

SDN:

The Philosophy of Split in Network

ywu@cs.hku.hk

What's IP-based network like?

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- Partial knowledge

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The fact is...

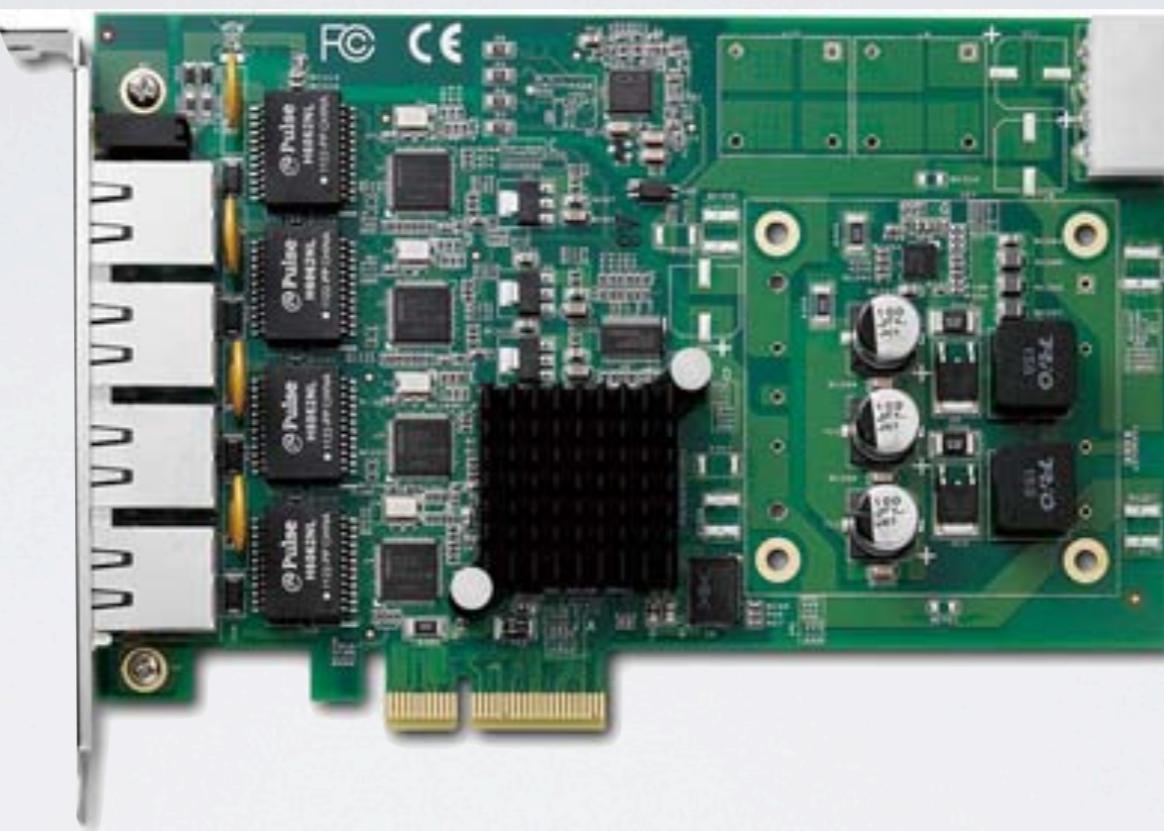
The fact is...

- Elastic cloud architectures evolves, mobile computing, new ideas to test...

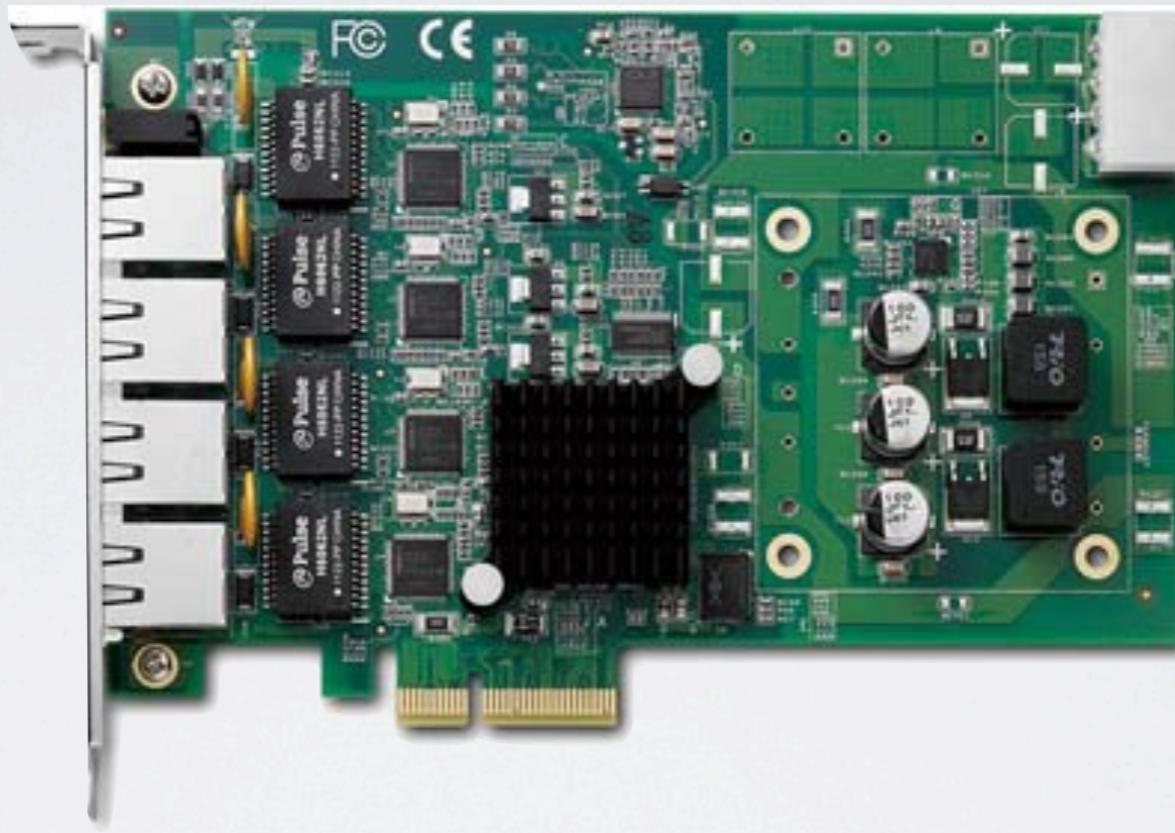
The fact is...

- Elastic cloud architectures evolves, mobile computing, new ideas to test...
- Additional network layer is needed, allowing network operators to control the network elements

