The -ization of Containerization

John Logan – Container Team

container tool

Containerization

What are containers?

Containerization principles

Extending Container

Building on Containerization

Adoption of Swift

Open Source Community

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Runtime properties

- Provide isolation from the host

Runtime properties

- Provide isolation from the host
- Provide isolation from other workloads

Runtime properties

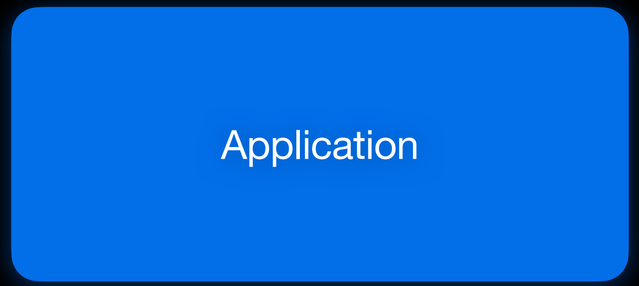
- Provide isolation from the host
- Provide isolation from other workloads
- Development environments

Runtime properties

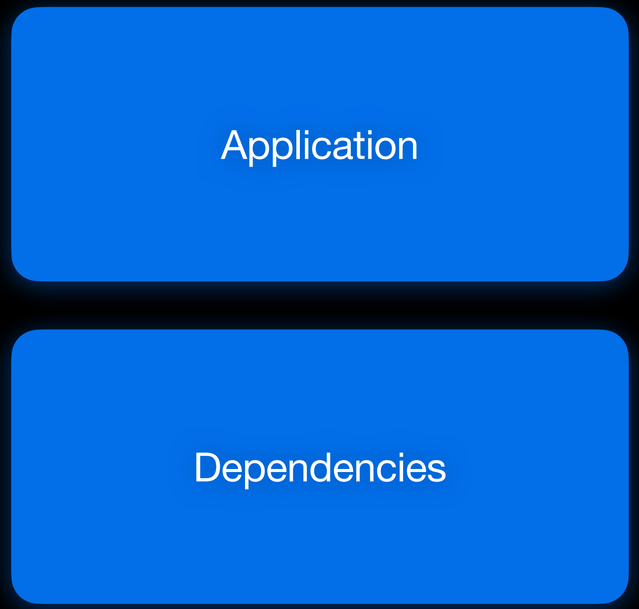
- Provide isolation from the host
- Provide isolation from other workloads
- Development environments

> Lightweight and fast

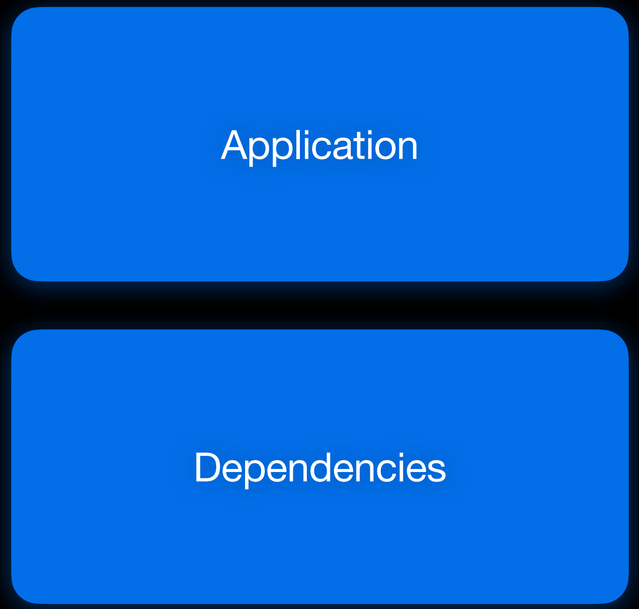
Packaging properties



Packaging properties



Packaging properties



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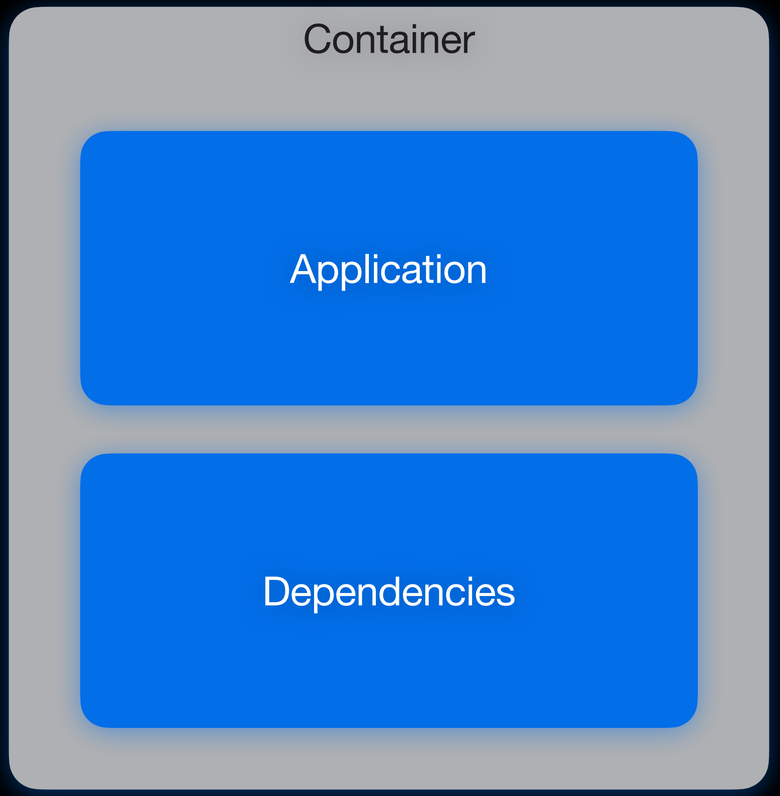

Demonstration

What are containers?

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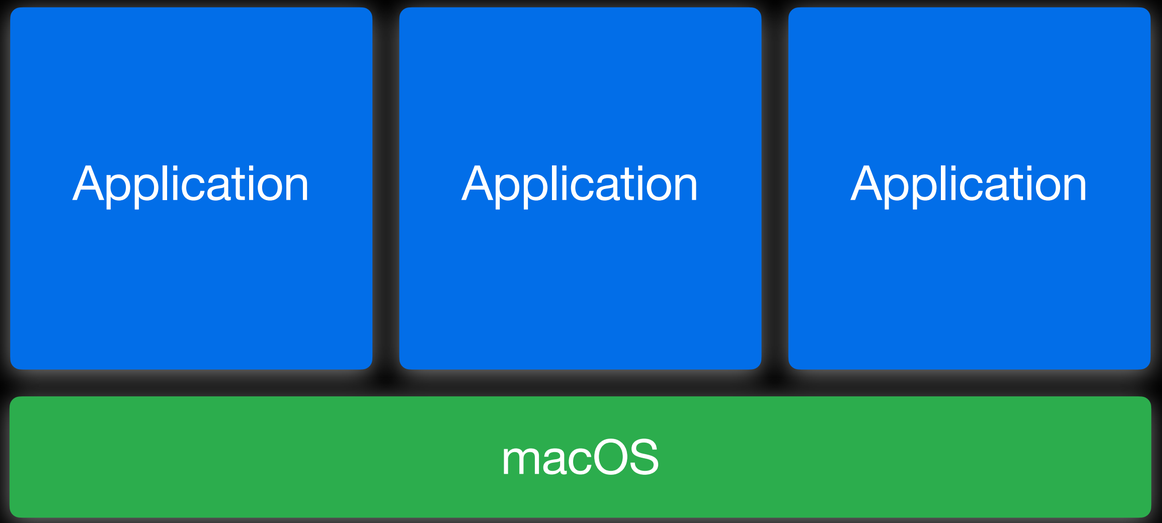
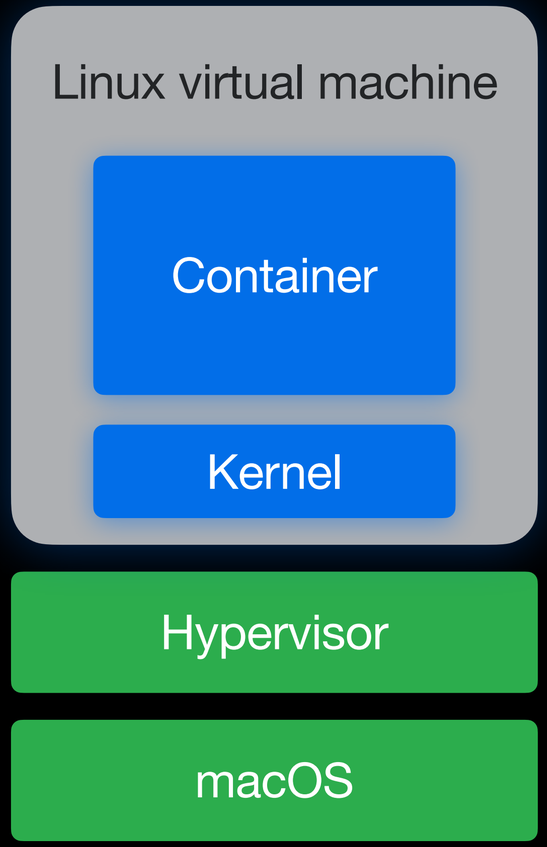


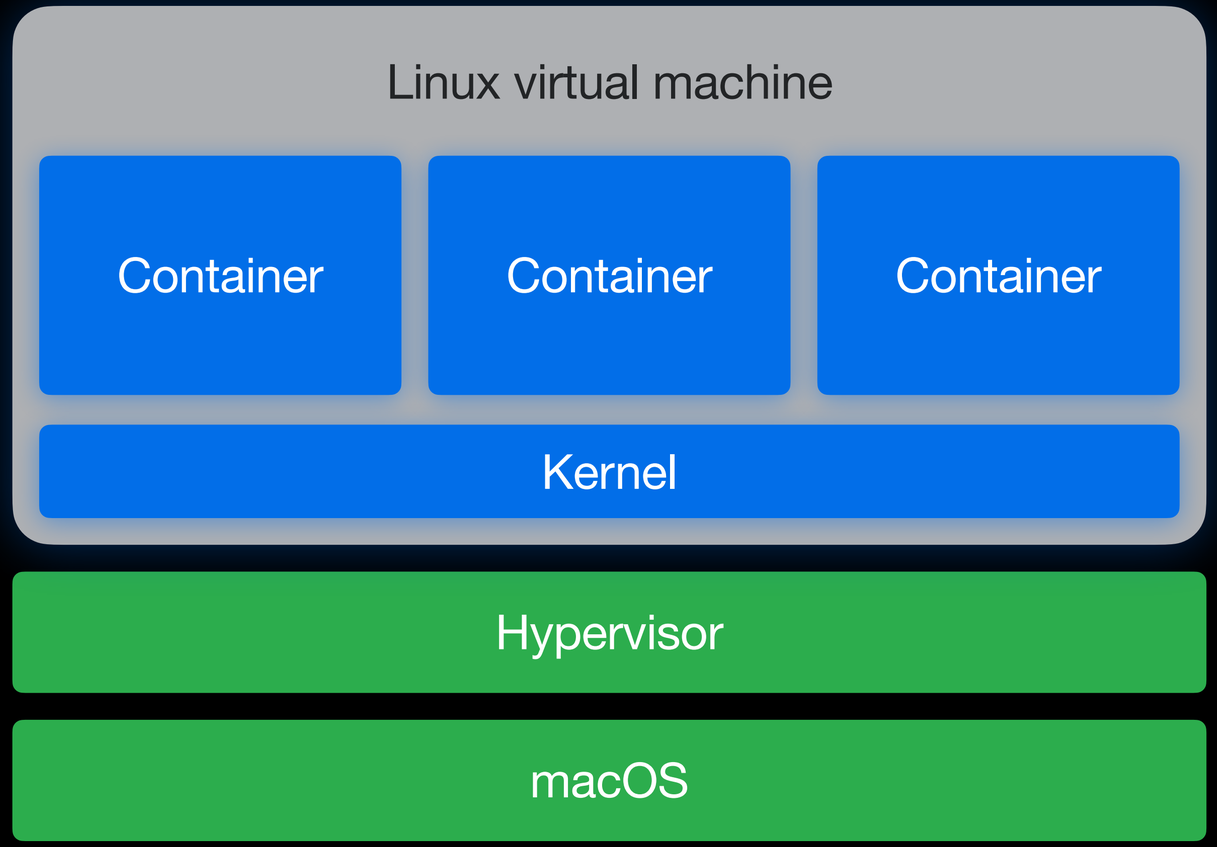
Isolation

- Memory - virtual addressing
- Process visibility - all host processes
- Storage - permissions
- Network - none



