File access-control per container with Landlock

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Secure user-space software

How to harden an application?

- secure development
- follow the least privilege principle
- compartmentalize exposed processes

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Container constraints

- each container image can be unique
- and independent from the host
- hence may need dedicated access-control rules

$\Rightarrow$ embedded security policy

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	Fine-grained control	**Embedded policy**	**Unprivileged use**
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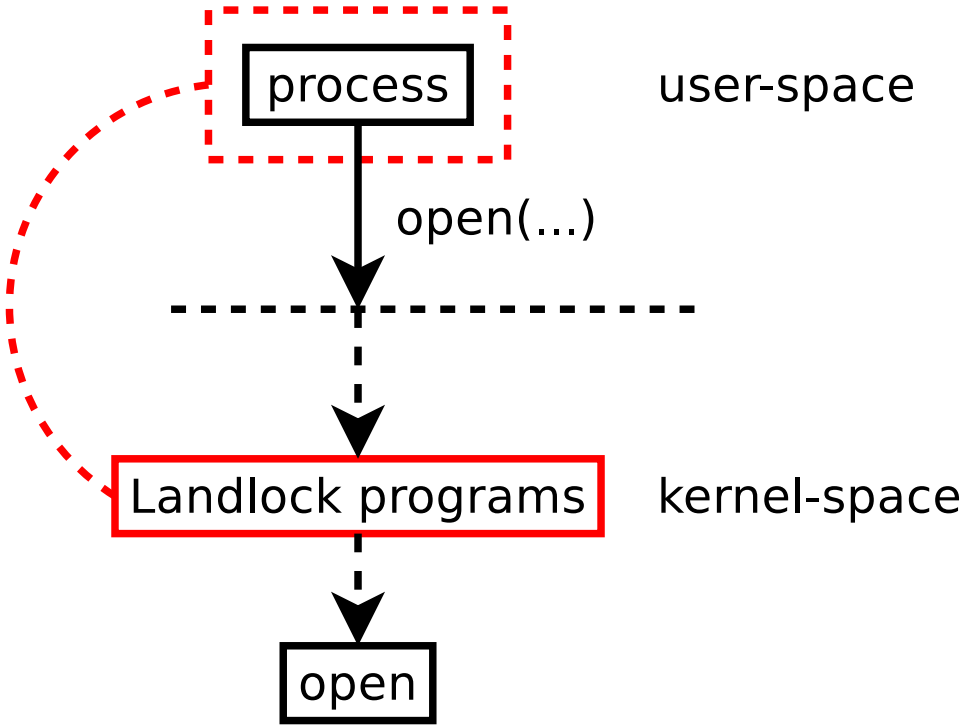
	Fine-grained control	Embedded policy	Unprivileged use
SELinux...	✓		
seccomp-bpf		✓	✓
namespaces		✓	∼
Landlock	✓	✓	✓[1]

Tailored access control to match your needs: programmatic access control

[1] Disable on purpose for the initial upstream inclusion, but planned to be enabled after a test period.

Landlock overview



Landlock: patch v8

- a minimum viable product
- focused on filesystem access control
- using eBPF

extended Berkeley Packet Filter

In-kernel virtual machine

- safely execute code in the kernel at run time
- widely used in the kernel: network filtering, seccomp-bpf, tracing...
- can call dedicated functions
- can exchange data through maps between eBPF programs and user-space

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Static program verification at load time

- memory access checks
- register typing and tainting
- pointer leak restrictions
- execution flow restrictions

The Linux Security Modules framework (LSM)

LSM framework

- allow or deny user-space actions on kernel objects
- policy decision and enforcement points
- kernel API: support various security models
- 200+ hooks: `inode_permission`, `inode_unlink`, `file_ioctl`...

