

5590, fall 2020

# software defined networking

anduo wang, Temple University

T 17:30-20:00

some materials in this slide are based on lectures by  
Jennifer Rexford <https://www.cs.princeton.edu/courses/archive/fall13/cos597E/>  
Nick Feamster <http://noise.gatech.edu/classes/cs8803sdn/fall2014/>

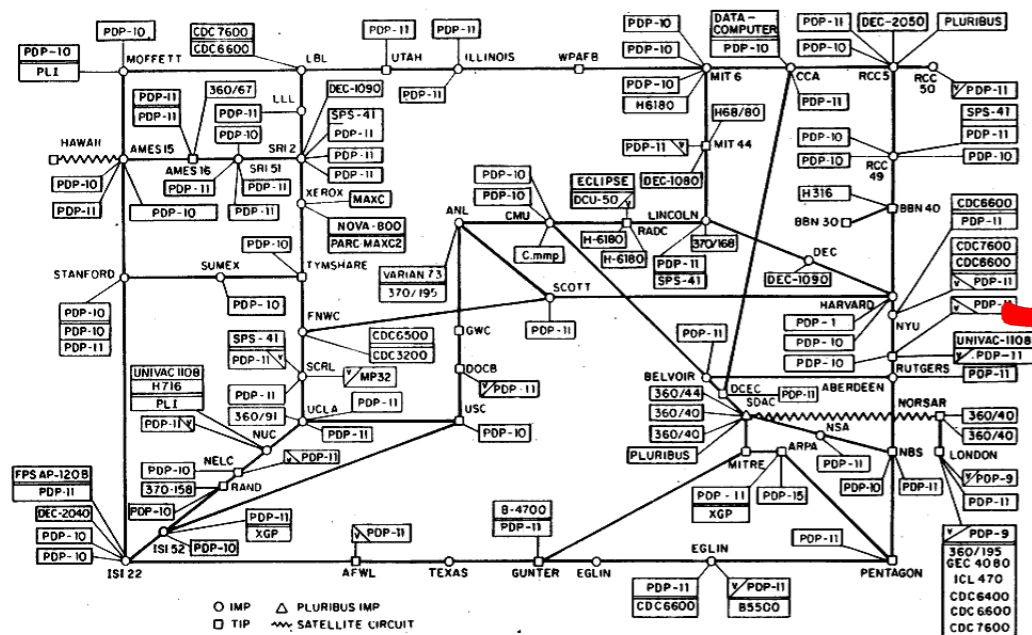
# the state of networking

# the Internet: a wonderful success

a remarkable story

— from research experiment to global infrastructure

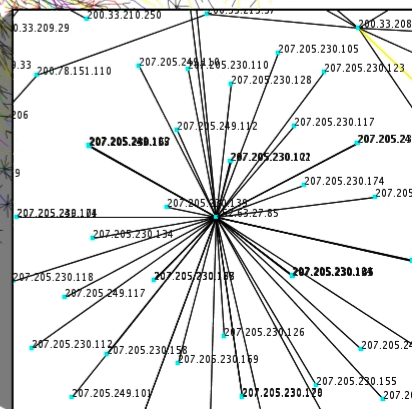
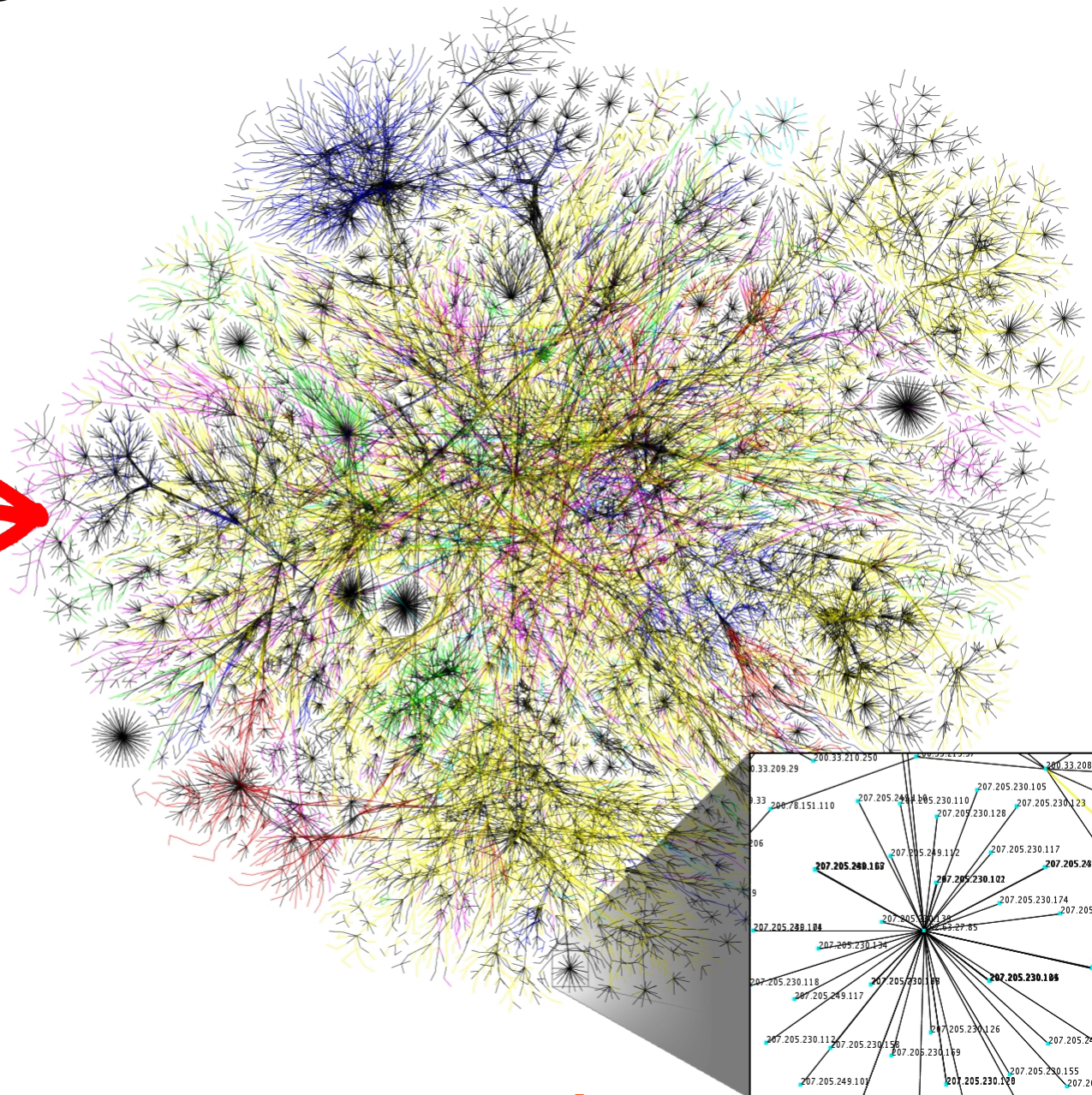
ARPANET LOGICAL MAP, MARCH 1977



(PLEASE NOTE THAT WHILE THIS MAP SHOWS THE MOST POPULATION OF THE NETWORK ACCORDING TO THE BEST INFORMATION OBTAINABLE, NO CLAIM CAN BE MADE FOR ITS ACCURACY)

NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES

## ARPANET, 1977



source: <https://en.wikipedia.org/wiki/Internet> today



# the Internet: a wonderful success

innovations for everyday life

- Web, P2P, VoIP, social networking ...



# the Internet: a wonderful success

## innovations take rapid transitions

Ahmed Khurshid., et al. “VeriFlow: Verifying Network-Wide Invariants in Real Time”

source: <https://www.usenix.org/conference/nsdi13/technical-sessions/presentation/khurshid>

NSDI **2013**



**3 years, \$8.2 million**

### **Veriflow Nabs \$8.2 Million For Clever Ideas About Network Outage Prevention**

JULY 19, 2016 BY DREW CONRY-MURRAY

Startup [Veriflow Networks](#) has landed \$8.2 million in series A funding. The A round was led by Menlo Ventures, along with its existing investor New Enterprise Associates.

<http://packetpushers.net/veriflow-nabs-8-2-million-clever-ideas-network-outage-prevention/>



# inside the 'Net': a different story



## vendor lock-in

- specialized hardware
- protocols/software bundled with hardware
- slow innovation, deployment
- \$\$\$\$\$\$

## increasingly complex

- operators today are *masters of complexity*

# discipline for networking?

operating systems

- time sharing

programming languages

- data abstractions

database management systems

- data independence

networking

- lack of discipline, but bags of protocols ...

to do

- watch Scott Shenker's talk on **“The Future of Networking, and the Past of Protocols”** <https://youtu.be/YHeyuD89nIY>



# networking needs ...

## break vendor lock-in

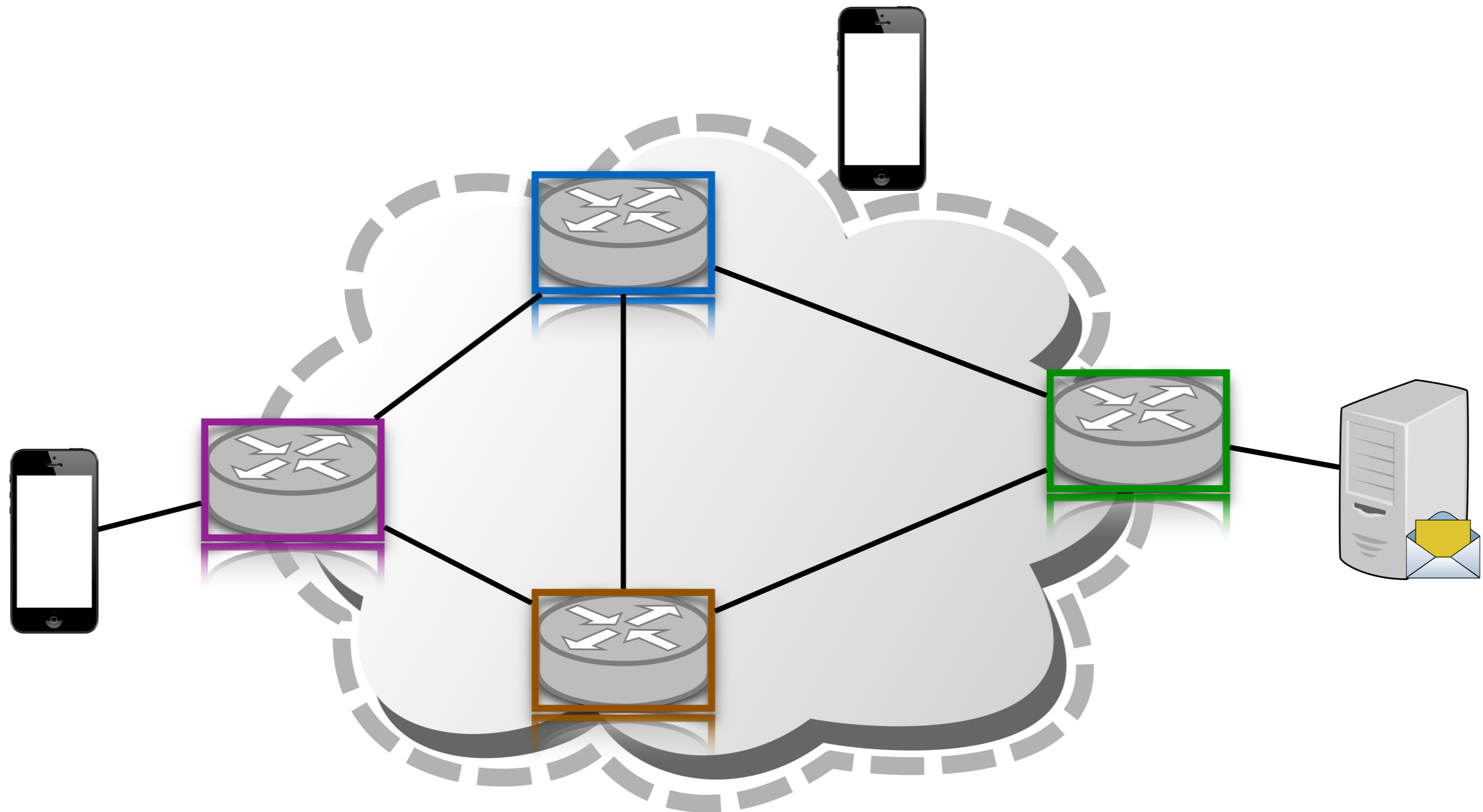
- freedom from suppliers
- freedom from low-level box by box configuration
- freedom of adding new services

## introduce disciplines

- systematic principles that guide networking practice

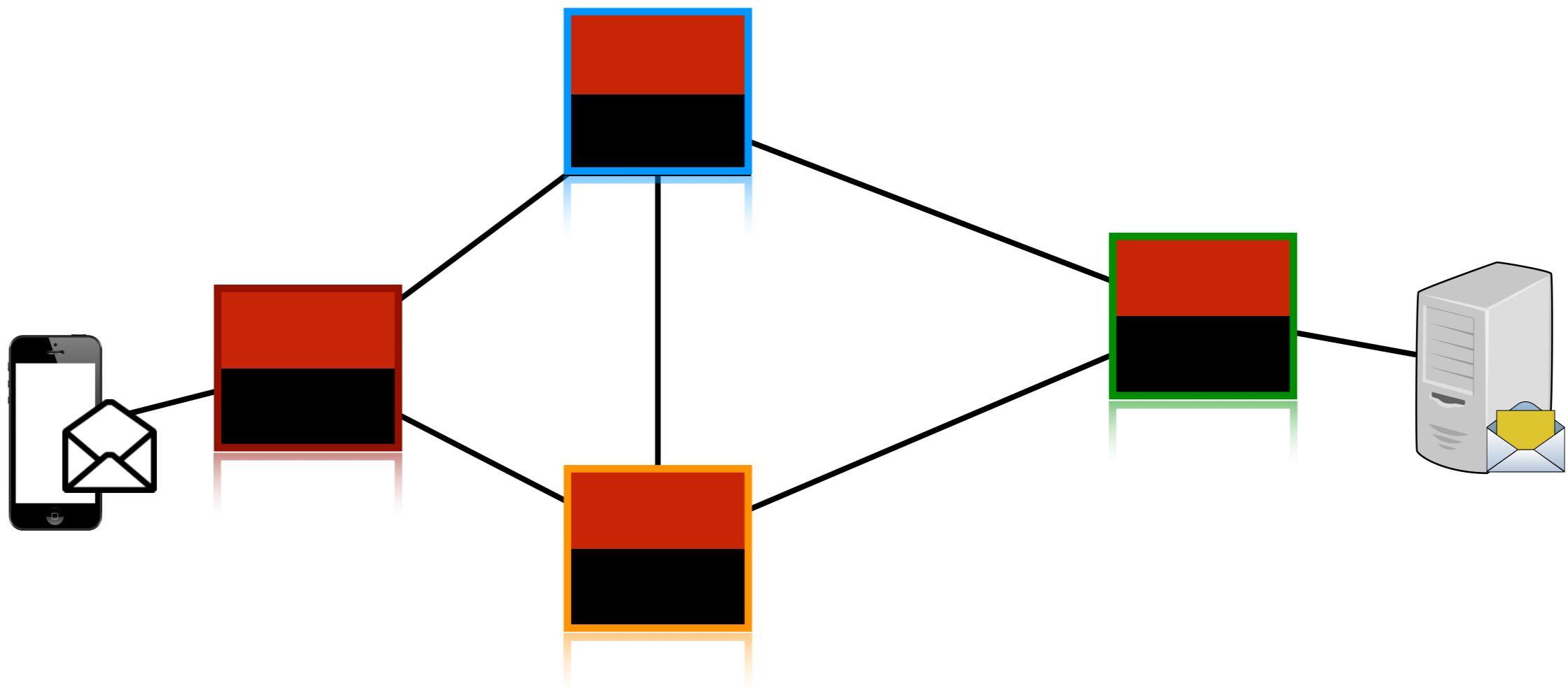
# software defined networking (SDN)

