Software Defined Networking
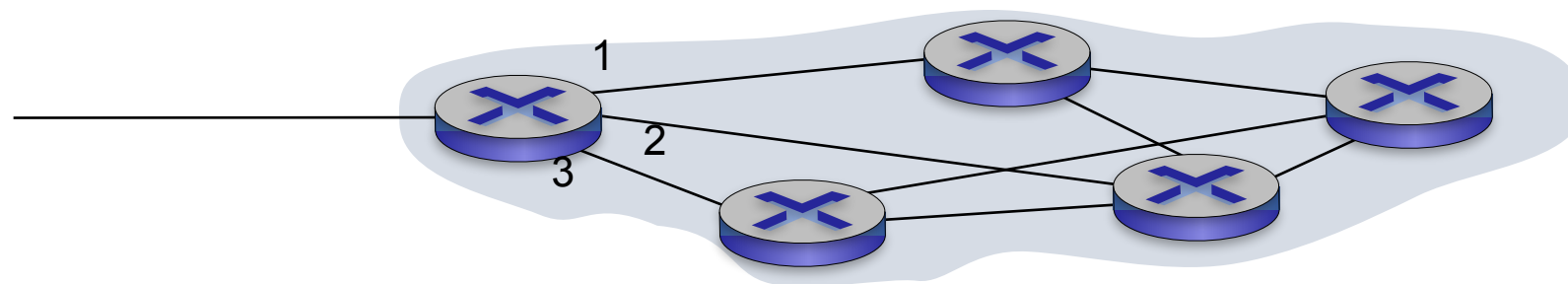
Mark Allman
mallman@case.edu