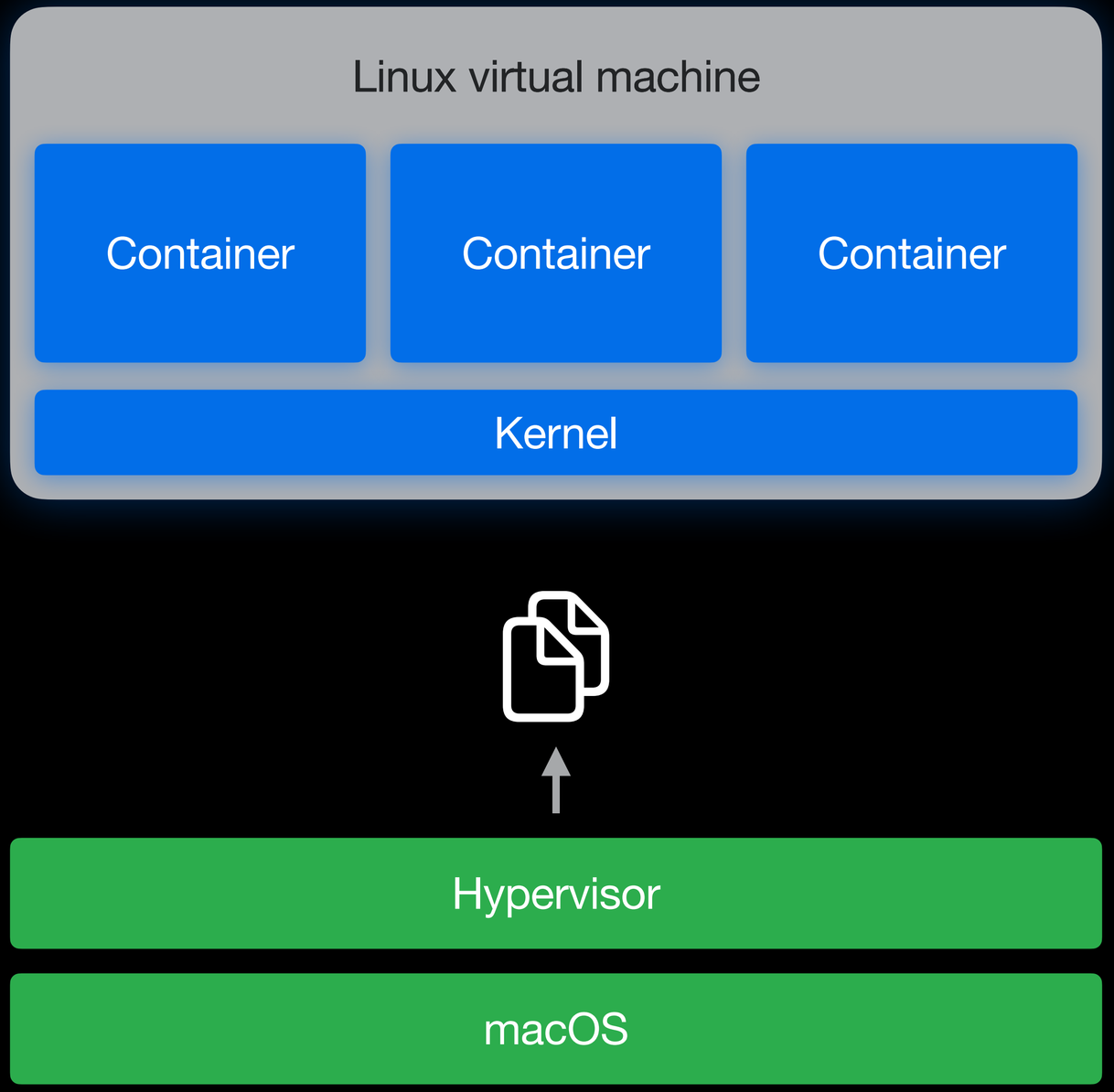
Host Isolation

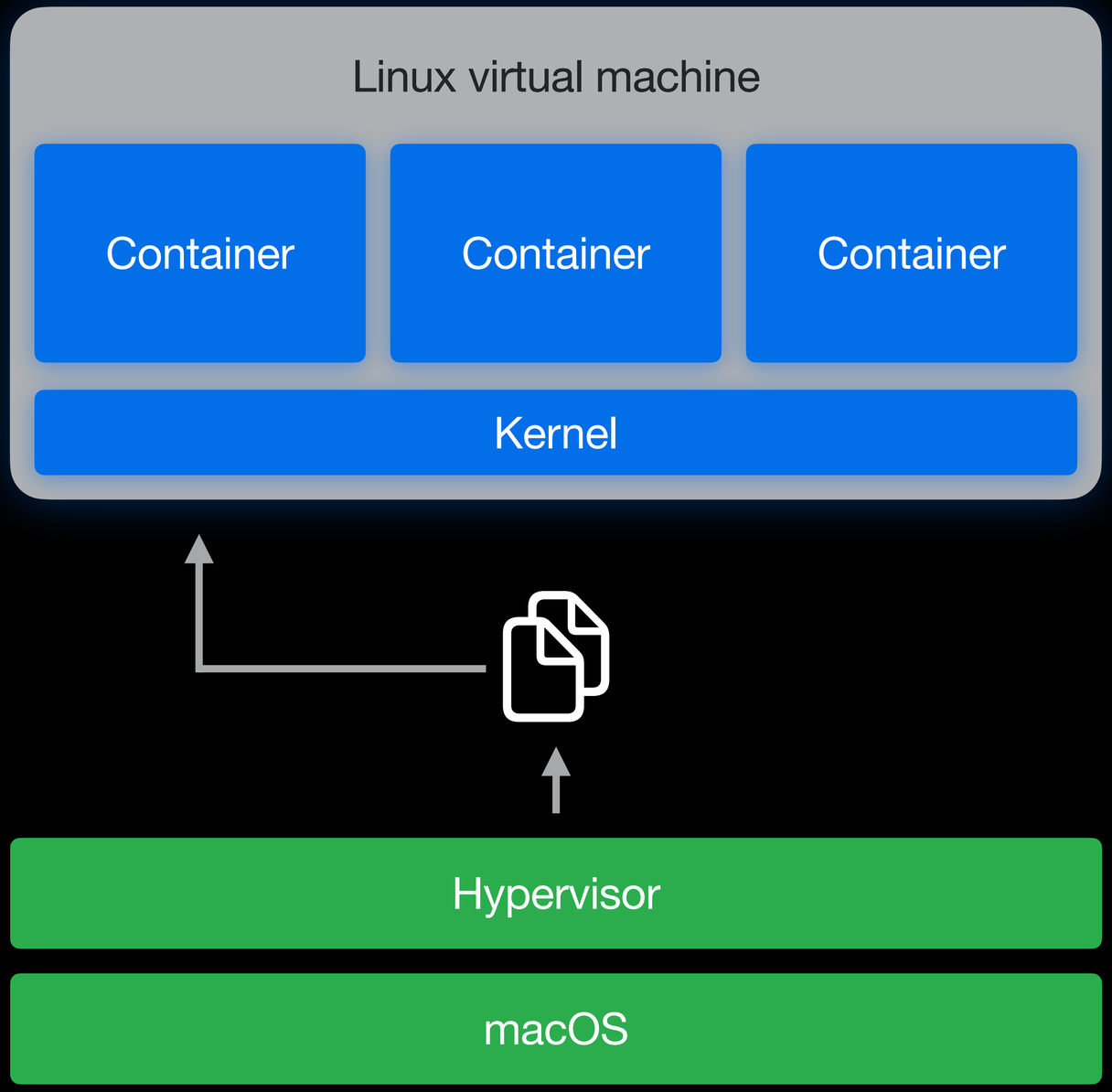
- Memory - nested paging
- Process visibility - none
- Storage - virtual devices
- Network - virtual interfaces
- Resources - VM configuration



Container Isolation

- Memory - virtual addressing
- Process visibility - namespaces
- Storage - namespaces
- Network - namespaces
- Resources - cgroups


Linux virtual machine
Container
Container
Container
Kernel
Hypervisor
macOS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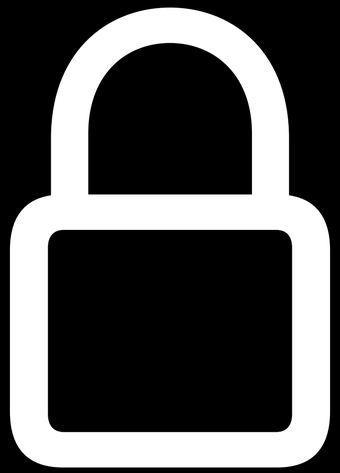
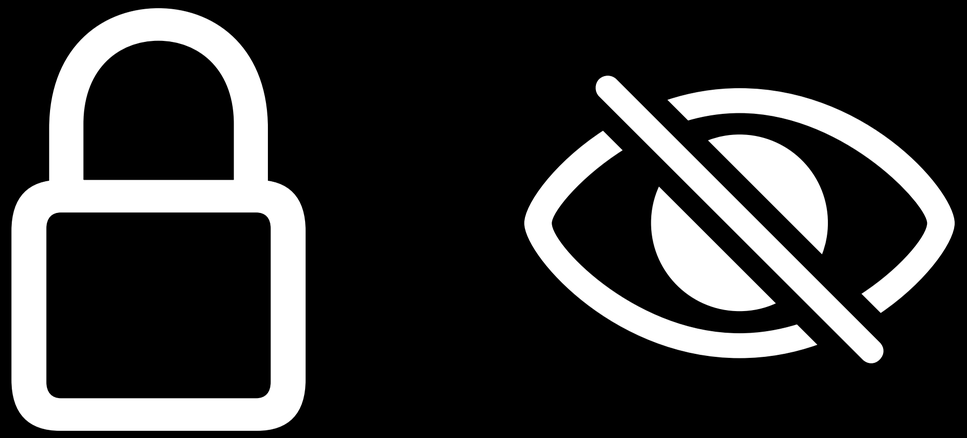
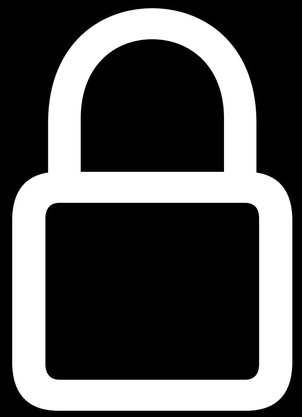