# software defined networks



# software defined networks

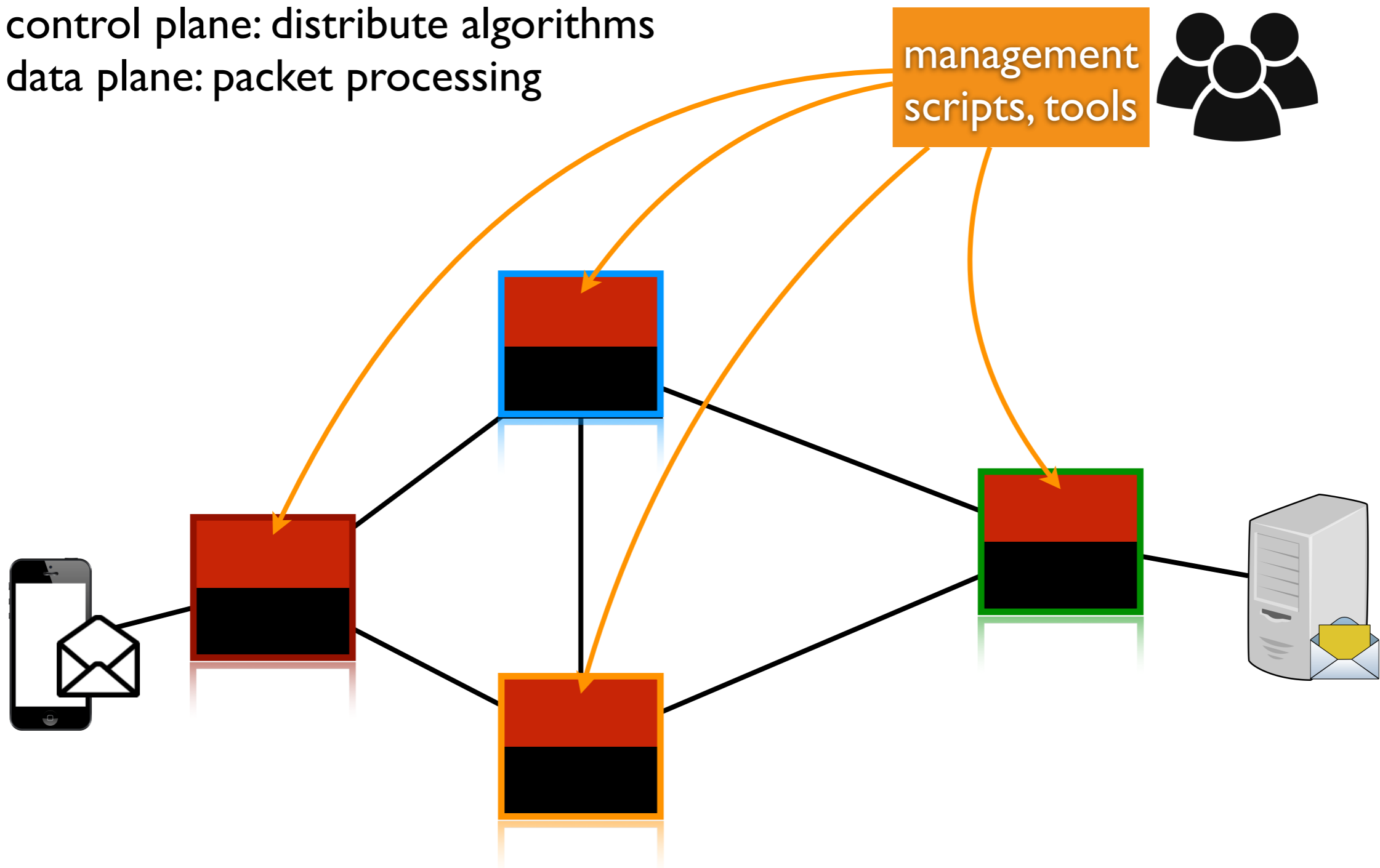
- control plane: distribute algorithms
- data plane: packet processing







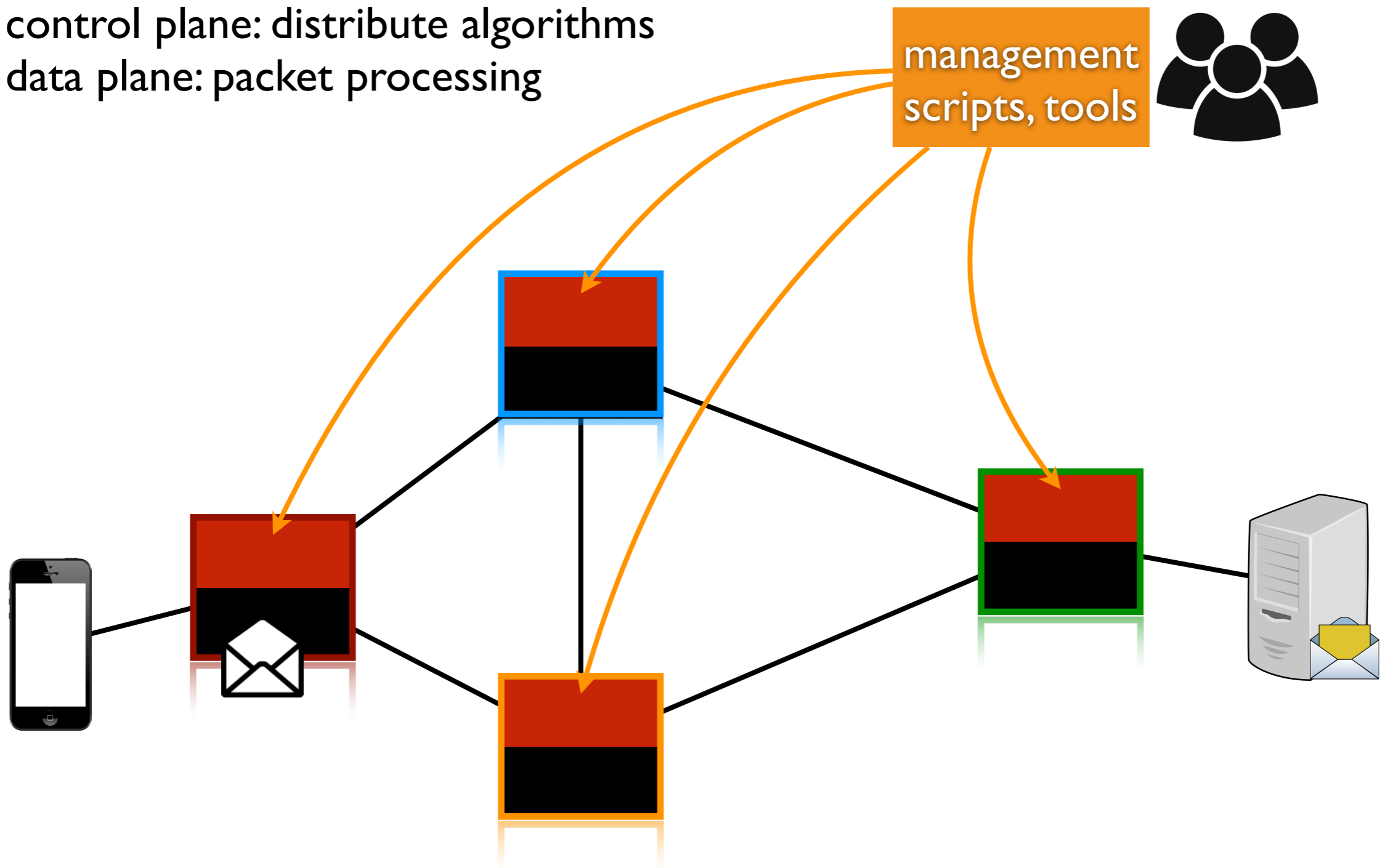
# software defined networks

- control plane: distribute algorithms
- data plane: packet processing



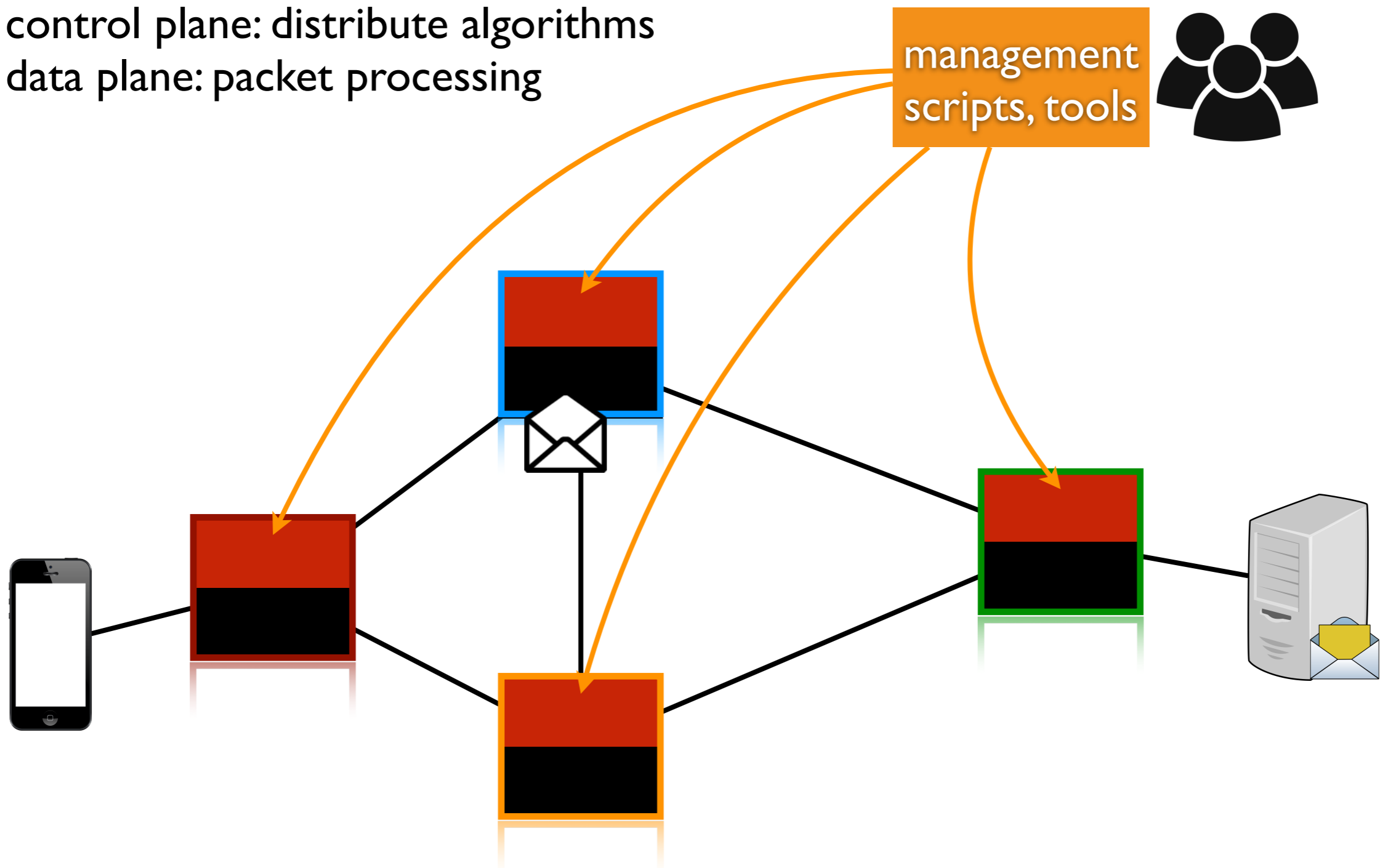
# software defined networks

-  control plane: distribute algorithms
-  data plane: packet processing





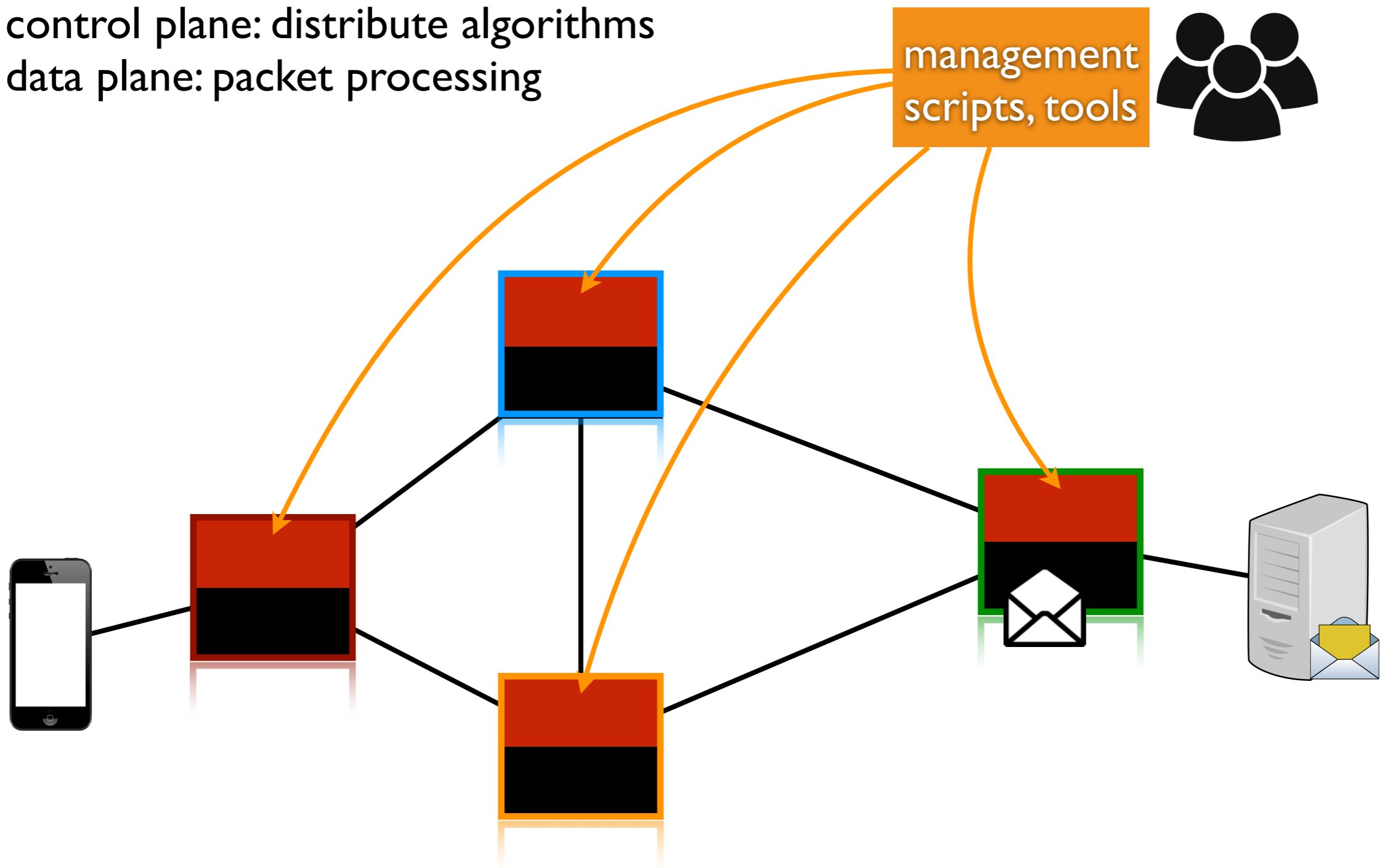
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- control plane: distribute algorithms
- data plane: packet processing



