OpenBSD

pf+rdomains create splendid multi-tenancy firewalls

AsiaBSDCon, Tokyo, March 11, 2017

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Trivia:

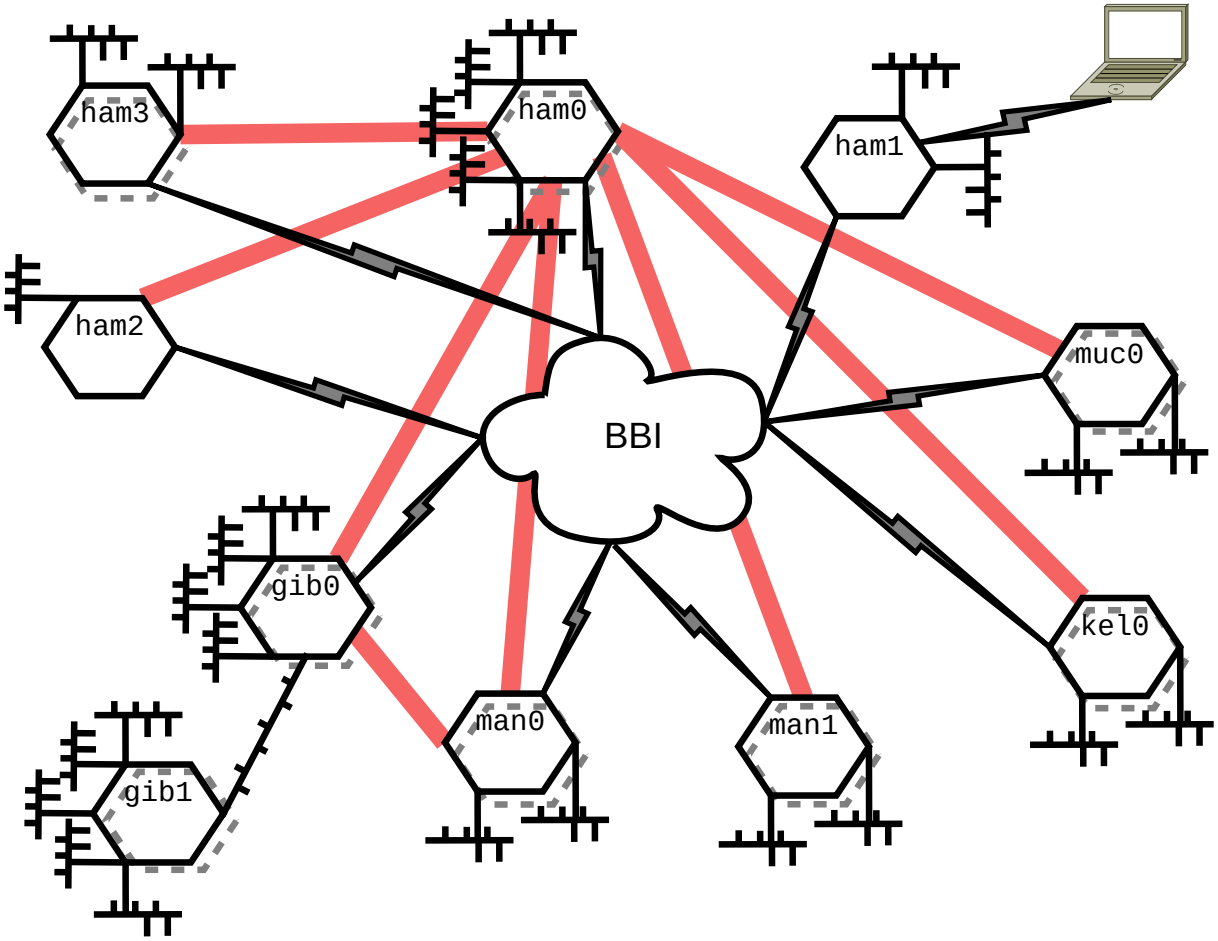
Technical lead at sysfive.com GmbH
Hacking computers since 1983
OpenBSD user since 2.7 (2000)
Developer (pf) 2002-2005

10 people — we're hiring
Apple][e
on i386, amd64, sparc64, macppc
slacked too much

Contents

- Opening
- Ze Problem
  - one and more tenants complexity
  - traditional approaches
- Introduce rdomains
  - interface based
  - tools aware or not
  - pair vs. pf.conf
- Gory details
  - (persistent) configuration
  - pair / pf.conf
  - ntpd(8), relayd(8)
  - pitfalls / debugging
- Test+Automation
  - packer / vagrant, ansible

sysfive.com network



my dia(1) skills are sub par, giving up..

complex network

basic tenant

Network segregation is a must and ends up in numbers if done deeply.

