SDN AND NFV INTRO

RESHAPING NETWORKS FOR THE 21ST CENTURY

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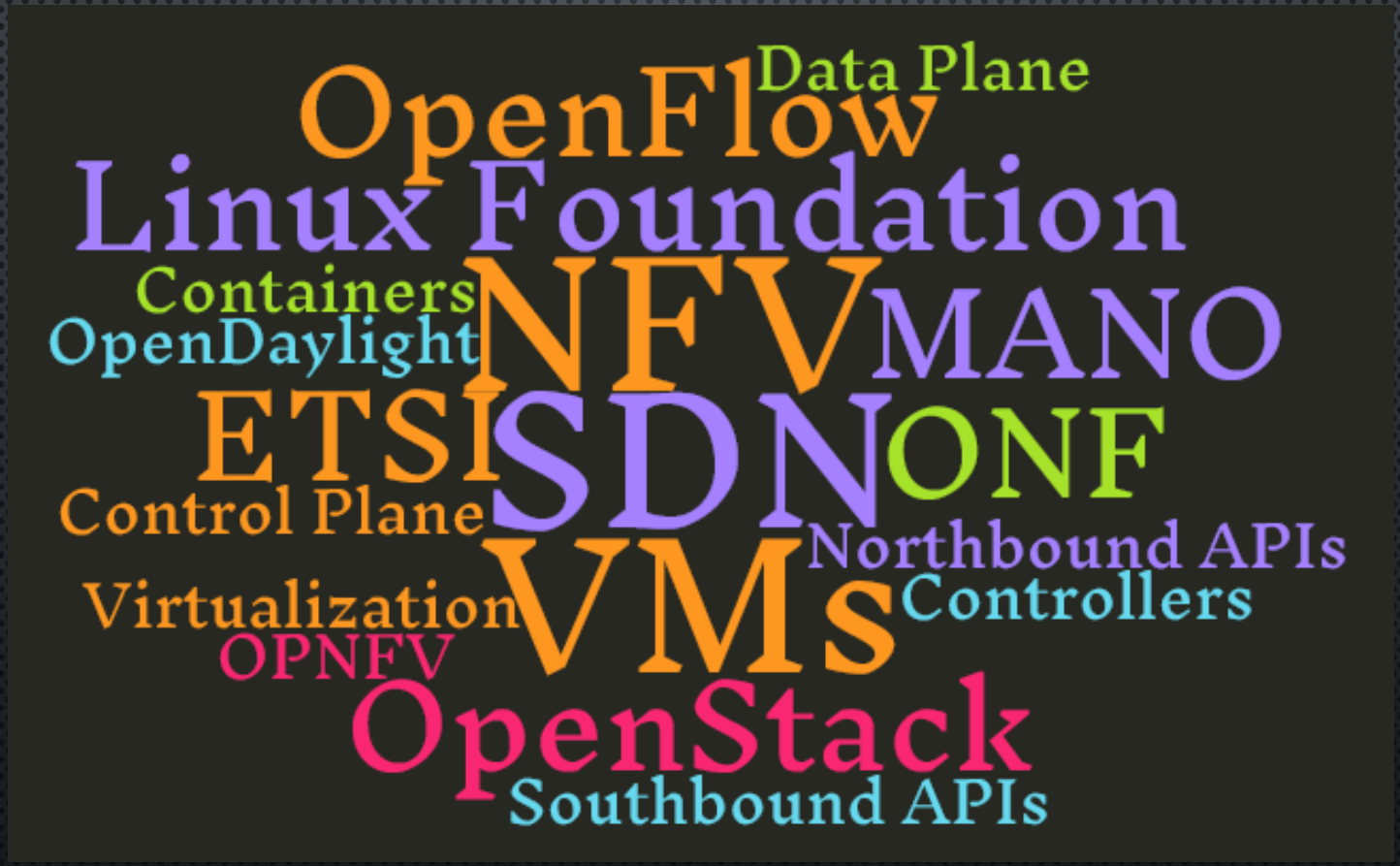
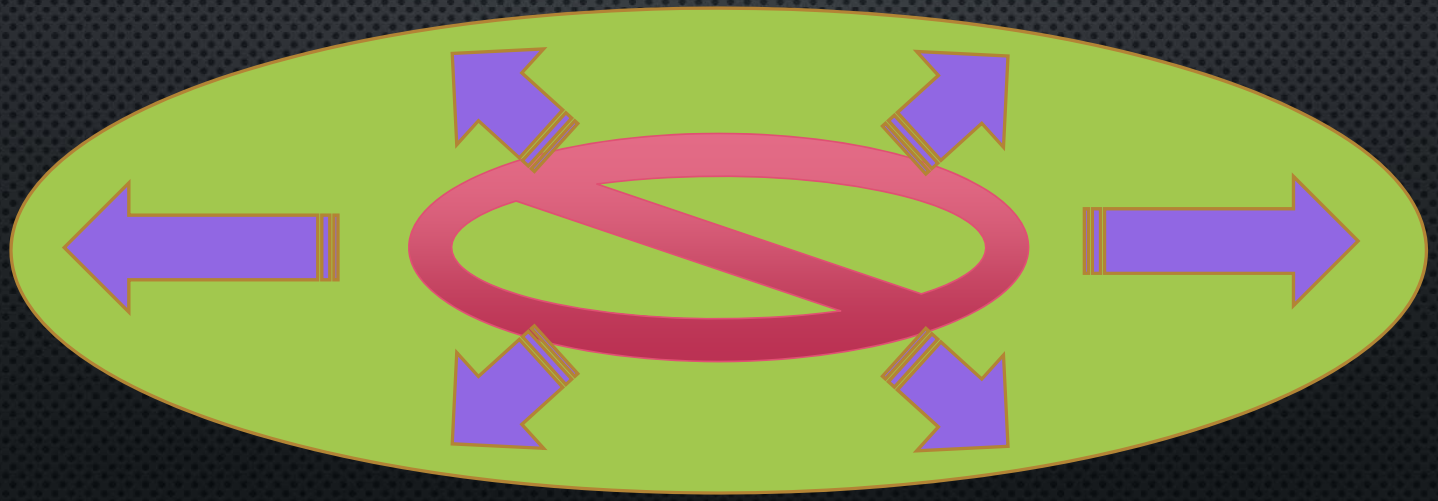
Word Soup – What does it all mean?



The Internet's *most fundamental concept*

Keep intelligence & policy out of the middle of the network, push it to (or as near) the edge as possible

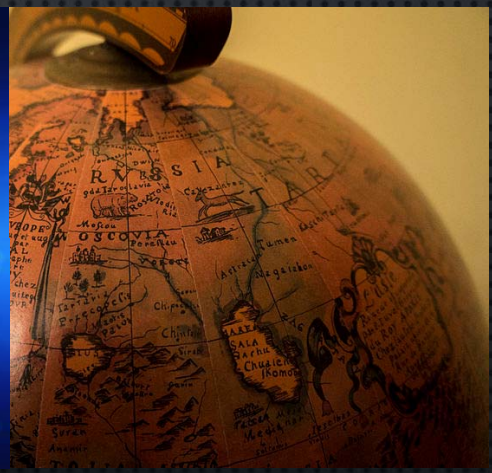
- Peer-to-peer (almost) always favored over hierarchical relationships
- Hardware often replaced by software



“

Software is eating the world.

— Mark Andreesen, in the Wall Street Journal, 2011 ”

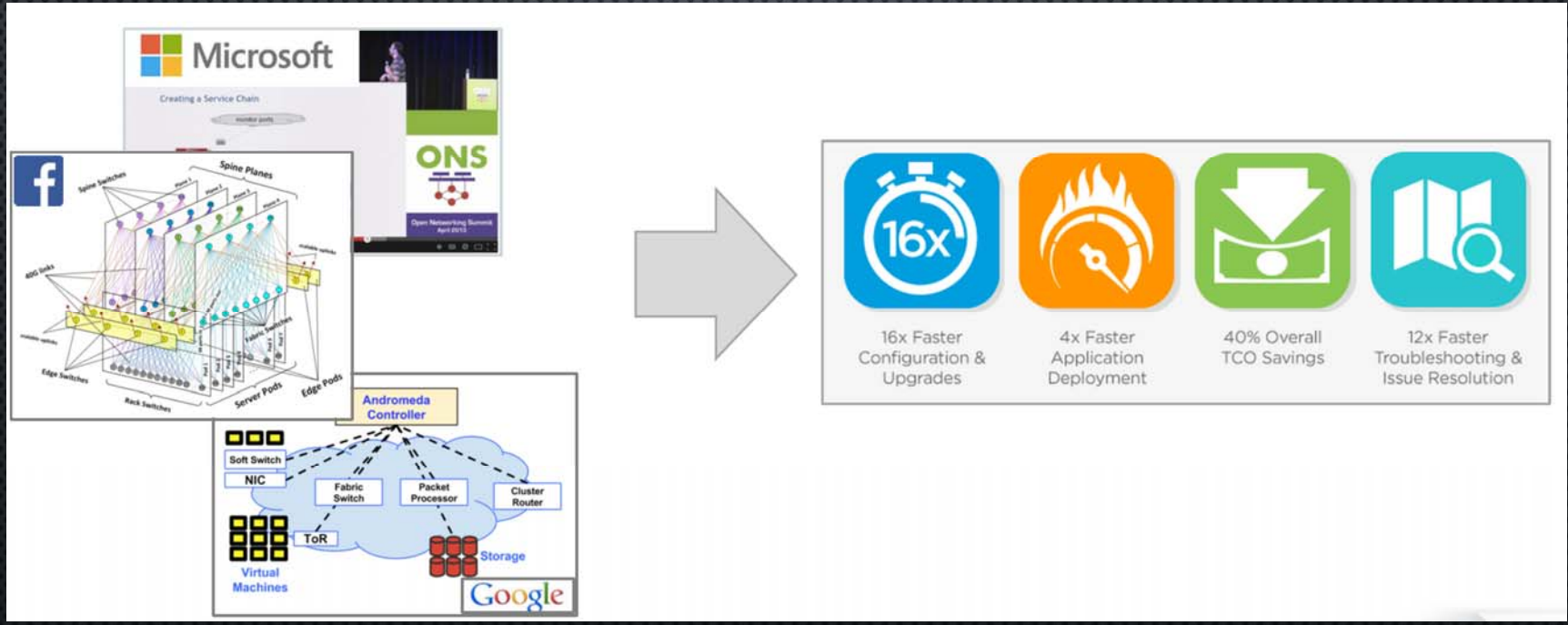
“Software: The expensive part that’s hard to change, as distinct from hardware.”

