Software-Defined Networking for the Data Center

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**We still use old technology… but we just "pimp it"**

- To make it suitable for recent needs
- That's far from being optimal…

Network innovation is impossible with closed/proprietary systems

- DC operators do not want to wait for all their vendors to implement a feature before being able to launch a new service
- Network technology is **not a driver for innovation** any more
- **Need an open solution** to implement new services with **short lead time**

Let's get back control of our networks!

- And here SDN & OpenFlow come in…

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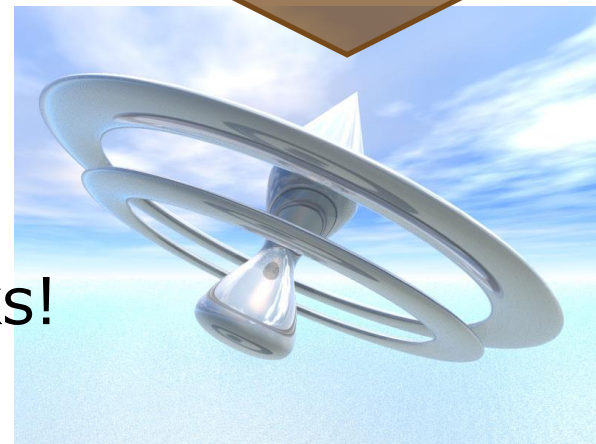
Network Technologies Not As Agile As Desired

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)
- difficult to add new features (upgrades)
- difficult to debug (look at all boxes)

Closed Systems (Vendor Hardware)
- stuck with given interfaces (CLI, SNMP, etc.)
- hard to collaborate meaningfully
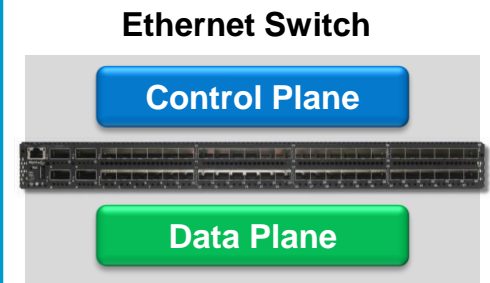- vendors reluctant to open up

NEED:

Openness and Programmability
- Flexibility, Innovation, Customization
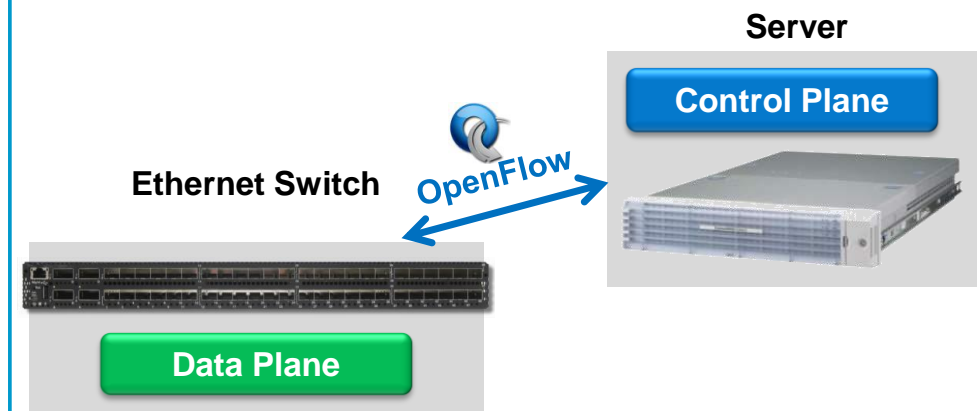- Rapid service deployment
- Cost efficiency

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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