EECS 325/425
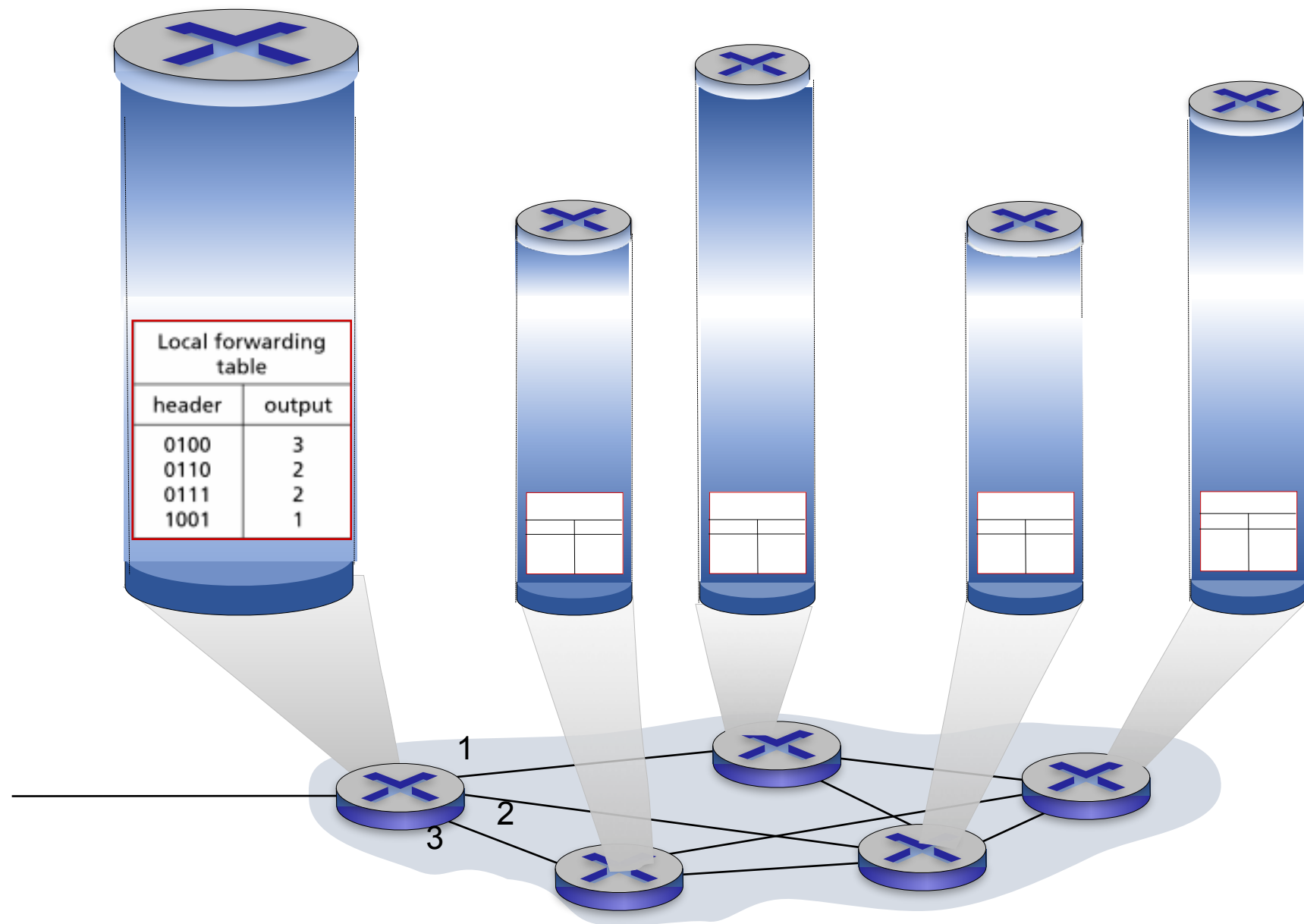Fall 2018

These slides are based on material from An Wang

Per-router Control Plane
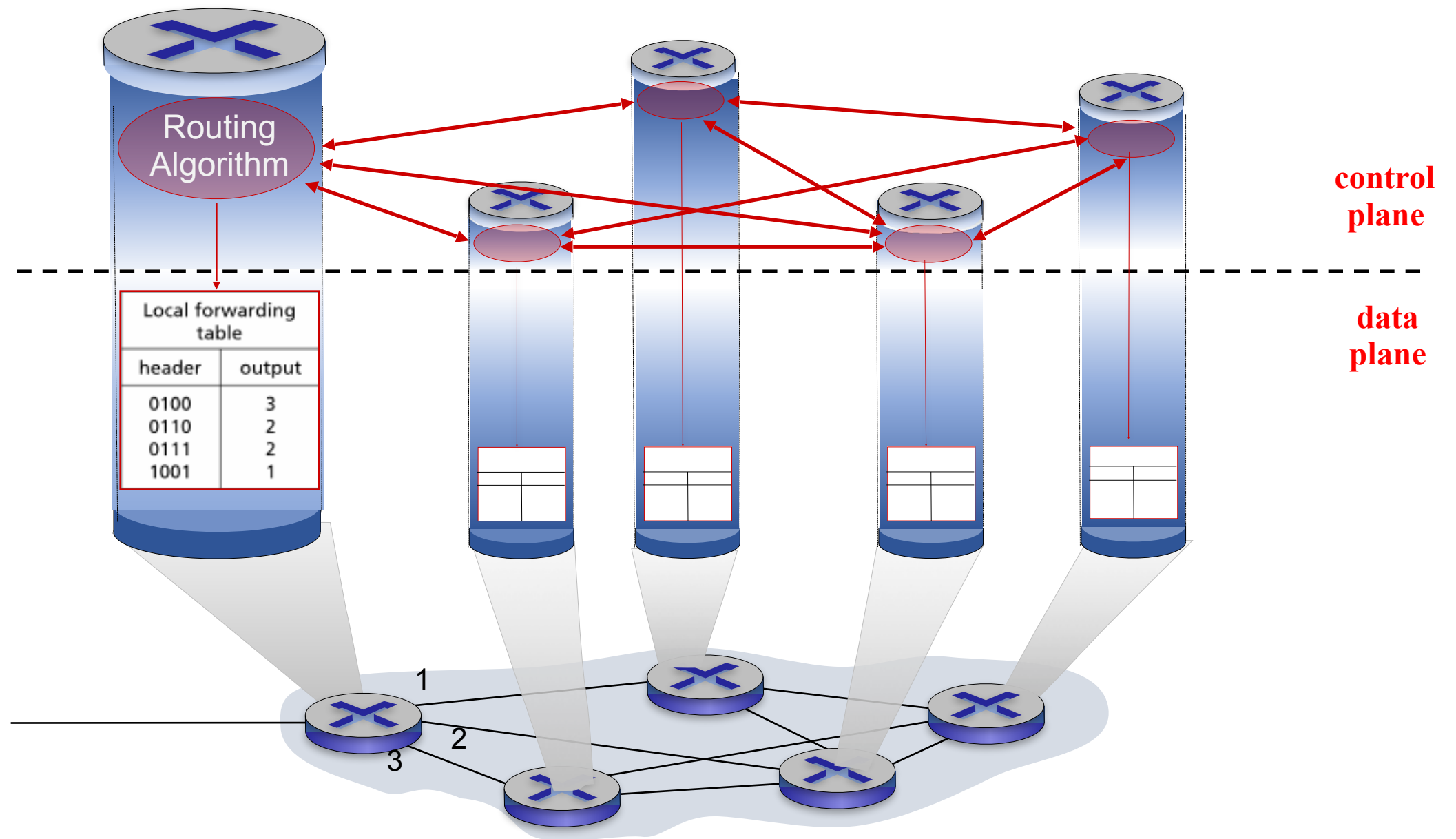
Per-router Control Plane

Per-router Control Plane

Local forwarding table	
header	output
0100	3
0110	2
0111	2
1001	1