— Ted Nelson, Computer Lib/Dream Machines

“Everything is deeply intertwingled.”

— Ted Nelson, Computer Lib, 1974

How Virtualization and SDN fabrics have transformed BIG real world apps

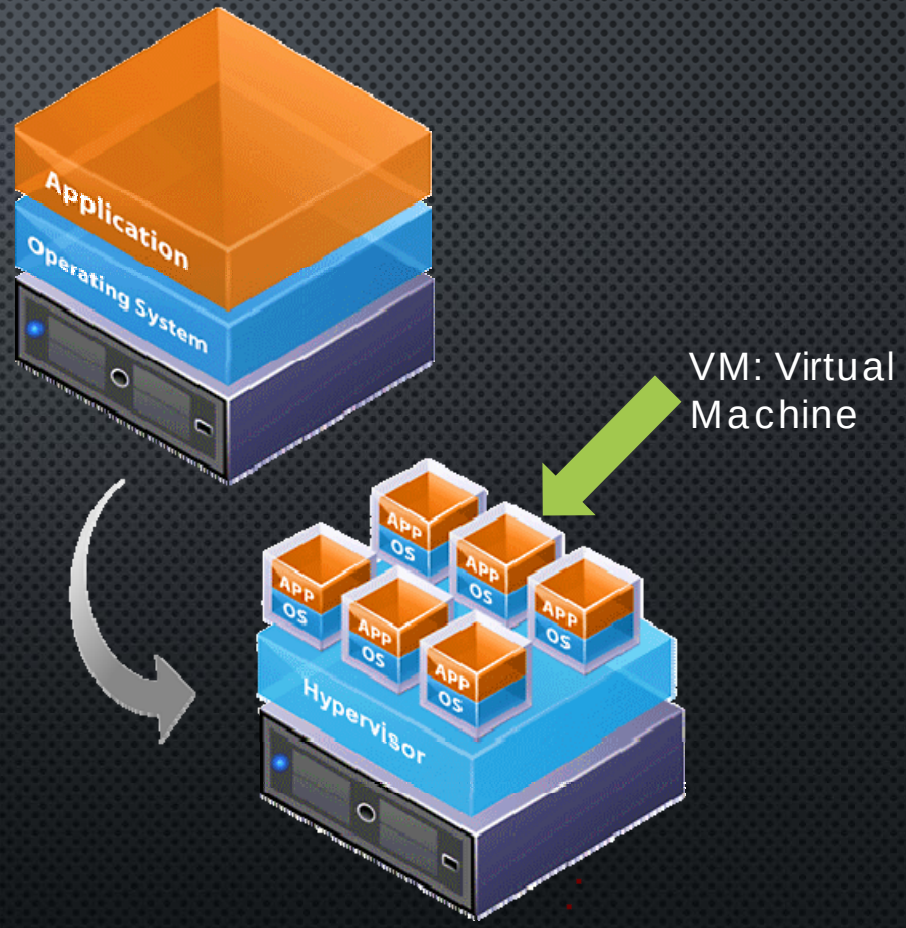


Source: Big Switch Networks

Server Virtualization

- Replace “full stack” of Drivers, OS, and Applications with slimmer version running either ”on bare metal” or on a host OS

- Some Popular Server Virtualization Hypervisors:
  - VMware ESXi
  - Microsoft Hyper-V
  - Red Hat KVM
  - Citrix Xen



Virtually everything is virtualized now...

- CPUs
- Operating Systems
- Libraries
- Interfaces
- Storage
- Networking
- ...

Networks "catching up" is a REVOLUTION

- Long overdue (IT/Server/Cloud guys are *years* ahead…)
- Brings fast deployments and Continuous Integration to infrastructure, not just application and software development
- Interesting observation: Original Internet used host-based routing – custom hardware & ASICS came much later…
- "With the role of the network reduced to the bare minimum, it became possible to join almost any networks together, no matter what their characteristics were, thereby solving Kahn's initial problem." - Wikipedia on History of the Internet

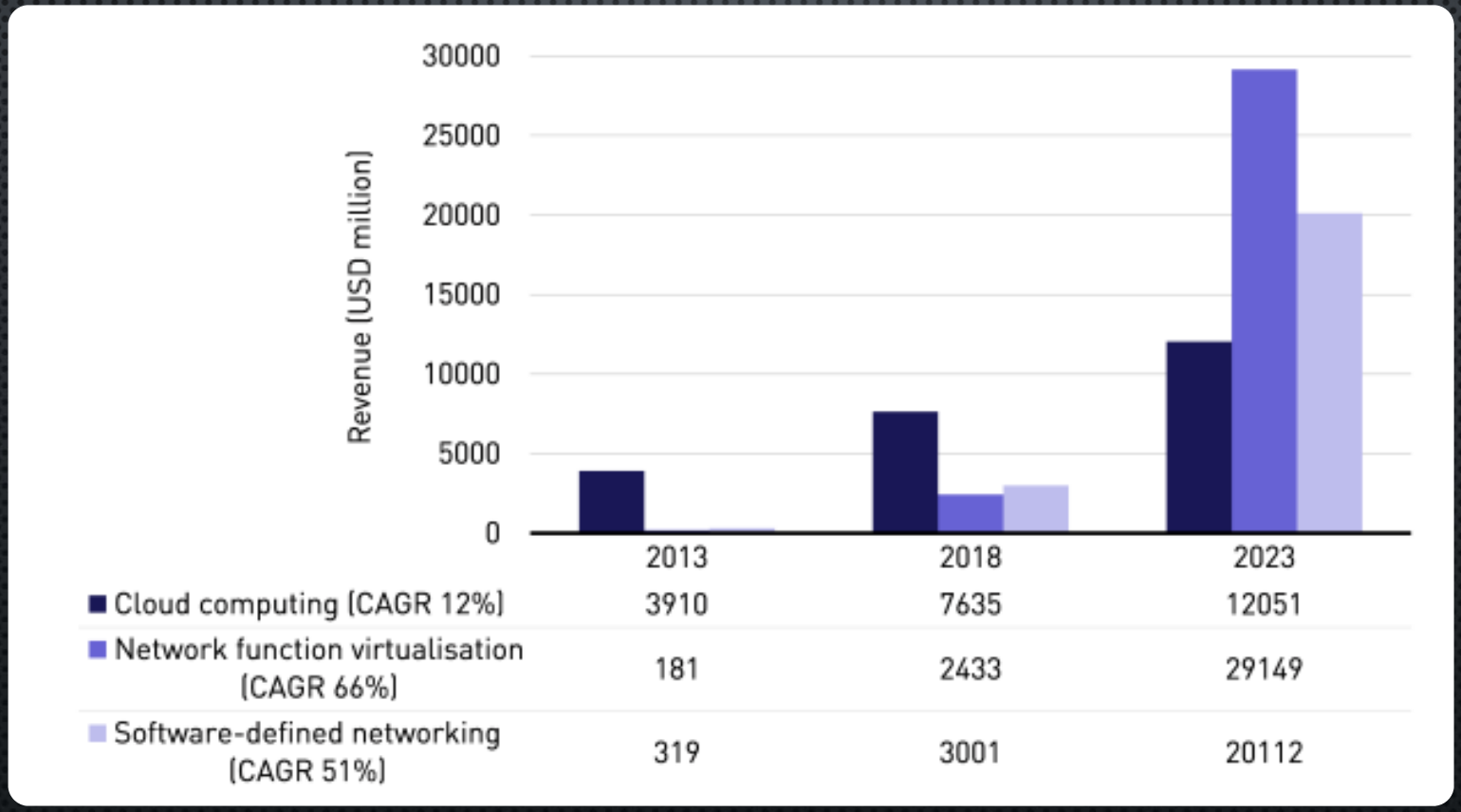
Technology Meta-drivers

- Demand is growing like mad, so better utilization is essential – need to make the most of all resources
- Pace of technological innovation is quickening
- Market and customer demand gap to state-of-the-art is closing
- General purpose hardware is now “fast enough”
- Cloud Data Center market has led to good, cheap “white box” servers, storage, and network switches
- Software and standards are maturing rapidly
- OpenSource is winning

Mutually Supporting Emergences

- Cloud Computing
- Big Data
- Fast Data
- On Demand Services
- Dynamic Reconfiguration/Optimization
- Cognitive Computing and AI
- Internet of Things
- SDN and NFV

Software Controlled Networking Revenue



	2013	2018	2023
Cloud computing (CAGR 12%)	3910	7635	12051
Network function virtualisation (CAGR 66%)	181	2433	29149
Software-defined networking (CAGR 51%)	319	3001	20112

Source: Analysys Mason, 2014

SDN/NFV Momentum is building

- AT&T's ECOMP Enhanced Control, Orchestration, Management, and Policy (open sourced to Linux Foundation for release in 2017) will be used to virtualize 75% of its network by 2020.
- Verizon (with Big Switch Networks, Dell, and Red Hat) develops pod-based OpenStack design used in the largest NFV OpenStack deployment across five data centers.

