The new VVorld

FreeBSD jail based virtualization

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The FreeBSD Project

BSDCan 2010

Overview

1. Virtualization
2. Virtualization at OS level
3. Virtual Network Stack
4. Use cases and numbers

What is virtualization

- Term more and more popular during the last decade.
- Have one real something but pretend to provide several.
- Q: Why doesn't it work with apples or oranges?
- Q: How does IT solve it?

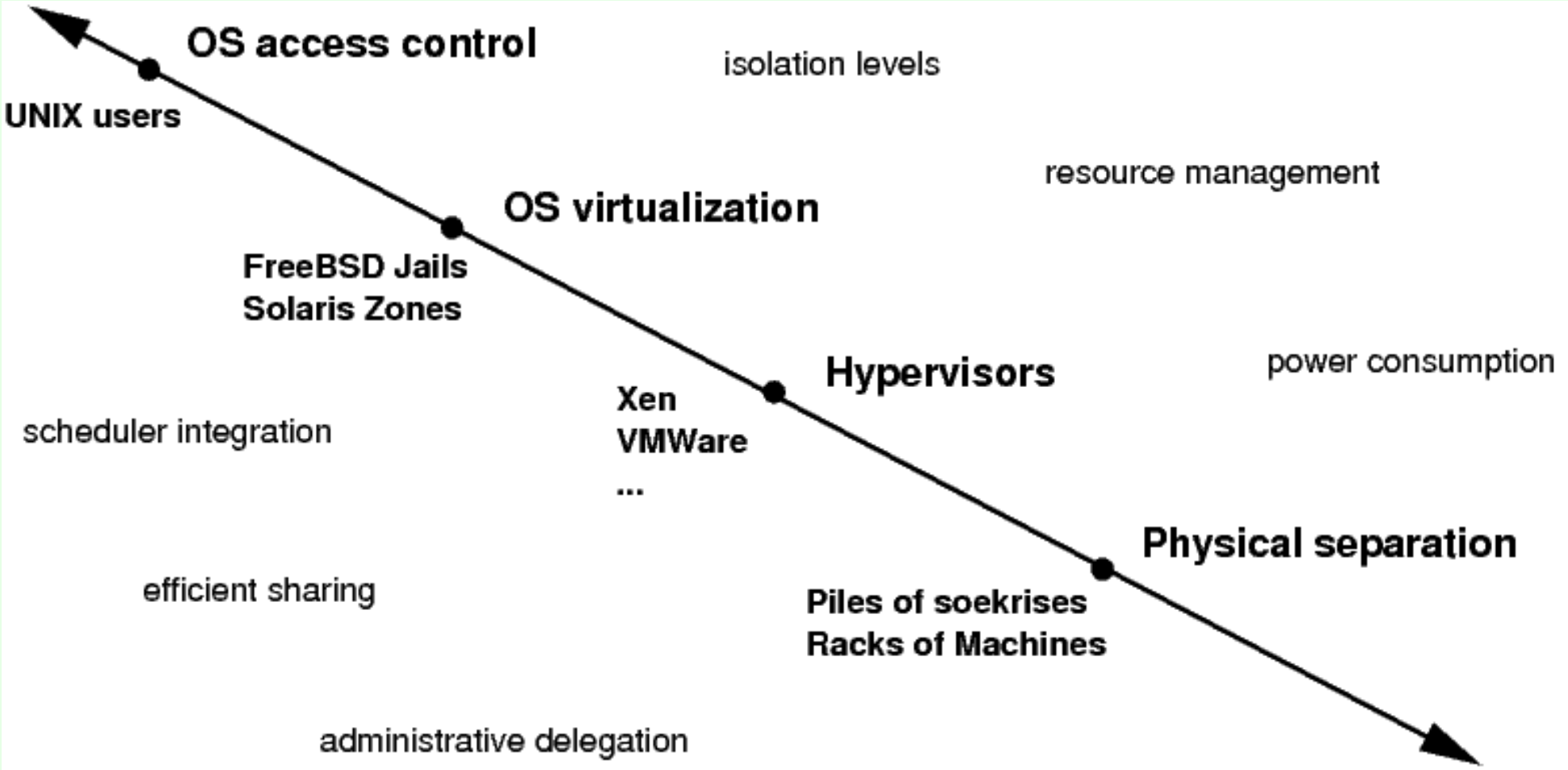
What is virtualization, samples

- In networking: VLANs, MPLS VPNs, ...
- For machines: 1 piece of hardware, many virtual instances.
- In operating systems: VM address spaces, ...
- In FreeBSD: Jails, as well as Xen, Virtualbox, ...
- A: Add a level of indirection.

Why virtualize?

- Use resources more efficiently.
- Make people believe they get it all but still share.
- Allow for (managed) overcommits.
- Consolidate resources.
- Delegation of administration.
- Build systems with better security footprints.

Virtualization spectrum



History of Jails

- April 1999: commit of the “mumbled about Jail feature”.
- May 1999: VMware Workstation 1.0
- 2002 M. Zec *BSD network stack virtualization*, BSDCon Europe
- 2007 Jail friendly file systems (ZFS).
- 2008 multi-IPv4/v6/no-IP patches.
- 2008 integration of virtual network stack starts.
- 2009 hierachical jails.