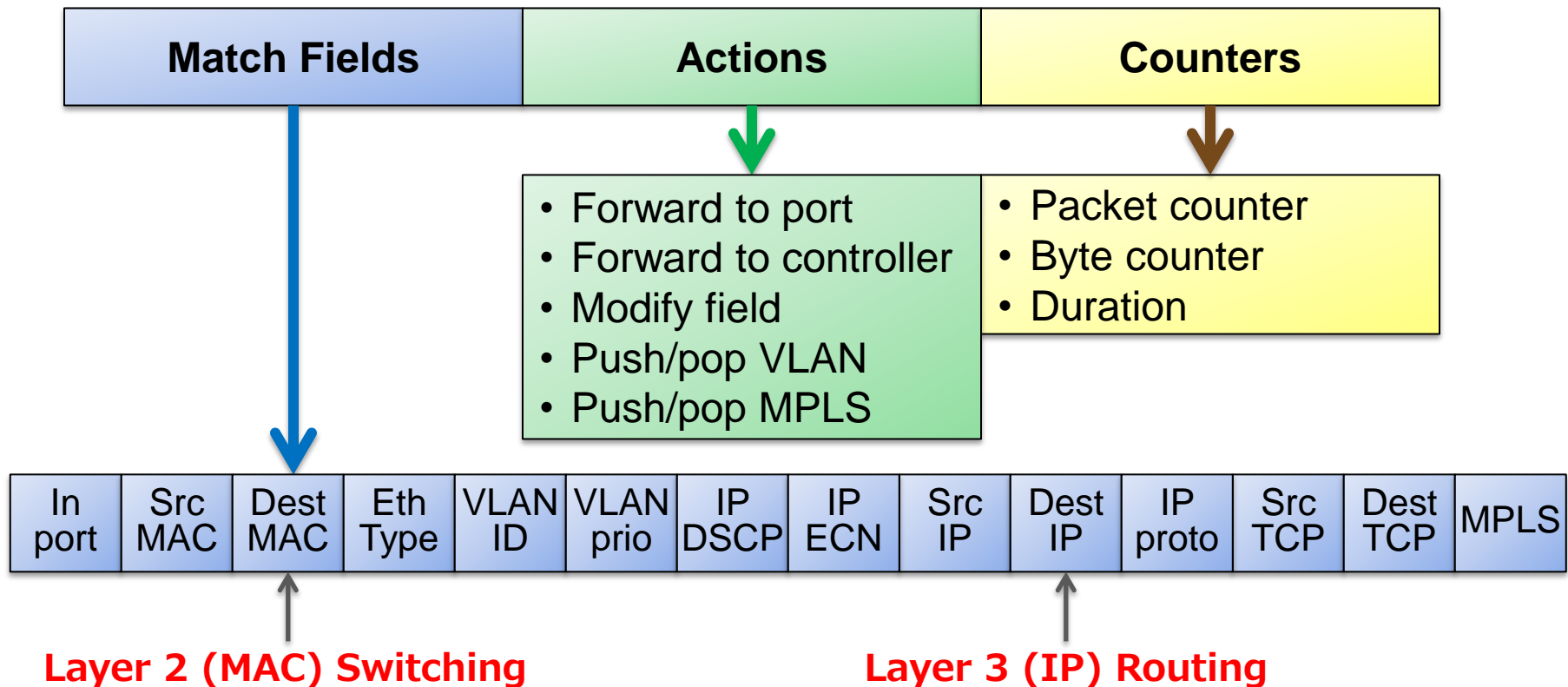▌ **Separate control and data planes** and open up control