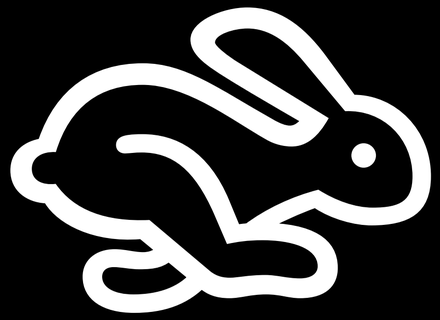


Private

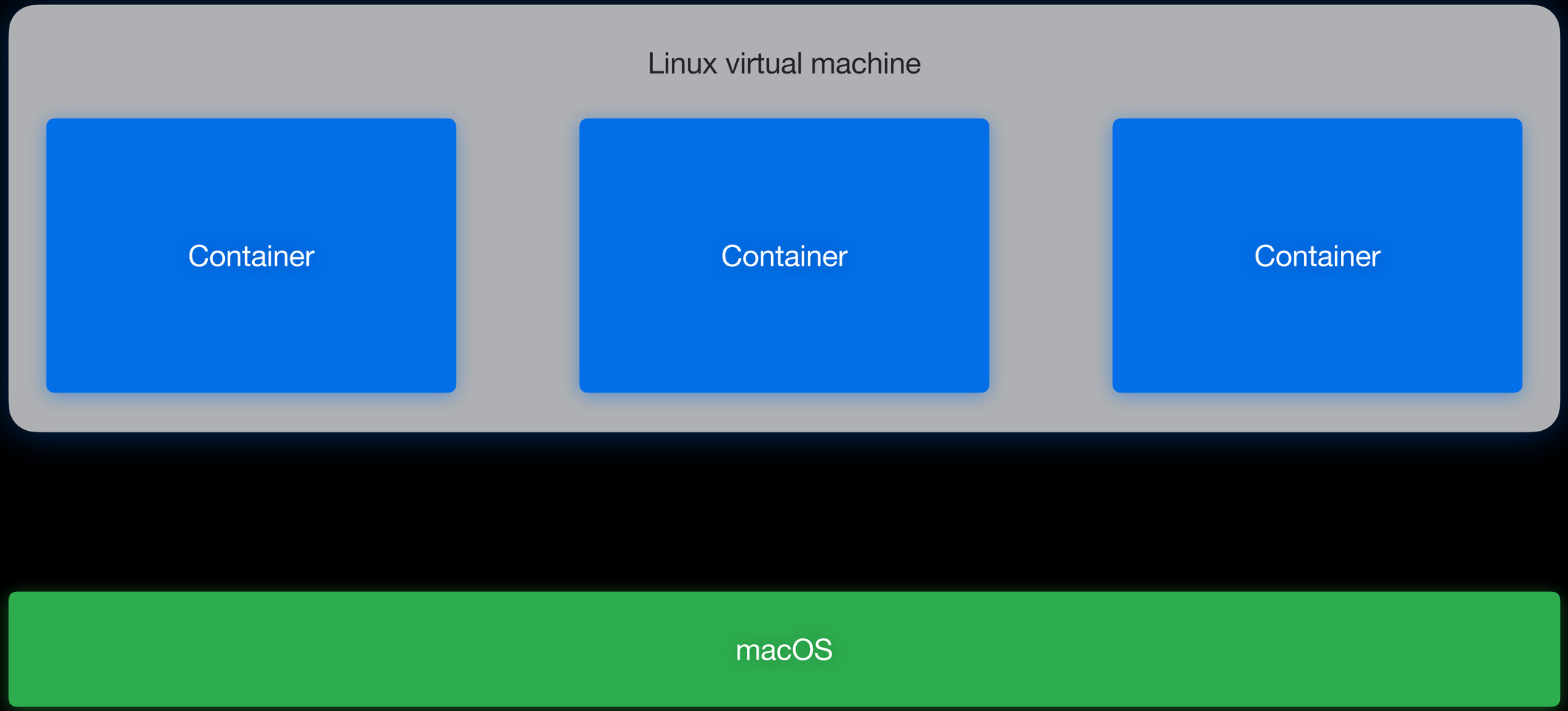


Secure

Private



Performant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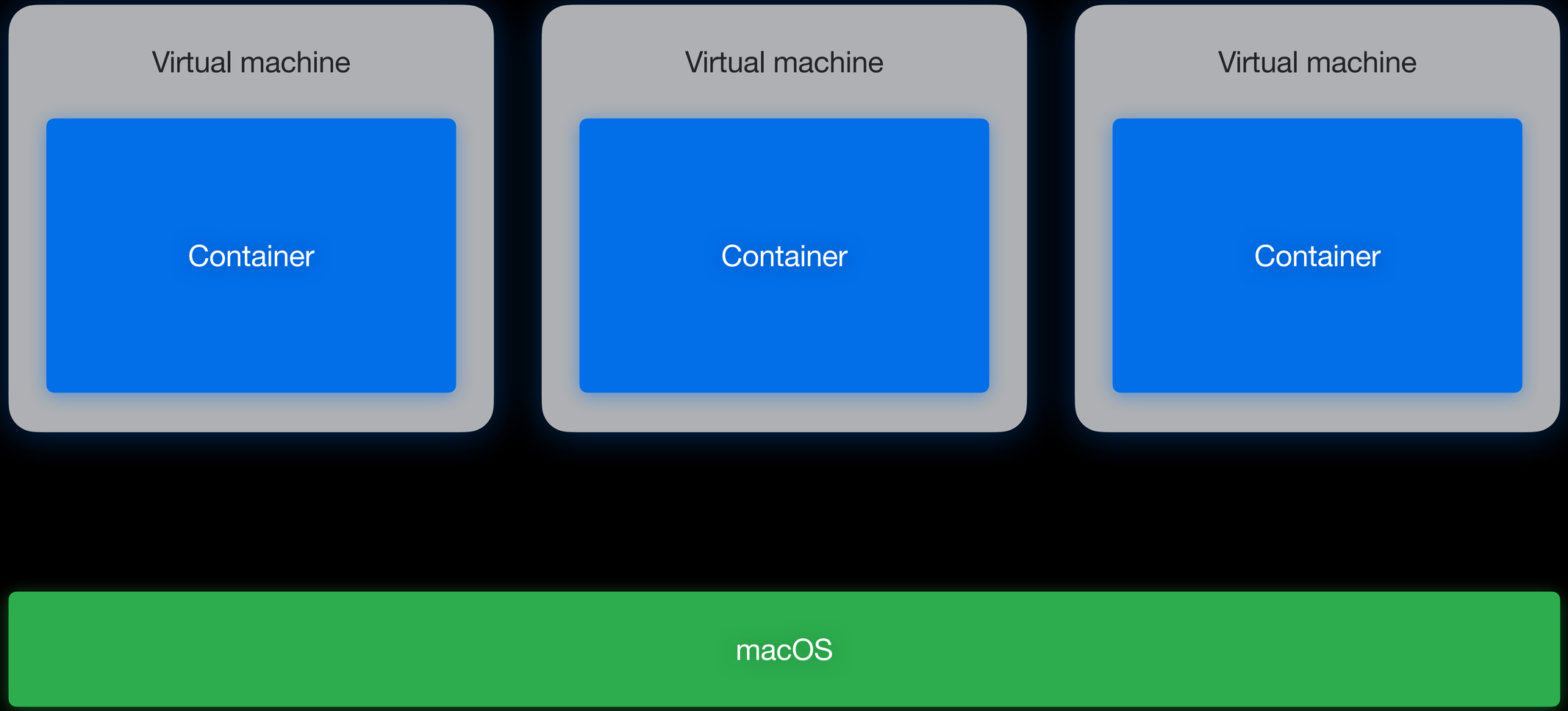
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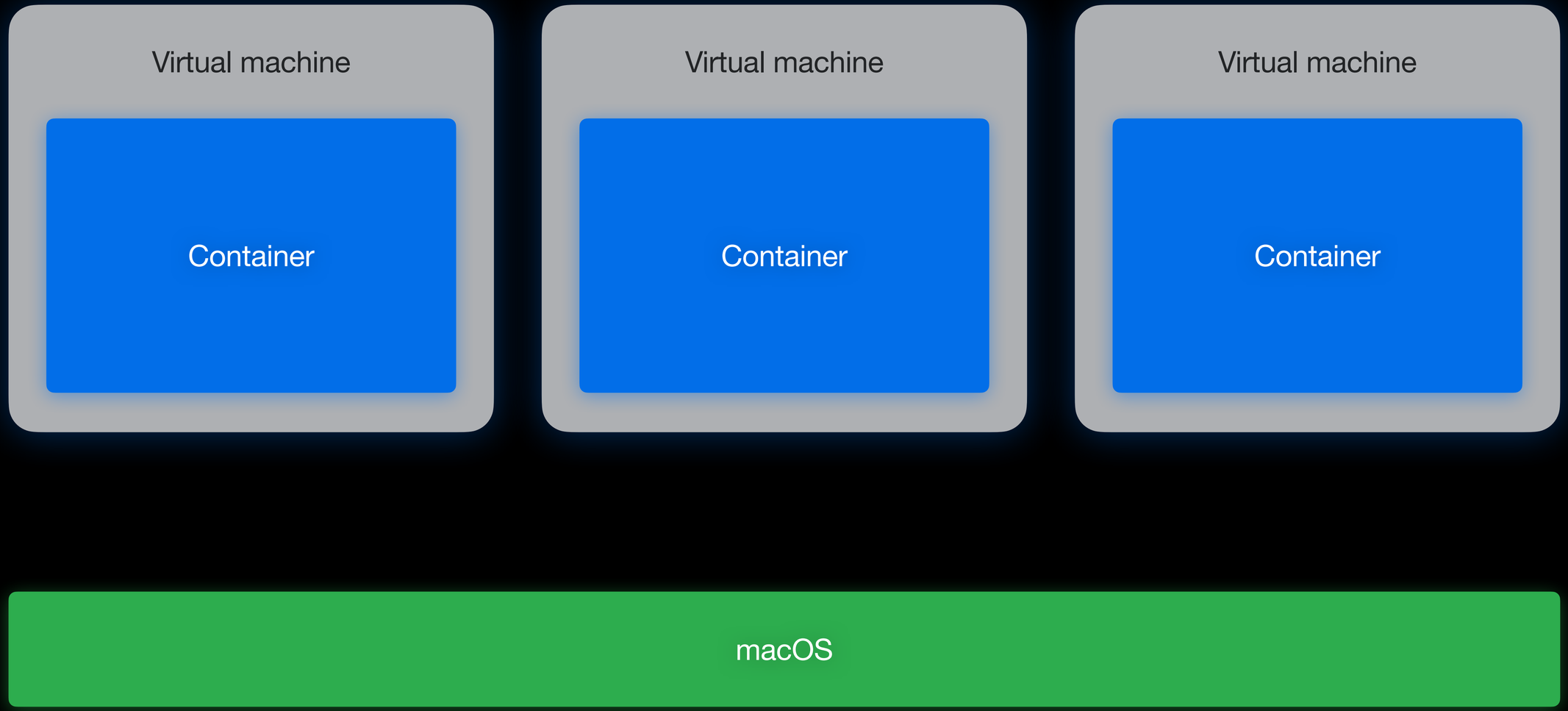
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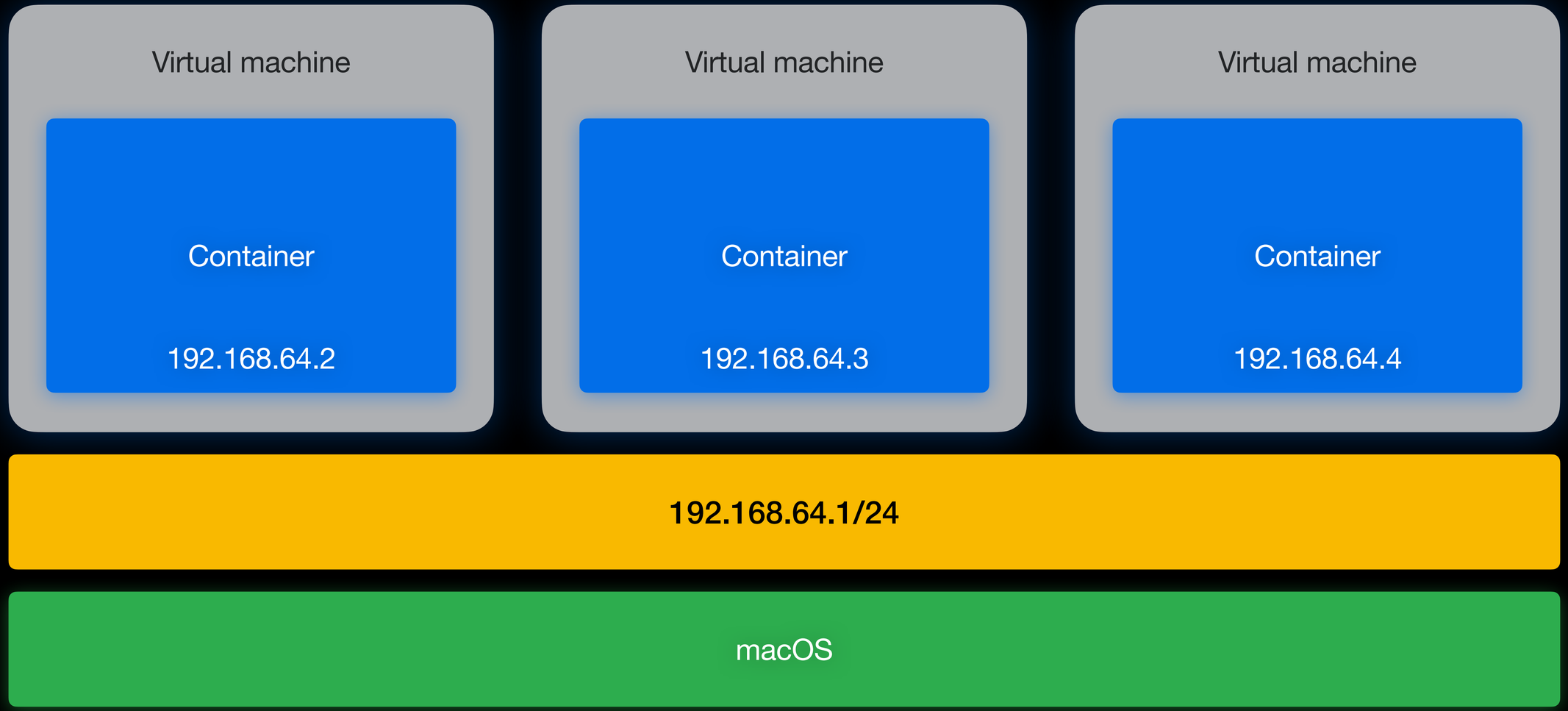
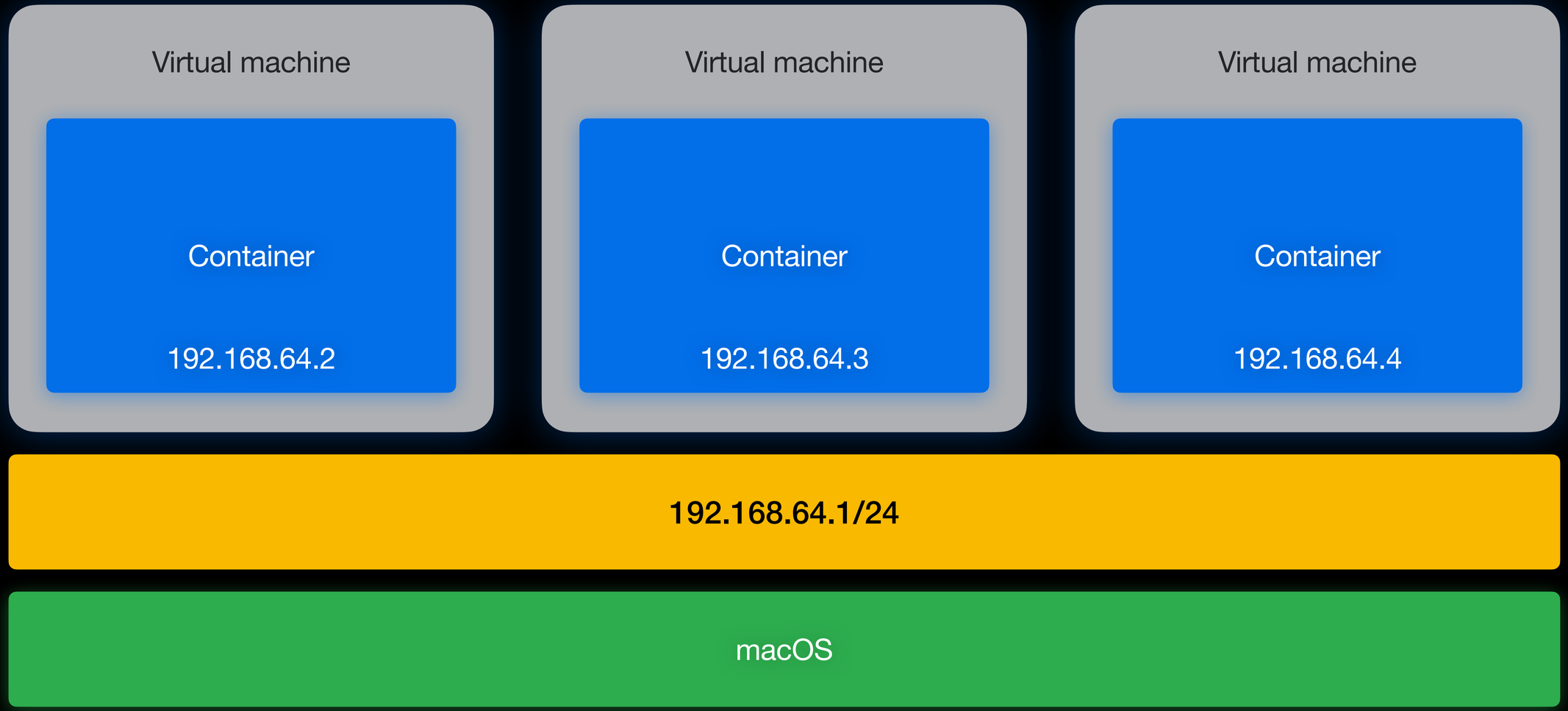