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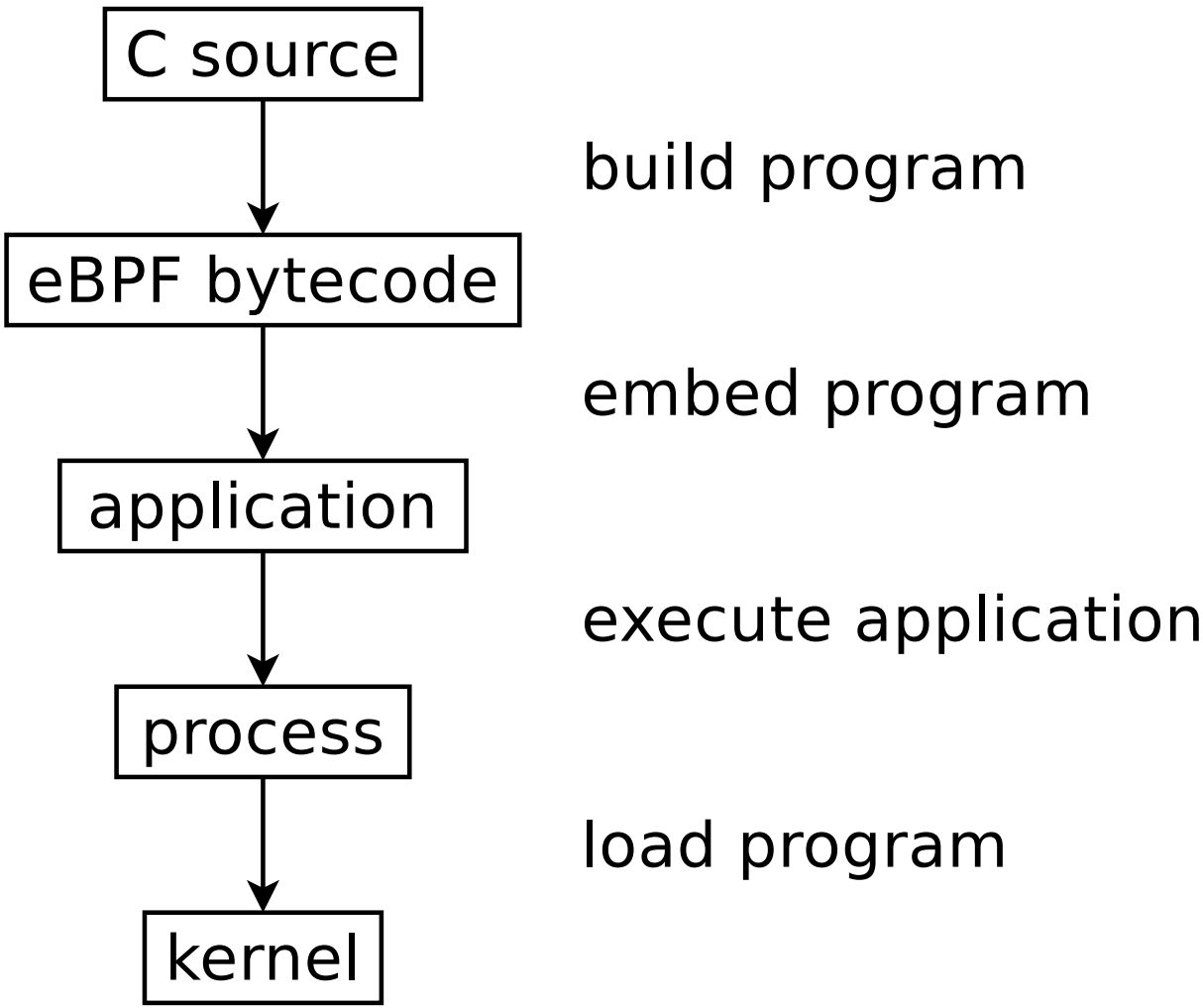
Landlock

- hook: set of actions on a specific kernel object (e.g. walk a file path)
- program: access-control checks stacked on a hook
- triggers: actions mask for which a program is run (e.g. read, write, execute, remove, IOCTL...)

Life cycle of a Landlock program



Landlock rule example

Goal

- whitelist of file hierarchies for read-only or write access
- enforced on each file system access request for a set of processes

Source code

`https://landlock.io` ⇒ FOSDEM 2018

eBPF inode map

Goal

restrict access to a subset of the filesystem

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- efficient
- updatable from user-space
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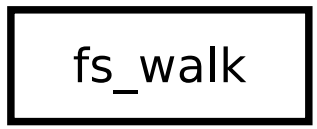
Solution

- new eBPF map type to identify an inode object (device + inode number)
- use inode as key and associate it with a 64-bits arbitrary value

Chained programs and session

Landlock programs and their triggers (example)



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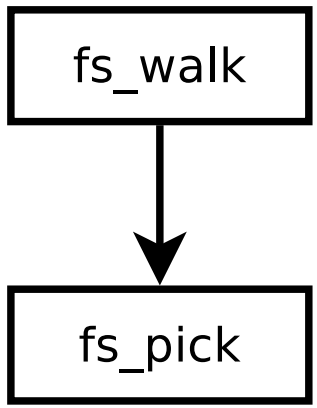

open, chdir, getattr...

Chained programs and session

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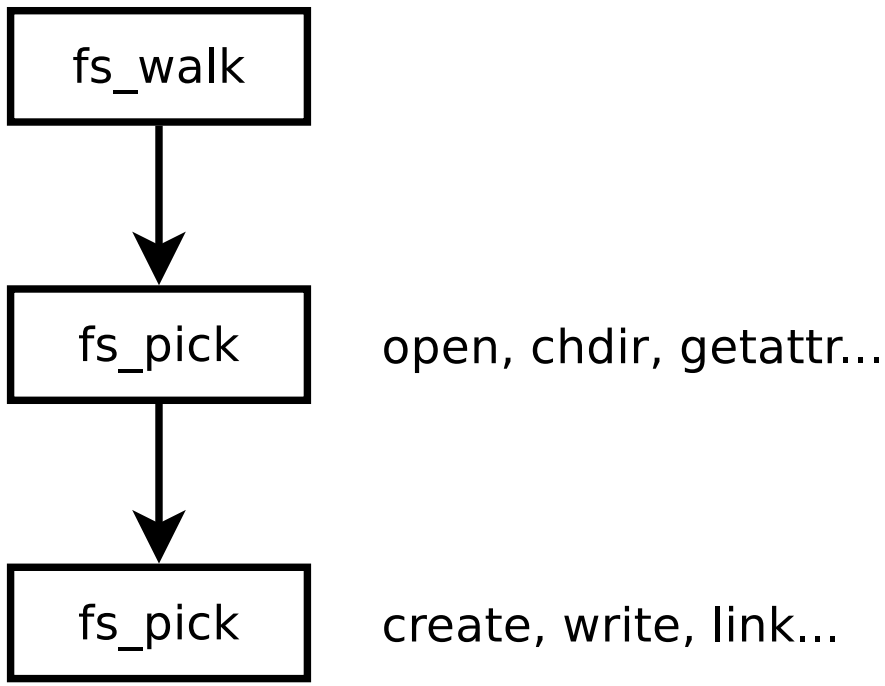
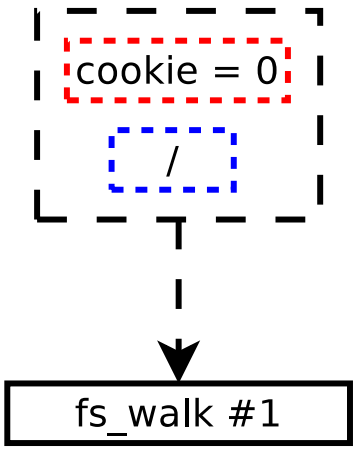


