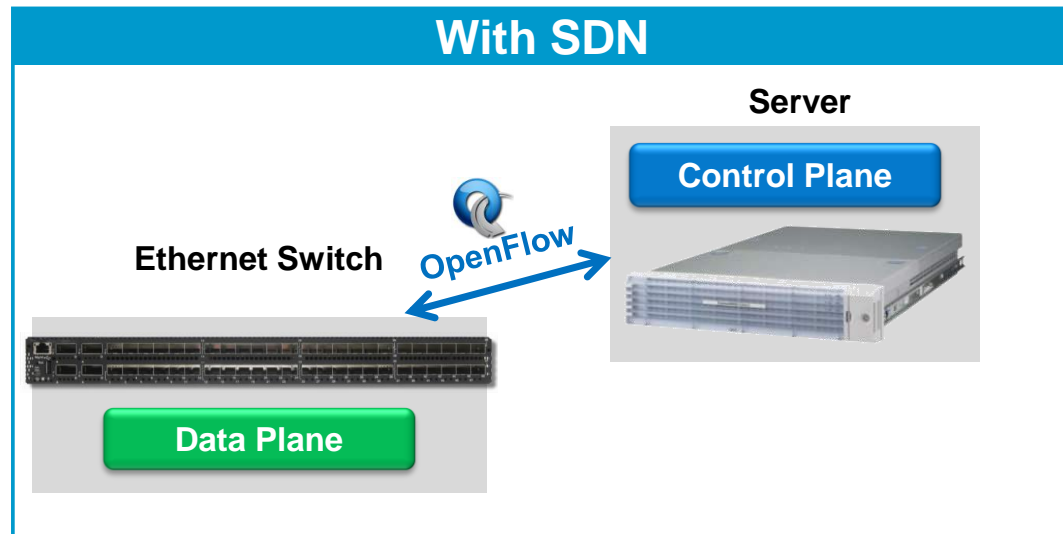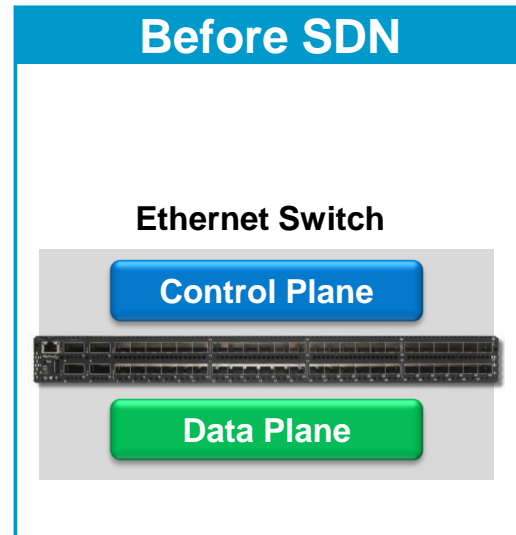# Software-Defined Networking (SDN) in the Data Center

Dr. Peer Hasselmeyer

SDN Technical & Marketing Centre,
NEC Europe Ltd.

What Is Software-Defined Networking?

- Idea of **Software-Defined Networking (SDN)**: make the network programmable

- Switches have a data plane and a control plane
  - **data plane** passes on packets; optimized for performance; does not change quickly
  - **control plane** more complex, but needs to adapt to different environments and new requirements more quickly

- **Separate control and data planes** and open up the control plane to enable rapid innovation

