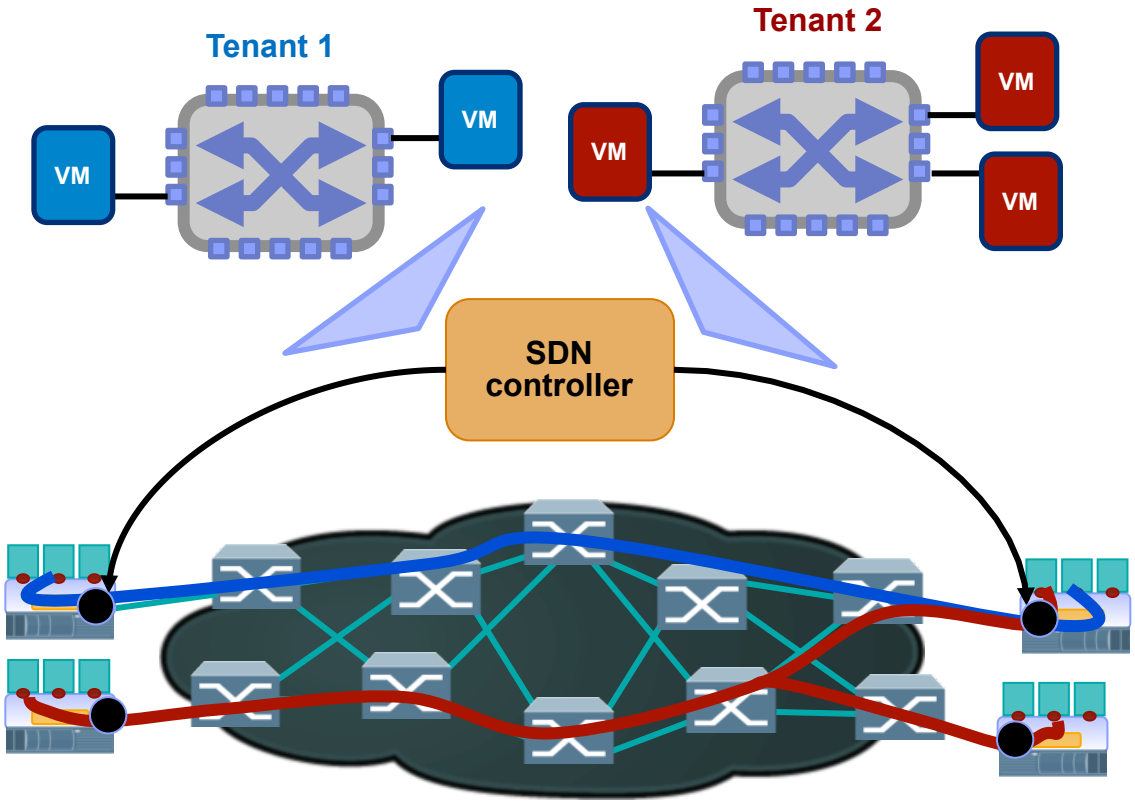
OpenFlow provides an industry-standard API and protocol to program packet handling in switches



- OpenFlow controller applications install match-action rules in switches
  - `if <src IP = x and dest IP = y> then forward to port 2`
  - `if <VLAN ≠ 200> then drop packet`
- Fine-grained and flexible control over packet handling

