Linux Containers: Future or Fantasy?

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Infosec, pentesting, Neg9/CTF

iSEC Partners for 5.5 years

  NCC Group for 0.1 years

Hacking Samsung Smart TVs @ BH USA 2013, Toorcon, etc

Macs in the age of the APT @ BH USA 2011, Source, etc

Disclaimer

These slides are not intended to be consumed without the corresponding presentation or whitepaper. The information contained within is designed for presenting and not 100% completeness with regards to risks, recommendations, findings, etc.

Story One: *The Server*

Once Upon a Time

Bob’s Ruby on Rails **app gets popped**
or his SQL database **server is compromised**
or his Wordpress plugin gives **RCE**
or ….

He wants to **add security**… But **how**?

Chroot ?

OLD

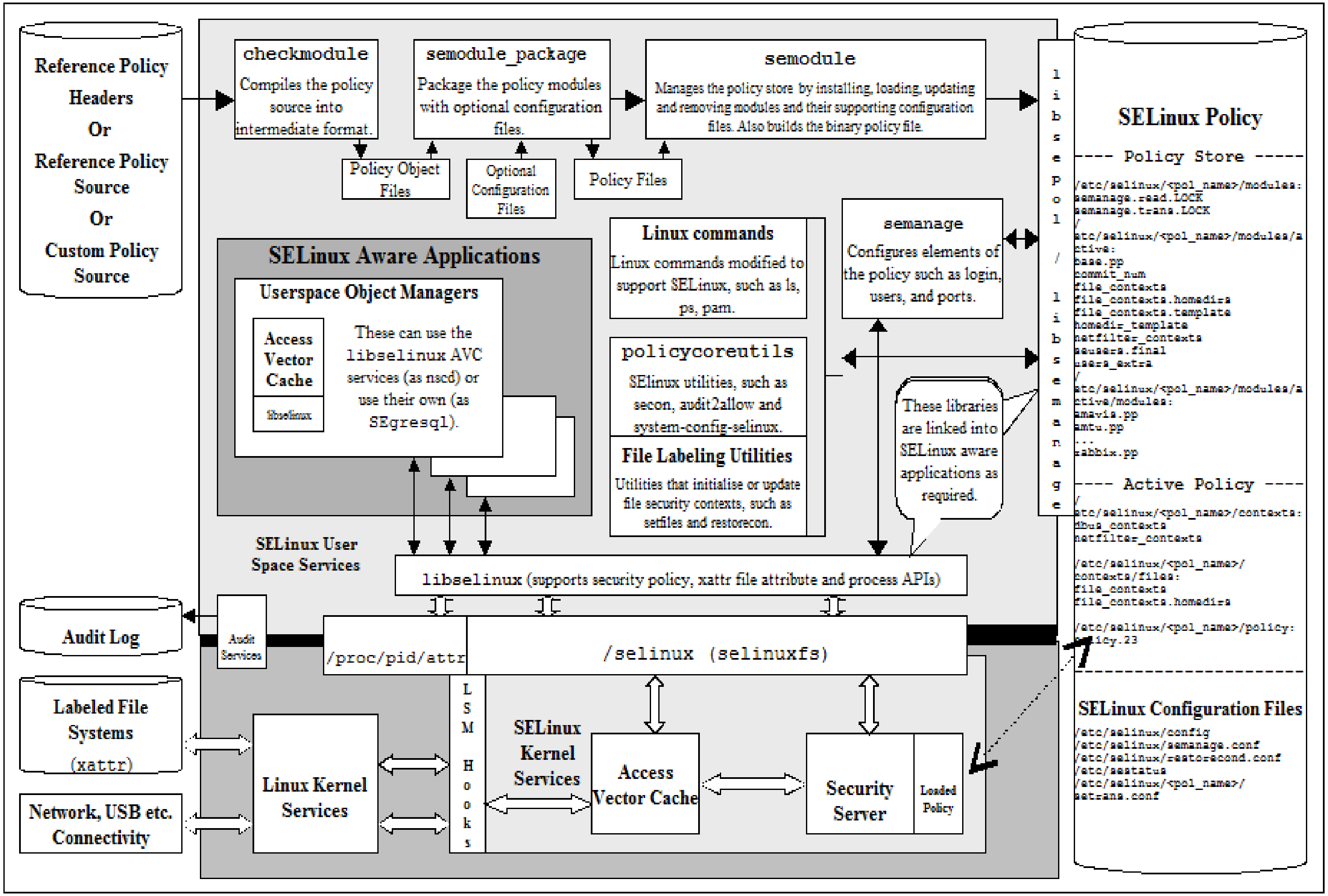
The tried and true still used today

Broken if you have root

Chroot ☹

```
mkdir(“ncc");
chroot(“ncc");
chdir("../..");  ← oh no…
chroot(".");
```

SELinux ?



Reference Policy Headers
Or
Reference Policy Source
Or
Custom Policy Source
checkmodule
Compiles the policy source into intermediate format.
semodule_package
Package the policy modules with optional configuration files.
semodule
Manages the policy store by installing, loading, updating and removing modules and their supporting configuration files. Also builds the binary policy file.
Policy Object Files
Optional Configuration Files
Policy Files
libsepol / libsemanage
SELinux Policy
---- Policy Store -----
/etc/selinux/<pol_name>/modules:
semanage.read.LOCK
semanage.trans.LOCK
/etc/selinux/<pol_name>/modules/active:
base.pp
commit_num
file_contexts
file_contexts.homedirs
file_contexts.template
homedir_template
netfilter_contexts
seusers.final
users_extra
/etc/selinux/<pol_name>/modules/active/modules:
amavis.pp
amtu.pp
...
zabbix.pp
---- Active Policy ----
/etc/selinux/<pol_name>/contexts:
dbus_contexts
netfilter_contexts
/etc/selinux/<pol_name>/contexts/files:
file_contexts
file_contexts.homedirs
/etc/selinux/<pol_name>/policy:
policy.23
SELinux Configuration Files
/etc/selinux/config
/etc/selinux/semanage.conf
/etc/selinux/restorecond.conf
/etc/sestatus
/etc/selinux/<pol_name>/setrans.conf
SELinux Aware Applications
Userspace Object Managers
Access Vector Cache
libselinux
These can use the libselinux AVC services (as nscd) or use their own (as SEgresql).
Linux commands
Linux commands modified to support SELinux, such as ls, ps, pam.
semanage
Configures elements of the policy such as login, users, and ports.
policycoreutils
SElinux utilities, such as secon, audit2allow and system-config-selinux.
File Labeling Utilities
Utilities that initialise or update file security contexts, such as setfiles and restorecon.
These libraries are linked into SELinux aware applications as required.
SELinux User Space Services
libselinux (supports security policy, xattr file attribute and process APIs)
Audit Log
Audit Services
/proc/pid/attr
/selinux (selinuxfs)
Labeled File Systems (xattr)
Network, USB etc. Connectivity
Linux Kernel Services
LSM Hooks
SELinux Kernel Services
Access Vector Cache
Security Server
Loaded Policy

SELinux ?