Virtual machine
Container
192.168.64.2
Virtual machine
Container
192.168.64.3
Virtual machine
Container
192.168.64.4
192.168.64.1/24
macOS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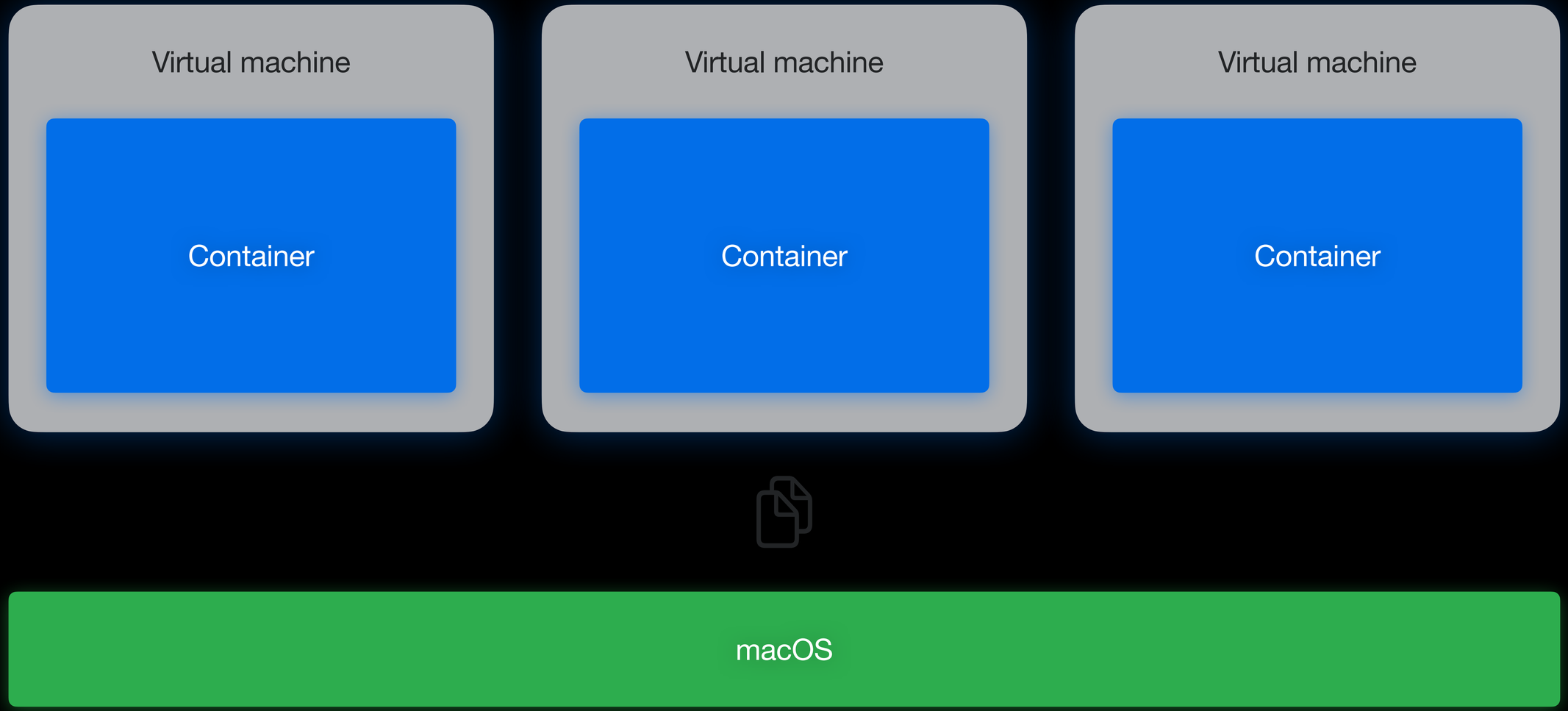
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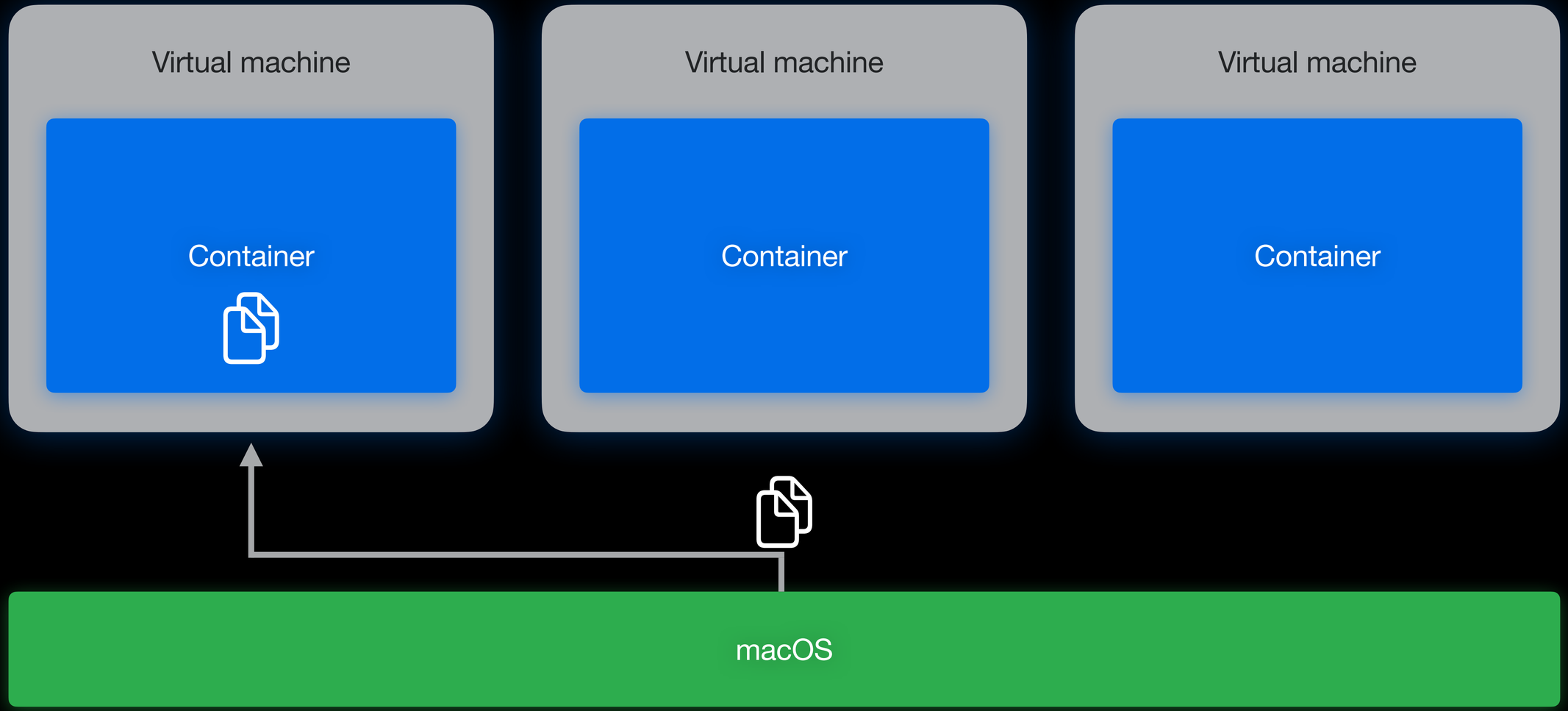
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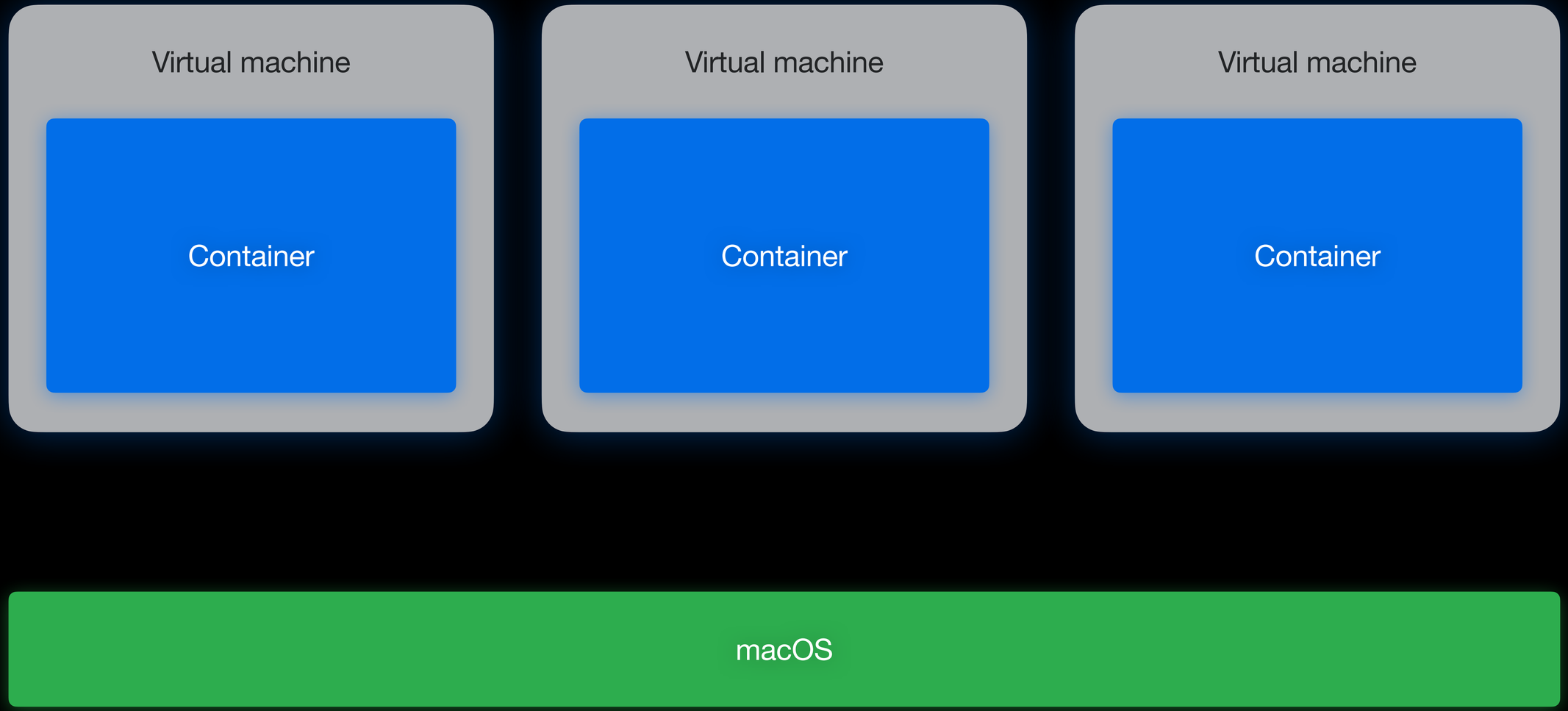
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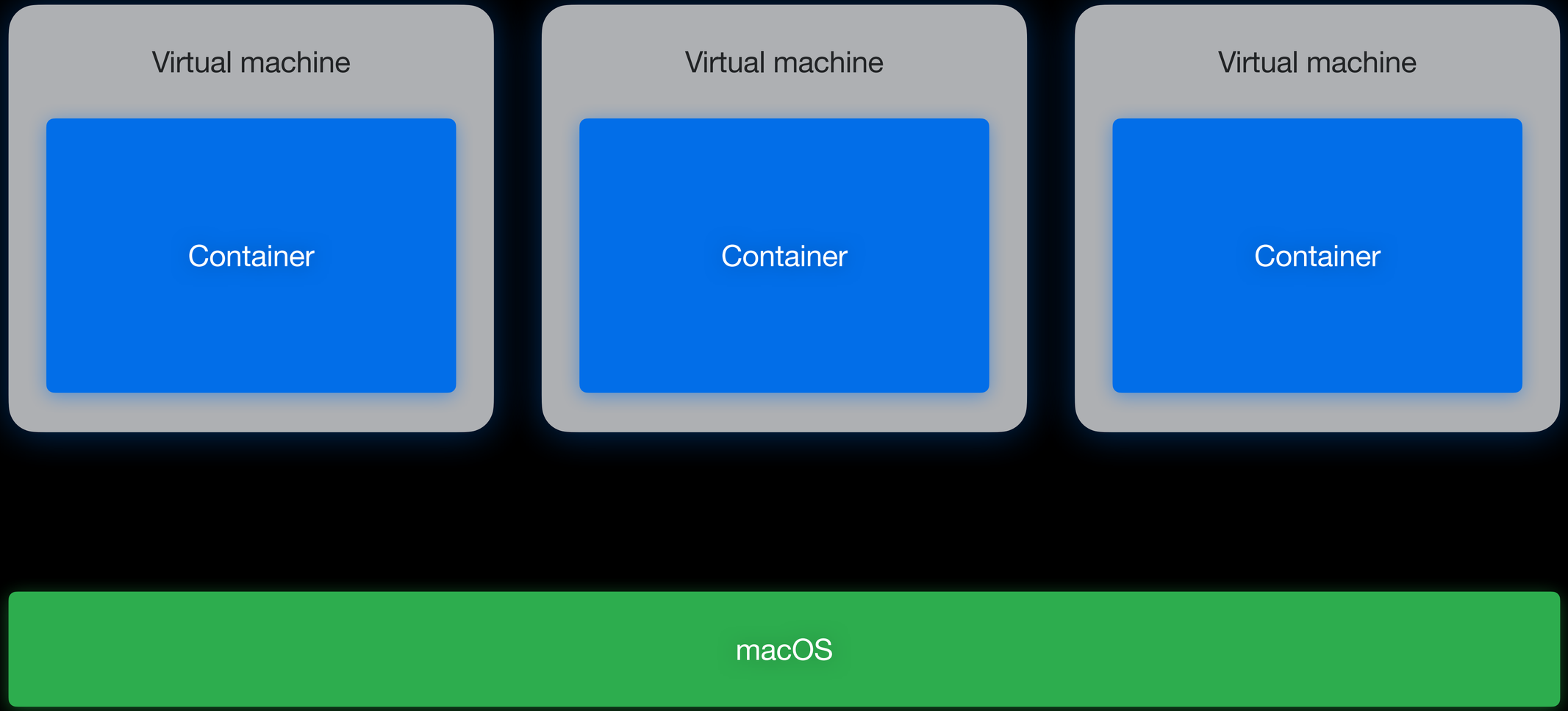
Virtual machine
Container
Virtual machine
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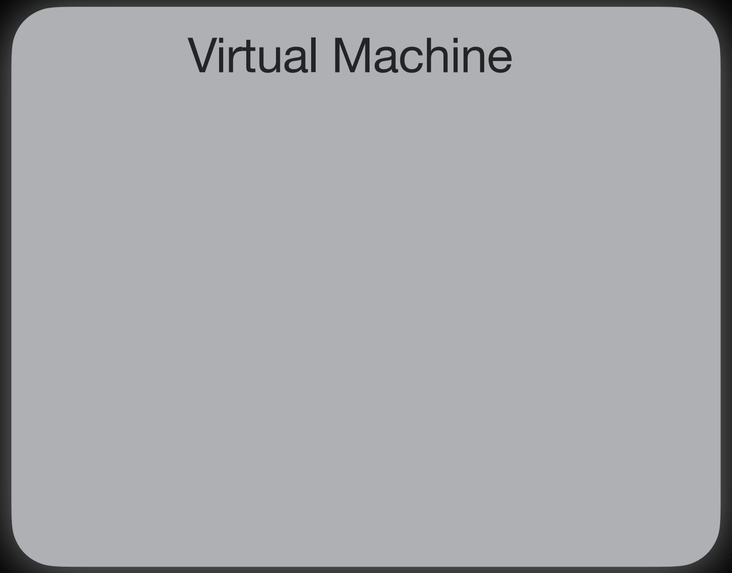
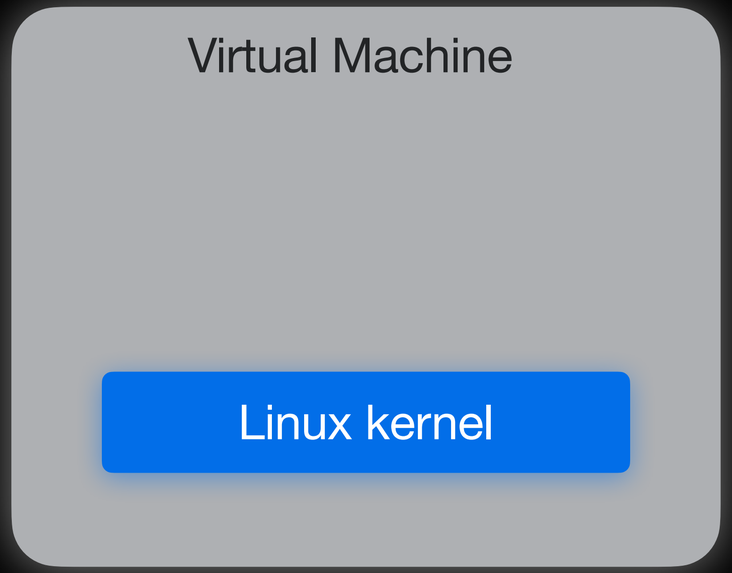
macOS