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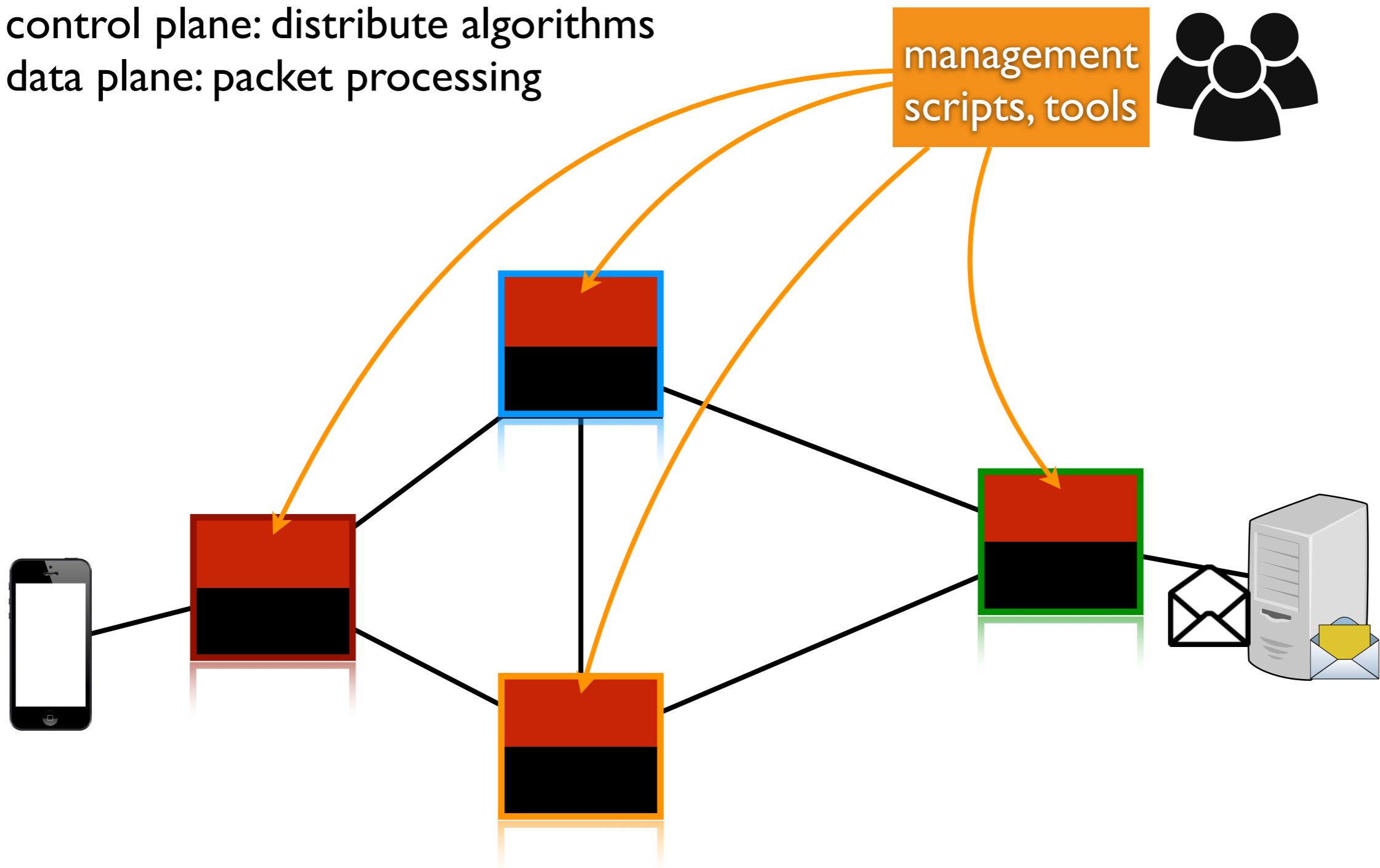
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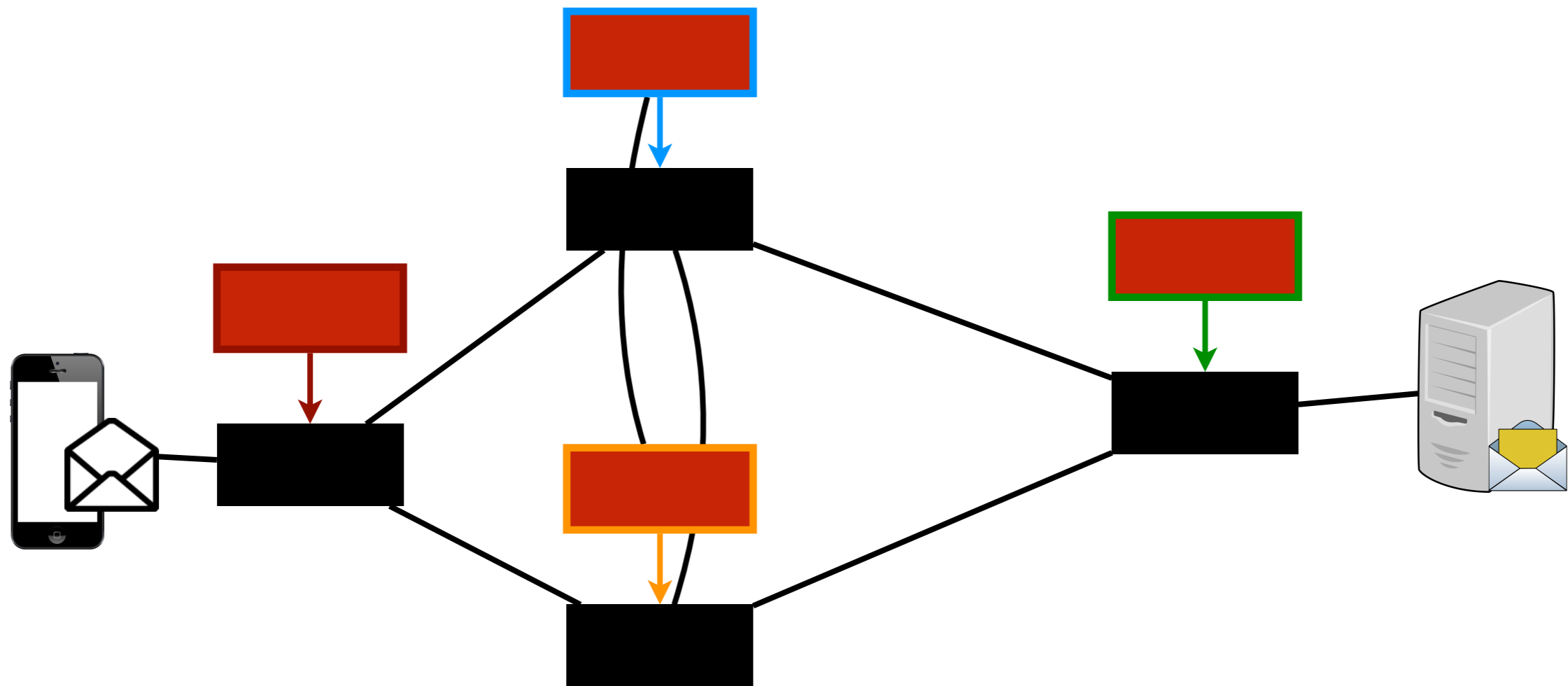
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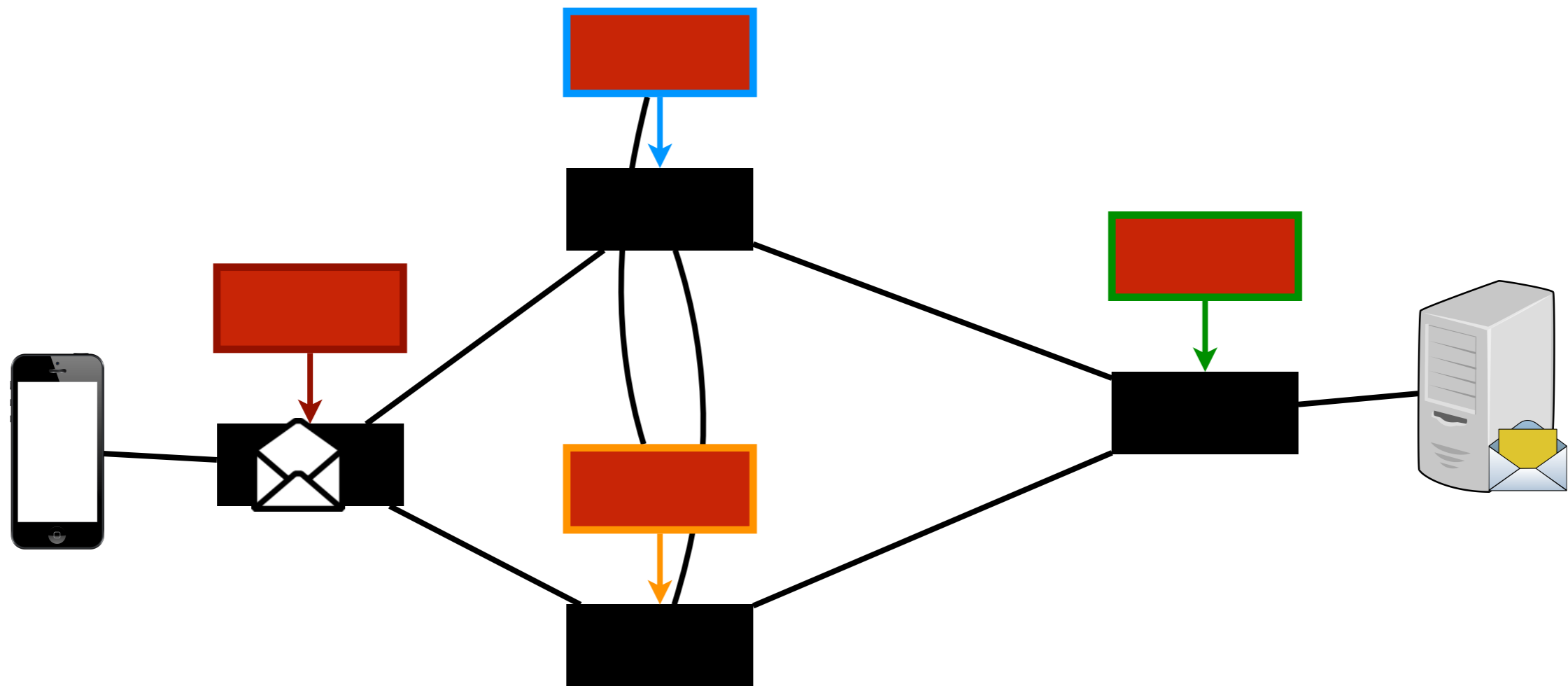
# software defined networks

decouple control and data planes



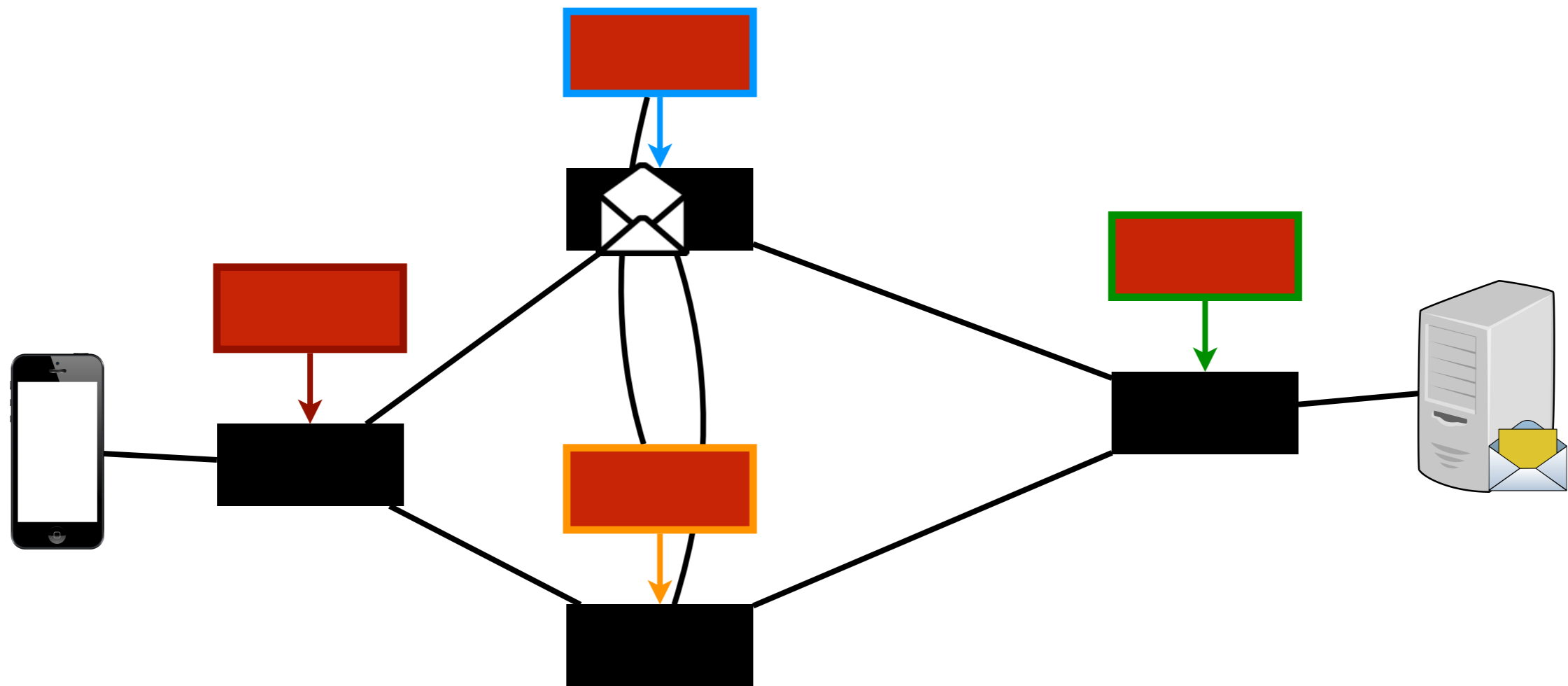
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decouple control and data planes