NSA made it

Complex type system for MLS systems

Good support on RHEL

SELinux (and other MAC) ☹

Complexity

Linus Torvalds problem

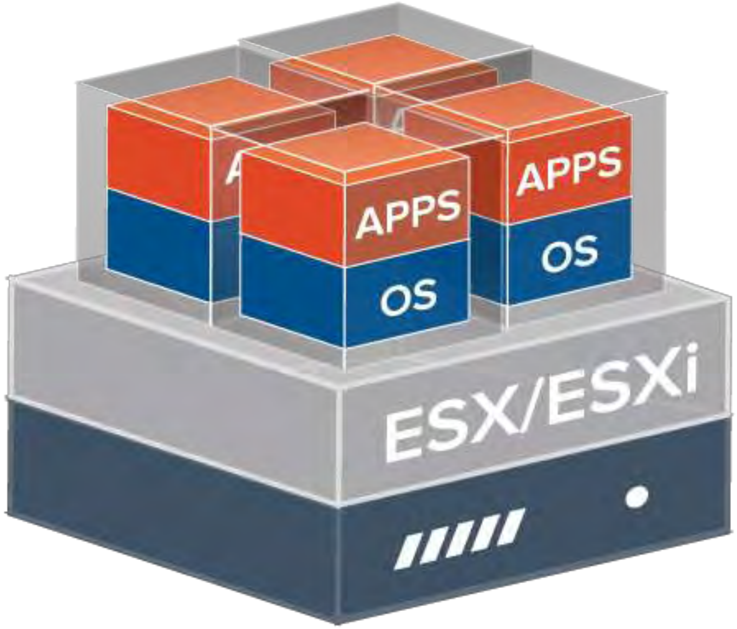
The **`setenforce 0`** problem

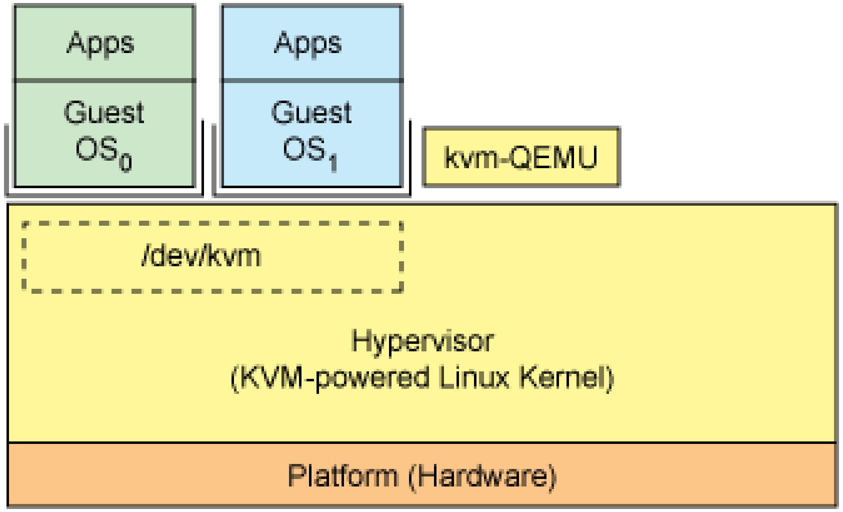
Kernel enforces it: *Kernel gotta kernel*

OK, No MAC but grsecurity!

Well you’ve protected the kernel, apps and helped prevention memory corruption and hardened against other attacks but…

Full Virtual Machines?





Full Virtual Machines ☹

QEMU, KVM or ESX escapes

Recent Xen/QEMU updates anyone?

VM for single process?
Nope.

Story Two: *The Client*

Once Upon a Time

"Gulenn" talks to a potential source named "citizenfour"

He can't use a Chromebook because he is paranoid of Google

Hey, just use Linux!

“Malware is just for Windows”

“OSX sucks, it’s insecure”

Linox is like… super sakure right?

aaaaannnnddd broken…

He’s one webkit or gekco bug away from a TBB compromise. **What app sandboxes?**

Pidgin and libpurple don’t have a great track record

LiveCDs are stale code by definition

Story Three: The Embedded

Once Upon a Time

Margaret is in charge of embedded security at D-LINK, Belkin, <insert IoT company>

She wants to add isolation between the web app, wpa_supplicant and DLNA stack

Tired of having **CSRF-able arbitrary code execution** via buggy input validation

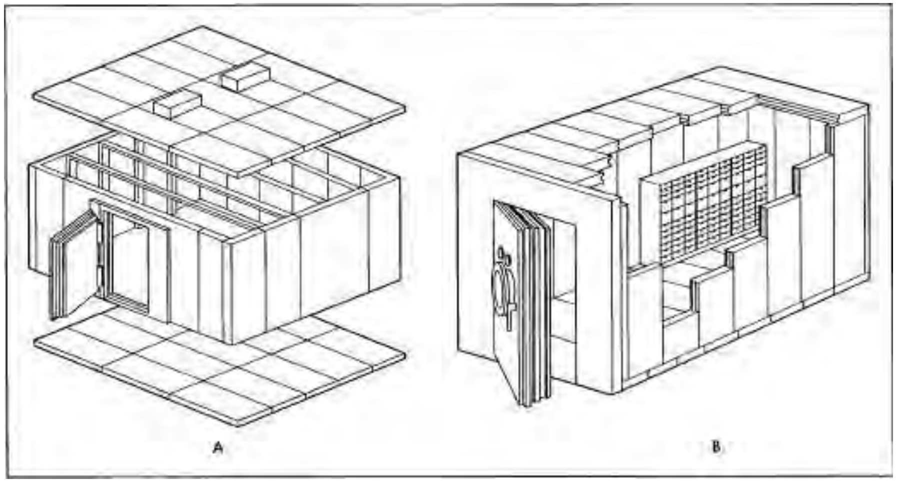
Margret isn't alone!

Everything runs as root

No security is added (because $$$)

You can't easily virtualize or segment ARM/MIPS within a router, but is there nothing we can do to improve IoT?

What do these stories have in common?



What do these stories have in common?

Attack surface matters *almost* more than anything else

Sandboxes and containers at least let us pick our battles: they **should be the rule not the exception** (Props to Google Chrome Browser, Adobe Reader X, Apple Seatbelt, Google ChromeOS, etc)

How can we work to improve server, desktop and embedded security for Linux ?

We have to try something new

Paul Smecker: They exited out the front door. They had no idea what they were in for. **Now they're staring at six men with guns drawn.** It was a fucking ambush.

Paul Smecker: This was a fucking bomb dropping on Beaver Cleaverville. **For a few seconds, this place was Armageddon!**

Officer Greenly: What if it was just **one guy with six guns**?

Paul Smecker: Why don't you let me do the thinking, huh, **genius**?

But Greenly was right… it was “il Duce”

What if it wasn't **one cpu with multiple kernels**, but

one kernel with multiple userlands?

OpenVZ

Linux Vservers

FreeBSD Jails

OpenBSD/NetBSD Sysjail

Solaris Zones

HP UX Containers

AIX Workload Partitions

A little bit about OS Virtualization

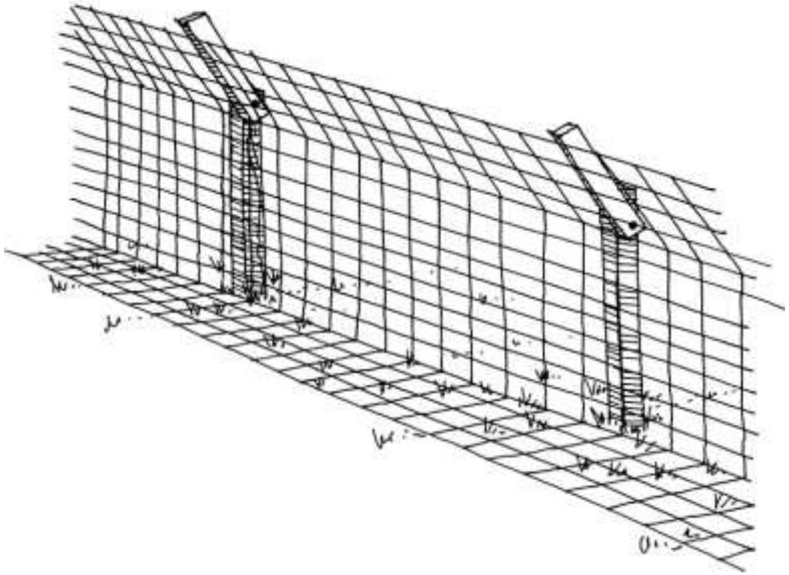
Fundamentally less secure than hardware virtualization

OS vs Hardware Virtualization

Hardware virtualization creates software emulation for pretty much everything

Software or OS virtualization partitions a single kernel and attempts to restrict or control access to hardware

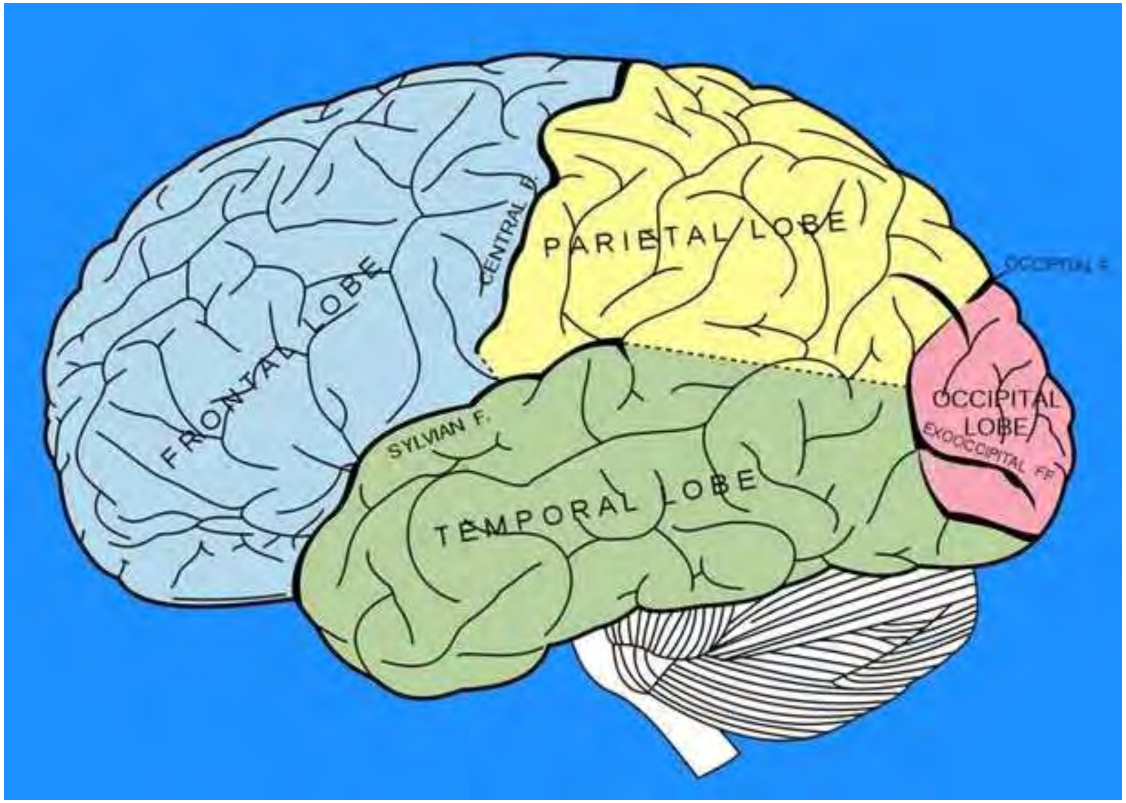
But we don’t want to depend on a **single method** for security …



