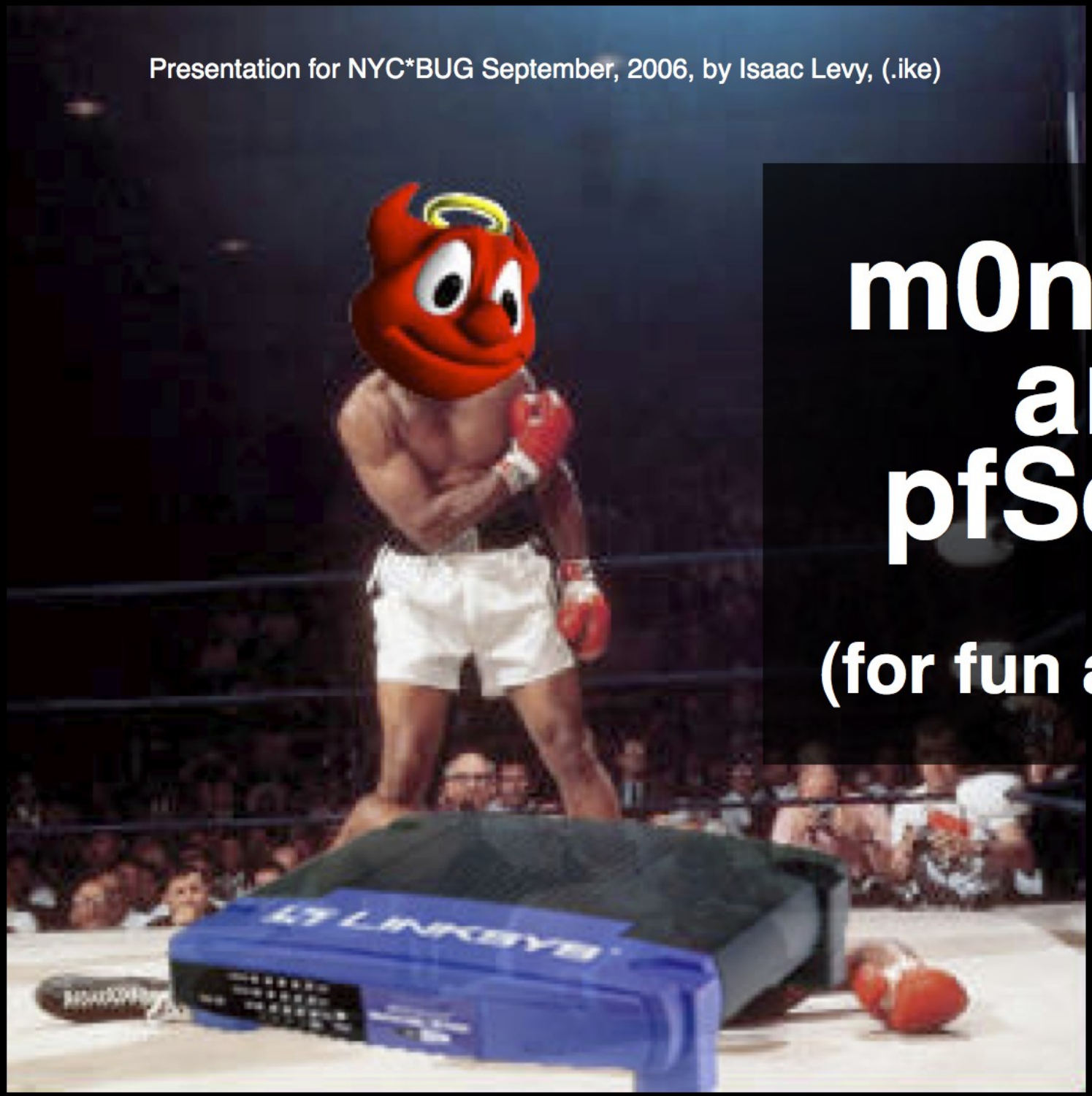
pfSense Practical Experiences

(From home routers, to High-Availability Datacenter Deployments)

Tokyo FreeBSD Benkyokai Group
第26回　FreeBSD勉強会

ike@blackskyresearch.net
Feb. 17, 2014


2026



Presentation for NYC*BUG September, 2006, by Isaac Levy, (.ike)

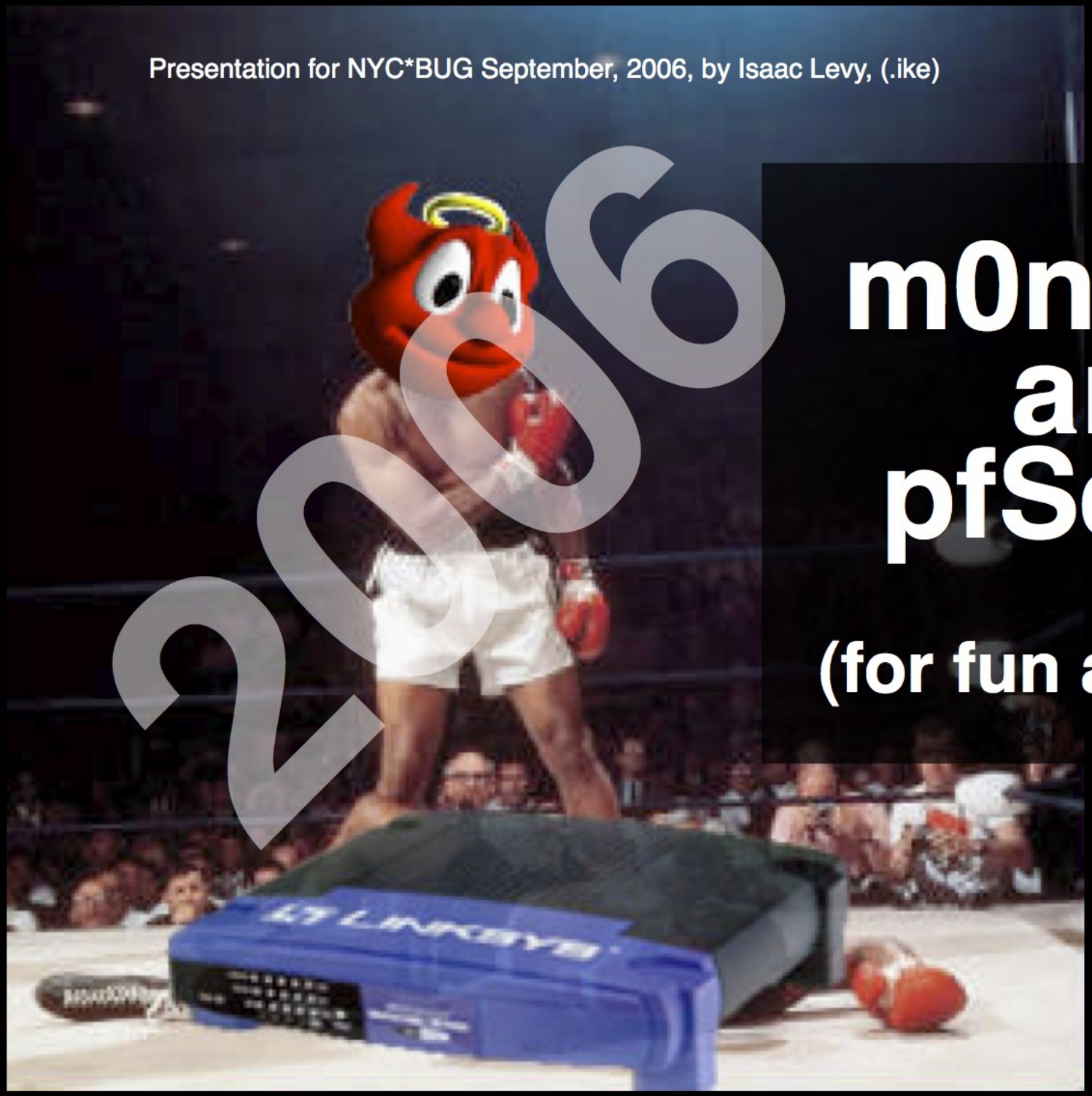
NYCBUG
New York City *BSD User Group

m0n0wall and pfSense

(for fun and profit)

m0n0wall

pfSense



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2006

m0n0wall and pfSense

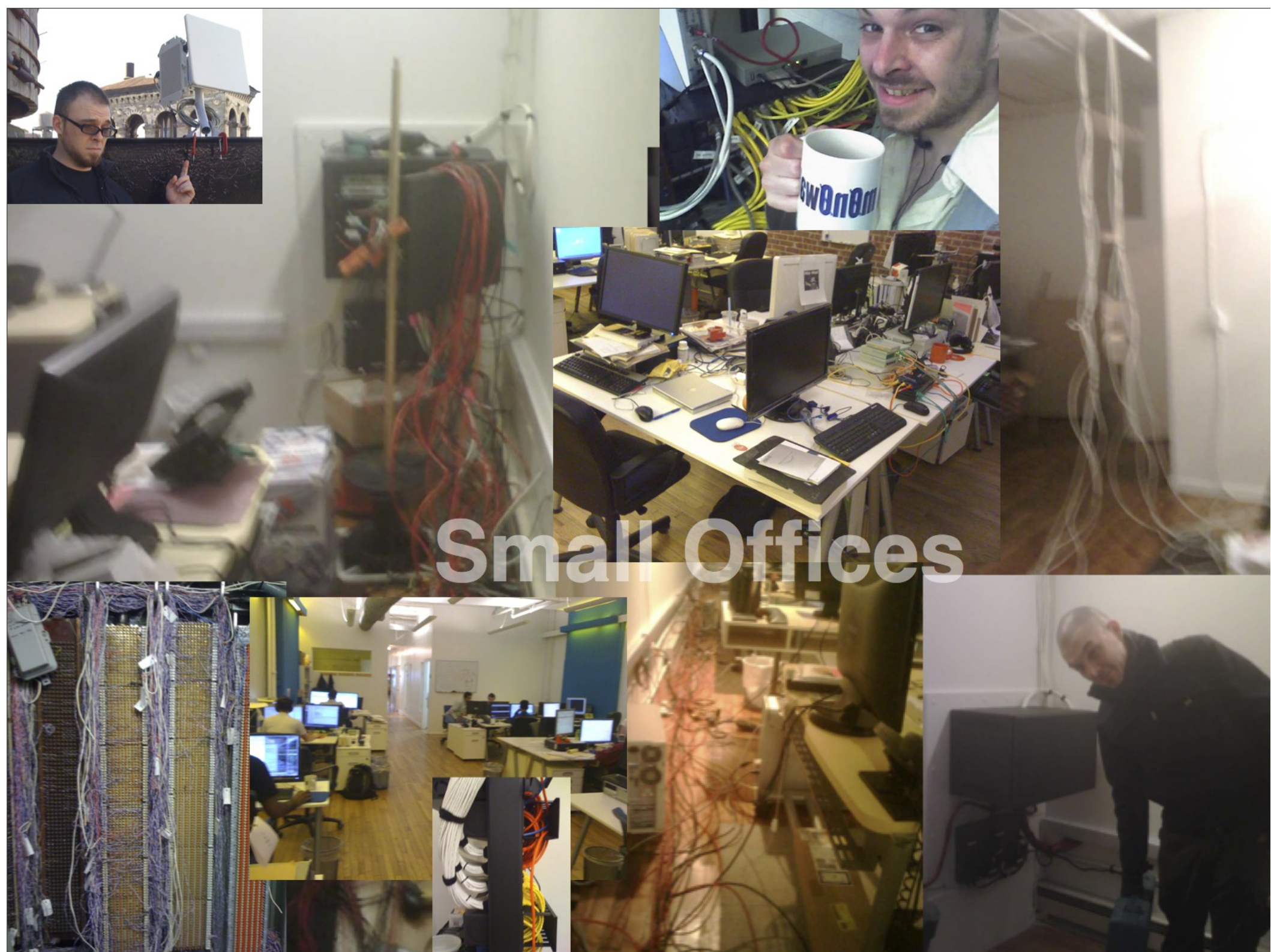
(for fun and profit)

m0n0wall

pfSense

In the meantime...


Colo/Datacenter
BEFORE
AFTER


Small Offices

DISCLAIMER 1

Ladies and gentlemen: the presentation you are about to hear contains fictional accounts of common network and server configurations- based on actual experiences.

IP addresses and hostnames have been changed to protect the innocent.

Any similarities with actual corporations, users, sysadmins, developers, or other persons or entities is completely coincidental.

DISCLAIMER 2

The views expressed in this presentation are my own and do not represent the views of my current or former employers; nor do they represent the PFSense project or developers; nor do they represent NYC*BUG as a whole.

I am not a PFSense developer.

DISCLAIMER 3

Contrary to typical NYC*BUG list/public protocol:

Vendor comparisons with regard to PFSense and networking are completely open for discussion in today's presentation, I will be recommending some vendors, dismissing others.

Use advise given here at your own risk,

(final) Disclaimer 4

(yawn)

(final) Disclaimer 4

Firewalls != Security

(final) Disclaimer 4

BOW TO MY FIREWALL!!!

(final) Disclaimer 4

BOW TO MY FIREWALL!!!

Where *are* the Firewalls and Routers? (a tangent)

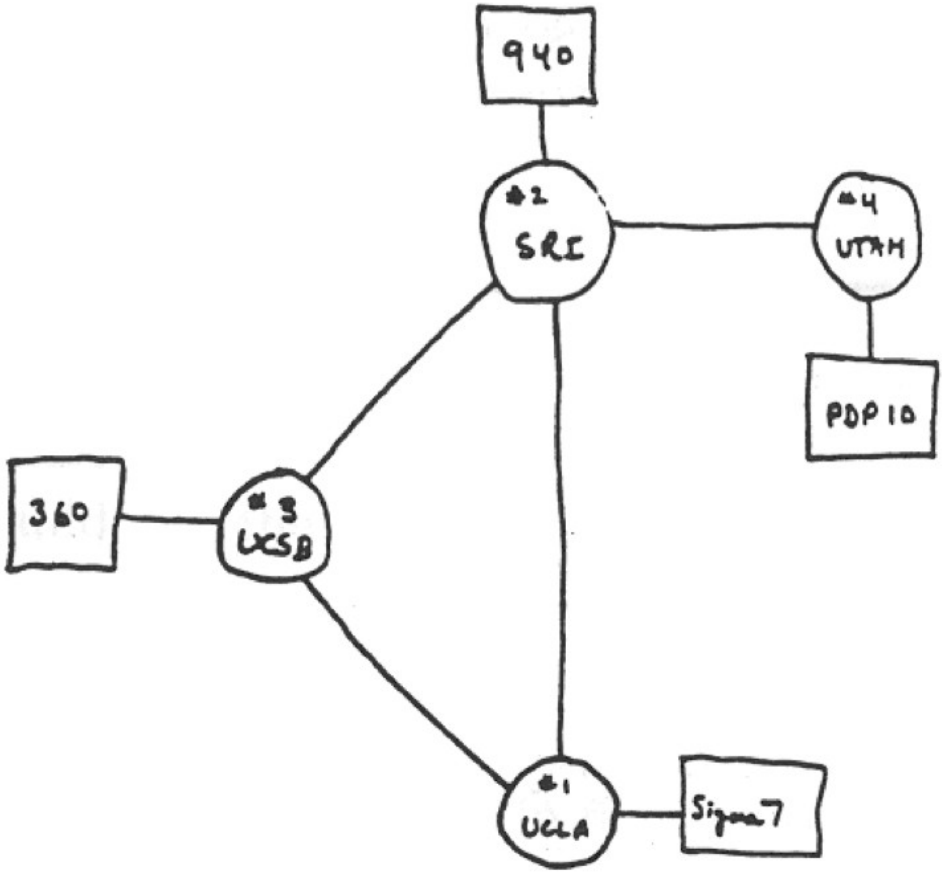
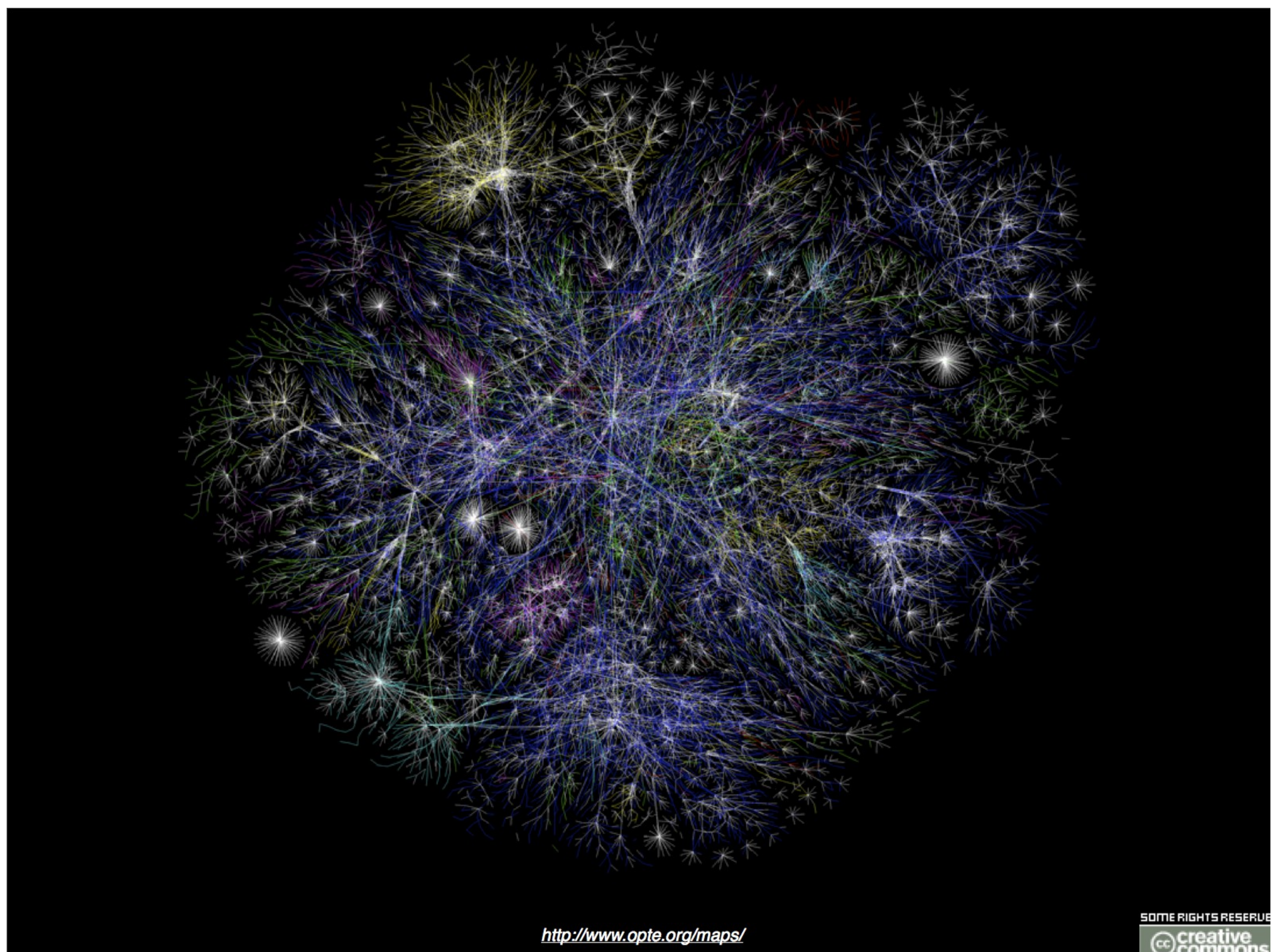
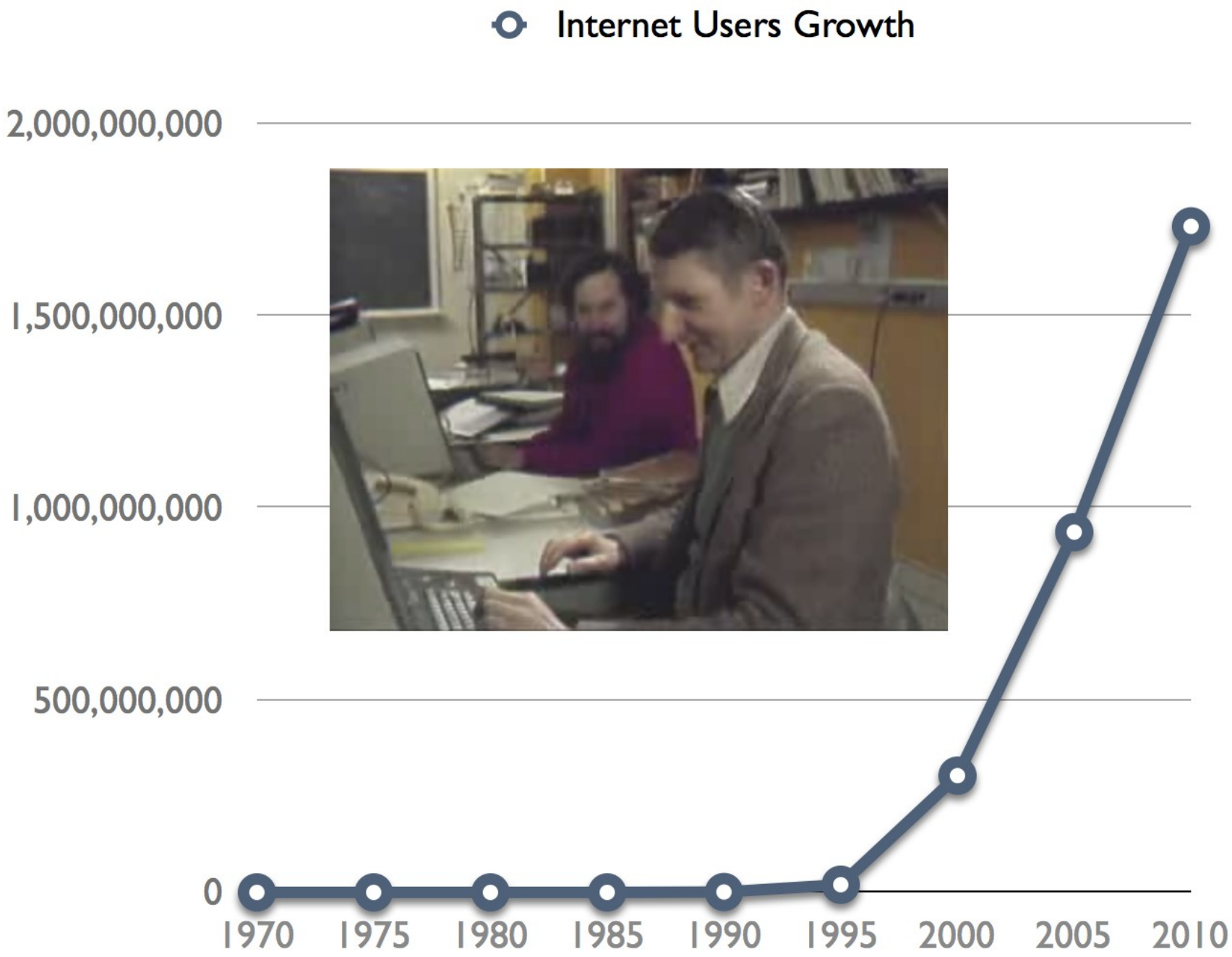
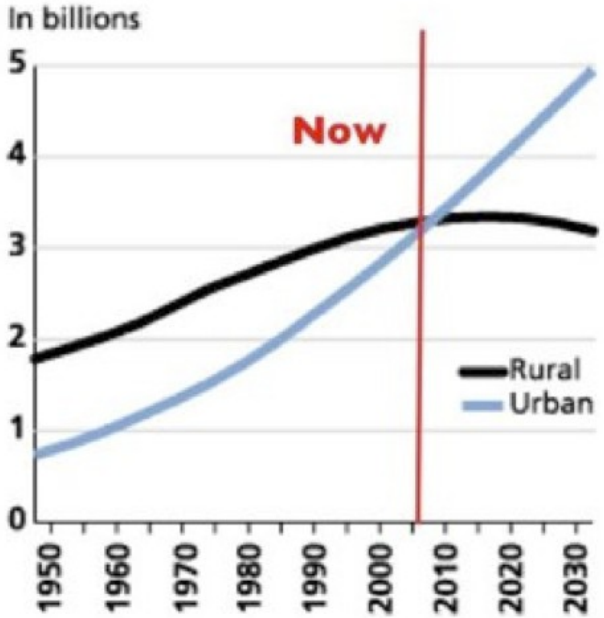


FIGURE 6.2 Drawing of 4 Node Network (Courtesy of Alex McKenzie)

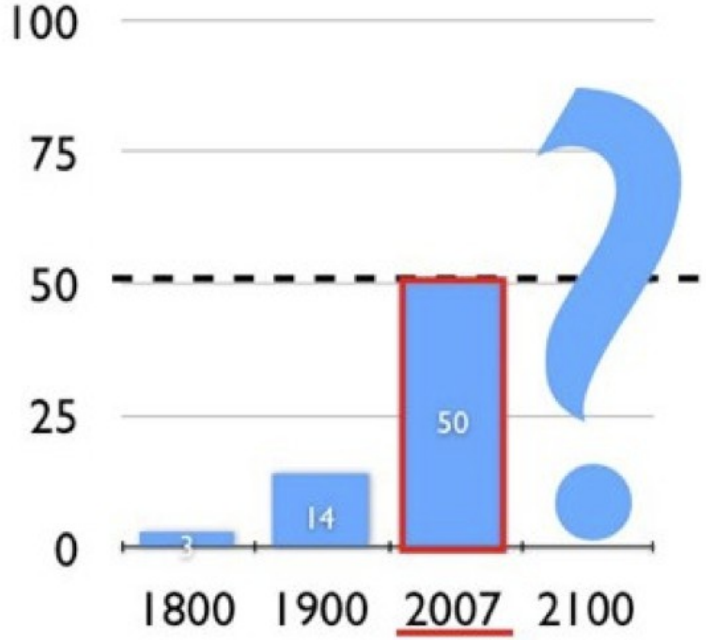




http://www.internetworldstats.com/emarketing.htm



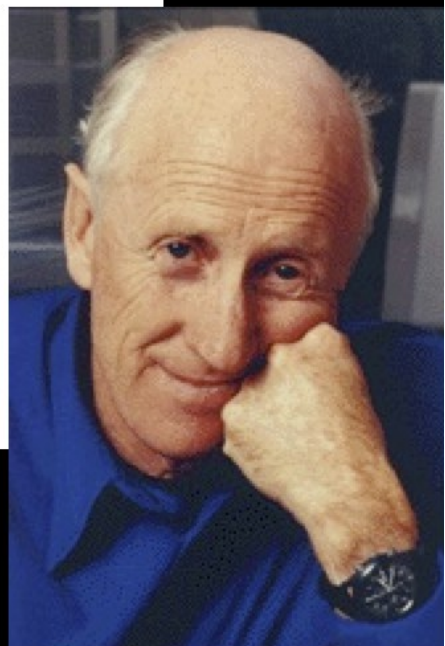
World population



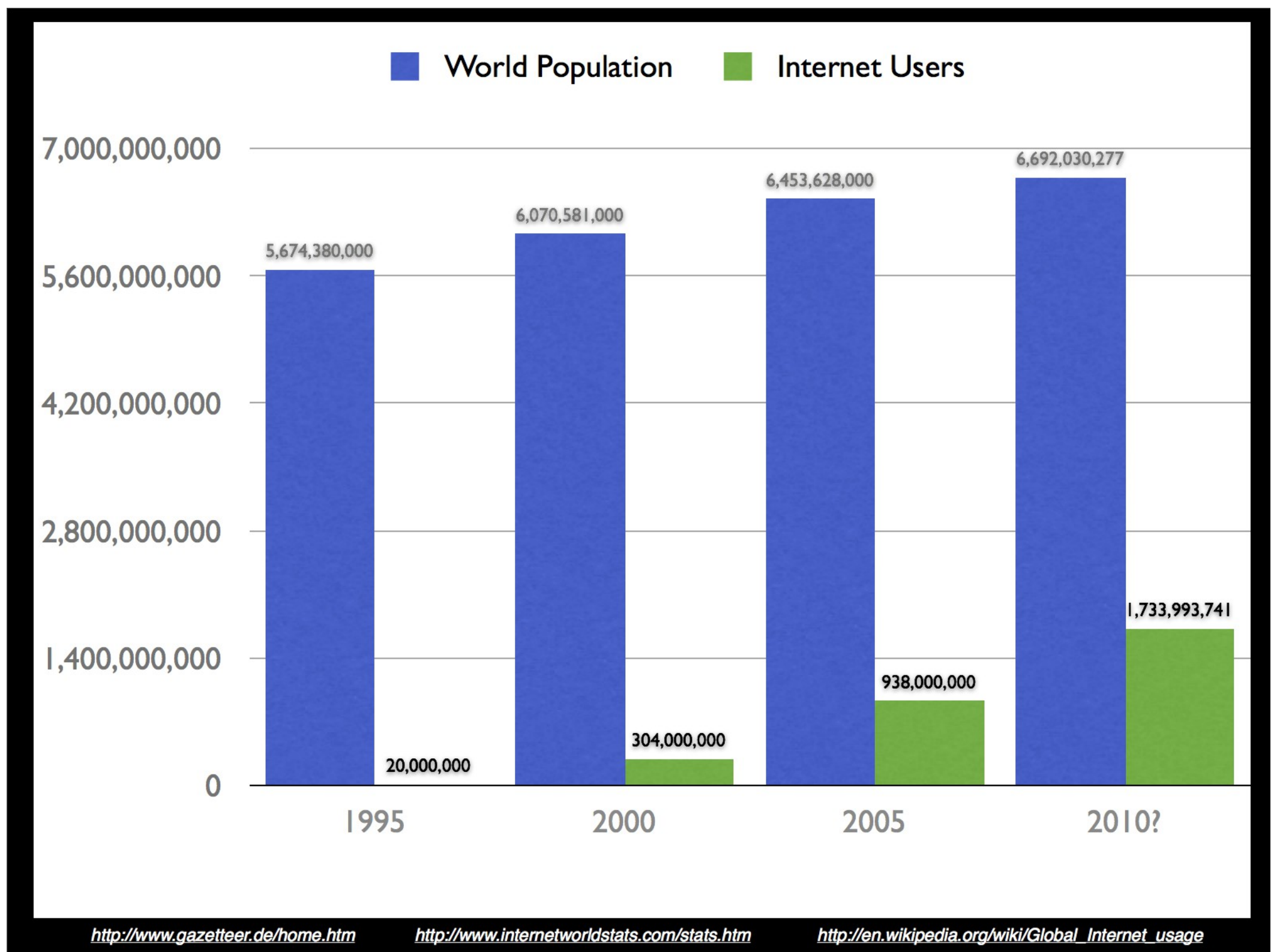
Percent of world urban

In 2007, 50% of the world is urban

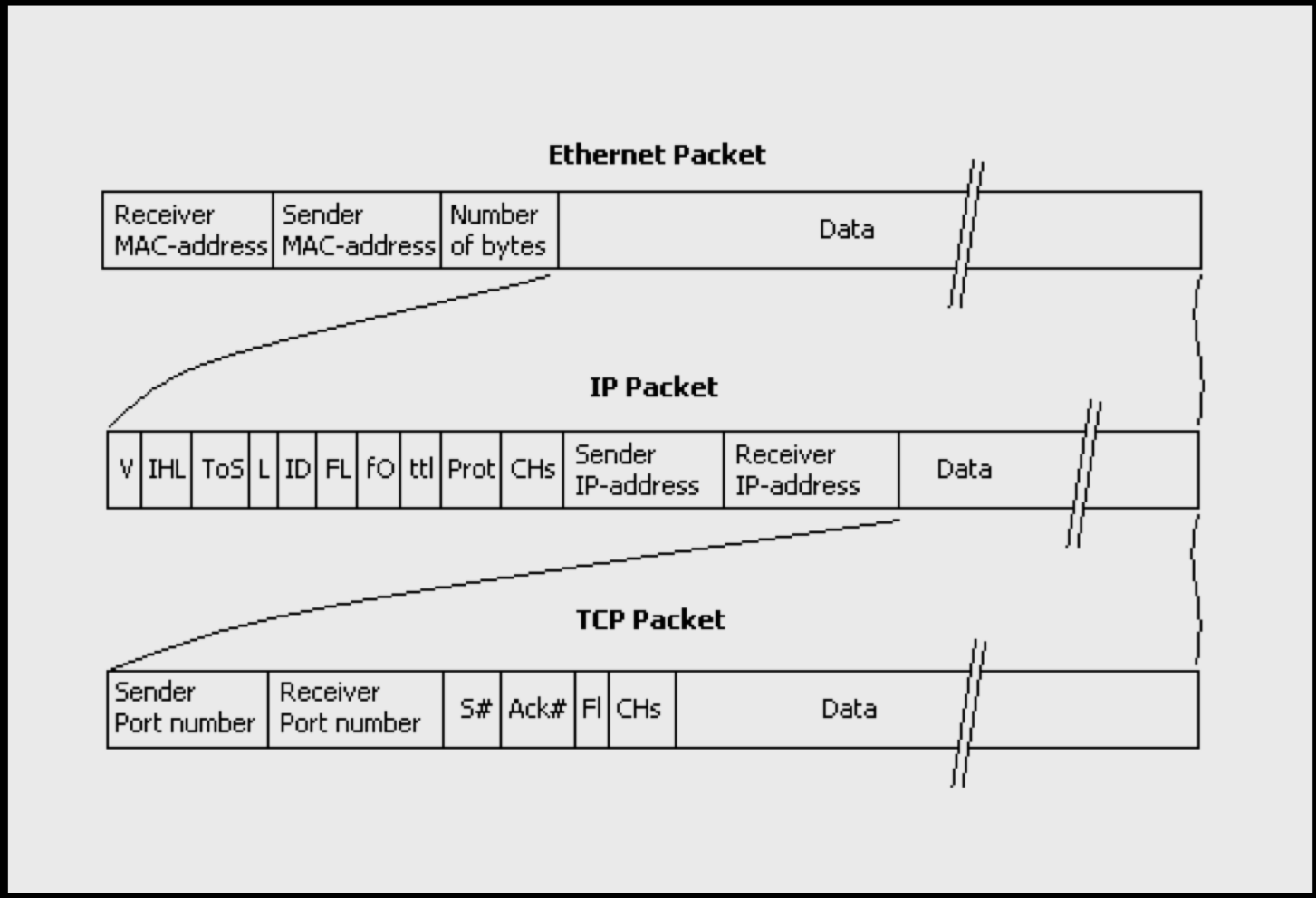
- It was **3%** in 1800
- **14%** in 1900
- **61%** expected in 2030

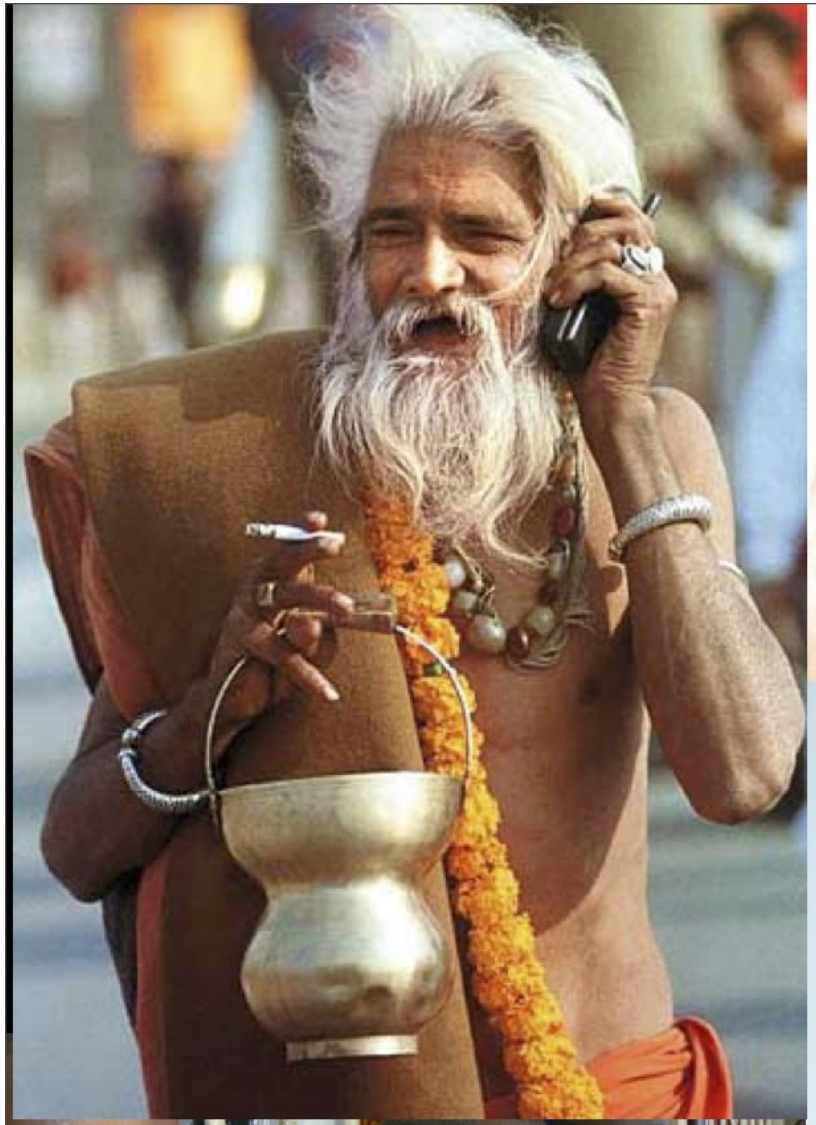


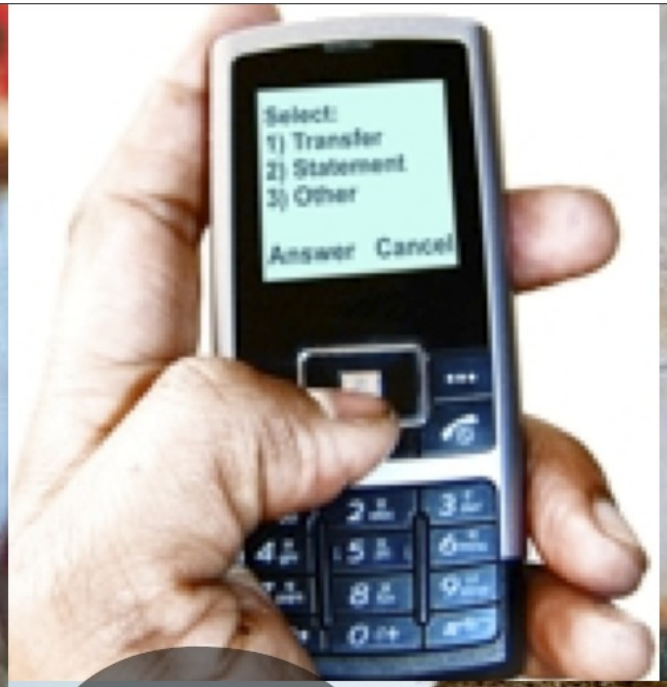
Stewart Brand, Currently working with the Long Now Foundation