Lightweight Virtual Machine



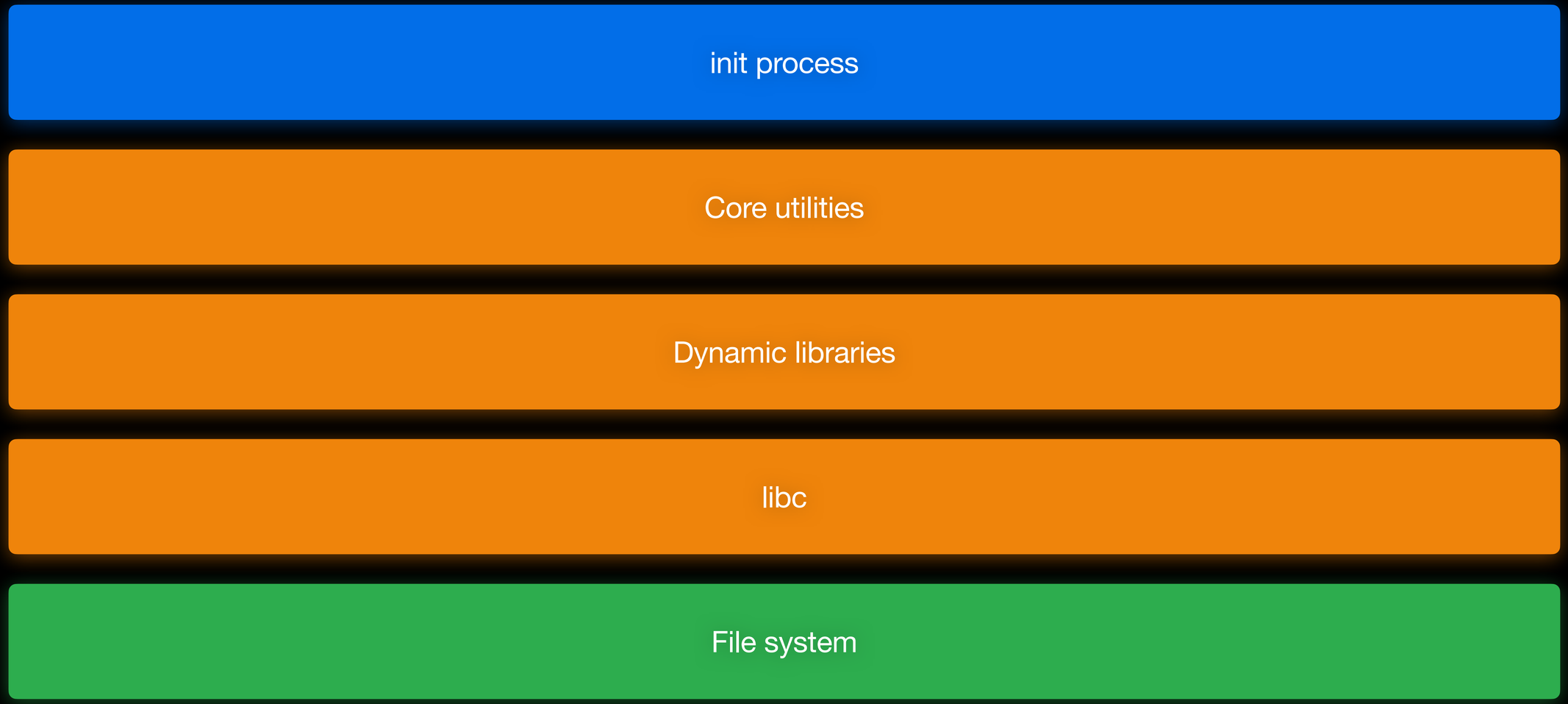
- ✓ minimal devices
- ✓ right sized memory
- ✓ right sized CPU