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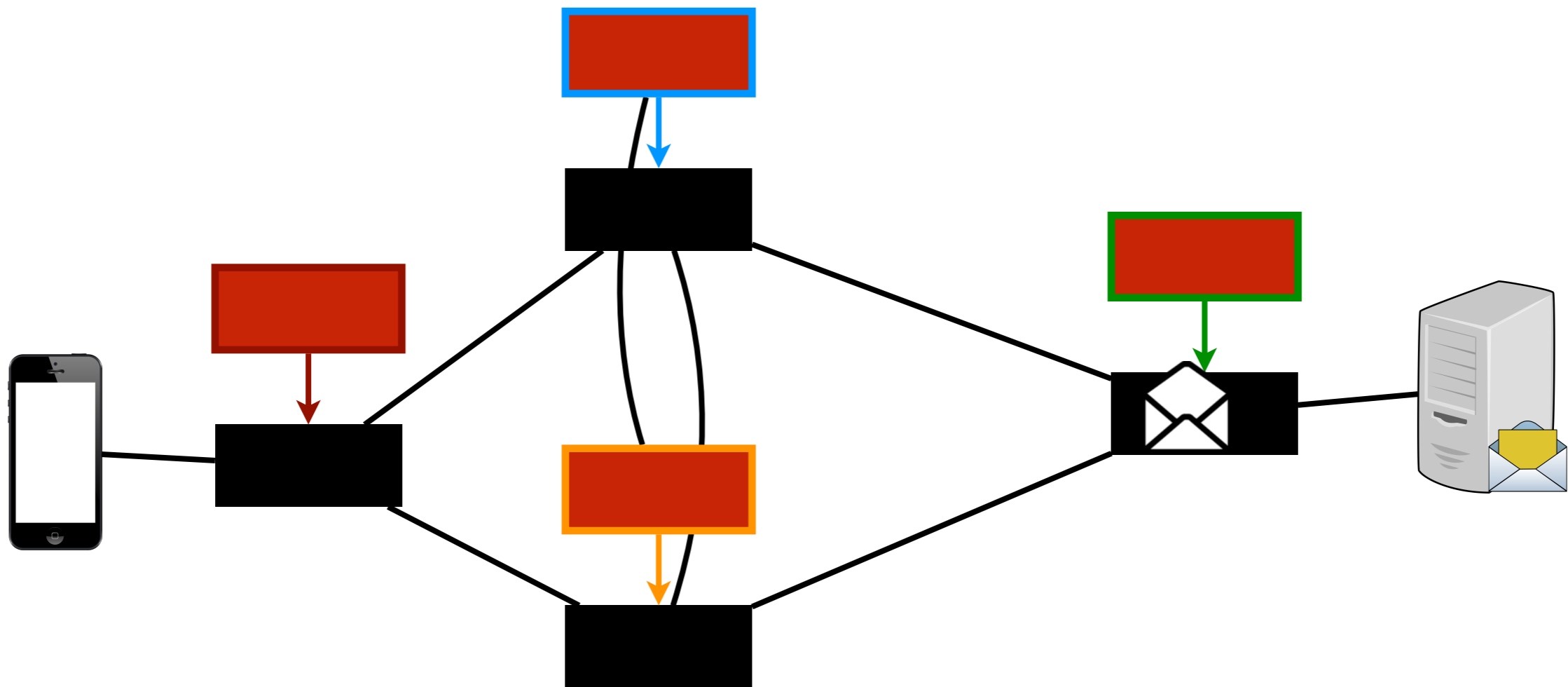
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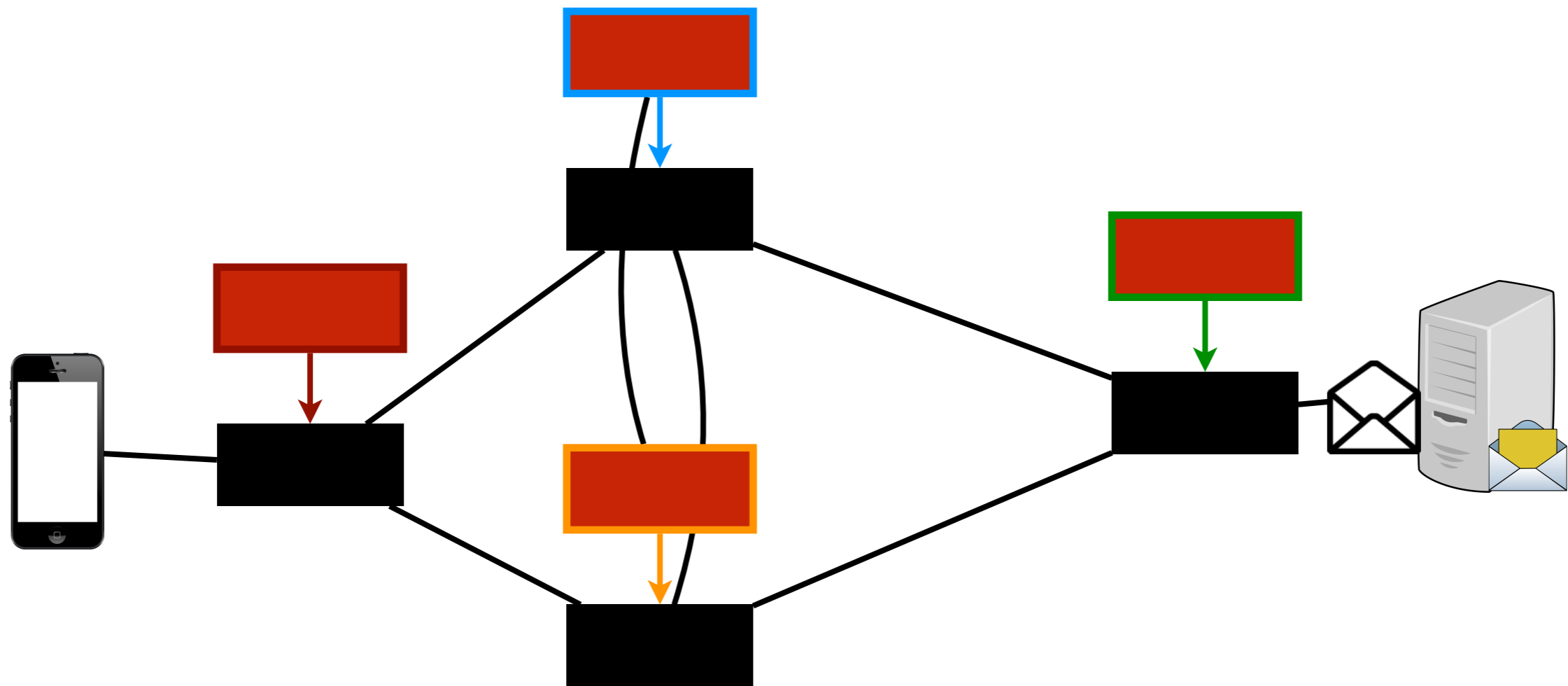
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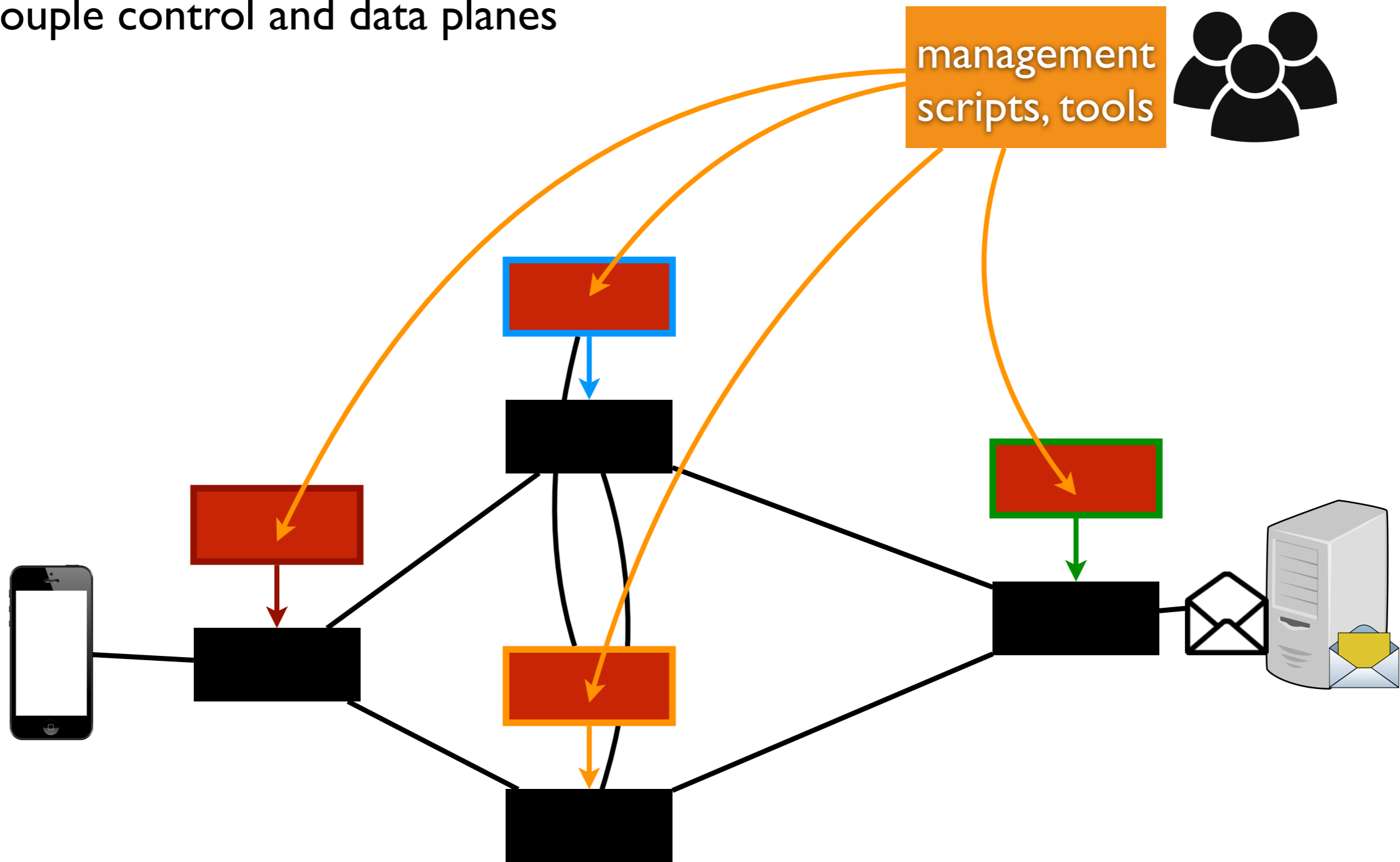
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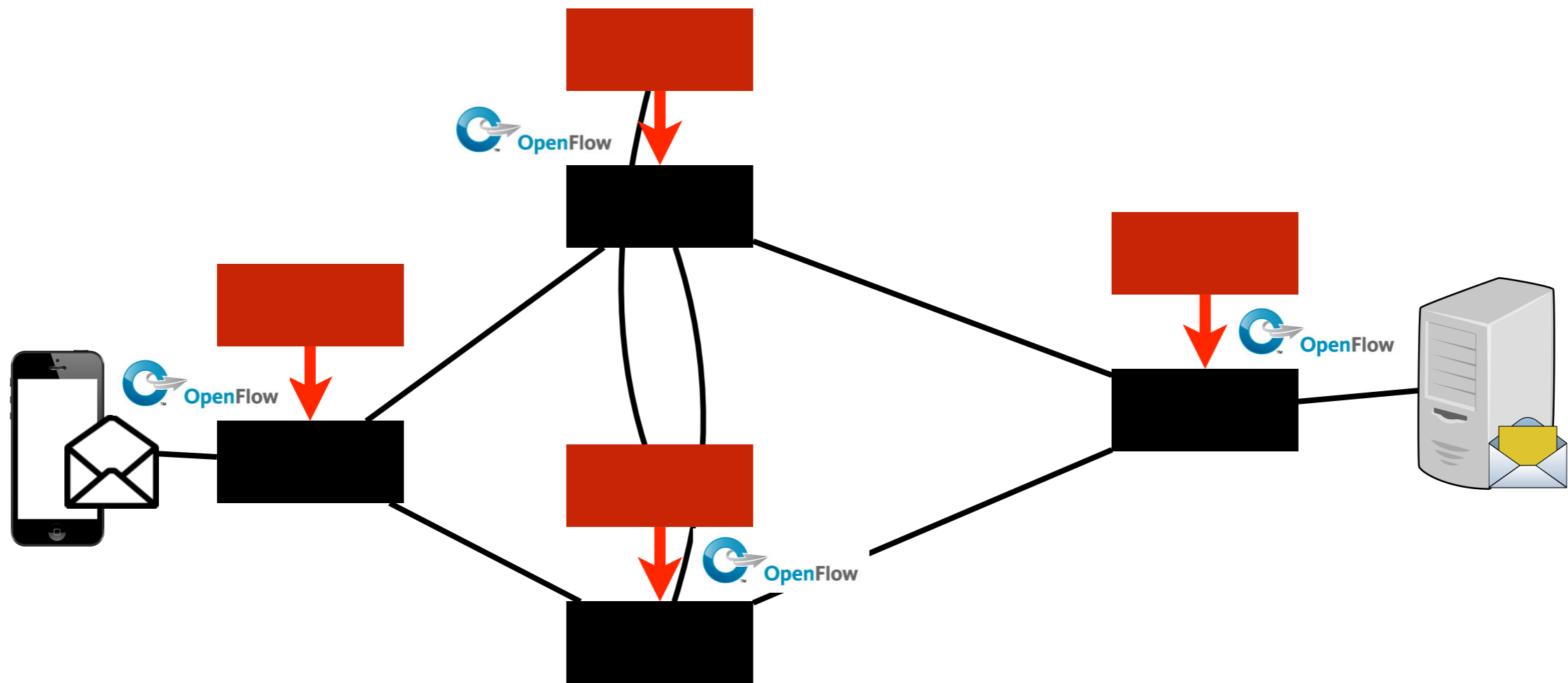
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decouple control and data planes