What are “Jails”?

- Operating system-level virtualization.
- One kernel.
- Chroot, IP address subsetting, . . .
- Safe super user delegation with restrictions.
- Efficient resoures sharing, allows overcommits.
- Very lightweight (no hypervisor, no virtual device overhead)
- Nowadays: multi IPv4/v6/no-IP jails, cpuset support, jail-friendly filesystems (ZFS).

Jails - what improvements?

- lightweight, secure, fast, simple (keep this).
- Does not depend on hardware support (keep it like this).
- ”ping does not work”, no loopback, . . . (improve).
- System V IPC troubles (improve).
- Why is that? Jails “subset” rather than “virtualize”.
- Cannot run “unnamed commercial OSes” (not going to happen).

What to virtualize?

- Start with network stack.
  - Immediate demand as just an address wasn't good enough anymore.
  - Marko Zec 2002 Prototype.
  - Make sure performance does not change noticably.
- Future: VIPC, ...

Subsystem virtualization - what to take care of?

- Global variables.
- Callouts (timers).
- Eventhandlers.
- Sysctl MIBs.
- Startup and shutdown.
- Debugging.

How to handle things?

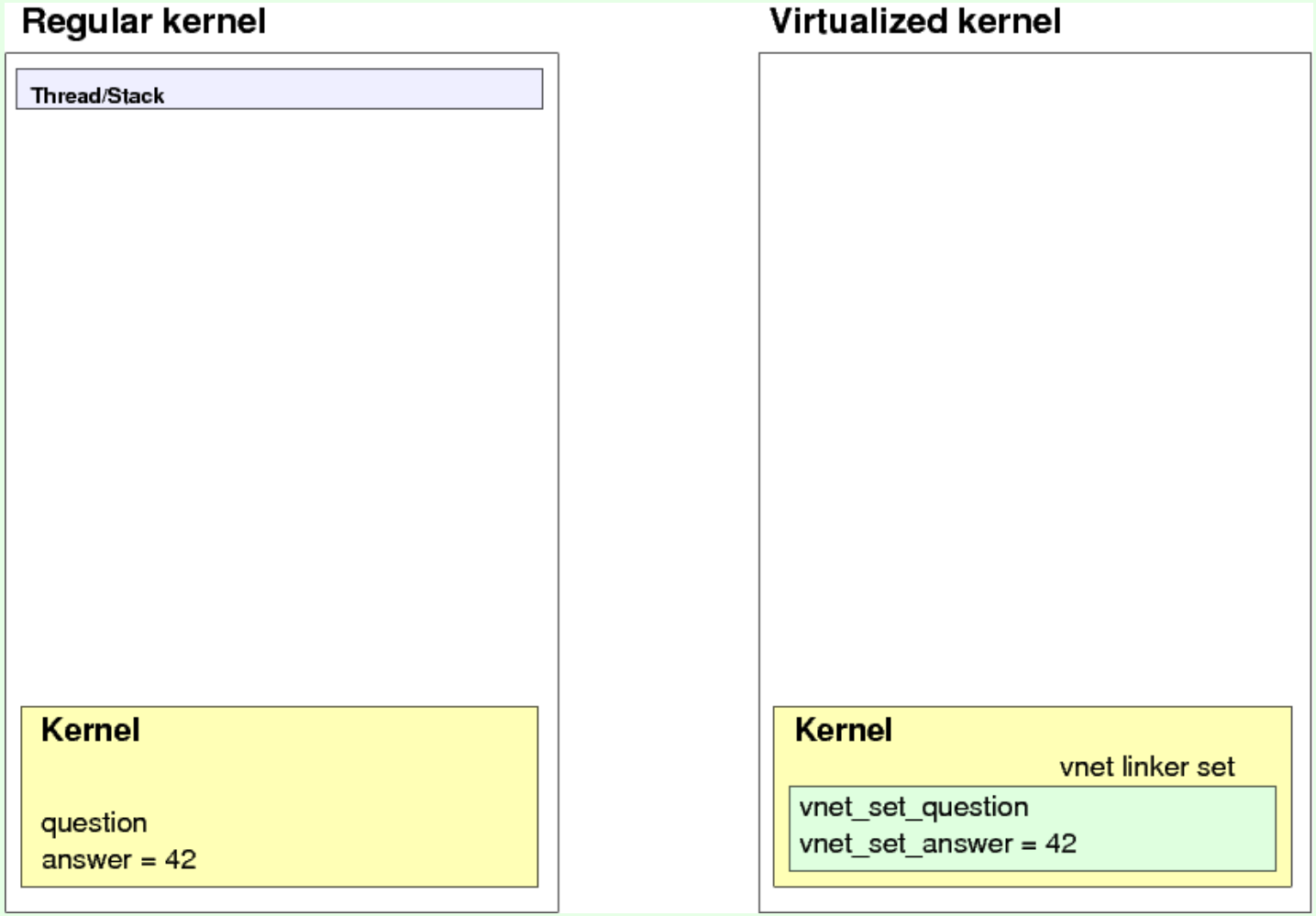
- Have “virtual instances” as abstraction level.
- Replicate global variables per instance.
- Duplicate or multiplex eventhandlers/timers per instance.
- Mark objects as part of an instance.
- Keep a clear security concept - do not grant insecure privileges.
- Be prepared for inter-instance interaction.
- Starting and Stopping?