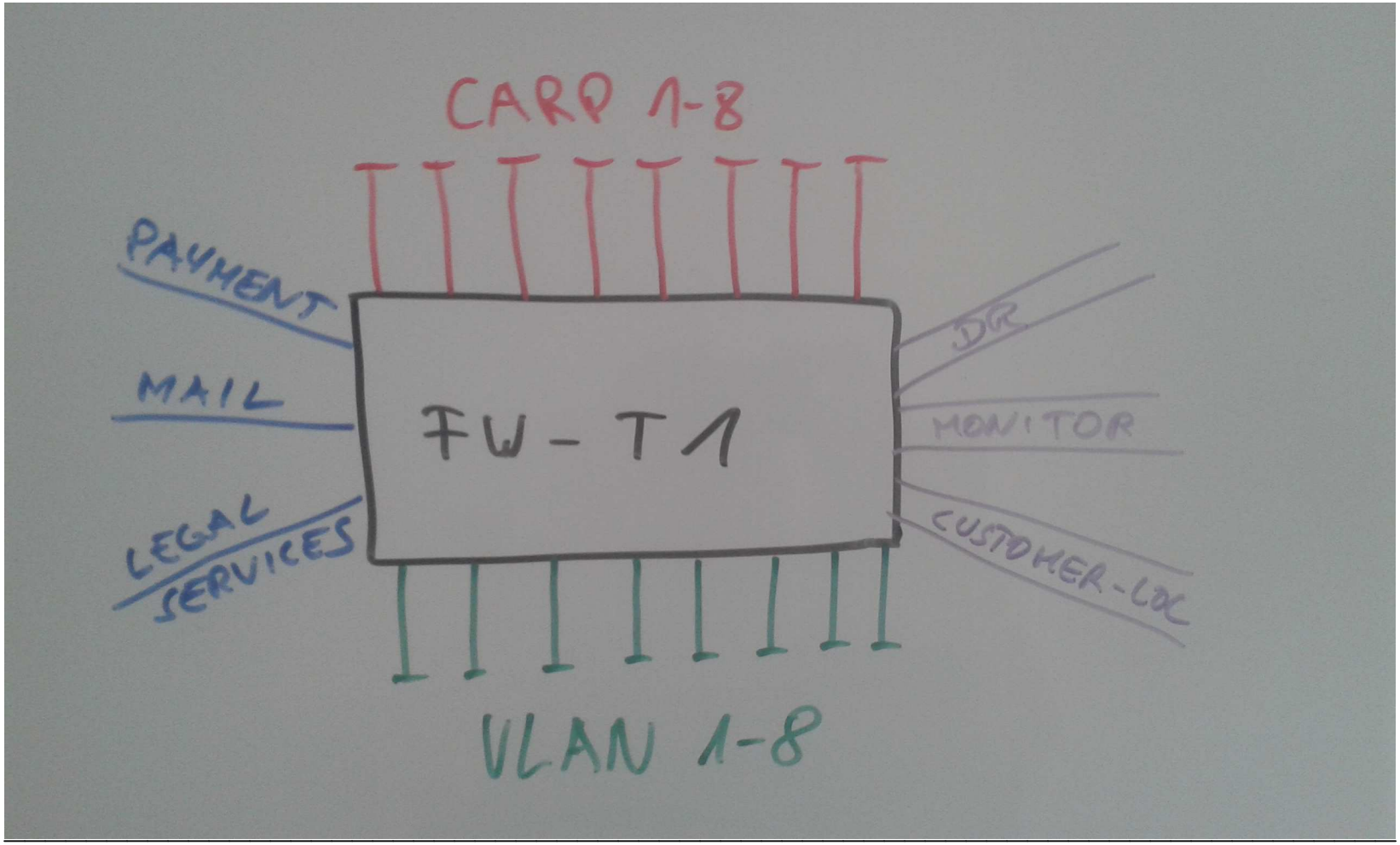
Management — IPMI/KVM, bootstrapping (PXE), monitoring, backup
Services — (rev)proxy, email, ntp, DNS
Application — devel, test/stage, main, DR
Datastorage — RDBMs, NoSQL, LDAP, redis, ..
Others/3rd party — payment services, weather widget, "all the funkyness"

one single real tenant firewall in numbers

```
$ ifconfig | egrep -c '^[a-z]'
      41

$ pfctl -sr | wc -l
     267

$ pfctl -a 'relayd/*' -sr | wc -l
      36
```

complex network

minimum tenant at ours



traditional approaches

’handcruft’

