Microsoft

Sandbox IDs with Landlock

FOSDEM

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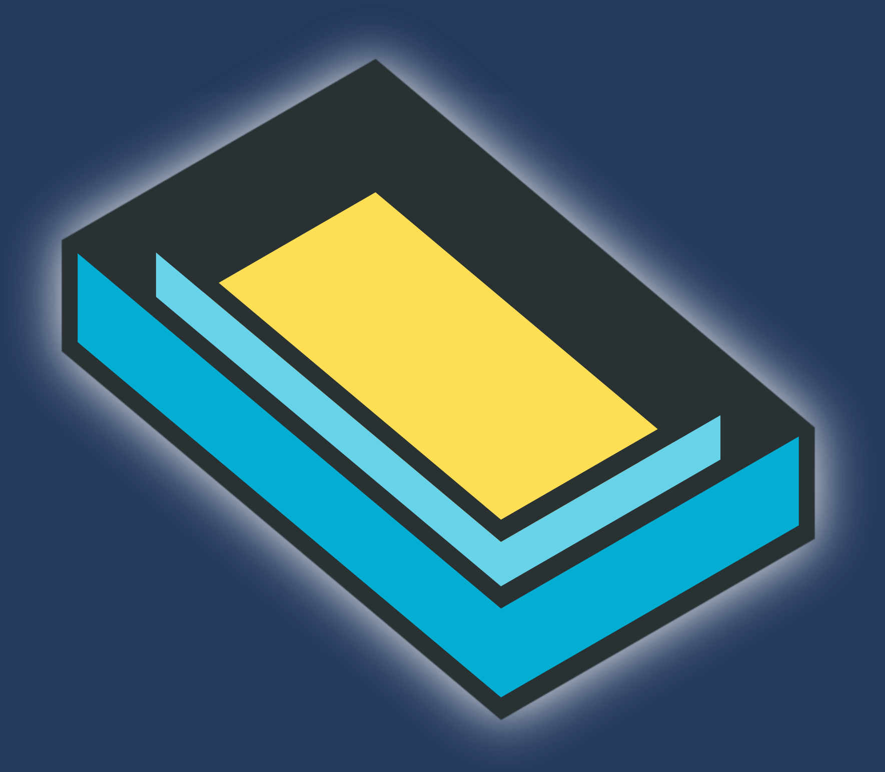

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What is sandboxing?

“A **restricted**, controlled **execution environment** that prevents potentially malicious software [...] from accessing any system resources except those for which the software is authorized.”

Landlock

- Access control system (orthogonal to namespaces)
- Dynamic security policies
- Embeddable in apps/services: unprivileged
- Enabled by default on most distros

Various use cases for IDs

Containers, IMA/EVM, audit…

Container label/ID properties

- Inherited from process to process
- ~~Immutable~~ only extendable (e.g., strings)
- Global for privileged services
- Relative for unprivileged services
- Persistence uniqueness for attestation (e.g., 128-bit UUID)
- Predictable ID for attestation?
- CRIU support

Landlock properties

Use case #1

Untrusted applications: protect from potentially malicious third-party code.

Candidates:

- Container runtimes
- Init systems

Use case #2

Exploitable bugs in trusted applications: protect from vulnerable code maintained by developers.

Candidates:

- Parsers: archive tools, file format conversion, renderers…
- Web browsers
- Network and system services