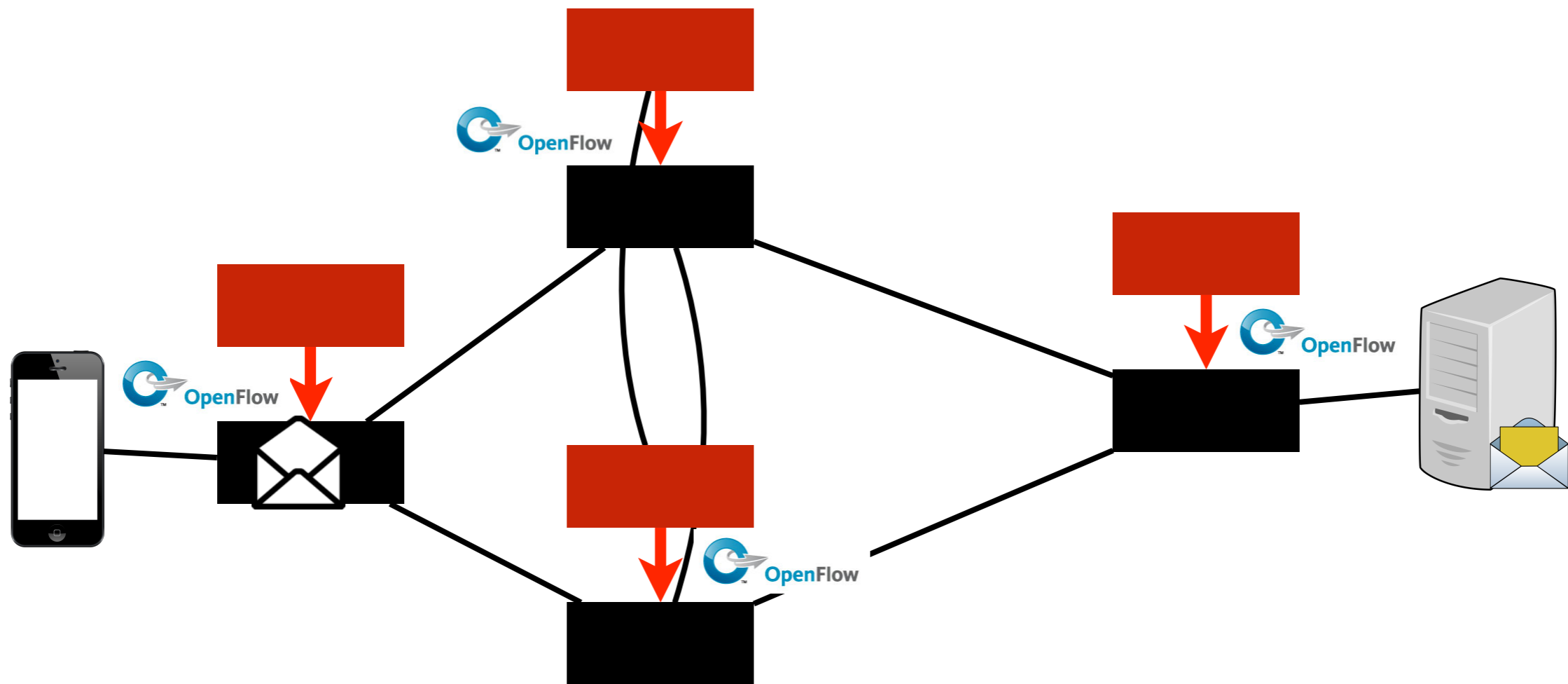
# open dataplane API

decouple control and data planes  
by providing **open standard API**  
**OpenFlow**



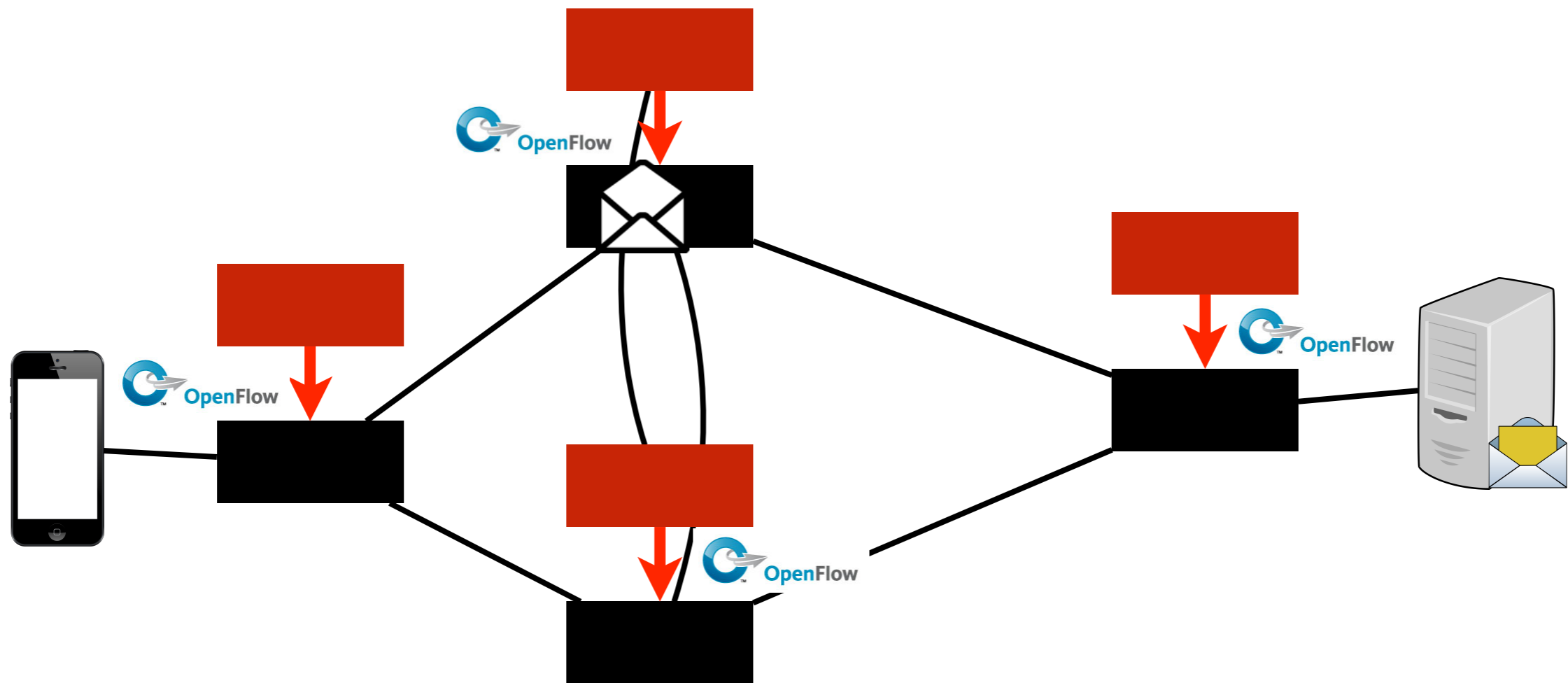
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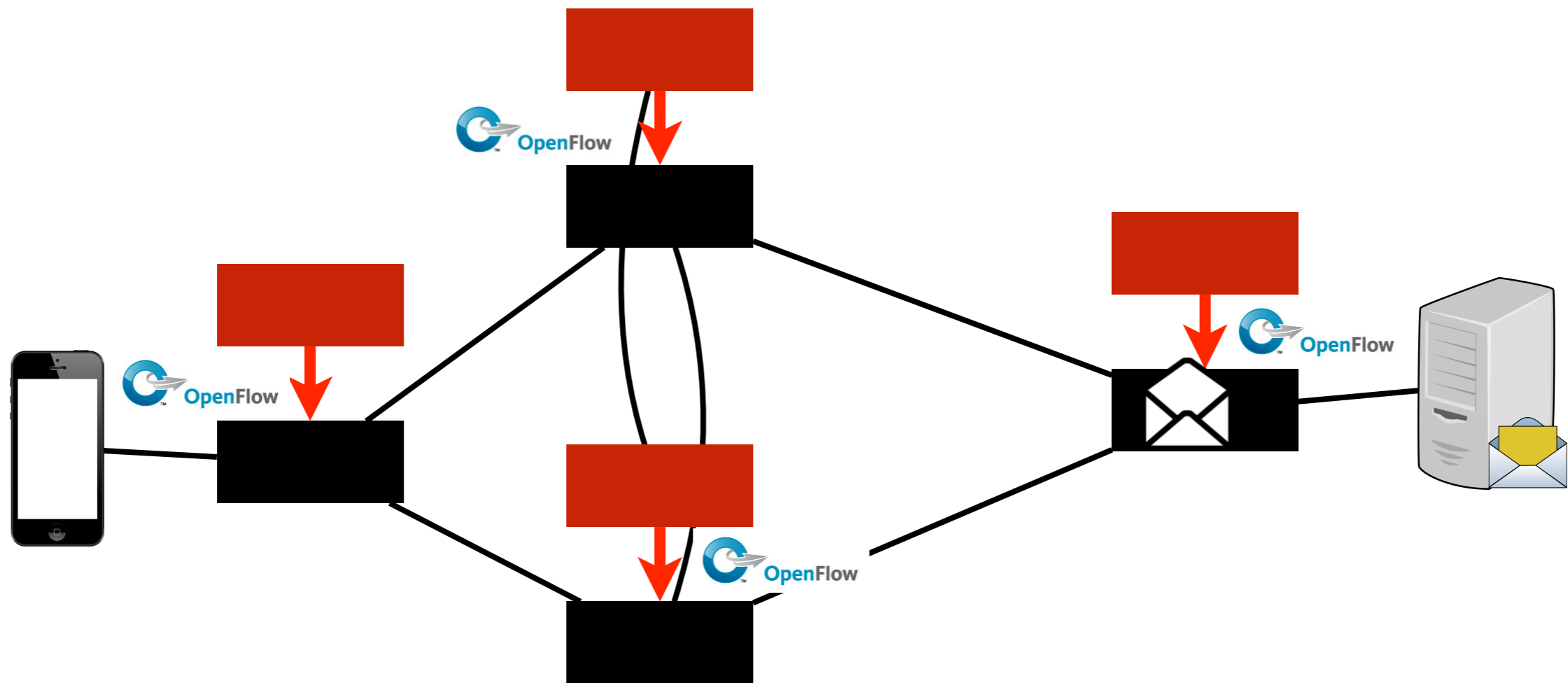
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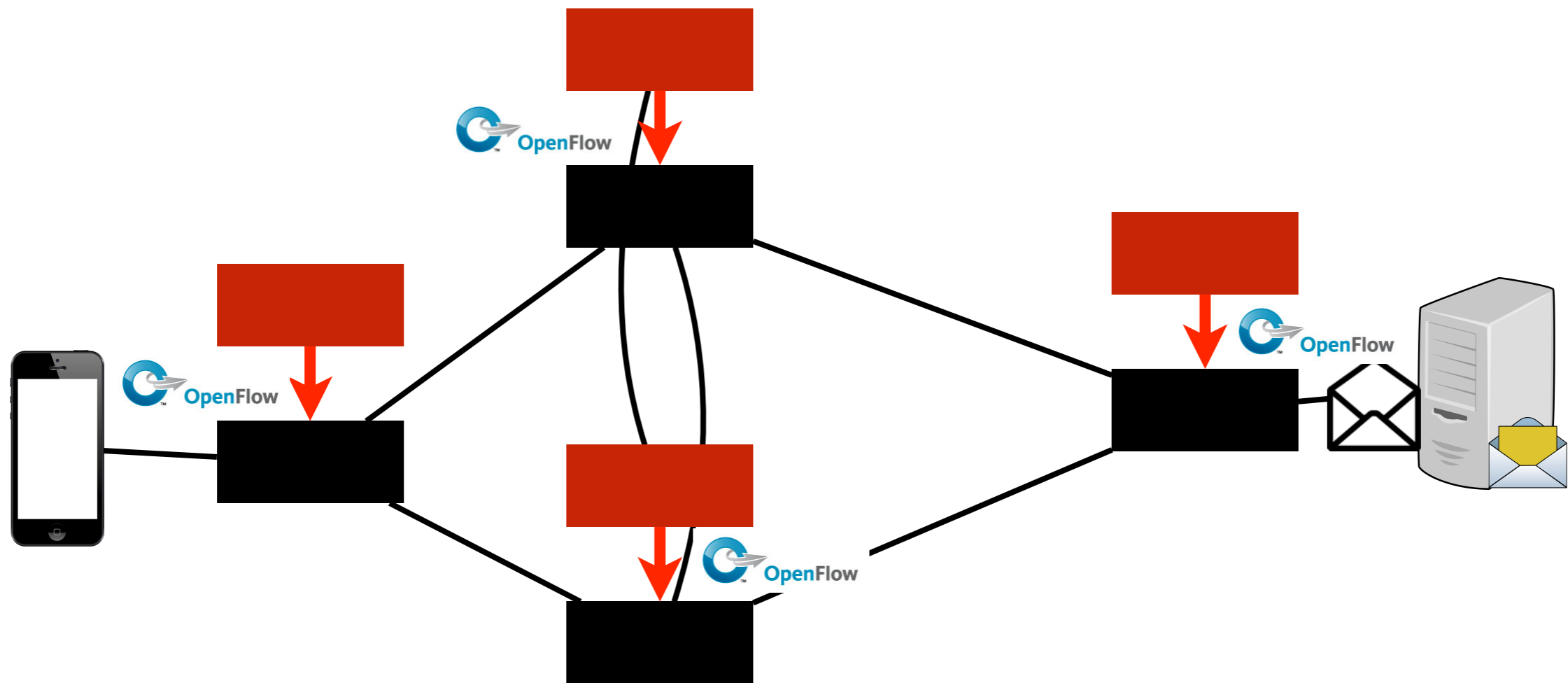
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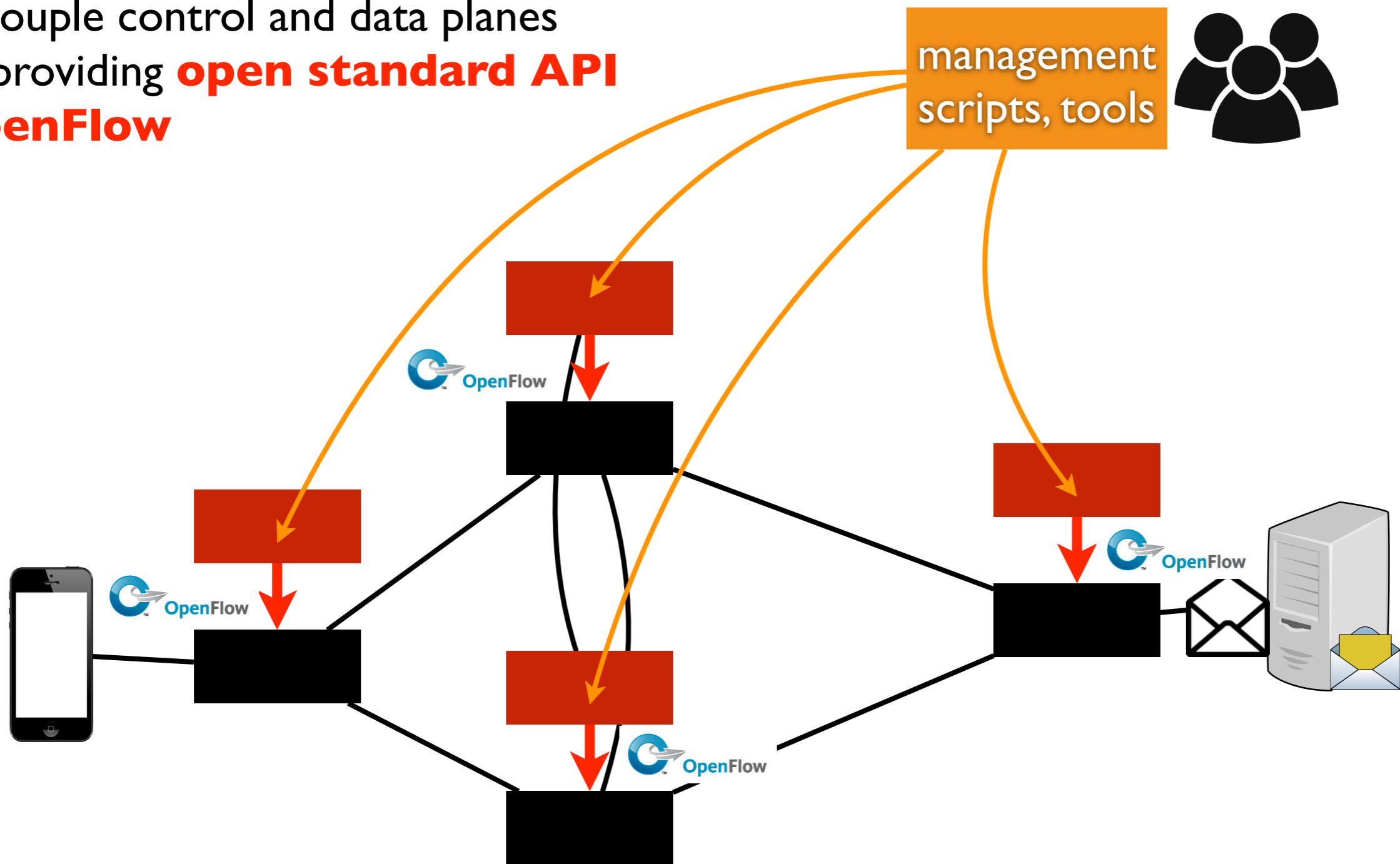
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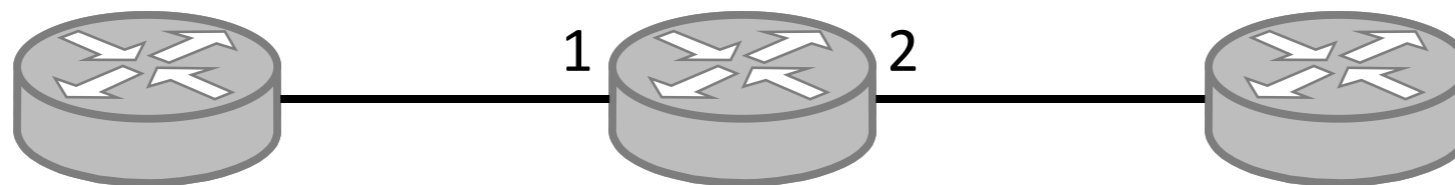
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# OpenFlow: simple open dataplane API