Per-router Control Plane

Routing Algorithm

Local forwarding table	
header	output
0100	3
0110	2
0111	2
1001	1

control plane

data plane

Per-router Control Plane

control plane

data plane

Routing Algorithm

Local forwarding table

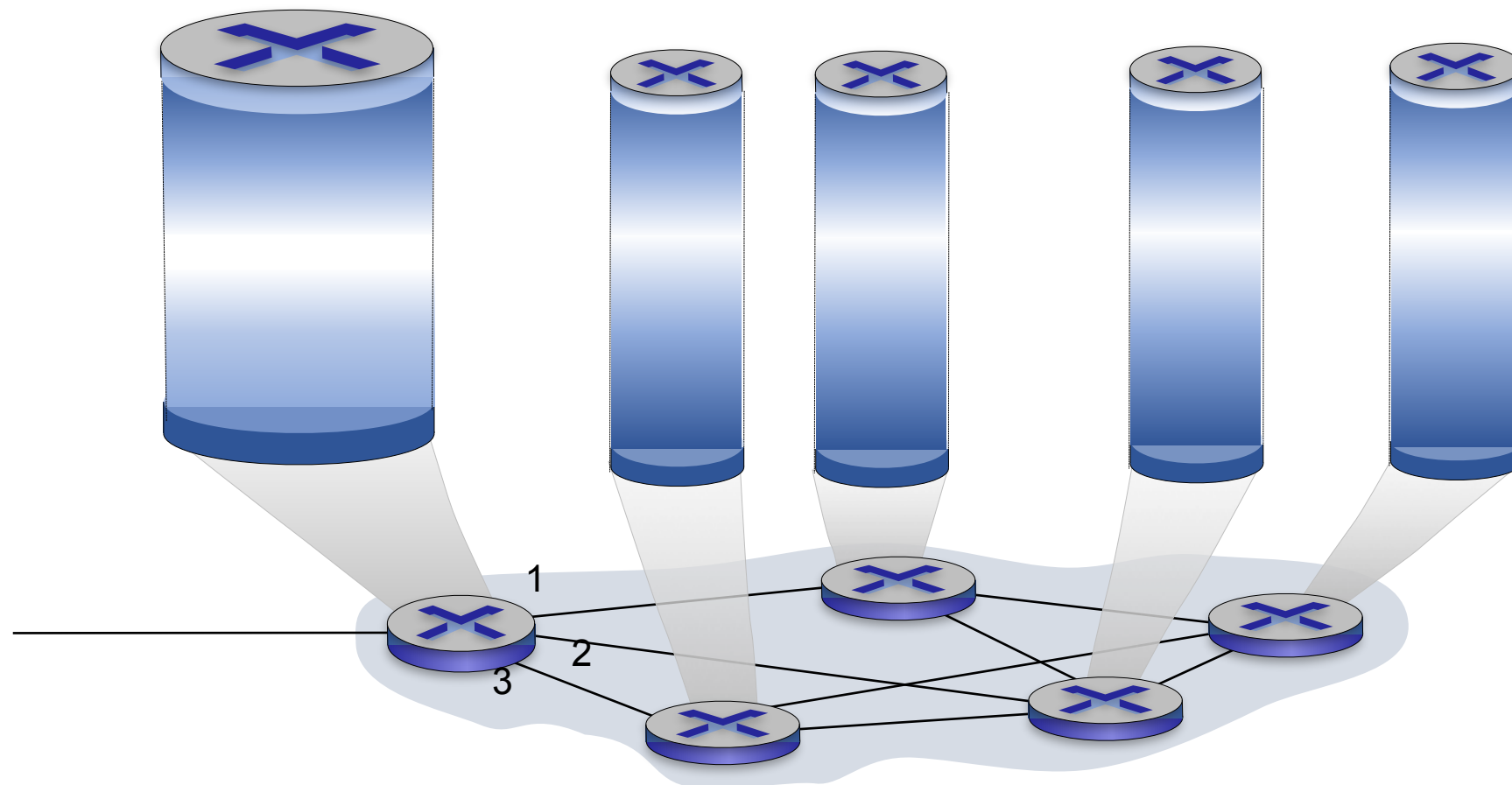| header	output
0100	3
0110	2
0111	2
1001	1

