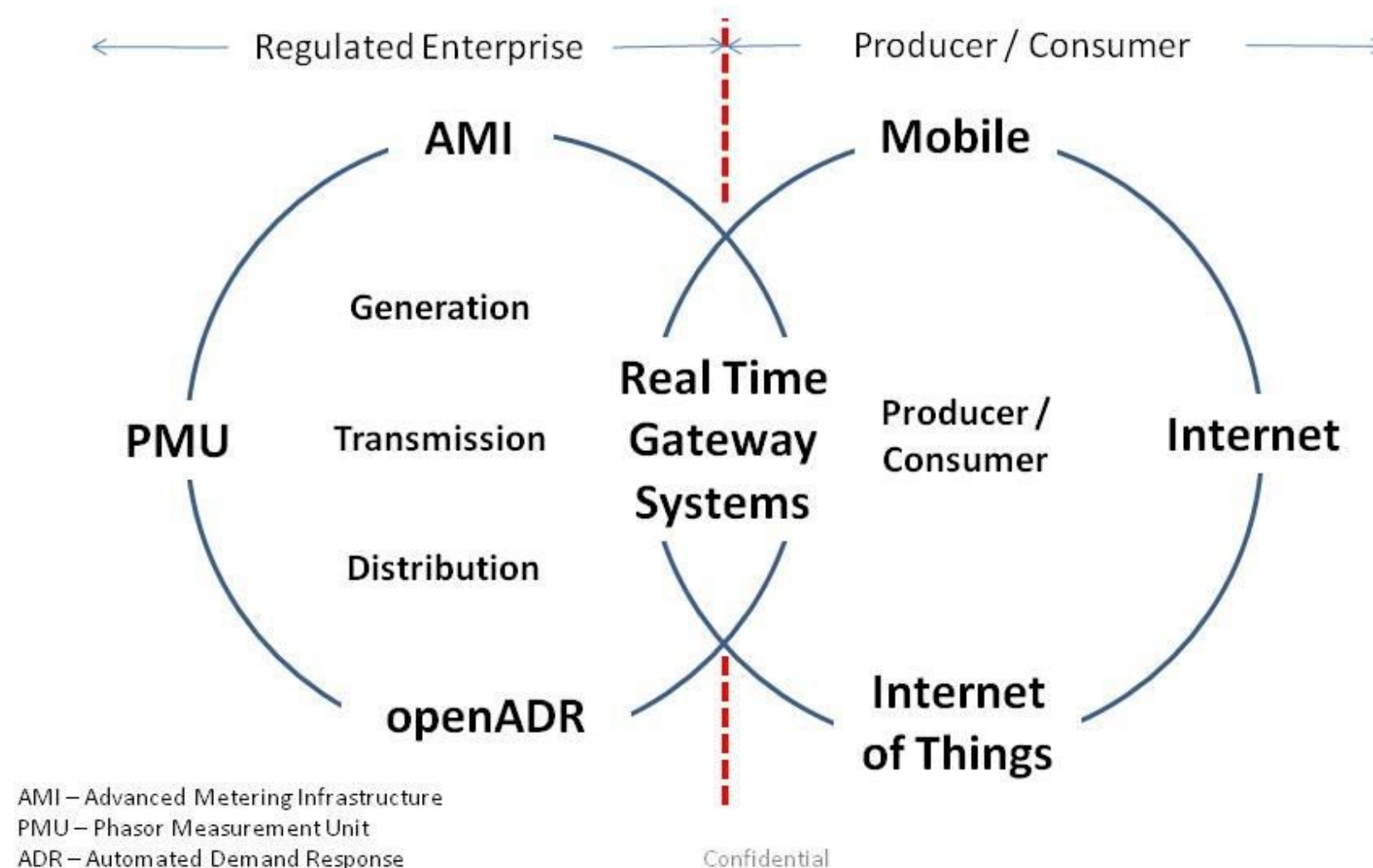




Open Source

A Catalyst for Innovation

Next Gen Smart Grid & Prosumer Service Driven Network





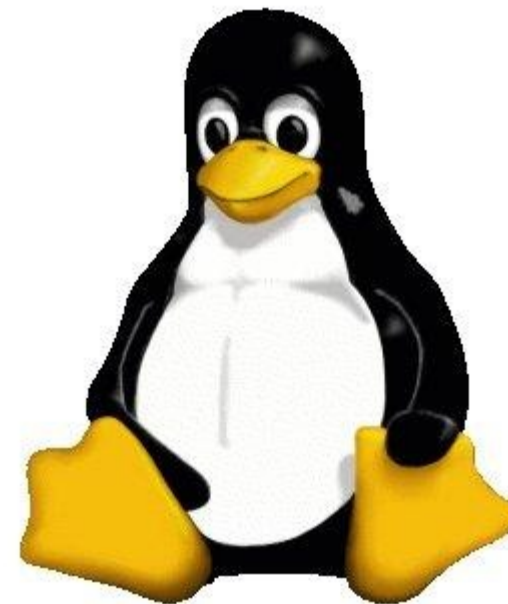
Examples of Open Source Platforms & Products

