5590, fall 2016
software defined networking

anduo wang, Temple University

TTLMAN 402, R 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/

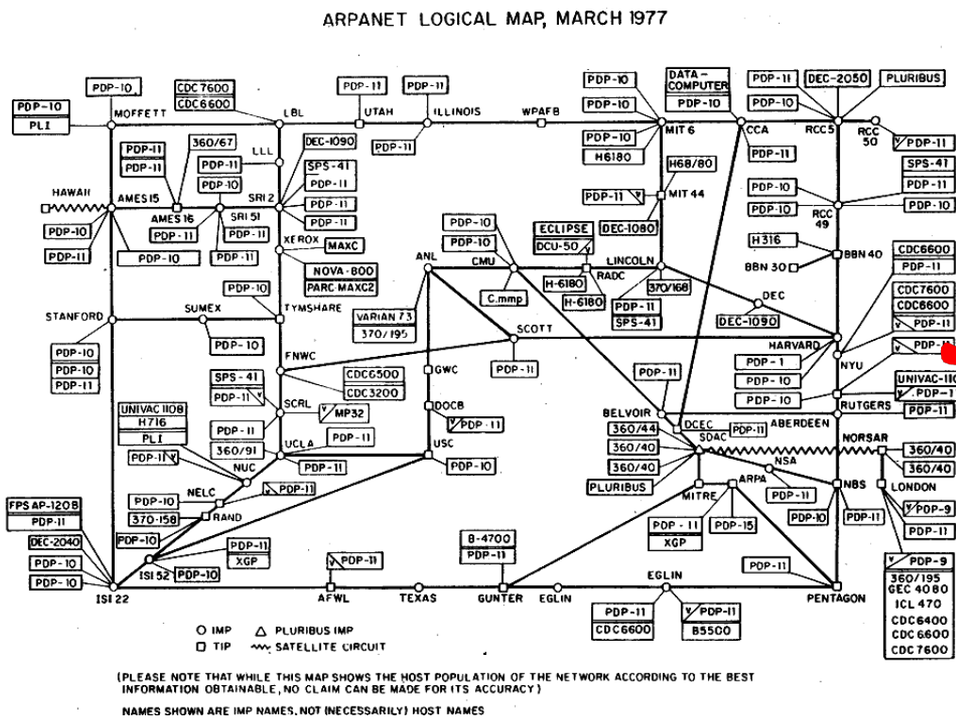
Nick Feamster http://noise.gatech.edu/classes/cs8803sdn/fall2014/

the state of networking

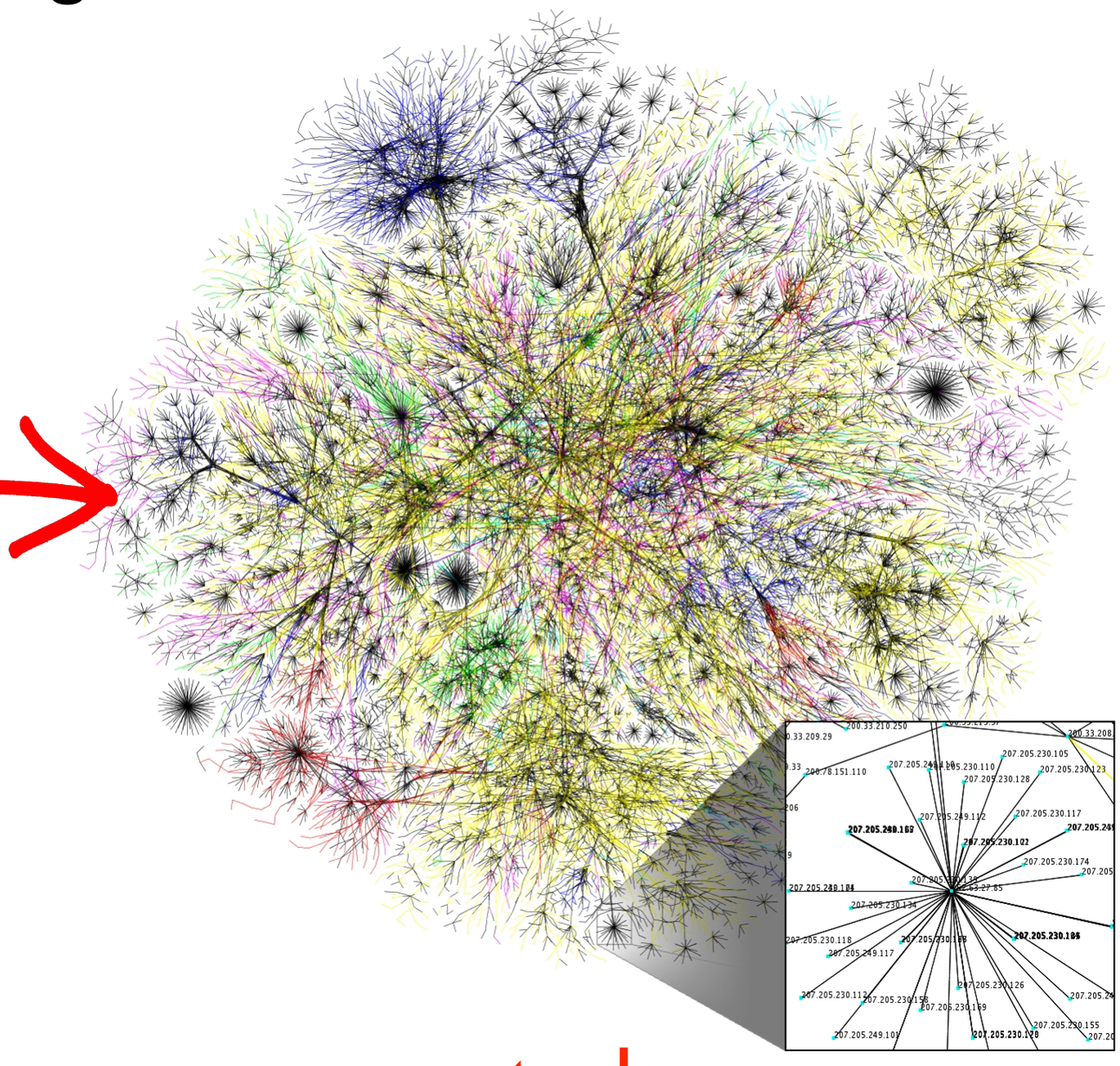
the Internet: a wonderful success

a remarkable story

- from research experiment to global infrastructure



ARPANET, 1977



today

source: https://en.wikipedia.org/wiki/Internet

the Internet: a wonderful success

innovations for everyday life

- Web, P2P, VoIP, social networking …

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- 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/YHeyuD89n1Y

networking needs …

break vendor lock-in

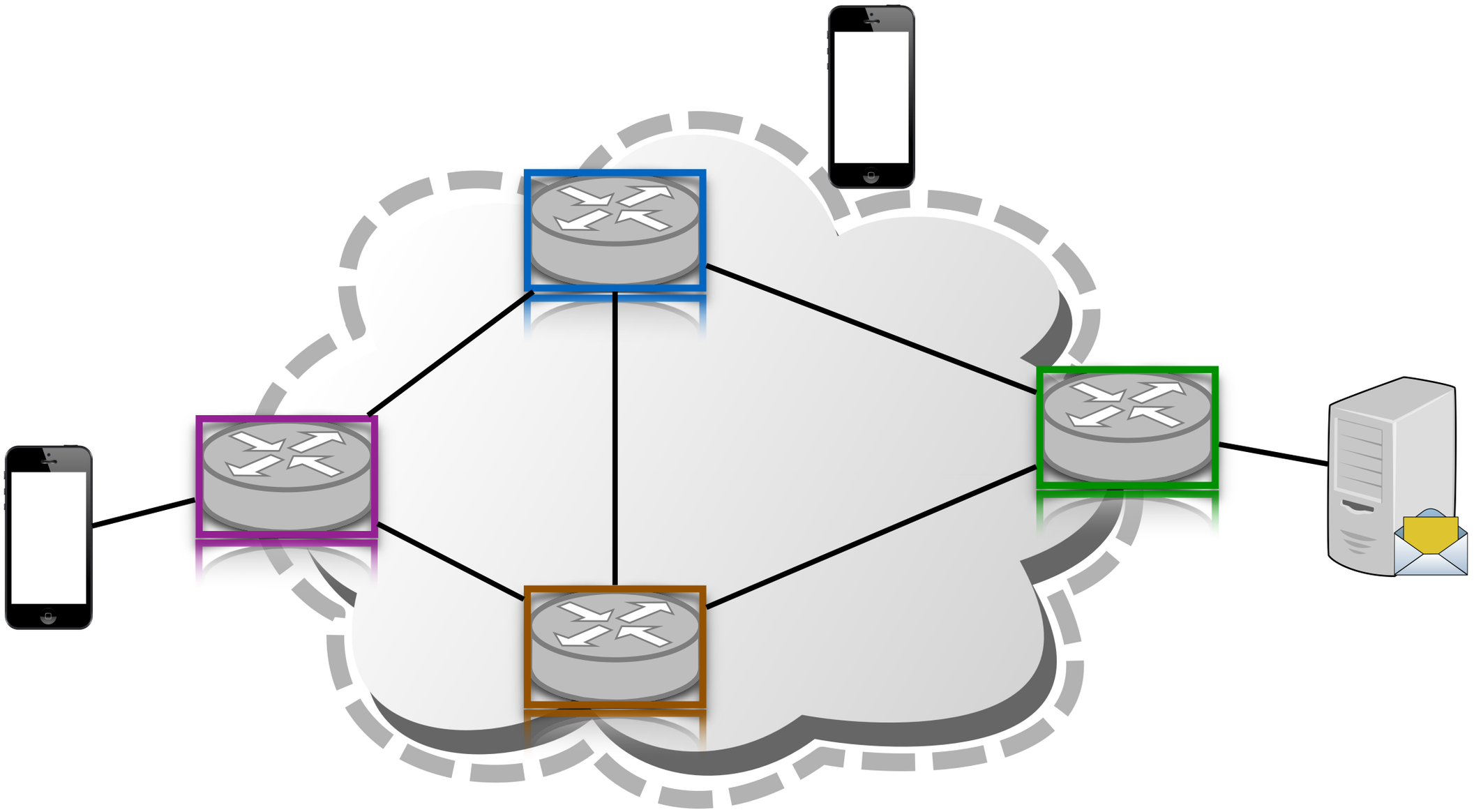
- freedom from suppliers
- freedom from low-level box by box configuration
- freedom of adding new services

introduce disciplines

- systematic principles that guide networking practice

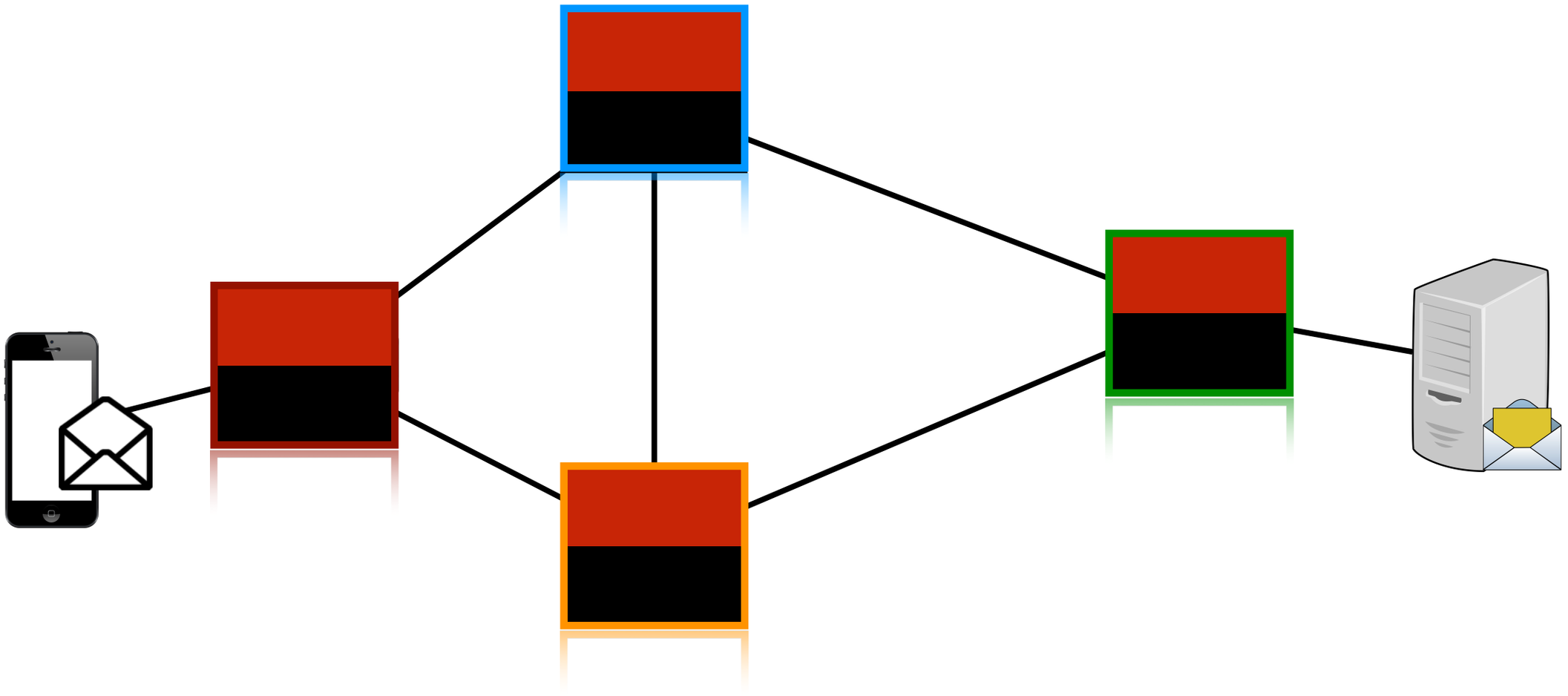
software defined networking (SDN)

