



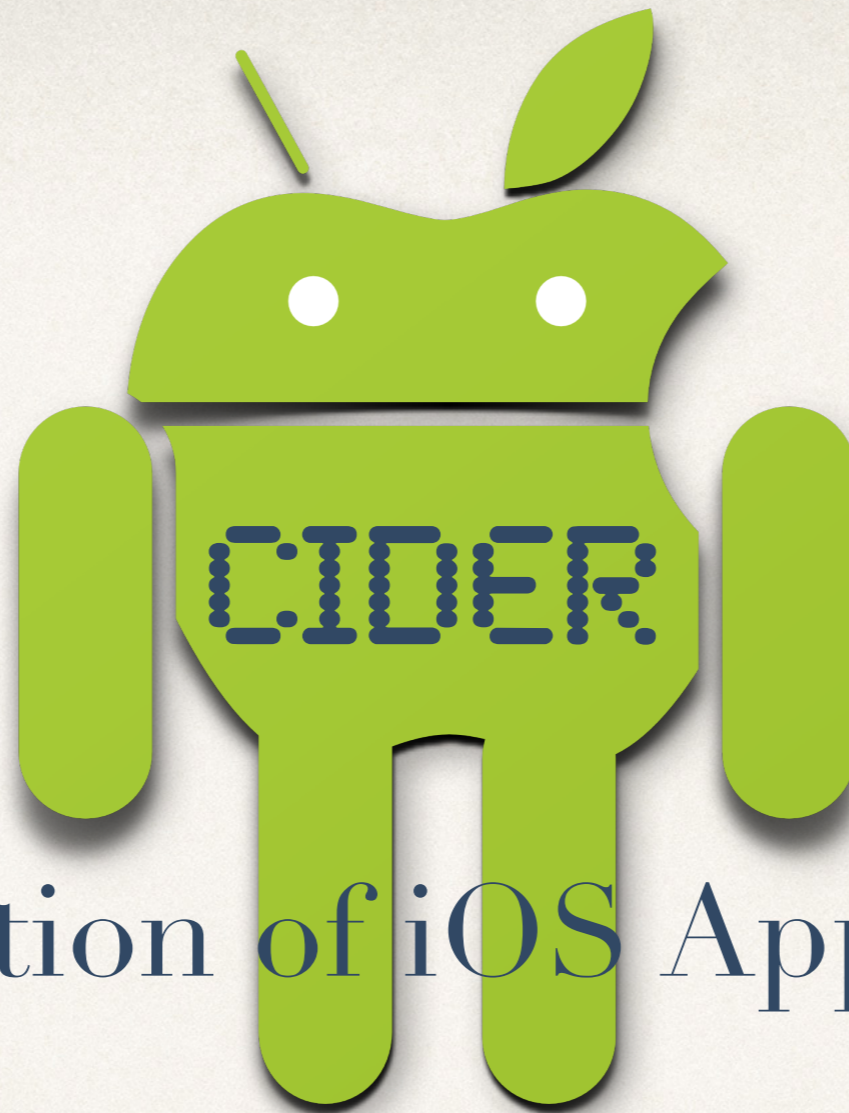
Native Execution of iOS Apps on Android

Jeremy Andrus (jeremya@cs.columbia.edu)

Alexander Van't Hof, Naser AlDuaij, Christoffer Dall, Nicolas Viennot, Jason Nieh