Hardware virtualization is even fundamentally less secure than physically different hardware…

(surrounded by guys with guns and fences)

Namespaces

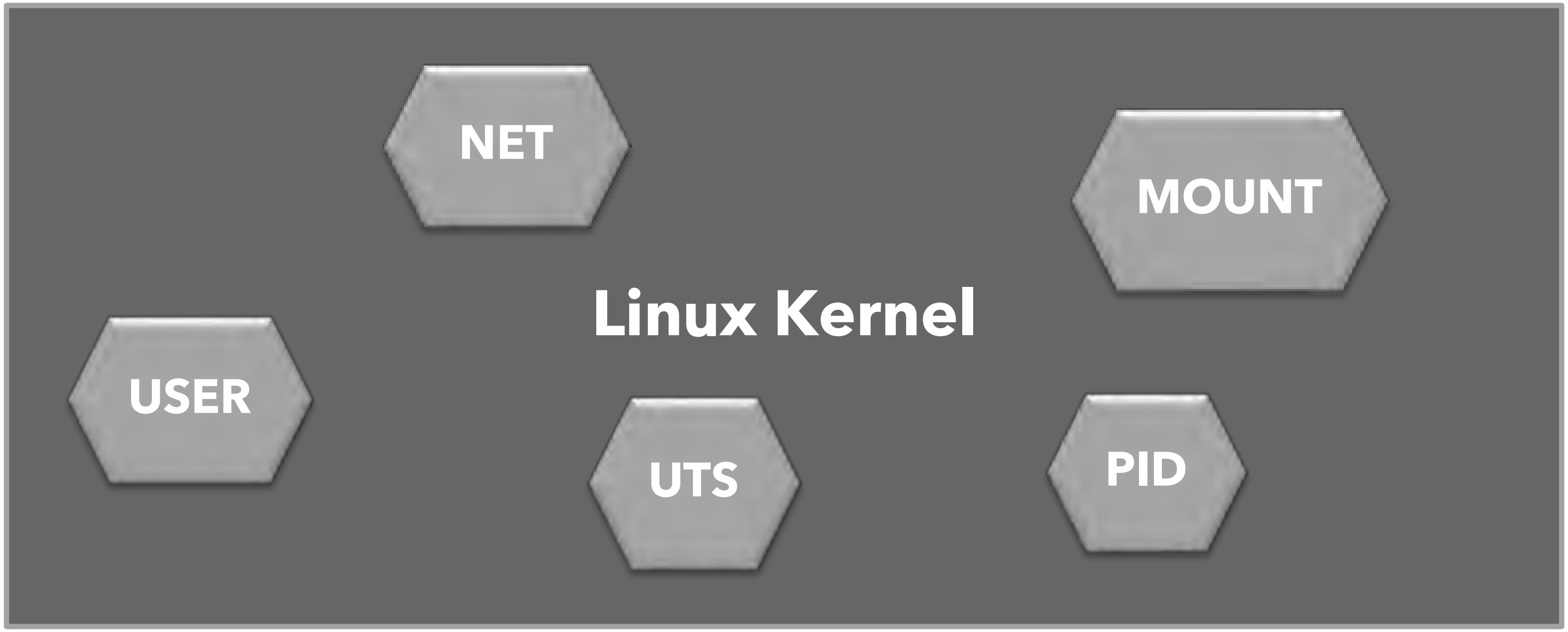

FRONTAL LOBE
CENTRAL F.
PARIETAL LOBE
OCCIPITAL F.
OCCIPITAL LOBE
EXOCCIPITAL FF.
SYLVIAN F.
TEMPORAL LOBE

Namespaces

Plan9

http://www.cs.bell-labs.com/sys/doc/names.html

Namespaces



It all starts with a `CLONE(2)`

```
clone(2)
```

"Kernel Execution Context"

```
set_ns(2)
unshare(2)
```

MOUNT Namespace

`CLONE_NEWNS`: Added in 2.4.19 kernel

Per user / via PAM

Per process view of files, disks, NFS

IPC Namespace

`CLONE_NEWIPC:` Added in 2.6.19

“System 4 IPC objects”

UTS Namespace

`CLONE_NEWUTS:` Added in 2.6.19

`uname(2), setdomainname(2), sethostname(2)`

PID Namespace

`CLONE_NEWPID:` Added in 2.6.24

Process IDs start at 1

Can be nested

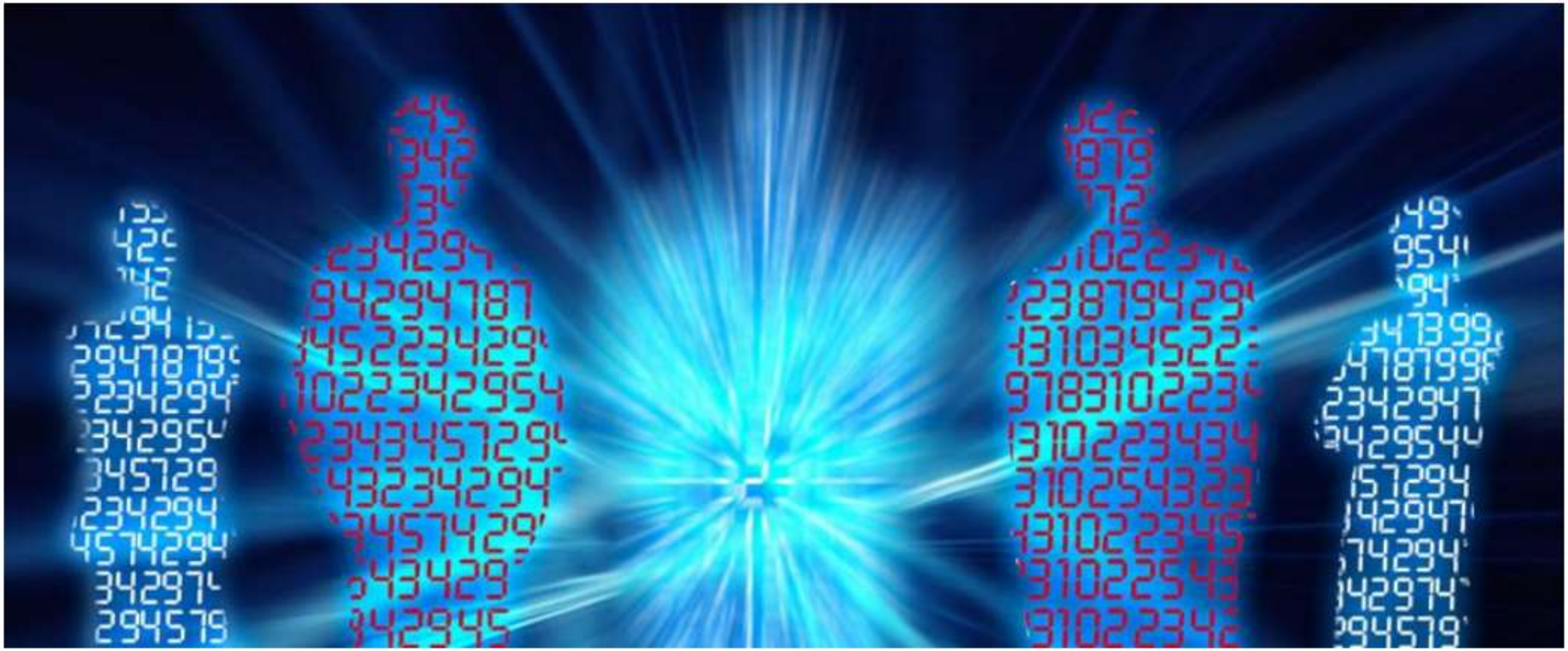
PID NS example

```
$ lxc-create -t busybox -n foo ; lxc-start -n foo

$ lxc-attach -n foo -- ps
PID   USER     COMMAND
    1 root     init
    5 root     /bin/sh
   10 root     ps
```

Unisys Stealth Solution Suite

You can't hack what you can't see. Changing the Security Paradigm.