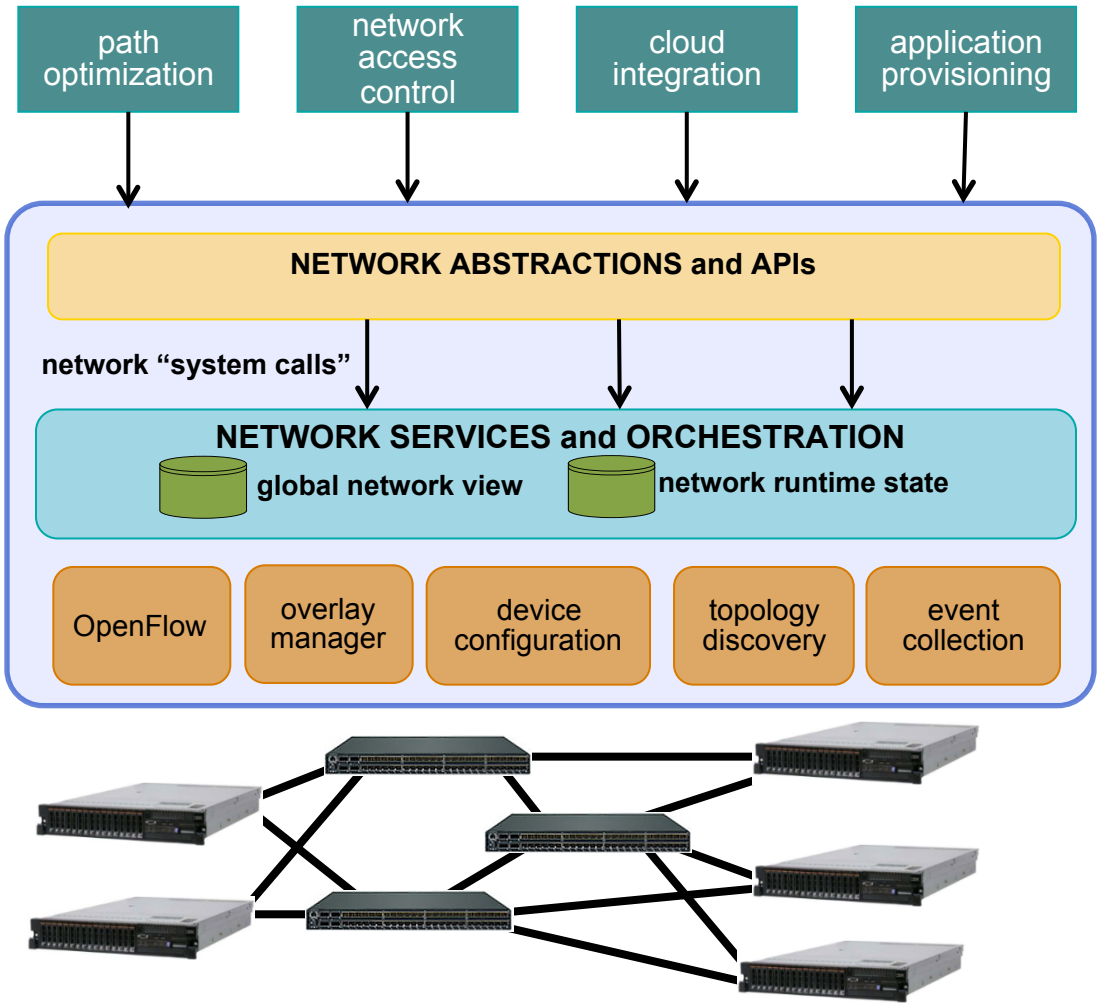
Multi-tenant network virtualization with overlays

- one-time deployment and configuration of the physical network
- provide each data center tenant with a **single virtual network** abstraction
- SDN controller manages software switches on end hosts
- uses overlays and encapsulation to virtualize physical network infrastructure



- virtual network implemented purely on end hosts by software switches and encapsulation
- create and destroy virtual networks on demand
- overcomes scaling limits of physical network virtualization