software defined networks



software defined networks

control plane: distribute algorithms
data plane: packet processing



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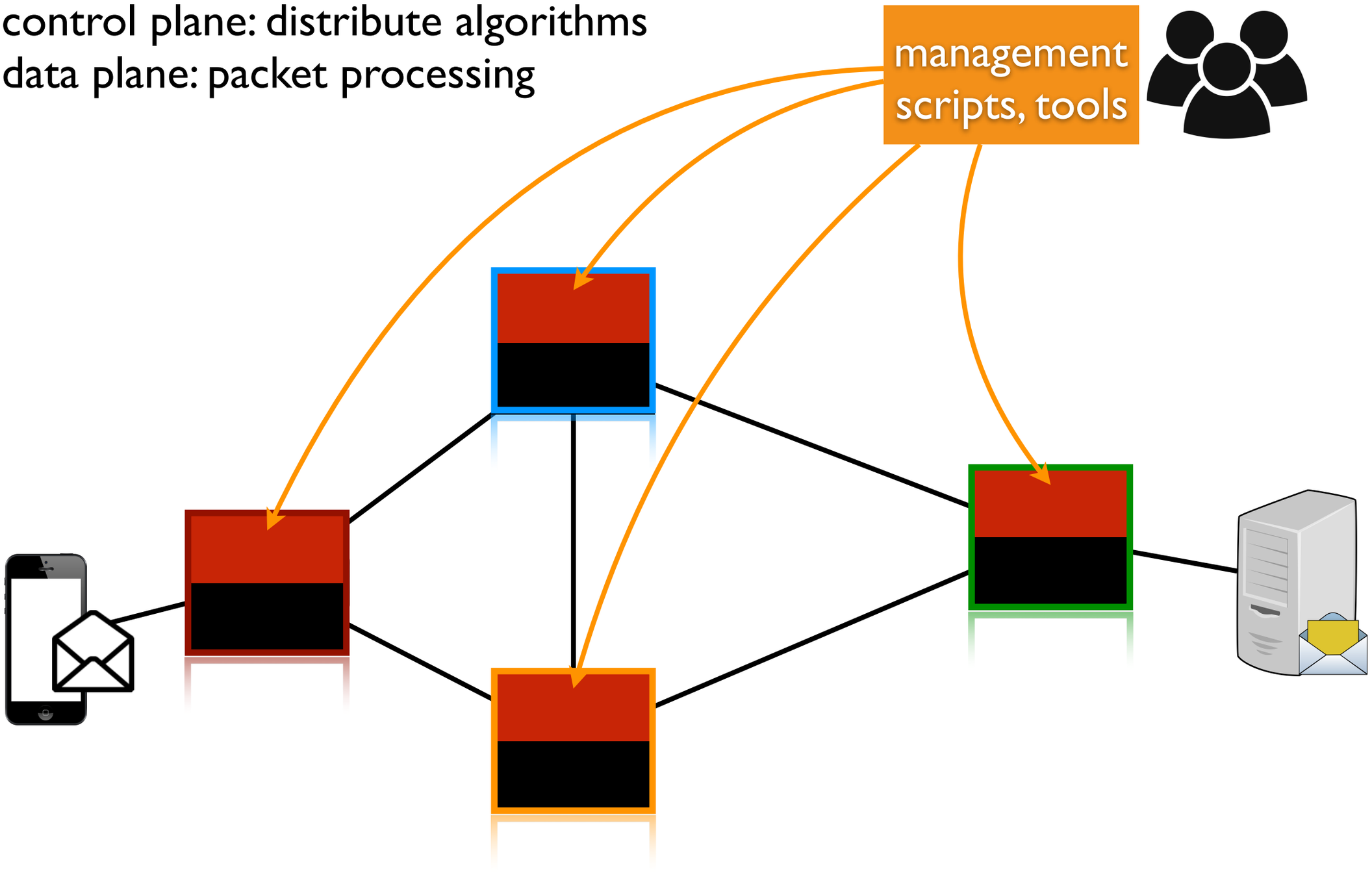

software defined networks

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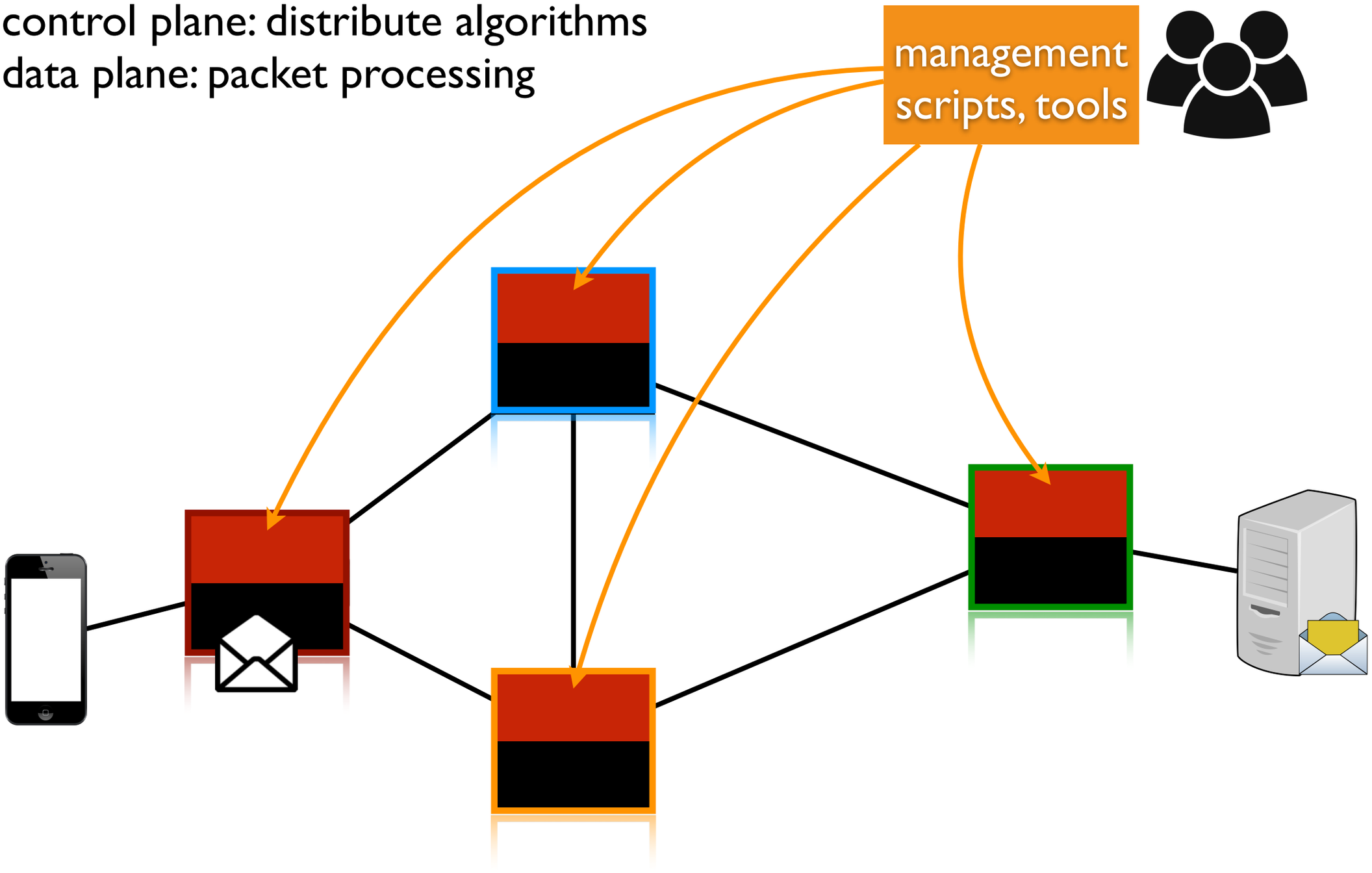
data plane: packet processing



software defined networks

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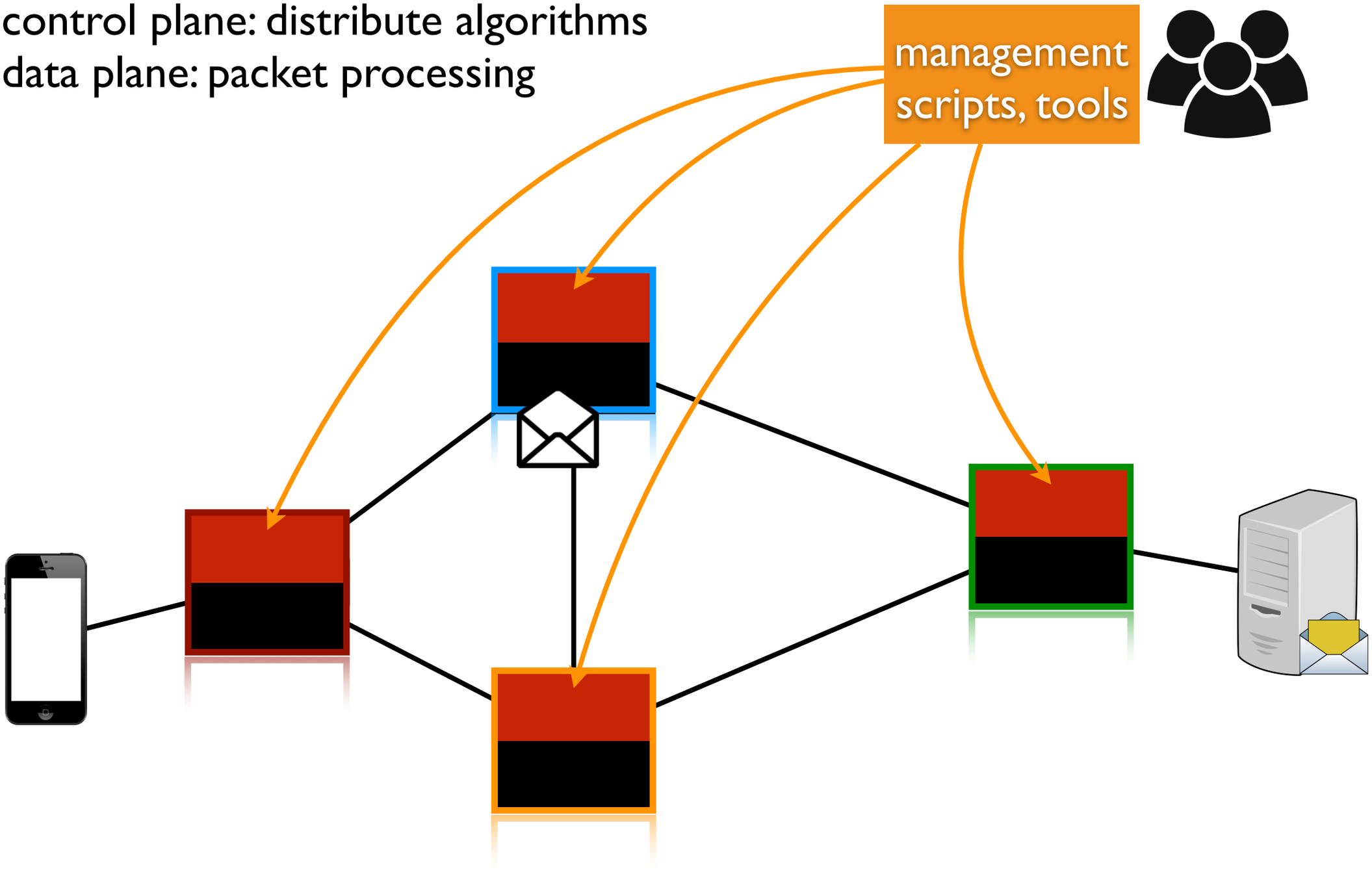

software defined networks

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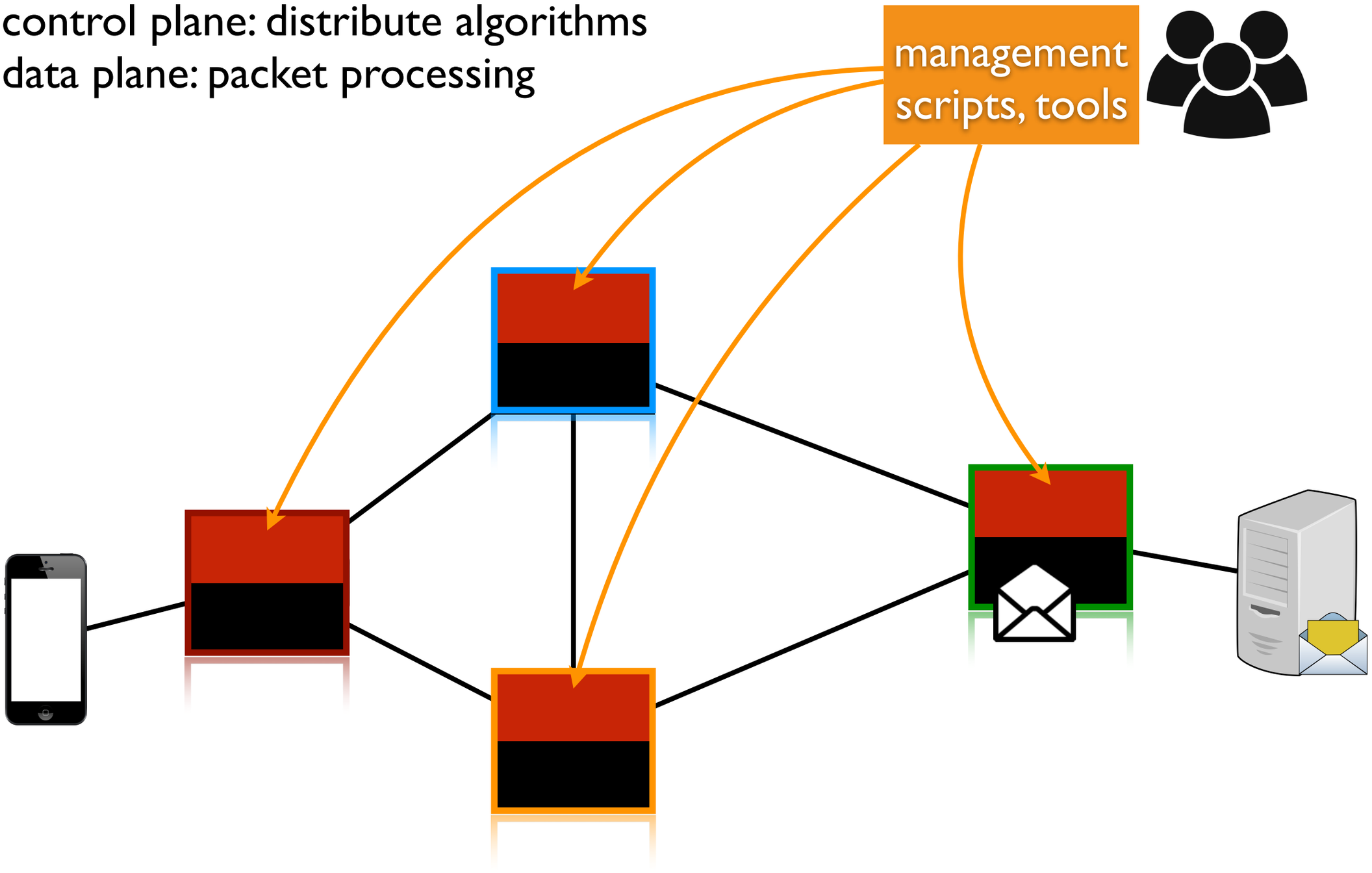