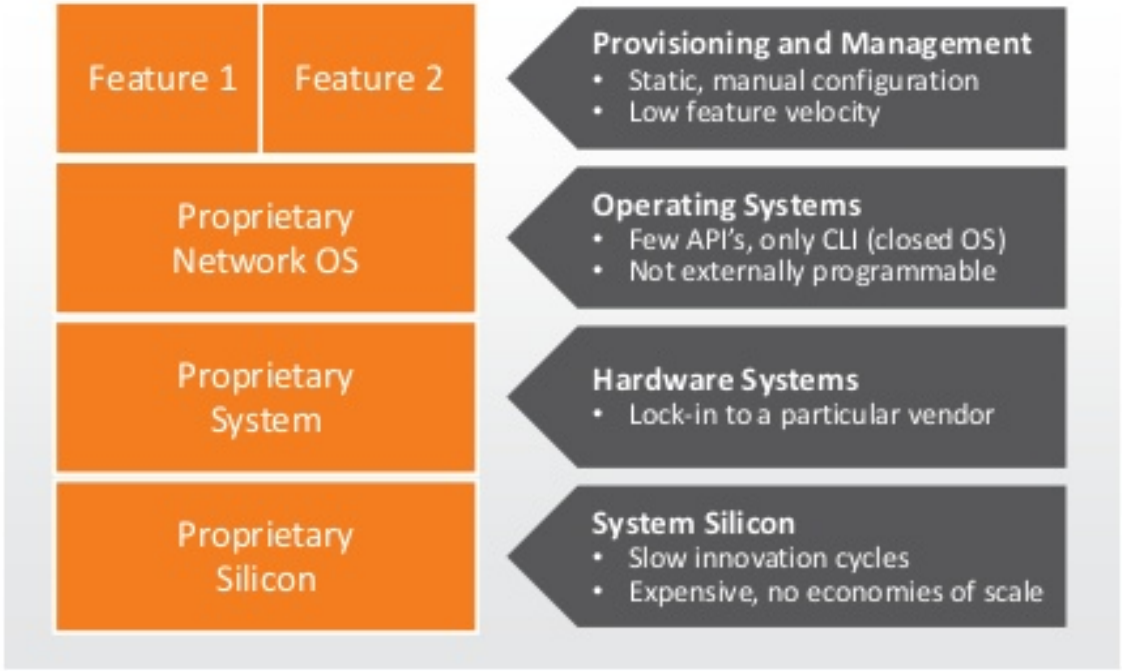
"There are techniques in software that allow us to provide the same reliability and even better. As we get better at this, we think the network can actually be even more reliable even though you're running on what's theoretically less reliable hardware underneath."
- Chris Emmons, Verizon

Source: Fierce Wireless/Telecom

The 20th Century way…

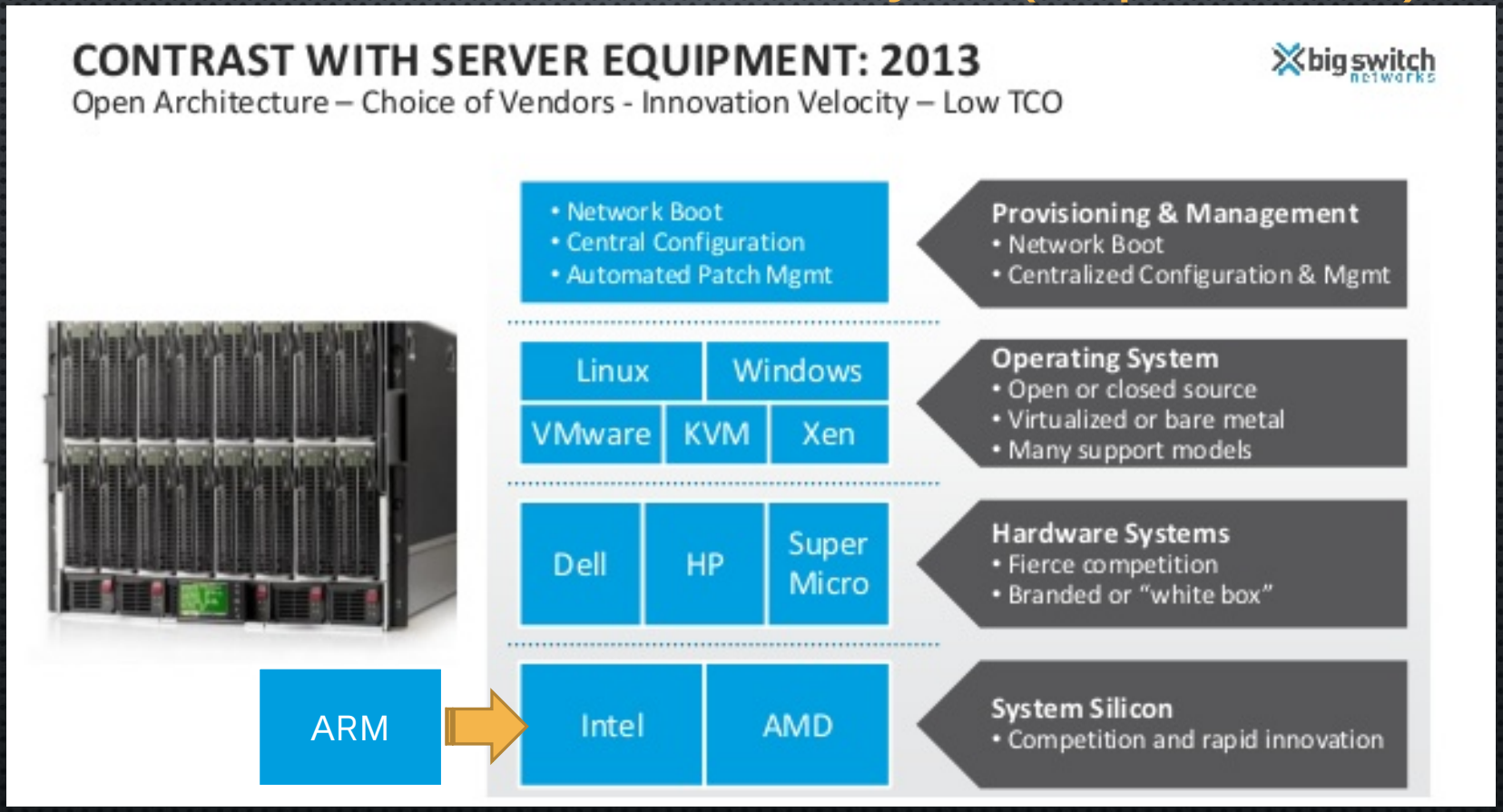
CLOSED & PROPRIETARY NETWORKING EQUIPMENT

Vertically Integrated Systems Have Changed Little Over the Past 15 Years



Source: Bigswitch Networks

Virtualization *is* 21st Century IT (esp. cloud)



Source: Bigswitch Networks

Evolution of Server Provisioning

Source: Bigswitch Networks

Evolution of Network Provisioning

1996

```
Router> enable
Router# configure terminal
Router(config)# enable secret cisco
Router(config)# ip route 0.0.0.0 0.0.0.0 20.2.2.3
Router(config)# interface ethernet0
Router(config-if)# ip address 10.1.1.1 255.0.0.0
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)# interface serial0
Router(config-if)# ip address 20.2.2.2 255.0.0.0
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)# router rip
Router(config-router)# network 10.0.0.0
Router(config-router)# network 20.0.0.0
Router(config-router)# exit
Router(config)# exit
Router# copy running-config startup-config
Router# disable
Router>
```

Terminal Protocol: **Telnet**

2013

```
Router> enable
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Router# disable
Router>
```

Terminal Protocol: **SSH**

Source: Bigswitch Networks

“White Box” hardware pushing out to CPE

Source: Advantech.com

Origins of SDN and NFV

- SDN
  - Created for Academic Cloud/Data Centers (Open Networking Foundation)

