Jail vnet by Examples

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To understand the Virtual Network feature (vnet), not to be confused with vtnet(4) for VirtIO Ethernet driver, let's begin with an extract from the vnet(9) man page:

```
DESCRIPTION
     vnet is the name of a technique to virtualize the network stack.
     (...).
     Each (virtual) network stack is attached to a prison, with vnet0
     being the unrestricted default network stack of the base system.
```

As a related prison feature, let's check the jail(8) man page section about vnet:

```
vnet     Create the jail with its own virtual network stack, with its own
         network interfaces, addresses, routing table, etc.  The kernel
         must have been compiled with the VIMAGE option for this to be
         available.  Possible values are "inherit" to use the system
         network stack, possibly with restricted IP addresses, and "new"
         to create a new network stack.
```

To resume, it's a feature that allows each jail to have its own routing table / ARD & NDP cache and interfaces

Vocabulary

- Host: The system hosting your jails

Examples

These examples use "empty" jails based on the host '/' to focus only on the vnet feature. They will all be in "persist" mode (because no processes are running).

Concerning the OS requirements:

- The shell used is /bin/sh.
- FreeBSD 12.1 minimum (can be 12-STABLE or even better a -head)

Useless Isolated vnet Jail

This useless example shows how to create an isolated vnet jail.

Command line parameters details:

- -c: create a new jail
- name: Name of the jail to avoid using its jail ID (JID) later
- host.hostname: For this example, only used to have a pretty output with command 'jls'
- persist: There is no process running on this jail, so force it running
- vnet: Enable the virtual network stack

```
# jail -c name=useless host.hostname=jvnet persist vnet
# jls
   JID  IP Address      Hostname                      Path
     1                  jvnet                         /
```

Here is the default network interface assigned and the content of its routing table for this new jail.

```
# jexec useless ifconfig
lo0: flags=8008<LOOPBACK,MULTICAST> metric 0 mtu 16384
        options=680003<RXCSUM,TXCSUM,LINKSTATE,RXCSUM_IPV6,TXCSUM_IPV6>
        groups: lo
        nd6 options=21<PERFORMNUD,AUTO_LINKLOCAL>
# jexec useless netstat -rn
Routing tables
```

There is an unconfigured loopback (disabled and no IP addresses assigned) and an empty routing table. Let's fix that.

```
# jexec useless service netif restart
Stopping Network: lo0.
lo0: flags=8008<LOOPBACK,MULTICAST> metric 0 mtu 16384
        options=680003<RXCSUM,TXCSUM,LINKSTATE,RXCSUM_IPV6,TXCSUM_IPV6>
        groups: lo
        nd6 options=21<PERFORMNUD,AUTO_LINKLOCAL>
Starting Network: lo0.
lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> metric 0 mtu 16384
        options=680003<RXCSUM,TXCSUM,LINKSTATE,RXCSUM_IPV6,TXCSUM_IPV6>
        inet6 ::1 prefixlen 128
        inet6 fe80::1%lo0 prefixlen 64 scopeid 0x1
        inet 127.0.0.1 netmask 0xff000000
        groups: lo
        nd6 options=21<PERFORMNUD,AUTO_LINKLOCAL>
# jexec useless netstat -rn
Routing tables

Internet:
Destination        Gateway            Flags      Netif Expire
127.0.0.1          link#1             UH           lo0
```

```
Internet6:
Destination                       Gateway                       Flags     Netif Expire
::1                               link#1                        UH          lo0
fe80::%lo0/64                     link#1                        U           lo0
fe80::1%lo0                       link#1                        UHS         lo0
```

This is a lot better! But we only have the loopback interface running. The next step is to create a virtual Ethernet tap interface and assign it to the jail. The ifconfig(8) man page extract:

```
vnet jail
        Move the interface to the jail(8), specified by name or JID.  If
        the jail has a virtual network stack, the interface will
        disappear from the current environment and become visible to the
        jail.
```

Let's do this:

```
# TAP=$(ifconfig tap create)
# ifconfig $TAP
tap0: flags=8802<BROADCAST,SIMPLEX,MULTICAST> metric 0 mtu 1500
        options=80000<LINKSTATE>
        ether 00:bd:70:98:00:00
        groups: tap
        media: Ethernet autoselect
        status: no carrier
        nd6 options=29<PERFORMNUD,IFDISABLED,AUTO_LINKLOCAL>
# ifconfig $TAP vnet useless
# ifconfig $TAP
ifconfig: interface tap0 does not exist
```

What happened? Just after we enabled the interface and assigned it to the jail, it disappeared! That is the expected behavior because this interface doesn't belong to your host network stack anymore. You can check its status on the jail and even assign an IP address to it:

```
# jexec useless ifconfig $TAP
tap0: flags=8802<BROADCAST,SIMPLEX,MULTICAST> metric 0 mtu 1500
        options=80000<LINKSTATE>
        ether 00:bd:70:98:00:00
        groups: tap
        media: Ethernet autoselect
        status: no carrier
        nd6 options=21<PERFORMNUD,AUTO_LINKLOCAL>
# jexec useless ifconfig $TAP inet 192.0.2.1/24 up
# jexec useless ifconfig $TAP inet
tap0: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> metric 0 mtu 1500
        options=80000<LINKSTATE>
        inet 192.0.2.1 netmask 0xffffff00 broadcast 192.0.2.255
# jexec useless ping -c 2 192.0.2.1
```

```
PING 192.0.2.1 (192.0.2.1): 56 data bytes
64 bytes from 192.0.2.1: icmp_seq=0 ttl=64 time=0.248 ms
64 bytes from 192.0.2.1: icmp_seq=1 ttl=64 time=0.525 ms

--- 192.0.2.1 ping statistics ---
2 packets transmitted, 2 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 0.248/0.387/0.525/0.139 ms
# jexec useless arp -na
? (192.0.2.1) at 00:bd:70:98:00:00 on tap0 permanent [ethernet]
# arp -na | grep 192.0.2.1
#
```

The jail can ping its own interface, its own ARP cache is populated with the corresponding entry, and all of these are isolated from the host networking stack.

