Participatory Networking

Andrew Ferguson, Arjun Guha, Jordan Place,
Rodrigo Fonseca, and Shriram Krishnamurthi

BROWN

The Problem with Networks

1. in the home

The Problem with Networks

1. in the home
2. in the enterprise

The Problem with Networks

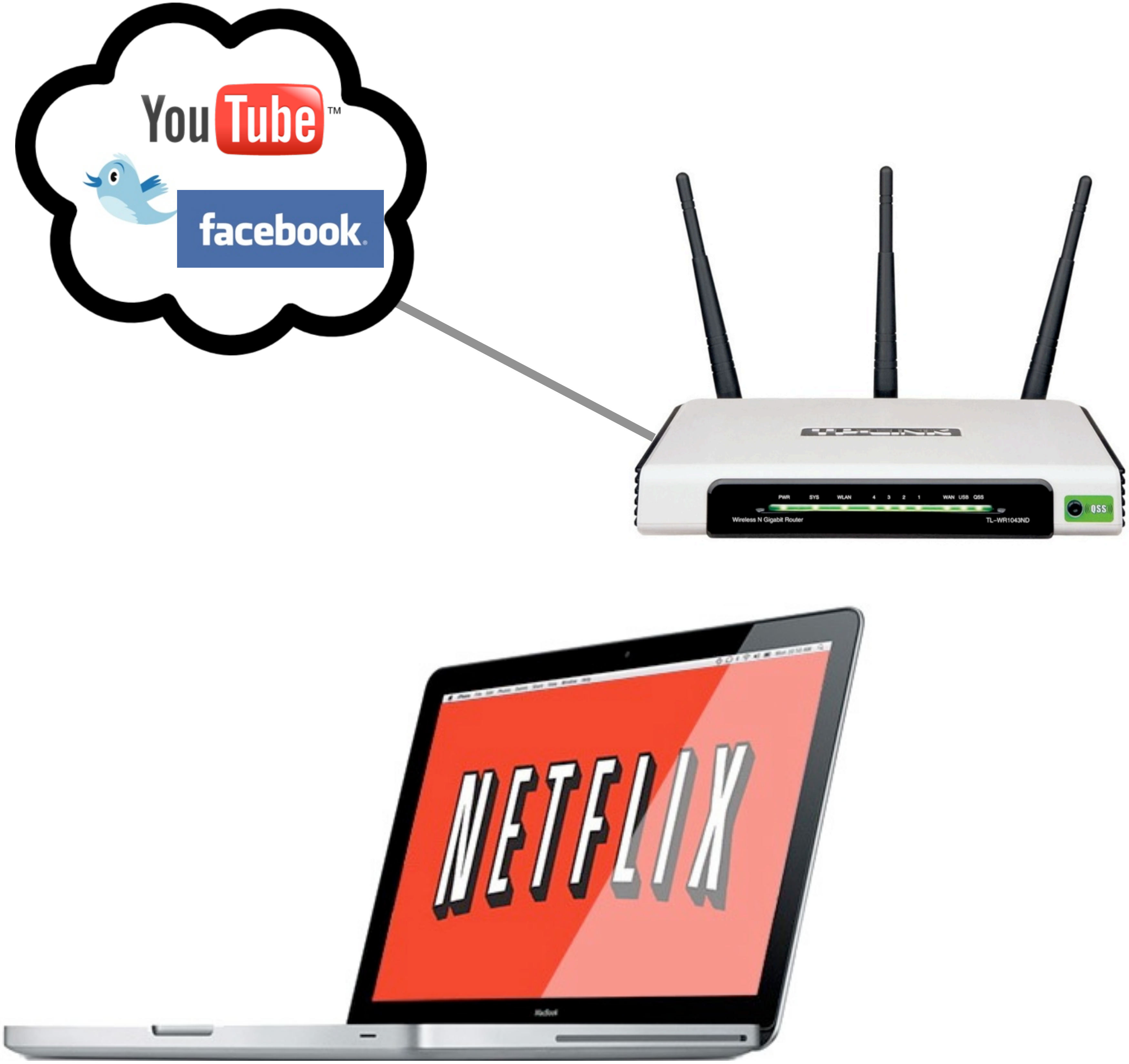
1. in the home
2. in the enterprise
3. in the cloud

The Problem with Networks

1. in the home
2. in the enterprise
3. in the cloud
4. in the datacenter

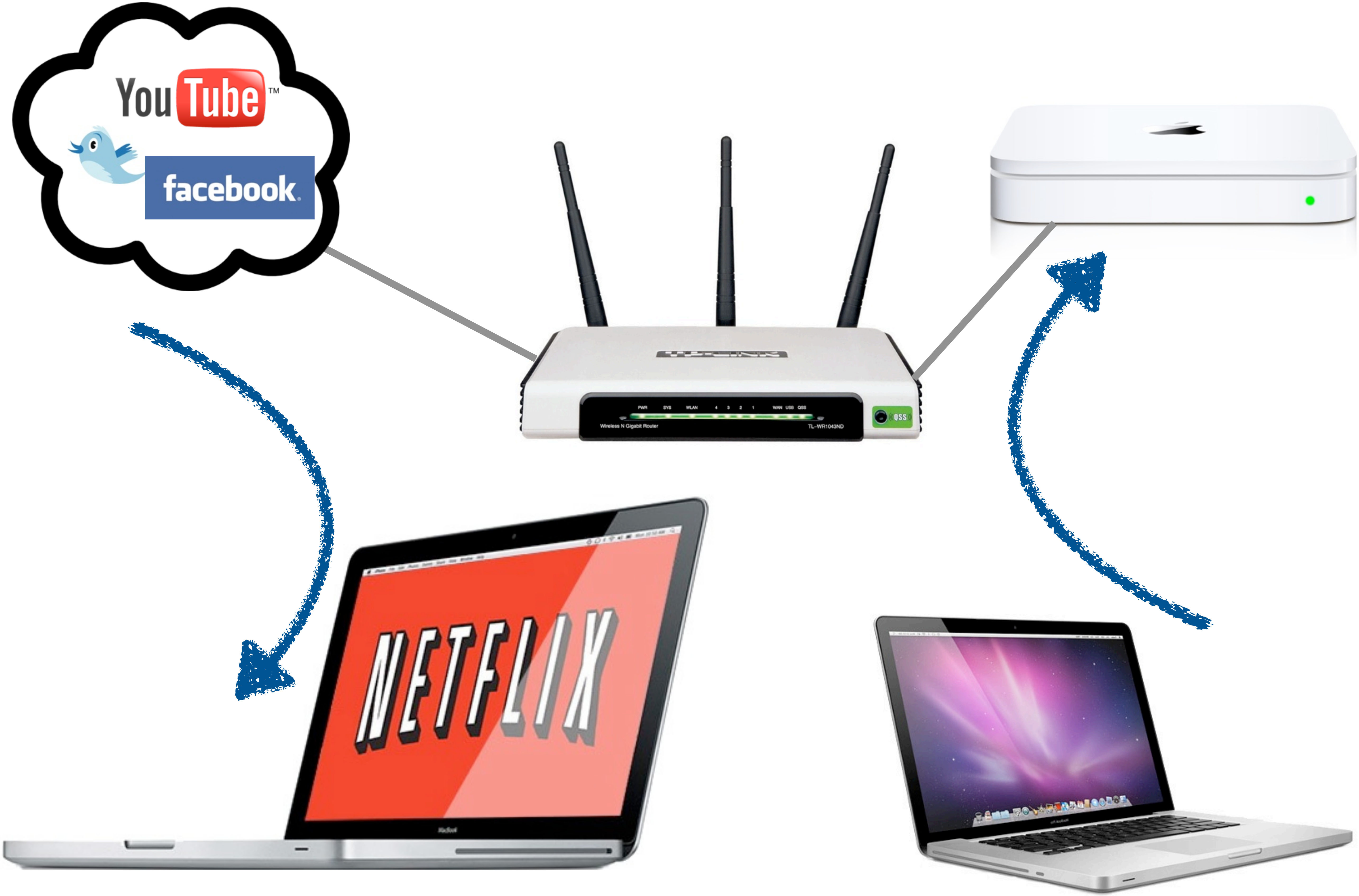
The Problem with Networks

A problem in the home


YouTube
facebook
Wireless N Gigabit Router
TL-WR1043ND
NETFLIX

89%

Buffering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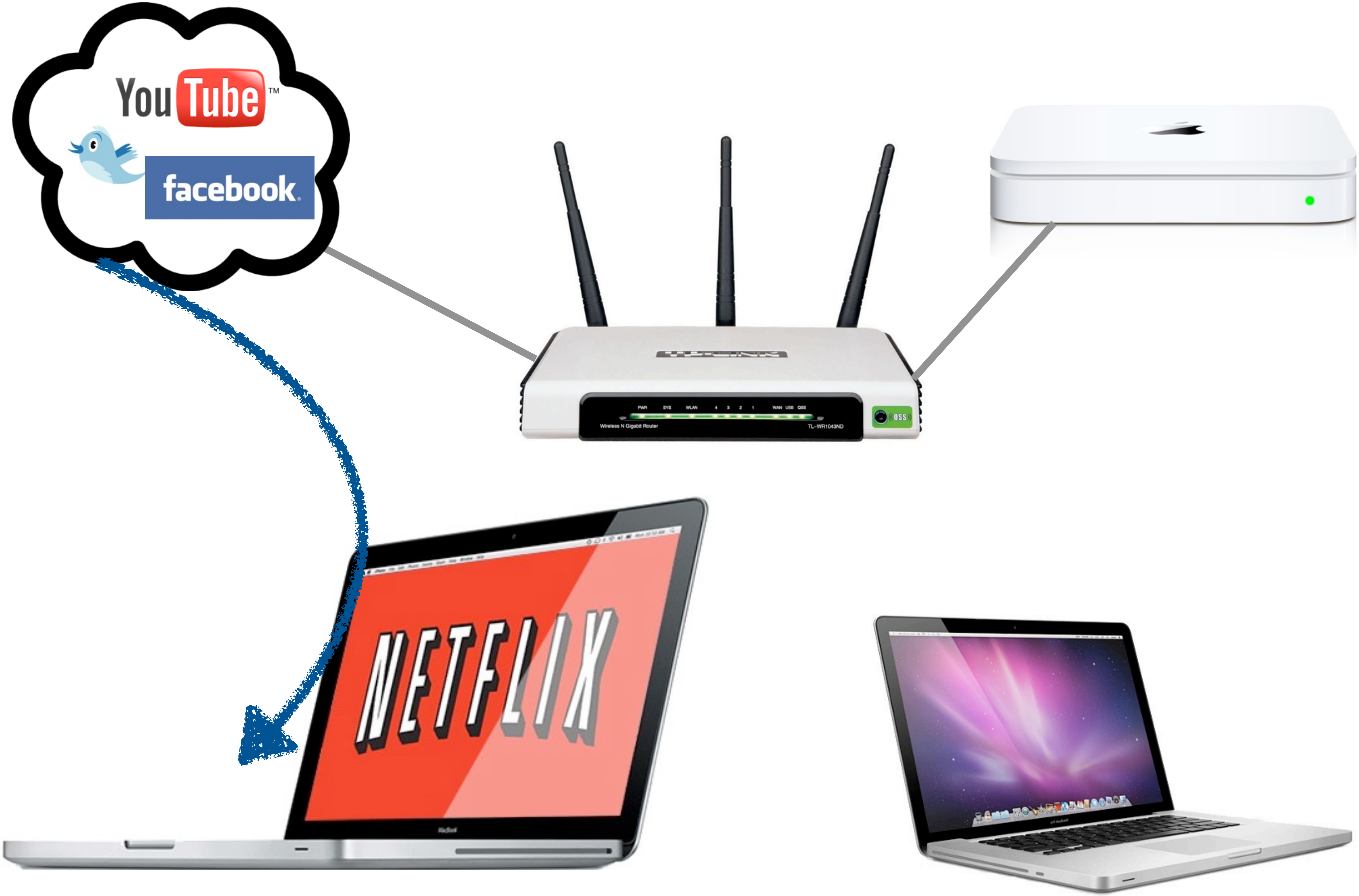
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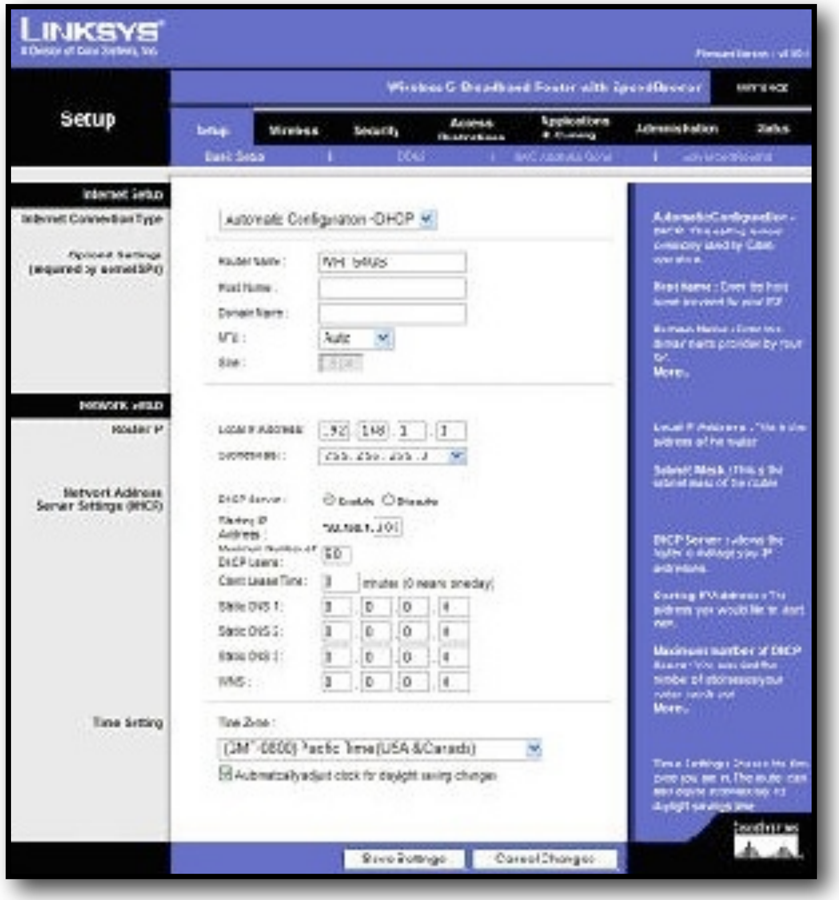
Wireless N Gigabit Router
TL-WR1043ND
QSS
NETFLIX



Internet Setup

Internet Connection Type: Automatic Configuration - DHCP

Optional Settings (required by some ISPs)

Router Name: WRT54GS

Host Name:

Domain Name:

MTU: Auto

Size: 1500

Network Setup

Router IP

Local IP Address: 192 . 168 . 1 . 1

Subnet Mask: 255.255.255.0

Network Address Server Settings (DHCP)

DHCP Server: ● Enable ○ Disable

Starting IP Address: 192.168.1. 100

Maximum Number of DHCP Users: 50

Client Lease Time: 0 minutes (0 means one day)

Static DNS 1: 0 . 0 . 0 . 0

Static DNS 2: 0 . 0 . 0 . 0

Static DNS 3: 0 . 0 . 0 . 0

WINS: 0 . 0 . 0 . 0

Time Setting

Time Zone:

(GMT-08:00) Pacific Time (USA & Canada)

☑ Automatically adjust clock for daylight saving changes

Automatic Configuration - DHCP: This setting is most commonly used by Cable operators.

Host Name: Enter the host name provided by your ISP.

Domain Name: Enter the domain name provided by your ISP.
More...

Local IP Address: This is the address of the router.

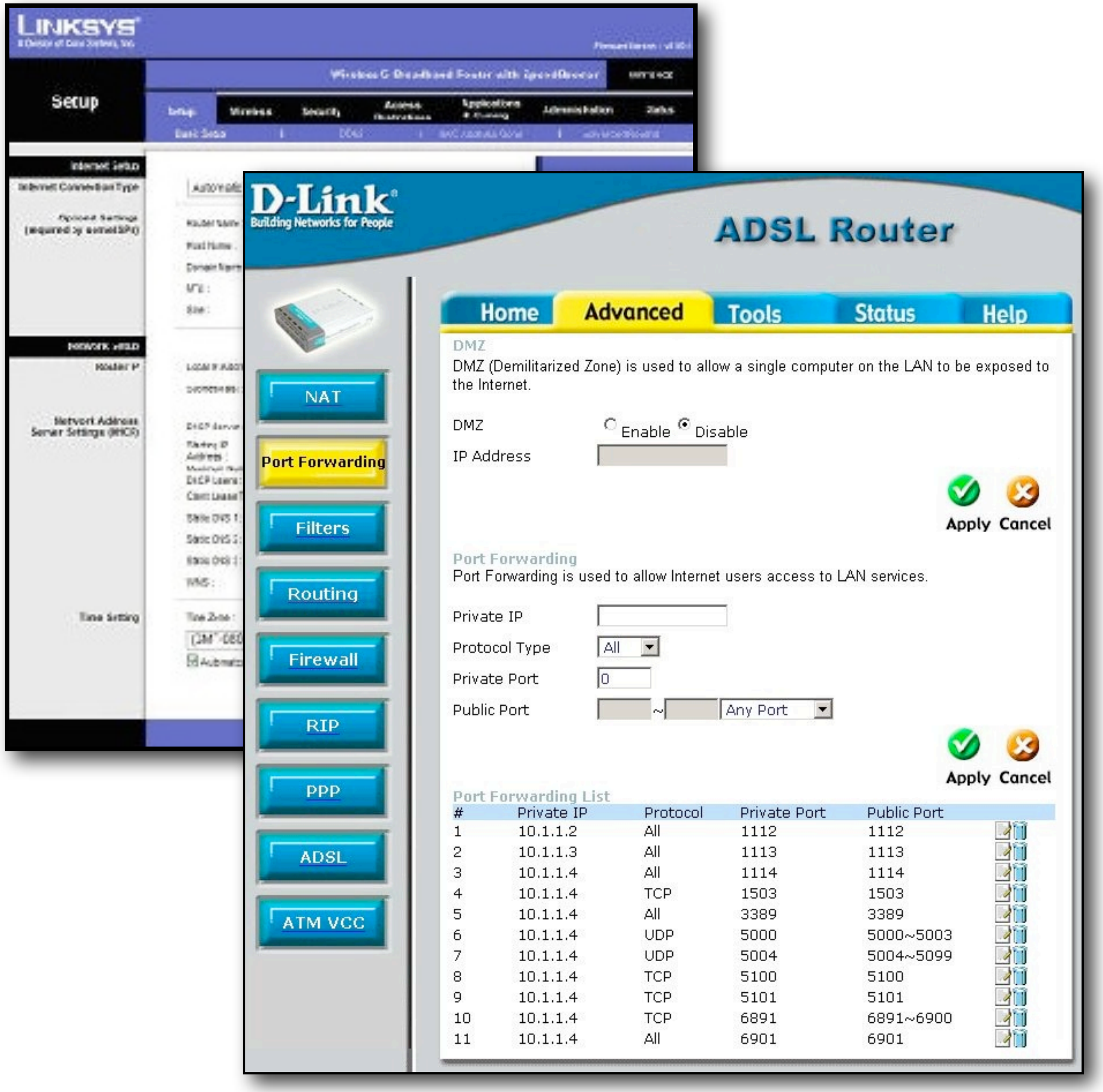
Subnet Mask: This is the subnet mask of the router.

DHCP Server: Allows the router to manage your IP addresses.

Starting IP Address: The address you would like to start with.

Maximum number of DHCP Users: You may limit the number of addresses your router hands out.
More...

Time Settings: Choose the time zone you are in. The router can also adjust automatically for daylight savings time.



DMZ

DMZ (Demilitarized Zone) is used to allow a single computer on the LAN to be exposed to the Internet.

DMZ ○ Enable ● Disable

IP Address

Apply Cancel

Port Forwarding

Port Forwarding is used to allow Internet users access to LAN services.

Private IP

Protocol Type All

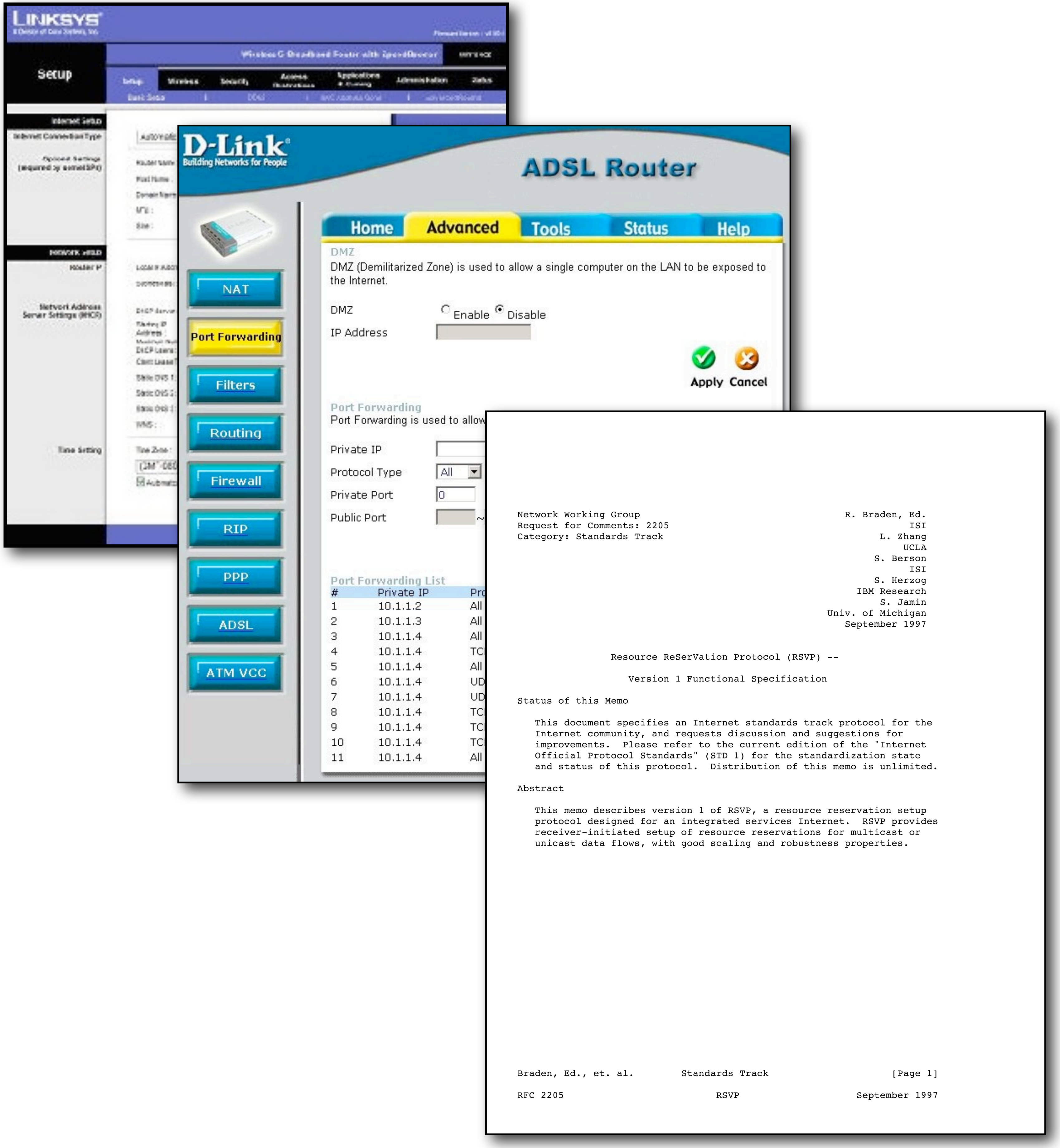
Private Port 0

Public Port ~ Any Port

Apply Cancel

Port Forwarding List

#	Private IP	Protocol	Private Port	Public Port
1	10.1.1.2	All	1112	1112
2	10.1.1.3	All	1113	1113
3	10.1.1.4	All	1114	1114
4	10.1.1.4	TCP	1503	1503
5	10.1.1.4	All	3389	3389
6	10.1.1.4	UDP	5000	5000~5003
7	10.1.1.4	UDP	5004	5004~5099
8	10.1.1.4	TCP	5100	5100
9	10.1.1.4	TCP	5101	5101
10	10.1.1.4	TCP	6891	6891~6900
11	10.1.1.4	All	6901	6901