- NFV
  - Created by consortium of Service Providers (European Telecommunications Standards Institute)

The technology players…

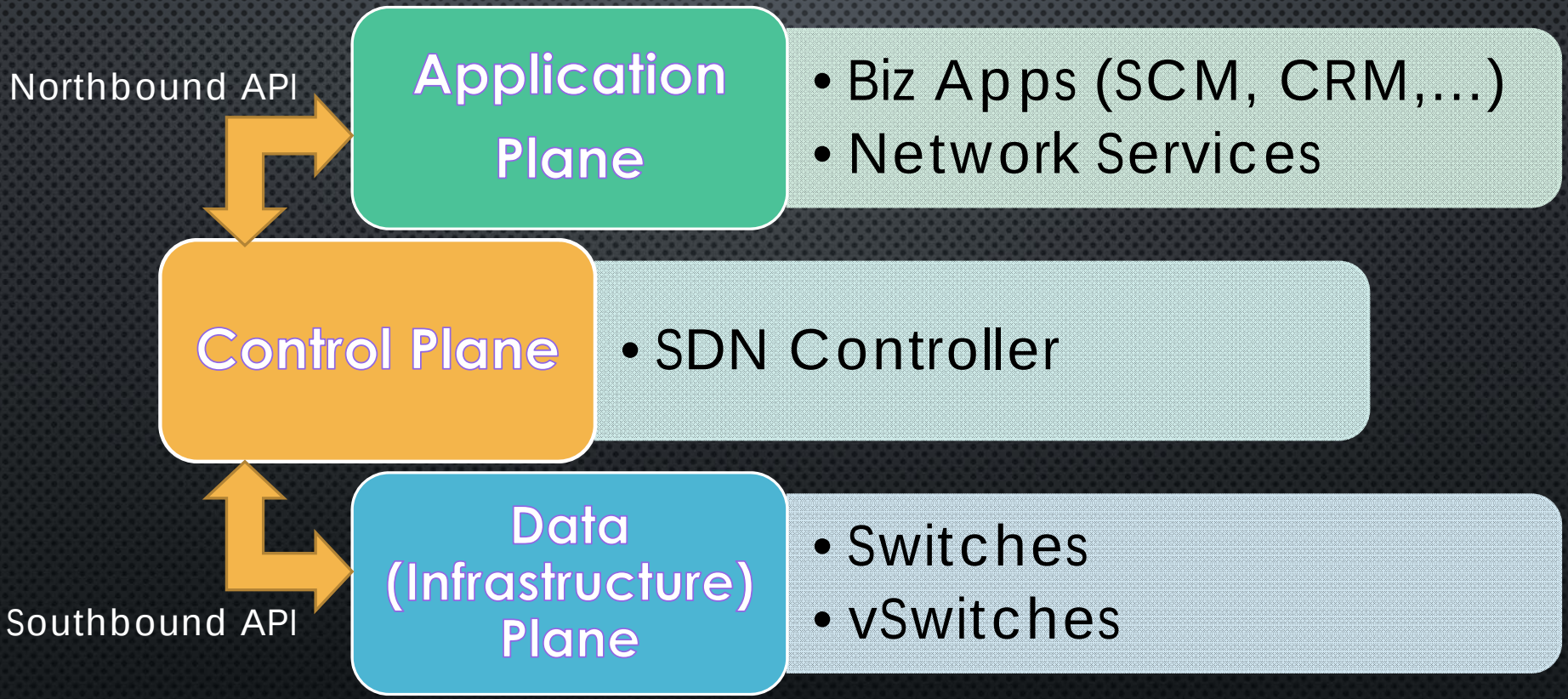
- SDN: separates the network's control (brains) and forwarding (muscle) planes and provides a centralized view of the distributed network for more efficient orchestration and automation of network services.
- NFV: focuses on optimizing the network services themselves. NFV decouples the network functions, such as DNS, Caching, etc., from proprietary hardware appliances, so they can run in software to accelerate service innovation and provisioning, particularly within service provider environments.
- NV: ensures the network can integrate with and support the demands of virtualized architectures, particularly those with multi-tenancy requirements.
- White Box: uses network devices, such as switches and routers, based on "generic" merchant silicon networking chipset available for anyone to buy, as opposed to proprietary "ASIC" silicon chips designed by and for a single networking vendor.

Source: Adapted from SDXcentral.com

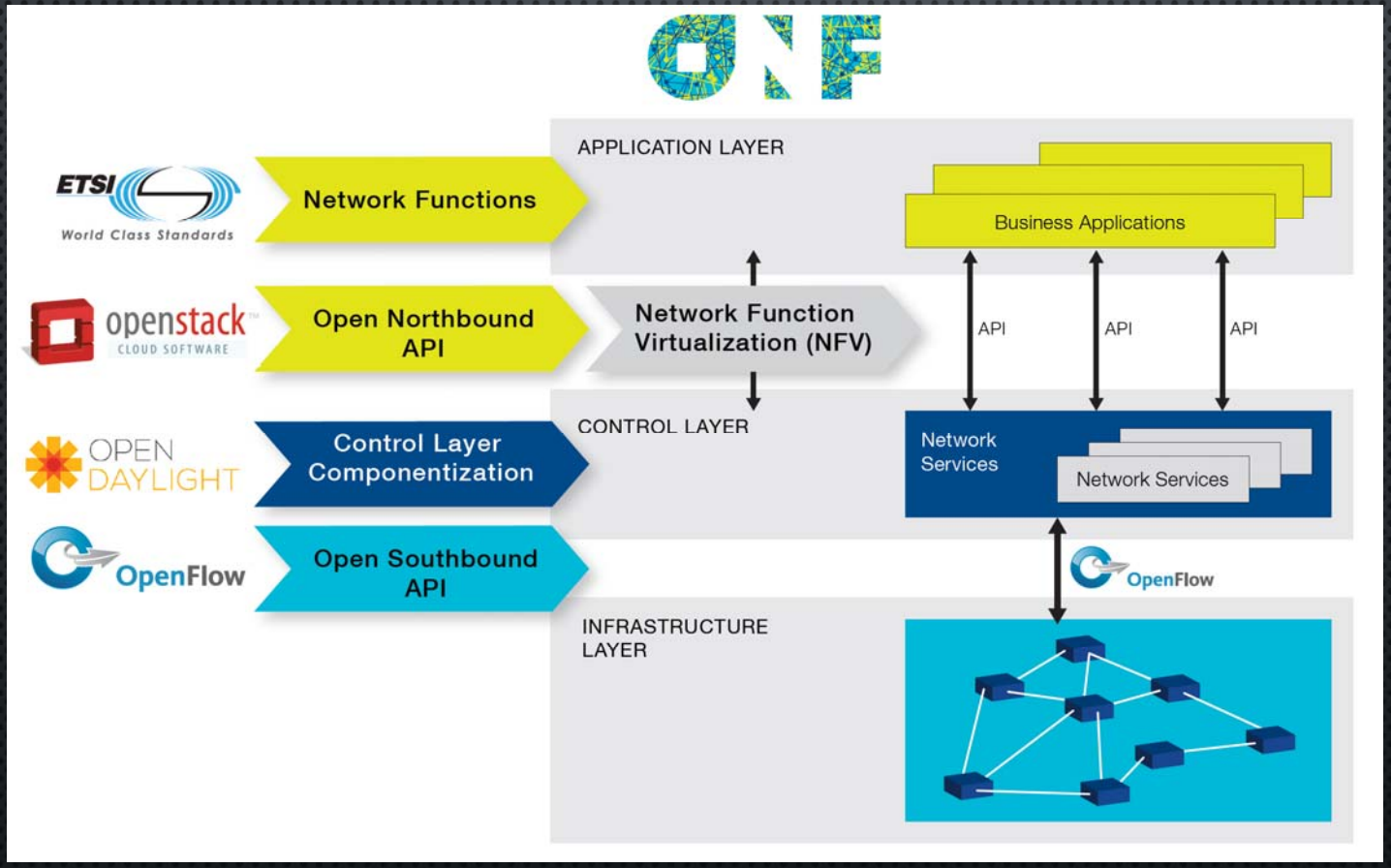
SDN Basics

- Key concept is separation of control and data planes
- Three primary components:
  - SDN Controller (Brains)
  - Southbound API
    - Pushes info to Switches and Routers “below”
    - OpenFlow is best-known example
  - Northbound API
    - Interfaces with apps and business logic “above”