A comprehensive software-defined networking platform



network control applications and integration points

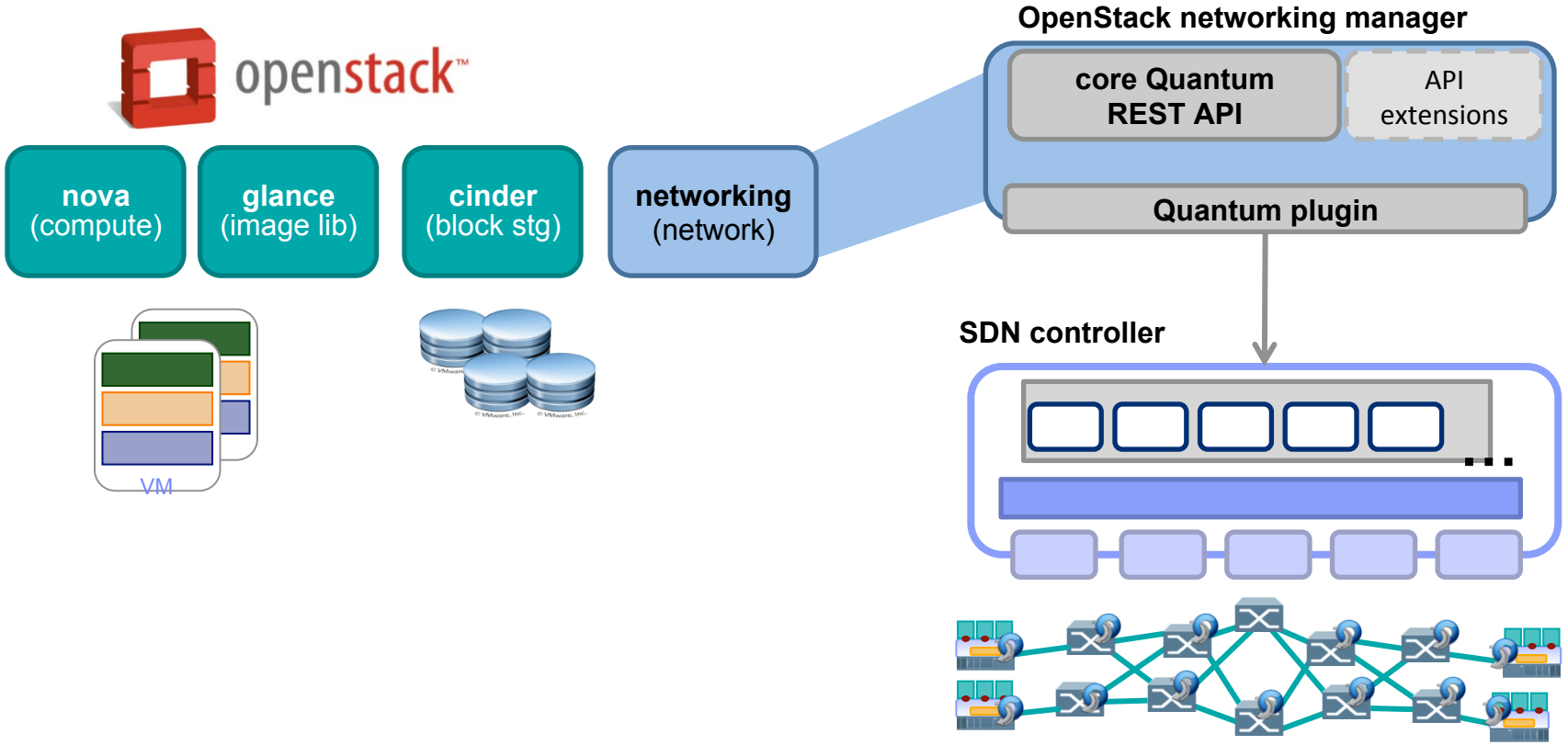
logical network models and application APIs

logical – physical translation , arbitration, network-wide services

"drivers" for controlling network devices and capabilities

SDN and cloud computing: OpenStack example

- Cloud computing provides virtual servers and storage on demand in a usage-based consumption model on shared infrastructure
- Cloud networking must fit into the same model – on-demand, programmable, multi-tenant



Examples of production SDN deployments

- Management of inter-data center WAN traffic with OpenFlow
  - lack of control and non-determinism in distributed protocols
  - non-standard vendor configuration APIs
  - centralized, system-wide control: faster convergence and higher efficiency

Google™

see Google presentations at ONS 2012 and IETF 85

- SDN-based network virtualization for public clouds
  - on-demand, rapid creation of customer networks at scale
  - enable per-customer private addressing and policies
  - enabled using overlay network virtualization (NVGRE)
  - virtual switches implement all policies in software

Windows Azure

see Microsoft presentation at ONS 2013

Active research topics in SDN

- Language support for programming the network
- Verifying, monitoring, and debugging SDNs
- Extending SDN from routing and switching to the network service plane (L4 – L7)
- SDN controller design, scale-out, and state replication
- Network abstractions and application API design

References – where to learn more about SDN and OpenFlow

- Open Networking Foundation (OpenFlow specification standardization)
  - https://www.opennetworking.org
- Open Networking Summit (Industry conference on SDN and OpenFlow)
  - http://opennetsummit.org
  - videos and charts available for 2011 – 2013 conferences
- ACM SIGCOMM Hot-SDN workshop
  - 2012 papers and videos available, 2013 program posted
- SDN and OpenFlow publicly available tools and technologies
  - http://www.opendaylight.org (Open Daylight Project)
  - http://onlab.us (Stanford / Berkeley)
  - http://www.projectfloodlight.org (BigSwitch)
  - …

Summary

- Software-defined networking aims to fundamentally change the way networks are deployed and operated
  - moving intelligence from hardware to software (new players)
  - programmability and integration in every device (devops)

- Rapid pace of industry adoption and interest with real deployments starting in cloud service providers and campuses

- "Openness" is a key characteristic of SDN
  - open standards, e.g., OpenFlow
  - open source platforms, e.g., OpenDaylight
  - open APIs

- Robust industry / research partnership in evolving SDN