Current access control

Implicit restrictions

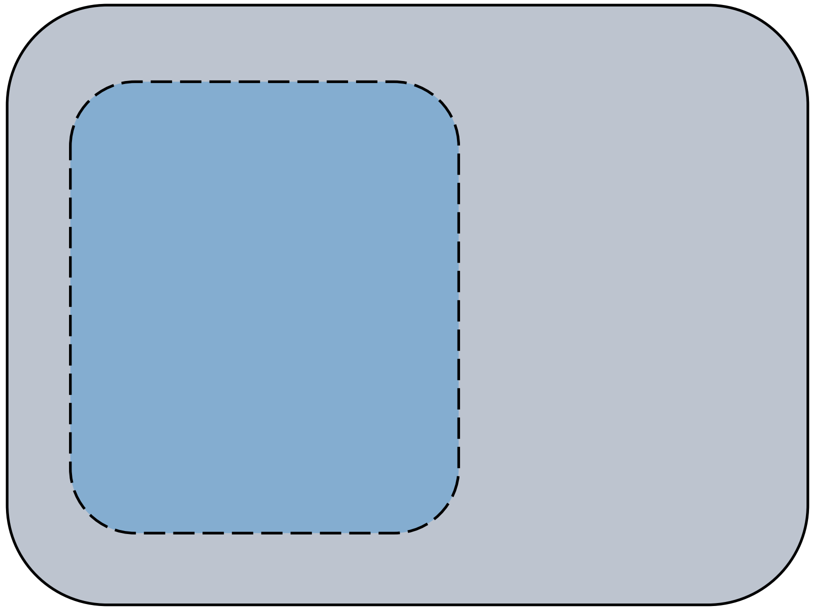
- Process impersonation (e.g., ptrace)
- Filesystem topology changes (e.g., mounts), when it makes sense

Explicit access rights

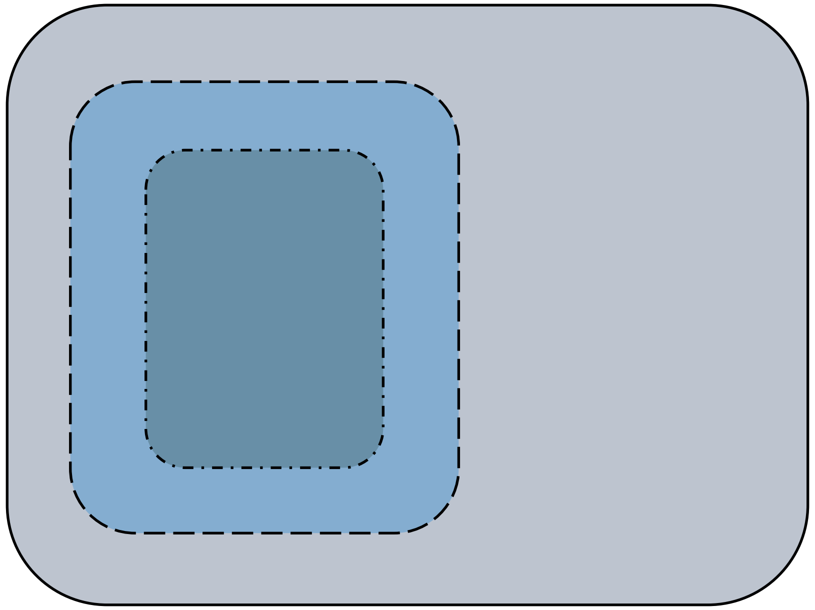
- Filesystem
- Networking
- Signaling
- Abstract unix socket

