Capsicum

Capability-Based Sandboxing

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https://linuxcontainers.org/lxc/

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LXC / Introduction

What's LXC?

LXC is a userspace interface for the Linux kernel containment features. Through a powerful API and simple tools, it lets Linux users easily create and manage system or application containers.

Features

Current LXC uses the following kernel features to contain processes:

- Kernel namespaces (ipc, uts, mount, pid, network and user)
- Apparmor and SELinux profiles
- Seccomp policies
- Chroots (using pivot_root)
- Kernel capabilities
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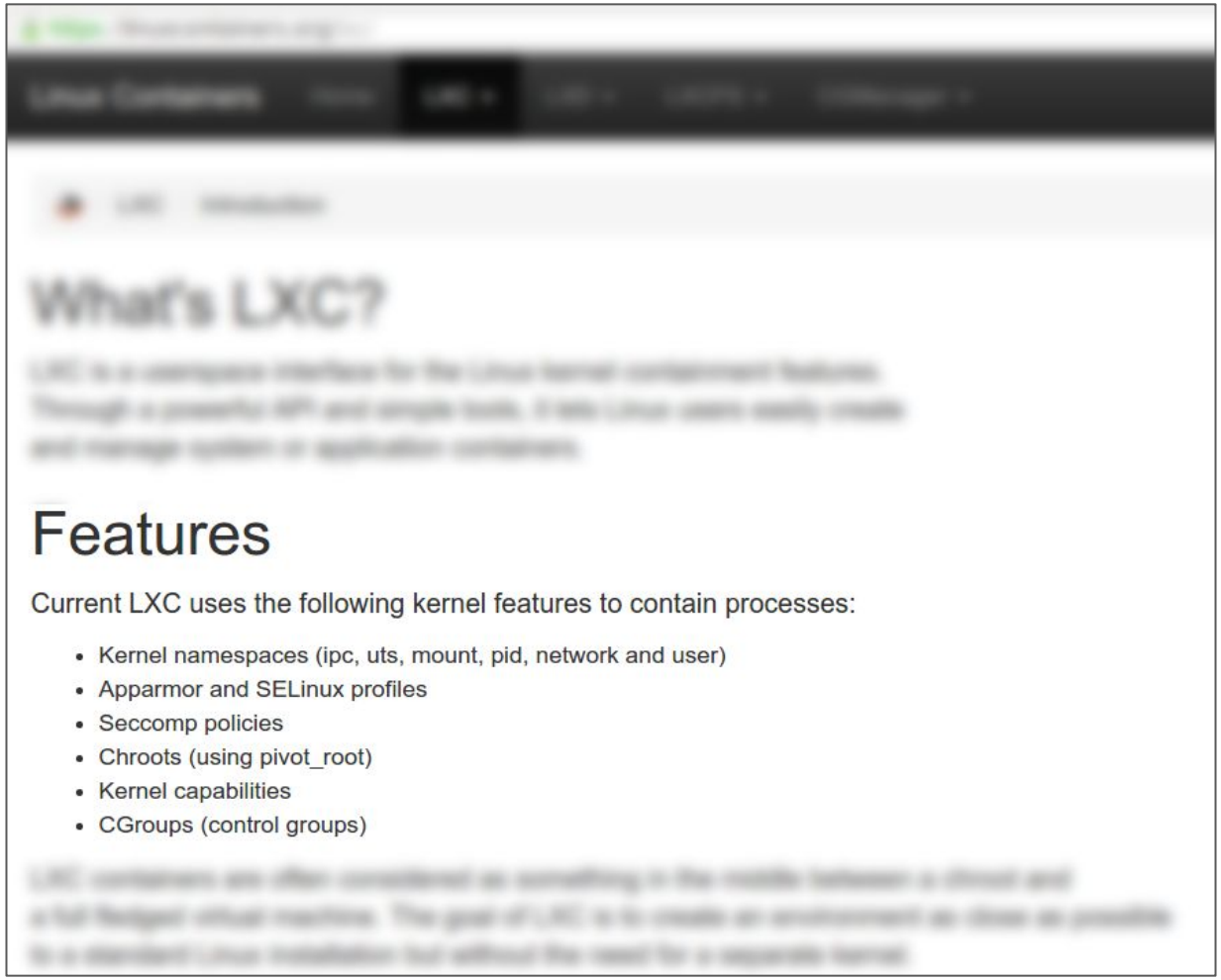
LXC containers are often considered as something in the middle between a chroot and a full fledged virtual machine. The goal of LXC is to create an environment as close as possible to a standard Linux installation but without the need for a separate kernel.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Agenda

