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seccomp-nurse

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Executive summary

New sandboxing environment on Linux

- Focusing on headless applications (think: “cloud”!)
- No recompilation
- No kernel patches
- Free Software (GPL)

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Why another one?

State of art

- Chroot+capabilities (+ Capsicum)
- `ptrace()` based
- Role Based Access Control (based on LSM)
- Virtualization

Why another one?

State of art

- Chroot+capabilities (+ Capsicum)
  - Huge attack surface
  - Jail evasion easy without kernel patches
- `ptrace()` based
- Role Based Access Control (based on LSM)
- Virtualization

Why another one?

State of art

- Chroot+capabilities (+ Capsicum)
- `ptrace()` based
  - Big attack surface
  - Complex to safely validate a syscall
  - Slow
- Role Based Access Control (based on LSM)
- Virtualization

Why another one?

State of art

- Chroot+capabilities (+ Capsicum)
- `ptrace()` based
- Role Based Access Control (based on LSM)
  - Huge attack surface
  - Brad Spengler proved his point many times
- Virtualization

Why another one?

State of art

- Chroot+capabilities (+ Capsicum)
- `ptrace()` based
- Role Based Access Control (based on LSM)
- Virtualization
  - Qubes OS
  - Just a shift of the attack surface

Why another one?

State of art

- Chroot+capabilities (+ Capsicum)
- `ptrace()` based
- Role Based Access Control (based on LSM)
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And the Google Chrome approach, based on `SECCOMP`.

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CONFIG_SECCOMP

SECure **COMP**uting

- Linux specific (neither POSIX, nor SUS or BSD)
- Introduced in 2.6.23 (2005)
- By Andrea Arcanlegi

CONFIG_SECCOMP

- Voluntary entrance by calling `prctl()`
- Four system calls allowed
  - `read()`
  - `write()`
  - `sigreturn()`
  - `_exit()`

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CONFIG_SECCOMP

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  - `_exit()`

Any deviance drives to `SIGKILL`

SECCOMP as sandboxing method?

Welcome seccomp-nurse!

- Fail safe
- Kernel's attack surface **really** limited[a]
- So limited that...

[a] More details at `http://bit.ly/aoxCEX`

SECCOMP as sandboxing method?

Welcome seccomp-nurse!

- Fail safe
- Kernel's attack surface **really** limited[a]

  On 440 vulnerabilities, only 13 were triggerable from a SECCOMP process
- So limited that...

[a] More details at `http://bit.ly/aoxCEX`

Even that program get killed

```c
#include <unistd.h>
#include <sys/prctl.h>

#define S "Hello Ekoparty!\n"

int main(int argc, char **argv) {
        prctl(PR_SET_SECCOMP, 1, 0);
        write(STDOUT_FILENO, S, sizeof S);

        return 0;
}
```

Because "return 0" calls exit() and not _exit() :-(

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Problematic

Two problems need to be solved to use SECCOMP as a sandbox:

- How to enter in SECCOMP mode?
- How to prevent applications to make forbidden system calls?

Problem #1: Entering SECCOMP

Constraints

- Without `ptrace()`
- No recompilation
- No instruction rewriting on-the-fly

Solutions

- `LD_PRELOAD` trick (`__libc_start_main`)
- GNU Linker feature: `LD_AUDIT`

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Problem #1: Entering SECCOMP

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Solutions

- ~~`LD_PRELOAD` trick (`__libc_start_main`)~~
- GNU Linker feature: `LD_AUDIT`

Problem #1: Entering SECCOMP

LD_AUDIT

```
$ man rtld-audit
```

The GNU dynamic linker (run-time linker) provides an auditing API that allows an application to be notified when various dynamic linking events occur.

1. Creation of an audit library which:
   - Allocate some pages for our code/variable
   - Intercept syscalls
   - Enter into SECCOMP
2. `/lib/ld-linux.so.2 --audit ./sandbox.so /bin/ls`

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Problem #1: Entering SECCOMP

LD_AUDIT

1. Creation of an audit library which:
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2. `/lib/ld-linux.so.2 --audit ./sandbox.so /bin/ls`

Barely used feature

- Only one known application using it (latrace[a])
- Thread Local Storage not behaving normally

[a] http://people.redhat.com/jolsa/latrace/

Problem #2: SIGKILL

Preventing application from doing forbidden syscalls

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Problem #2: SIGKILL

Preventing application from doing forbidden syscalls

- Without `ptrace()`
- Without library overloading
- Without recompilation

Problem #2 : SIGKILL

How do syscalls work?

```
kill:
    mov     %ebx,%edx
    mov     0x8(%esp),%ecx
    mov     0x4(%esp),%ebx
    mov     $0x25,%eax
    call    *%gs:0x10
    mov     %edx,%ebx
    cmp     $0xfffff001,%eax
    jae     2aa30 <kill+0x20>
    ret
```

- On x86, the libc no longer inlines "`int 0x80`"
- Instead, it calls an indirect function stored in VDSO

`call *%gs:$0x10`

(This is what the mysterious `libc6-686` package provides)

Problem #2 : SIGKILL

Hijacking VDSO

```
call *%gs:$0x10
```

- %gs is overwritten to point into our handler
- From now on, every (legit) syscalls are intercepted

Well, syscalls are intercepted. . . and now?