Lightweight Virtual Machine

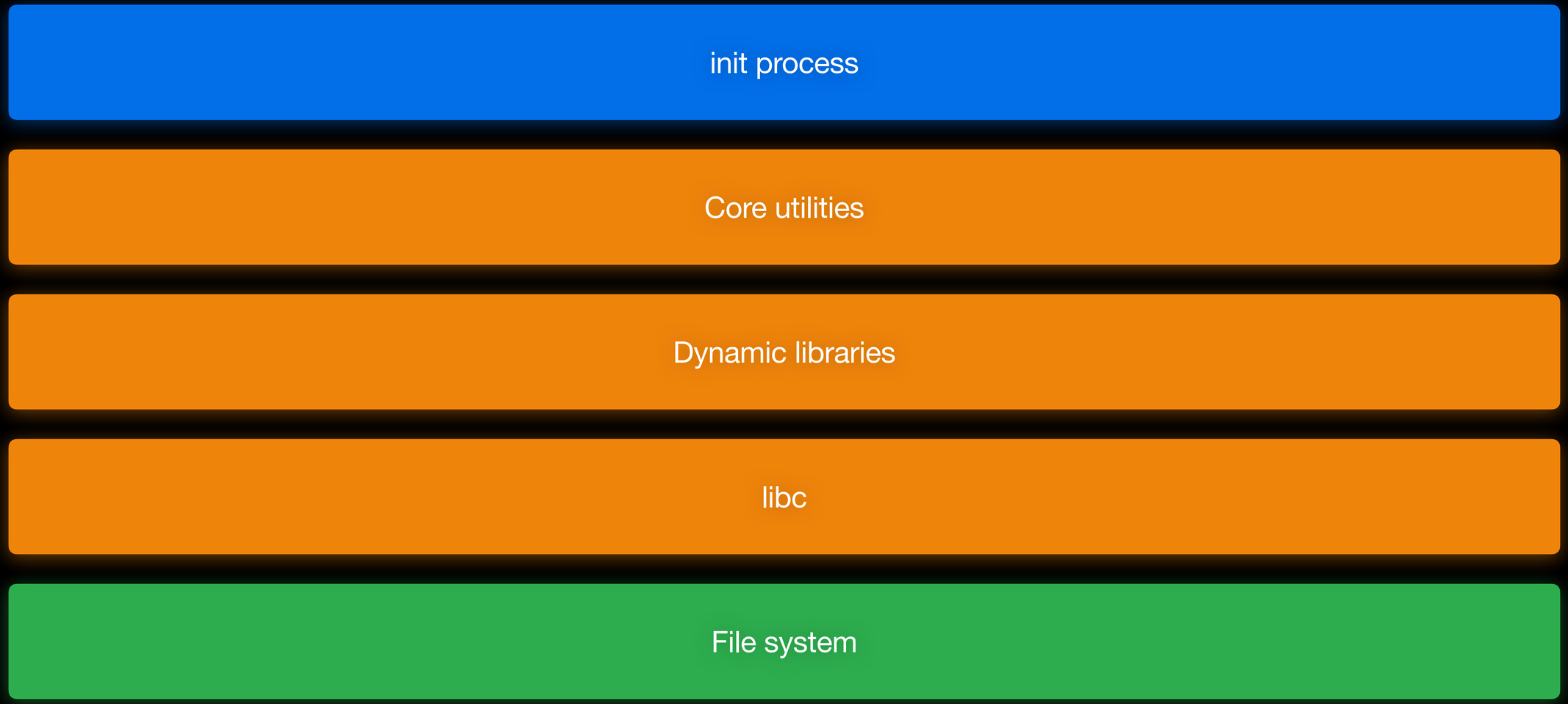


- ✓ direct boot kernel
- ✓ minimal kernel config

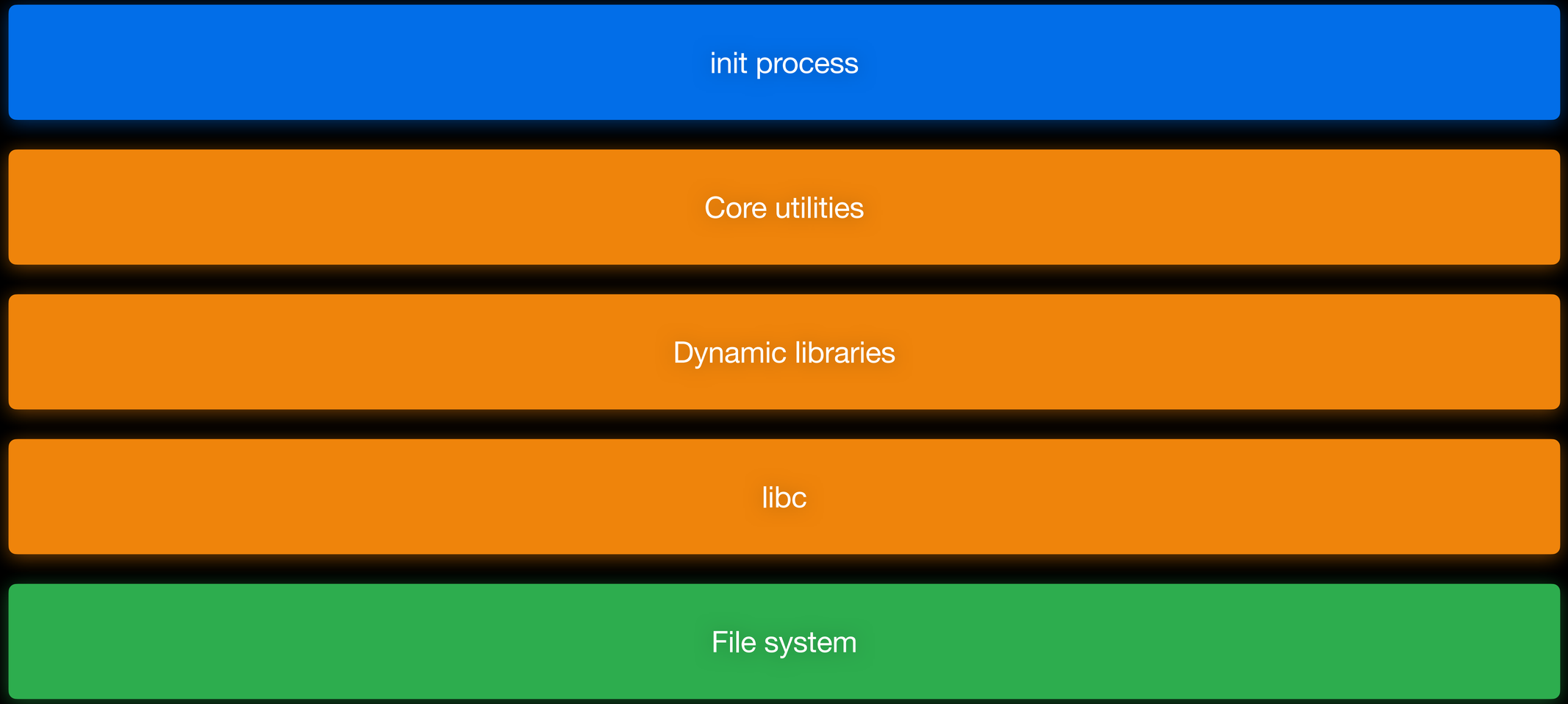
Typical initial filesystem



Typical initial filesystem



Typical initial filesystem



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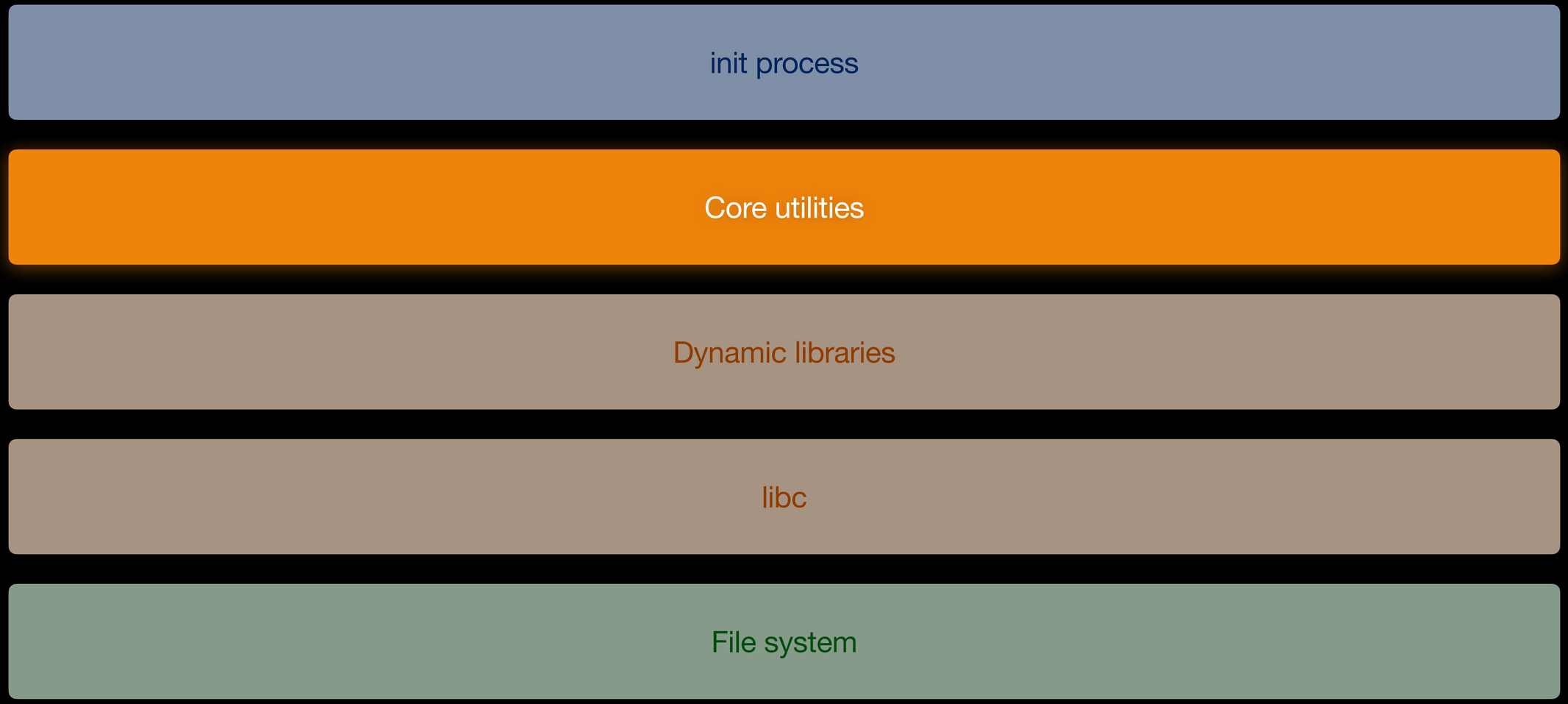