Generic SDN Architecture



SDN/NFV Industry Protocol Map



Source: ONF

SDN Architecture Characteristics

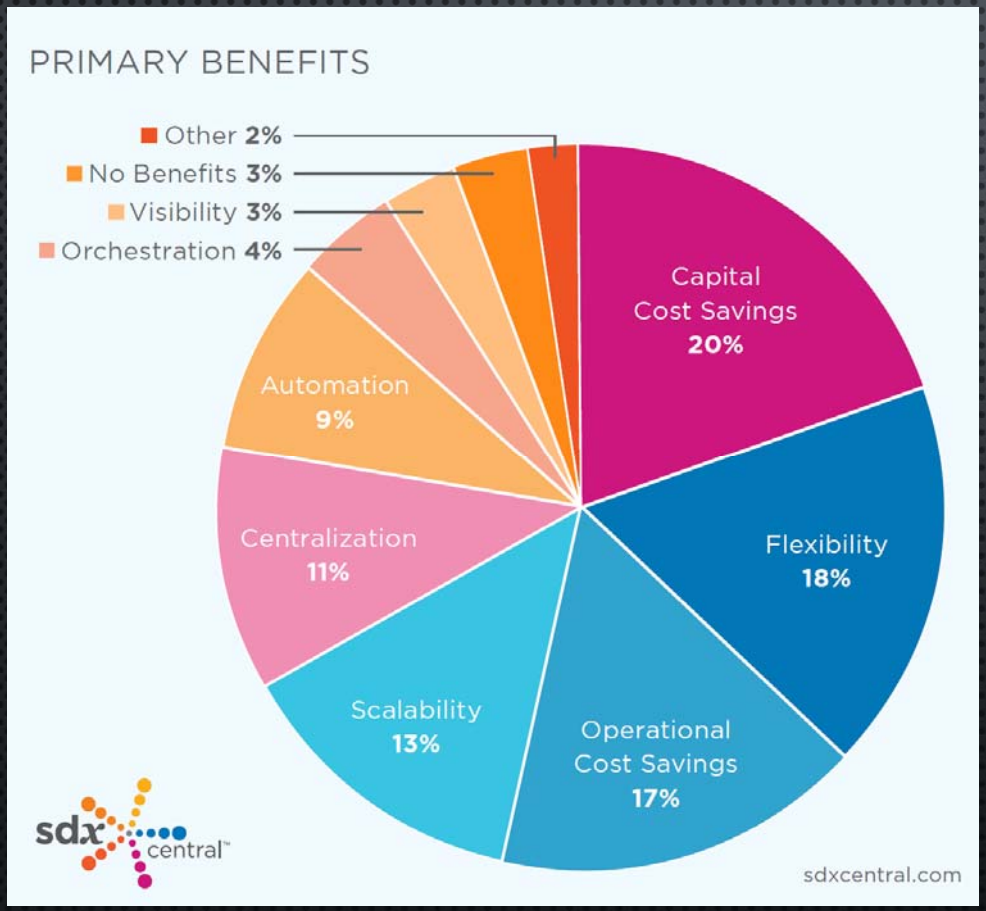
- Logically Centralized Intelligence
  - Moves away from Autonomous System concept behind today's network where nodes are unaware of the overall state of the network
- Programmability
  - Allows automation; w/ open APIs, can provide unprecedented innovation and differentiation
- Abstraction
  - Services are abstracted from underlying network technologies, devices abstracted from Control Layer, "future-proofing" investments in network services

Aside: Some Keys to SDN/NFV Success

In short:

- Attempts to centralize too much will almost always fail – don't forget that fundamental guiding principle of the Internet…
- This is still at least equal parts art and science: knowing what to push or retain at what place will determine whether the SDN (and/or NFV) deployment will be successful
- Determining who and what gets to set which policies and how is still, as always, an issue. (In other breaking news, turf battles expected to continue…)
- You are using new Power Tools. POWER TOOLS CAN KILL!

SDN Drivers & Benefits



Top Three:

- Lower costs (CAPEX & OPEX)
- Increased Flexibility & Agility
- Simplified Management

SDN Drivers & Benefits

- Applications can request services (low latency, secure routing)
- Reduced OSS complexity via automation
  - Easier automation of Provisioning & Maintenance (API vs CLI)
  - Automate Network Access Control & Intrusion Protection
  - Eases integration of policy across wired & wireless networks
  - Centralized control of multi-vendor environments

SDN Drivers & Benefits (cont'd)

- Supports faster-paced Innovation (Time-to-Market)
- Reduction of BOTH CapEx AND OpEx
- Agility: More flexible and granular control
- WAN link utilization to 95% or better is possible (Google)
- Note: Most of these things are *possible* w/o SDN, *but much more difficult* to configure and manage

Reducing Operational Expenditures

"A side benefit of using less expensive commodity hardware is that an organization can potentially cycle the hardware more often to improve the overall performance of the network.

By upgrading the network every 2 to 3 years, instead of the traditional 5 to 7, an organization can continue to effectively address the changing demands placed on their network and increase the value captured throughout the lifetime of those servers."

Source: SDXcentral.com

Reducing Operational Expenses

“Common automation and operating procedures utilized by commodity hardware simplifies roll out and ongoing management.

Standardized hardware, as well as standardized software, such as hypervisors and orchestration systems, often use automation scripts and platforms that deliver, on average, management efficiencies between 1:10/1:100 to 1:1000.”

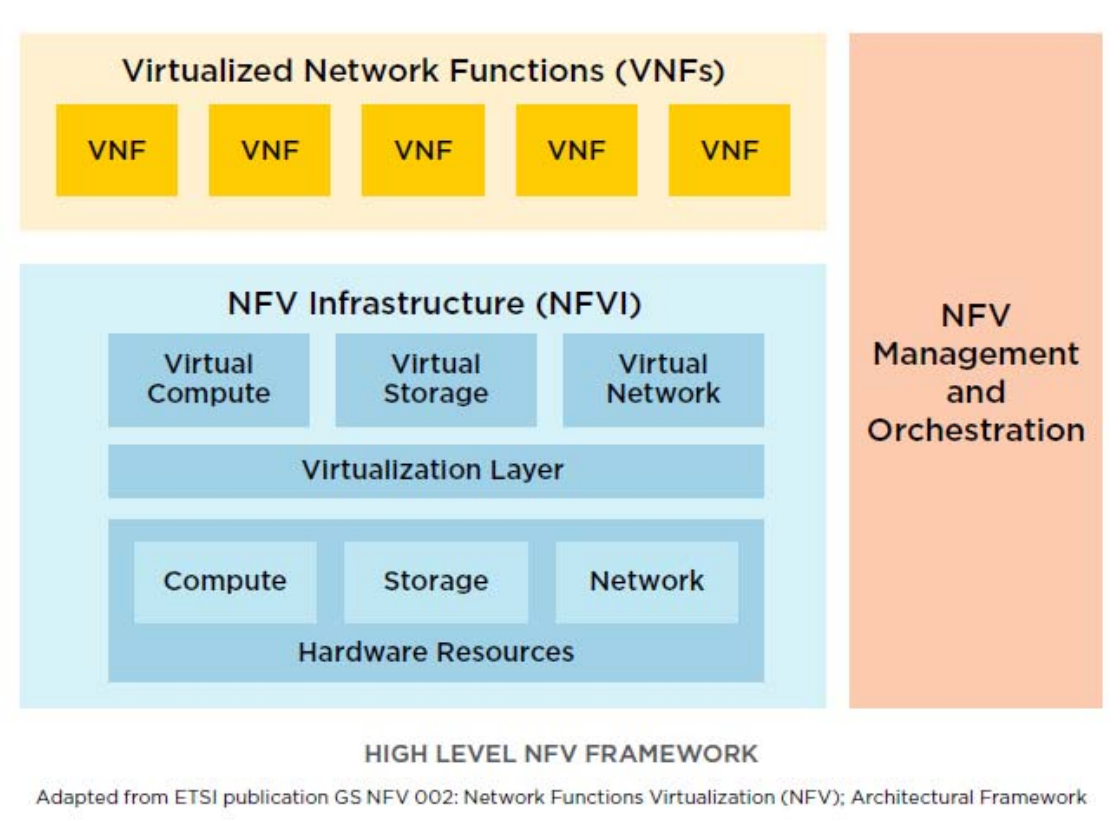
Source: SDXcentral.com

Network Function Virtualization Definition

- Network Functions Virtualization (NFV) decouples network services from the hardware that delivers them. As a result, functions, such as network address translation (NAT), firewalling, intrusion detection, domain name service (DNS) and caching, can be delivered in software and deployed on general purpose appliances. This gives organizations a lot more flexibility in the way they design, deploy and manage their network services.

Source: SDXcentral.com

NFV Architecture: VNFs atop NFV platform



Sample VNFs

- NAT
- Caching/CDN
- Firewall
- Intrusion Detection
- AI Threat Protection
- Domain Name Service (DNS)
- Federated Auth & ID Services
- Deep Packet Inspection

SDN/NFV Challenges & Success Barriers

"SDN and NFV will not achieve their potential value until OSS and BSS systems are aligned with the new technologies. A service can be turned up or torn down quickly but until provisioning, configuration, billing and fault management are automated, dynamic, and intelligent, SDN and NFV cannot be fully leveraged."