- overview
- ordering (pf.conf)
- ikwid — I know what I did - you do not
- testing
- panic

templates

- double the above
- exceptions / divergent config

multiple fw

- what-is-where
- IPv4 scarcity
- rackspace (dah, VMs...)
- time to launch physically

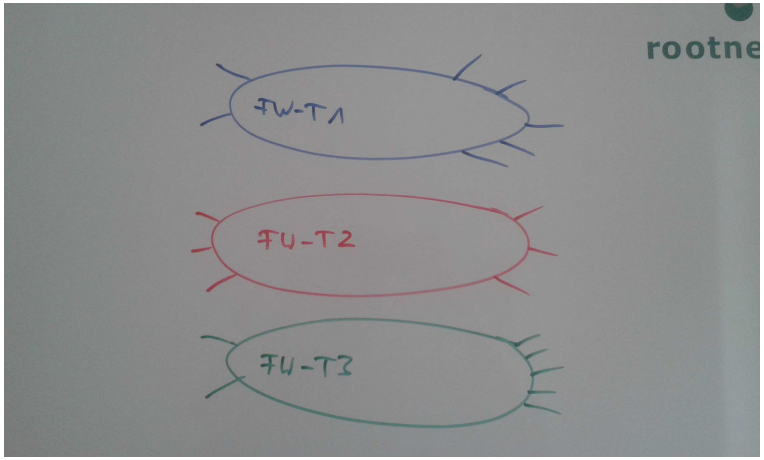
overall problems to be addressed

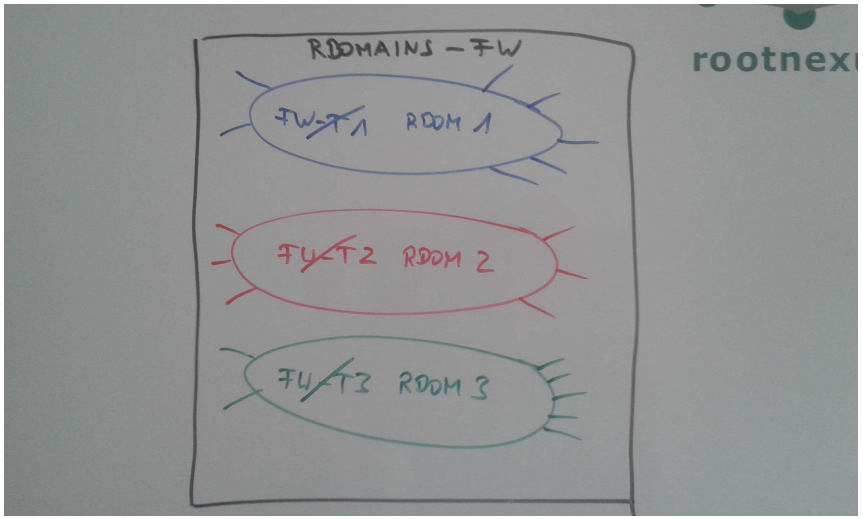
In general:

- growth
- change
- pf.conf ordering matters much
- quick-fix, leads to
- long debug
- tenants might buy others, bringing:
- IP address conflicts (overlap locally and/or VPN)

Sidenote: rdomains(4) might also be very useful when you cannot control (esp. IP-address-ranges) connected networks; not scope of this talk.

rdomains — many in one





composition: multiple interfaces create one rdomain
multi routing: each tenant haves its own routing table (and more)
tools aware: direct invocation by passing rdomain IDs
daemons: several instances started in different rdomains
pair(4): mesh all the things (connect rdomains)
pf.conf(5): includes, anchors, ..
limits: not again... but not many

aware tools

The following network tools can be invoked with an argument to operate on the given rdomain

netstat(1)
- -T <tableid>: show information for given rdomain

route(8)
- -T <tableid>: show/operate for given rdomain
- exec: start a process in rdomain (next page)

arp(8) / ndp(8)
- -V <tableid>: limit to given rdomain

ping(8)
- -V <tableid>: ping from rdomain

traceroute(8)
- -V <tableid>: trace a route from rdomain

nc(1)
- -V <tableid>: bind socket in given rdomain

ps(1)
- -o rtable: adds ID of rtable/rdomain the process runs within

pkill(1)/pgrep(1)
    -T <tableid>: limit search/results to given rdomain

tcpbench(1)
    -V <tableid>: run benchmark within given rdomain

telnet(1)
    -V <tableid>: use given rdomain

ftp-proxy(8)
    somewhat via pf(4) tagging — really? ftp?

bgpd(8)/ospfd(8)/ripd(8)/eigrpd(8)/ldpd(8)
    rtable/rdomain keywords — out of scope

authpf(8)
    limited support

relayd(8)
    (details pages)

rcctl(8)/rc.d(8)
    (details pages)

ntpd(8)
    (details pages)

ifconfig(8)/hostname.if(5)
    (details pages)

not aware tools

route exec

Any other tool or daemon can be started (multiple times) within a given rdomain via route(8).