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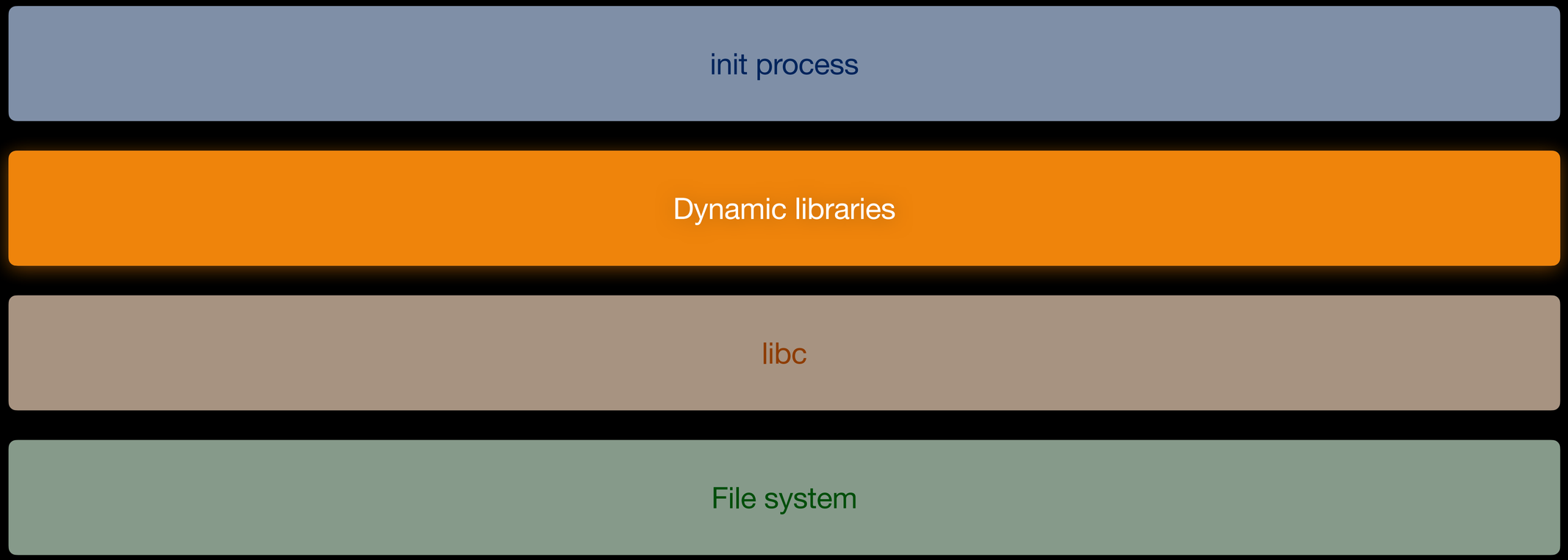

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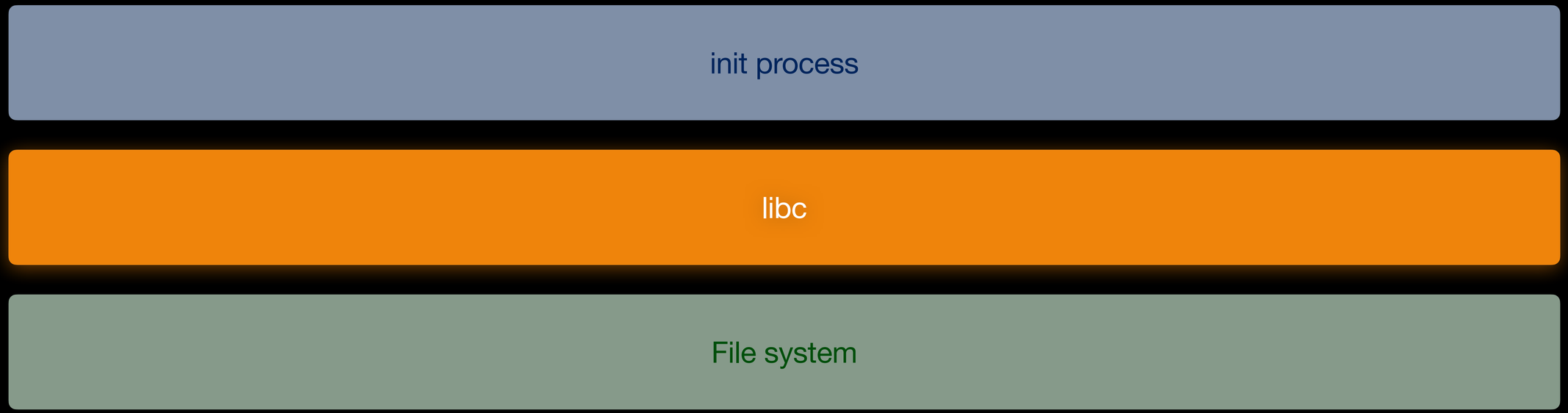
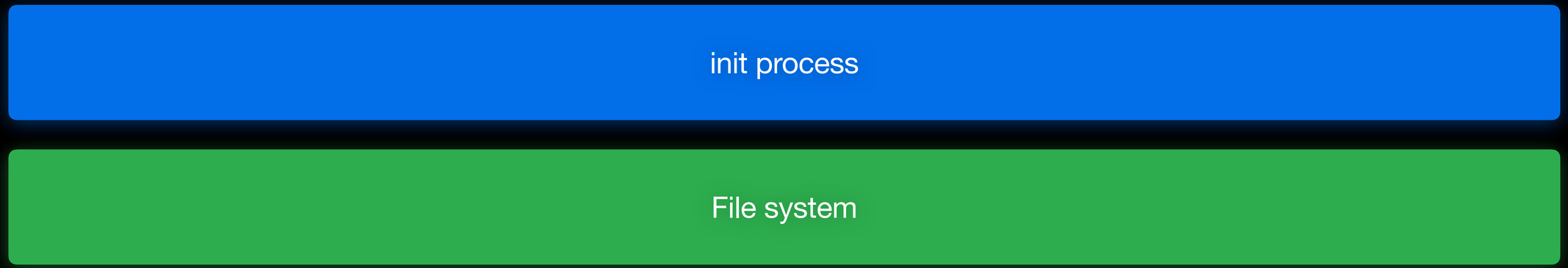
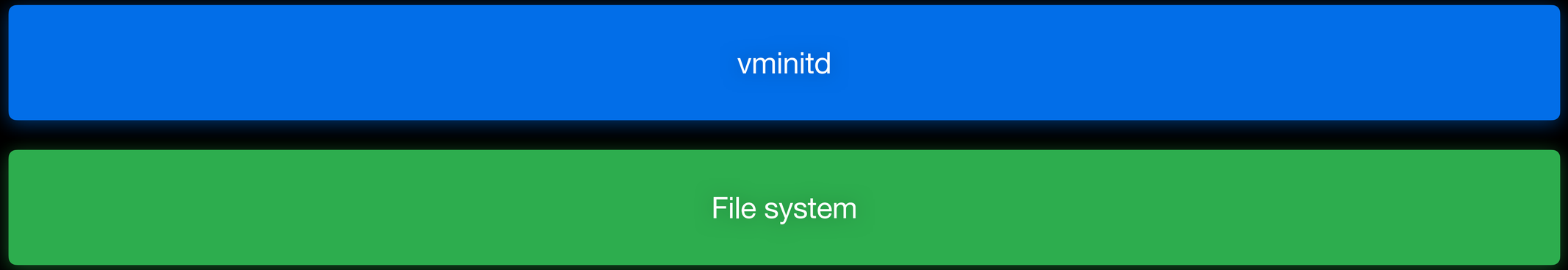