– ONF, "Impact of SDN and NFV on OSS/BSS"

NFV Network Challenges for Carrier Operators

- Fixed Configurations: Today's network hardware appliances have fixed IPs for years
- Manually Intensive Management: Automation is required
- Rapid growth of IP endpoints: Will grow much faster than today's networks (millions for residential/mobile apps.)
- Network Endpoint Mobility: NFV breaks IP/Location/ID linkage
- Elasticity: Continual reconfiguration as VNFs created/destroyed
- Multi-Tenancy: Cloud-like "X-as-a-Service" offerings require decoupled policy

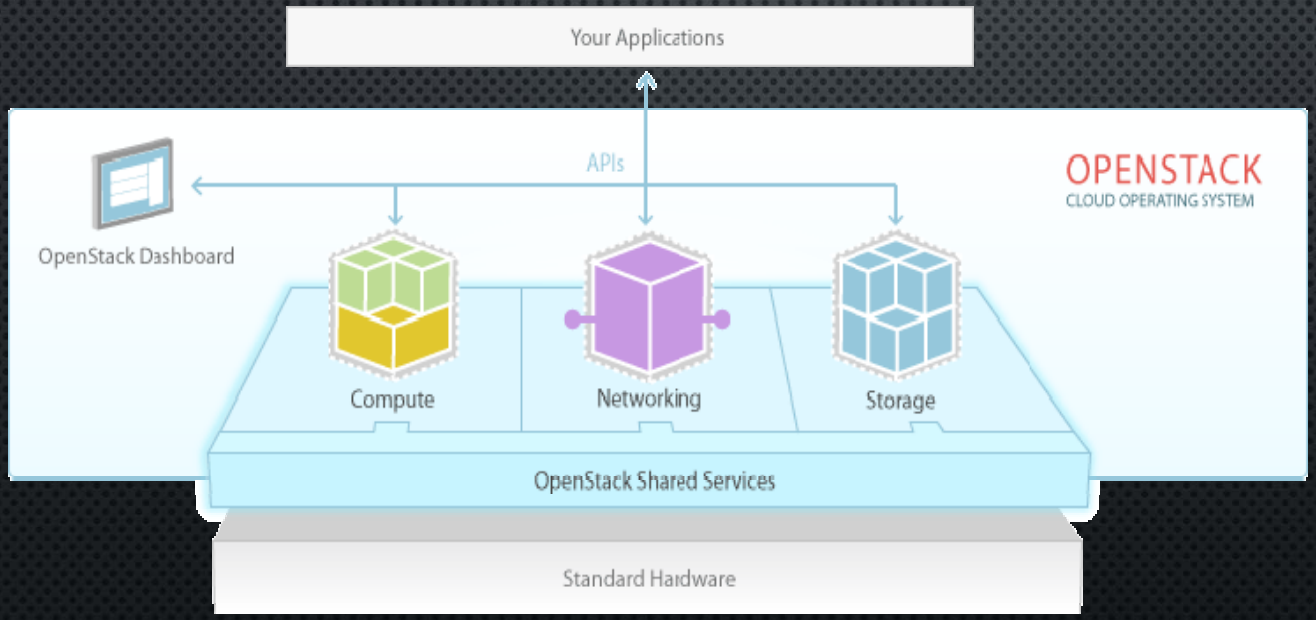
Source: ONF SDN/NFV Solution Brief

NFV Interoperability Challenges

- NFV vendors are fragmented: interoperability doesn't, yet
- SDN/NFV platforms available today deeply tied down to hardware infrastructure or up to MANO plane
- No clear winner for SDN Northbound API
- Threatens to derail some near-term 5G rollouts
  - 5G gateways at edge instead
- This may backfire on vendors, creating strong demand for more open solutions

OpenStack

- Originated in 2010 by Rackspace and NASA as an open source effort to build all the infrastructure required to deploy complex cloud services (like offered by Amazon Web Services (AWS))

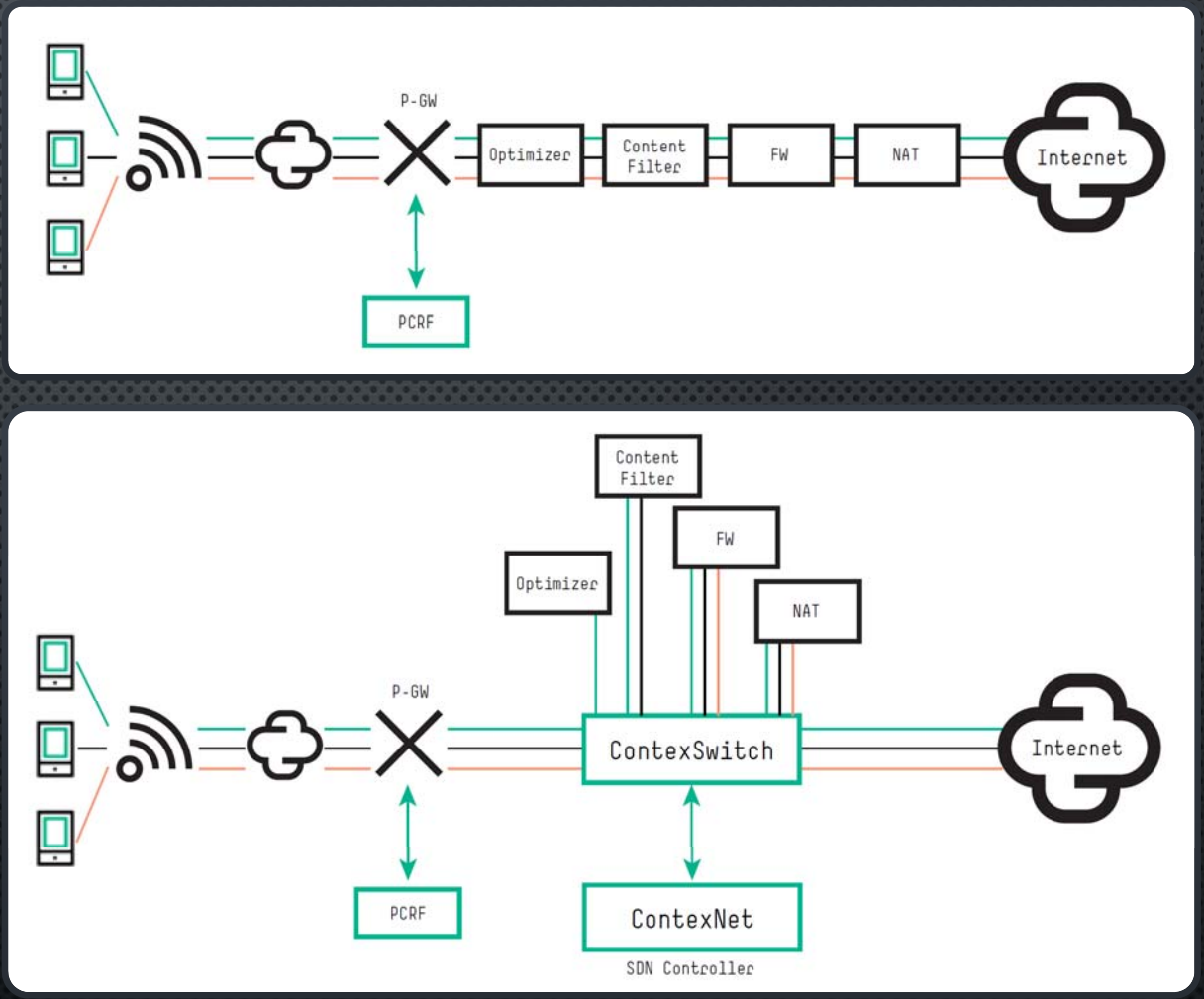


Current OpenStack projects:

- Compute
- Networking
- Block & Object Storage
- Identity & Key Management
- Dashboard & Telemetry
- Orchestration
- Workflow
- Database
- Elastic Map-Reduce
- Bare Metal
- Messaging
- Shared Filesystem
- DNS
- Search

NFV Service Chaining

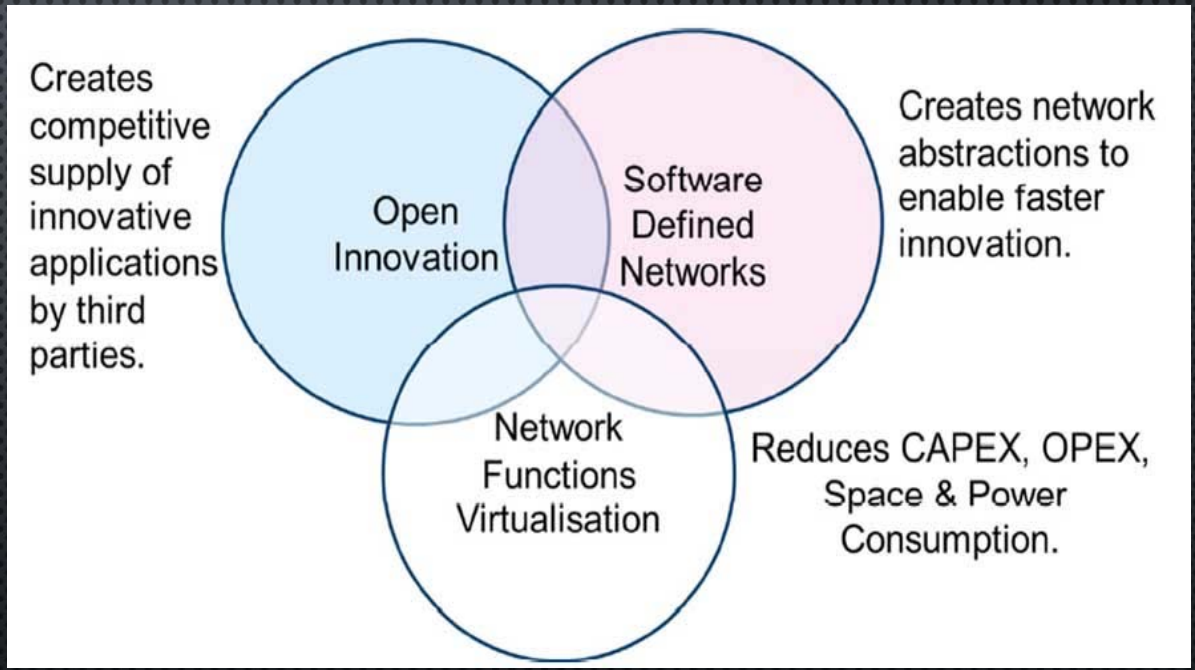
- Today's methods are not optimal – brittle, traffic loads boxes needlessly, hard to optimize (4K VLAN limit, etc.)
- With NFV Service Chaining, each app gets only the services it needs,
- The proper path can be configured *a priori*, or on the fly by policy, inspection, and/or tagging.