Before SDN

Ethernet Switch

Control Plane

Data Plane

With SDN

Server

Control Plane

Ethernet Switch

OpenFlow

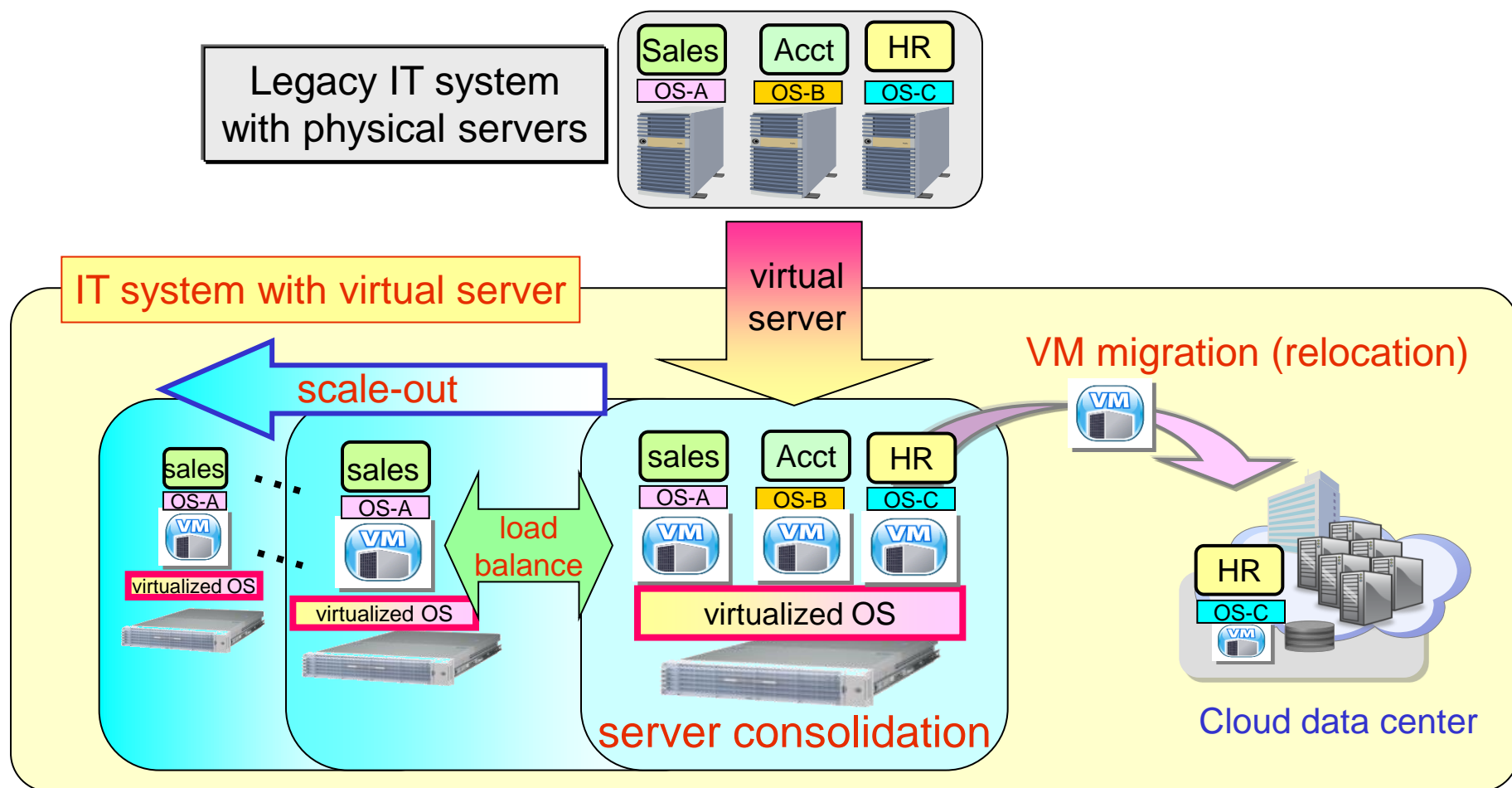Data Plane

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Network Technology Is Aging

- Networking stack works great so far
- But age is starting to show
- Technology was not designed to support current hot use cases
  - massive scalability
  - multi-tenant networks
  - virtualization, cloud
  - mobility (users, devices, VMs)
- Protocols are box-centric, not fabric-centric
  - difficult to configure correctly (consistency across all boxes)
  - difficult to add new features (upgrade all boxes)
  - difficult to debug (look at all boxes)
- Summary: network technologies are not as agile as one would hope for

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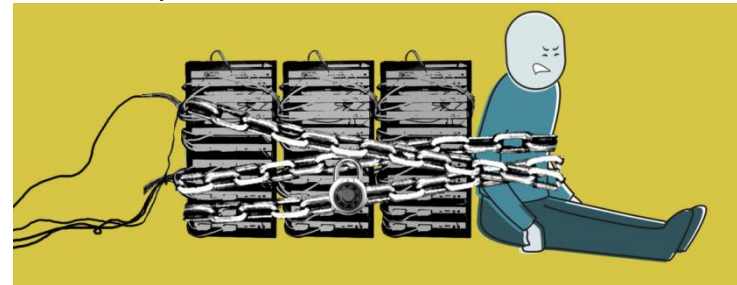
Evolution of Server Virtualization Technology

Operation improvement with Server Virtualization in Data Centres

Legacy IT system with physical servers

Sales OS-A
Acct OS-B
HR OS-C

virtual server

IT system with virtual server

scale-out

sales OS-A virtualized OS

sales OS-A virtualized OS

load balance

sales OS-A
Acct OS-B
HR OS-C
virtualized OS

server consolidation

VM migration (relocation)

HR OS-C

Cloud data center

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Impact of Virtualized Servers on the Network

Network has not been virtualized in line with servers/storage
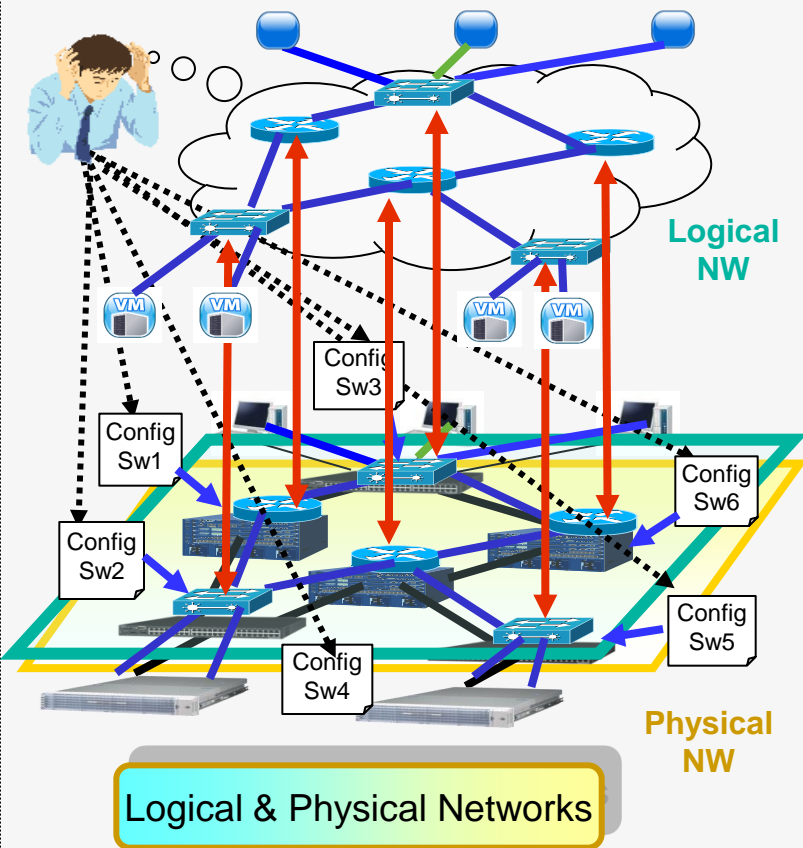
Complex operation skills and long lead-times required

migration of IT resources to Cloud

Cloud Data Center

Enterprise data center

virtual storage

HR

Virtual servers

Legacy enterprise data center

Sales   Acct   HR

server consolidation

Sales   Acct   HR

interaction

virtual server

NW as is

NW change: complex operation causes rising costs!