COLUMBIA UNIVERSITY

IN THE CITY OF NEW YORK



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The Goal



Virtualization

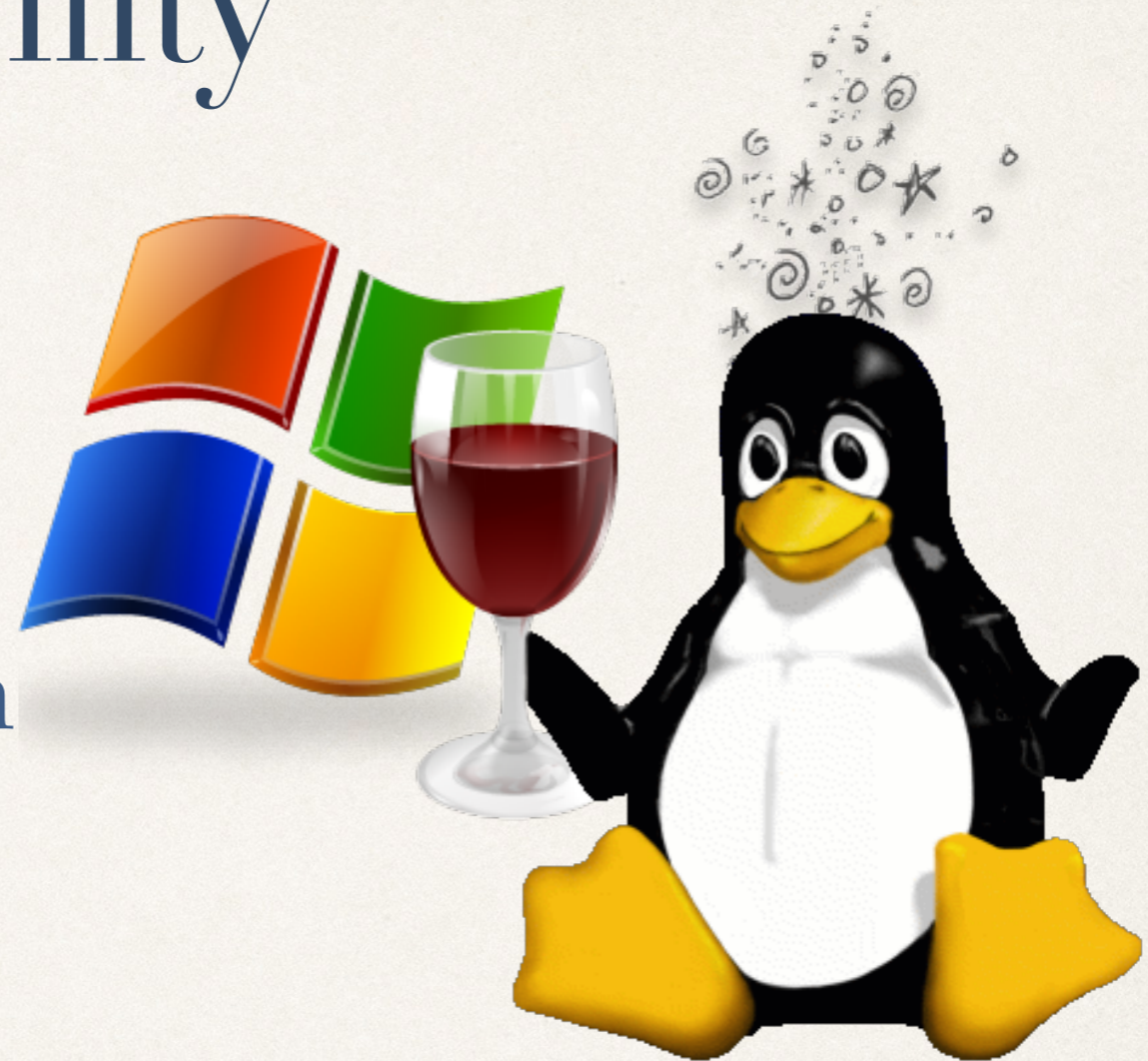


Binary Compatibility

Binary Compatibility

WINE

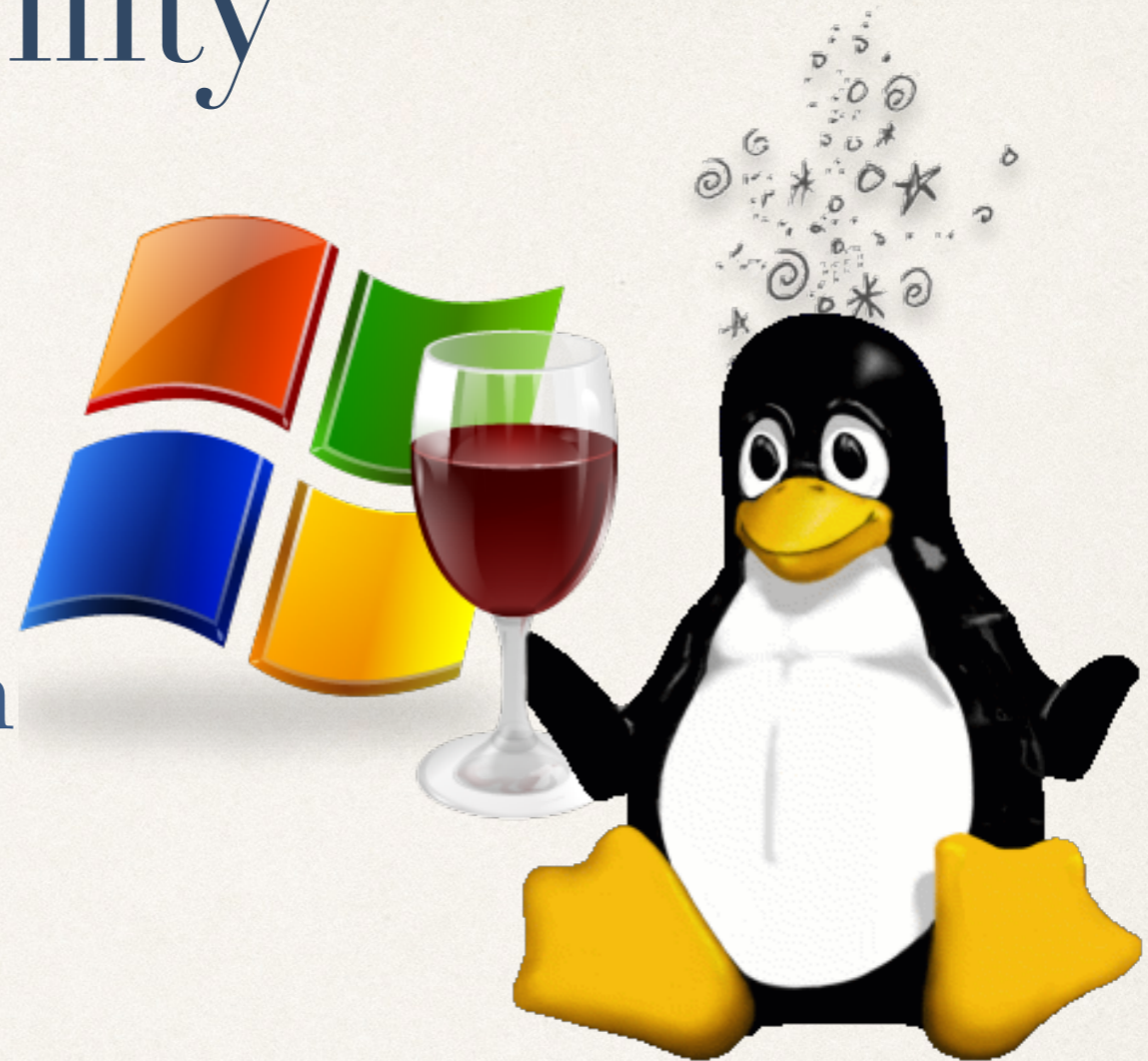
API Reimplementation



Binary Compatibility

WINE

API Reimplementation



- ❖ **immense implementation**
- ❖ **20 years later: still incomplete**

Binary Compatibility

Binary Compatibility

Kernel ABI Compatibility

Binary Compatibility



Kernel ABI Compatibility

BSD LINUX COMPATIBILITY

Binary Compatibility



Kernel ABI Compatibility

BSD LINUX COMPATIBILITY

- ❖ **missing kernel subsystem**
- ❖ **opaque driver interfaces**

Binary Compatibility



Kernel ABI Compatibility

BSD LINUX COMPATIBILITY

- ❖ **missing kernel subsystem**
- ❖ **opaque driver interfaces**

Cider

Cider : OS Compatibility

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- ❖ Direct execution of unmodified iOS apps

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- ❖ Direct execution of unmodified iOS apps
- ❖ Reuse existing libraries

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- ❖ Direct execution of unmodified iOS apps
- ❖ Reuse existing libraries
- ❖ Reuse existing open source kernel code

Cider : OS Compatibility

- ❖ Direct execution of unmodified iOS apps
- ❖ Reuse existing libraries
- ❖ Reuse existing open source kernel code
- ❖ iOS apps can use Android libraries

Cider : OS Compatibility

Cider : OS Compatibility

- ❖ Personas

- distinguish iOS and Linux threads

Cider : OS Compatibility

- ❖ Personas
 - ➔ distinguish iOS and Linux threads
- ❖ Duct Tape
 - ➔ XNU code in the Linux kernel

Cider : OS Compatibility

- ❖ Personas
 - distinguish iOS and Linux threads
- ❖ Duct Tape
 - XNU code in the Linux kernel
- ❖ Diplomats
 - iOS apps use Android libraries

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Cider : OS Compatibility

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Linux syscall
Interface

Cider Linux Kernel

Cider : OS Compatibility



Linux syscall
Interface

Cider Linux Kernel

Mach-O
Loader

Cider : OS Compatibility



XNU syscall
Interface

Linux syscall
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Per-Thread Personas



XNU syscall
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Linux syscall
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XNU syscall
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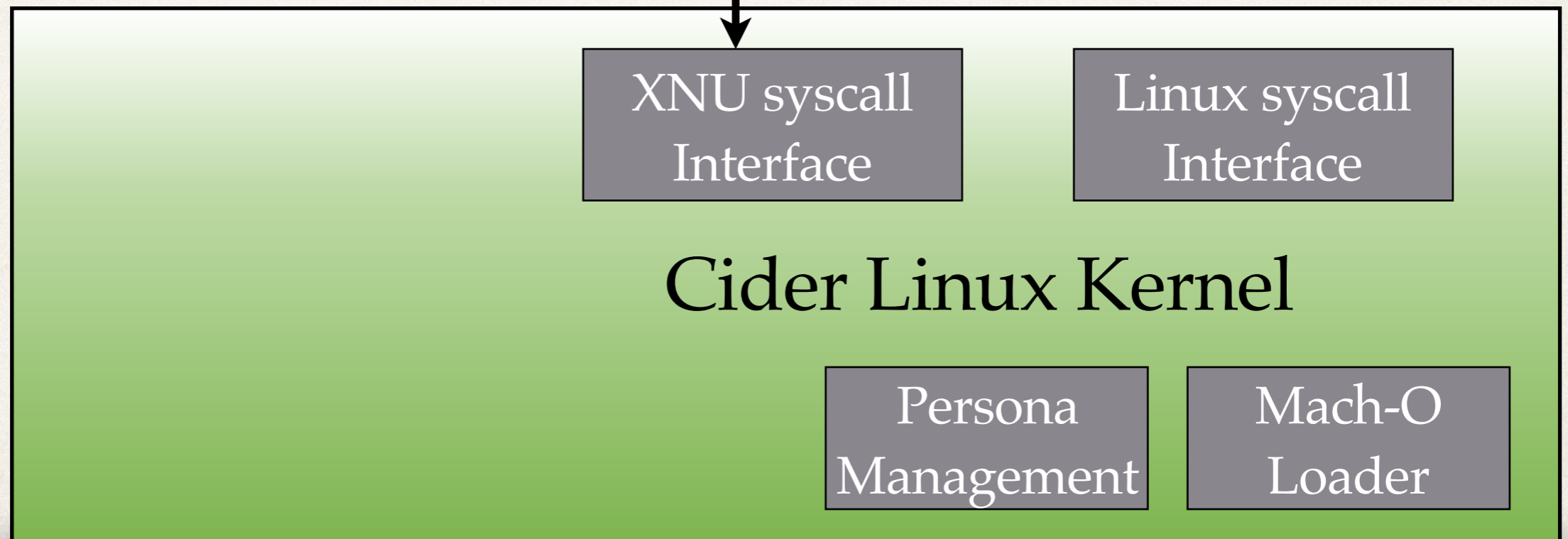
Linux syscall
Interface