DMZ

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DMZ ○ Enable ● Disable

IP Address

Port Forwarding

Port Forwarding is used to allow

Private IP

Protocol Type: All

Private Port: 0

Public Port

Port Forwarding List

#	Private IP	Pro
1	10.1.1.2	All
2	10.1.1.3	All
3	10.1.1.4	All
4	10.1.1.4	TC
5	10.1.1.4	All
6	10.1.1.4	UD
7	10.1.1.4	UD
8	10.1.1.4	TC
9	10.1.1.4	TC
10	10.1.1.4	TC
11	10.1.1.4	All

```
Network Working Group                                  R. Braden, Ed.
Request for Comments: 2205                                        ISI
Category: Standards Track                                    L. Zhang
                                                                 UCLA
                                                            S. Berson
                                                                  ISI
                                                            S. Herzog
                                                         IBM Research
                                                             S. Jamin
                                                    Univ. of Michigan
                                                       September 1997


                Resource ReSerVation Protocol (RSVP) --

                   Version 1 Functional Specification

Status of this Memo

   This document specifies an Internet standards track protocol for the
   Internet community, and requests discussion and suggestions for
   improvements.  Please refer to the current edition of the "Internet
   Official Protocol Standards" (STD 1) for the standardization state
   and status of this protocol.  Distribution of this memo is unlimited.

Abstract

   This memo describes version 1 of RSVP, a resource reservation setup
   protocol designed for an integrated services Internet.  RSVP provides
   receiver-initiated setup of resource reservations for multicast or
   unicast data flows, with good scaling and robustness properties.




Braden, Ed., et. al.        Standards Track                    [Page 1]

RFC 2205                          RSVP                   September 1997
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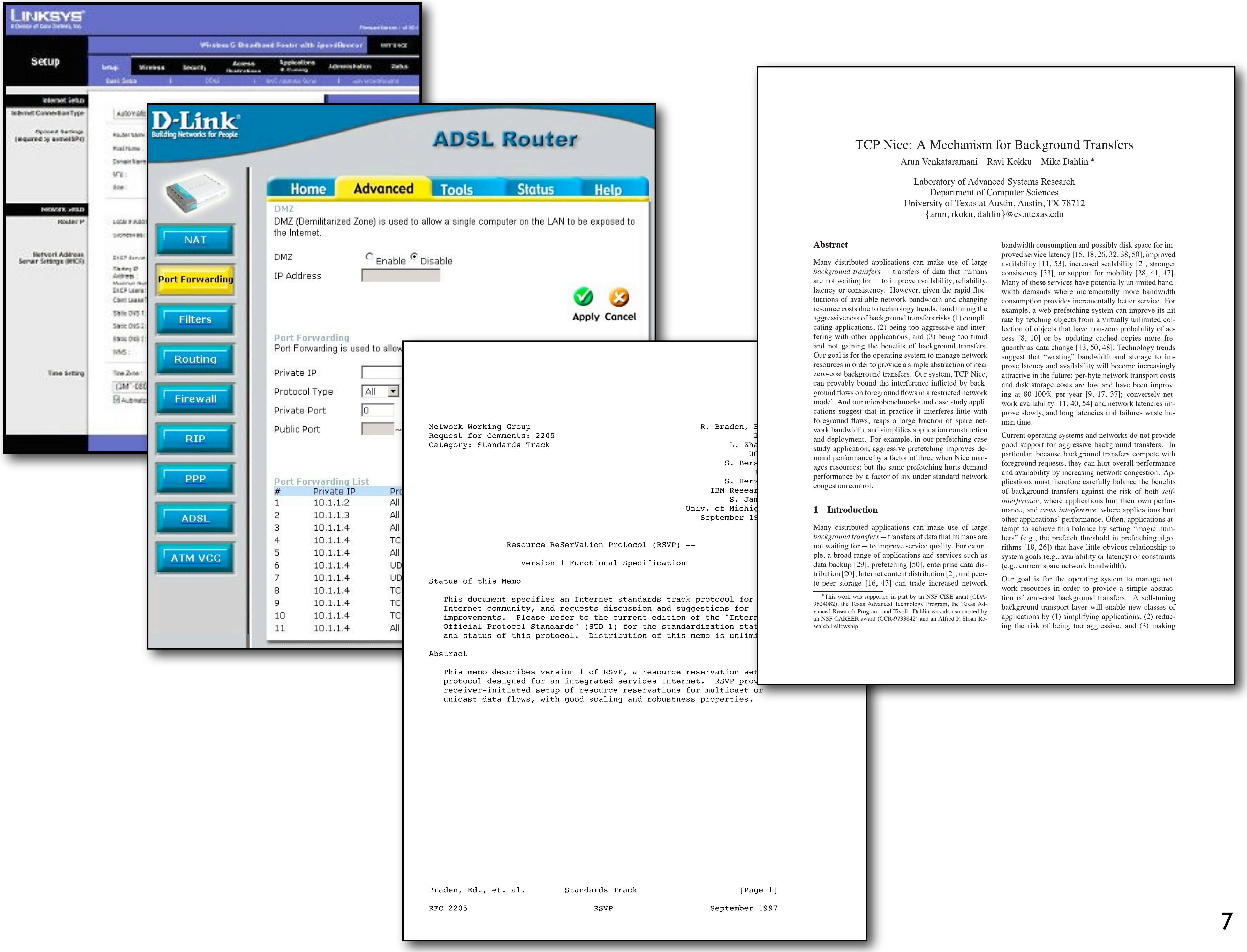

DMZ

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IP Address

Port Forwarding

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Private Port 0

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Port Forwarding List

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3	10.1.1.4	All
4	10.1.1.4	TC
5	10.1.1.4	All
6	10.1.1.4	UD
7	10.1.1.4	UD
8	10.1.1.4	TC
9	10.1.1.4	TC
10	10.1.1.4	TC
11	10.1.1.4	All

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Network Working Group                                        R. Braden, E
Request for Comments: 2205                                              I
Category: Standards Track                                          L. Zha
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                                                              Univ. of Michig
                                                               September 19


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Braden, Ed., et. al.        Standards Track                    [Page 1]

RFC 2205                          RSVP                     September 1997
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TCP Nice: A Mechanism for Background Transfers

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Abstract