It's the same for the routing table:

```
# jexec useless route add -net 198.51.100.0/24 192.0.2.2
add net 198.51.100.0: gateway 192.0.2.2
# jexec useless netstat -4rn
Routing tables

Internet:
Destination        Gateway            Flags     Netif Expire
127.0.0.1          link#1             UH          lo0
192.0.2.0/24       link#2             U          tap0
192.0.2.1          link#2             UHS         lo0
198.51.100.0/24    192.0.2.2          UGS        tap0
# netstat -4rn | grep 198.51.100.0
#
```

Before continuing to the next example, we will clean up the existing jail and destroy the tap interface. We need to use the -R (upper case) option to remove a jail created without a configuration file. Using option -r (lower case), the vnet interface will not be removed to the host automatically.

```
# jail -R useless
# ifconfig $TAP destroy
```

vnet Jail Connected to the Host

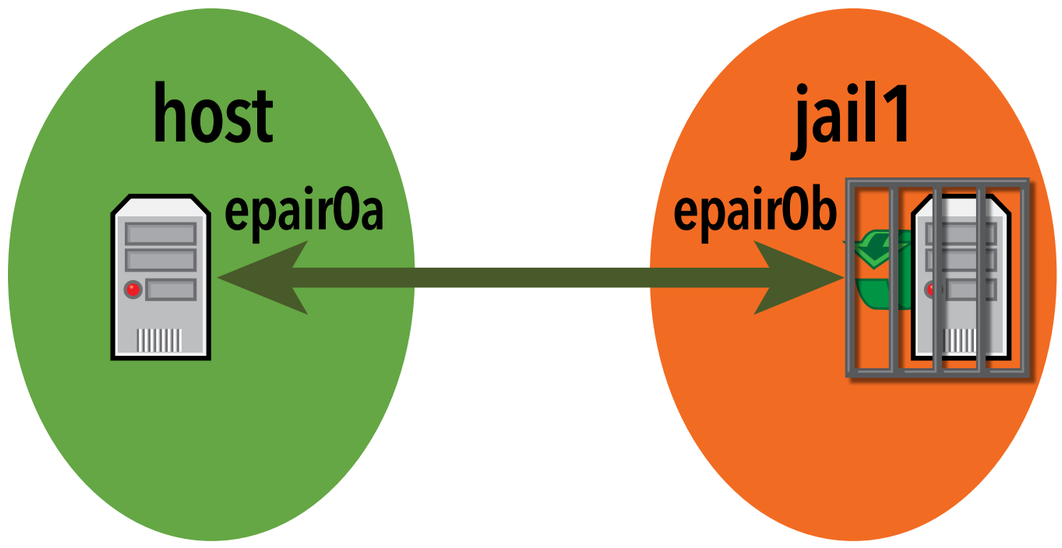
This example shows how to communicate between the jail and the host itself. The main problem is that any interface put into a vnet will disappear from the host networking stack.

So, we could imagine this setup:

1. Create a bridge and assign an IP address to it
2. Create a tap interface and add it into the bridge
3. Assign the tap interface to the jvnet jail

But this will not work. The TAP interface will move from the host (=disappear from the host) to join the jail's vnet, and so it will disappear from the bridge too!

To solve this problem, the epair(4) interface (Ethernet pair) was created. This special network interface represents two interfaces (epairXa and epairXb) that will behave like two Ethernet interfaces cross-connected between them. By assigning each side to a different vnet, they will still exchange frames between them.



Start by creating a new epair pair.

```
# ifconfig epair create
epair0a
# ifconfig -g epair
epair0b
epair0a
```

The host is showing its two new interfaces: epair0a and epair0b.
Create a new jail, named “jvnet” and assign interface epair0b to it.

```
# jail -c name=jvnet host.hostname=jvnet persist vnet vnet.interface=epair0b
```

Interface epair0b no longer belongs to the host system network stack, but the other epair0a still does! Let’s configure an IP address on epair0a.

```
# ifconfig -g epair
epair0a
# ifconfig epair0a inet 192.0.2.1/24 up
```

Then do the same on epair0b belonging to the jail and check their connectivity.

```
# jexec jvnet ifconfig epair0b inet 192.0.2.2/24 up
# ping -c 2 192.0.2.2
PING 192.0.2.2 (192.0.2.2): 56 data bytes
64 bytes from 192.0.2.2: icmp_seq=0 ttl=64 time=0.285 ms
64 bytes from 192.0.2.2: icmp_seq=1 ttl=64 time=0.532 ms

--- 192.0.2.2 ping statistics ---
2 packets transmitted, 2 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 0.285/0.408/0.532/0.124 ms
# arp -na | grep 192.0.2.
? (192.0.2.2) at 02:77:29:04:9e:0b on epair0a expires in 1139 seconds [ethernet]
? (192.0.2.1) at 02:77:29:04:9e:0a on epair0a permanent [ethernet]
```

