

# **ProgrammableFlow: OpenFlow Network Fabric**

**Information Technologies Group (ITG)  
Enterprise Technologies Unit  
NEC Corporation of America**

# It's ME between YOU and LUNCH

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- But if you watch this talk, you will see
- A spaceship
- A car with a jet engine
- A powerful robot (twice!)
- And a **fully programmable network** 😊



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# WHY OPENFLOW?

The internet is a **great invention!**

But, ehem..



Houston, we have a problem...

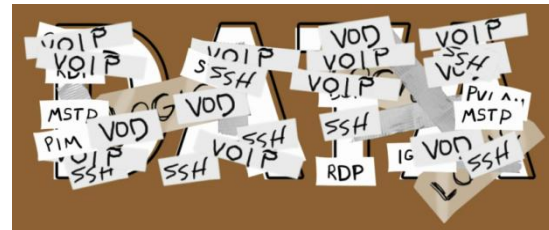
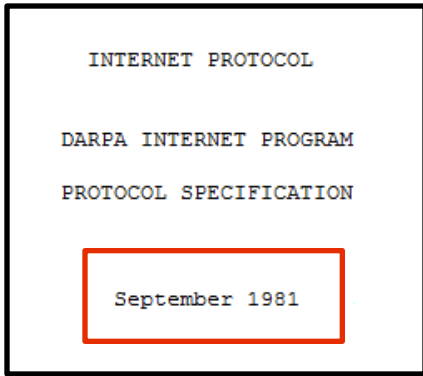
# Internet Technology ... somehow stuck ...

Internet Protocol (IP) forms the basis of current communication networks...



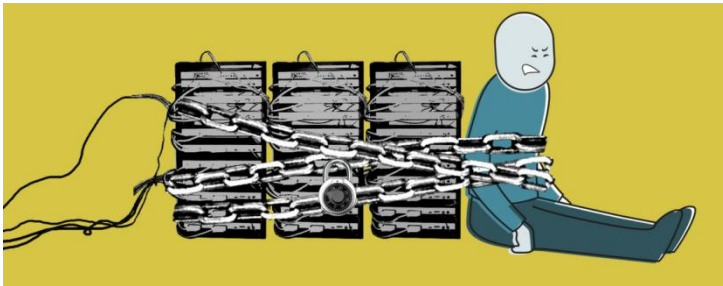
... the technology originates from the **Sixties**...

**Workarounds** have been applied so that it survived



It works ... but ... we're stuck.  
**No innovation**

(BTW, How long do we talk about introducing IPv6???)



# Current technology can't cope with business needs

Network innovation is impossible with closed/proprietary systems

- Need an **open solution** to implement new services with **short time to market**
  - Operators do not want to wait for all their vendors to implement before being able to launch a new service

**The Cloud Age** is here!

- Dynamically store data and compute everywhere
- Move virtual machines or services around on the fly
  - IP technology has not been designed for that!



-> Business changes rapidly, the network cannot even follow  
(this used to be the other way round...)

# Something's wrong...

We still use old technology... “pimp It” to make it suitable for recent needs and spend our time in managing and deploying it...



Let's get back control over our networks!

# NEC and OpenFlow

## History

- Co-Founded CleanSlate Lab at Stanford
- NEC first generation OpenFlow switch released in 2009
- NEC switches **deployed in more than 23 universities and labs** globally
- 5 years of NEC research and development on OpenFlow



## Commercialization

- NEC **first generally available** OpenFlow switch and controller
- ProgrammableFlow: First Network Virtualization solution leveraging OpenFlow
- ProgrammableFlow first **commercial deployment** of OpenFlow in DC, Enterprise
- Best of Interop in Infrastructure Category

**ProgrammableFlow**

## Standard Participation

- Member of Open Network Foundation, contribution to reference code
- Actively contributing to all ONF working groups



## Deployment and Showcases

- Interoperability demonstrated at Interop LV 2011
- NEC has showcased the first Multi-DC RDMA transfer using OpenFlow
- NEC showcasing OpenFlow support in Windows 8 at Build 2011
- Demonstrated 6 different use cases at Open Networking Summit
- Demonstrations at **Supercomputing 2011**



