Failover Firewalls with OpenBSD and CARP

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Introduction

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- Should be both a guardian and a guide
- Often a single point of failure
- Failover Firewalls are as vital as HA Application clusters
- Chicks dig redundancy

History of OpenBSD

- A leading secure UNIX-like operating system
- Emphasize code robustness and security
- Open licensing is crucial
- OpenBSD Packet Filter (PF) born out of IPFilter license change

PFSYNC Protocol

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- Other firewalls will update their own state tables
- Synchronized state == graceful failover

Before CARP

- OpenBSD lacked failover mechanism
- Virtual Router Redundancy Protocol (VRRP) assigns virtual gateway between physical routers
- Operates at OSI Layers 2 and 3
- Master/Backup relationship
- VRRP encumbered by Cisco patent

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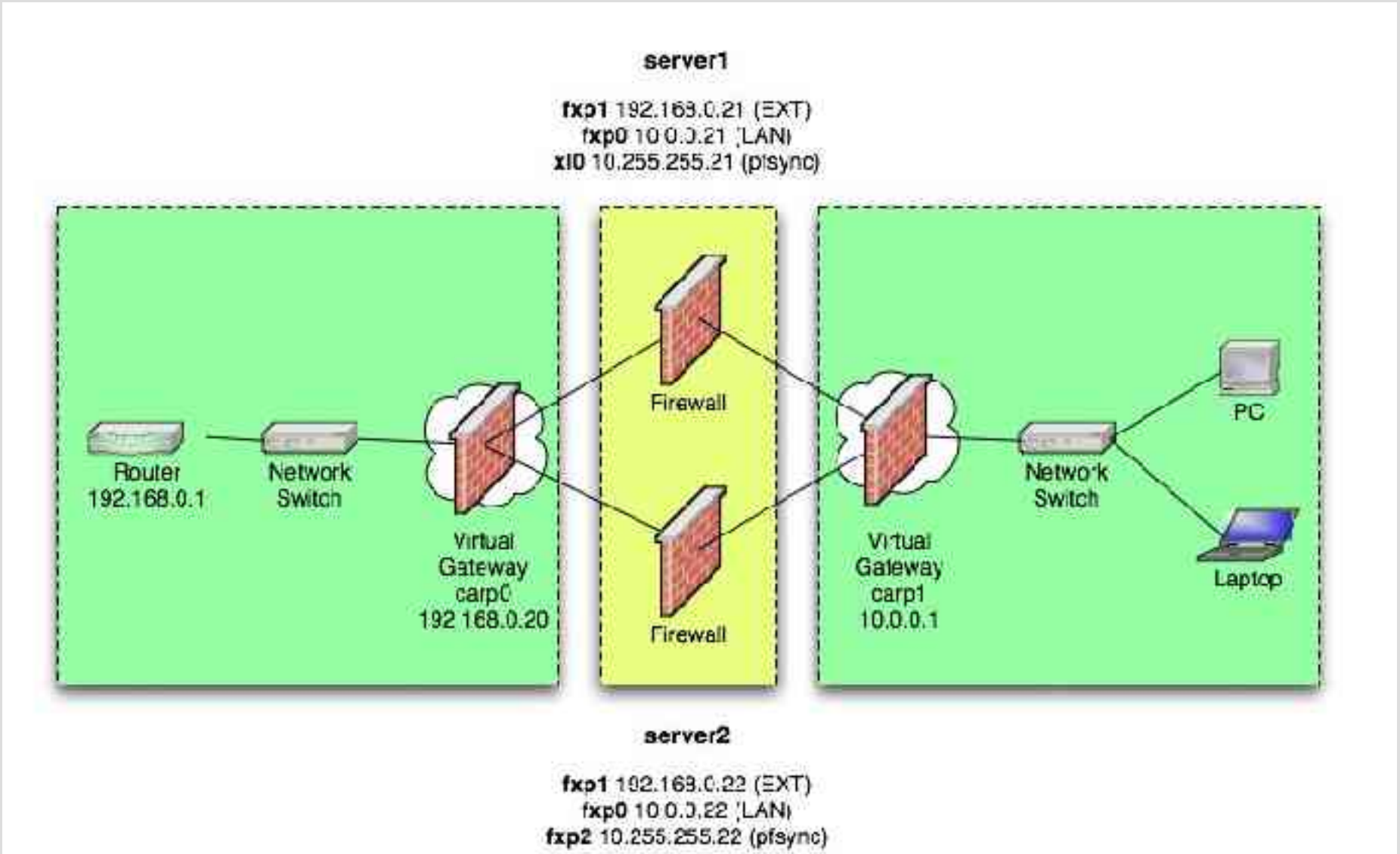
- Common Address Redundancy Protocol (IP Protocol 112)
- Addressed the need for a patent-free failover mechanism
- Virtual MAC and IP addresses
- Supports IPv4 and IPv6
- Also provides load-balancing, preemption, and crypto hashed announcements

