The VFS paradigm from the perspective of a component OS

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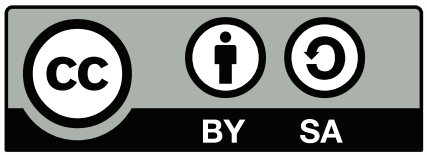

Outline

1. Motivation
2. History of the VFS in Genode
3. Where are we now?
4. Main course finished, dessert anyone?

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- Gradual decomposition (kernelization) of sensitive parts
- Reconstruction of complex (single-purpose) software not appealing
- Consequently traditional applications will always be around

A square peg into a round hole?

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- Fairly global view on resources as a tree of directories and files
- File abstraction grants access to data on storage, configuration, hardware peripherals, (graphical) user interfaces, to some extent even networking

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Many attractive applications require a POSIX environment.

- Fairly global view on resources as a tree of directories and files
- File abstraction grants access to data on storage, configuration, hardware peripherals, (graphical) user interfaces, to some extent even networking
- Mostly traditional access control (user/group permission bits)
- C/C++ runtime
- Extensive system API (only a small share used)

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Our playground is Genode.

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- Microkernel-based
- Capability-based
  - No global namespace
  - Fine-grained access control to resources
  - Recursive system structure
- Component-based
  - Versatile combination of components according to use case
  - Spectrum from strong dependency to loose coupling
  - Only integrate what's needed to solve the task
  - Low software complexity as primary goal

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- Runtime environment including VFS

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- Customized C library
- Runtime environment including VFS
- How about the world beyond the frame of the sand pit?
- Connect to Genode services

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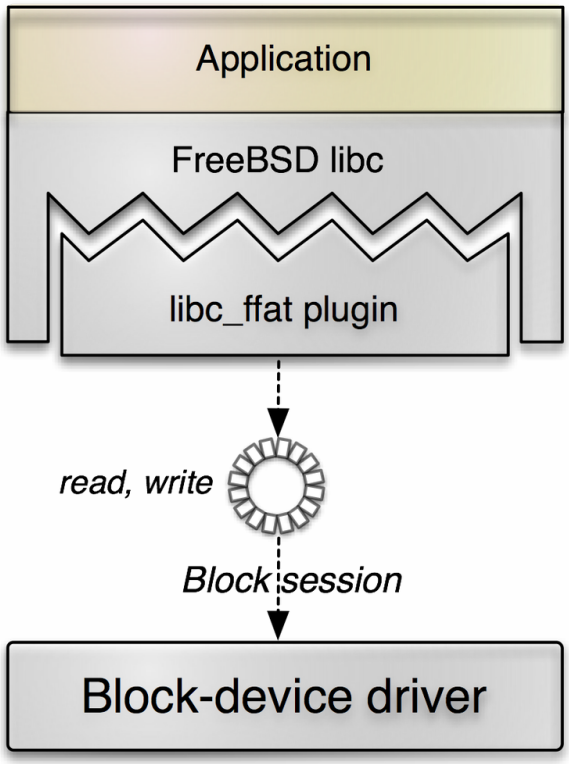
- Some emulated mechanisms to satisfy applications (e. g., UIDs, permissions, sysctl)
- Gradually develop C library plugins to access Genode services
  - File-system libraries (FFAT, FUSE) use Block service
  - Network-stack libraries (lwip, lxip) use Nic service
  - Terminal service
  - File-system service
  - Special-purpose (e. g., libdrm/gallium)

Customized C library



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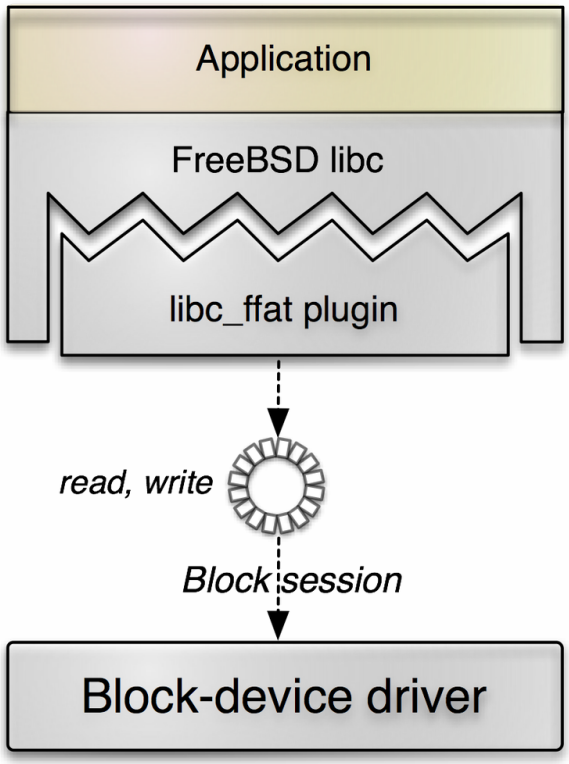