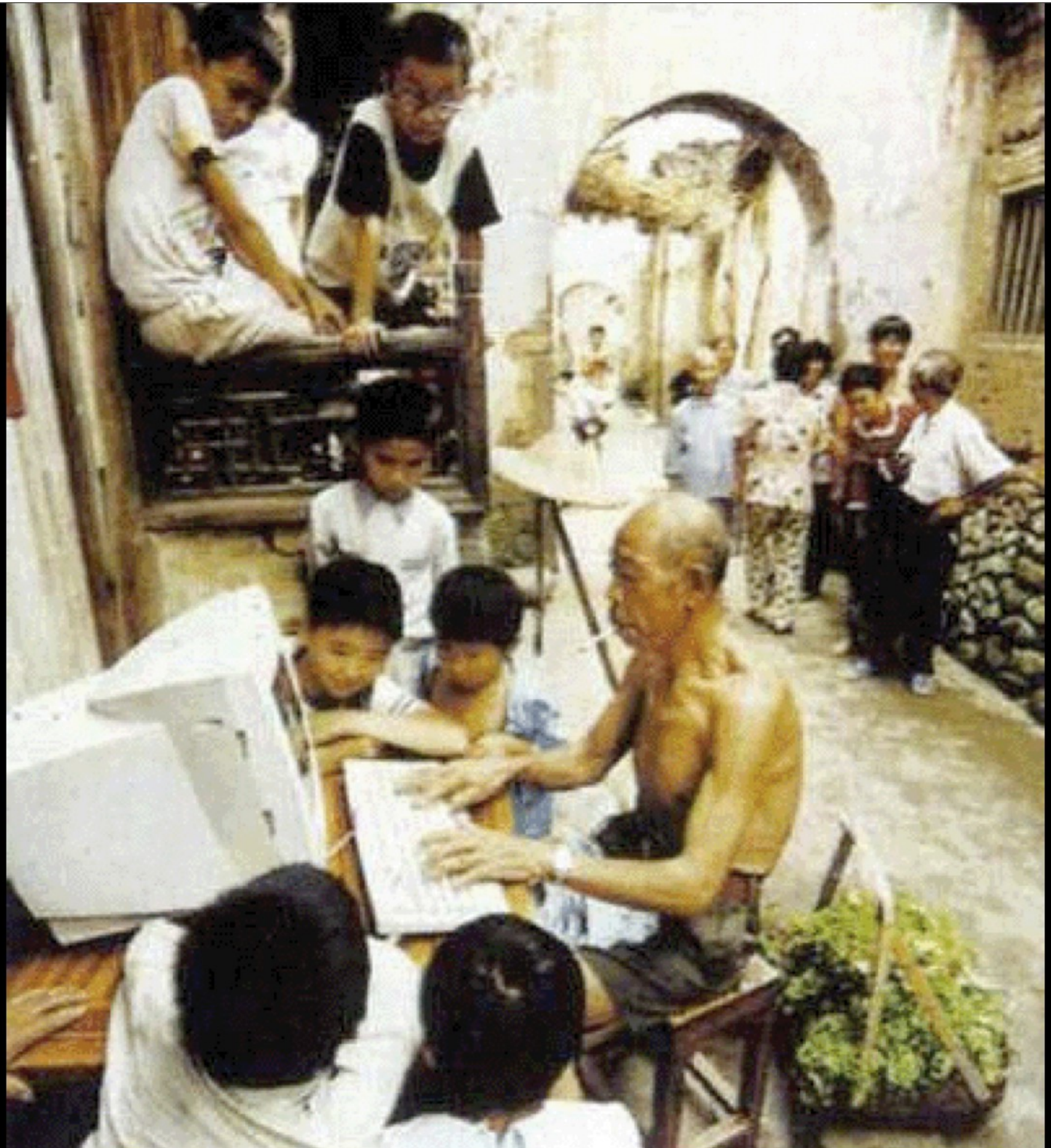
http://www.gazetteer.de/home.htm http://www.internetworldstats.com/stats.htm http://en.wikipedia.org/wiki/Global_Internet_usage

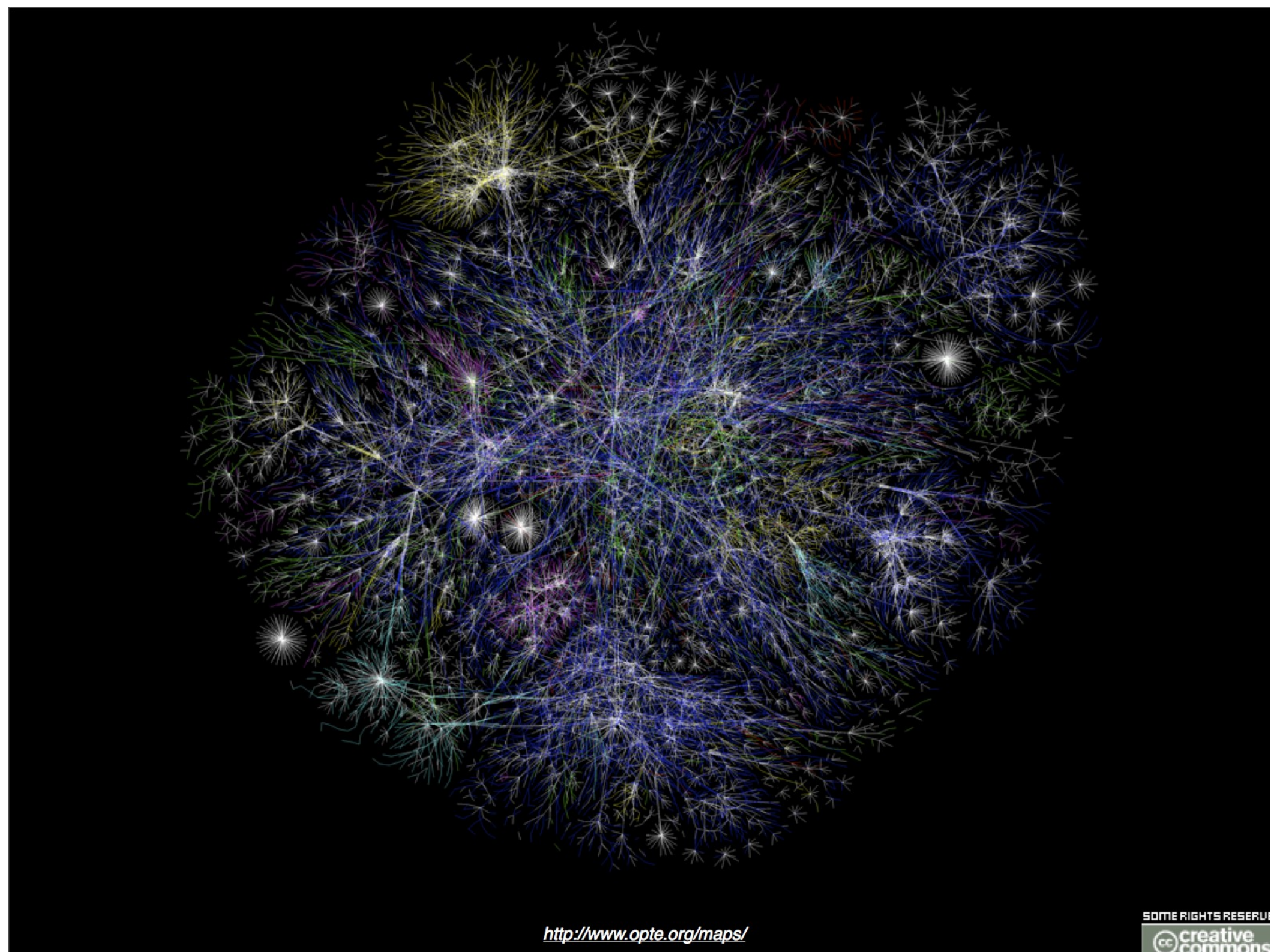

Ethernet Packet
Receiver MAC-address
Sender MAC-address
Number of bytes
Data
IP Packet
V
IHL
ToS
L
ID
FL
fO
ttl
Prot
CHs
Sender IP-address
Receiver IP-address
Data
TCP Packet
Sender Port number
Receiver Port number
S#
Ack#
Fl
CHs
Data




Select:
1) Transfer
2) Statement
3) Other
Answer Cancel


Select:
1) Transfer
2) Statement
3) Other
Answer Cancel
OMFG!!
facebook
skype
Google
twitter



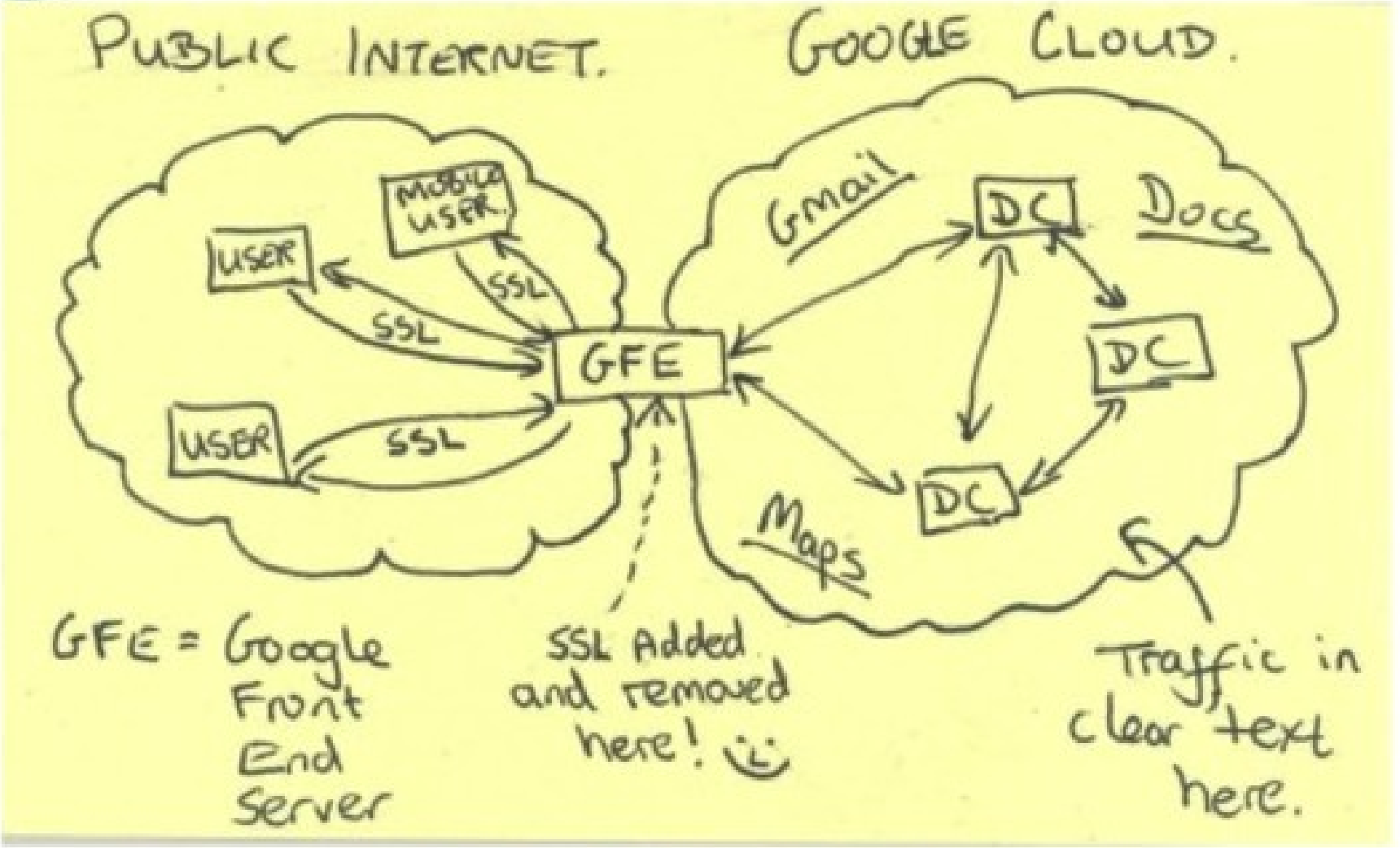


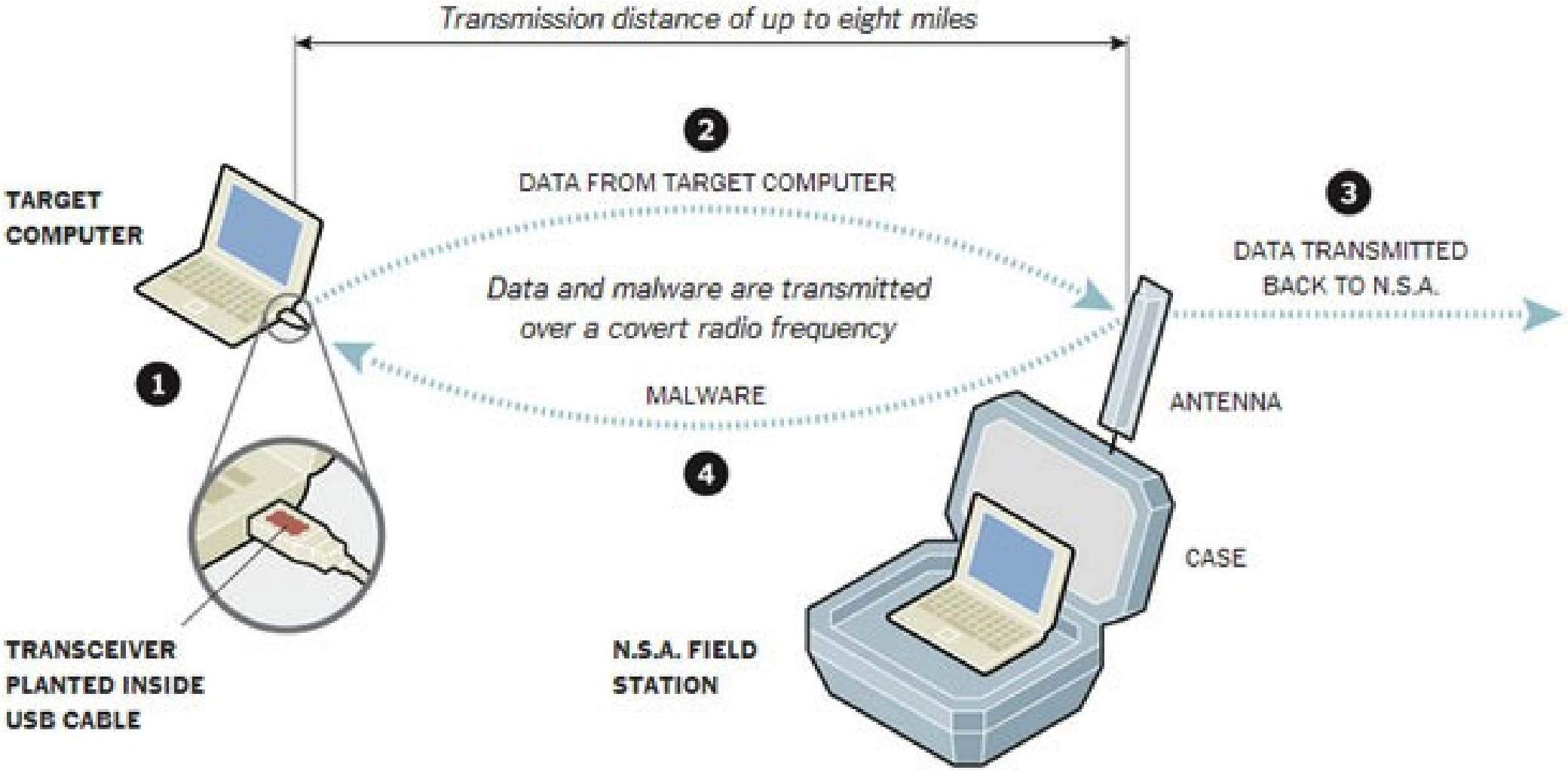
< June 3, 2013


June 4,
2013

January, 2014...

Current Efforts - Google




Transmission distance of up to eight miles
2
DATA FROM TARGET COMPUTER
3
DATA TRANSMITTED BACK TO N.S.A.
TARGET COMPUTER
Data and malware are transmitted over a covert radio frequency
1
MALWARE
4
ANTENNA
CASE
TRANSCEIVER PLANTED INSIDE USB CABLE
N.S.A. FIELD STATION

(TS//SI//NF) FAA702 Operations

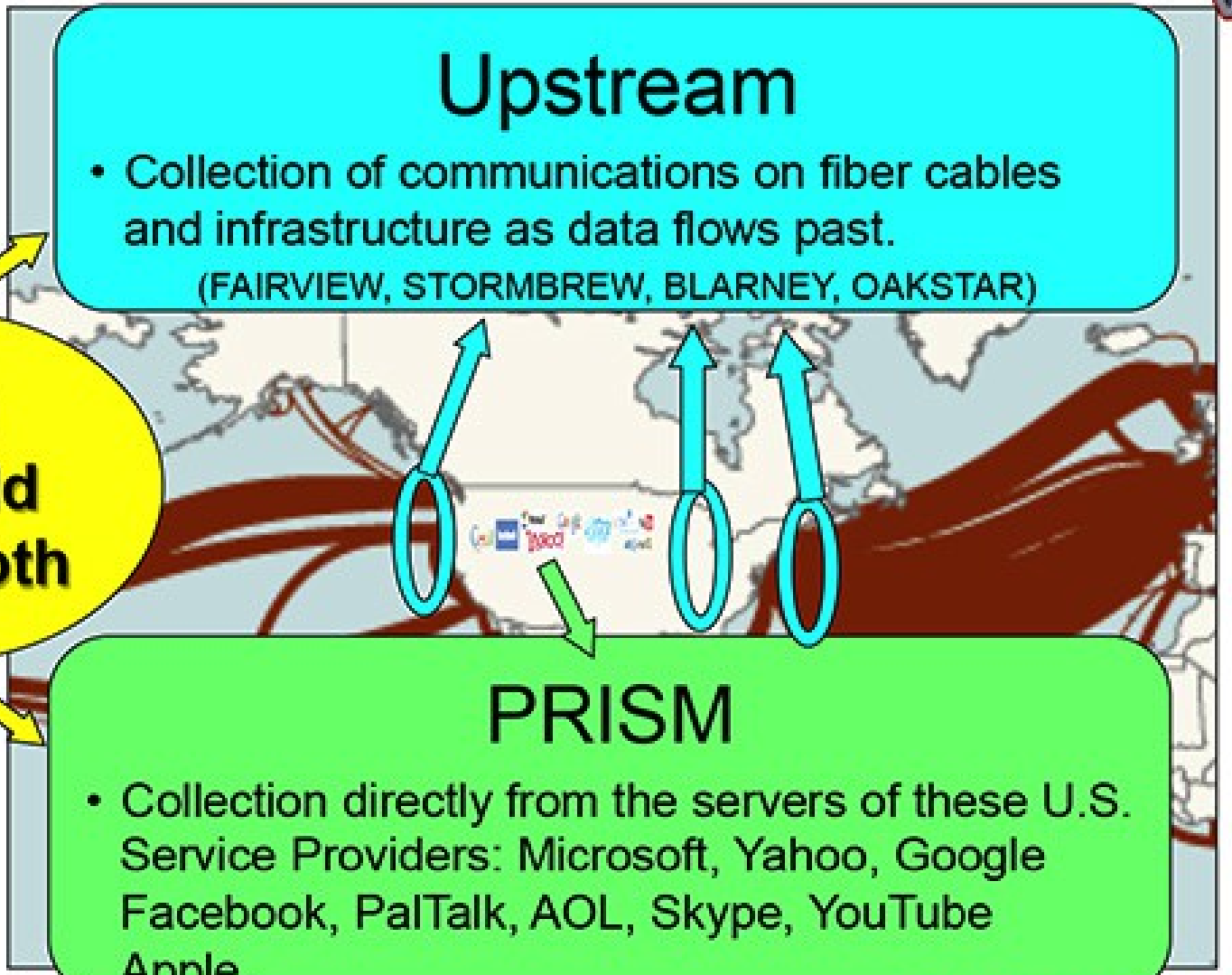
Two Types of Collection

Upstream

- Collection of communications on fiber cables and infrastructure as data flows past.

(FAIRVIEW, STORMBREW, BLARNEY, OAKSTAR)

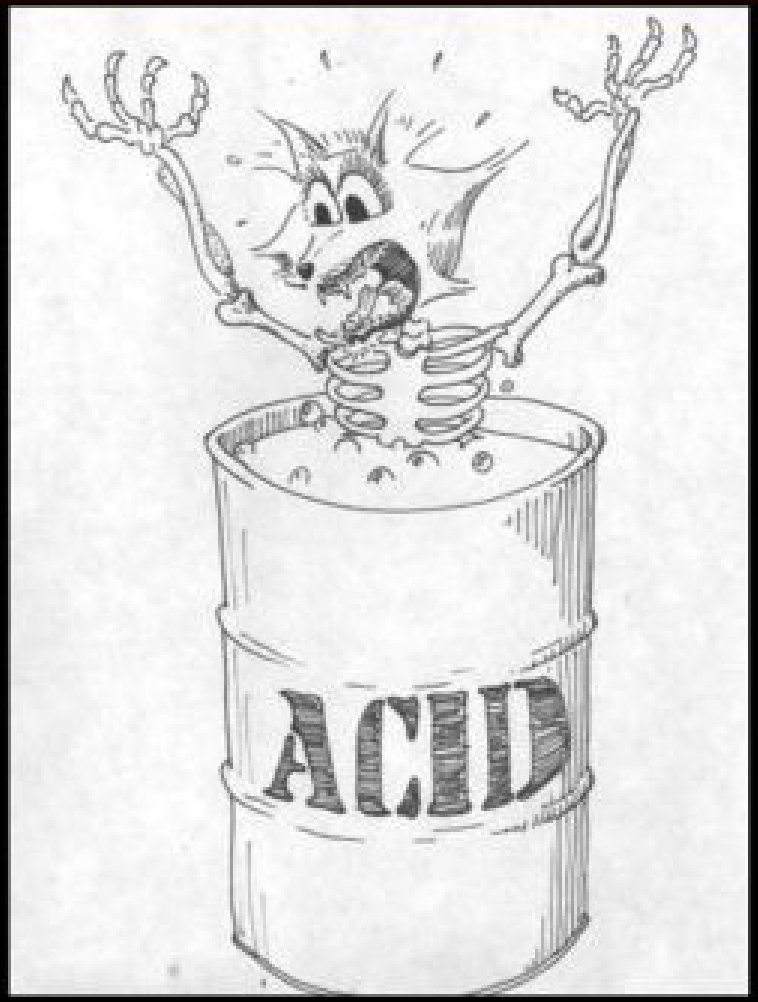
You Should Use Both

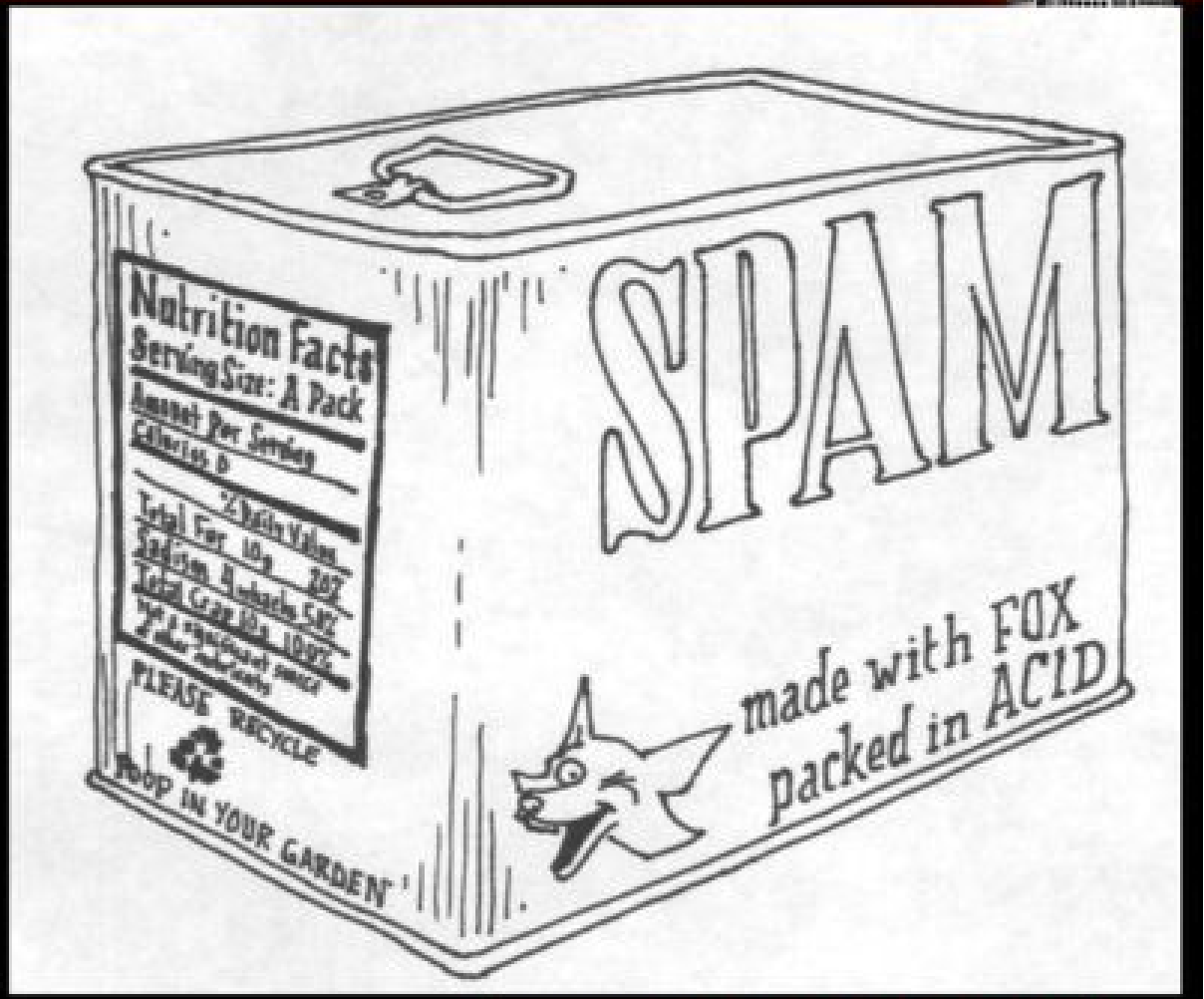


PRISM

- Collection directly from the servers of these U.S. Service Providers: Microsoft, Yahoo, Google Facebook, PalTalk, AOL, Skype, YouTube Apple.

FOXACID





Driver 1: Worldwide SIGINT/Defense Cryptologic Platform

High Speed Optical Cable
Covert, Clandestine or Coorperative Large Accesses

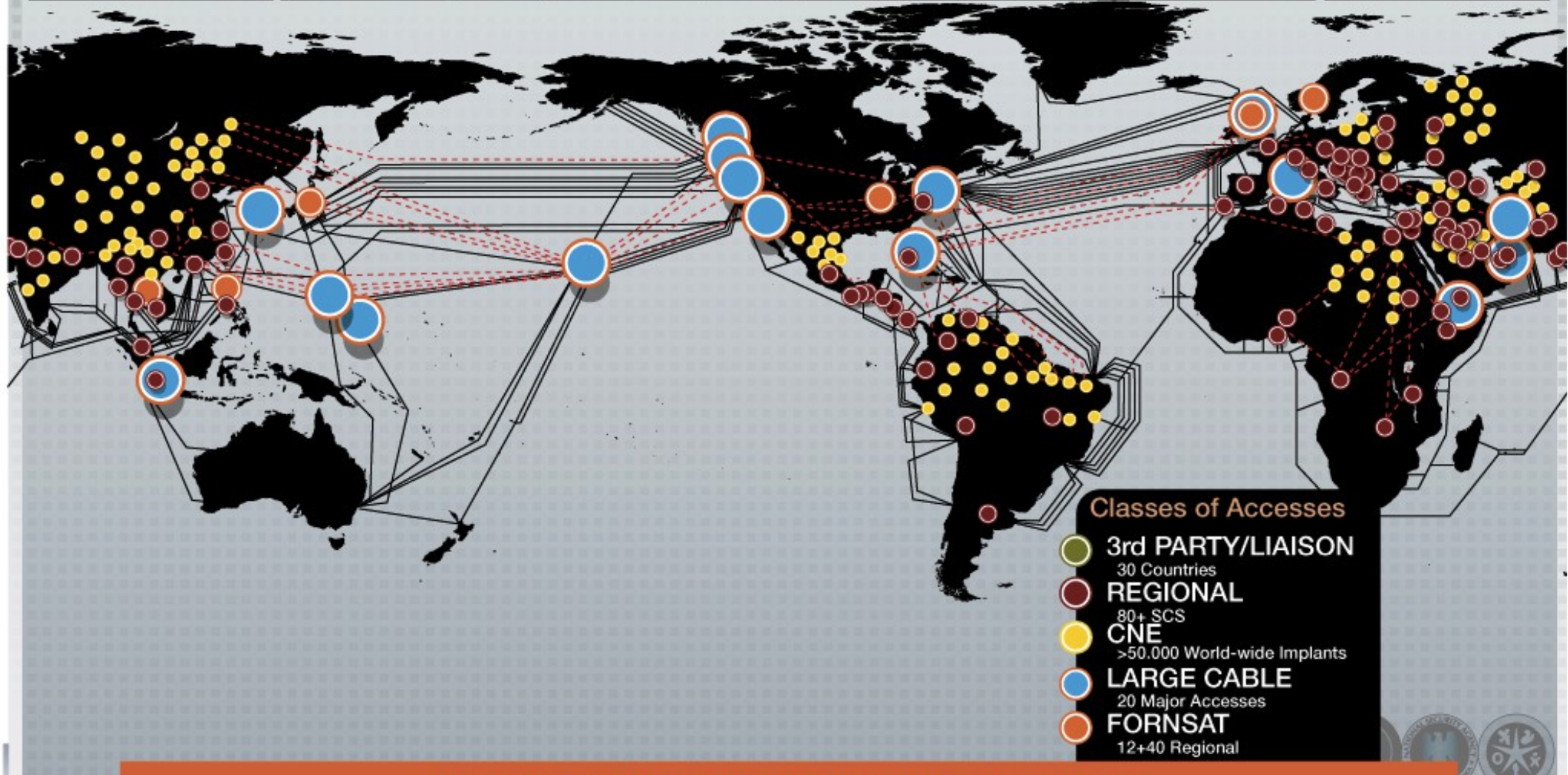
20 Access Programs Worldwide

Regional

[redacted]	Caracas	Havana	[redacted]	Kinshasa	Sofia	[redacted]	Berlin	[redacted]	Pristina	Guatemala City	[redacted]
[redacted]	Tegucigalpa	Panama City	[redacted]	Lusaka	[redacted]	Bangkok	[redacted]	[redacted]	Tirana	[redacted]	RESC
Geneva	Bogota	[redacted]	[redacted]	[redacted]	[redacted]	New Delhi	[redacted]	Phnom Penh	[redacted]	[redacted]	[redacted]
Athens	Mexico City	[redacted]	[redacted]	Budapest	[redacted]	[redacted]	Frankfurt	Sarajevo	[redacted]	[redacted]	Milan
Rome	Brasilia	[redacted]	[redacted]	Prague	[redacted]	Paris	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Quito	Managua	[redacted]	Lagos	Vienna	Rangoon	[redacted]		[redacted]	La Paz	[redacted]	Langley
San Jose	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Zagreb	[redacted]	[redacted]	Vienna Annex	Reston

FORNSAT

STELLAR	INDRA
SOUNDER	IRONSAND
SNICK	JACKKNIFE
MOONPEN	CARBOY
NY	TIMBERLIN
LADYLOVE	E



http://www.chrisharrison.net/projects/InternetMap/

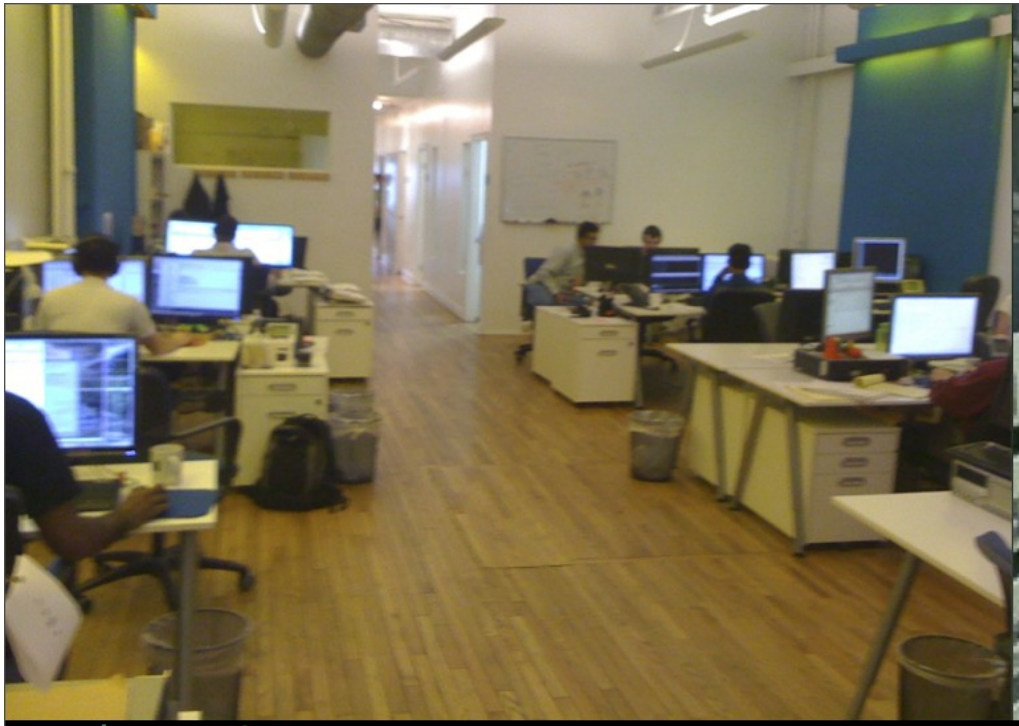
Routers!