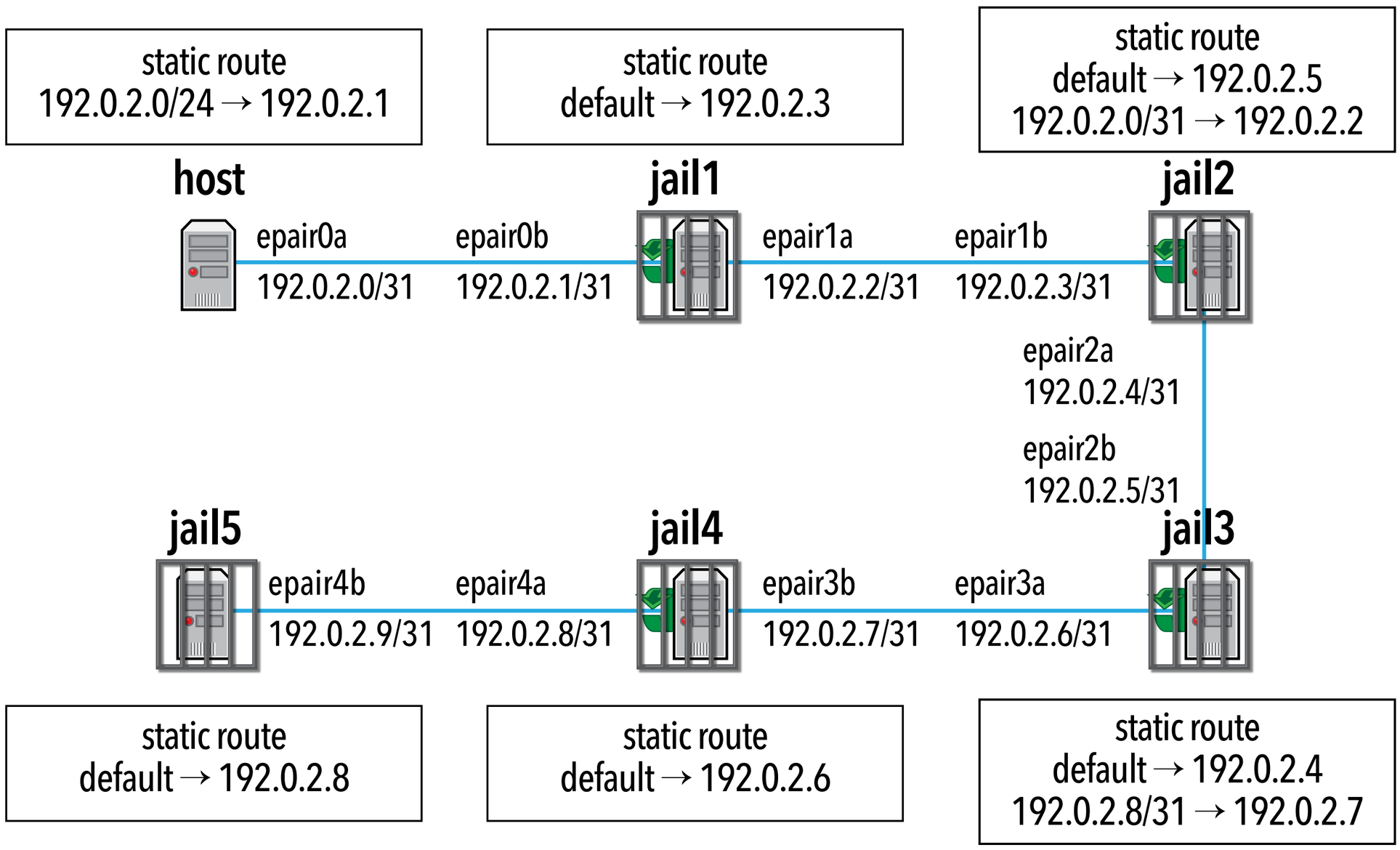
By displaying their MAC address, you will notice that epair are using specific MAC address. Destroy this jail and the epair pair interfaces before continuing to the next example:

```
# jail -R jvnet
# ifconfig epair0a destroy
```

Now that we've got a basic setup working, let's complexify a little more using multiple jails configured in serial and with routing between them.

Chained Routed vnet Jails

In this example we will create four jails to route traffic from the host toward a fifth jail.



Start to generate the five epairs with a first loop.

```
# for i in $(jot 5); do ifconfig epair create; done
epair0a
epair1a
epair2a
epair3a
epair4a
```

Then generate five jails with epair assigned to them with a mix of loop and manual assignment.

```
# for i in $(jot 4); do jail -c name=hop$i host.hostname=hop$i persist vnet \
vnet.interface=epair$((i-1))b vnet.interface=epair${i}a; done
# jail -c name=hop5 host.hostname=hop5 persist vnet vnet.interface=epair4b
# jls
   JID  IP Address      Hostname                      Path
     3                  hop1                          /
     4                  hop2                          /
```

```
5               hop3                    /
6               hop4                    /
7               hop5                    /
```

Now configure IP addresses, enable routing on some jails, and set the static routes.

```
# ifconfig epair0a inet 192.0.2.0/31 up
# jexec hop1 ifconfig epair0b inet 192.0.2.1/31 up
# jexec hop1 ifconfig epair1a inet 192.0.2.2/31 up
# jexec hop2 ifconfig epair1b inet 192.0.2.3/31 up
# jexec hop2 ifconfig epair2a inet 192.0.2.4/31 up
# jexec hop3 ifconfig epair2b inet 192.0.2.5/31 up
# jexec hop3 ifconfig epair3a inet 192.0.2.6/31 up
# jexec hop4 ifconfig epair3b inet 192.0.2.7/31 up
# jexec hop4 ifconfig epair4a inet 192.0.2.8/31 up
# jexec hop5 ifconfig epair4b inet 192.0.2.9/31 up
# for i in $(jot 4); do jexec hop$i sysctl net.inet.ip.forwarding=1; done
net.inet.ip.forwarding: 0 -> 1
net.inet.ip.forwarding: 0 -> 1
net.inet.ip.forwarding: 0 -> 1
net.inet.ip.forwarding: 0 -> 1
# route add 192.0.2.0/24 192.0.2.1
add net 192.0.2.0: gateway 192.0.2.1
# jexec hop1 route add default 192.0.2.3
add net default: gateway 192.0.2.3
# jexec hop2 route add default 192.0.2.5
add net default: gateway 192.0.2.5
# jexec hop2 route add 192.0.2.0/31 192.0.2.2
add net 192.0.2.0: gateway 192.0.2.2
# jexec hop3 route add default 192.0.2.4
add net default: gateway 192.0.2.4
# jexec hop3 route add 192.0.2.8/31 192.0.2.7
add net 192.0.2.8: gateway 192.0.2.7
# jexec hop4 route add default 192.0.2.6
add net default: gateway 192.0.2.6
# jexec hop5 route add default 192.0.2.8
add net default: gateway 192.0.2.8
```

Test your setup by pinging the fifth jail from the host network stack.

```
# ping -c 2 192.0.2.9
PING 192.0.2.9 (192.0.2.9): 56 data bytes
64 bytes from 192.0.2.9: icmp_seq=0 ttl=60 time=0.265 ms
64 bytes from 192.0.2.9: icmp_seq=1 ttl=60 time=0.482 ms

--- 192.0.2.9 ping statistics ---
2 packets transmitted, 2 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 0.265/0.373/0.482/0.108 ms
```

```
# traceroute -n 192.0.2.9
traceroute to 192.0.2.9 (192.0.2.9), 64 hops max, 40 byte packets
 1  192.0.2.1  0.060 ms  0.243 ms  0.244 ms
 2  192.0.2.3  0.180 ms  0.202 ms  0.263 ms
 3  192.0.2.5  0.050 ms  0.159 ms  0.205 ms
 4  192.0.2.7  0.194 ms  0.197 ms  0.191 ms
 5  192.0.2.9  0.261 ms  0.201 ms  0.188 ms
```