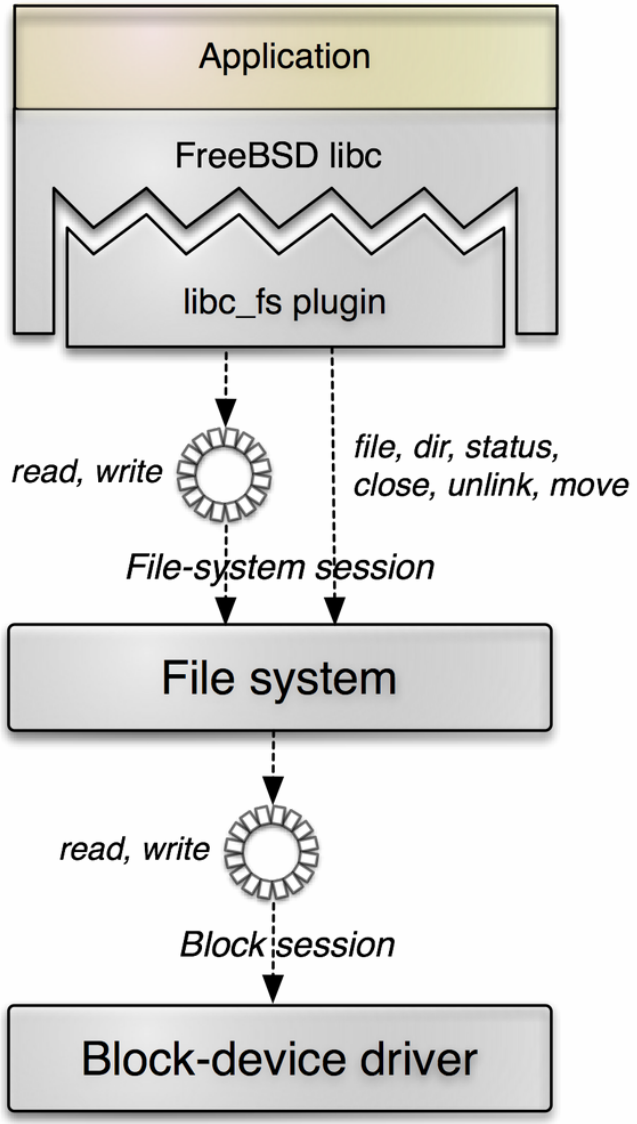

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- Configure and build with original GNU build system
- From process-local to Noux-wide resource representation

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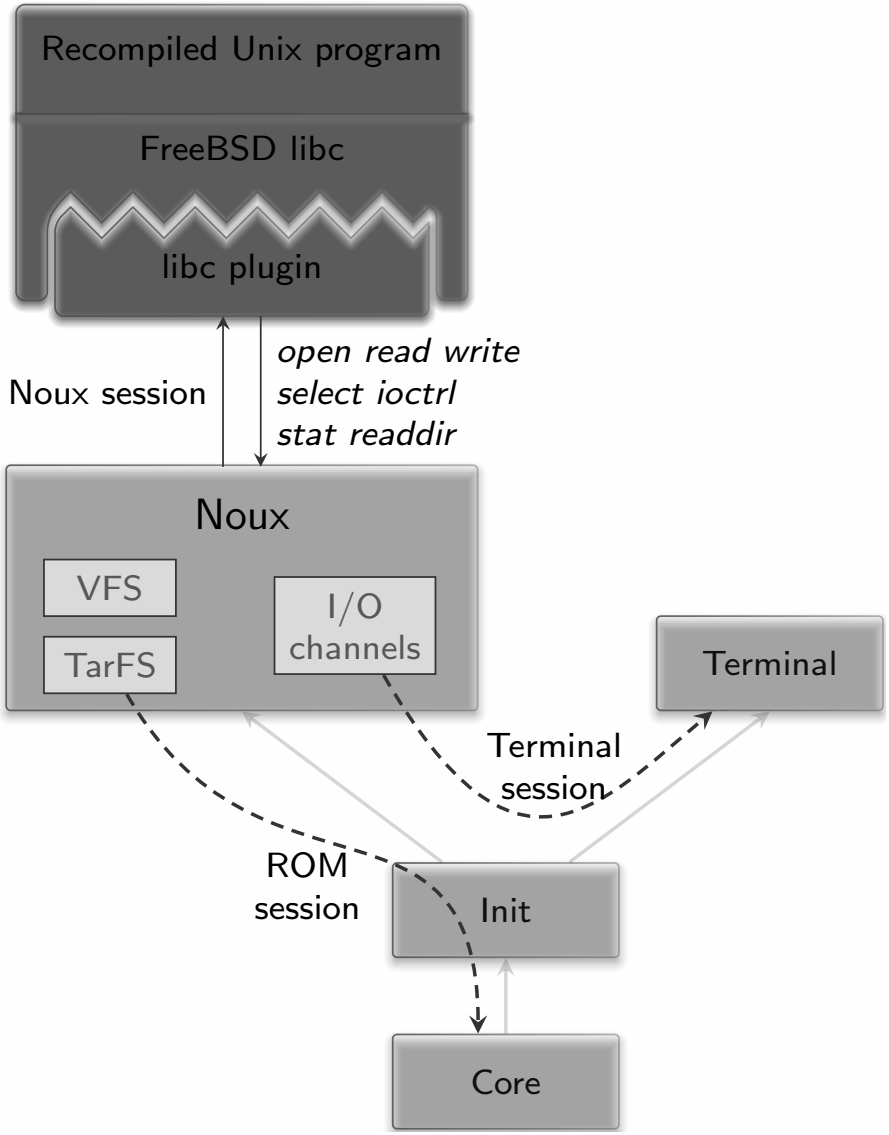