Cider Linux Kernel

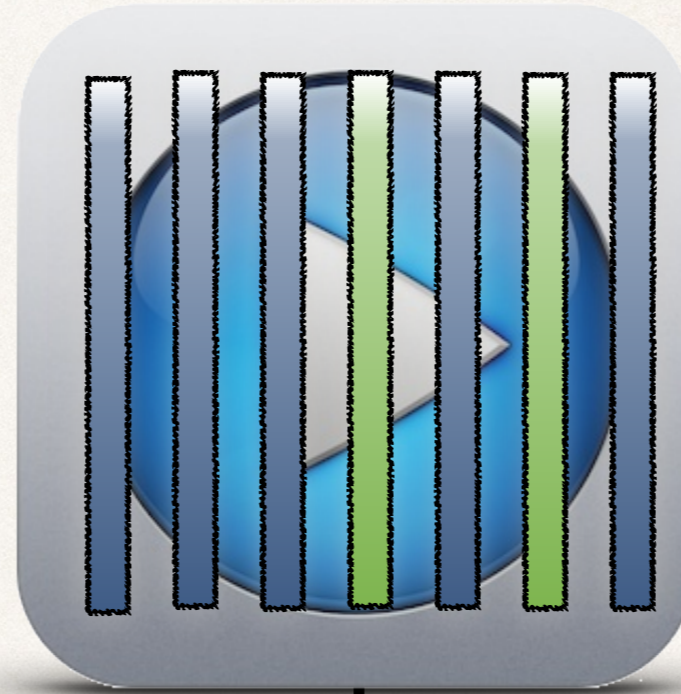
Persona
Management

Mach-O
Loader

Per-Thread Personas



Per-Thread Personas



XNU syscall
Interface

Linux syscall
Interface

Cider Linux Kernel

Persona
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Per-Thread Personas



XNU syscall
Interface

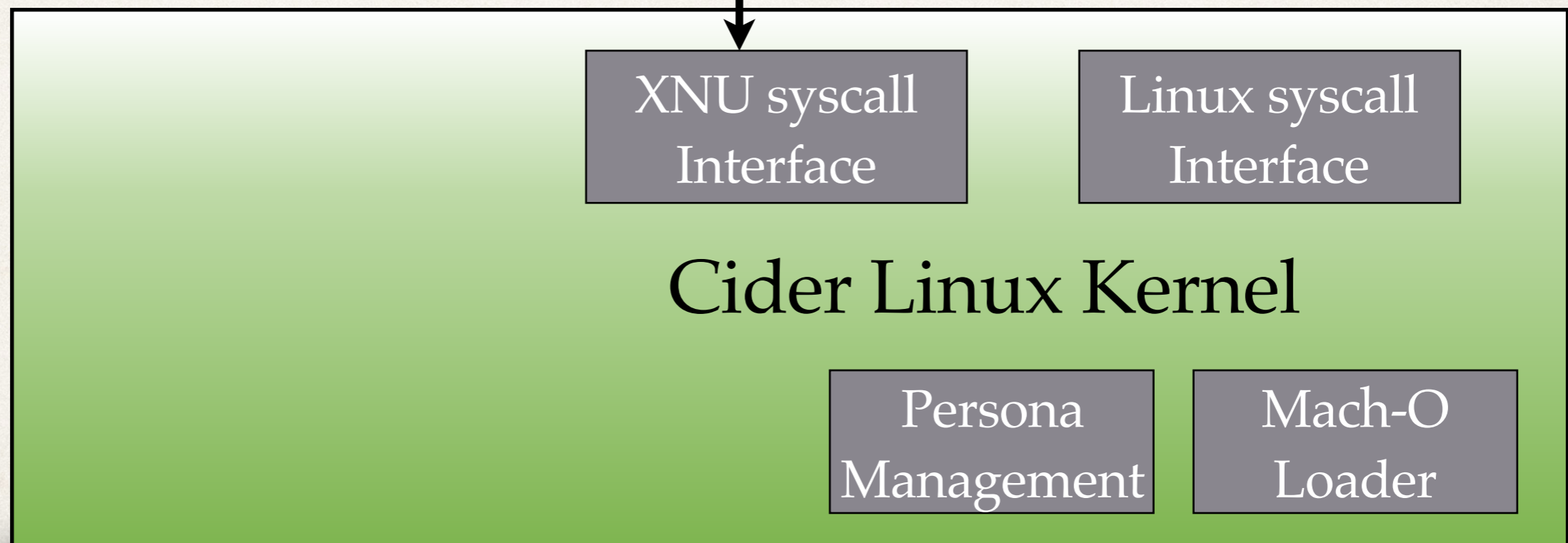
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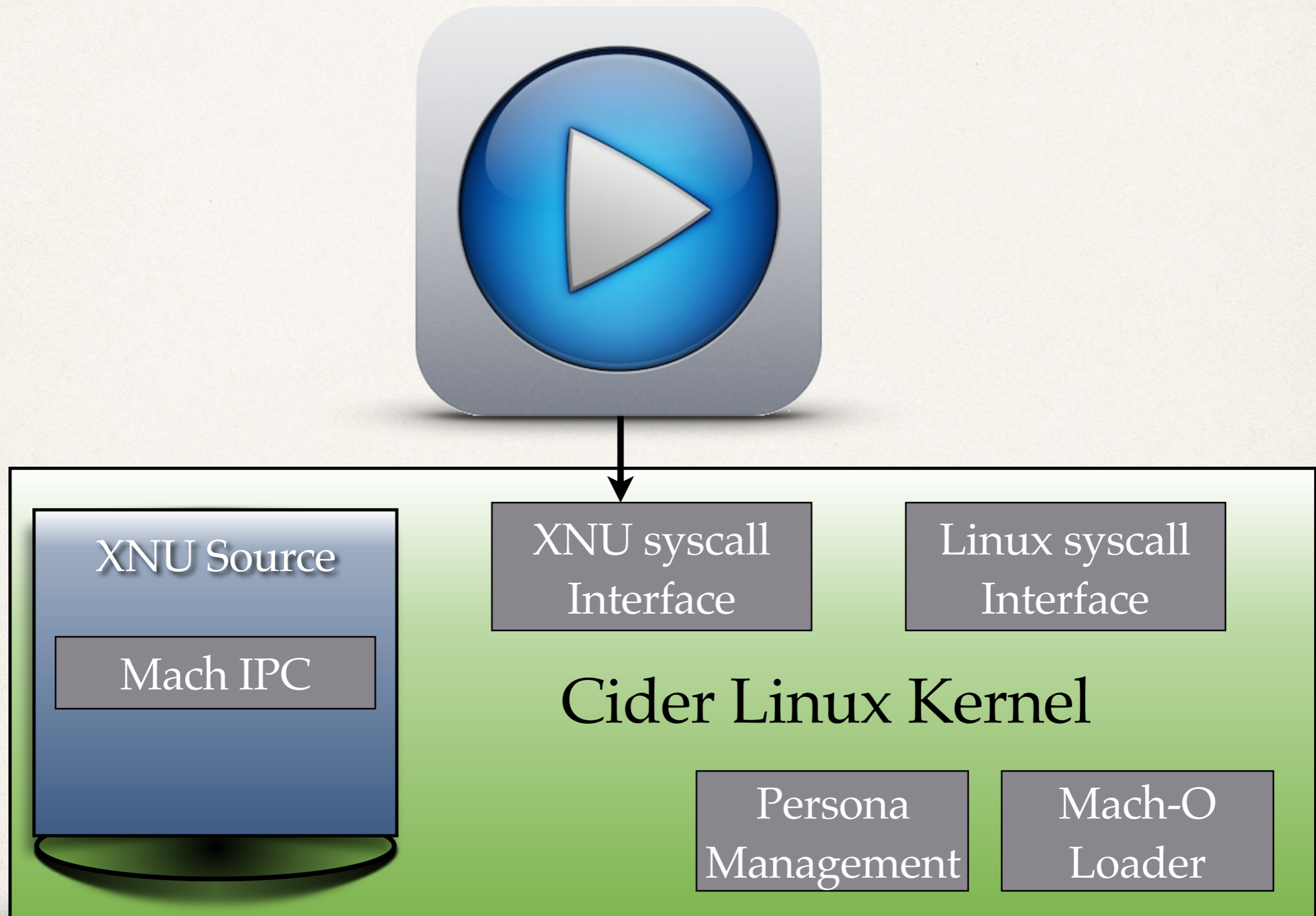
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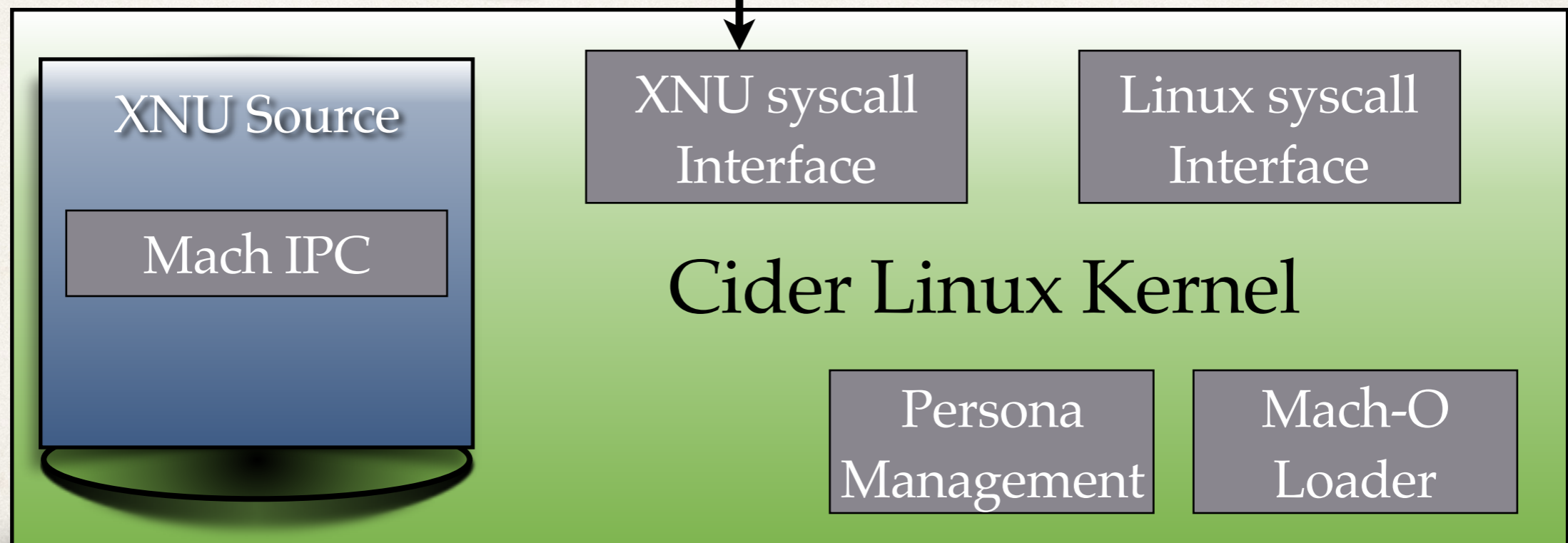
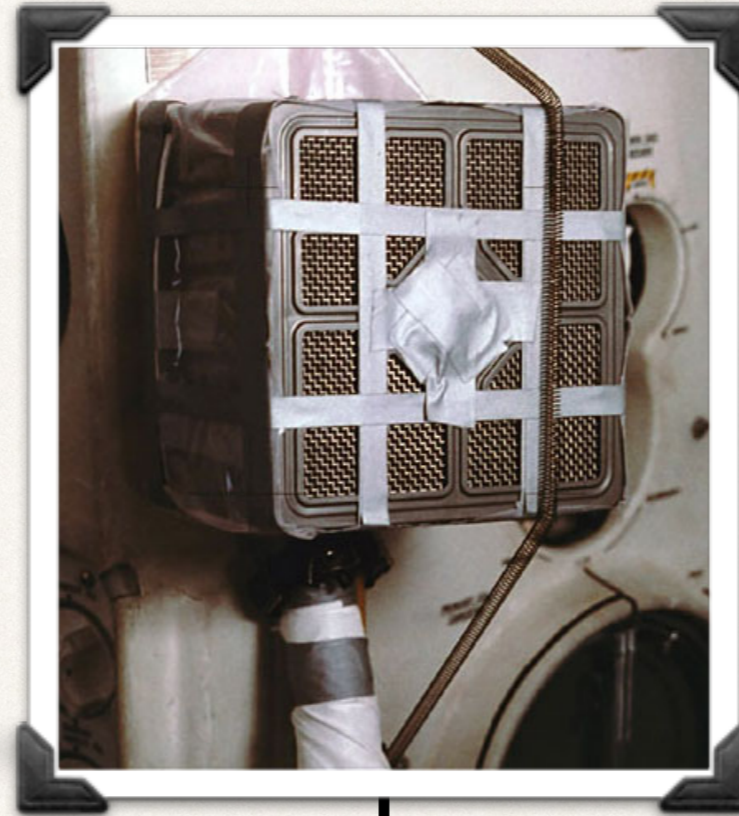
Cider : OS Compatibility