Step by step walkthrough

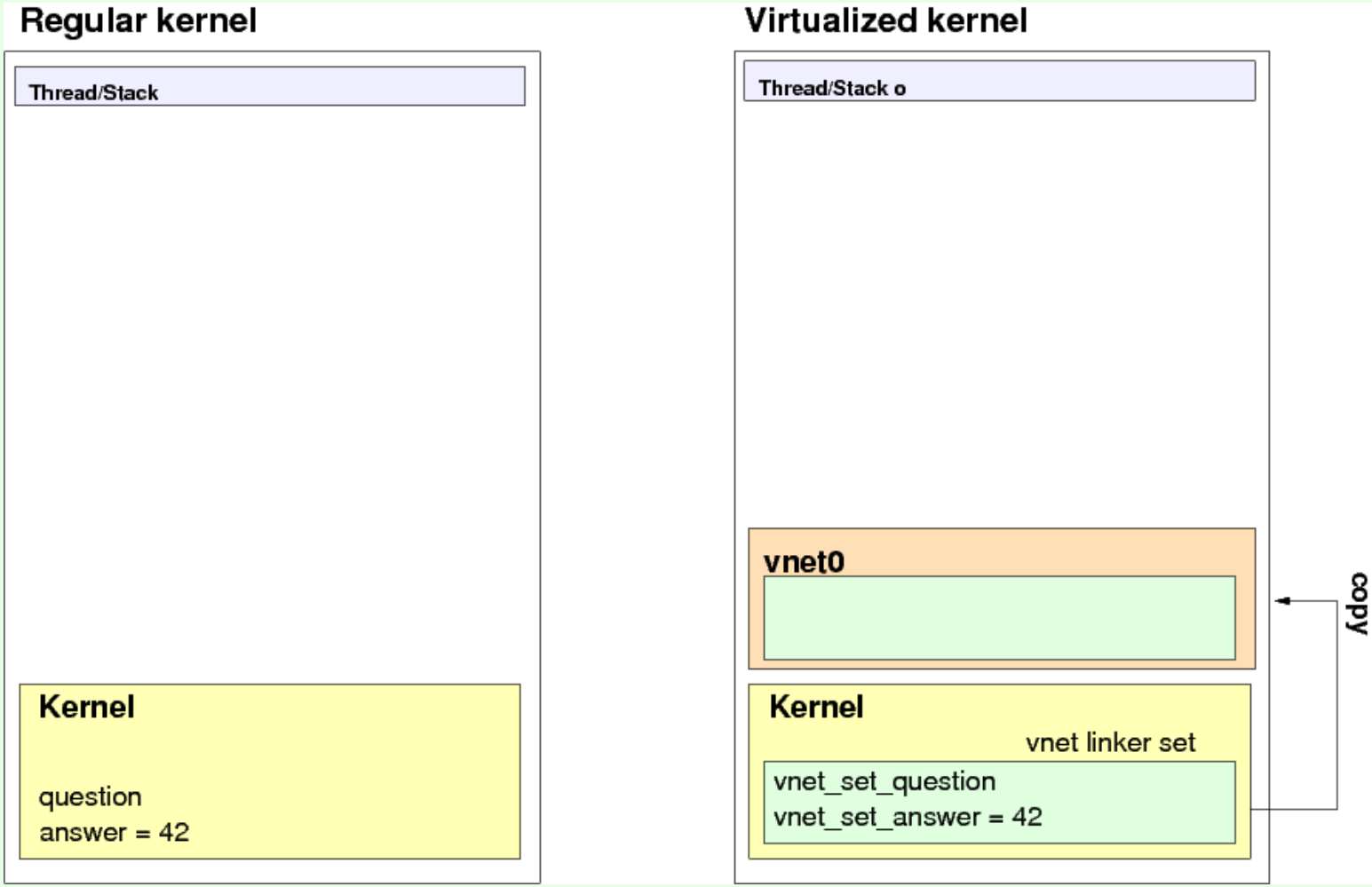
- Step by step walkthrough - how virtualization works.