VPN/Internet
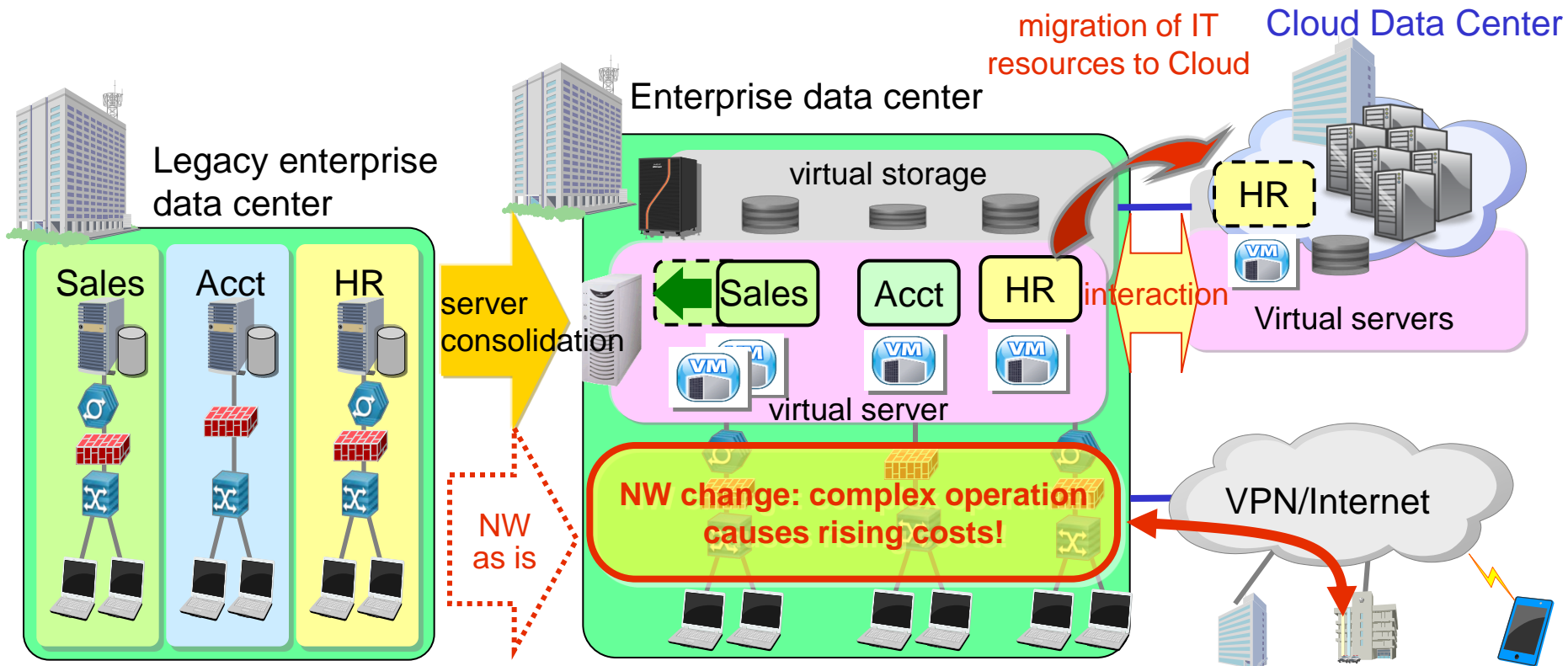
◆ **The network needs to become as agile as the server/IT domain!**

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Simplified Network Design with SDN

