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OpenBSD Security Mitigations

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Stack Overflow

1. random gap
2. non executable
3. stack protector
4. retguard
5. immutable
6. random location

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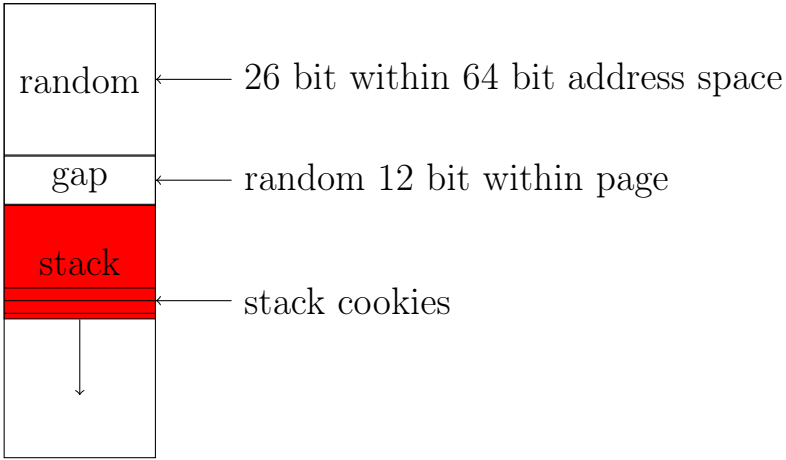
Stack Layout



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Heap Overflow

- `malloc(3)` options
- guard page
- random chunk order
- canaries
- meta data `mprotect(2)` and `mimmutable(2)`

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Heap Use-After-Free

- unmap freed
- junk at alloc
- junk at free
- SSH use-after-free
- limit chunk reuse

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Return Oriented Programming

- map stack
- retguard
- avoid 0xc3 due to %rbx
- fork+exec
- `sigreturn(2)` cookie
- `setjmp(3)`, `longjmp(3)` cookie
- ARM BTI & Intel IBT endbr64
- random relinking

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Mapping Protection

- `mprotect(2)`
  - W^X
  - xonly
- `mimmutable(2)`
- `mmap(2)`
  - MAP_STACK
  - MAP_CONCEAL

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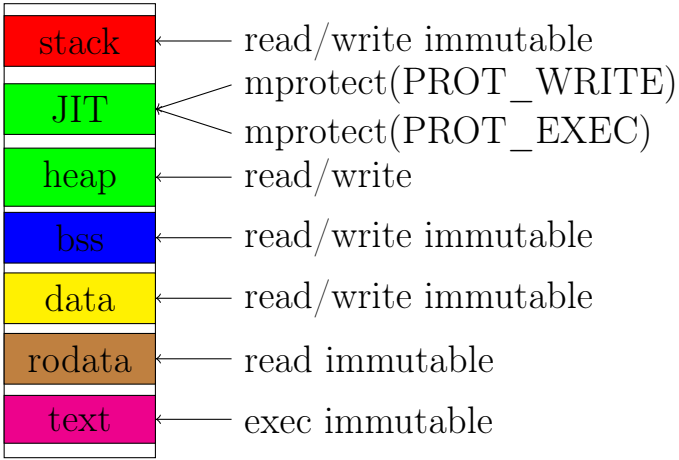
Address Space Protection



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Hardware xonly

- arm64, riscv64 have RWX
- new amd64 have PKU

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Opportunistic xonly

```
addr = mmap(NULL, 4096, PROT_NONE,
    MAP_PRIVATE | MAP_ANON, -1, 0);
mprotect(addr, 4096, PROT_READ);
printf("%p: %08x\n", addr, *(int *)addr);
mprotect(addr, 4096, PROT_EXEC);
printf("%p: %08x\n", addr, *(int *)addr);

0x73d15433000: 00000000
0x73d15433000: 00000000
```

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Trap xonly

```
addr = mmap(NULL, 4096, PROT_NONE,
    MAP_PRIVATE | MAP_ANON, -1, 0);
mprotect(addr, 4096, PROT_READ);
mprotect(addr, 4096, PROT_EXEC);
printf("%p: %08x\n", addr, *(int *)addr);

Segmentation fault (core dumped)
```