Internet Map
city-to-city connections
LINKSYS
net4801
Power Error Net Disk
SOEKRIS
Engineering
SONICWALL
SONICWALL
PRO 2040
Cisco 1800 Series

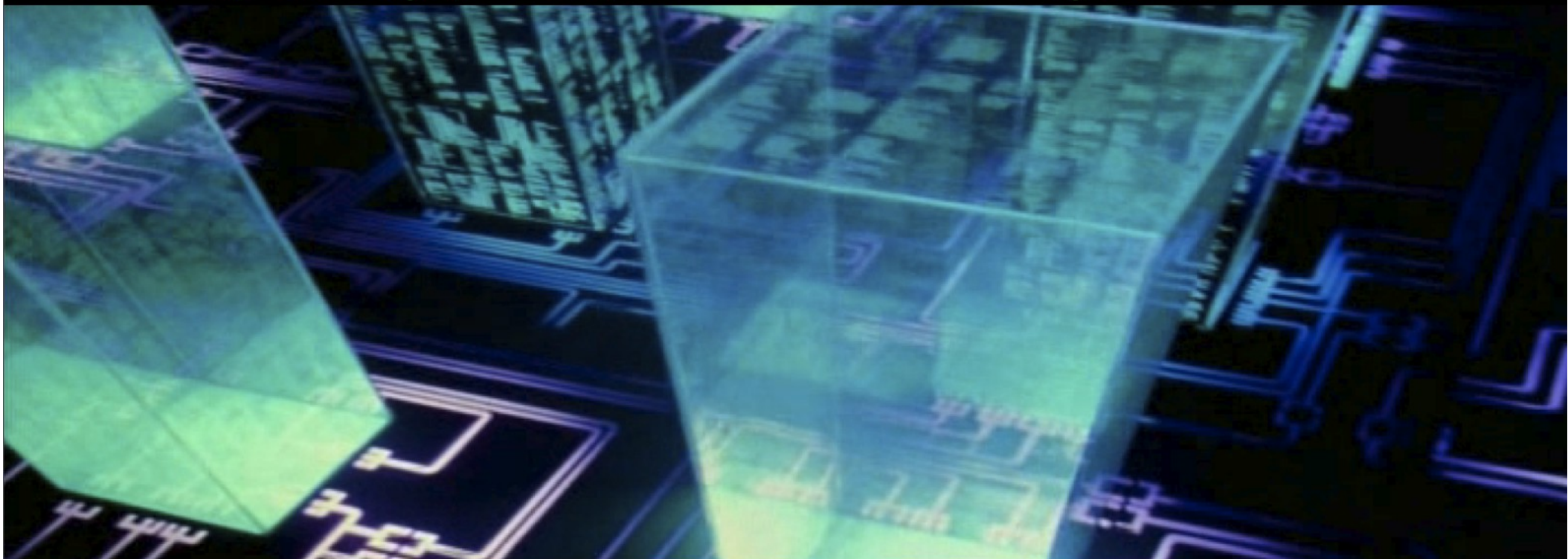
http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=4333

(Sysadmin) Context

http://www.darksky.org/key/ny.html



```
$ uptime
19:56  up 519 days,  7:45, 18 users, load averages: 0.01 0.02 0.01
```

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Male Virility Supplement
VigRX Plus
The World's Leading Male Enhancement Product*
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www.strelna.ru
License Borrowed
The license on this machine has been borrowe
from a license server
You can continue to use this product during the borrow period without a connection
license server.
Close
You need to restart your computer.
button for several seconds or press
Veuillez redémarrer votre ordinateu
de démarrage enfoncée pendant plu
appuyez sur le bouton de réinitialis
Sie müssen Ihren Computer neu sta
die Einschalttaste einige Sekunden
Sie die Neustart-Taste.
コンピュータを再起動する必要があり
数秒間押し続けるか、リセットボタン
Starting saving /dev/sda1
/dev/sda1 filesysten: ext2
Checking file system integ
The file systen in /dev/sd
's recommended to boot t
autonatically or use fsck
! Clonezilla still can save
you want to quit now, pres
49,049 INFO Starting installation of RPM files [('/root/scalix-11.0.1-GA/software
4.i386.rpm', 'scalix-server')]
51,058 ERROR Operation failed: Install /bin/rpm -U -v --percent /root/scalix-11.0.1-GA
erver/scalix-server-11.0.1.11-1.rhel4.i386.rpm: (1) [Preparing packages for
-11.0.1.11-1.rhel4.i386) scriptlet failed, exit status 10
skipping scalix-server-11.0.1.11-1.rhel4']
51,058 CRITICAL Operation failed: Installation of packages failed
51,058 ERROR Operation failed: Aborting installation thread.

Sm/Med Businesses

- Few Sysadmin Resources (people, gear)
- Mostly, Infrastructure 'just works' (except when it doesn't...
- Network activity is not necessarily made transparent to company users (it either "works", or it doesn't)
- Unless the business *is* infrastructure, (ISP, etc...), technical personnel and resources are often all focused on abstract business goals (new apps, features, etc...)

Small Business IT

- BUSINESS STOPS WHEN THE NETWORK STOPS

~~Small Business IT~~

- EVERYONE STOPS WHEN THE NETWORK STOPS

Network Deployment

- Deploys: "Performing an Oil Change at 80mph" (quoting Michael Lucas)
- Most businesses, if they're hiring sysadmins, have a "network"
- Few businesses participate in an economy where $10k routers are common


SALT

talking points:

Corporate Office/Colo
Life with pfSense

talking points:

Quickly/Safely Training

Junior/Senior Network

talking points:

Taking the Magic/ Macho out of HA networking

talking points:

Networking can be:

Reliable

Securable

Understandable

Fun

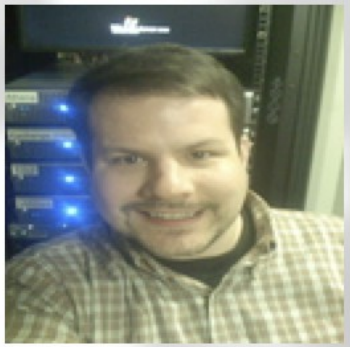
PFSense Bootstrap

What **is** pfSense?

- Networking Appliance, (built on FreeBSD)
- Router/Firewall/More
- Originally, fork of **m0n0wall**
- Commercial support available
  - Electric Sheep Fencing
- Open Source, BSD Licenced
  - Various packages may have other licences

AVAILABLE ONLINE

pfSense Tutorial



BSDCan 2008

From zero to hero with pfSense

May 13, 2008

Chris Buechler <cmb@bsdperimeter.com>
Scott Ullrich <sullrich@bsdperimeter.com>

Hardware (x86)

- LiveCD
- Full Install (to a harddrive)
- Embedded
- USB Drive

Hardware (x86)

- LiveCD
- Full Install (to a harddrive)
- Embedded
- USB Drive

Minimum Reqs

- CPU - 100 MHz (500+ MHz for best experience)
  RAM - 128 MB (256 MB or more is encouraged)
- Platform Specific Live CD
- CD-ROM drive (currently USB CD-ROM devices are not supported)
- USB flash drive or floppy drive to store configuration Full Installation
- CD-ROM for initial installation
- 1 GB hard drive Embedded
- 128 MB CF serial port for console null modem cable

Going Green

- You *can* use older hardware
- Power cost, and reliability are issues

Popular Hardware

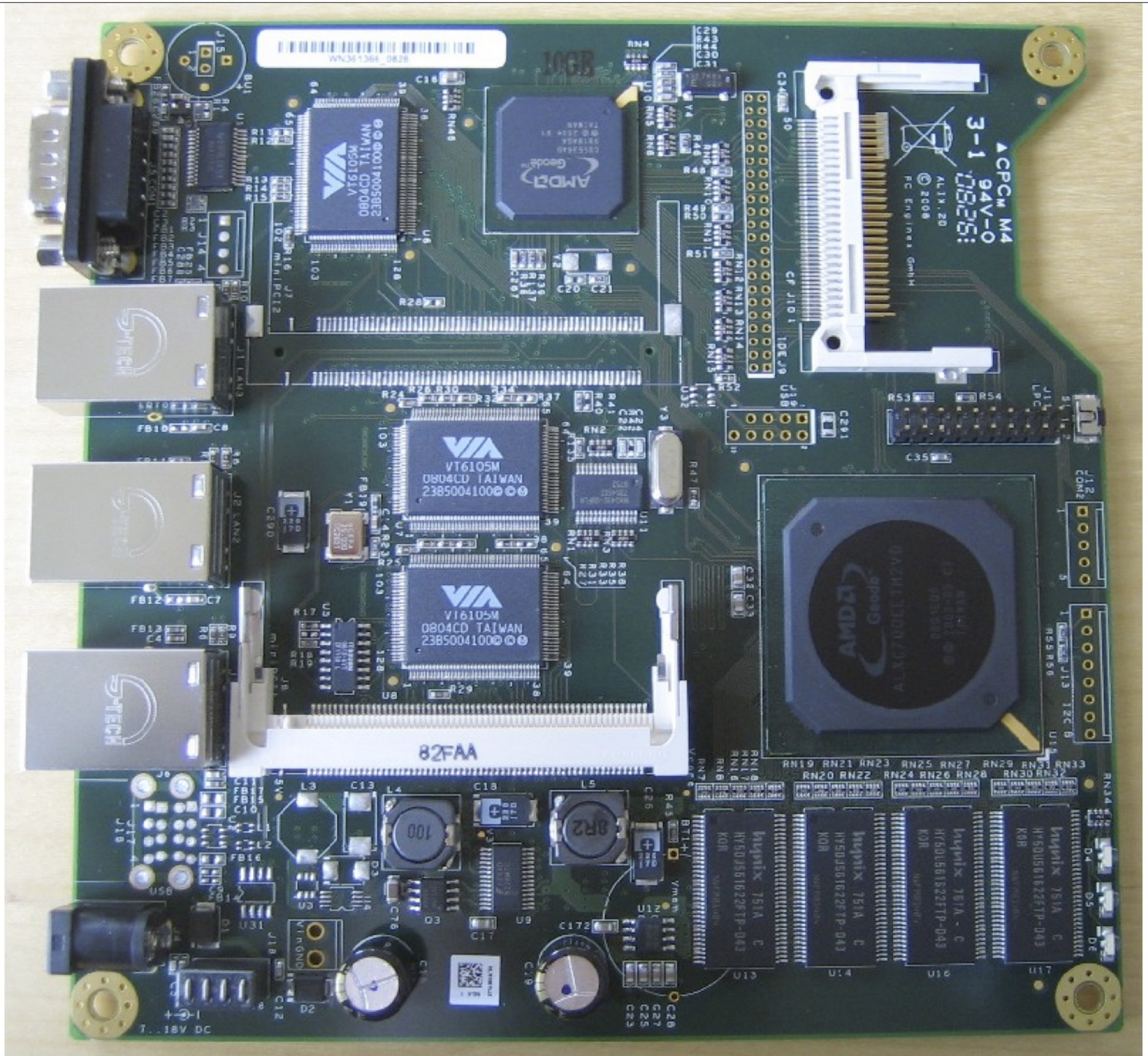
- NICs - Intel Pro/100 and Pro/1000
- Embedded hardware
  - PC Engines WRAP and ALIX, Soekris, Nexcom, Hacom, Mini ITX,

- Most Dell servers work well, Many HP and Compaq servers work well, Many Supermicro/Greybox x86 work well
- VMware - entire product line


Q'TY :
N.W. :
G.W. :
VOL :
FRAGILE
ELECTRONIC
EQUIPMENT
PCS.
KGS.
KGS.
Cubic Ft.

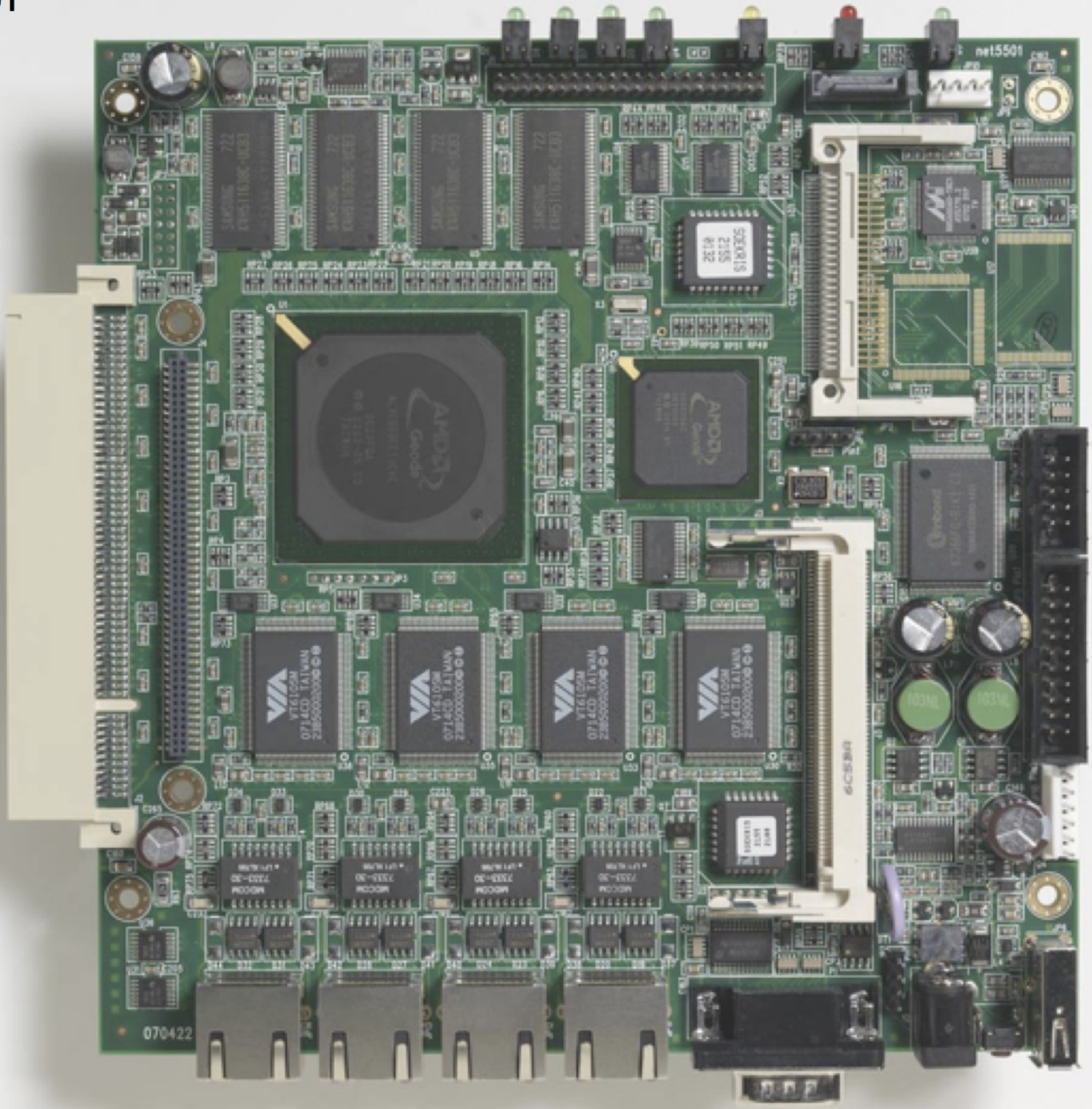
ACT/LNK
SPEED
ACT/LNK
SPEED
stems
A1-31094
1-800-820-BSD

ALIX.2C
$140us



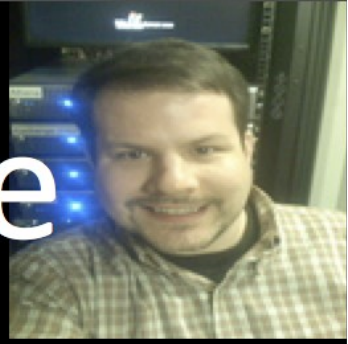
ALIX.2C Case
$15us

Soekris 5501
$300us

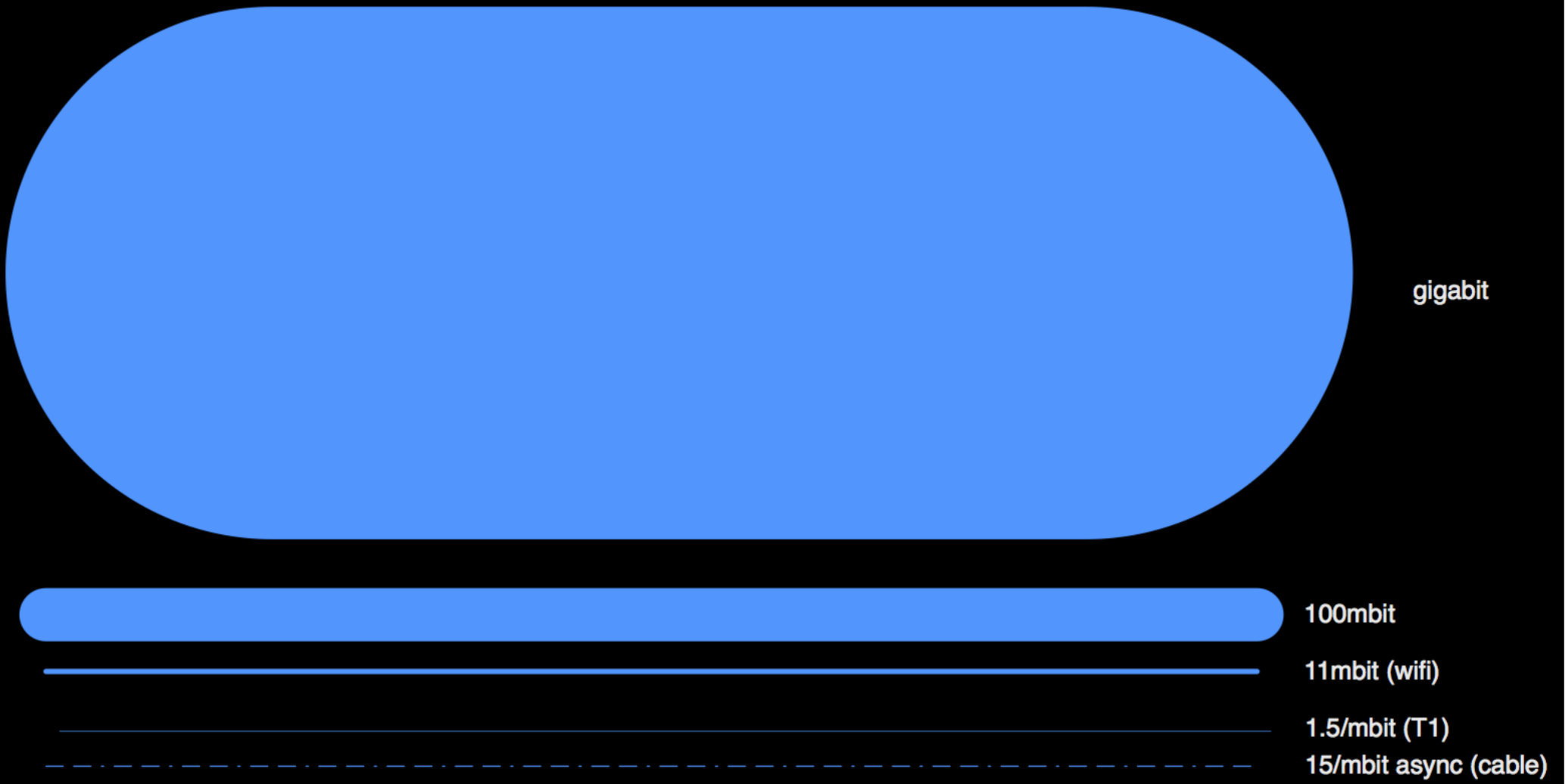


Soekris 5501
$400us

Hardware Sizing Guide

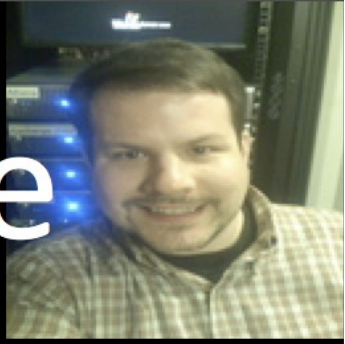


- Throughput Considerations Packets per second Bandwidth required
- 10-20 Mbps - No less than 266 MHz CPU 21-50 Mbps - No less than 500 MHz CPU 51-200 Mbps - No less than 1.0 GHz CPU 201-500 Mbps - server class or newer desktop hardware
- PCI-x or PCI-e network adapters
- No less than 2.0 GHz CPU 501+ Mbps - server class hardware
- PCI-x or PCI-e network adapters No less than 3.0 GHz CPU


gigabit
100mbit
11mbit (wifi)
1.5/mbit (T1)
15/mbit async (cable)

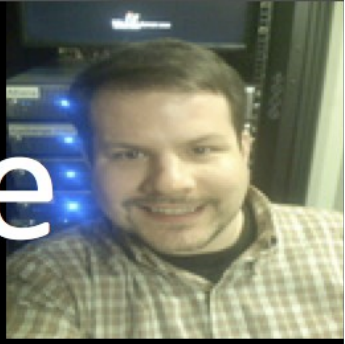

100mbit
11mbit (wifi)
1.5/mbit (T1)
15/mbit async (cable)

Hardware Sizing Guide



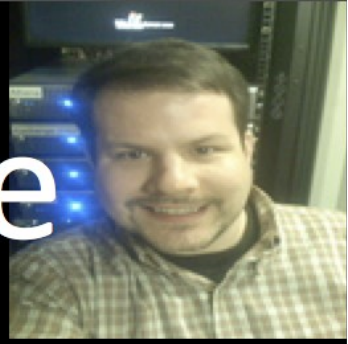
- Feature Considerations
- VPN
- Number of connections not much of a factor Very CPU intensive Throughput
- 4 Mb - 266 MHz 10 Mb - 500 MHz

Hardware Sizing Guide



- Feature Considerations Large and busy Captive Portal deployments
- Increased CPU requirements Large state tables
- 1 KB per state RAM requirement 100,000 states = ~97 MB RAM 500,000 states = ~488 MB RAM 1,000,000 states = ~976 MB RAM etc...

Hardware Sizing Guide



- Feature Considerations Packages
- RAM hungry example:
  - ntop
  - Snort
- Disk I/O example
  - Squid

Typical Deployments

- Perimeter firewall
  - BGP router
- LAN router
  - VLAN
  - Multiple interfaces
- WAN router
  - for Ethernet WAN services

Install

- Embedded
- Full Disk

Embedded Install

- Download Embedded Image File
- copy image to a CF card using DD:

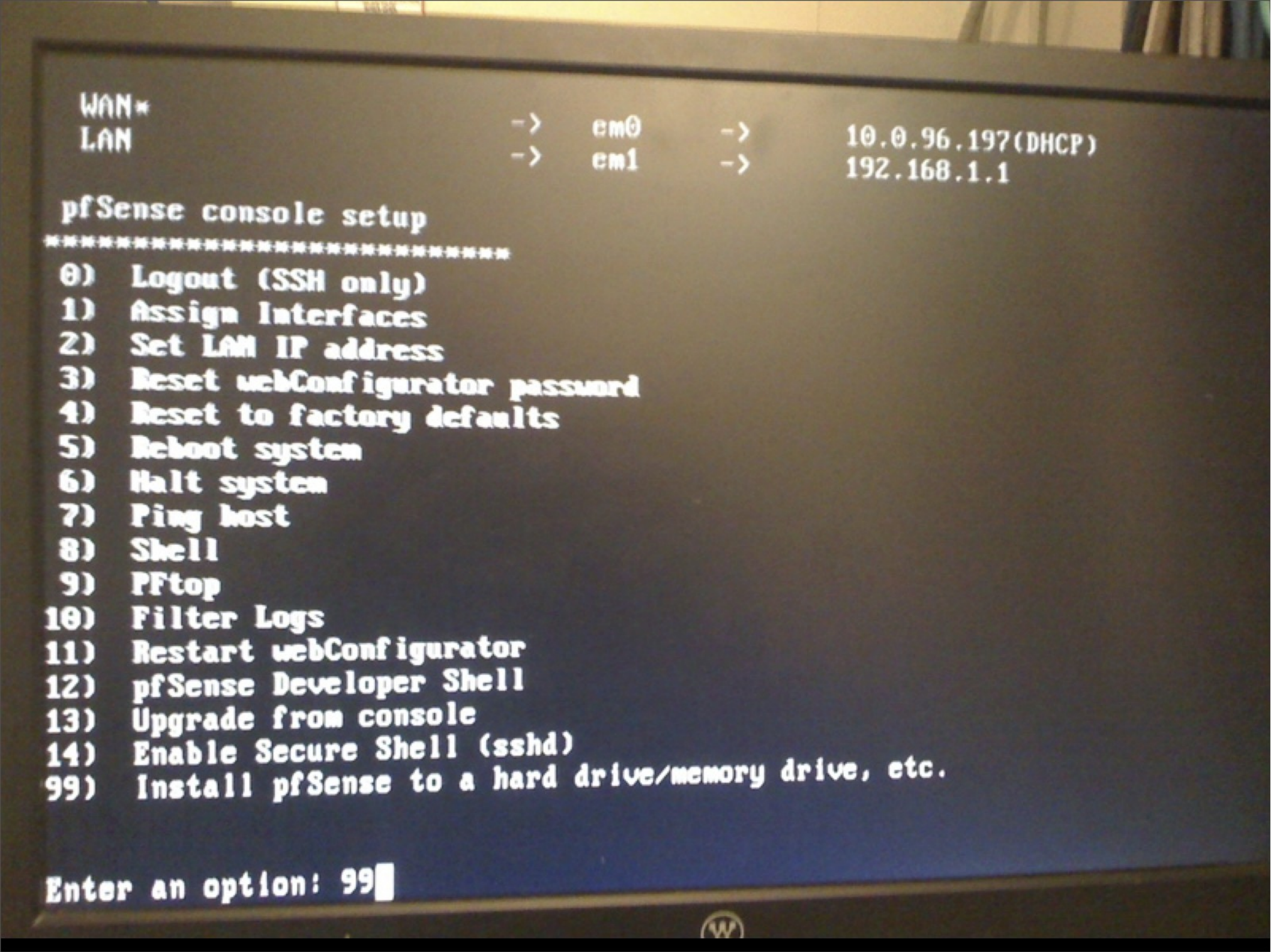
```
$ gzcat pfsense-embedded.img.gz | dd of=/dev/disk3s1 bs=16k
```

- Insert CF Card into Embedded machine and move on to configuration

Full (hd) Install

Configuration Methods

- Serial Console (Menu-Based [and Shell])
- http via DHCP, just hit http://192.168.1.1/
  - (assuming you know which interface your LAN side is?!)


WAN*
LAN
-> em0 -> 10.0.96.197(DHCP)
-> em1 -> 192.168.1.1
pfSense console setup
0) Logout (SSH only)
1) Assign Interfaces
2) Set LAN IP address
3) Reset webConfigurator password
4) Reset to factory defaults
5) Reboot system
6) Halt system
7) Ping host
8) Shell
9) PFtop
10) Filter Logs
11) Restart webConfigurator
12) pfSense Developer Shell
13) Upgrade from console
14) Enable Secure Shell (sshd)
99) Install pfSense to a hard drive/memory drive, etc.
Enter an option: 99

Post-Configuration

Critical Reccomendations:

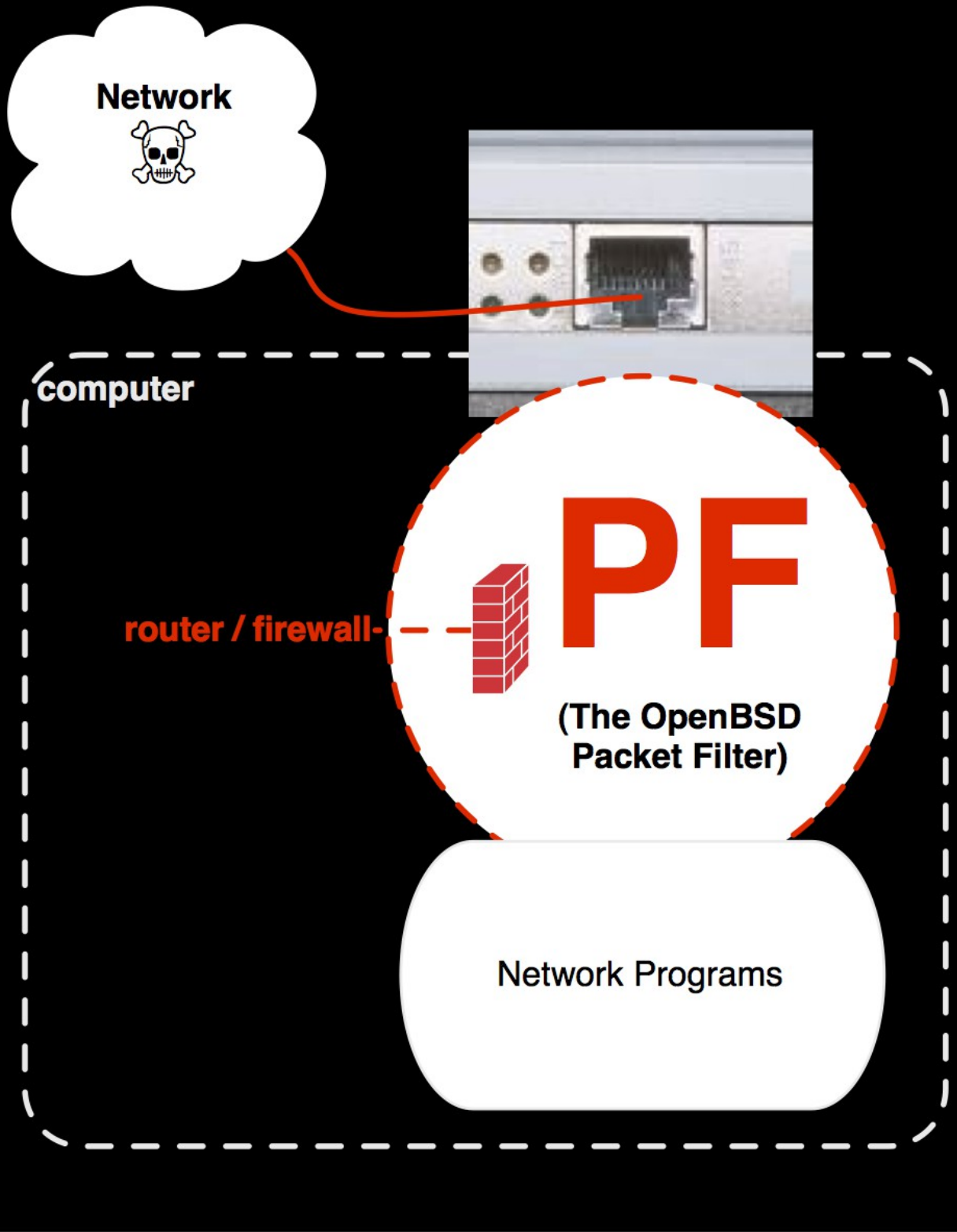
- Set web management to HTTPS
  - can load your own certs, or auto-gen!
- Can turn on SSH immediately if you want it
  - can load your own ssh pub keys!

setup can be demo'd after presentation

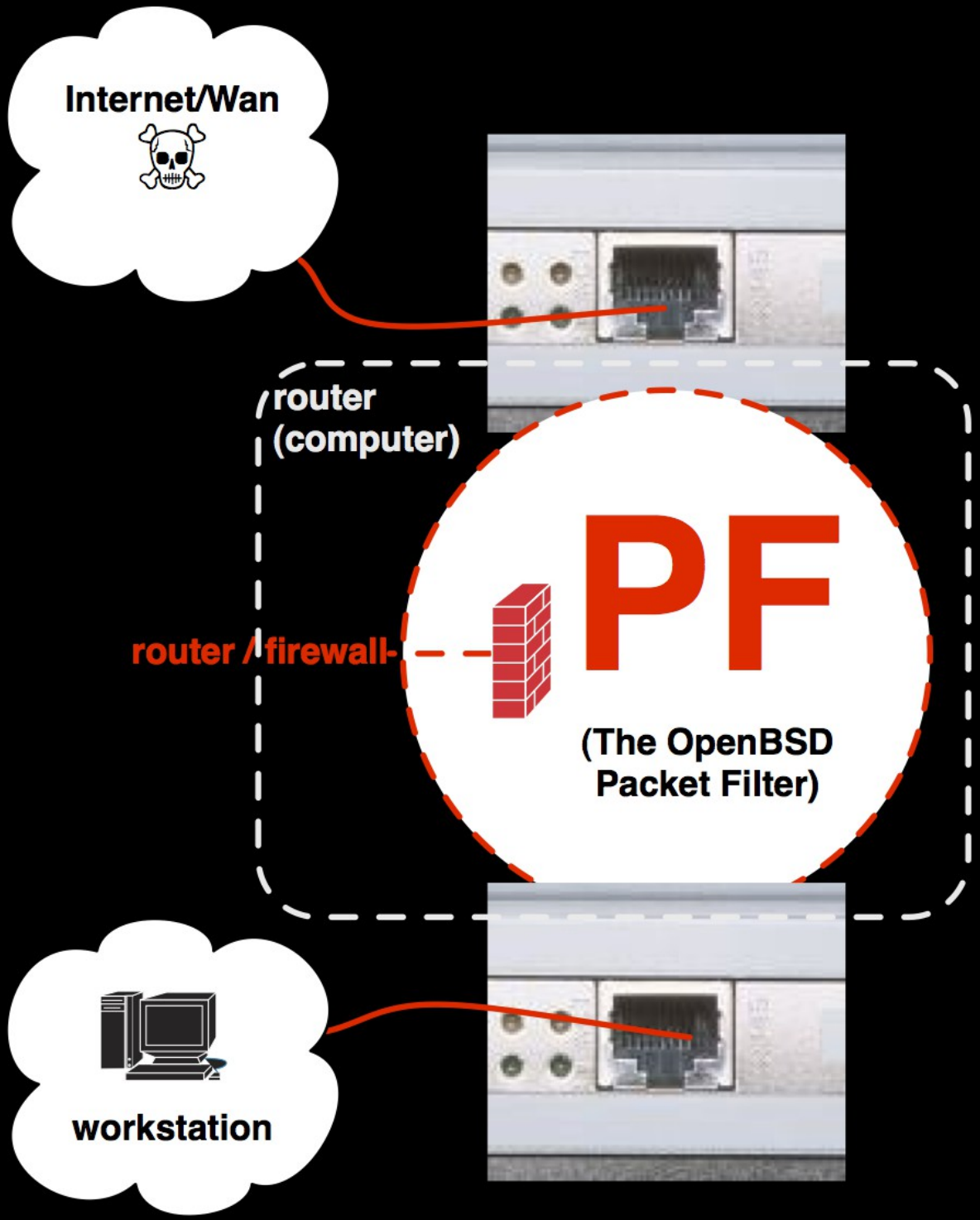
PFSense Firewall

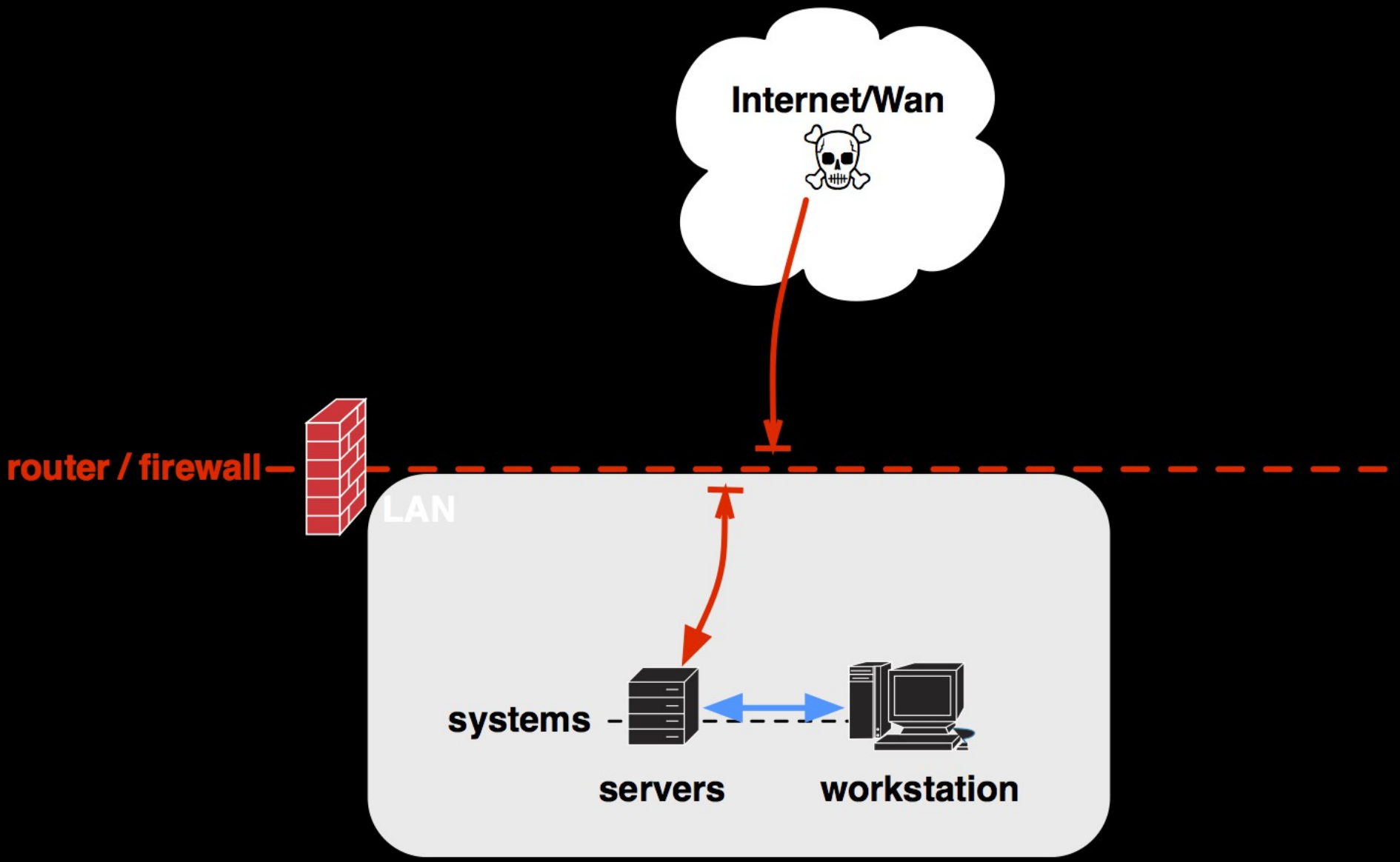
wait,
what is a firewall?