Legacy Network

Logical network **closely coupled with** physical network

Logical NW

VM VM VM VM

Config Sw3
Config Sw1
Config Sw2
Config Sw4

Config Sw6
Config Sw5

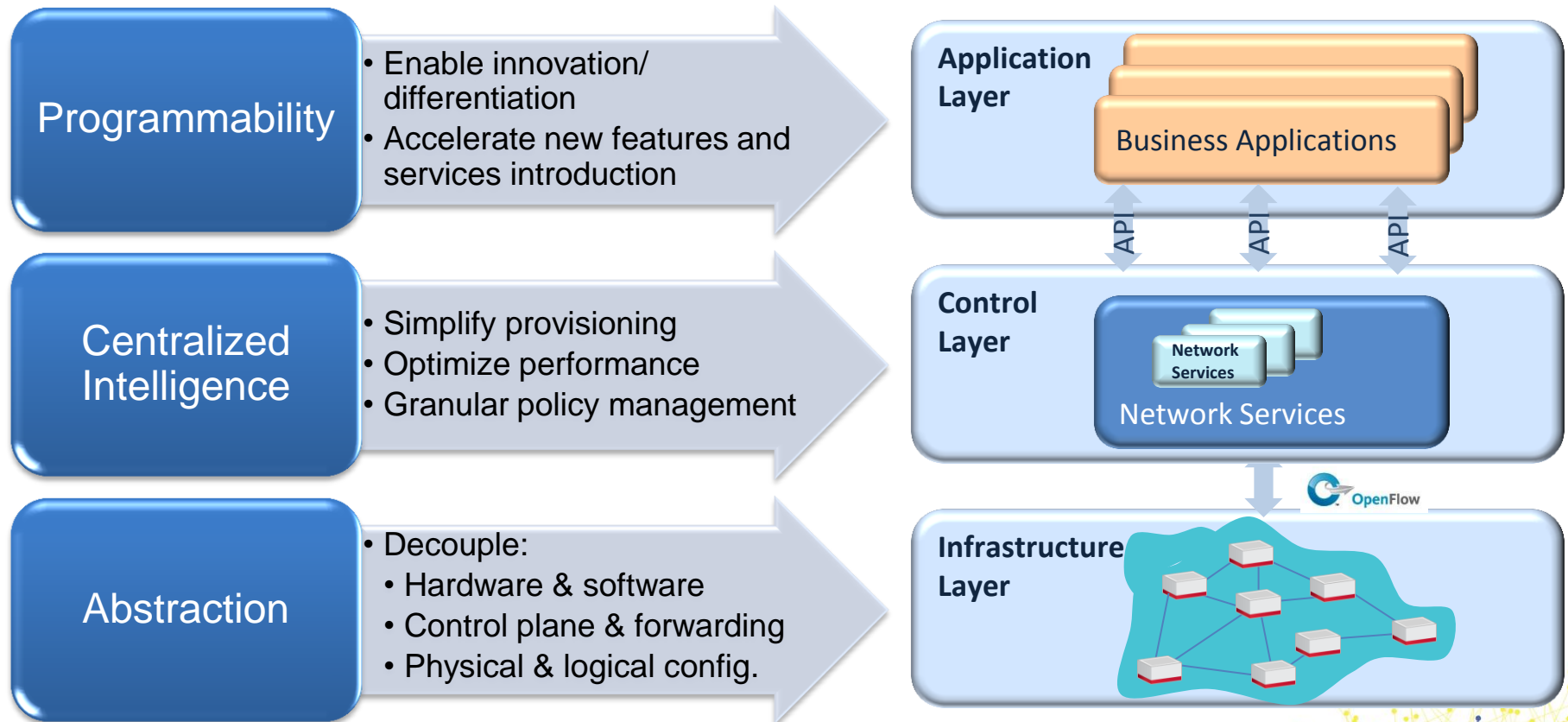Physical NW

Logical & Physical Networks

SDN Network

- Virtual network design **independent of** physical network
- NWs mapped automatically at runtime

Virtual Network

logical design

Logical NW

VM VM VM VM

OFC

OpenFlow

Rule Action Statistics
Rule Action Statistics
Rule Action Statistics

Automatic Flow Table setting

OFS

Physical NW

Physical Network

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ONF SDN Architecture

Programmability
- Enable innovation/differentiation
- Accelerate new features and services introduction

Application Layer

Business Applications

API   API   API

Centralized Intelligence
- Simplify provisioning
- Optimize performance
- Granular policy management

Control Layer

Network Services

Network Services

OpenFlow

Abstraction
- Decouple:
  - Hardware & software
  - Control plane & forwarding
  - Physical & logical config.

Infrastructure Layer
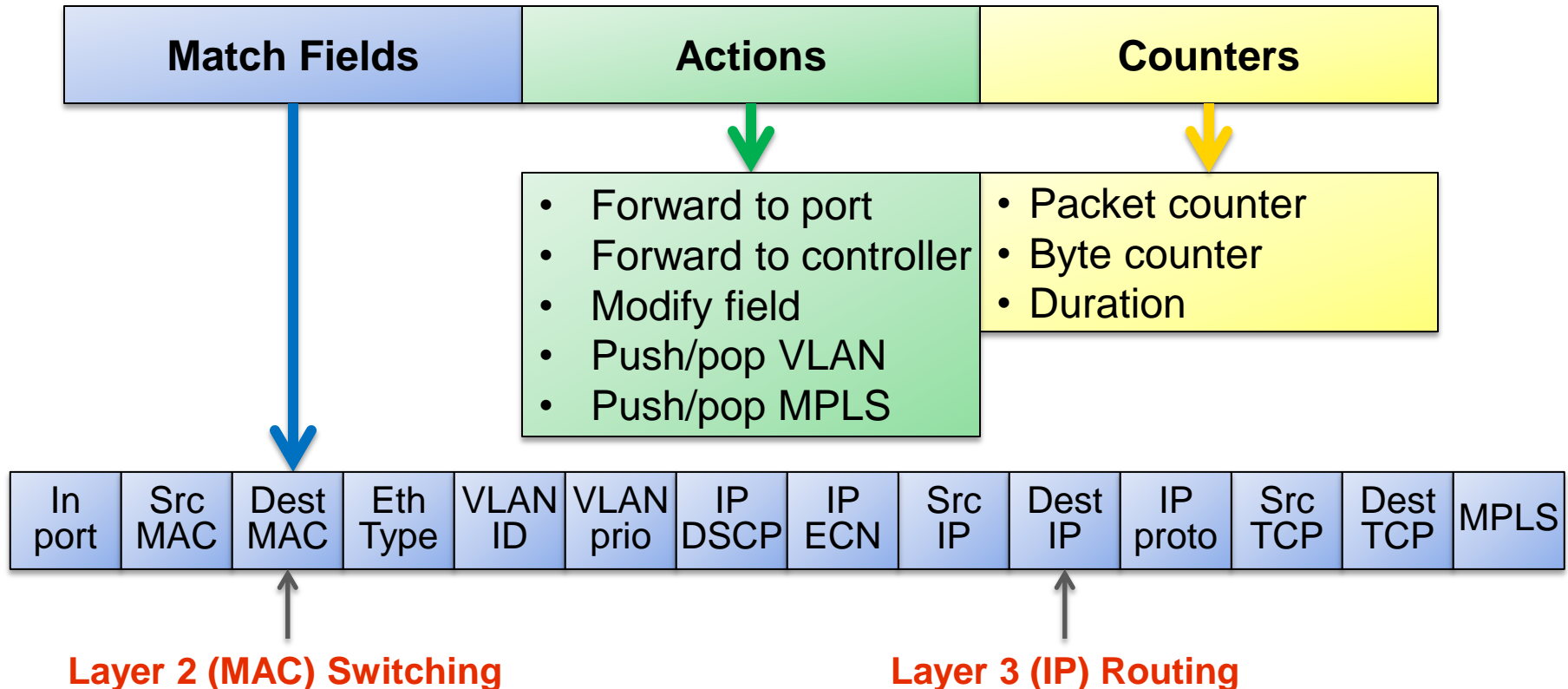
OpenFlow Flow Table Entries

OpenFlow:
A flow is defined by any combination of the packet header fields. Wildcards allow for any size of flow granularity.