Many distributed applications can make use of large *background transfers* — transfers of data that humans are not waiting for — to improve availability, reliability, latency or consistency. However, given the rapid fluctuations of available network bandwidth and changing resource costs due to technology trends, hand tuning the aggressiveness of background transfers risks (1) complicating applications, (2) being too aggressive and interfering with other applications, and (3) being too timid and not gaining the benefits of background transfers. Our goal is for the operating system to manage network resources in order to provide a simple abstraction of near zero-cost background transfers. Our system, TCP Nice, can provably bound the interference inflicted by background flows on foreground flows in a restricted network model. And our microbenchmarks and case study applications suggest that in practice it interferes little with foreground flows, reaps a large fraction of spare network bandwidth, and simplifies application construction and deployment. For example, in our prefetching case study application, aggressive prefetching improves demand performance by a factor of three when Nice manages resources; but the same prefetching hurts demand performance by a factor of six under standard network congestion control.

1 Introduction

Many distributed applications can make use of large *background transfers* — transfers of data that humans are not waiting for — to improve service quality. For example, a broad range of applications and services such as data backup [29], prefetching [50], enterprise data distribution [20], Internet content distribution [2], and peer-to-peer storage [16, 43] can trade increased network bandwidth consumption and possibly disk space for improved service latency [15, 18, 26, 32, 38, 50], improved availability [11, 53], increased scalability [2], stronger consistency [53], or support for mobility [28, 41, 47]. Many of these services have potentially unlimited bandwidth demands where incrementally more bandwidth consumption provides incrementally better service. For example, a web prefetching system can improve its hit rate by fetching objects from a virtually unlimited collection of objects that have non-zero probability of access [8, 10] or by updating cached copies more frequently as data change [13, 50, 48]; Technology trends suggest that "wasting" bandwidth and storage to improve latency and availability will become increasingly attractive in the future: per-byte network transport costs and disk storage costs are low and have been improving at 80-100% per year [9, 17, 37]; conversely network availability [11, 40, 54] and network latencies improve slowly, and long latencies and failures waste human time.

Current operating systems and networks do not provide good support for aggressive background transfers. In particular, because background transfers compete with foreground requests, they can hurt overall performance and availability by increasing network congestion. Applications must therefore carefully balance the benefits of background transfers against the risk of both *self-interference*, where applications hurt their own performance, and *cross-interference*, where applications hurt other applications' performance. Often, applications attempt to achieve this balance by setting "magic numbers" (e.g., the prefetch threshold in prefetching algorithms [18, 26]) that have little obvious relationship to system goals (e.g., availability or latency) or constraints (e.g., current spare network bandwidth).

Our goal is for the operating system to manage network resources in order to provide a simple abstraction of zero-cost background transfers. A self-tuning background transport layer will enable new classes of applications by (1) simplifying applications, (2) reducing the risk of being too aggressive, and (3) making

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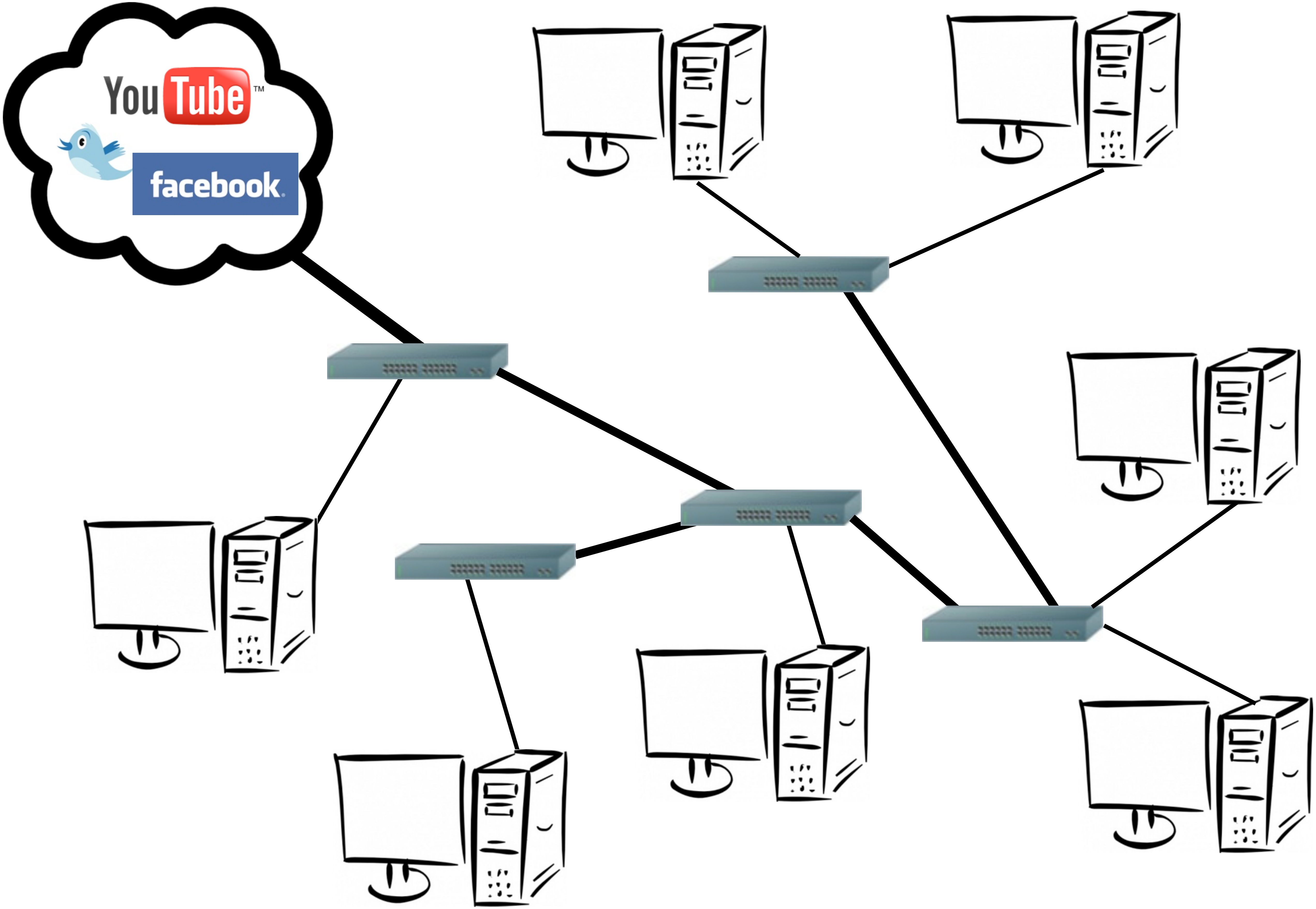