Walking through a file path

Example: `open /public/web/index.html`



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/etc	1 (ro)
/public	1 (ro)
/tmp	2 (rw)

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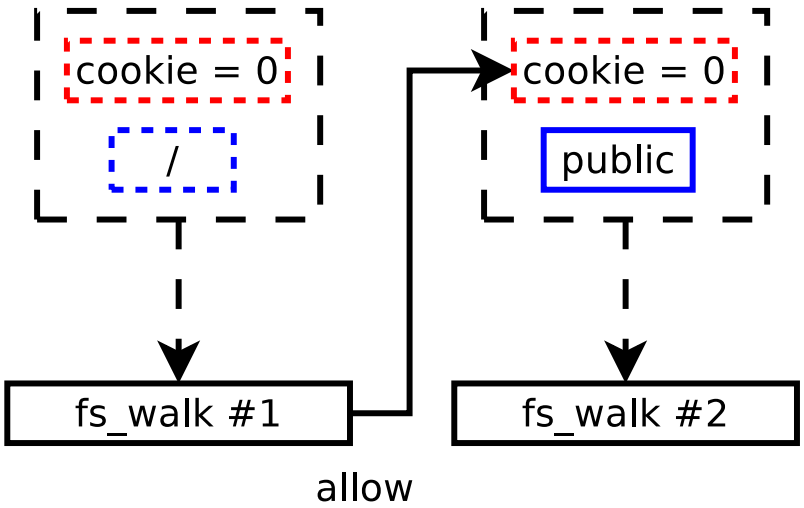

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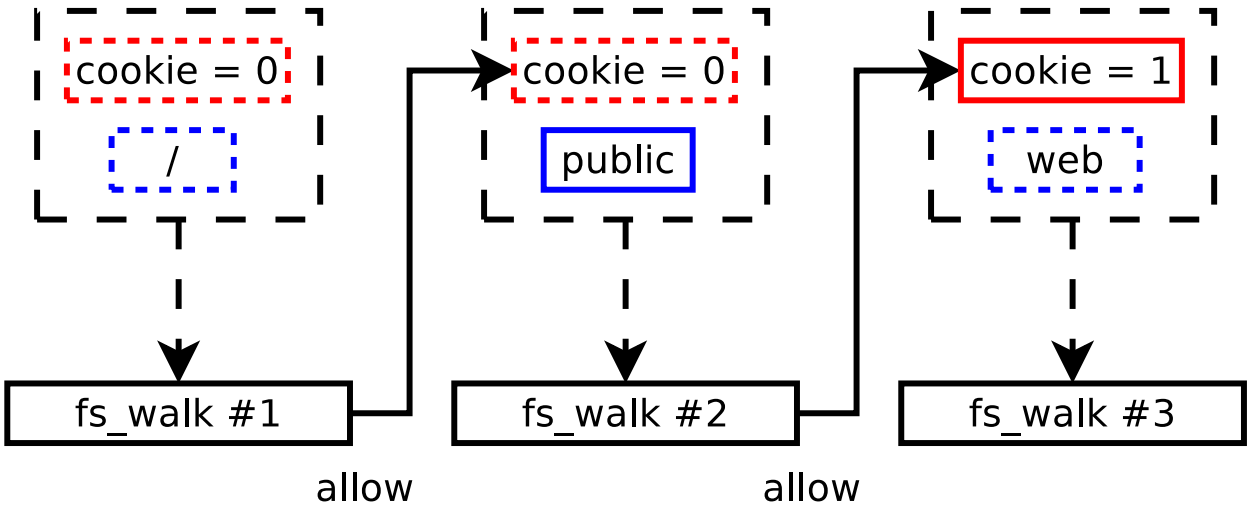