Optionally, add a little more fun to this setup (with a big IPv6 range it should be easy to automate a text-to-traceroute script populating DNS configuration file).

```
# cat >> /etc/hosts <<EOF
? 192.0.2.1 once.upon.a.time.in.the.middle
? 192.0.2.3 of.winter.when.the.flakes.of
? 192.0.2.5 snow.were.failling.like
? 192.0.2.7 feathers.from.the.sky
? 192.0.2.9 a.queen.sat.at.a.window.sewing
? EOF
# traceroute 192.0.2.9
traceroute to 192.0.2.9 (192.0.2.9), 64 hops max, 40 byte packets
 1  once.upon.a.time.in.the.middle (192.0.2.1) 0.237 ms  0.508 ms  0.540 ms
 2  of.winter.when.the.flakes.of (192.0.2.3) 0.489 ms  0.361 ms  0.373 ms
 3  snow.were.failling.like (192.0.2.5) 0.343 ms  0.337 ms  0.285 ms
 4  feathers.from.the.sky (192.0.2.7) 0.255 ms  0.296 ms  0.271 ms
 5  a.queen.sat.at.a.window.sewing (192.0.2.9) 0.328 ms  0.271 ms  0.242 ms
```

Going Further

Connecting Jails with the Outside World

Multiple choice here:

1. With SR-IOV compliant NIC, generate multiple Virtual NIC and assign them to the jails.
2. Virtual-Interface (drivers specific)
3. Using VLAN and assigning VLAN interfaces to each jail, the limitation is one jail per VLAN maximum per Ethernet port.
4. Using if_bridge interface (and it's possible to mix with VLAN, too) is the easiest setup but there is some performance penalty when using if_bridge.

SR-IOV

This feature, initially designed for virtual machine use, creates multiple Virtual Function (VF = Virtual NIC in our case). And by using the default non-passthrough mode, it will present multiple virtual NIC to the host, each of which could be attached to vnet-jail.

Here is an example using two Chelsios interfaces (cxl0 and cxl1) to create 10 VF for each.

```
# sysrc iovctl_files="/etc/iovctl.cxl0.conf /etc/iovctl.cxl1.conf"
# sysrc kld_list+=if_cxgbev
# cat > /etc/iovctl.cxl0.conf <<EOF
? PF {
? device : "cxl0";
? num_vfs : 10;
```

```
? }
? EOF
# cat > /etc/iovctl.cxl1.conf <<EOF
? PF {
? device : "cxl1";
? num_vfs : 10;
? }
? EOF
# iovctl -C -f /etc/iovctl.cxl0.conf
# iovctl -C -f /etc/iovctl.cxl1.conf
# kldload if_cxgbev
# tail /var/log/messages
(...) kernel: t5vf18: <Chelsio T540-CR VF> at device 0.41 on pci4
(...) kernel: cxlv18: <port 0> on t5vf18
(...) kernel: cxlv18: Ethernet address: 06:44:2e:e5:90:18
(...) kernel: cxlv18: 2 txq, 1 rxq (NIC)
(...) kernel: t5vf18: 1 ports, 2 MSI-X interrupts, 4 eq, 2 iq
(...) kernel: t5vf19: <Chelsio T540-CR VF> at device 0.45 on pci4
(...) kernel: cxlv19: <port 0> on t5vf19
(...) kernel: cxlv19: Ethernet address: 06:44:2e:e5:90:19
(...) kernel: cxlv19: 2 txq, 1 rxq (NIC)
(...) kernel: t5vf19: 1 ports, 2 MSI-X interrupts, 4 eq, 2 iq
# ifconfig -l
cxl0 cxl1 igb0 lo0 cxlv0 cxlv1 cxlv2 cxlv3 cxlv4 cxlv5 cxlv6 cxlv7 cxlv8 cxlv9 cxlv10
cxlv11 cxlv12 cxlv13 cxlv14 cxlv15 cxlv16 cxlv17 cxlv18 cxlv19
```

Now we can keep cxl0 (=physical interface) for the host and all cxlvX interfaces can be assigned to a different jvnet-jail.

Notice that:

1. some NIC (like Intel) need more parameters (allow-promisc, allow-set-mac, mac-anti-spoof) to allow specific usage like CARP with the VF.
2. A FreeBSD 12 with Intel ix(4) drivers couldn't attach drivers to these VF.

```
ixv0: <Intel(R) PRO/10GbE Virtual Function Network Driver> at device 0.128 on pci4
ixv0: ...reset_hw() failure: Reset Failed!
ixv0: IFDI_ATTACH_PRE failed 5
device_attach: ixv0 attach returned 5
```

Virtual-Interface (driver specific)

Chelsio driver supports another mode called Virtual Interface; here is an example asking to create four VI per port.

```
# echo hw.cxgbe.num_vis=\"4\" >> /boot/loader.conf
```

After a reboot the new interfaces (vcxlX) will be available and show in dmesg as:

```
vcxl0: <port 0 vi 1> on cxl0
vcxl0: Ethernet address: 00:07:43:2e:e5:91
vcxl0: netmap queues/slots: TX 2/1023, RX 2/1024
vcxl0: 1 txq, 1 rxq (NIC); 2 txq, 2 rxq (netmap)
vcxl1: <port 0 vi 2> on cxl0
vcxl1: Ethernet address: 00:07:43:2e:e5:92
vcxl1: netmap queues/slots: TX 2/1023, RX 2/1024
vcxl1: 1 txq, 1 rxq (NIC); 2 txq, 2 rxq (netmap)
(...)
```