Plug VFS into C library

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- Gradually replace C library plugins by VFS plugins
- Process-local VFS instance
- Individual configuration

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VFS instance as XML node in component configuration

```
<config> <vfs>...</vfs> </config>
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Directories

```
<vfs> <dir name="dev">...</dir> </vfs>
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Plugins as nodes in the tree

```
<vfs> <dir name="dev"> <log/> </dir> </vfs>
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Configure C library mechanisms to use VFS nodes

```
<libc stdout="/dev/log" stderr="/dev/log"/>
```

Basic configuration

```
<config>
  <vfs>
    <dir name="dev"> <log/> </dir>
  </vfs>
  <libc stdout="/dev/log" stderr="/dev/log"/>
</config>
```

- Precise *declaration* of resource representation in VFS
- Plugins can be single files or whole directory sub-trees
- Nodes in a directory organized as stack (or union mount)
- Tweaking of C library behavior

VFS plugins at a glance

Files backed by ROM service

```
<rom name=".vimrc" label="vimrc.txt"/>
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<inline name="app.config">avatar = /avatar.png</inline>
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Handy tools

```
<null/> <zero/> <symlink name="editor" target="/bin/vim"/>
```

VFS plugins at a glance

RAM-backed storage (like tmpfs)

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Integration of package-archive trees

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File-to-service wrappers

```
<log/> <rtc/> <terminal/> <block/>
```

VFS plugins at a glance

Expandable by custom shared objects

```
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<gtotp name="gtop.service.net" secret="IMGLPG6VANGX3UCP"/>
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File-system session to use persistent storage

```
<fs name="home"/>
<fs name="cfg" label="config" writeable="yes"/>
<fs name="bin" label="bin" root="/usr"/>
```

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VFS configuration is component-local → access control by policies in parent and service components (e. g., file-system service)

```
<policy label="app -> "       root="/home" writeable="yes"/>
<policy label="app -> config" root="/app/config" writeable="no"/>
<policy label="app -> bin"    root="/" writeable="no"/>
```

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- Robust implementation of file-system service
- File-system itself implemented as VFS plugin
- One VFS configuration for multiple components
- Multiplex access to all aggregated resources
- Differentiate client permissions by policies

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- Dynamic reconfiguration of server applies to all clients
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- Now, at the latest, HURD translators come into mind...

Is there more about that server?

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Shared resources could be provided by large plugins.

- Dedicated rump (ext2) server superseded by plugin
- Network stack based on lxip/lwip

```
<!-- server -->
<vfs> <lxip/> </vfs>

<!-- client -->
<vfs> <dir name="/socket"> <fs/> </dir> </vfs>
<libc socket=/socket>
```

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Review our goals

- Audited system resource discovery and access
- C library integration enables existing POSIX applications
- Versatile combination inside component and via VFS server
- Abstraction from Genode services
- Future extension is easy (e. g., USB service adapter for libusb)

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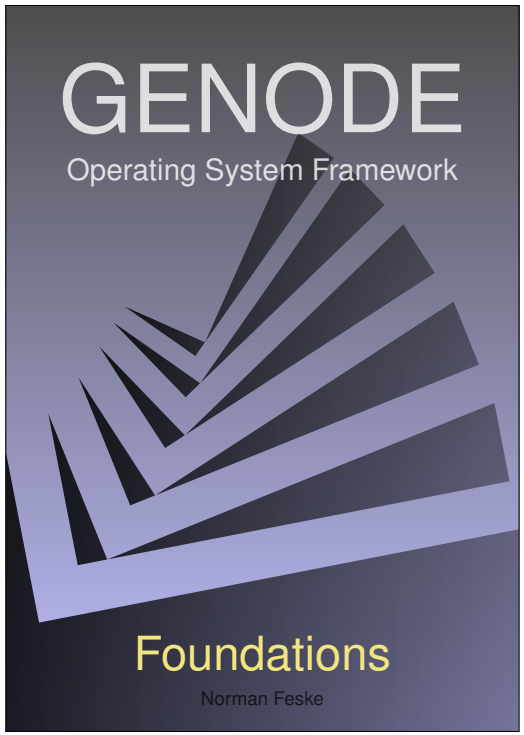
Application-stack architectures range from multiple components connected by file-system sessions to unikernel-like monoliths.

Thank you



Genode OS Framework

`https://genode.org/`

Genode Labs GmbH

`https://www.genode-labs.com/`

Source code on GitHub

`https://github.com/genodelabs/genode`

Genode Foundations book

`https://genode.org/documentation/genode-foundations-16-05.pdf`