Linux



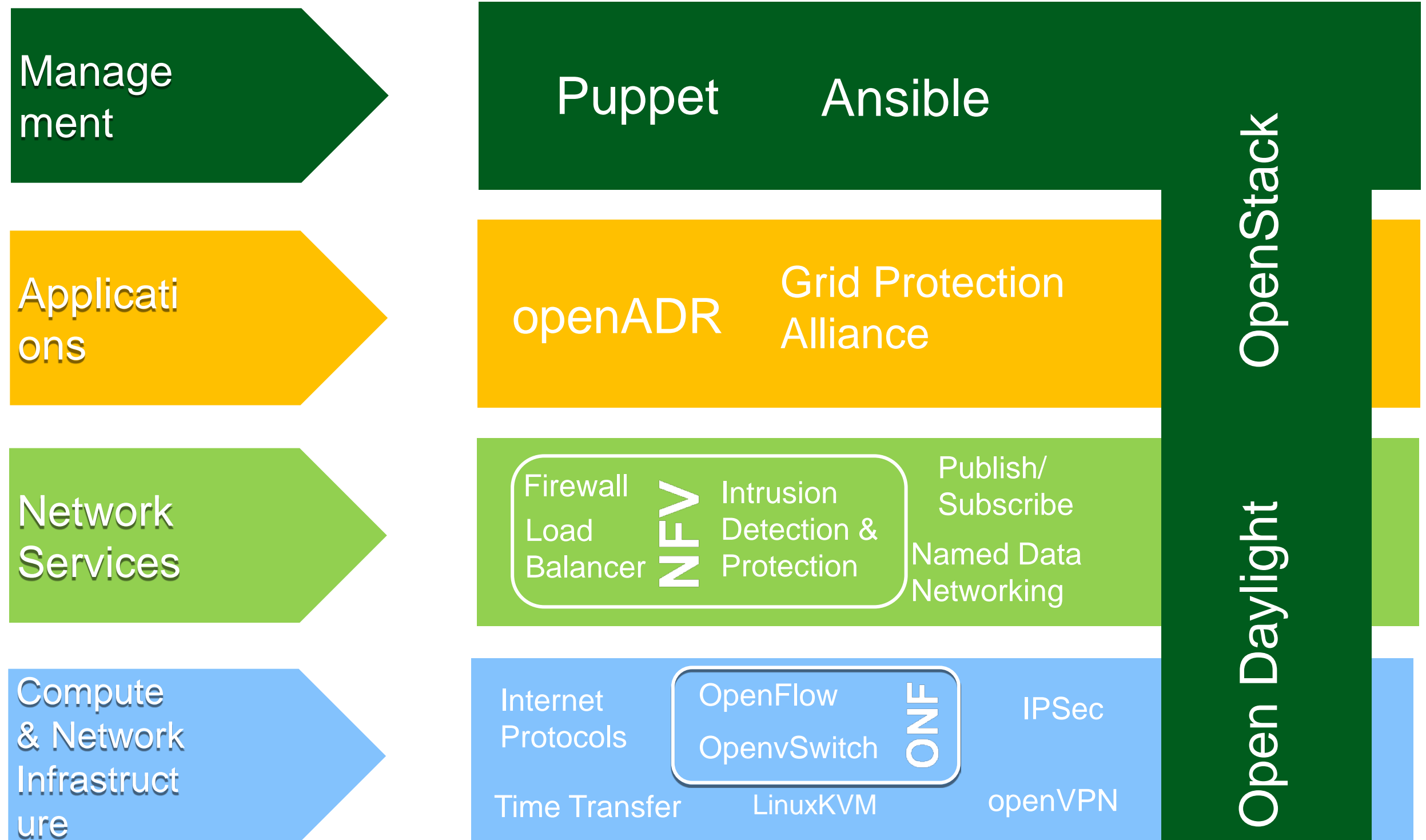
Popular Mainstream Linux Distributions

- Debian
- Ubuntu
- Linux Mint
- Fedora
- Arch Linux
- Red Hat Enterprise Linux (commercial product)
- SUSE Linux Enterprise Server (commercial product)
- Yocto Project (platform for embedded Linux systems)