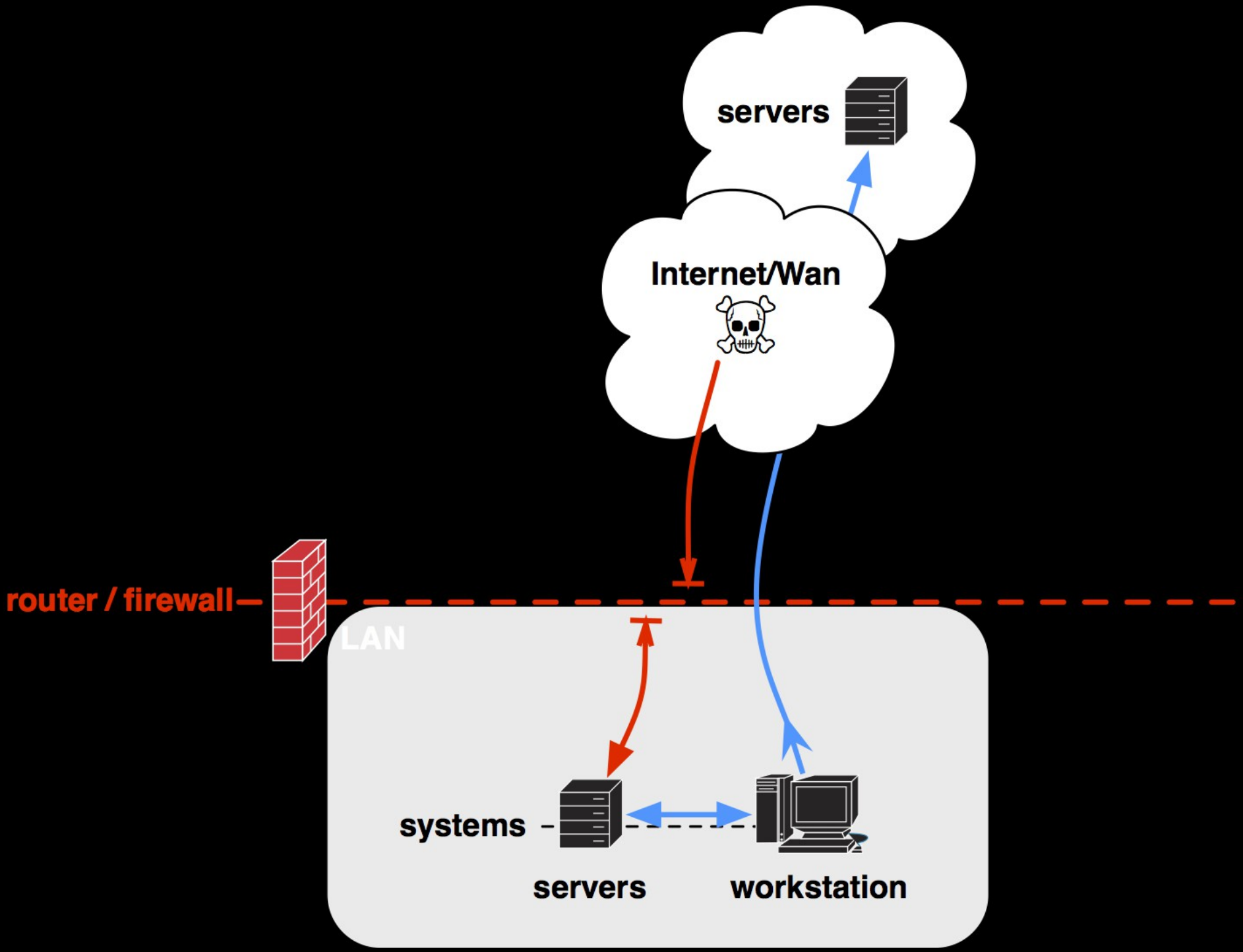
host firewall

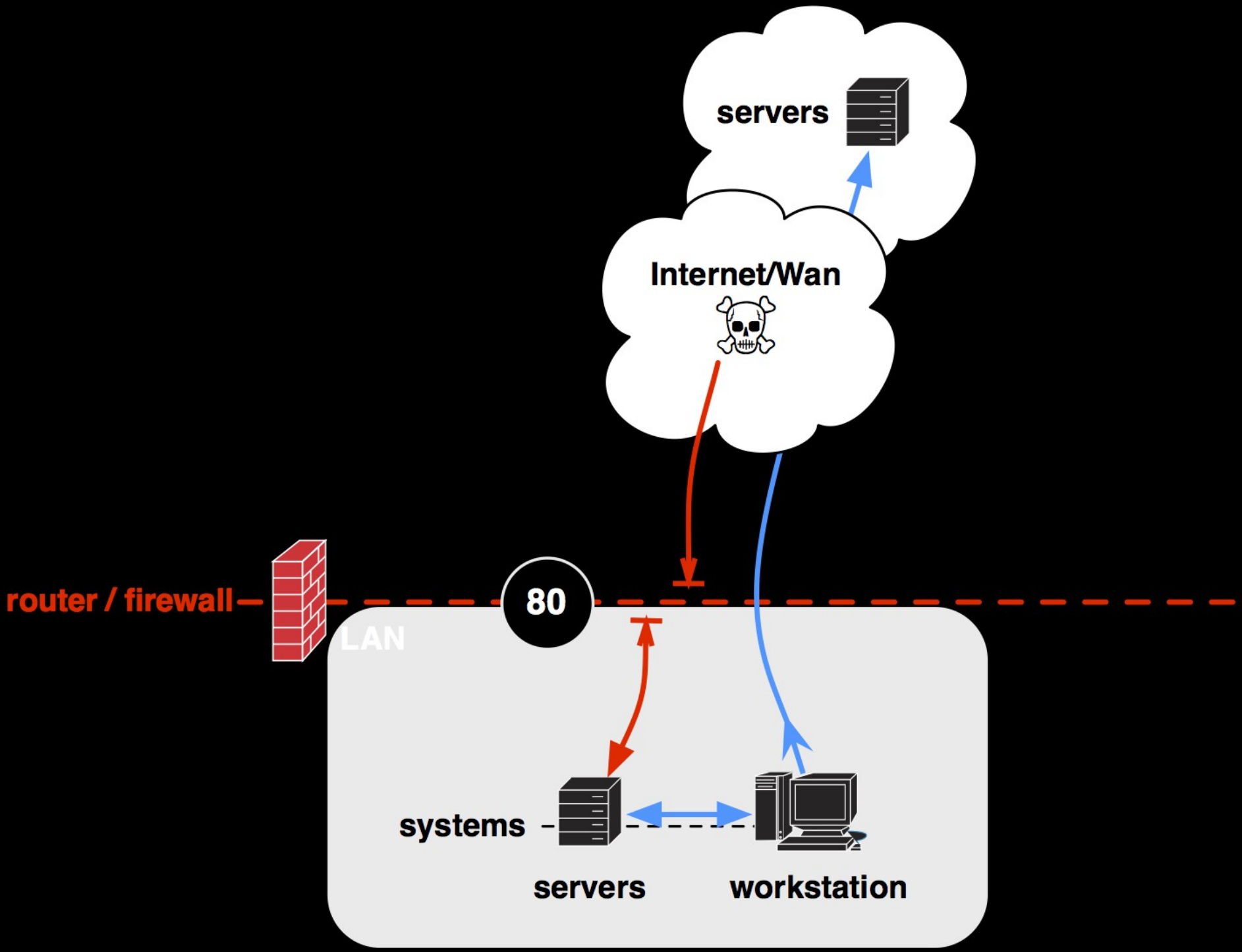


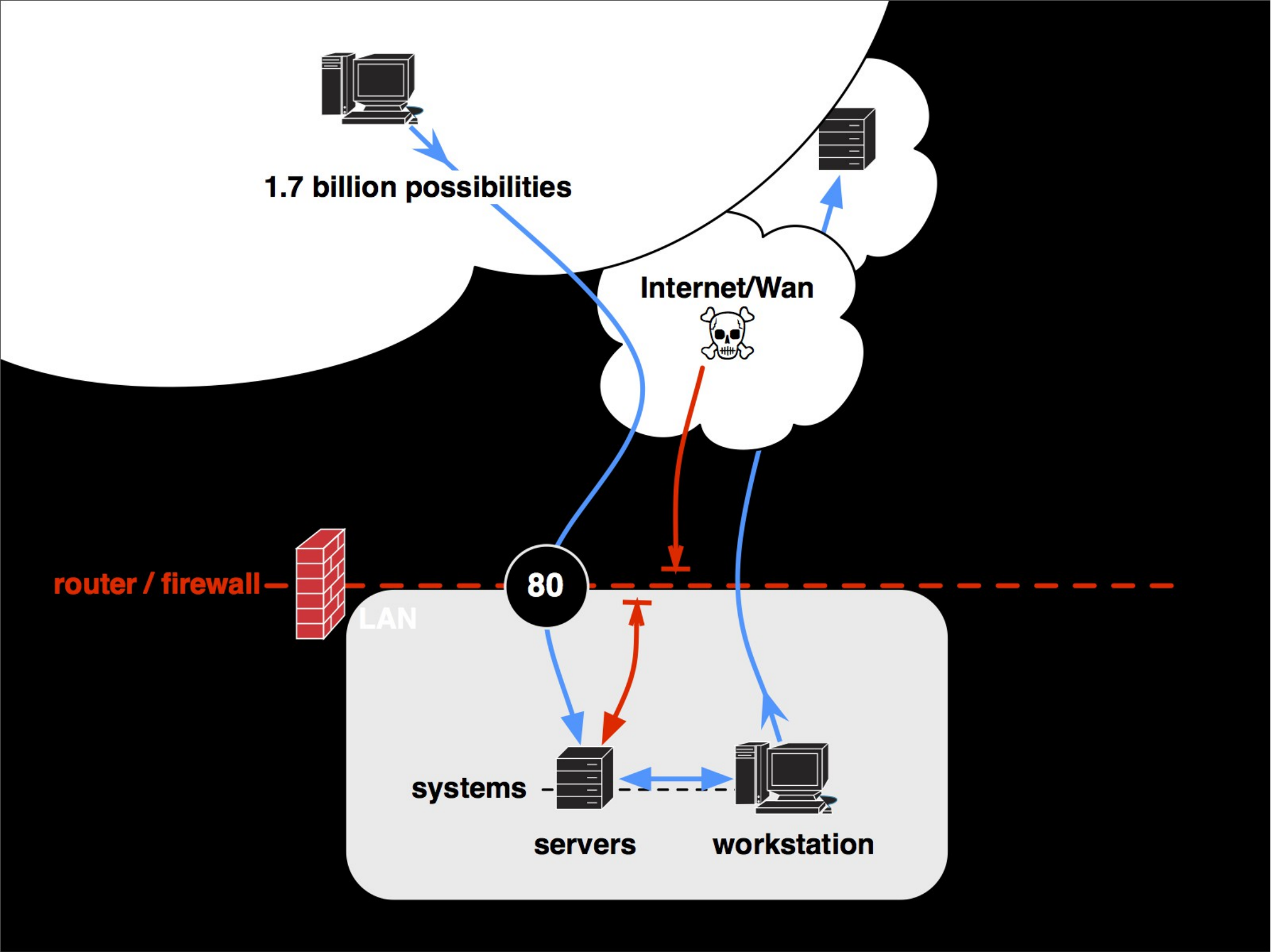
network firewall




Internet/Wan
router / firewall
LAN
systems
servers
workstation


servers
Internet/Wan
router / firewall
LAN
systems
servers
workstation

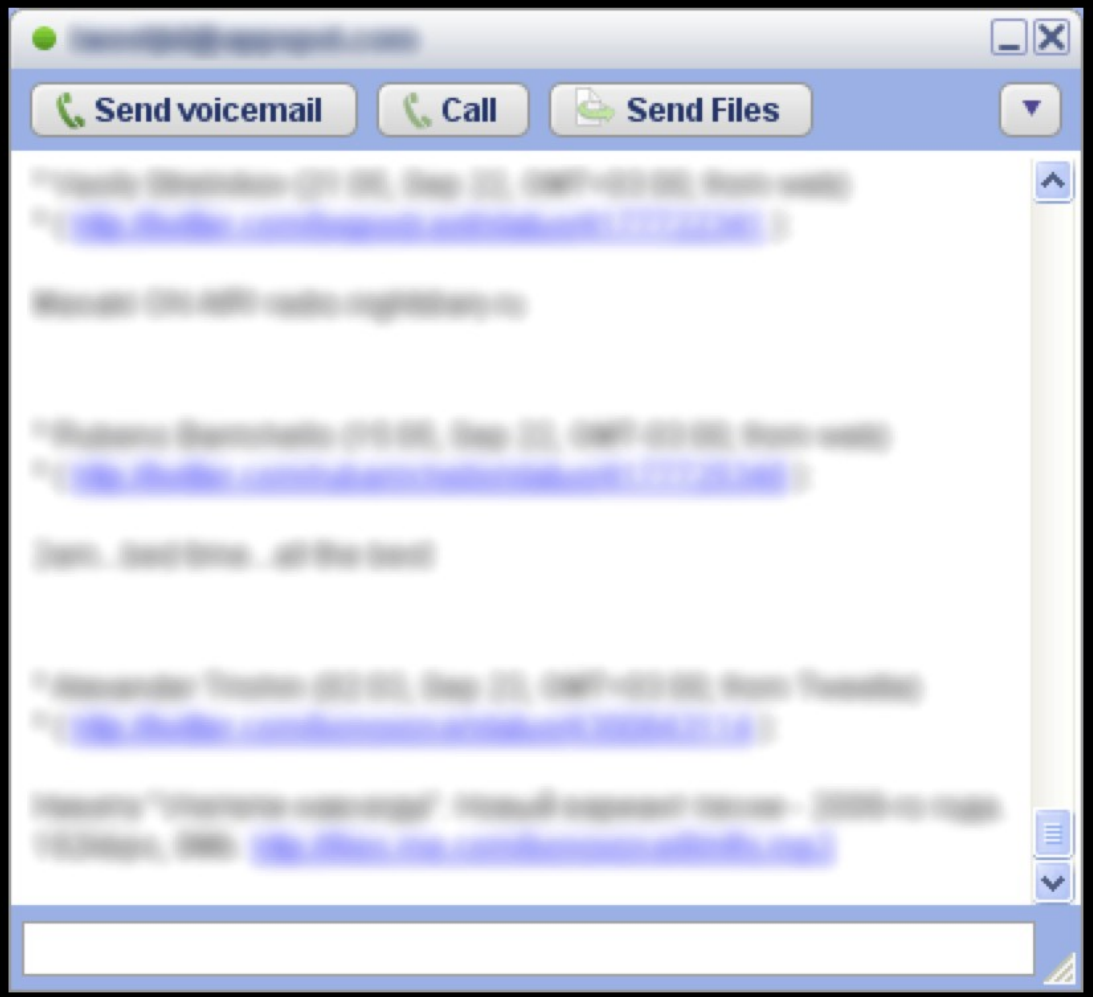

servers
Internet/Wan
router / firewall
80
LAN
systems
servers
workstation

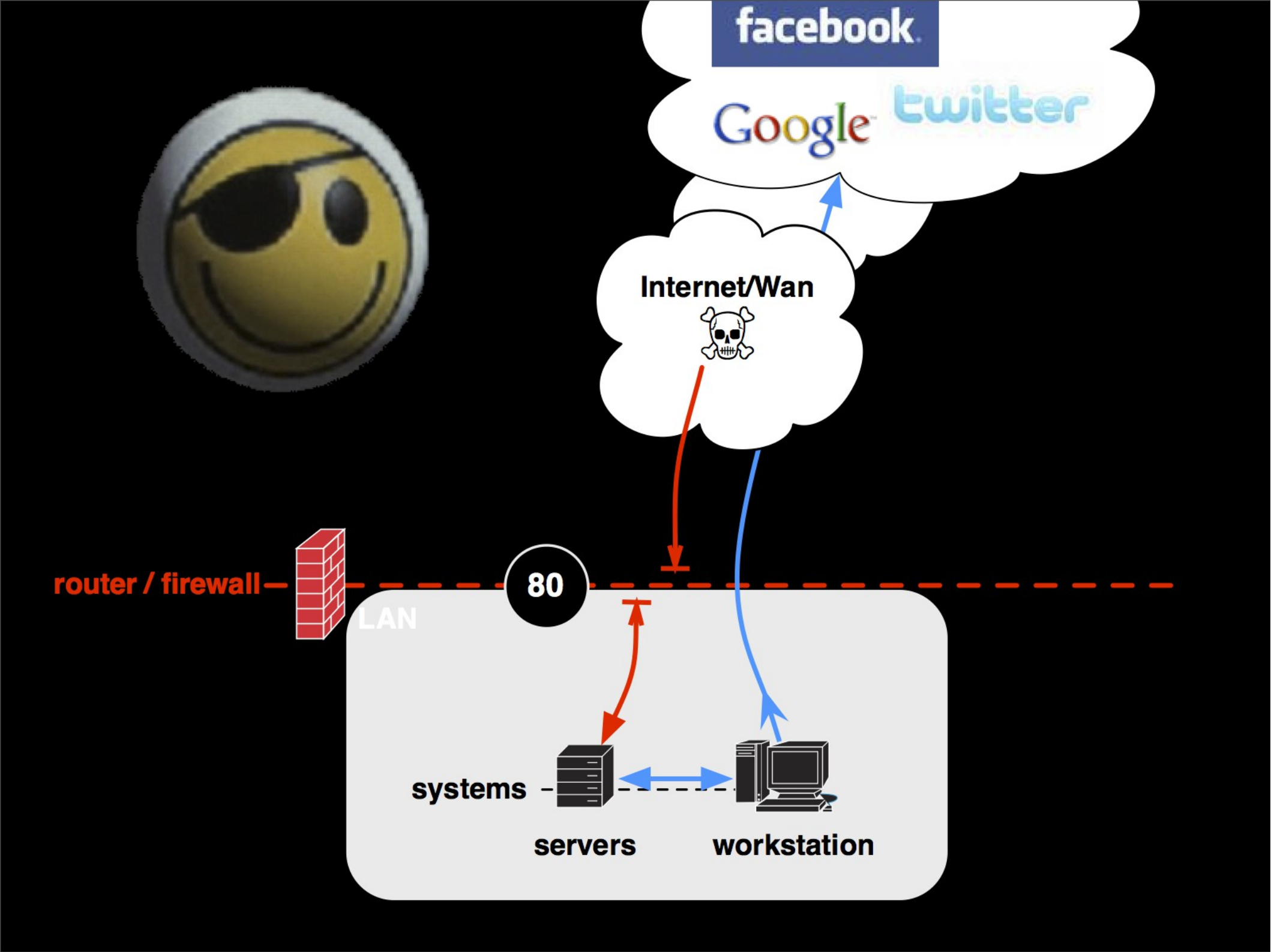

1.7 billion possibilities
Internet/Wan
router / firewall
80
LAN
systems
servers
workstation


demo.local - Firewall: Rules
https://10.0.22.1/firewall_rules.php?if=wan
pfSense
demo.local
System
Interfaces
Firewall
Services
VPN
Status
Diagnostics
Firewall: Rules
LAN
WAN
WANTS
WILAN
Proto
Source
Port
Destination
Port
Gateway
Schedule
Description
RFC 1918 networks
Block private networks
Reserved/not assigned by IANA
Block bogon networks
LAN net
Default WAN -> any (LETS GO CRAZY TEST)
ICMP
WAN address
temp for speakeasy ping
live demo...
pass
pass (disabled)
block
block (disabled)
reject
reject (disabled)
log
log (disabled)
Hint:
that if you use block rules, you'll
Terminal — ssh — 80×24
pfTop: Up State 1-21/87, View: default, Order: none, Cache: 10000 23:49:52
PR D SRC DEST STATE AGE EXP PKTS BYTES
tcp I 10.0.22.199:49255 64.94.184.79:993 4:4 227h 86280 50604 8777K
tcp O 10.0.22.199:49255 64.94.184.79:993 4:4 227h 86280 50604 8777K
tcp I 10.0.22.199:60329 98.130.1.186:143 4:4 6601m 86274 35773 7780K
tcp O 10.0.22.199:60329 98.130.1.186:143 4:4 6601m 86274 35773 7780K
tcp I 10.0.22.199:62303 98.130.1.186:143 4:4 5706m 86279 21937 1726K
tcp O 10.0.22.199:62303 98.130.1.186:143 4:4 5706m 86279 21937 1726K
powered by FreeBSD

but what do we let through our ports?

pure ajax evil




facebook
Google
twitter
Internet/Wan
router / firewall
80
LAN
systems
servers
workstation

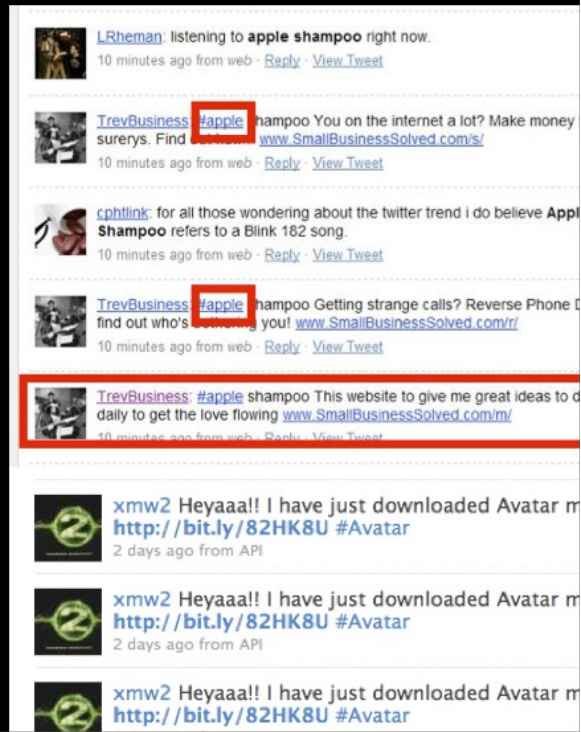
SOCIAL ZOMBIES II

YOUR FRIENDS NEED MORE BRAINS

scary videos
online
DEFCON17
ShmooCon

More Evil Twitter Bots

- Bots that pull trending topics...post malware links
- Used recently to promote warez like pirated movies
- Easy to code. Twitter API FTW



it’s open source software, defensible...

pfSense

pfsense.local

System | Interfaces | Firewall | Services | VPN | Status | Diagnostics

Services: Snort 2.8.4.1_1 pkg v. 1.6 Beta

Settings | Update Rules | Categories | Rules | Servers | Blocked | Whitelist | Threshold | Alerts | Advanced

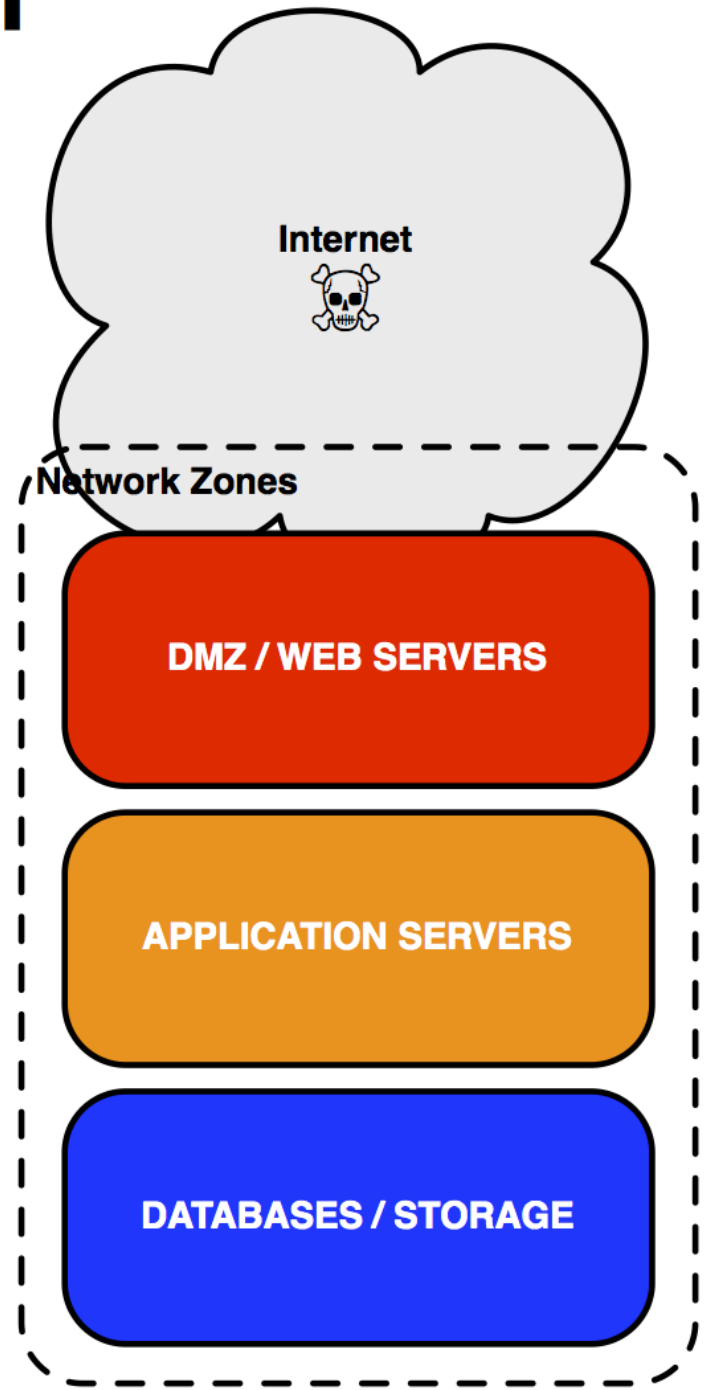
Interface	LAN WAN OPT1 Select the interface(s) Snort will listen on.
Performance	ac-bnfa ac method is the fastest startup but consumes a lot more memory. acs/ac-banded and ac-sparsebands/mwm/lowmem methods use quite a bit less. ac-sparsebands is recommended.
Oinkmaster code	[redacted] Obtain a snort.org Oinkmaster code and paste here.
Snort.org subscriber	Check this box if you are a Snort.org subscriber (premium rules).
Block offenders	Checking this option will automatically block hosts that generate a snort alert
Remove blocked hosts every	1 hour Please select the amount of time hosts are blocked
Update rules automatically	7 days Please select the update times for rules.
Whitelist VPNs automatically	Checking this option will install whitelists for all VPNs.
Convert Snort alerts urls to clickable links	Checking this option will automatically convert URLs in the Snort alerts tab to clickable links.

Snort Package?!

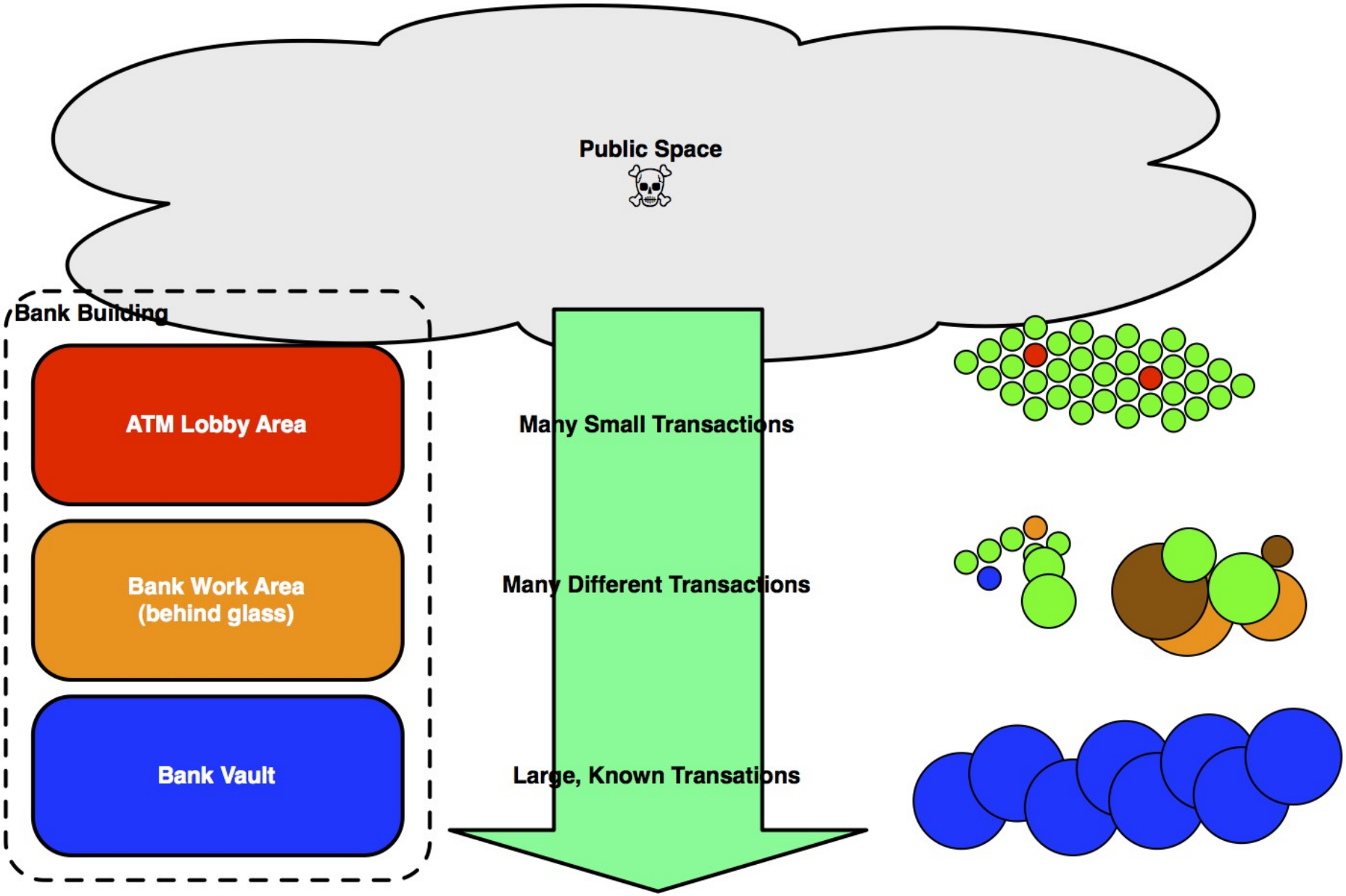
full install platform

(not embedded)

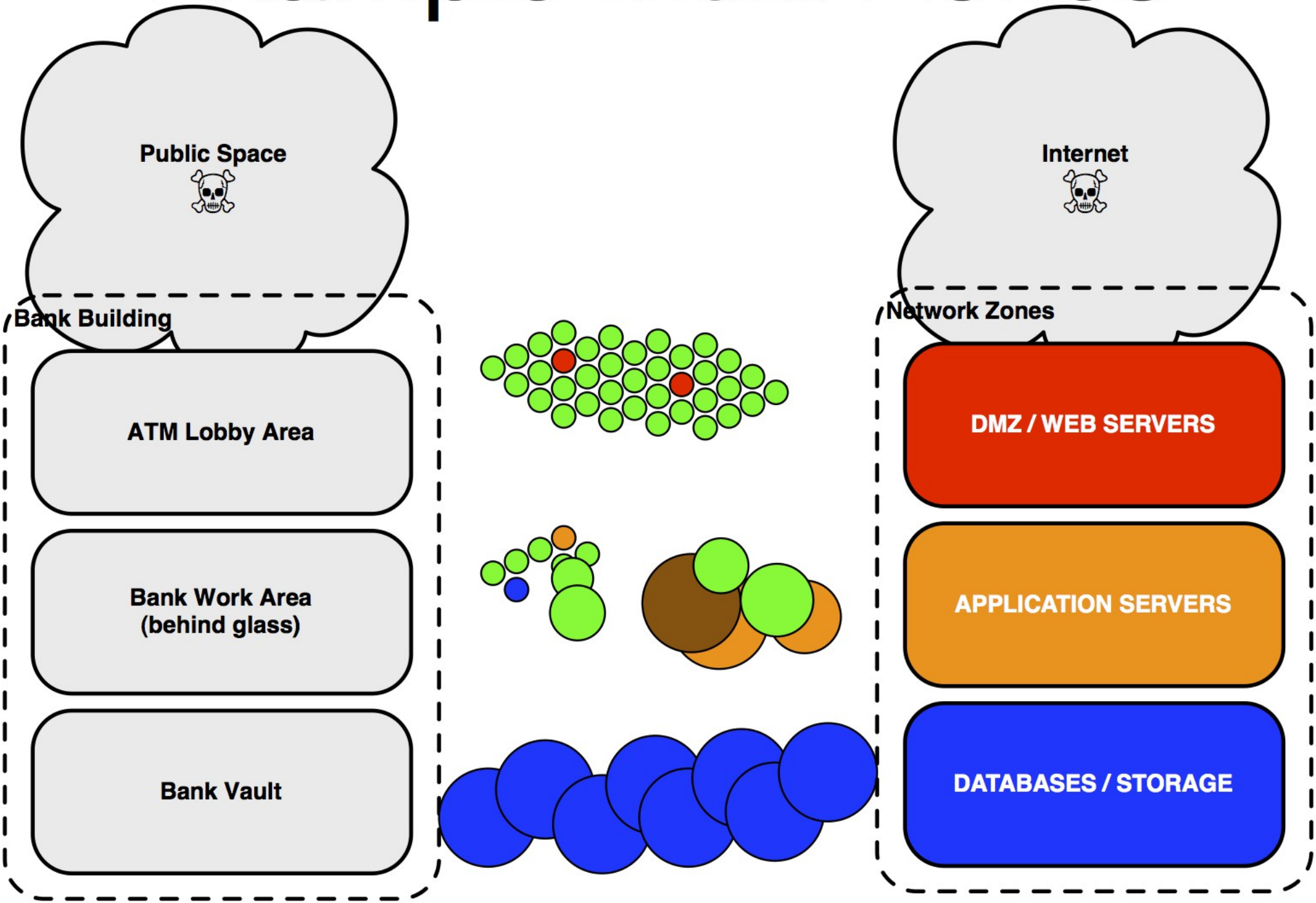
Example Multi-Zones



Bank Design?