Match Fields	Actions	Counters

Actions:
- Forward to port
- Forward to controller
- Modify field
- Push/pop VLAN
- Push/pop MPLS

Counters:
- Packet counter
- Byte counter
- Duration

In port	Src MAC	Dest MAC	Eth Type	VLAN ID	VLAN prio	IP DSCP	IP ECN	Src IP	Dest IP	IP proto	Src TCP	Dest TCP	MPLS

Layer 2 (MAC) Switching

Layer 3 (IP) Routing

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What You Can Do With SDN

- With proper programming, one can do
  - switching
  - routing

    "traditional" networking

  - NAT
  - L3/L4 access control

    network appliances

  - network slicing
  - traffic steering
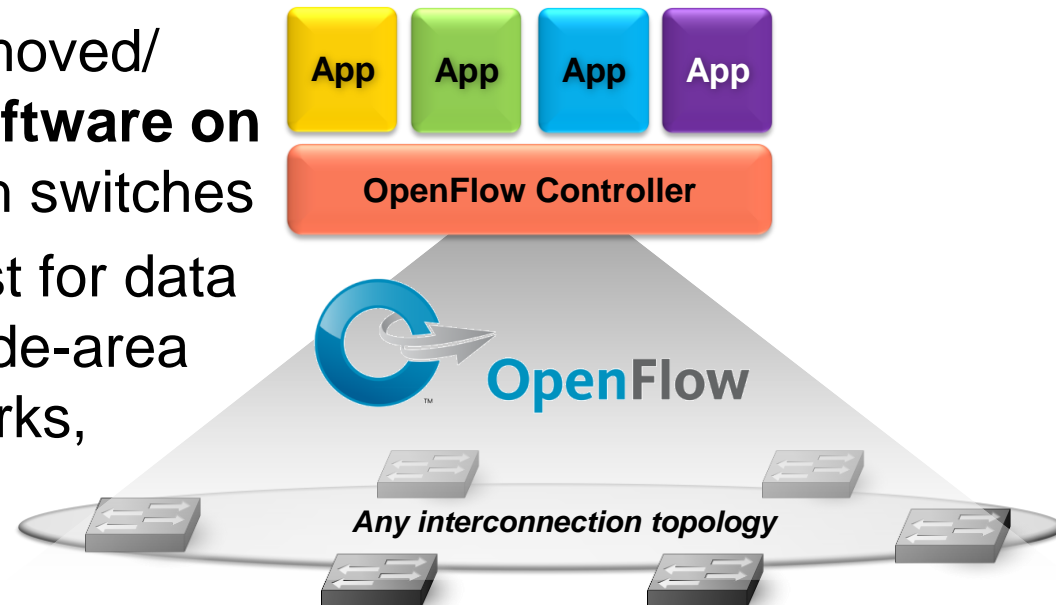
    application-specific functions

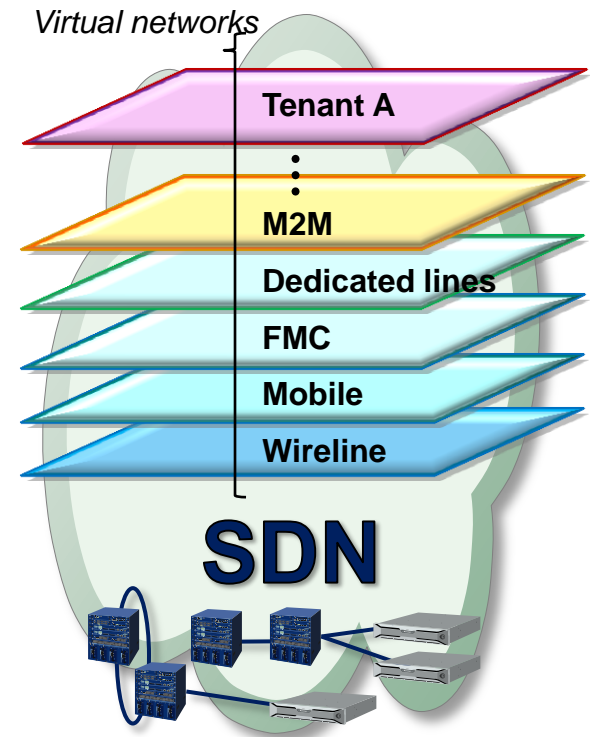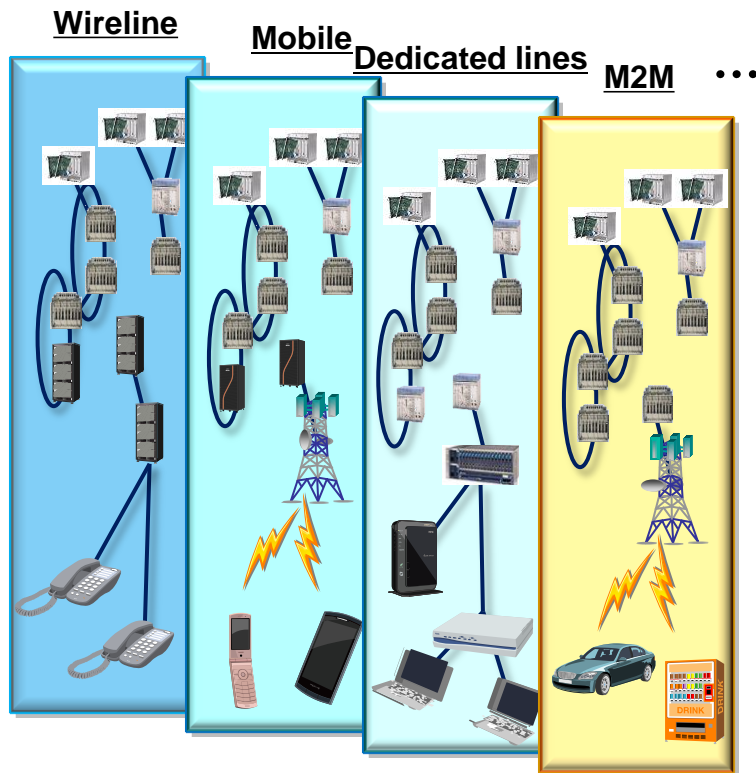- Functions can be added/removed/ changed by **configuring software on controller**; no need to touch switches