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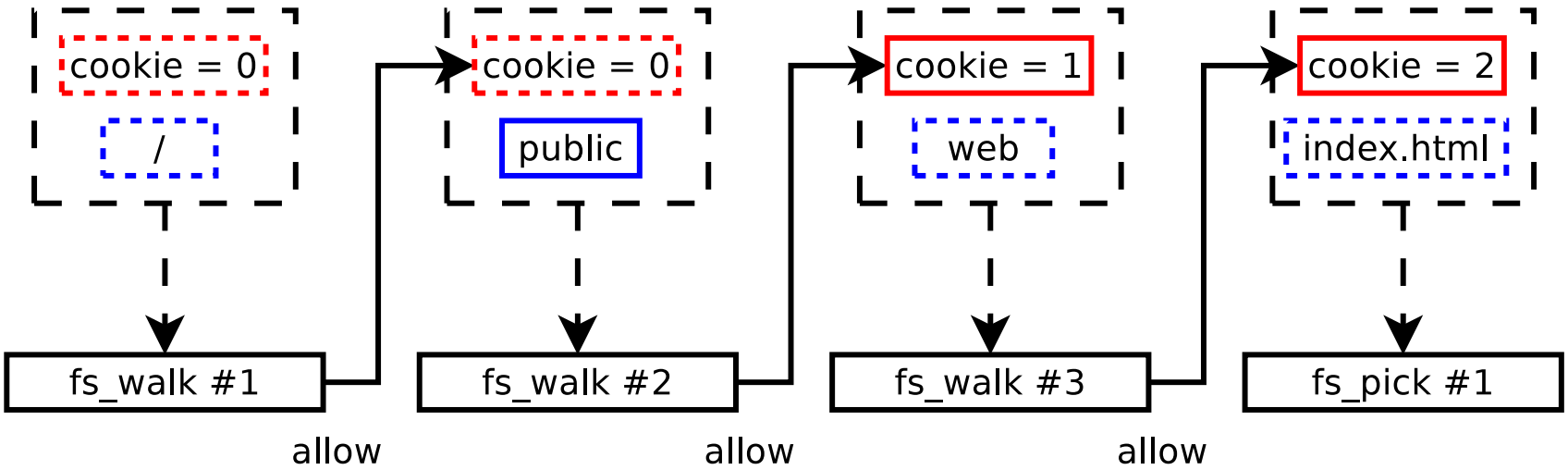

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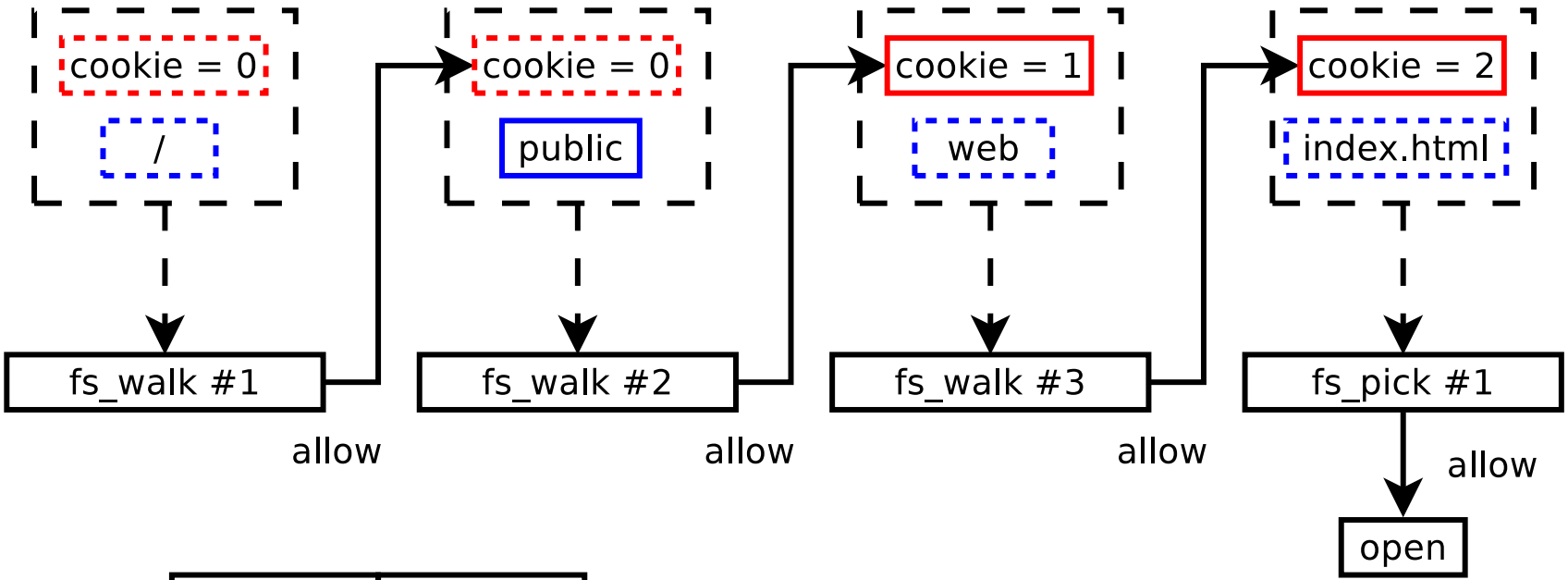