Empowered by Innovation

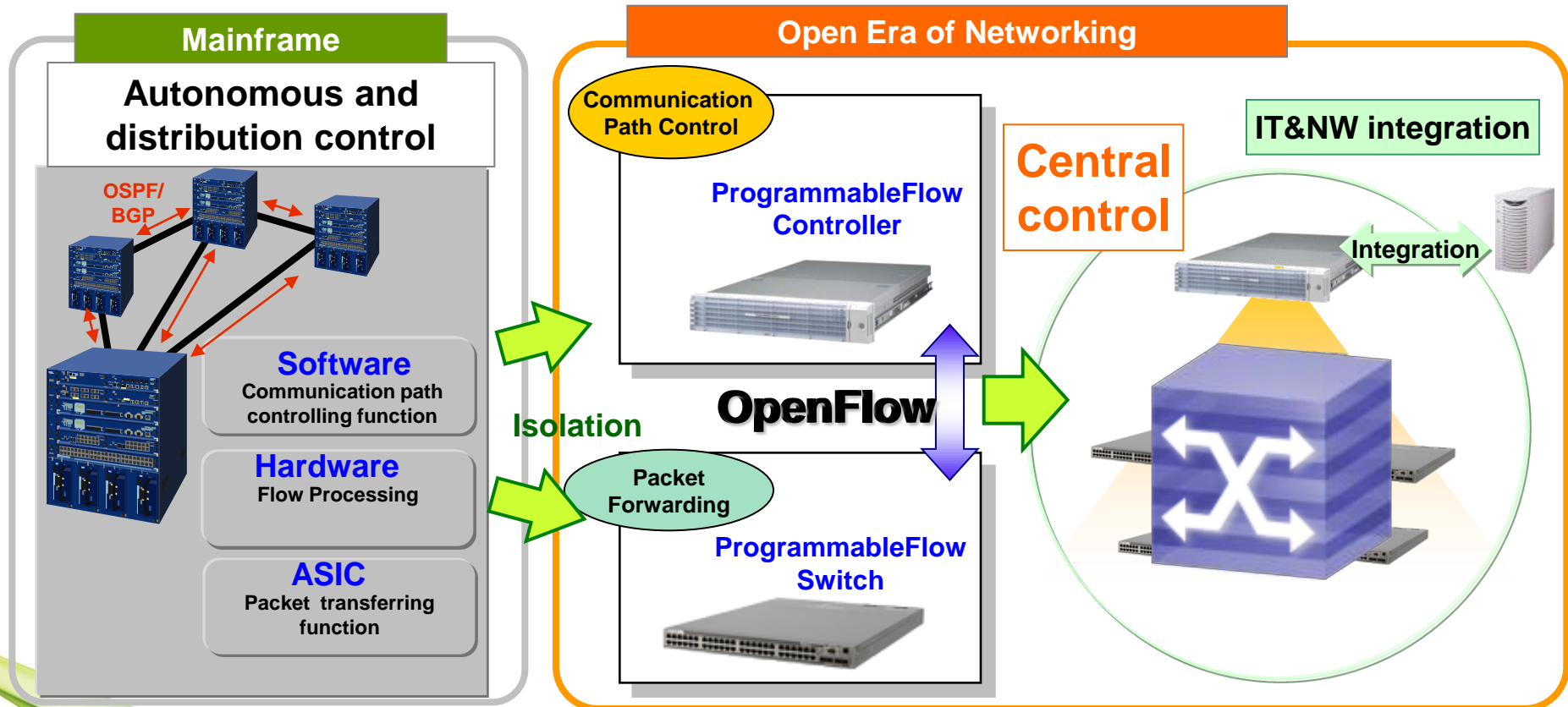
**NEC**

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# HOW OPENFLOW WORKS

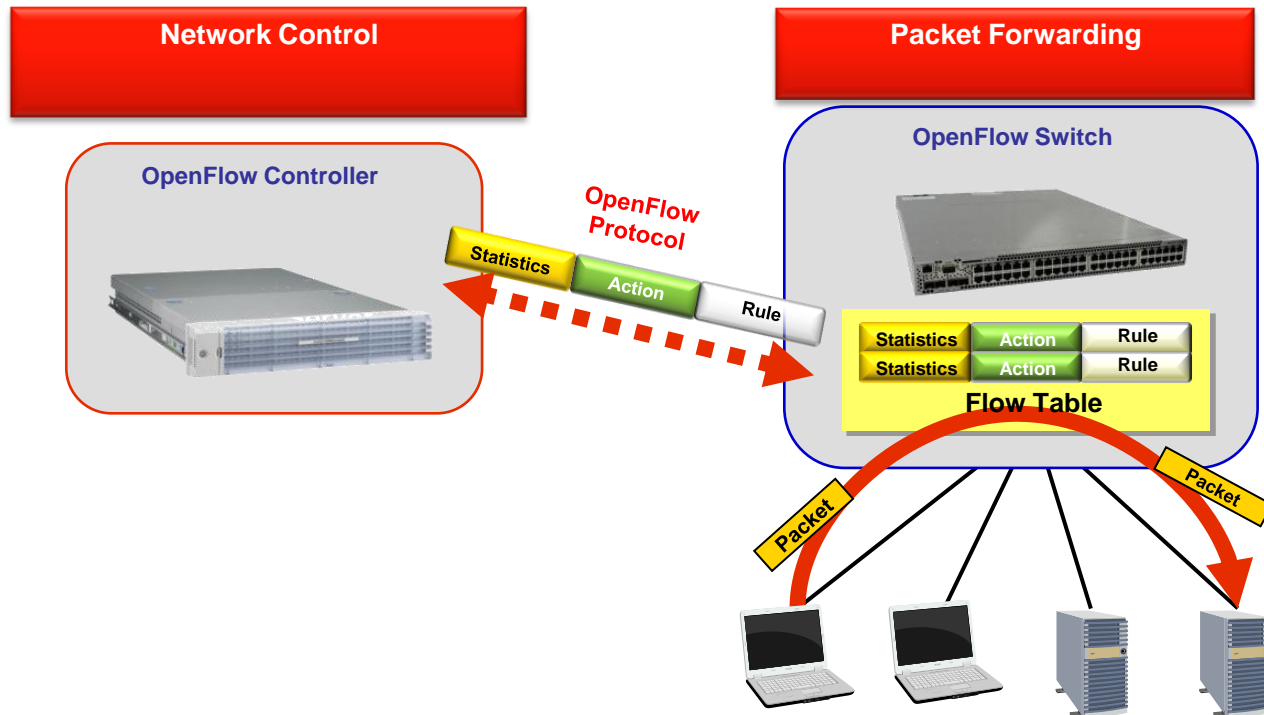
# Networking Evolving from Mainframe to Open Era