Standard kernel

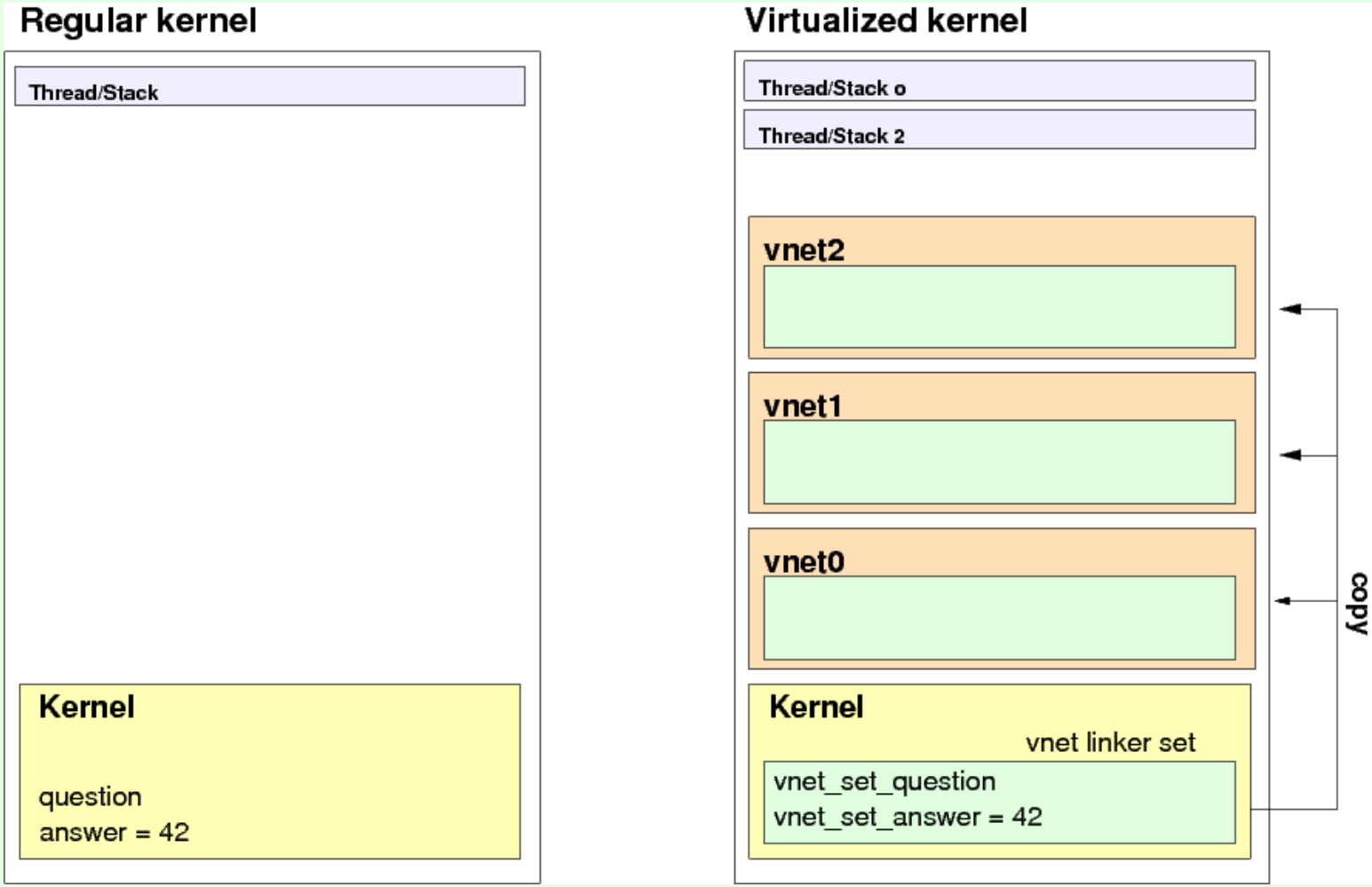
Virtualized kernel



The base system network



Start more instances, procs/threads not virtualized



Globals

Unvirtualized globals:

```
static int question;
int answer = 42;
```

Now virtualize this:

```
static VNET_DEFINE(int, question);
static VNET_DEFINE(int, answer) = 42;
#define V_question  VNET(question);
#define V_answer    VNET(answer);
```

Sysctls, System initialization

```
SYSCTL_VNET_INT(_hhgttg, OID_AUTO, question,
    CTLFLAG_RW, &VNET_NAME(question), 0, "Q:");
SYSCTL_VNET_INT(_hhgttg, OID_AUTO, answer,
    CTLFLAG_RW, &VNET_NAME(answer), 0, "A:");

static void
hhgttg_init(void __unused)
{
        if (V_question)
                goto_page(V_answer);
}
VNET_SYSINIT(hhgttg_init, SI_SUB_PSEUDO,
    SI_ORDER_FIRST, hhgttg_init, NULL);
```

Virtual Network Stack

- own loopback interface
- virtual iterfaces or netgraph subsystem to get connectivity to network stacks
- can give dedcicated hardware resources (NIC) to a virtual network stack
- own statistics
- own IPsec, firewalls, . . .
- own everything network stacky basically
- use forwarding or bridging between instances or outer world
- still very lightweight