Before SDN

Ethernet Switch

Control Plane

Data Plane

With SDN

Server

Control Plane

Ethernet Switch

OpenFlow

Data Plane

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OpenFlow Flow Table Entries

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

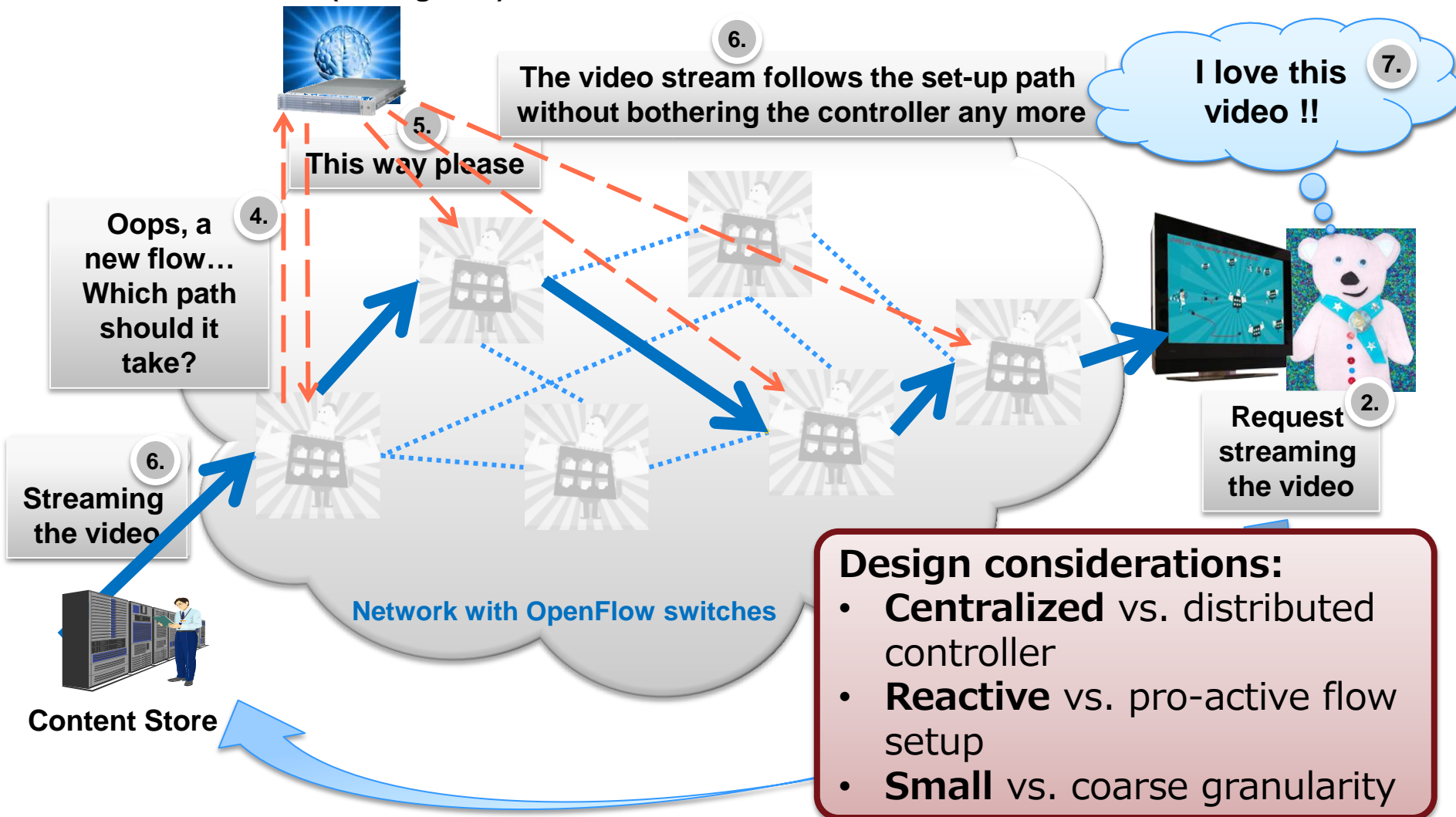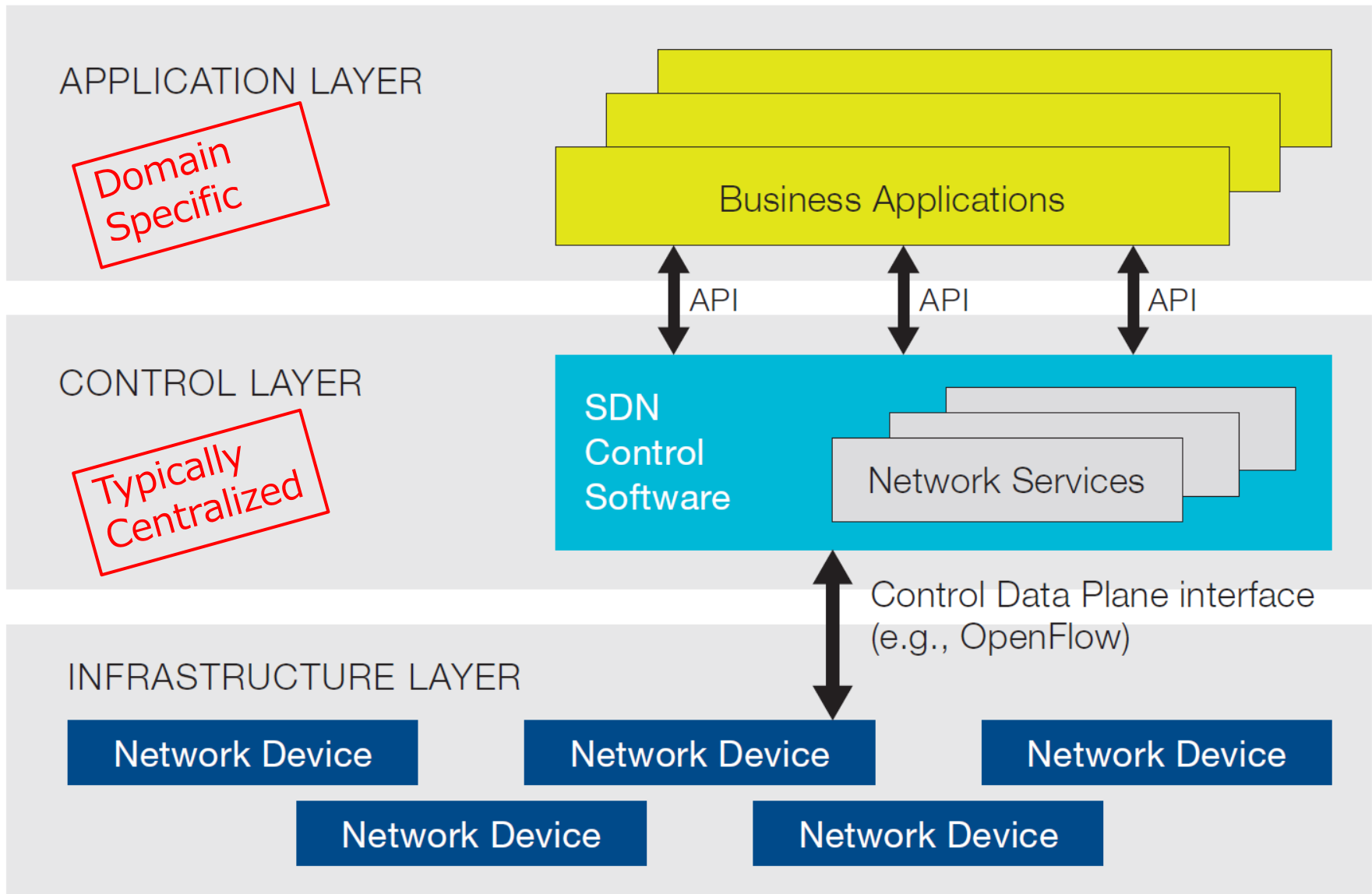| In port	Src MAC	Dest MAC	Eth Type	VLAN ID	VLAN prio	IP DSCP	IP ECN	Src IP	Dest IP	IP proto	Src TCP	Dest TCP	MPLS