software defined networks

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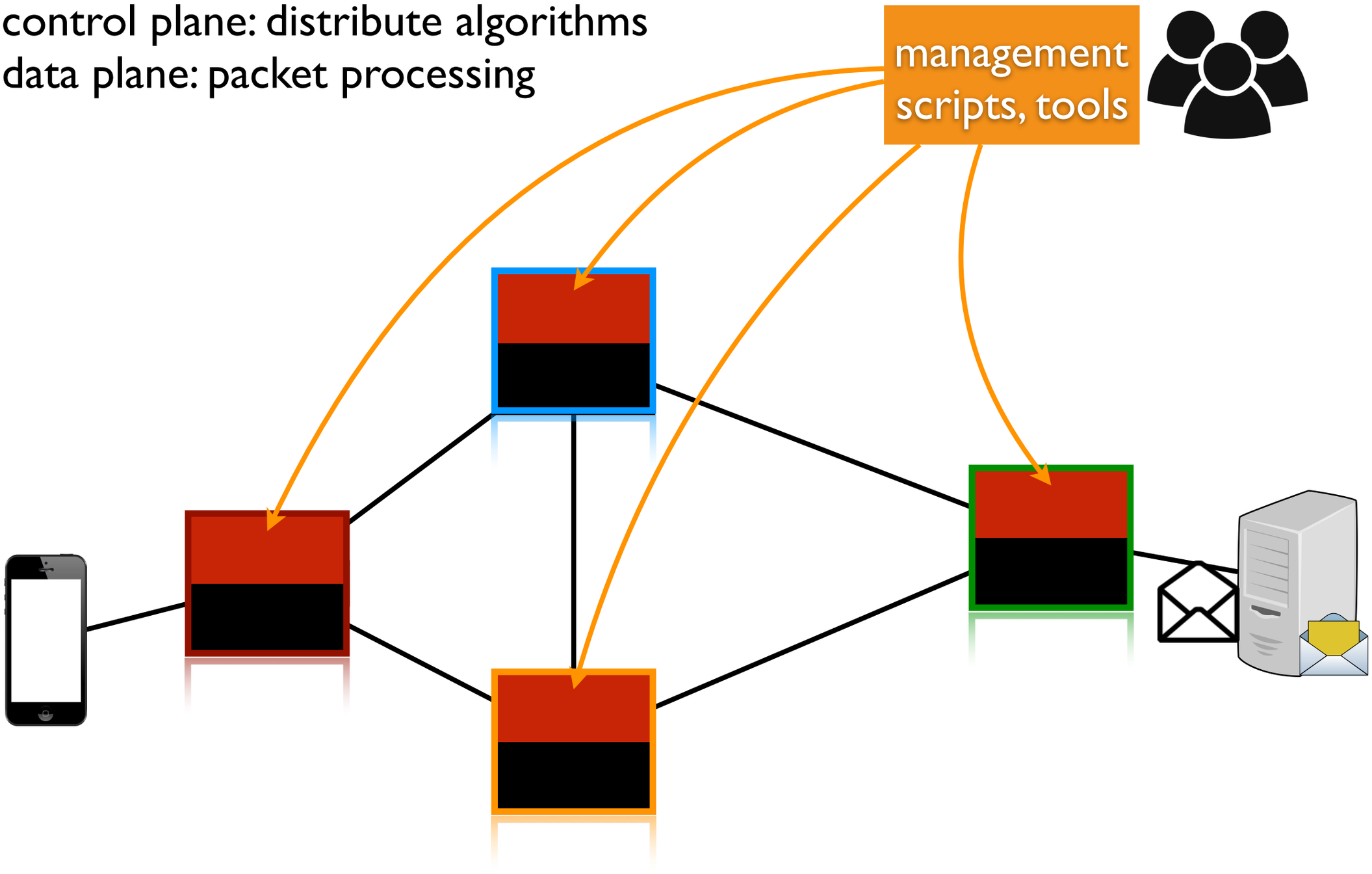
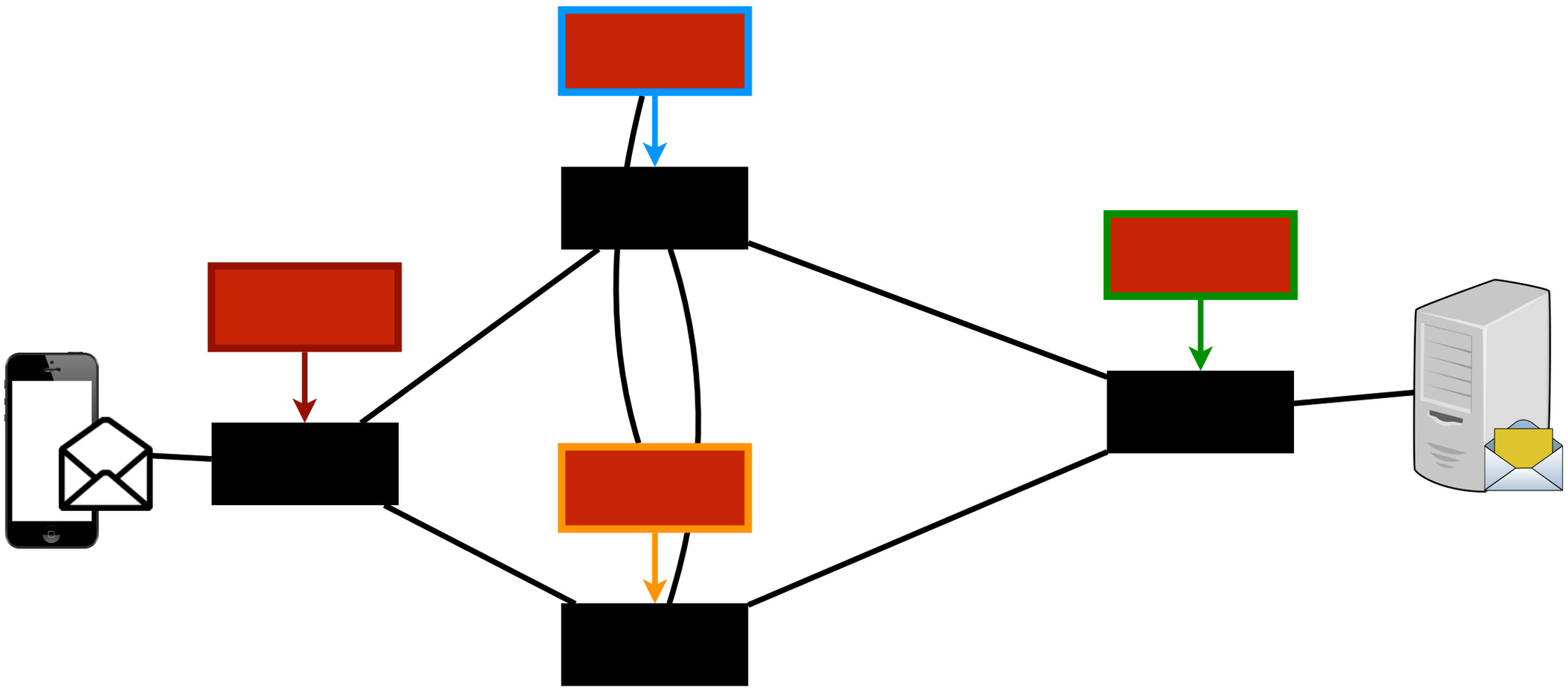


software defined networks

decouple control and data planes



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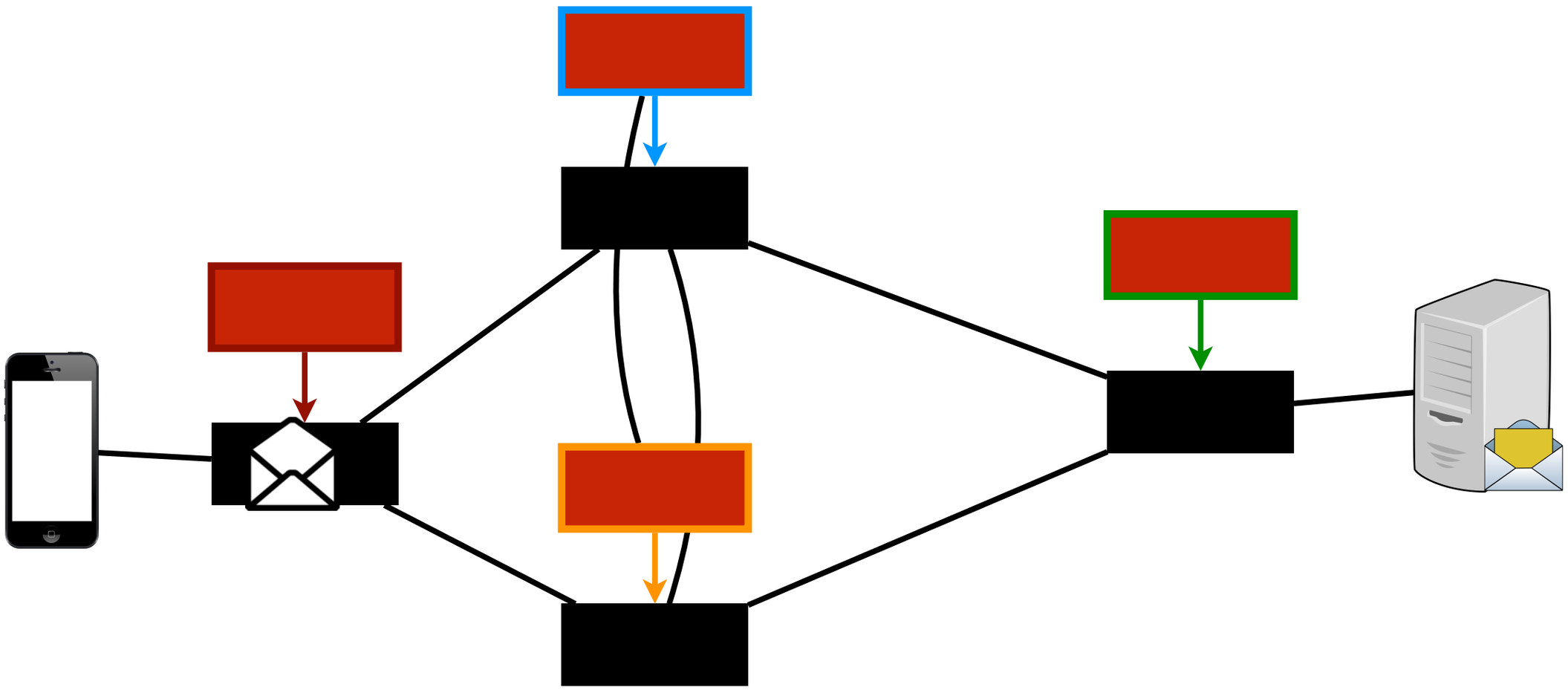

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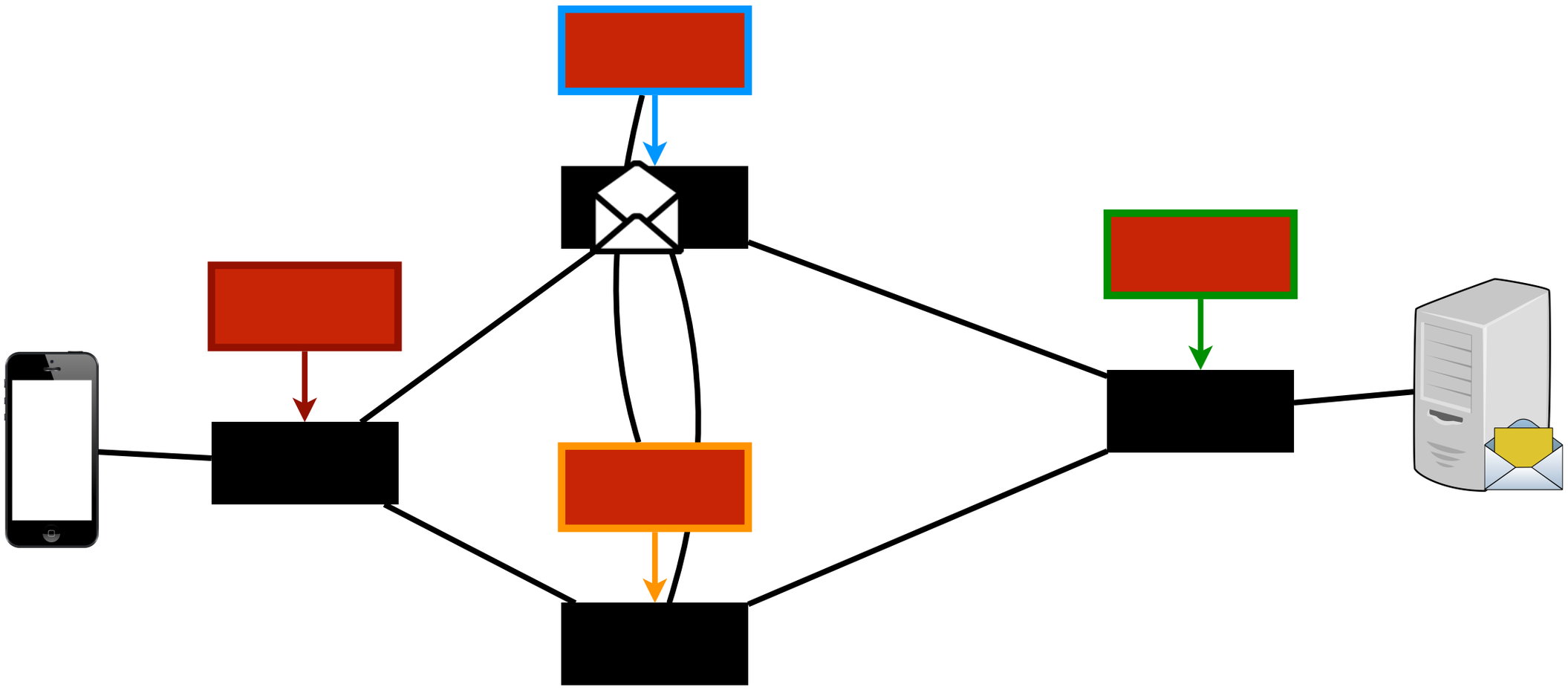