NETWORK Namespace

`CLONE_NEWNET:` Added in 2.6.24

Separate network device, IP, MAC, routing table, firewall

USER Namespace

`CLONE_NEWUSER`: Added in 2.6.23 but finished 3.8

Important for actually securing containers

… also a high risk area of the kernel :/

USER NS example

```
$ lxc-attach -n foo -- sh
```

```
BusyBox v1.21.1 (Ubuntu 1:1.21.0-1ubuntu1) built-in shell
(ash) …
$ id
uid=0(root) gid=0(root)
$ sleep 1337
```

```
100000   17110  0.0  0.0   2184  260 pts/14   S+   12:03   0:00 sleep 1337
```

Capabilities

CAP_WAKE_ALARM

CAP_NET_RAW

CAP_SETGID

CAP_MAC_ADMIN

CAP_NET_ADMIN

CAP_SYS_CHROOT

CAP_SYS_PTRACE

CAP_SYS_RAWIO

CAP_SETUID

root

CAP_SYS_BOOT

CAP_SYS_PCAP

CAP_SYS_ADMIN

CAP_AUDIT_WRITE

CAP_SYSLOG

CAP_NET_BIND_SERVICE

CAP_SYS_MODULE

CAP_SYS_TIME

CAP_DAC_READ_SEARCH

CAP_MKNOD

Capabilities

Pros: Kernel devs adding them ☺

Cons: Busy (and lazy) kernel devs ☹

Result: Semi-working capabilities model!

Examples of Capabilities

```
CAP_NET_ADMIN
CAP_NET_RAW
CAP_NET_BIND_SERVICE
CAP_SYS_RESOURCE
CAP_SYS_PTRACE
CAP_SYS_RAWIO
CAP_KILL
```

Dropping Capabilities

What should be dropped ?

Everything!

What if I leave just “CAP_FOO” enabled?

It depends…

Fixing ping

```
$ ls -l /bin/ping
-rwsr-xr-x 1 root root 44168 May 7 2014 /bin/ping

$ cp /bin/ping /tmp ; ls -l /tmp/ping
-rwxr-xr-x 1 root root 44168 Mar 18 11:02 /tmp/ping

$ /tmp/ping localhost
ping: icmp open socket: Operation not permitted
```

Fixing ping

```
$ sudo setcap cap_net_raw=p /tmp/ping

$ getcap /tmp/ping
/tmp/ping = cap_net_raw+p

$ /tmp/ping localhost
PING localhost (127.0.0.1) 56(84) bytes of data
64 bytes from localhost (127.0.0.1): icmp_seq ...
```

Some Dangerous Capabilities

SYS_CHROOT

SYS_MODULE

SYS_RAWIO

SYS_PTRACE

MAC_ADMIN

MAC_OVERRIDE

DAC_READ_SEARCH

NET_RAW

NET_ADMIN

CAP_MKNOD

CAP_SYS_ADMIN == root

* Perform a range of system administration operations including: quotactl(2),

mount(2), umount(2), swapon(2), swapoff(2), sethostname(2), and setdomainname(2);

* perform privileged syslog(2) operations (since Linux 2.6.37, CAP_SYSLOG should

be used to permit such operations);

* perform VM86_REQUEST_IRQ vm86(2) command;

* perform IPC_SET and IPC_RMID operations on arbitrary System V IPC objects;

* perform operations on trusted and security Extended Attributes (see attr(5));

* use lookup_dcookie(2);

* use ioprio_set(2) to assign IOPRIO_CLASS_RT and (before Linux 2.6.25)

IOPRIO_CLASS_IDLE I/O scheduling classes;

* forge UID when passing socket credentials;

* perform administrative operations on many device drivers.

* exceed /proc/sys/fs/file-max, the system-wide limit on the number of open files, in system calls that open files (e.g., accept(2), execve(2), open(2), pipe(2));

* employ CLONE_* flags that create new namespaces with clone(2) and unshare(2);

* call perf_event_open(2);

* access privileged perf event information;

* call setns(2);

* call fanotify_init(2);

* perform KEYCTL_CHOWN and KEYCTL_SETPERM keyctl(2) operations;

* perform madvise(2) MADV_HWPOISON operation;

* employ the TIOCSTI ioctl(2) to insert characters into the input queue of a terminal other than the caller's controlling terminal.

* employ the obsolete nfsservctl(2) system call;

* employ the obsolete bdflush(2) system call;

* perform various privileged block-device ioctl(2) operations;

* perform various privileged filesystem ioctl(2) operations;

See False Boundaries and Arbitrary Code Execution post by Spender

https://forums.grsecurity.net/viewtopic.php?f=7&t=2522

Control groups

cgroups

Hierarchical and inheritable

Controls different subsystems
(Dev, CPU, Mem, I/O, Network)

ulimit on steroids

cgroups

Controlling access to resources based on subgroups:

devices, CPU, I/O, Mem, …

Filling **some gaps** of namespaces

cgroups

Controlling cgroups is typically performed via a virtual filesystem: **`/sys/fs/cgroup`**

Main configuration (besides container configs): **`/etc/cgrules.conf`**, **`/etc/cgconfig.conf`**

cgroups

cgexec

cgmanager

Container platforms make it easy

Putting that all together…

Putting it all together…

Namespaces logically isolate kernel elements

Capabilities help enforce namespaces and reduce undesired privileges

Cgroups limit hardware resources

Enter: Containers (LXC, Docker, CoreOS rkt, Heroku, Flockport, Kubernets, Joyant, etc)

Linux Containers

Better than chroot!

Still not virtualization…

Mount options

Beyond ro, nodev, noexec, nosuid

Bind, Overlay, Union, CoW, Versioning, even sshfs

Namespaces, Capabilities and Cgroups: where are they now on Linux *servers*?

Self-hosted PaaS systems

Amazon EC2

Google App Engine

Rackspace, Heroku

Namespaces, Capabilities and Cgroups: where are they now on Linux *clients*?

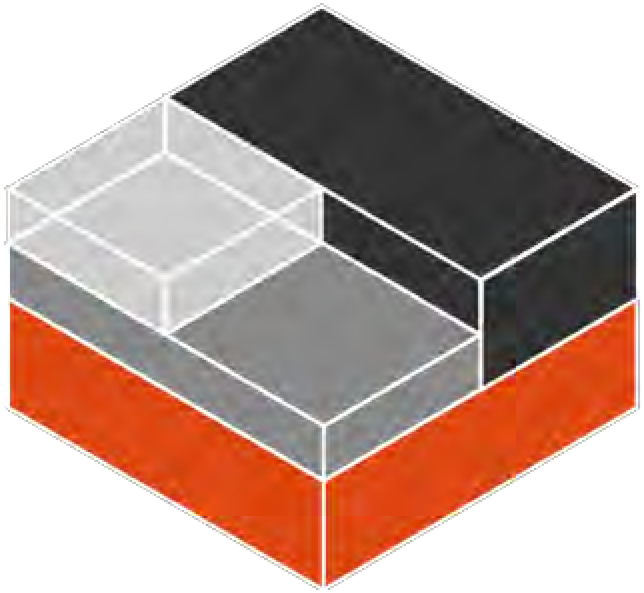
ChromeOS and the Chrome browser

Limited use in Android

Some Linux distros

Sandboxing tools: minijail, mbox

LinuX Containers: **LXC**



LXC: Template: Basics

```
lxc.rootfs = /var/lib/lxc/defcon-ctf/rootfs
lxc.utsname = isec
lxc.start.auto = 1
lxc.mount.entry = /lib lib none ro,bind,nodev 0 0
lxc.mount.entry = /lib64 lib64 none ro,bind,noexec 0 0
```

LXC: Template: Cgroups

```
lxc.cgroup.tasks.limit = 256
lxc.cgroup.devices.deny = a
lxc.cgroup.devices.allow = b 9:0 r
lxc.cgroup.memory.limit_in_bytes = 4000000
```

LXC: Template: Other Security

```
lxc.cap.keep = sys_time sys_nice
lxc.aa_profile = lxc-container-default
lxc.seccomp = /path/to/seccomp.rules
```

Recent Advancements

Unprivileged Containers

Non-root users can now create/start containers **and be "root" inside the container**

Weird things can obviously happen

More work and auditing to be done

What about that kernel attack surface?

There are **190 syscalls** in Linux **2.2**
There are **337 syscalls** in Linux **2.6**
There are **340 syscalls** in Linux **4.1**

How many does your app *really* need?