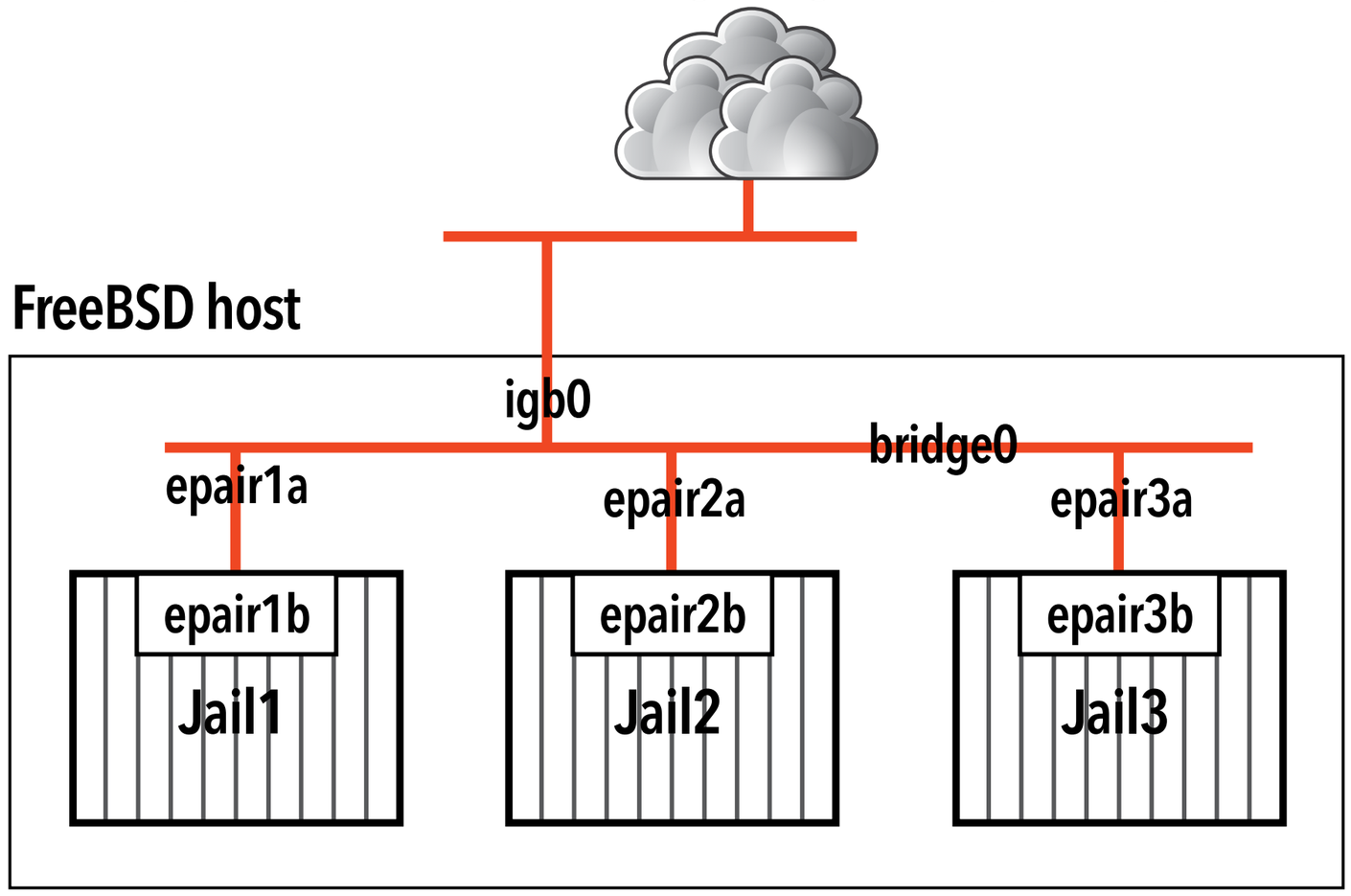
Now you can assign these Virtual interfaces (vxclX) to the vnet-jail.

VLAN
Without a NIC supporting SR-IOV or Virtual-Interface features, one other possibility is to create multiple VLAN and assign the VLAN interface to the vnet-jail. The restriction is that VLAN ID are unique per interface, so if two vnet-jails need to be assigned a vlan sub-interface in the same VLAN, you need to use two physical interfaces.

```
# ifconfig igb0.6 create vlan 6 vlandev igb0 up
# ifconfig igb0.7 create vlan 7 vlandev igb0 up
# ifconfig igb1.6 create vlan 6 vlandev igb1 up
```

In this example, new interfaces igb0.6, igb0.7, and igb1.6 are available for the vnet-jails.

Bridge + epair
To remove the restriction of unique VLAN ID per physical interface, there is still the classical approach, but with some performance impact using bridge and epair setup.



This small diagram is generated with these commands:

```
# ifconfig bridge create up
bridge0
# for i in $(jot 3); do ifconfig epair$i create up; done
```