Public Space
Bank Building
ATM Lobby Area
Bank Work Area
(behind glass)
Bank Vault
Many Small Transactions
Many Different Transactions
Large, Known Transations

Example Multi-Zones



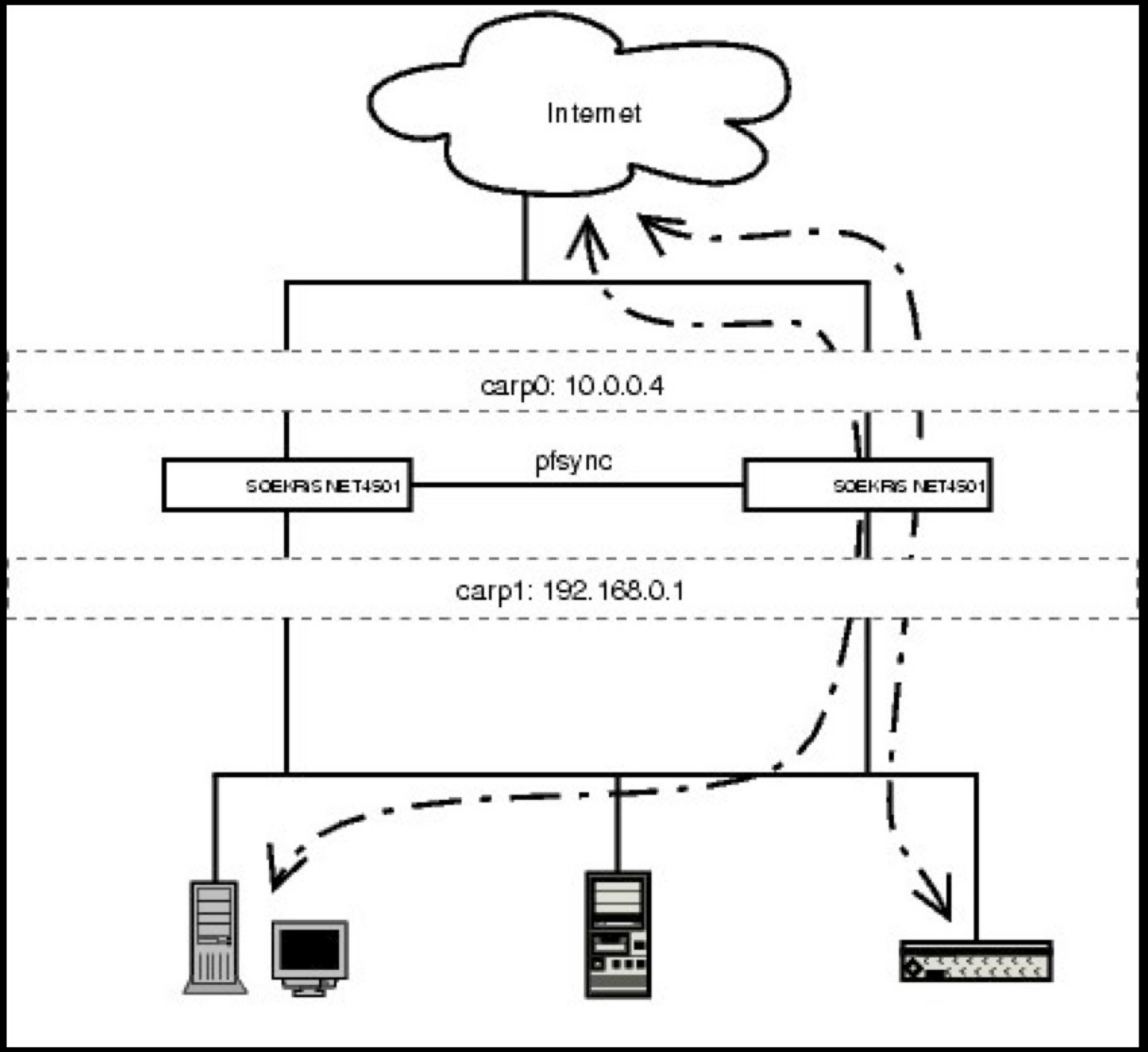
High-Availability

CARP

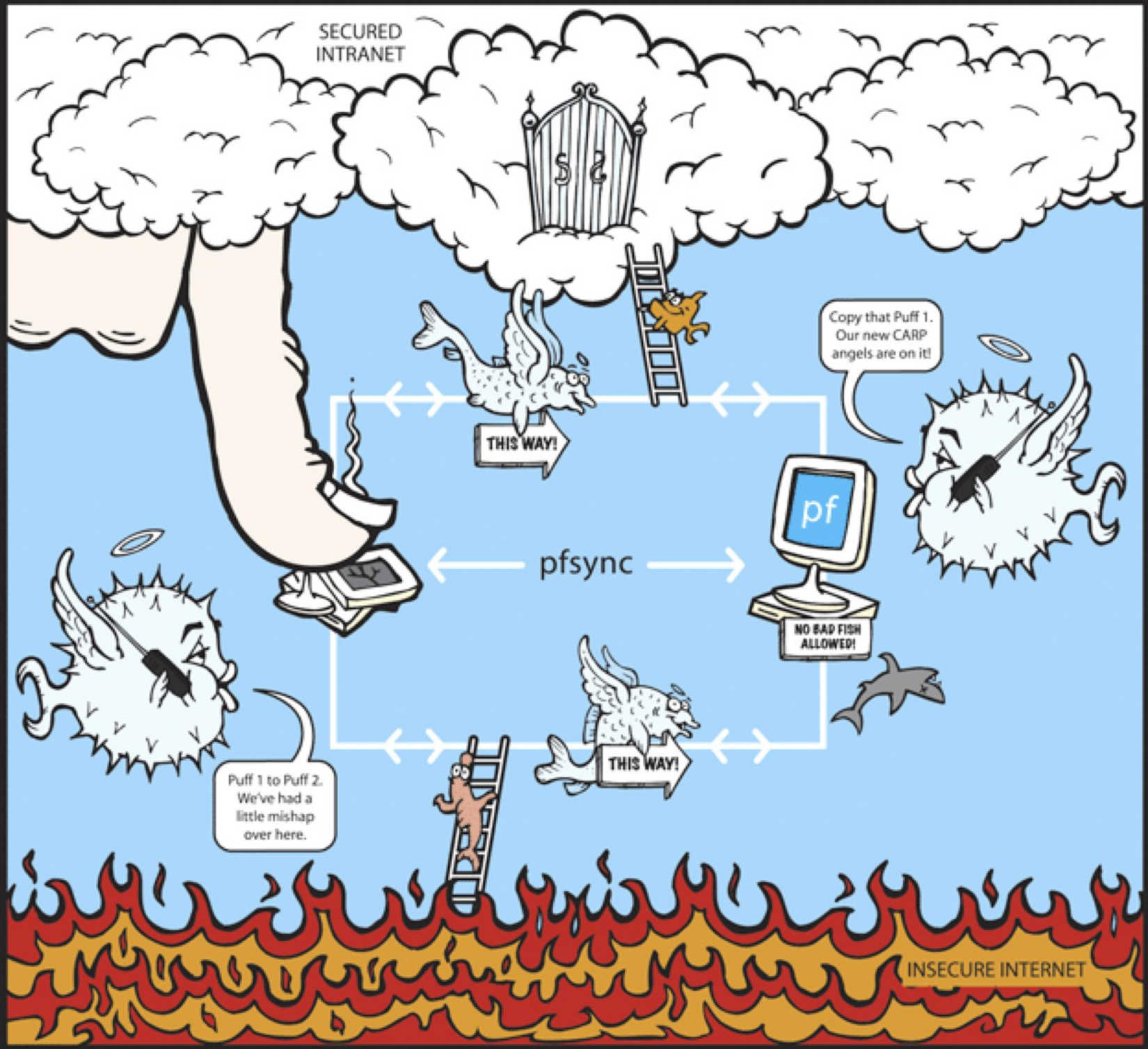
- Came from OpenBSD
- Sister Protocol: PFSync
- PFSense syncs additional softwares

http://www.countersiege.com/doc/pfsync-carp/

Router Failover

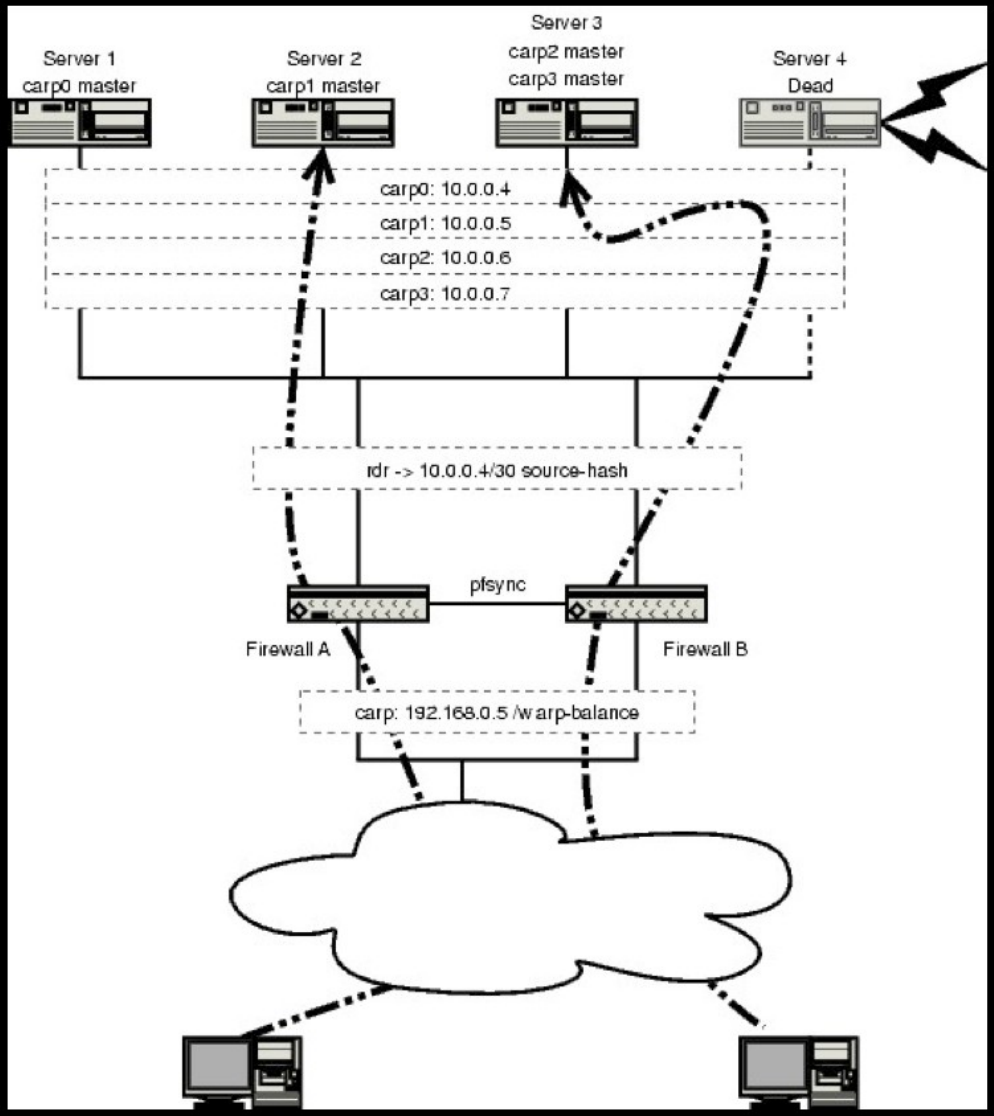


http://www.countersiege.com/doc/pfsync-carp/


SECURED
INTRANET
THIS WAY!
Copy that Puff 1.
Our new CARP
angels are on it!
pf
pfsync
NO BAD FISH
ALLOWED!
Puff 1 to Puff 2.
We've had a
little mishap
over here.
THIS WAY!
INSECURE INTERNET

Load Balancing

(without any load balancer!)



Not Covered Tonight

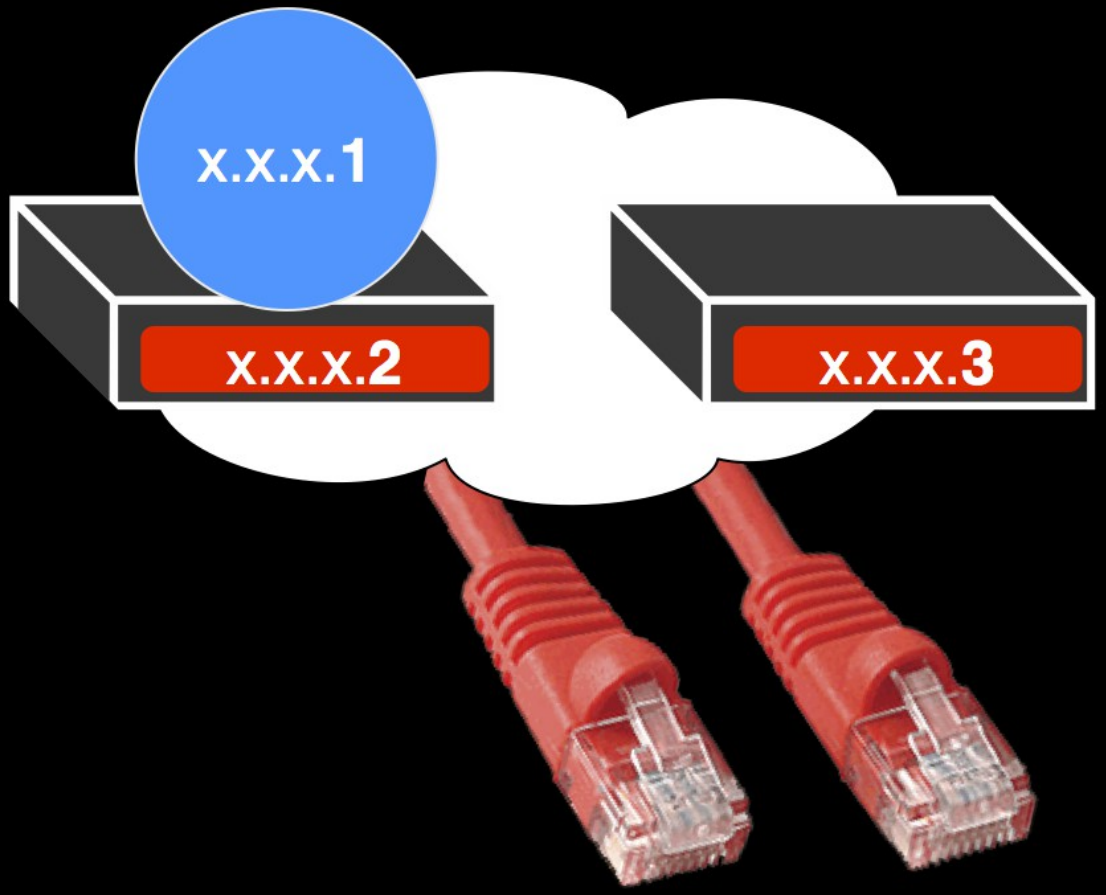
http://www.countersiege.com/doc/pfsync-carp/

Redundancy from your ISP

- Typical Provisioning:
  - HSRP (hot standby router protocol)
    - very common
  - VRRP (virtual router redundancy protocol)
  - GLBP (gateway load balancing protocol)
- Sadly, all Cisco, yet all common...

Redundancy from your ISP

- HSRP (hot standby router protocol)

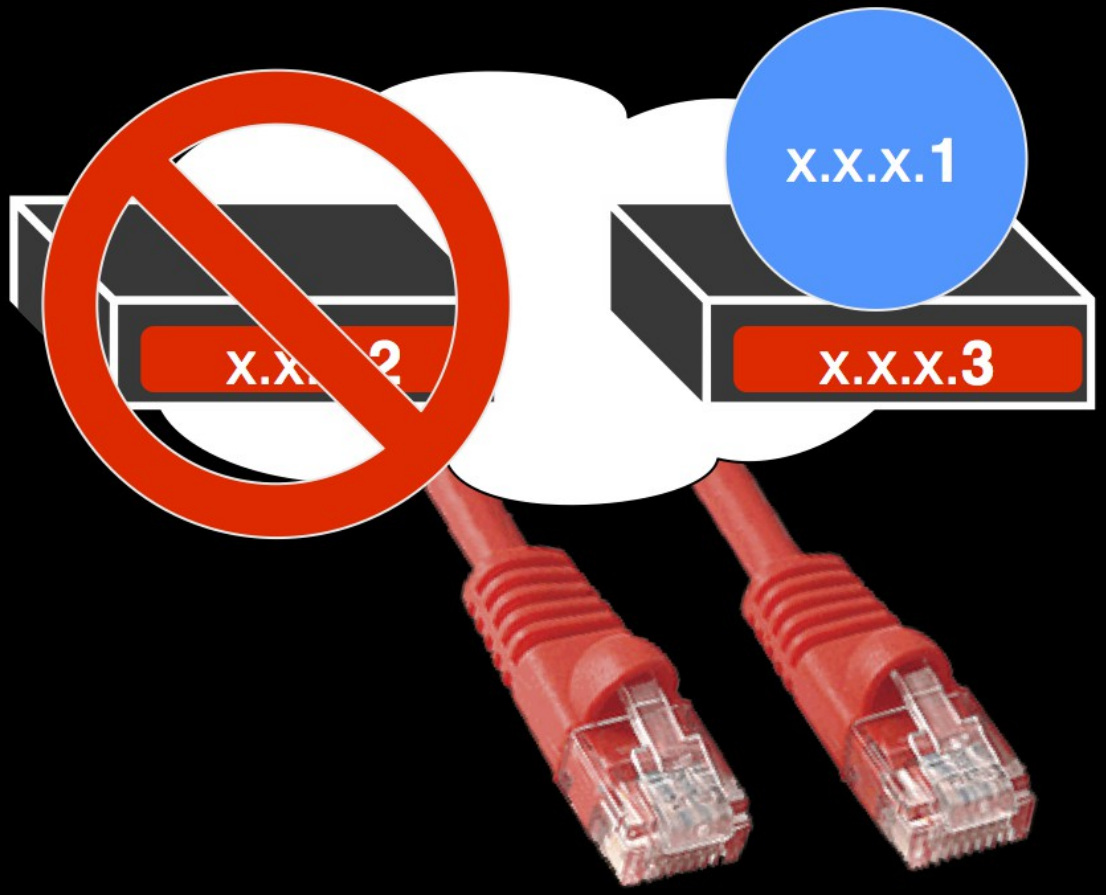


you route to:

x.x.x.1

Redundancy from your ISP

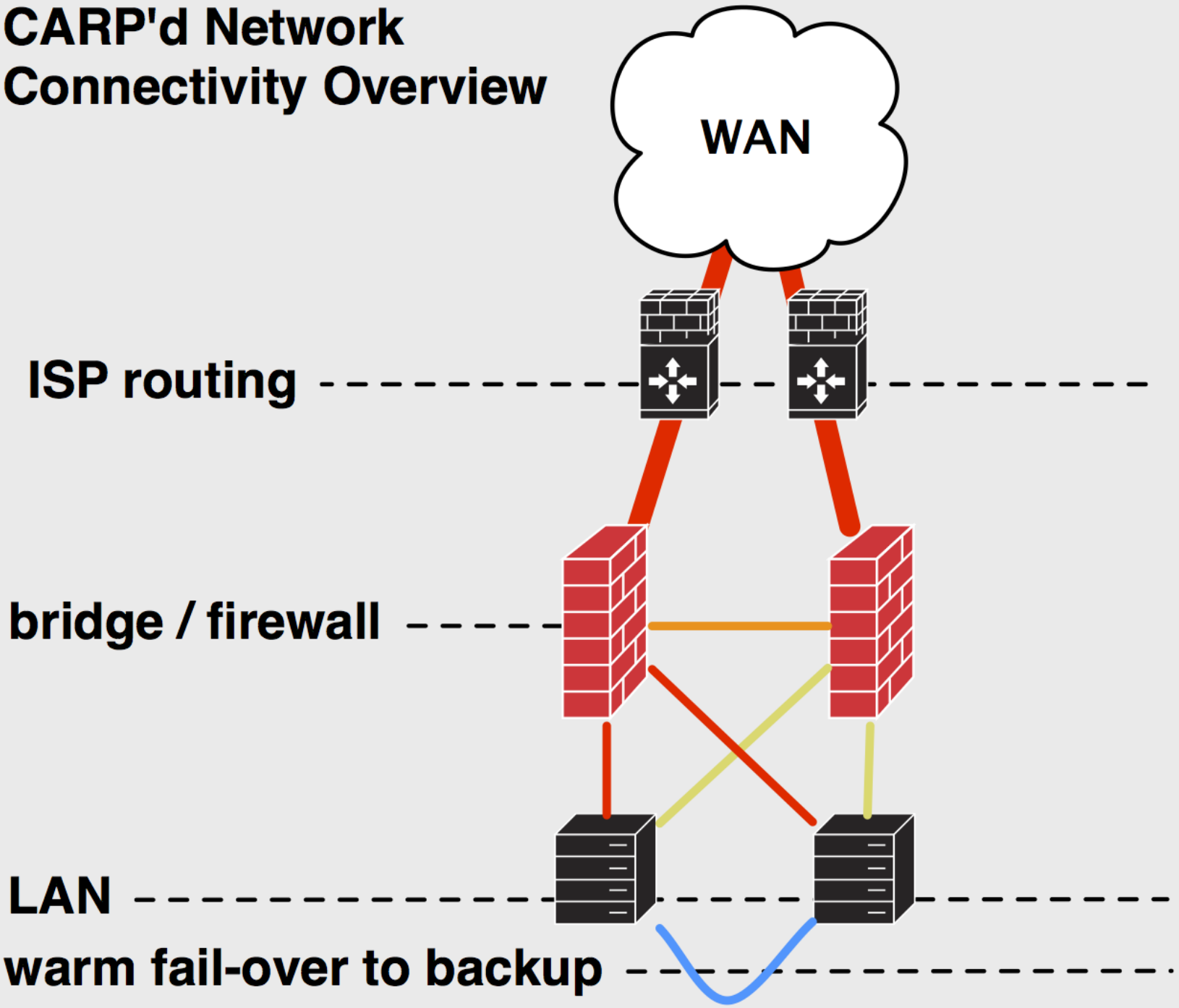
- HSRP (hot standby router protocol)



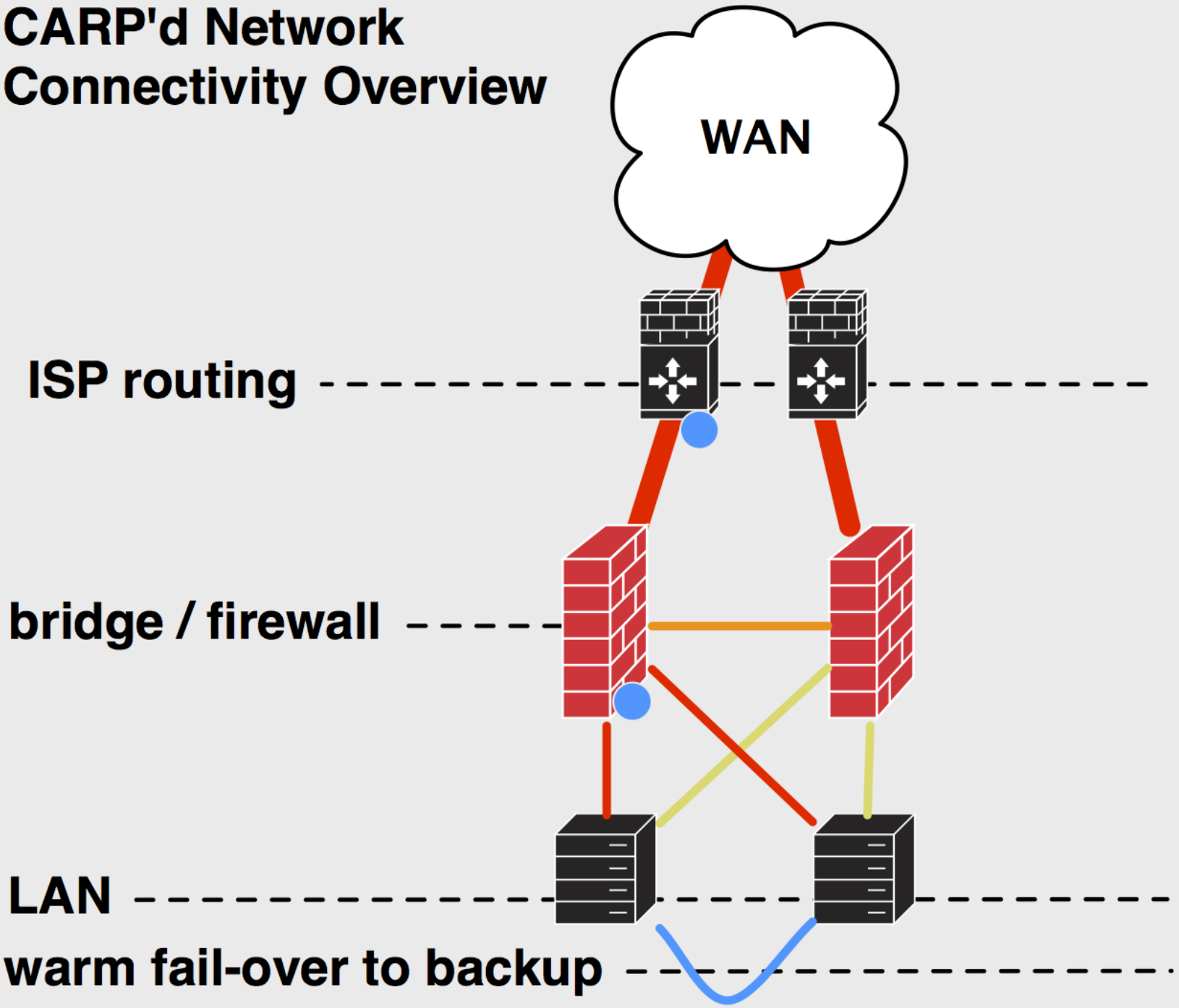
you route to:

x.x.x.1

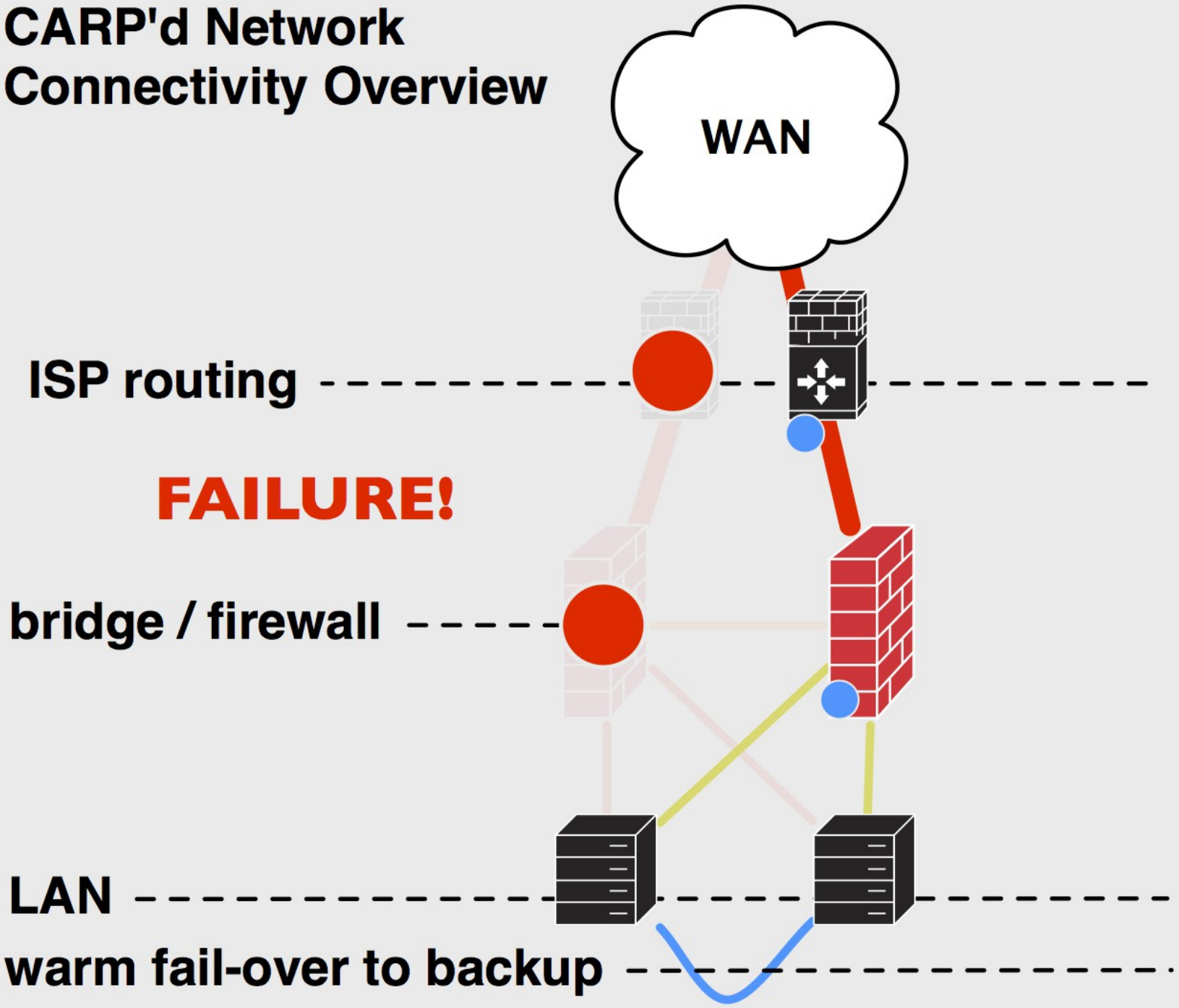
CARP'd Network Connectivity Overview



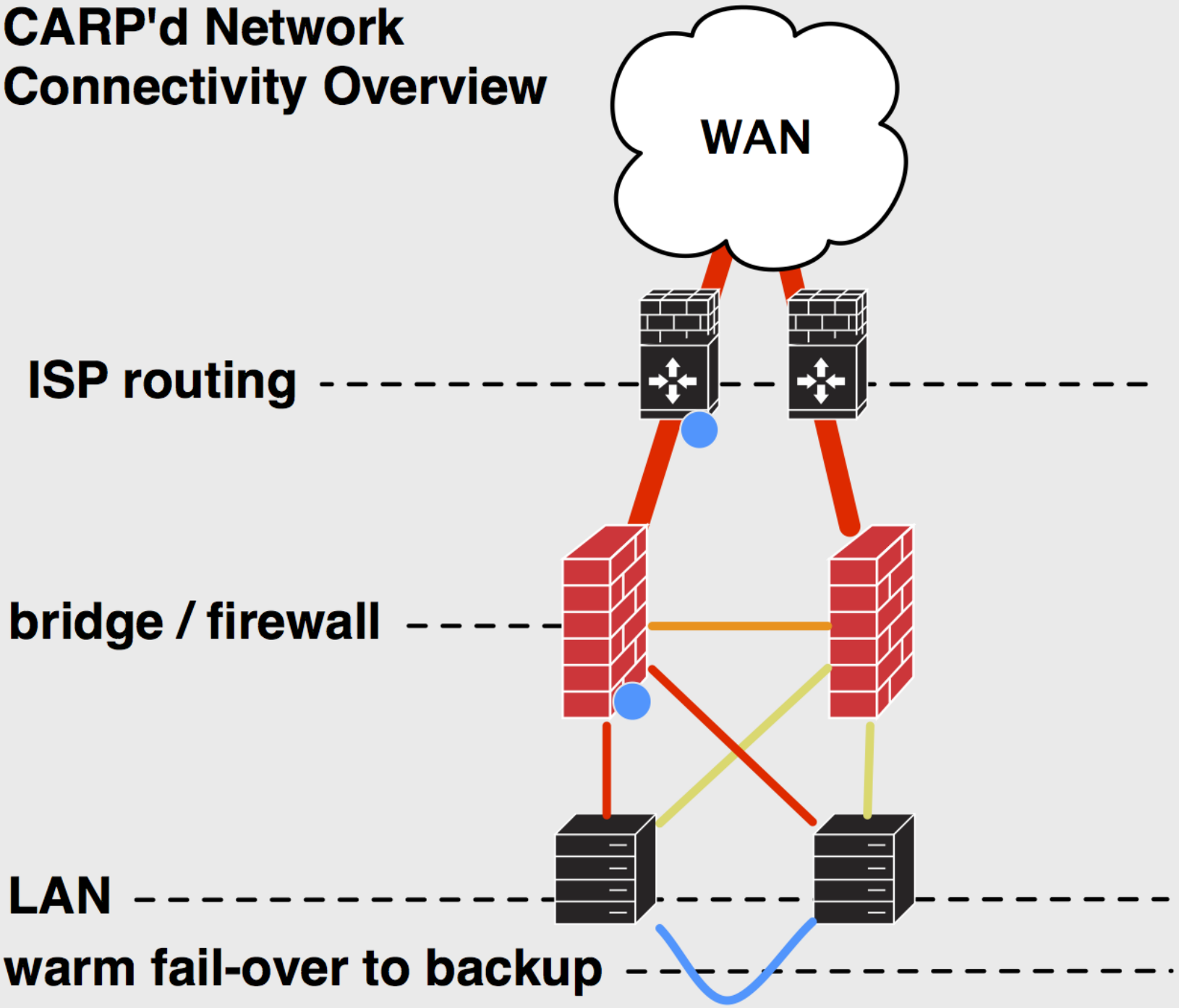
CARP'd Network Connectivity Overview



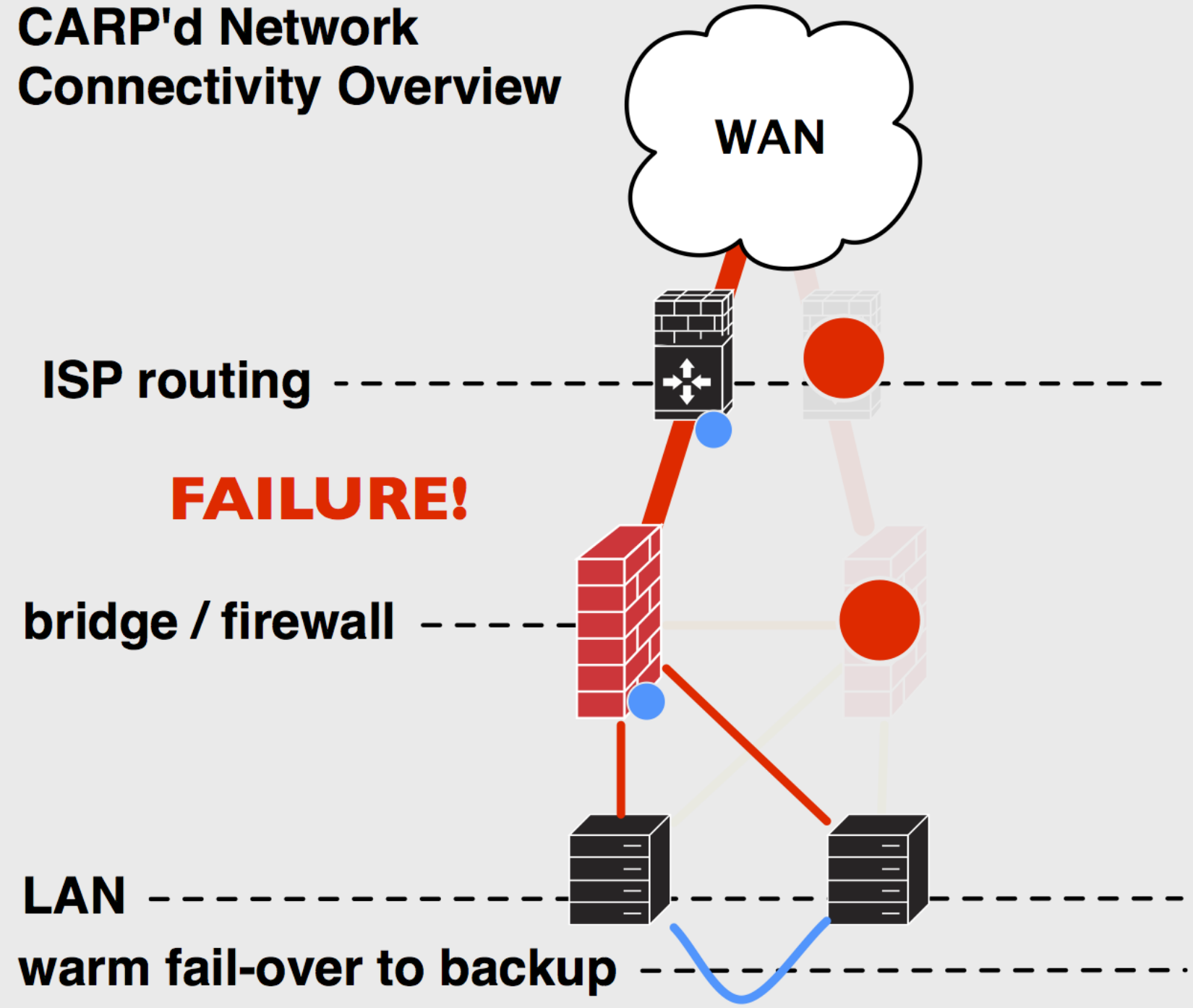
CARP'd Network Connectivity Overview



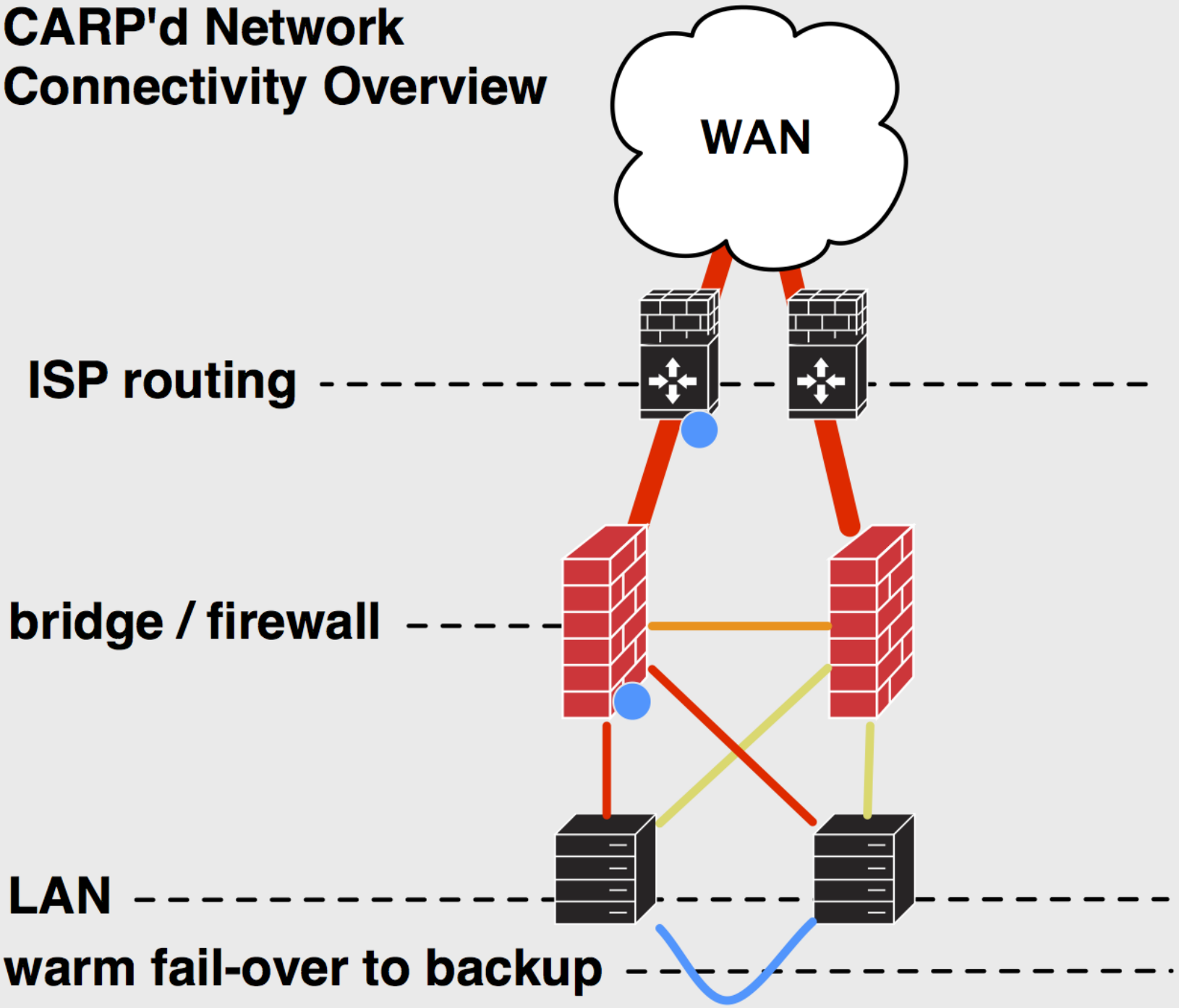
CARP'd Network Connectivity Overview

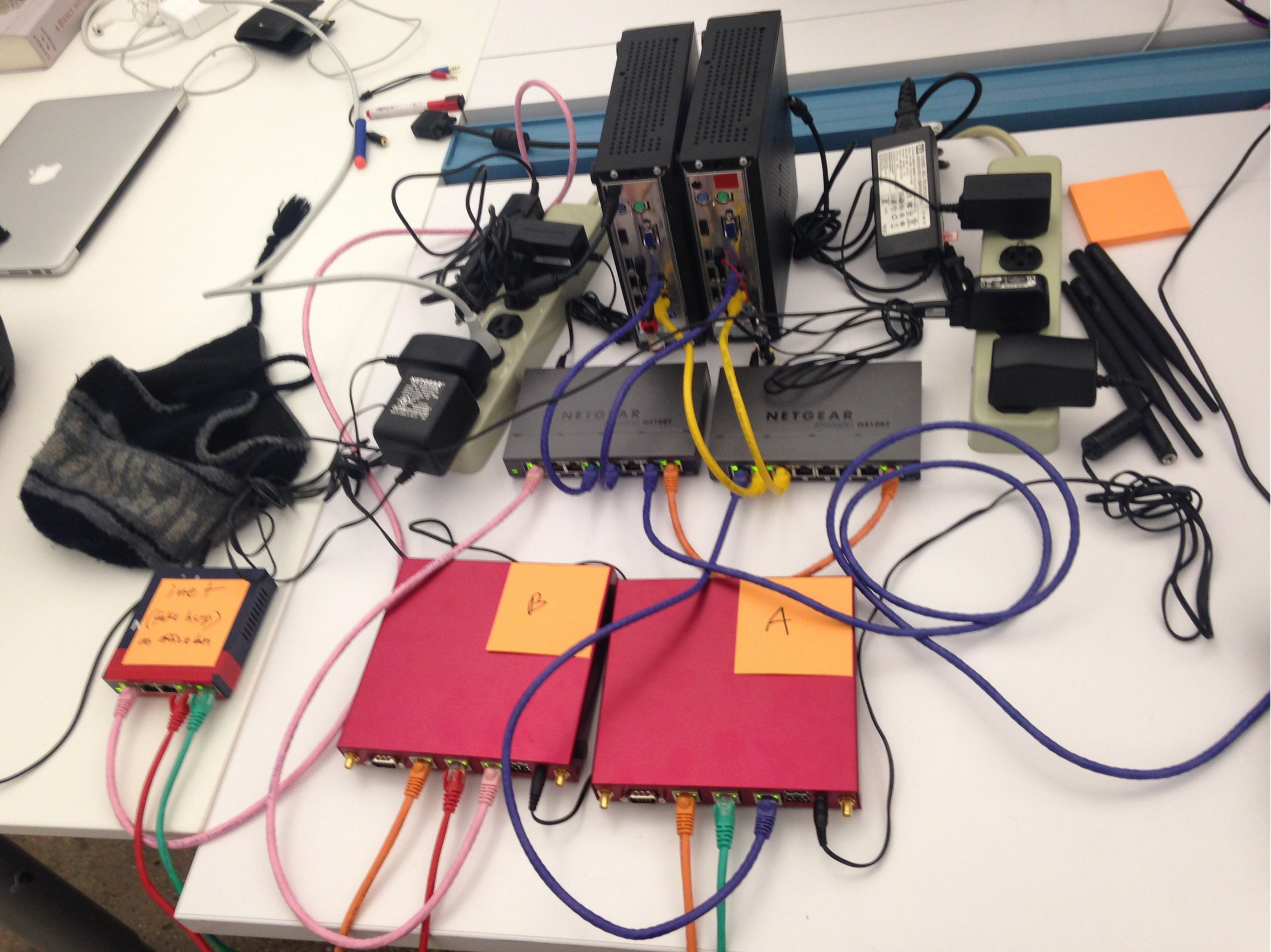


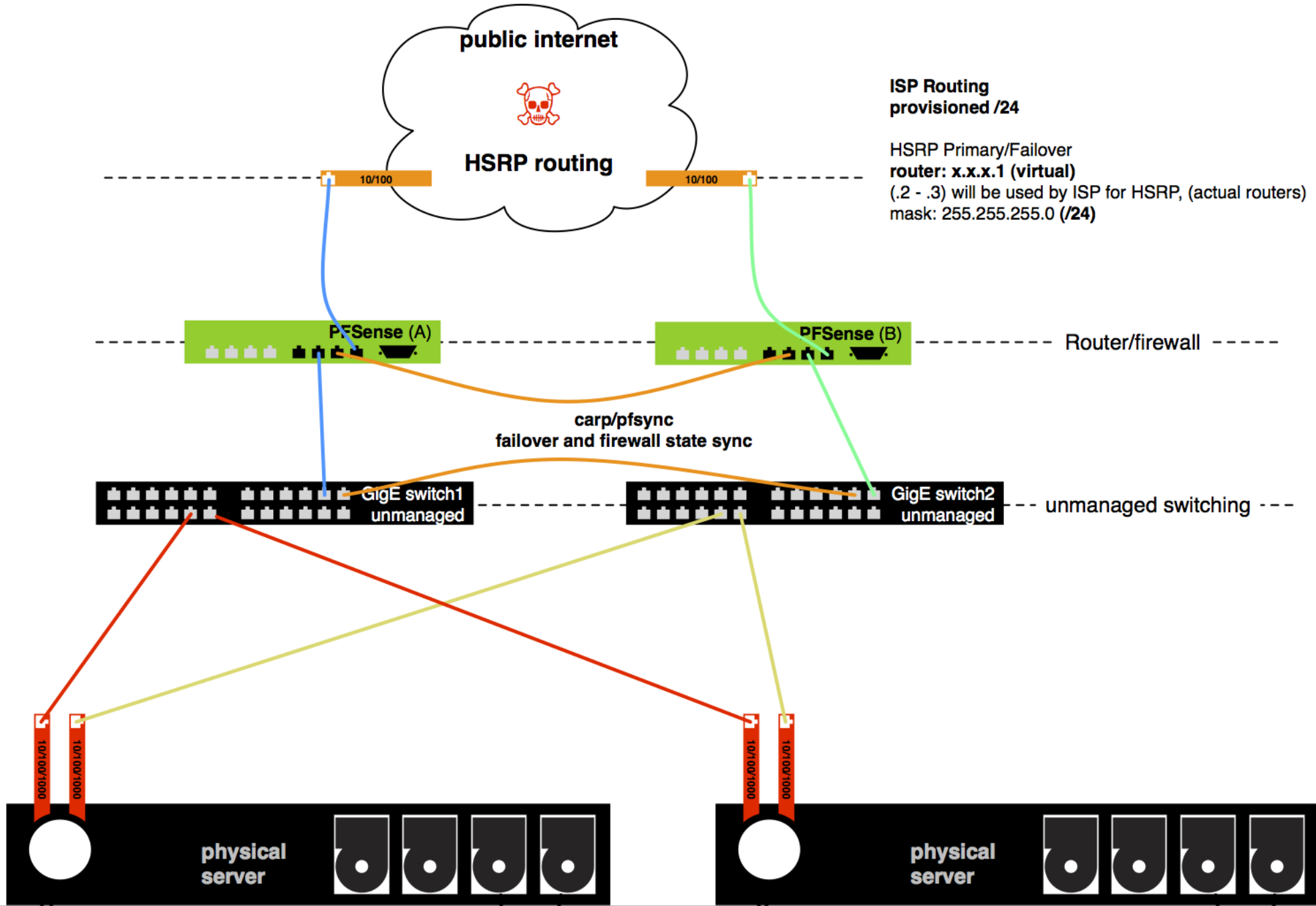
CARP'd Network Connectivity Overview



CARP'd Network Connectivity Overview



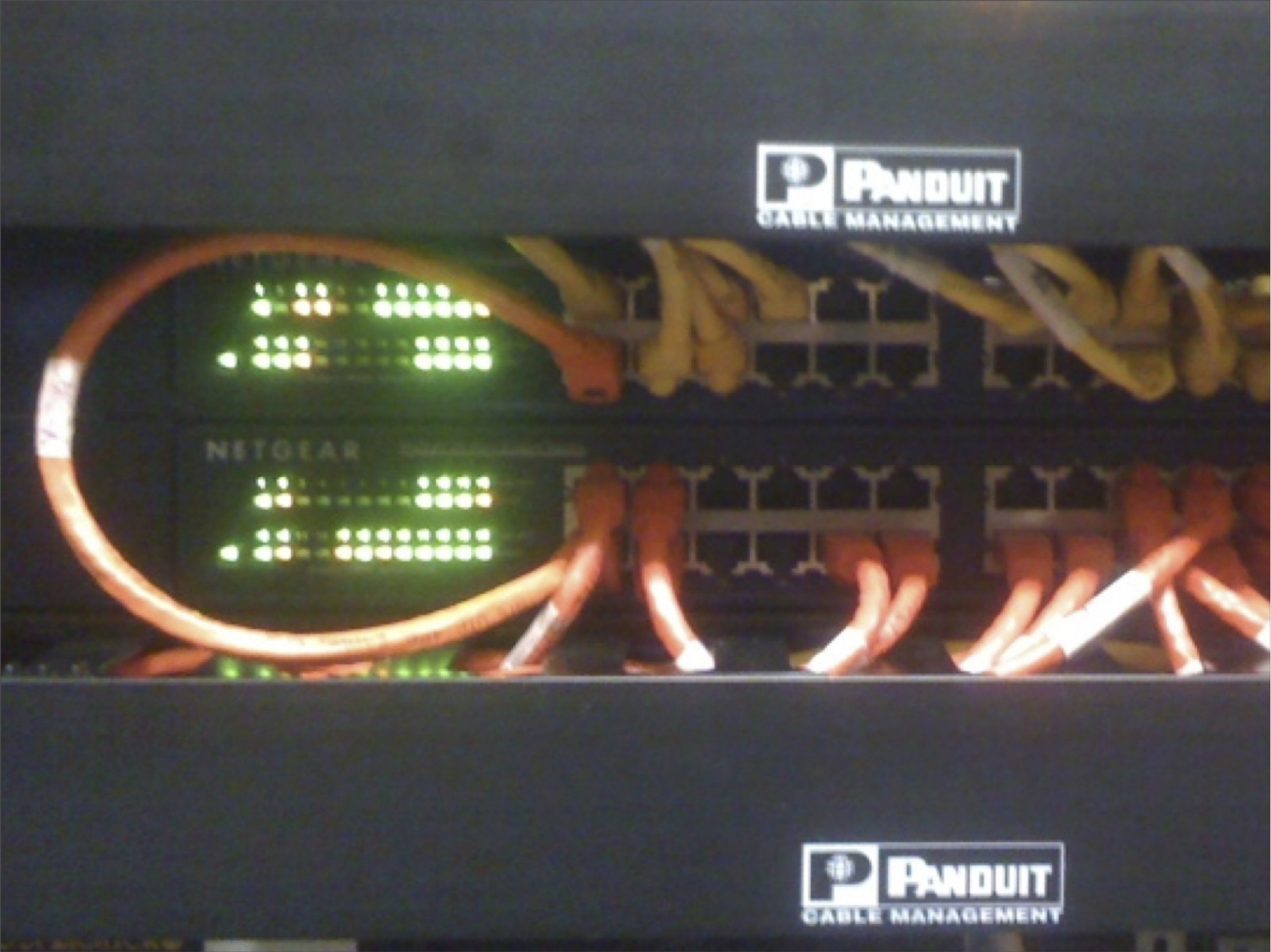

NETGEAR
NETGEAR
B
A

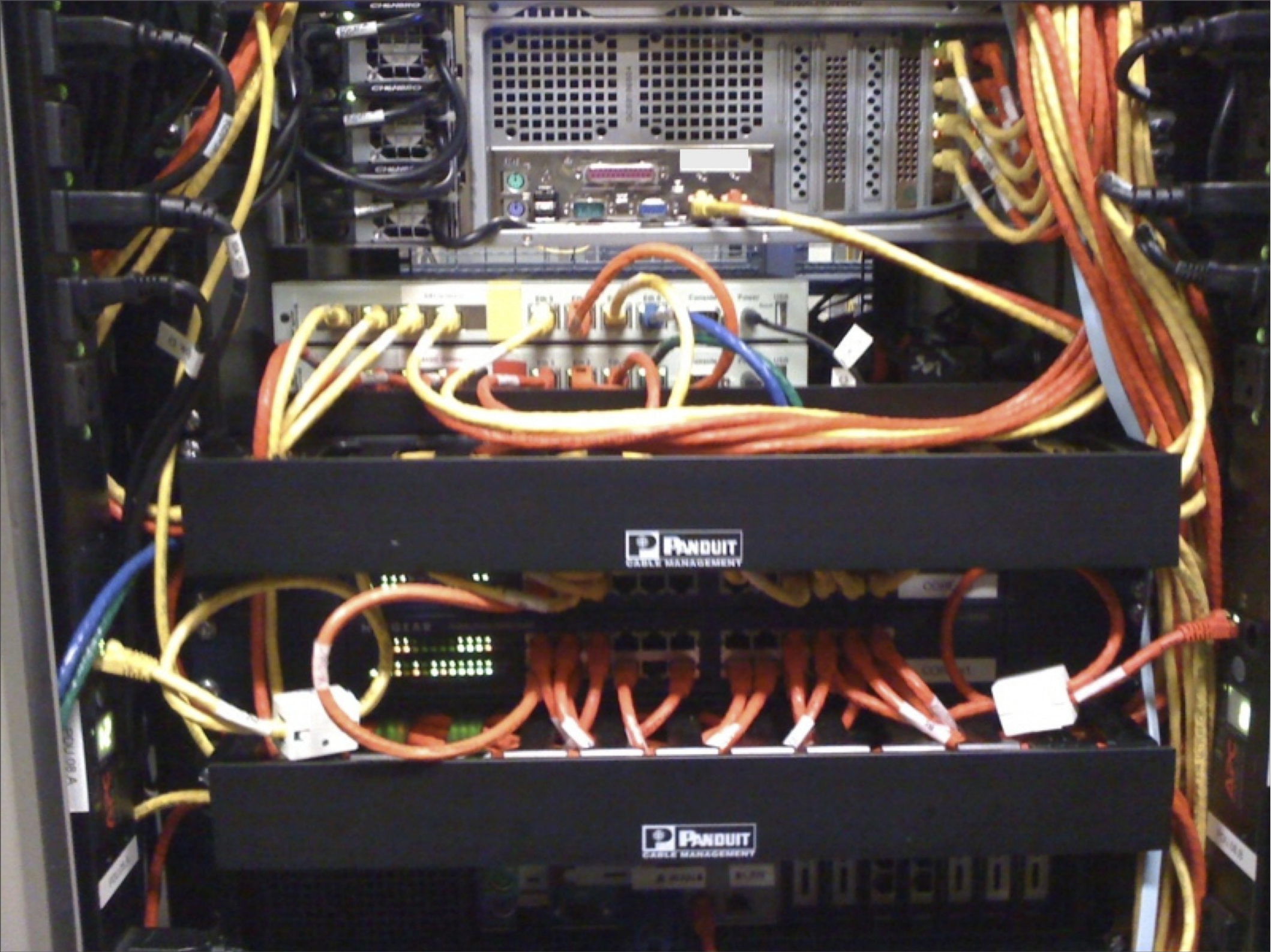

public internet
HSRP routing
10/100
10/100
ISP Routing
provisioned /24
HSRP Primary/Failover
router: x.x.x.1 (virtual)
(.2 - .3) will be used by ISP for HSRP, (actual routers)
mask: 255.255.255.0 (/24)
PFSense (A)
PFSense (B)
Router/firewall
carp/pfsync
failover and firewall state sync
GigE switch1
unmanaged
GigE switch2
unmanaged
unmanaged switching
10/100/1000
10/100/1000
10/100/1000
10/100/1000
physical
server
physical
server

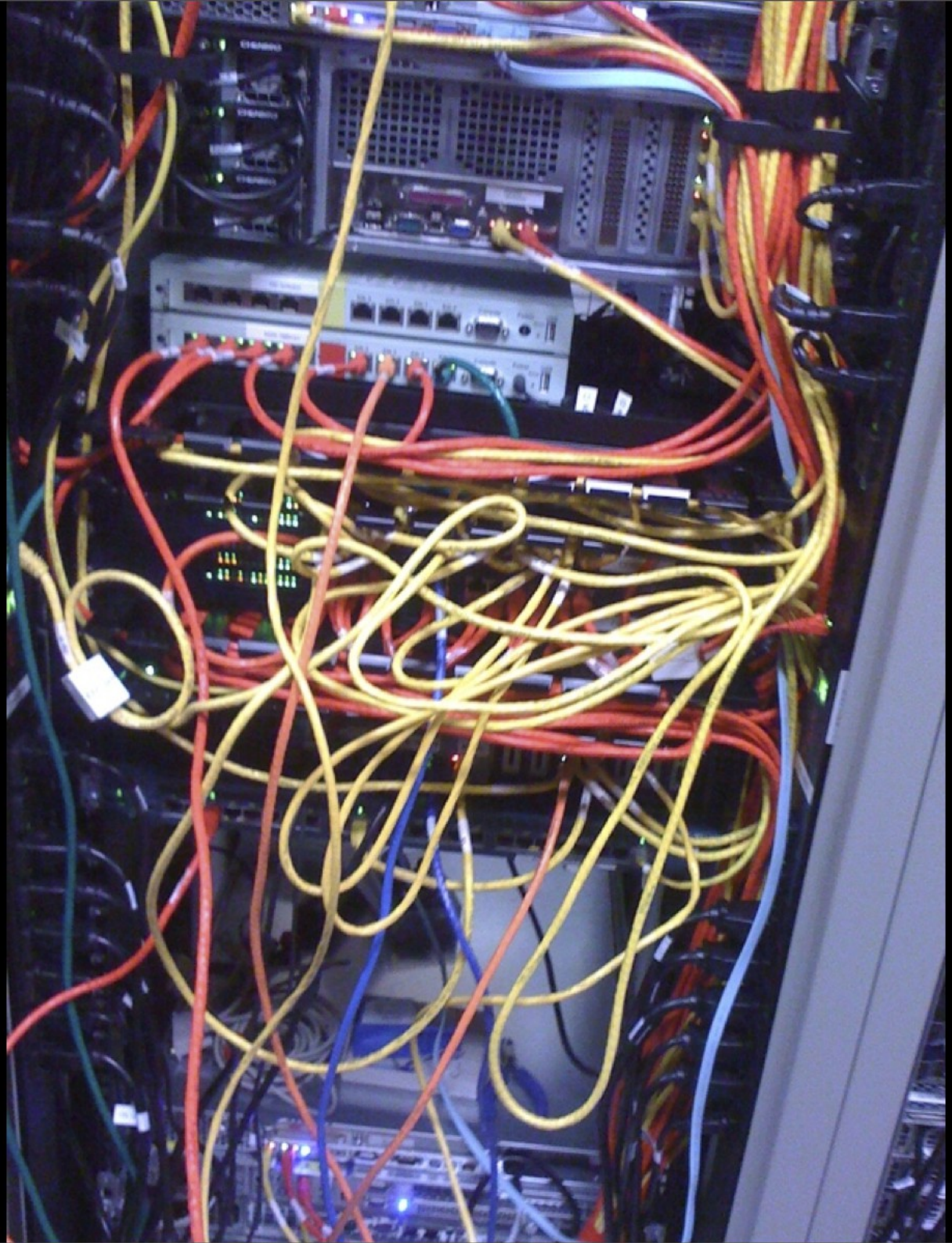
Neat CARP Trick

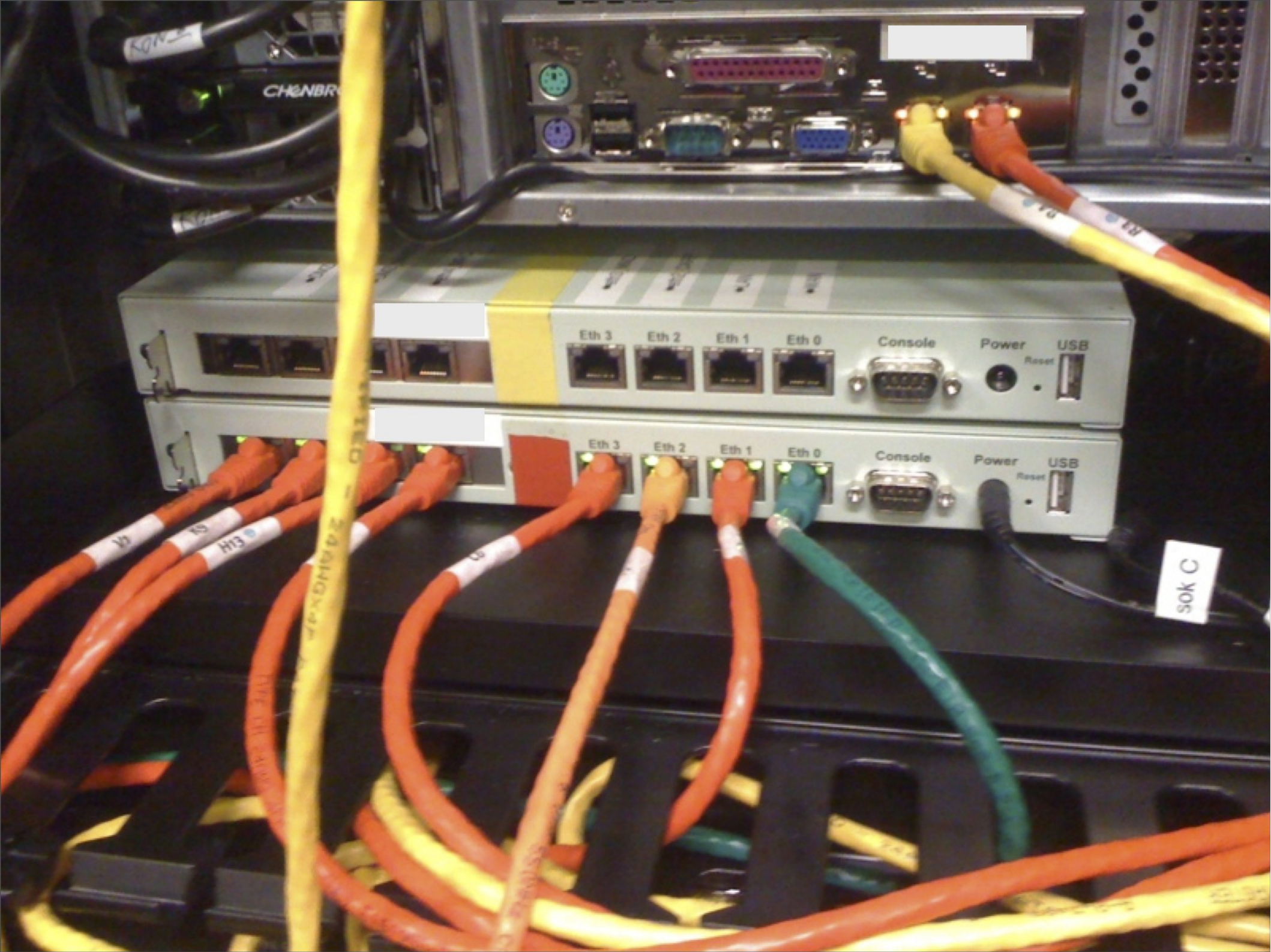

PANDUIT

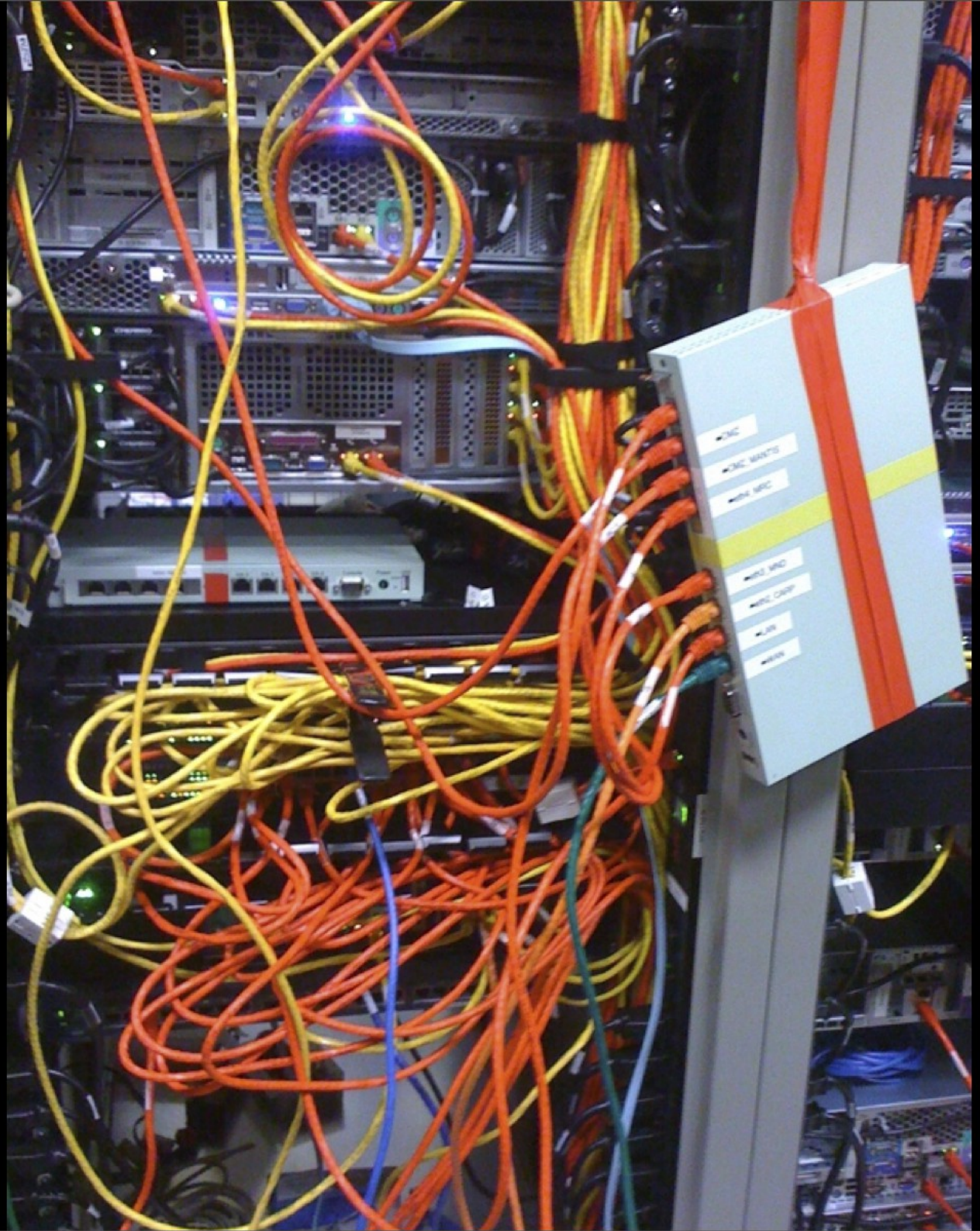

CHENBRO
munson
HONSHU
Eth 3
Eth 2
Eth 1
Eth 0
Console
Power
USB
Reset

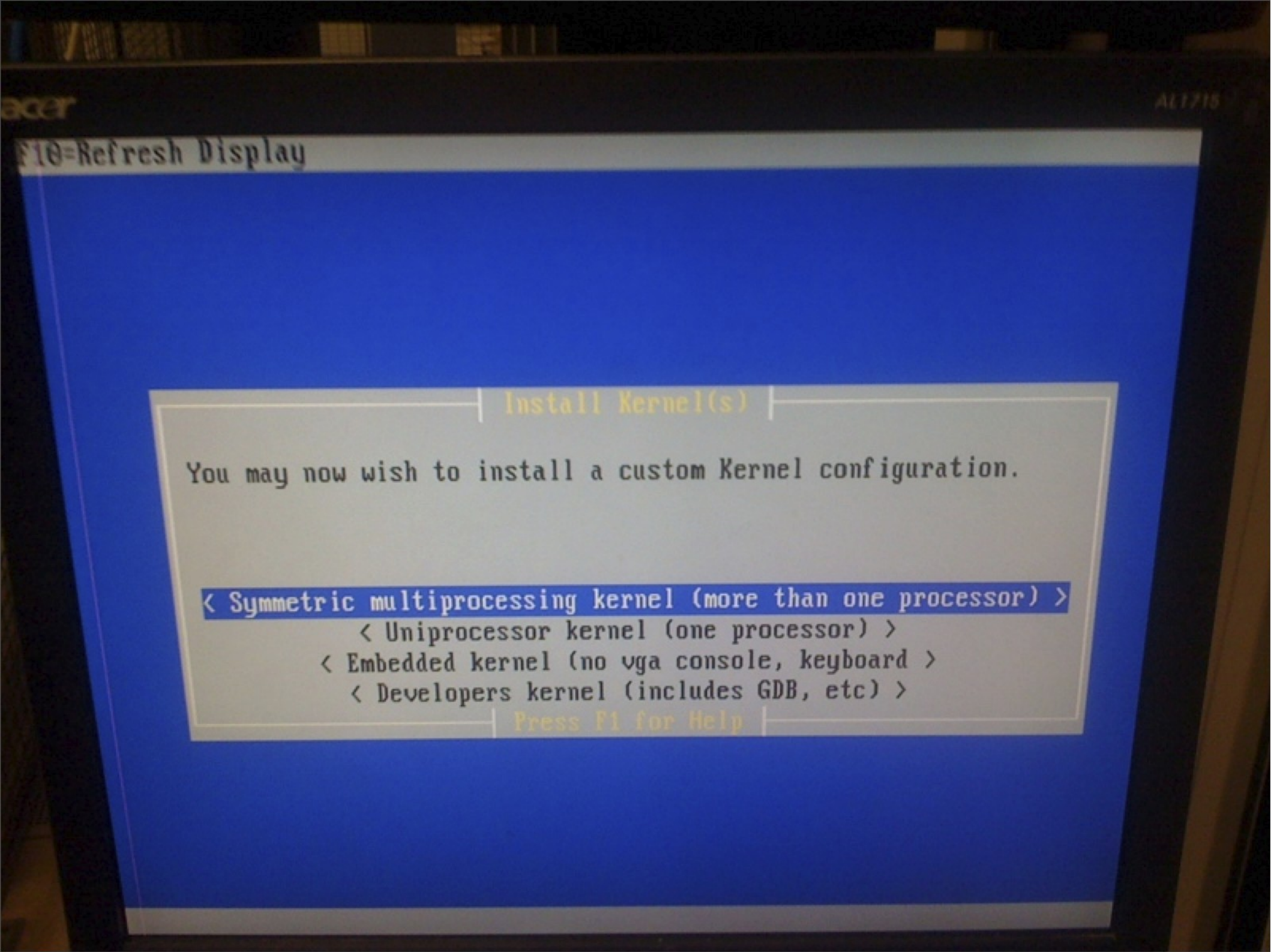

PANDUIT
CABLE MANAGEMENT
NETGEAR
PANDUIT
CABLE MANAGEMENT


PANDUIT
CABLE MANAGEMENT
PANDUIT
CABLE MANAGEMENT




Eth 3
Eth 2
Eth 1
Eth 0
Console
Power
Reset
USB
Eth 3
Eth 2
Eth 1
Eth 0
Console
Power
Reset
USB
sok C




F10=Refresh Display
Install Kernel(s)
You may now wish to install a custom Kernel configuration.
< Symmetric multiprocessing kernel (more than one processor) >
< Uniprocessor kernel (one processor) >
< Embedded kernel (no vga console, keyboard >
< Developers kernel (includes GDB, etc) >
Press F1 for Help