Custom Hardware

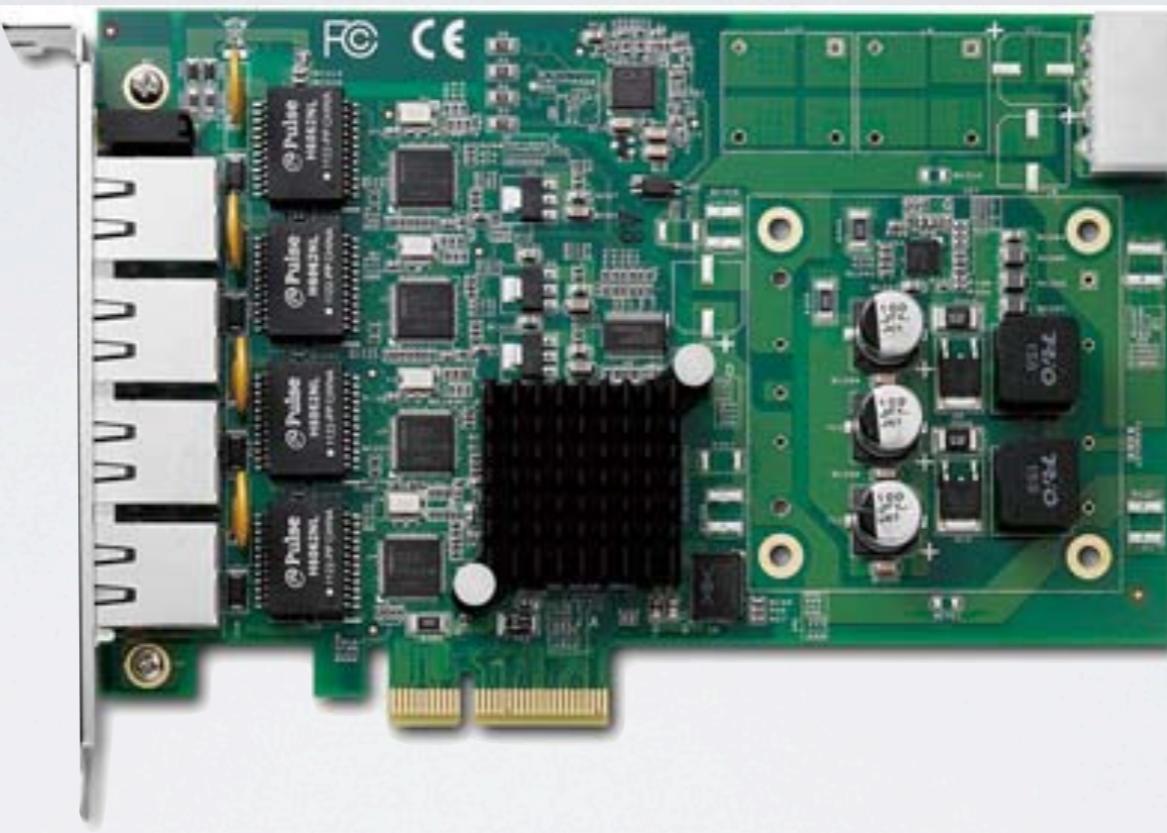


Custom Hardware



**Difficult to develop
Behind industry
\$
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Custom Hardware



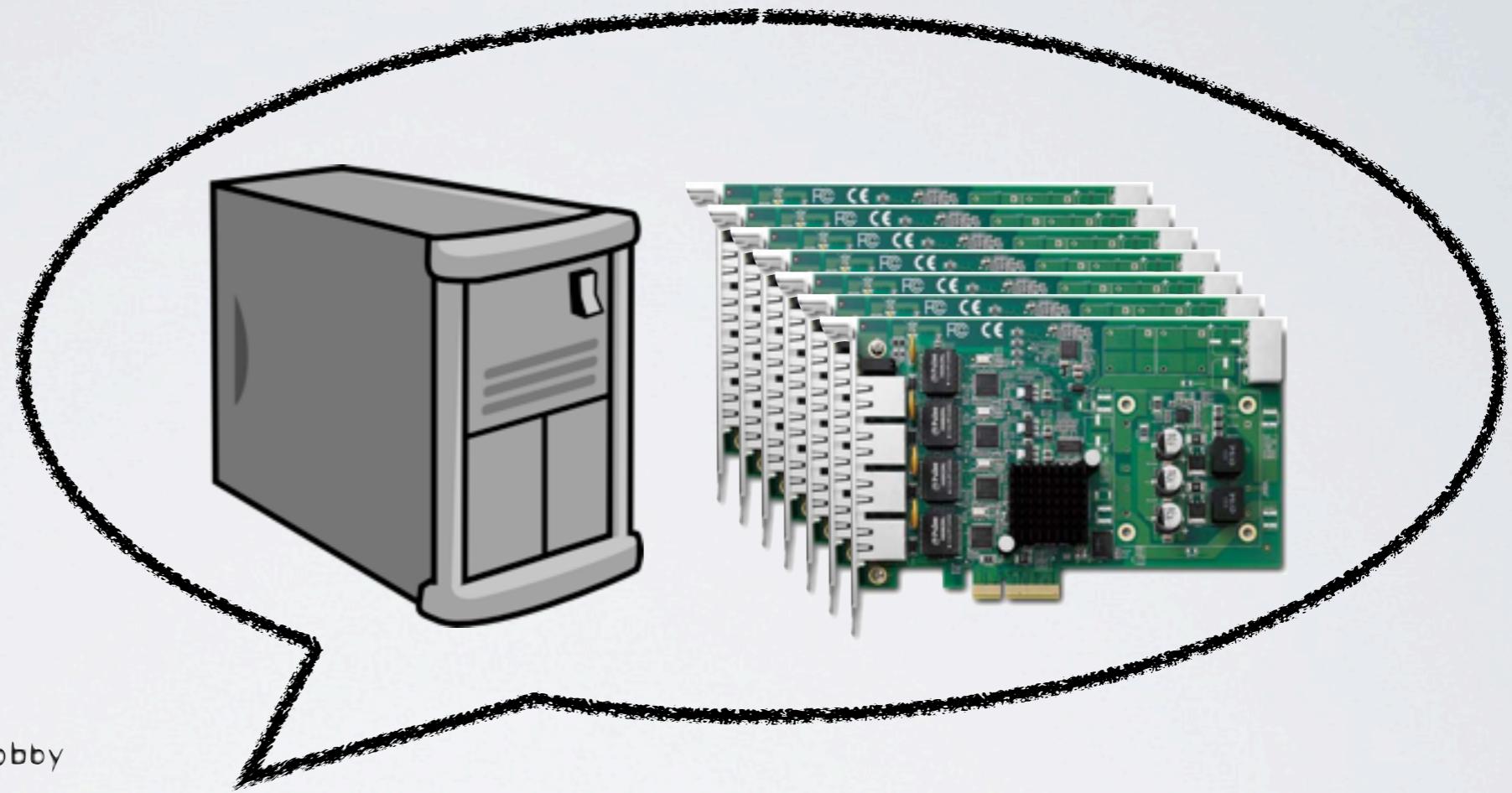
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PC + Multi-Port NIC

A Computersloth
is the type of
person who
runs an APACHE
server...



...as a hobby



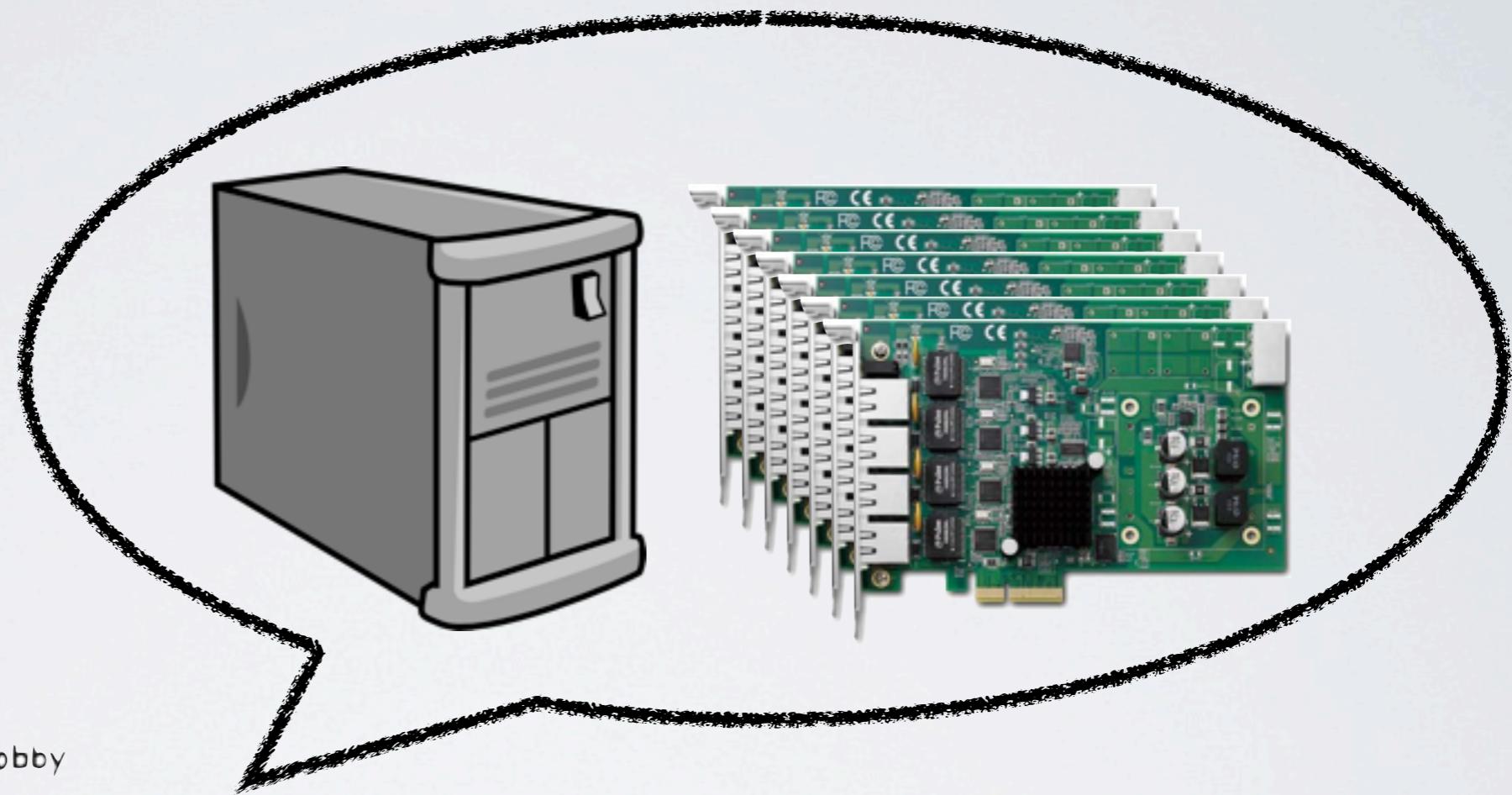
© JL3 2005

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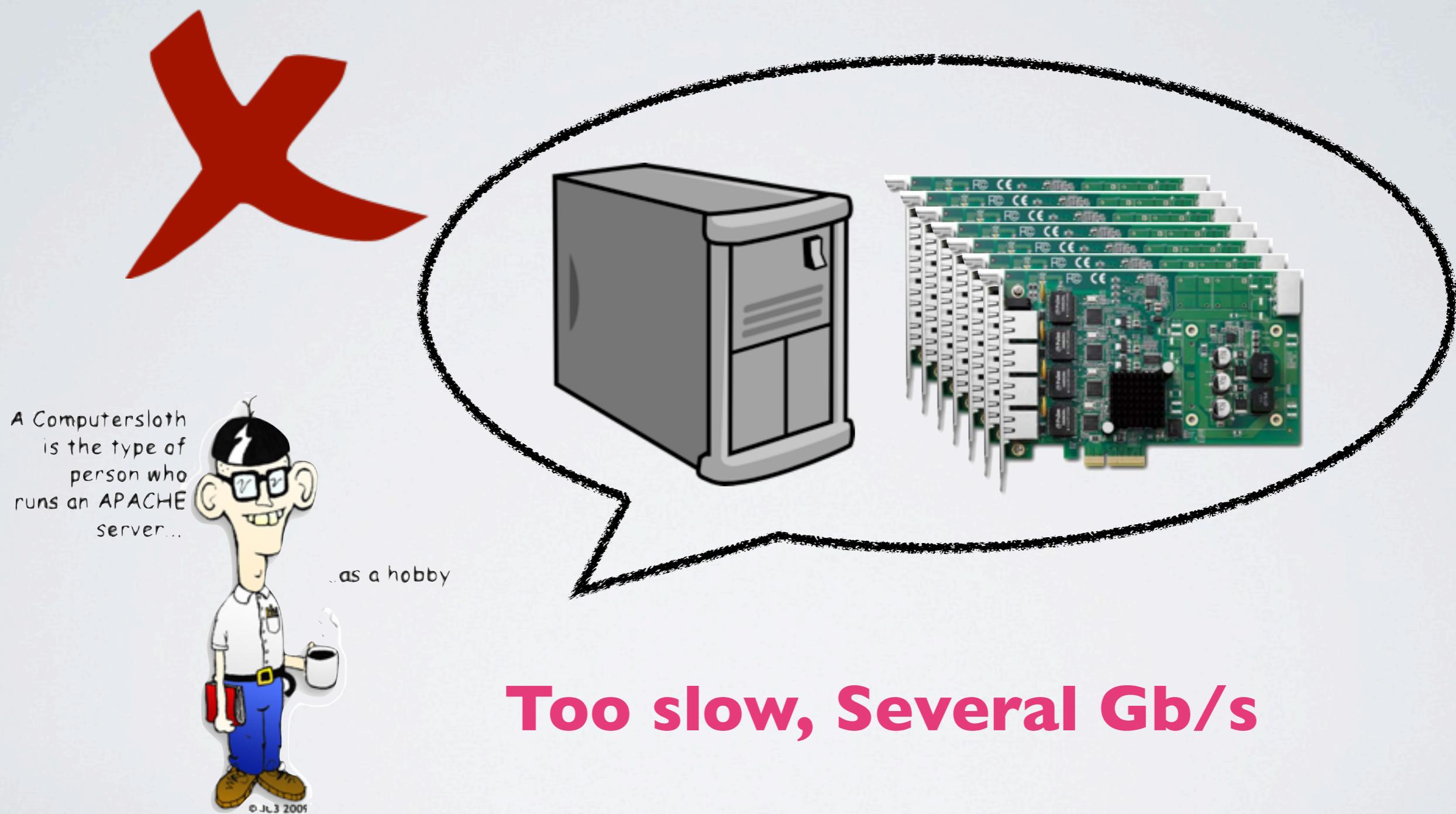


