Privilege Separation and Pledge

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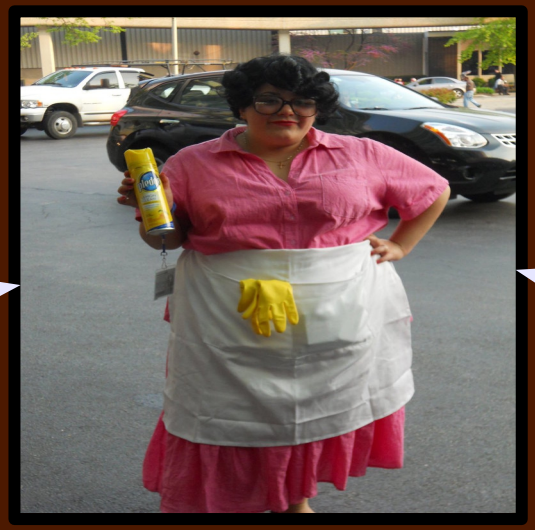
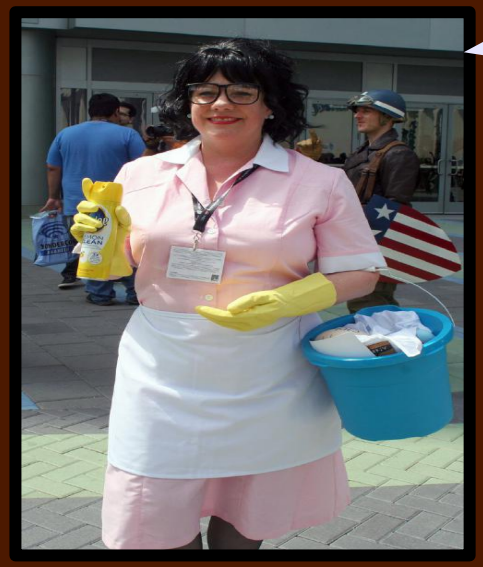
  OpenBSD

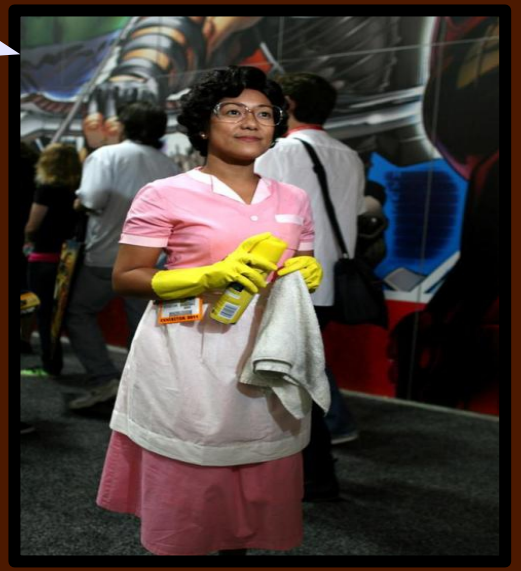
Main maid



DNS maid



NTP protocol maid



Many small changes to improve security

Application software (ports) (Educating upstream about better practices)
Own Applications: design & architecture (**Privilege Separation**, Privilege Drop, auditing, ...)
Address Space and other resources (ASLR, W^X, cookies, ...)
Libraries (especially libc) (strlcpy, arc4random, strict malloc, auditing, ...)
System call interface (**pledge**)
Kernel (Some ASLR, W^X, ...)
Hardware and BIOS (cry into our beer...)

Focus on interaction between these two parts

Privilege Separation

A design pattern — splits a program into processes performing different sub-functions

Each process is designed to operate in a separate security domain

Processes cooperate over pipes using some protocol

Subset of “sandboxing” concept

Separated at birth

(Our own ntpd as an example)

Master process

Runs as root, only does settimeofday()

DNS Servicer

Does DNS lookups

Internet Speaker

Speaks NTP to Internet

Privilege Separation examples

The original 3:

- Qmail
- Postfix
- OpenSSH

And…. Chrome

Defence in Depth

We designed & modified many more programs to use this design pattern

Experience gained with 60 more programs!!!

Routing daemons, Mail daemons, dhcp tools, tcpdump…

Let’s build a mechanism which enforces security domains!

Major ones..

bgpd, dhclient, dhcpd, dvmrpd, eigrpd, file, httpd, iked, ldapd, ldpd, mountd, npppd, ntpd, ospfd, ospf6d, pflogd, radiusd relayd, ripd, script, smtpd, syslogd, tcpdump, tmux, xconsole, xdm, X server, ypldap, pkg_add

Pledges are POSIX subsets

Pledge syscall requests that only (a carefully selected) subset of POSIX functionality be permitted

Subsets such as: stdio rpath wpath cpath fattr inet dns getpw proc exec sendfd recvfd …

Deep functional support in the kernel — more sophisticated than "seccomp"

Privsep – enforce with Pledge

(Our own ntpd as an example)

Master process

Pledge "settime"

DNS Servicer

Pledge "dns"

Internet Speaker

Pledge "inet"

Processes select own pledge – inline

"I pledge this is the only subset of POSIX I will use"

Make the promise in the code when ready.

```
imsg_init(ibuf_dns, pipe_ntp[1]);

if (pledge("stdio dns", NULL) == -1)
        err(1, "pledge");

while (quit_dns == 0) {
```

Cannot undo the promise…

Good debugging experience

Most violations result in process being killed

```
234    prog    CALL   socket(AF_LOCAL, 0x1<SOCK_STREAM,0)
234    prog    PLDG   socket, "inet", errno 1 Operation not permitted
234    prog    PSIG   SIGABRT SIG_DFL
234    prog    NAMI   "prog.core"
```

core is dumped — go ahead use gdb

Privsep mistakes identified

Implementation errors found in 10% of privsep programs

Sub-processes did actions beyond design rule! tsk tsk.

ntpd, bgpd, tcpdump, …

Validate program operation matches design rule

Future work

OpenSSH privilege separation is dated, and could be improved...

Continue refining semantics

Cooperate if another OS wants pledge

Observe impact on upstream software, and assist

General Observation

Perfection is impossible to achieve unless an enforcement mechanism keeps us honest