- Ideas
  - Privilege Separation
  - Capabilities
- Capsicum
  - Hybrid with POSIX
  - Application changes
- Linux container features
- Status/Outlook

Check Your Privileges

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- Divide up software according to what privileges are needed
  - E.g. separate media processing from credentials processing
- Examples:
  - OpenSSH: credential checking process
  - Chrome: renderer processes
- Design impact:
  - Do privileged operations first
  - Pass resources down a privilege gradient

Capability-Based Security

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  - Identifies the object
  - Accompanying ***rights*** give allowed operations
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- Access *objects* via unforgeable token: the ***capability***
  - Identifies the object
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  - Can only reduce, not increase rights
  - Can pass capabilities around
- Remove other ways of accessing objects
  - No access by name, i.e. no global namespaces

Analogy: File Descriptors

- Refers to kernel object (open file, open socket, ...)
- Can only be created by the kernel
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- ... but no real model of *rights*
  - **`O_RDONLY`** / **`O_RDWR`** not good enough

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  - `CAP_READ, CAP_WRITE, CAP_LOOKUP, CAP_FCHMOD, ...`
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  - `CAP_BIND, CAP_ACCEPT, CAP_CONNECT, CAP_SETSOCKOPT, ...`
- Capability mode
  - Remove access to global namespaces
  - Turn off most ways of minting new (unrestricted) file descriptors
    - `openat(dfd, "path"...)` allowed
    - `accept(socket ...)` allowed

Example: `strings`

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```
+   cap_rights_t rights;
+   cap_rights_limit(fileno(stdout), cap_rights_init(&rights, CAP_WRITE, CAP_FSTAT));
+   cap_rights_limit(fileno(stderr), cap_rights_init(&rights, CAP_WRITE));
```

```
    for (ii = 0; ii < num_streams; ++ii) {
        ...
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+   cap_rights_init(&rights, CAP_READ, CAP_SEEK, CAP_FSTAT, CAP_FCNTL);
+   for (ii = 0; ii < num_streams; ++ii) {
+     if (streaminfo[ii].stream)
+       cap_rights_limit(fileno(streaminfo[ii].stream), &rights);
+   }