values in arriving packet header

0111

1
2
3
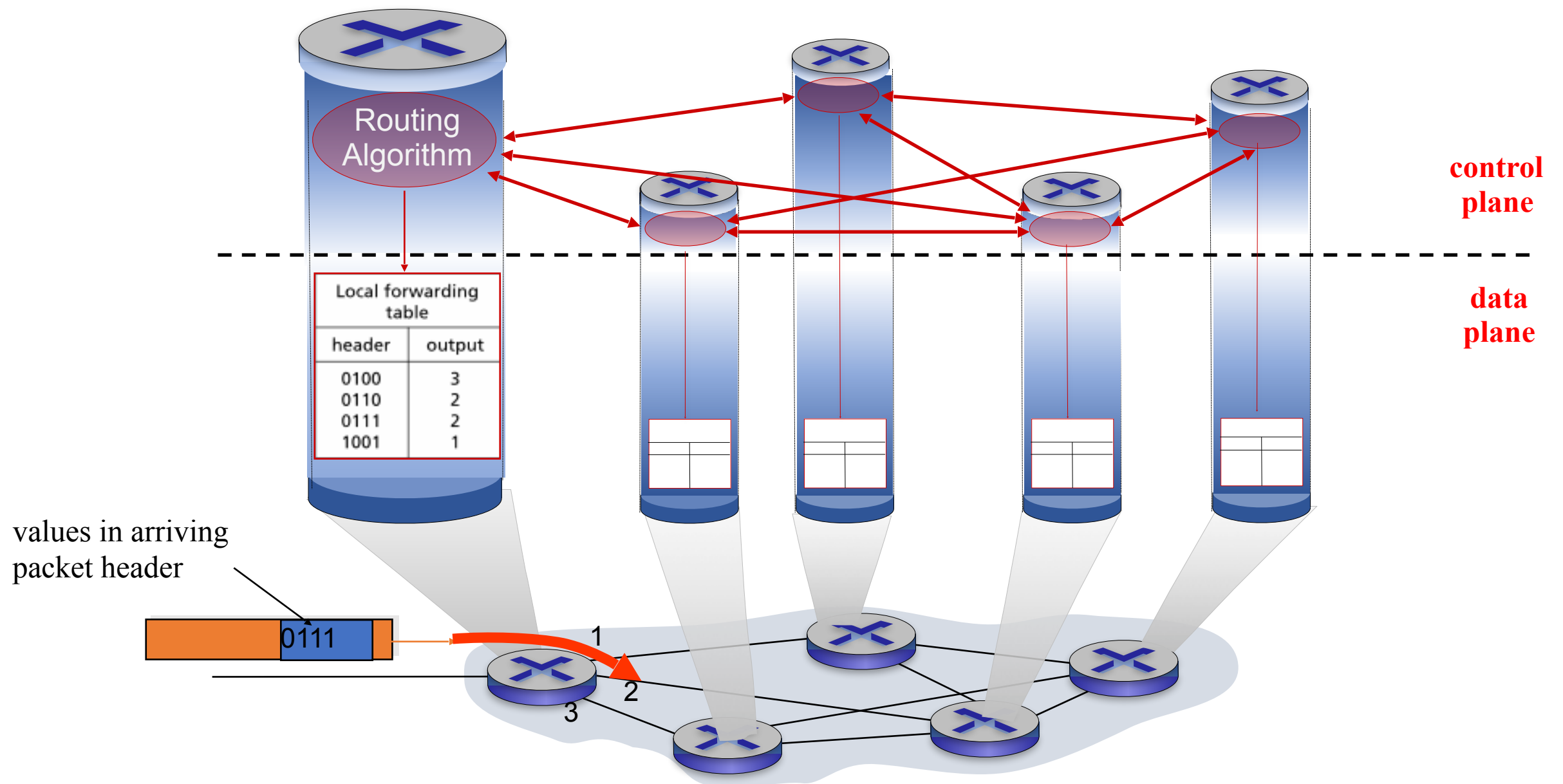
Inside the 'Net'
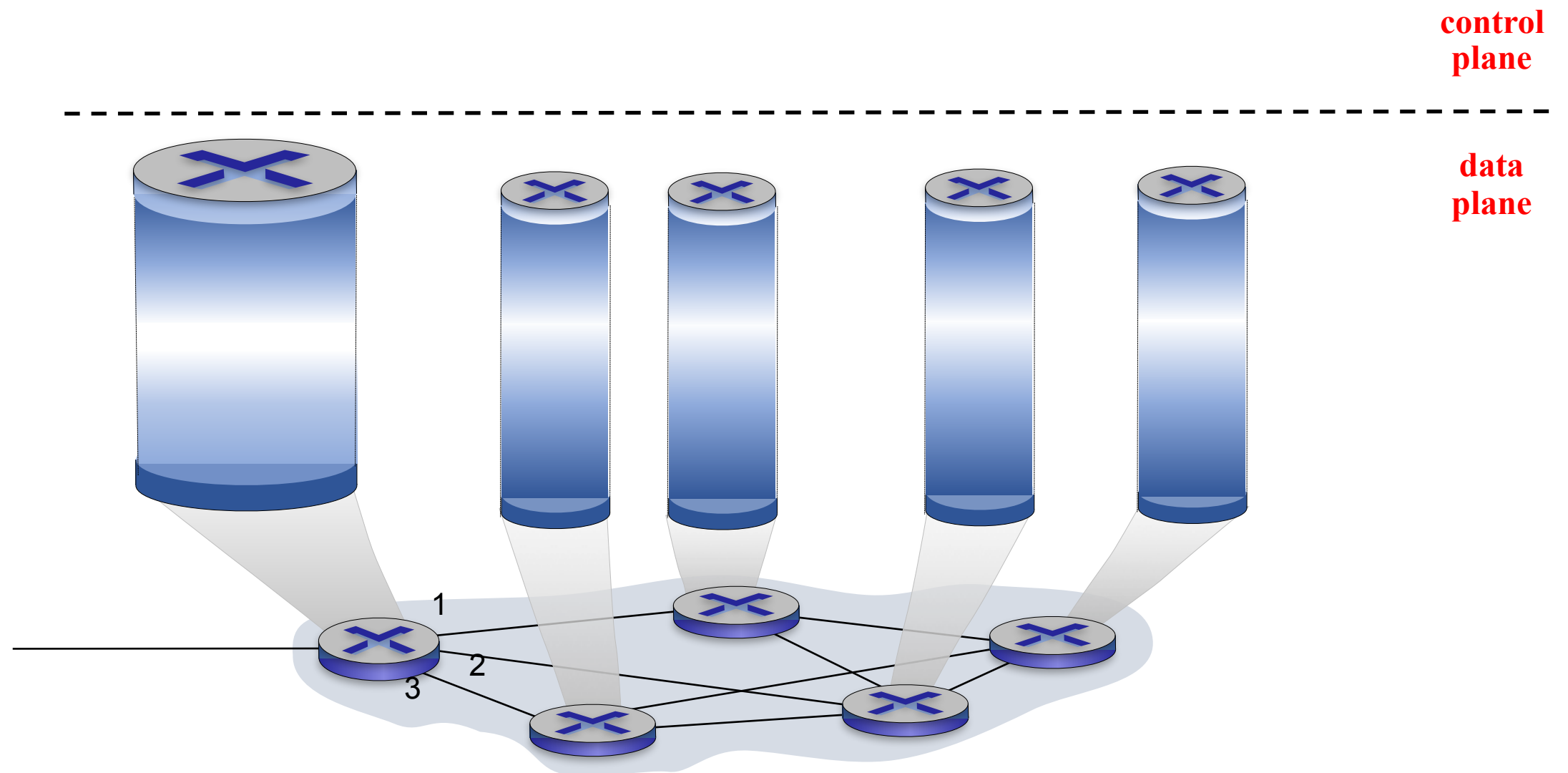
◉ Closed equipment
- Software bundled with hardware
- Vendor-specific interfaces