PANDUIT
PANDUIT

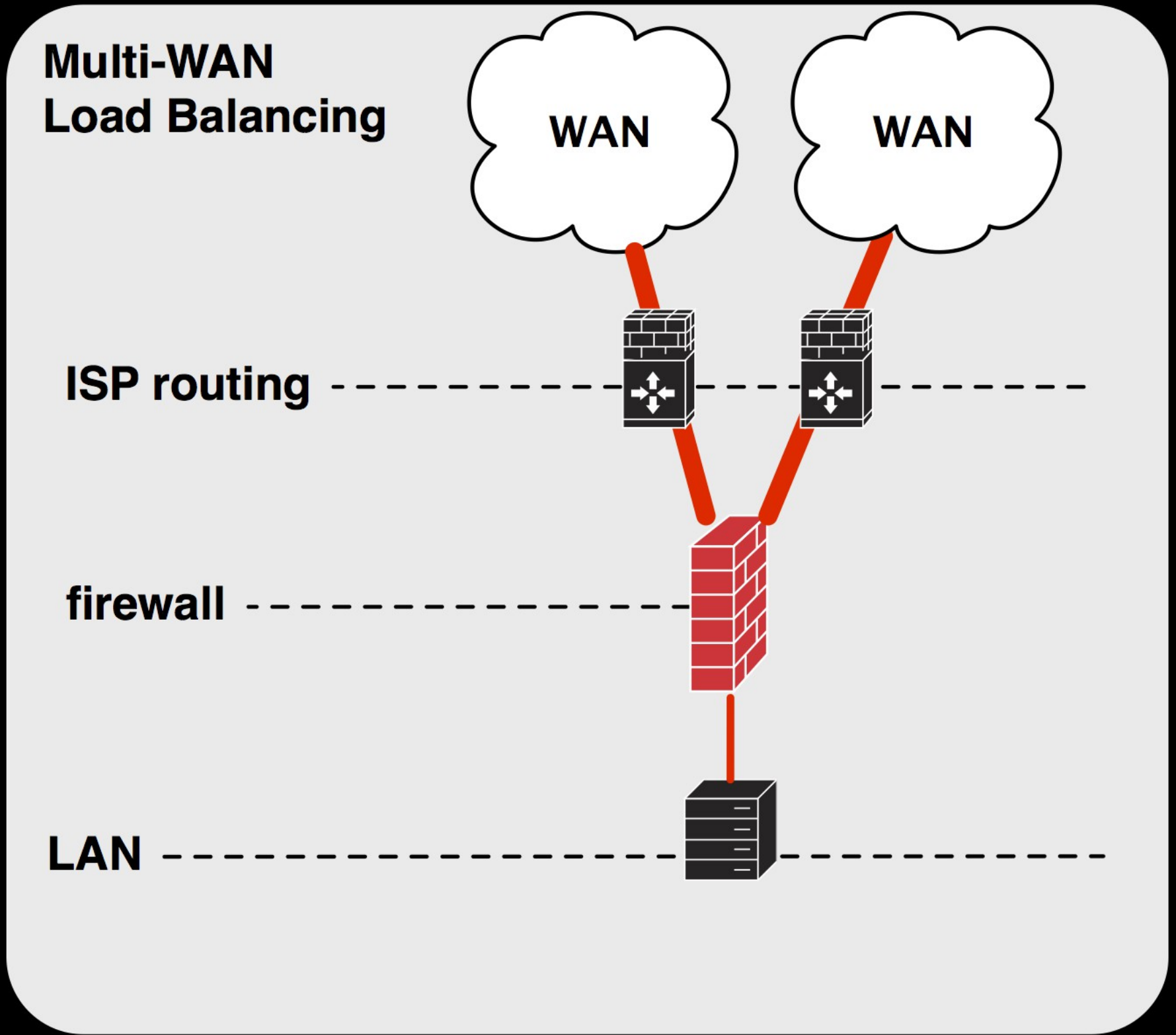

PANDUIT
CABLE MANAGEMENT

10x GigE

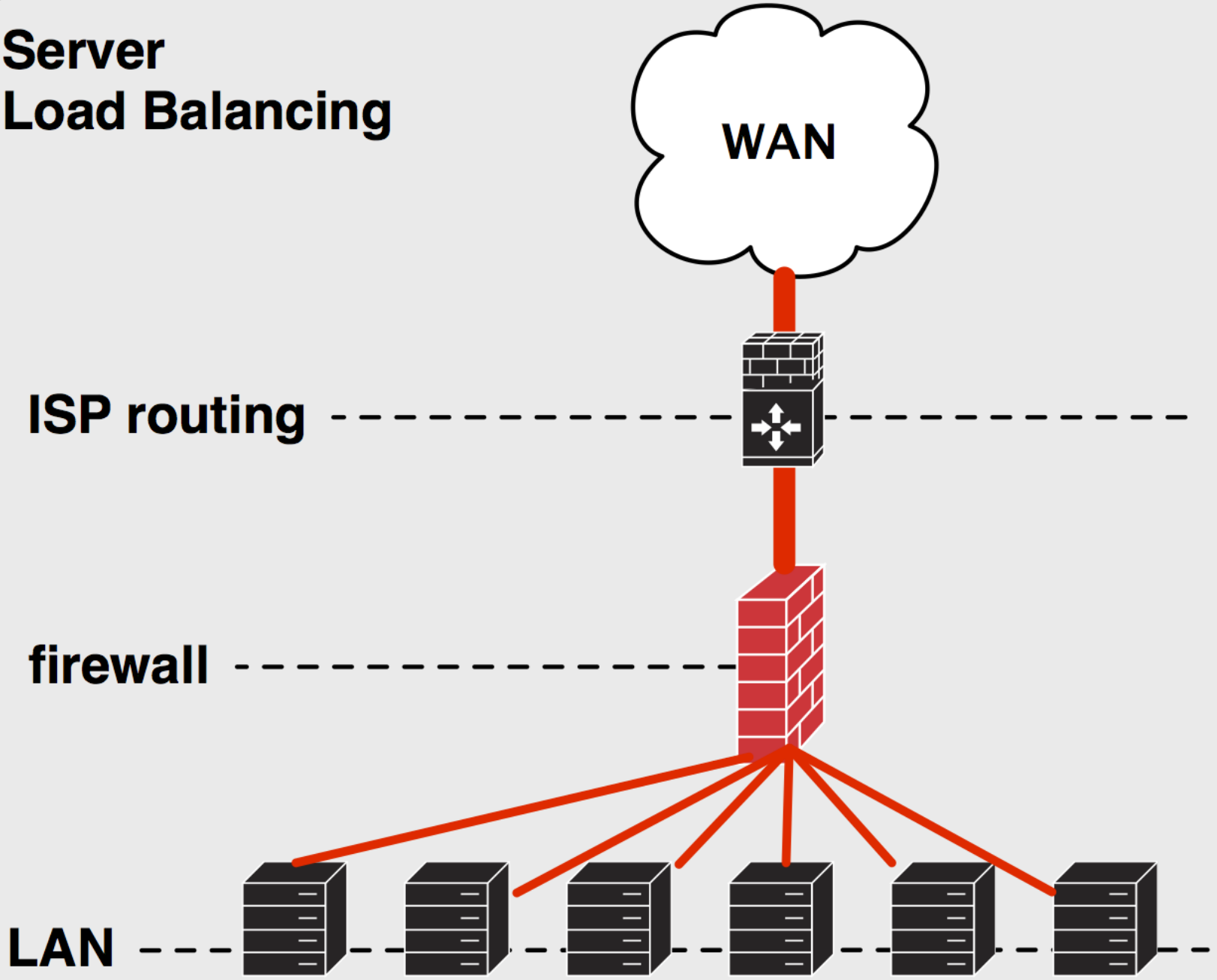
- Supermicro Chassis, Intel dual-core CPU's
- Dual em(4) Gigabit on-board
- Added 2x Quad Intel igb(4) YUCK!!!
  - First Intel nics to bit me in a long time
  - read up on your hardware

igb correction <- next page

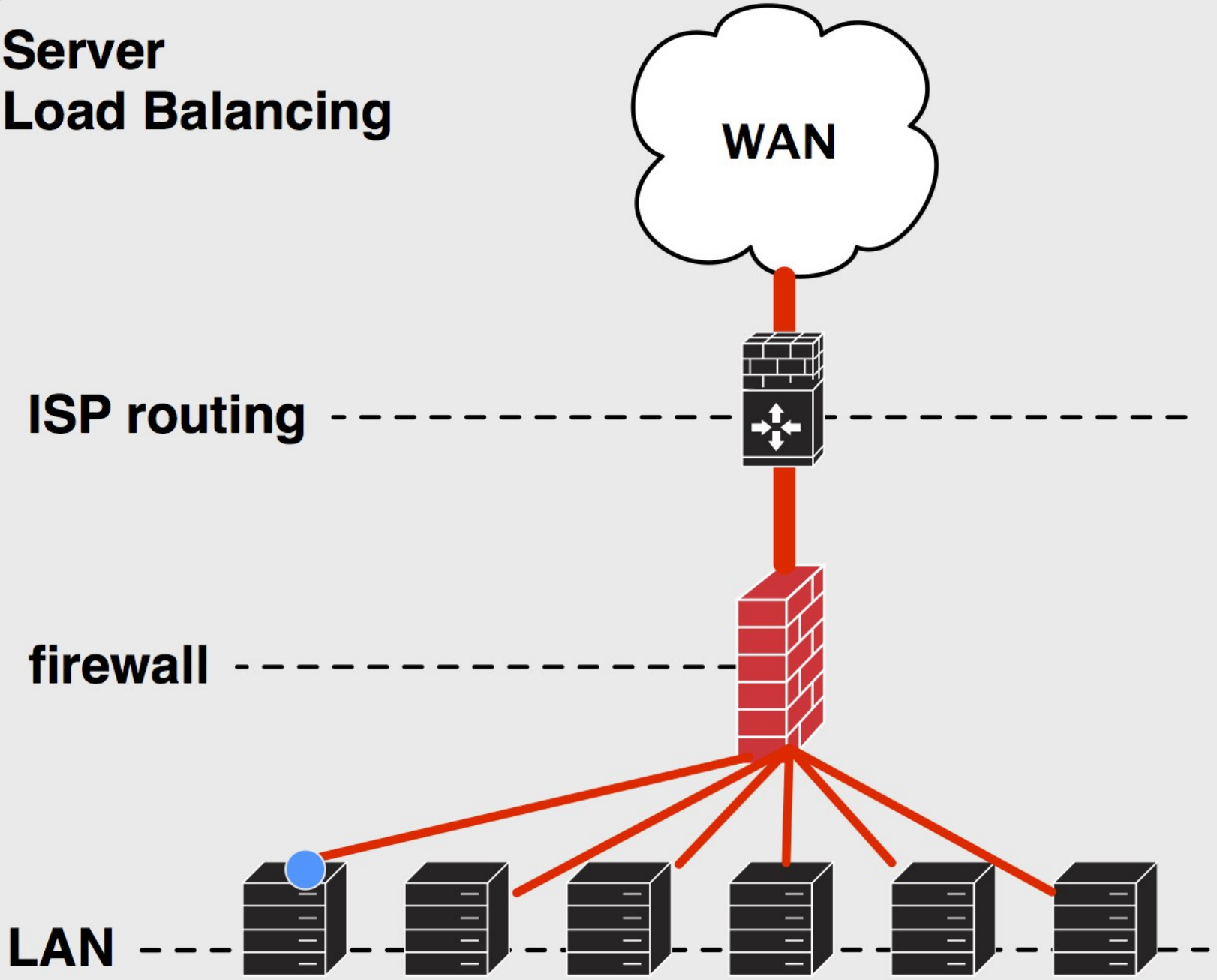
- Fully Redundant Load Balancing, 2 common