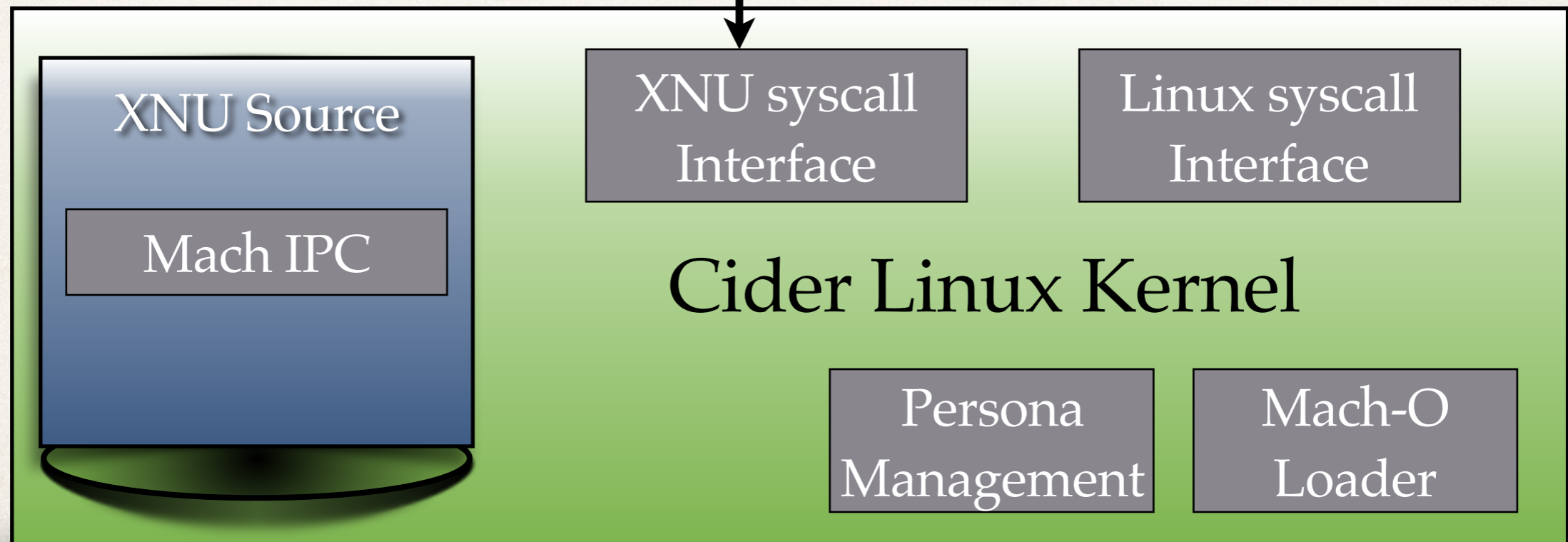
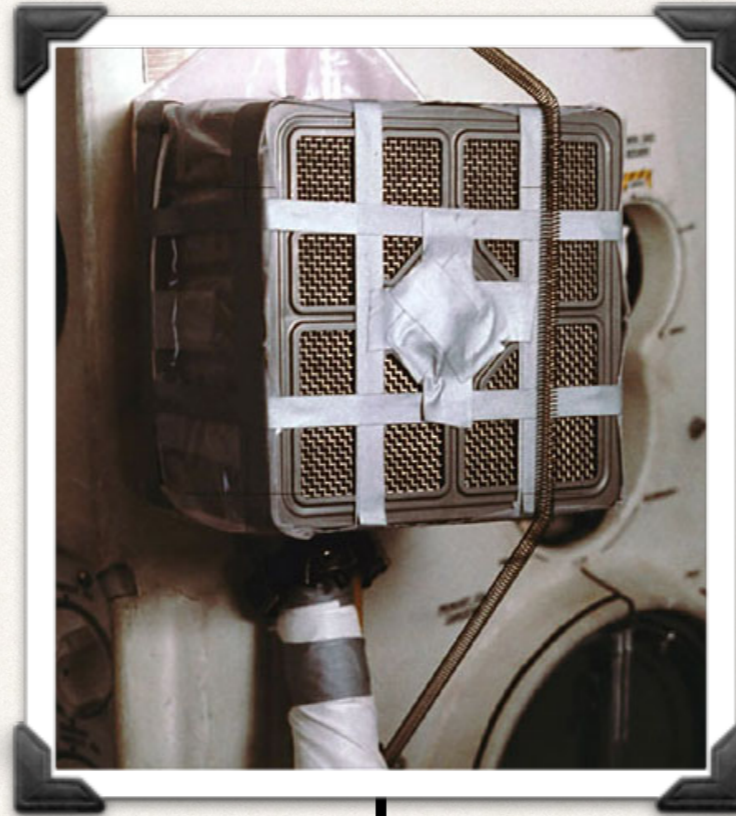
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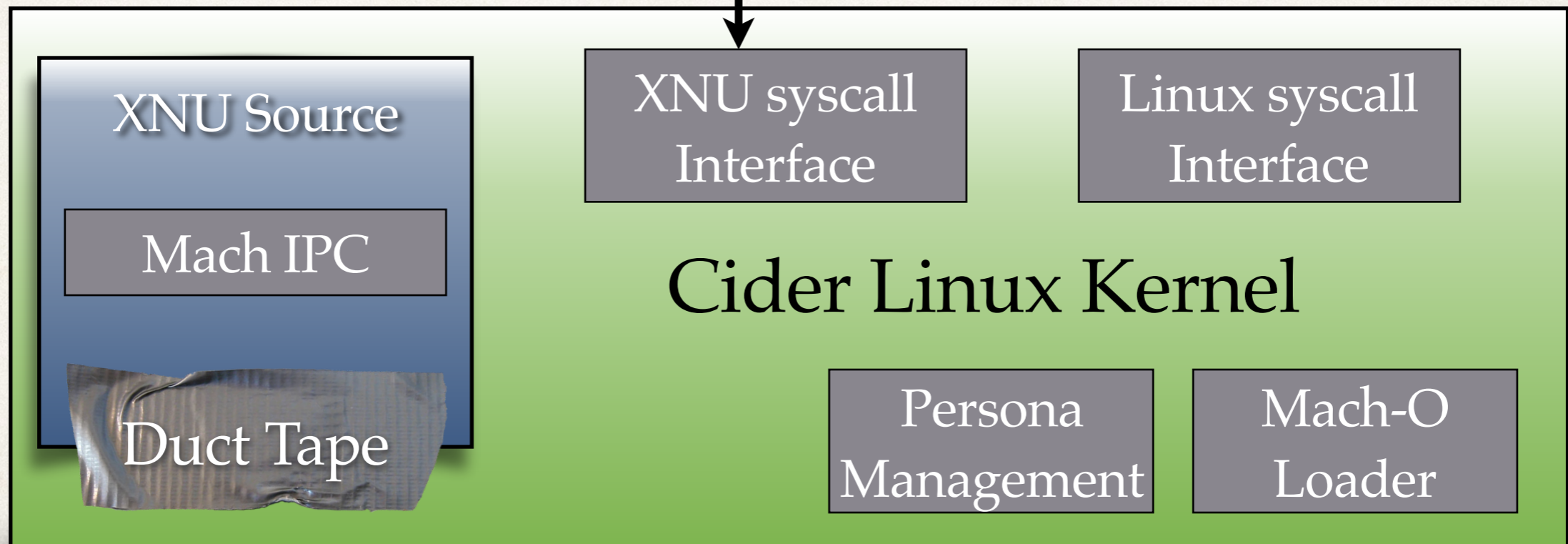
Cider : OS Compatibility