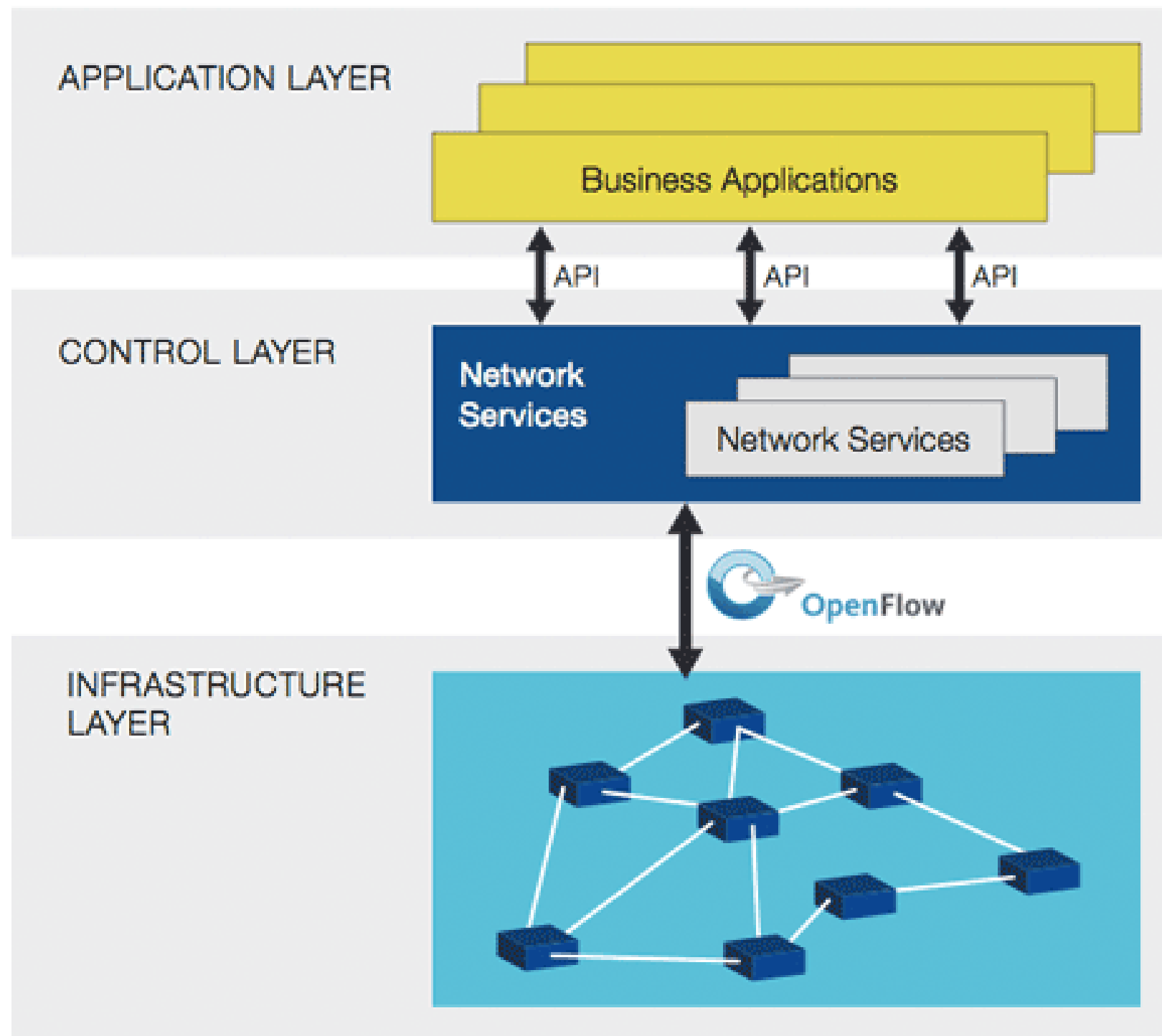




Open Source & Service Driven Network



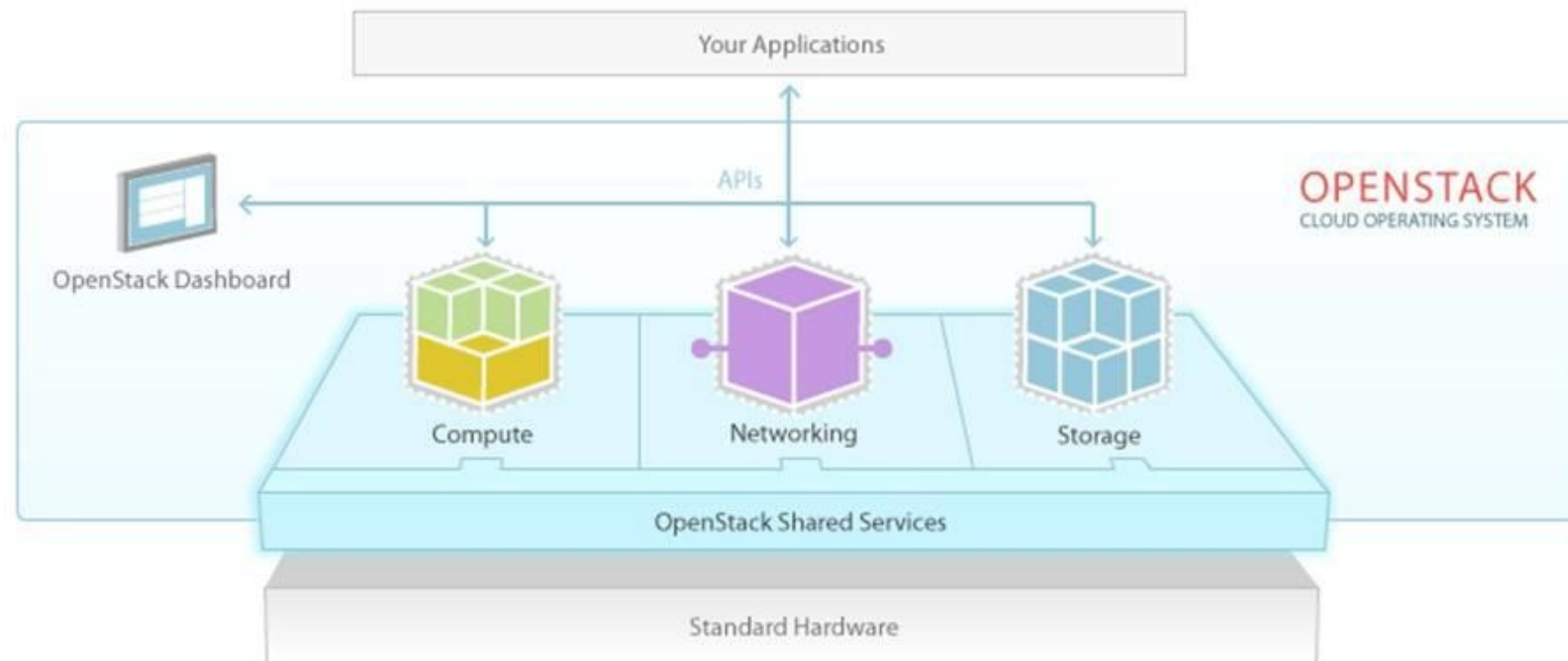
Open Network Foundation (ONF)



ONF Board Members

- Google
- Facebook
- Yahoo
- Microsoft
- NTT Communication
- Deutsche Telekom
- Verizon
- Goldman Sachs

OPENSTACK

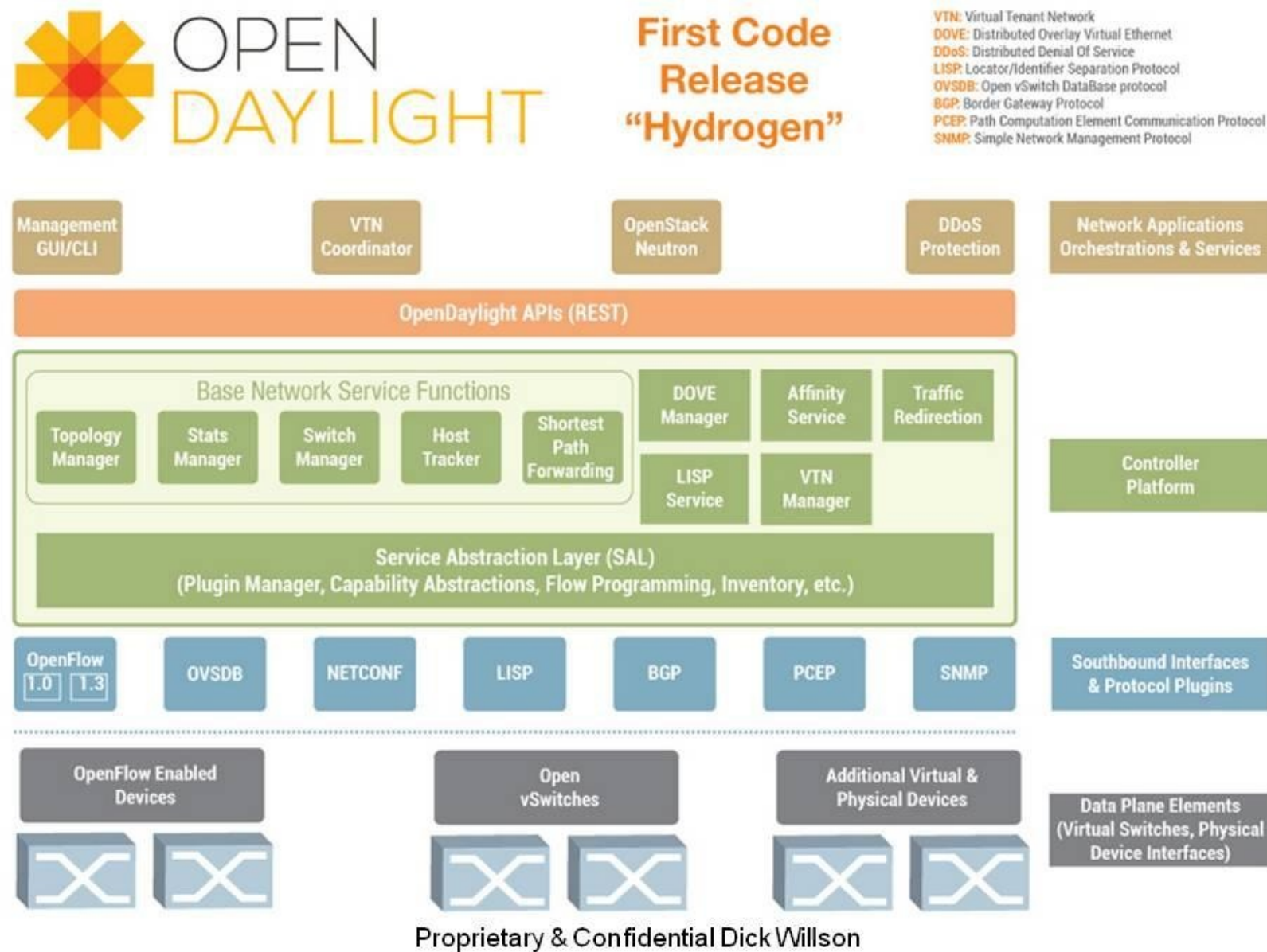


Project Founders:

- RackSpace
- NASA

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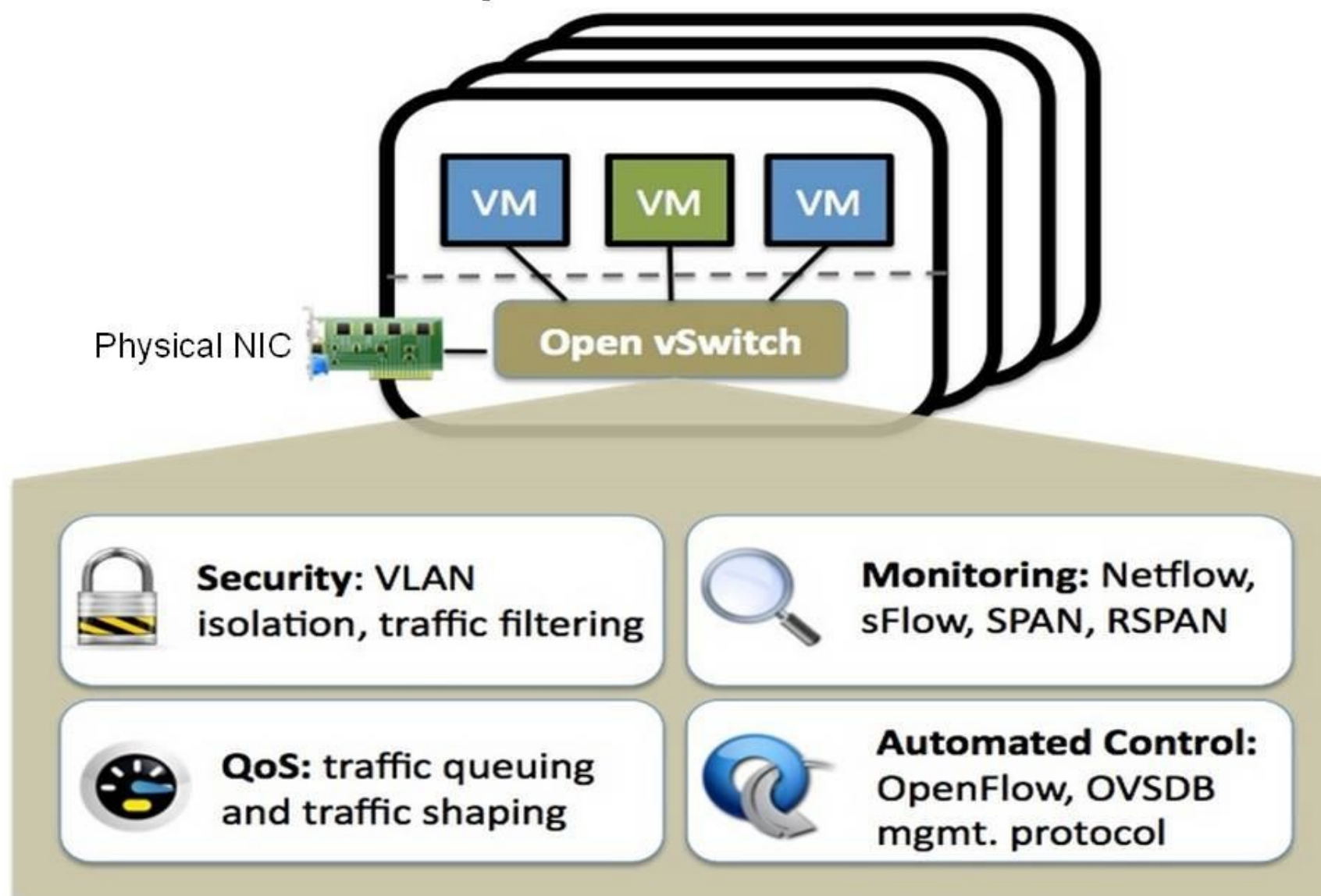
OpenDaylight



Project Founders:

- Cisco
- IBM
- Microsoft
- Ericsson
- VMware

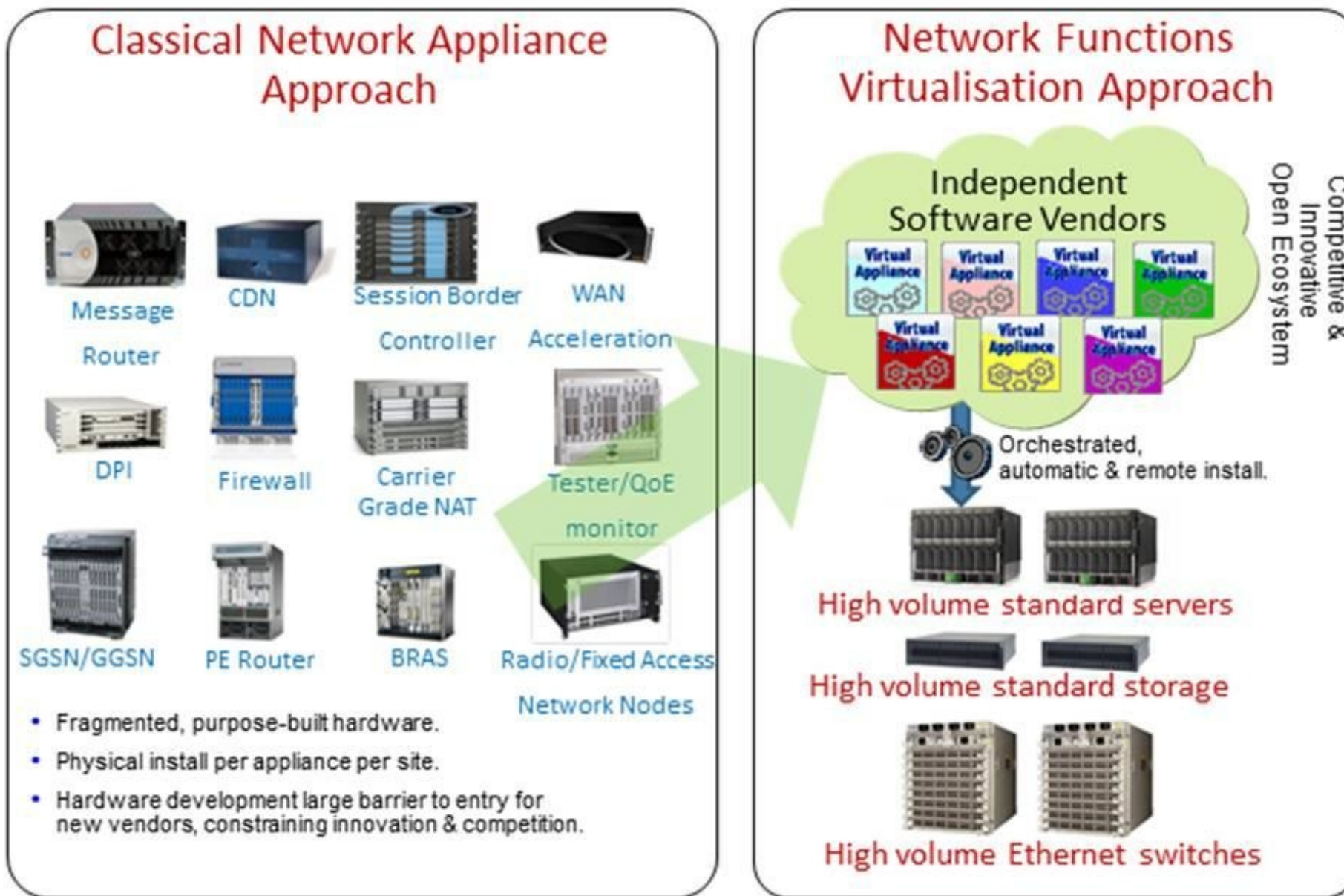
Open VSwitch



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Network Functions Virtualisation (NFV)

Network Functions Virtualisation: Vision



NFV is an ETSI project with founding members

- AT&T
- BT
- Deutsche Telekom
- Orange
- Telecom Italia
- Telefonica
- Verizon

Source: Defining NFV: Network Functions Virtualization (NFV) Dr. Prodip Sen Chair, ETSI NFV ISG



Shipping OpenFlow Products



Switches -Commercial

- Arista 7500/7150
- Brocade MLX/NetIron products
- Cisco Nexus 3000
- Dell N3000/N400
- Extreme BlackDiamond
- HP ProCurve
- IBM BNT G8264
- Juniper MX & EX9200 (not GA)
- NEC ProgrammableFlow switches
- Smaller vendors (Mikrotik, ODMs)

Switches -Open Source

- Open vSwitch(Xen, KVM)
- NetFPGA reference implementation
- OpenWRT
- Mininet(emulation)

Controllers - Commercial

- NEC ProgrammableFlowController
- VMware NSX
- Big Switch Networks
- Cisco eXtensibleNetwork Controller
- HP VAN SDN Controller

Controllers -Open Source

- Open Daylight (Java)
- NOX (C++/Python)
- Beacon (Java)
- Floodlight (Java)
- Maestro (Java)
- RouteFlow(NOX, Quagga, ...)
- NodeFlow(JavaScript)
- Trema(Ruby)



OpenFlow @ Google



Problem

- Traffic engineering in inter-DC WAN backbone

Solution

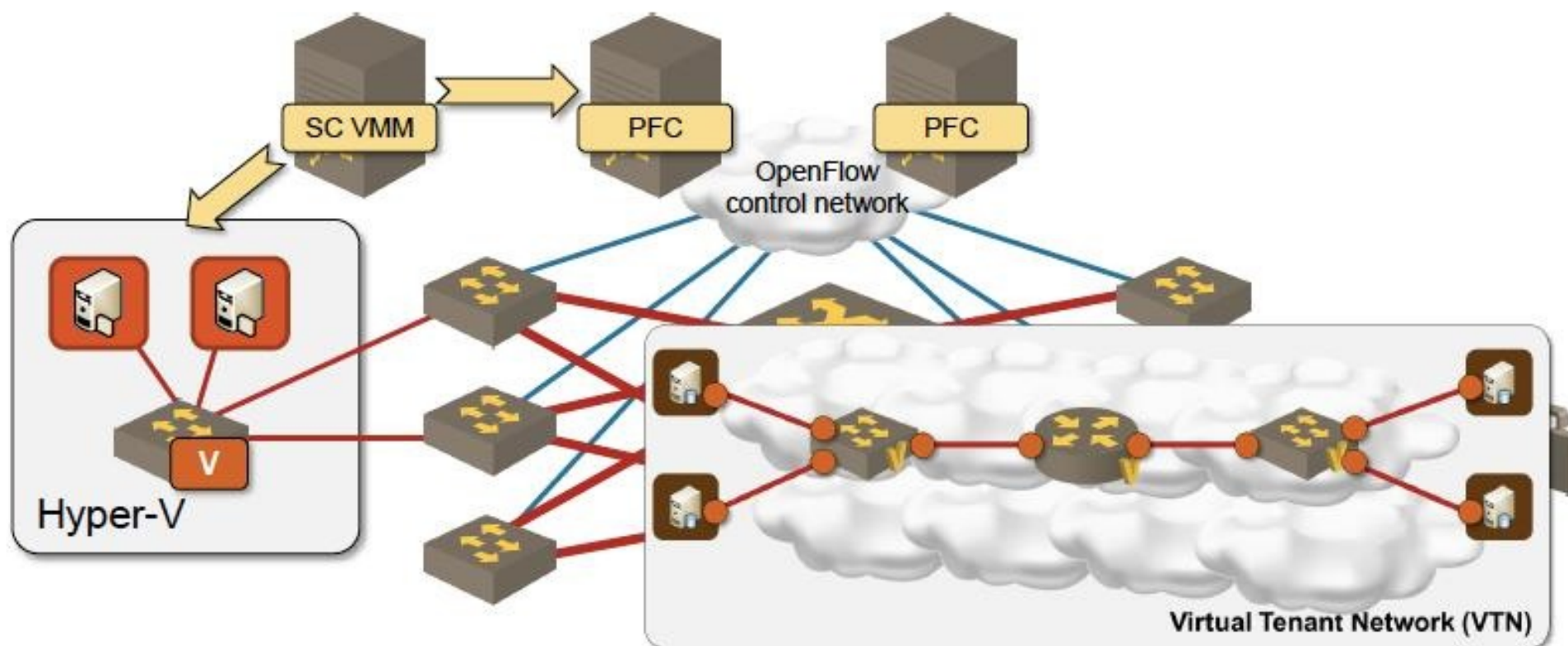
- Custom data center edge switches
- Cluster of OpenFlow controllers in each data center data center edge switches behave like a single node
- BGP and IS-IS between OpenFlow controllers; classic routing between data centers
- Centralized traffic engineering application path elements are downloaded into individual controllers