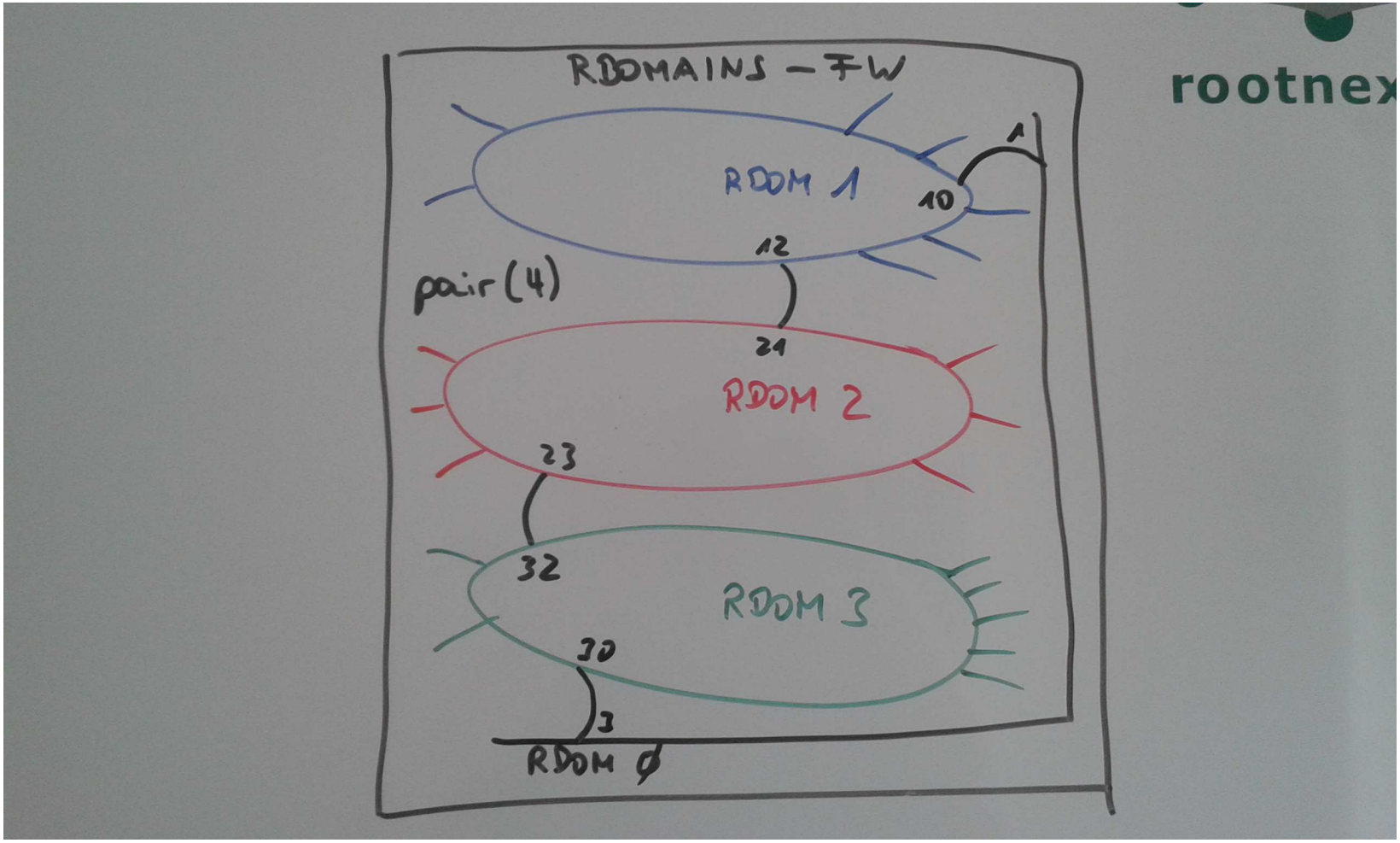
```
route -T 23 exec iked -ddvvf /etc/iked.conf.23
route -T 42 exec iked -ddvvf /etc/iked.conf.42
```