Dynamic policy composition

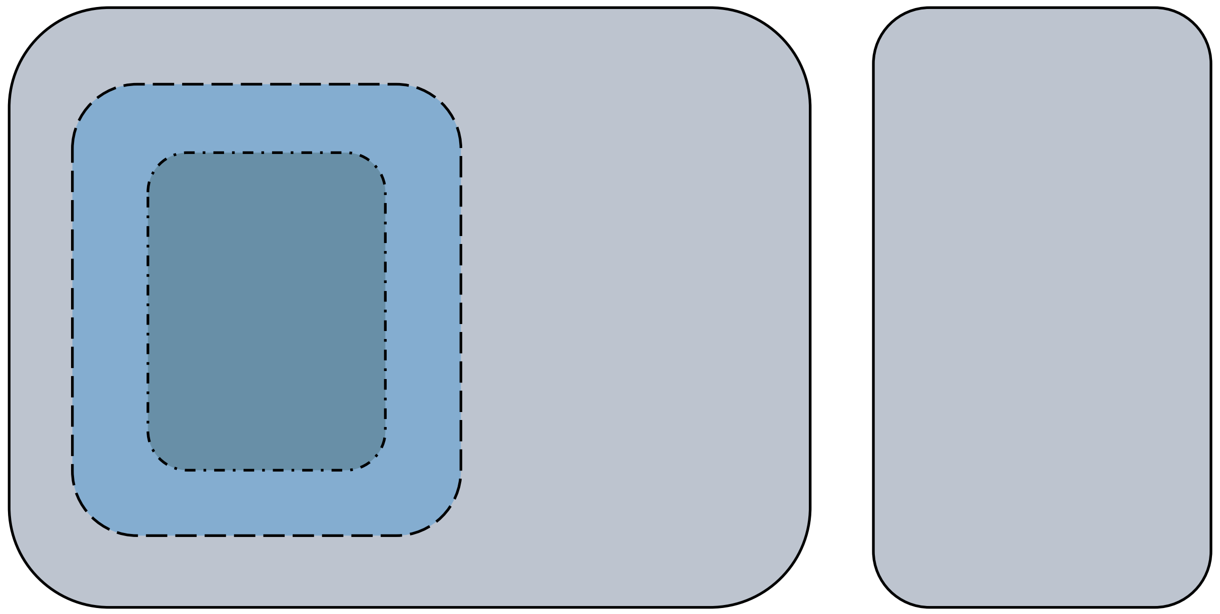
Dynamic policy composition



Dynamic policy composition



Dynamic policy composition



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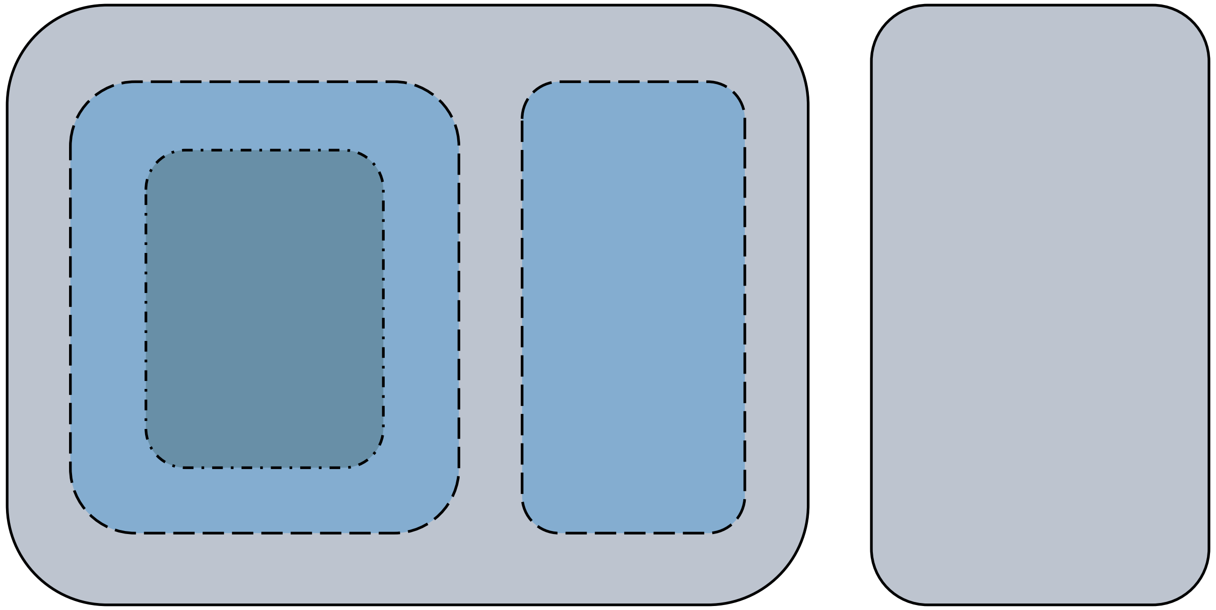
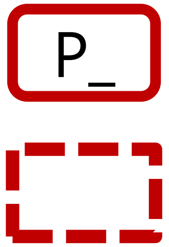