◉ Over specified
- Slow protocol standardization

◉ Few people can innovate
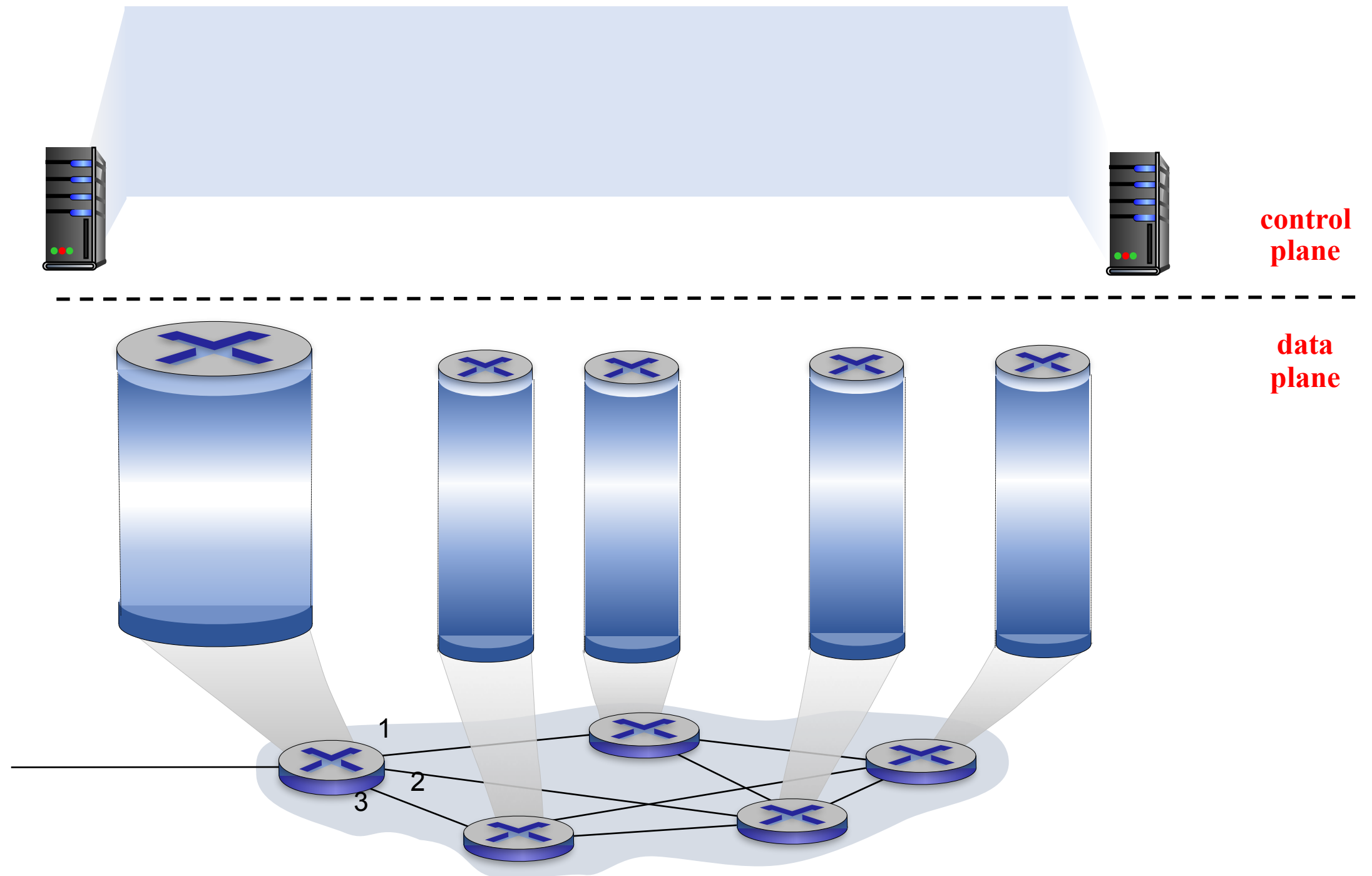- Equipment vendors write the code
- Long delays to introduce new features
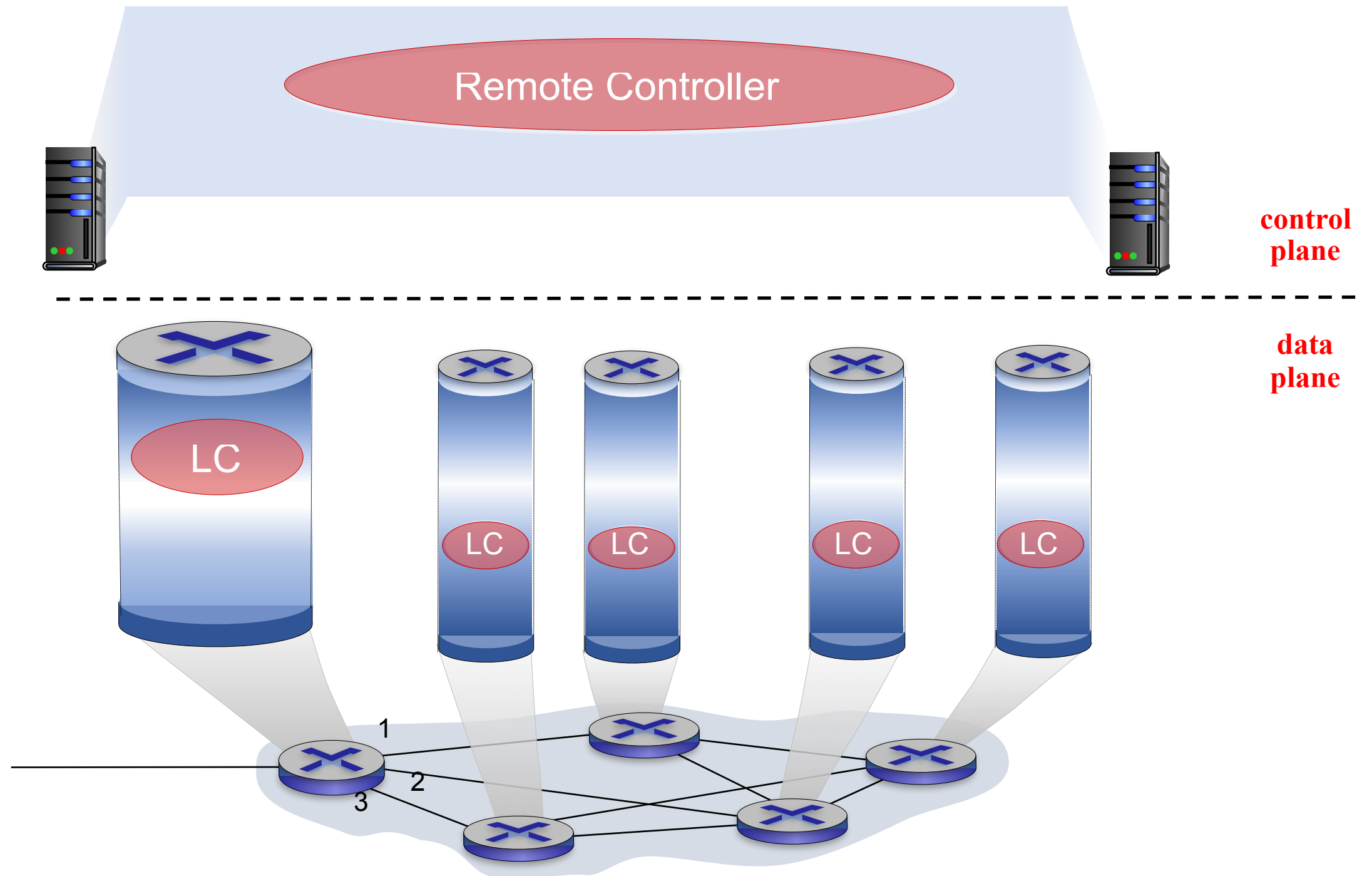
"Logically Centralized" Control Plane