A problem in the enterprise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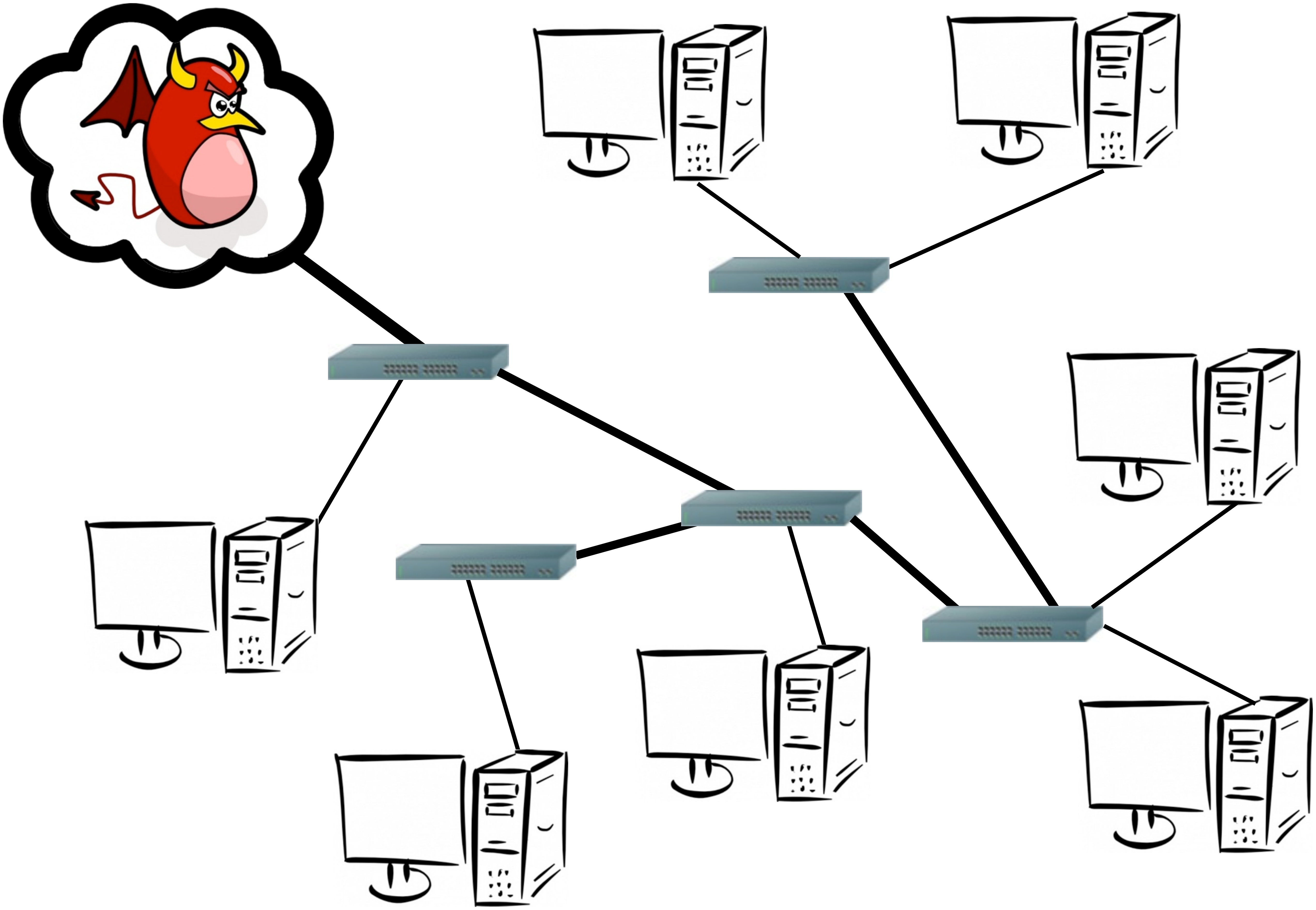

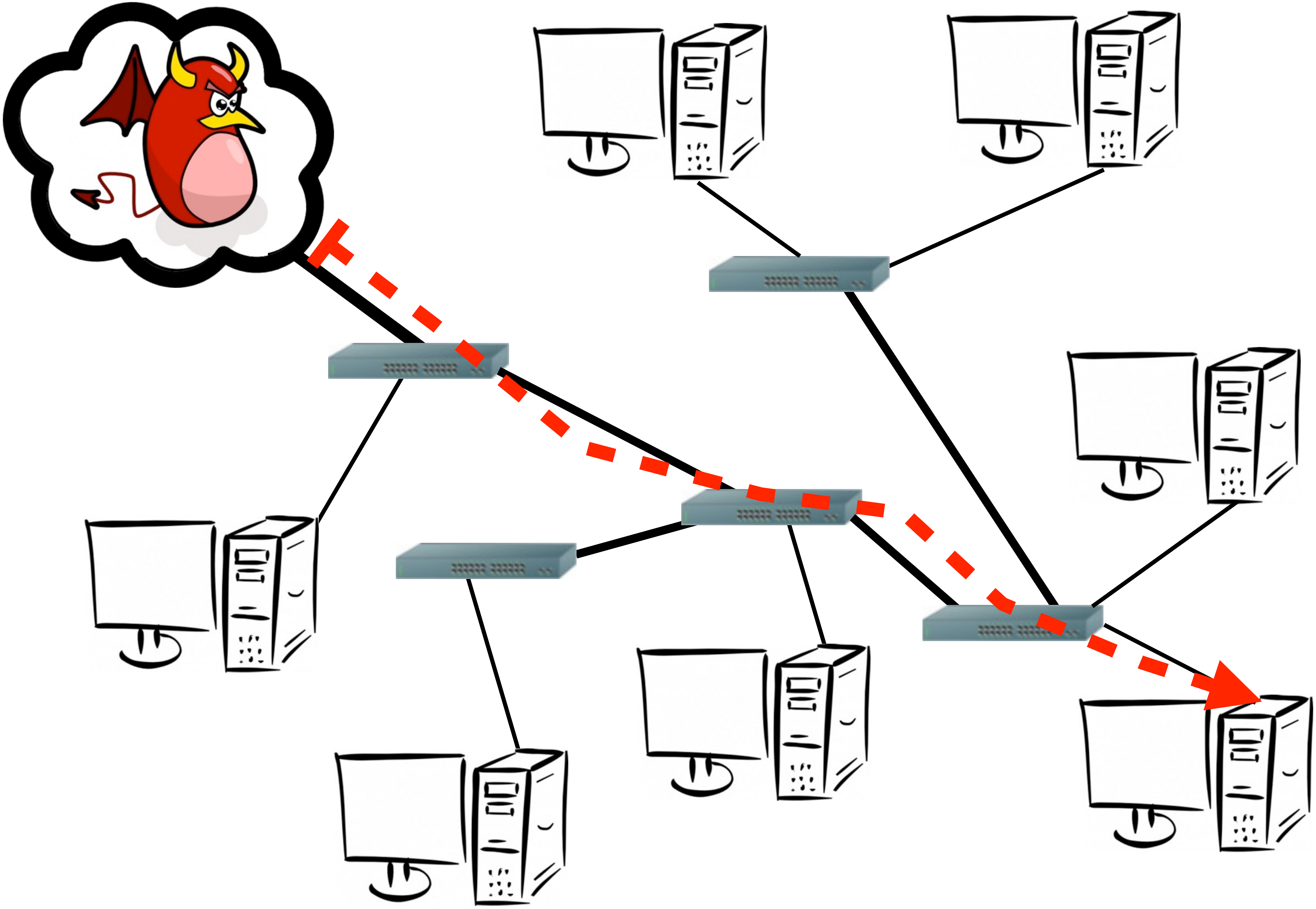

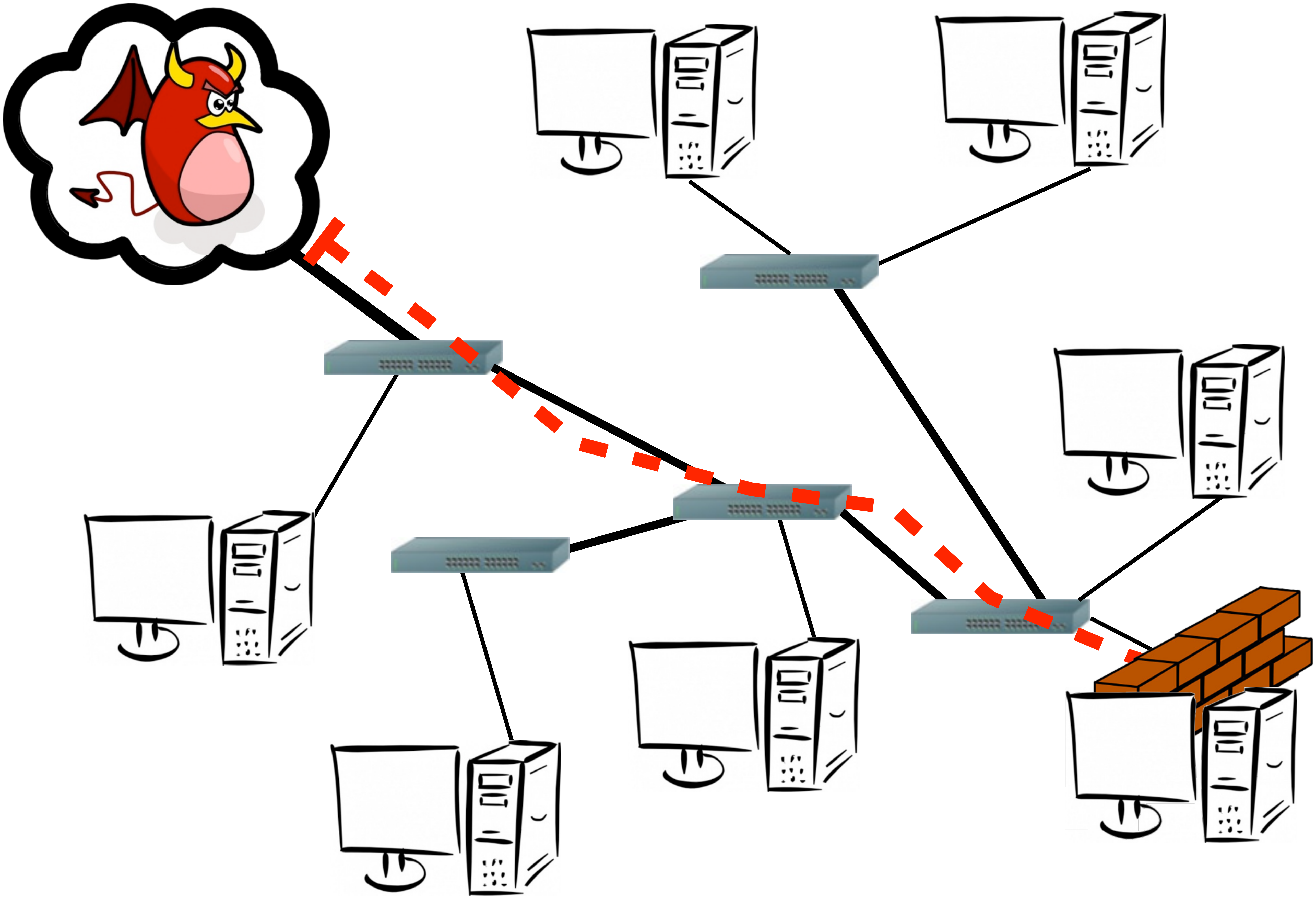

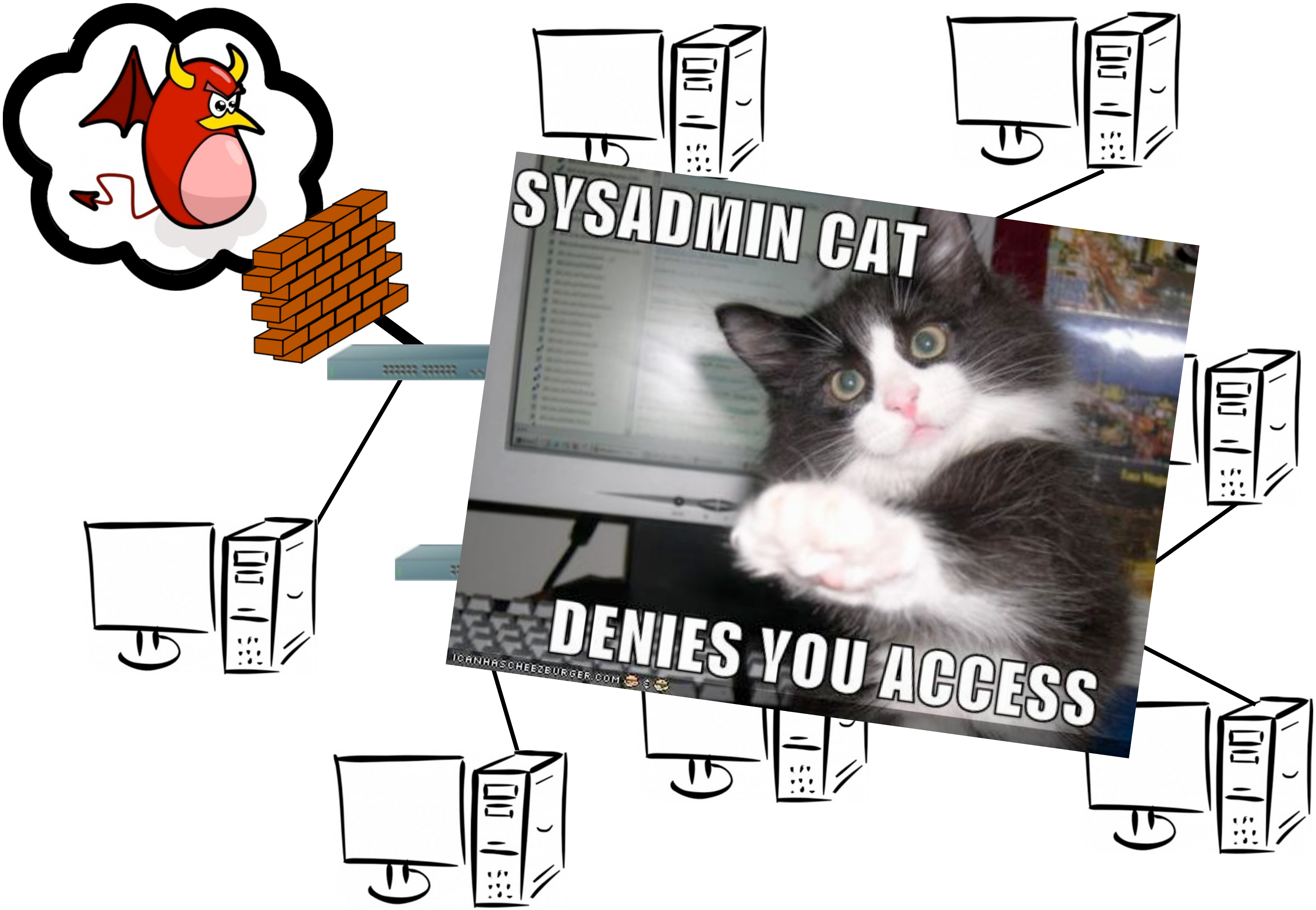
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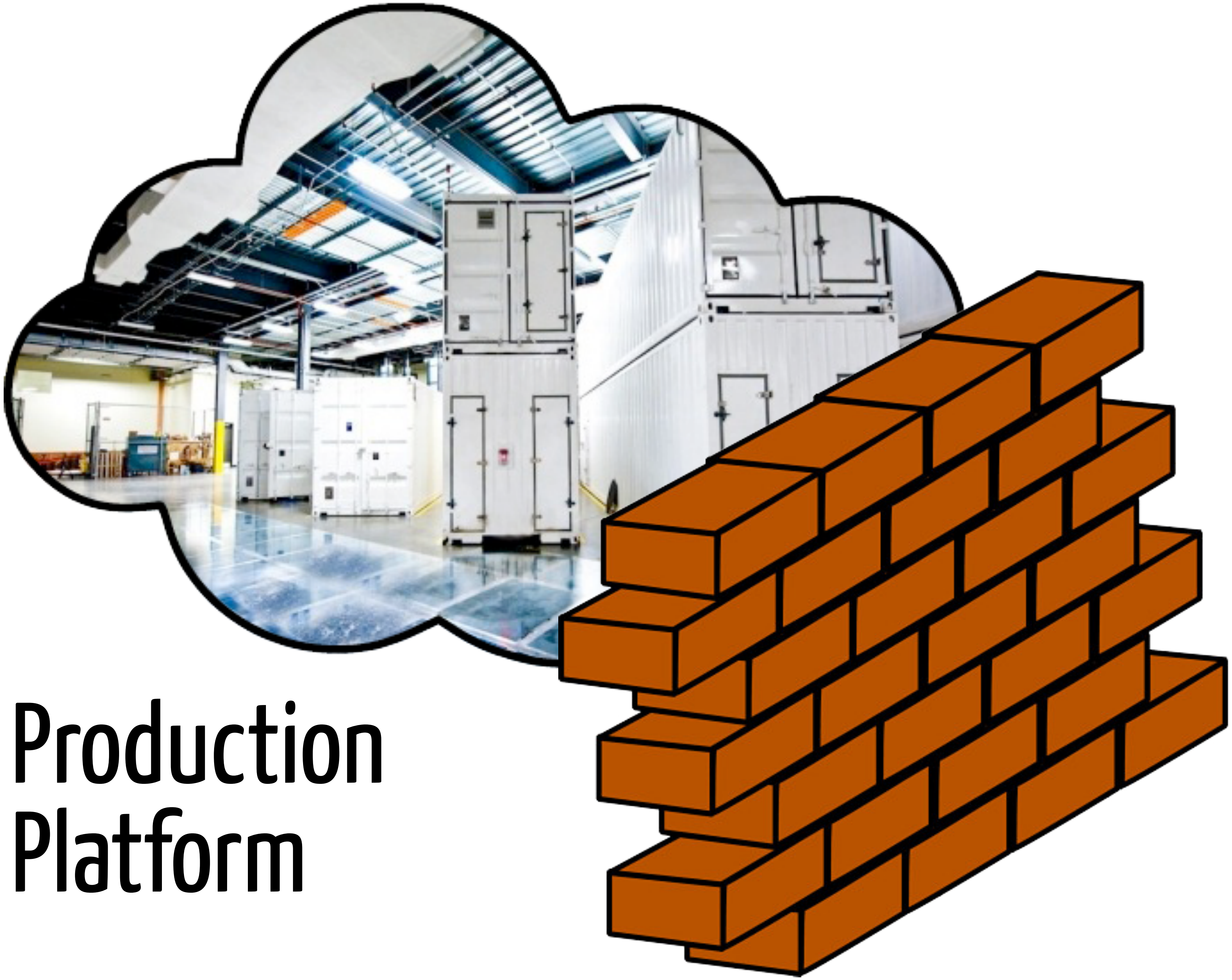
A problem in the cloud

Production Platform

Based on “Delusional Boot: Securing Cloud Hypervisors without Massive Re-Engineering” (EuroSys 2012)

Production Platform



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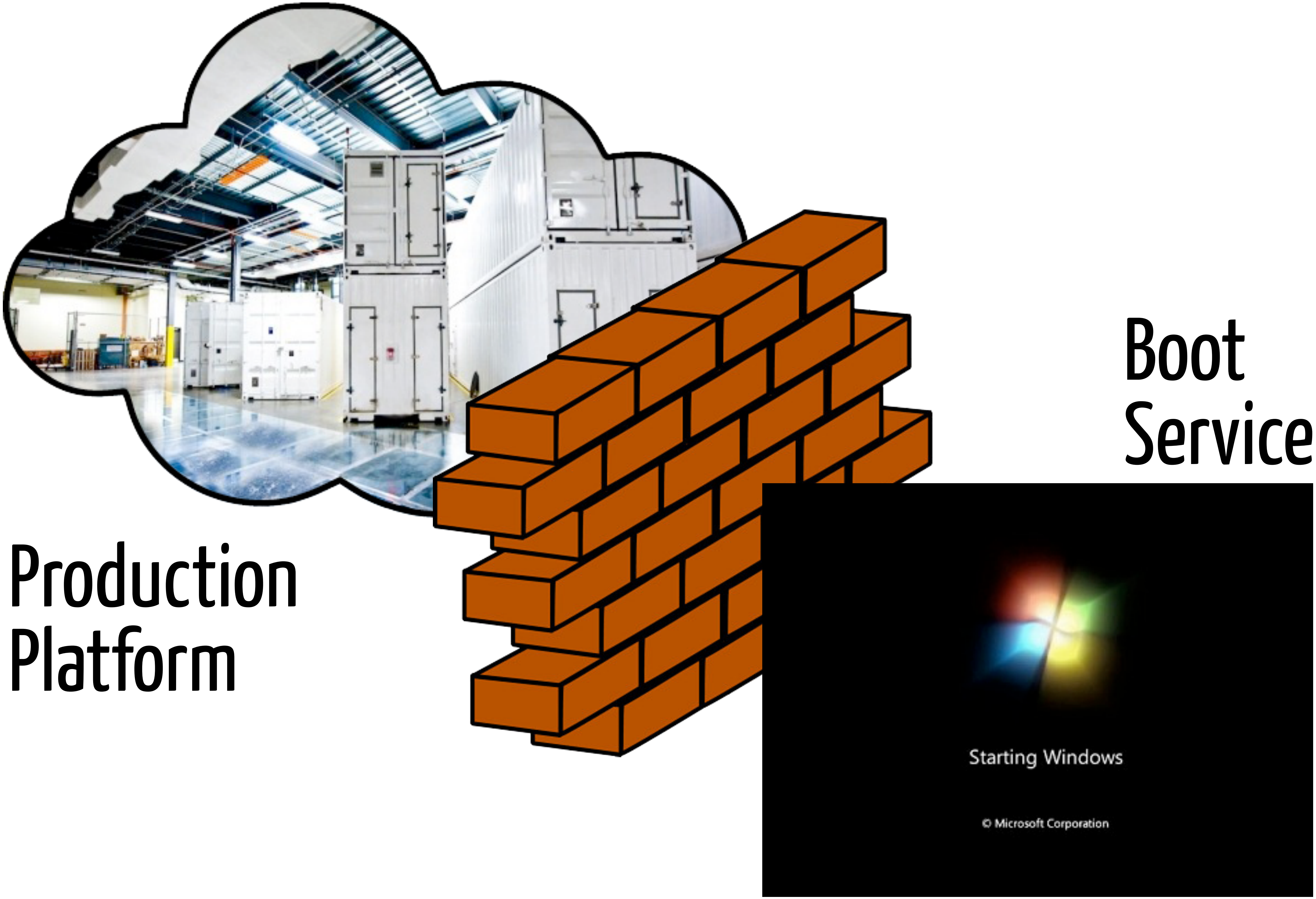


Starting Windows

© Microsoft Corporation

Boot Service

Production Platform

Based on "Delusional Boot: Securing Cloud Hypervisors without Massive Re-Engineering" (EuroSys 2012)

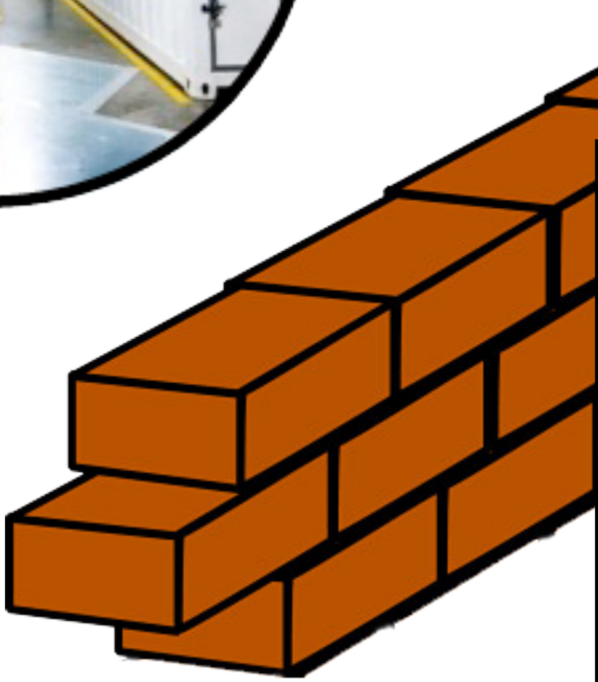
Steve
Password
Windows 7 Ultimate

Production Platform

Boot Service

Based on "Delusional Boot: Securing Cloud Hypervisors without Massive Re-Engineering" (EuroSys 2012)

Production Platform



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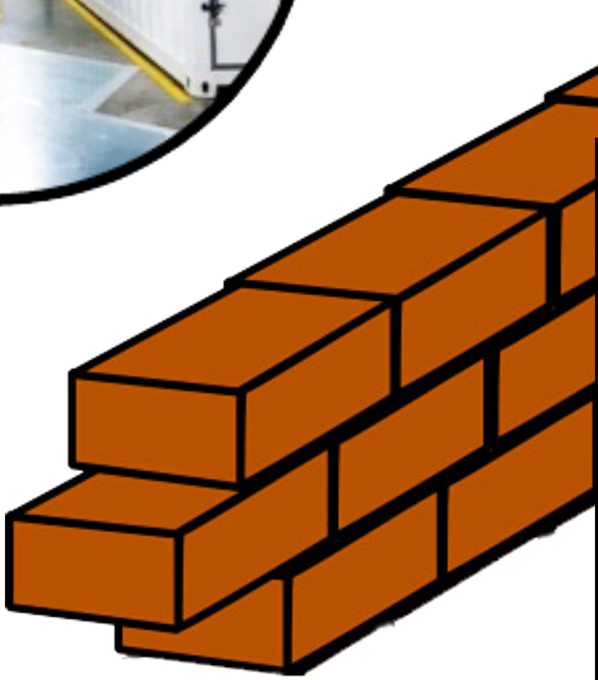

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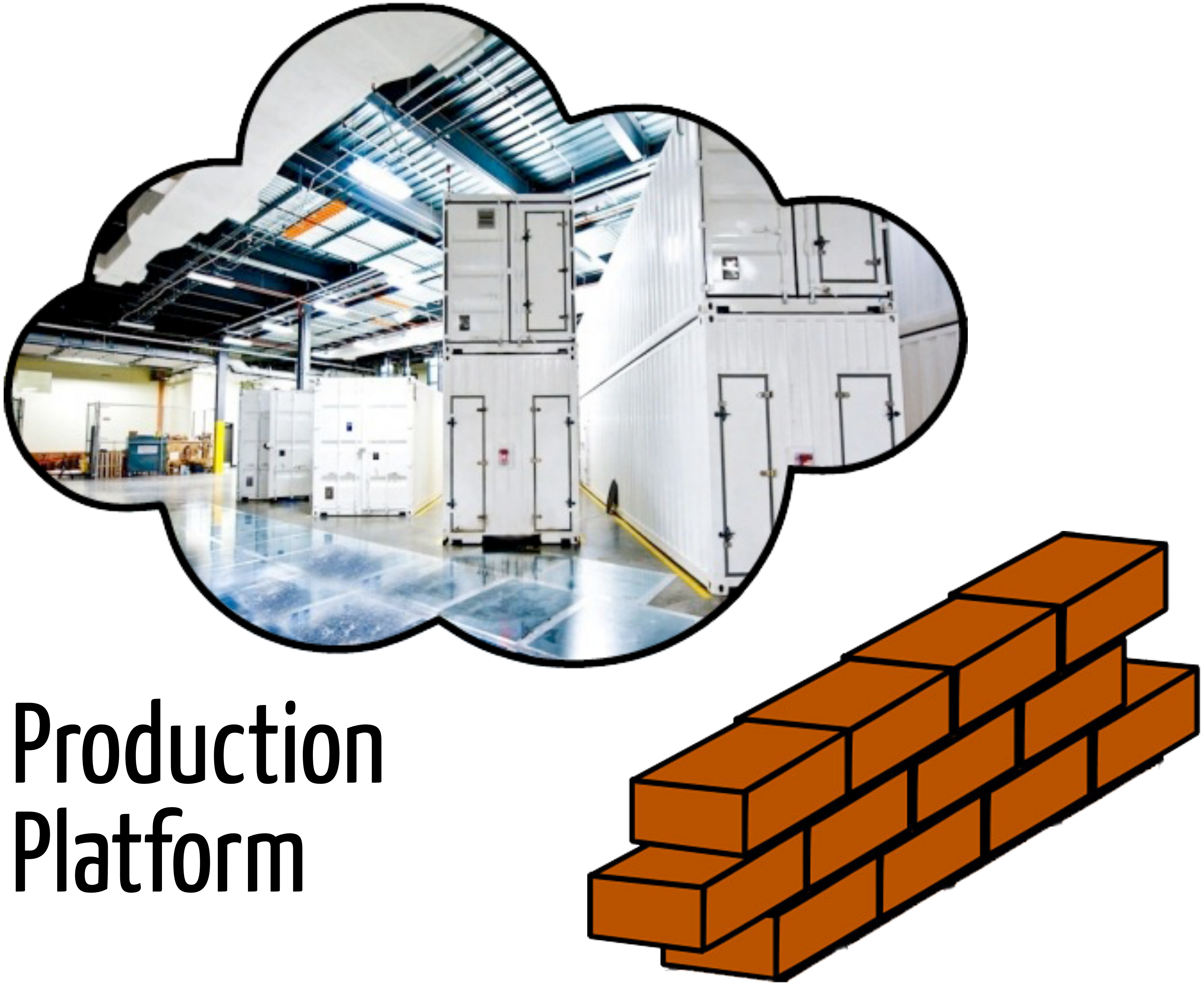

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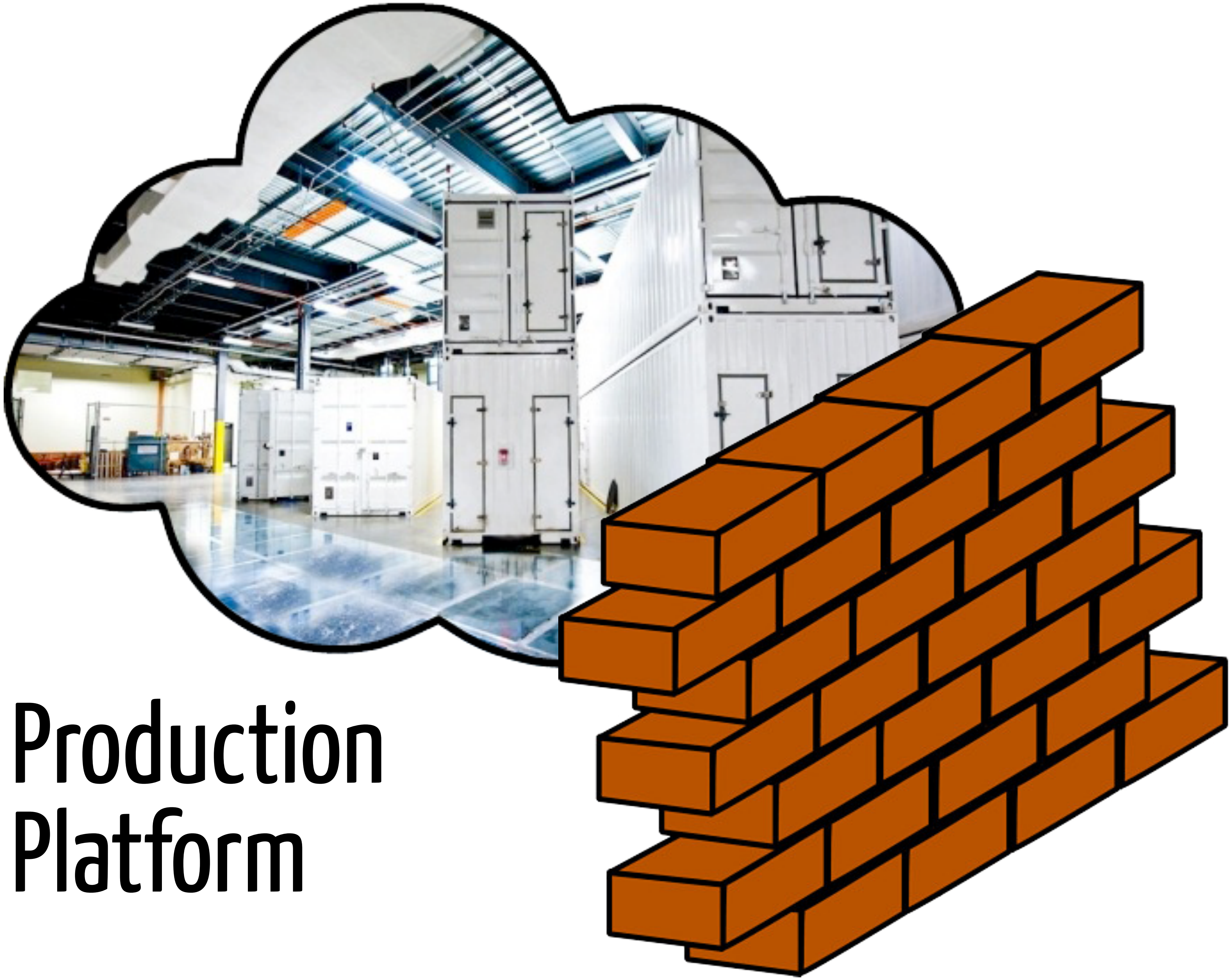

Production Platform

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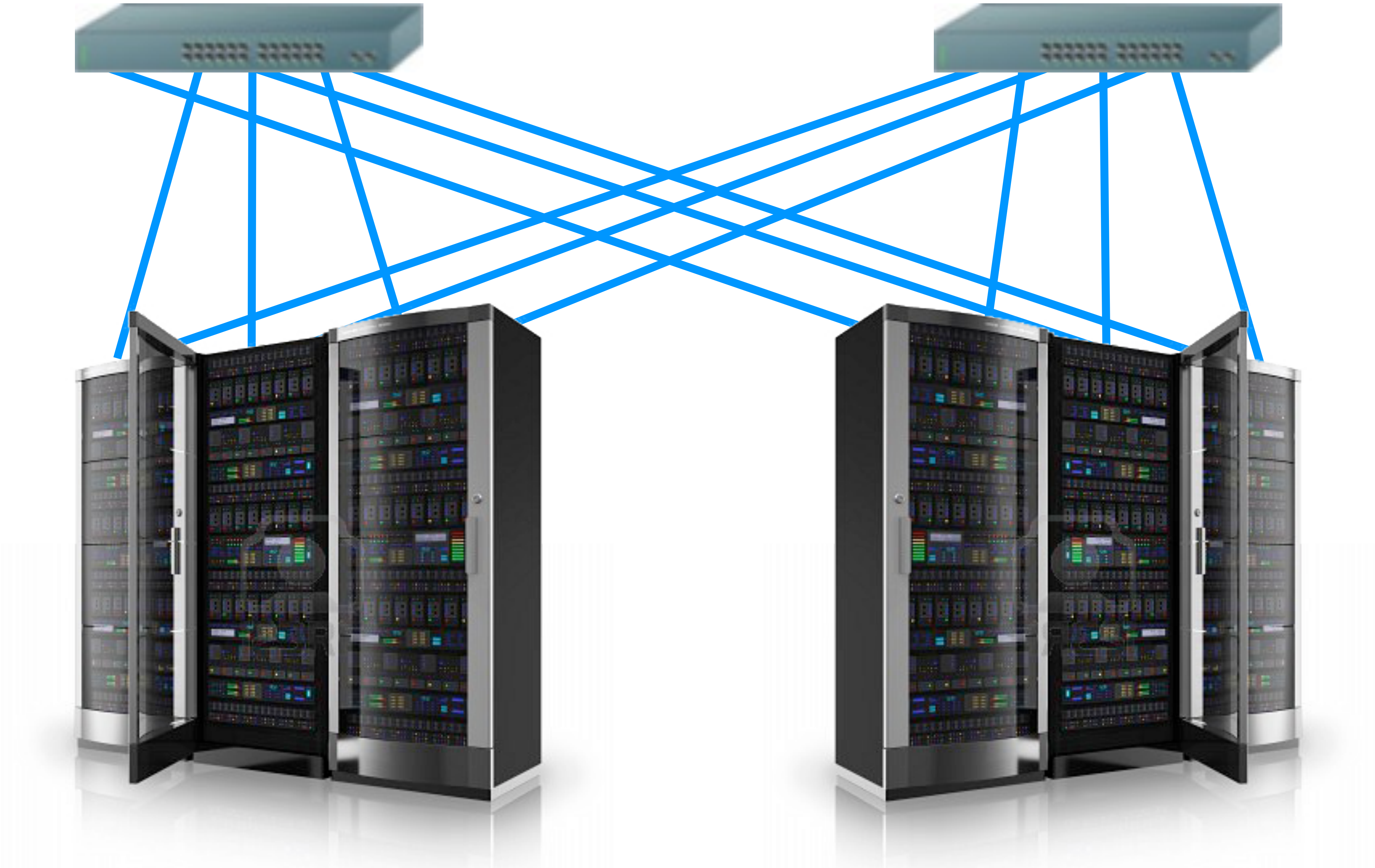
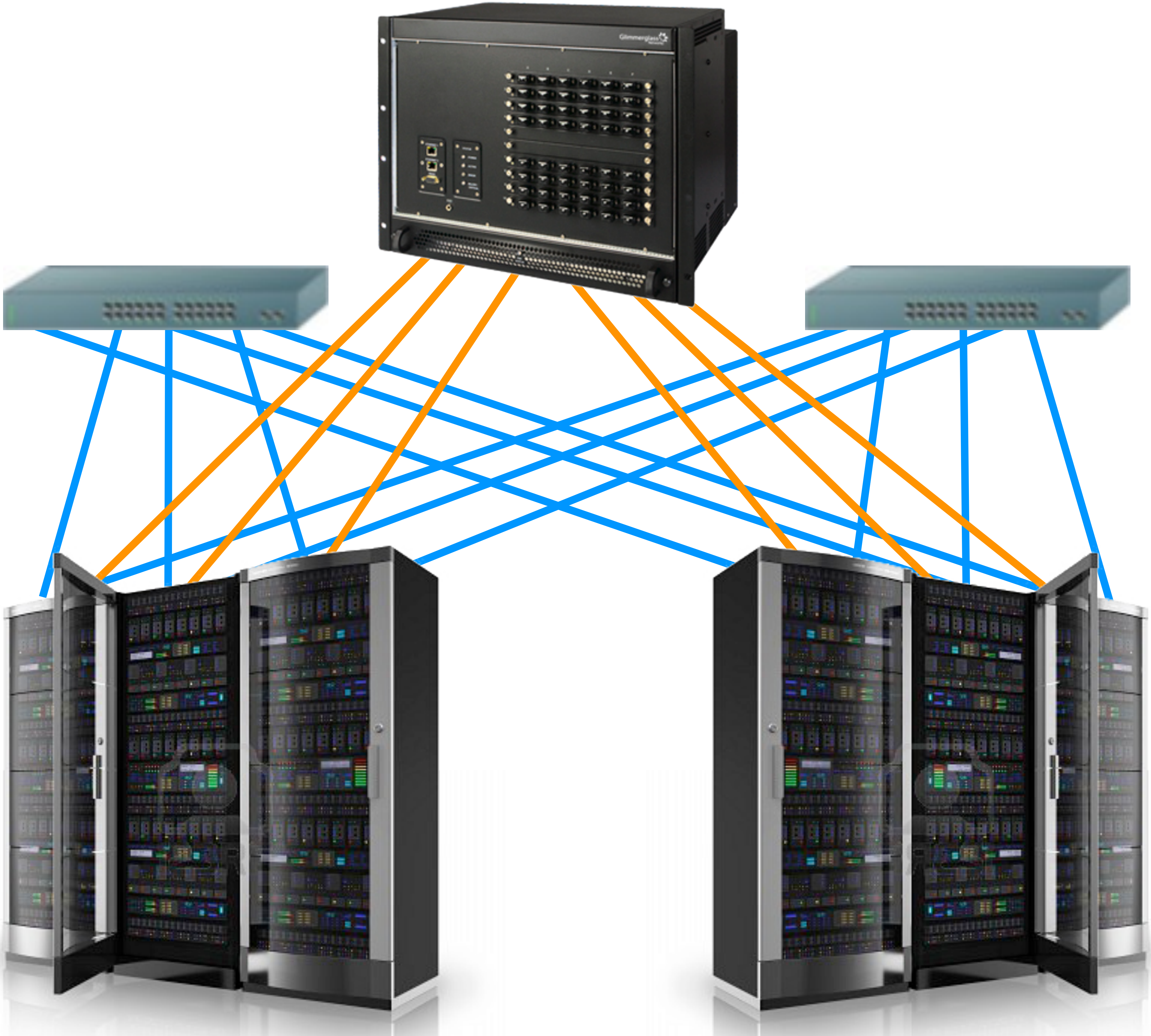
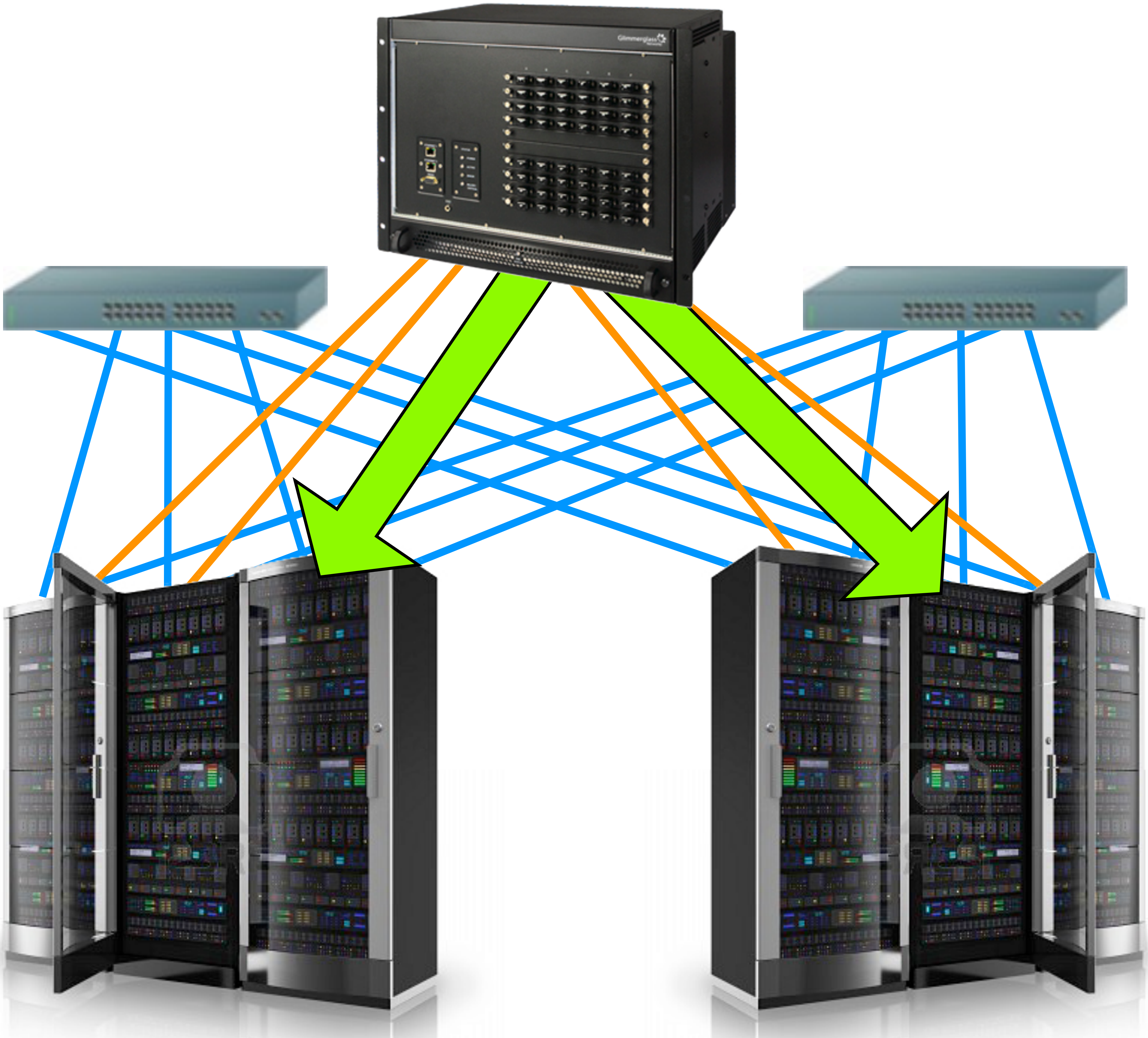
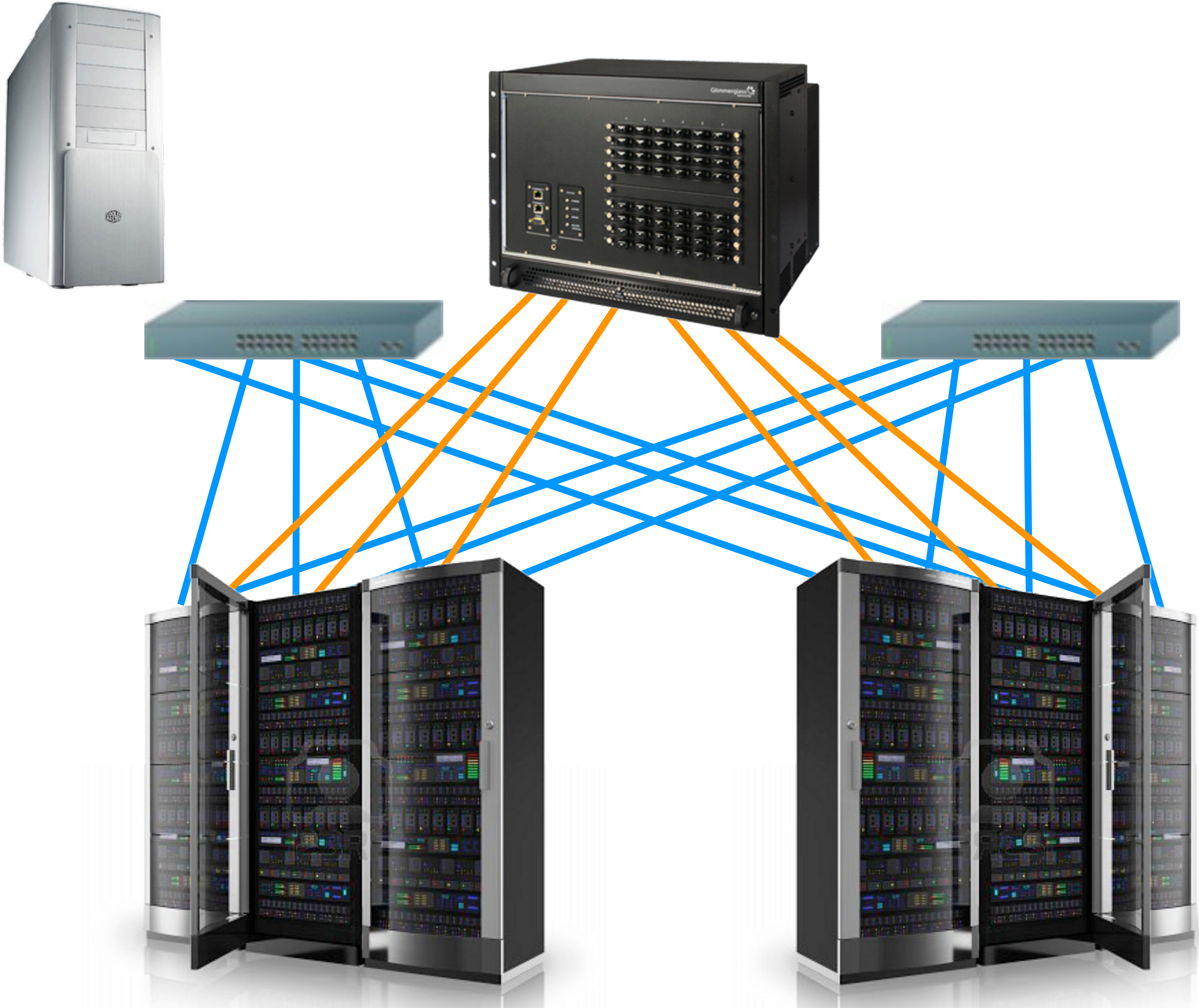
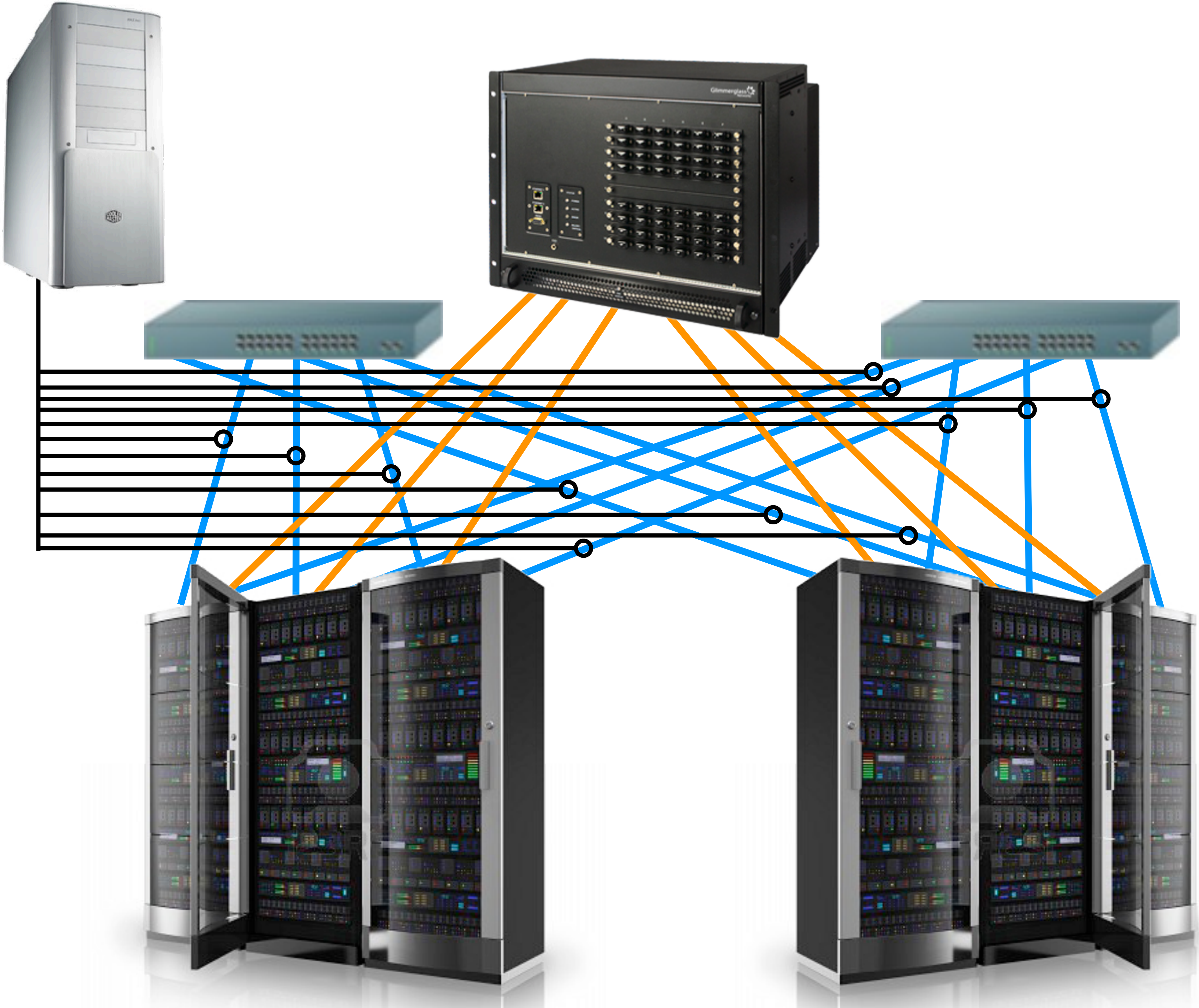
A problem in the datacenter

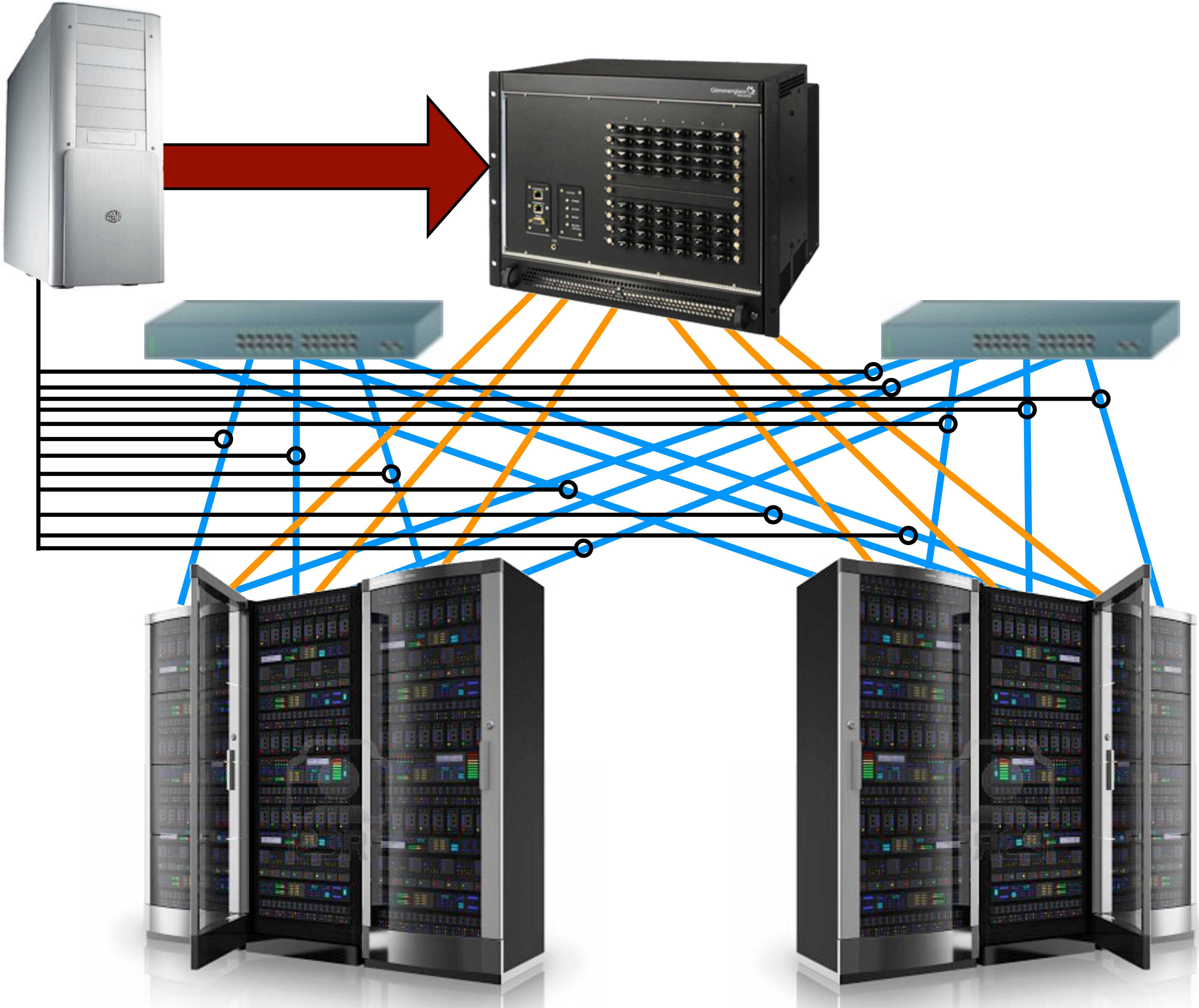




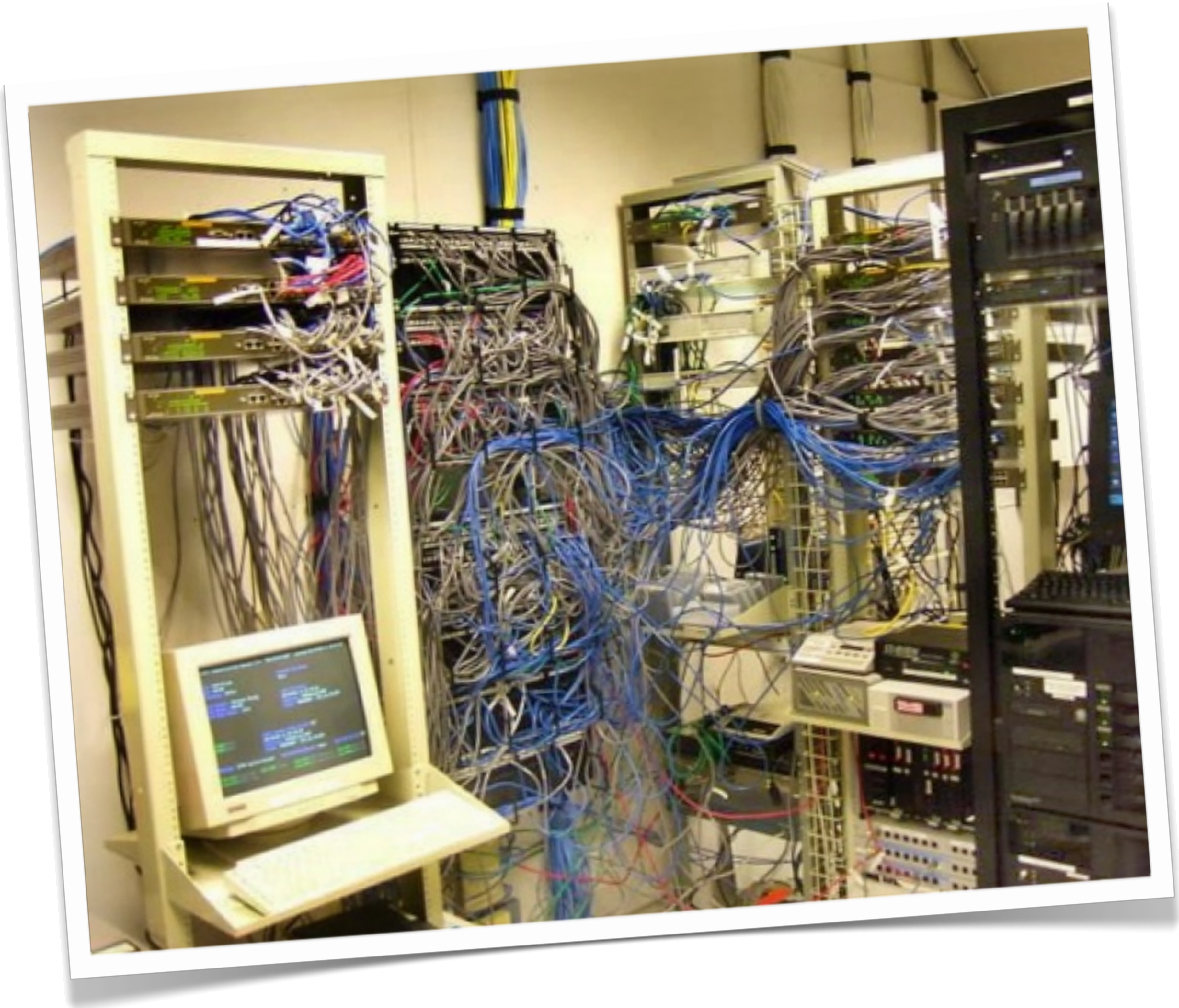








Proposal



Participatory Networking

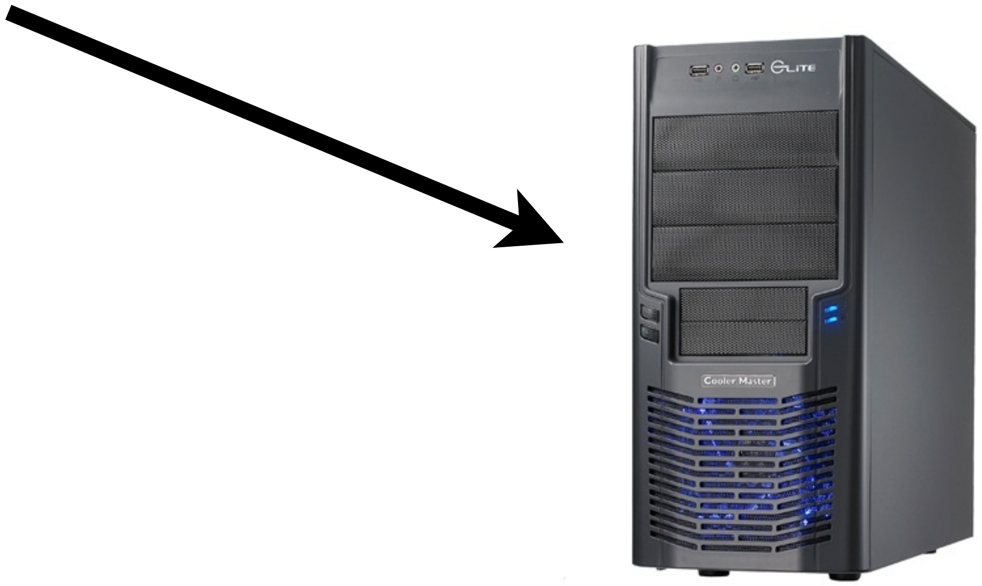
Participatory Networking

Participatory Networking

PANE

Participatory Networking

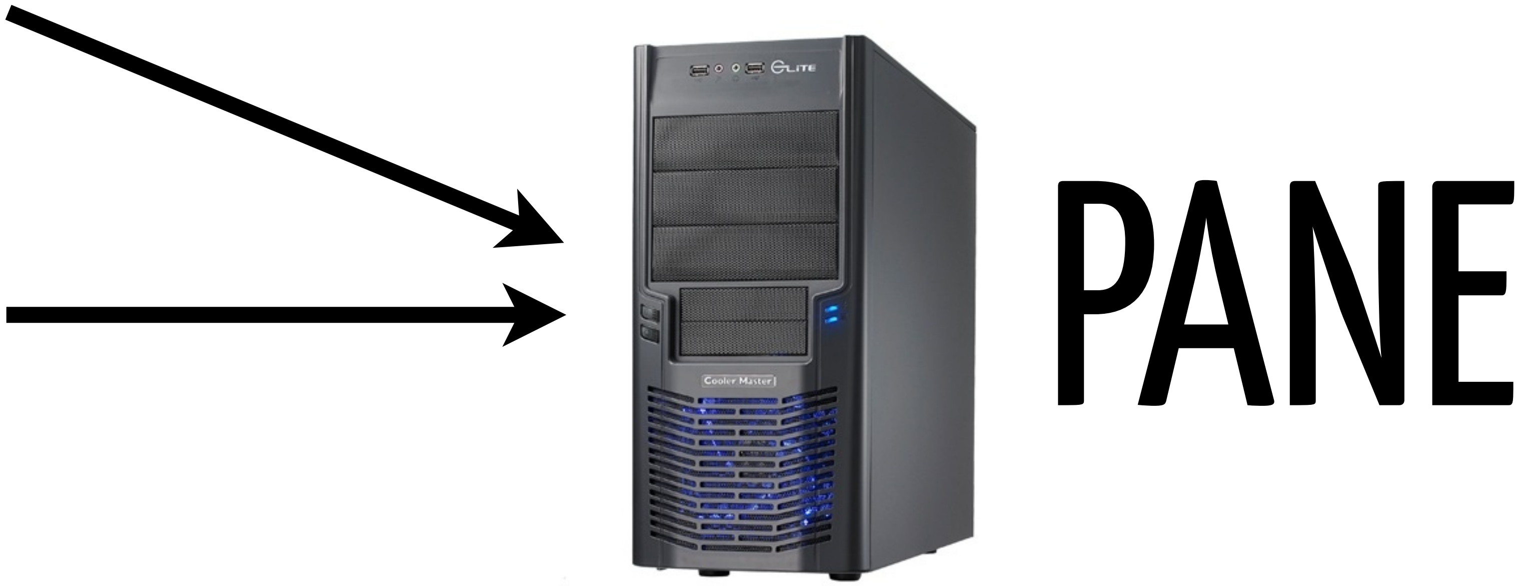
1. Requests



PANE

Participatory Networking

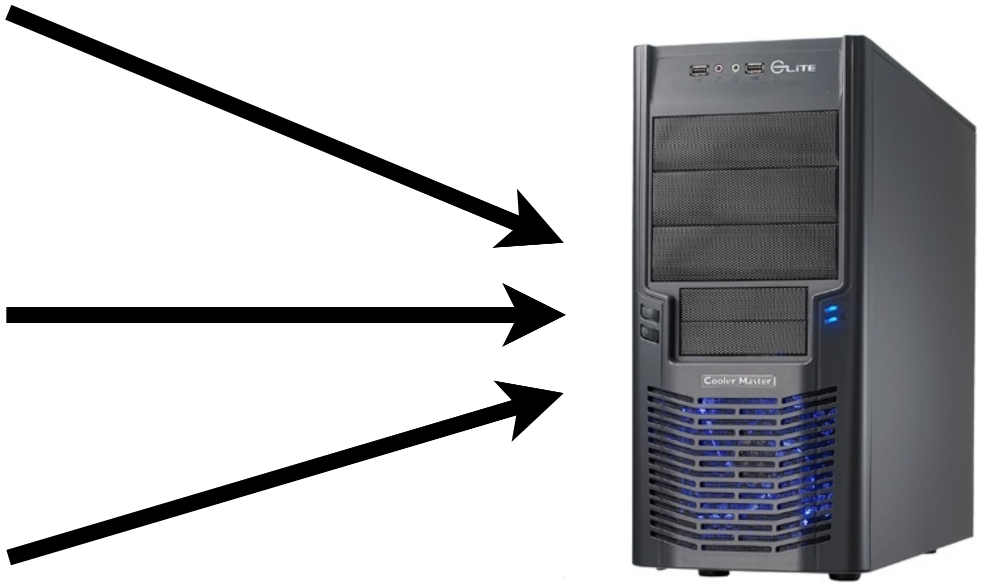
1. Requests
2. Hints



PANE

Participatory Networking

1. Requests
2. Hints
3. Queries



PANE

Participatory Networking

Participatory Networking

Safe?

Participatory Networking

Safe?

Secure?

Participatory Networking

Safe?

Secure?

Fair?

Participatory Networking

Secure?

Safe?

Fair?

Practical?

Participatory Networking

Safe?

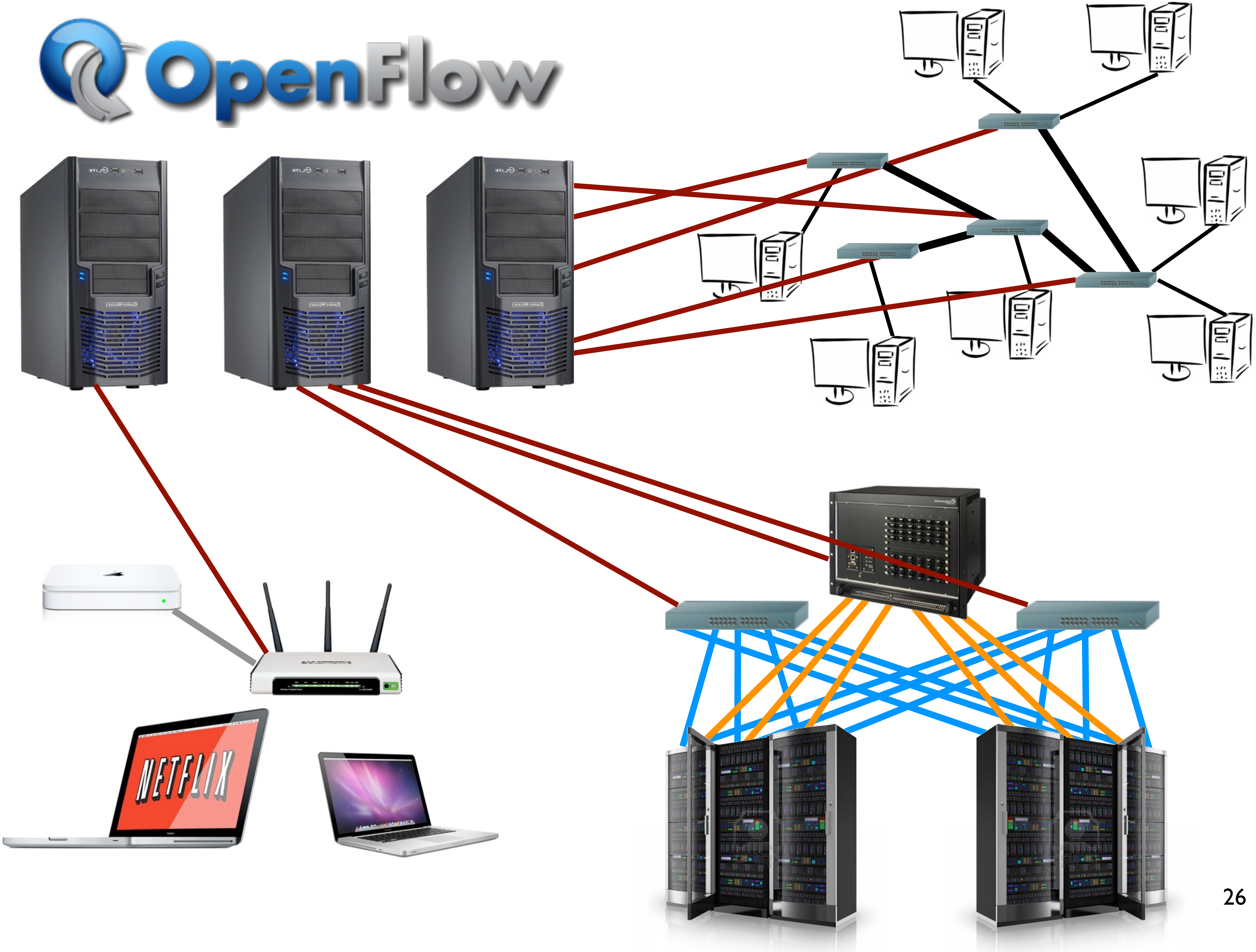
Secure?

Fair?

Practical?

Efficient?

OpenFlow



Participatory Networking

Participatory Networking

- End-user API for SDNs

Participatory Networking

- End-user API for SDNs
- Exposes existing mechanisms

Participatory Networking

- End-user API for SDNs
- Exposes existing mechanisms
- No effect on unmodified applications

The PANE prototype

1. semantics

The PANE prototype

1. semantics
2. protocol

The PANE prototype

1. semantics
2. protocol
3. controller

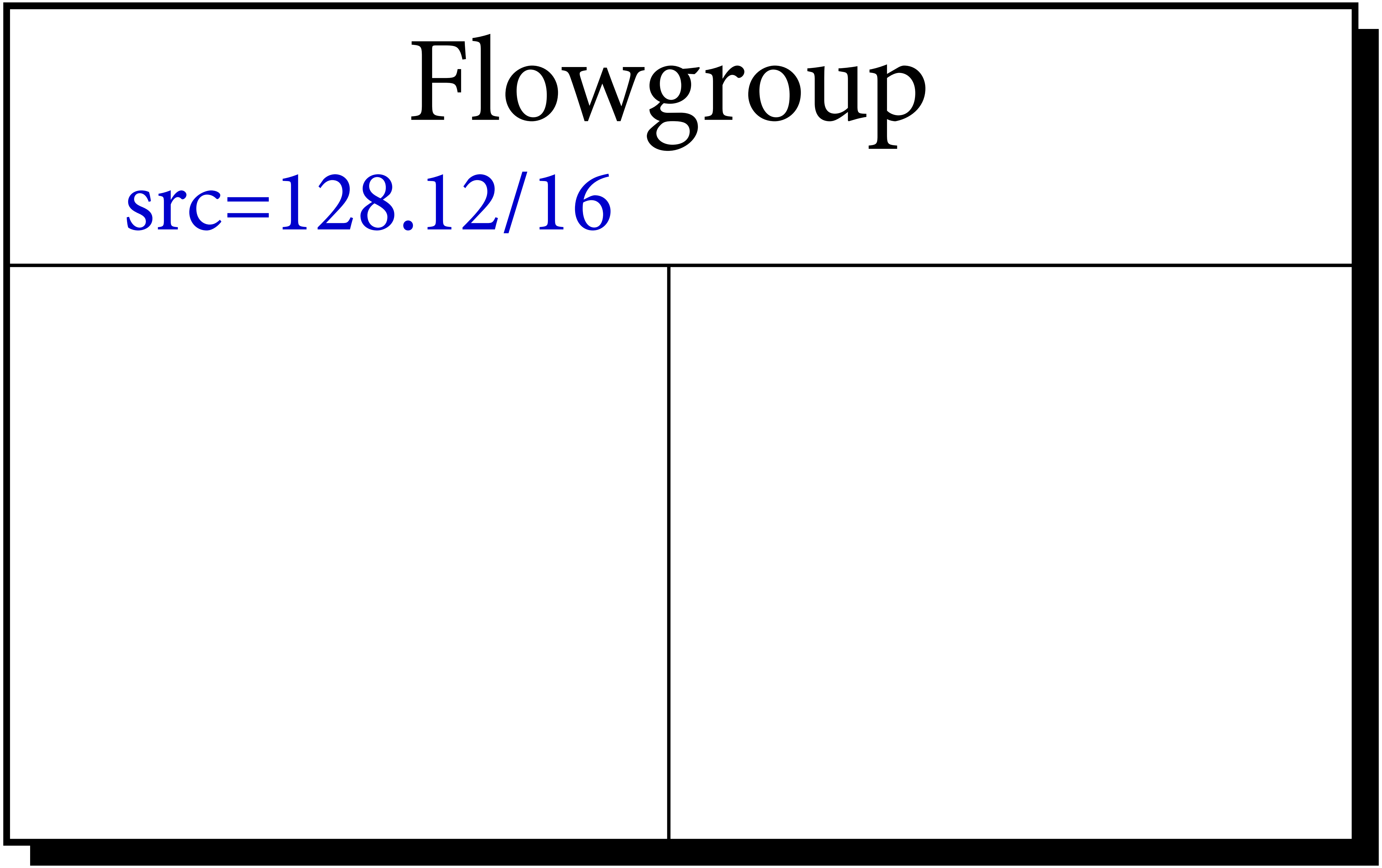
The PANE prototype

1. semantics
2. protocol
3. controller

The PANE prototype

Semantics

Flowgroup



Flowgroup

src=128.12/16

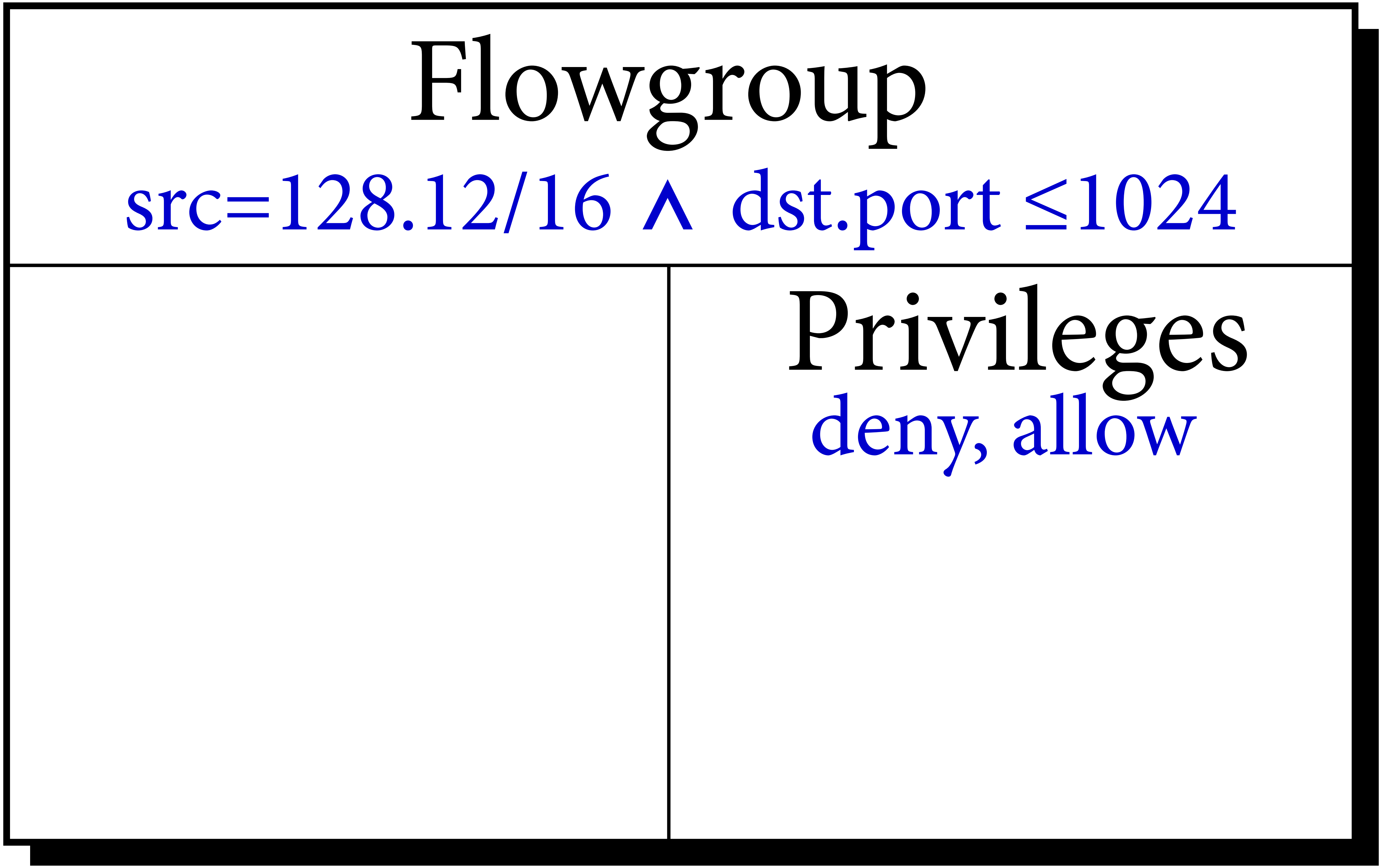
Flowgroup

$\text{src}=128.12/16 \wedge \text{dst.port} \leq 1024$

Flowgroup

src=128.12/16 ∧ dst.port ≤1024

Privileges



Flowgroup

src=128.12/16 $\wedge$ dst.port $\leq$1024

Privileges

deny, allow

Flowgroup

src=128.12/16 ∧ dst.port ≤1024

Privileges

deny, allow

bandwidth: 5Mb/s

limit: 10Mb/s

Flowgroup

src=128.12/16 ∧ dst.port ≤1024

Privileges

deny, allow

bandwidth: 5Mb/s

limit: 10Mb/s

hint

query

Flowgroup

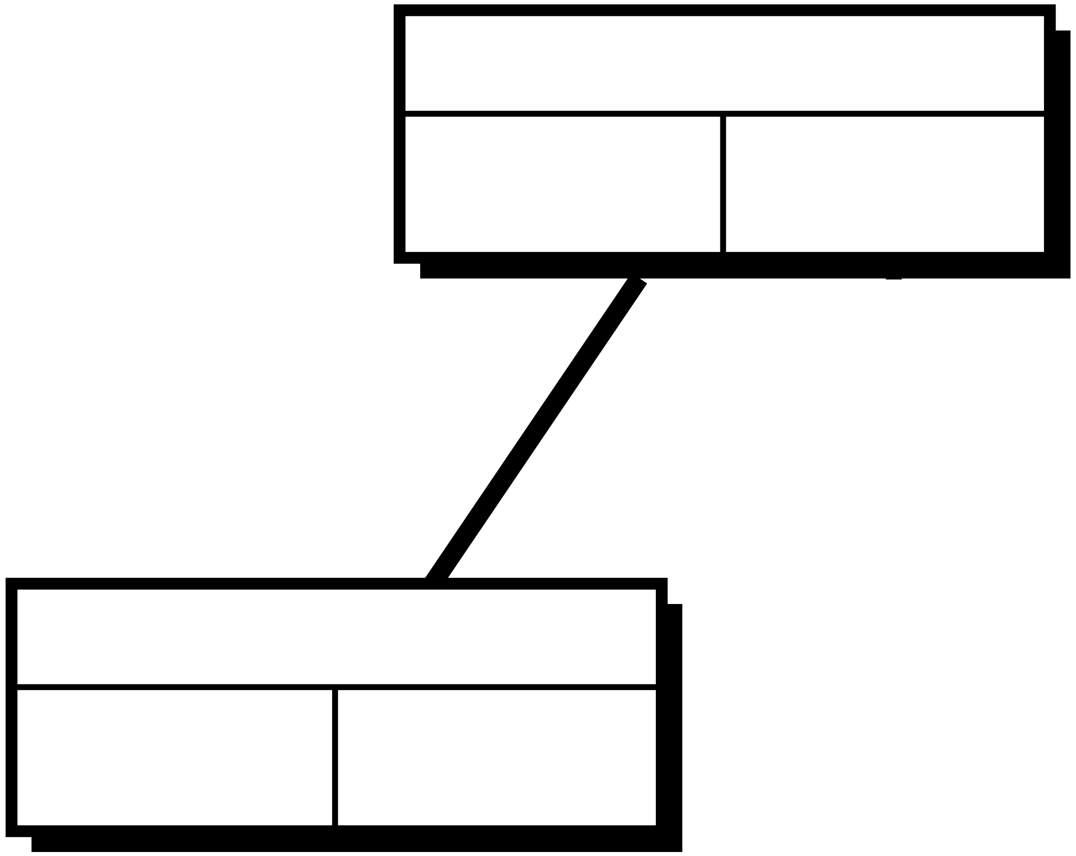
src=128.12/16 ∧ dst.port ≤1024

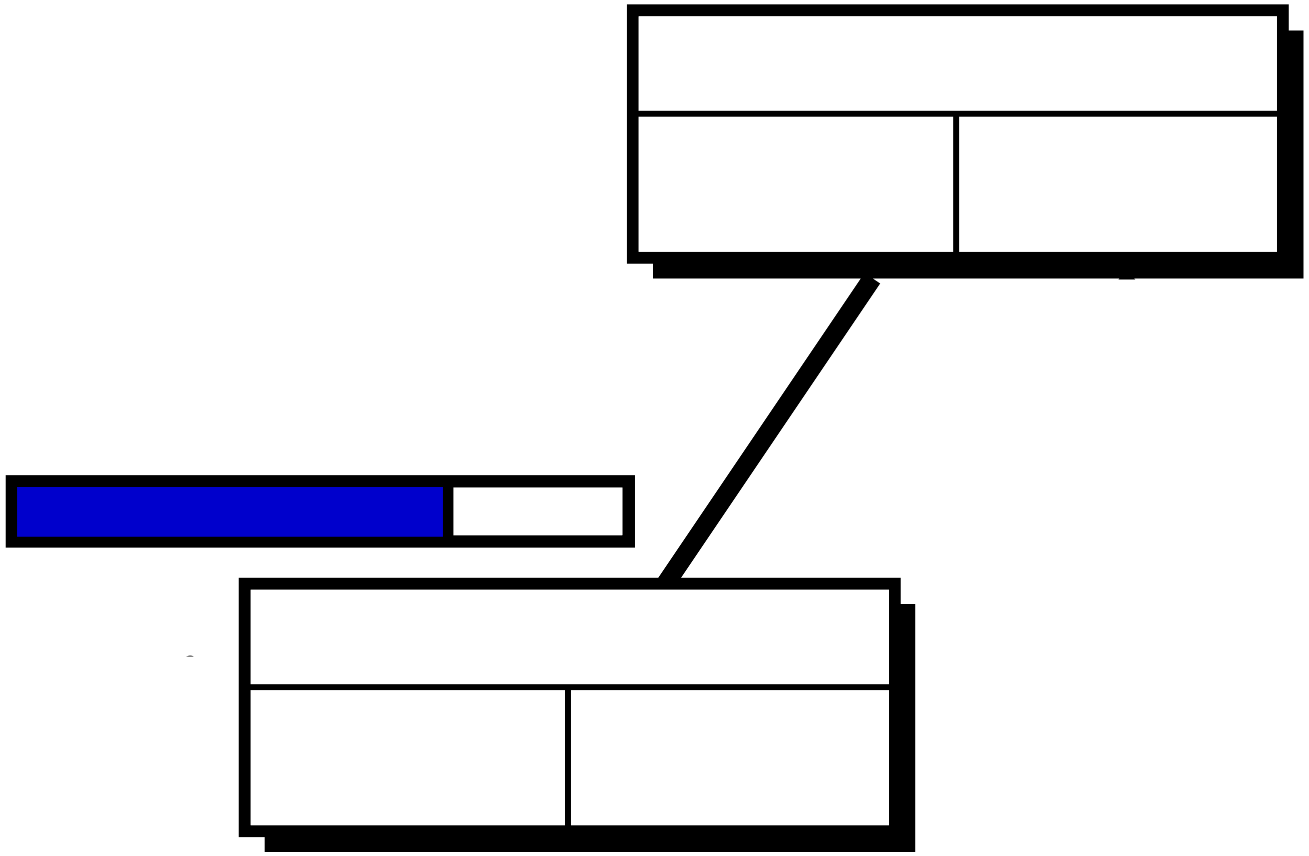
Speakers	Privileges
	deny, allow bandwidth: 5Mb/s limit: 10Mb/s *hint* *query*

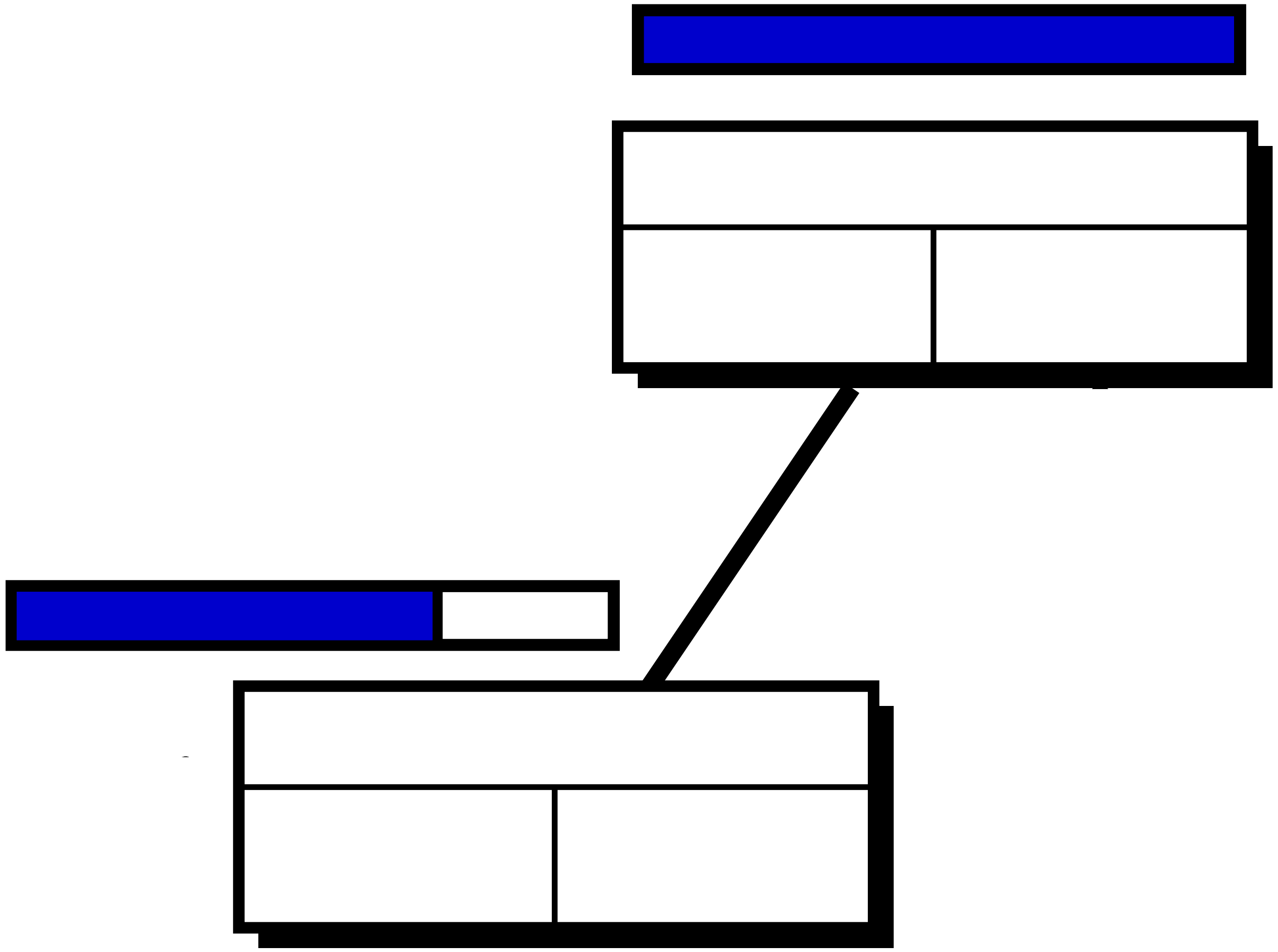