- Products, demos, ideas exist for data center & cloud networks, wide-area networks, broadband networks, mobile networks, optical networks, …
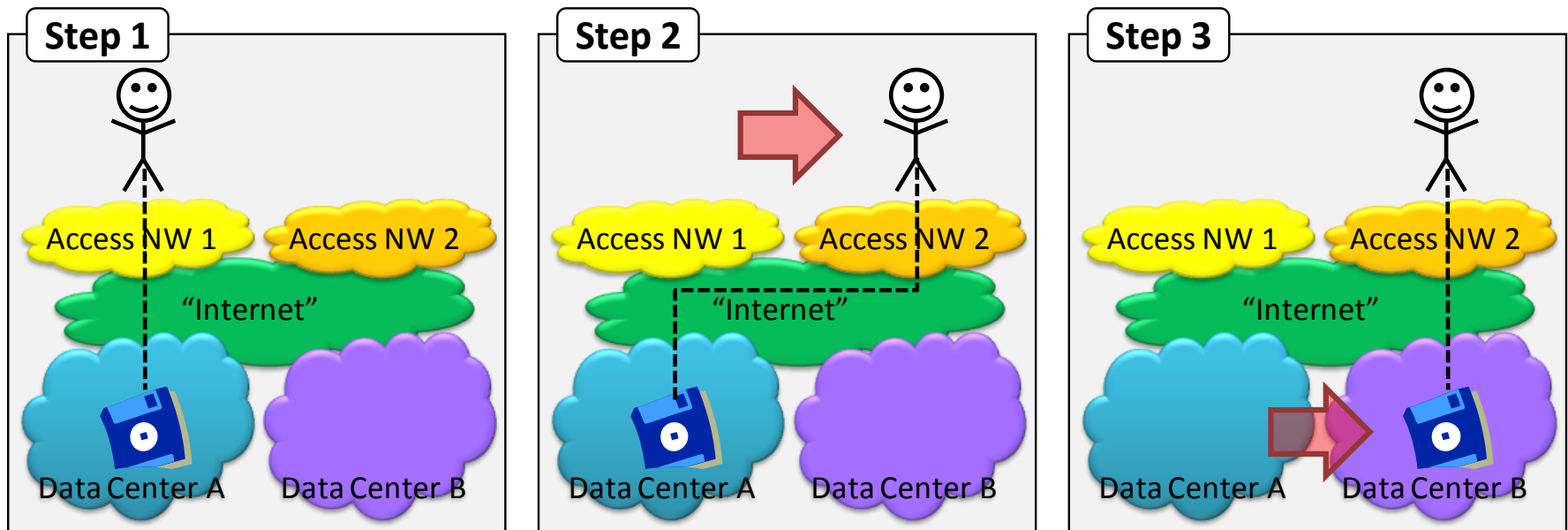

App App App App

OpenFlow Controller

OpenFlow

Any interconnection topology

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SDN Example 1: Network Virtualization

From vertical network silos… → **…to diversification of services on single common network**

Wireline

Mobile

Dedicated lines

M2M

Virtual networks

Tenant A

M2M

Dedicated lines

FMC

Mobile

Wireline

SDN

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# SDN Example 2: Follow-Me Cloud

Many cloud services are location-dependent (latency!)

Follow-Me Cloud migrates VMs **including network environment** depending on user movements to improve quality-of-experience

- migration hidden from users and applications by using OpenFlow

Step 1 — Access NW 1, Access NW 2, "Internet", Data Center A, Data Center B

Step 2 — Access NW 1, Access NW 2, "Internet", Data Center A, Data Center B

Step 3 — Access NW 1, Access NW 2, "Internet", Data Center A, Data Center B

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SDN Example 3: Disaster Recovery

Moving NW configurations between data centers is extremely difficult and time-consuming with existing technology