"Logically Centralized" Control Plane

control
plane

data
plane

1
2
3

"Logically Centralized" Control Plane

control
plane

data
plane

1

2

3

"Logically Centralized" Control Plane

Remote Controller

control plane

data plane

LC

LC   LC   LC   LC

1

2

3

"Logically Centralized" Control Plane

Remote Controller

control plane

data plane

LC

LC

LC

LC

LC

1

2

3

"Logically Centralized" Control Plane

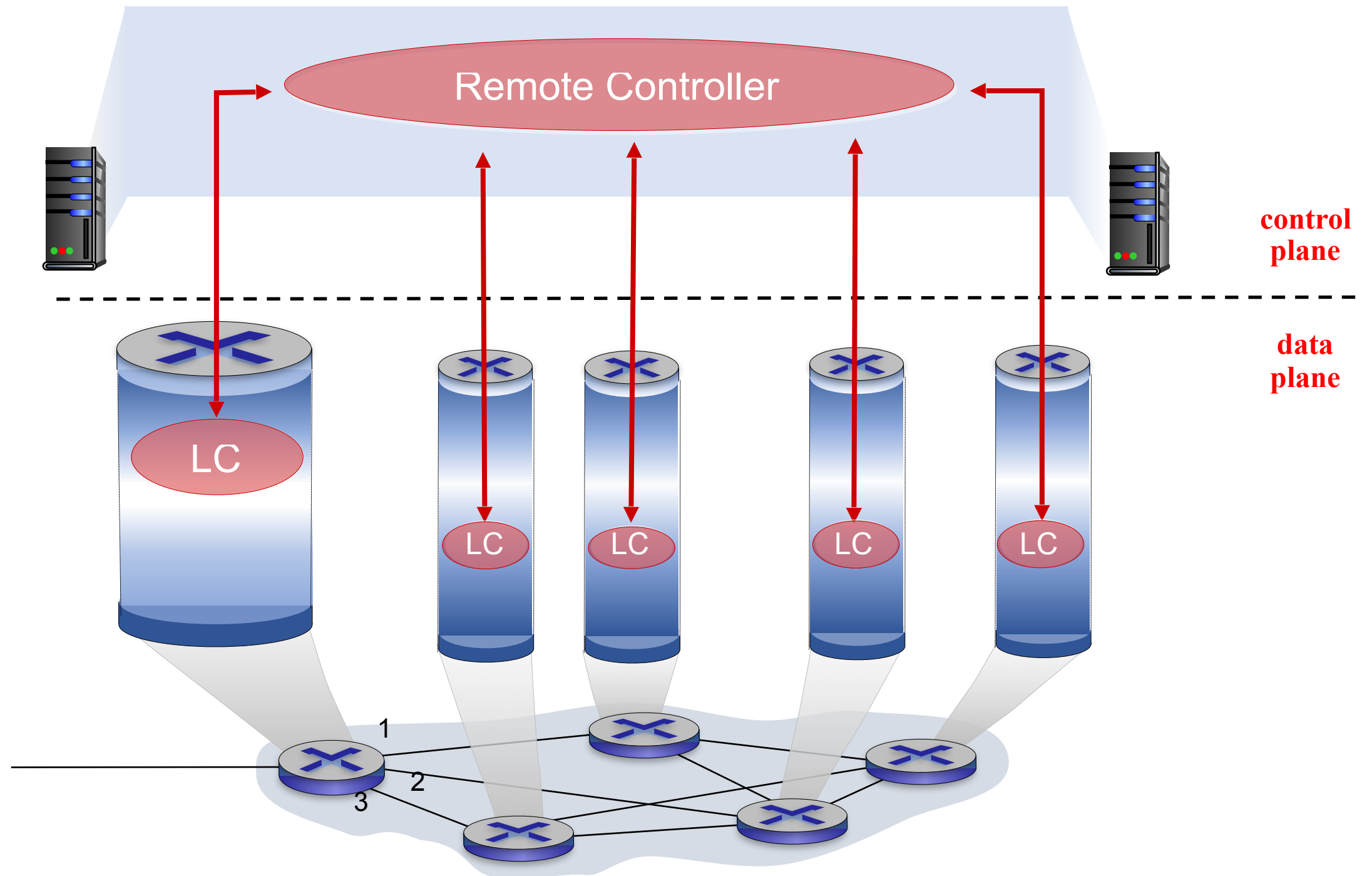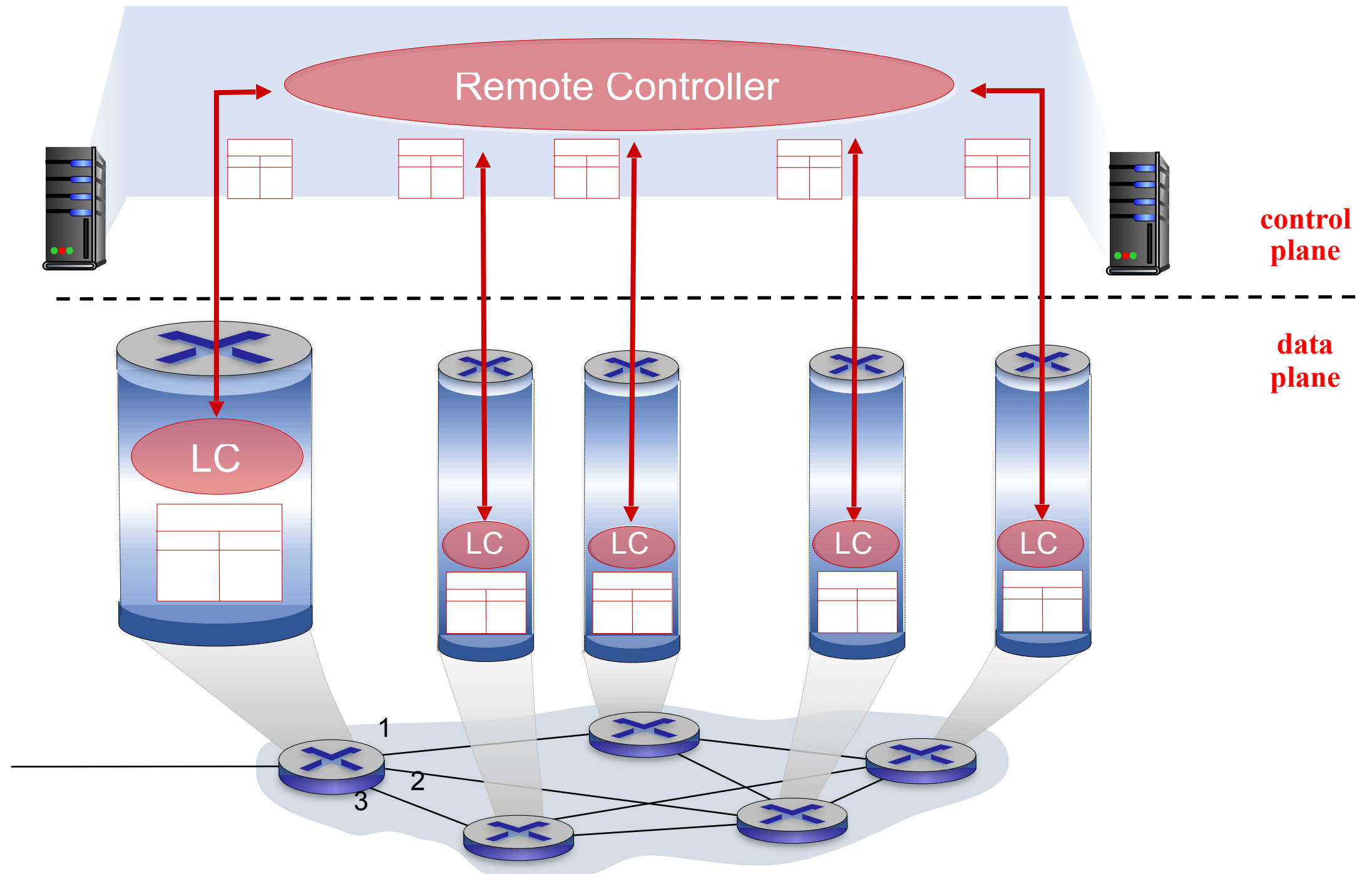Remote Controller
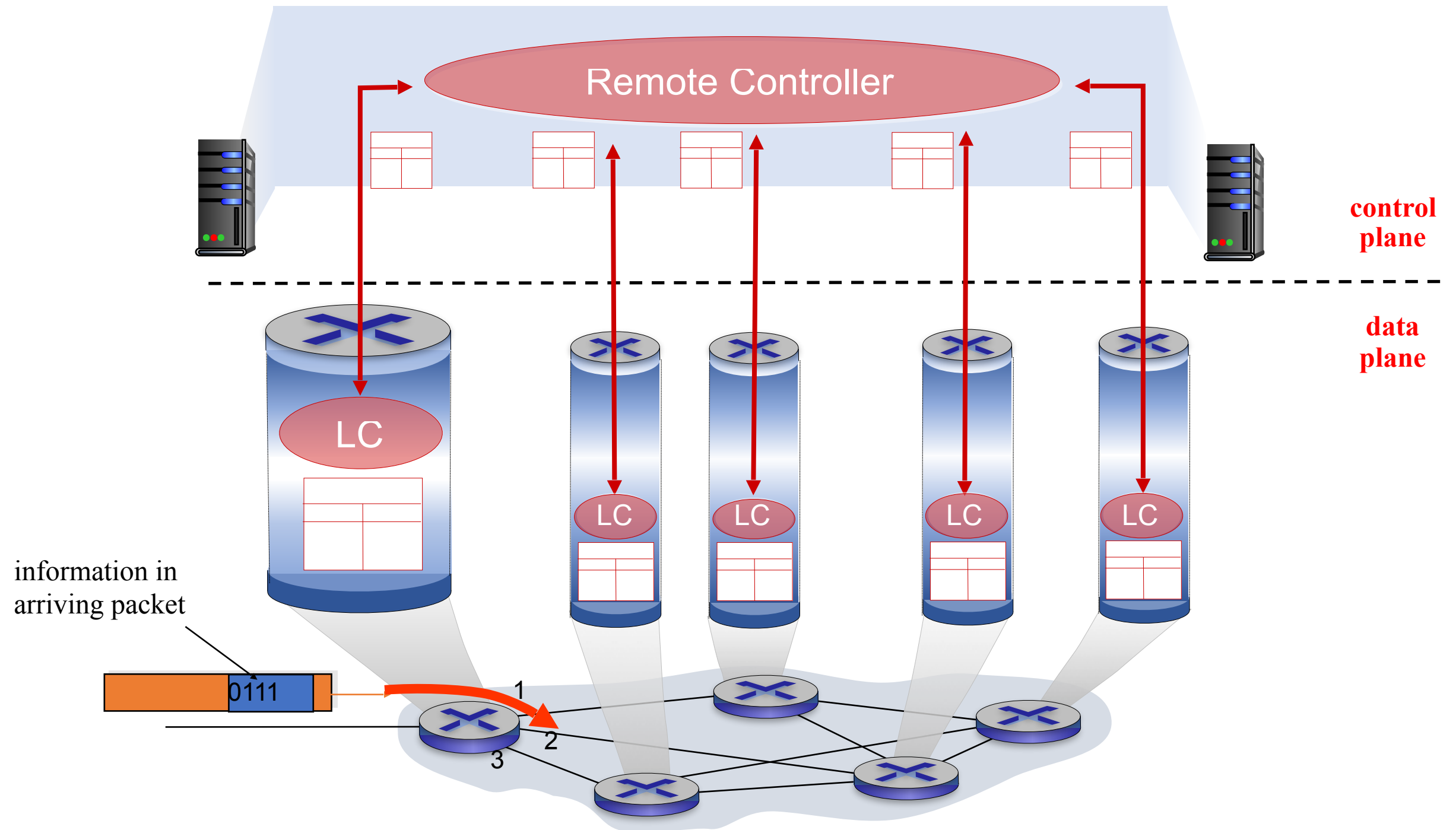
control plane