Basic CARP Failover



Basic CARP Example

- Single CARP virtual host on each gateway

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- Virtual host ID (vhid)
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- Attach CARP device to interface (carpdev)

Basic CARP Example (cont'd)

- Auto-recovery (net.inet.carp.preempt)

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- Auto-recovery (net.inet.carp.preempt)
- Secure pfsync interface OR peer address (syncpeer) + IPSec
- Filter and translate on the physical interface
- Must allow PFSYNC and CARP protocols

Basic Filtering - pf.conf

```
# Macros
ext_if="fxp1"
int_if="fxp0"
pfsync_if="xl0"

# Options
set skip on { lo $int_if }

# Normalization
scrub in

# Translation
nat on $ext_if from $int_if:network \
    to any -> (carp0)


# cont'd ...
```

Basic Filtering - pf.conf

```
# ... cont'd


# Filtering
block in
pass out keep state
pass quick on { $ext_if $int_if } \
    proto carp keep state
pass quick on $pfsync_if proto pfsync
pass in on $ext_if inet proto icmp \
    icmp-type echoreq keep state
pass in on $ext_if inet proto tcp \
    port ssh flags S/SA keep state
pass out on $ext_if all keep state
```

Basic Setup – server1

```
server1# ifconfig carp0 vhid 1 pass foo \
> carpdev fxp1 192.168.0.20 255.255.255.0
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server1# ifconfig carp0 vhid 1 pass foo \
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server1# sysctl -w net.inet.carp.preempt=1
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Basic Setup – server2