Pitfalls: daemons operating on shared/global information can still mess up each other, e.g. ntpd(8). Remote control (sockets), PID-files etc. must be configurable or running multiple instances can be a pain.

limits

- maximum of 256 routing domains (sys/socket.h: RT_TABLEID_MAX)
- any carp(4) devices must be in the same rdomain as its ’carpdev’ — remedy shown later
- some daemons not yet fully aware/usable, but should so:
  - authpf(8) — unable to choose different configuration paths; fixable
  - iked(8) — no option for choosing socketname; fixable
  - relayd(8) — can handle in ’routers’, not yet for ’relays’; fix in progress
  - 3rd party / ports — unchecked, base requirement is multi-instance capability

pair(4)


RDOMAINS – FW
ROOM 1
1
10
12
pair(4)
21
ROOM 2
23
32
ROOM 3
30
3
ROOM 0
rootnex

pf.conf syntax

on / rtable

```
pass in on rdomain 21 from $tenant-app to $tenant-email
#
pass out from $backup to <tenant1> rtable 21
```

anchors

```
anchor "tenant1.21" on rdomain 21 {
    block
    pass out proto tcp from any to any port { 80 443 }
}

anchor "tenant2.41" on rdomain 41 {
    block
    match out to any nat-to $ext-41-ip rtable 0 tag TENANT_41
    pass out tagged TENANT_41
}
```

hostname.if

physical(4)/vlan(4)/carp(4)/pair(4)

Creating rdomains is done by assigning ’rdomain N’ to an interface, naturally this can be done in hostname.if(5).

Hint: put ’rdomain’ before any address configuration (inet/inet6).

```
/etc/hostname.em0:
rdomain 0
inet 10.40.40.254/24

/etc/hostname.vlan41:
description "gw-vlan-41"
vlan 41 vlandev em2
rdomain 41
group "rdom41"
inet 10.40.41.1/24

/etc/hostname.carp1
description "gw-carp-1"
rdomain 0
vhid 1
pass onetwomany
carpdev em0
inet 10.60.5.1/24

/etc/hostname.pair21
description "gw-pair-21"
rdomain 21
inet 10.200.21.2/30
patch pair0
!/sbin/route -T 21 -n add default 10.200.21.1
```

pair(4) (I)

With pair(4) and route(8) one can interconnect rdomains. Being virtualized ethernet it needs two endpoints that are then patched to each other:

```
$ doas ifconfig pair0 rdomain 0 10.200.21.1/30 up
$ doas ifconfig pair21 rdomain 21 10.200.21.2/30 up
$ doas ifconfig pair0 patch pair21
```

The pair(4) devices can be added to a bridge(4), too. STP dragons around.

To persist the above setup:

```
/etc/hostname.pair0:
description "gw-pair-0"
rdomain 0
inet 10.200.21.1/30

/etc/hostname.pair21:
description "gw-pair-21"
rdomain 21
inet 10.200.21.2/30
patch pair0
!/sbin/route -T 21 -qn add default 10.200.21.1
```

pair(4) (II)

finalized setup would look like this:

```
pair0: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        lladdr fe:e1:ba:d0:4a:8a
        description: gw-pair-0
        index 7 priority 0 llprio 3
        patch: pair21
        groups: pair
        media: Ethernet autoselect
        status: active
        inet 10.200.21.1 netmask 0xfffffffc broadcast 10.200.21.3
pair21: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> rdomain 21 mtu 1500
        lladdr fe:e1:ba:d1:ca:a3
        description: gw-pair-21
        index 8 priority 0 llprio 3
        patch: pair0
        groups: pair
        media: Ethernet autoselect
        status: active
        inet 10.200.21.2 netmask 0xfffffffc broadcast 10.200.21.3

Destination        Gateway            Flags   Refs      Use   Mtu  Prio Iface
default            10.200.21.1        UGS        0        1     -     8 pair21
10.20.21/24        10.20.21.1         UC         0        0     -     4 vlan21
10.20.21.1         08:00:27:5b:02:b2  UHLl       0        0     -     1 vlan21
10.20.21.255       10.20.21.1         UHb        0        0     -     1 vlan21
10.200.21.0/30     10.200.21.2        UC         1        0     -     4 pair21
10.200.21.1        link#8             UHLc       1        1     -     4 pair21
10.200.21.2        fe:e1:ba:d1:ca:a3  UHLl       0        0     -     1 pair21
10.200.21.3        10.200.21.2        UHb        0        0     -     1 pair21
```

rcctl(8) / rc.d(8)