    for (ii = 0; ii < num_streams; ++ii) {
        ...
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+  for (ii = 0; ii < num_streams; ++ii) {
+    if (streaminfo[ii].stream)
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+  }
+  cap_enter();
+
   for (ii = 0; ii < num_streams; ++ii) {
       ...
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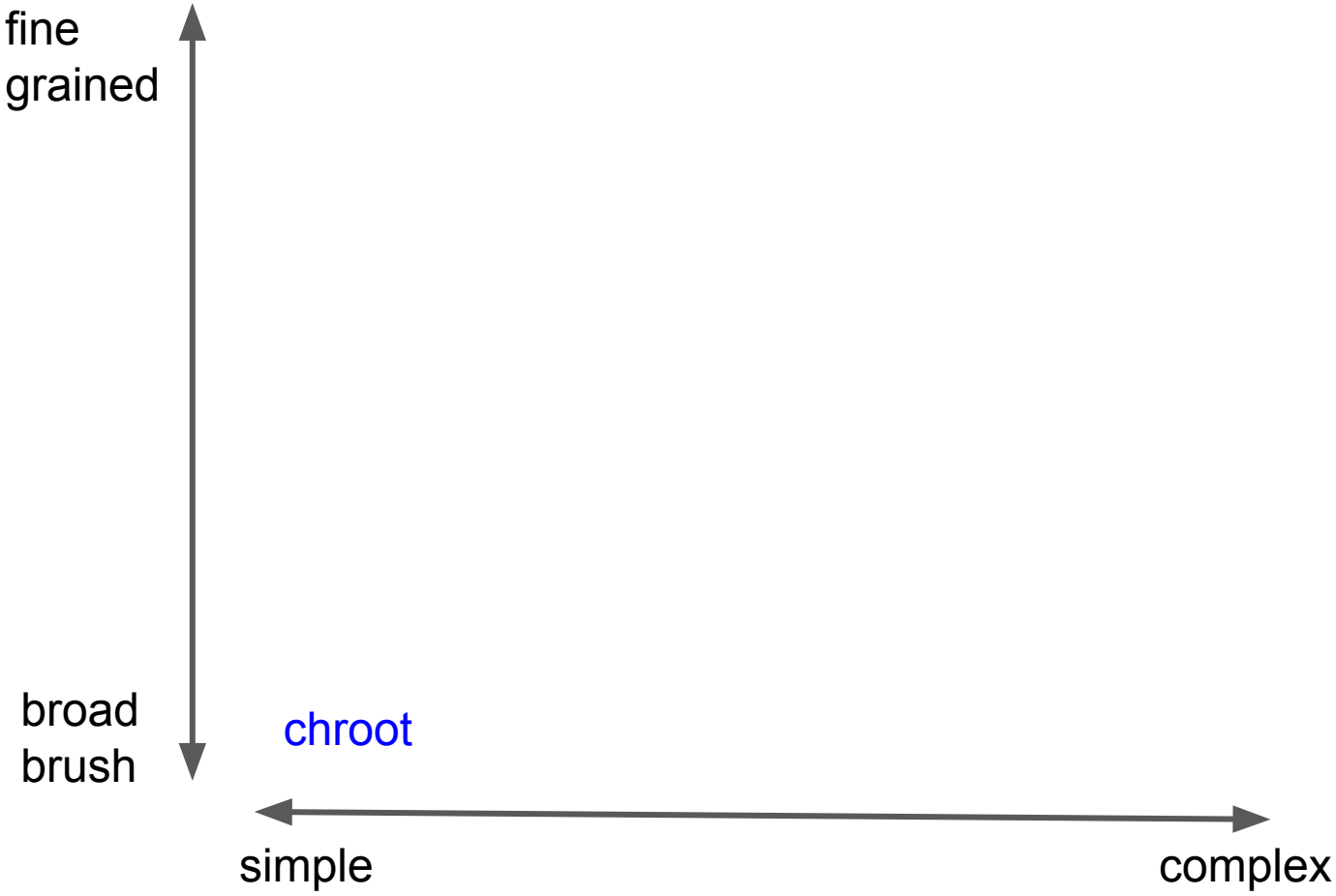
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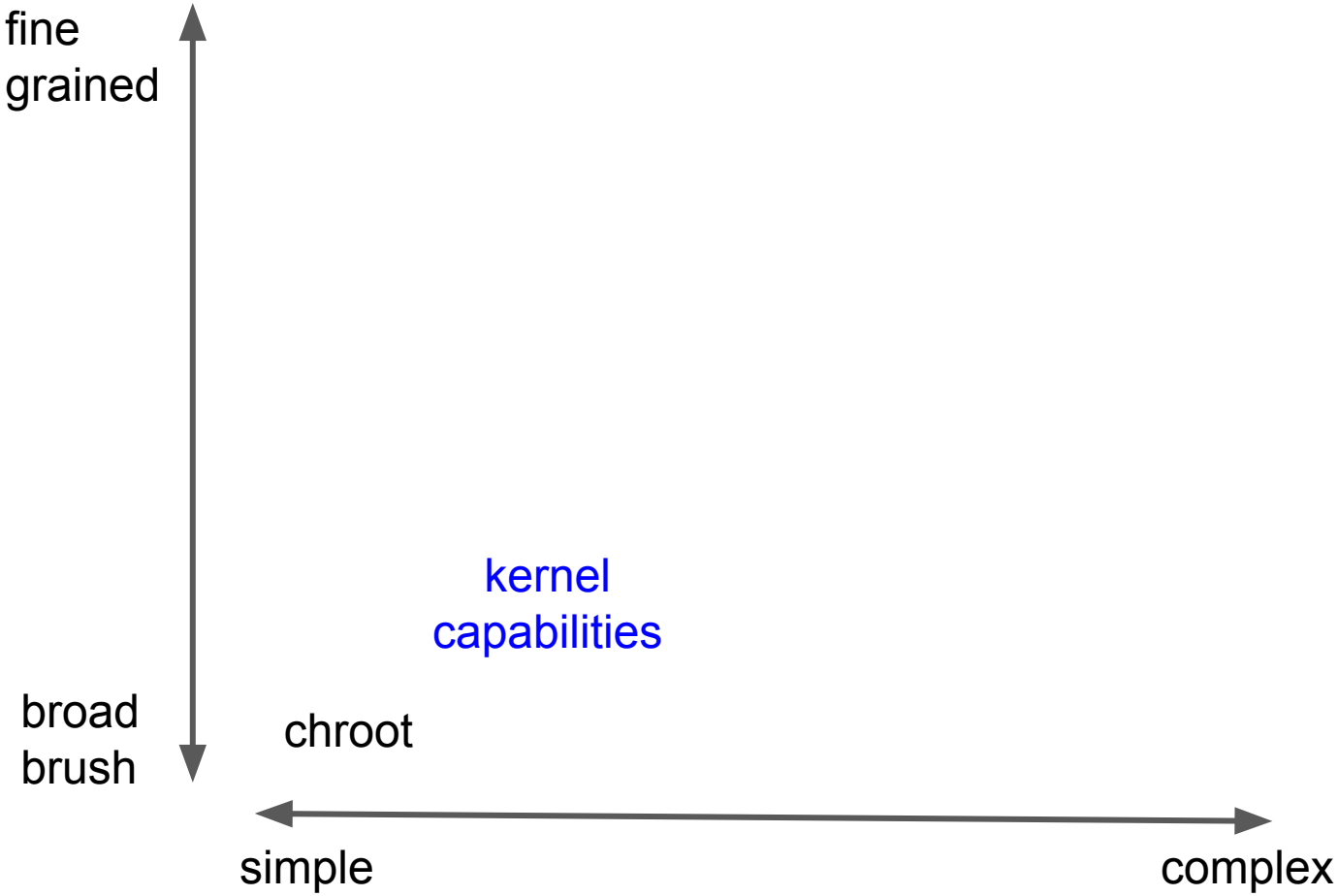
complex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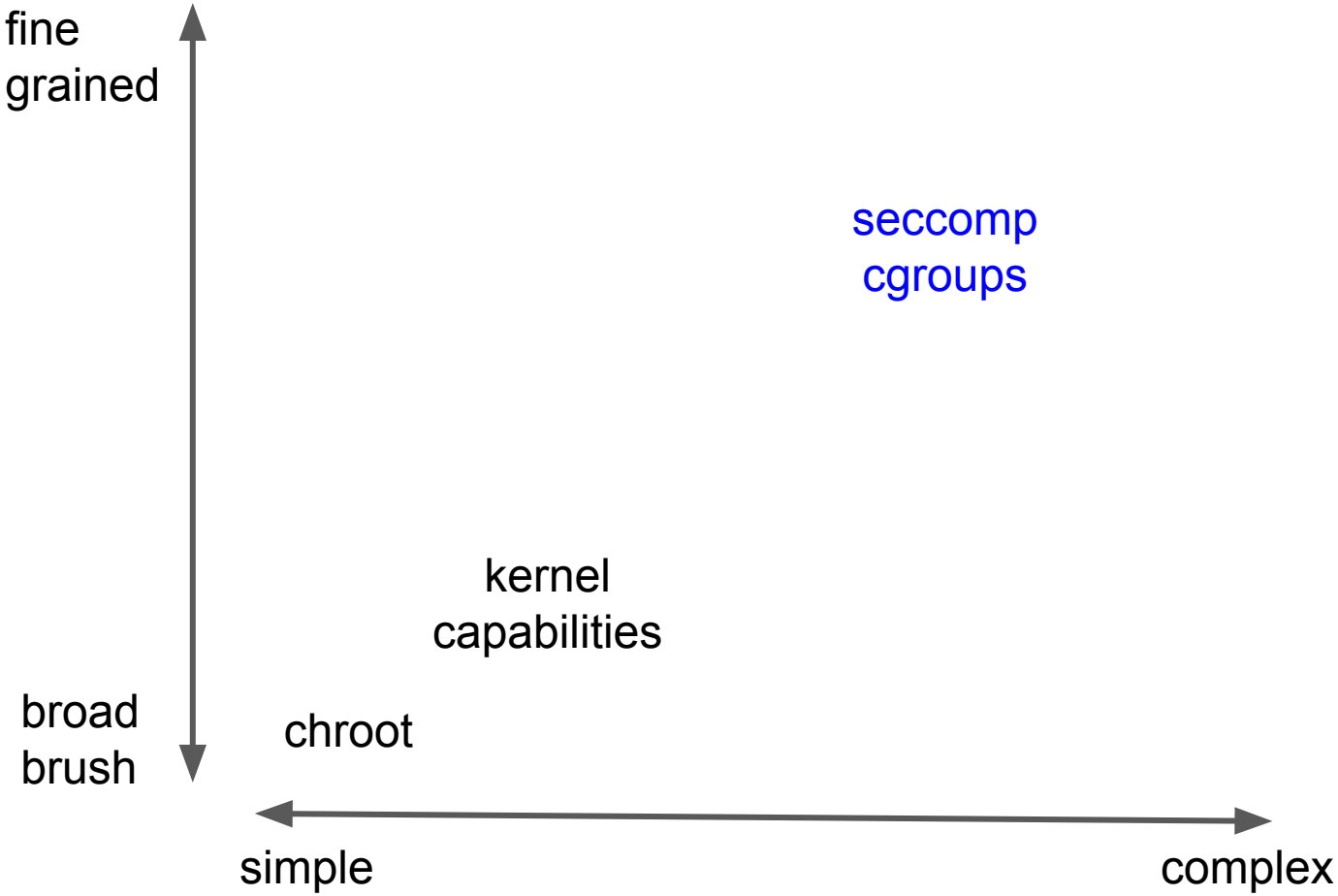
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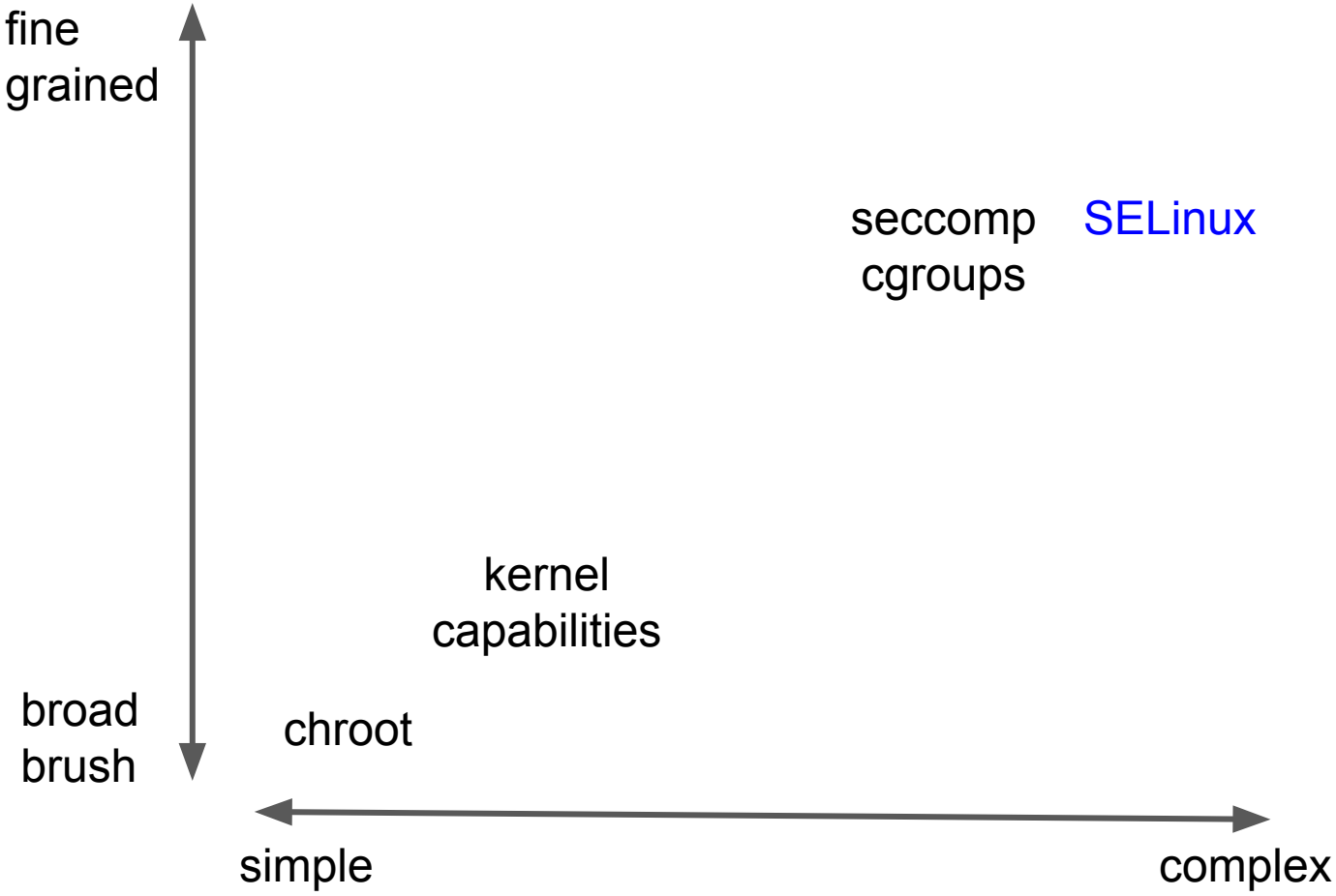