Source: HP Enterprise, "Virtualization of Gi-LAN Functions"

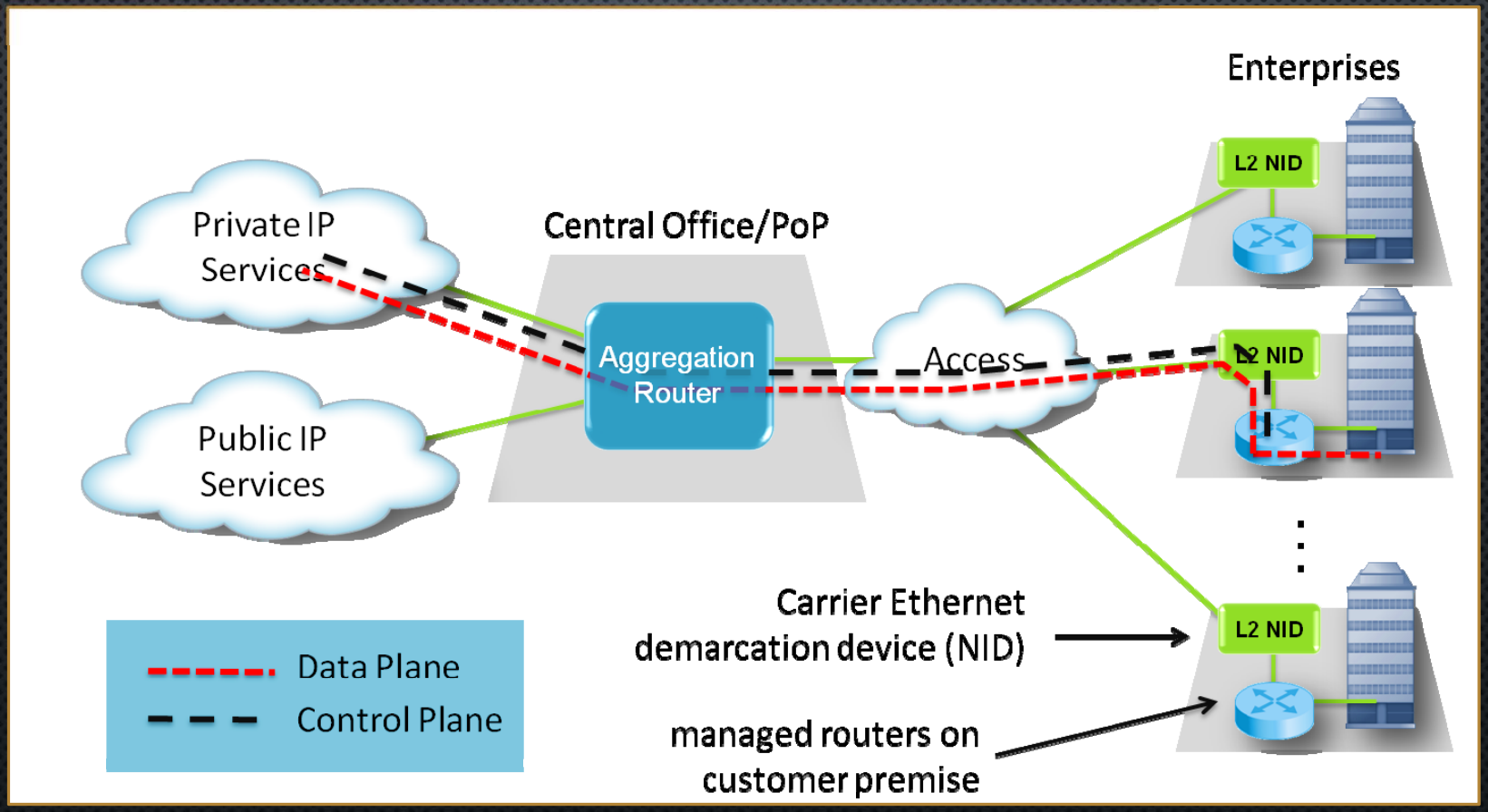
SDN vs NFV

- Complementary, BUT each can stand alone
- In Common:
  - Software Controlled
  - Favor commodity servers and switches
  - Leverage APIs
  - Enable orchestration and automation of network services