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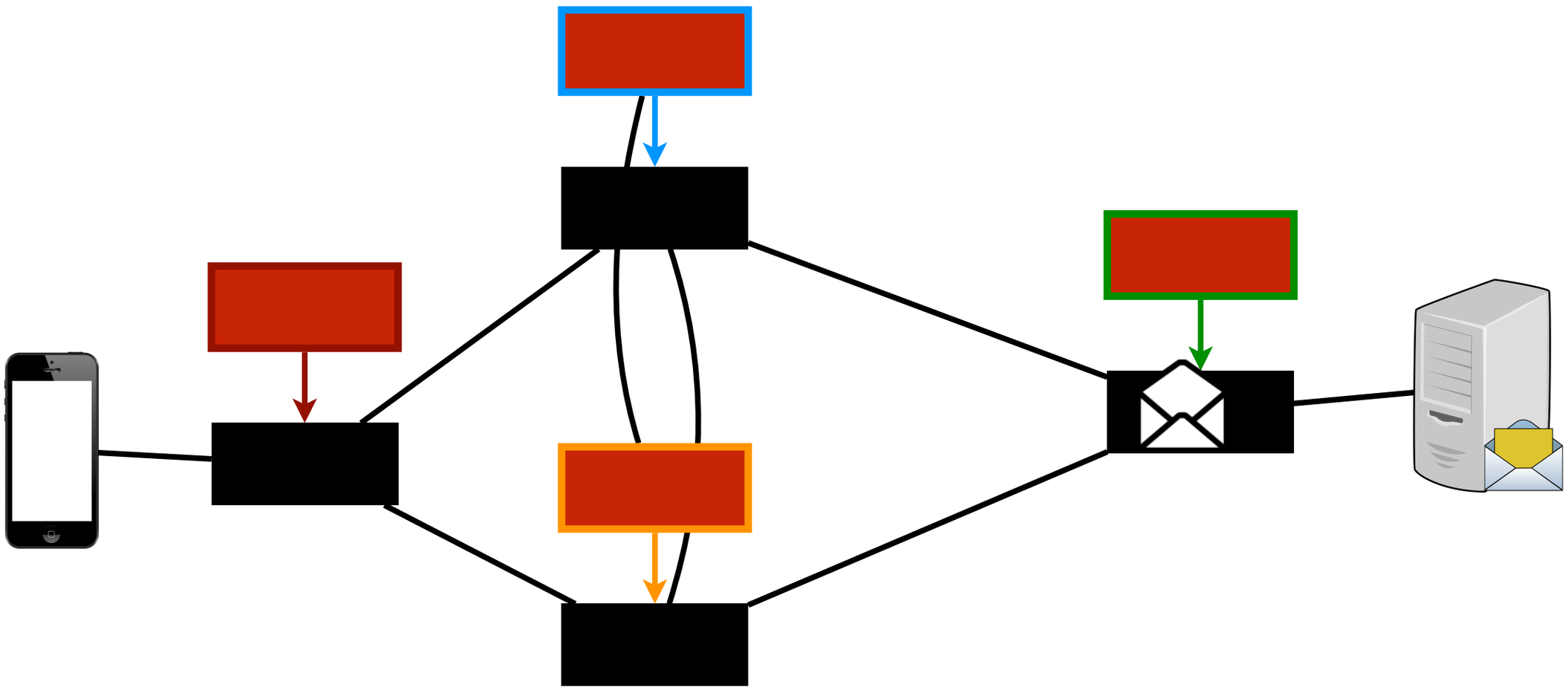

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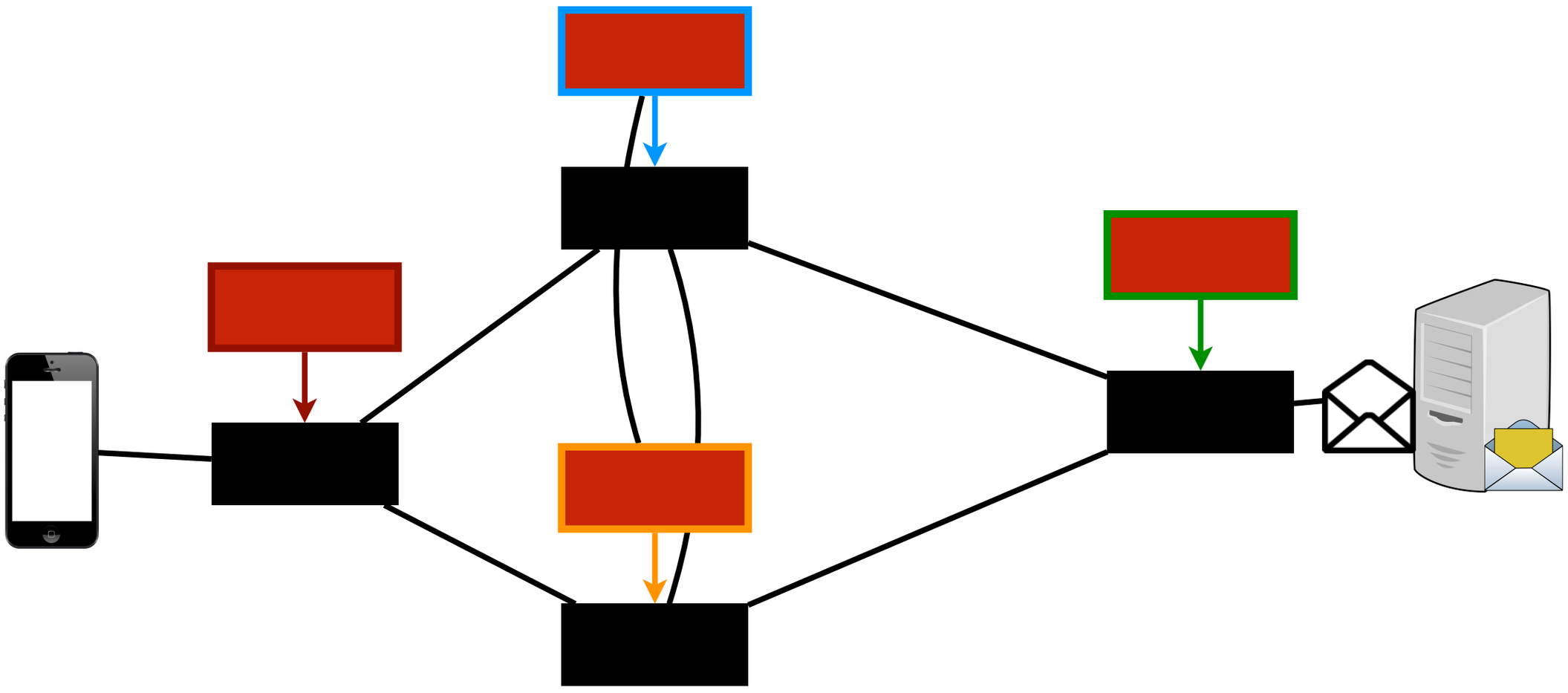

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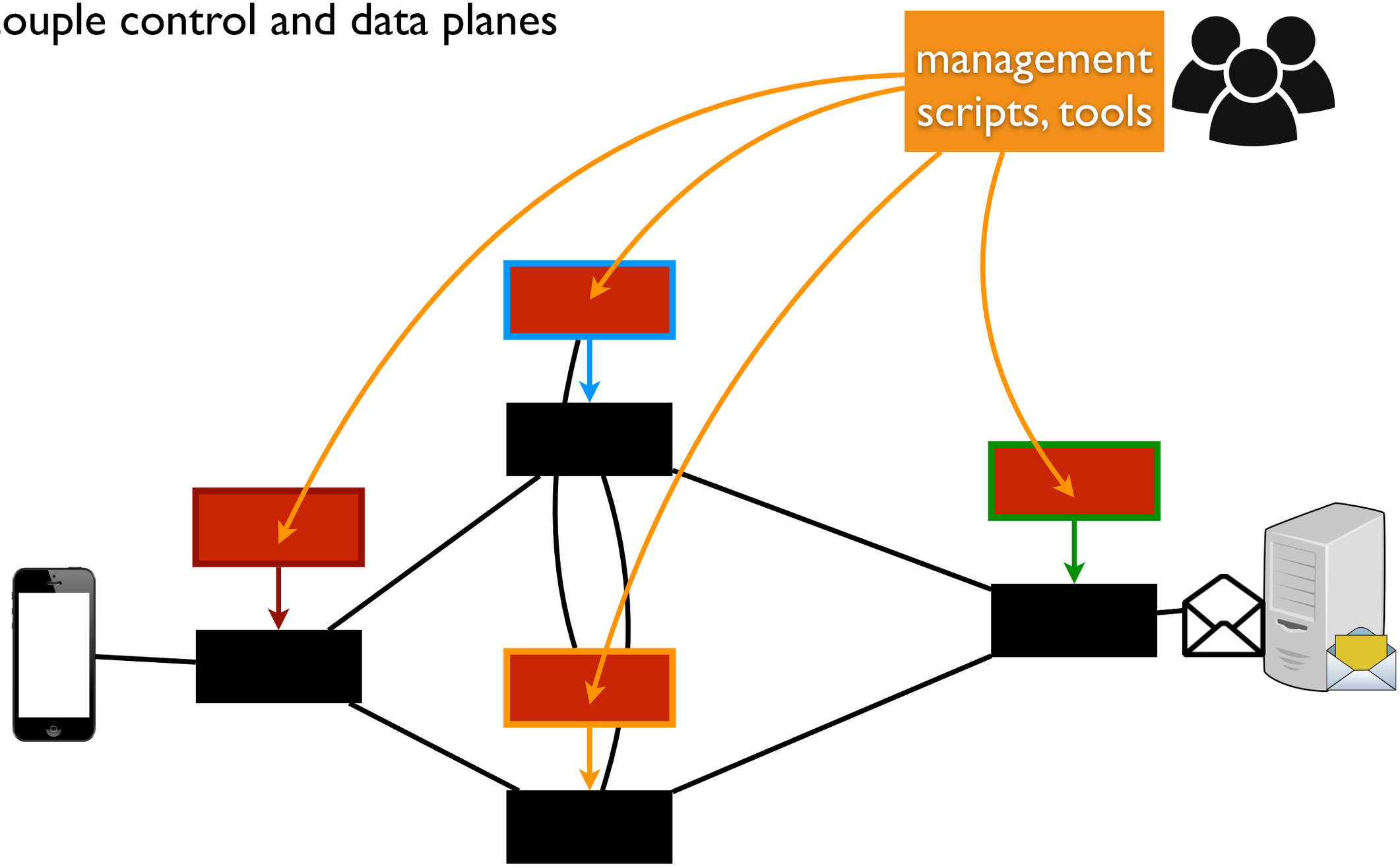
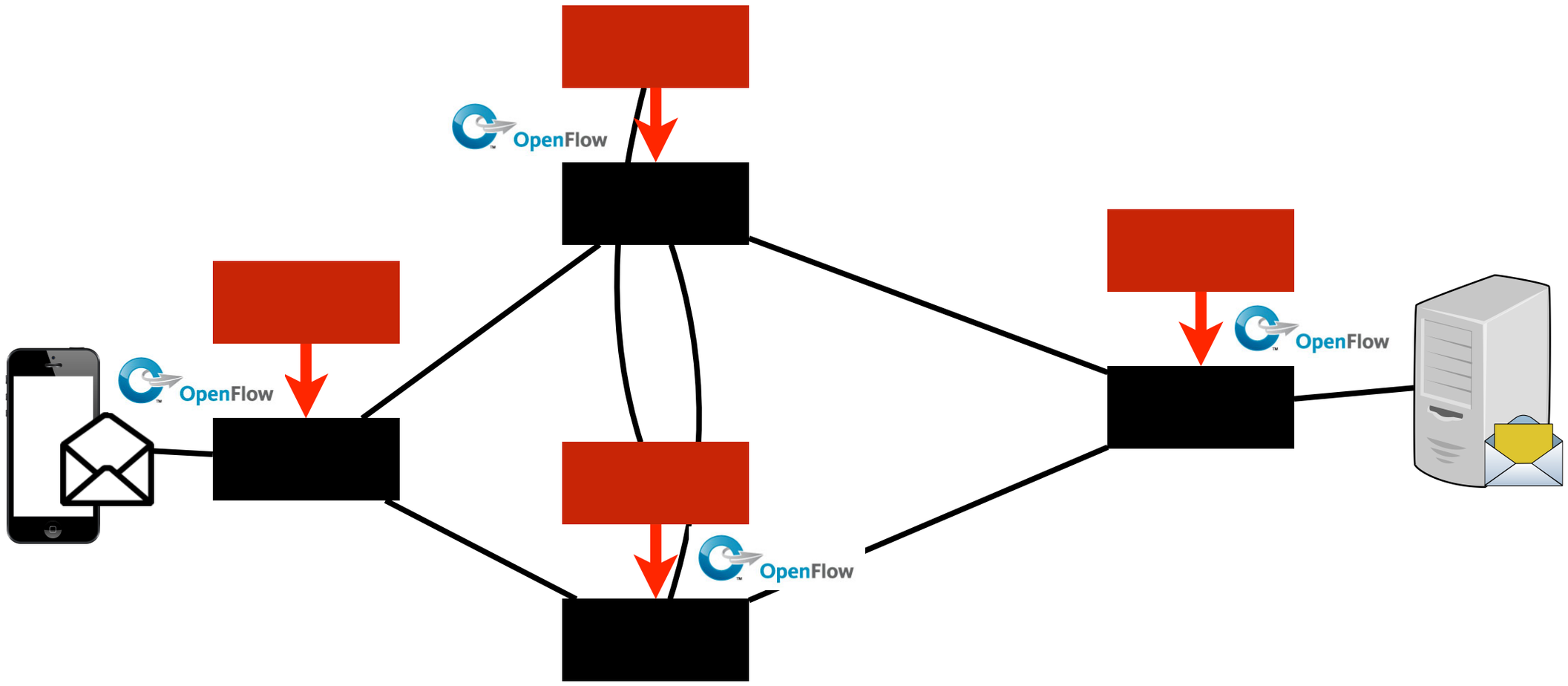


open dataplane API

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



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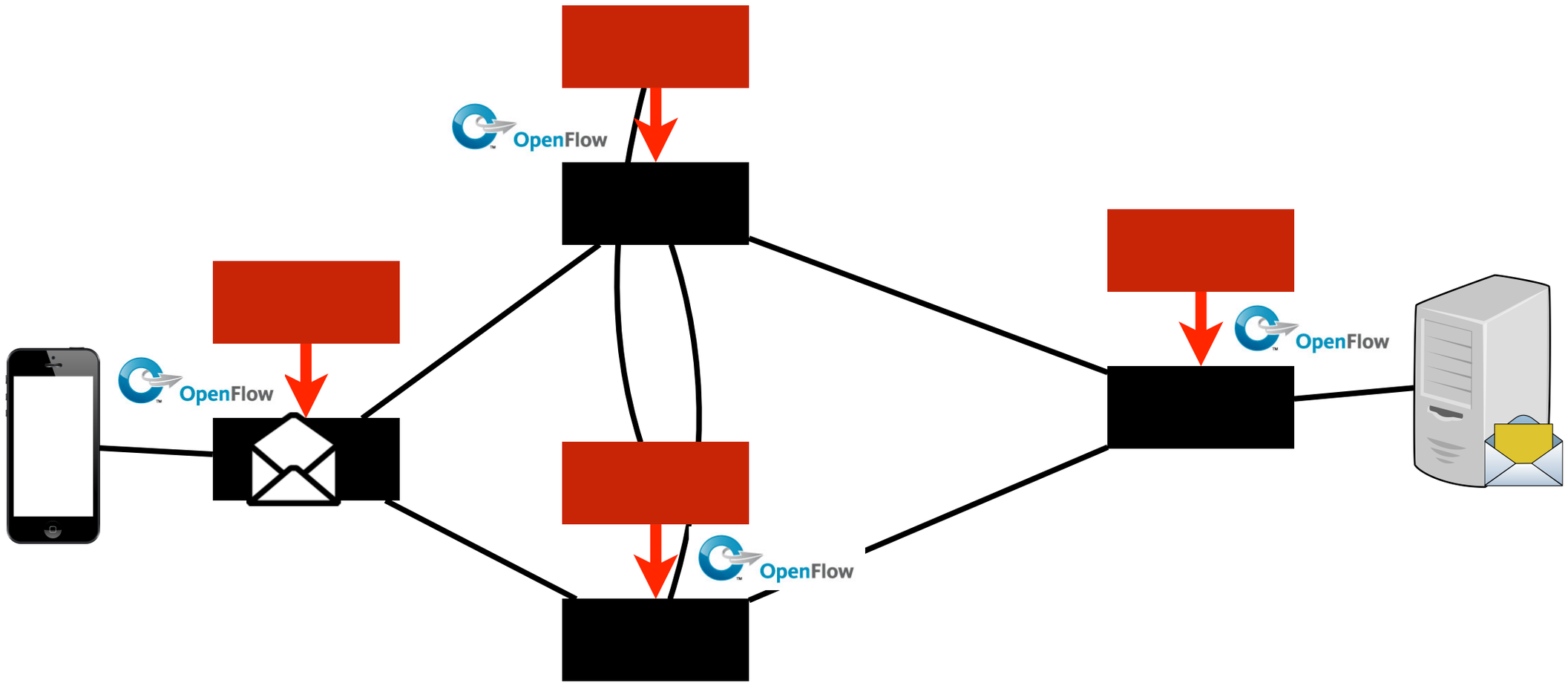