Seccomp-bpf

SECure **COMP**uting

Filtering the kernel (yet again)

“**System call filtering isn't a sandbox.** It provides a clearly defined **mechanism for minimizing the exposed kernel surface**.” – Will @redpig Drewry, Google

Seccomp-bpf

Syscall arguments can also be filtered (mostly)

Large number of filters = performance hit

Only really supports x86 and x86_64 (for now)

You'll need LXC, Minijail or Mbox

(Docker /contrib now, release branch soon (1.8?))

Seccomp-bpf

`prctl(2)` – operations on a process

`PR_SET_SECCOMP:`

```
  SECCOMP_MODE_STRICT (old)
  SECCOMP_MODE_FILTER (new hotness)
```

Seccomp-bpf

```
struct sock_filter filter[] = {
      BPF_STMT(BPF_LD+BPF_W+BPF_ABS, syscall_nr),
      BPF_JUMP(BPF_JMP+BPF_JEQ+BPF_K, __NR_ptrace, 1, 0),
      BPF_STMT(BPF_RET+BPF_K, SECCOMP_RET_ALLOW),
      BPF_STMT(BPF_RET+BPF_K, SECCOMP_RET_KILL)
  };

struct sock_fprog prog = {(unsigned short) (sizeof(filter) /
sizeof(filter[0])), filter };

prctl(PR_SET_NO_NEW_PRIVS, 1, 0, 0, 0);
prctl(PR_SET_SECCOMP, SECCOMP_MODE_FILTER,
&prog);
```

Berkeley Packet Filter

```
# tcpdump -p -nqi wlan0 -d ‘tcp and port 80’
(000) ldh      [12]
(001) jeq      #0x86dd         jt 2 jf 8
(002) ldb      [20]
(003) jeq      #0x6            jt 4 jf 19
(004) ldh      [54]
(005) jeq      #0x50           jt 18    jf 6
(006) ldh      [56]
(007) jeq      #0x50           jt 18    jf 19
(008) jeq      #0x800          jt 9 jf 19
(009) ldb      [23]
. . . . .
```

Seccomp-bpf: where

ChromeOS / Google Chrome

Firejail

OpenSSH

Capsicum

Tor

Mbox

vsftpd

BIND

LXC

QEMU

Opera Browser

Docker (/contrib)

So who is implementing and supporting containers?

Docker

CoreOS

Flockport

Sandstorm.io

RancherOS

Heroku (ish)

Joyent

Amazon

VMware

Google/Kubernets

… and many more

Lets talk about the big two

What is the "big deal"

Packaging and deployment focused – one *app per container*

Devs and Ops, DevOps, DevCyberOps, DevSecOps, BlackOps, etc

Developing PaaS

Makes it **easy**

So Docker is just LXC? Nope.

libcontainer, libchan, libswarm, etc

Written in go

REST API

Running docker daemon (as root)

Docker Ecosystem

Docker **images**:

```
$ docker run --name mynginx -v \
                    /opt/content:/usr/share/nginx/html:ro -d nginx
```

Docker **Hub**:

```
$ sudo docker run ubuntu:14.04 /bin/echo 'Hello world’
Hello world
```

Orchestration, Communication, Management

CoreOS

CoreOS

Minimal OS for hosting containers

Launching the rkt and app container spec

App container spec picked up by VMware Photon

Separation from Docker and LXC

Why Docker, Rocket, etc?

Takes **some** of the configuration away

FreeBSD::OSX → LXC::Docker

Additional packaged tools | features

Why Docker, Rocket, etc?

LXC: *You want to run a containerized OS or single app.* ***Hard mode with the most flexibility.***

Docker: *You want to run a single app per container.* ***Easy mode with some costs.***

CoreOS: *You want to host Docker containers or try and use rkt.* ***So much bleeding it's rated R.***

Going on the attack

Lets think about this....

Container to other container

Container to itself

Container to host

Container to support infrastructure

Container to local network

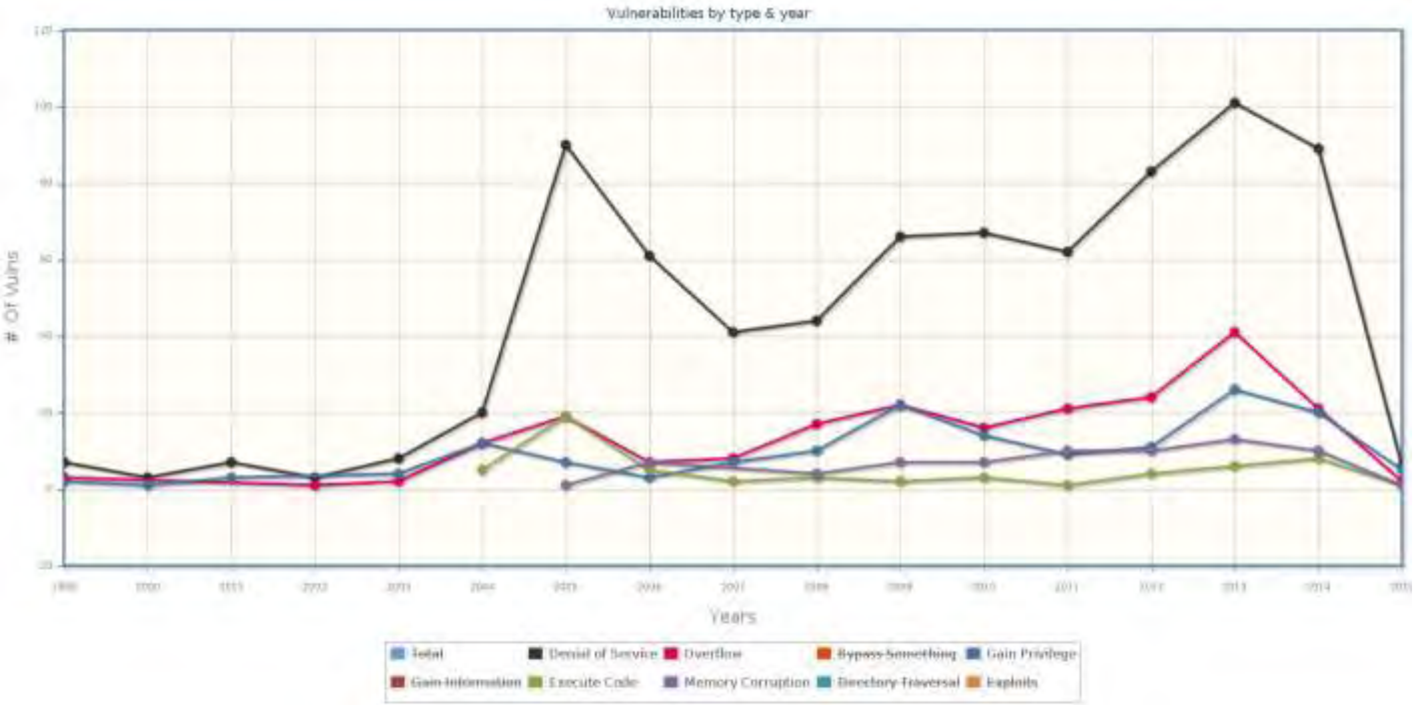
Container to …

Starting at the top

Starting at the top

Kernel who?

Lots of drivers, old code, weird filesystems, old syscalls, platform specific problems strange or unused network protocols



Not.... Dropping caps

If you don’t drop the right ones: **game over**

Not dropping caps also allows kernel code exec... `CAP_NET_ADMIN` (CVE-2013-4588, CVE-2011-2517, CVE-2011-1019, ...)

Not…. Dropping caps

Speaking of dropping capabilities, a Docker shocker: **`CAP_DAC_READ_SEARCH`**

"Invoke **`open_by_handle_at(2)`**"

Brute force the inode of **/etc/shadow**

Props to Stealth aka Sebastian Kramer

Not…. Dropping caps

Without a MAC system, capability dropping and the user namespace are your *only line of defense*

Not…. Limiting access

Procfs:	`/proc/kcore,`
	`/proc/sys/modprobe,`
	`/proc/sys/kernel/sysrq`
Sysfs:	`/sys`
Cgroups does not limit:	`mknod`
Kernel ring buffer:	`dmesg`
Network access:	`br0`
Unintended devfs:	`/dev, /dev/shm`

Not…. Limiting resources

Forkbomb!

```
:(){ :|:& };:
```

Memory, disk, entropy…

When good containers go stale

When was the **last time you updated OpenSSL** in your Docker container?

How do you deal with *updates in place* if apt-get upgrade is a “no-no”?