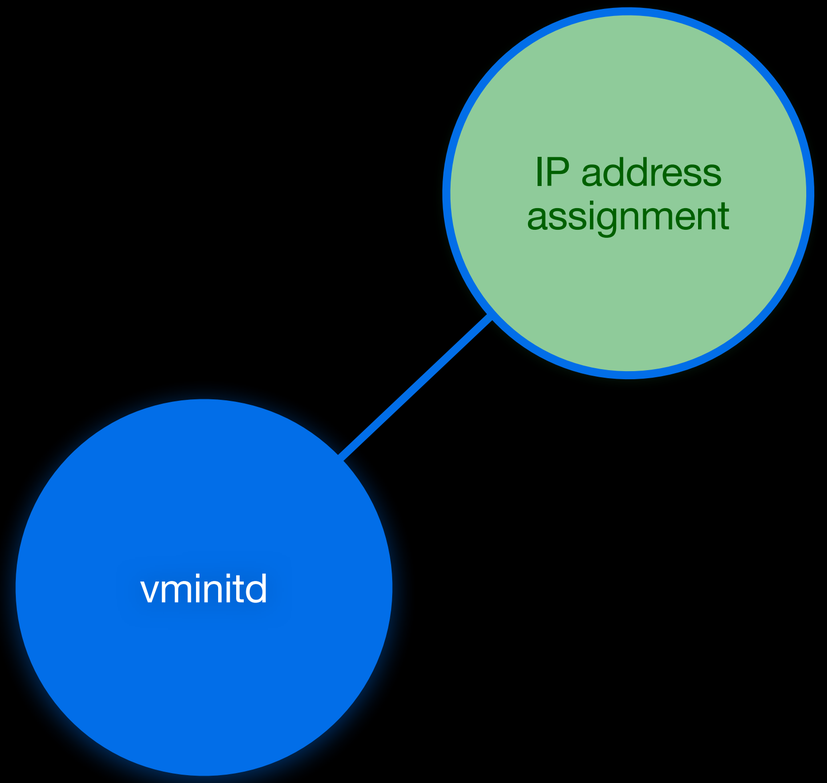
Containerization init filesystem

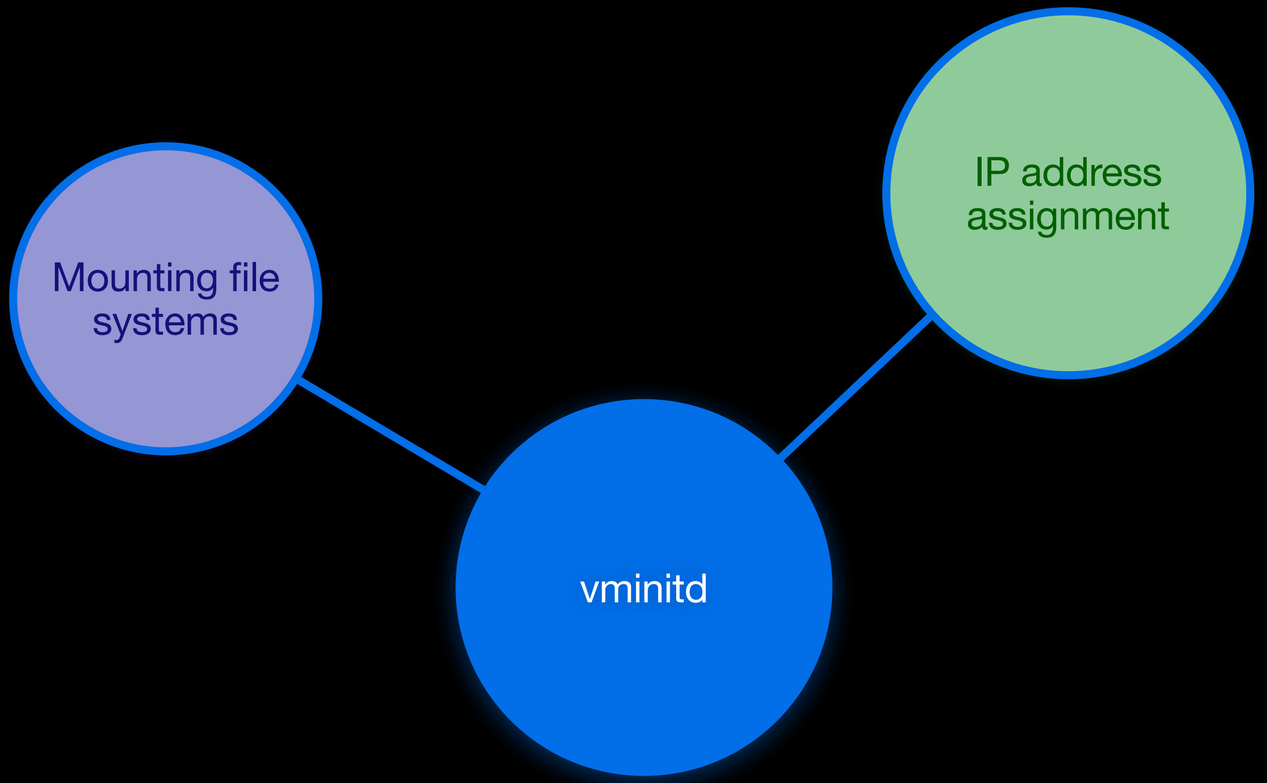


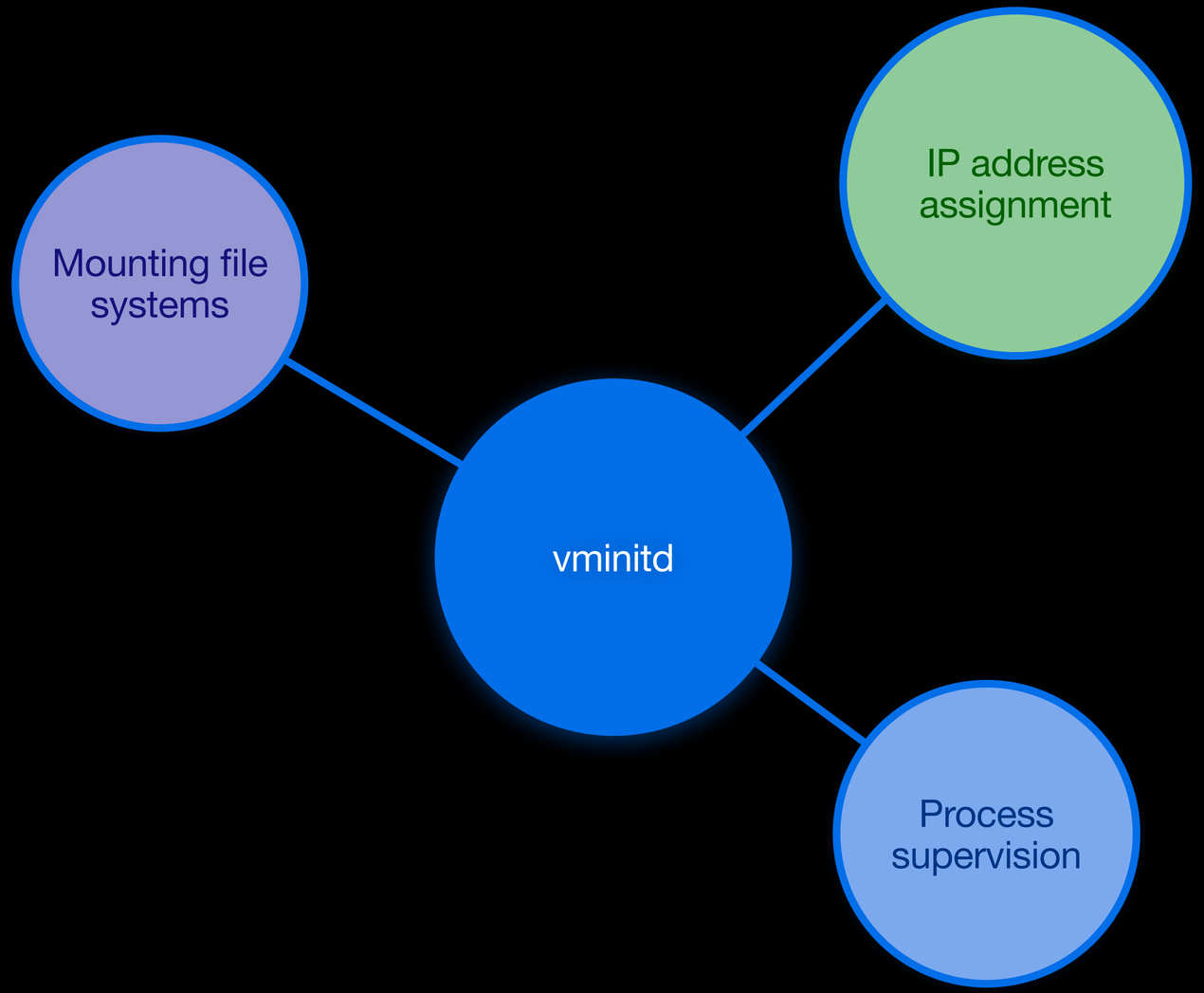
Containerization init filesystem

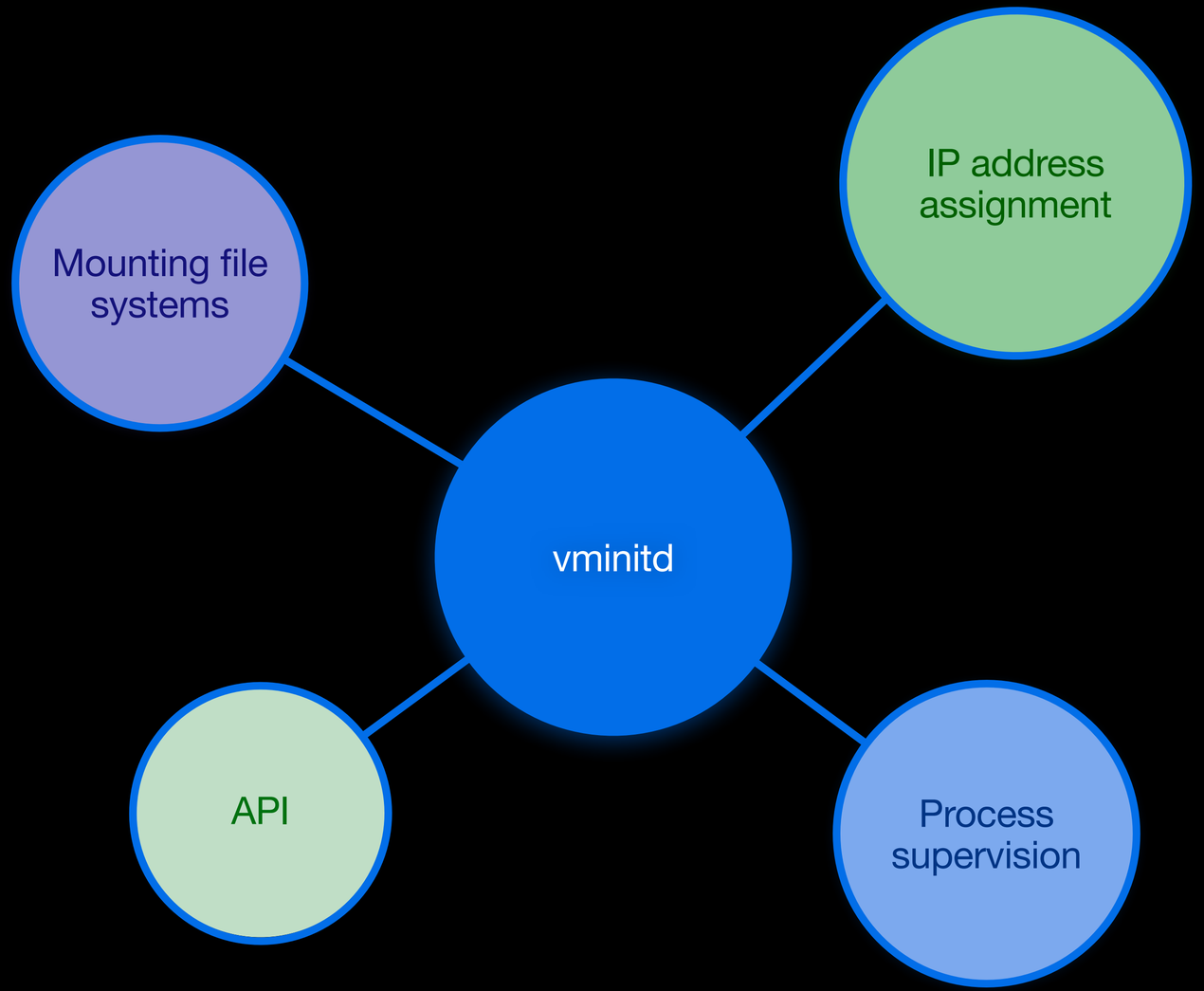



vminitd


IP address
assignment
vminitd


Mounting file systems
IP address assignment
vminitd


Mounting file systems
IP address assignment
vminitd
Process supervision


Mounting file systems
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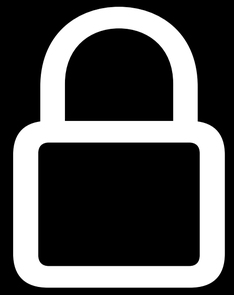
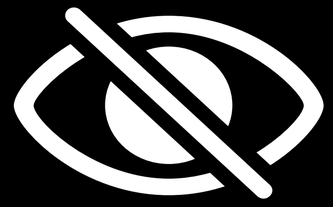
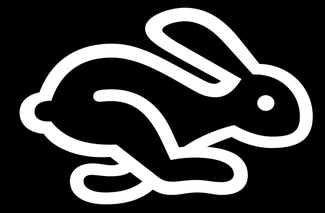
vminitd
API
Process supervision

Minimal kernel	✓		✓
Direct boot			✓
Static init process purpose built for containers	✓		✓
Each workload in its own virtual machine	✓	✓	✓

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Building on Containerization

Adoption of Swift

Open Source Community

Container plugin framework

- Enable developers to extend functionality without modifying core code.
- Types of plugins:
  - CLI plugins: extend command line with new subcommands
  - Daemon plugins: background services

- Plugins used for key system components today:

```
container-runtime-linux | container-core-images | container-network-vmnet
```

Developing your own plugin

Automatic plugin discovery

Simple structure:

```
plugin-name/
|- bin/plugin-name
|- config.json

cat config.json
{
  “abstract”: “Your CLI plugin description”
  “version”: “1.0”,
  “author”: “your name”
}
```

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Containerization: building blocks for containers

- Key packages:

```
|- Containerization
|- ContainerizationOS
|- ContainerizationNetlink
|- ContainerizationOCI
|- ContainerizationEXT4
|- ContainerizationIO
```

Protocol-based
Layered Architecture

Containerization: layered architecture

High-Level

Low-Level

Container Orchestration
ContainerManager | LinuxContainer | LinuxPod | ImageStore

Process + VM Control
LinuxProcess | VirtualMachineInstance | Vminitd | SocketRelay

Primitives
Configuration: Mount, Interface, DNS, RLimit
Storage: Image, Unpacker, EXT4
OS Utilities: Command, Terminal, Networking

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Using Swift

- C Interoperability

Using Swift

- C Interoperability
- Enums/tagged unions and optionals

Using Swift

- C Interoperability
- Enums/tagged unions and optionals
- Memory safety

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- Static Linux SDK

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- C Interoperability
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- Static Linux SDK
- Native integration with frameworks like Virtualization

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Project goals

Project goals

- Grow the contributor community
  - Give us feedback!
  - Search the issues and PRs
  - File an issue before coding, describe your work
  - Review and understand what your AI wrote
  - Include clear reproduction steps for bug reports
  - Discussion topics for questions and design work

Project goals

- Encourage new projects built on top of Containerization

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- Encourage new projects built on top of Containerization
- Grow the container ecosystem through plugins

Areas of Investigation

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- Distro plugin for non-ephemeral Linux development environments

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- Distro plugin for non-ephemeral Linux development environments
- Kubernetes development environment using Containerization

Areas of Investigation

- Distro plugin for non-ephemeral Linux development environments
- Kubernetes development environment using Containerization
- Improving container image build performance by creating a Swift native builder

Areas of Investigation

- Distro plugin for non-ephemeral Linux development environments
- Kubernetes development environment using Containerization
- Improving container image build performance by creating a Swift native builder
- Ecosystem integration (orchestrators, dev containers)

Next Steps

- Try the tool
- Build something on top of Containerization, or extend container
- Join the community

github.com/apple/containerization

github.com/apple/container