OpenFlow @ NEC



NEC ProgrammableFlow: OpenFlow in Data Center

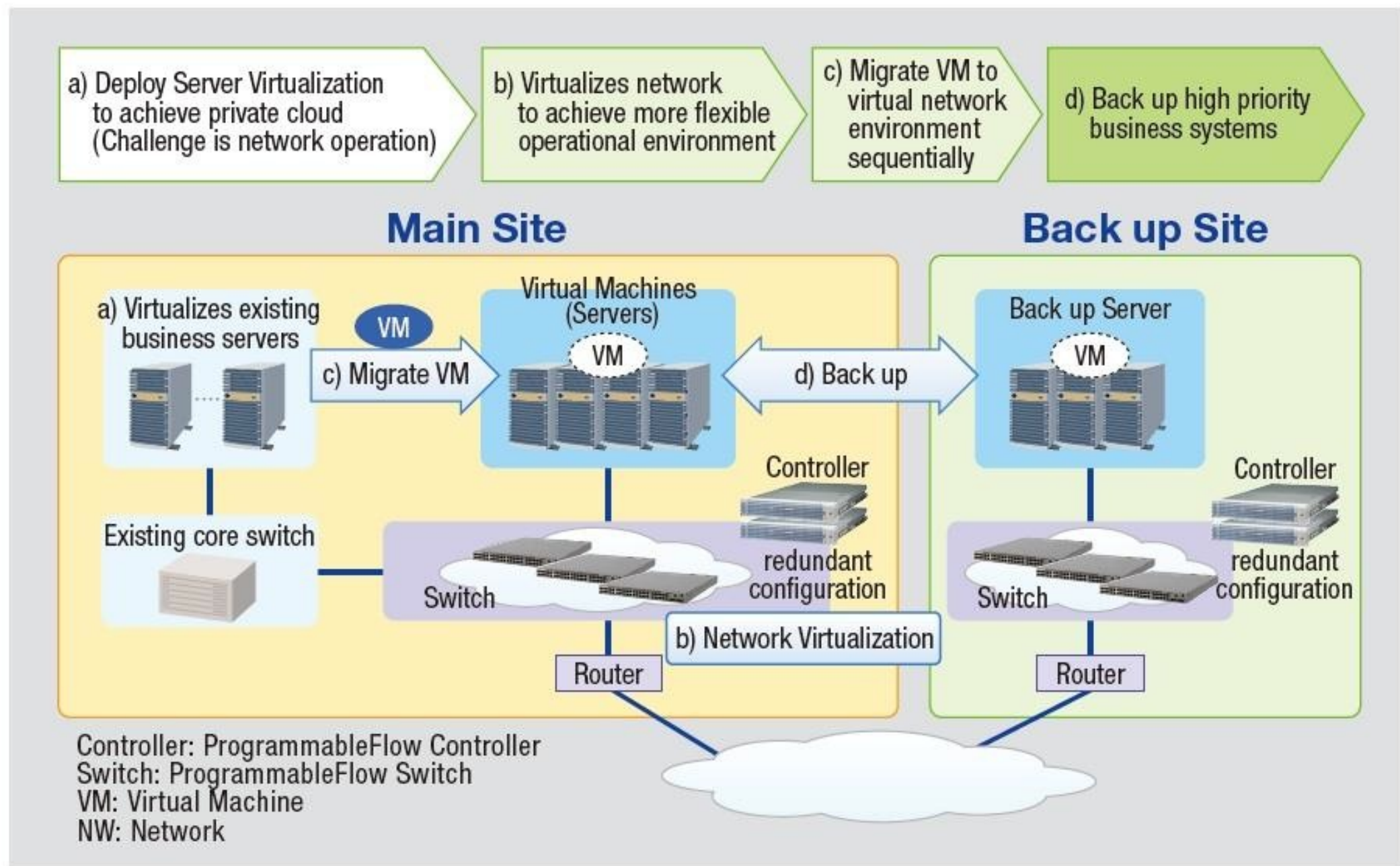


- Fabric of physical and hypervisor (Hyper-V) switches
- Single control, management and configuration entity
- Virtual bridges, routers, packet filters, traffic redirection and QoS
- Use case: mid-sized virtualized data centers

NEC @ NIPPON EXPRESS



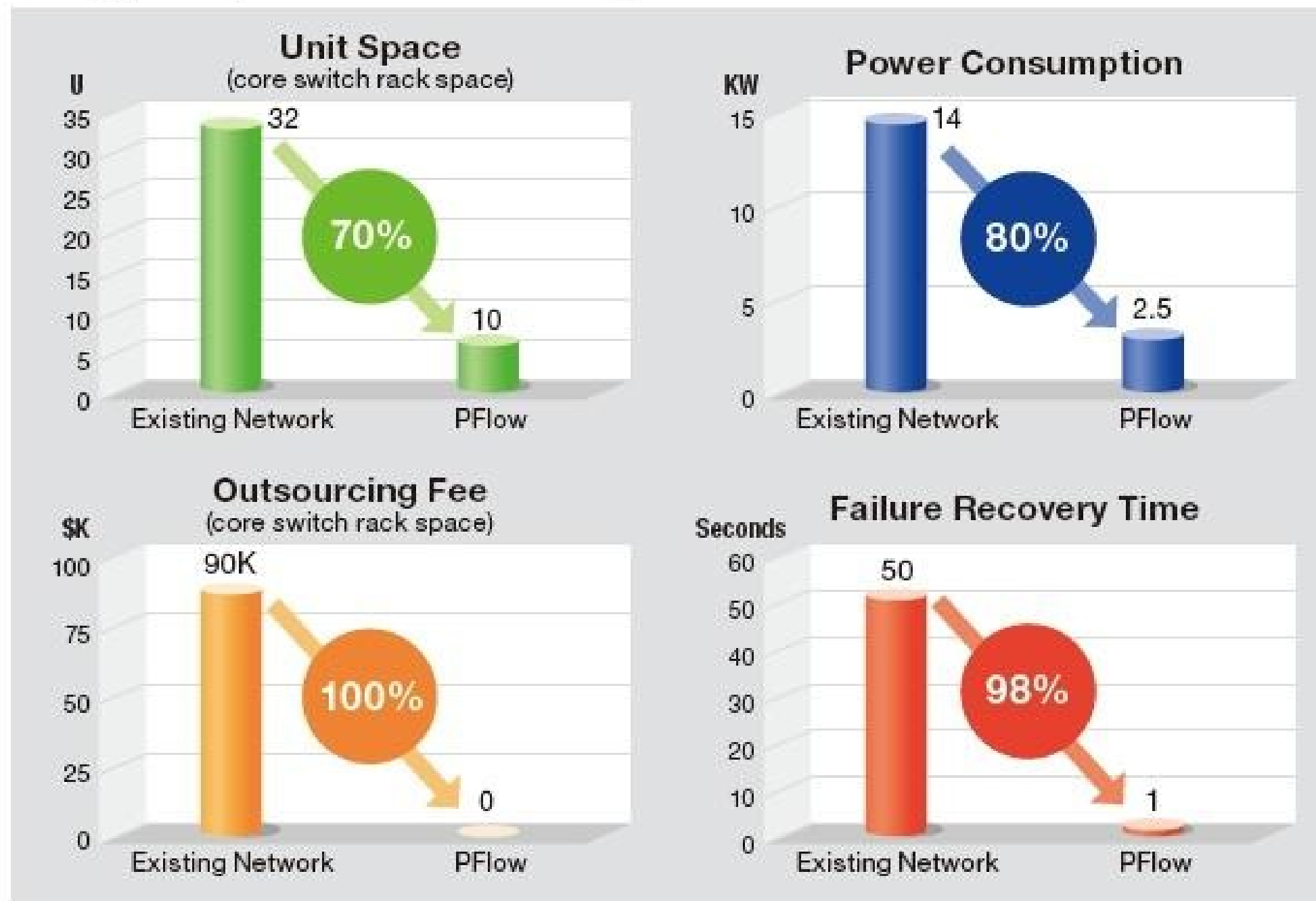
- Network migration from existing virtual environment to ProgrammableFlow