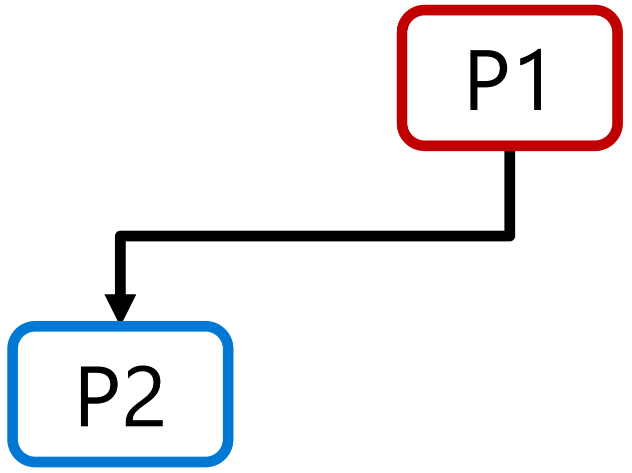
Inherited security policies

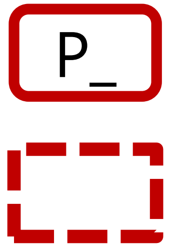


Sandboxed process

Sandbox domain

Inherited security policies





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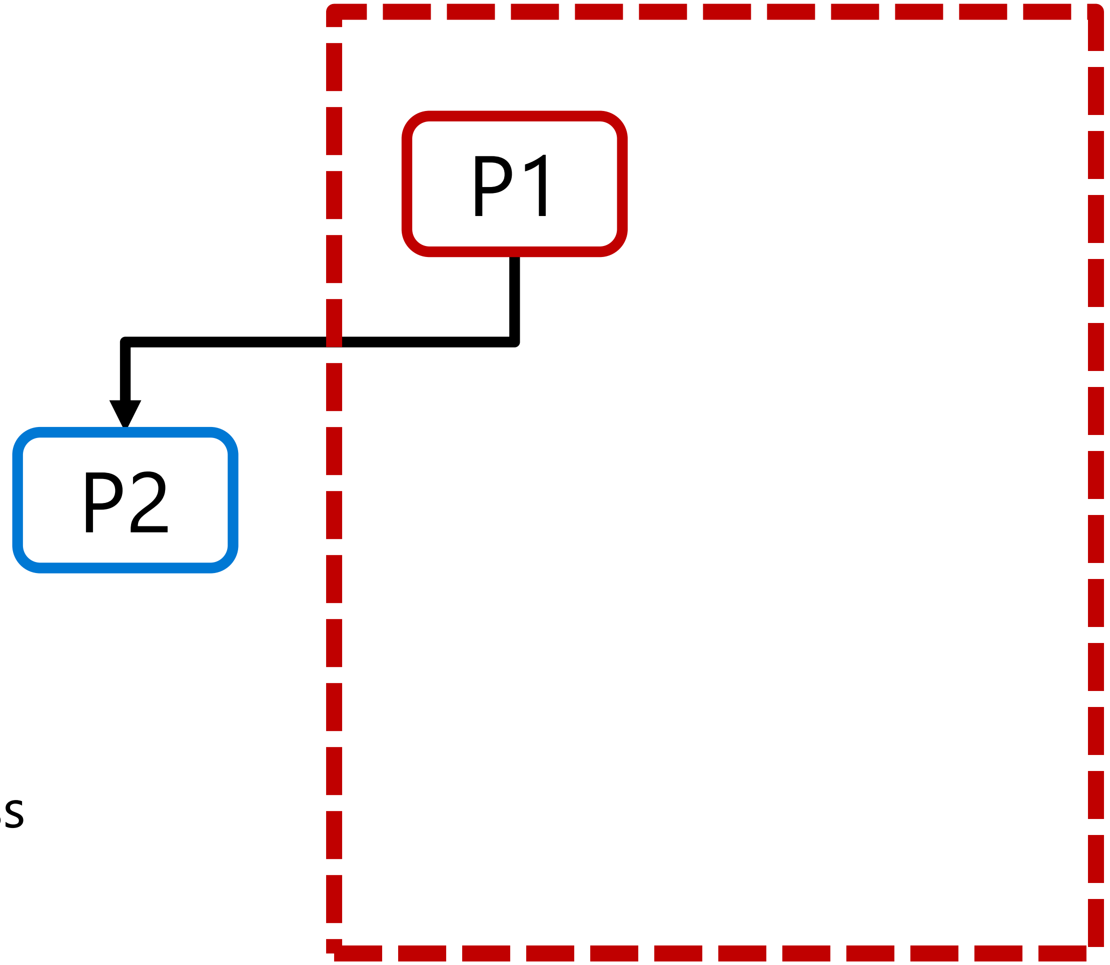