Layer 2 (MAC) Switching   **Layer 3 (IP) Routing**

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

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How Does it Work? An Example

Controller (Intelligence)

6.
The video stream follows the set-up path without bothering the controller any more

7.
I love this video !!

5.
This way please

4.
Oops, a new flow… Which path should it take?

6.
Streaming the video

2.
Request streaming the video

Network with OpenFlow switches

Content Store

Design considerations:
- **Centralized** vs. distributed controller
- **Reactive** vs. pro-active flow setup
- **Small** vs. coarse granularity

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SDN Increases Level of Abstraction

APPLICATION LAYER

Domain Specific

Business Applications

API ↕ API ↕ API ↕

CONTROL LAYER

Typically Centralized

SDN Control Software

Network Services

Control Data Plane interface (e.g., OpenFlow)

INFRASTRUCTURE LAYER

Network Device

Network Device

Network Device

Network Device

Network Device

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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

App App App App

OpenFlow Controller

OpenFlow

Any interconnection topology

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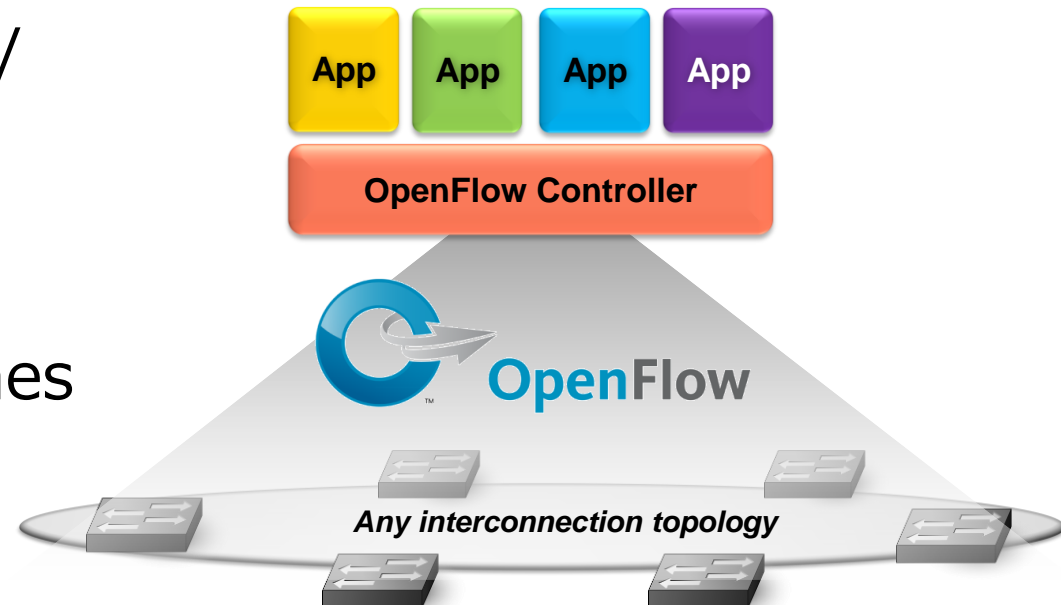
Use Case: Network Virtualization

One virtual network per tenant; mapped onto single physical network.