For automated startup, rc.d(8) has ’daemonname_rtable=<N>’ support (default to 0). Consequently this can be configured using rcctl(8):

```
$ doas rcctl set httpd status on
$ doas rcctl set httpd rtable 21

$ doas rcctl get httpd
httpd_class=daemon
httpd_flags=
httpd_rtable=21
httpd_timeout=30
httpd_user=root

$ doas rcctl start httpd
httpd(ok)

$ ps auxo rtable | grep http # note last column
www      46042  0.0  0.7   744  1740 ??  Sp     4:43PM    0:00.00 httpd: server (h     21
[...]
```

The daemon was started like a manual ’route -T 21 exec httpd’.

ntpd(8)

- run only one ntpd(8) or the clock will go very funky — VERY
- ´server(s)´ go to rdomain 0 (or whichever it uses to reach them)
- ´listen´ can be repeated for every rdomain needed, flagged with ´rtable N´

```
server de.pool.ntp.org
listen 127.0.0.1
listen 127.0.0.1 rtable 69
listen 10.20.21.1 rtable 21
listen 10.40.41.1 rtable 41
```

pf.conf(5) (I)

before / after

all-in-one:

```
match out on $if_ext inet proto { icmp udp tcp } \
  from <net_tenant1> to !<rfc1918> nat-to $nat_tenant1

match out on $if_ext inet proto tcp from any \
  to !<rfc1918> port 25 nat-to $nat_tenant1_mail

match out on $if_ext inet proto { icmp udp tcp } \
  from <net_tenant2> to !<rfc1918> nat-to $nat_tenant2
```

rdomains:

```
anchor "tenant1" on rdomain 21 {

  match out on $if_ext inet proto tcp from any \
    to !<rfc1918> port 25 nat-to $nat_tenant1_mail

  match out on $if_ext inet proto { icmp udp tcp } \
    from <net_tenant1> to !<rfc1918> nat-to $nat_tenant1
}

anchor "tenant2" on rdomain 41 {

  match out on $if_ext inet proto { icmp udp tcp } \
   from <net_tenant2> to !<rfc1918> nat-to $nat_tenant2
}
```

pf.conf(5) (II)

before / after

all-in-one /etc/pf.conf:

```
set skip on lo0 enc0 enc1
set optimization aggressive

block in from $tenant1 to $tenant2 # watch out XXX!

pass from $tenant1 to any nat-to $tenant1_public

match out from $tenant2 to any nat-to $tenant2_public #on request call 3am

match out from any to any nat-to (egress)
```

rdomains with (anchored) includes /etc/pf.conf:

```
include "/etc/pf/globals.conf"
include "/etc/pf/management.conf"
anchor "tenant1" on rdomain 21 {
  include "/etc/pf/tenant1.conf"
}
anchor "tenant2" on rdomain 41 {
  include "/etc/pf/tenant2.conf"
}
# EOF
```

Pitfalls (I)

- route lookup: if there’s none, nothing will happen (even with pf.conf), some sane default if not using pair(4):

```
/etc/hostname.vlan21:
up
rdomain 21
!/sbin/route -T21 -qn add -net 127 127.0.0.1 -reject
!/sbin/route -T21 -qn add default 127.0.0.1 -blackhole
```

- rdomains(4): rdomains/rtable is not removable so look out for ’remains’ when playing (adding/removing/..) around
- ifconfig(8): when adding (changing) an rdomain, the inet or inet6 configuration will be removed
- bridge(4): when adding pair(4) it’s "easy" to create a loop, use ’stp’ on the pair members

```
$ doas ifconfig bridge0 add pair0 add pair21 stp pair0 stp pair21 up
```

- ping(8), traceroute(8): careful with ’bind-address’ esp. when overlapping IP-networks around

Pitfalls (II)

- iked(8): no choosable socket (but ikectl(8) can..)
- authpf(8): tricky to use different config files
- isakmpd(8), iked(8): needs one enc(4) per rdomain(4) or no IPsec packets will flow
- carp(4): by its nature, it must be in the same rdomain as its parent ’carpdev’. As a remedy virtual interfaces that can be inserted for abstraction: vlan(4) or vether(4)+bridge(4) as below:

```
$ doas ifconfig vether51 rdomain 51 10.51.1.2 up
$ doas ifconfig vether52 rdomain 52 10.52.1.2 up
$ doas ifconfig bridge0 add em1 add vether51 add vether52 \
        stp em1 stp vether51 stp vether52 up
$ doas ifconfig carp51 rdomain 51 carpdev vether51 10.51.1.1 up
$ doas ifconfig carp52 rdomain 52 carpdev vether52 10.52.1.1 up
```