prioritized list of rules

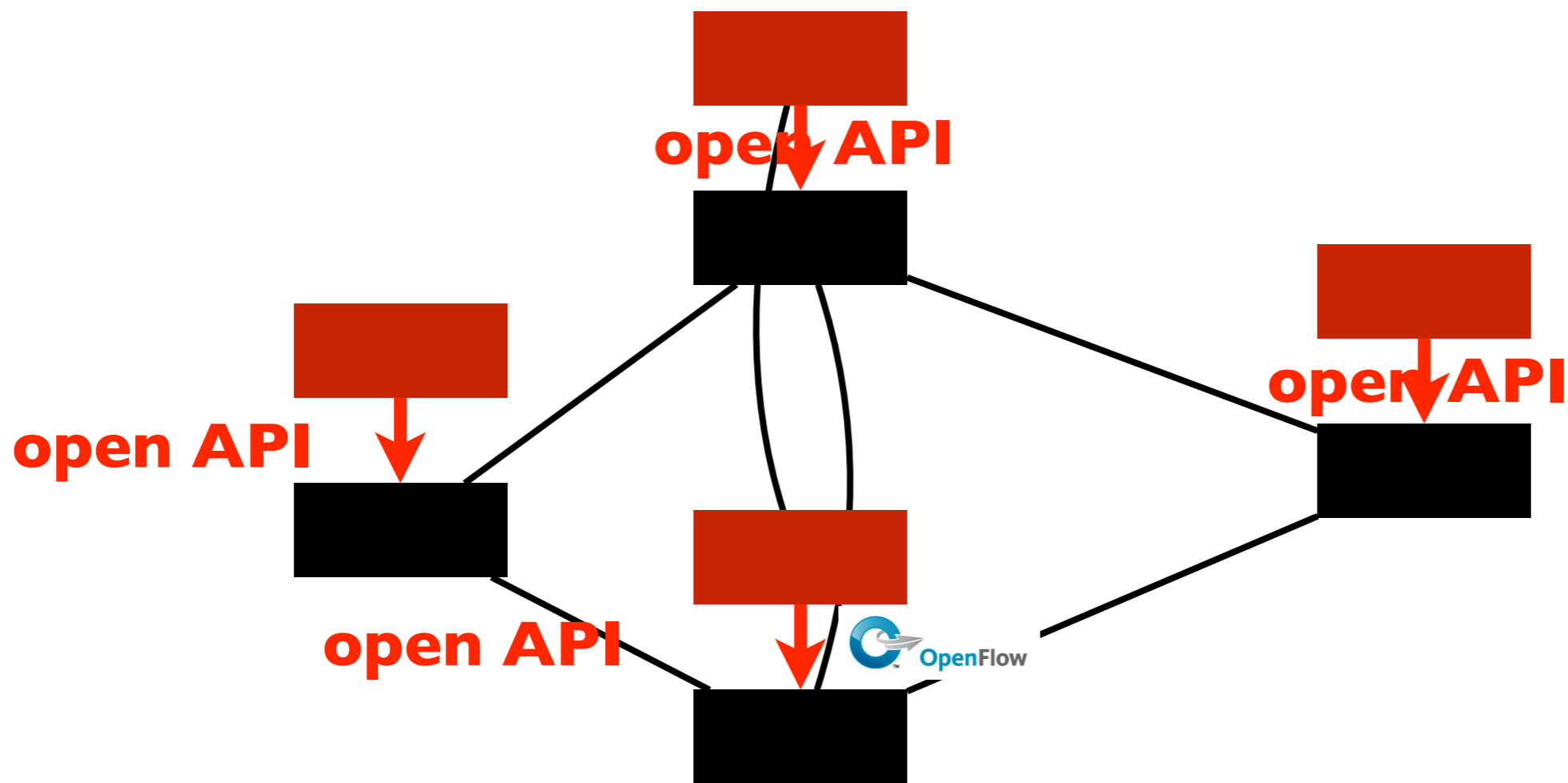
- pattern → action
  - pattern: match packet header bits
  - actions: drop, forward, modify, send to controller
- priority: disambiguate overlapping patterns



1. src=1.2.\*.\* , dest=3.4.5.\* → drop
2. src = \*.\*.\*.\* , dest=3.4.\*.\* → forward(2)
3. src=10.1.2.3, dest=\*.\*.\*.\* → send to controller

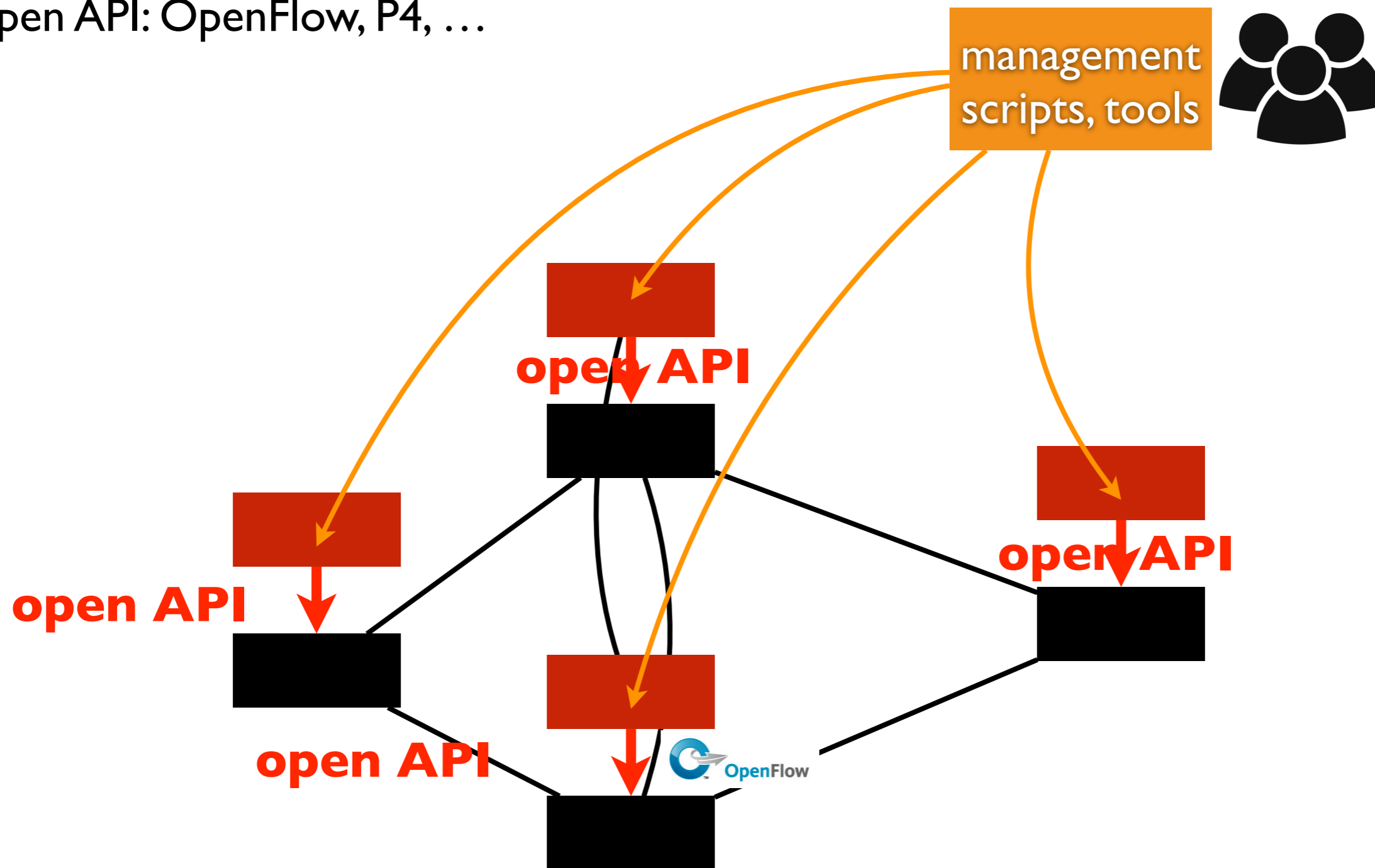
# open dataplane interface

open API: OpenFlow, P4, ...



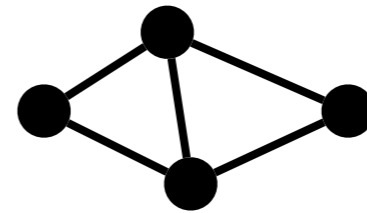
# open dataplane interface

open API: OpenFlow, P4, ...