- OpenFlow enables network logic to move into the application stack, decoupling network software from hardware
- ProgrammableFlow Leverages OpenFlow to provide *true network virtualization*

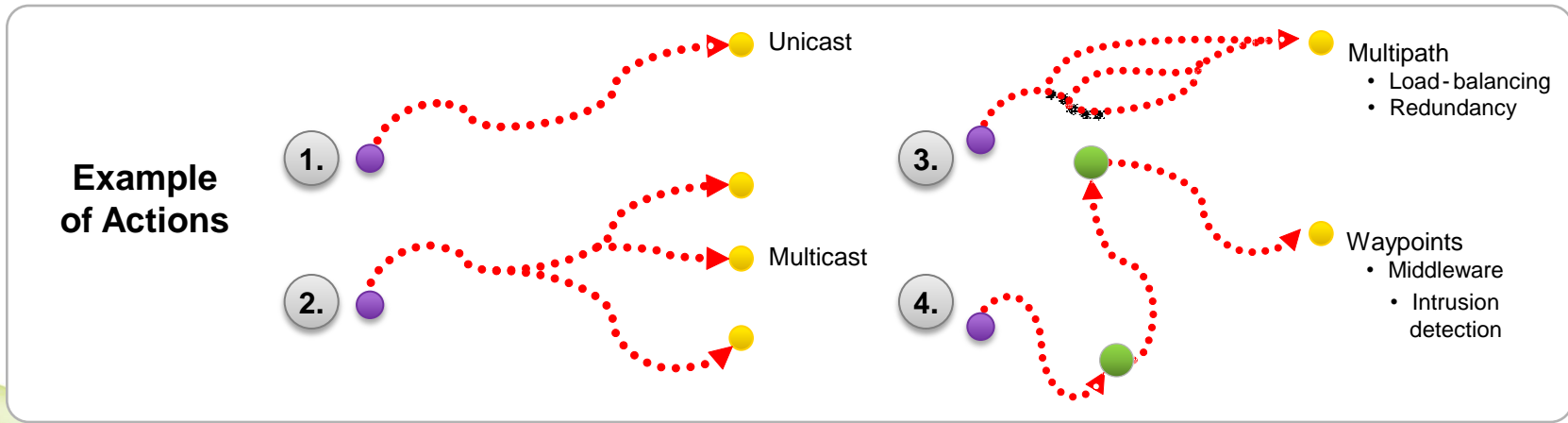
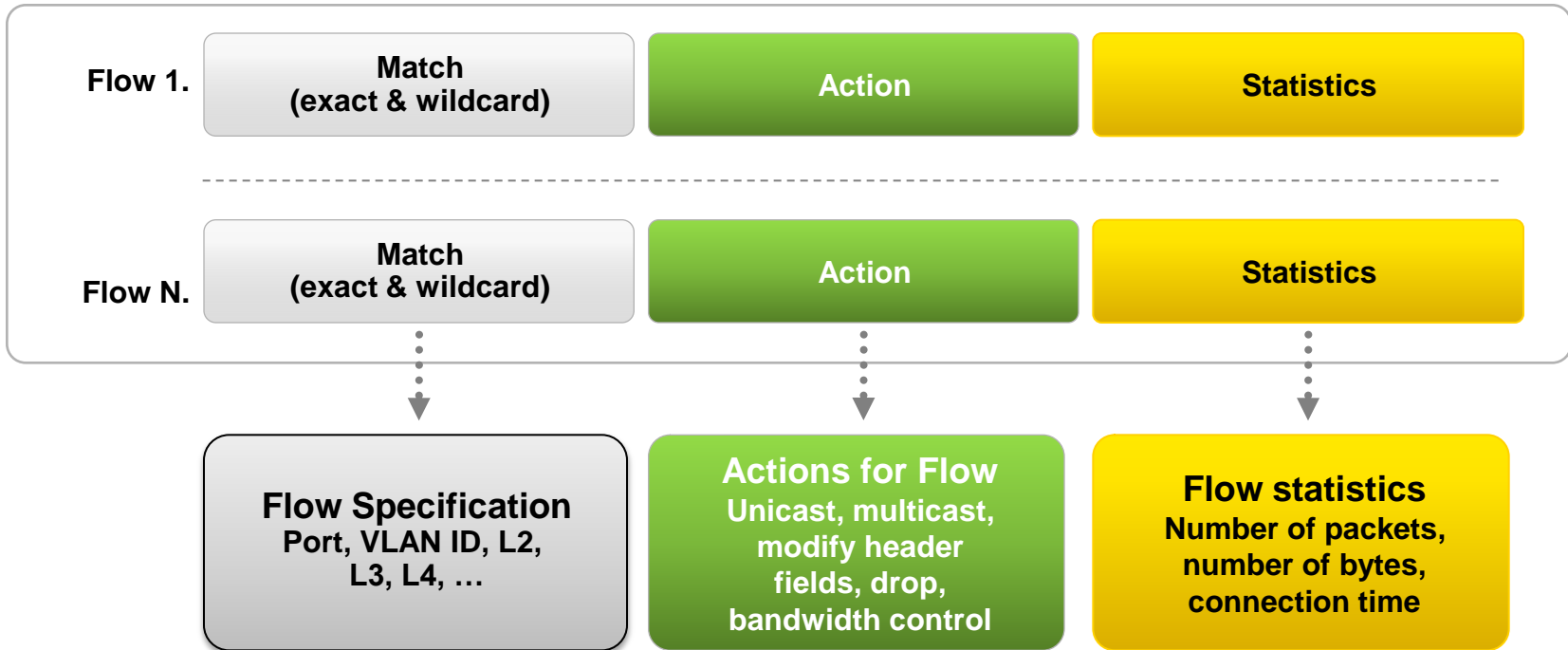