```
server2# ifconfig carp0 vhid 1 pass foo \
> advskew 100 carpdev fxp1 \
> 192.168.0.20 255.255.255.0
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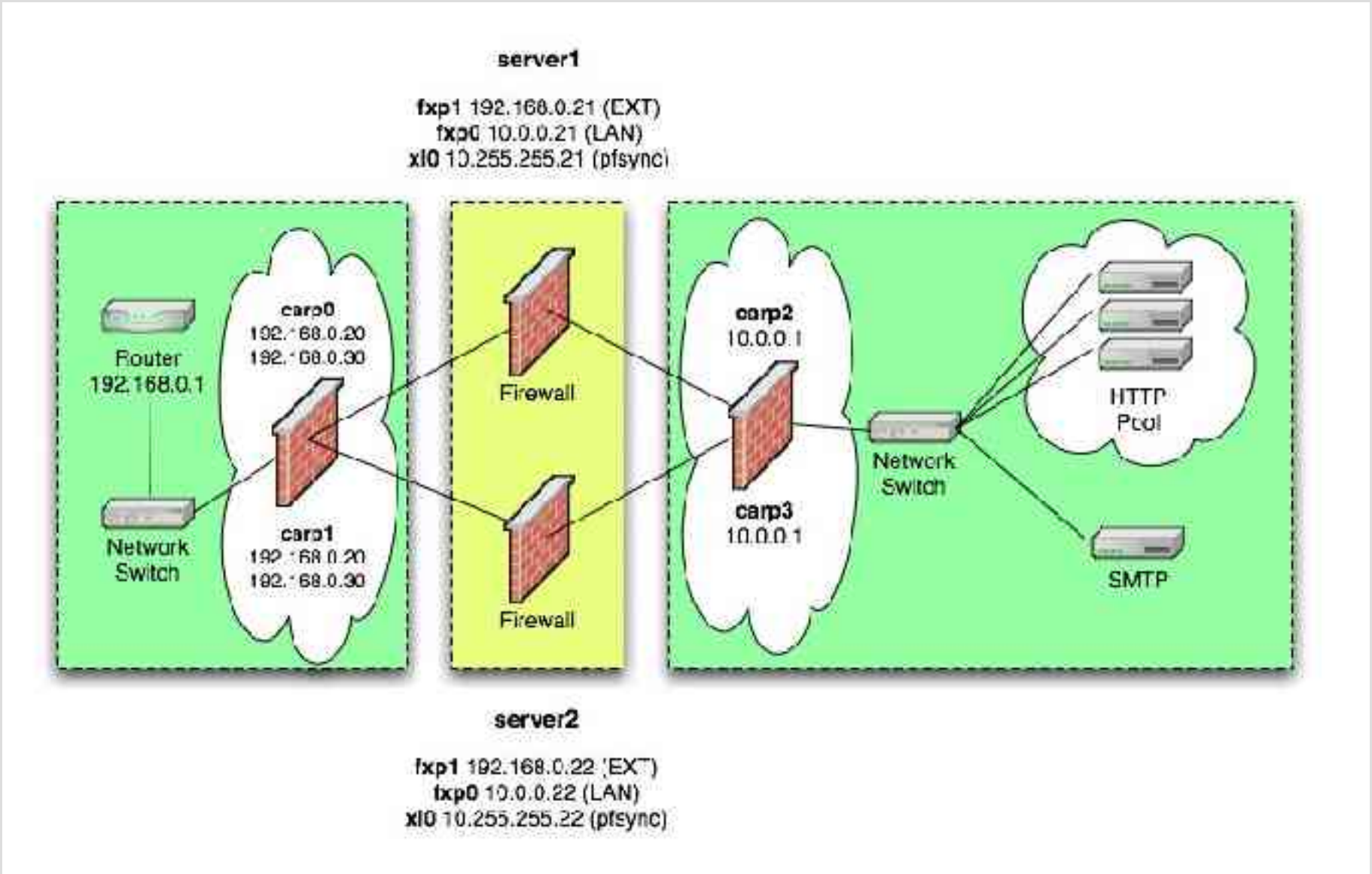
server2# pfctl -f /etc/pf.conf
```

Demonstration

Basic Example - Troubleshooting

- Tools:
  - Tcpdump, ifconfig, arp, pfctl, vmstat, pftop
- Items to check:
  - CARP, PFSYNC announcements
  - Interface state (MASTER, BACKUP, INIT)
  - LAN client settings (CARP gateway)
- Application tests:
  - Ping
  - Large file transfer (scp/sftp)
  - Multimedia over NFS
- Failover mechanisms:
  - Down CARP interface
  - Unplug ethernet cable
  - Power down CARP member

Advanced Failover with Load-Balancing



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- Virtual host ID (vhid) must be unique for each CARP interface on each segment
- Each CARP member will serve as MASTER for one CARP interface, and BACKUP as the other
- Load-balance at the packet level (net.inet.carp.arpbalance)

Advanced Filtering - pf.conf

```
# Macros
ext_if="fxp1"
int_if="fxp0"
pfsync_if="xl0"
http_ext="192.168.0.20"
http_int="10.0.0.50"
smtp_ext=”192.168.0.30”
smtp_int=”10.0.0.60”

# Options
set skip on { lo $int_if }

# Normalization
scrub in

# Translation
binat on $ext_if from any to $smtp_ext \
    -> $smtp_int
rdr on $ext_if from any to $http_ext \
    port http -> $http_int source-hash