Lack of MAC (Mandatory Access Controls)

"The flawed assumption of modern computing environments"

Eggs in one (kernel) basket

AppArmor does a decent job

LXC Weaknesses

Bad defaults: Capability dropping, networking,

Unprivileged containers finished-ish

A few security fixes have lagged :/

Docker Weaknesses

Capability dropping: a shocker

Root daemon plus root to use it

Weak REST API authentication defaults

Docker “github all the way down”

Docker Weaknesses

Does not drop all capabilities by default, drops all except "those needed" (still includes some dangerous capabilities CAP_NET_RAW, CAP_FOWNER, CAP_MKNOD, …)

Docker binds container port maps to all interfaces *by default*

Base images are huge… apt-get is hungry

Docker networking defaults allow cross-container networking and access to Docker host

Docker Weaknesses

Giving low rights users access to Docker means giving them root on the Docker host

Currently missing support for key security features: seccomp-bpf and the User Namespace

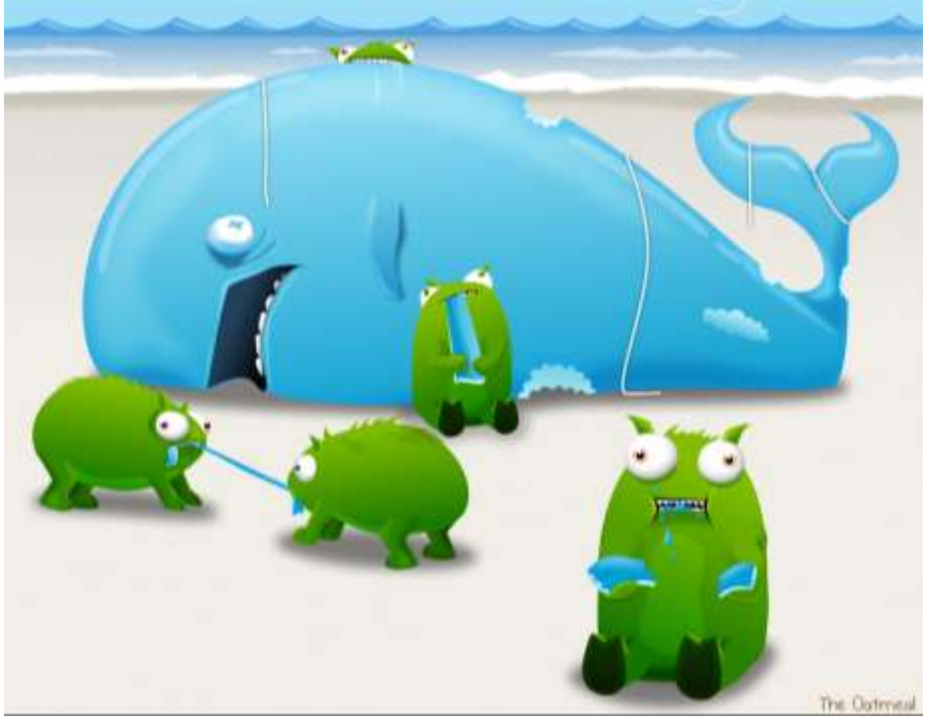
Exposing the socket/REST API inside a container for introspection <- don’t do that

Docker Weaknesses

About that lack of User namespace….:

Hi all, **I'm a maintainer of Docker.** As others already indicated this doesn't work on 1.0. But it could have. Please remember that at this time, **we don't claim Docker out-of-the-box is suitable for containing untrusted programs with root privileges**. So if you're thinking "pfew, good thing we upgraded to 1.0 or we were toast", you need to change your underlying configuration now. Add apparmor or selinux containment, map trust groups to separate machines, or ideally don't grant root access to the application. **Docker will soon support user namespaces**, which is a great additional security layer but also not a silver bullet! **When we feel comfortable saying that Docker out-of-the-box can safely contain untrusted uid0 programs, we will say so clearly.**

Posted one year ago :/



CoreOS “rkt” Weaknesses

Rocket (rkt) is extremely new

No root daemon but rkt still requires root…

CoreOS "rkt" Weaknesses

Rocket does **not drop many dangerous Capabilities or support the User namespace**

CoreOS "rkt" Weaknesses

Seccomp ? **Nope.**

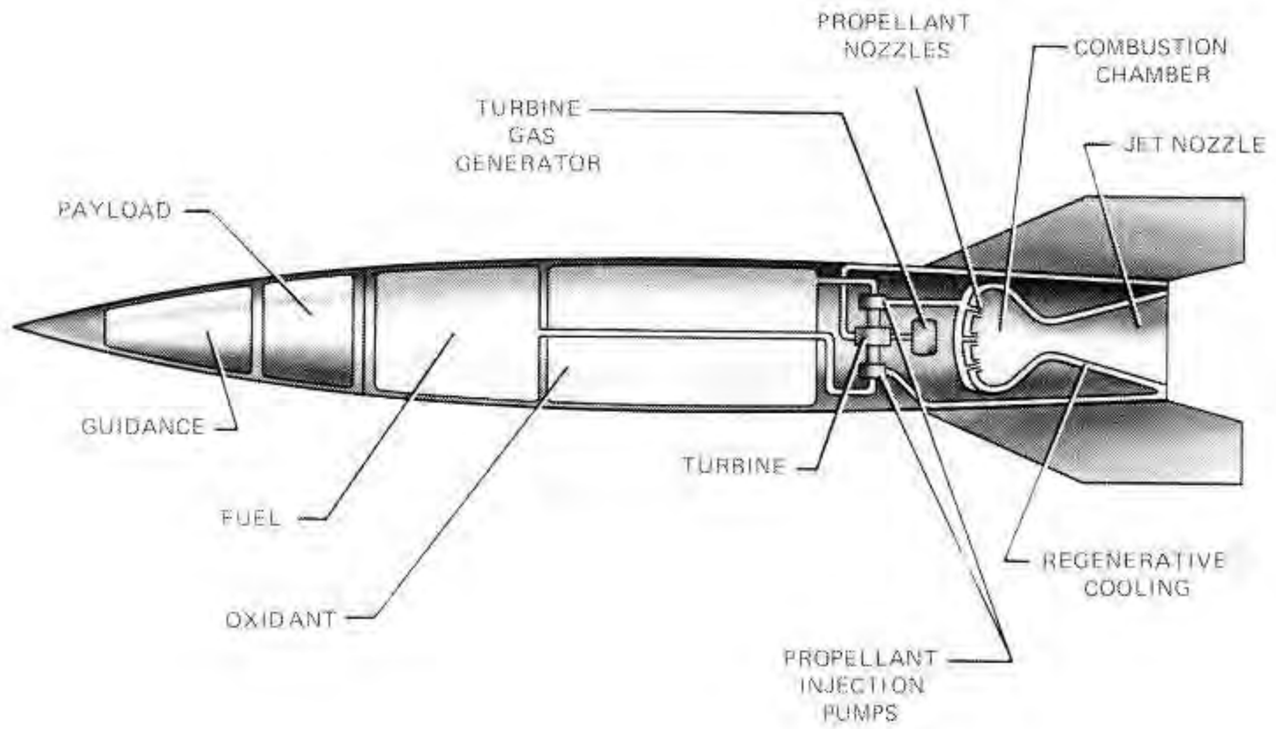
Apparmor ? **Nope.**

SELinux? **Kinda.**

Root inside container? **Yep.**

/proc, /proc/sys limits? **Nope.**

The Dream

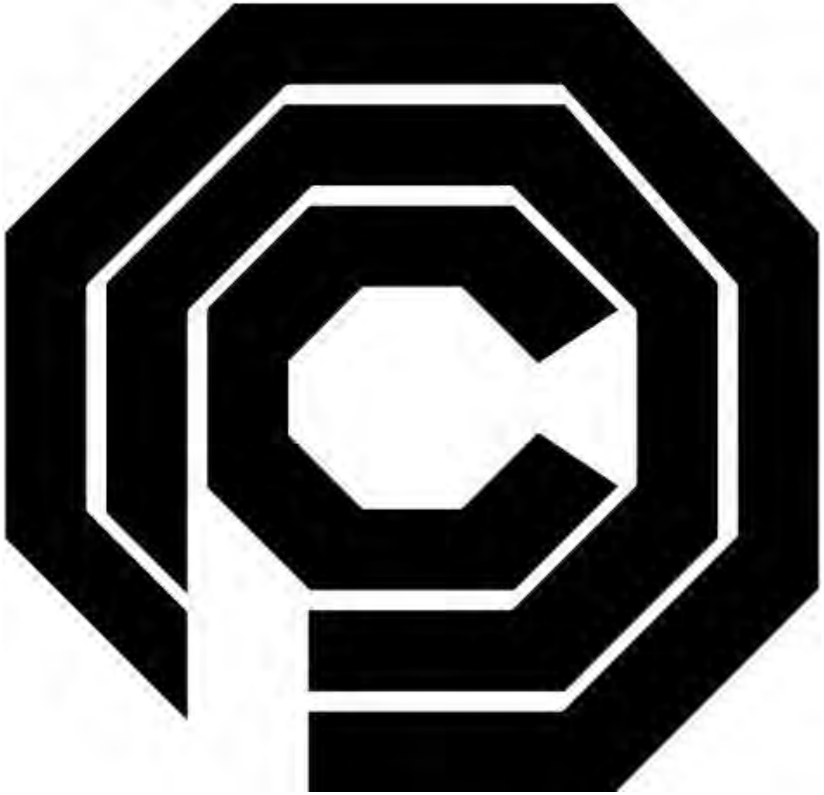

PROPELLANT NOZZLES
COMBUSTION CHAMBER
TURBINE GAS GENERATOR
JET NOZZLE
PAYLOAD
GUIDANCE
TURBINE
FUEL
REGENERATIVE COOLING
OXIDANT
PROPELLANT INJECTION PUMPS

The Implementation

Open Container Project (OCP)

Robert 'Bob' Morton: At Security Concepts, we're projecting the end of crime in Old Detroit within forty days.