...as a hobby



Too slow, Several Gb/s

PC + Multi-Port NIC



Network Element

Data Plane

- Specialized data path

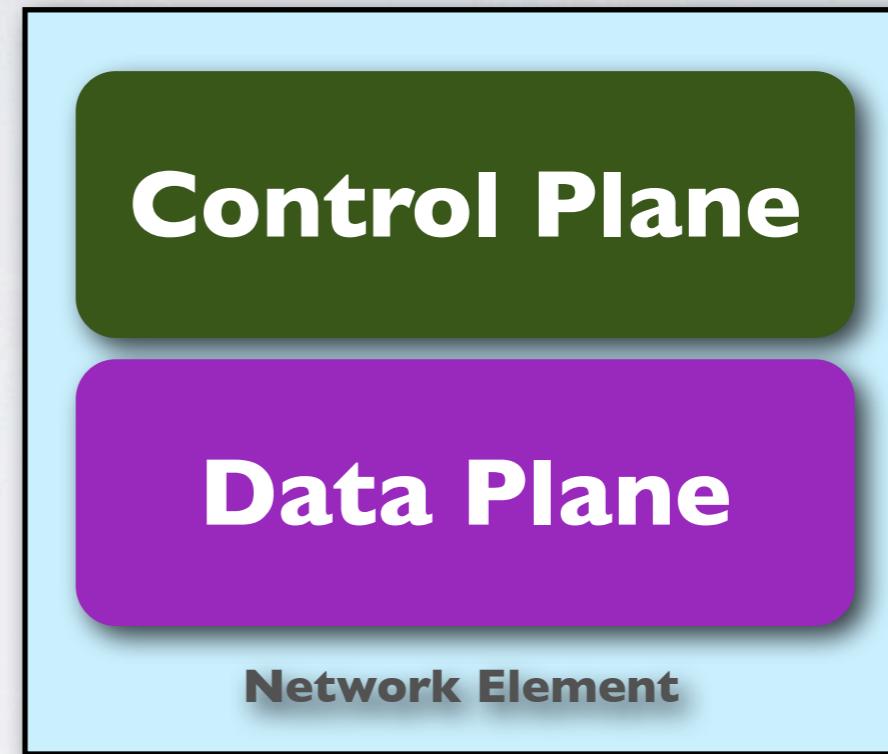
- Fast

Control Plane

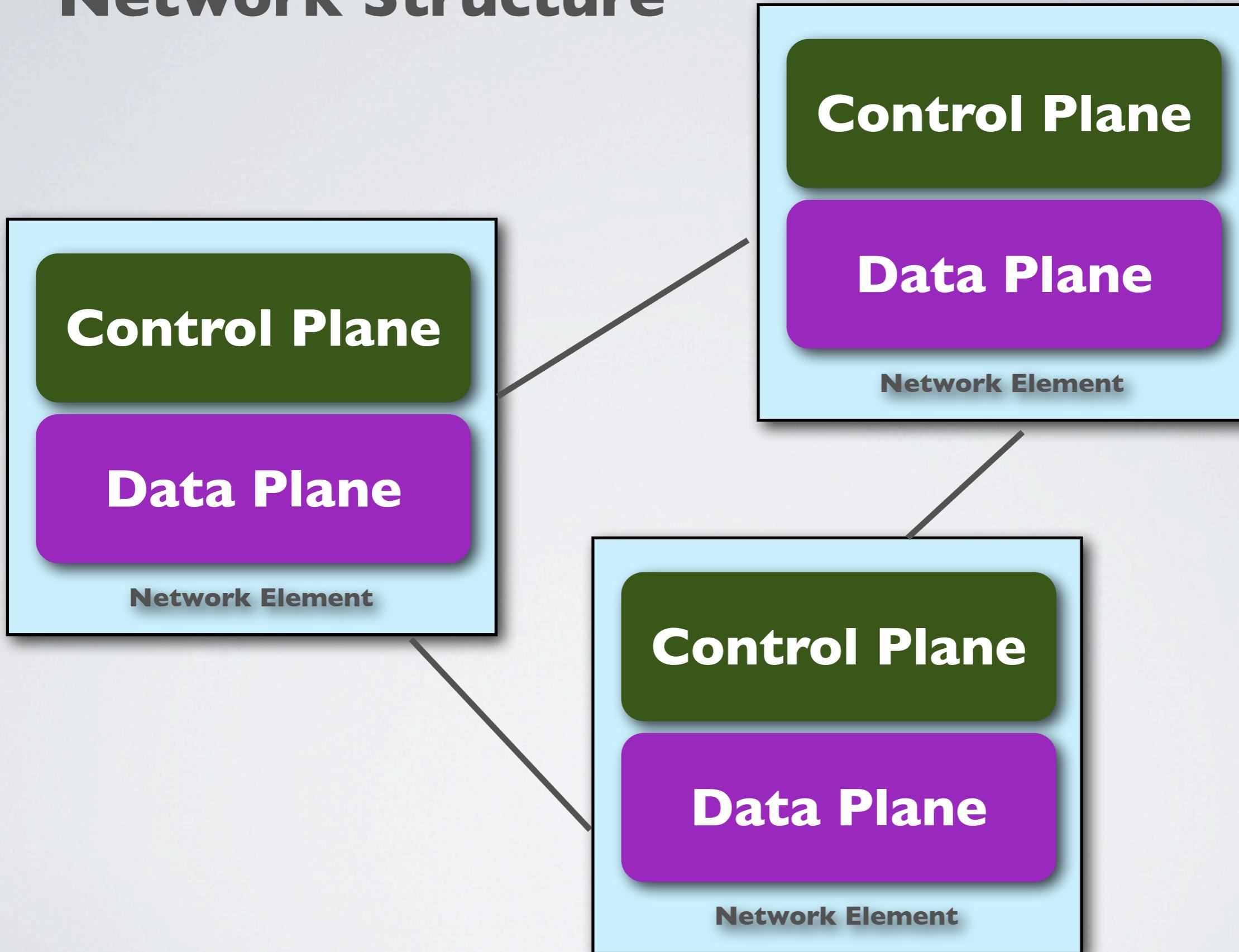
- How & Where

- Routing, traffic engineering, firewall state