Virtual Network

Physical Network

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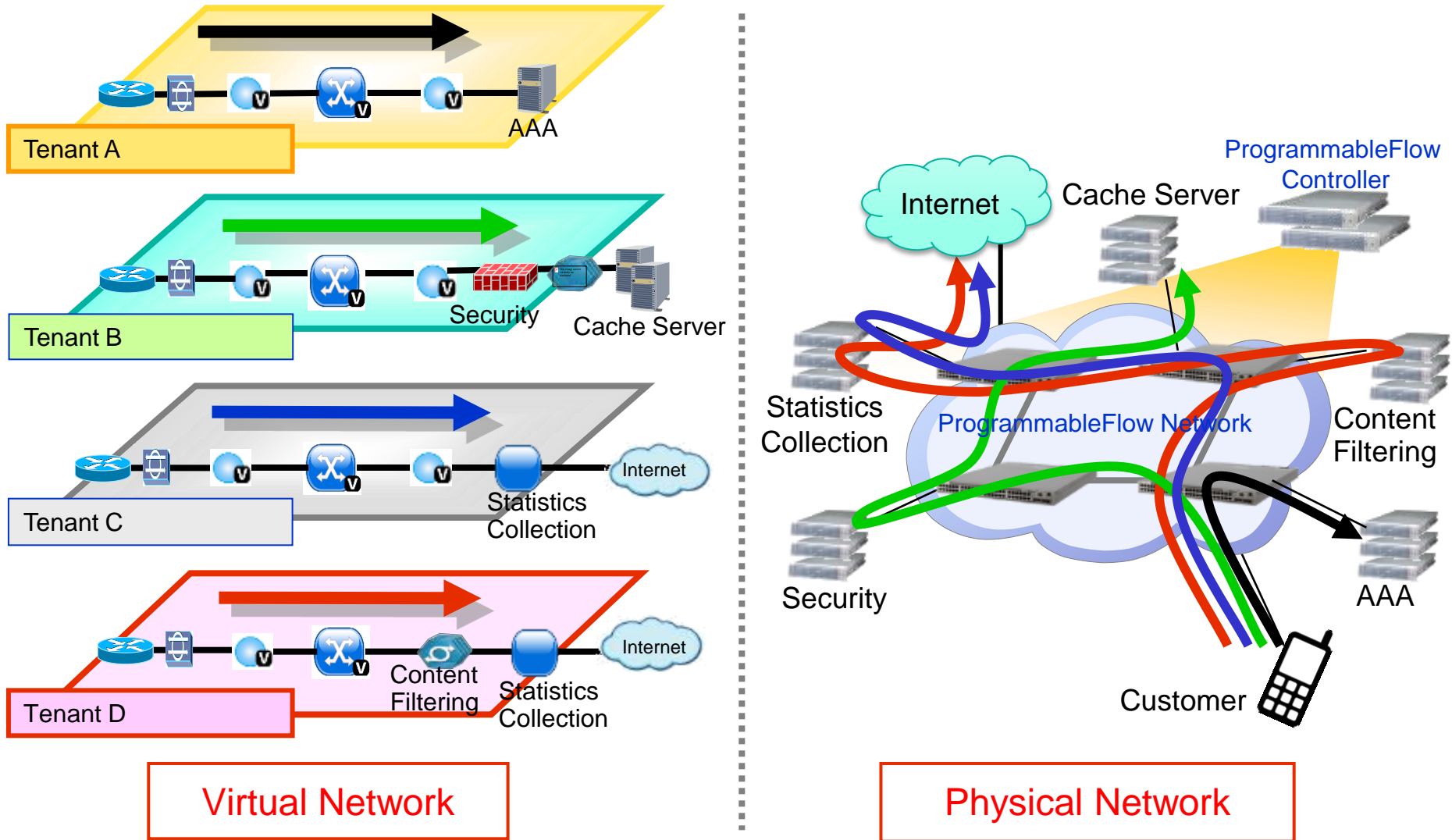
Use Case: Network DevOps

▌ Network configuration is usually an operations task

▌ But with SDN, network configuration can be "**code**"

▌ Changes to network configuration are therefore code changes → **programming**!