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Landlock program's metadata

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1  static union bpf_prog_subtype metadata = {
2          .landlock_hook = {
3                  .type = LANDLOCK_HOOK_FS_PICK,
4                  .options = LANDLOCK_OPTION_PREVIOUS,
5                  .previous = 2, /* landlock2 */
6                  .triggers = LANDLOCK_TRIGGER_FS_PICK_APPEND | \
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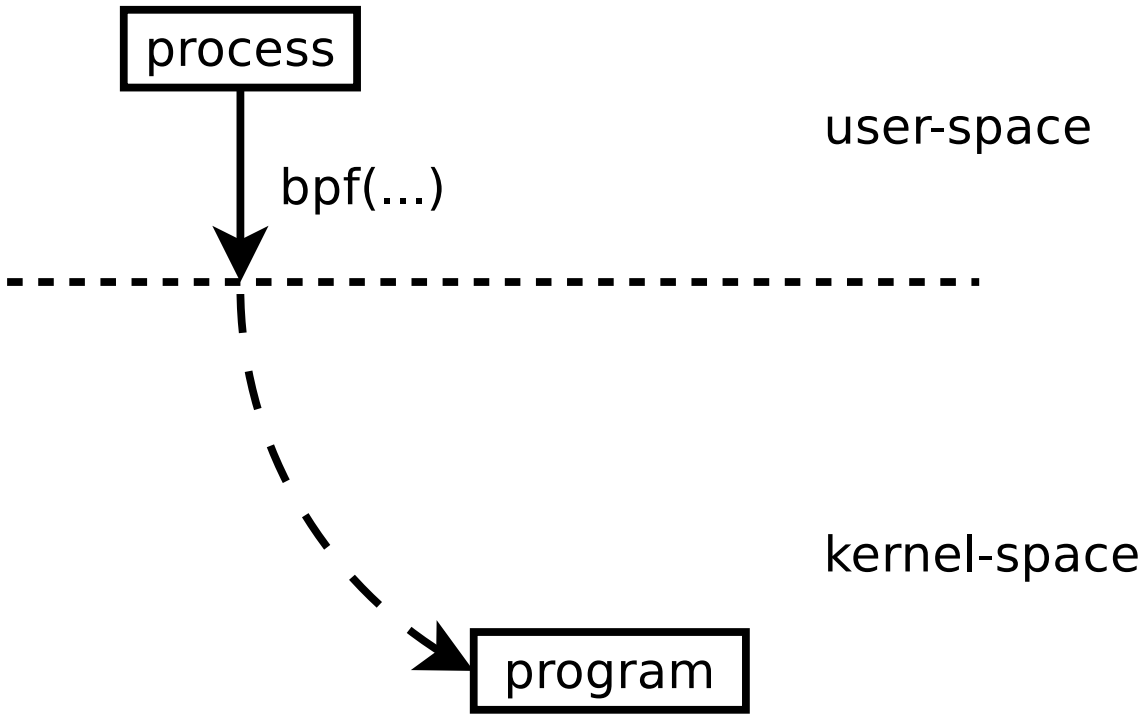

Applying a Landlock program to a process

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1 seccomp(SECCOMP_PREPEND_LANDLOCK_PROG, 0, &prog_fd);
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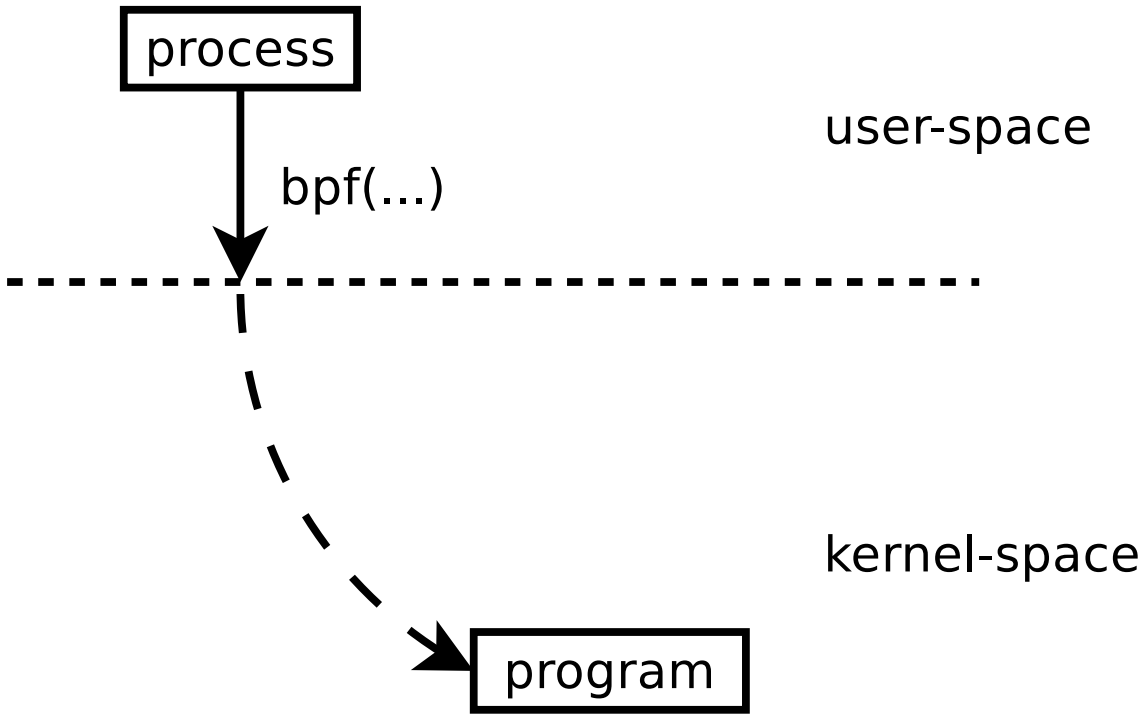