Flowgroup

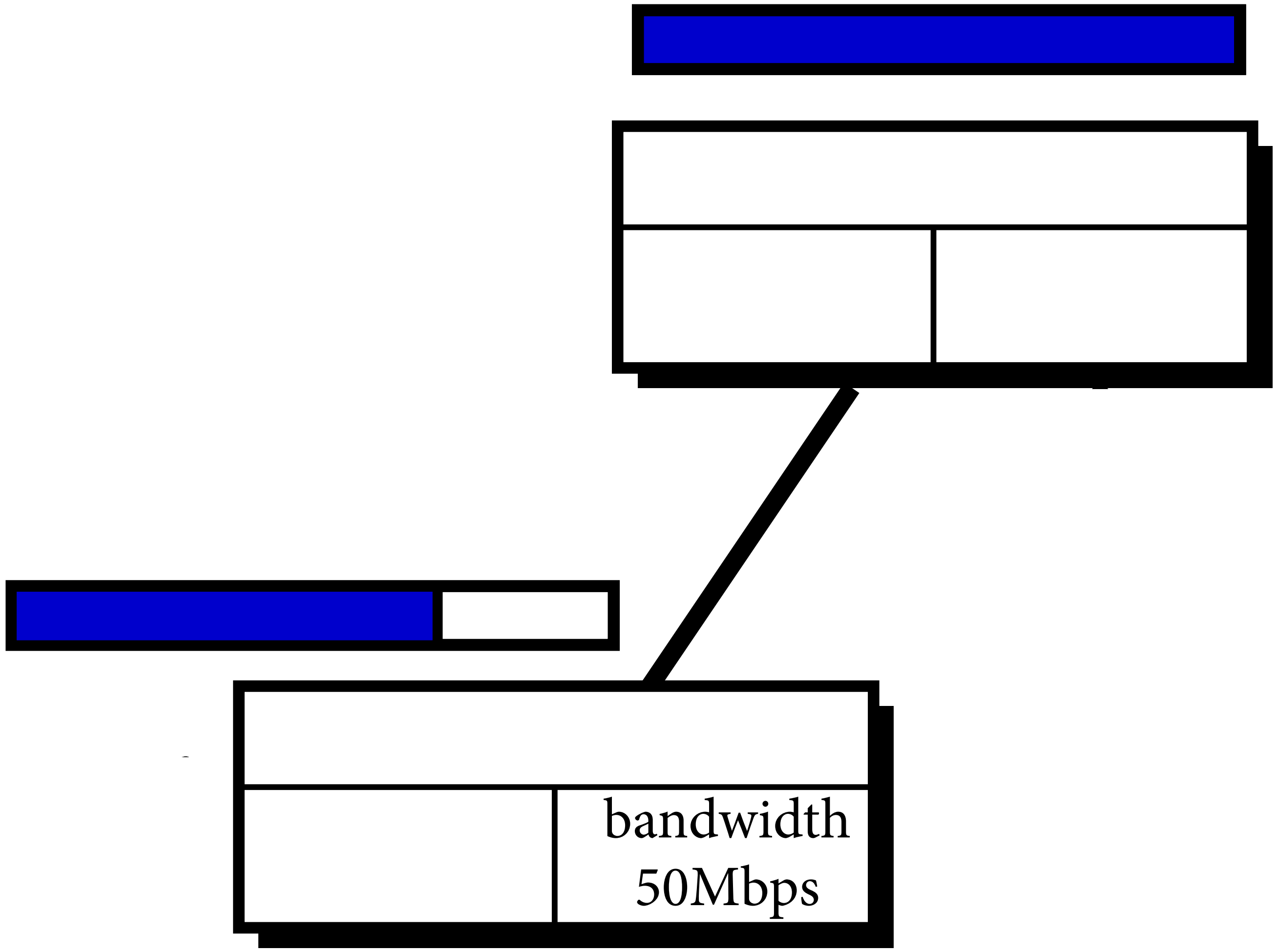
$src=128.12/16 \wedge dst.port \leq 1024$

Speakers	Privileges
Alice Bob	deny, allow bandwidth: 5Mb/s limit: 10Mb/s *hint* *query*

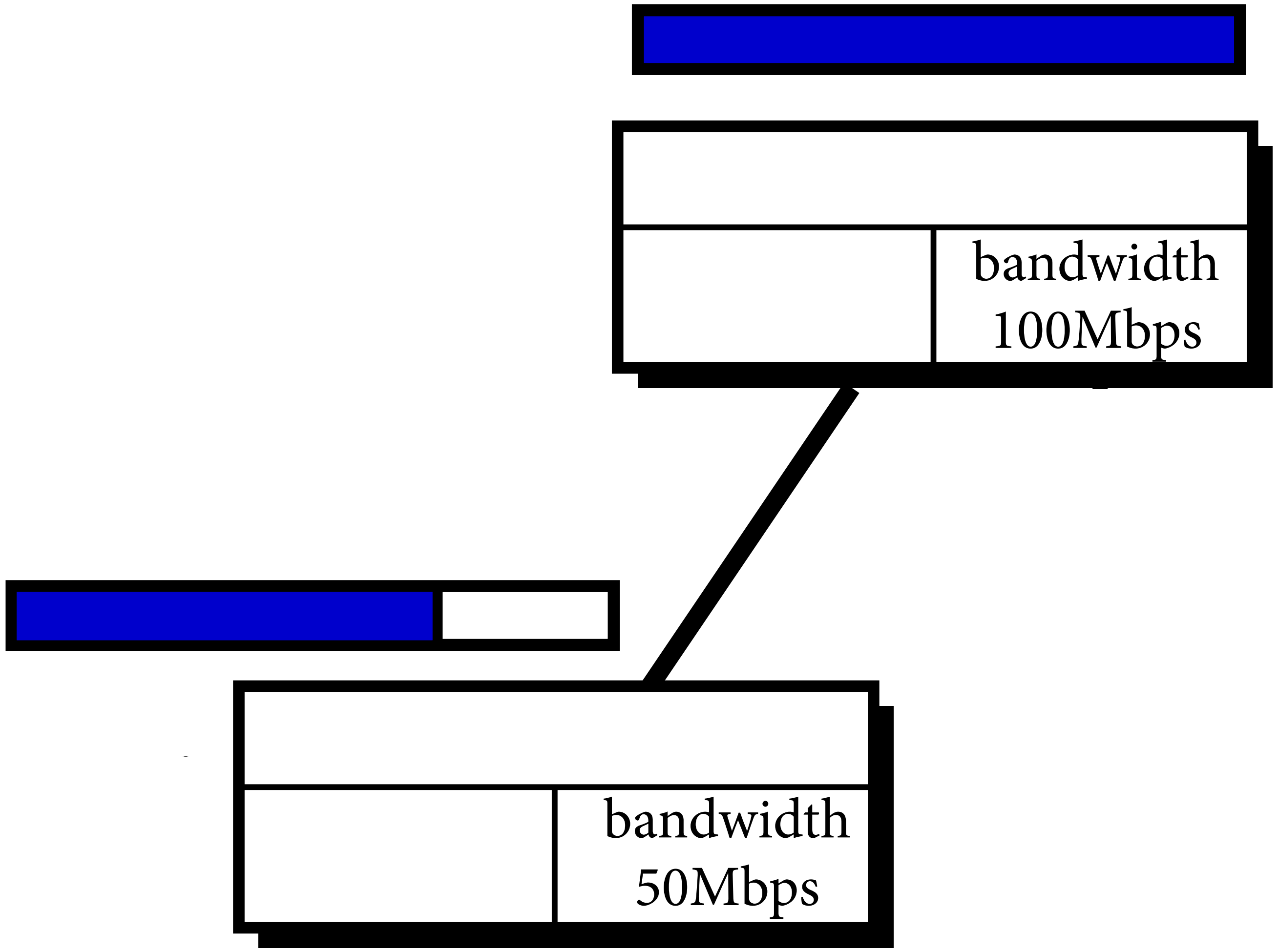


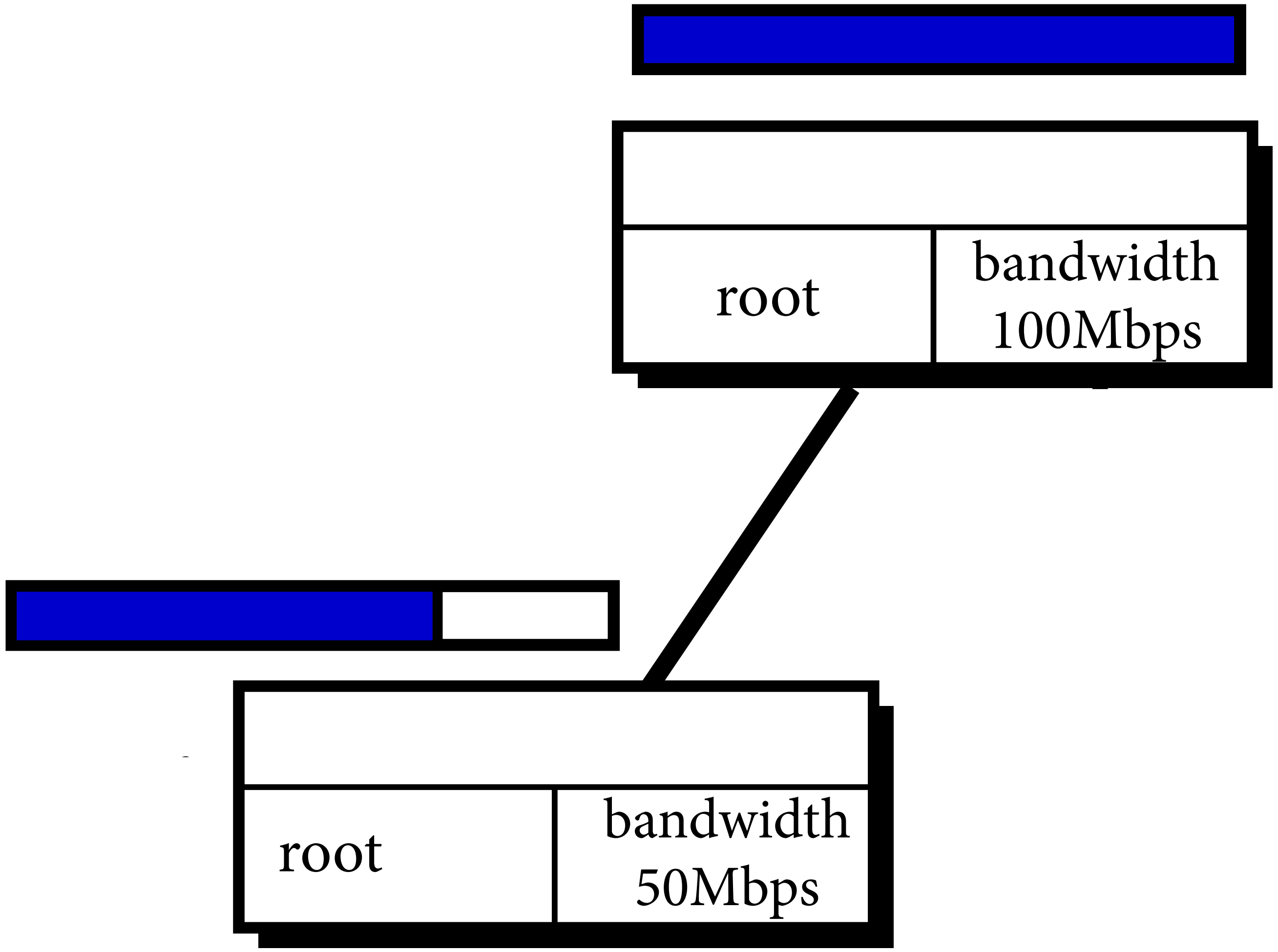


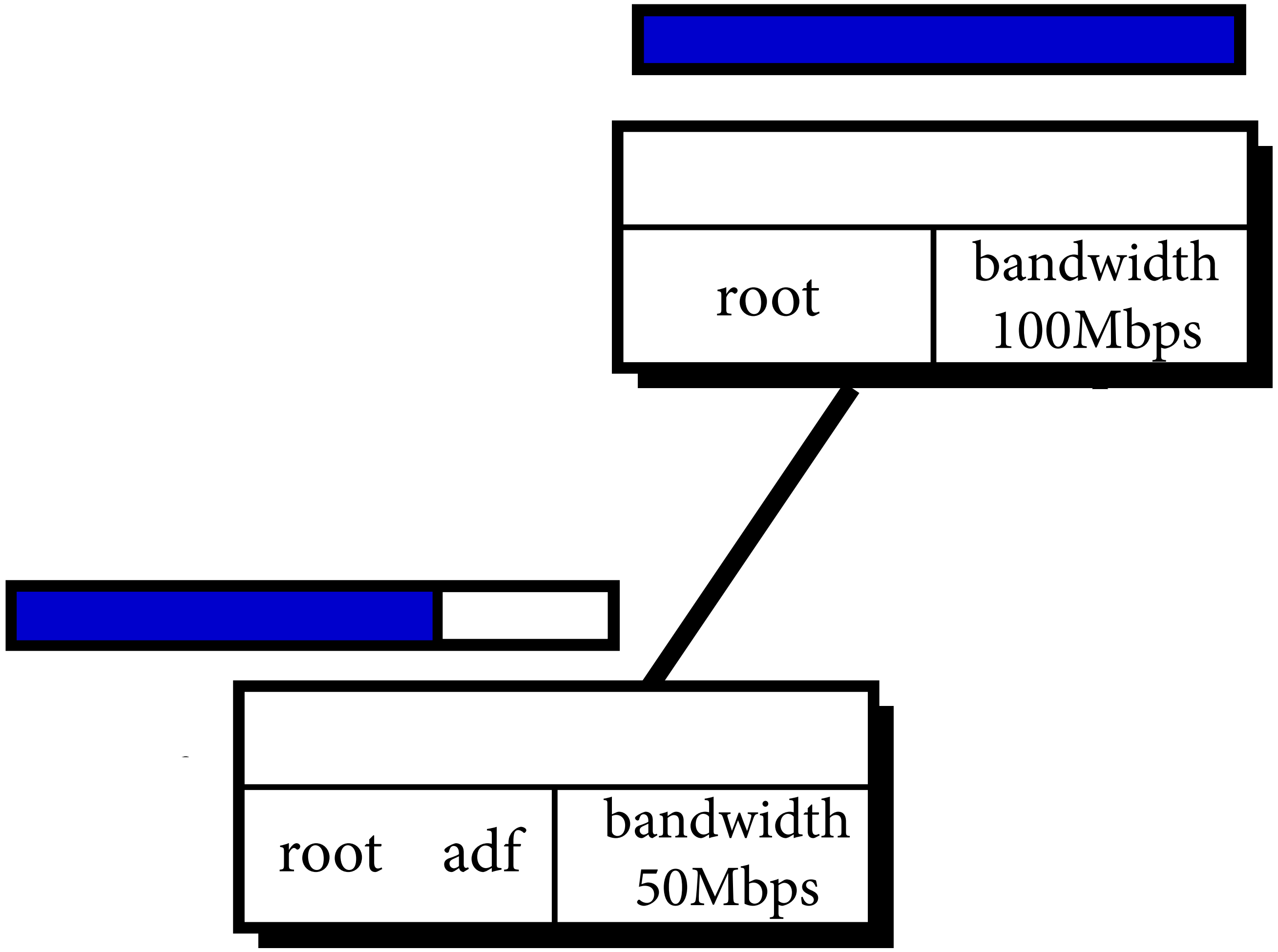


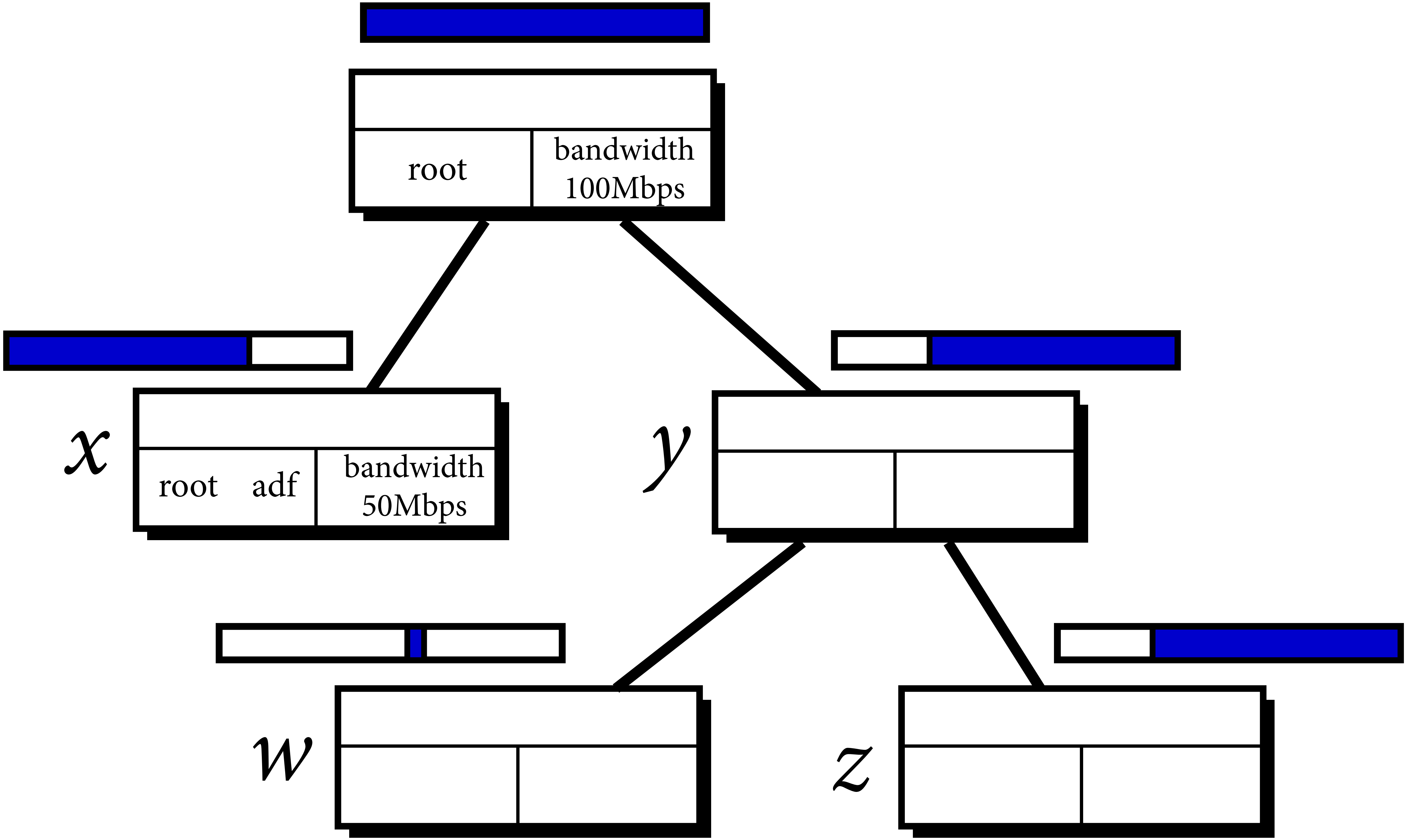


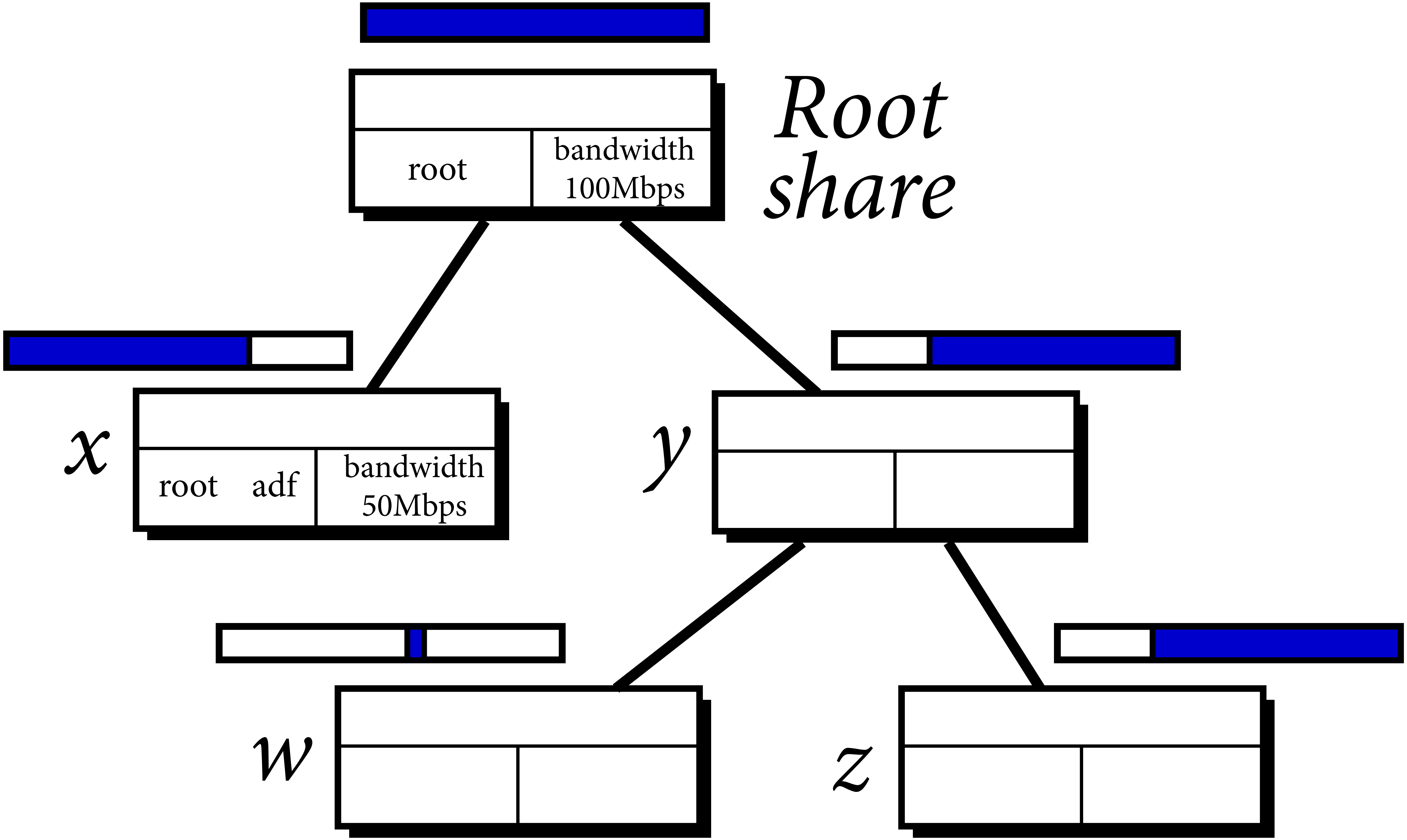
bandwidth 50Mbps

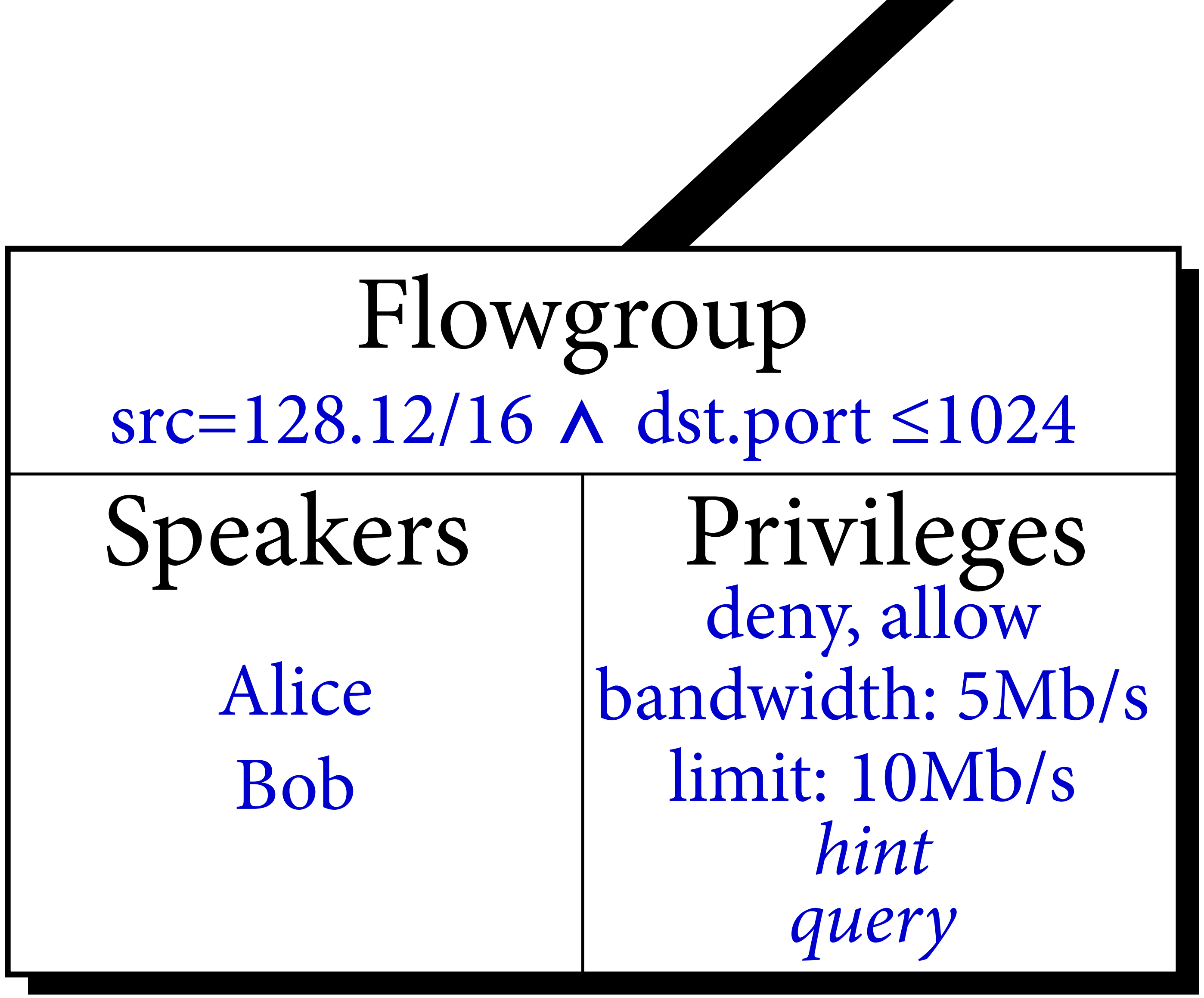

bandwidth 100Mbps
bandwidth 50Mbps


root
bandwidth 100Mbps
root
bandwidth 50Mbps


root
bandwidth
100Mbps
root
adf
bandwidth
50Mbps


root
bandwidth
100Mbps
x
root
adf
bandwidth
50Mbps
y
w
z


root
bandwidth
100Mbps
Root
share
x
root
adf
bandwidth
50Mbps
y
w
z



Flowgroup

src=128.12/16 ∧ dst.port ≤1024

Speakers

Alice

Bob

Privileges

deny, allow

bandwidth: 5Mb/s

limit: 10Mb/s

hint

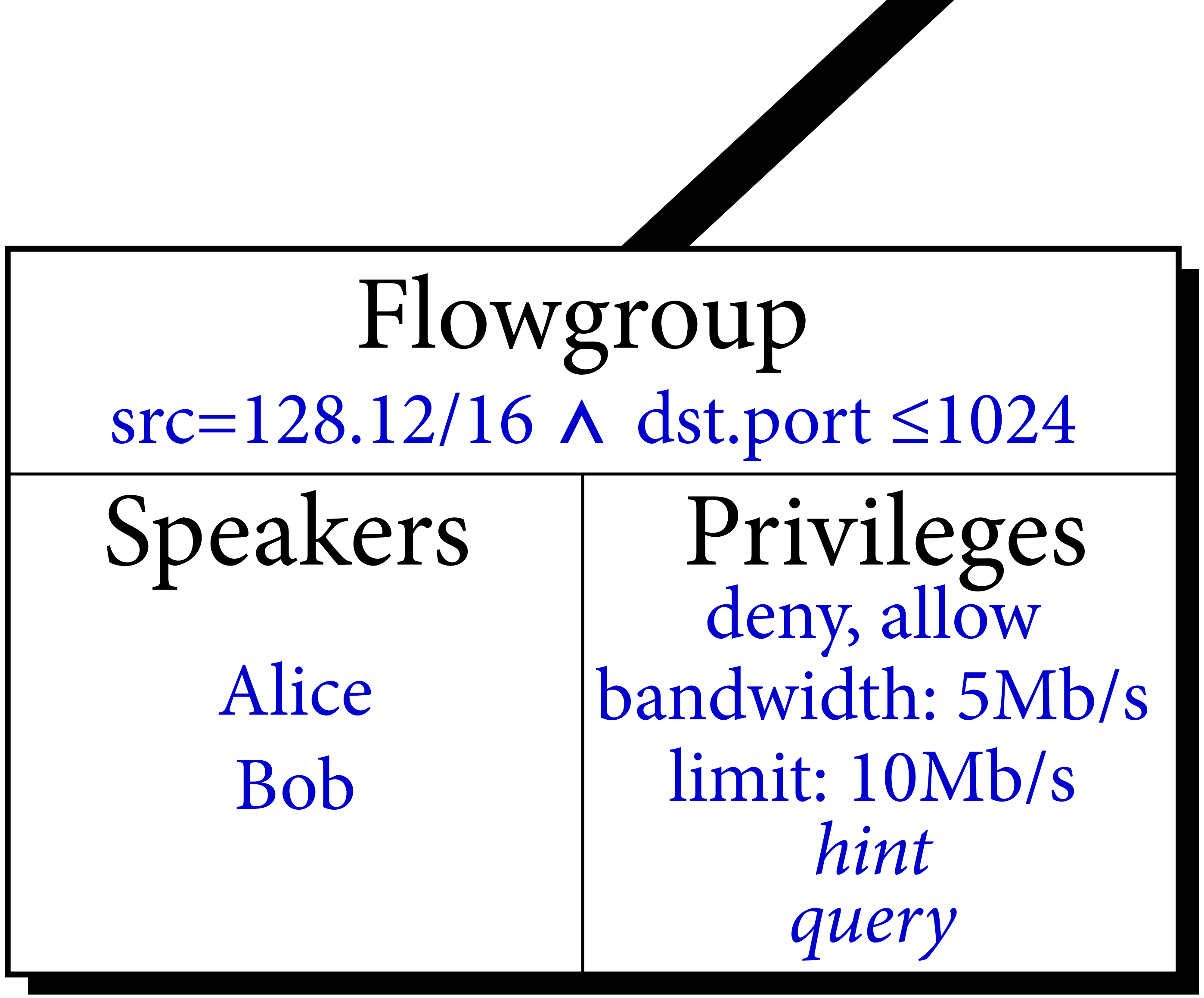
query

Flowgroup

src=128.12/16 ∧ dst.port ≤1024

Speakers	Privileges
Alice Bob	deny, allow bandwidth: 5Mb/s limit: 10Mb/s *hint* *query*

PANE



Flowgroup

src=128.12/16 ∧ dst.port ≤1024

Speakers	Privileges
Alice Bob	deny, allow bandwidth: 5Mb/s limit: 10Mb/s *hint* *query*

Reserve 2 Mbps from now to +5min?

PANE

Flowgroup

src=128.12/16 ∧ dst.port ≤1024

Speakers	Privileges
Alice Bob	deny, allow bandwidth: 5Mb/s limit: 10Mb/s *hint* *query*

Yes

PANE

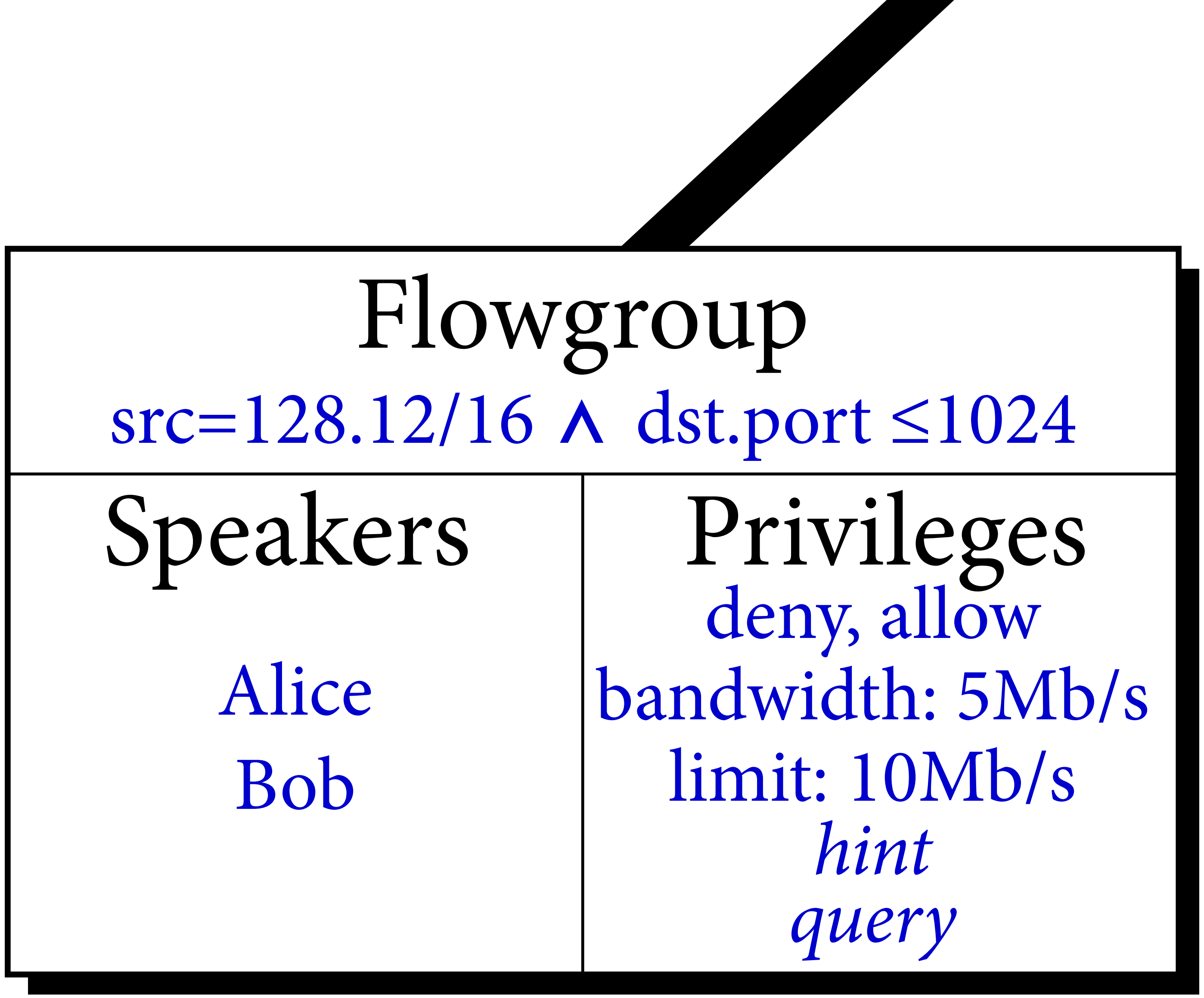
Flowgroup

src=128.12/16 ∧ dst.port ≤1024

Speakers	Privileges
Alice Bob	deny, allow bandwidth: 5Mb/s limit: 10Mb/s *hint* *query*

This traffic will be short and bursty

PANE



Flowgroup

src=128.12/16 ∧ dst.port ≤1024

Speakers	Privileges
Alice Bob	deny, allow bandwidth: 5Mb/s limit: 10Mb/s *hint* *query*

OK

PANE

Flowgroup

src=128.12/16 ∧ dst.port ≤1024

Speakers	Privileges
Alice Bob	deny, allow bandwidth: 5Mb/s limit: 10Mb/s *hint* *query*

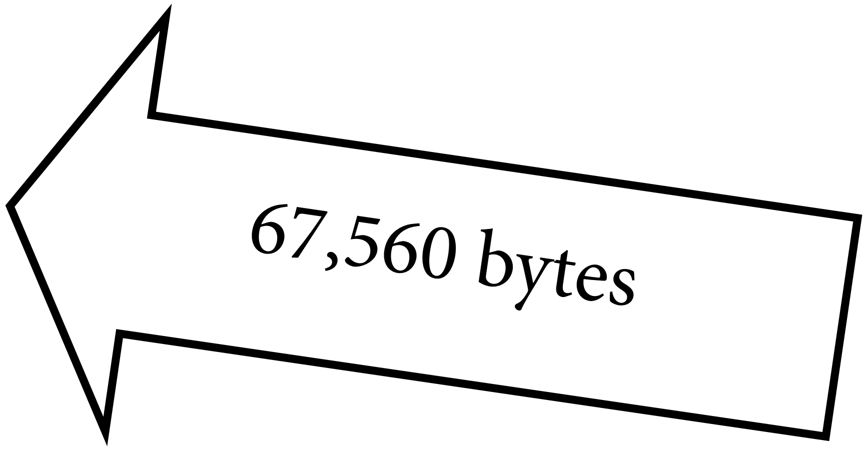
How much web traffic in the last hour?

PANE

Flowgroup

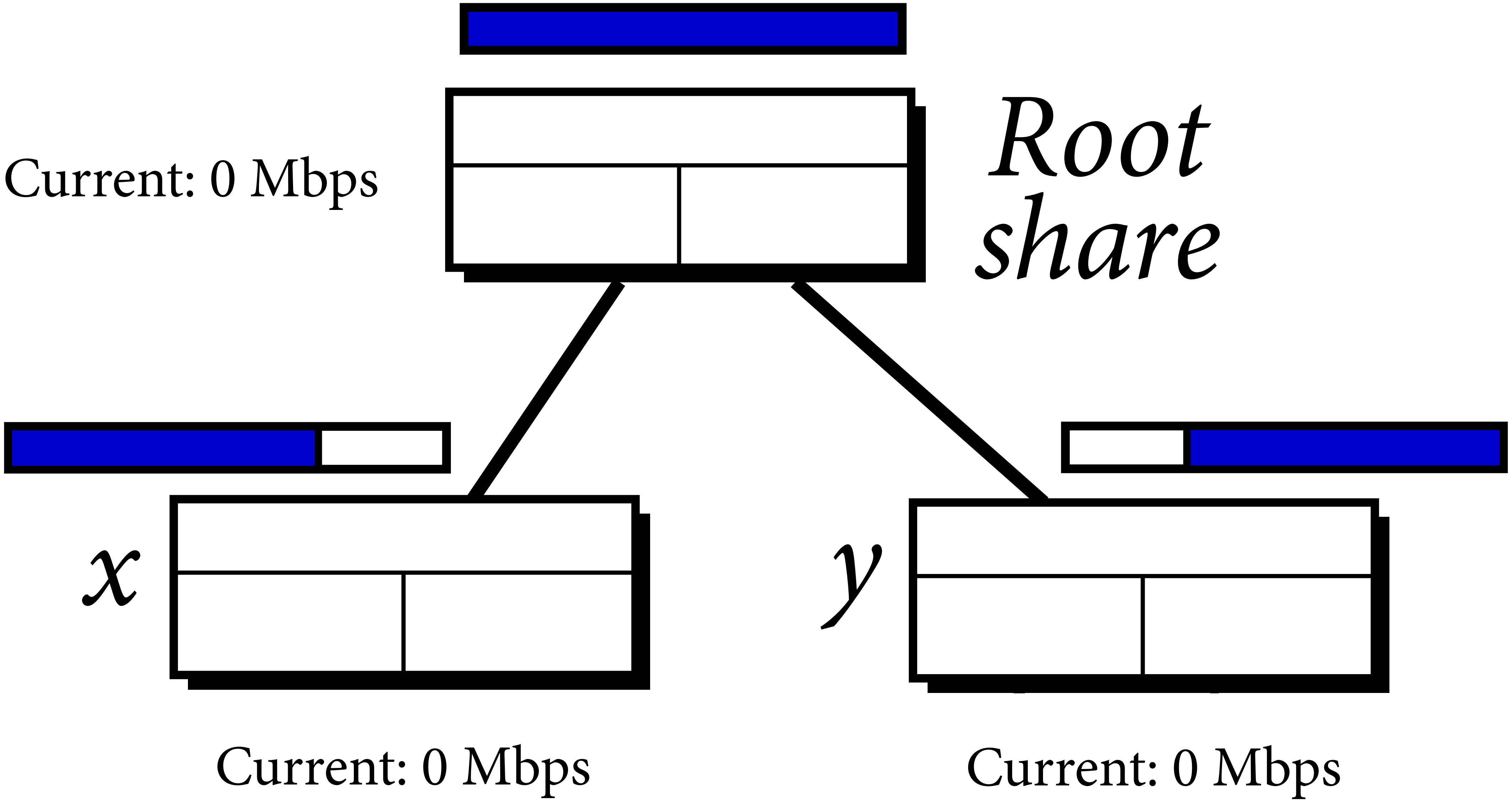
src=128.12/16 ∧ dst.port ≤1024

Speakers	Privileges
Alice Bob	deny, allow bandwidth: 5Mb/s limit: 10Mb/s *hint* *query*



67,560 bytes

PANE



Current: 0 Mbps

Root share

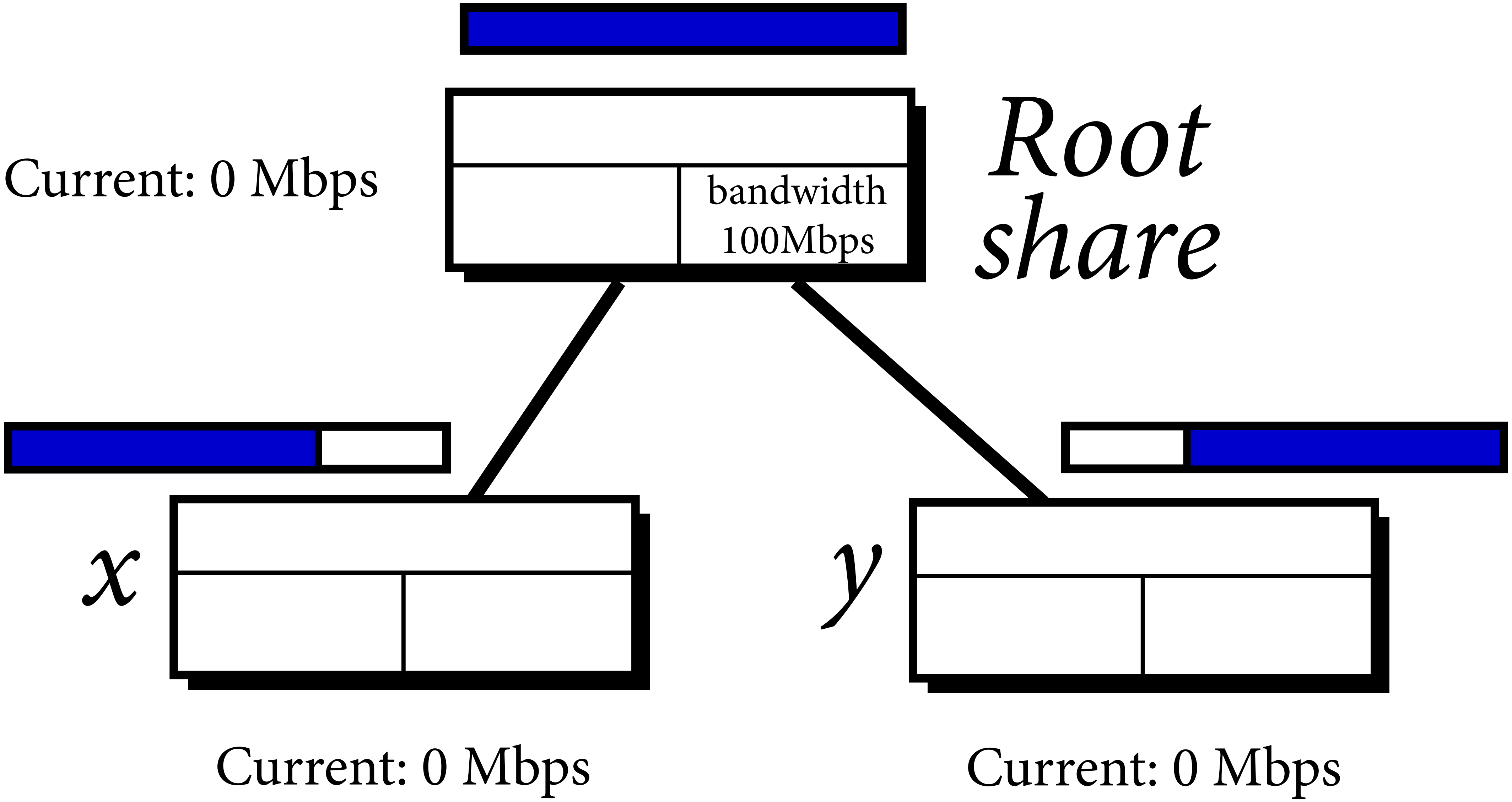
x

y

Current: 0 Mbps

Current: 0 Mbps

PANE



Current: 0 Mbps

bandwidth
100Mbps

Root share

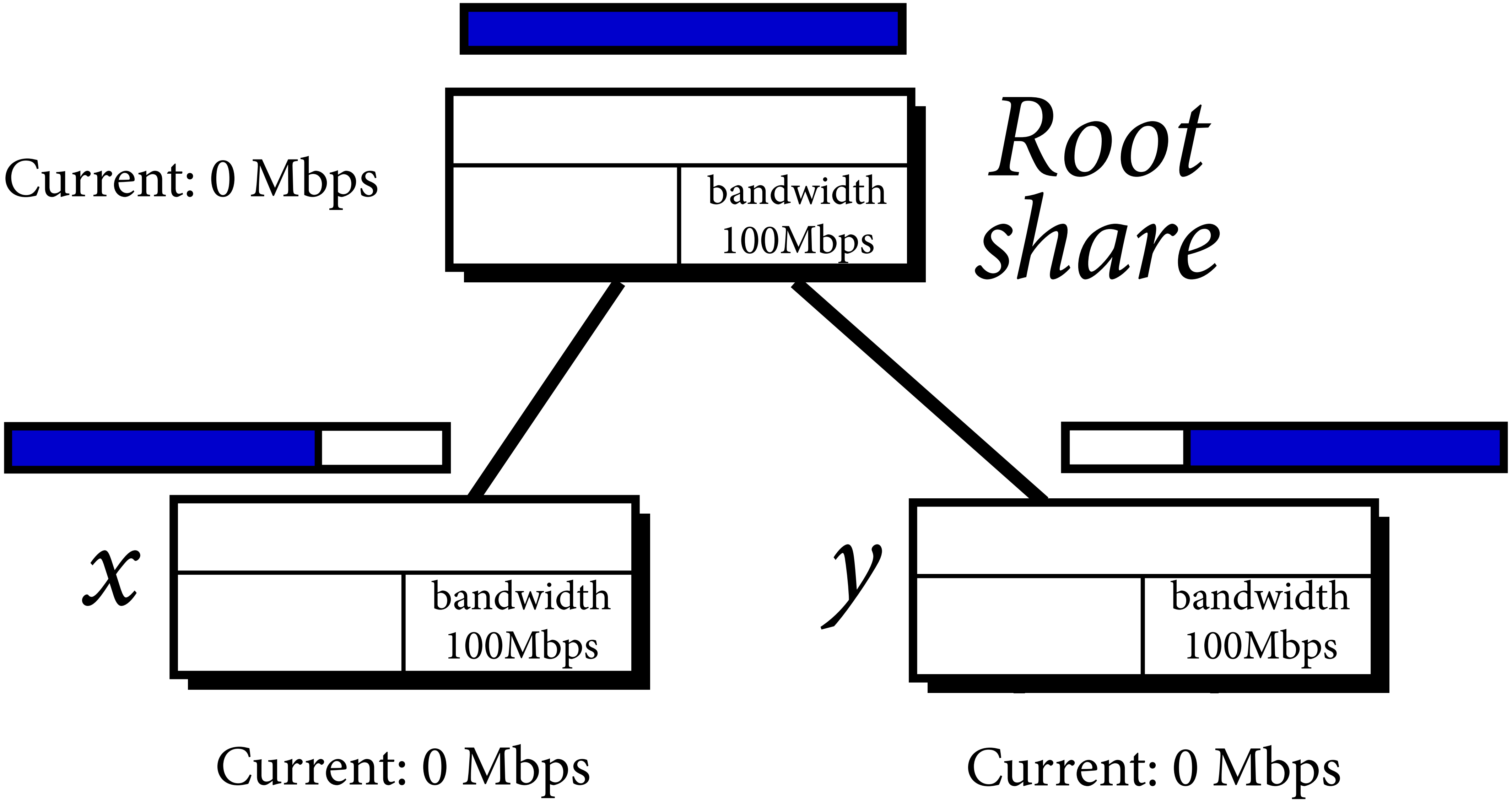
x

y

Current: 0 Mbps

Current: 0 Mbps

PANE



Current: 0 Mbps

bandwidth 100Mbps

Root share

x

bandwidth 100Mbps

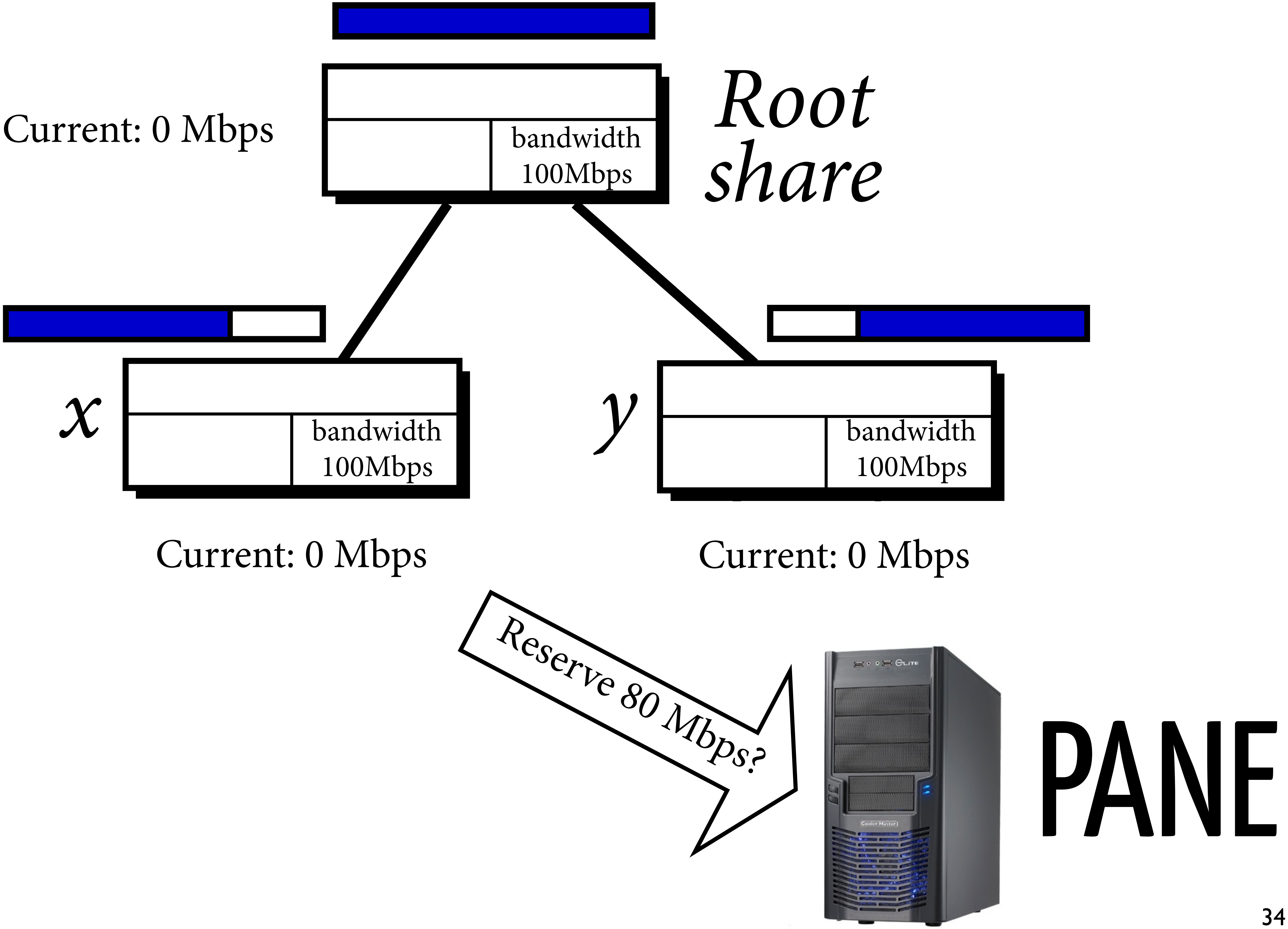
Current: 0 Mbps

y

bandwidth 100Mbps

Current: 0 Mbps

PANE



Current: 0 Mbps

bandwidth
100Mbps

Root share

x

bandwidth
100Mbps

Current: 0 Mbps

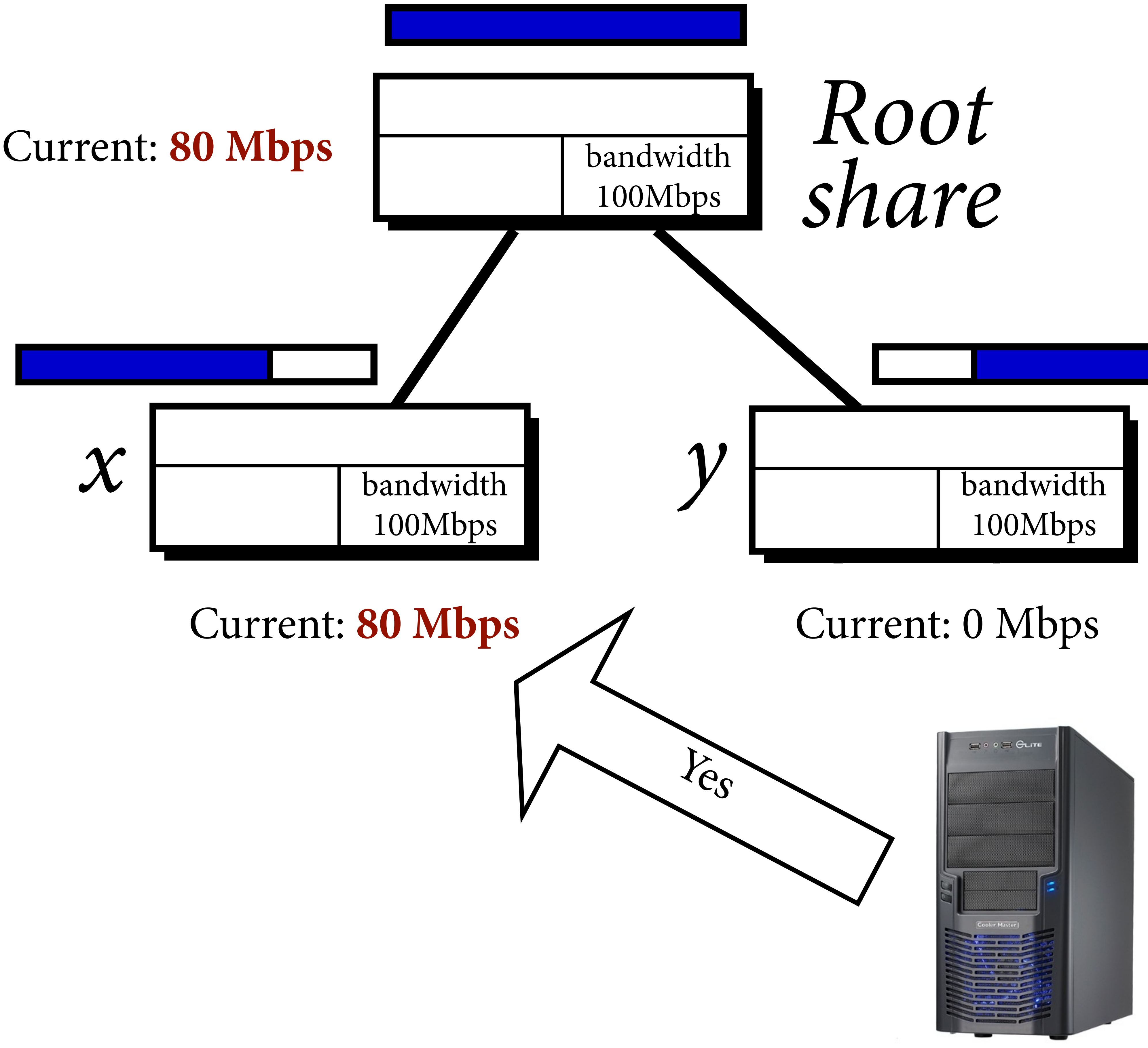
y

bandwidth
100Mbps

Current: 0 Mbps

Reserve 80 Mbps?

PANE



Current: **80 Mbps**

Root share

bandwidth 100Mbps

x

bandwidth 100Mbps

y

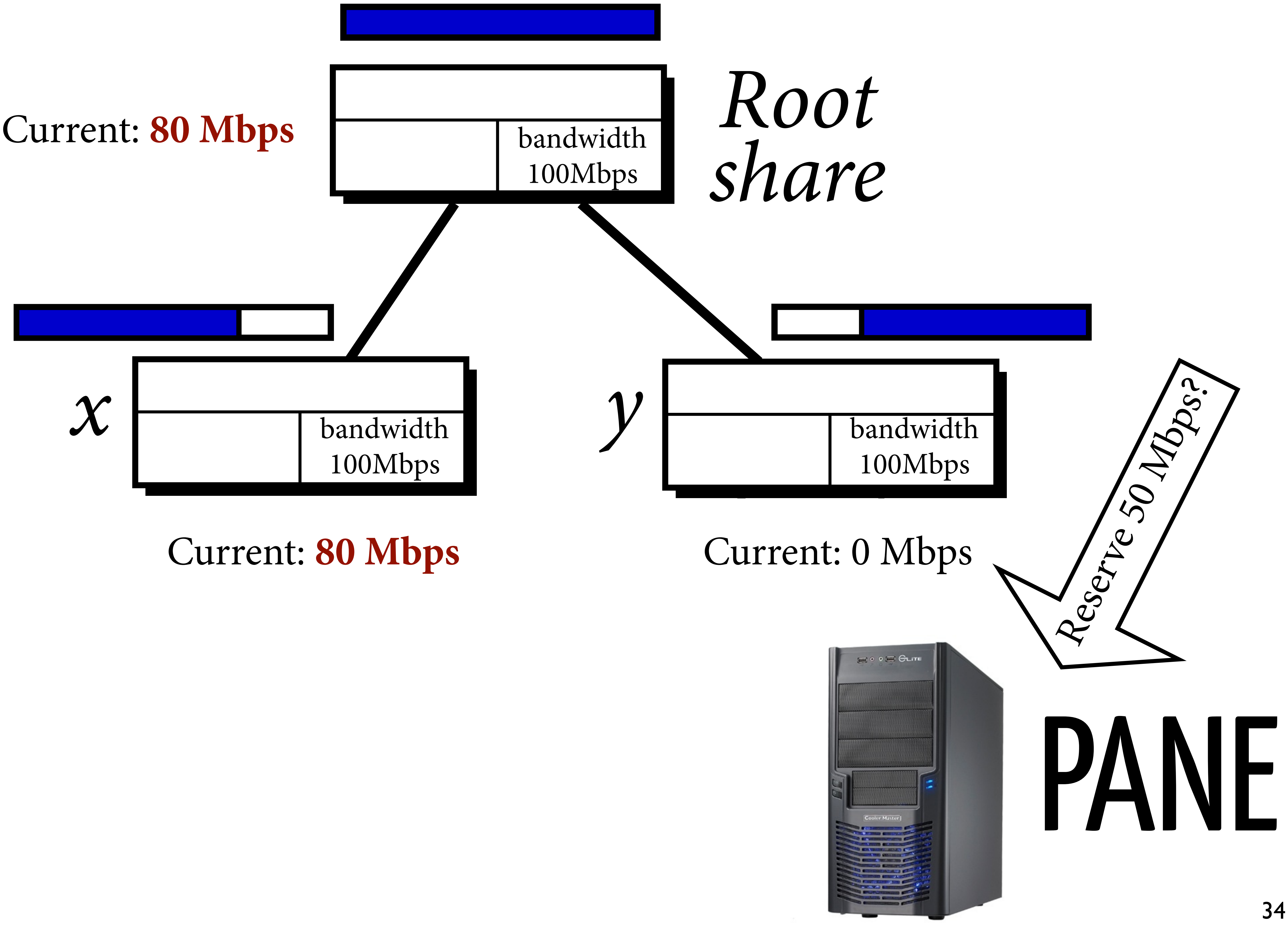
bandwidth 100Mbps

Current: **80 Mbps**

Current: 0 Mbps

Yes

PANE



Root share

Current: **80 Mbps**

bandwidth 100Mbps

x

bandwidth 100Mbps

Current: **80 Mbps**

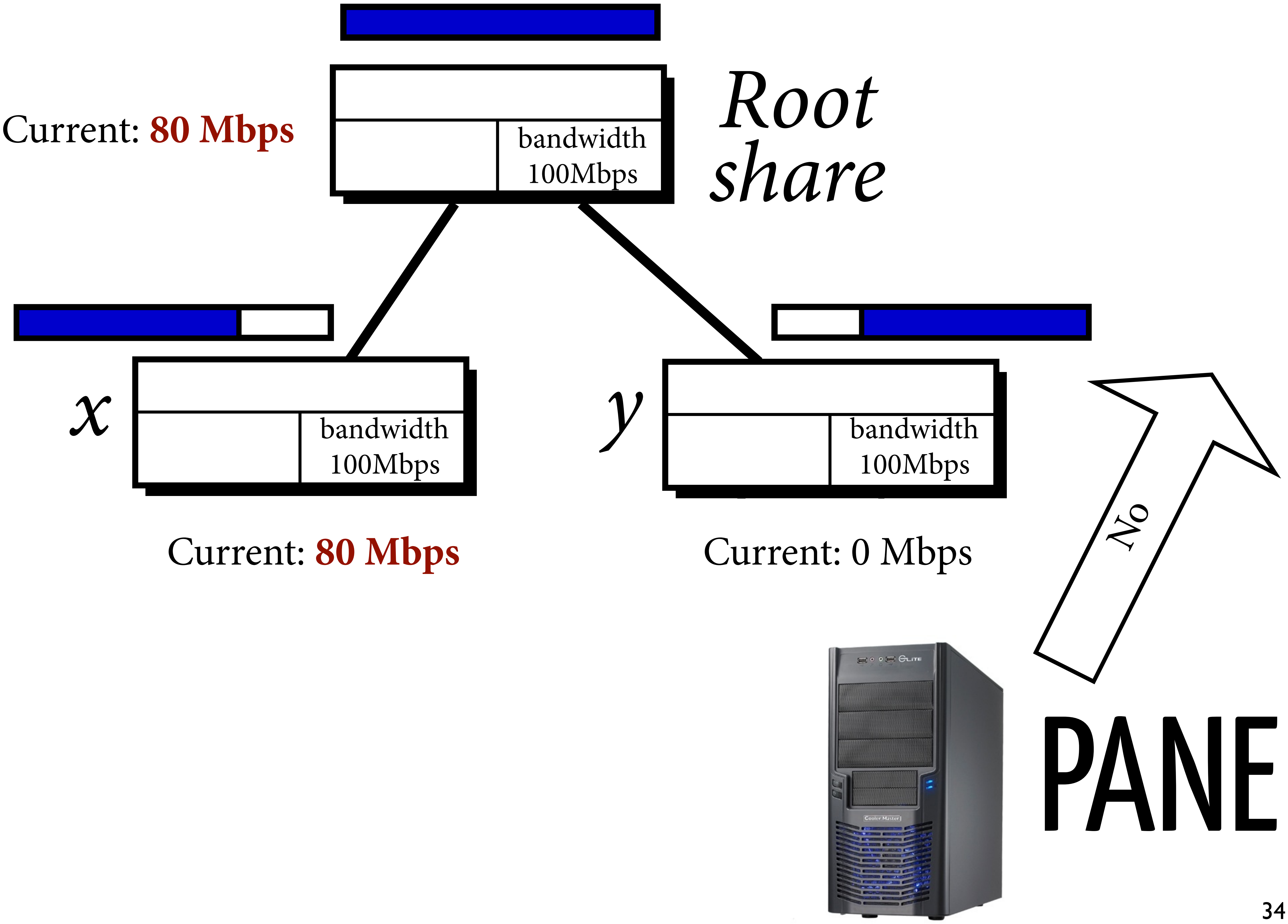
y

bandwidth 100Mbps

Current: 0 Mbps

Reserve 50 Mbps?

PANE



Current: **80 Mbps**

Root share

bandwidth 100Mbps

x

bandwidth 100Mbps

y

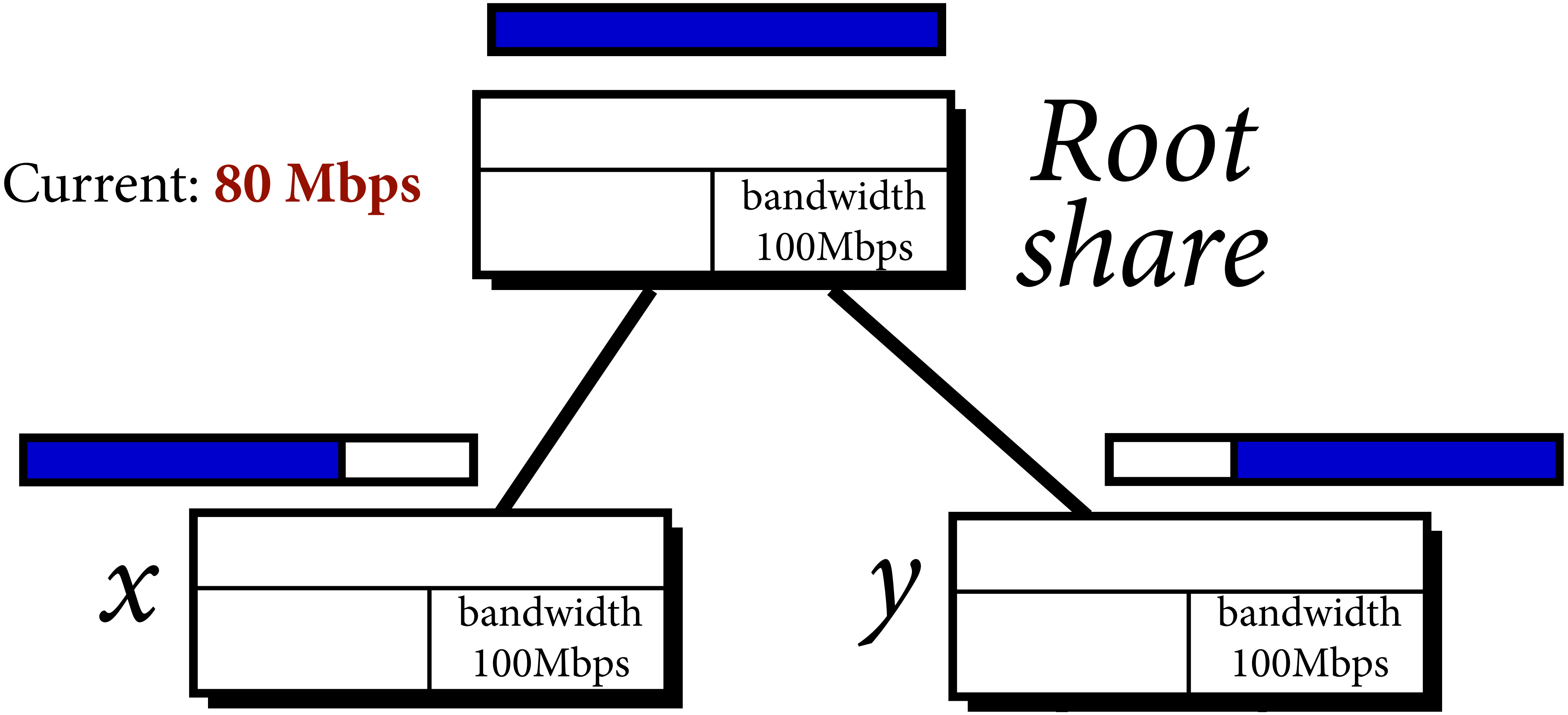
bandwidth 100Mbps

Current: **80 Mbps**

Current: 0 Mbps

No

PANE



Root share

Current: **80 Mbps**

bandwidth 100Mbps

x

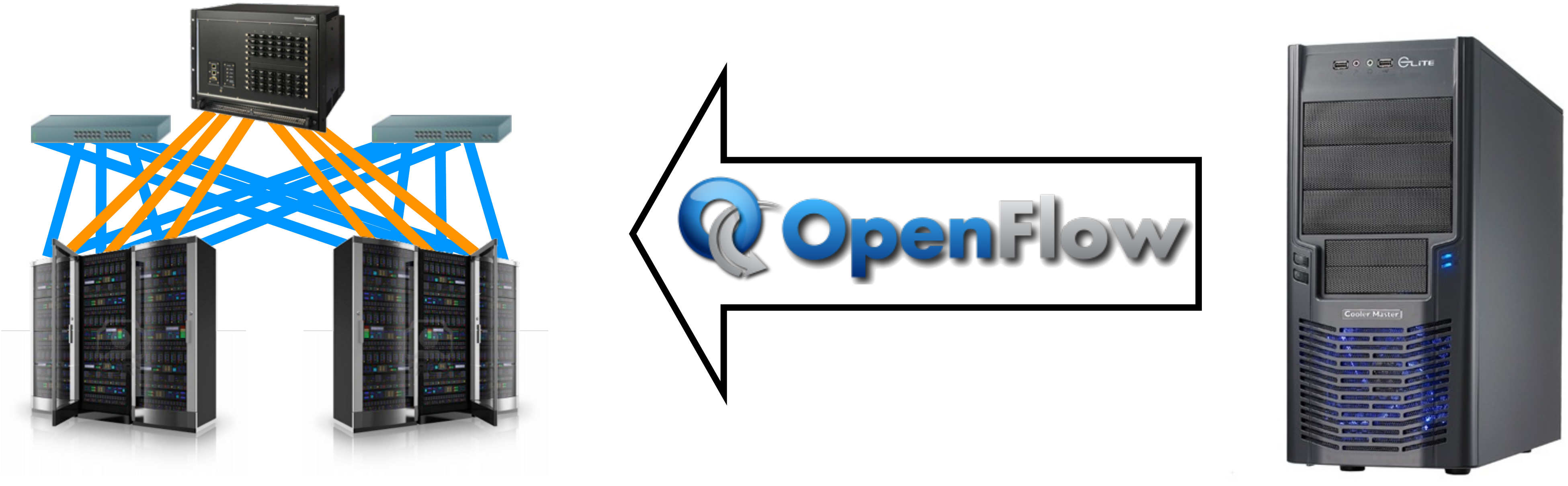
bandwidth 100Mbps

y

bandwidth 100Mbps

Current: **80 Mbps**

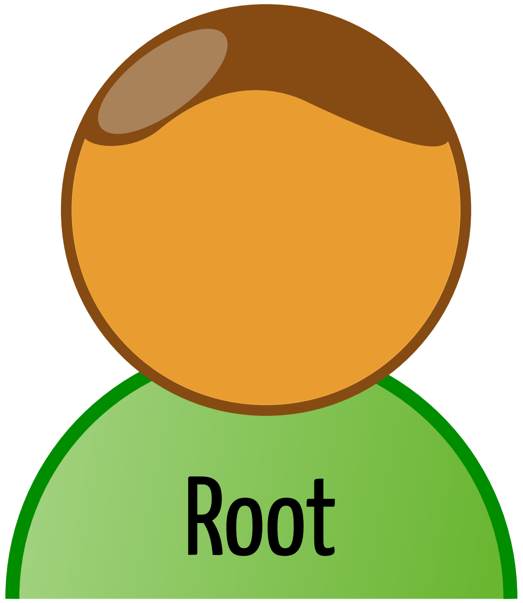
Current: 0 Mbps



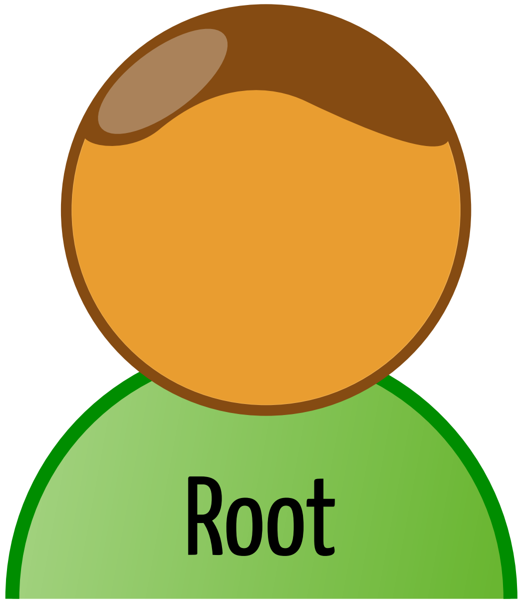
PANE

Protocol

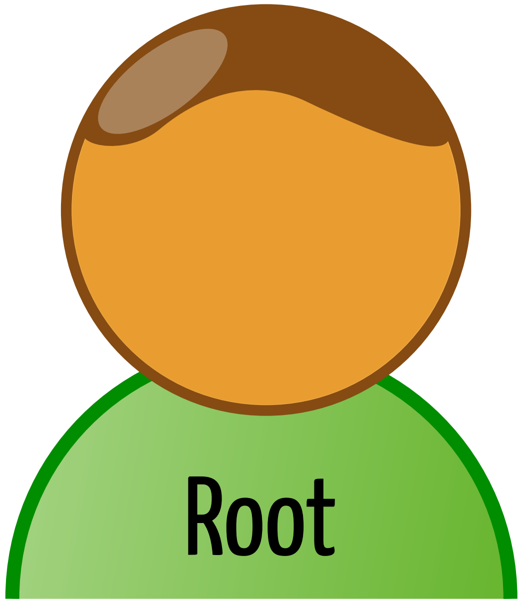
PANE



PANE

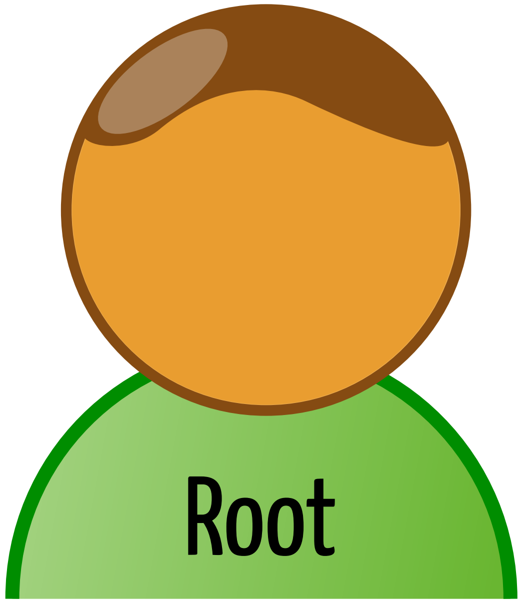


PANE