# How it works on a switch level

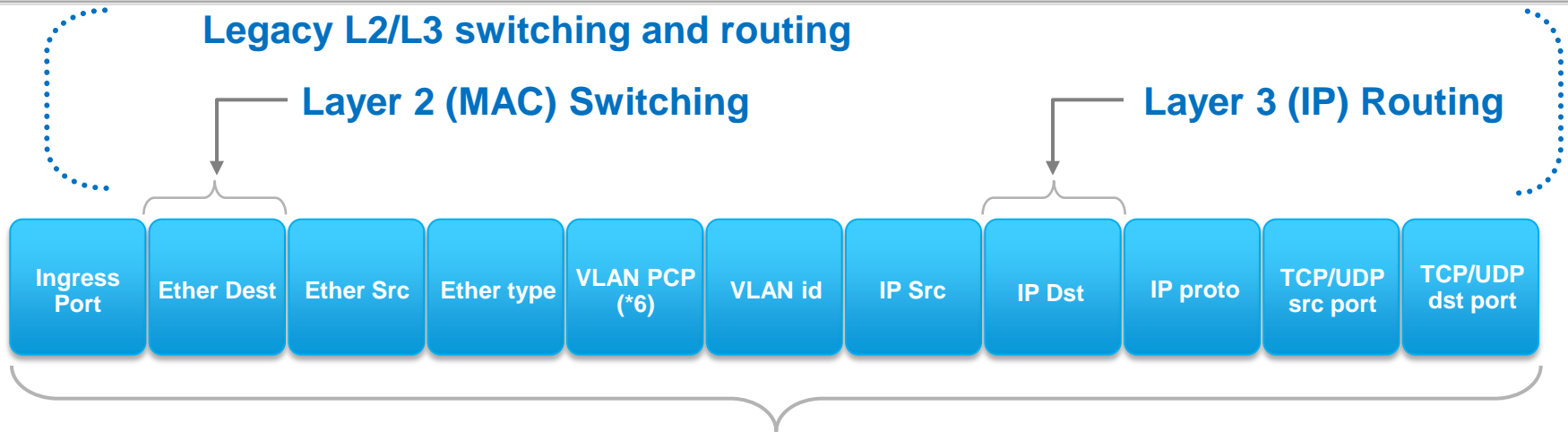
- A plain OpenFlow switch only forwards frames in case it has a flow entry
- In case it does not have one, *it can ask somebody who knows* 😊
  - Asks the controller for an according flow entry



# Flow-based Matching & Actions



# OpenFlow Flow Switching Definition



## Flow Switching with any combinations of tuples as a key

- Exact Matching
- Wild Card Matching
  - Aggregated MAC-subnet: MAC-src: A.\*, MAC-dst: B.\*
  - Aggregated IP-subnet: IP-src: 205.16.\*/\*24, IP-dst: 206.12.\*/\*24

No worries, extensions for **MPLS**, **IPv6**, ... available / on the way

- Standard is being expanded these days at ONF



In Openflow, **the world is flat**. Headers only serve as criteria for flow matching