Output: https://gist.github.com/double-p/d3a20fded7e8ced30735705e1dfea5c4

relayd(8)

- Currently: Limited capability of doing rdomains(4):
  - no choosable anchorname — be very careful in redirect "naming"
  - no choosable socket — relayctl(8) will work on the last started instance
  - ´routers' — can insert routes in given rtable
  - ´redirects' — only uses 'on rdomain' in which relayd(8) was started.
- Future?: work in progress effort:
  - -s : choose a socketname — must be a config option for relayd(8)
  - -a : choose an anchorname instead of 'relayd/*' — also config option
  - rtable in 'redirect' : lookup up destination in choosable rtable; any 'check' would still be in the rdomain that relayd was started with

Diffs on http://github.com/double-p/smtf/tree/master/patches

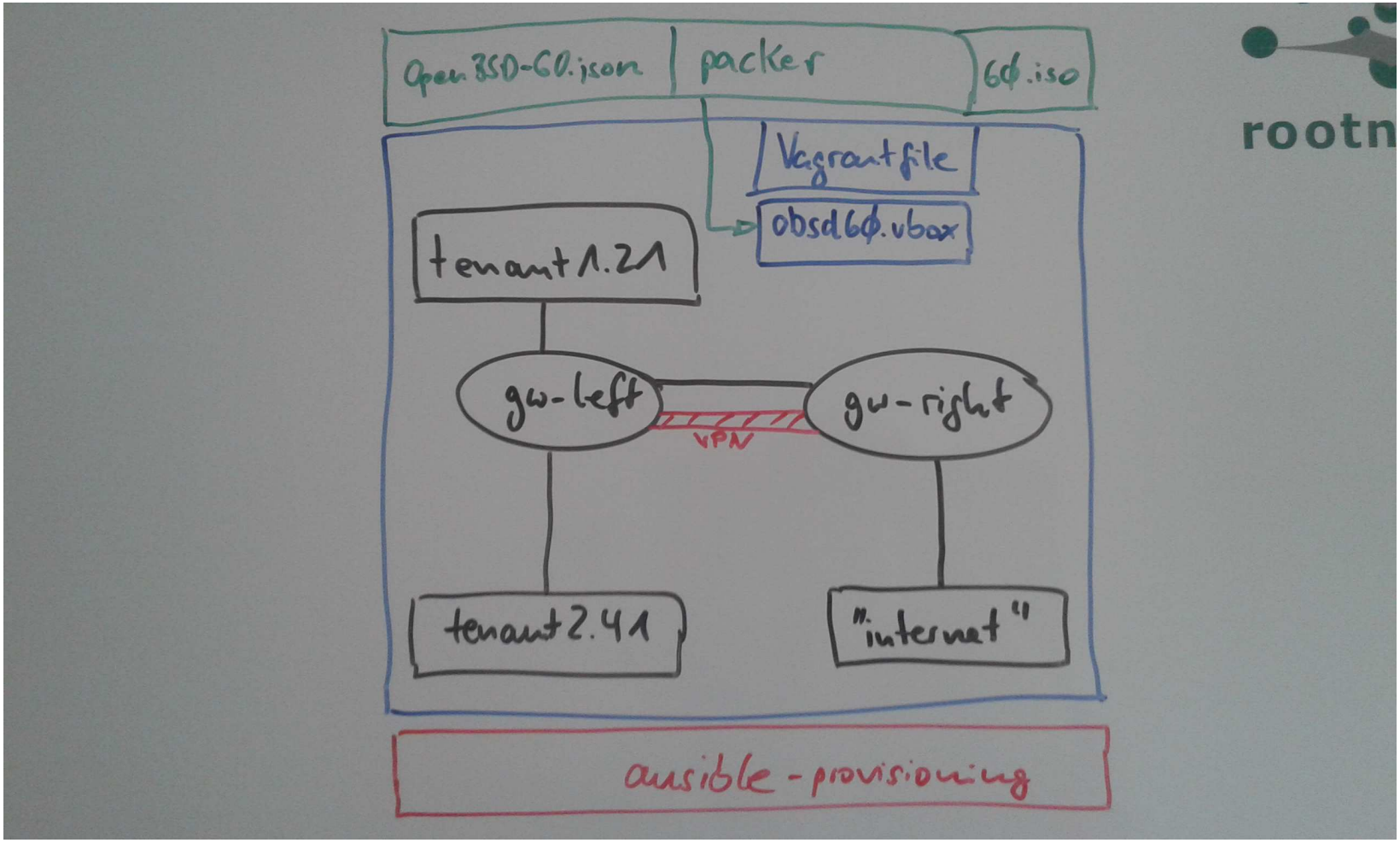
```
$ cat /etc/relayd.conf
table <local> { 127.0.0.21 }
redirect "foo" { listen on 127.0.0.1 port http
forward to <local> port 8000 check icmp rtable 21 }

$ doas route -T 21 exec relayd -a rdr21 -s /var/run/relayd21.sock

$ doas pfctl -a 'rdr21/*' -sr
anchor "foo" all {
 pass in quick on rdomain 21 inet proto tcp from any to 127.0.0.21 port = 80 flags
 S/SA keep state (tcp.established 600) rtable 21 rdr-to <foo> port 8000 round-robin
}
```