Duct tape



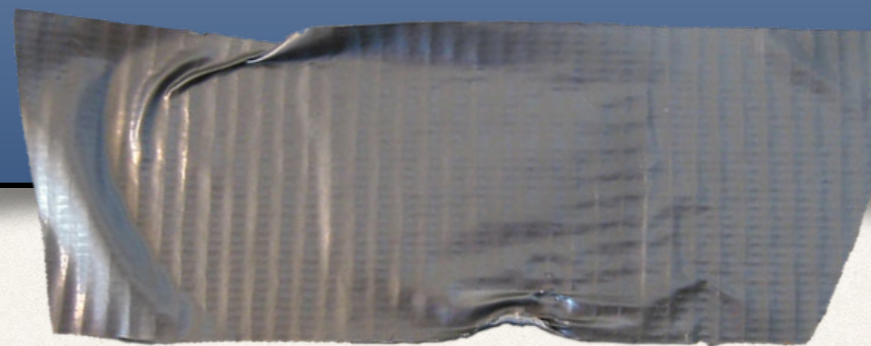
Duct tape



Duct tape

XNU Source

Mach IPC

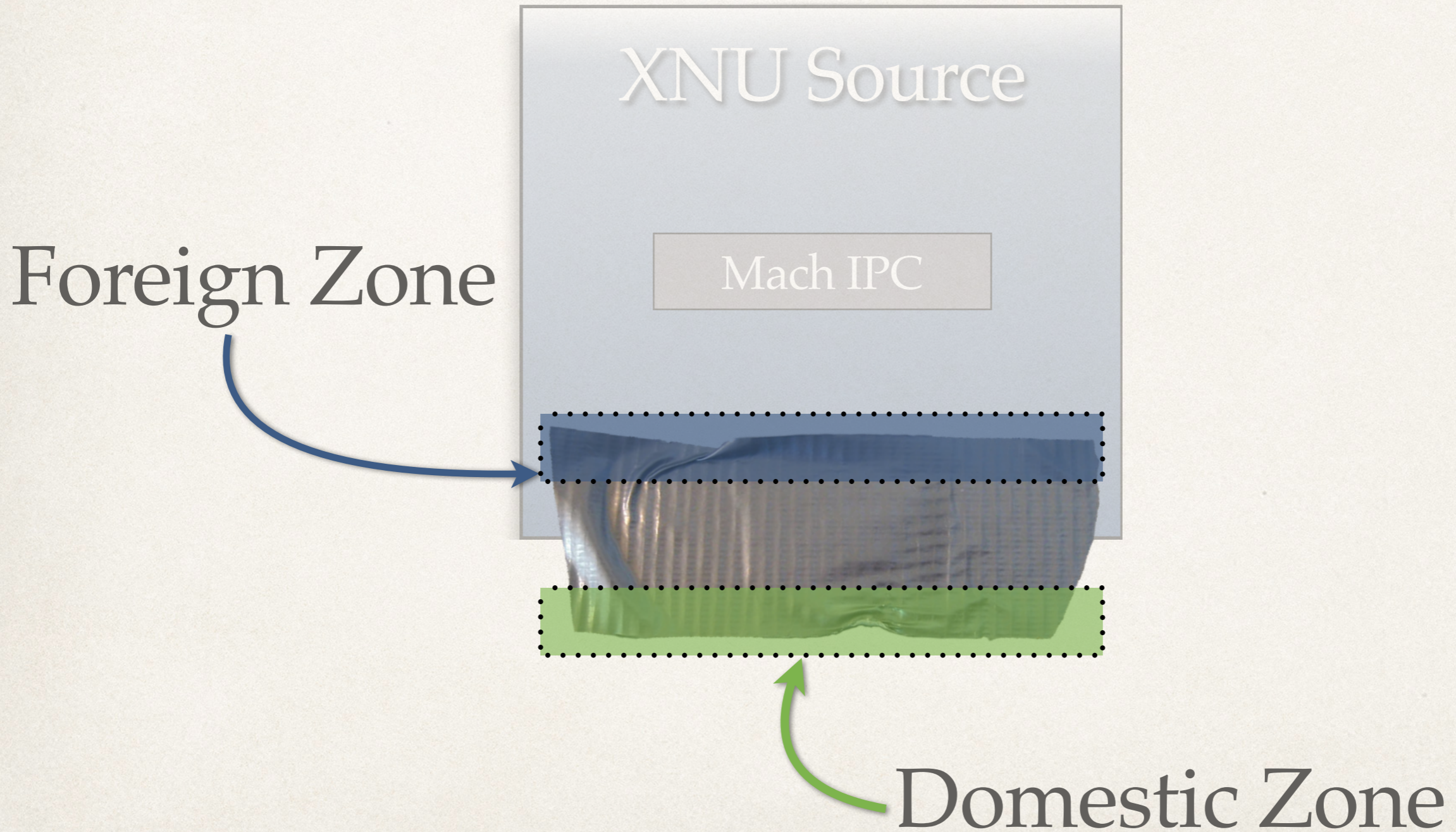


Duct tape

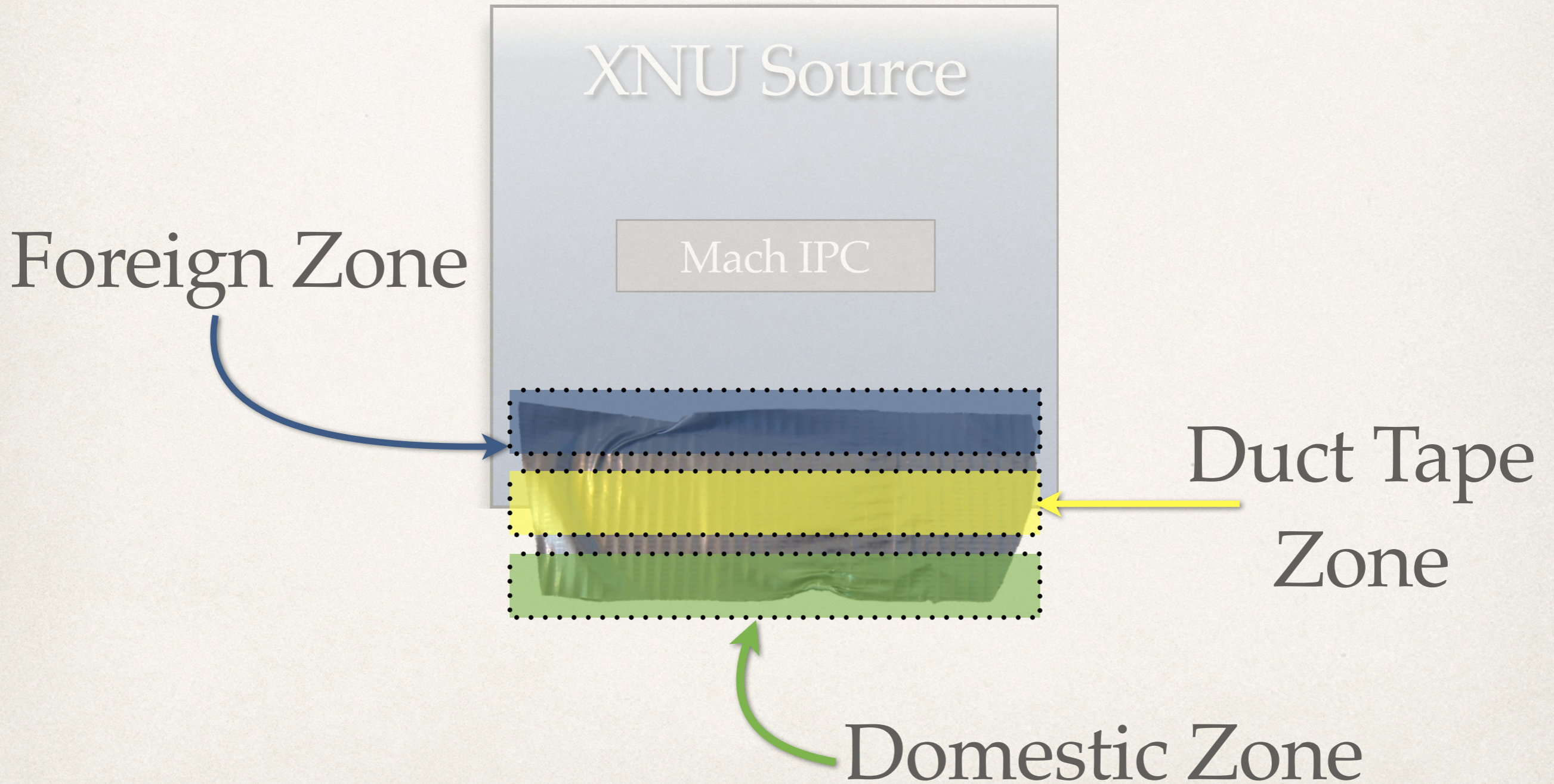
Foreign Zone



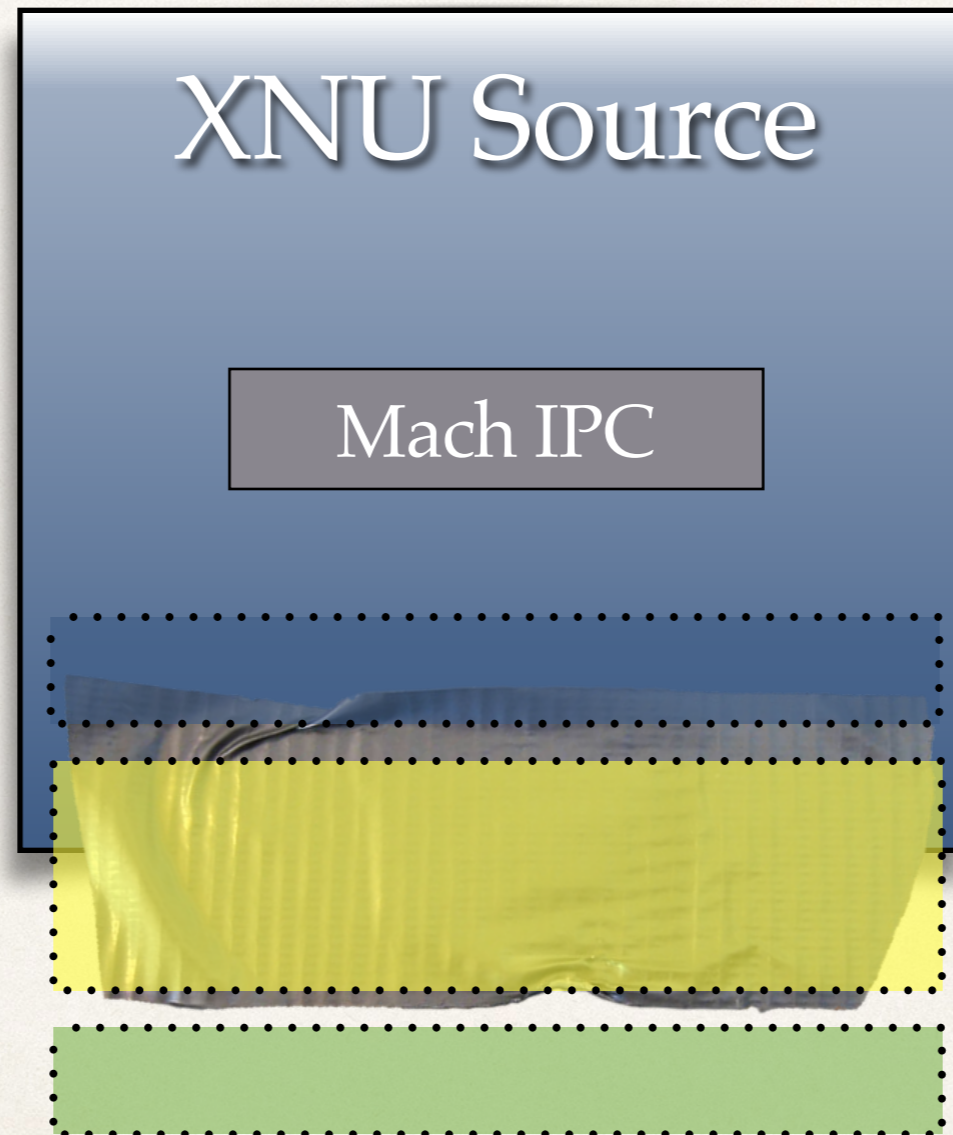
Duct tape



Duct tape