- And to talk to the outside world 😊

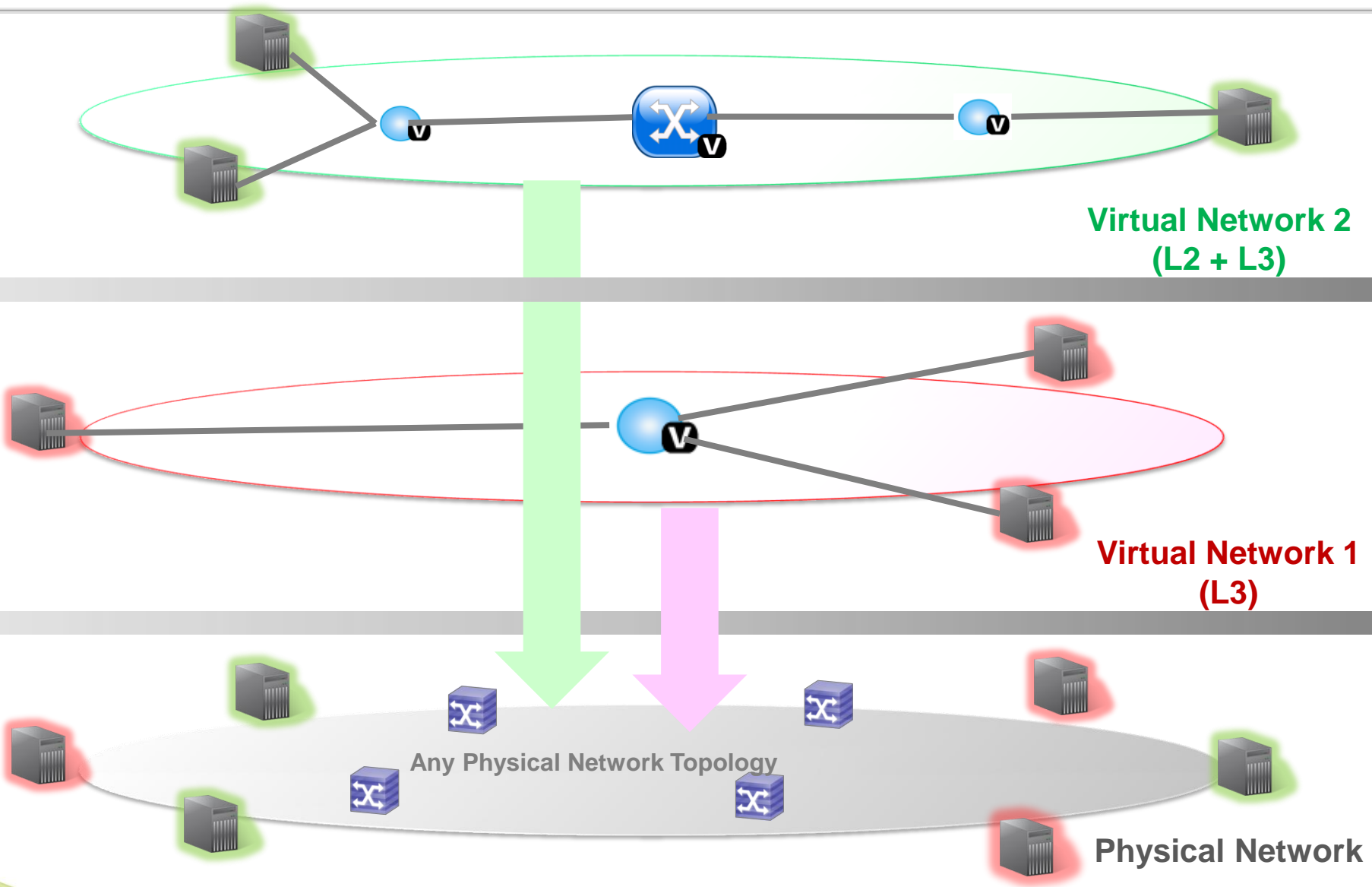
# Flow Definition Examples

Ingress Port	Ether src	Ether dst	Ether type	IP ToS	VLAN id	IP src	IP dst	IP proto	TCP/UDP src port	TCP/UDP dst port	
*	*	*	*	*	*	*	*	*	*	22	drop
*	*	*	*	*	*	*	1.2.3.4	*	*	*	port 4
4	*	*	0x9100	*	*	1.2.3.4	*	*	*	80	port 2

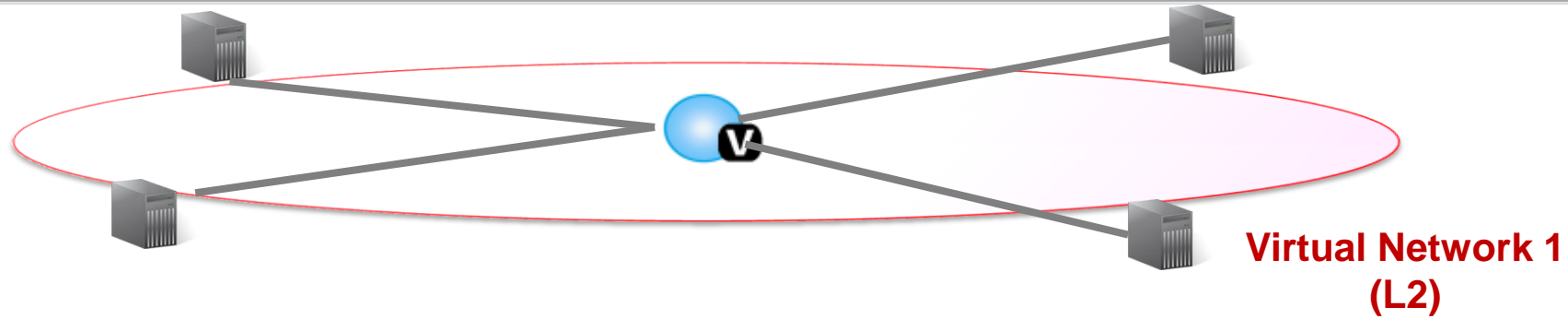
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# OPENFLOW SWITCH USE CASES

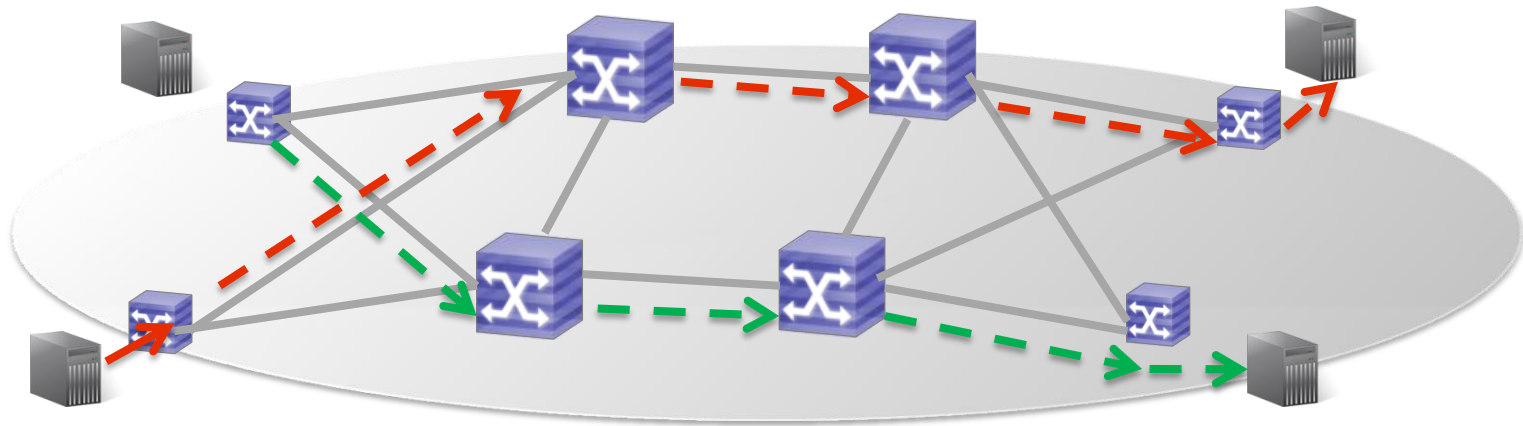
# Multi-tenant Virtual Networks on one Physical Network