Automation Toolbox

To create reproducible and consistent environments for debugging, development, testing some additional software can complement the OpenBSD bolts.

- Vagrant: start ’baseimages’ in distinct VMs based on VirtualBox, VMware,.. and configure base ("physical") networks and other resources. Even multiple VMs from a single, not too complex, configuration file can be defined and operated.
- packer: using a JSON configuratio file create a ’baseimage’ from an ISO; to be used from Vagrant
- ansible: based on variable files (YAML) and templates (Jinja2) the needed configuration can be created, written and activated in the VMs

Testbed layout



packer

Toolkit to create "vagrant" base boxes (and others) based on installNN.iso.
Workflow from the configuration on github looks like:

- create a temporary VBox-VM
- boot install60.iso
- write out install.conf (keyboard emulation)
- autoinstall(8) from that
- add sudo and python (used by vagrant / ansible)
- shutdown and create a box-file that can be used with Vagrant.

Sidenote: do not forget to adapt iso_url and iso_checksum when updating to current/snapshot/6.1

Vagrant

A descriptive, repeateable toolkit to create VMs based on VirtualBox, VMware and many more.

Most notable bits in the provided config for customization:

```
# must match the imported packer image (Packer/README.md)
config.vm.box = "obsd60"

# vm.network in same prefixes are "cable connected" automatically
v.vm.network :private_network, ip: "1.2.3.4"

# if networking goes totally wrong, have a VirtualBox-GUI-console ready
vb.gui = true;

# run the script on the top to change the automatically added routing
v.vm.provision "shell", inline: $inlprv, args: "10.40.40.254"
```

(Someone in this room might add vmd(8) to vagrant the other day).

ansible

A python based framework enabling to provision nodes of almost any kind. The 'smtf' repo bits are able to do the following work:

- vagrant-pb.yml — create Vagrantfile and matching ansible 'inventory' file
- rdomain-pb.yml — provision /etc/hostname.if for all needed devices; adapt sysctl; "PS1"

Basis for the above are several files:

- group_vars — network-definition, carp-key, if-family
- host_vars — interface config (no change needed, deviates from group_vars)
- roles/vagrant/templates — Vagrantfile and ansible inventory
- roles/all/templates — hostname.if, ksh-profile
- roles/all/tasks/main.yml — sysctl.conf and activation

Closing wrapup

- Complex setups are difficult to operate without fallouts
- Three times the above if it’s 3 in the morning
- rdomains keep tenants seperated without need for a ruleset
- rulesets can be seperated by includes and/or anchors
- seperated setups are easier to operate, even from "junior" staff
- Scared? Test in virtualized environment to remove breakage
- Testing creates confidence in your setup
- Automation + provisioning saves the day (and weekend)
- Check back for further development of ’smtf’ on github

Input + Thanks

Peter Hessler
: for the talks, experiences and help in rdomains

Ingo Schwarze
: for helping out with roff/gpresent to create this doc

OpenBSD developers
: for adding this and OpenBSD itself

sysfive.com GmbH
: for giving enough working hours to get this done

Some more to learn from - and foundations for this talk

manpages (kid you not) • pf.conf(5), route(1), rdomain(4), pair(4), ..

https://www.youtube.com/watch?v=BizrC8Zr-YY • Peter Hessler on rdomains (BSDCan2015)

http://www.openbsd.org/papers • All OpenBSD presentations, including the above talks

http://github.com/double-p/smtf • This talk and paper, relayd patches and automation environment

https://www.youtube.com/watch?v=ufeEP_hzFN0 Reyk Floeter on vxlan/cloud networks

https://www.youtube.com/watch?v=mN5E2EYJnrw David Gwynne on pf/pfsync