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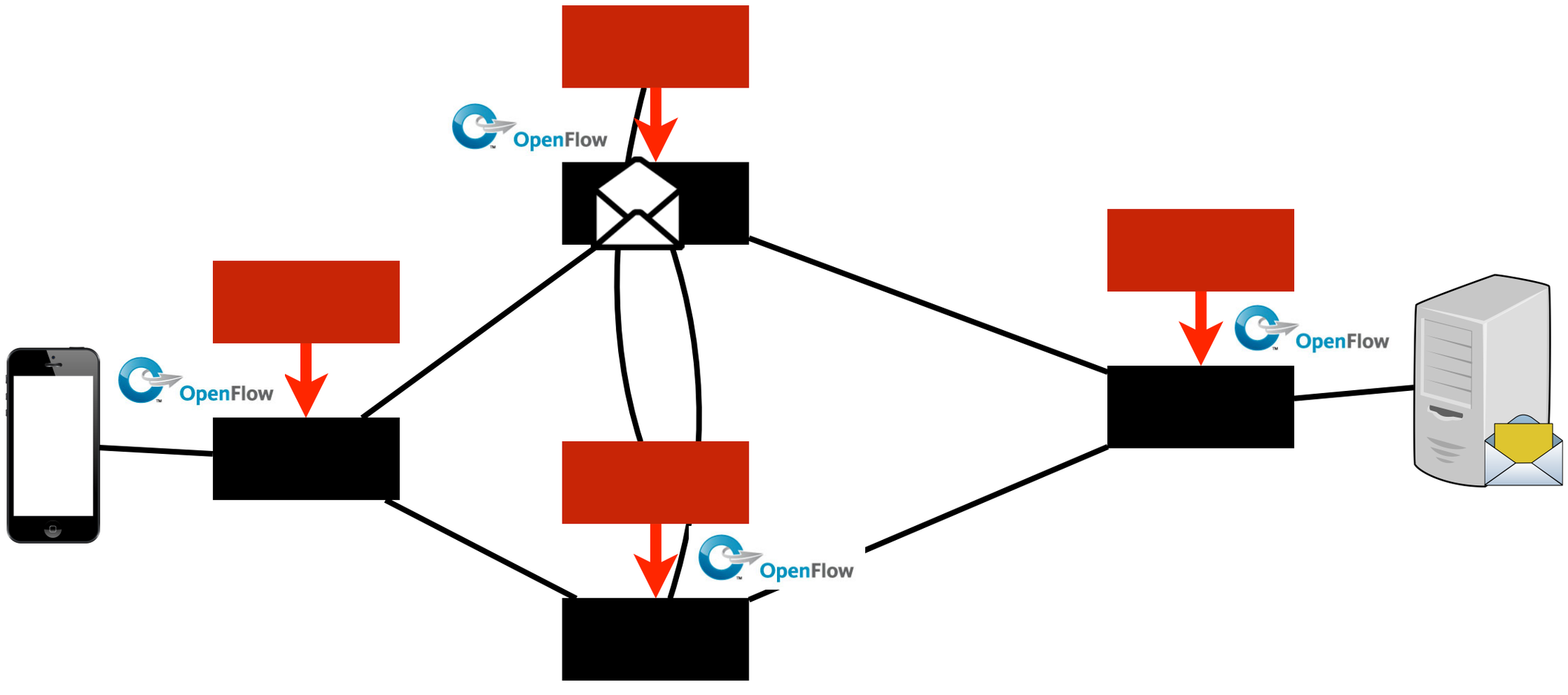

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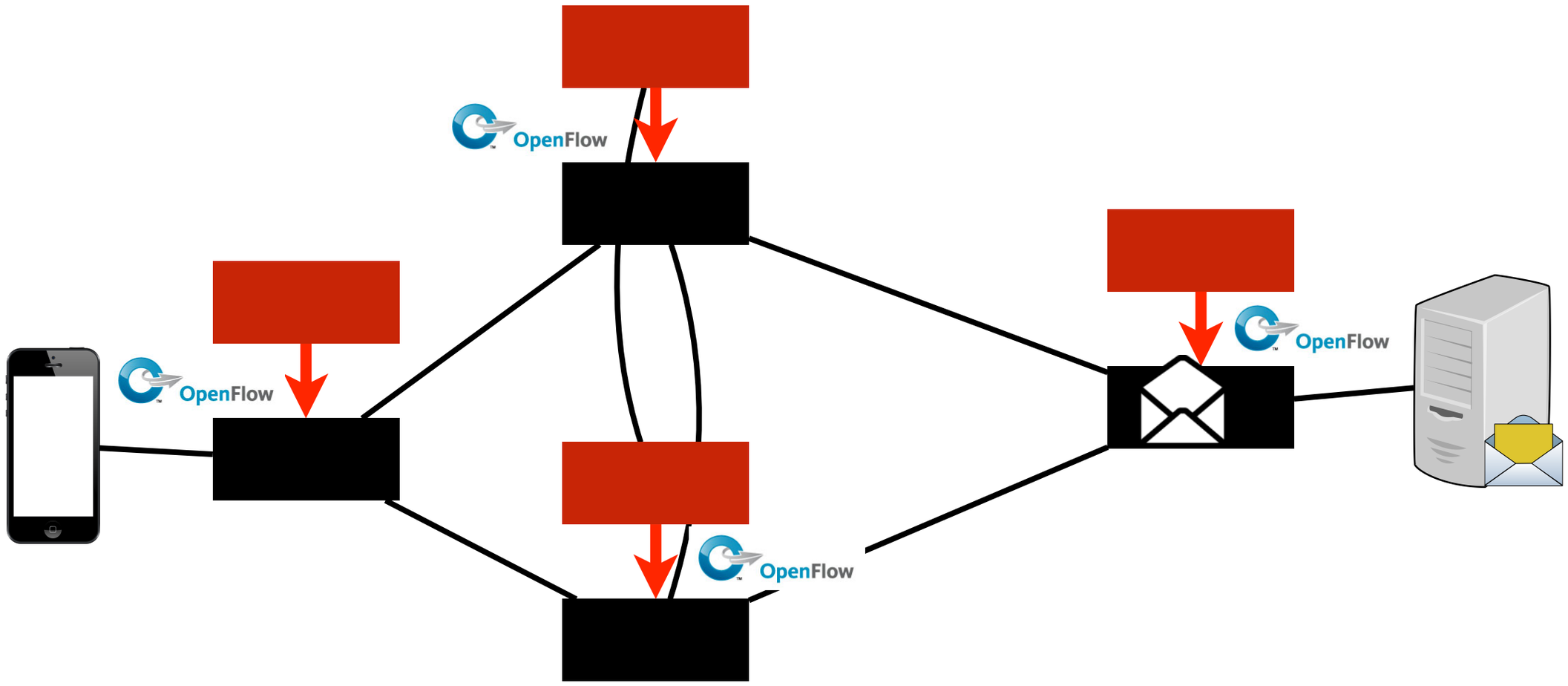

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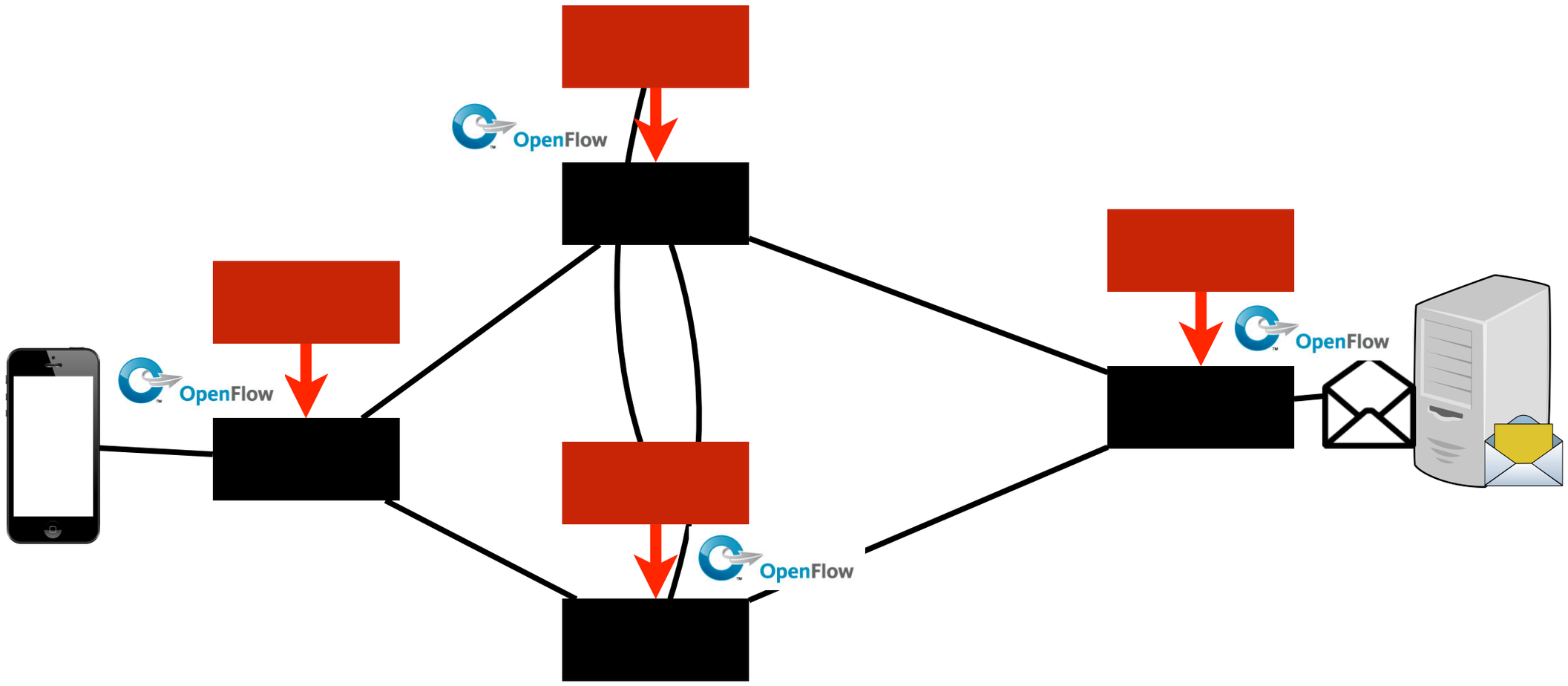

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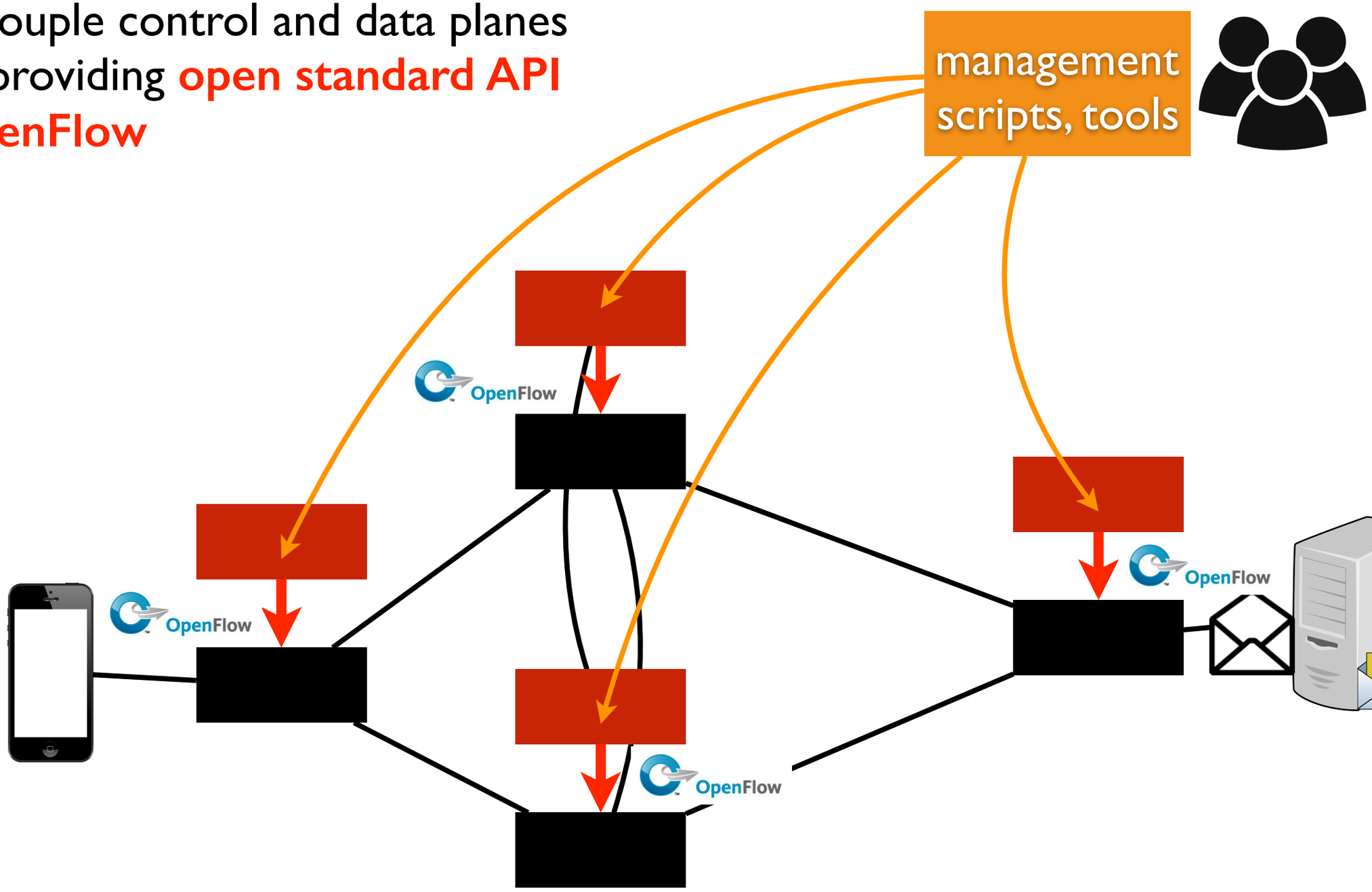
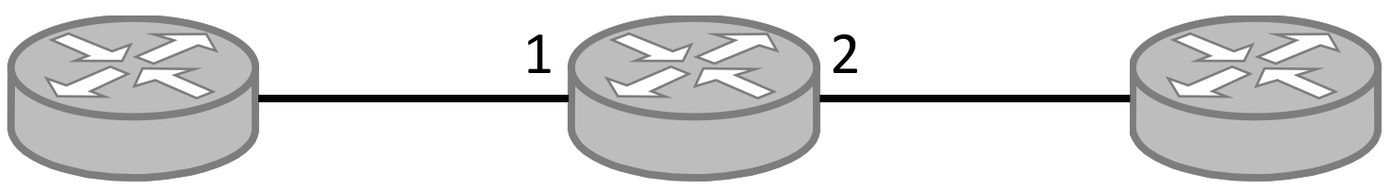