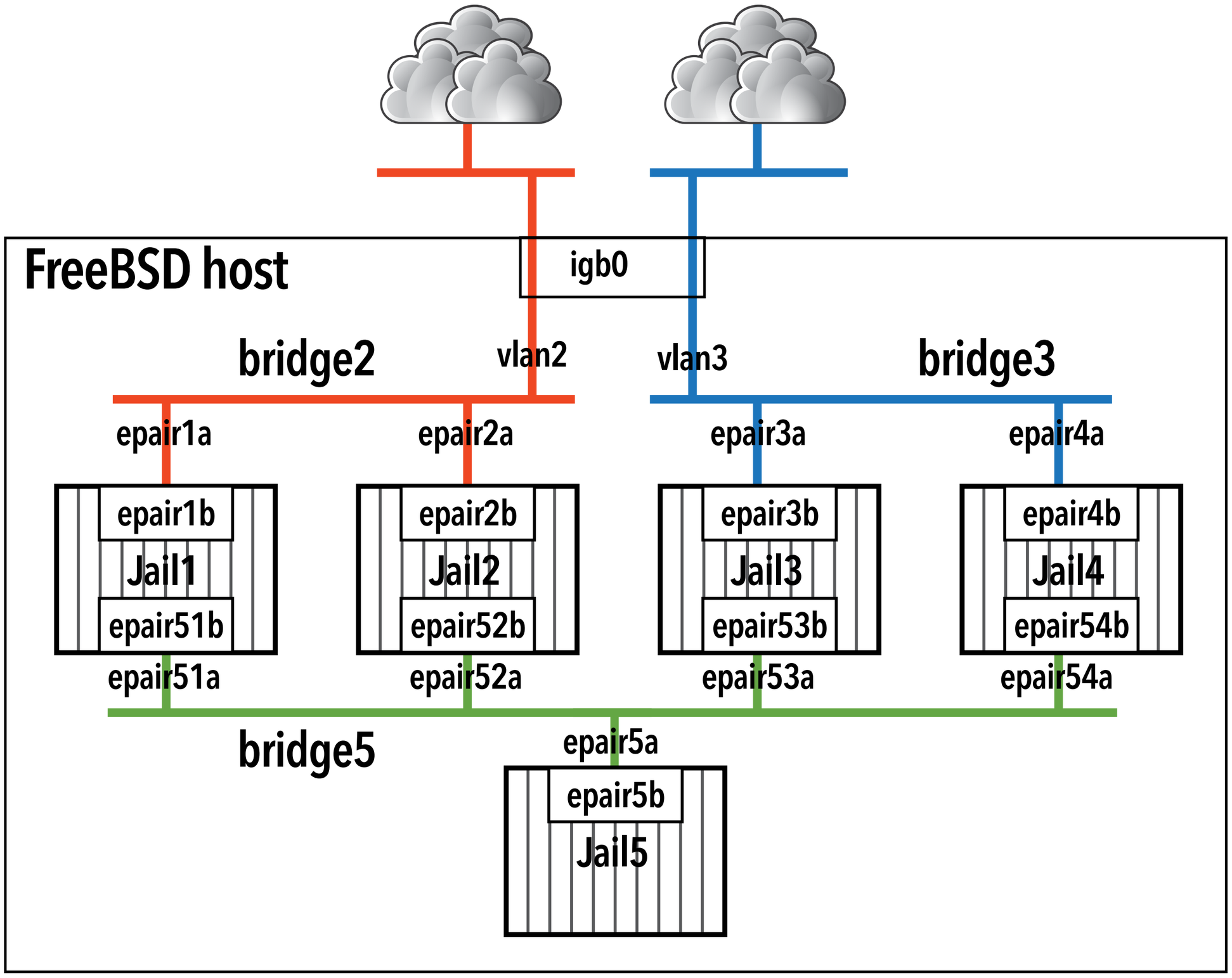
```
epair1a
epair2a
epair3a
# ifconfig bridge0 inet 192.0.2.254/24 addm igb1 addm epair1a addm epair2a \
addm epair3a
# for i in $(jot 3); do jail -c name=jail$i host.hostname=jail$i persist vnet \
vnet.interface=epair${i}b; jexec jail$i ifconfig epair${i}b inet \
192.0.2.${i}/24 up; jexec jail$i ifconfig epair${i}b inet; done
epair1b: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> metric 0 mtu 1500
        options=8<VLAN_MTU>
        inet 192.0.2.1 netmask 0xffffff00 broadcast 192.0.2.255
epair2b: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> metric 0 mtu 1500
        options=8<VLAN_MTU>
        inet 192.0.2.2 netmask 0xffffff00 broadcast 192.0.2.255
epair3b: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> metric 0 mtu 1500
        options=8<VLAN_MTU>
        inet 192.0.2.3 netmask 0xffffff00 broadcast 192.0.2.255
# ping -c 2 192.0.2.1
PING 192.0.2.1 (192.0.2.1): 56 data bytes
64 bytes from 192.0.2.1: icmp_seq=0 ttl=64 time=0.158 ms
64 bytes from 192.0.2.1: icmp_seq=1 ttl=64 time=0.103 ms

--- 192.0.2.1 ping statistics ---
2 packets transmitted, 2 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 0.103/0.130/0.158/0.027 ms
# ping -c 2 192.0.2.2
PING 192.0.2.2 (192.0.2.2): 56 data bytes
64 bytes from 192.0.2.2: icmp_seq=0 ttl=64 time=0.189 ms
64 bytes from 192.0.2.2: icmp_seq=1 ttl=64 time=0.104 ms

--- 192.0.2.2 ping statistics ---
2 packets transmitted, 2 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 0.104/0.146/0.189/0.042 ms
# ping -c 2 192.0.2.3
PING 192.0.2.3 (192.0.2.3): 56 data bytes
64 bytes from 192.0.2.3: icmp_seq=0 ttl=64 time=0.201 ms
64 bytes from 192.0.2.3: icmp_seq=1 ttl=64 time=0.091 ms

--- 192.0.2.3 ping statistics ---
2 packets transmitted, 2 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 0.091/0.146/0.201/0.055 ms
```

And to clean up this example.

```
# for i in $(jot 3); do jail -R jail$i; ifconfig epair${i}a destroy; done
# ifconfig bridge0 destroy
```