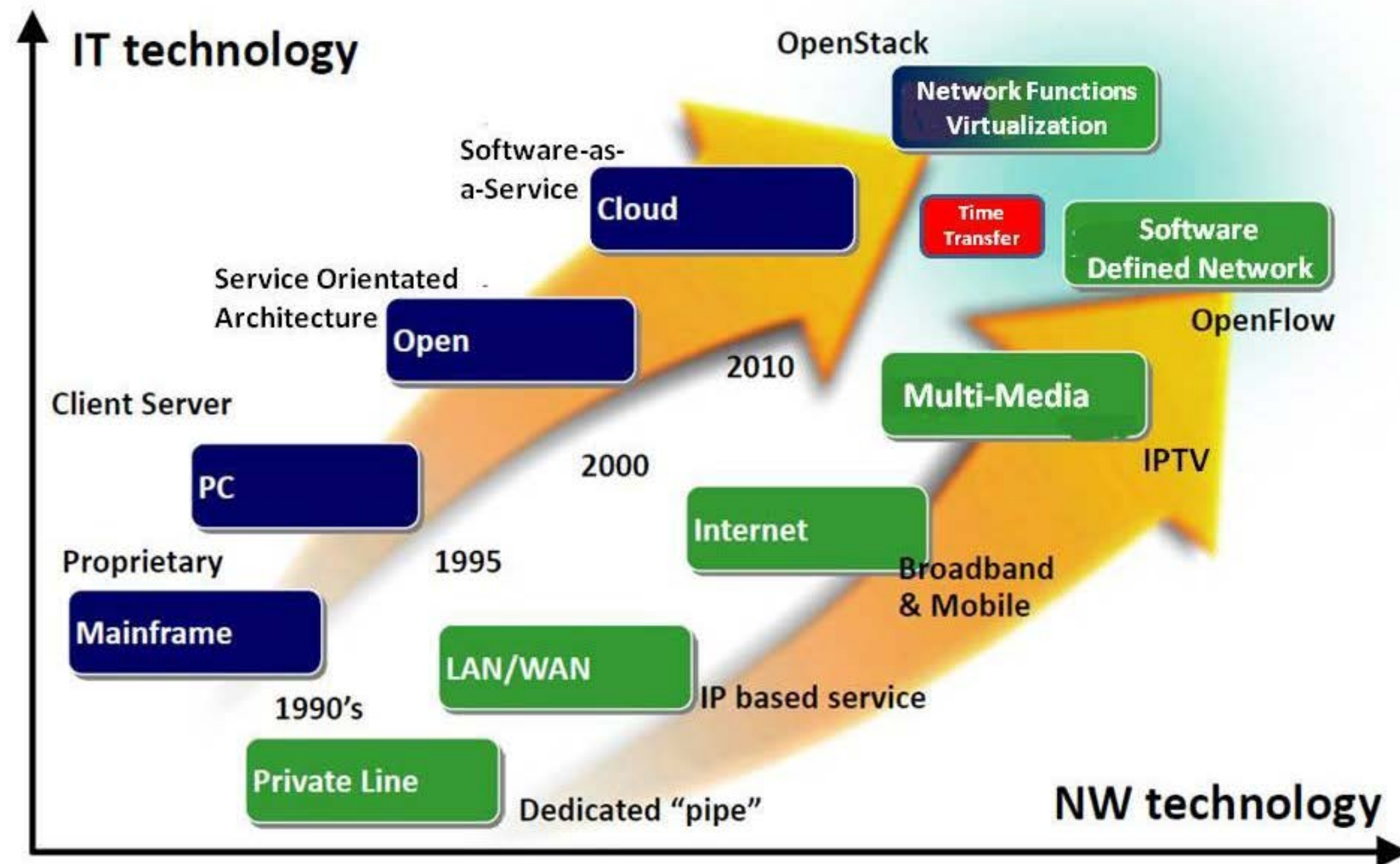
NEC @ NIPPON EXPRESS



● Nippon Express benefits from ProgrammableFlow



Networking & IT Open Source Convergence



Source: www.nec.com modified by Dick Willson

Confidential



OpenFlow Control of Real-Time Flows

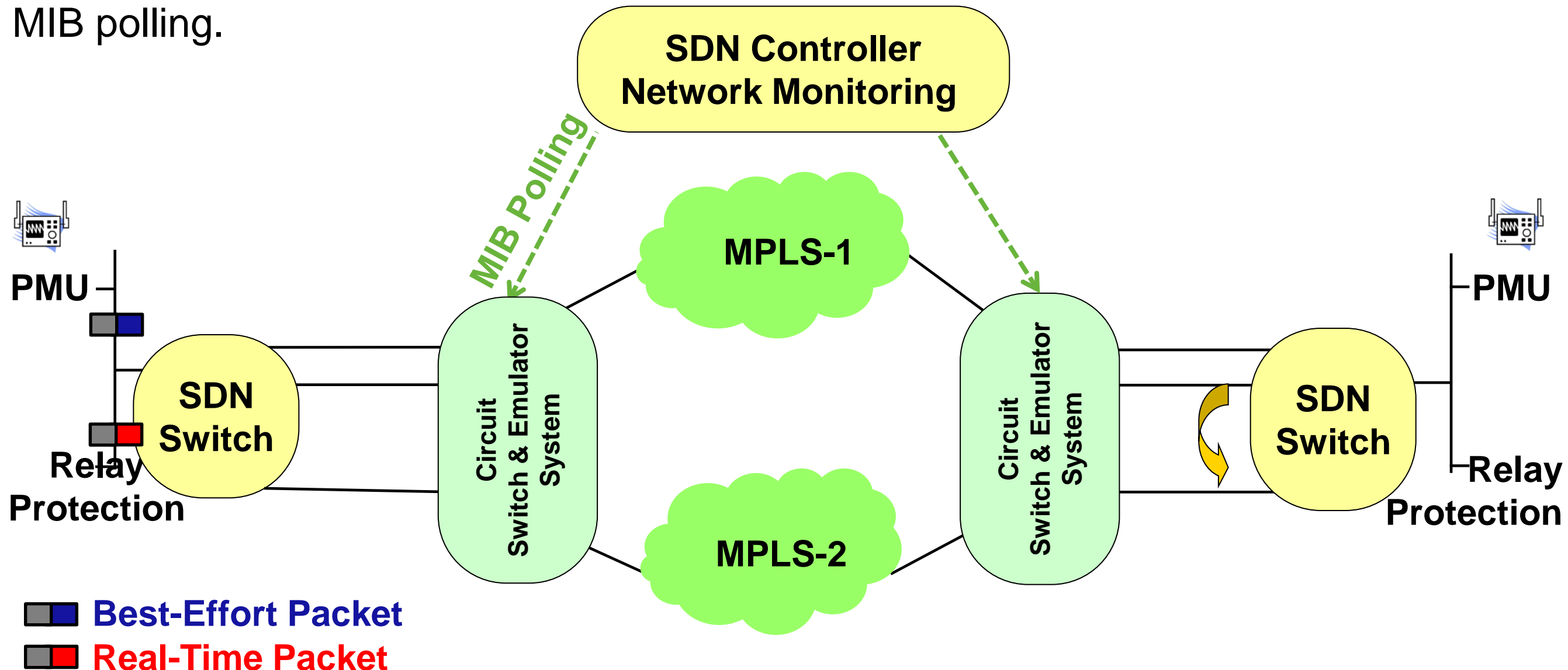
Proof of Concept

Improving SLA of “Real-Time” Traffic by SDN

SDN (Software-Defined Networking) can switch the traffic flows for real-time packets to different MPLS paths based on the measured jitter and delay.

Choose best path for “real time” traffic

- Both real-time and best-effort packets go through MPLS-1.