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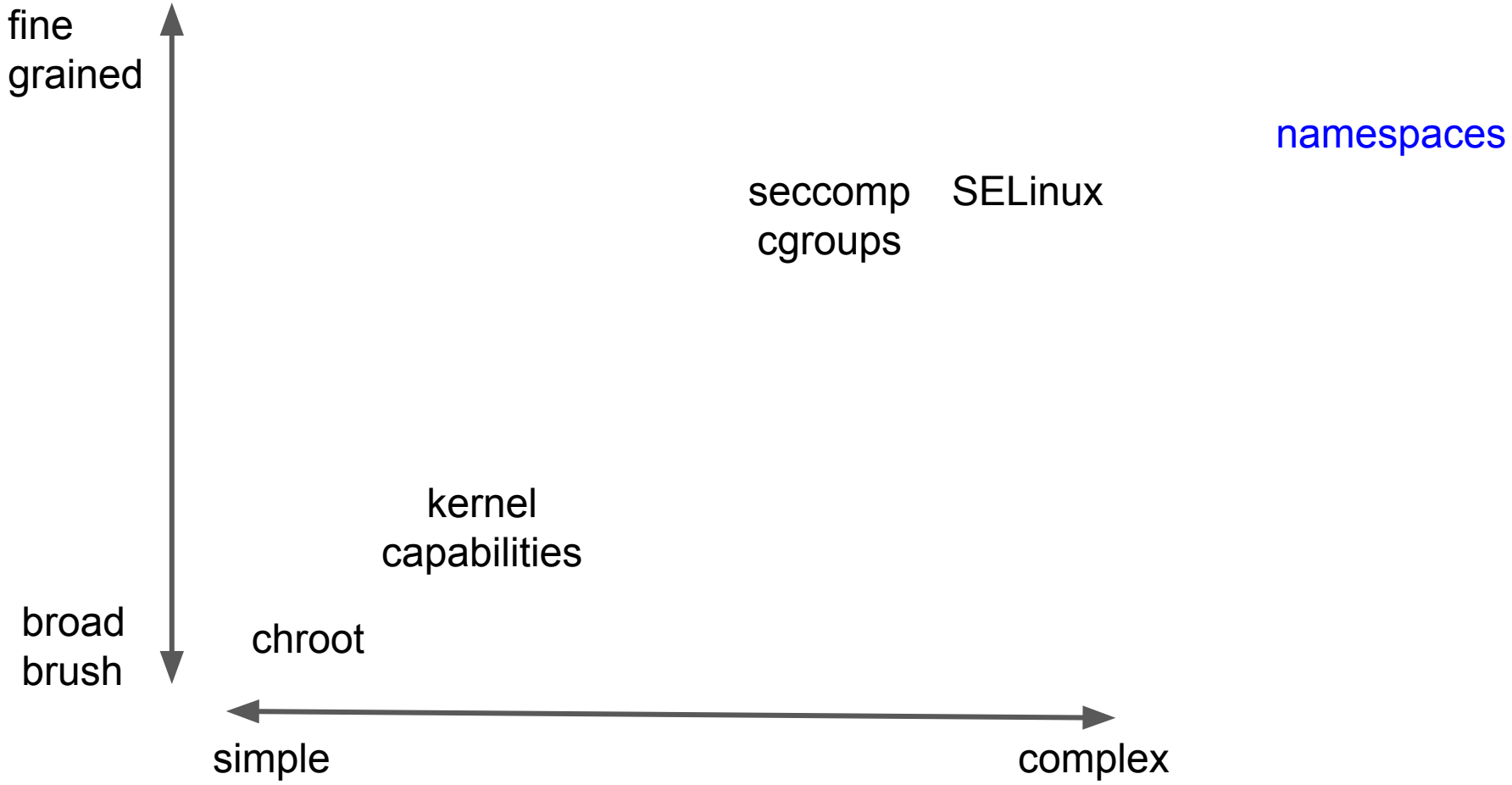
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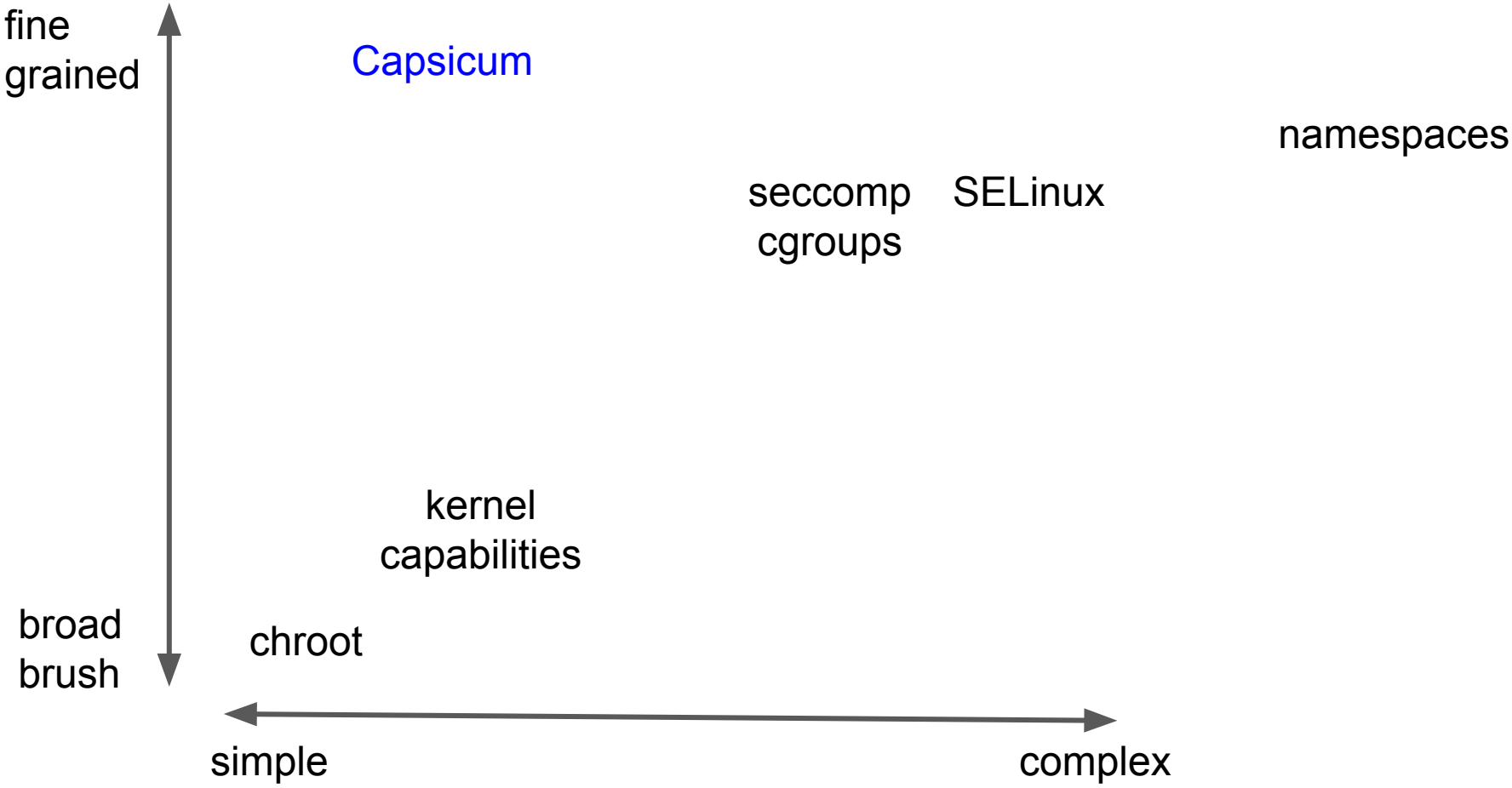
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Themes

- Involves code changes
- Less flexible in some ways
  - But simple to understand & apply
  - Not specific to `root`
- More fine-grained in other ways
  - FD-by-FD, not application-wide
- Easy to analyze
- Composes with other features

Status

- OS Support
  - In FreeBSD >= 10.x
  - Out-of-tree patch set for Linux (github.com/google/capsicum-linux)
- Application Support
  - ~20 in-tree FreeBSD applications
  - OpenSSH / tcpdump / xz
  - (Chromium)
- Next
  - More applications (join us!)
  - More debugging facilities

References

- Home page: http://www.cl.cam.ac.uk/research/security/capsicum/
- Linux home page: http://capsicum-linux.org/
- Intro article: http://capsicum-linux.blogspot.co.uk/2015/02/an-overview-of-capsicum.html
- Linux source code: https://github.com/google/capsicum-linux
- Test suite: https://github.com/google/capsicum-test
- Projects list: https://github.com/google/capsicum-test/wiki/Projects
- Strings vulnerability: https://lcamtuf.blogspot.co.uk/2014/10/psa-dont-run-strings-on-untrusted-files.html

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