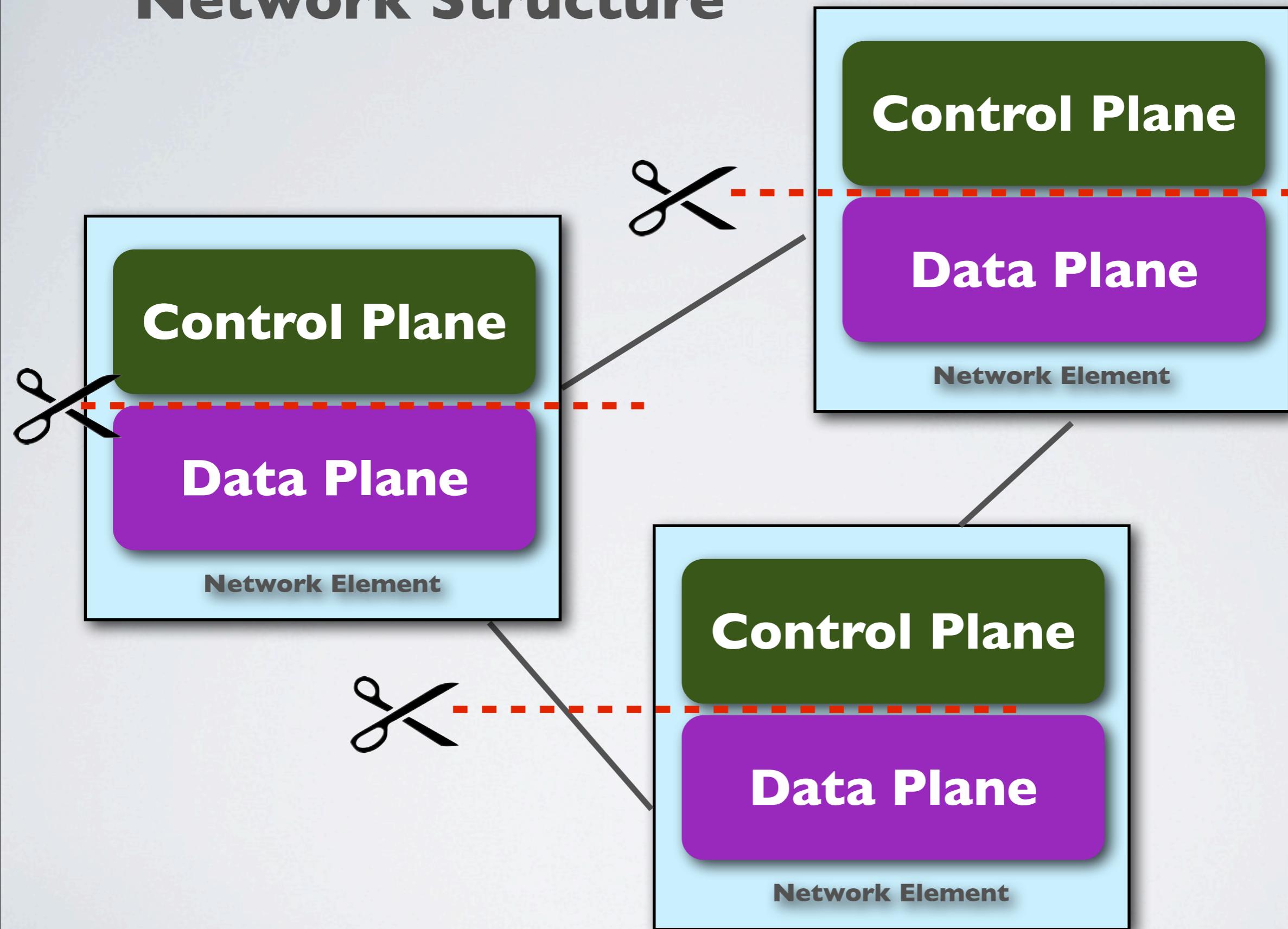
- Slow



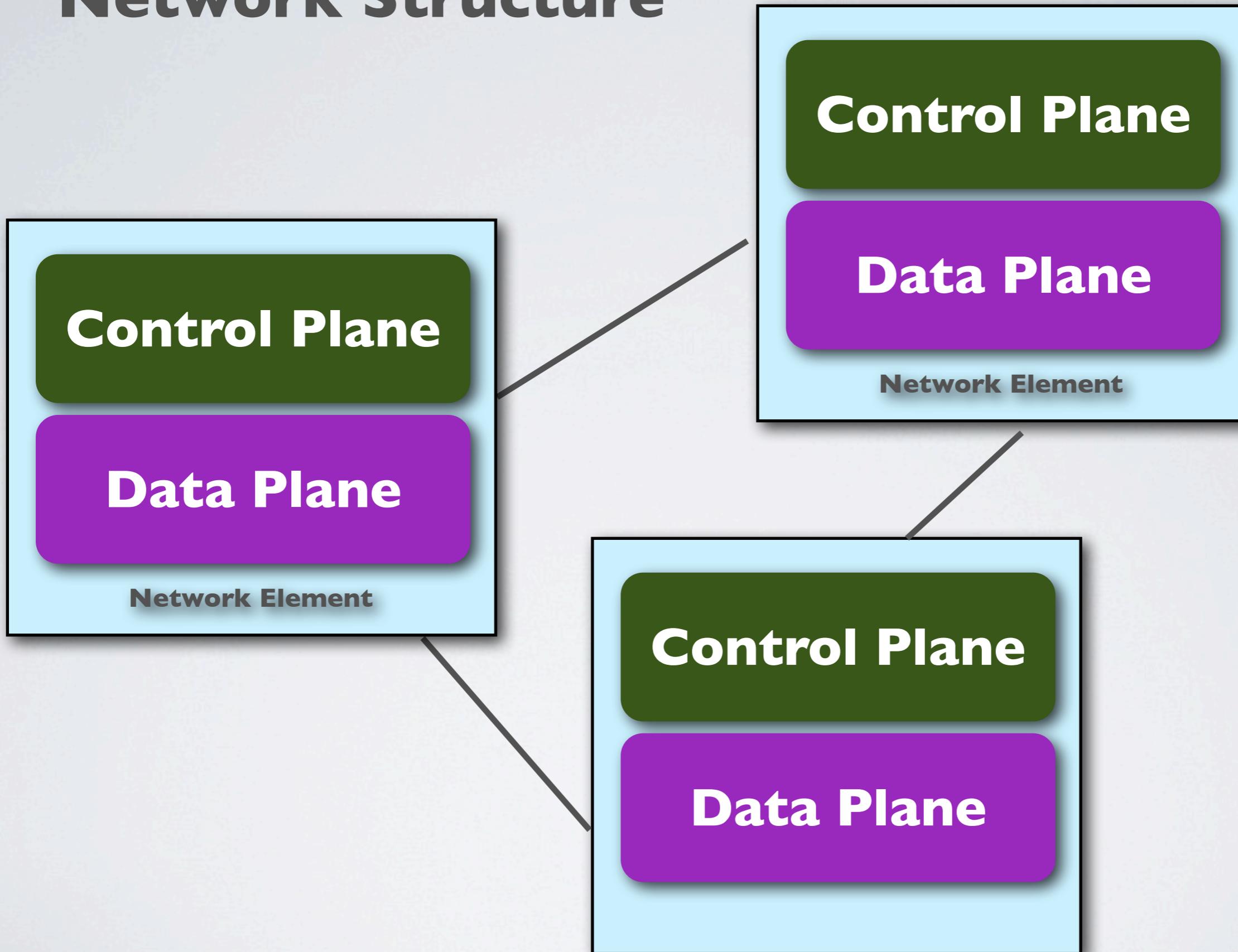
Network Structure



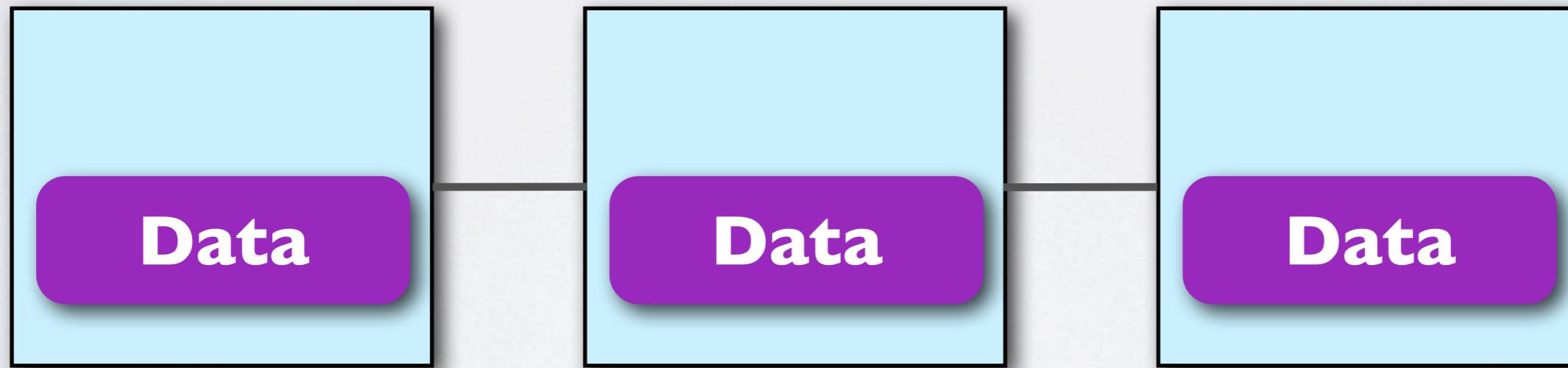
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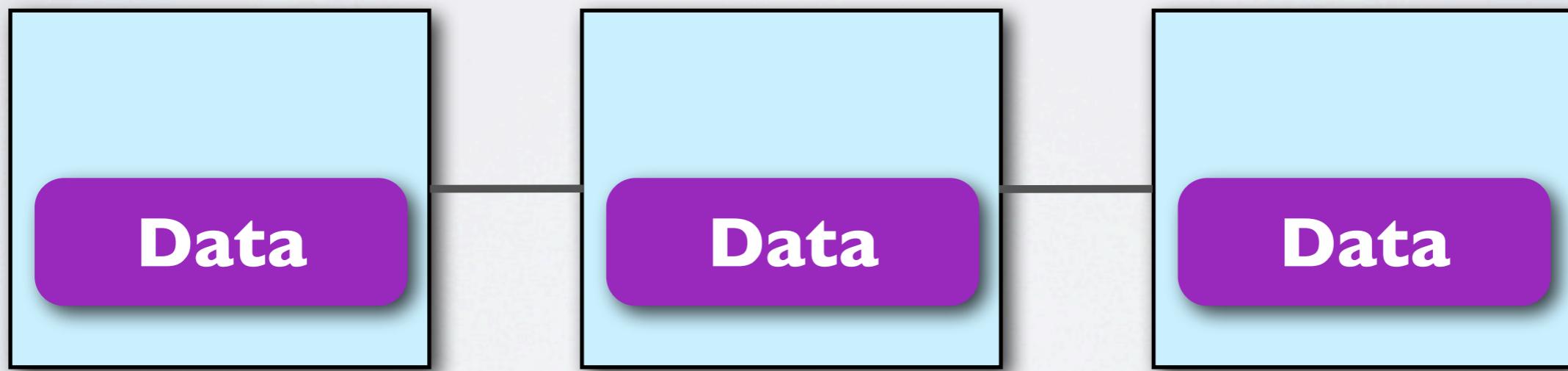