# Optimizing the physical network



- Automatically discovers multiple paths
- Automatically avoids loops
- Automatically balances flows across paths
- No route flapping

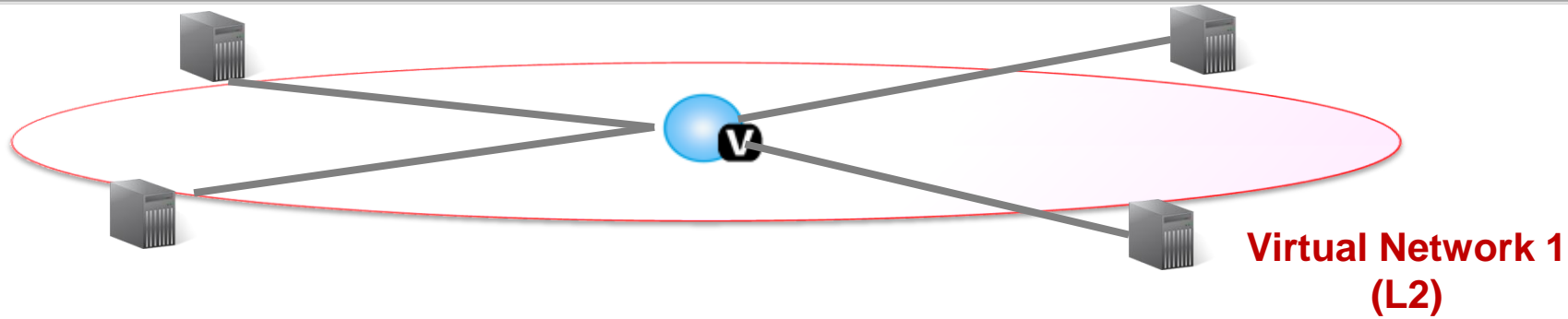


Physical Network

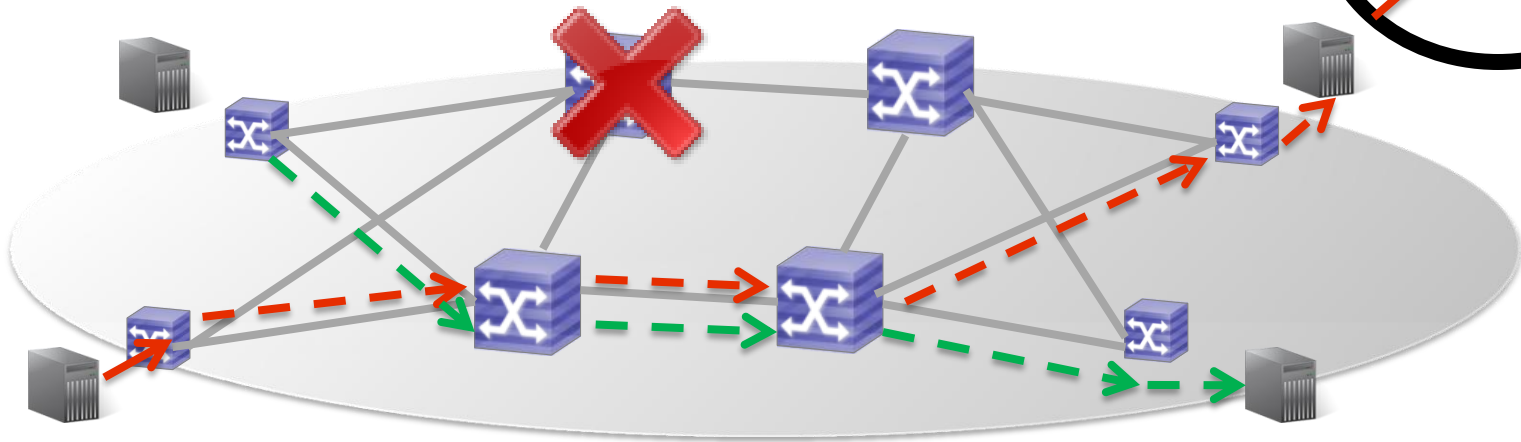
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# Adding End-to-End Reliability



- Automated monitoring of switch/link status
- Automatically re-computed alternate path
- Automatically shifts flows to alternate path
- Fast due to avoiding convergence time as in STP