- SDN network monitoring periodically checks delay between circuit emulators via MIB polling.

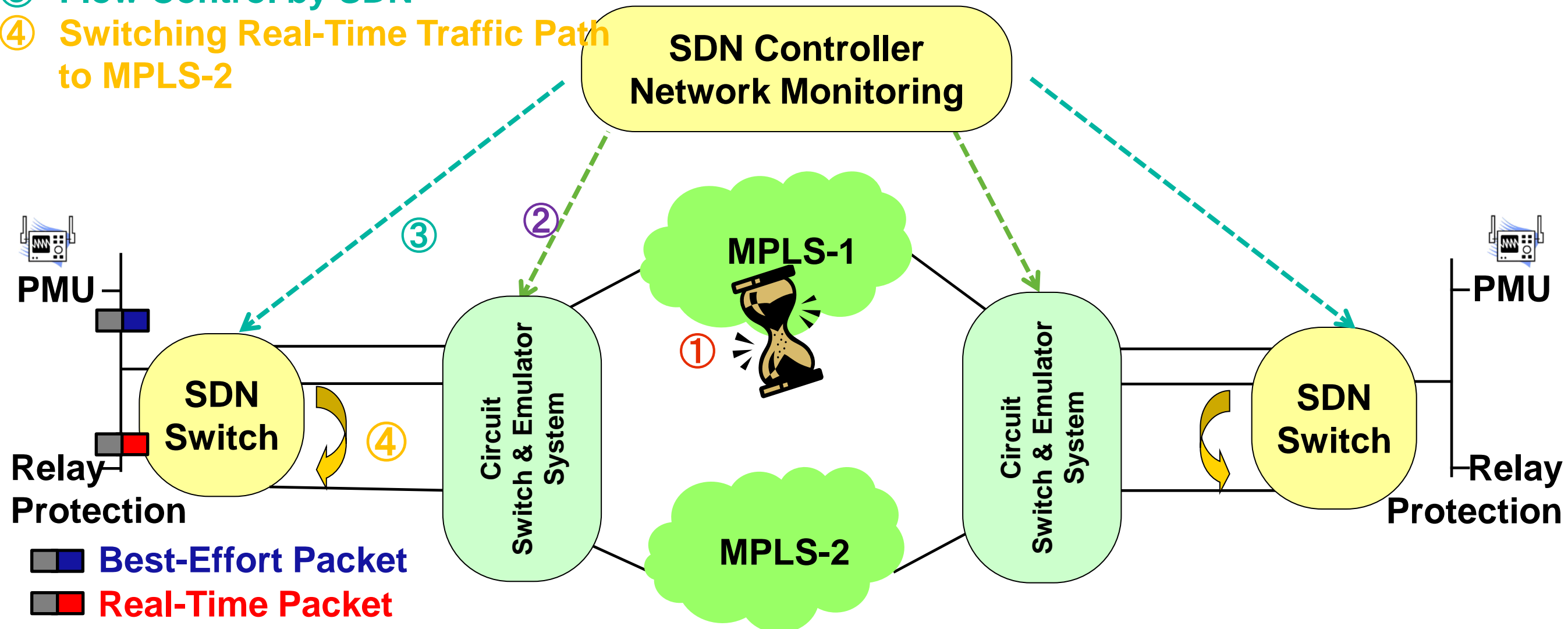


Switching Real-Time Traffic to Avoid Congested Path

SDN (Software-Defined Networking) switches the real-time traffic flows based on the delay over the MPLS cloud.

Congested Traffic Condition

- ① Heavy Traffic in MPLS-1
- ② Delay Detection by monitoring tool
- ③ Flow Control by SDN
- ④ Switching Real-Time Traffic Path to MPLS-2



Proof of Concept: Experimental Environment

Real-time traffic switching has been achieved by NetInsight's Circuit Emulator 'Nimbra' and NEC's SDN Technology 'ProgrammableFlow.'