Data

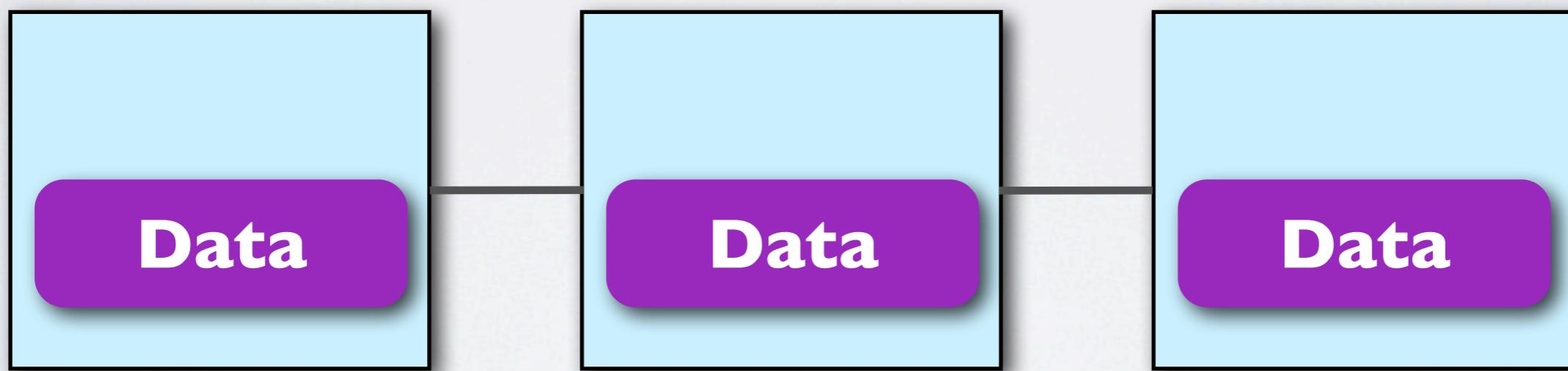
Data

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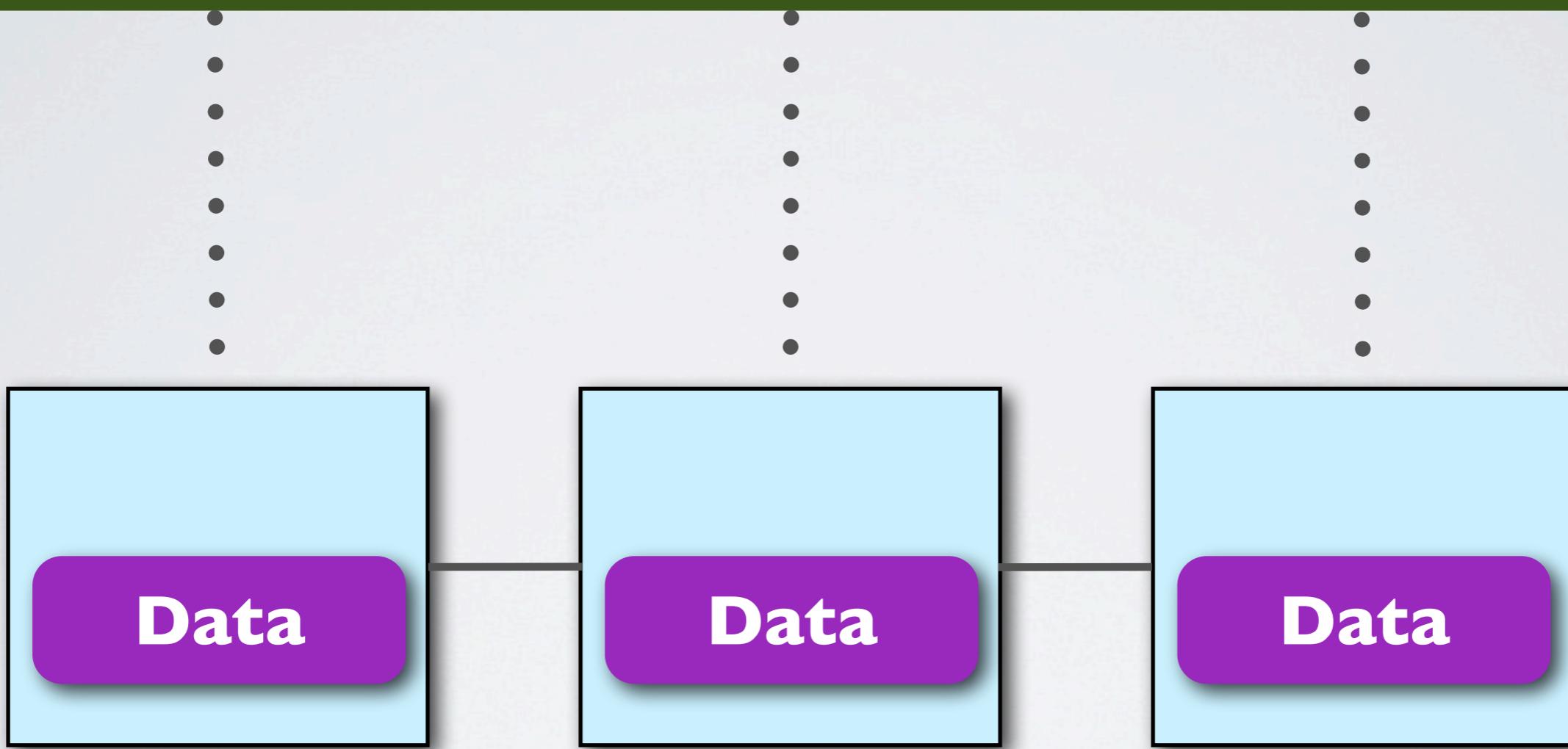
Control Plane



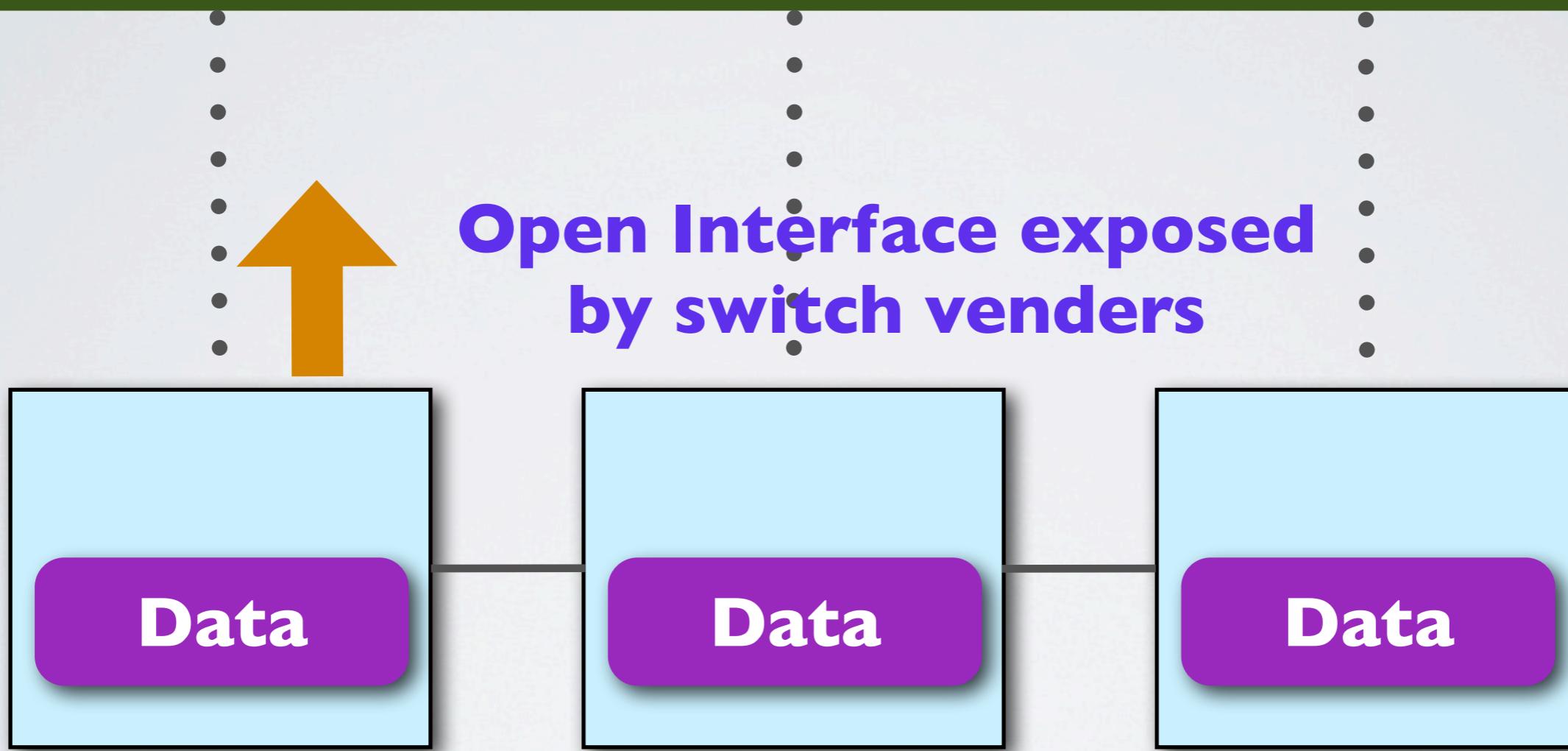
Control Plane (Network OS)



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Simplified Open API

Control Plane (Network OS)

**Open Interface exposed
by switch vendors**



Simplified Open API

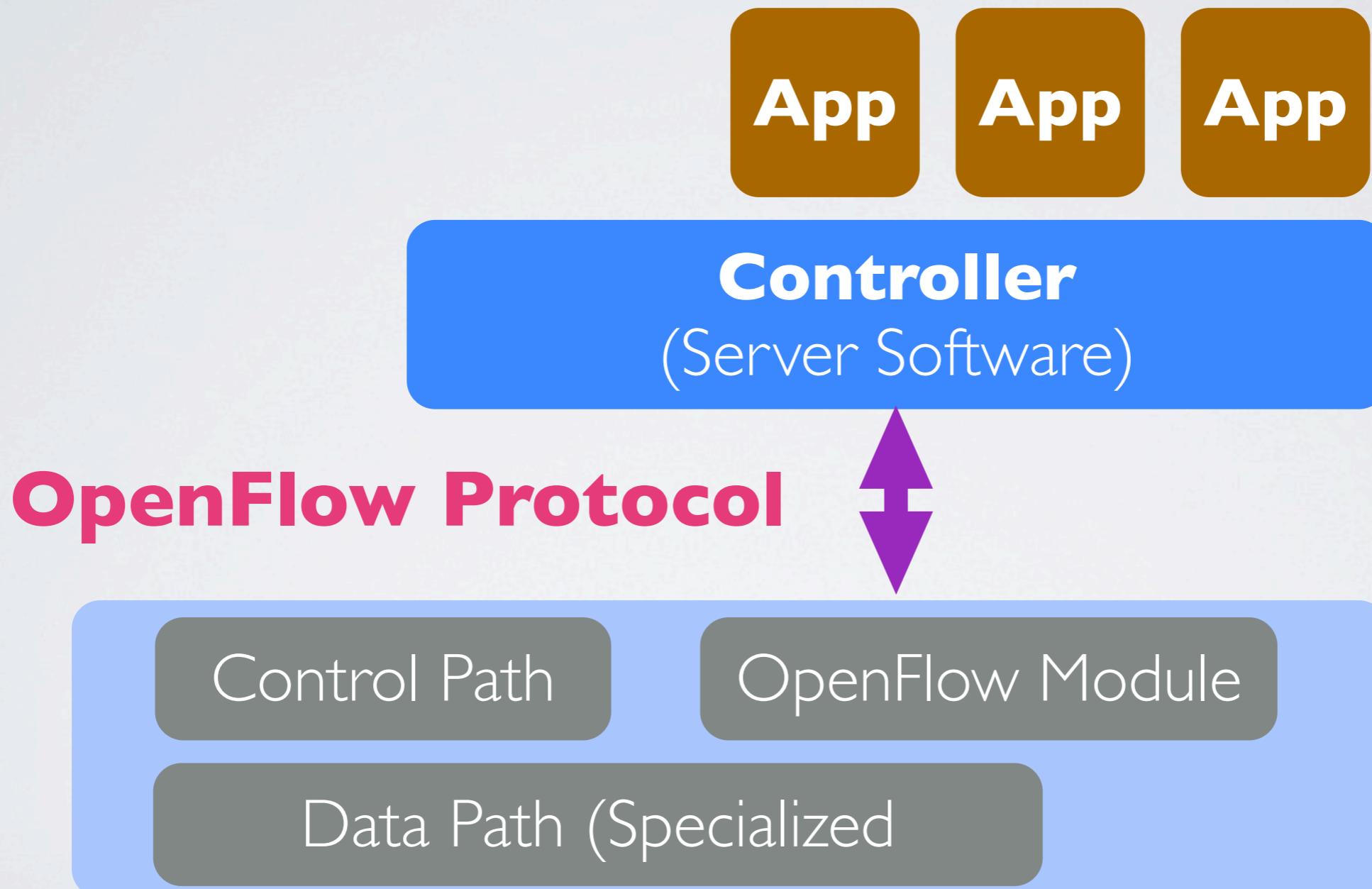
Control Plane (Network OS)