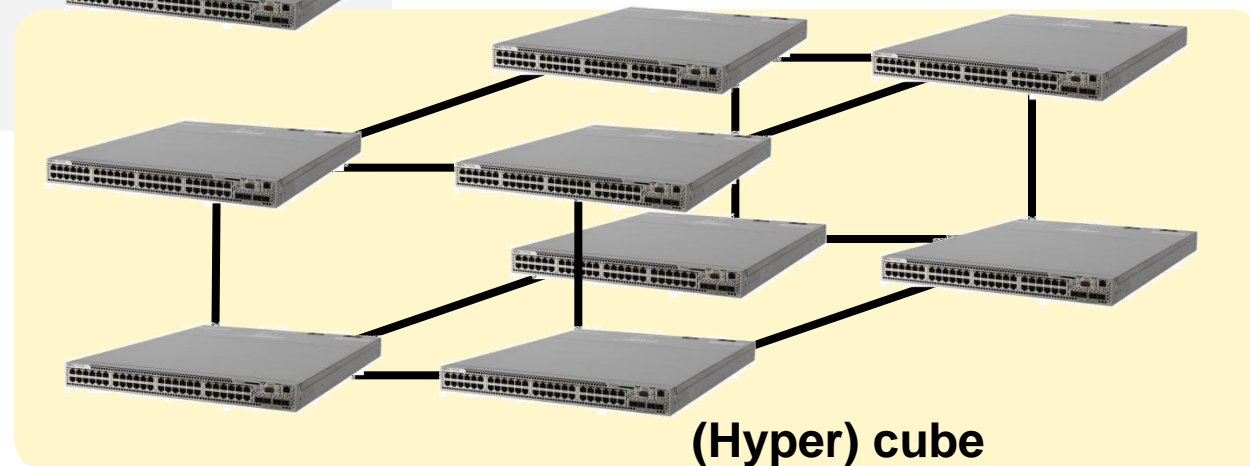
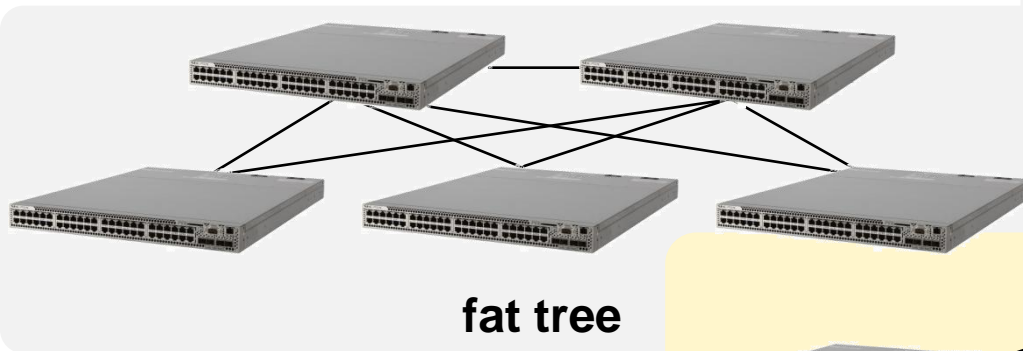
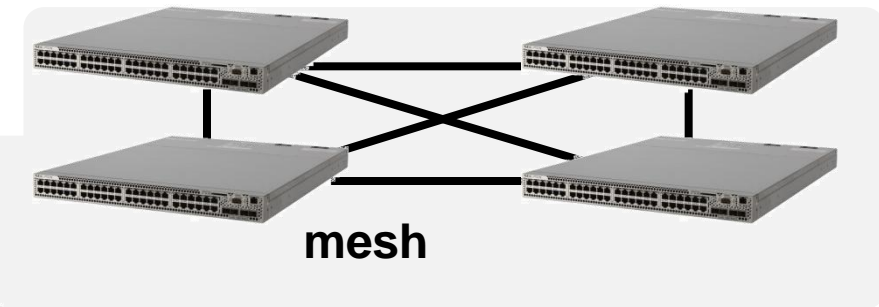
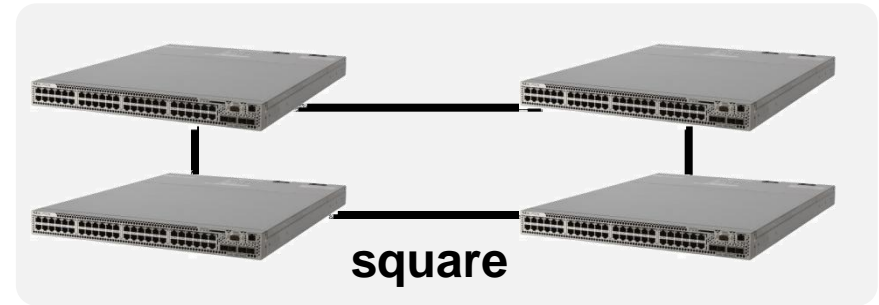


Physical Network

# Scale – No Topology Restrictions

Scalability

- OpenFlow enables a variety of network topologies
- Full bandwidth can be utilized
- Stackable without special cabling, chassis



# Switch Differentiators in the Open Network Era

## Hardware

- Throughput – 1G/10G/40G
- CPU resources flow add / mod /del
- Form factor – port density, wiring