With SDN, you can simply move description of virtual network
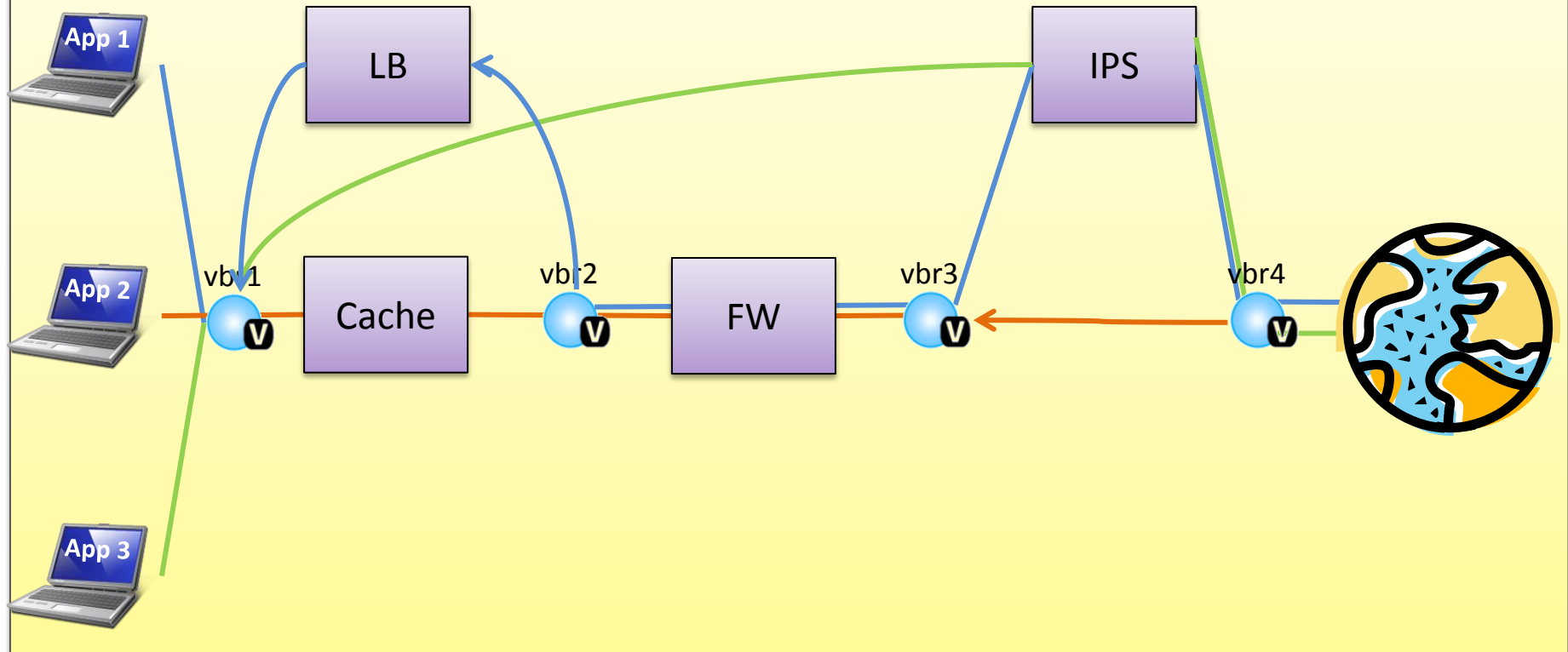
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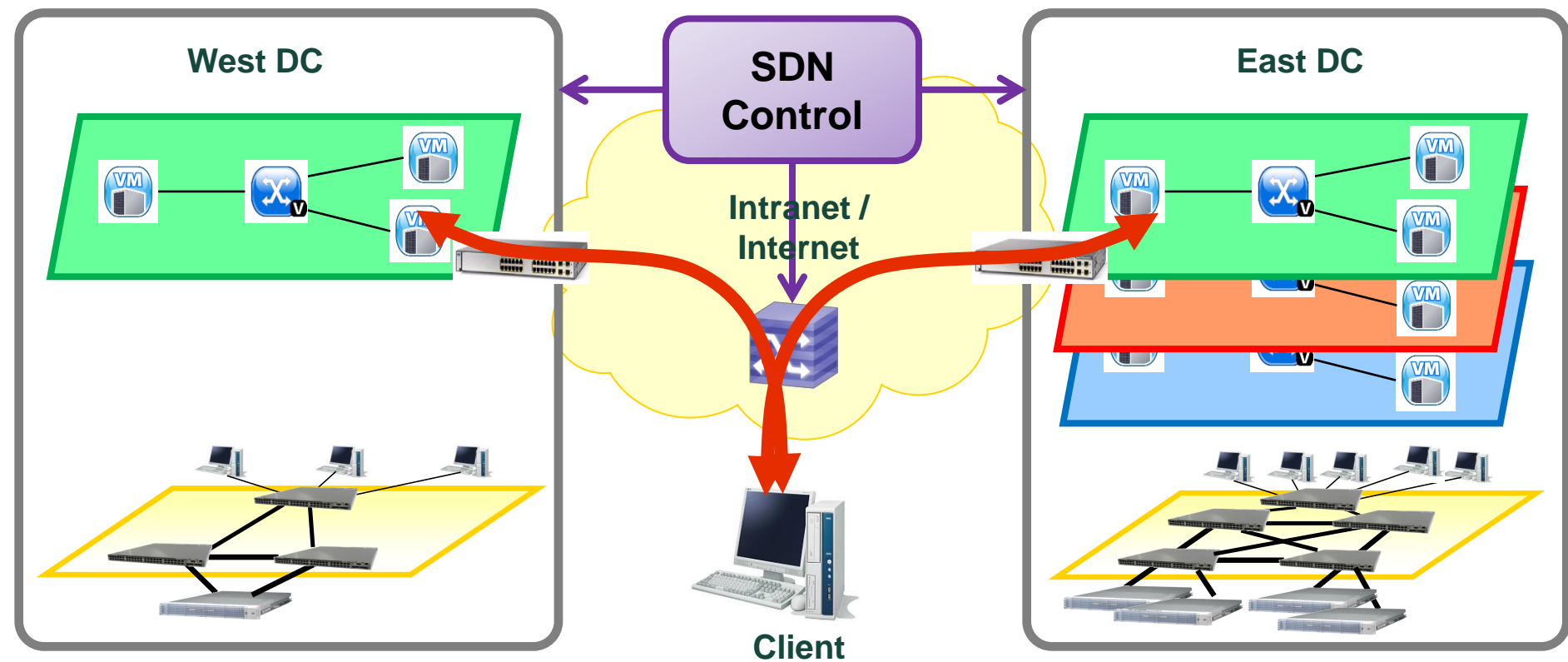
SDN Example 4: Service Chaining