```
NewShare aBW for
(user=Alice) [reserve <= 10Mb]
on rootShare.
```

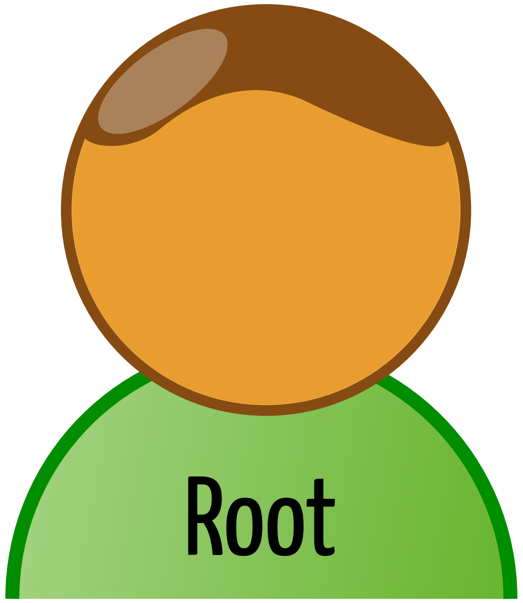
PANE



```
NewShare aBW for
(user=Alice) [reserve <= 10Mb]
on rootShare.
```

```
OK
```

PANE

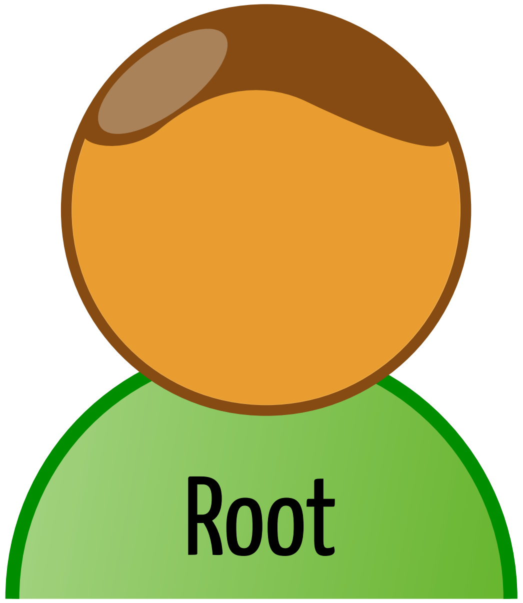


```
NewShare aBW for
(user=Alice) [reserve <= 10Mb]
on rootShare.
```

OK

```
Grant aBW to Alice.
```

PANE



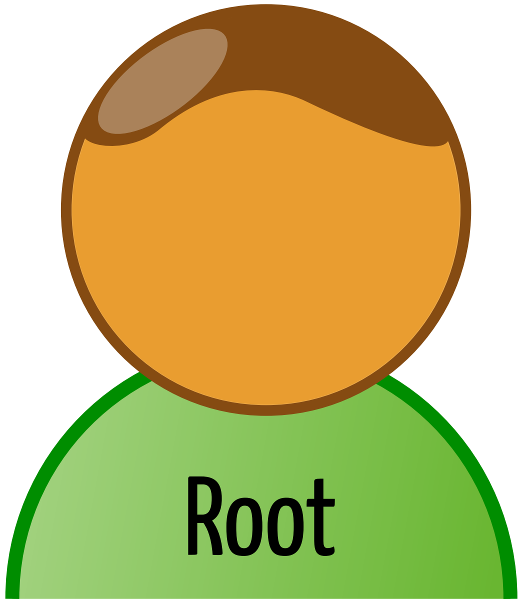
```
NewShare aBW for
(user=Alice) [reserve <= 10Mb]
on rootShare.
```

OK

```
Grant aBW to Alice.
```

OK

PANE



```
NewShare aBW for
(user=Alice) [reserve <= 10Mb]
on rootShare.
```

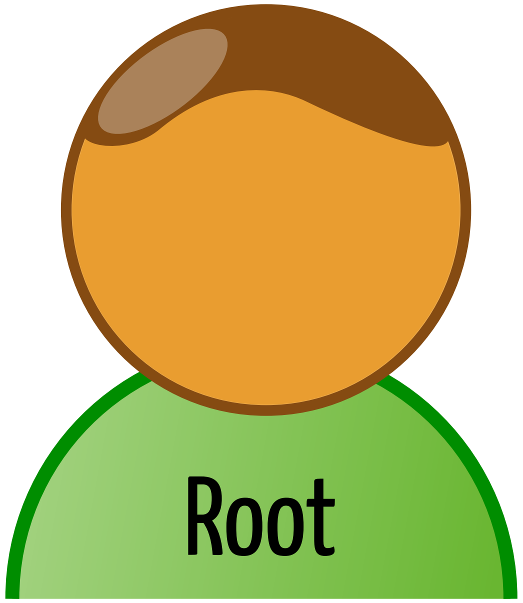
OK

```
Grant aBW to Alice.
```

OK

```
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from now to +10min.
```

PANE



NewShare aBW for
(user=Alice) [reserve <= 10Mb]
on rootShare.

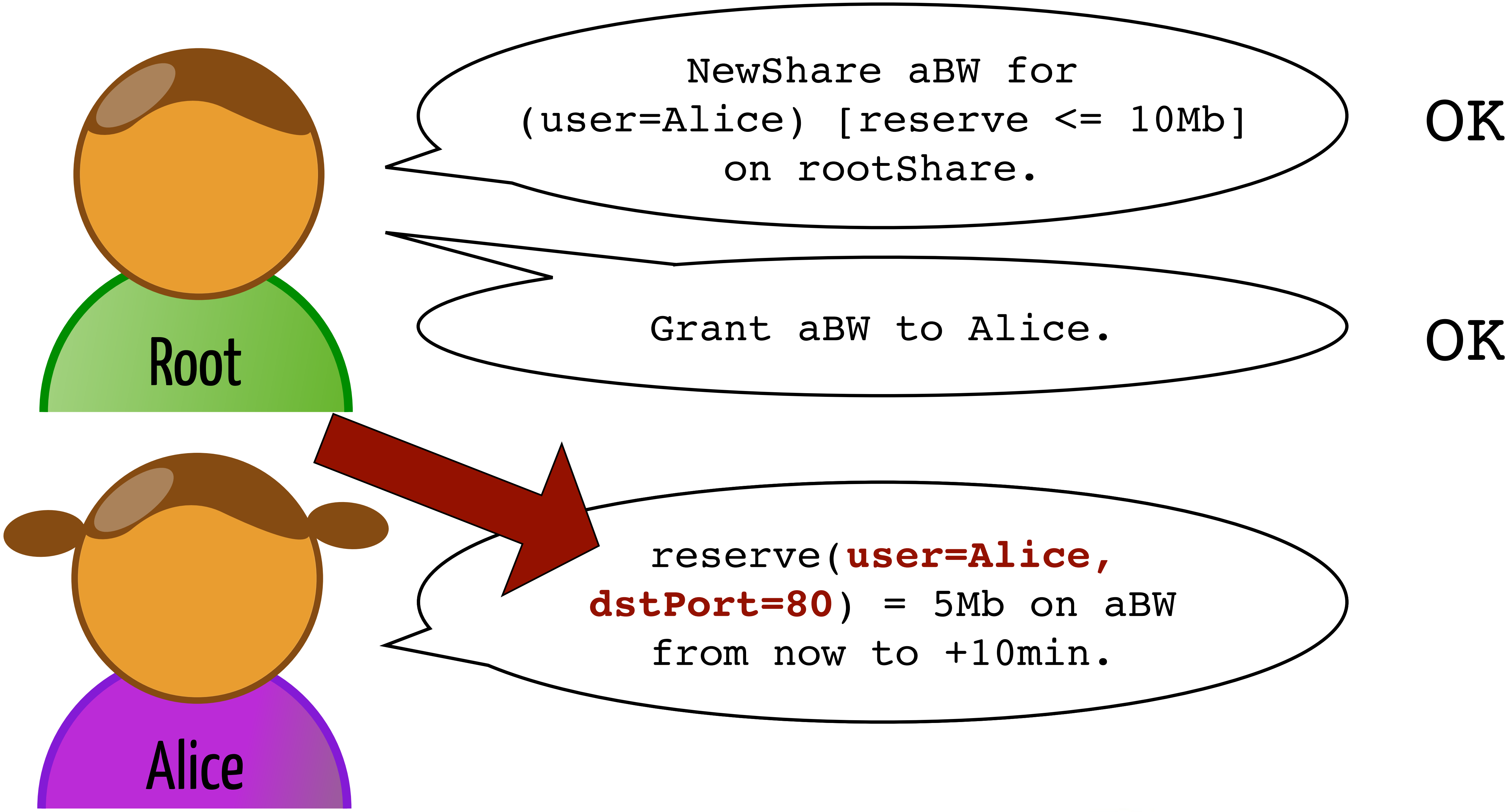
OK

Grant aBW to Alice.

OK

reserve(user=Alice,
dstPort=80) = 5Mb on **aBW**
from now to +10min.

PANE



NewShare aBW for
(user=Alice) [reserve <= 10Mb]
on rootShare.

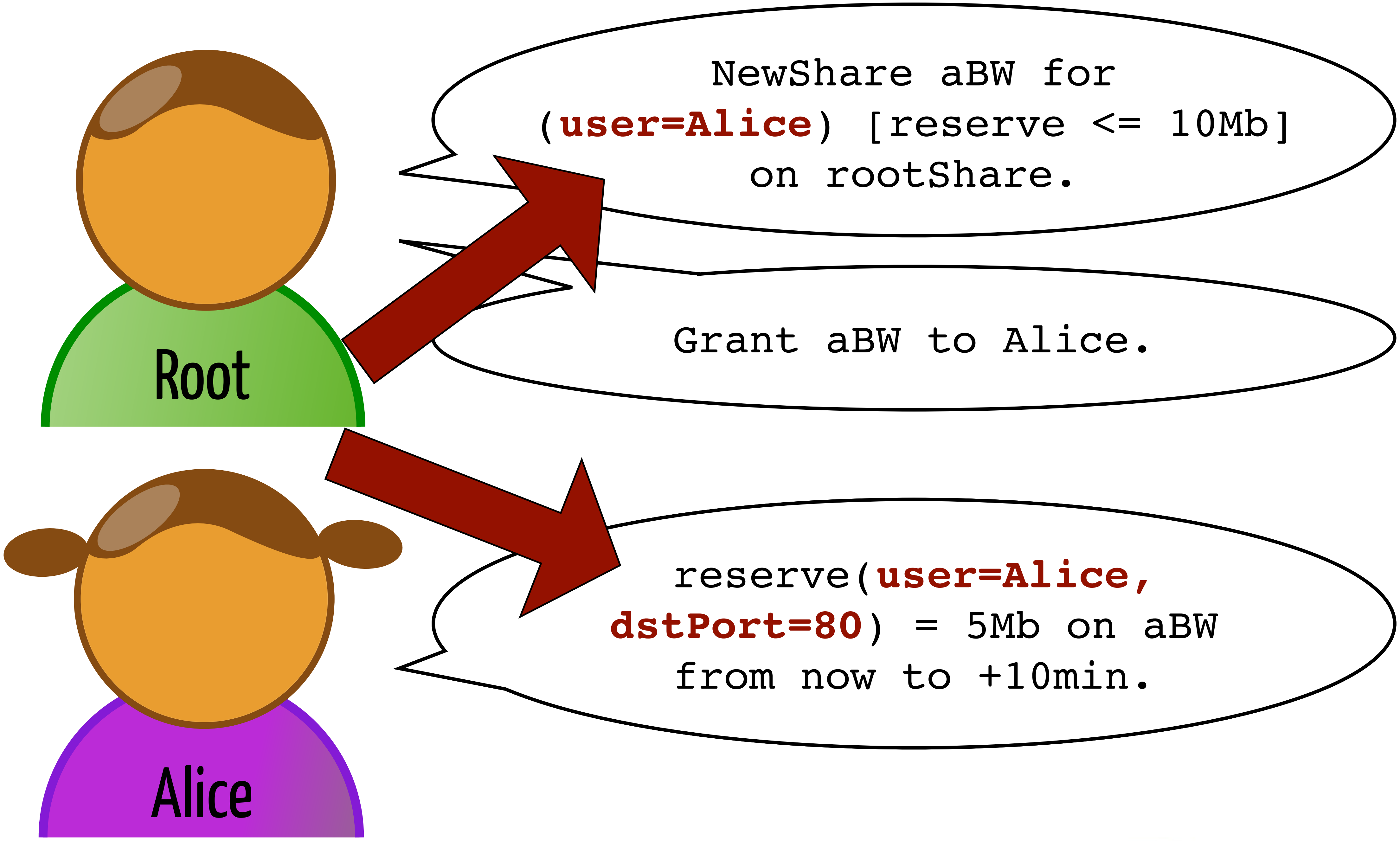
OK

Grant aBW to Alice.

OK

reserve(**user=Alice,**
dstPort=80) = 5Mb on aBW
from now to +10min.

PANE



NewShare aBW for (user=Alice) [reserve <= 10Mb] on rootShare.

OK

Grant aBW to Alice.

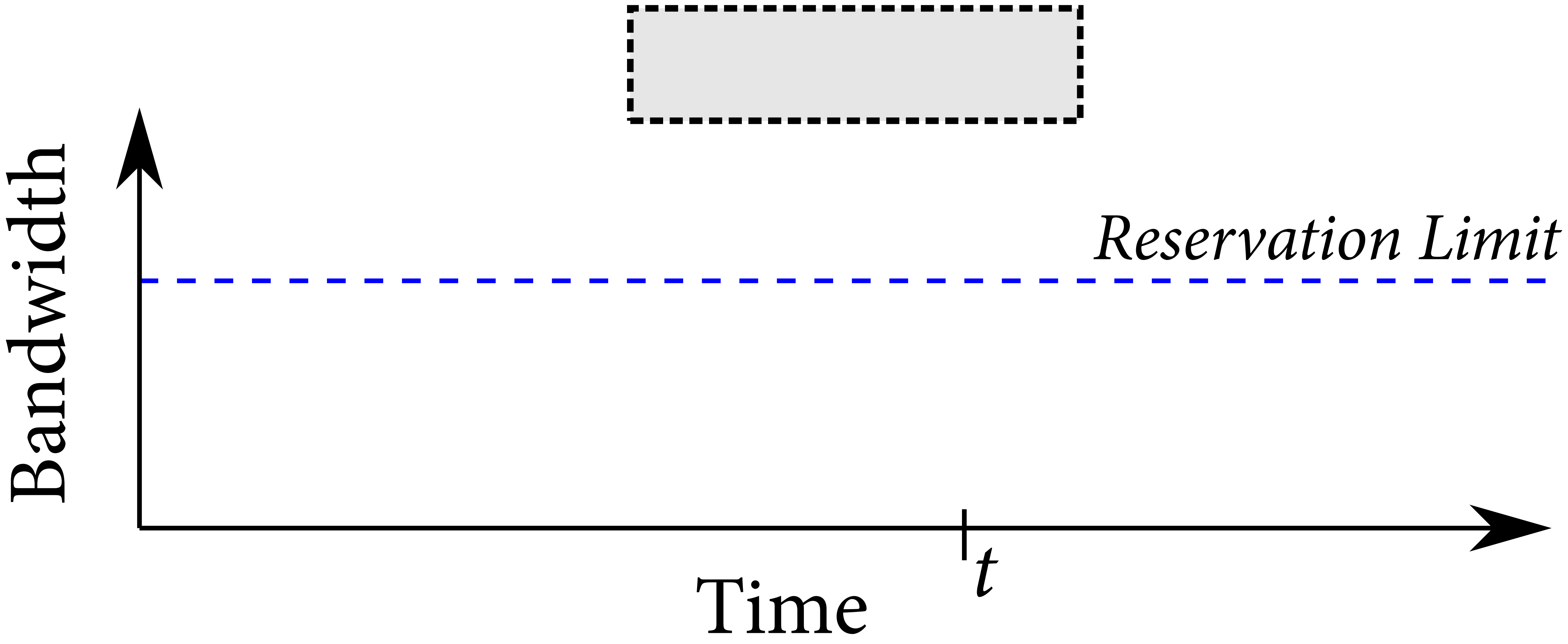
OK

reserve(user=Alice, dstPort=80) = 5Mb on aBW from now to +10min.

PANE

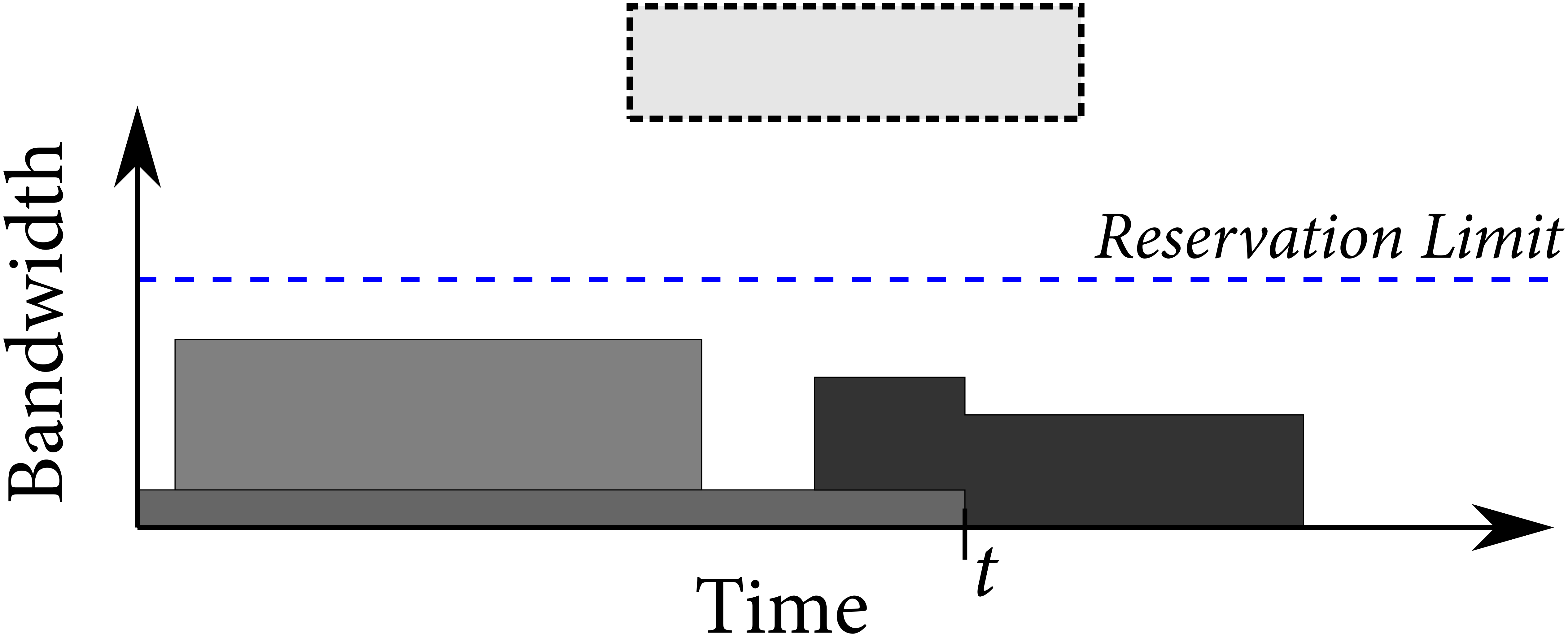
```
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from now to +10min.
```

PANE



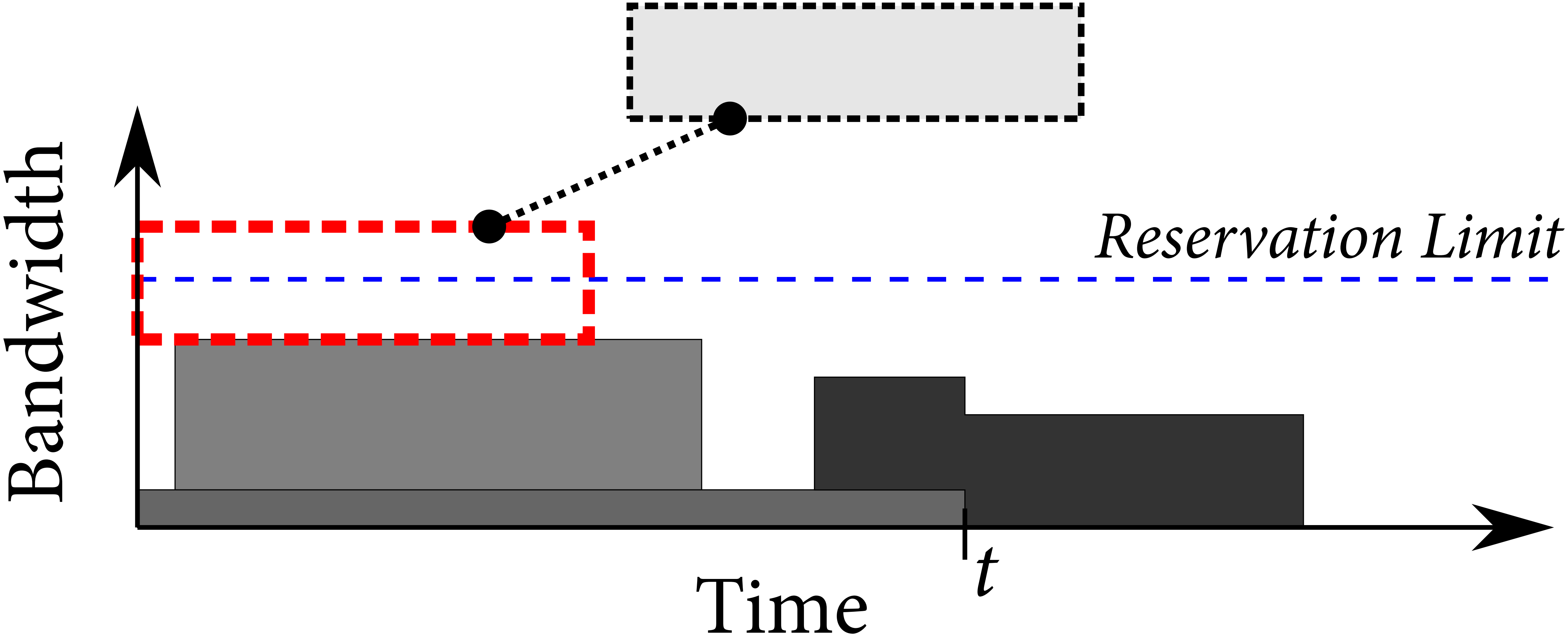
```
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from now to +10min.
```

PANE



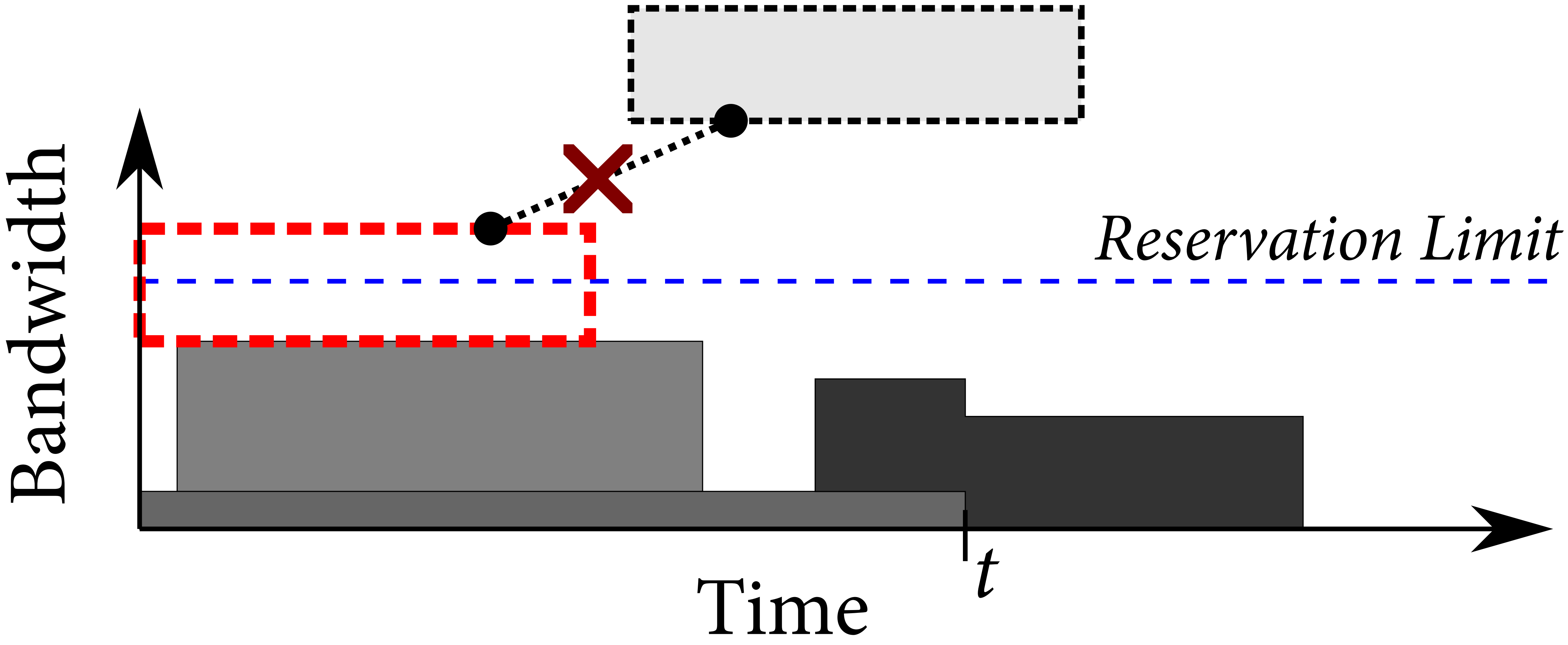
```
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from now to +10min.
```

PANE



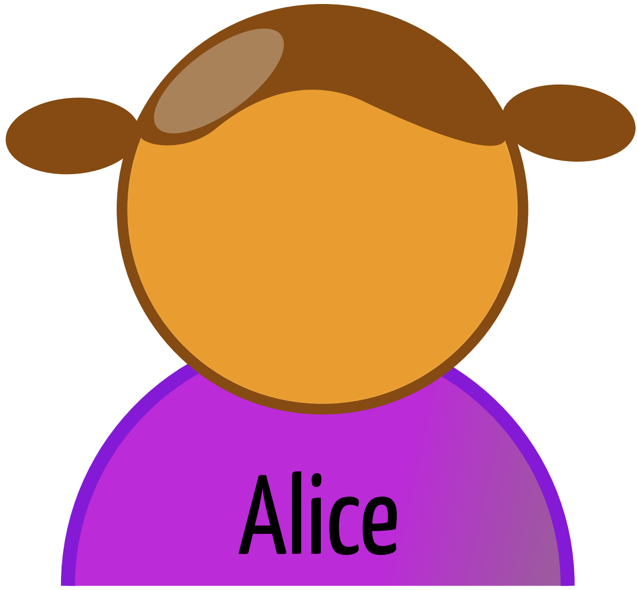
reserve(user=Alice, dstPort=80) = 5Mb on aBW from now to +10min.

PANE



reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from now to +10min.

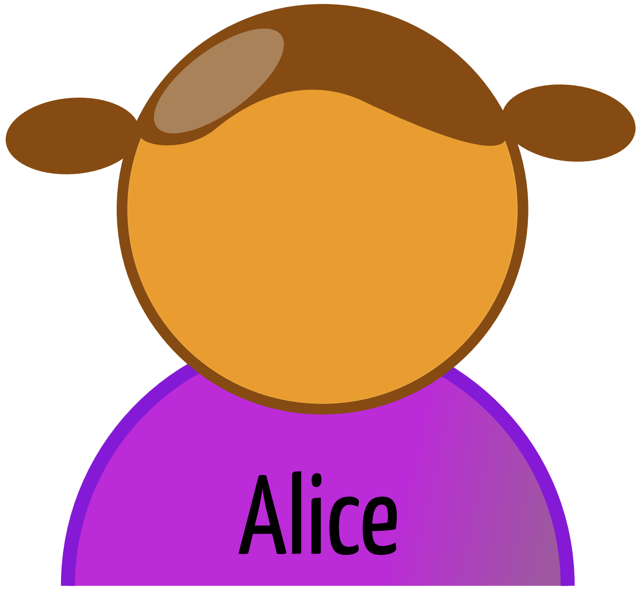
PANE