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Random Everywhere

- `arc4random(3)`
- `arc4random_uniform(3)`
- `srand_deterministic(seed)`
- `getentropy(2)`
- ELF header `.openbsd.randomdata`
- boot /etc/random.seed

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Address Space Layout Randomization

1. shared library mapping
2. heap `mmap(2)`
3. stack gap
4. PIE program text
5. relink libc
6. relink `sshd(8)`

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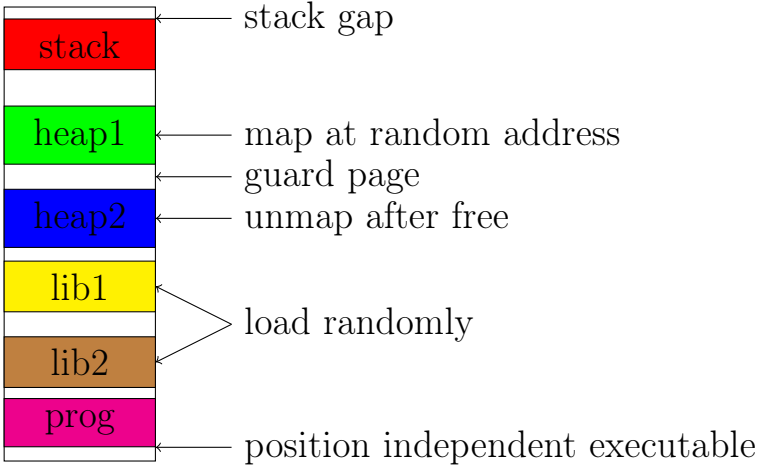
Address Space Layout



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Process Mapping

```
sleep 1 & procmap $!
```

- `Start End` random
- `rwxSeIpc` xonly, stack, system call entry, immutable
  - `--x-eIp+` text
  - `r----Ip+` read only
  - `rw---Ip-` data
  - `rw----p-` heap
  - `rw-S-Ip-` stack

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Kernel Exec

- check argc > 0
- random stack
- random signal cookie
- exec pledge
- setuid open stdin, stdout, stderr

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Dynamic Loader

- init random `getentropy(2)`
- fix permissions `mimmutable(2)`
- random layout `mmap(2)`
- syscall area `msyscall(2)`
- exec area `pinsyscall(2)`
- lazy-binding `kbind(2)`

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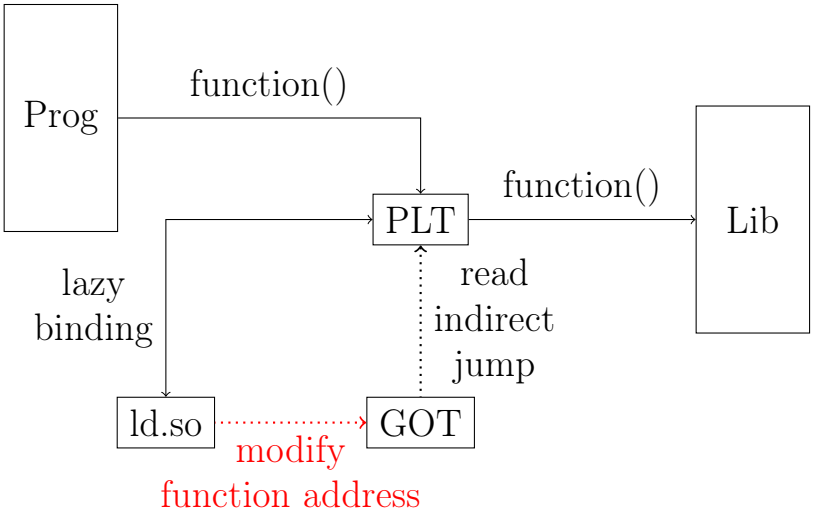
Lazy Binding kbind(2)



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Pledge and Unveil

- ps -ax -o stat | grep p ⇒ 86% pledged
- ps -ax -o stat | grep U ⇒ 39% unveiled
- easy to use
- structures design securely
- daily violation mail
- `lastcomm(1)`, `acct(5)`, `accton(8)`