OpenFlow: simple open dataplane API

prioritized list of rules

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

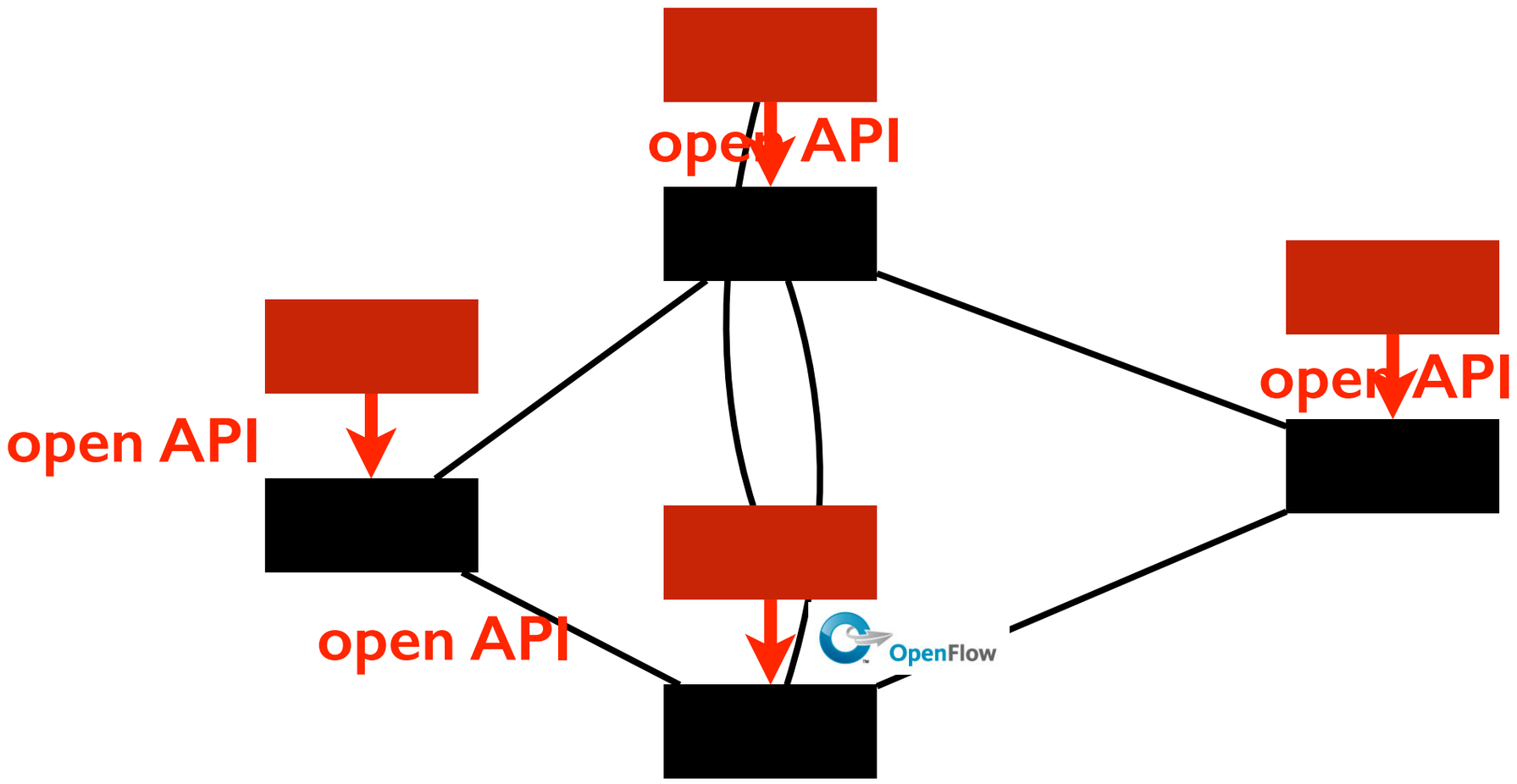


1. src=1.2.*.*, dest=3.4.5.* → drop
2. src = *.*.*.*, dest=3.4.*.* → forward(2)
3. src=10.1.2.3, dest=*.*.*.* → send to controller

Nick McKeown., et al. "OpenFlow: enabling innovation in campus networks"