OpenFlow

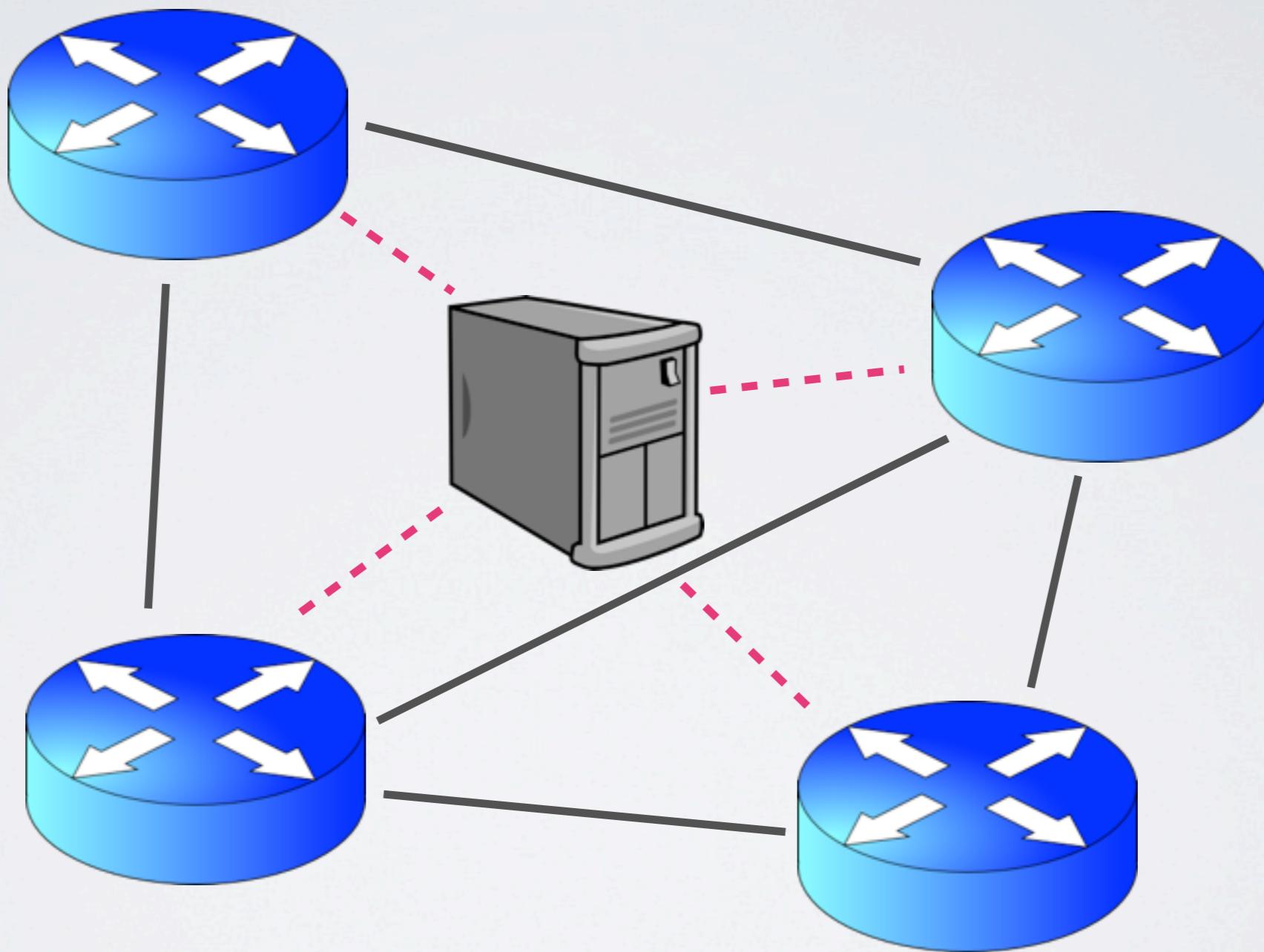
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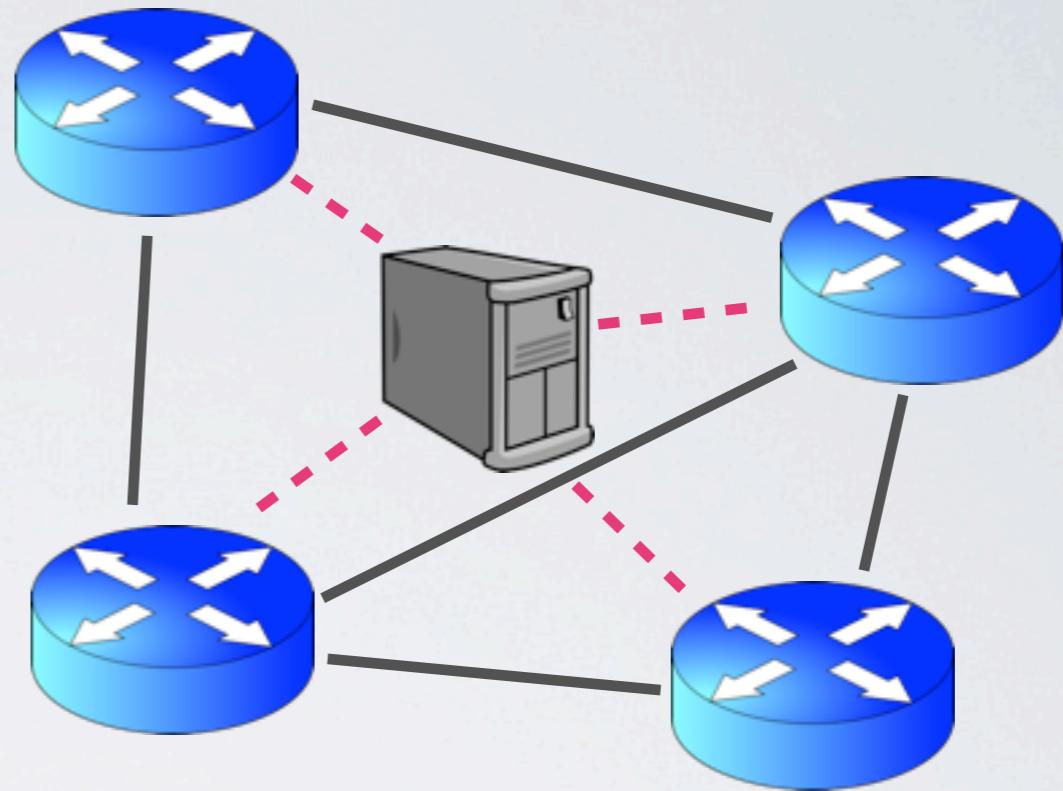
OpenFlow Basics



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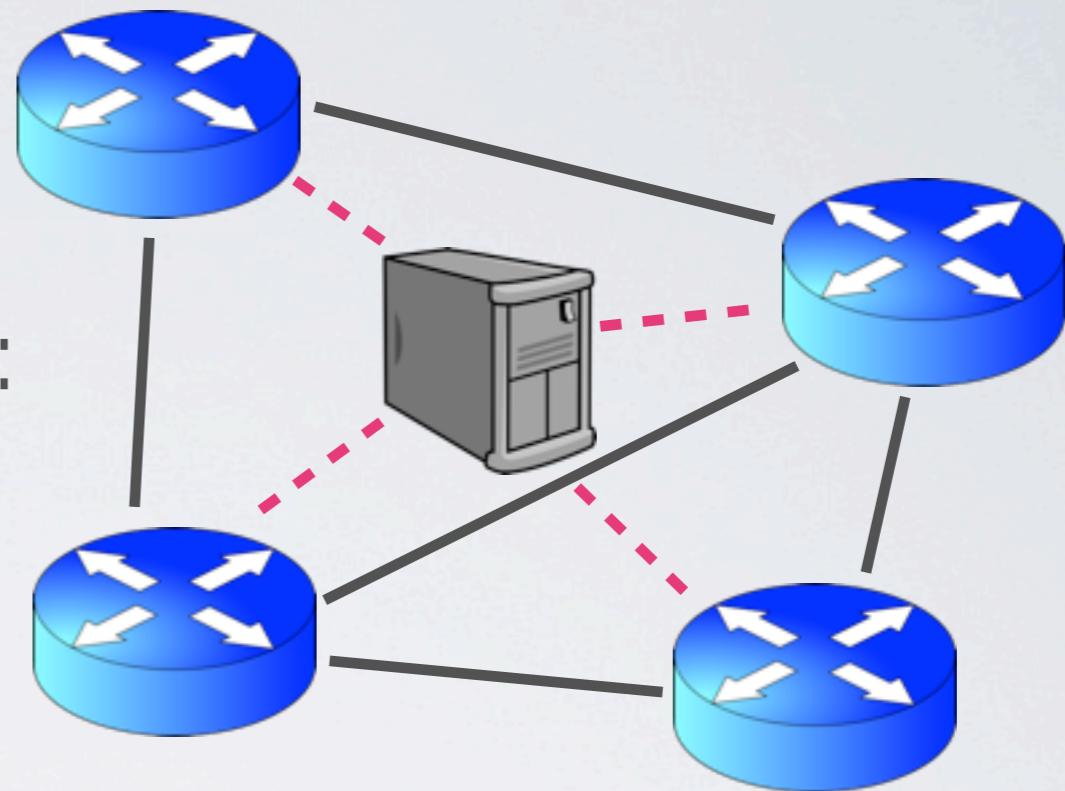


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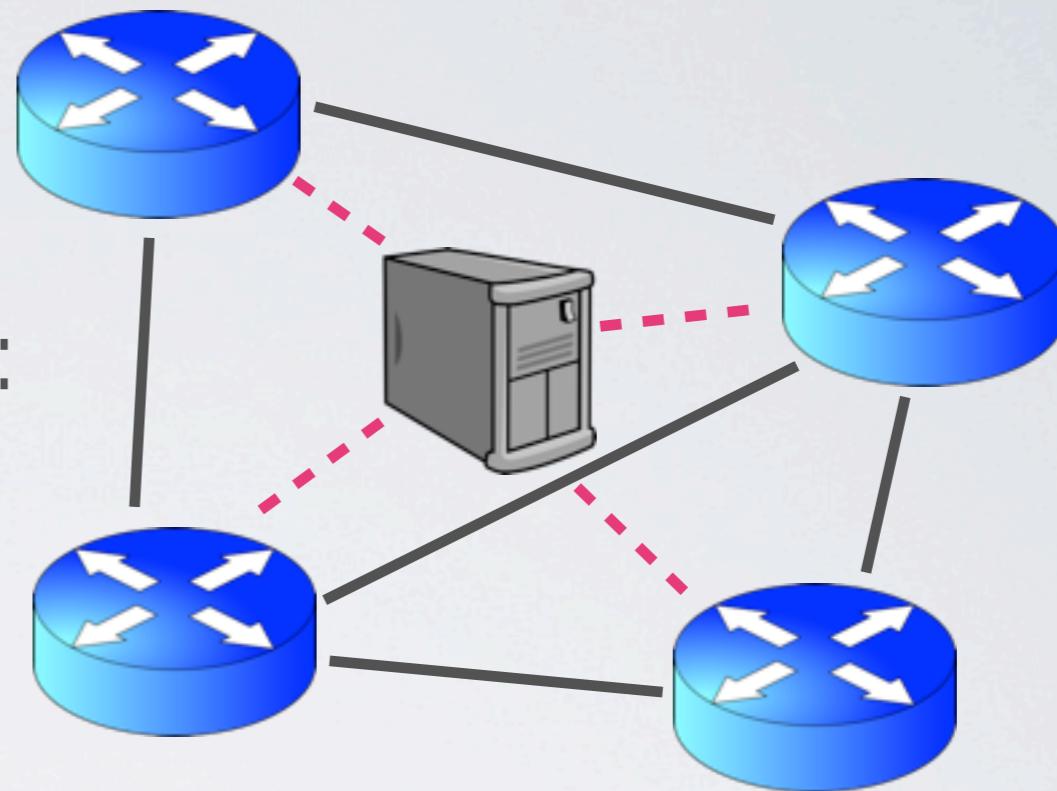
Important data structure:



OpenFlow Basics

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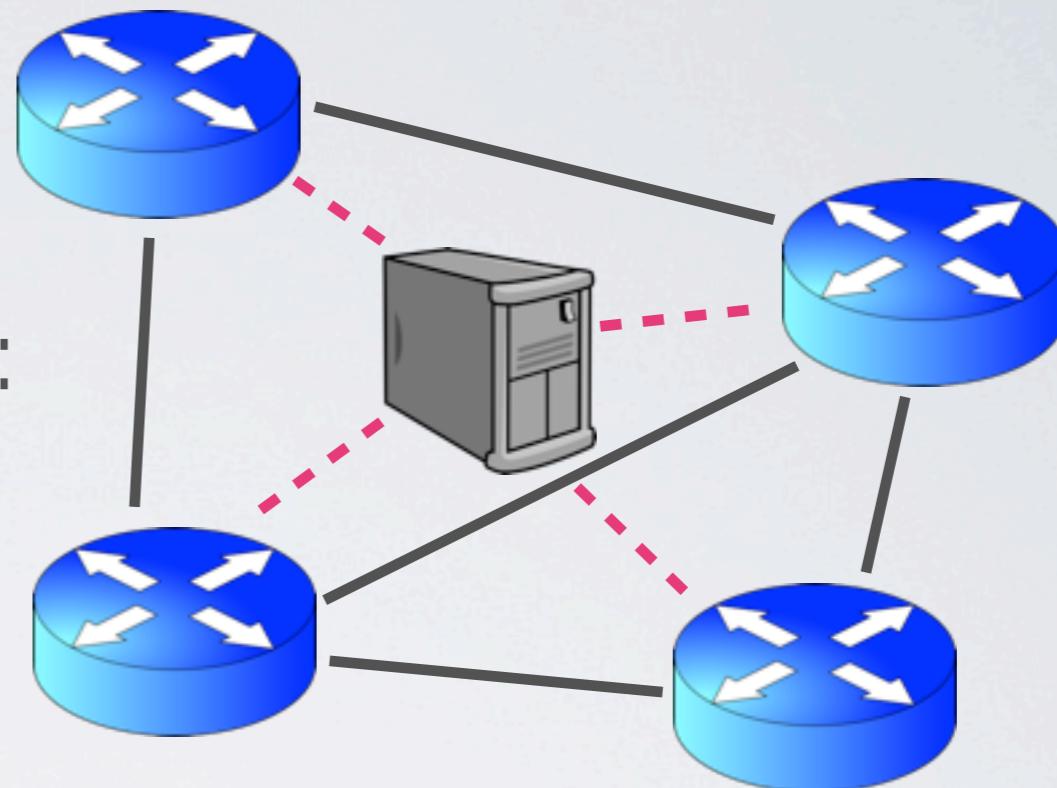
Flow Table



OpenFlow Basics

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Flow Table

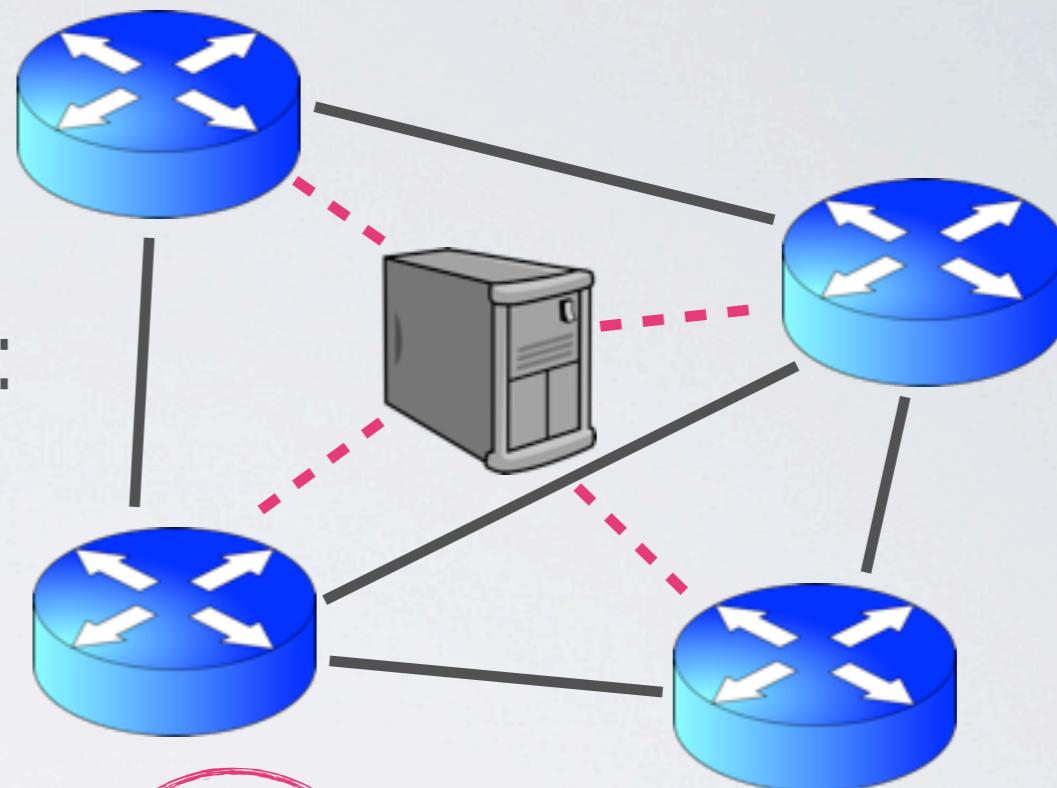


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id1	fwd to port ..
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New problems...

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Scalability, availability, responsiveness...

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Logically centralized structure can be realized in a physically distributed infrastructure

Real world problems...

Brandon heller et al., *The controller Placement Problem* , HotSDN'12

Real world problems...

“How many controllers are needed?”

“Where should they go?”

Brandon heller et al., *The controller Placement Problem* , HotSDN'12



Models (Facility location problem)

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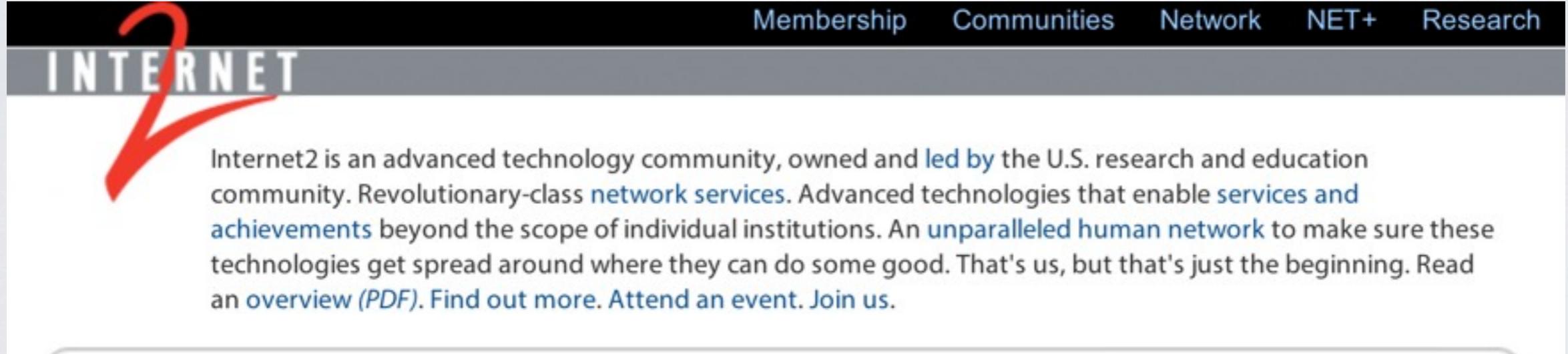
Average-case
$$L_{avg}(S') = \frac{1}{n} \sum_{v \in V} \min_{s \in S'} d(v, s)$$