# cont'd ...
```

Advanced Filtering - pf.conf

```
# ... cont'd

# Filters
block in
pass quick on { $ext_if $int_if } \
    proto carp keep state
pass quick on $pfsync_if proto pfsync
pass in on $ext_if inet proto icmp \
    icmp-type echoreq keep state
pass in on $ext_if inet proto tcp \
    from any to ($ext_if) port ssh \
    flags S/SA keep state
pass in on $ext_if inet proto tcp \
    from any to $smtp_int port smtp \
    flags S/SA keep state
pass in on $ext_if inet proto tcp \
    from any to $http_int port http \
    flags S/SA keep state
pass out on $ext_if keep state

# EOF
```

Advanced Setup - server1

```
server1# ifconfig carp0 vhid 1 pass foo carpdev fxp1 \
> 192.168.0.20 255.255.255.0

server1# ifconfig carp0 vhid 1 pass foo carpdev fxp1 \
> alias 192.168.0.30 255.255.255.0

server1# ifconfig carp1 vhid 2 pass foo carpdev fxp1 \
> advskew 100 192.168.0.20 255.255.255.0

server1# ifconfig carp1 vhid 2 pass foo carpdev fxp1 \
> advskew 100 alias 192.168.0.30 255.255.255.0

server1# ifconfig carp2 vhid 1 pass bar carpdev fxp0 \
> 10.0.0.1 255.255.255.0

server1# ifconfig carp3 vhid 2 pass bar carpdev fxp0 \
> advskew 100 10.0.0.1 255.255.255.0

server1# sysctl -w net.inet.carp.arpbalance=1
net.inet.carp.arpbalance: 0 -> 1
```

Advanced Setup - server2

```
server2# ifconfig carp0 vhid 1 pass foo carpdev fxp1 \
> advskew 100 192.168.0.20 255.255.255.0

server2# ifconfig carp0 vhid 1 pass foo carpdev fxp1 \
> advskew 100 alias 192.168.0.30 255.255.255.0

server2# ifconfig carp1 vhid 2 pass foo carpdev fxp1 \
> 192.168.0.20 255.255.255.0

server2# ifconfig carp1 vhid 2 pass foo carpdev fxp1 \
> alias 192.168.0.30 255.255.255.0

server2# ifconfig carp2 vhid 1 pass bar carpdev fxp0 \
> advskew 100 10.0.0.1 255.255.255.0

server2# ifconfig carp3 vhid 2 pass bar carpdev fxp0 \
> 10.0.0.1 255.255.255.0

server2# sysctl -w net.inet.carp.arpbalance=1
net.inet.carp.arpbalance: 0 -> 1
```

Brief Intermission

sasyncd

- IPSec SA synchronization daemon

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- Messages encrypted using AES key
- /etc/sasyncd.conf
- Shared IPSec keys for CARP hosts

IPSec Failover Setup – CARP hosts

```
server1# cat /etc/hostname.carp0
vhid 1 pass foo carpdev fxp1 192.168.0.20 255.255.255.0
!ipsecadm flush
!ipsecadm flow -addr 10.0.0.0/24 10.10.10.0/24 \
    -src 192.168.0.20 -dst 192.168.0.23 \
    -proto esp -out -require
!ipsecadm flow -addr 10.10.10.0/24 10.0.0.0/24 \
    -src 192.168.0.20 -dst 192.168.0.23 \
    -proto esp -in -require
!sasyncd


server1# cat /etc/sasyncd.conf
carp interface carp0
peer 10.255.255.22
sharedkey /etc/sasyncd.key
```

Summary

- HA Firewall & VPN solution
- Commodity hardware
- Available for all BSDs and Linux (uCARP)
- Competes with (or exceeds) functionality of commercial offerings

References

- OpenBSD -- http://www.openbsd.org/
- PF -- http://www.benzedrine.cx/pf.html
- VRRP RFC 3768 -- http://www.faqs.org/rfcs/rfc3768.html
- OpenBSD FAQ -- http://www.openbsd.org/faq/index.html
- PF User's Guide -- http://www.openbsd.org/faq/pf/index.html
- Userland CARP -- http://www.ucarp.org/

Stateful Failover