- add/remove/change endpoints
- add/remove/change switches, routers, firewalls, …
- add/remove/change ACLs, QoS, …

▌ Common coding and deployment **tools** can be utilized

- not only editors, grammar checkers, etc.,
- but also code repositories, versioning tools, …

```
vbridge myBridge {
  mac-map allowed {
    mac-address 1234.5678.90AB
    mac-address FEDC.BA98.7654
}}
```

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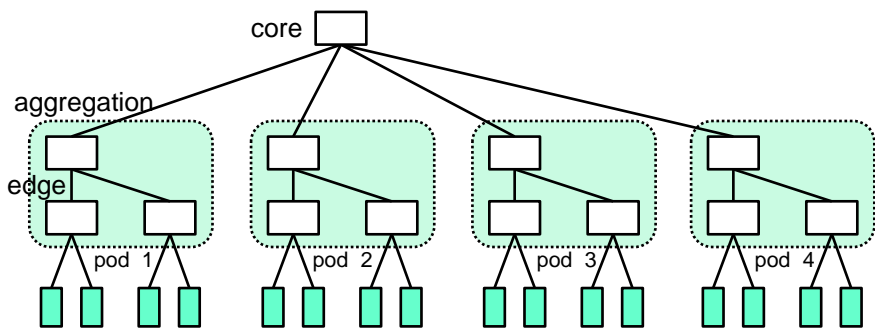# Use Case: Virtual Network Migration

- SDN allows NW configuration to be copied & moved
- With existing technology, that's extremely difficult
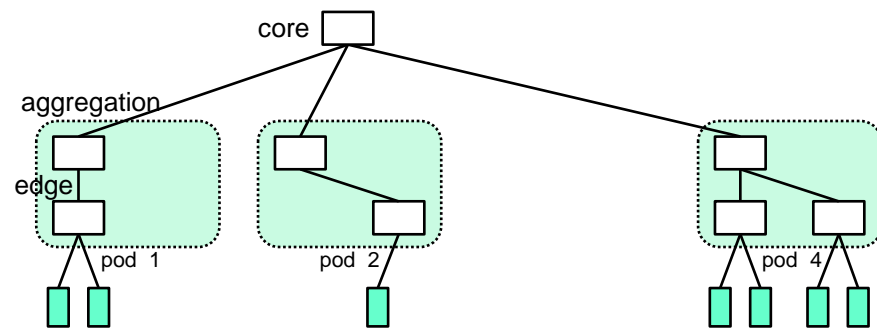- With SDN, you simply move description of VN (text!)