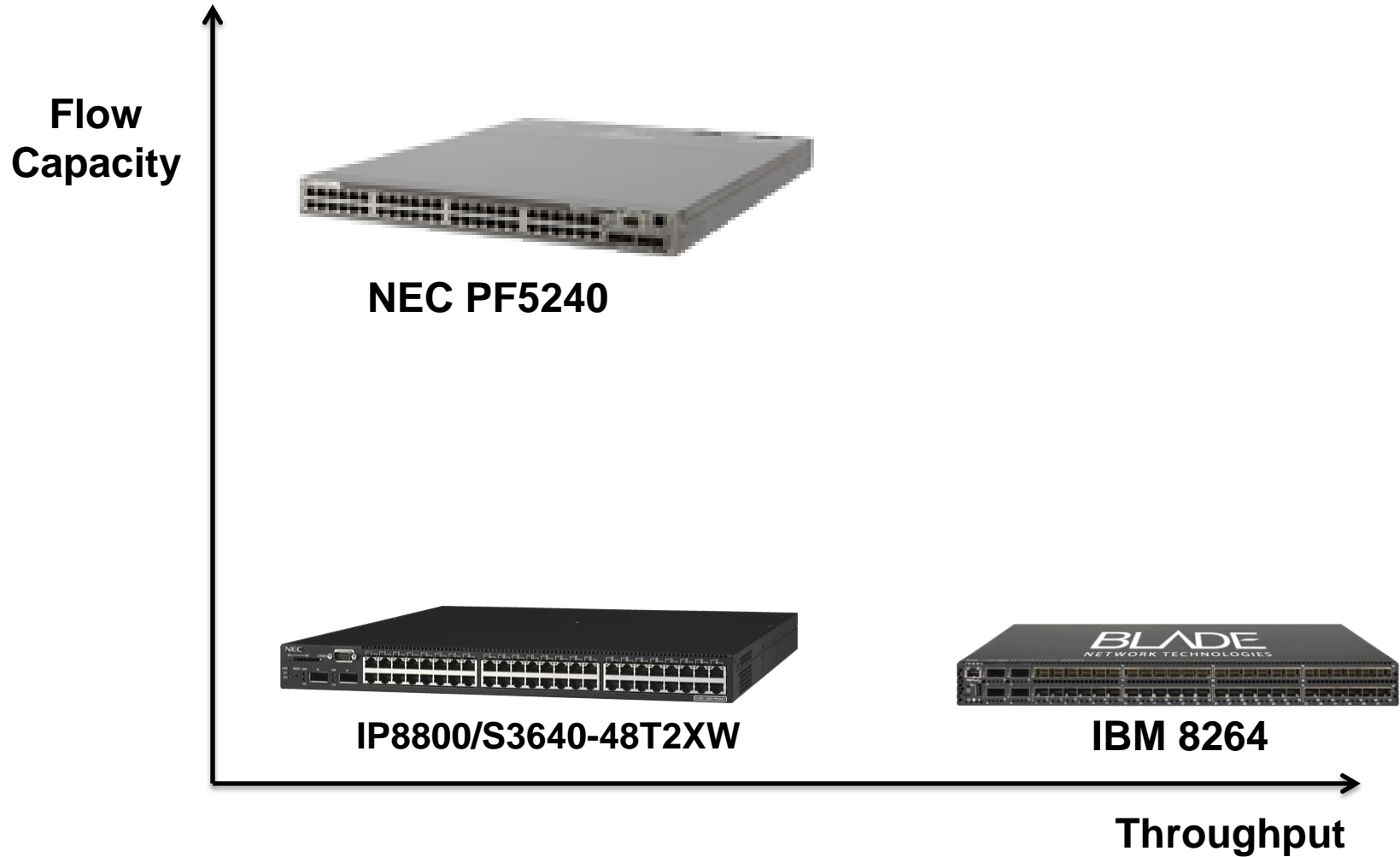
## OpenFlow Capabilities

- Flow entry capacity – requirements depend on the application
- Matching rules - 5, 7, 12 tuple – determines the policies that can be created
- Actions – options abound in the specification
- Hardware support for header translation, actions

## Software Still Matters

- Topology discovery
- Controller connections
- Hybrid mode

# Switch Hardware Taxonomy



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# **SUMMARY**

## **(AND THE ROBOT AGAIN)**

# The New Era of Open Networks



**ProgrammableFlow**

## Simple

- Deploy Multi-Tenant Virtual Networks as easily as deploying VMs
- Integrate network and application policy
- Centralized network management and control
- Eliminates need for spanning tree or other distributed protocols

## Open

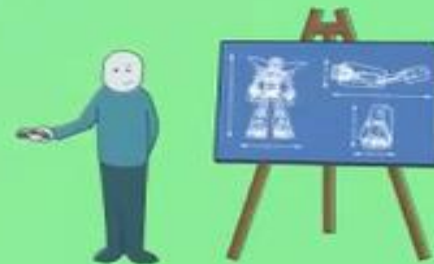
- Create multivendor OpenFlow enabled switches, virtual switches and NICs

## Scalable

- Scales from single switch to entire data center fabric
- Policy based appliance integration

## Fast

- Hardware forwarding
- Quick convergence times
- Network load balancing



# Some Links

OpenFlow - Enabling Innovation in Your Network

<http://www.openflow.org/>

Open Networking Foundation

● <https://www.opennetworking.org/>

NEC's ProgrammableFlow Video

- <http://www.youtube.com/watch?v=4kno-X49QoM>
- ... or search for "NEC OpenFlow" on Youtube

NEC ProgrammableFlow

● <http://www.necam.com/pflow/>