Duct tape



Duct tape

XNU Source

Mach IPC

Synchronization, List Mgmt

Mach Semantics

Mach IPC syscall stubs

Duct tape

XNU Source

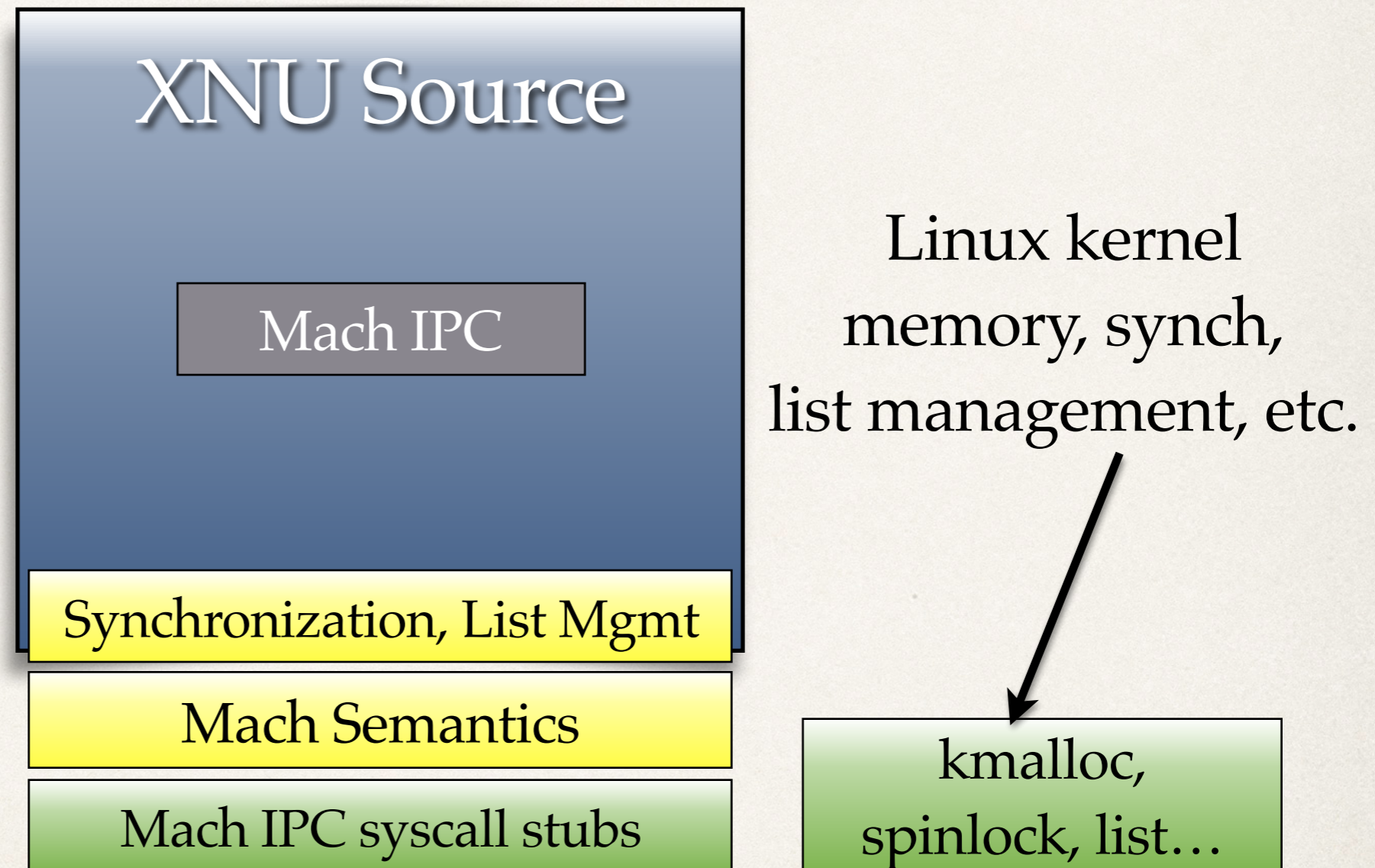
Mach IPC

Synchronization, List Mgmt

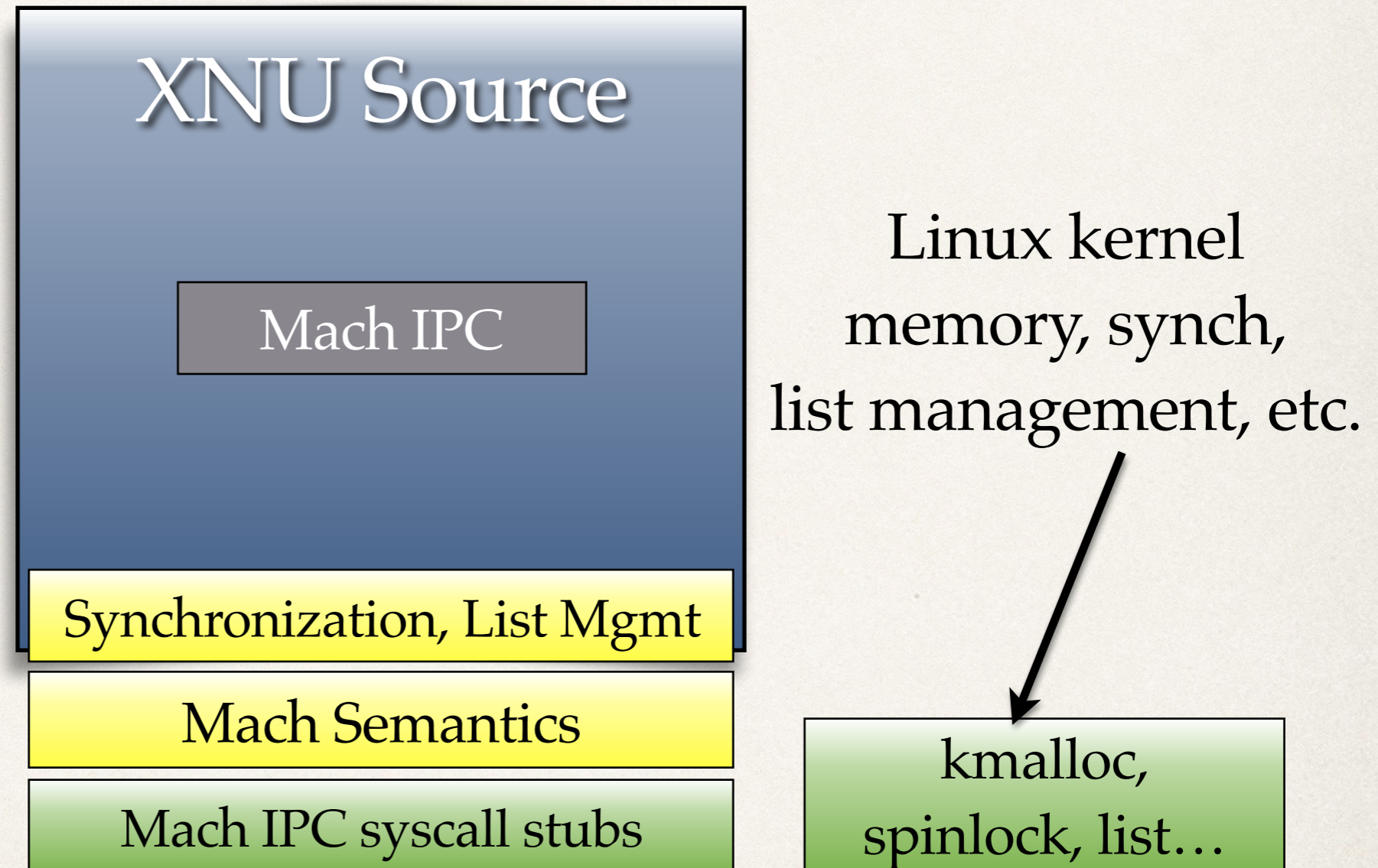
Mach Semantics