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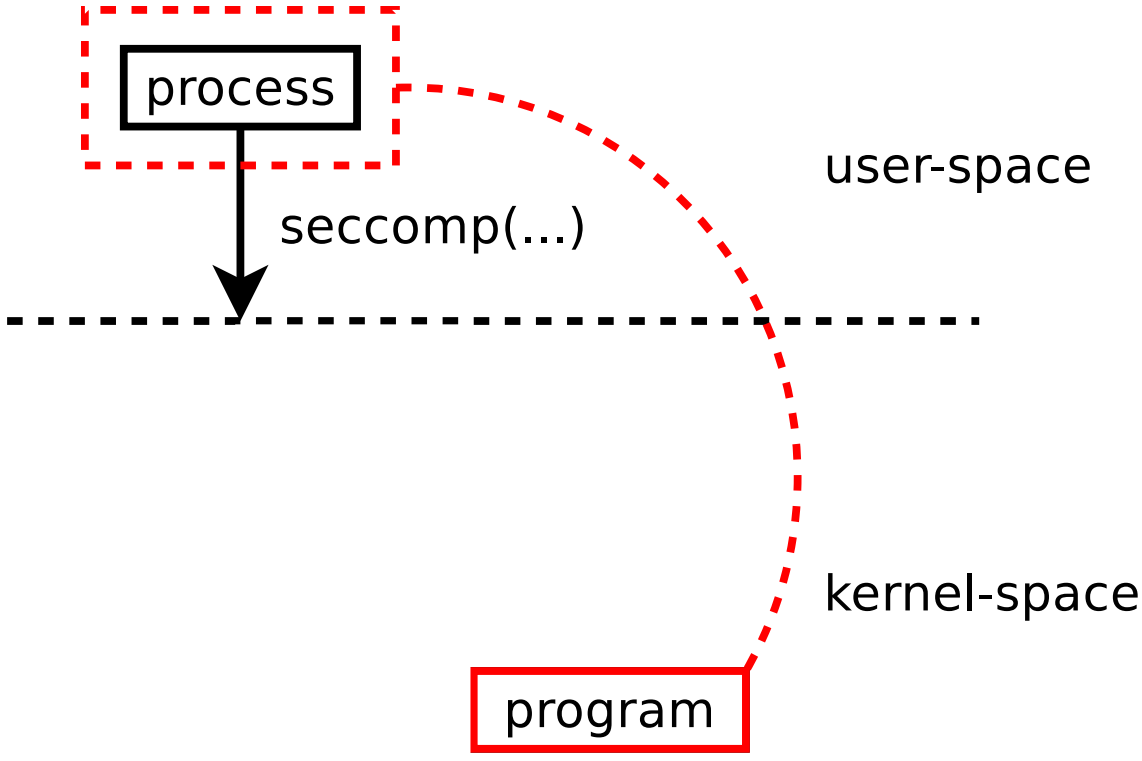

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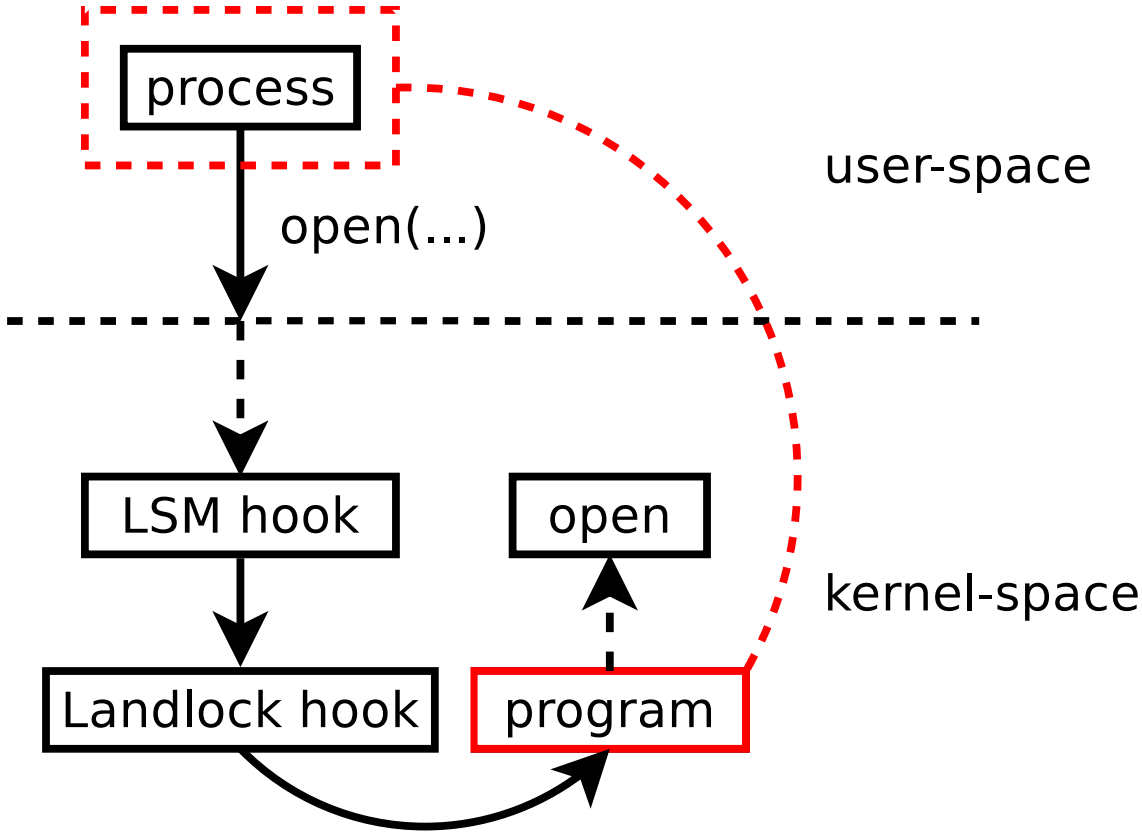