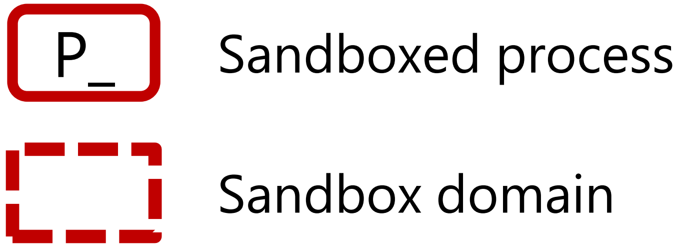

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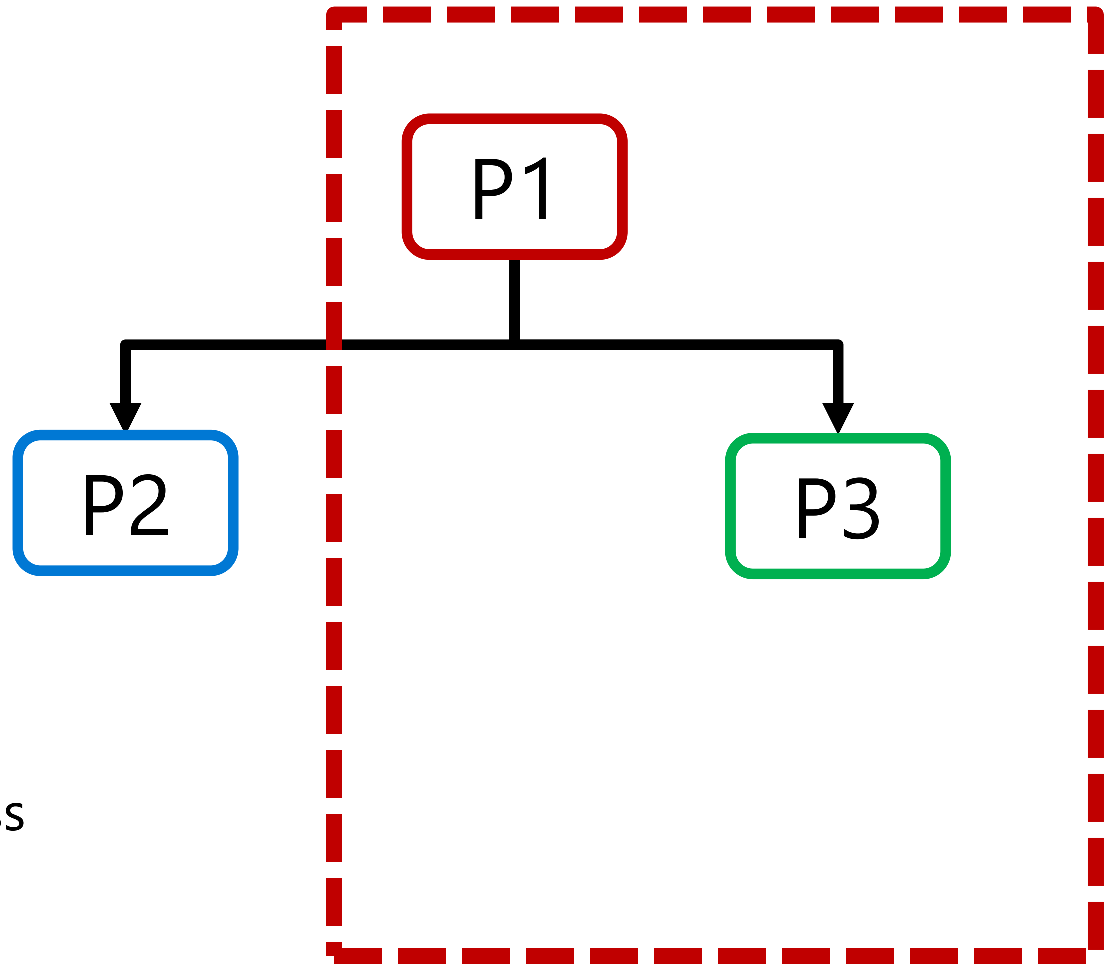
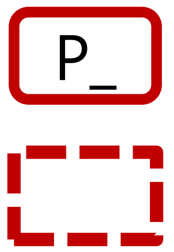
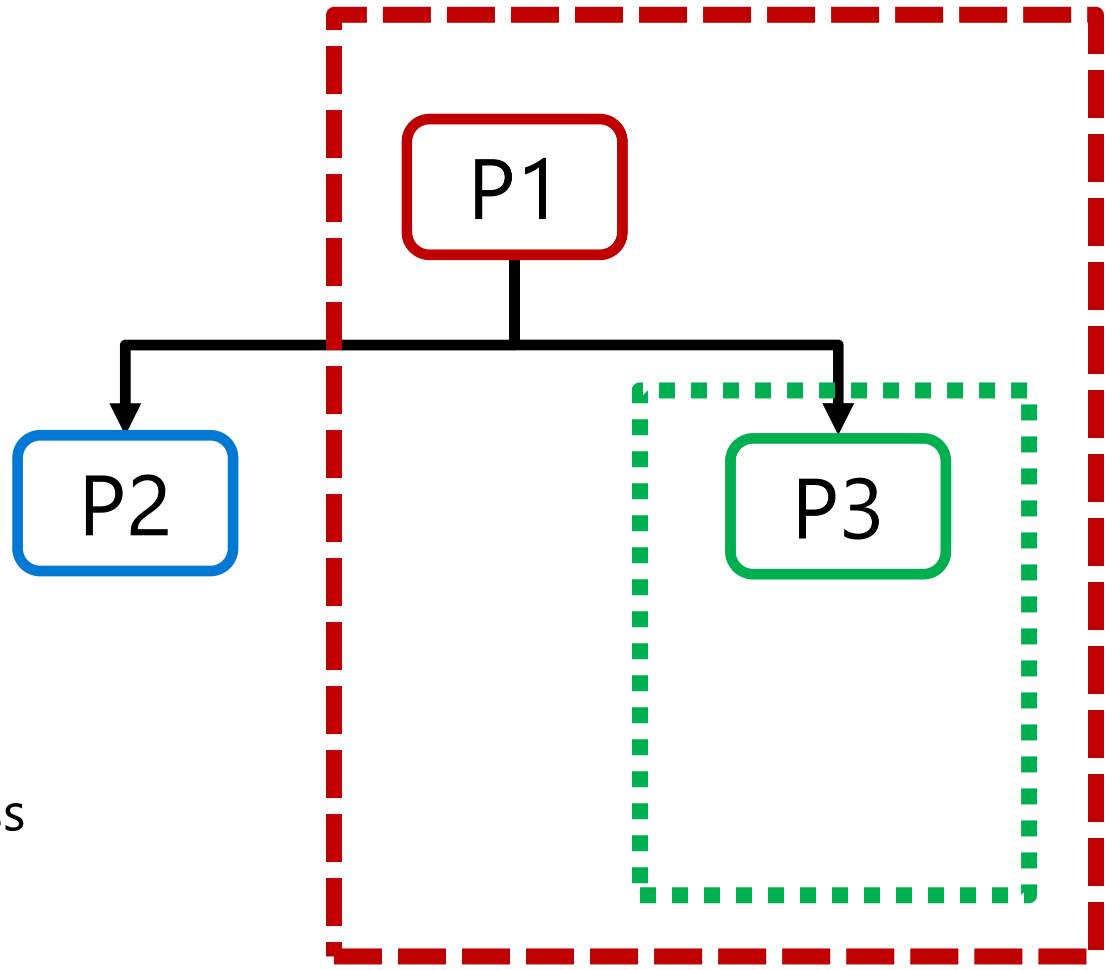