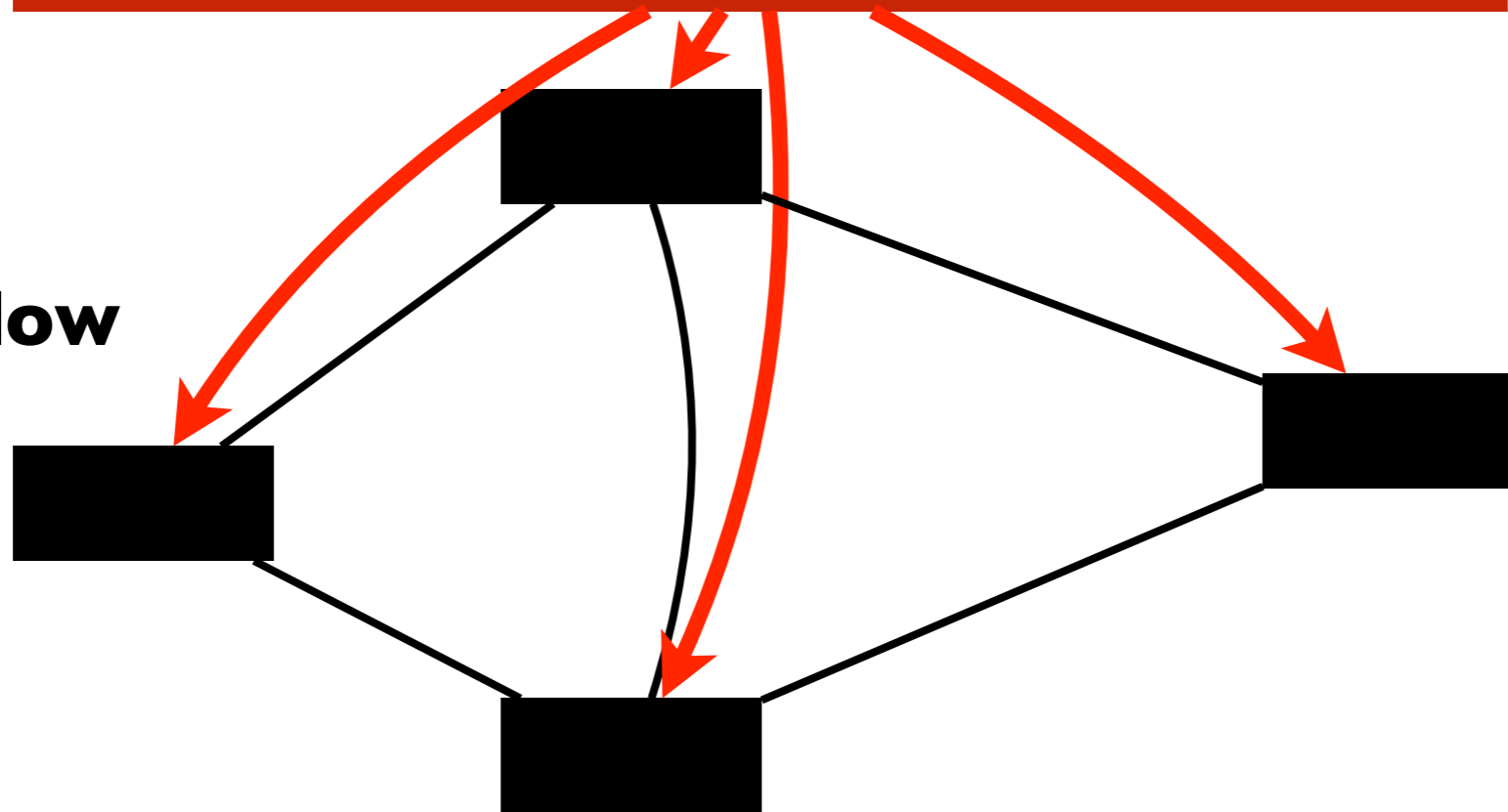


# (logically) centralized controller

**global network view**

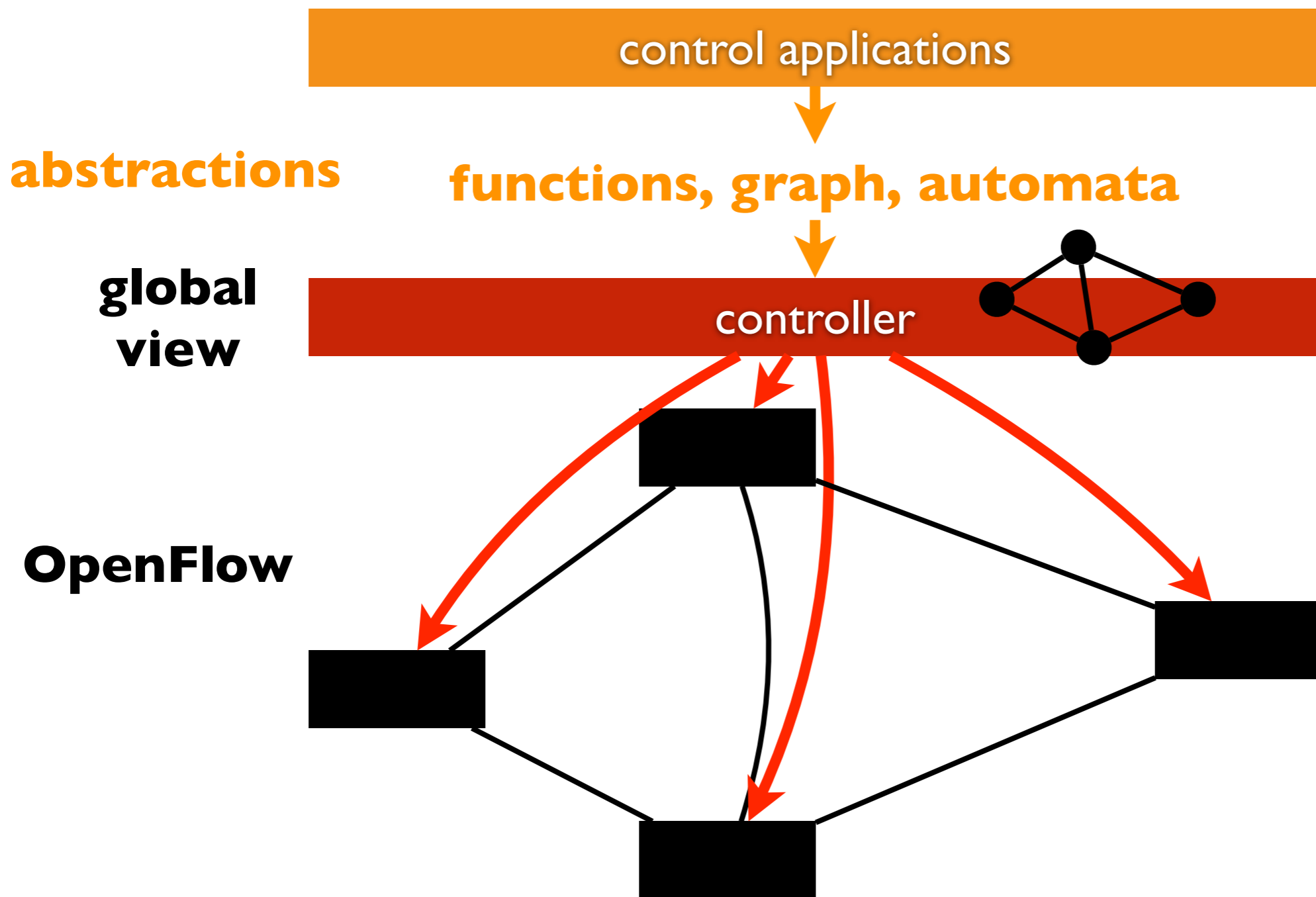


**OpenFlow**

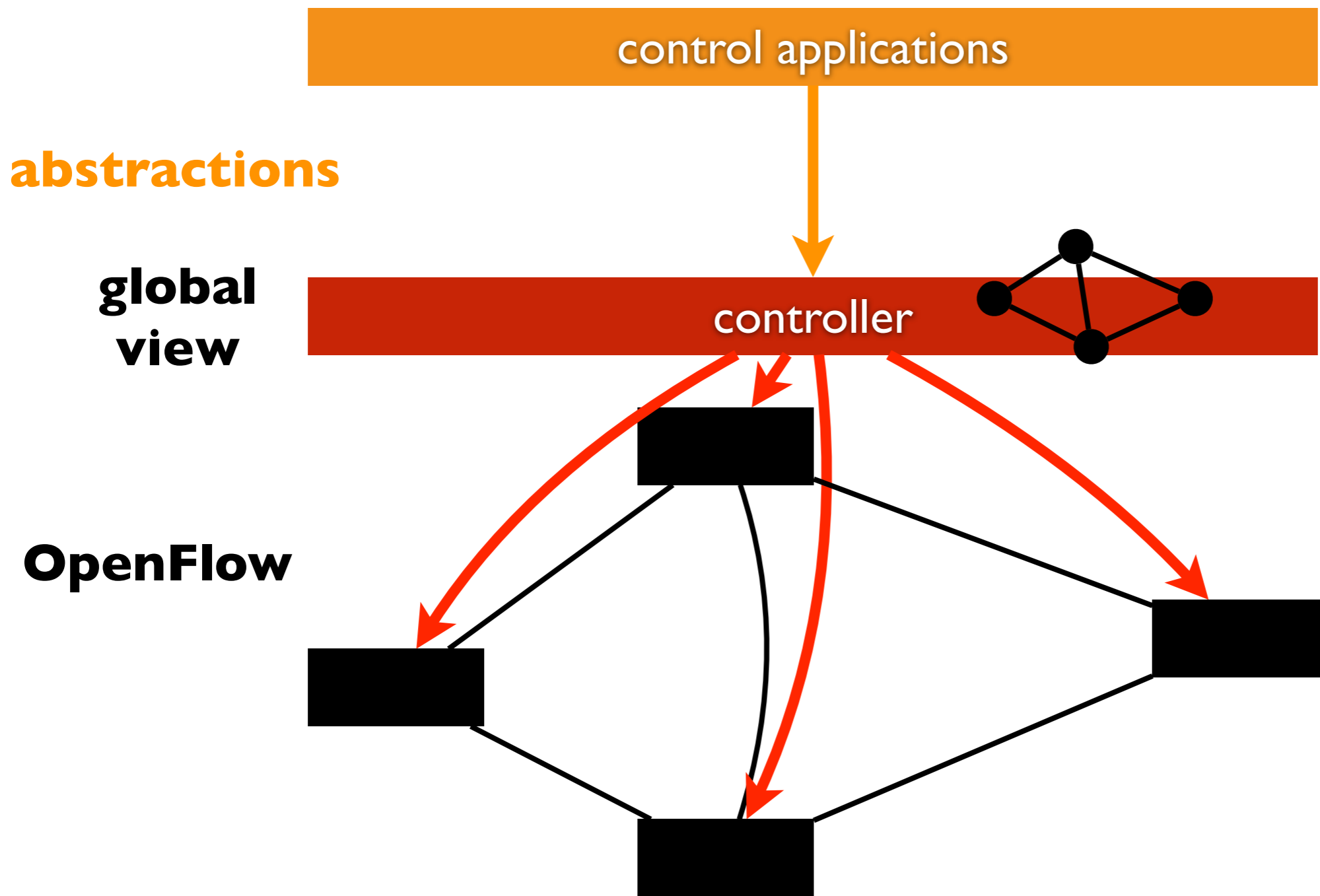




# higher-level abstractions



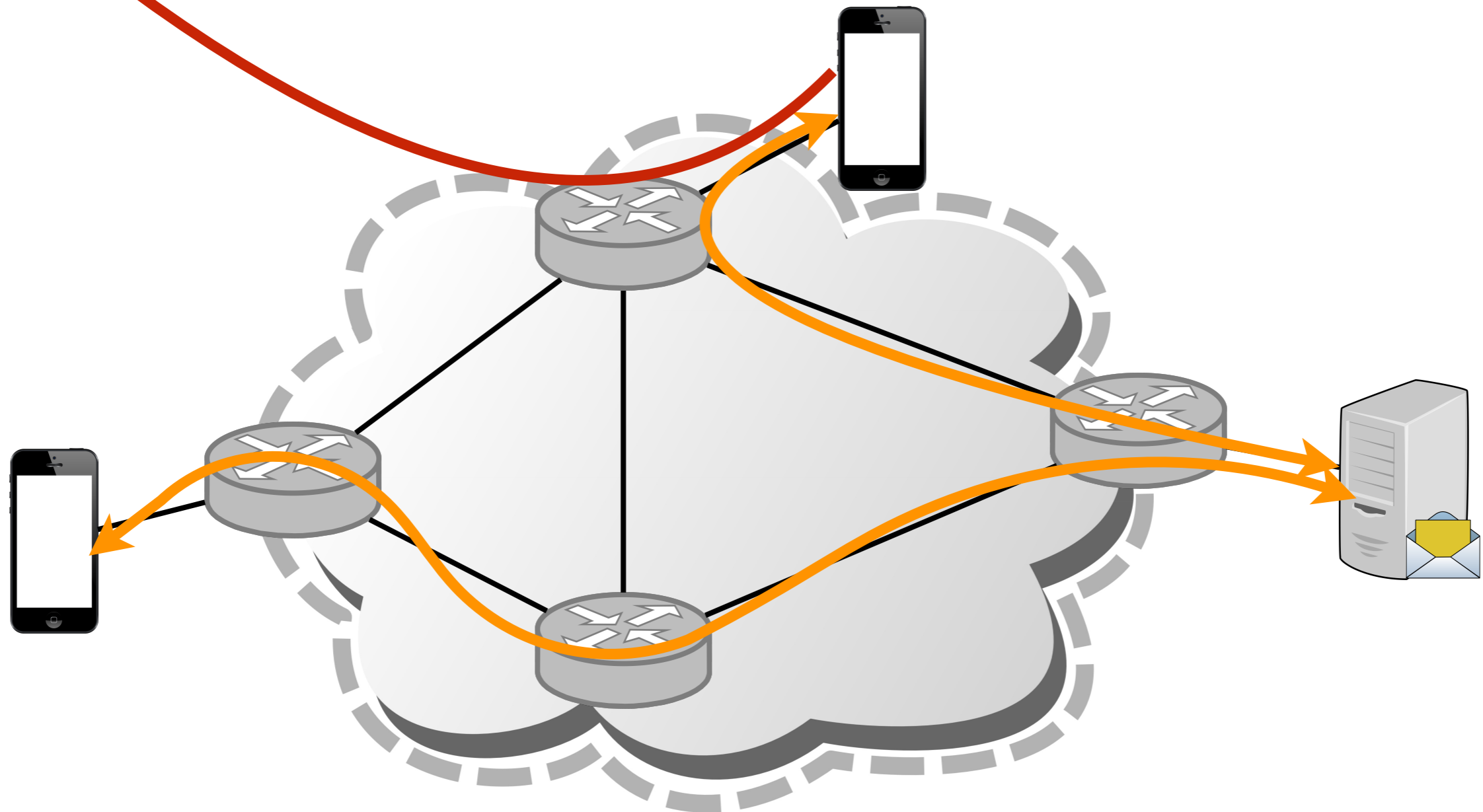
# protocols → applications



# application: seamless mobility

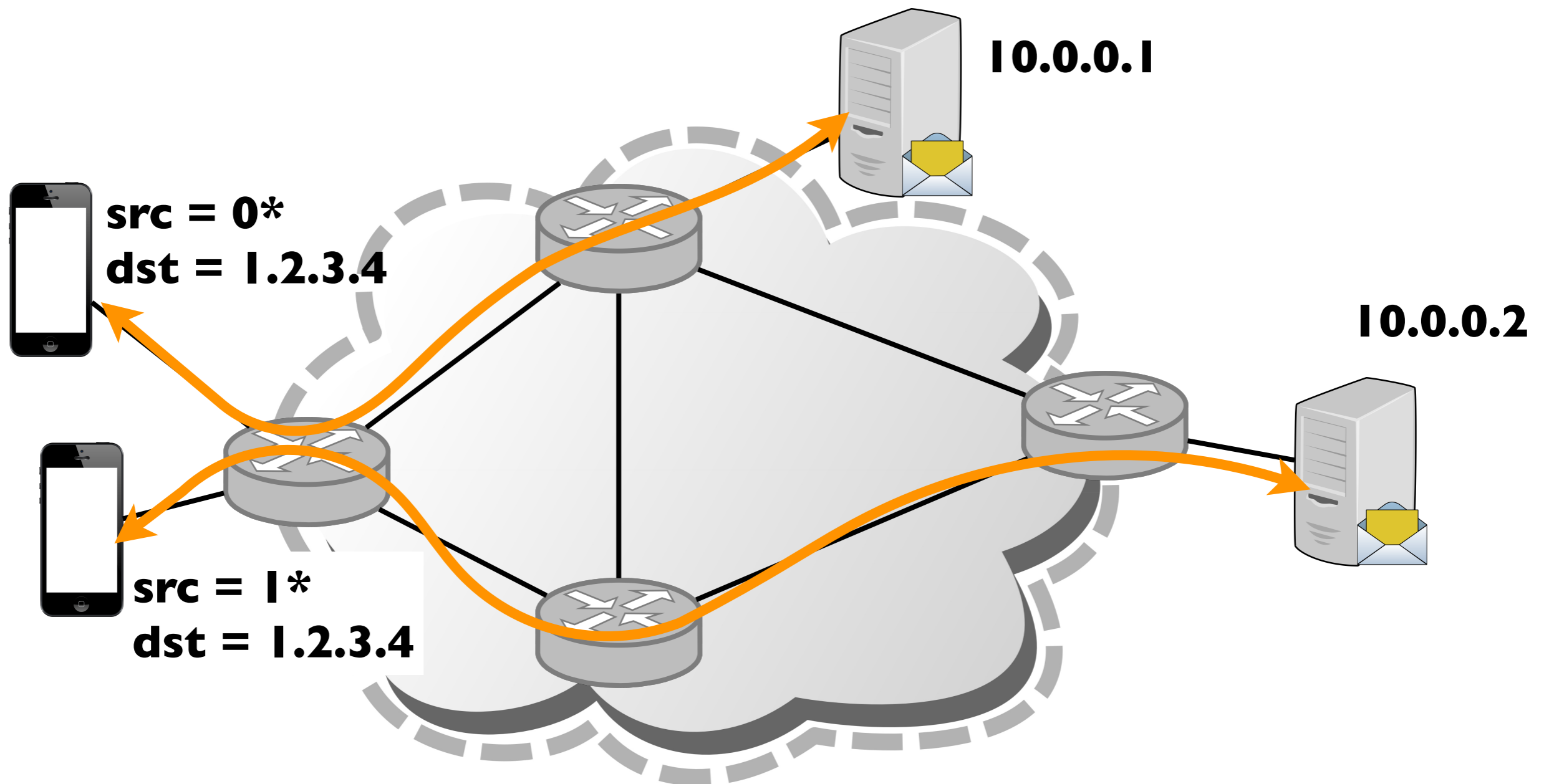
app

- See host sending traffic at new location
- Modify rules to reroute the traffic

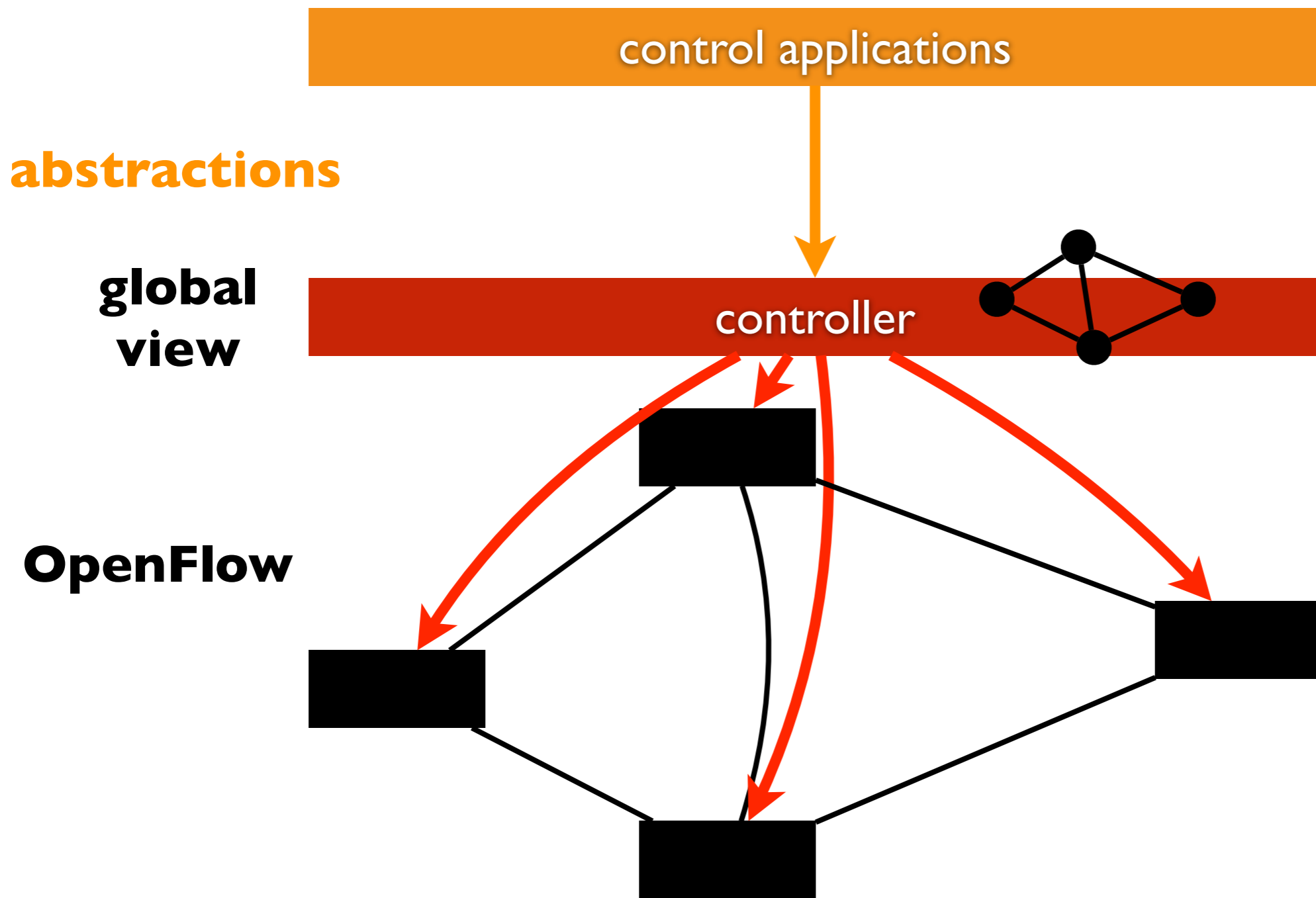


# application: server load balancing

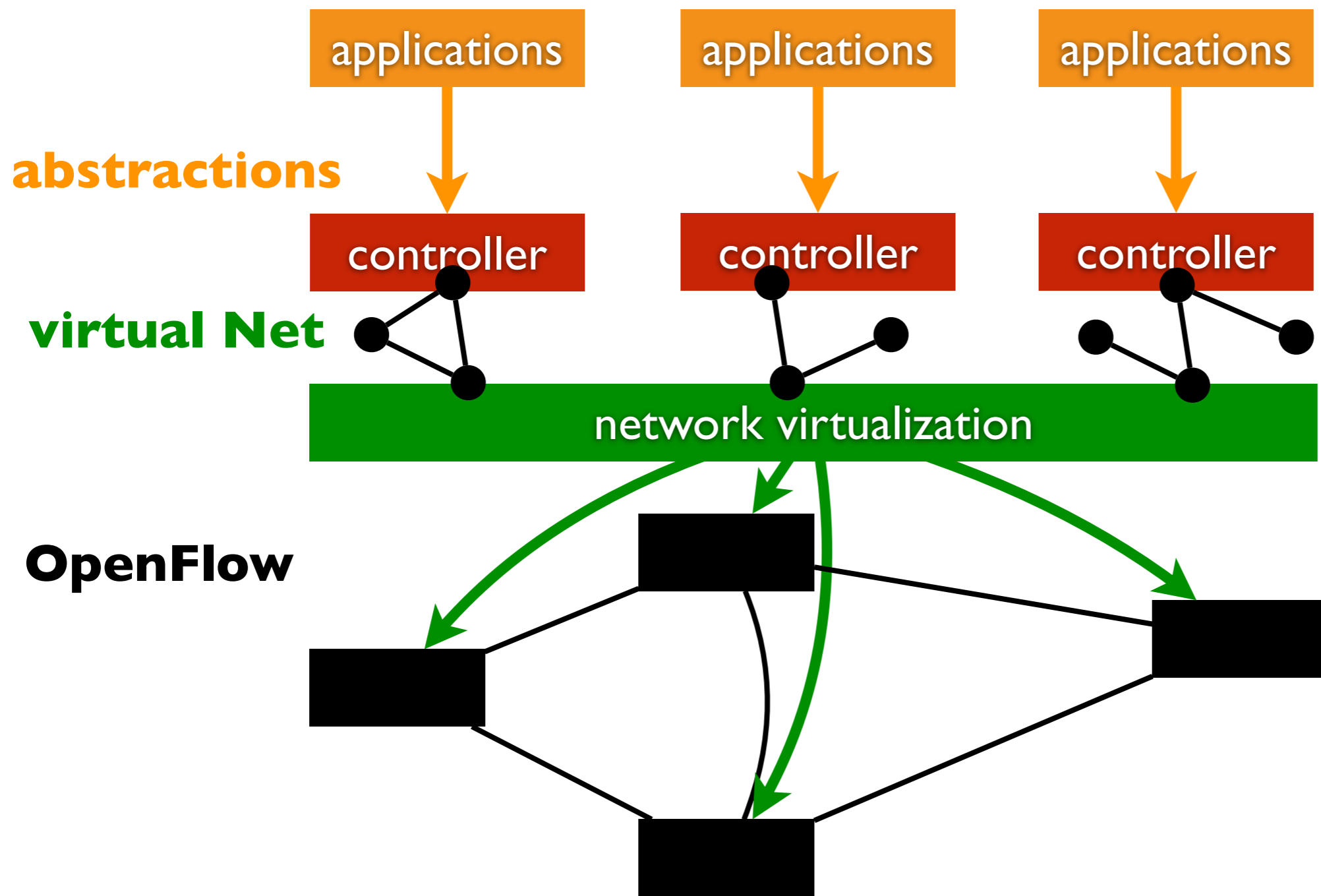
- pre-install load-balancing policy
- split traffic based on source IP



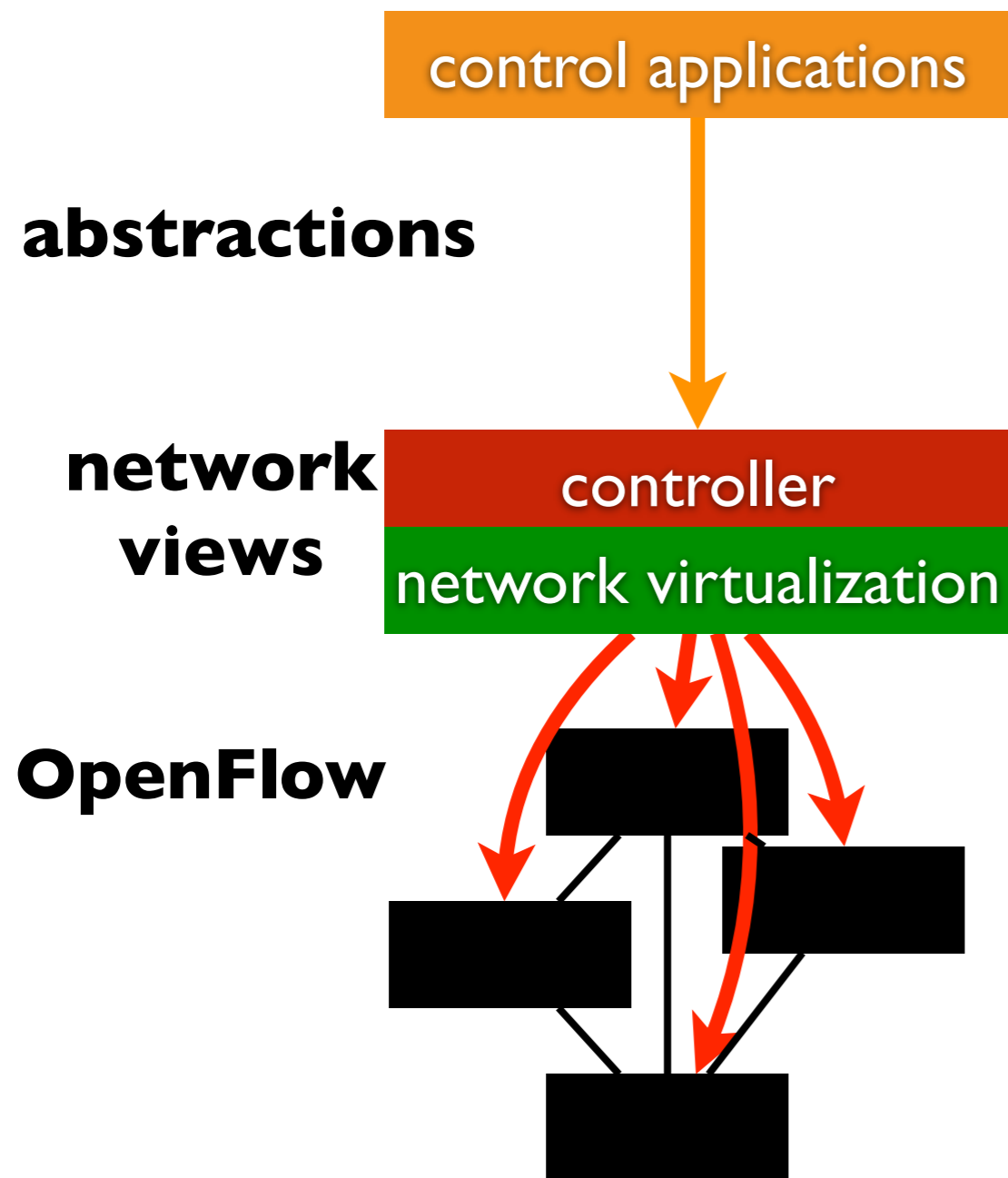
# protocols → applications



# network virtualization



# recap: SDN technologies



supporting technologies