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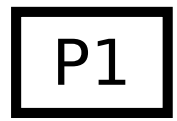

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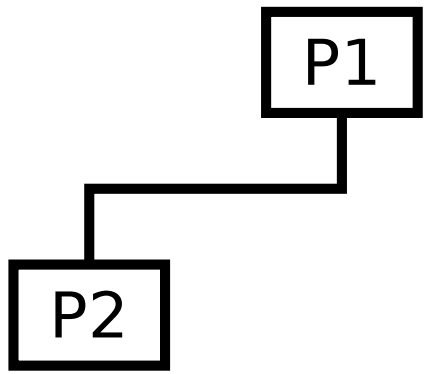

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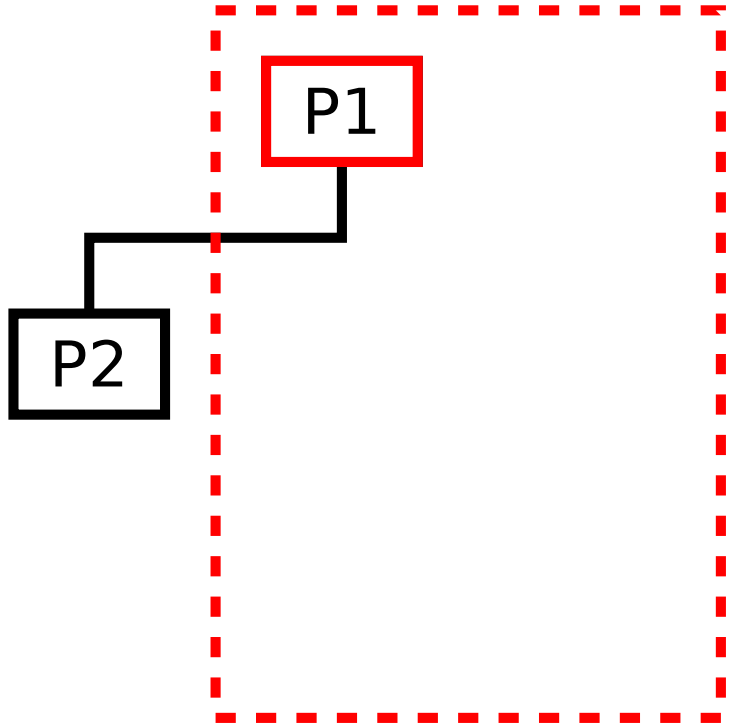

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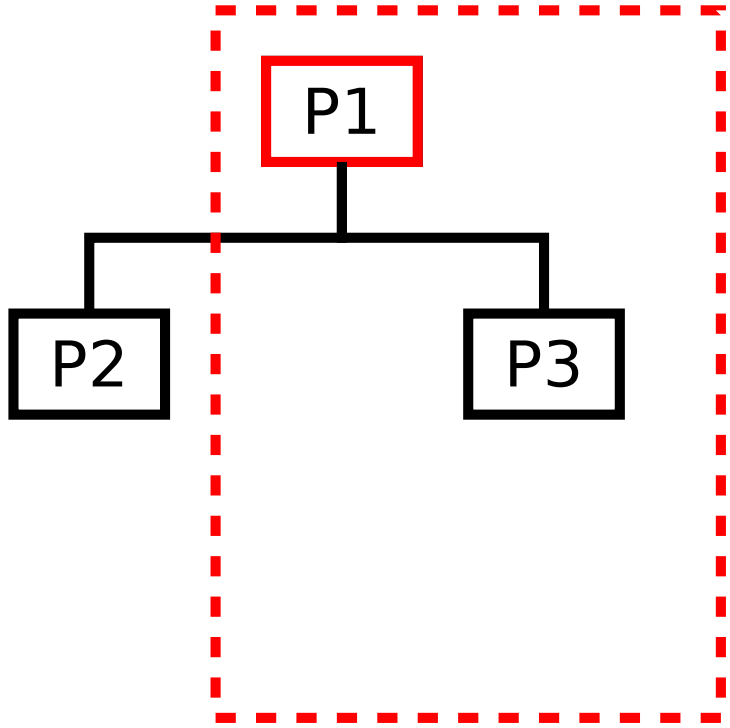