data plane
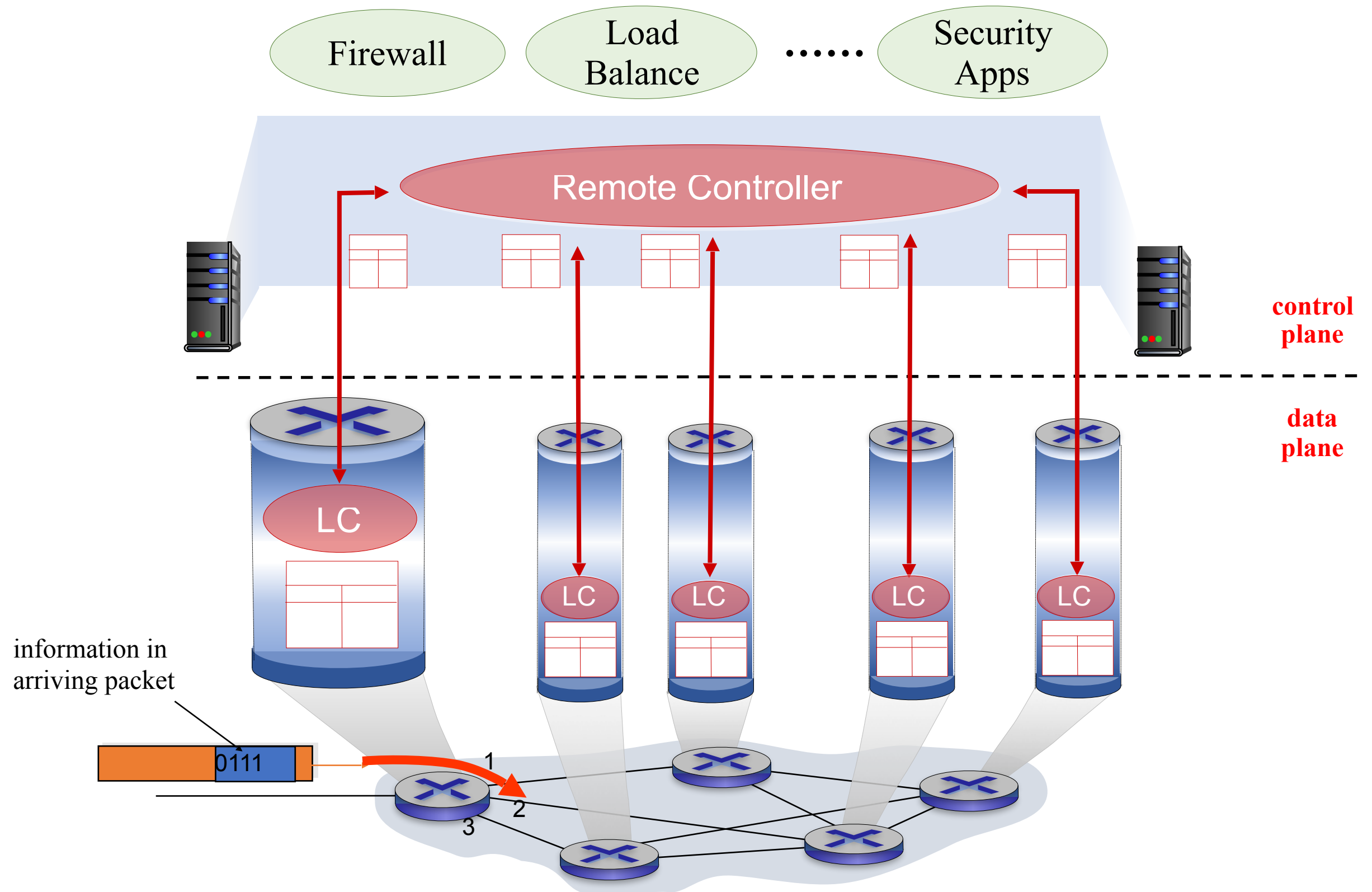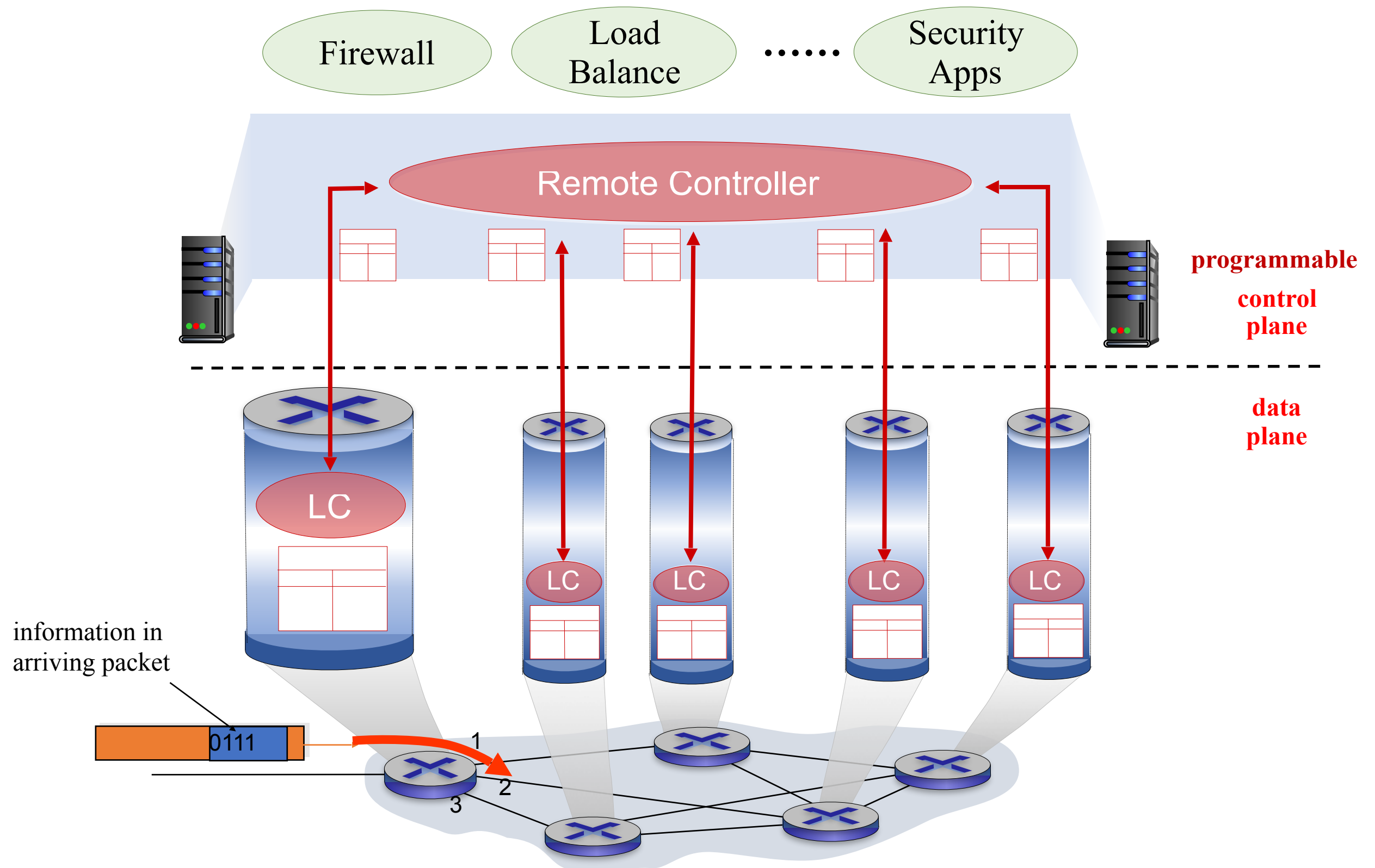
LC