There's a new guy in town. His name is **RoboCop**.



Open Container Initiative (OCI?)

Working on a joint specification (OCF) for containers

Launched **runc**. An OCF implementation using libcontainer from Docker.

Unfortunately still not working on **RoboCop**.

That all sounds bad/easy to mess up

… and how to make it better

Recommendations

Kernel Hardening

Grsecurity/PaX is the only serious kernel hardening patchset. **Just do it**

Typical sysctl hardening

Minimal kernel modules

Dropping all the Capabilities

Gotta drop them all!

Design for the smallest set

Assume the worst

Adding a MAC Layer

AppArmor
Grsecurity RBAC

SMACK
SELinux

AppArmor

Defaults to enabled for LXC and Docker!

Can be nested!

Path based, but hey it works

Docker Specific Hardening

Don’t allow access to docker user or group

Don’t run privileged or root containers

Drop additional capabilities

Upgrade to 1.8 when released (or use /contrib now) which has seccomp-bpf and User namespace support, w00t!

Checkout docker-bench-security and other solid work by Docker Security team

Use small base images

Seccomp-bpf

Use a whitelist if you can but a blacklist will do *OK*

Docker is exploring a “high”, “med”, “low” default for 1.8+ but what is really needed is profiles for each Containerized app.

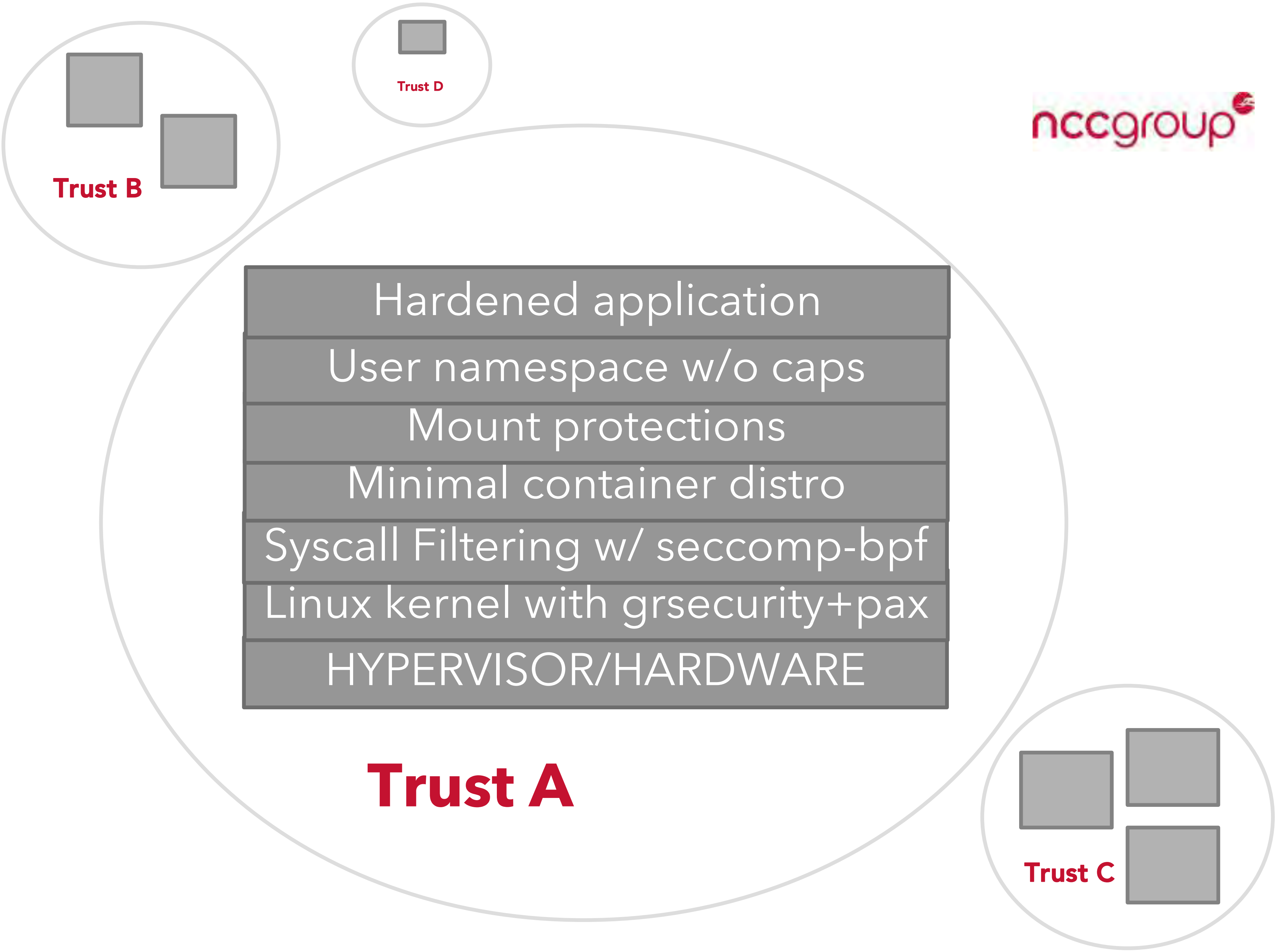
Normal System Hardening

Mount security, Extended filesystem attributes, Access controls, Permissions, Logging, Firewalls, Auditing, Hardened Toolchain, Safe languages, Attack surface reduction, Least privileges, Least Access, Resource Limits, 2FA, Reduced Complexity, Pentesting

Network Hardening

Listening on “all interfaces” (includes docker0/lxcbr0)

Containers are great for network auditing/traceflow!



Trust B

Trust D

Hardened application

User namespace w/o caps

Mount protections

Minimal container distro

Syscall Filtering w/ seccomp-bpf

Linux kernel with grsecurity+pax

HYPERVISOR/HARDWARE

Trust A

Trust C

Where do we go from here?

Where do we go from here?

More namespaces (proc, dev)

Minimal hypervisors (ClearContainers)

Minimal container distros

Android or other non-x86 that needs app/system segmentation/sandboxing

Where do we go from here?