West DC

East DC

SDN Control

Intranet / Internet

Client

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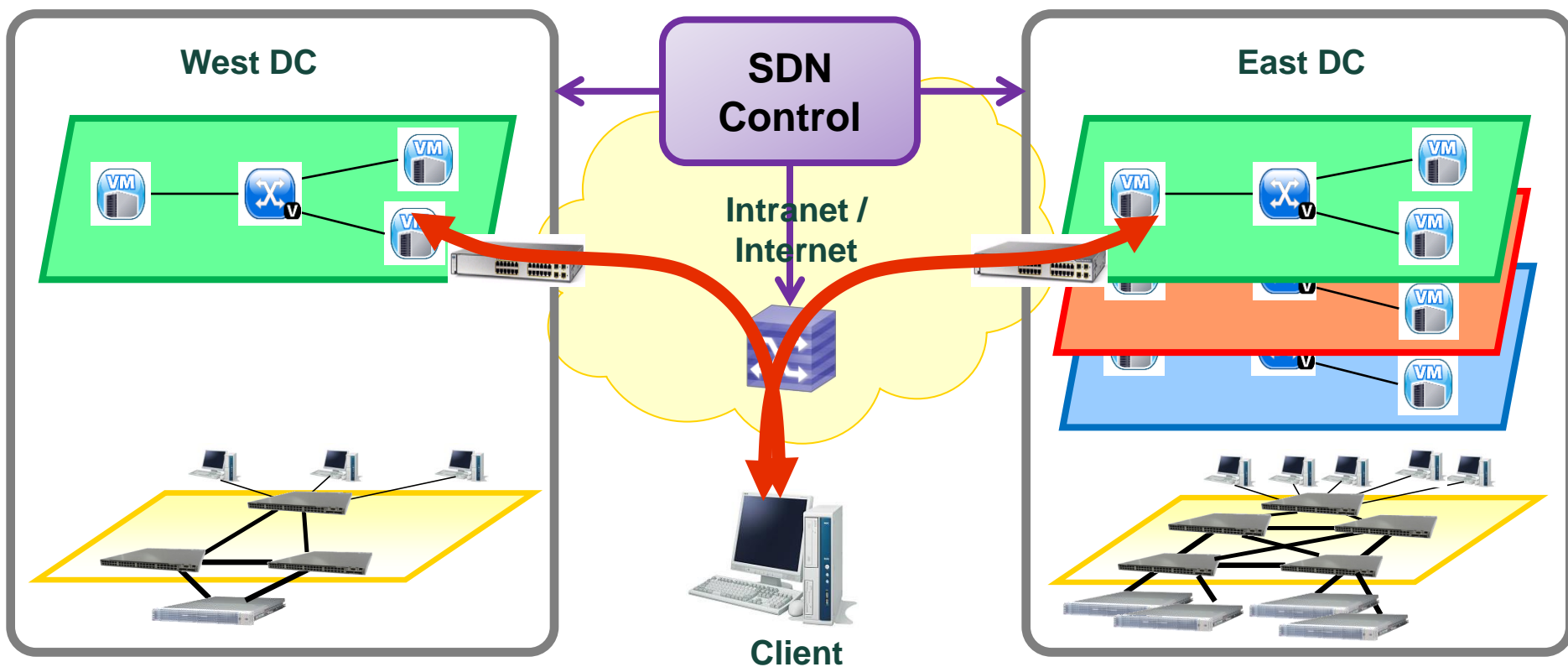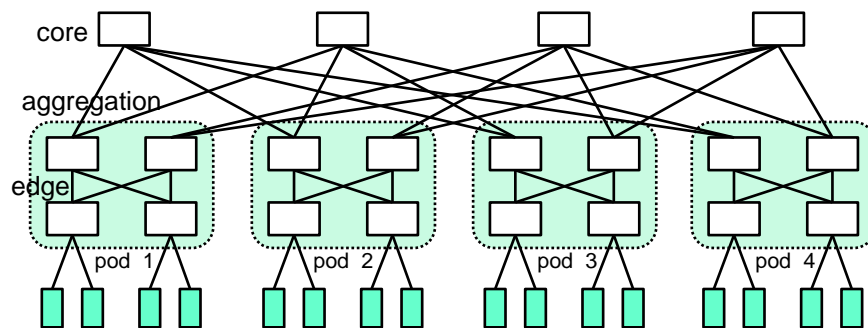
Fat tree topology

Consolidated traffic (fat tree subset)

Consolidated traffic & workload

Traffic can be consolidated on a small number of links

Remaining (empty) switches and links can be turned off

SDN in Practice: Some Examples

Standardization

   ForCES, I2RS

Open Source Controller (Platforms)

Open Source Software Switch

- openVSwitch

Commercial Products (switch/controller)

- NEC's **ProgrammableFlow** & many others

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SSICLOPS H2020 Project

- "Scalable and Secure Infrastructures for Cloud Operations"
- Project works on optimizing and securing packet transport in and across data centers
- Includes various components: TCP/IP stack, congestion control, path management
- Includes SDN, to see how centralized information and control can help achieve that goal

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Conclusion

- SDN is the **new norm for networking**

- SDN **opens up** the previously closed **networking boxes** to increase innovation in the networking space

- **OpenFlow** is main architecture and protocol in SDN

- OpenFlow provides low-level **programming facilities**

- **Intelligence** is programmed into controller

- SDN can replicate existing networking functions and decrease management costs

- More importantly, though, SDN increases the **level of abstraction** and allows for **innovative new applications** well beyond current networking capabilities

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