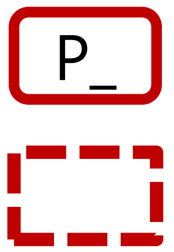


Sandboxed process

Sandbox domain

Inherited security policies





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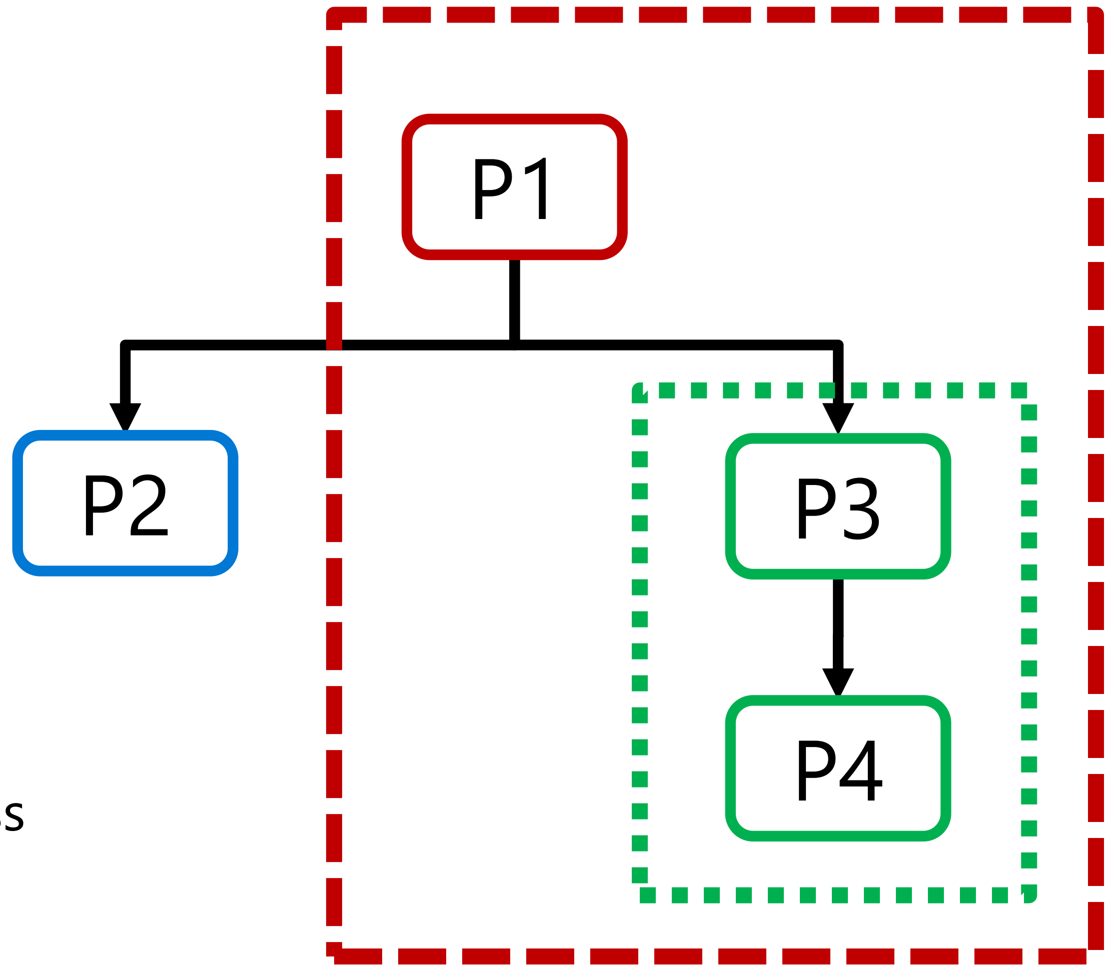