```
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from now to +10min.
```

NO

PANE

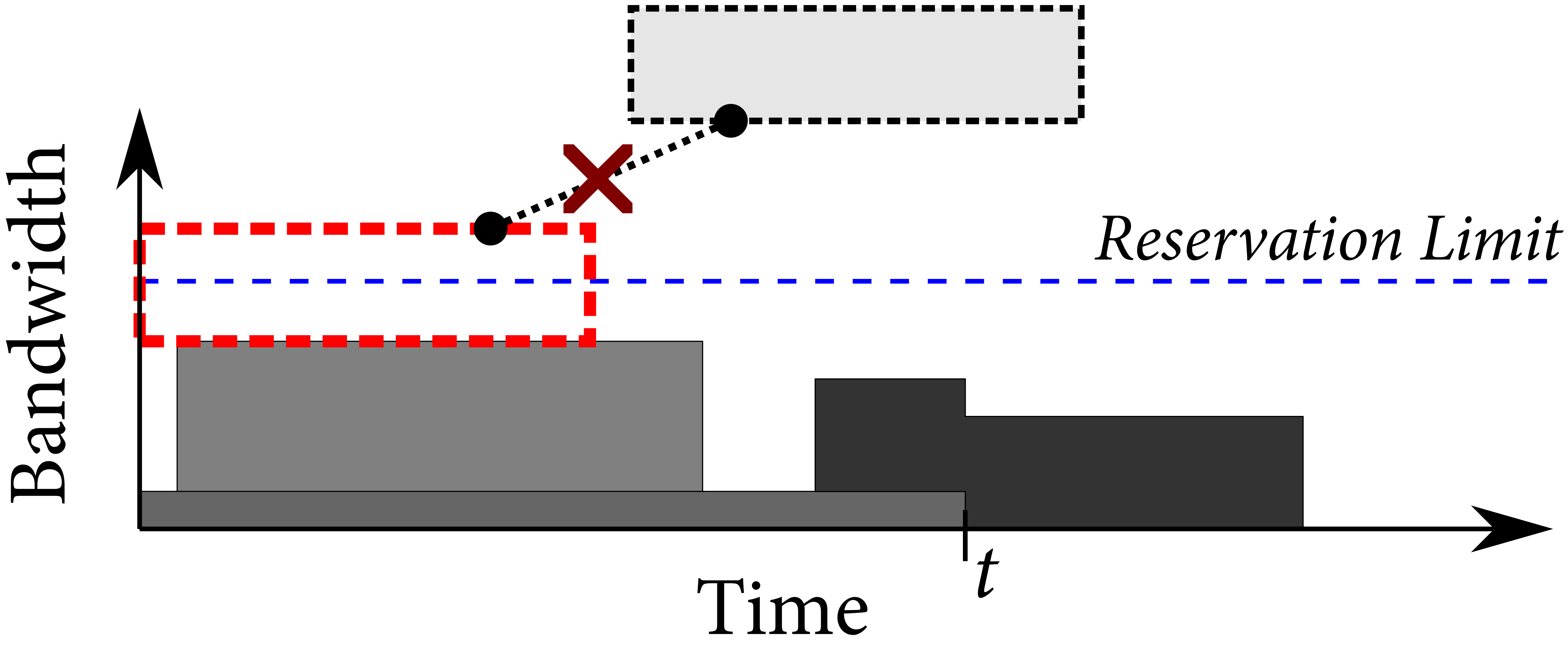


```
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from now to +10min.
```

NO

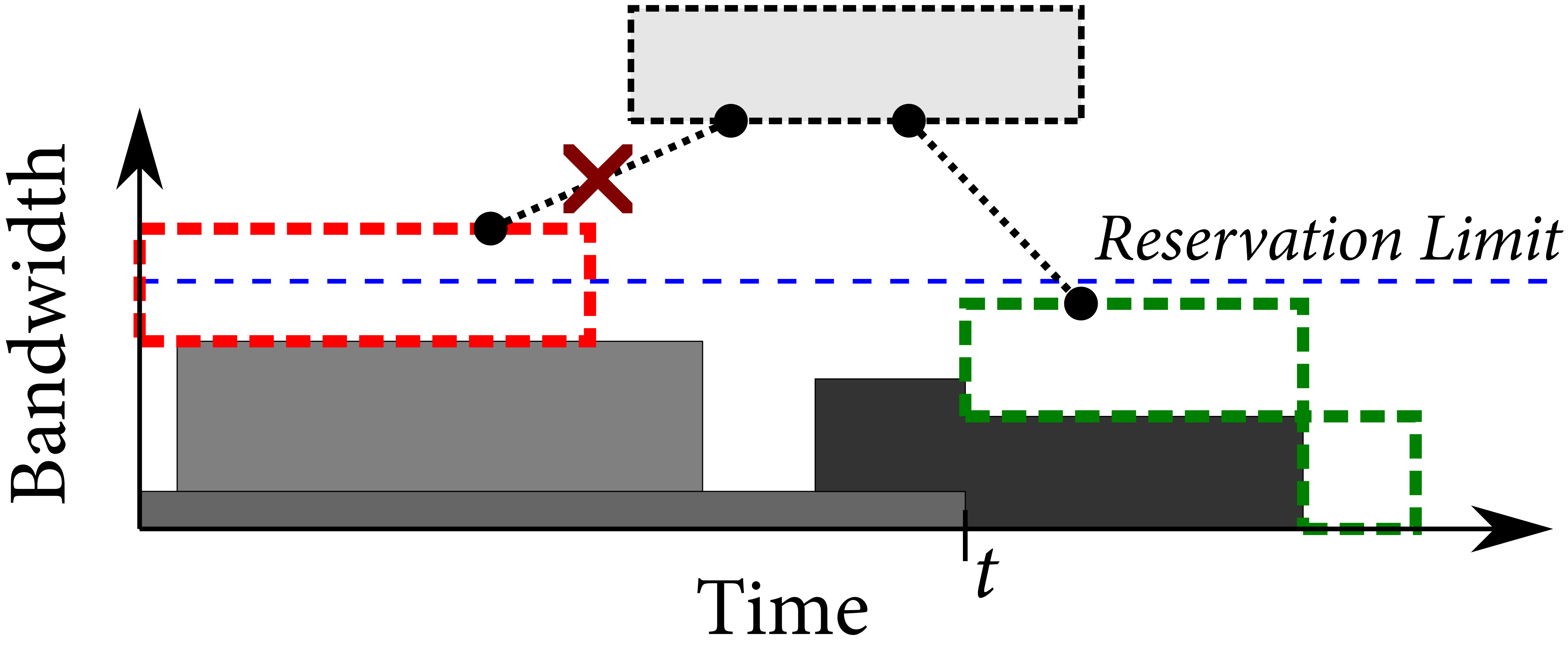
```
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from +20min to +30min.
```

PANE



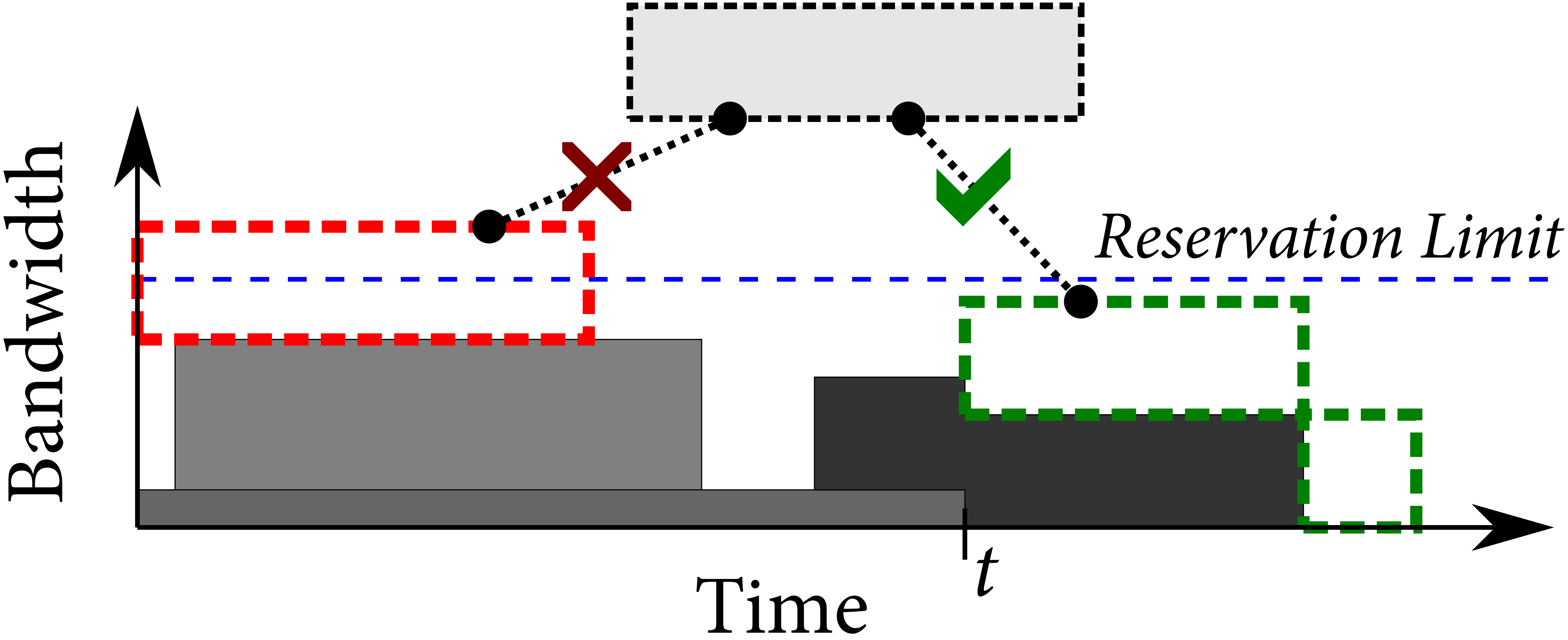
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from +20min to +30min.

PANE



```
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from +20min to +30min.
```

PANE



reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from +20min to +30min.

PANE

```
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from now to +10min.
```

NO

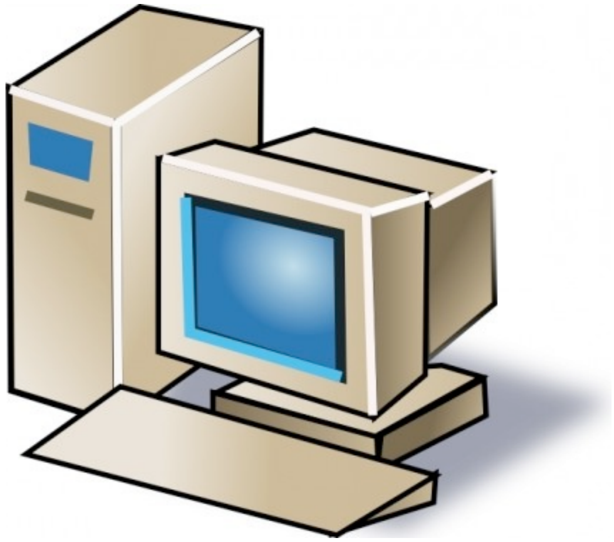
```
reserve(user=Alice,
dstPort=80) = 5Mb on aBW
from +20min to +30min.
```

OK

PANE

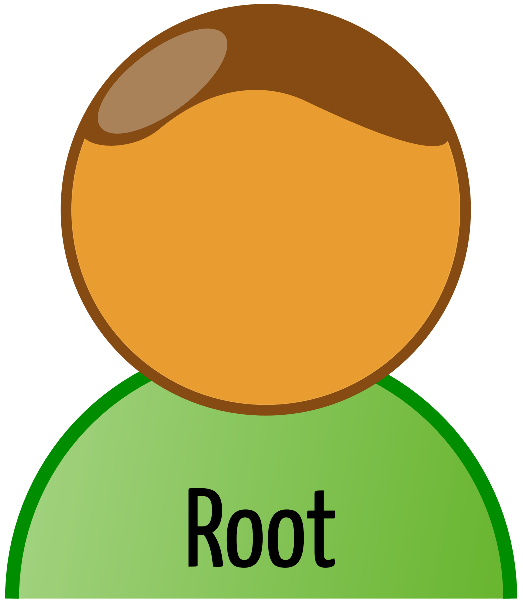
PANE

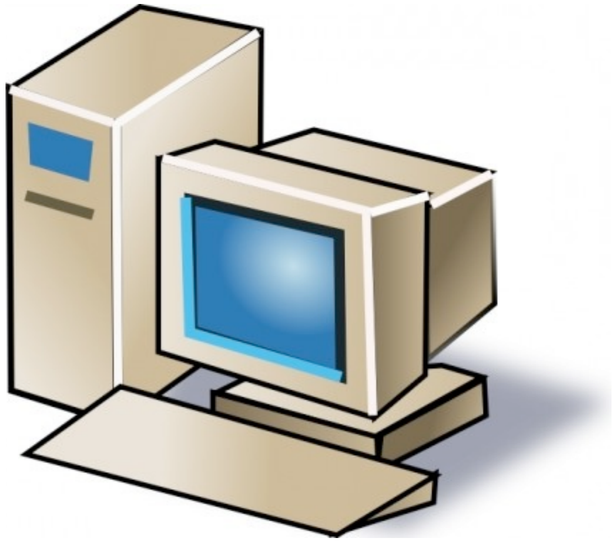
PANE



10.0.0.2

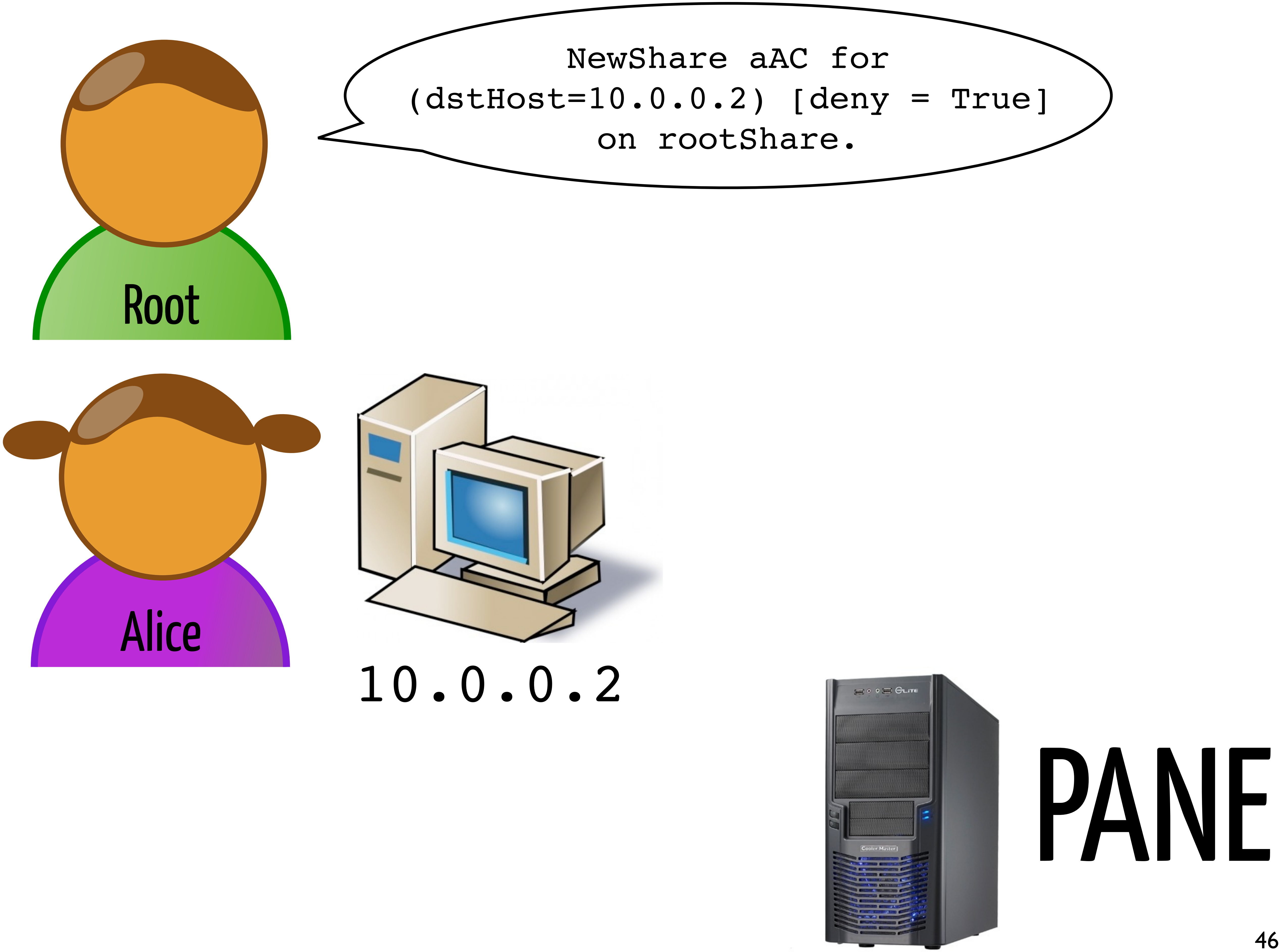
PANE



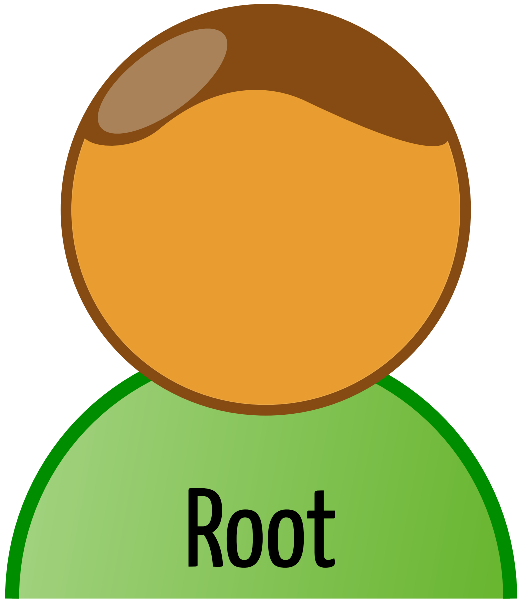


10.0.0.2

PANE

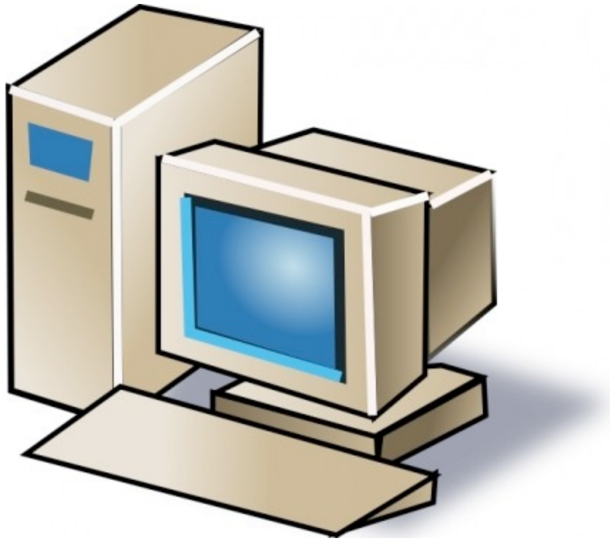


```
NewShare aAC for
(dstHost=10.0.0.2) [deny = True]
on rootShare.
```



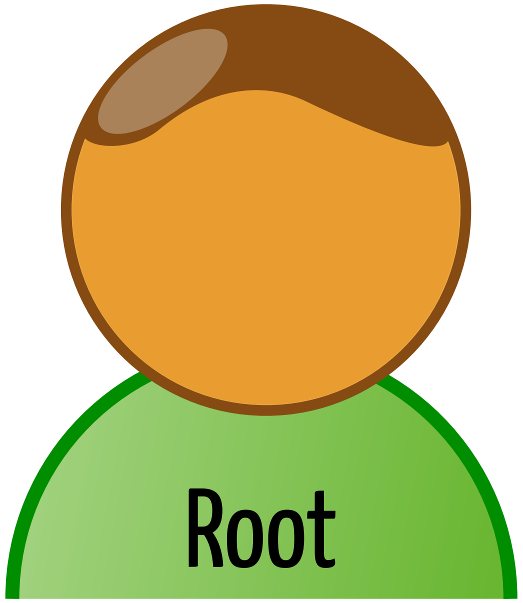
NewShare aAC for
(dstHost=10.0.0.2) [deny = True]
on rootShare.

OK



10.0.0.2

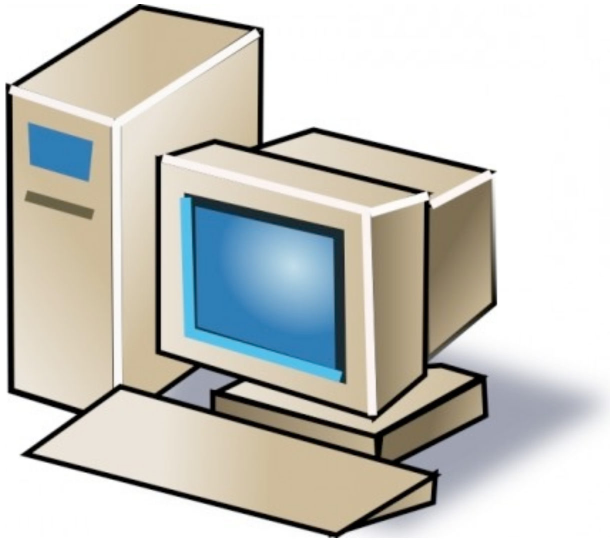
PANE



NewShare aAC for
(dstHost=10.0.0.2) [deny = True]
on rootShare.

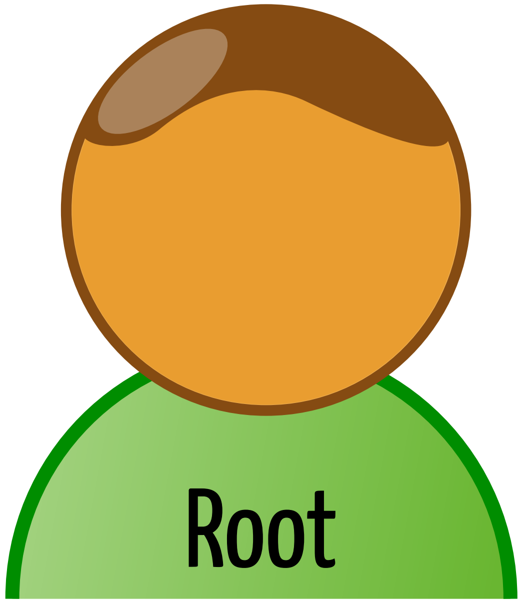
OK

Grant aAC to Alice.



10.0.0.2

PANE

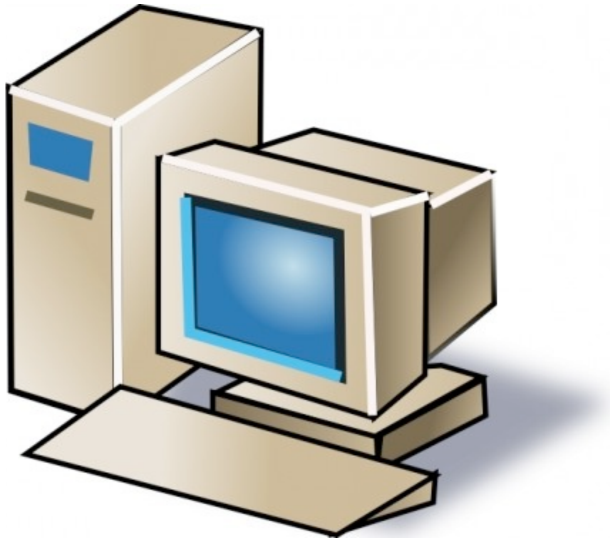


NewShare aAC for
(dstHost=10.0.0.2) [deny = True]
on rootShare.

OK

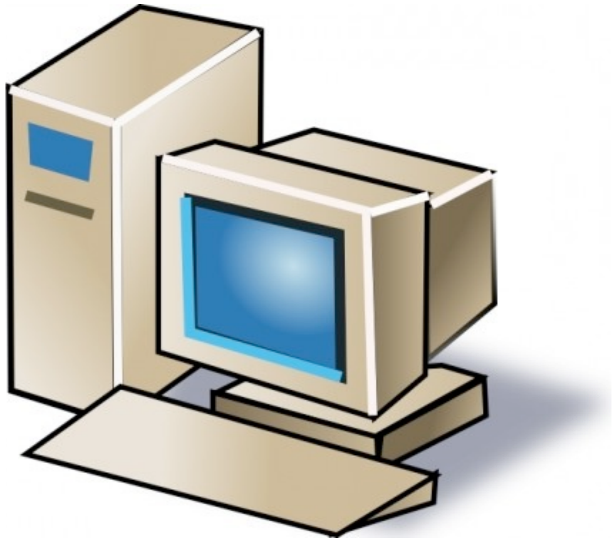
Grant aAC to Alice.

OK



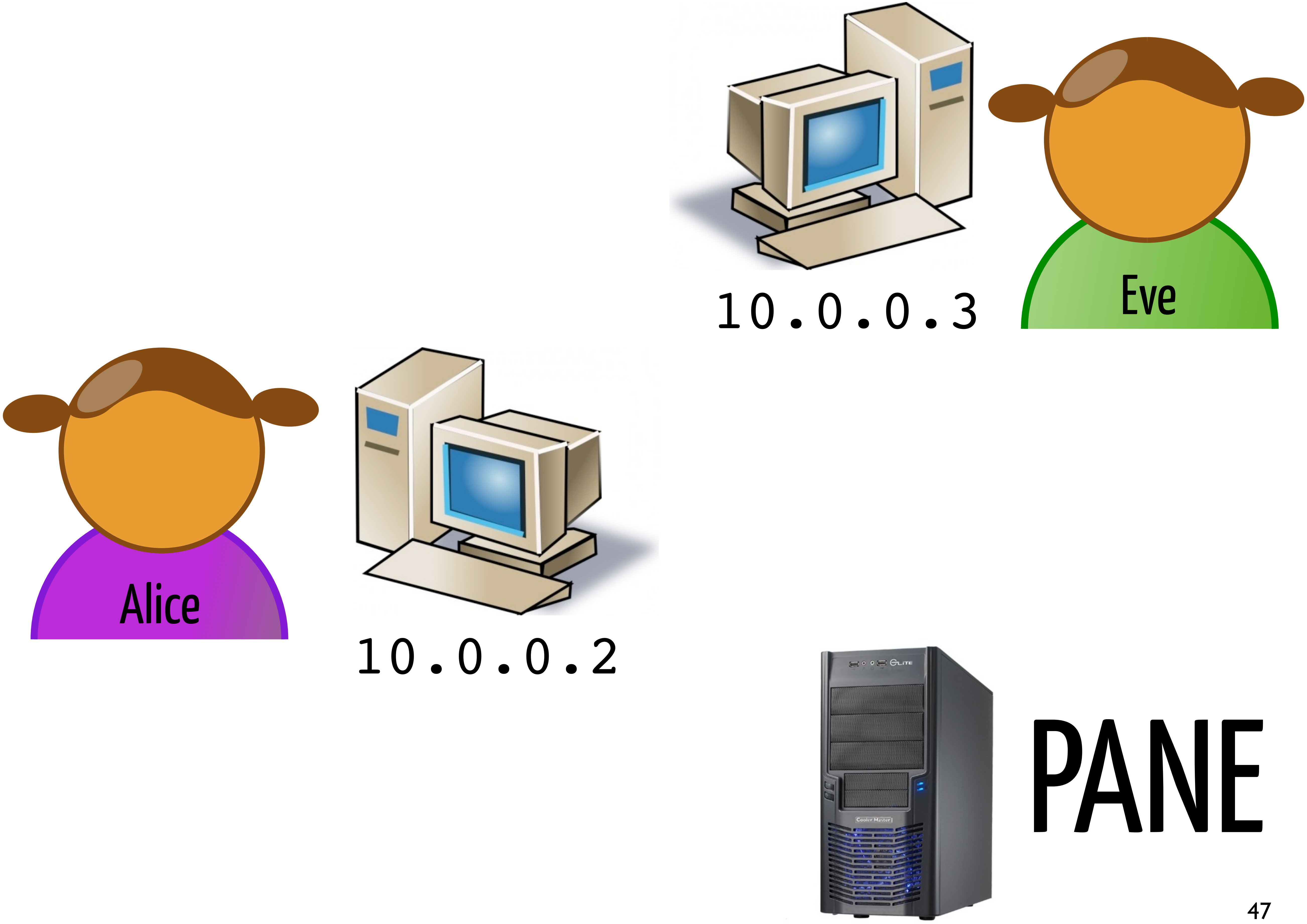
10.0.0.2

PANE



10.0.0.2

PANE



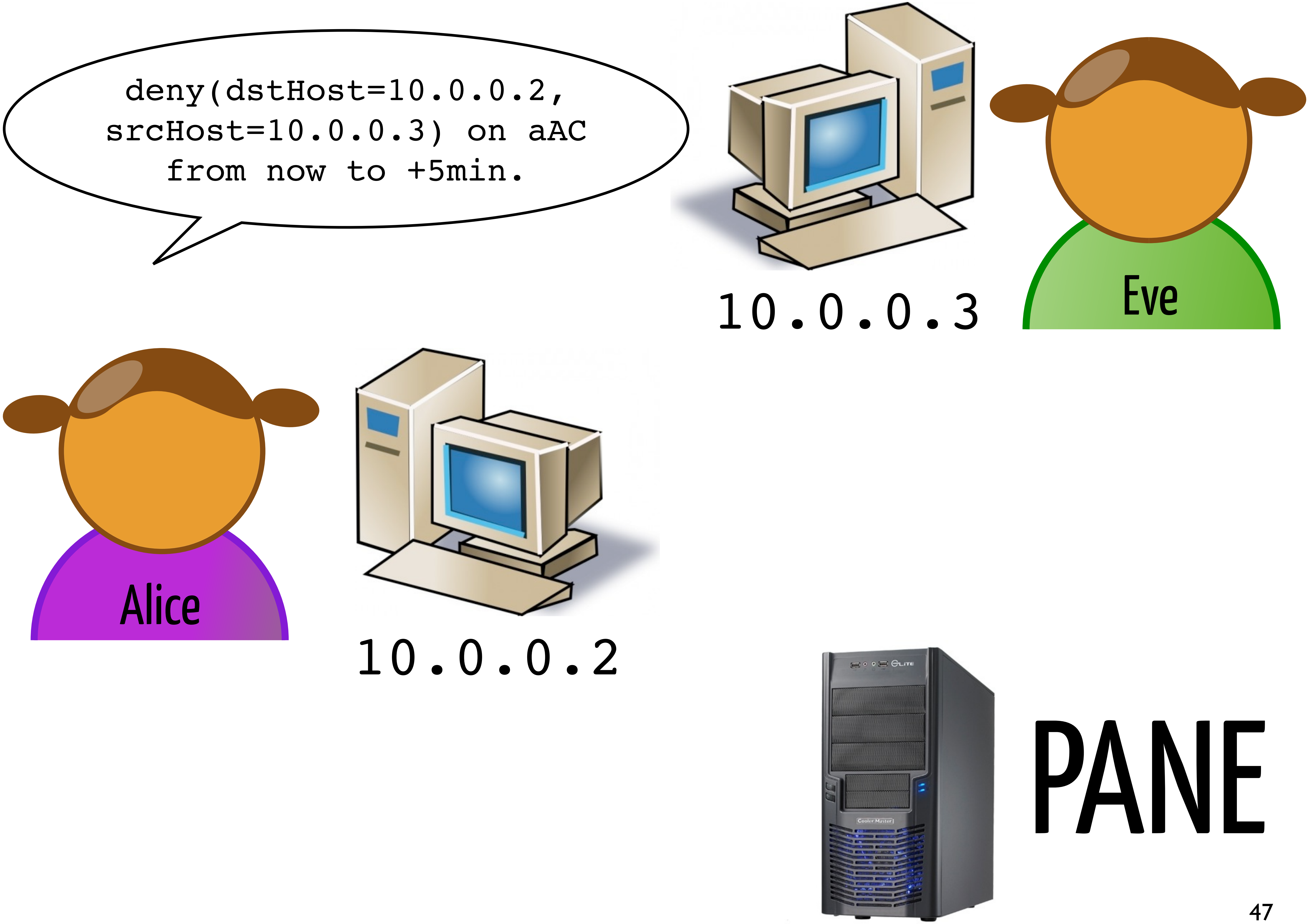
10.0.0.3

Eve

Alice

10.0.0.2

PANE