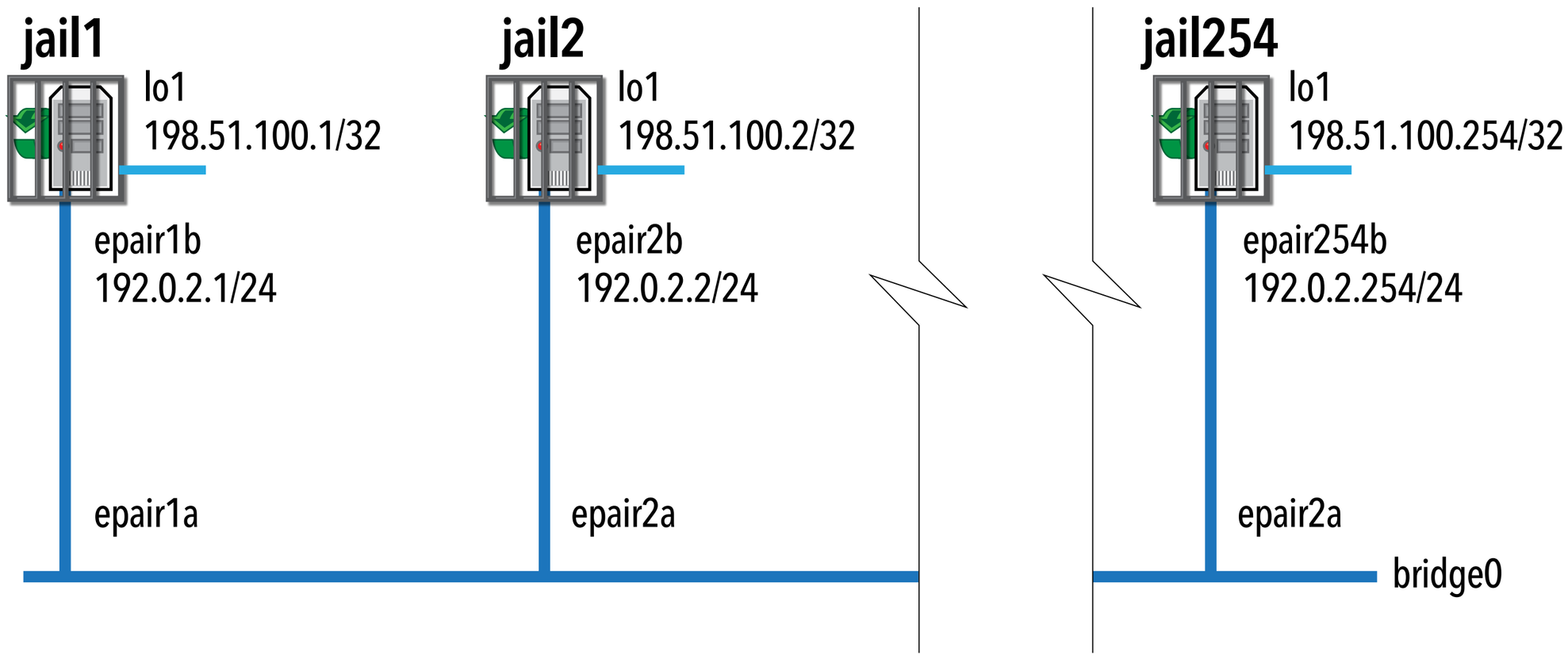
Final Exercise

Now you should be able to set up this kind of lab on your own.



How Light Is a Jail Compared to a VM?

Let's use a small device like PC Engines APU2 (4 core AMD GX-412TC SOC 1Ghz, 4GB of RAM, 16Gb flash). On this device, how many jails executing a real process (bird using OSPF to announce each jail's loopback) can we start?



This small shell script is used to start 480 jails with a bird OSPF tuned to use large numbers of neighbors on a shared link:

- MTU increased to 9000, allowing large numbers of neighbors (you can only have about 350 maximum OSPF neighbors with the default 1500 bytes MTU)
- Hello and dead interval increased to reduce multicast storm on the bridge interface

```
#!/bin/sh
set -eu
dec2dot () {
    # $1 is a decimal number
    # output is pointed decimal (IP address format)
    printf '%d.%d.%d.%d\n' $(printf "%x\n" $1 | sed 's/../0x& /g')
}
# Need to increase some network value a little bit
# to avoid "No buffer space available" messages
# maximum number of mbuf clusters allowed
sysctl kern.ipc.nmbclusters=1000000
sysctl net.inet.raw.maxdgram=16384
sysctl net.inet.raw.recvspace=16384
# Start addressing shared LAN at 192.0.2.0 (in decimal to easily increment it)
ipepairbase=3221225984
# start addressing loopbacks at 198.51.100.0
iplobase=3325256704
ifconfig bridge create name vnetdemobridge mtu 9000 up
for i in $(jot 480); do
    ifconfig epair$i create mtu 9000 up
    ifconfig vnetdemobridge addm epair${i}a edge epair${i}a
    jail -c name=jail$i host.hostname=jail$i persist \
         vnet vnet.interface=epair${i}b
    ipdot=$( dec2dot $(( iplobase + i)) )
    jexec jail$i ifconfig lo1 create inet ${ipdot}/32 up
    ipdot=$( dec2dot $(( ipepairbase + i)) )
    jexec jail$i ifconfig epair${i}b inet ${ipdot}/20 mtu 9000 up
    cat > /tmp/bird.${i}.conf <<EOF
protocol device {}
protocol kernel { ipv4 { export all; }; }
protocol ospf {
  area 0 {
    interface "epair${i}b" {
      hello 60;
      dead 240;
    };
    interface "lo1" {
      stub yes;
    };
  };
}
EOF
```

```
    jexec jail$i bird -c /tmp/bird.$i.conf -P /tmp/bird.$i.pid \
          -s /tmp/bird.$i.ctl -g birdvty
done
```

Install net/bird2, execute this script, and after the OSPF DR/BDR election and database synchronization, network traffic on the bridge interface should still be quite high with only the OSPF keep-alives on the bridge interface:

```
# netstat -ihw 1 -I vnetdemobridge
            input vnetdemobridge              output
   packets  errs idrops      bytes    packets  errs      bytes colls
       490     0     0       826K       29k     0       7.0M     0
       981     0     0       1.7M       65k     0        22M     0
      1.5k     0     0       3.3M       92k     0        25M     0
       596     0     0       337K      102k     0        35M     0
       732     0     0       479K      100k     0        33M     0
```

After a few minutes, check number of neighbors detected (should be 479). DR/BDR election should have chosen jail479 as BDR and jail480 as DR and number of learned routes.

```
# birdcl -s /tmp/bird.1.ctl show ospf
BIRD 2.0.6 ready.
ospf1:
RFC1583 compatibility: disabled
Stub router: No
RT scheduler tick: 1
Number of areas: 1
Number of LSAs in DB:   481
        Area: 0.0.0.0 (0) [BACKBONE]
                Stub:   No
                NSSA:   No
                Transit:        No
                Number of interfaces:   2
                Number of neighbors:    479
                Number of adjacent neighbors:   2

# jexec jail1 netstat -4rn | grep UGH1 | wc -l
     479
```