“Desktop” applications in containers

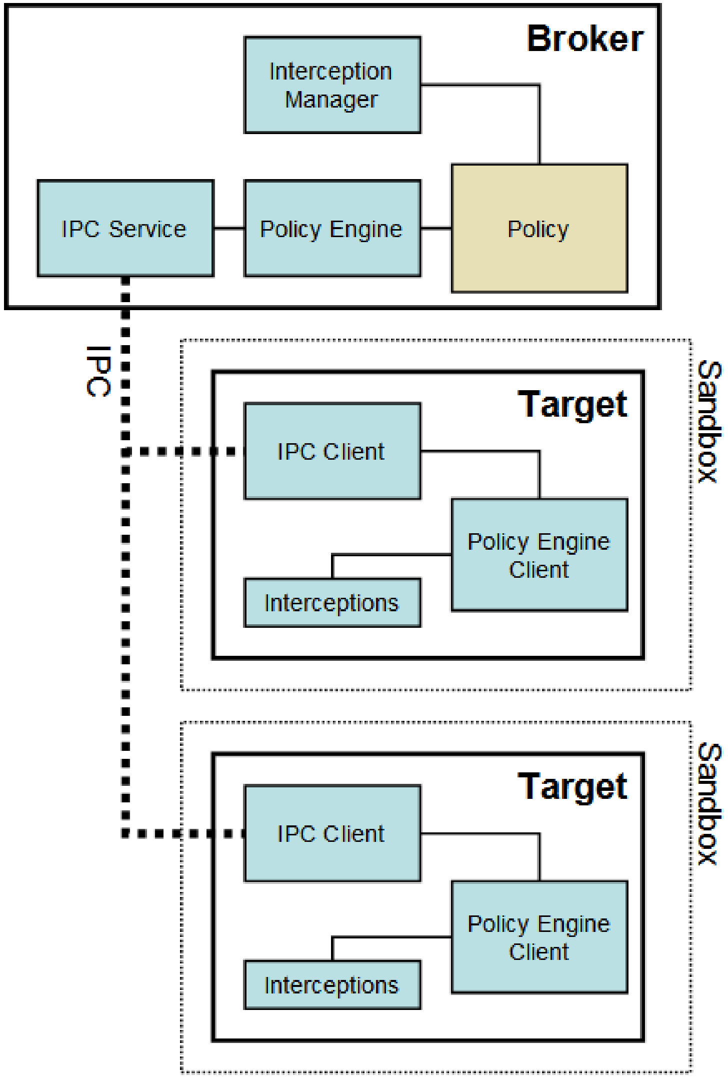
Improved seccomp-bpf argument filtering

Hopefully more granular capabilities

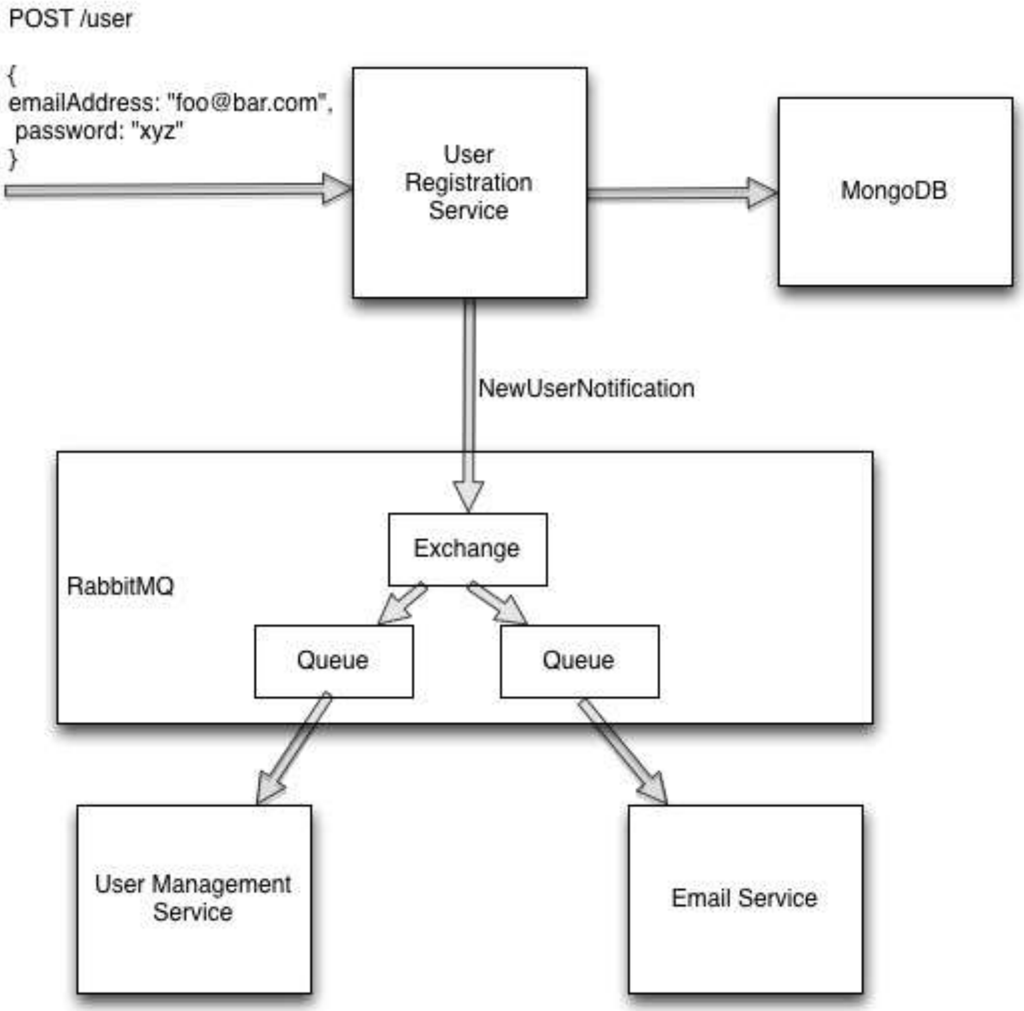
….. more vulnerabilities too! :/

Where do we go from here?

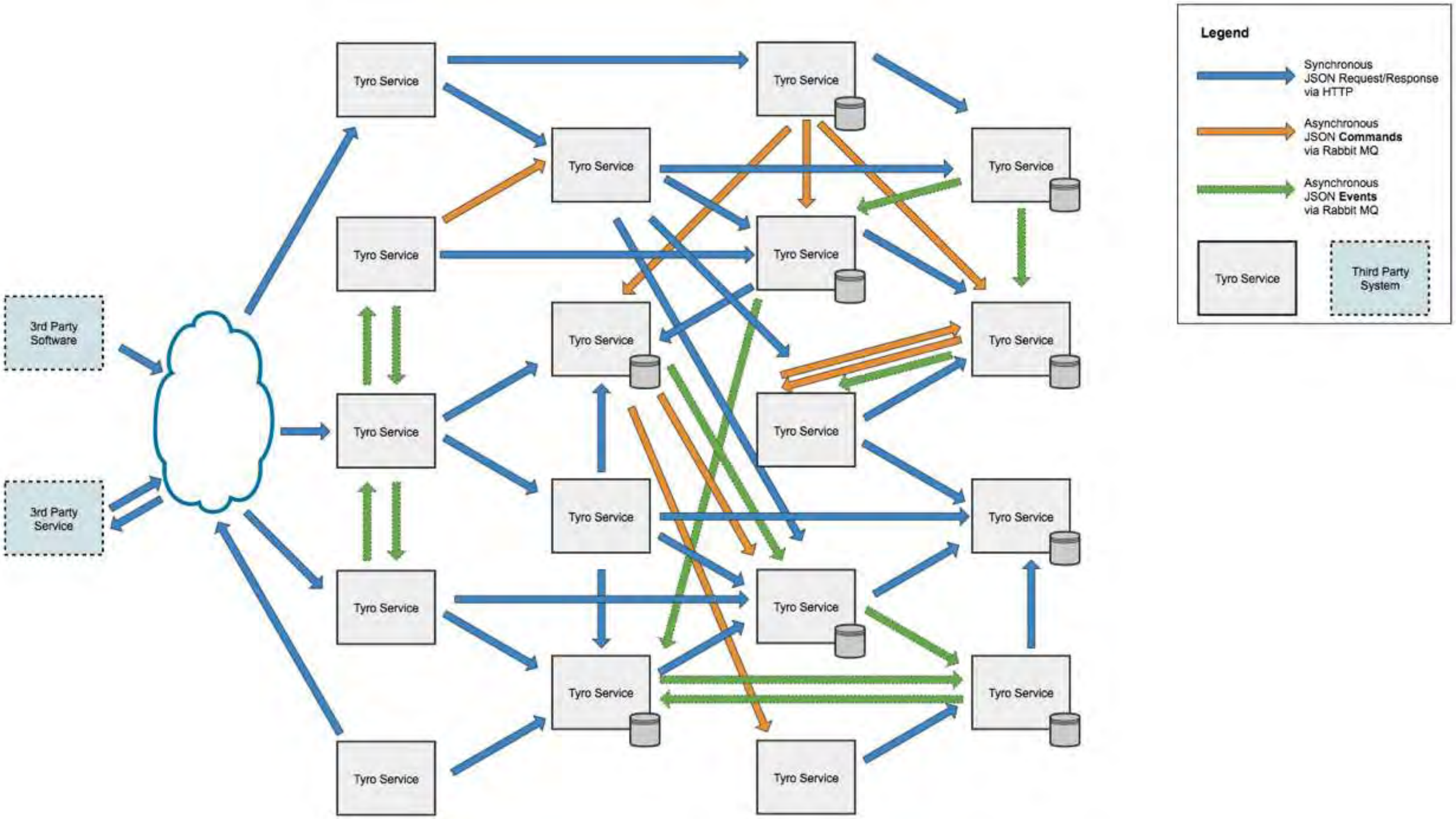
Microservices



Where do we go from here?



Where do we go from here?



Conclusion

In closing

It's not about perfect security but improving the current state and making attackers work harder

The technologies to support containers can be used to help **secure existing non-container Linux systems**

Microservices architecture fits a least-privilege and least-access container/security model

Physically **separate critical security** barriers and **isolate by trust**

Coming soon!

My whitepaper: **"Understanding and Hardening Linux Containers"**…

Covers everything here in muuuch **more depth**!

(background, namespaces, all the capabilities, cgroups, explores MAC, seccomp-bpf, past container attacks, overall and specific weaknesses, security recommendations for LXC, Docker, rkt deployments)

Coming soon!

When will the whitepaper be released ?

Hopefully in the **next few weeks**!

How can I make sure I get it?

Email me! or follow me on Twitter! **@dyn___** (totally not a ploy for more followers)

Thanks!

Any Questions/Comments?

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