```
deny(dstHost=10.0.0.2,
srcHost=10.0.0.3) on aAC
from now to +5min.
```

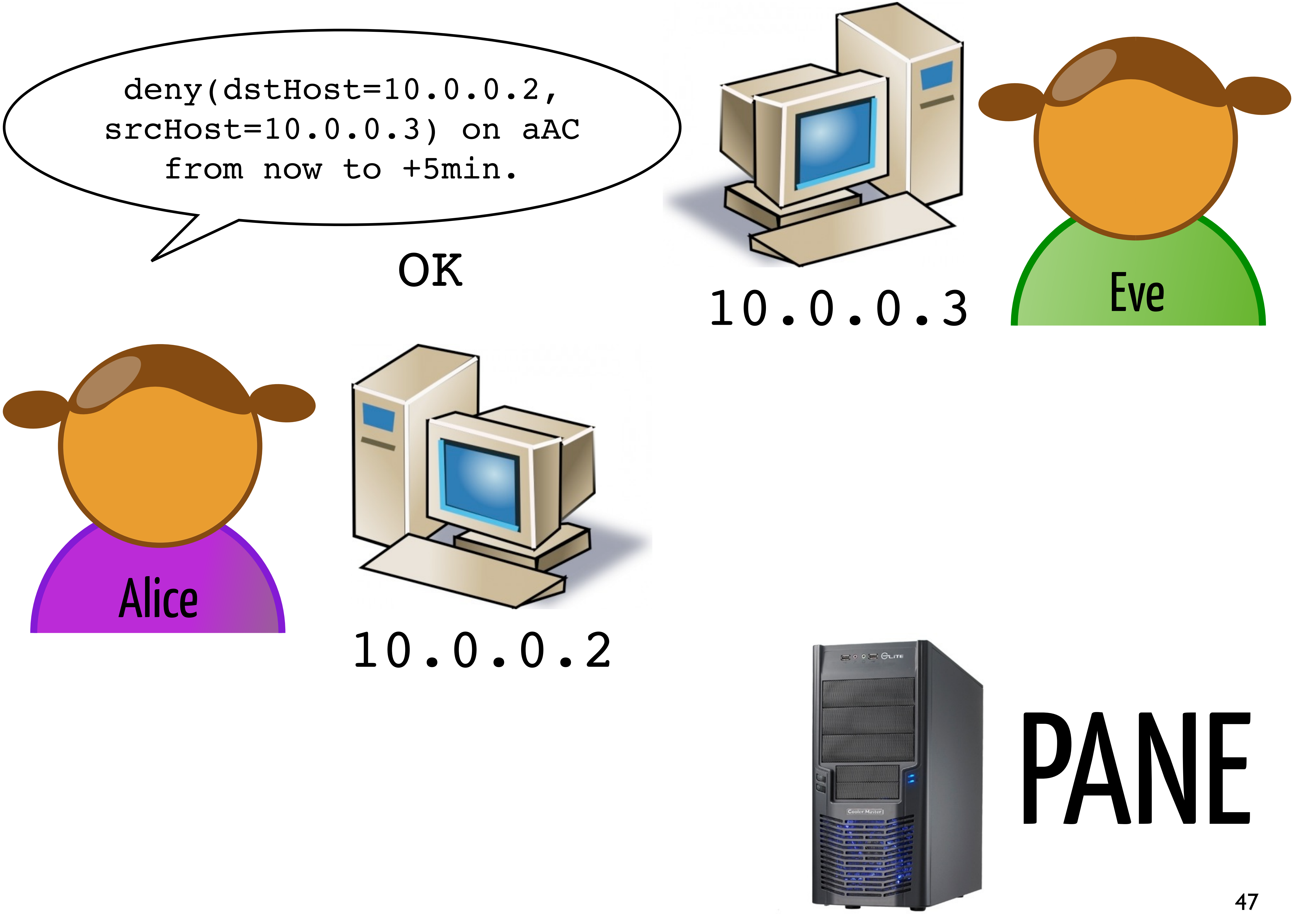
10.0.0.3

Eve

Alice

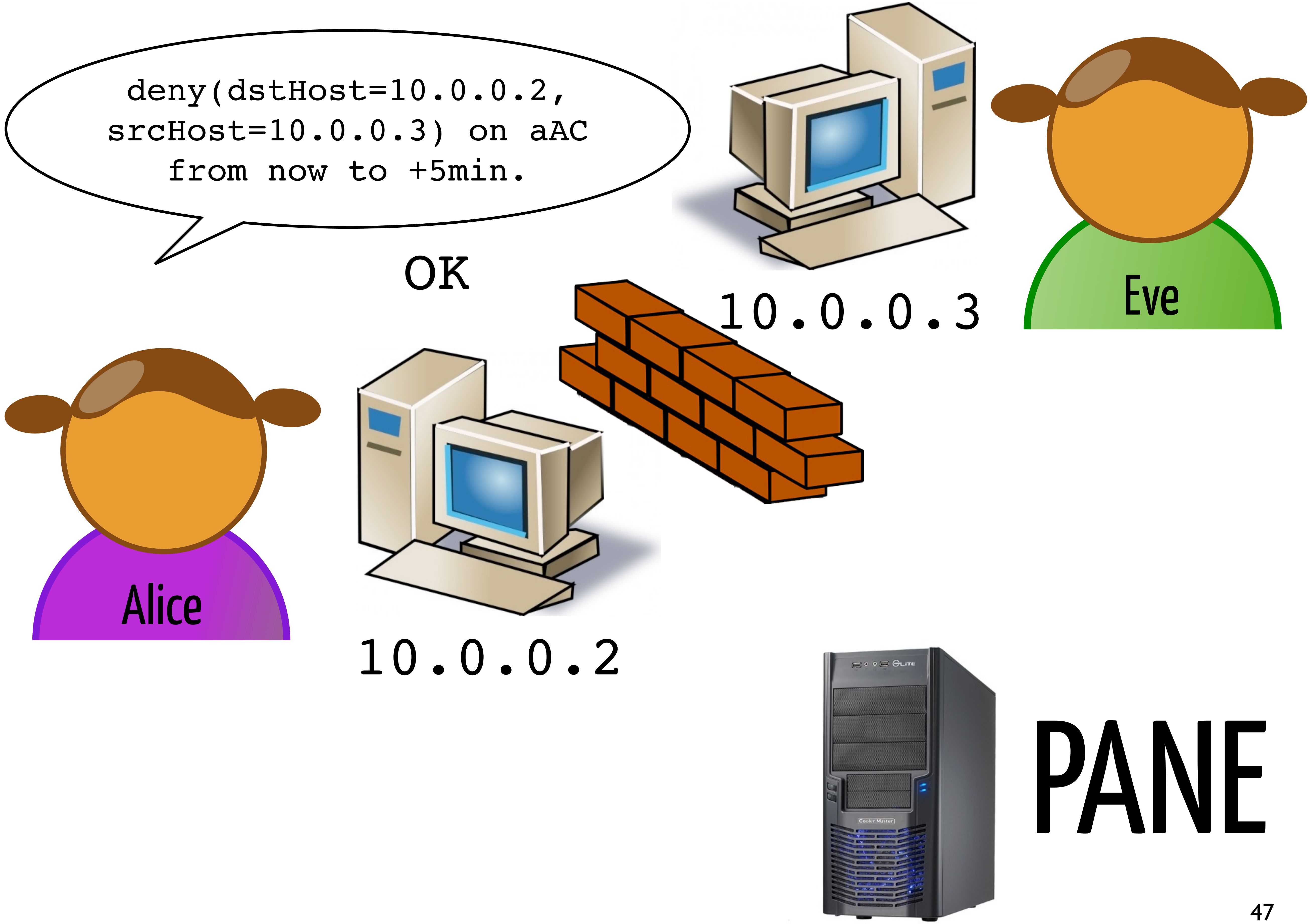
10.0.0.2

PANE



```
deny(dstHost=10.0.0.2,
srcHost=10.0.0.3) on aAC
from now to +5min.
```

OK



```
deny(dstHost=10.0.0.2,
srcHost=10.0.0.3) on aAC
from now to +5min.
```

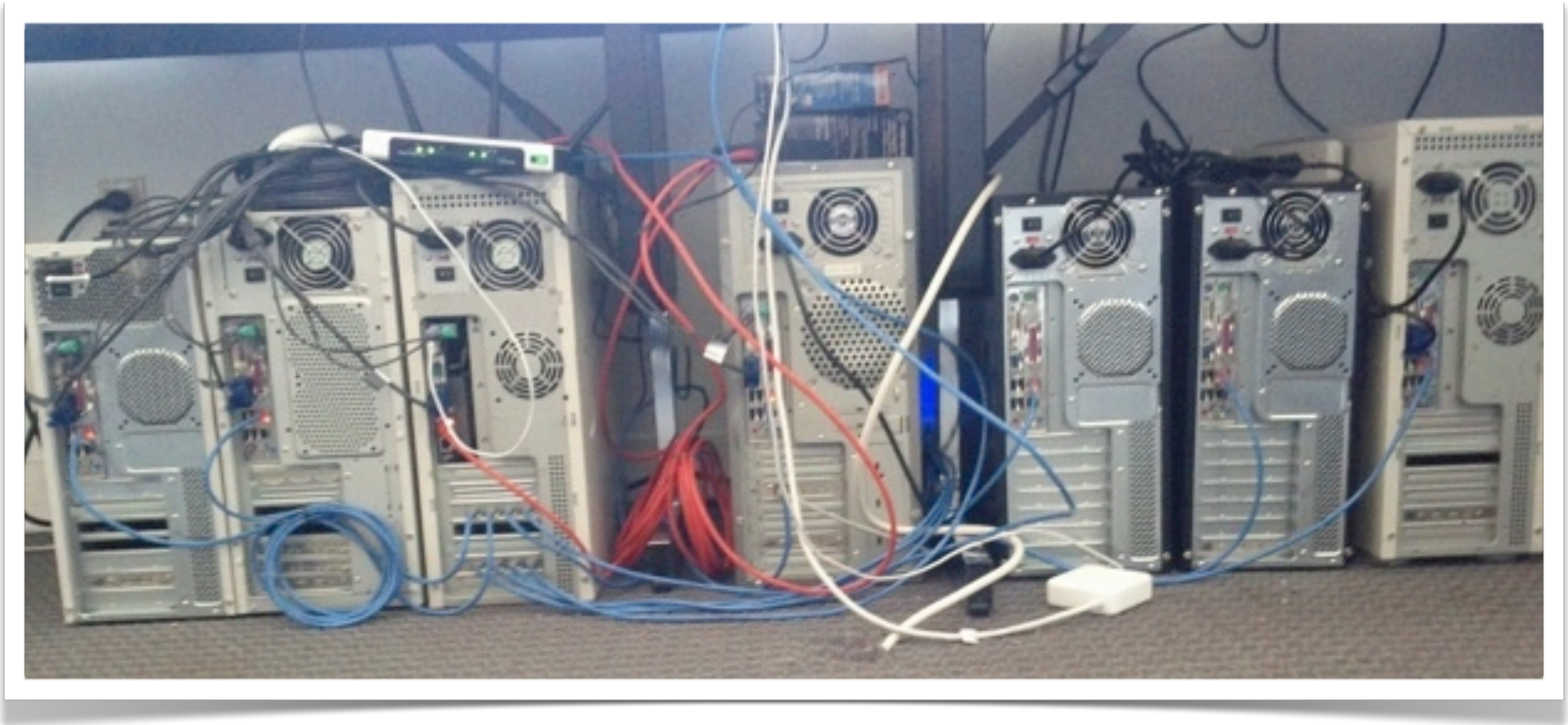
OK

10.0.0.3

10.0.0.2

PANE

Current Status



Conclusion

```
3640-123#show
running-config
Building
configuration...
Current
configuration :
1432 bytes
version 12.3
service config
service timestamps
debug datetime msec
service timestamps
log datetime msec
service password-
encryption
hostname 3640-123
boot-start-marker
boot-end-marker
enable password 7
02050D4808095E731F
no aaa new-model
resource policy
voice-card 3
ip subnet-zero
ip cef
no ip dhcp use vrf
connected
!--- This is the
Cisco IOS Firewall
configuration.
!--- IN-OUT is the
inspection rule for
traffic that flows
!--- from the
inside interface of
the router to the
outside interface.
ip inspect name IN-
OUT tcp
ip inspect name IN-
OUT udp
ip inspect name IN-
OUT ftp
ip inspect name IN-
OUT http
ip inspect name IN-
OUT icmp
!--- OUT-IN is the
inspection rule for
traffic that flows
!--- from the
outside interface
of the router to
the inside
interface.
!--- This rule is
where SMTP/ESMTP
inspection is
specified.
ip inspect name
OUT-IN smtp
no ip ips deny-
action ips-
```

```
no ftp-server
write-enable
controller T1 3/0
 framing sf
 linecode ami
!--- The outside
interface.
interface
Ethernet2/0
 ip address
172.22.1.16
255.255.255.0
!--- Apply the
access list to
permit SMTP/ESMTP
connections
!--- to the mail
server. This also
allows Cisco IOS
Firewall
!--- to inspect
SMTP or ESMTP
commands.
 ip access-group
101 in
 ip nat outside
!--- Apply the
inspection rule
OUT-IN inbound on
this interface.
This is
!--- the rule that
defines SMTP/ESMTP
inspection.
 ip inspect OUT-IN
in
 ip virtual-
reassembly
 half-duplex
interface Serial2/0
 no ip address
 shutdown
!--- The inside
interface.
interface
Ethernet2/1
 ip address
10.10.10.1
255.255.255.0
 ip nat inside
!--- Apply the
inspection rule IN-
OUT inbound on this
interface.
 ip inspect IN-OUT
in
 ip virtual-
reassembly
 half-duplex
ip http server
no ip http secure-
server
ip classless
```

```
!--- The static
translation for the
mail server.
ip nat inside
source static
10.10.10.2
172.22.1.110
ip nat inside
source static
10.10.10.5
172.22.1.111
!--- The access
list to permit SMTP
and ESMTP to the
mail server.
!--- Cisco IOS
Firewall inspects
permitted traffic.
access-list 101
permit tcp any host
172.22.1.110 eq
smtp
control-plane
voice-port 1/0/0
voice-port 1/0/1
voice-port 1/1/0
voice-port 1/1/1
line con 0
line aux 0
line vty 0 4
 password 7
121A0C0411045D5679
 login
end
Current
configuration:
version 12.2
service timestamps
debug uptime
service timestamps
log uptime
no service
password-encryption
hostname sec-3640
aaa new-model
aaa group server
tacacs+ RTP
 server
171.68.120.214
aaa authentication
login default group
RTP none
aaa authorization
exec default group
RTP none
aaa authorization
auth-proxy default
group RTP
enable secret 5
$1$pqRI
$3TDNFT9FdYT8Sd/
q3S0VU1
enable password ww
```

```
ip inspect name
myfw cuseeme
timeout 3600
ip inspect name
myfw ftp timeout
3600
ip inspect name
myfw http timeout
3600
ip inspect name
myfw rcmd timeout
3600
ip inspect name
myfw realaudio
timeout 3600
ip inspect name
myfw smtp timeout
3600
ip inspect name
myfw sqlnet timeout
3600
ip inspect name
myfw streamworks
timeout 3600
ip inspect name
myfw tftp timeout
30
ip inspect name
myfw udp timeout 15
ip inspect name
myfw tcp timeout
3600
ip inspect name
myfw vdolive
ip auth-proxy auth-
proxy-banner
ip auth-proxy auth-
cache-time 10
ip auth-proxy name
list_a http
ip audit notify log
ip audit po max-
events 100
interface
Ethernet0/0
 ip address
40.31.1.144
255.255.255.0
ip access-group 116
in
 ip nat outside
ip auth-proxy
list_a
 no ip route-cache
 no ip mroute-cache
 speed auto
 half-duplex
 no mop enabled
interface
Ethernet1/0
 ip address
10.14.14.14
255.255.255.0
```

```
   the syslog
server or router.
ip urlfilter audit-
trail
!--- use the ip
urlfilter urlf-
server-log
   command in
global
configuration mode
to enable the
logging of
system messages on
the URL filtering
server.
ip urlfilter urlf-
server-log
!--- use the ip
urlfilter server
vendor command
   in global
configuration mode
to configure a
vendor server for
URL filtering.
   Here we have
configured a
websense server
for URL filtering
ip urlfilter server
vendor websense
192.168.15.15
no ftp-server
write-enable
!--- Below is the
basic interface
configuration
  on the router
interface
FastEthernet0
 ip address
192.168.5.10
255.255.255.0
 ip virtual-
reassembly
!--- use the ip
inspect command in
interface
   configuration
mode
to apply a set of
inspection rules to
an interface.
   Here the
inspection name
TEST is
applied to the
interface
FastEthernet0.
 ip inspect test in
 duplex auto
 speed auto
interface
```

```
 ip virtual-
reassembly
 duplex auto
 speed auto
interface
FastEthernet2
 ip address
10.77.241.109
255.255.255.192
 ip virtual-
reassembly
 duplex auto
 speed auto
interface
FastEthernet2
 no ip address
interface Vlan1
 ip address
10.77.241.111
255.255.255.192
 ip virtual-
reassembly
ip classless
ip route 10.10.10.0
255.255.255.0
172.17.1.2
ip route 10.77.0.0
255.255.0.0
10.77.241.65
!--- Configure the
below commands to
enable
   SDM access to
the cisco routers
ip http server
ip http
authentication
local
no ip http secure-
server
line con 0
line aux 0
line vty 0 4
 privilege level 15
 transport input
telnet ssh
end
version 12.4
service timestamps
debug datetime msec
service timestamps
log datetime msec
no service
password-encryption
hostname 2851-cme2
logging message-
counter syslog
logging buffered
51200 warnings
no aaa new-model
clock timezone mst
-7
clock summer-time
```

```
no ip dhcp use vrf
connected
ip dhcp pool
pub-112-net
   network
172.17.112.0
255.255.255.0
   default-router
172.17.112.1
   dns-server
172.16.1.22
   option 150 ip
172.16.1.43
   domain-name
bldrtme.com
ip dhcp pool
priv-112-net
   network
192.168.112.0
255.255.255.0
   default-router
192.168.112.1
   dns-server
172.16.1.22
   domain-name
bldrtme.com
   option 150 ip
192.168.112.1
ip domain name
yourdomain.com
no ipv6 cef
multilink bundle-
name authenticated
voice translation-
rule 1
 rule 1 // /1001/
voice translation-
profile default
 translate called 1
voice-card 0
 no dspfarm
interface
GigabitEthernet0/0
 description $ETH-
LAN$$ETH-SW-LAUNCH$
$INTF-INFO-GE 0/0$
 ip address
172.16.112.10
255.255.255.0
 ip nat outside
 ip virtual-
reassembly
 duplex auto
 speed auto
interface
GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
interface
GigabitEthernet0/1.
132
 encapsulation
```

```
interface
GigabitEthernet0/1.
152
 encapsulation
dot1Q 152
 ip address
192.168.112.1
255.255.255.0
 ip nat inside
 ip virtual-
reassembly
interface
FastEthernet0/2/0
interface
FastEthernet0/2/1
interface
FastEthernet0/2/2
interface
FastEthernet0/2/3
interface Vlan1
 ip address
198.41.9.15
255.255.255.0
router eigrp 1
 network
172.16.112.0
0.0.0.255
 network
172.17.112.0
0.0.0.255
 no auto-summary
ip forward-protocol
nd
ip http server
ip http access-
class 23
ip http
authentication
local
ip http secure-
server
ip http timeout-
policy idle 60 life
86400 requests
10000
ip http path
flash:/gui
ip nat inside
source list 111
interface
GigabitEthernet0/0
overload
access-list 23
permit 10.10.10.0
0.0.0.7
access-list 111
deny   ip
192.168.112.0
0.0.0.255
192.168.0.0
0.0.255.255
access-list 111
permit ip
192.168.112.0
```

99%

```
3640-123#show
running-config
Building
configuration...
Current
configuration :
1432 bytes
version 12.3
service config
service timestamps
debug datetime msec
service timestamps
log datetime msec
service password-
encryption
hostname 3640-123
boot-start-marker
boot-end-marker
enable password 7
02050D4808095E731F
no aaa new-model
resource policy
voice-card 3
ip subnet-zero
ip cef
no ip dhcp use vrf
connected
!--- This is the
Cisco IOS Firewall
configuration.
!--- IN-OUT is the
inspection rule for
traffic that flows
!--- from the
inside interface of
the router to the
outside interface.
ip inspect name IN-
OUT tcp
ip inspect name IN-
OUT udp
ip inspect name IN-
OUT ftp
ip inspect name IN-
OUT http
ip inspect name IN-
OUT icmp
!--- OUT-IN is the
inspection rule for
traffic that flows
!--- from the
outside interface
of the router to
the inside
interface.
!--- This rule is
where SMTP/ESMTP
inspection is
specified.
ip inspect name
OUT-IN smtp
no ip ips deny-
action ips-
```

```
no ftp-server
write-enable
controller T1 3/0
 framing sf
 linecode ami
!--- The outside
interface.
interface
Ethernet2/0
 ip address
172.22.1.16
255.255.255.0
!--- Apply the
access list to
permit SMTP/ESMTP
connections
!--- to the mail
server. This also
allows Cisco IOS
Firewall
!--- to i
SMTP or ES
commands.
 ip access
101 in
 ip nat out
!--- Apply
inspection
OUT-IN inbou
this interfa
This is
!--- the rule
defines SMTP/
inspection.
 ip inspect OU
in
 ip virtual-
reassembly
 half-duplex
interface Seria
 no ip address
 shutdown
!--- The inside
interface.
interface
Ethernet2/1
 ip address
10.10.10.1
255.255.255.0
 ip nat inside
!--- Apply the
inspection rule IN-
OUT inbound on this
interface.
 ip inspect IN-OUT
in
 ip virtual-
reassembly
 half-duplex
ip http server
no ip http secure-
server
ip classless
```

```
!--- The static
translation for the
mail server.
ip nat inside
source static
10.10.10.2
172.22.1.110
ip nat inside
source static
10.10.10.5
172.22.1.111
!--- The access
list to permit SMTP
and ESMTP to the
mail server.
!--- Cisco IOS
Firewall inspects
permitted traffi

aaa authentication
login default group
RTP none
aaa authorization
exec default group
RTP none
aaa authorization
auth-proxy default
group RTP
enable secret 5
$1$pqRI
$3TDNFT9FdYT8Sd/
q3S0VU1
enable password ww
```

```
ip inspect name
myfw cuseeme
timeout 3600
ip inspect name
myfw ftp timeout
3600
ip inspect name
myfw http timeout
3600
ip inspect name
myfw rcmd timeout
3600
ip inspect name
myfw realaudio
timeout 3600
ip inspect name

ip access-group 116
in
 ip nat outside
ip auth-proxy
list_a
 no ip route-cache
 no ip mroute-cache
 speed auto
 half-duplex
 no mop enabled
interface
Ethernet1/0
 ip address
10.14.14.14
255.255.255.0
```

```
   the syslog
server or router.
ip urlfilter audit-
trail
!--- use the ip
urlfilter urlf-
server-log
   command in
global
configuration mode
to enable the
logging of
system messages on
the URL filtering
server.

inspect command in
interface
   configuration
mode
to apply a set of
inspection rules to
an interface.
   Here the
inspection name
TEST is
applied to the
interface
FastEthernet0.
 ip inspect test in
 duplex auto
 speed auto
interface
```

```
 ip virtual-
reassembly
 duplex auto
 speed auto
interface
FastEthernet2
 ip address
10.77.241.109
255.255.255.192
 ip virtual-
reassembly
 duplex auto
 speed auto

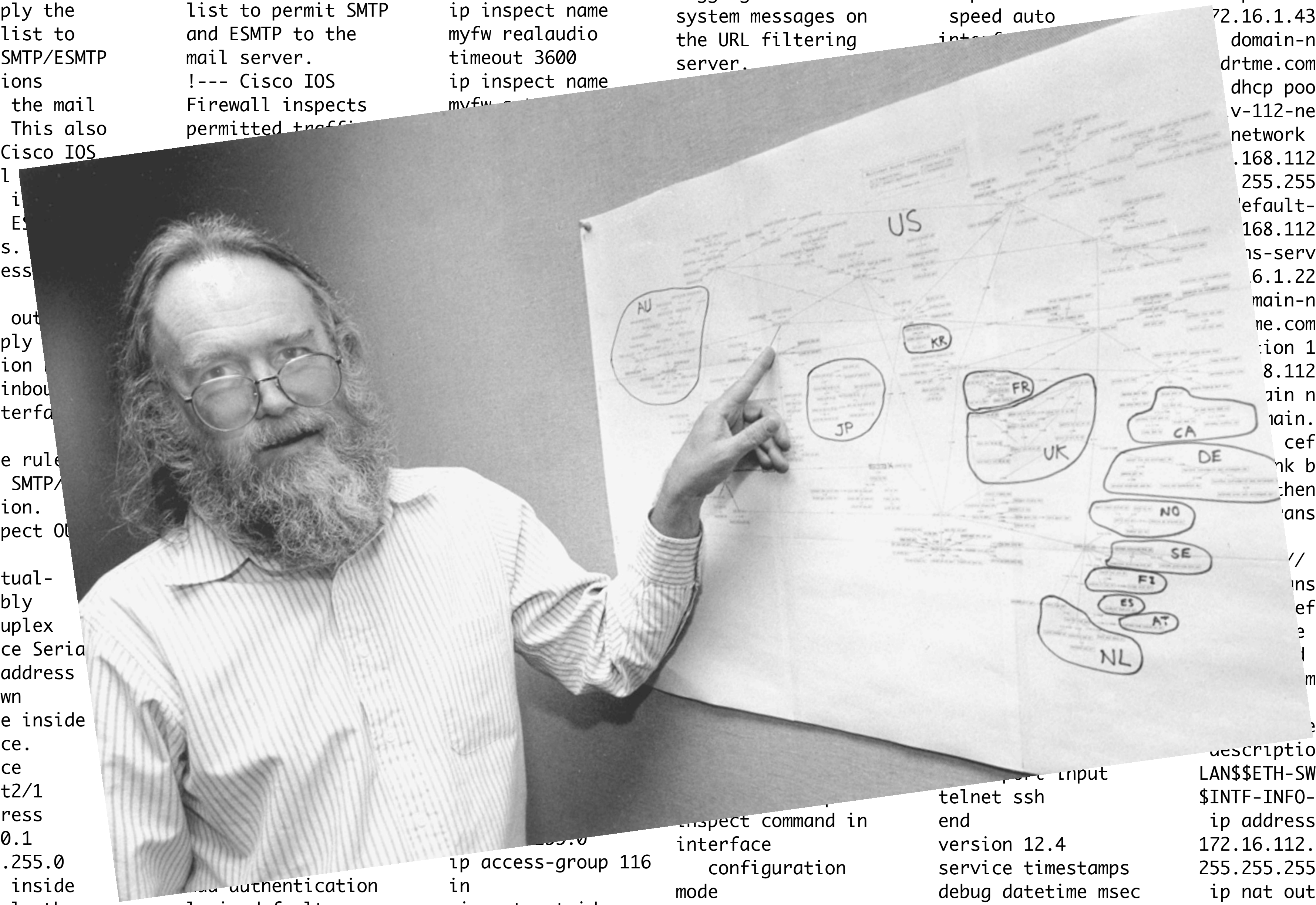
telnet ssh
end
version 12.4
service timestamps
debug datetime msec
service timestamps
log datetime msec
no service
password-encryption
hostname 2851-cme2
logging message-
counter syslog
logging buffered
51200 warnings
no aaa new-model
clock timezone mst
-7
clock summer-time
```

```
no ip dhcp use vrf
connected
ip dhcp pool
pub-112-net
   network
172.17.112.0
255.255.255.0
   default-router
172.17.112.1
   dns-server
172.16.1.22
   option 150 ip
72.16.1.43
   domain-name
drtme.com
   dhcp pool
 v-112-net
   network
 .168.112.0
 255.255.255.0
   efault-router
 168.112.1
   ns-server
 6.1.22
   main-name
 me.com
   ion 150 ip
 8.112.1
   ain name
 ain.com
 cef
 nk bundle-
 chenticated
 anslation-

 // /1001/
 nslation-
 efault
 e called 1
 l 0
 m

 ernet0/0
 description $ETH-
LAN$$ETH-SW-LAUNCH$
$INTF-INFO-GE 0/0$
 ip address
172.16.112.10
255.255.255.0
 ip nat outside
 ip virtu
reassembly
 du lex aut
 peed aut
interface
 bitEth net0/1
 no ip add
 duplex auto
 speed auto
interface
GigabitEthernet0/1.
132
 encapsulation
```

```
interface
GigabitEthernet0/1.
152
 encapsulation
dot1Q 152
 ip address
192.168.112.1
255.255.255.0
 ip nat inside
 ip virtual-
reassembly
interface
FastEthernet0/2/0
interface
FastEthernet0/2/1
interface
FastEthernet0/2/2
interface
FastEthernet0/2/3
interface Vlan1
 ip address
198.41.9.15
255.255.255.0
router eigrp 1
 network
172.16.112.0
0.0.0.255
 network
172.17.112.0
0.0.0.255
 no auto-summary
ip forward-protocol
nd
ip http server
ip http access-
class 23
ip http
authentication
local
ip http secure-
server
ip http timeout-
policy idle 60 life
86400 requests
10000
ip http path
flash:/gui
ip nat inside
source list 111
interface
GigabitEthernet0/0
overload
access-list 23
permit 10.10.10.0
0 0.0.7
access-list 111
deny   ip
1 .8.112.0
0.0.0.255
192.168.0.0
0.0.255.255
access-list 111
permit ip
```



<1%

CENTRE STREET
SOUTH
OCCUPY
EVERYTHING
#OCCUPYWALLST
WE ALREADY KNOW THAT WE OWN EVERYTHING--THE TASK IS TO EXCLUDE THE INTRUSIONS OF CAPITAL AND POWER
Beware
BANKS
BAILED
WE

Participatory Networking

Participatory Networking

1. management API

Participatory Networking

1. management API
2. network controller

Participatory Networking

1. management API
2. network controller

→ Safe

Participatory Networking

1. management API
2. network controller

→

Safe
Secure

Participatory Networking

1. management API
2. network controller

→

Safe
Secure
Fair

Questions?

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Co-authors

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- Jordan Place
- Rodrigo Fonseca
- Shriram Krishnamurthi

Questions?

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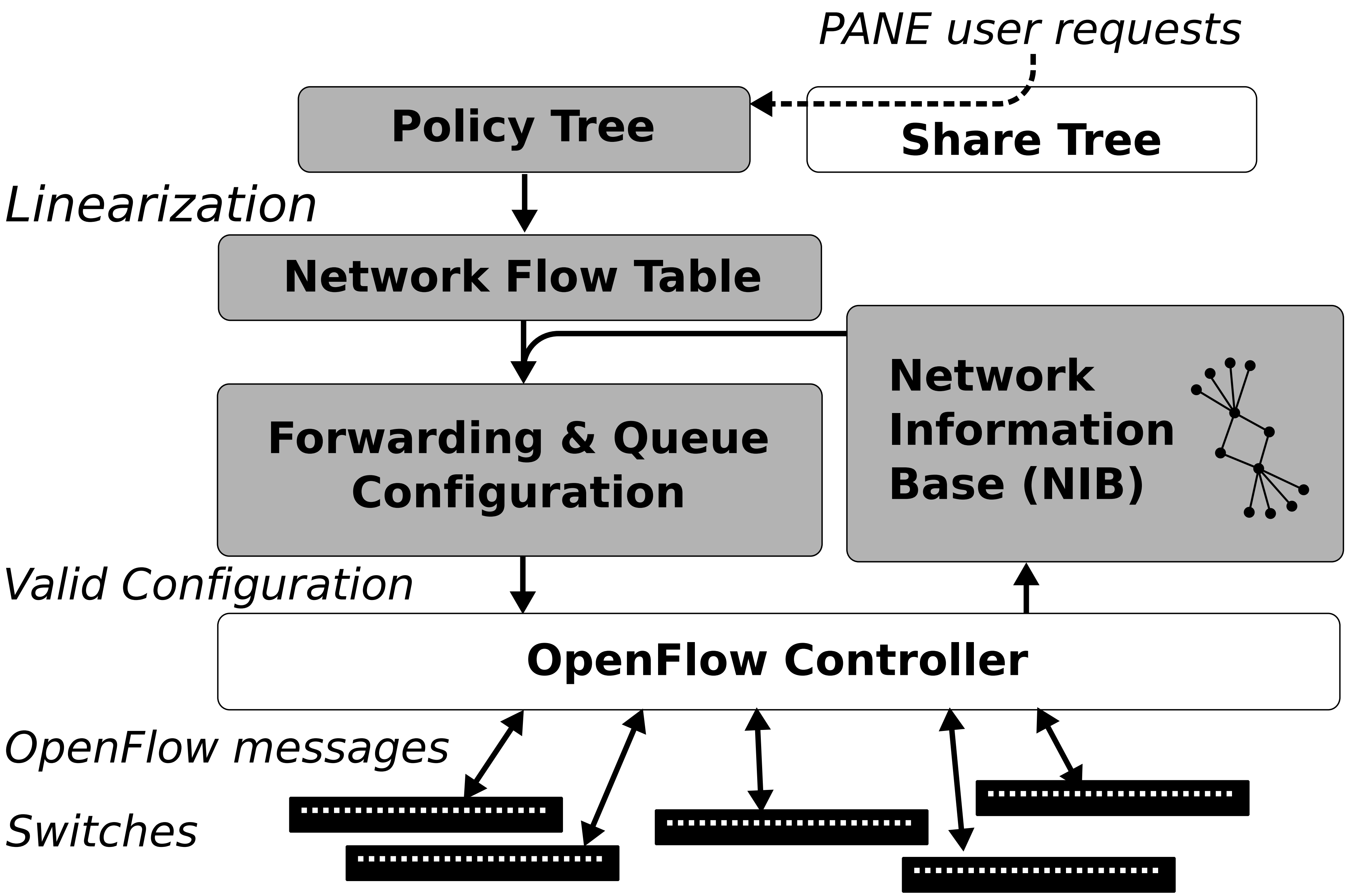
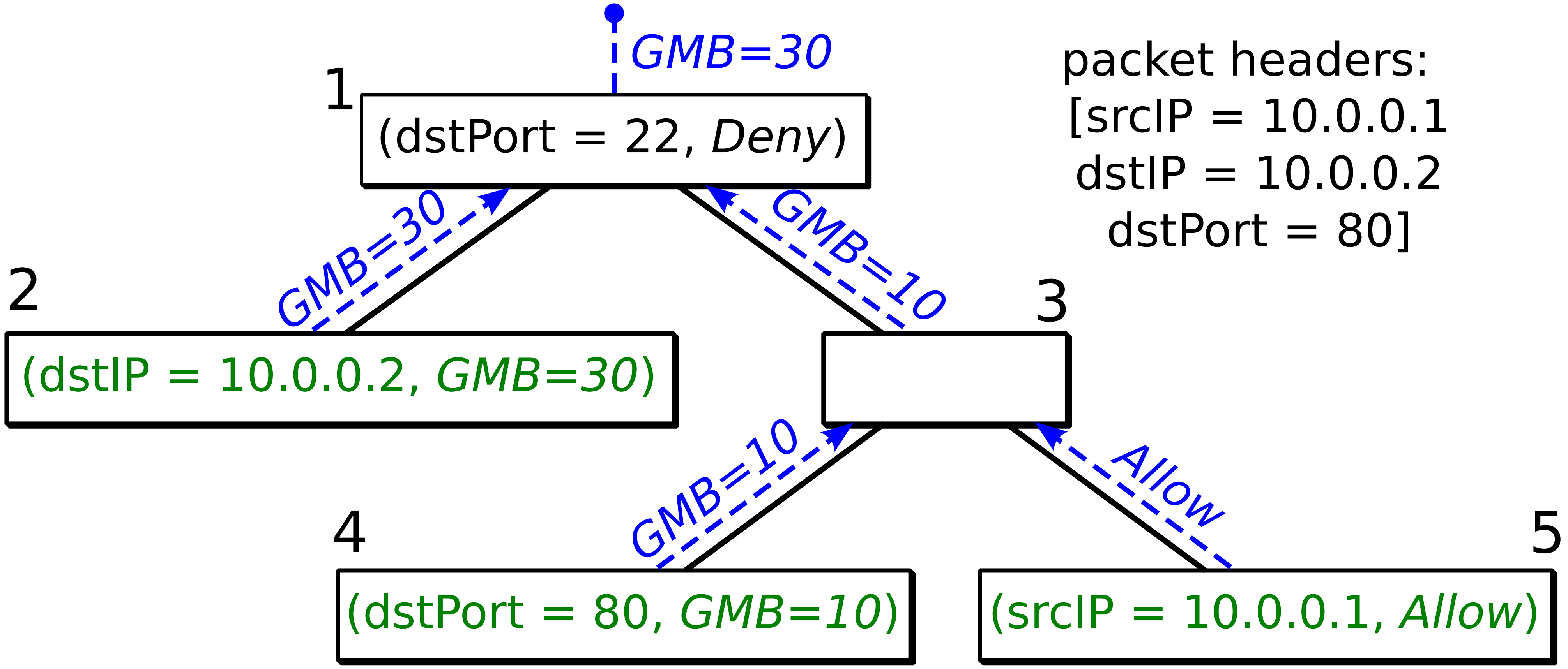
Backup Slides



PANE Implementation



packet headers:
[srcIP = 10.0.0.1
dstIP = 10.0.0.2
dstPort = 80]

PANE Policy Tree