The syscall handler still runs into SECCOMP. . .

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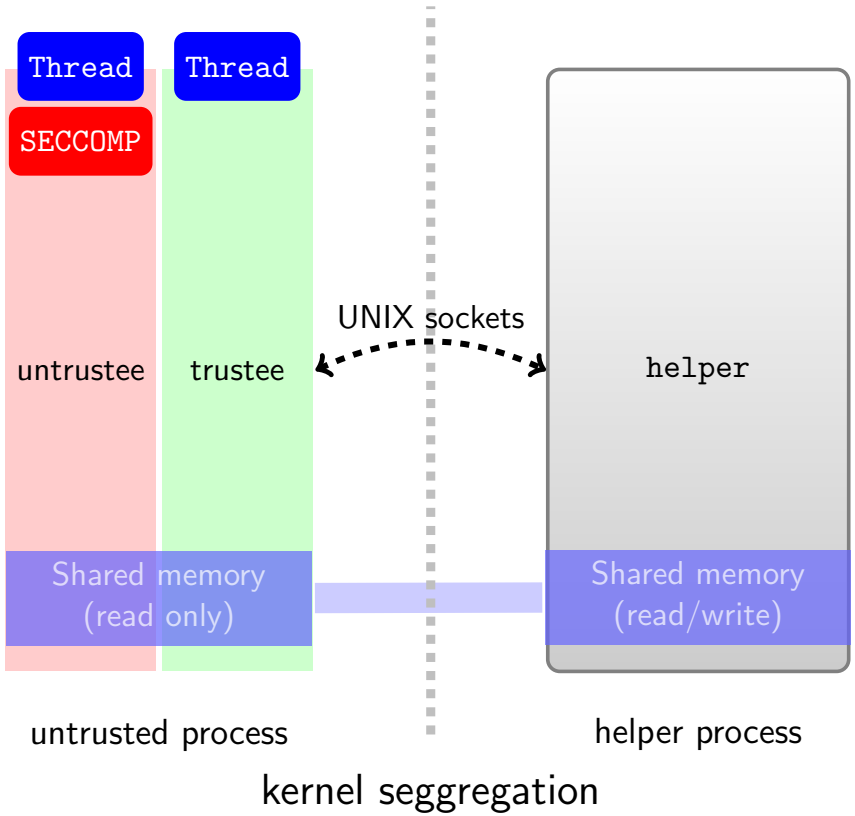
The syscall handler still runs into SECCOMP. . .

It needs to be assisted by another process, the helper

1. The untrusted application makes a syscall
2. The handler intercepts it and notifies the helper
3. The helper does something
4. The helper pass a return value to the handler
5. The handler gives the return value to the untrusted application

Well, syscalls are intercepted. . . and now?



- Two processes
- In the untrusted process, two threads:
  - Trustee
  - Untrustee, under `SECCOMP`
- The original program and our handler runs in untrustee

Good fences make good neighbors

- When a syscall is made in the untrustee, our handler kicks in and notifies the helper
- The helper is written in Python
  - Implementing access control (policy engine)
  - Delegating syscall execution to the trustee
- The trustee is a tiny assembly routine
  - Executing orders from the helper

Thread magic^Wvoodoo

Programming 101

Threads share **everything** except CPU registers

- File descriptors
- Address space
- Locks

Any action in a thread is propagated in the other.

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Cool!

The trustee will perform syscalls on behalf of the untrustee

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Cool!

The trustee will perform syscalls on behalf of the untrustee

WARNING

So the trustee code runs in a hostile environment.
It can only use CPU registers!

Helper: policy engine

When a syscall is intercepted and then sent to the helper, the security policy is checked. Like:

```
class Security:
    def open(self, filename, perms, mode):
        path = os.path.realpath(filename) # Bug #990669
        for authorized_path in self.fs_whitelist:
            if path.startswith(authorized_path):
                return True
        return False

    def access(self, filename, mode):
        return True # XXX
```

Demo time!

Hope it will work (or cheat-sheet in appendix 6)...

Status

What is implemented?

- Core system
- Trustee "self-protection"

What is **not** implemented?

Most of the policy engine :(

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Is it usable?

Yes!

You can already run most of classic "conversion" tools:

- Image manipulation: no more libpng harm!
- PDF transformation: do not be afraid of opening PDF!
- Python interpreter: think Google App Engine!

Limitations

Sorry...

- Linux specific
- Needs a "recent" GNU Libc ($>$ 2005) compiled for 686
- Will (most likely) never support:
  - `clone()`
  - `execve()`
- `dlopen()` not yet implemented

Future

- Implementation of more syscalls
- Use Google Chrome's `libseccomp-sandbox`
- Get peer reviews!

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HIT ME!

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Thank you!

http://chdir.org/~nico/seccomp-nurse/

```
foobar@debian32:~/python-2.6$ sandbox  -- ./python
Python 2.6.5+ (release26-maint:82382M, Jul  6 2010, 15:41:57) [GCC 4.4.4] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> fd=open('/etc/resolv.conf')
>>> for line in fd:
...     print line,
...
nameserver 192.168.9.2
domain vmlab
search vmlab
>>> import os
>>> os.getpid()
27997
>>> open('/secret/password')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IOError: [Errno 1] Operation not permitted: '/secret/password
>>> os.access('/secret/password', os.R_OK)
True
```