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Privilege Separation in Processes

- identify isolated tasks with high risk
- `socketpair(2)`
- `fork(2)`
- `chroot(2)`
- `setuid(2)`
- `pledge(2)`
- `imsg_init(3)`
- file descriptor passing

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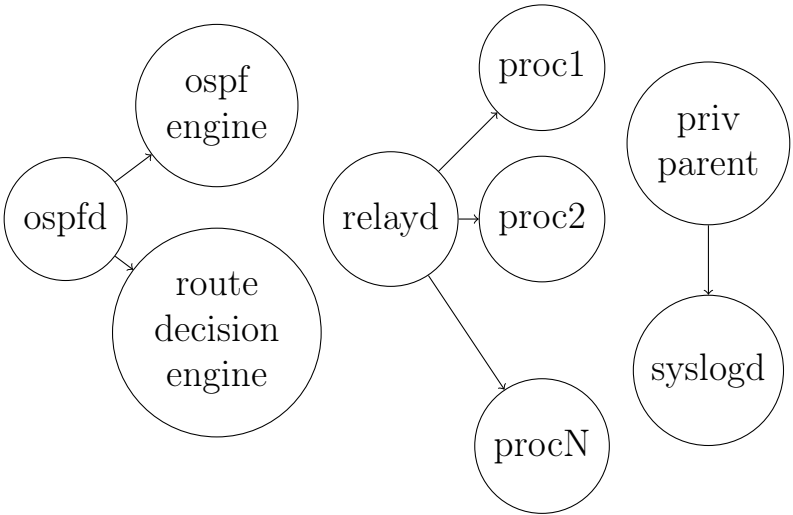
Programs with Privsep



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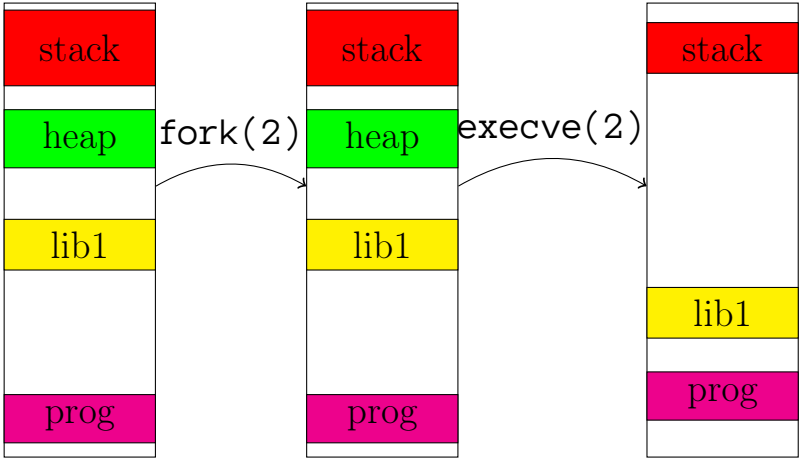
fork+exec



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API Changes

- `strlcpy(3)`, `strlcat(3)`
- `reallocarray(3)`
- `explicit_bzero(3)`
- `freezero(3)`
- `malloc_conceal(3)`
- `printf(3)` without %n

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File Descriptors

- `getdtablecount(2)`
- `sendsyslog(2)`
- `socket(2)` type SOCK_DNS

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Ports Pain

- BTI and IBT
- xonly
- map stack
- W^X
- otto@ malloc

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Default and Force

- control: kernel, libc, base
- adapt: ports
- last resort: mount and program flags
  - mount -o wxallowed
  - ld -z wxneeded
  - ld -z nobtcfi
  - NOT execstack, force-bti, force-ibt

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SSH Agent Library Exploit

`dlopen(3)` 4 libraries:

- ELF header executable stack
- init signal handler SIGSEGV
- ELF flag NODELETE
- on load segmentation fault

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Not Yet

- ARM pointer authentication
- shadow stack
- remove `syscall(2)`

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Conclusion

- powerful combination
- cheap and effective
- always on
- works with ports

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Questions

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