open dataplane interface

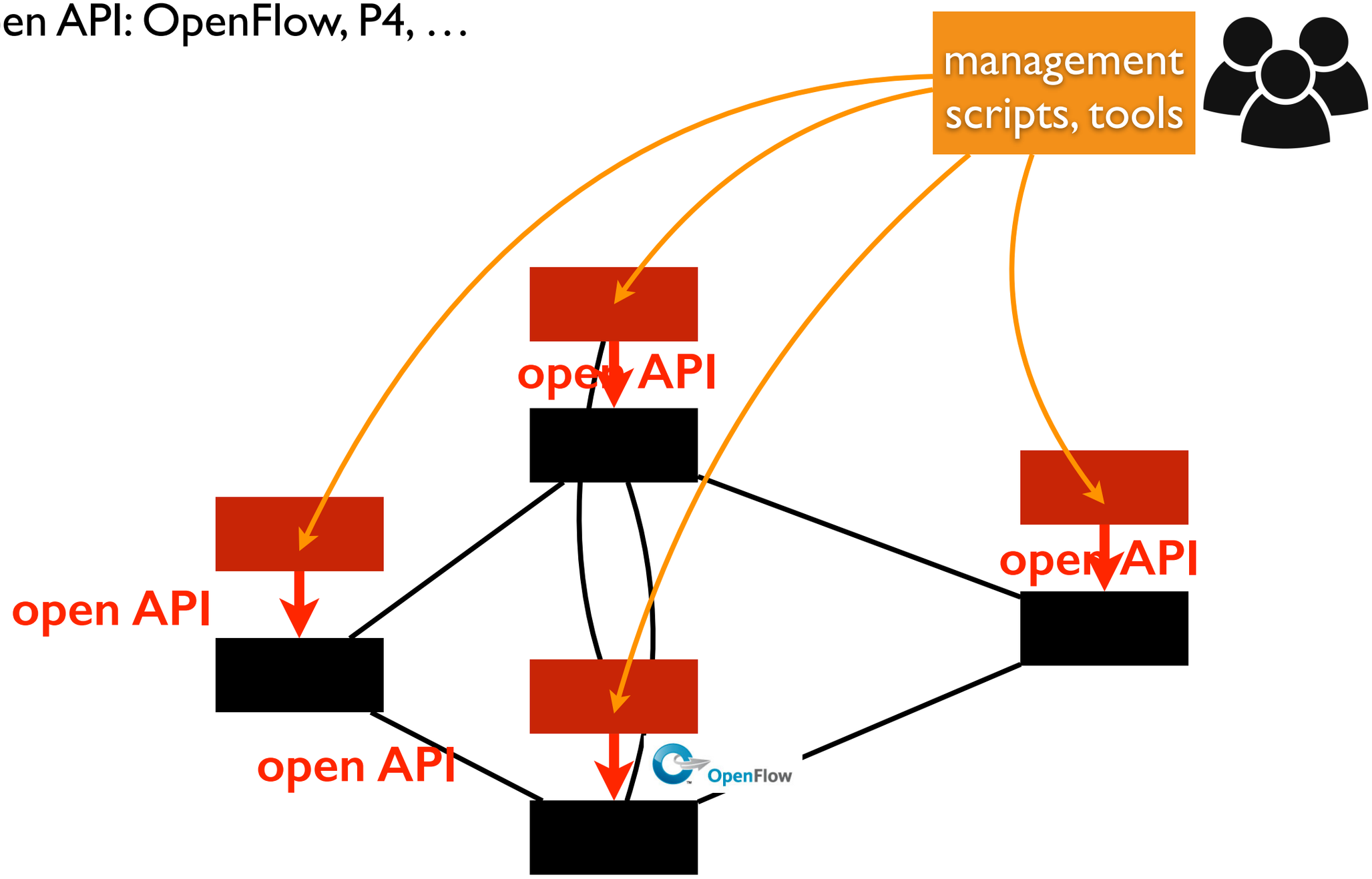
open API: OpenFlow, P4, …



P. Bosshart., et al. P4: Programming Protocol-Independent Packet Processors

open dataplane interface

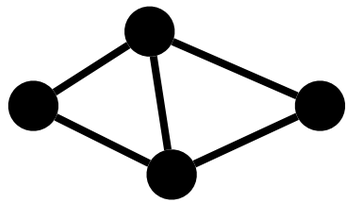
open API: OpenFlow, P4, …

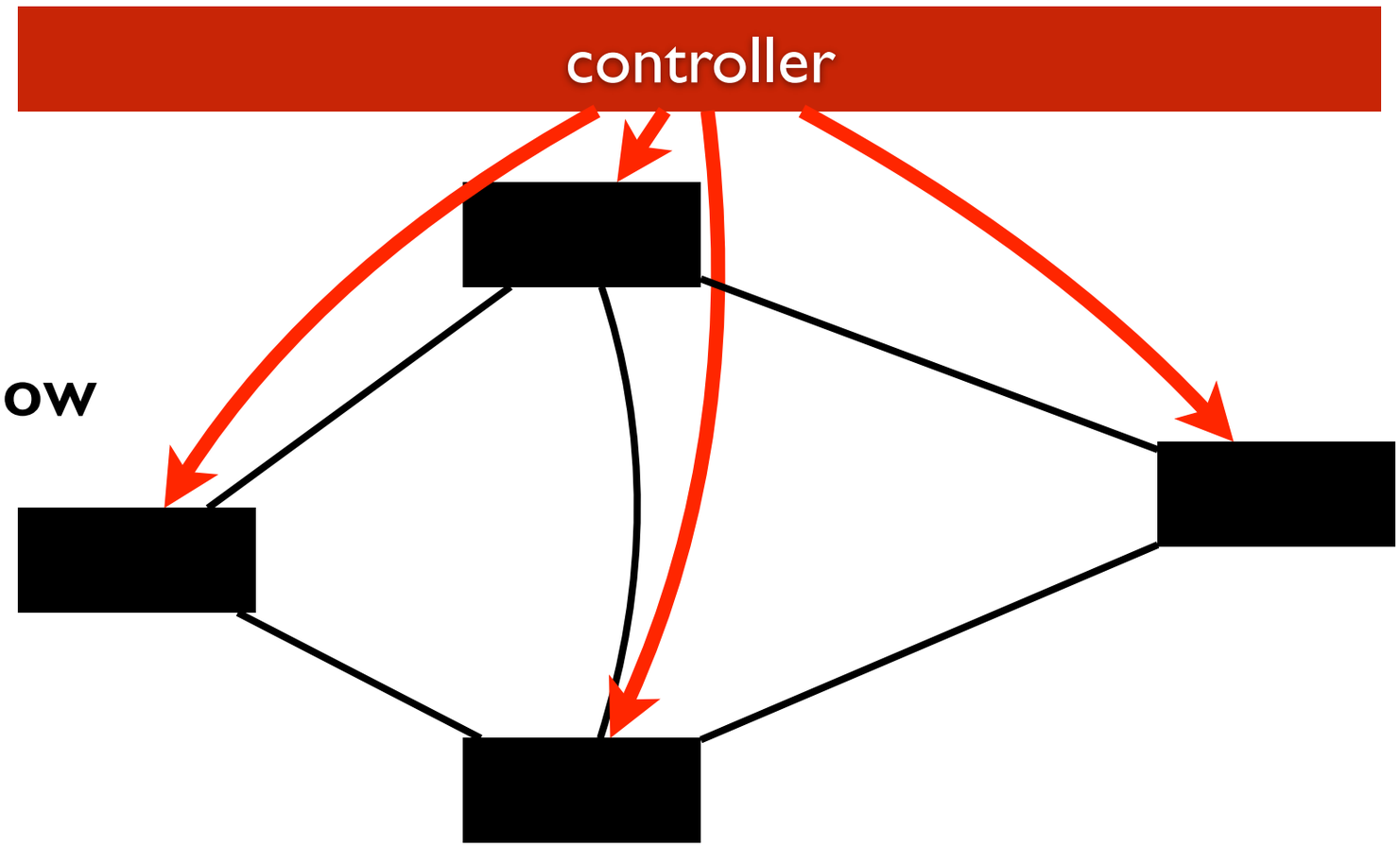


P. Bosshart., et al. P4: Programming Protocol-Independent Packet Processors

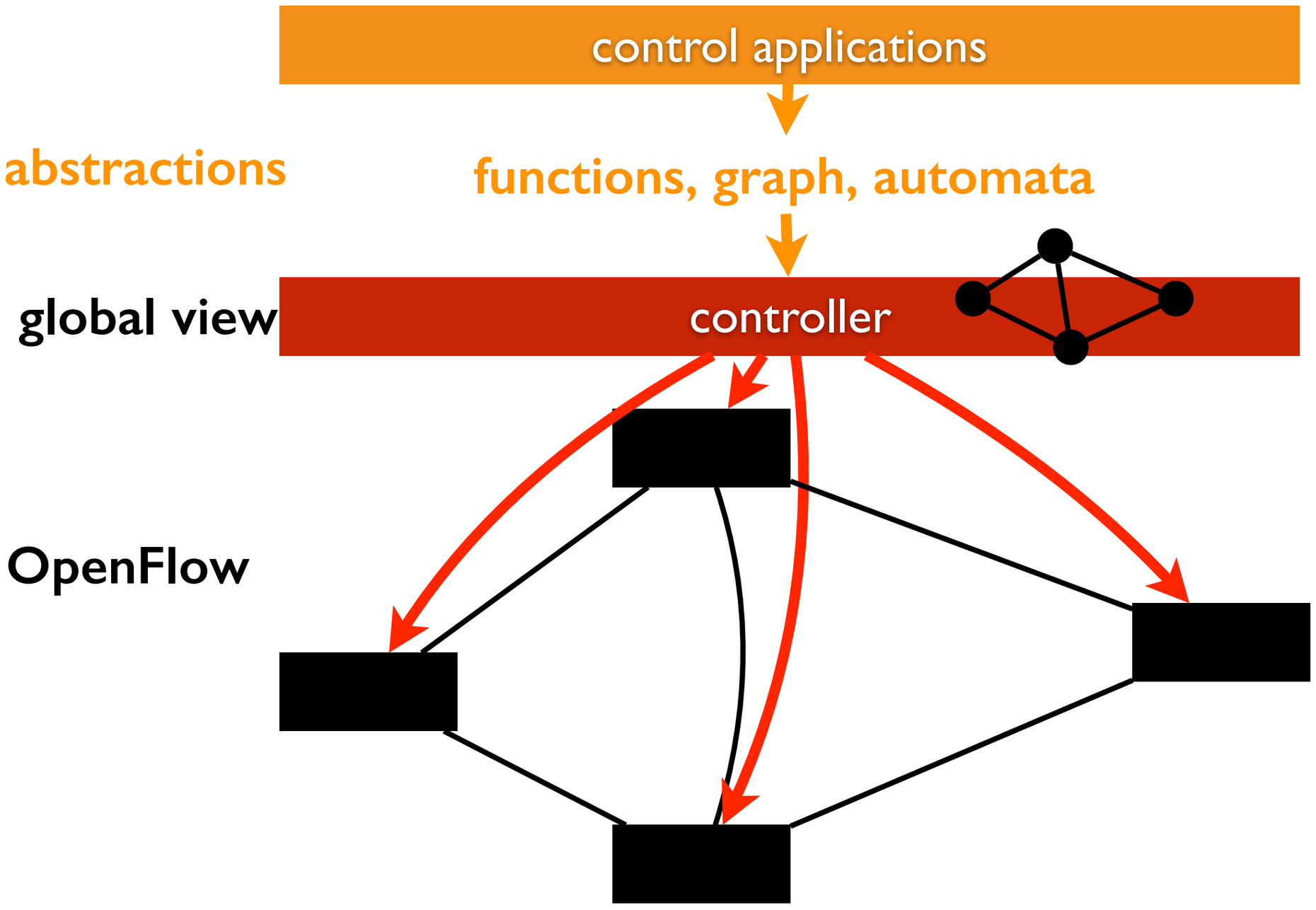
(logically) centralized controller

global network view

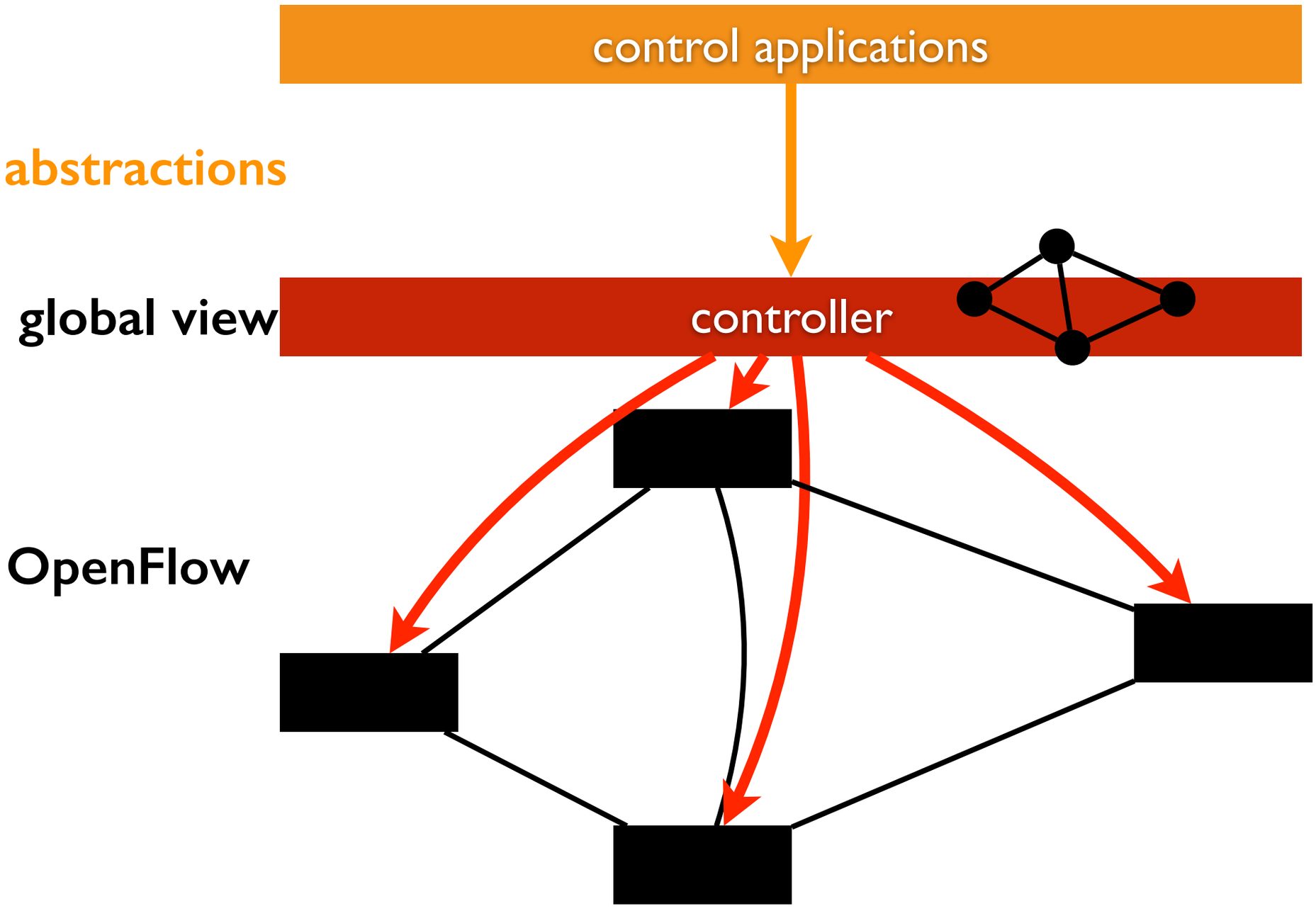




higher-level abstractions



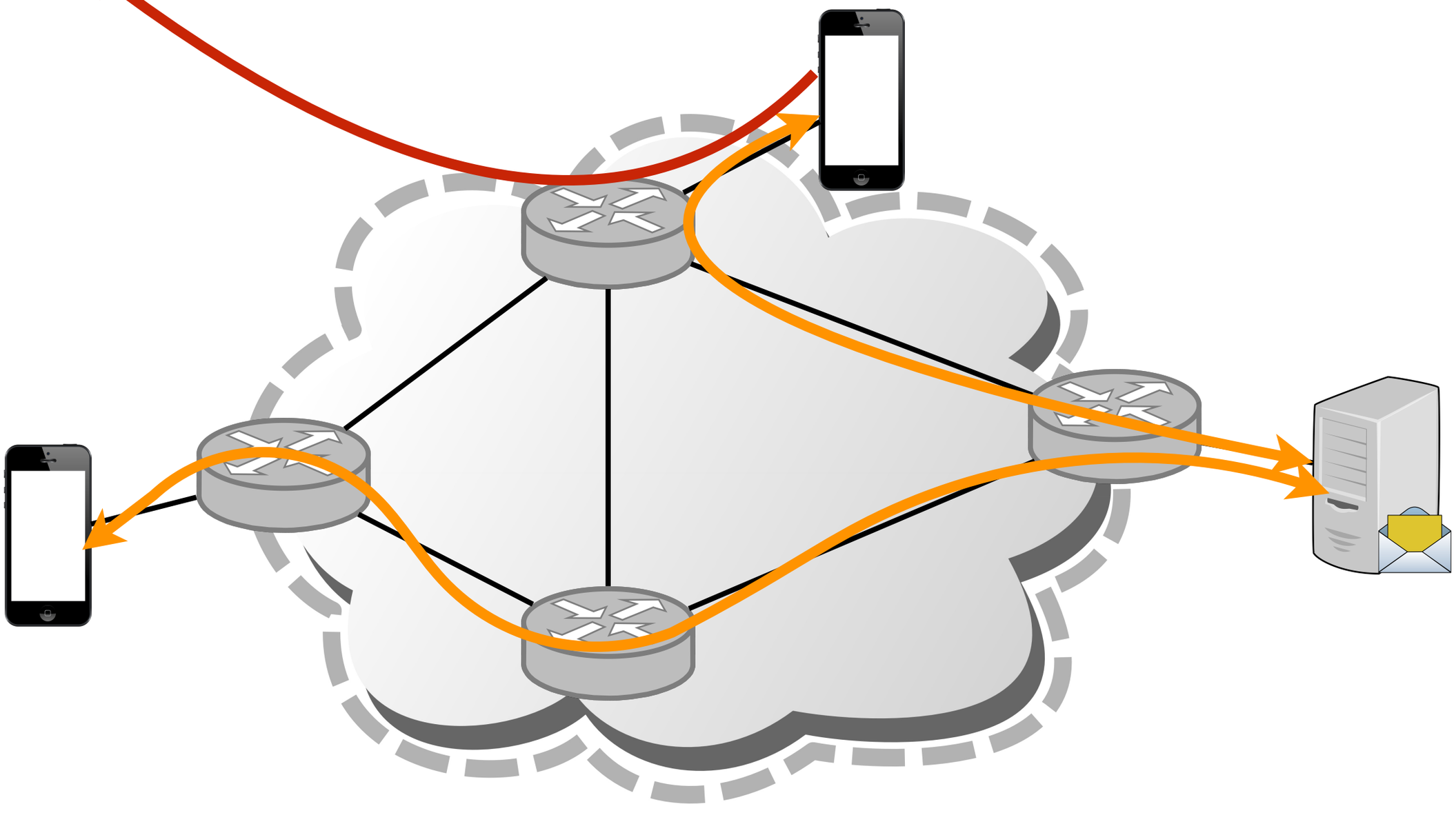
protocols ➔ applications



application: seamless mobility

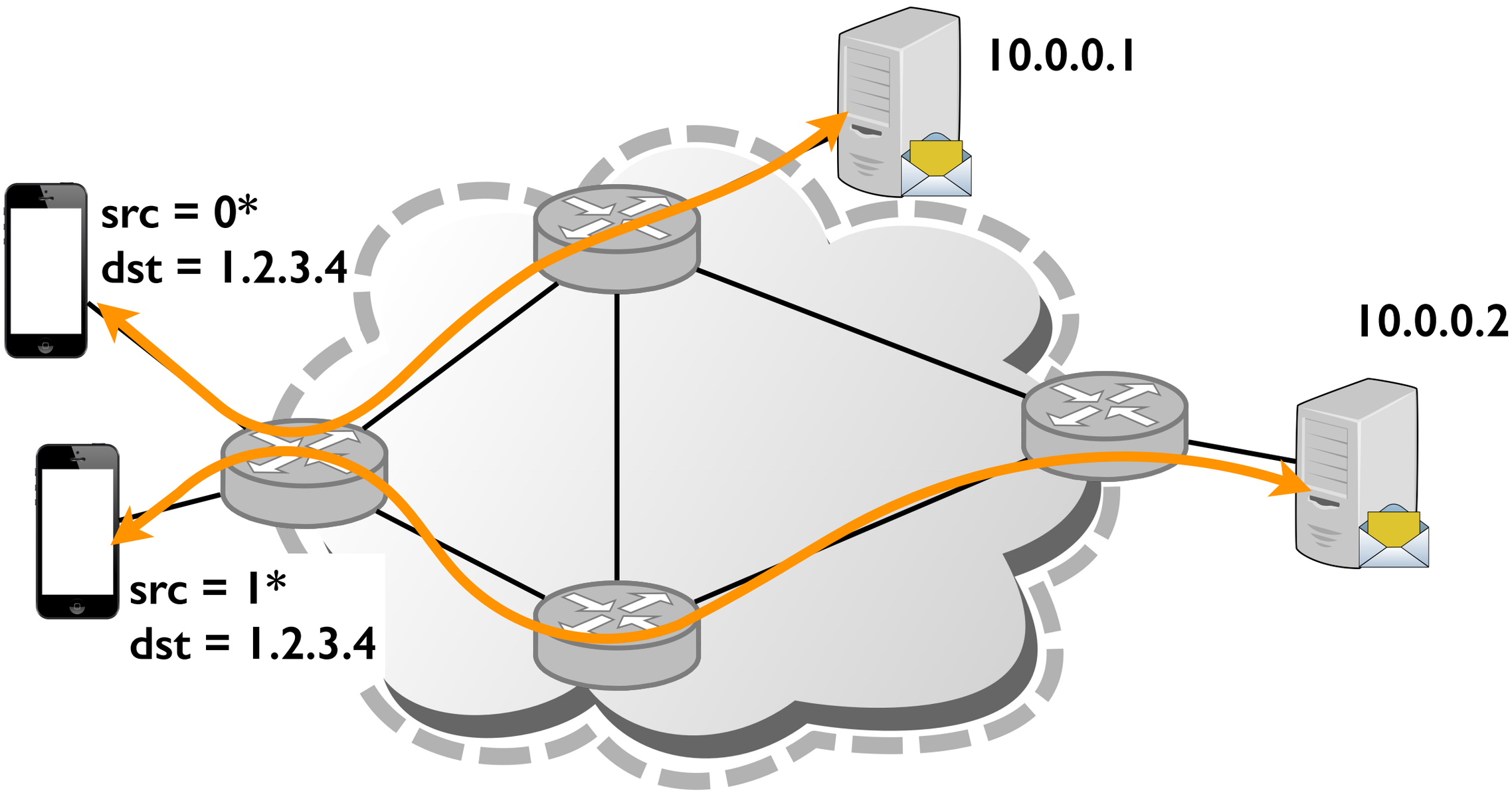
app

- 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

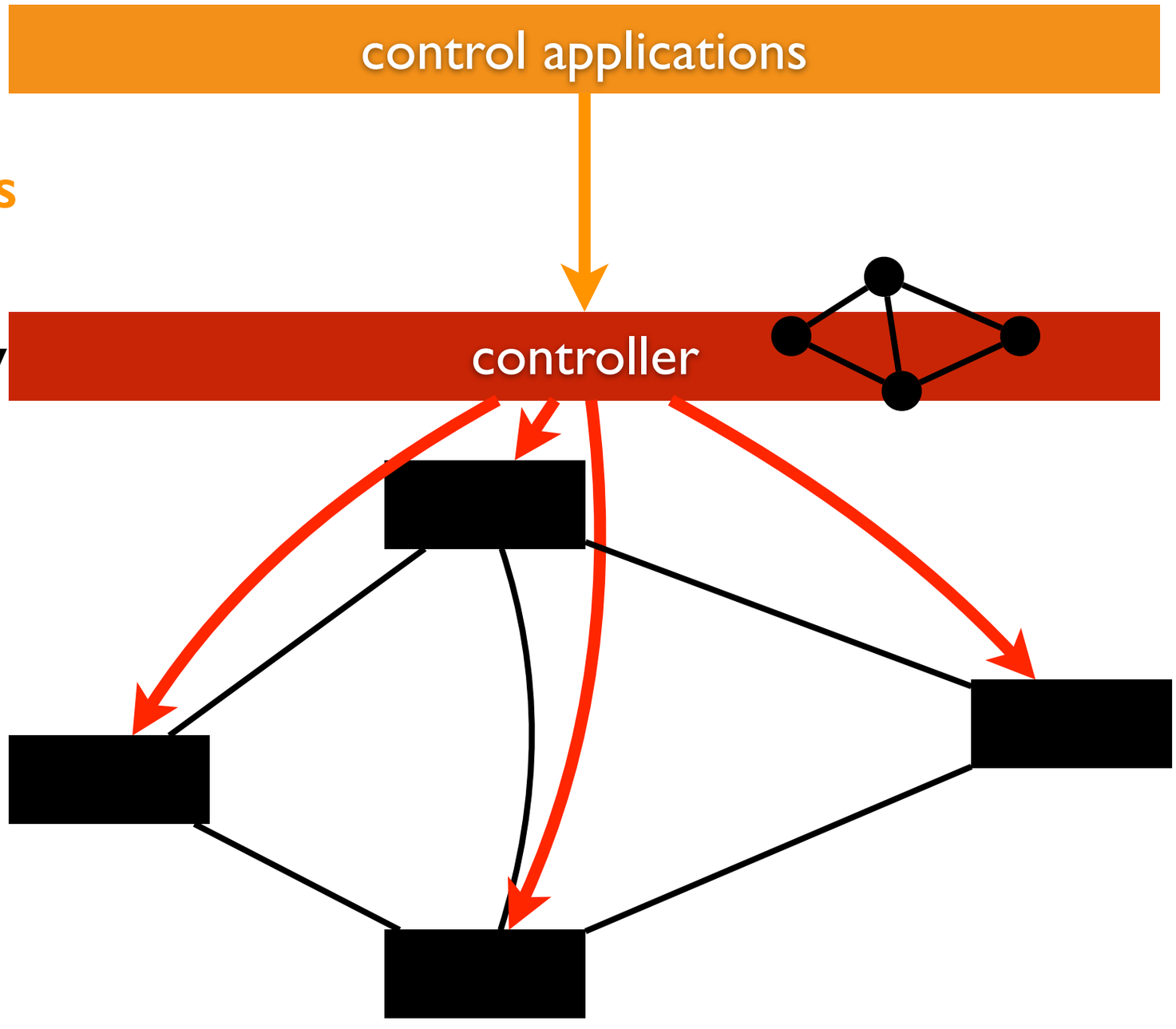


protocols ➔ applications

abstractions

global view

OpenFlow

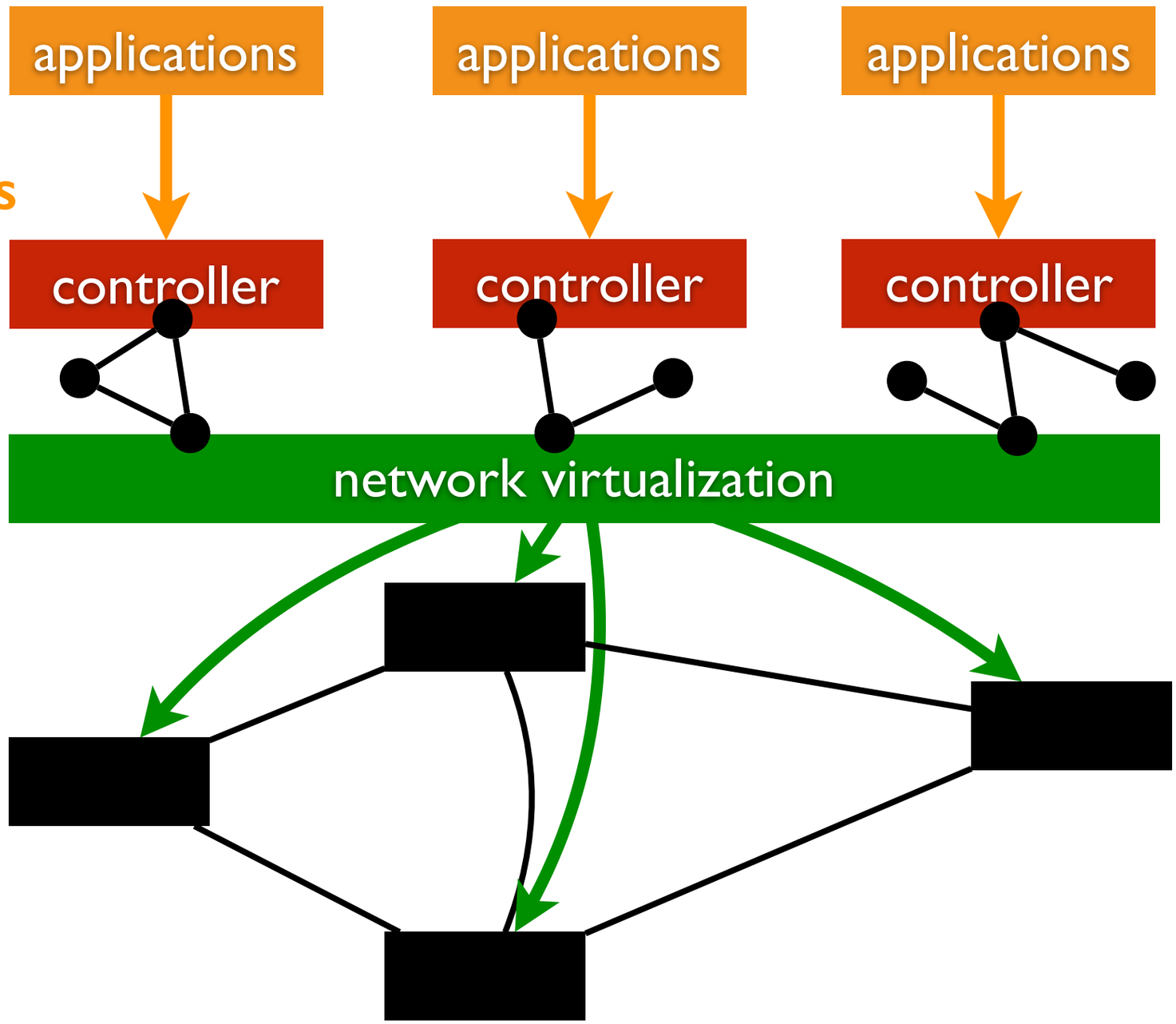


network virtualization

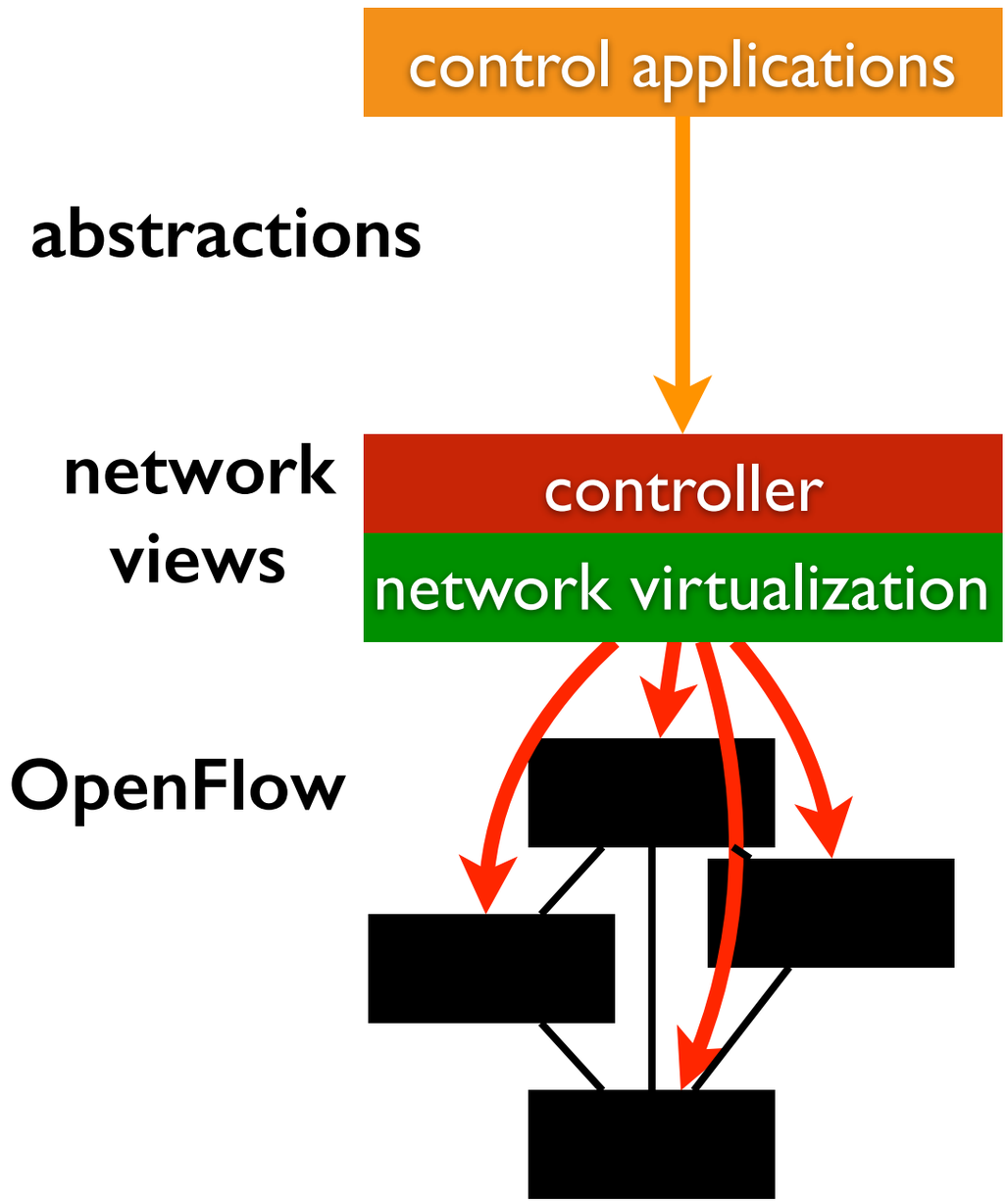
abstractions

virtual Net

OpenFlow



recap: SDN technologies



supporting technologies

- central network control
- programmability
- network virtualization

benefits

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

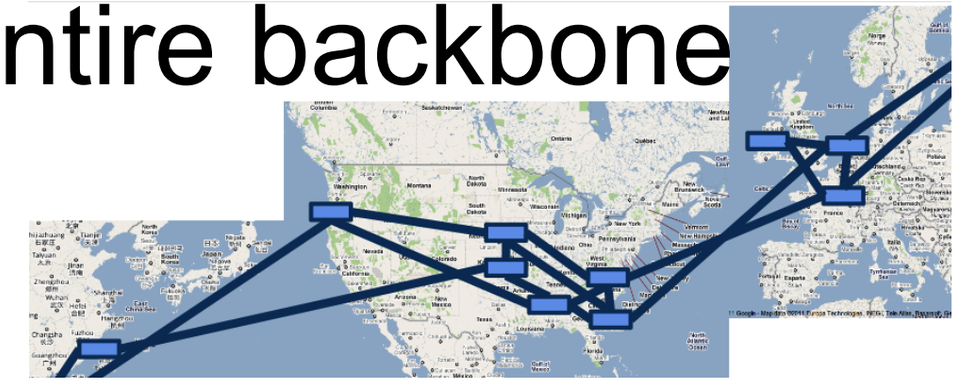
a major trend in networking

OPEN NETWORKING FOUNDATION

Deutsche Telekom · facebook · Goldman Sachs · Google · Microsoft · NTT Communications · verizon · YAHOO!

Google

Entire backbone



runs on SDN

nicira

Bought for **$1.2 x 10^9**
(mostly cash)

an opportunity to rethink

disciplines

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

structure of the course

syllabus

introduction

- review, historical evolution

SDN basics

- centralized control, programmability, network virtualization

advanced topic

- network function virtualization (NFV)

innovation and application

- verification, synthesis

paper reading

read 2~4 papers for each class (2 lectures)

- recent research papers on SDN
- basis for discussion in class

write review for 2 (1 page each)

- summary (problem, solution)
- what you like, to improve, to avoid

one in class oral presentation

- conference style: 20min talk + 5min Q&A

to do

- read "How to Read" on today's syllabus

lightweight assignments

programming assignments

- Mininet platform
- POX, Ravel controller

assignments are *not* graded

collaboration policy

- can freely collaborate with others

will help your course project

course project

final research project

- work alone or in pair
- your own topic, or from a list we suggest

schedule

- talk to me (and others) about project ideas
- 5pm Thur Oct 20: short proposal due
- 5pm Sun December 18: written report due
- last week: short oral presentation

grading

- 0% programming assignments
- 30% class participation (discussion, presentation)
- 40% paper reviews
- 30% course project (paper, talk)

to do

next steps

- join the Piazza site
  - piazza.com/temple/fall2016/5590
- course web site
  - cis-linux1.temple.edu/~tug29203/16-5590/