- central network control
- programmability
- network virtualization

benefits

- simplified operation with direct, network-wide control
- cost reduction with open hardware



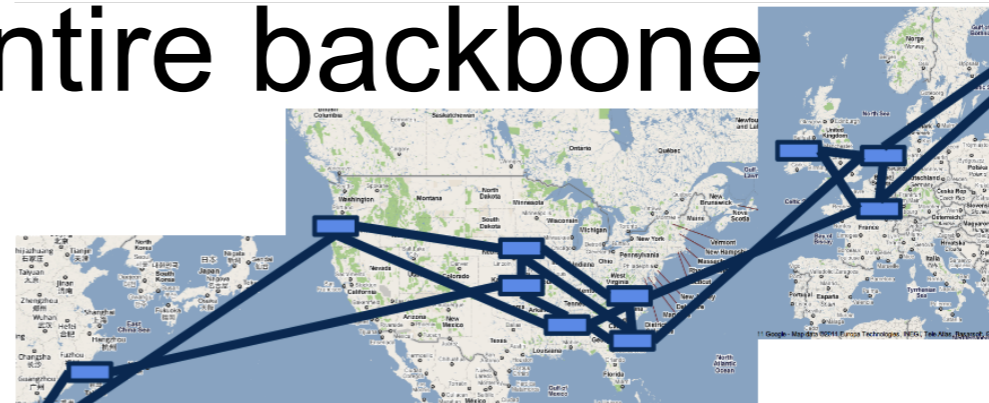
# a major trend in networking



OPEN NETWORKING  
FOUNDATION



Entire backbone



runs on SDN

Bought for  $\$1.2 \times 10^9$   
(mostly cash)

The logo for Nicira, featuring the word 'nicira' in a bold, black sans-serif font, with several vertical bars of various colors (green, orange, red, blue) above it.

nicira

# an opportunity to rethink

## disciplines

- how should future networks be?
  - designed, programmed, operated, managed ...
- what are the right abstractions?
  - single task, integration, updates ...