Different function chains for different applications

- steer traffic to elements of function chain by SDN
- functional elements can be located anywhere in the data center

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SDN Status

Standardization

 OpenFlow

 IETF   ForCES, I2RS

Open Source Controller (Platforms)

 OPEN DAYLIGHT   POX   *Trema*   Floodlight

Open Source Software Switch

- openVSwitch

Commercial Products (switch/controller)

 NEC   …and others

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ONF Members (141 as of April)

https://www.opennetworking.org/membership/member-listing
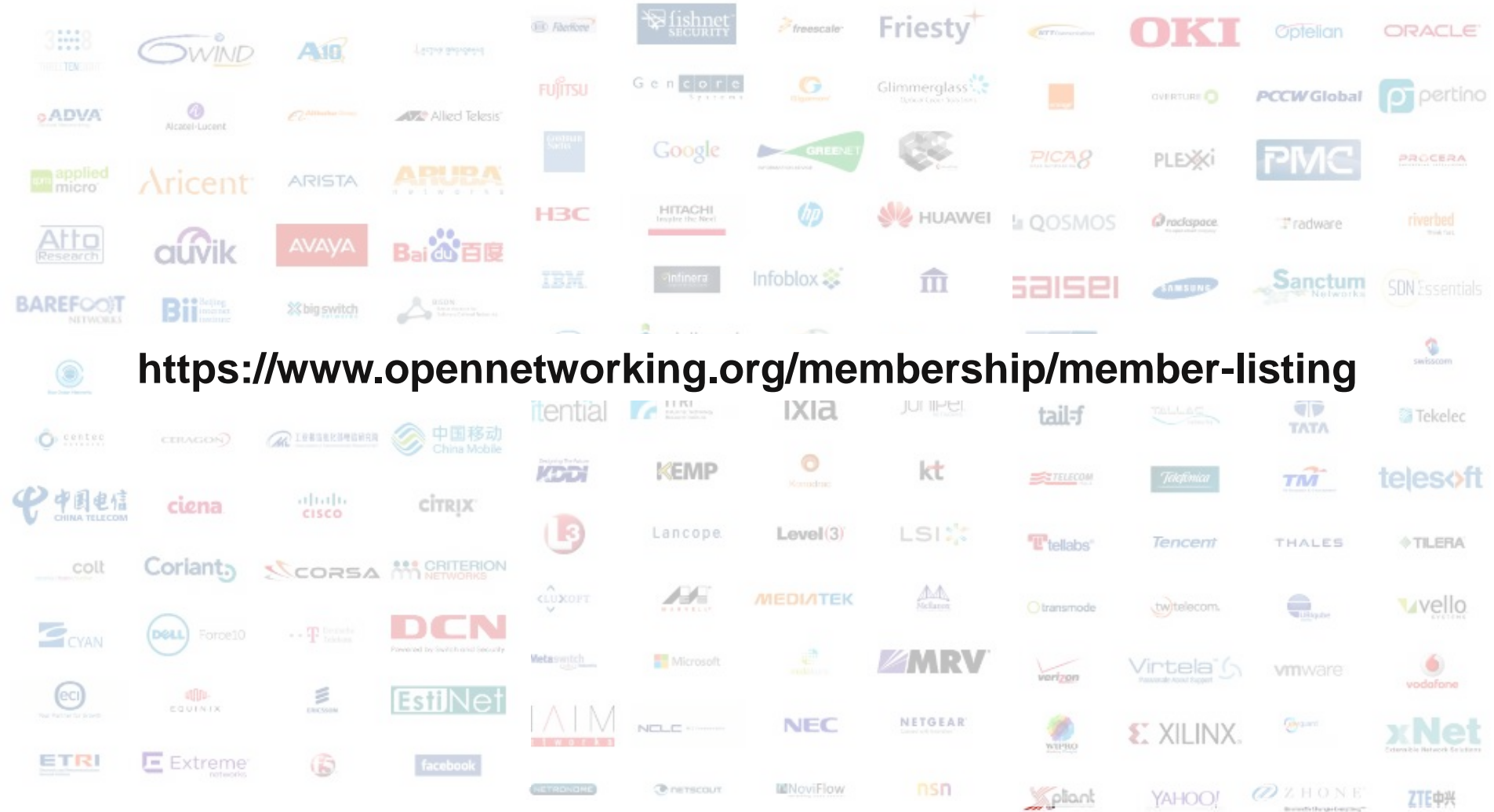
Topics For Further Investigation

- SDN **scalability** for hardware-based switches
  - **Number of flows** that a node can store is (very) limited
  - **Writing flow entries** into specialized memory (TCAM) is slow
- **Software flow-processing**
  - **Networking performance** of typical COTS servers not optimal due to a number of bottlenecks in HW and SW architecture
- **Involvement** of the **controller**
  - In SDN, all traffic forwarding decisions are moved to the controller
  - For some applications, **round-trip** to the controller **is too slow** and **limits scalability**
  - Some decisions can and should be delegated to the switch, but: How much **control** should be **given back to the switch**?
- Additional **use cases** for SDN

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Software-Defined Networking in the Data Centre

- Current system of introducing new networking features is **not scalable** and **not sustainable**
  - Introduction of new features takes several years
  - Configuration complex and error-prone
- SDN & OpenFlow move control from closed hardware boxes to **open software systems**
  - **Opens up network** to application programmers
  - Networking features become as **agile** as server applications
- SDN/OpenFlow provides
  - **Instant** network re-configuration
  - **Reduced time-to-service**
  - **Central point** of configuration
  - **Transparency of configuration** is increased by centralized control
  - Introduction of **application-specific networking** capabilities

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