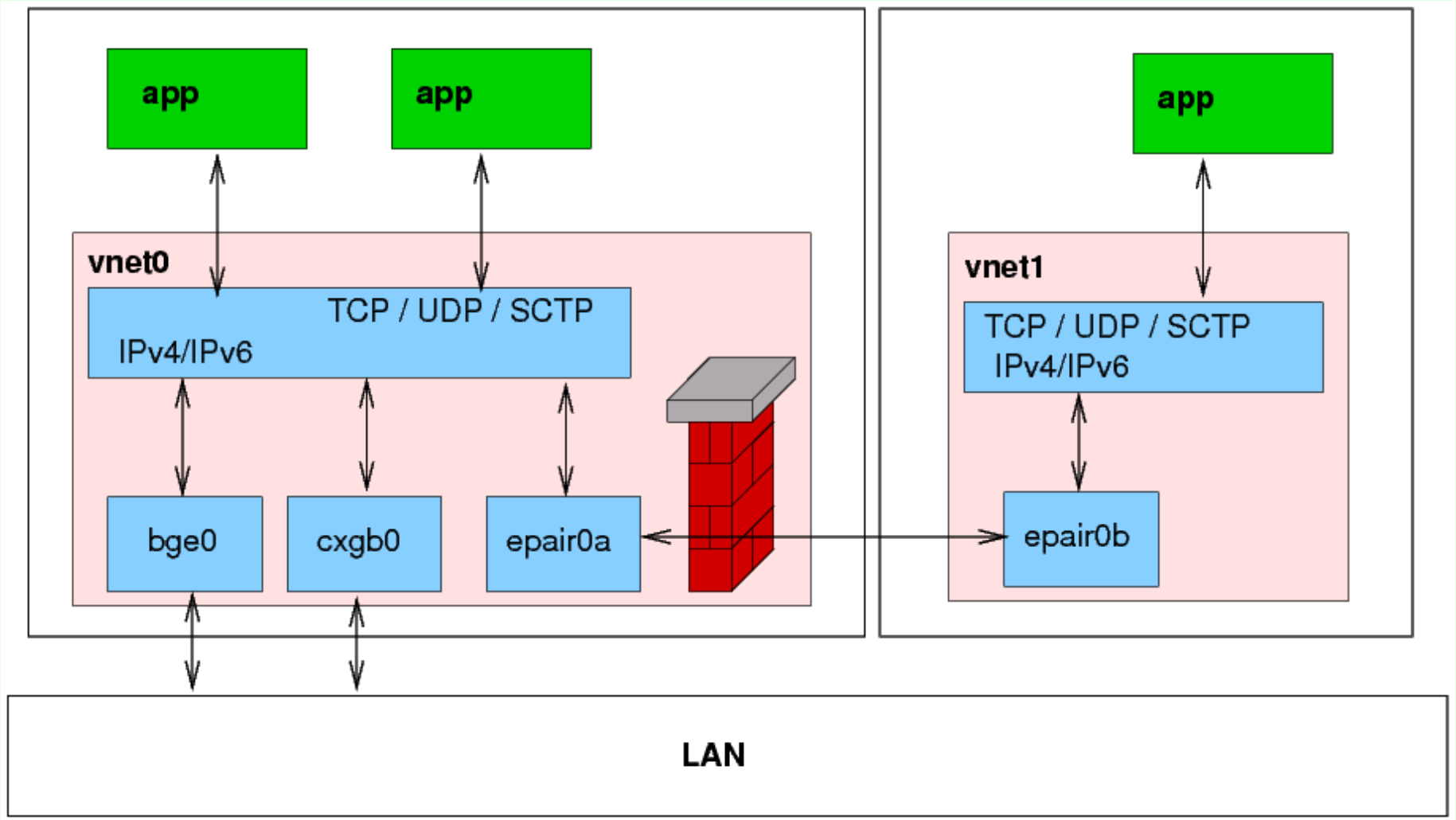
What's the major problem left?

- Shutdown is really hard. "Why?", you ask?
- Up to now we booted and the reset pin handled did the "shutdown" for us.
- We need destructors.