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Duct tape

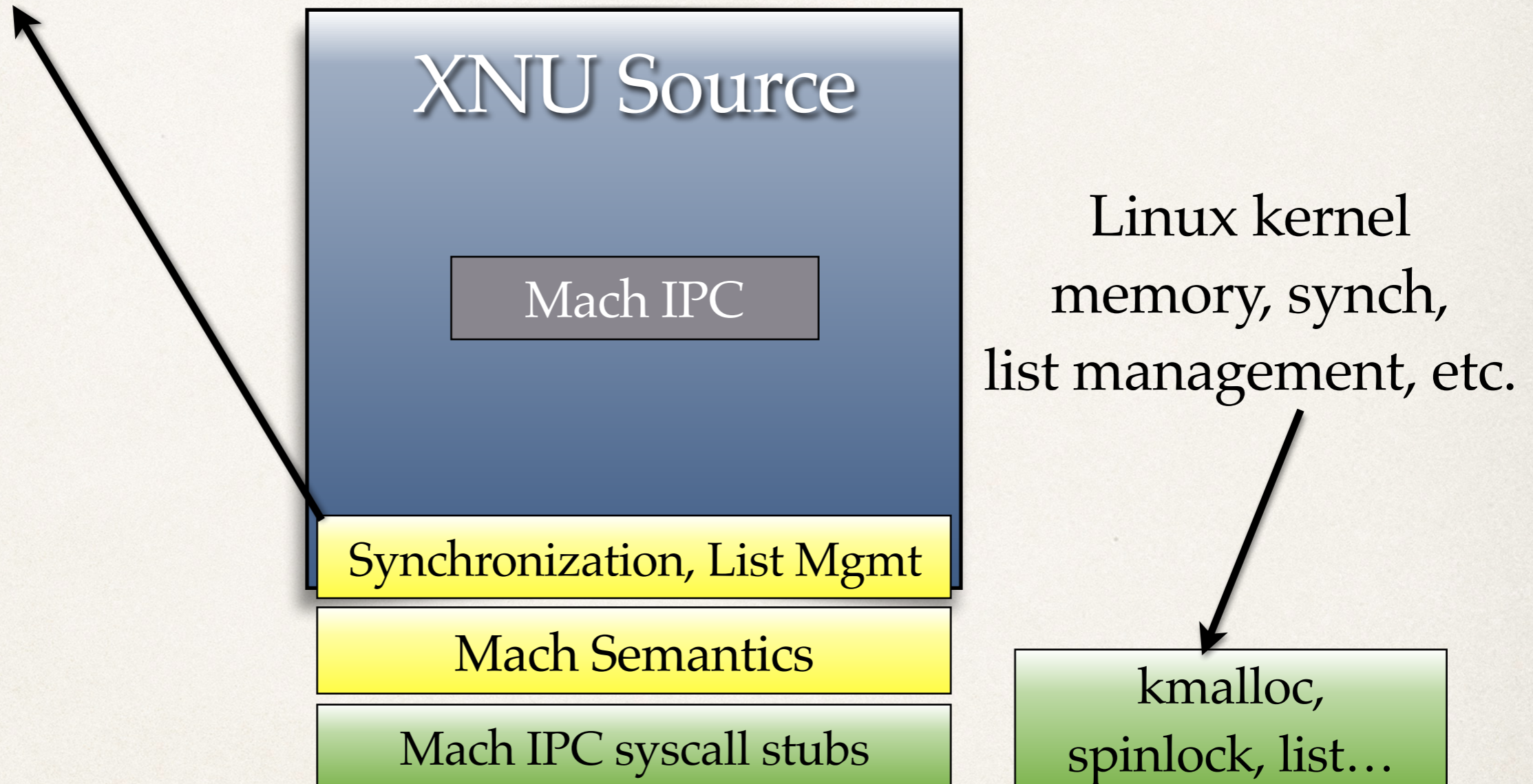


Duct tape



Duct tape

`lck_mtx_lock()` → `mutex_lock()`
`lck_mtx_t` → `struct mutex`



Duct tape

```
lck_mtx_lock() ➔ mutex_lock()  
lck_mtx_t ➔ struct mutex
```

XNU Source