"Logically Centralized" Control Plane

"Logically Centralized" Control Plane

"Logically Centralized" Control Plane

"Logically Centralized" Control Plane

"**Software Defined Networking"** (SDN)

Firewall   Load Balance   ......   Security Apps

Remote Controller

programmable control plane

data plane

LC

LC   LC   LC   LC

information in arriving packet

0111

1
2
3
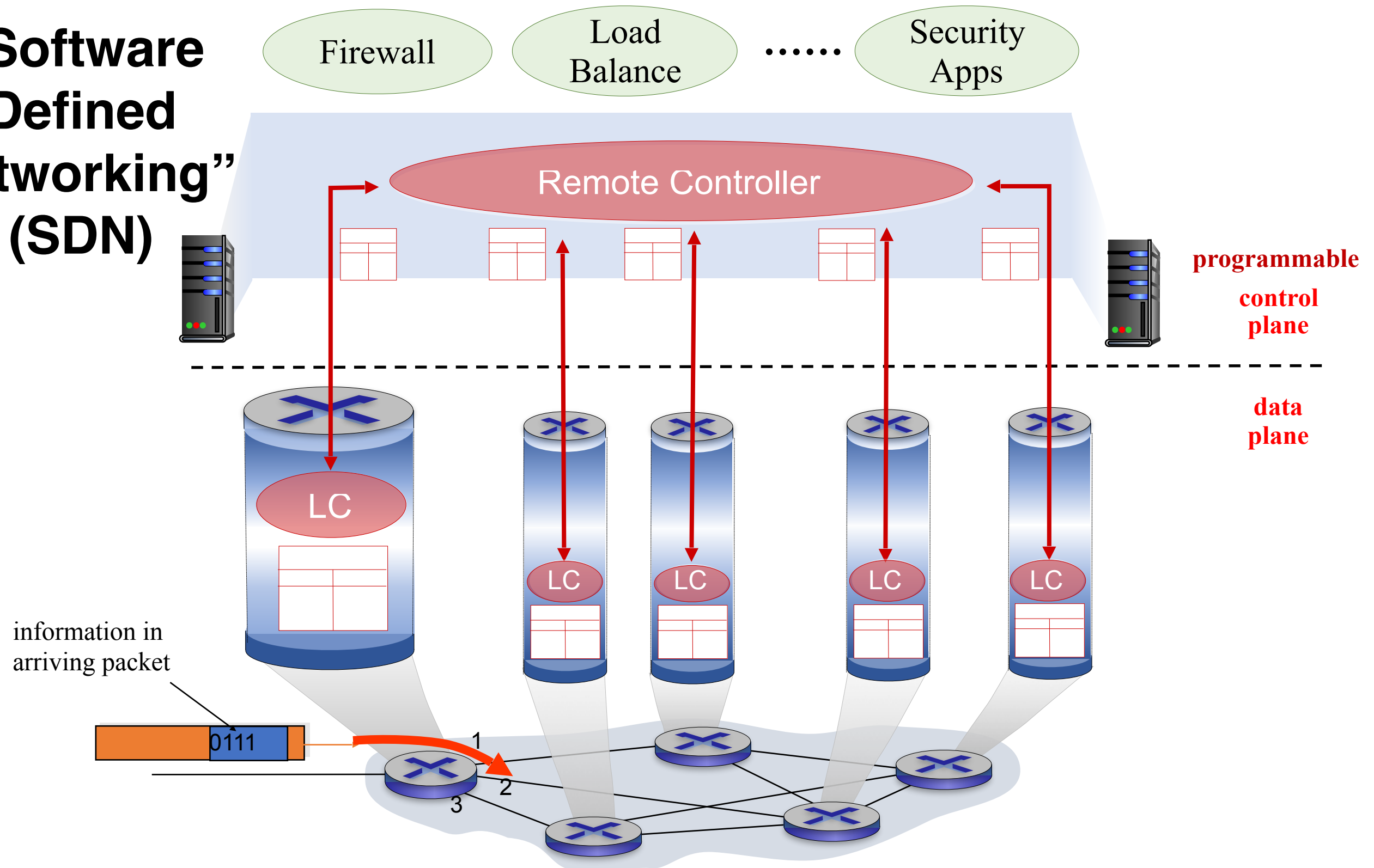
Opportunities: Where Separation Helps

⊙ Data centers: VM migration, Layer 2 routing

⊙ Routing: More control over decision logic

⊙ Enterprise networks: Security applications

⊙ Research networks: Coexistence with production

Example: Data Centers (Yahoo!)

⦿ 20,000 servers/cluster = 400,000 VMs
- Any-to-any, 1024 distinct inter-host links
- Sub-second migration, guaranteed consistency

⦿ Problem: Keeping 20k devices in sync with 400k+ entities

⦿ Solution: Program switch from a central database

Other Opportunities

⊙ Dynamic access control

⊙ Seamless mobility/migration

⊙ Server load balancing

⊙ Network virtualization

⊙ Using multiple wireless access points

⊙ Energy-efficient networking

⊙ Adaptive traffic monitoring

⊙ Denial-of-Service attack detection

How is SDN Shaping Industry

Open Networking Foundation (ONF) -
(www.opennetworking.org)

- New non-profit standards organization (Mar 2011)

- Defining standards for SDN, starting with OpenFlow

- Board of Directors
  - Google, Facebook, Microsoft, Yahoo, DT, Verizon

- 100+ Member Companies
  - Cisco, VMware, IBM, Juniper, HP, Broadcom, Citrix, NTT, Intel, Ericsson, Dell, Huawei, …

Practical Deployment of SDN

- Google B4: deployed SDN to manage cross data center traffic

- Microsoft SWAN: software defined WAN

- Facebook: infrastructure team exploring SDN

- Vmware: Nicira, overlay approach to SDN

- Intel: OpenFlow switch

- Cisco: OpenFlow switch

- AT&T: Domain 2.0

- …

SDN Startups

- Affirmed Networks: virtualized subscriber and content management tools for mobile operators

- Big Switch Networks: OpenFlow-based SDN switches, controllers and monitoring tools

- Embrane: layer 3-7 SDN services to enterprises and service providers

- Accelera: software defined wireless networks funded by Stanford Professor Andrea Goldsmith

- Barefoot Networks: a merchant chip company which sells programmable switch ASICs and production-quality switches

…

How is SDN Shaping Research

- Ease of trying new ideas
  - Existing tools: Floodlight, NOX, Beacon, software switches, Mininet
  - More rapid technology transfer
  - GENI, FIND and many more

- A stronger foundation to build upon
  - Provable properties of forwarding
  - New languages and specification tools

- ACM SIGCOMM, USENIX NSDI, IEEE INFOCOM sessions and SDN workshop/symposium