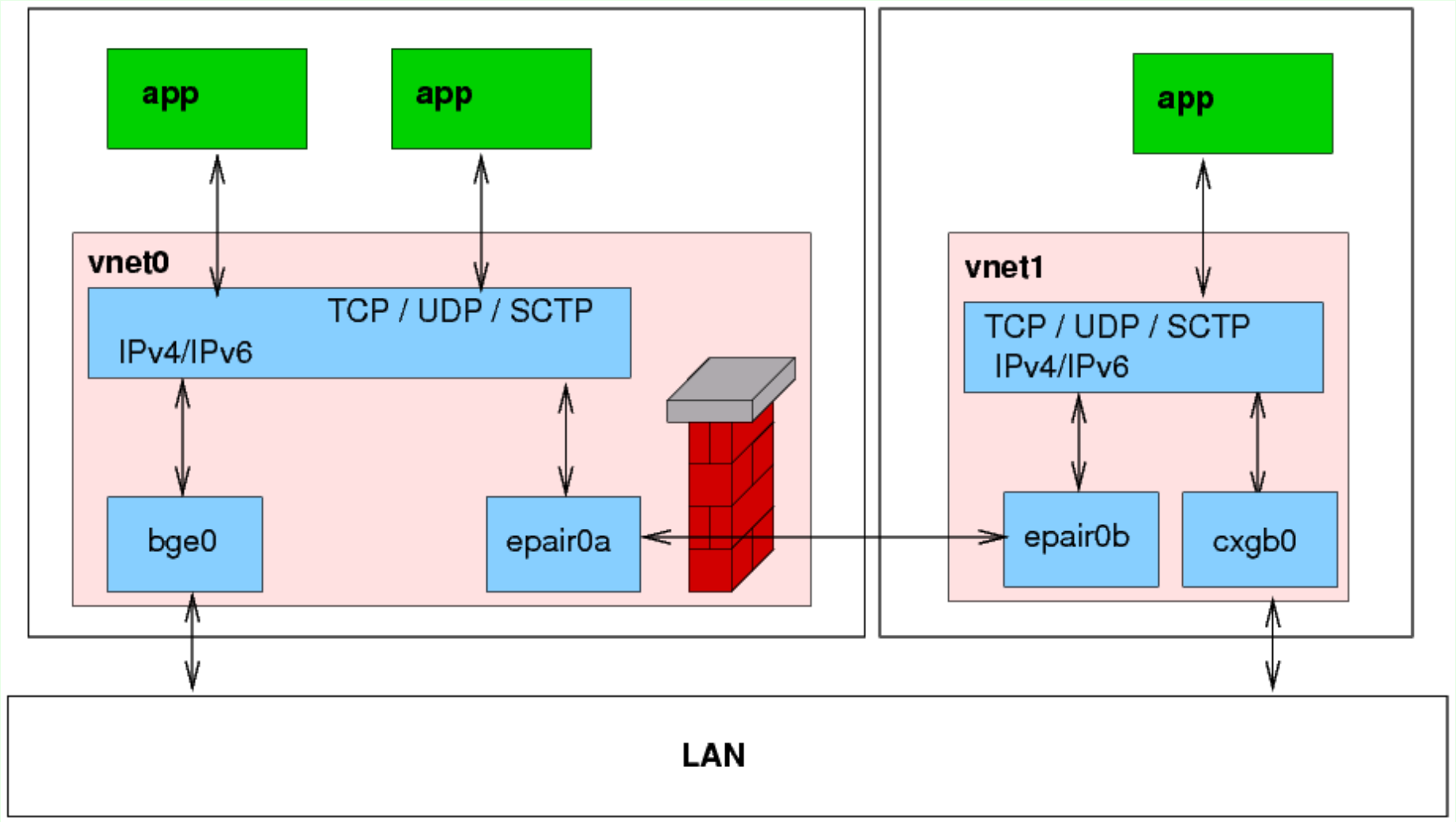
Where are we?

- VIMAGE is a “highly experimental” feature in FreeBSD 8.0.
- Known memory leaks, known crash conditions.
- A bit this and that left todo: (IPX, Appletalk, 1.5 firewalls, . . .).
- FreeBSD Foundation helps to make us make progress.
- Goal: production quality VIMAGE somewhen in 9.x.