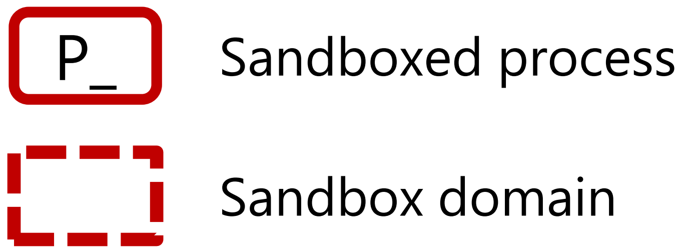

Landlock domain IDs

Landlock domain ID properties

- Unique during the lifetime of the running system: ~2^{60} IDs
- First value randomly picked between 2^{32} and 2^{33}
  - Force u64 type to limit parsing issues
  - Limit collision in logs, can be concatenated with the boot ID for fleet-unique IDs
  - Mostly aligned IDs: ~same numbers of (hexadecimal) characters
- Sequential but not necessarily consecutives IDs: incremented between 1 and 16
  - Limit cover channels
  - Still expose sequentially domain creation: useful for domain ordering and to optimize ID lookup

Use cases for Landlock IDs

Because of nested sandboxes there are two main use cases:

1. You create a sandbox and want to identify if a process is in this sandbox
2. You want to identify the latest layer of sandboxing restricting a task (i.e., the full sandbox)

pidfd

- File descriptor referencing a process:
  - Proper kernel object with clear lifetime
  - Avoid race conditions (e.g., TOCTOU)
- Created from a PID or from a unix socket to identify a peer
- Used to send signal, wait… and read process properties thanks to the new PIDFD_GET_INFO IOCTL (for a set of properties):
  - PIDFD_INFO_CREDS
  - PIDFD_INFO_CGROUPID…

Extended PIDFD_GET_INFO

Two new PIDFD_GET_INFO flags:

- PIDFD_INFO_LANDLOCK_LAST_DOMAIN
- PIDFD_INFO_LANDLOCK_FIRST_DOMAIN

[RFC PATCH v1 0/3] Expose Landlock domain IDs via pidfd

Future work

- Add a new interface for CRIU
- Add a dedicated introspection interface to safely read all properties of a sandbox; some ideas:
  - Properties (e.g., “comm”) of the process that sandbox itself, which could be used to give a name to sandboxes, or to **label containers**?
  - Read properties of Landlock rulesets used to create domains
  - Walk through domain hierarchies
  - Get notifications about denied access requests…

Could these IDs be used for other use cases?

- ✓ Inherited from process to process
- ✓ Immutable and extendable (e.g., ~~strings~~)
- ✓ Global for privileged services
- ✓ Relative for unprivileged services
- ✓ Persistence uniqueness for attestation: add boot ID to a Landlock domain ID? (e.g., 128-bit UUID)
- ✗ Predictable ID for attestation?
- ✓ Predictable label for attestation?
- ! CRIU support

Wrap-up

Landlock roadmap

Ongoing work:

- Audit support to ease debugging and provide metrics
- Introspection interfaces (e.g., pidfd)
- New access-control types: socket creation, UDP port use…

Contribute

- Develop new access types or features
- Improve libraries: Rust, Go…
- Challenge the implementation
- Improve documentation or tests
- Sandbox your programs and others’
  - Secure Open Source Rewards
  - Google Patch Rewards

Try Landlock

```
# WARNING: The "sandboxer" is a demonstration program,
# not a tool with a stable interface.

$ cargo install landlock --examples

$ sandboxer
```

Questions?

landlock@lists.linux.dev

Thank you!