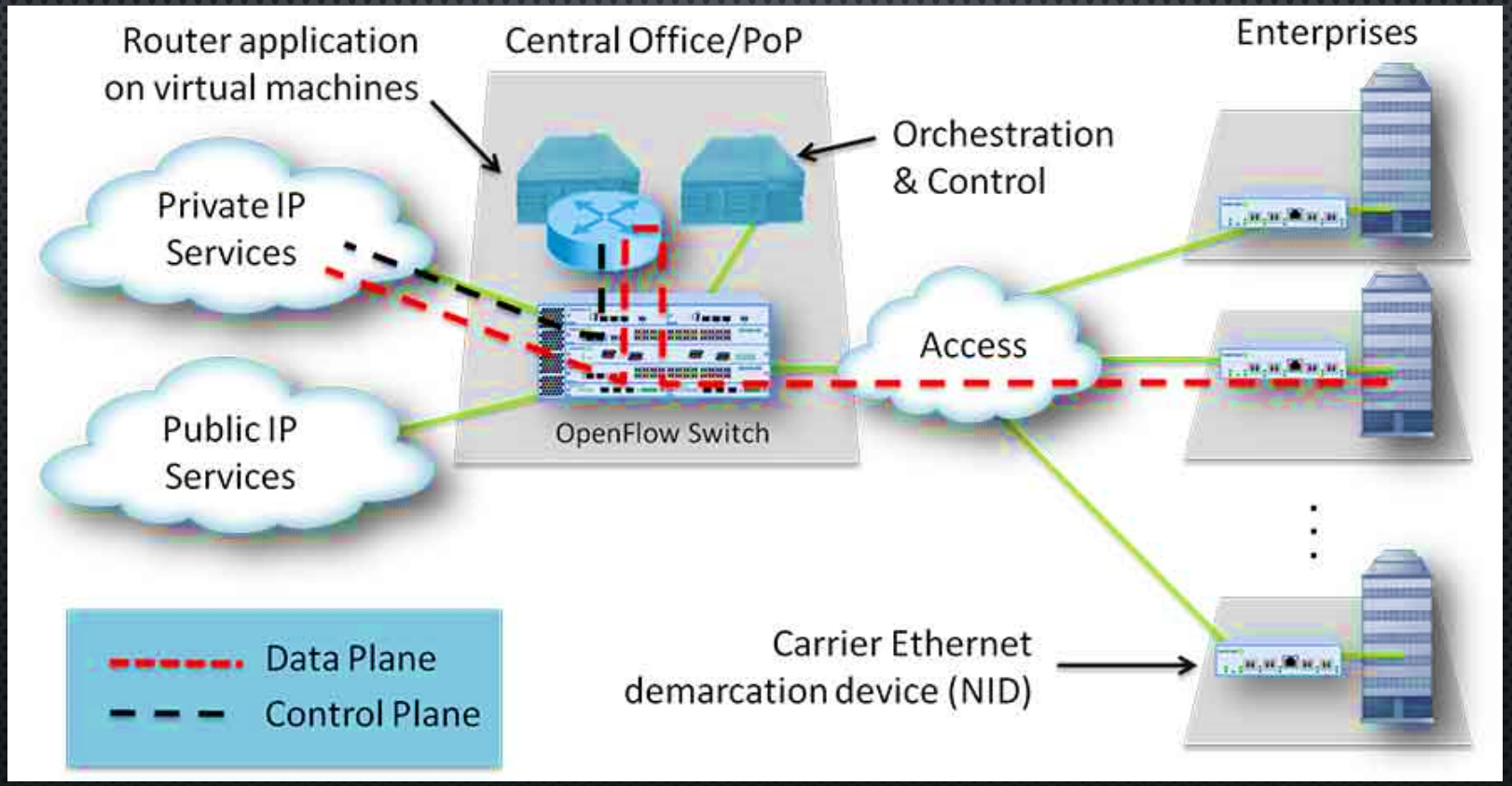
Source: ETSI NFV White Paper

Managed Router Service Today



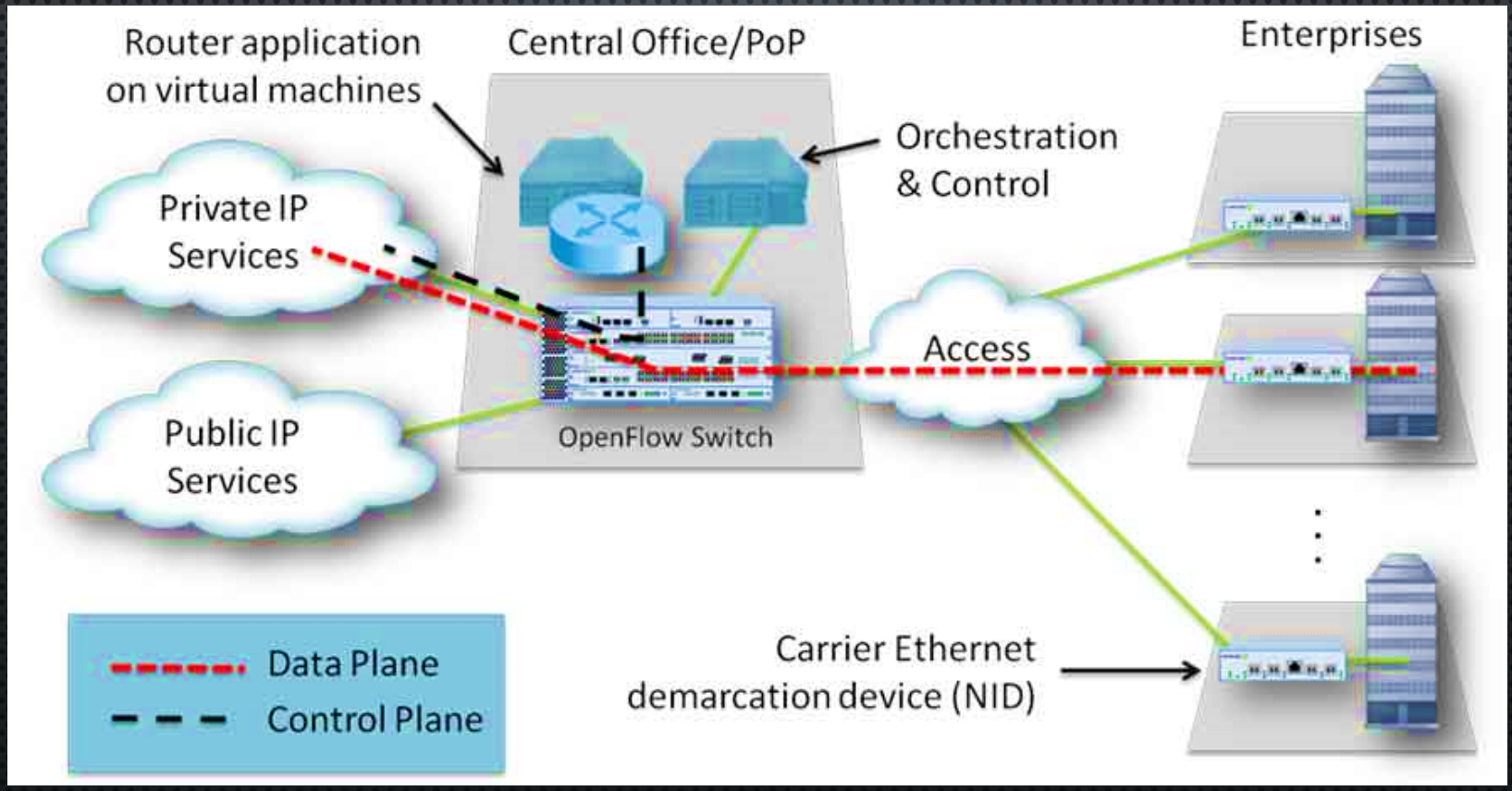
Source: SDXcentral.com

Managed Router Service using NFV



Source: SDXcentral.com

Managed Router Service using NFV & SDN



Source: SDXcentral.com

SDN+NFV advantages

- Expensive, dedicated appliance replaced by generic hardware and advanced software.
- The software control plane is moved from an expensive location (in dedicated platform) to an optimized location (server in a data center or POP).
- The control of the data plane has been abstracted and standardized, allowing for network and application evolution without the need for upgrades of network devices.

SDN, NFV Summary & Differences

	SDN	NFV
Reason for Being	Separation of control and data, centralization of control and programmability of network	Relocation of network functions from dedicated appliances to generic servers
Location/Origin	Campus, data center / cloud	Service provider network (carriers)
Target Devices	Commodity servers and switches	Commodity servers and switches
Initial Applications	Cloud orchestration and networking	Routers, firewalls, gateways, CDN, WAN accelerators, SLA assurance
New Protocols	OpenFlow	None yet
Formalization	Open Networking Forum (ONF)	ETSI NFV Working Group

Source: SDXcentral.com

Major Top-Level Standards Efforts

- SDN
  - OpenFlow (Open Networking Forum)
  - Open Daylight (Linux Foundation)
- NFV
  - ETSI NFV (European Telecommunications Standards Institute)
  - OPNFV – Open Platform for NFV (Linux Foundation)
  - ZOOM (TM Forum)
  - SFC – Service Function Chaining (IETF)

Since automation is essential, so are the platforms to manage it…

MANO – MANagement and Orchestration is one of the hottest areas this year

CurrentAnalysis recently released a market leader report for "carrier grade" MANO vendors:

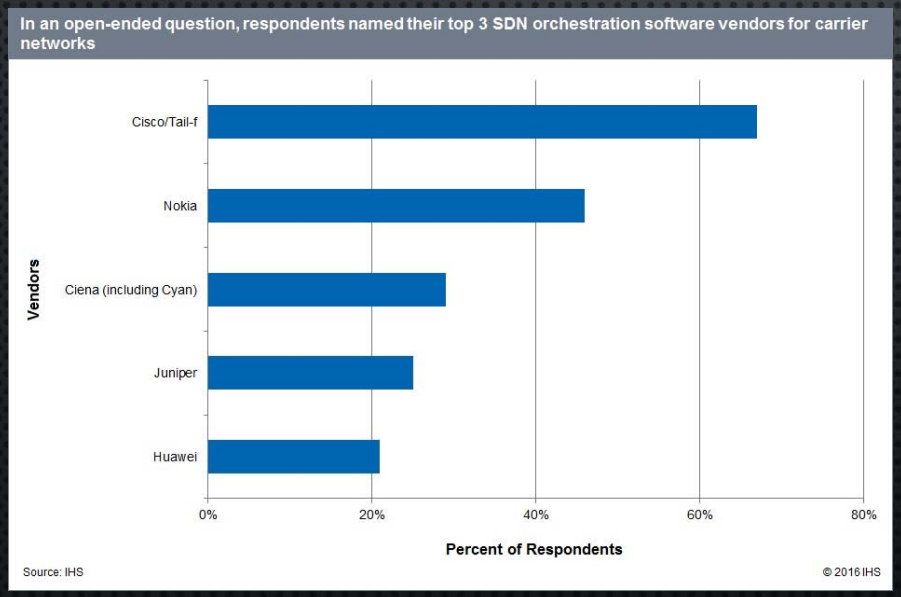
- Top ranked: Netcracker
- Very Strong: Cisco, HPE, Nokia
- Strong: Ericsson, Huawei, Oracle

- "this simply reflects a 'starting position' in what will be a long race and there are many factors which will shape the market over the next year, not least the impact of the multiple open source MANO initiatives which have recently emerged."

Source: RCR Wireless

Since automation is essential, so are the platforms to manage it…

Another similar survey by HIS Markit found "global service providers" that have deployed or plan to deploy SDN and NFV ranked vendors as follows:



"Over three quarters of our operator respondents will use telecom equipment manufacturers, among other supplier types, to supply SDN hardware and software for their networks… Carriers envision a world of multisupplier SDN and NFV, with centralized orchestration of network services and equipment, and new control mechanisms and network architectures. They'll use a variety of suppliers to avoid vendor lock-in."

Source: RCR Wireless

Resources

- ONF (SDN: OpenFlow)
  - *https://www.opennetworking.org/*
- *ETSI (NFV)*
  - http://www.etsi.org/technologies-clusters/technologies/nfv
- Linux Foundation
  - https://linuxfoundtion.org/projects/directory
- SDXcentral
  - https://sdxcentral.com/nfv https://sdxcentral.com/sdn

Resources

- Verizon SDN/NFV Reference Architecture (220 pg Guide) (w/Cisco, Ericsson, HPE, Intel, Nokia, Red Hat, Samsung)
  - *http://innovation.verizon.com/content/dam/vic/PDF/Verizon_SDN-NFV_Reference_Architecture.pdf*
- *OpenFlow-enabled SDN and Network Functions Virtualization*
  - *https://www.opennetworking.org/images/stories/downloads/sdn-resources/solution-briefs/sb-sdn-nvf-solution.pdf (yes, nvf, not nfv)*