The current system limit of this test is due to 4GB of RAM consumed by all the bird processes.

```
last pid: 16459;  load averages: 34.76, 37.35, 28.18
up 0+00:36:15  08:36:46
497 processes: 1 running, 496 sleeping
CPU: 14.4% user,  0.0% nice,  6.3% system, 10.2% interrupt, 69.2% idle
Mem: 1177M Active, 454M Inact, 2816K Laundry, 1891M Wired, 17M Buf, 395M Free
```

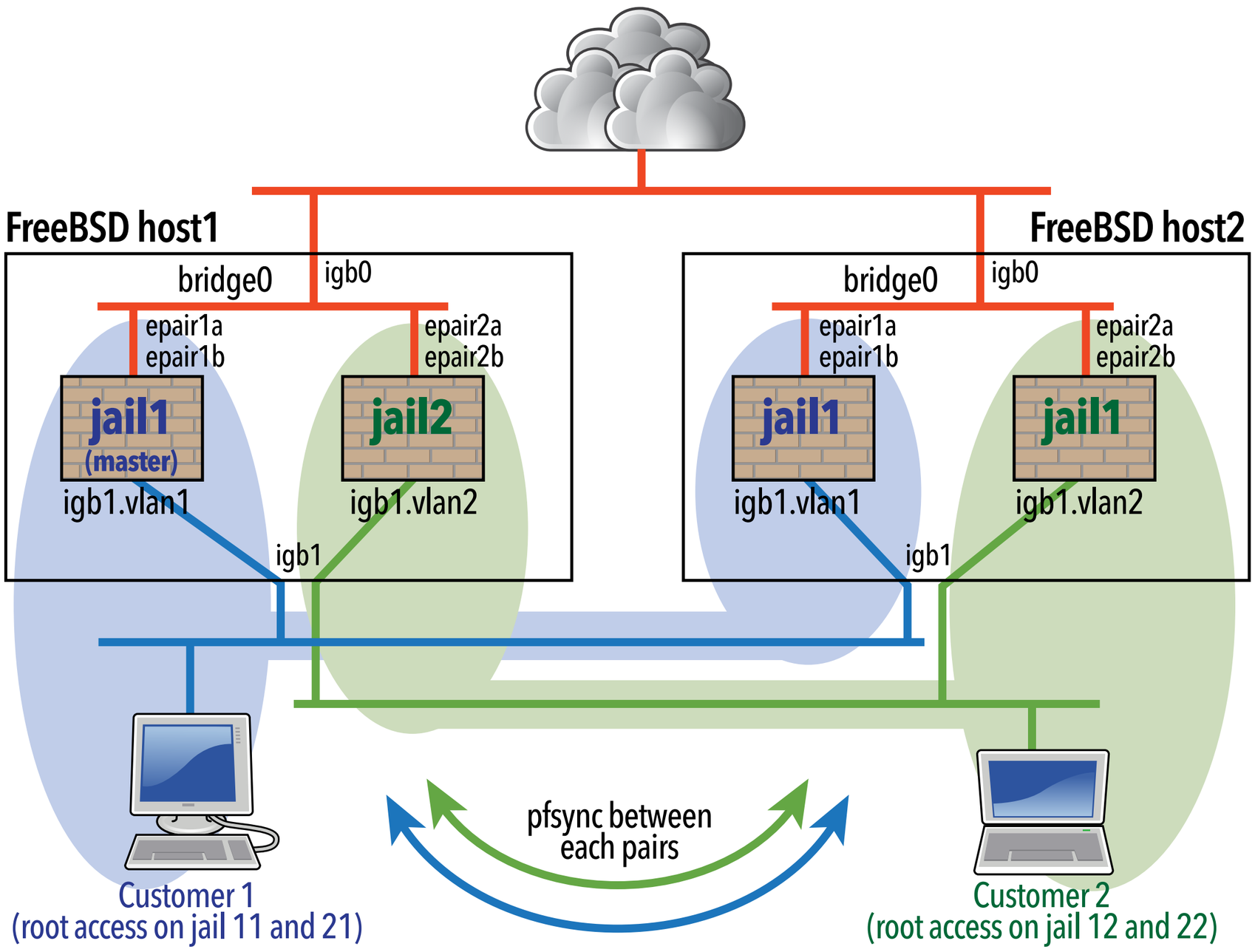
```
  PID USERNAME    THR PRI NICE   SIZE    RES STATE    C   TIME    WCPU COMMAND
13529 root          1  20    0    32M    20M select   1   0:45   2.04% bird
13553 root          1  20    0    29M    17M select   3   0:41   0.71% bird
16459 root          1  20    0    14M  3568K CPU1     1   0:00   0.62% top
13512 root          1  20    0    20M  7372K select   2   0:03   0.39% bird
 8003 root          1  20    0    20M  7316K select   0   0:03   0.38% bird
 7913 root          1  20    0    20M  7260K select   0   0:03   0.38% bird
13466 root          1  20    0    20M  7172K select   0   0:03   0.34% bird
 7887 root          1  20    0    20M  7288K select   1   0:03   0.33% bird
 7832 root          1  20    0    20M  7260K select   2   0:03   0.33% bird
```

Here is the script to delete/clean up all the jails, but you should reboot because your system will panic during this cleanup:

```
#!/bin/sh
set -eu
for i in $(jot 480); do
    echo Deleting jail$i
    jail -R jail$i
    ifconfig epair${i}a destroy
    rm /tmp/bird.$i.*
done
ifconfig vnetdemobridge destroy
```

Firewalls

pf and ipfw are vnet compliant, which allows the building of a multi-tenant firewall in an HA scenario like the one presented here:



This setup is more complex because it needs to enable specific kernel features to be useable as a jail. (A detailed example of such setup could be presented in a future article.) Meanwhile, this setup is explained as a BSD Router Project example here (using some helper scripts to configure a jail that hides complexity):
https://bsdrp.net/documentation/examples/multi-tenant_ha_pf_firewalls

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OLIVIER COCHARD-LABBÉ discovered FreeBSD in 2005 by customizing m0n0wall to create FreeNAS. As a network engineer, he created the BSD Router Project in 2009 and since then has been endeavoring to bench the FreeBSD network stack. He received his port commit bit in 2016 and is currently a software developer in tests at Netflix.