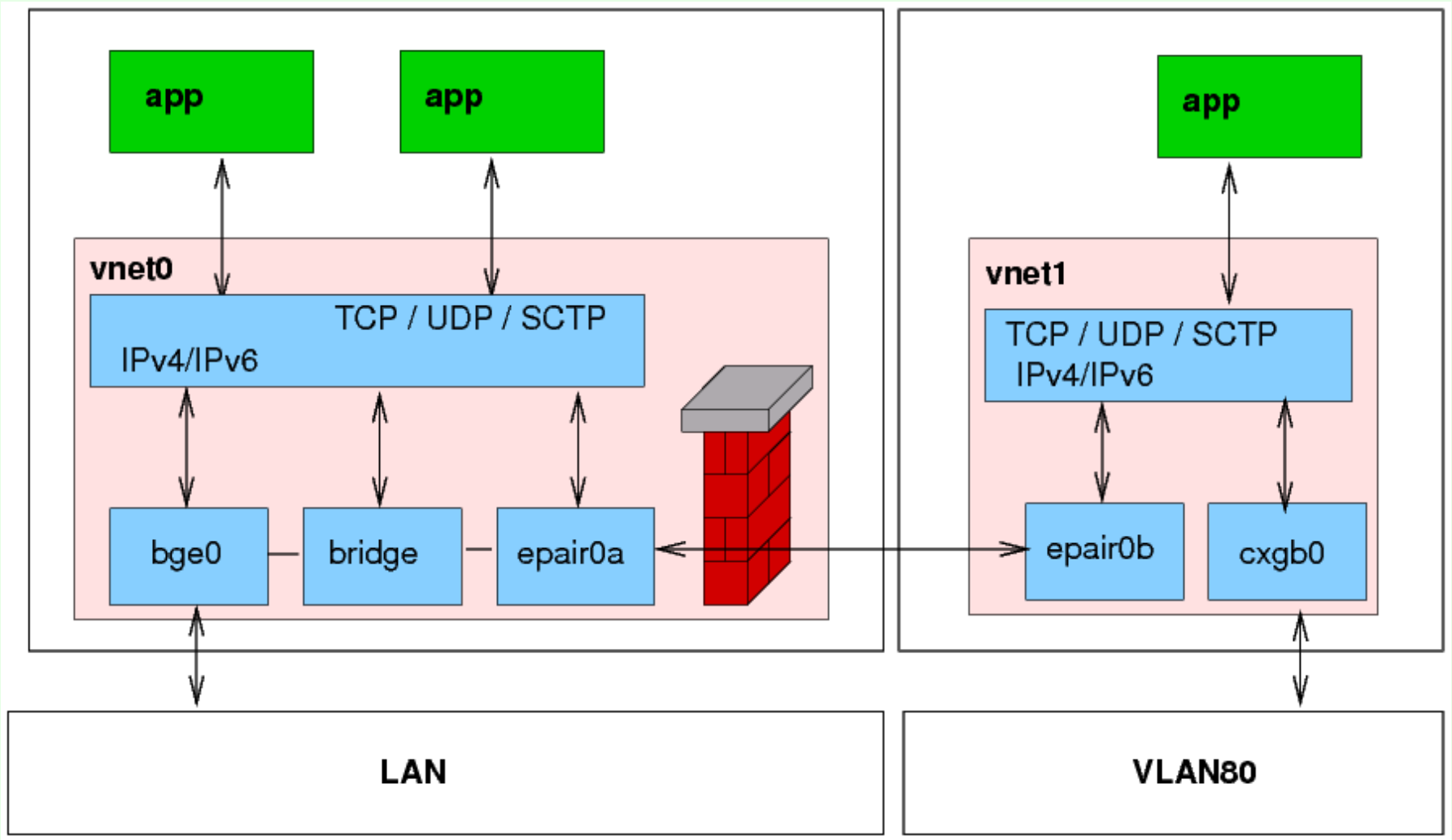
Virtual Network stack sample 1



Virtual Network stack sample 2



Virtual Network stack sample 3

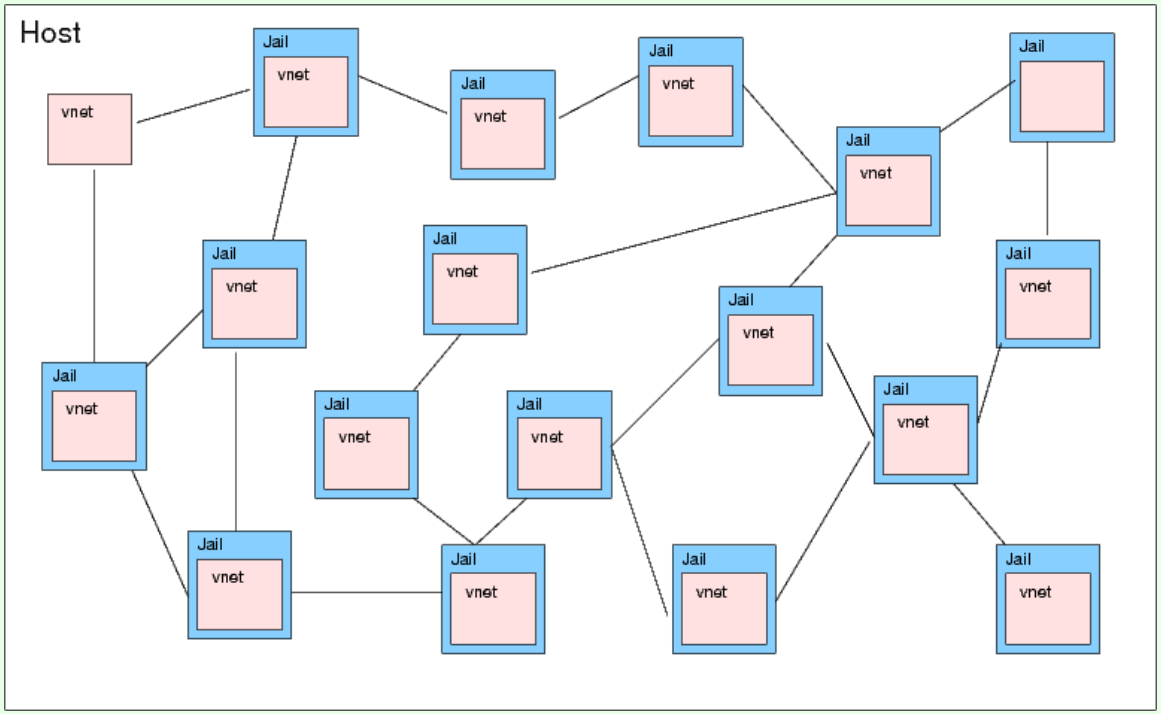


Protocol development or Admin/Operation

- BSD the classic OS for (network protocol) research.
- Easily test with various nodes on one piece of metal.
- Have all the debugging tools available, like tcpdump, DTrace, . . .
- Can more easily correlate data.

Simulations

Arbitrary structure, 1000s of nodes with independent network stacks



ISPs and Hosters

- Run tens, hundreds or thousands of jails on a box.
- As low as 2MB + user data per virtual instance using a read only base image and nullfs mounts technique or ZFS.
- Allow shell logins and root access to a virtual instance.
- Add dedicated/virtual resources only where needed.
- Provide IPsec, own firewall, ability to tcpdump, ping, . . . to users.