Worse-case
$$L_{wc}(S') = \max_{v \in V} \min_{s \in S'} d(v, s)$$

Experiment Result

Testbed: Internet2

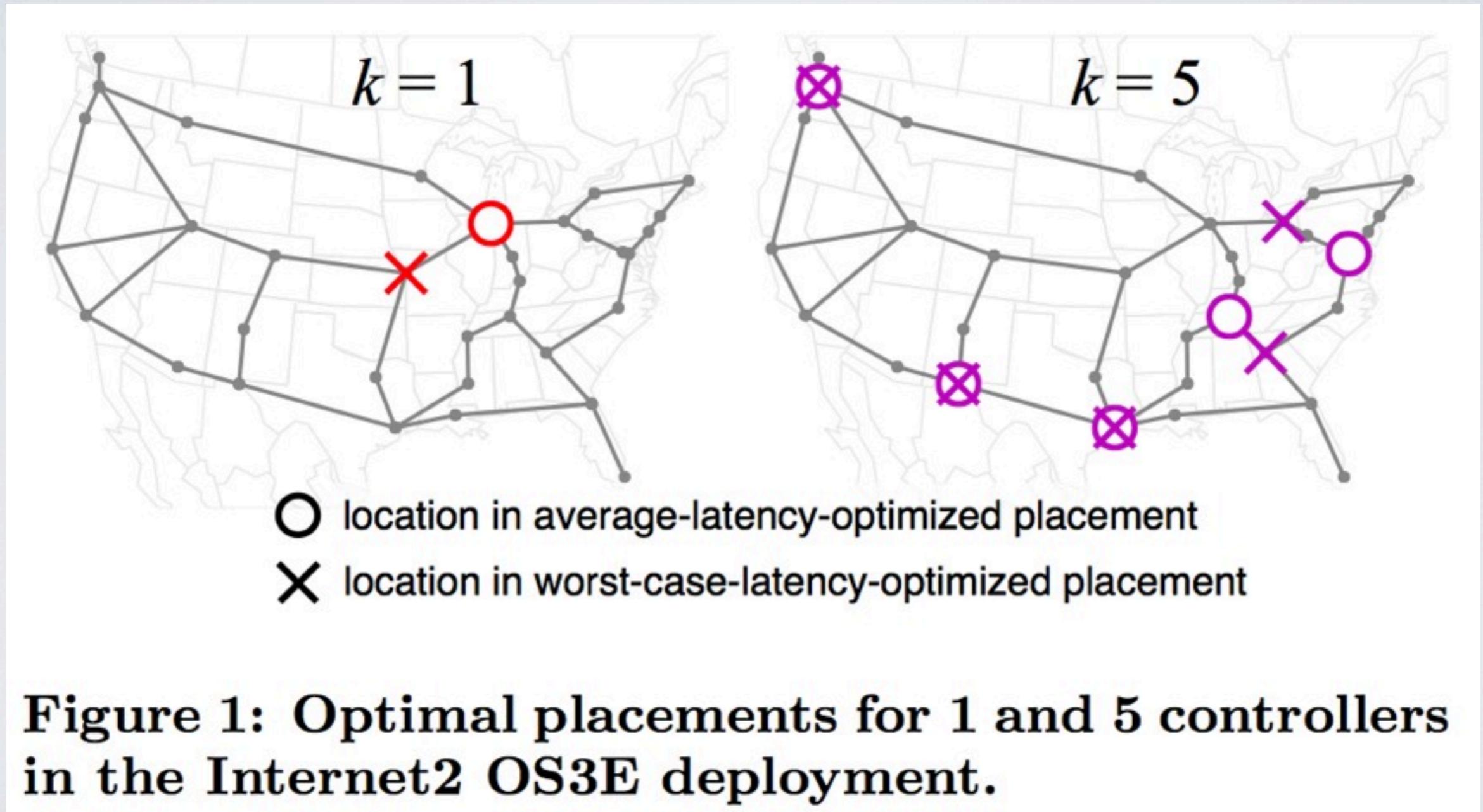
<http://www.internet2.edu/>



The screenshot shows the Internet2 website. The header features a black bar with the word "INTERNET" in white, where the "I" is stylized with a red swoosh. To the right of the swoosh is a grey bar containing navigation links: Membership, Communities, Network, NET+, and Research. Below the header, the main content area contains a paragraph about Internet2's mission and services.

Internet2 is an advanced technology community, owned and **led by** the U.S. research and education community. Revolutionary-class **network services**. Advanced technologies that enable **services and achievements** beyond the scope of individual institutions. An **unparalleled human network** to make sure these technologies get spread around where they can do some good. That's us, but that's just the beginning. Read an **overview (PDF)**. Find out more. Attend an event. Join us.

Experiment Result (I)



Experiment Result (2)

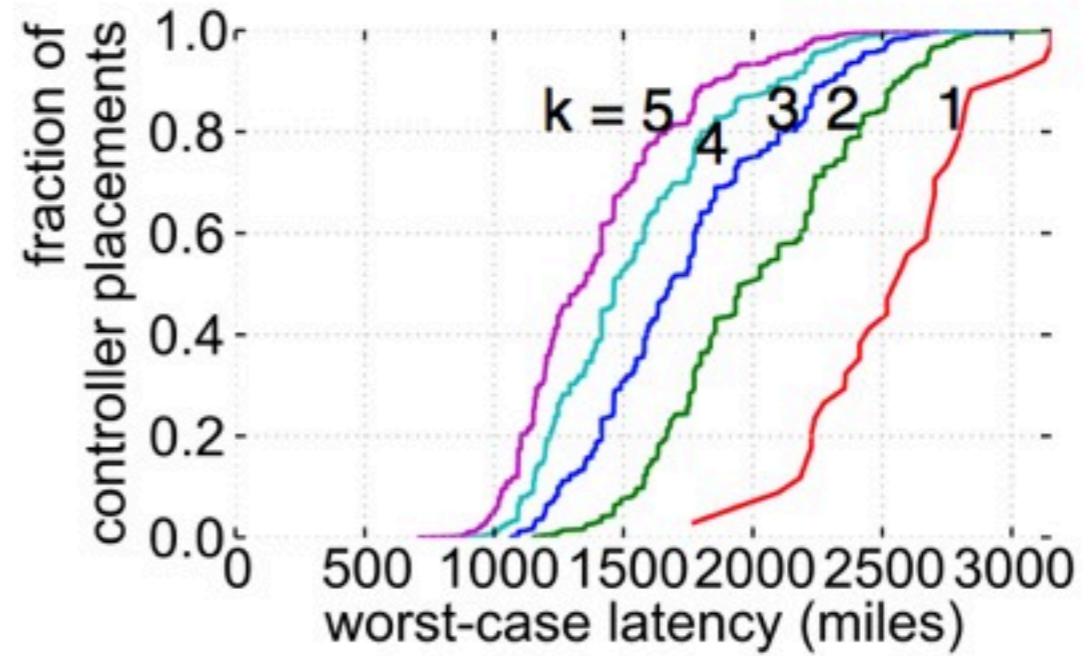
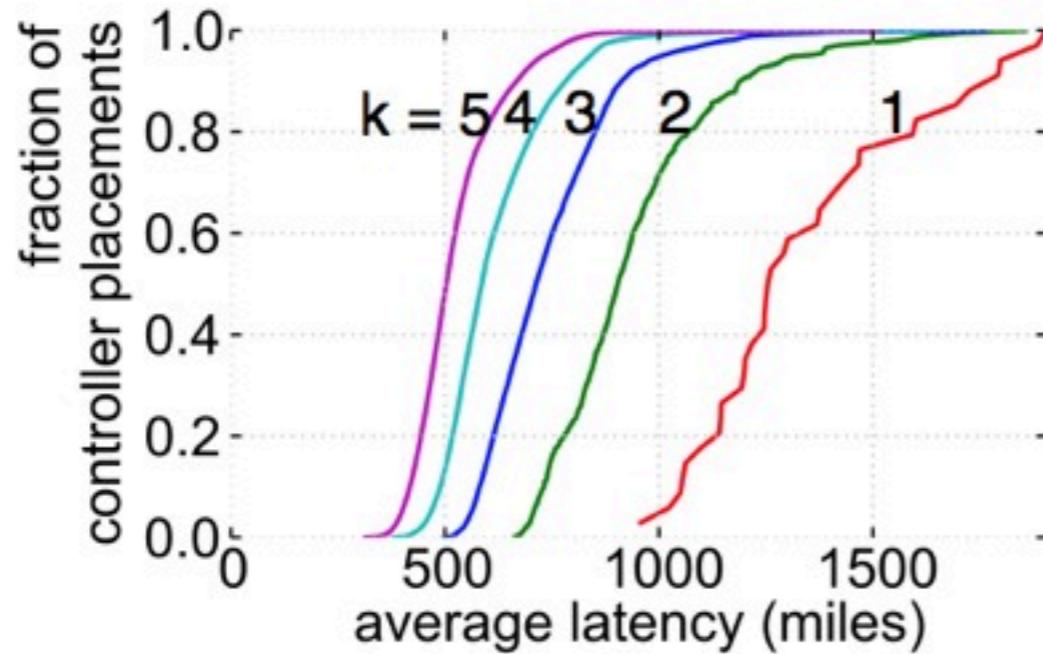
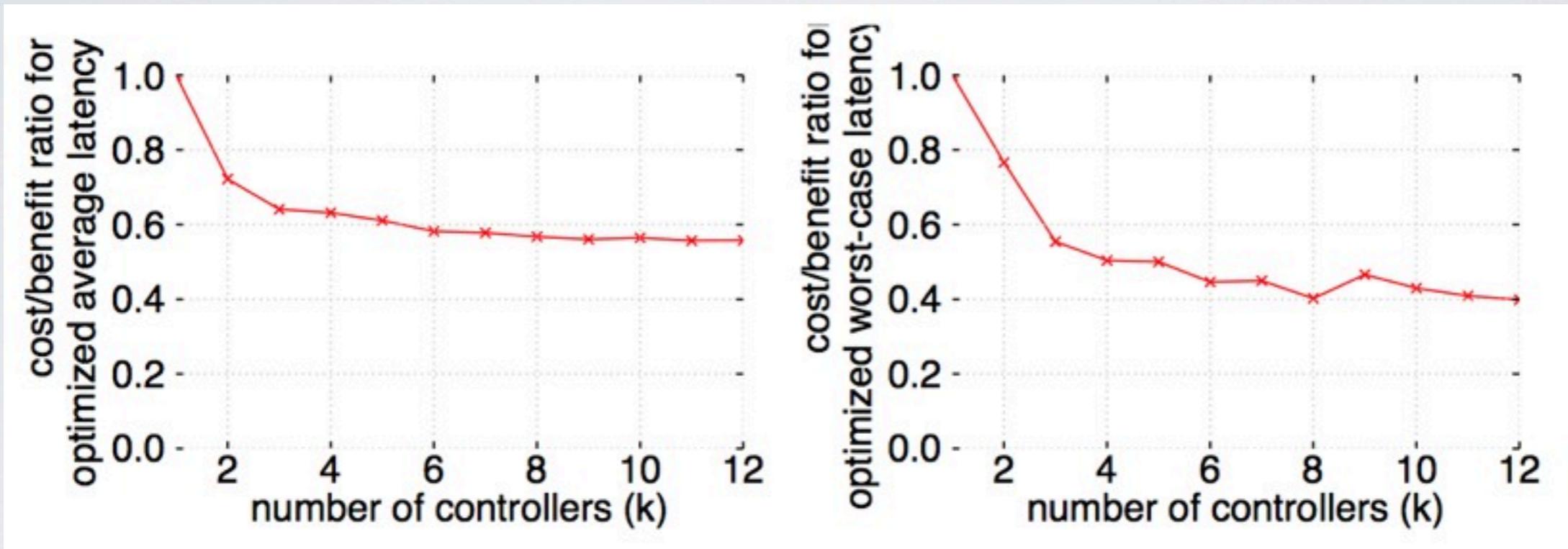


Figure 2: Latency CDFs for all possible controller combinations for $k = [1, 5]$: average latency (left), worst-case latency (right).

Experiment Result (3)



Take-aways messages...

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- Control plane and data plane decoupling may give more chances for state-oriented methods, e.g., DHT, rather than message-based approaches.

Status of SDN:

- Open Networking Foundation
- More products on market
- SDN has won the war of words, the real battle over customer adoption is just beginning.