Multi-WAN
Load Balancing
WAN
WAN
ISP routing
firewall
LAN

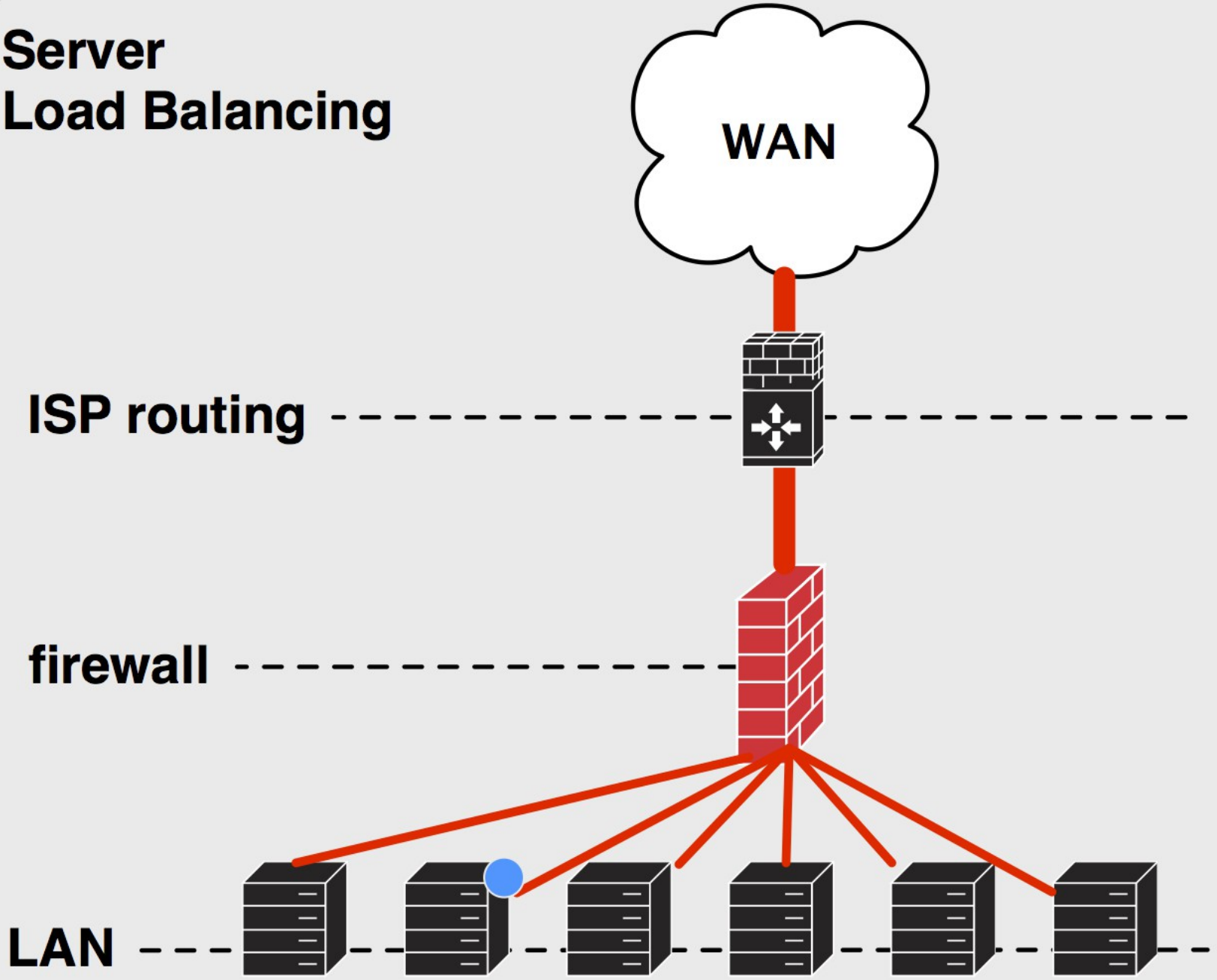
Server Load Balancing



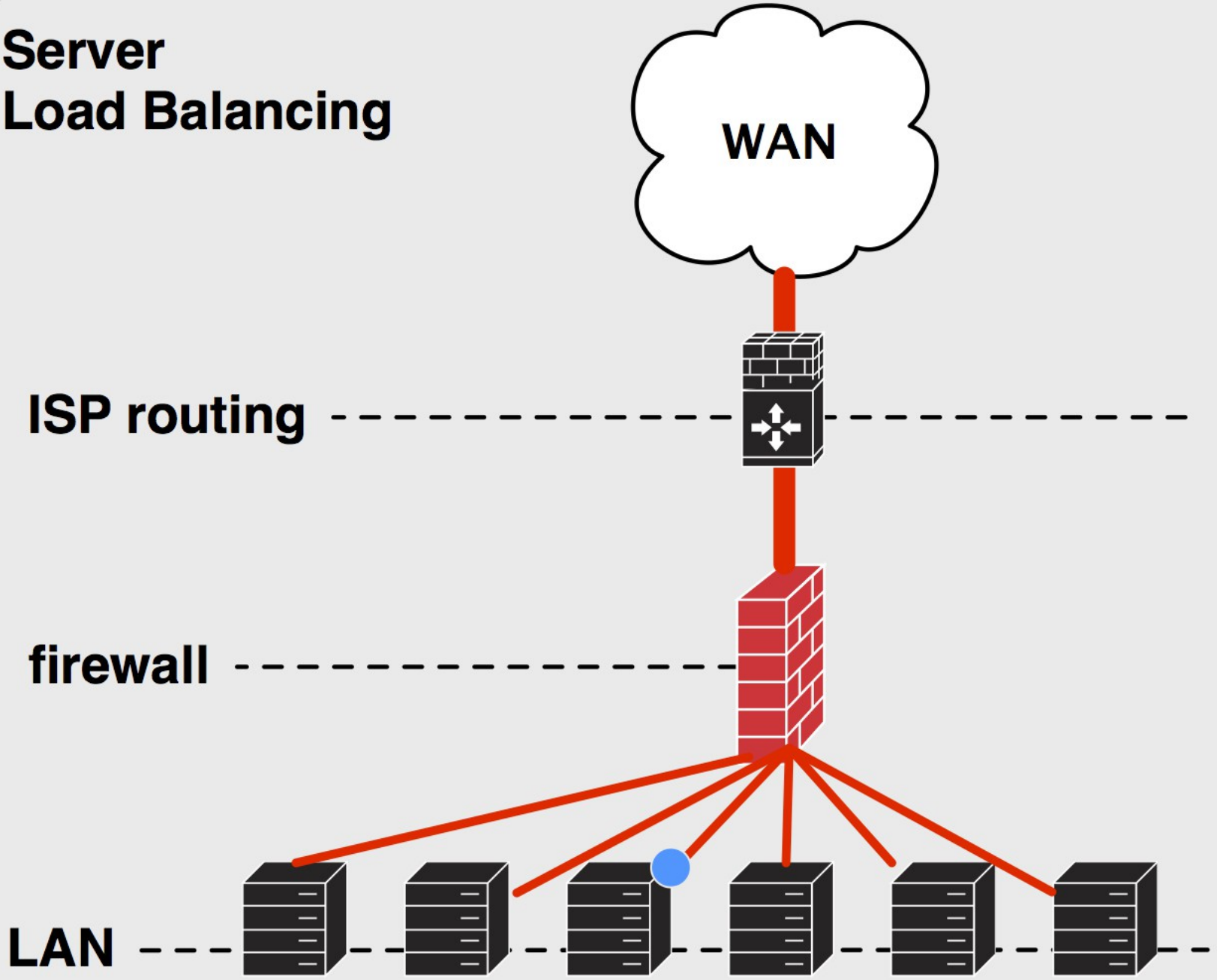
Server Load Balancing



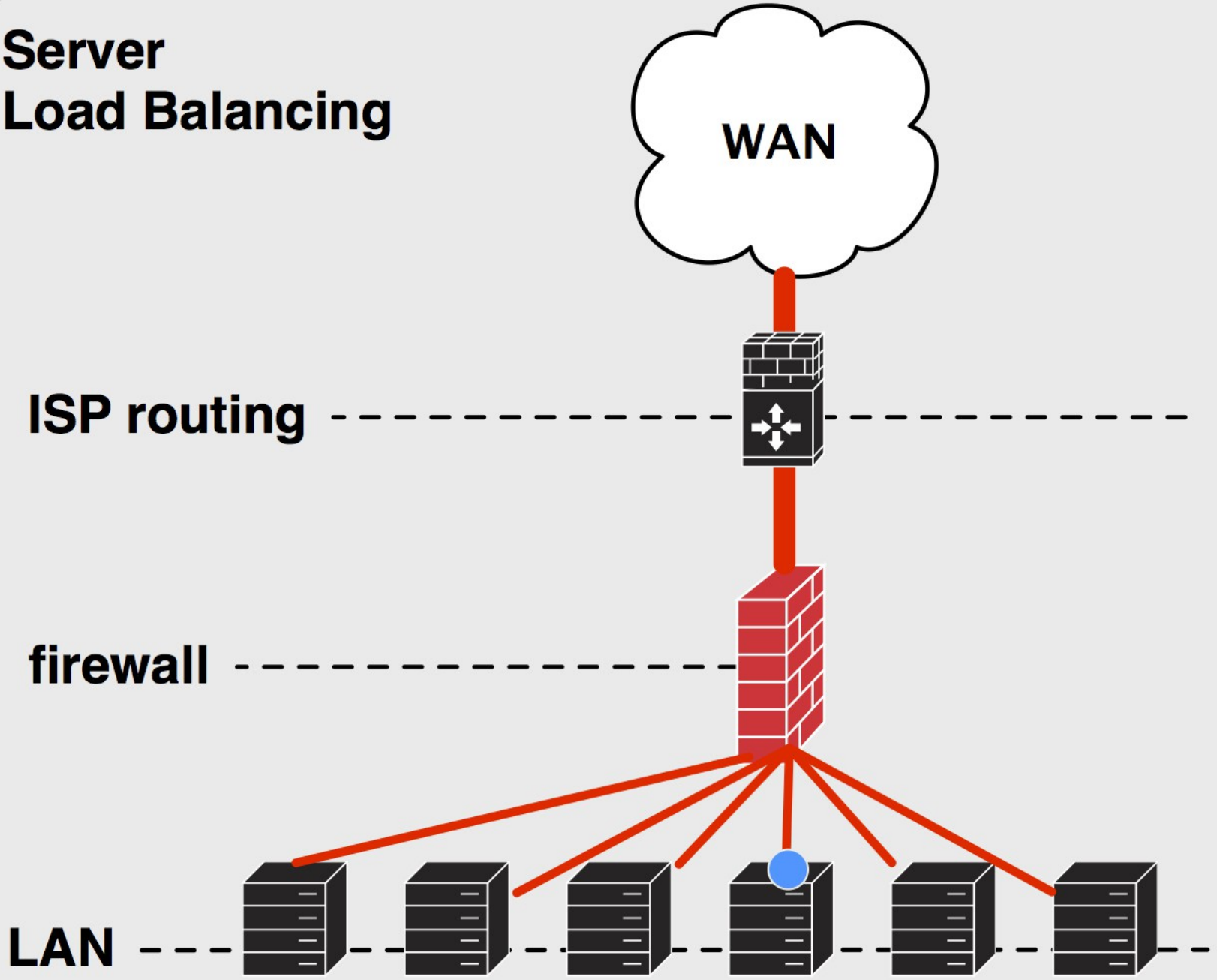
Server Load Balancing



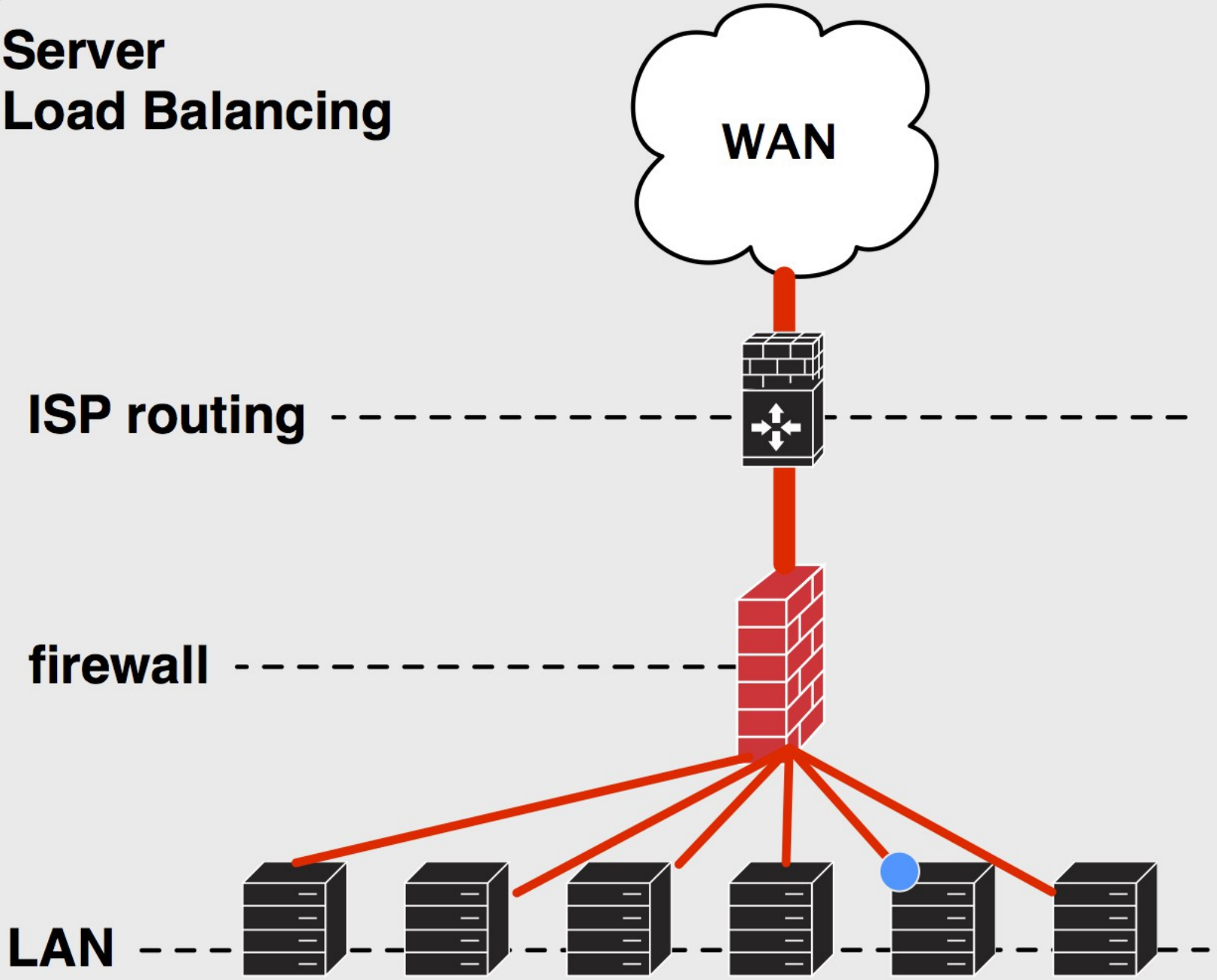
Server Load Balancing



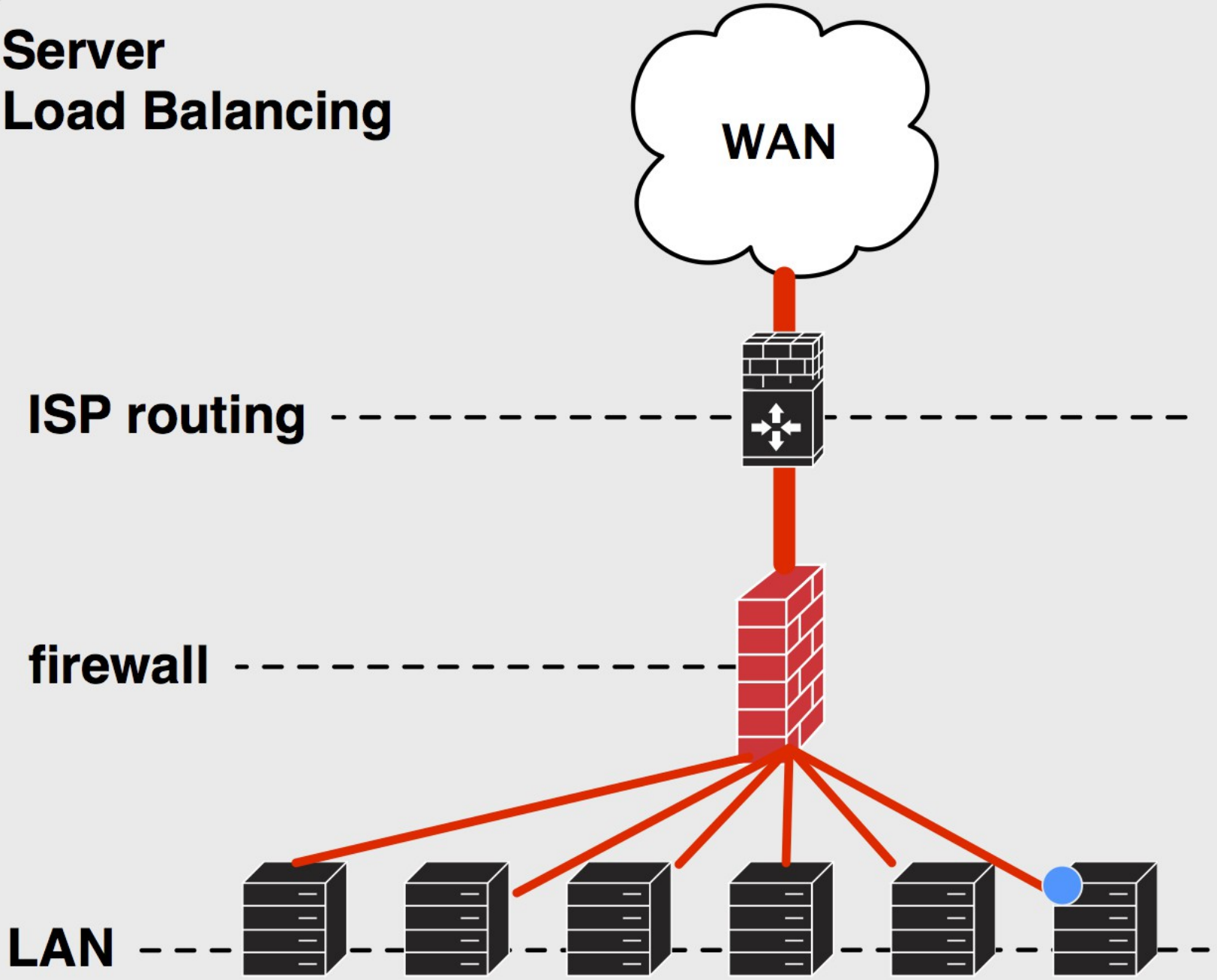
Server Load Balancing



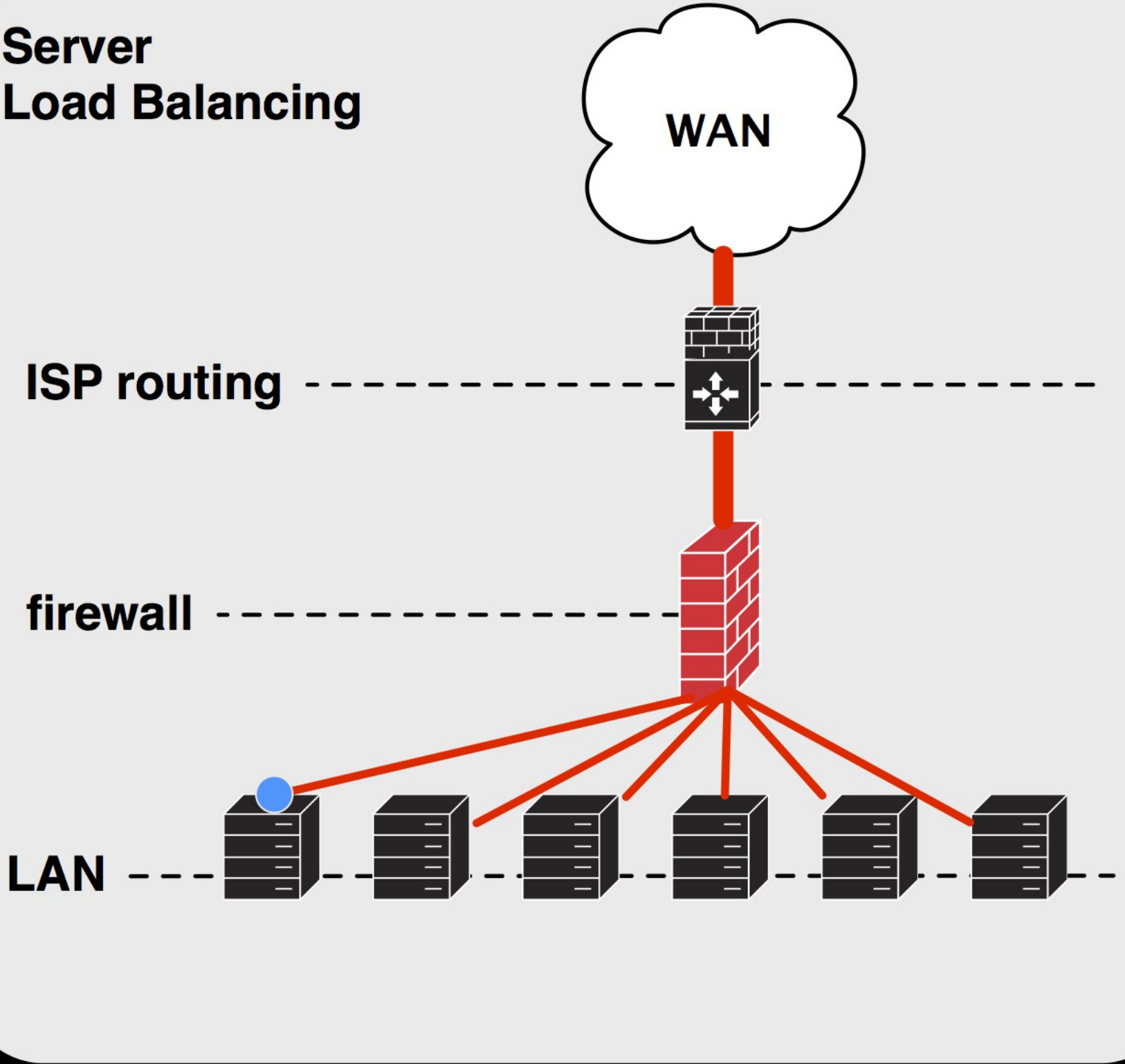
Server Load Balancing



Server Load Balancing

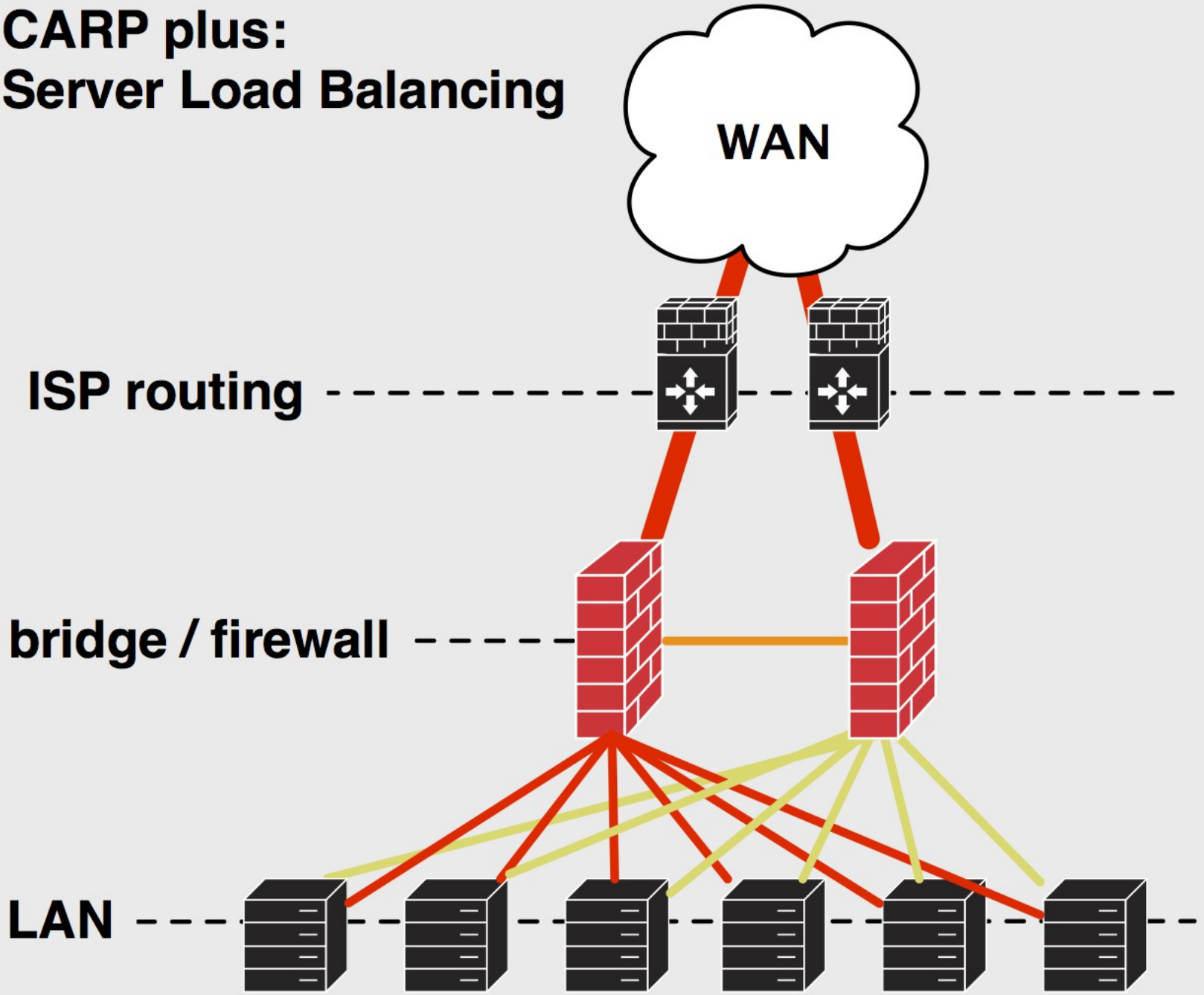


Server Load Balancing

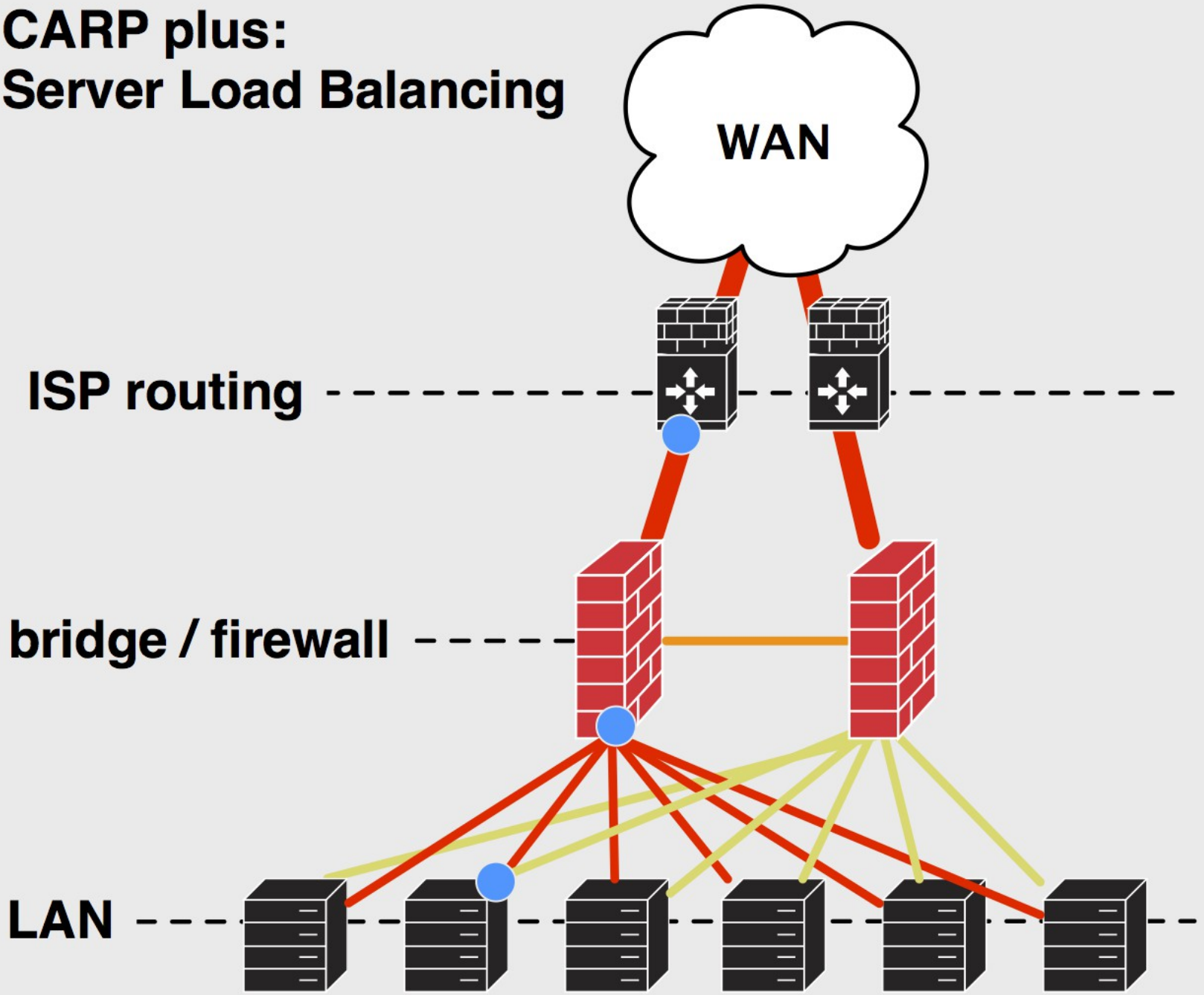


mix n’ match

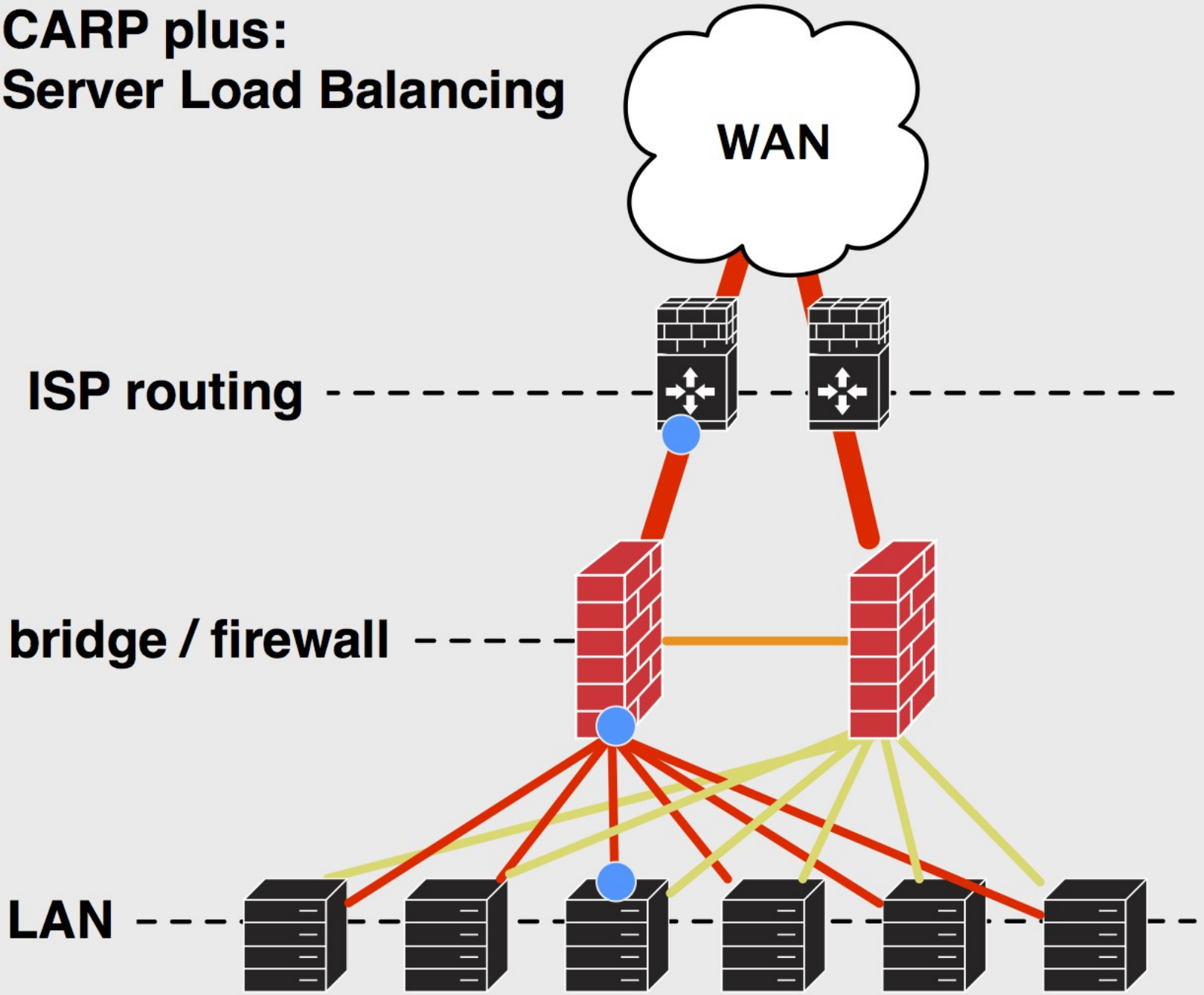
CARP plus:
Server Load Balancing



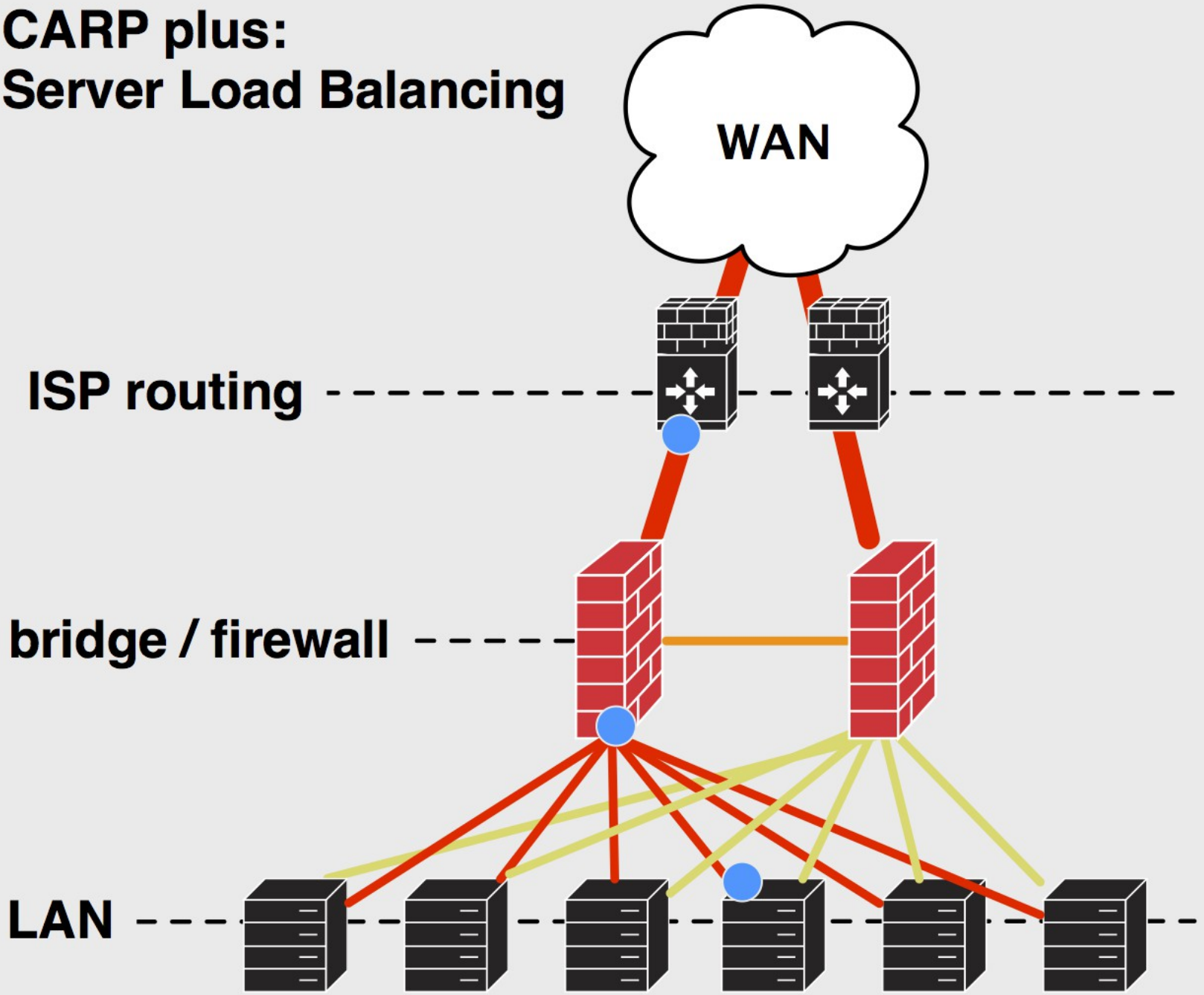
CARP plus:
Server Load Balancing



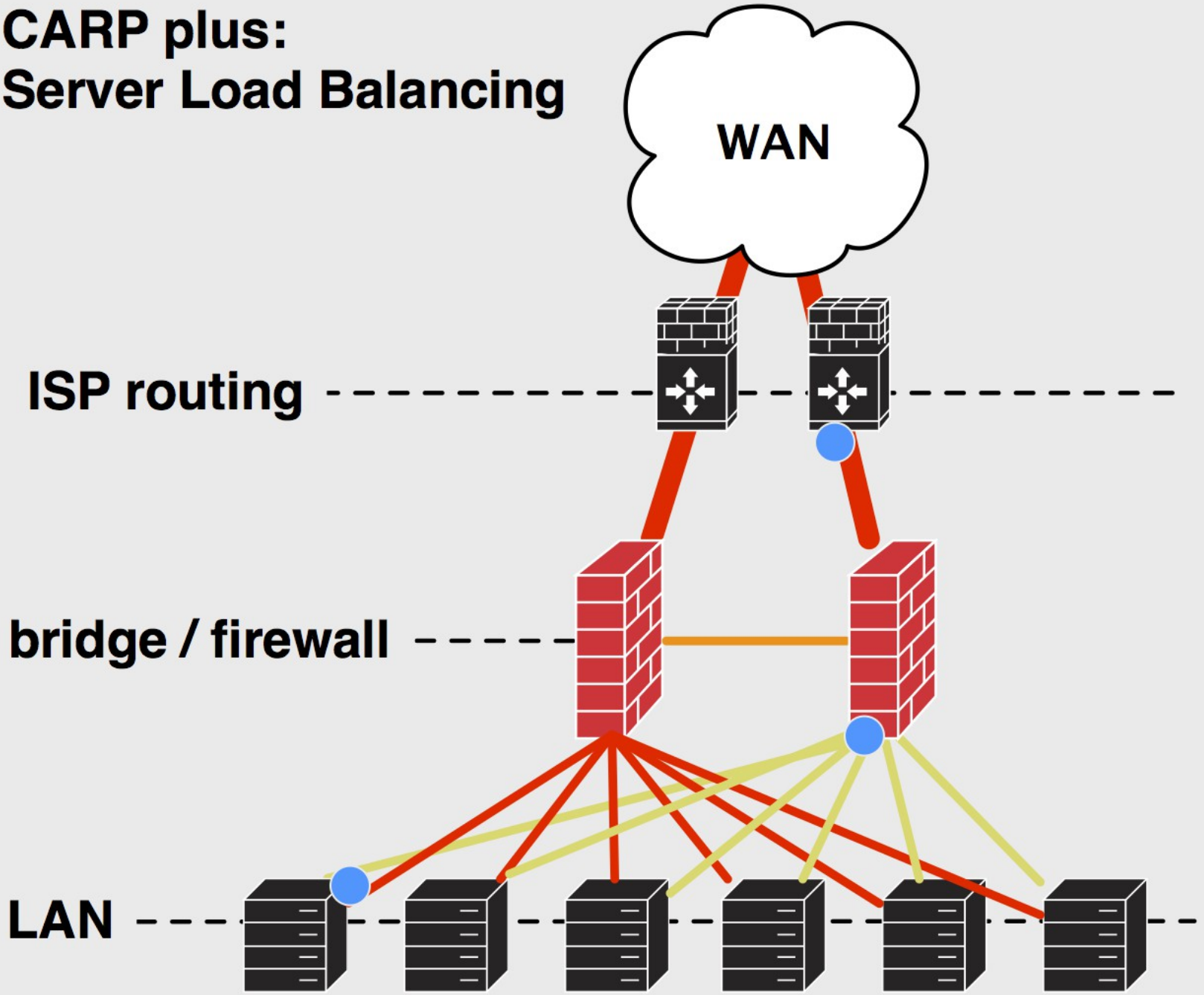
CARP plus:
Server Load Balancing



CARP plus:
Server Load Balancing



CARP plus:
Server Load Balancing



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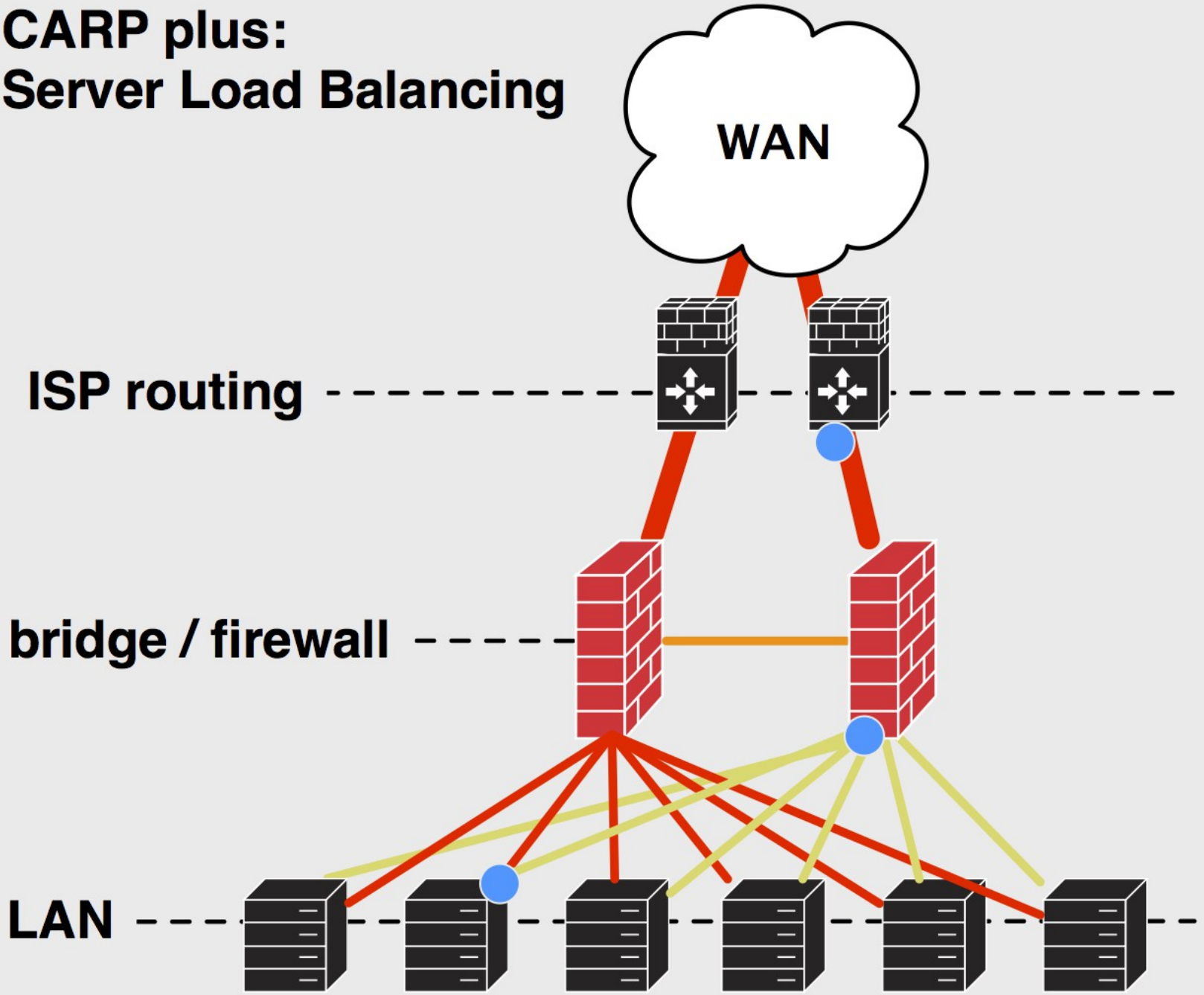

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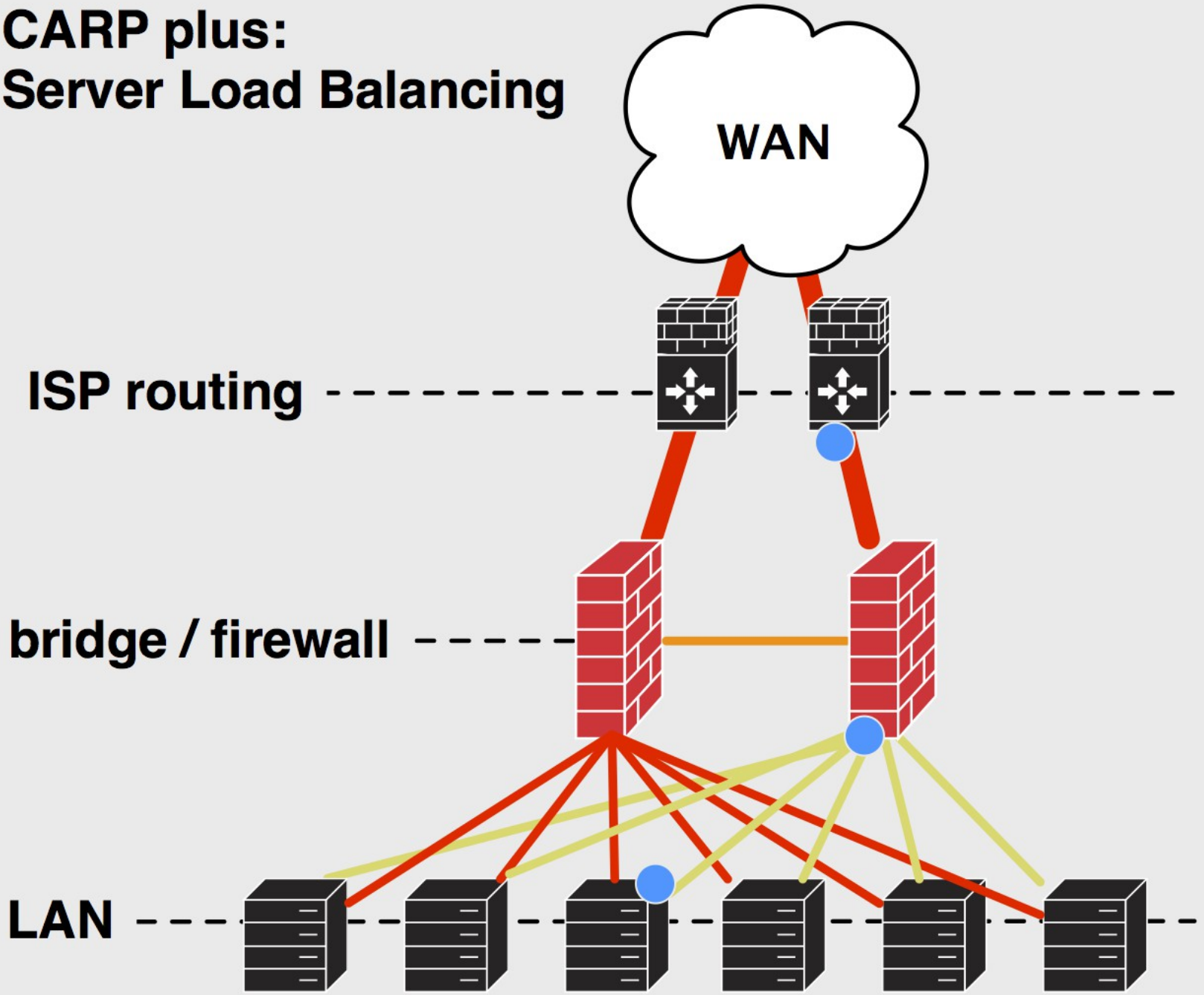

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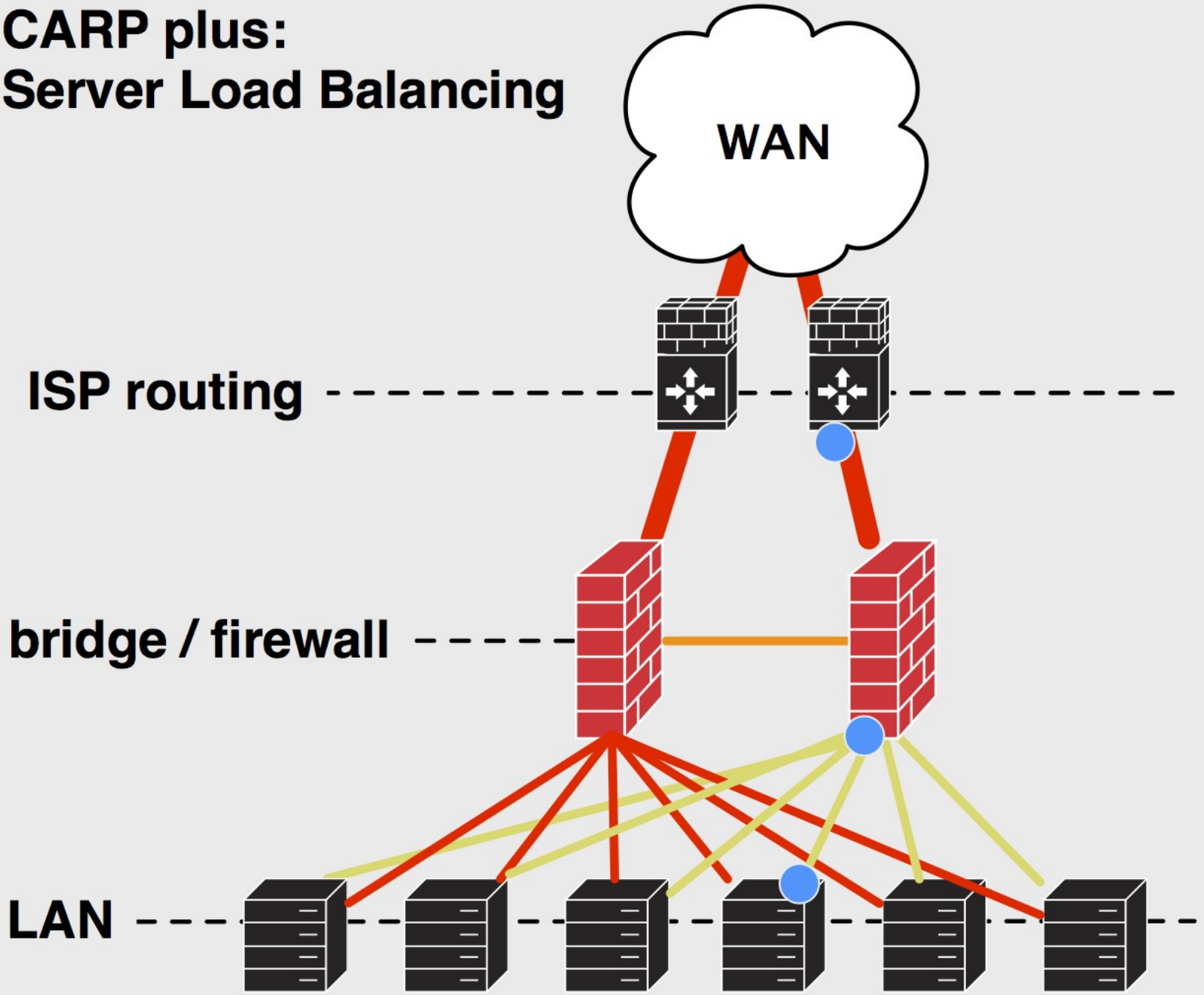


you get the idea

what does it take for one of these to do all that?


citrix

$ ¥ / ?

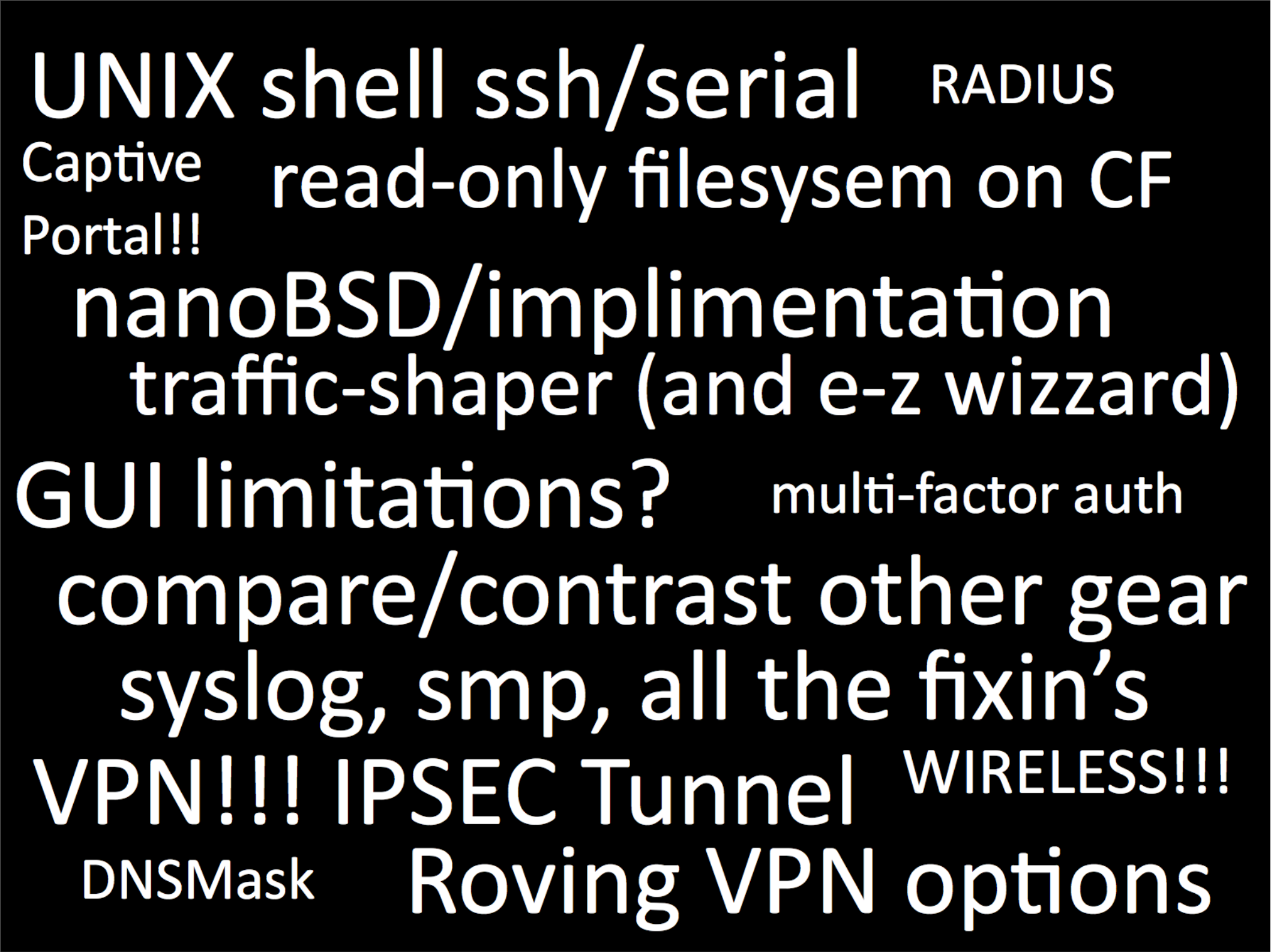

BARRACUDA
WAN
LAN
Load Balancer 340
BARRACUDA


BIG-IP
f5

Config Management

Config Management

- Downloadable XML file
  - That's it. Really.
- Accessable from Shell
  - (Be careful!)
- Contains hashed/plaintext for various 'important' items


UNIX shell ssh/serial
RADIUS
Captive Portal!!
read-only filesysem on CF
nanoBSD/implimentation
traffic-shaper (and e-z wizzard)
GUI limitations?
multi-factor auth
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VPN!!! IPSEC Tunnel
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DNSMask
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The Bleeding Edge Future?

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cisco / facebook / intel

Heck yeah! Facebook's Open Compute Project is making an open source switch

by Stacey Higginbotham MAY. 8, 2013 - 10:30 AM PST

6 Comments +1

A▼ A▲

Not content with open sourcing the server and storage hardware inside data centers, Facebook's Open Compute Project has teamed up with others to build an open source top of rack switch. Here's why it matters.

photo: Stacey Higginbotham

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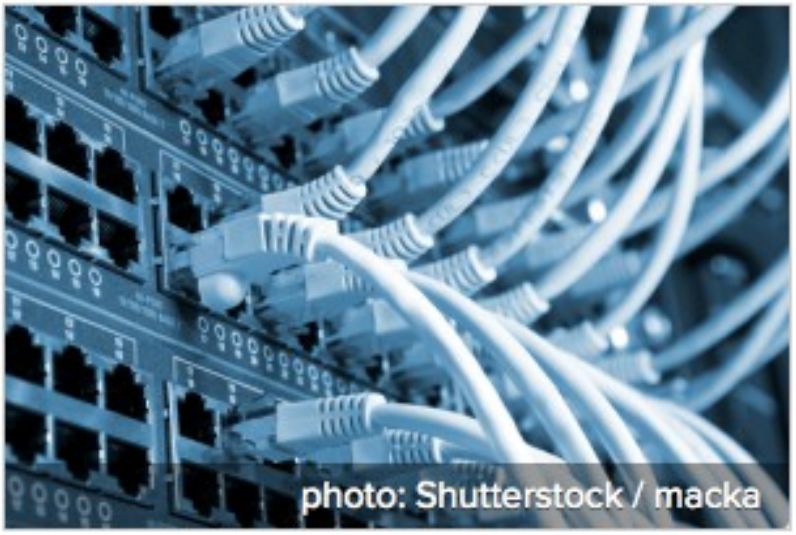
Facebook's hardware VP says we're very close to open source switches

by Derrick Harris NOV. 11, 2013 - 1:03 PM PST

SUMMARY: *The Facebook-led Open Compute Project is set to vote on four new specifications that would make open source networking switches and OS software a reality in the near future.*



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Six months ago, the Facebook-led Open Compute Project shared its plans to work with networking vendors on creating an open source top-of-rack switch, and now

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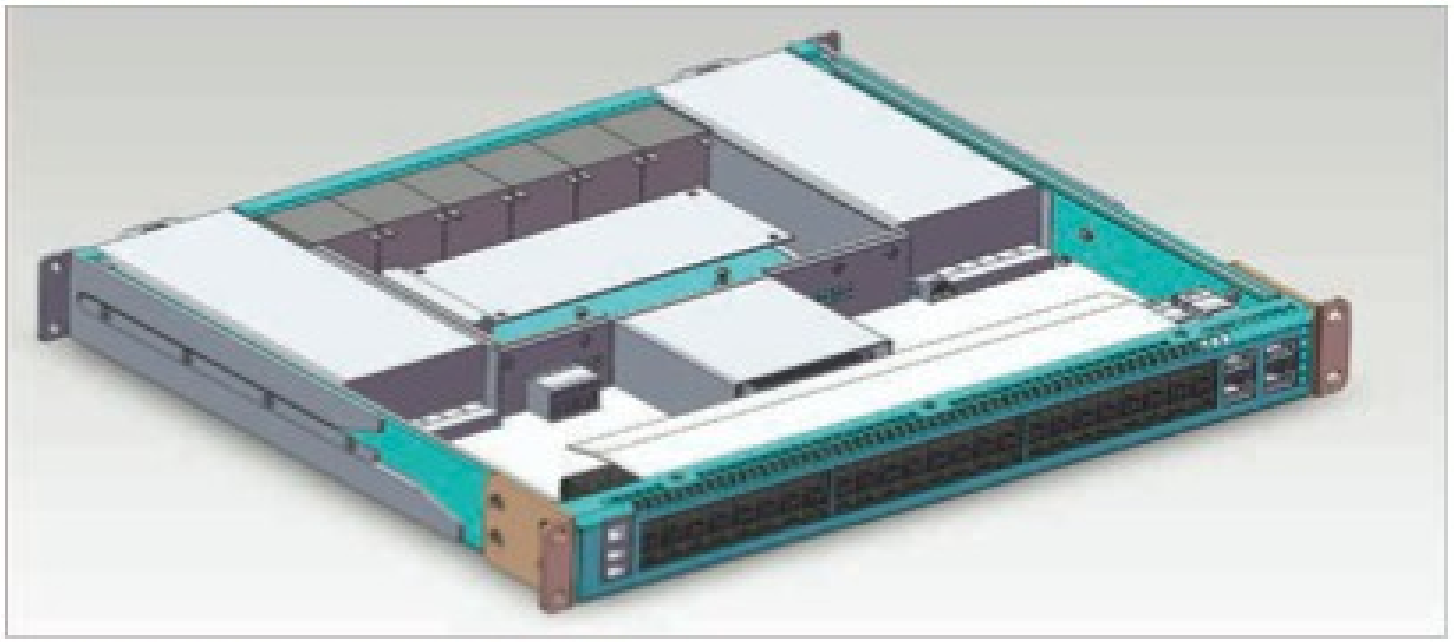
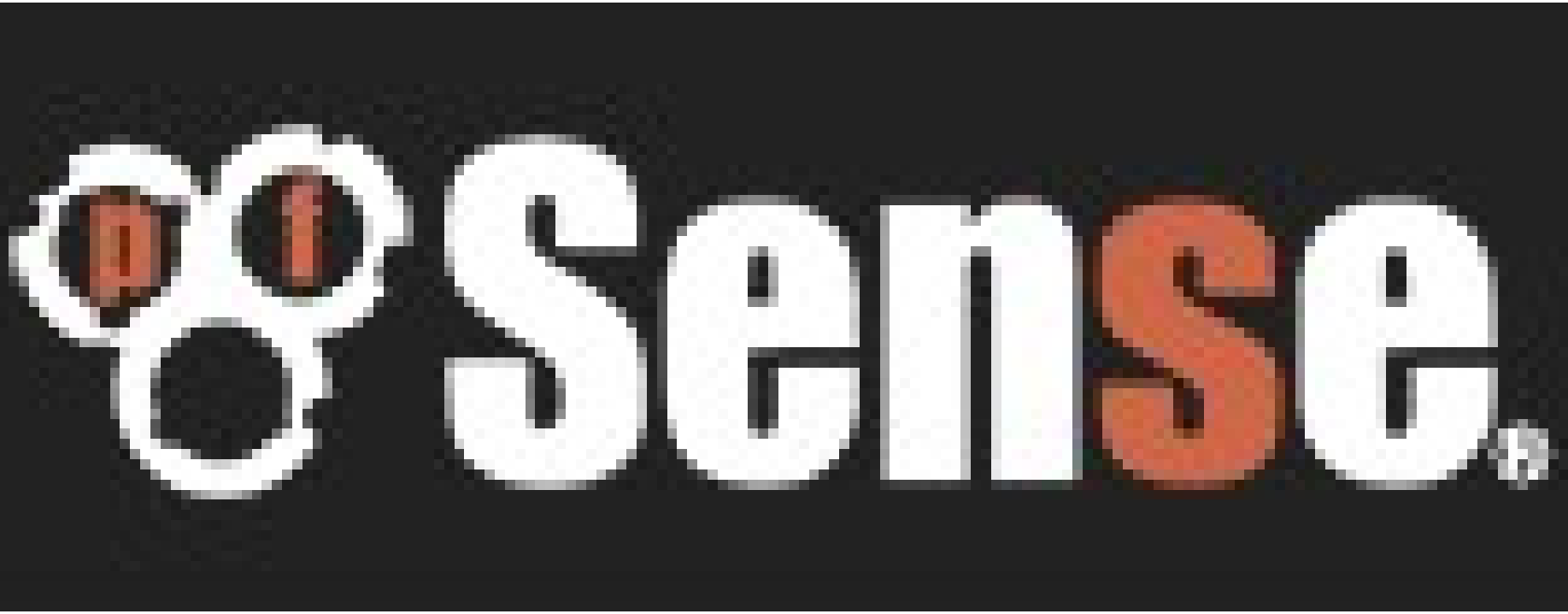
48 10 GbE ports plus four 40 GbE ports in a 1U, SDN-enabled ToR Switch

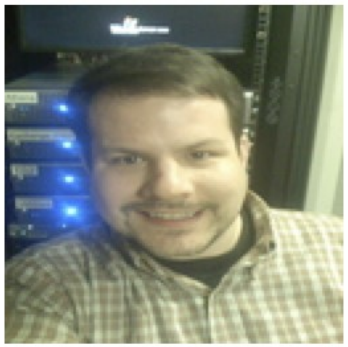
The Intel® Open Network Platform Switch Reference Design provides 48 SFP+ 10GbE and four QSFP 40GbE ports in a 1U top of rack (ToR) switch form factor. It includes the Intel® FM6764 Ethernet switch silicon, which supports enhanced features critical for today's SDN-enabled data center switching environments including low latency, scalability, L3 routing, data center bridging, as well as support for load balancing, NAT, NVGRE, VXLAN, TRILL, 802.1Qbg, 802.1Qbh, FCoE and DCBx. The Intel® FM6764 delivers tremendous flexibility using the advanced FlexPipe™ technology, while maintaining best-in-class latency and throughput. The reference platform also includes the Intel control plane processor codenamed Crystal Forest with the Cave Creek chip set on a pluggable AMC module.




Sense

Special Thanks to:

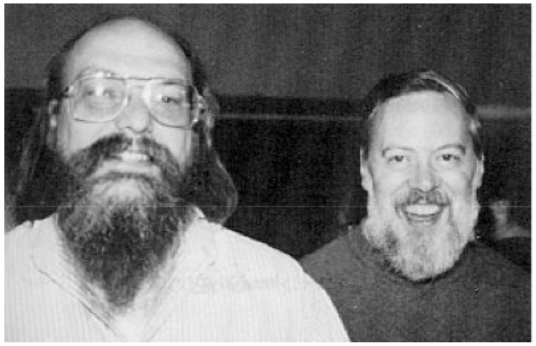
Chris Buechler



Scott Ullrich

(Plus all the pfSense Developers, and countless 3rd party software developers!)

and,



Ken and Dennis

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