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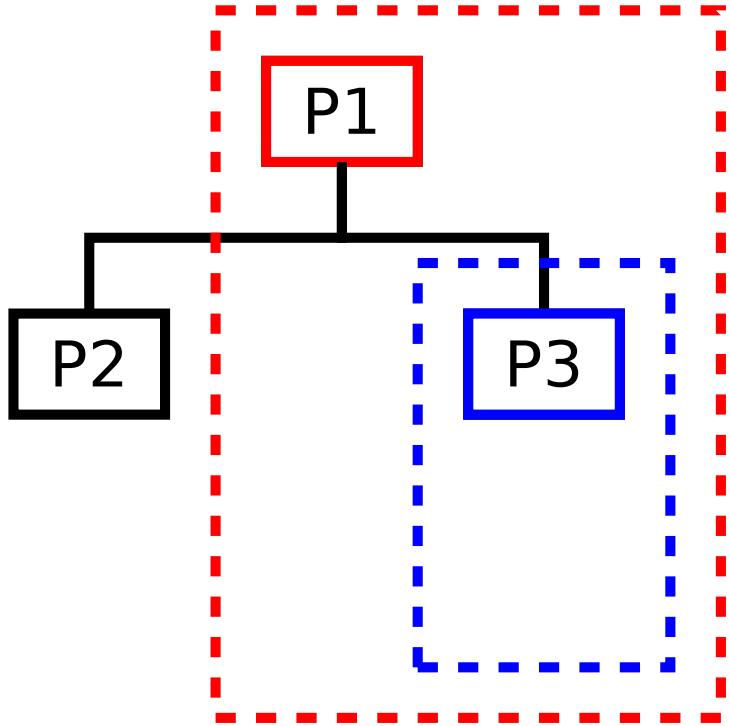

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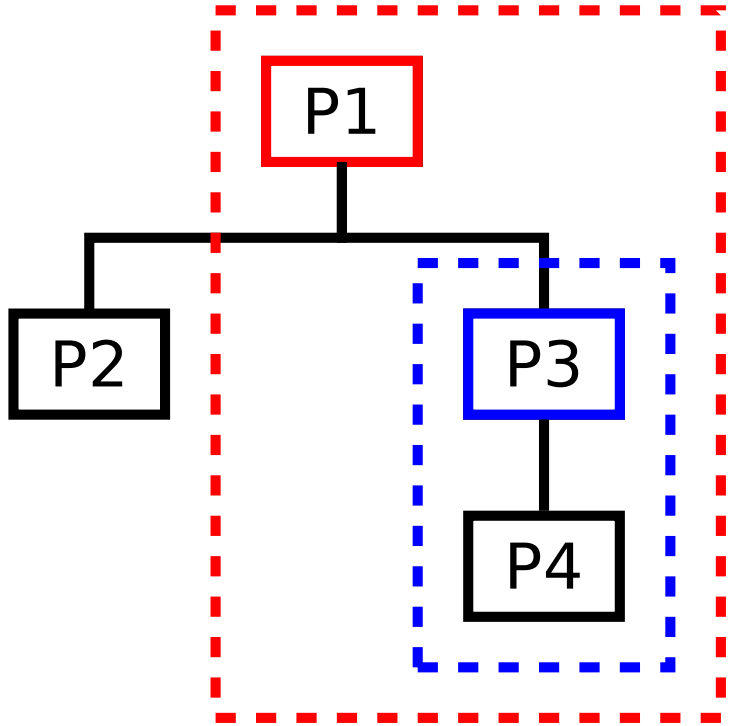

Demonstration

Read-only accesses...

- `/public`
- `/etc`
- `/usr`
- `...`

...and read-write accesses

- `/proc/self/fd/1`
- `/tmp`
- `...`

Landlock: wrap-up

User-space hardening

- programmatic and embeddable access control
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Current status

- autonomous patches merged in net/bpf, security and kselftest trees
- `security/landlock/*`: ∼1600 SLOC
- ongoing patch series: LKML, `@l0kod`
- stay tuned for the final v8 in the following weeks

https://landlock.io

Unprivileged access control

Why?

embed a security policy in any application, following the least privilege principle

Unprivileged access control

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Challenges

- applying a security policy requires privileges
- unlike SUID, Landlock should only reduce accesses
- prevent accesses through other processes: ptrace restrictions
- protect the kernel: eBPF static analysis
- prevent information leak: an eBPF program shall not have more access rights than the process which loaded it

Enforcement through cgroups

Why?

user/admin security policy (e.g. container): manage groups of processes

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Challenges

- complementary to the process hierarchy rules (via *seccomp(2)*)
- processes moving in or out of a cgroup
- unprivileged use with cgroups delegation (e.g. user session)

Future Landlock program types

fs_get

tag inodes: needed for relative path checks (e.g. *openat(2)*)

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net_*

check IPs, ports, protocol...