Scalability

- A classic jail w/o process is about 5k on 64bit.
- A jail + vnet w/o processes is about 300-500k on 64bit.
  Depending on kernel configuration.
- We can give you six 9s (at least sounds good:)
- A 64bit machine, netbooted, 8GB RAM can start >5000 jails + vnet + epair
  (*) actually higher number.
- The number will always depend on your environment, number of processes, workload, ...

How to try it out?

- Use 8-STABLE or 9-CURRENT.
- Compile kernel with `options VIMAGE`
- Still simple commands:

```
jail -i -c vnet name=foo \
   host.hostname=foo.example.net path=/ persist
ifconfig epair0 create
ifconfig epair0a vnet foo
jexec foo /bin/csh
```

- http://wiki.freebsd.org/Image
- Experimental - you have been warned.

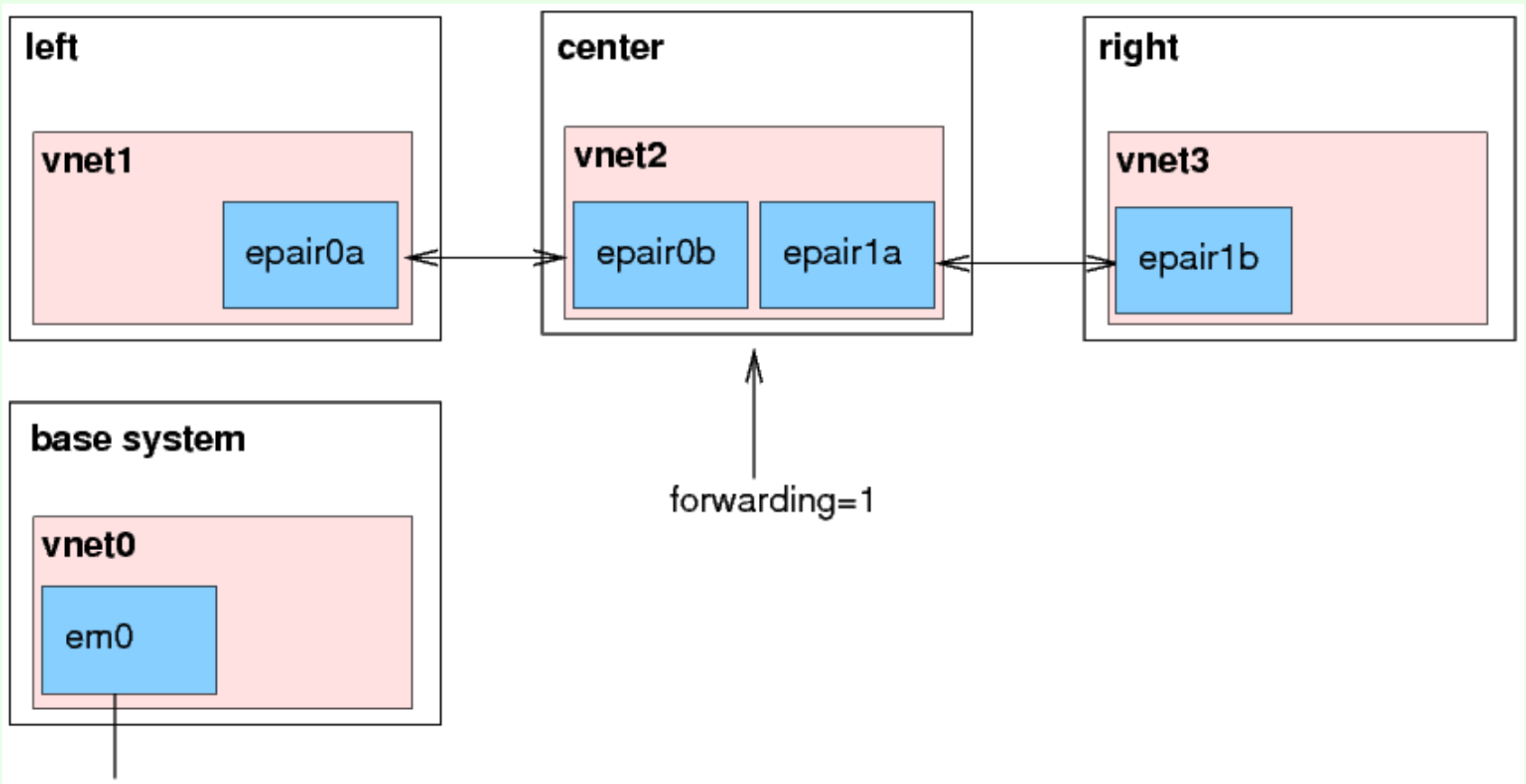
Conclusions

- Virtual kernel subsystem, like vnet, become reality.
- Prototype increasingly stable.
- Very little performance overhead.
- Enlarges FreeBSD's portfolio, can be combined with Xen.
- Coming soon(ish).

So long for now

- Special thanks to the FreeBSD Foundation.
- If you are interested let us know: bz@FreeBSD.org, freebsd-virtualization@FreeBSD.org.
- We will have ideas how you could help.
- That's it. Thanks!

Demo


left
vnet1
epair0a
center
vnet2
epair0b
epair1a
right
vnet3
epair1b
base system
vnet0
em0
forwarding=1