Mach IPC

Synchronization, List Mgmt

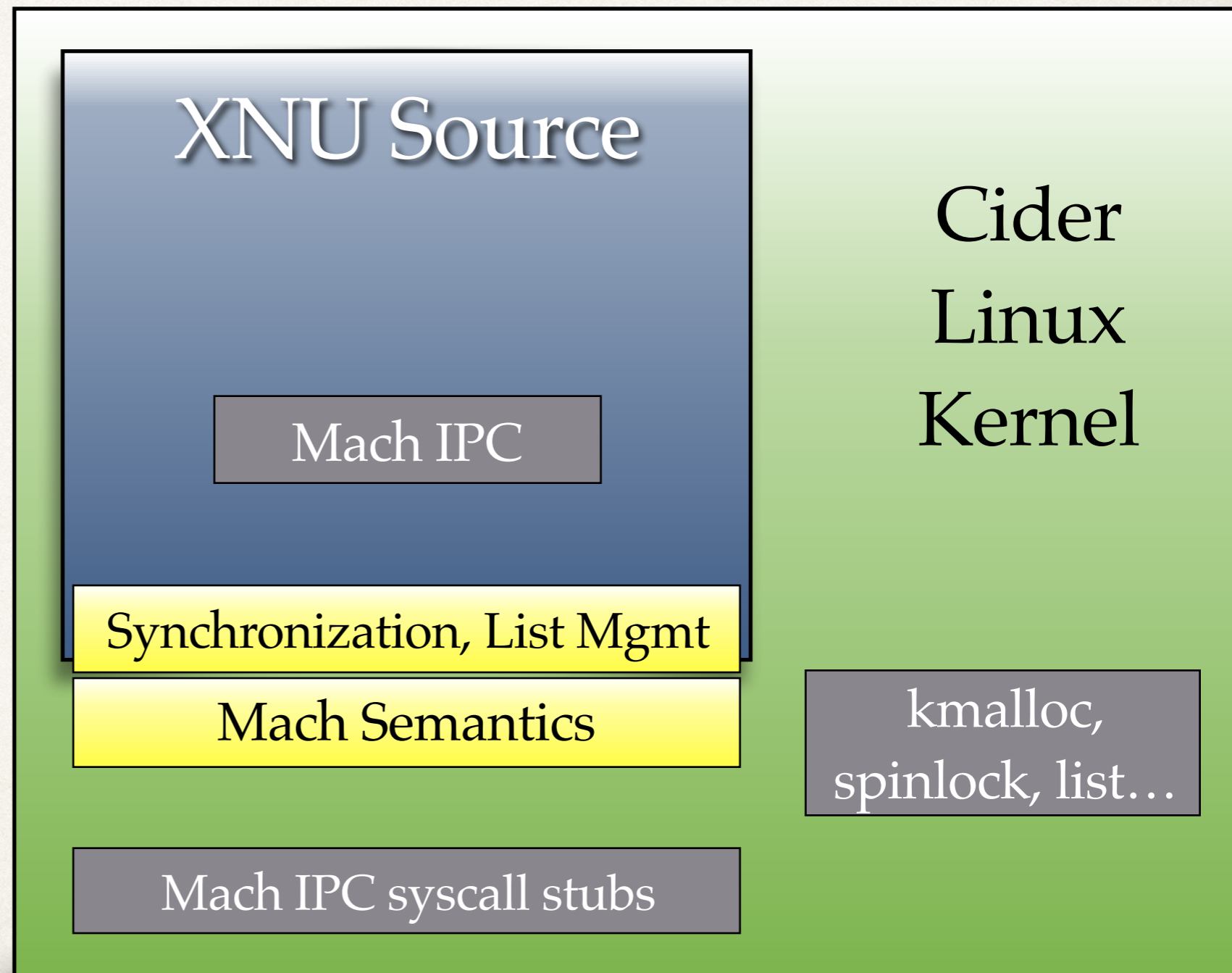
Mach Semantics

Mach IPC syscall stubs

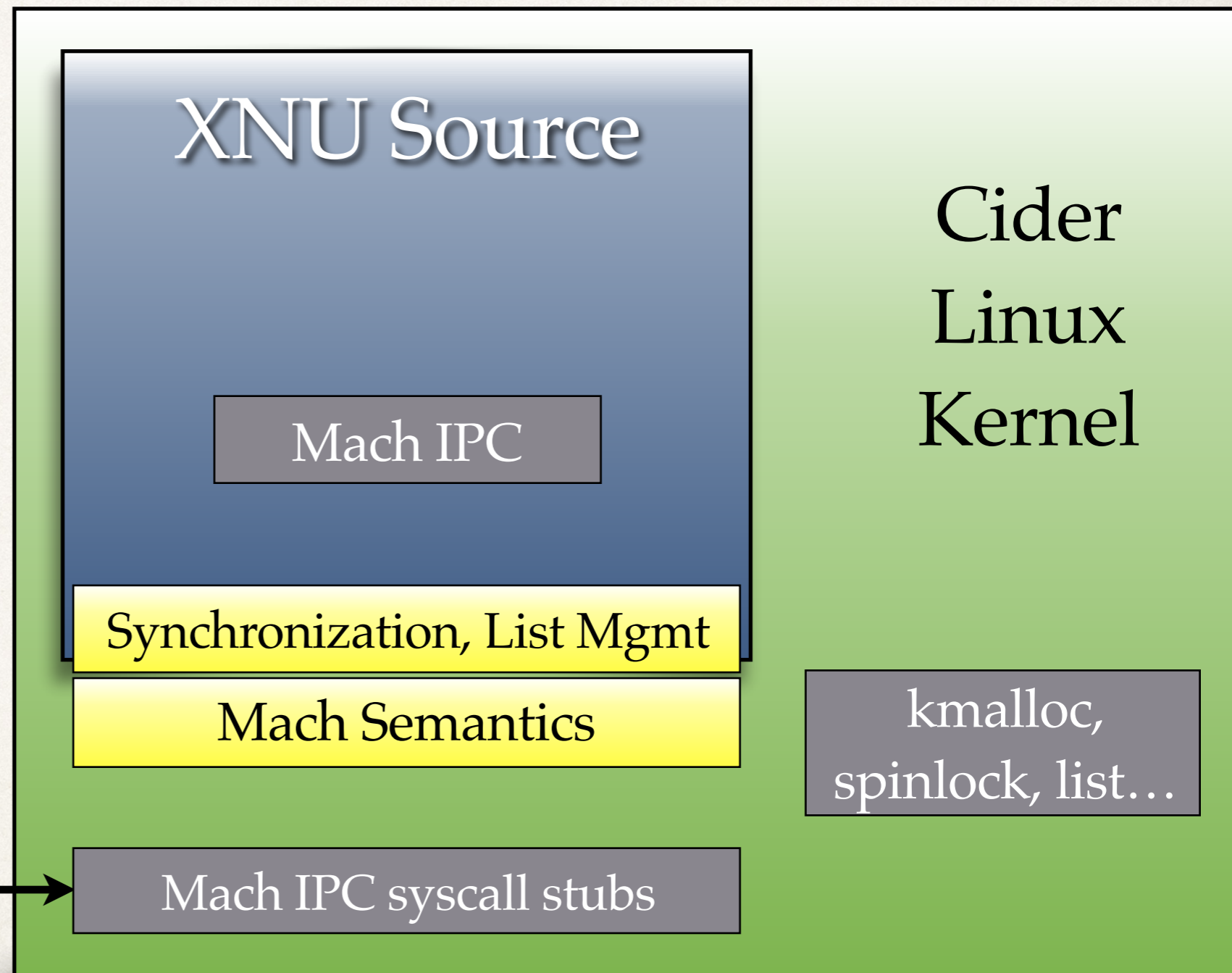
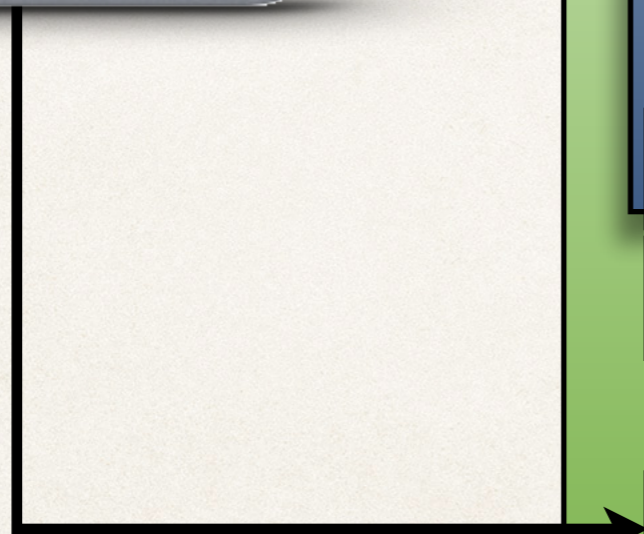
Linux kernel
memory, synch,
list management, etc.

kmalloc,
spinlock, list...

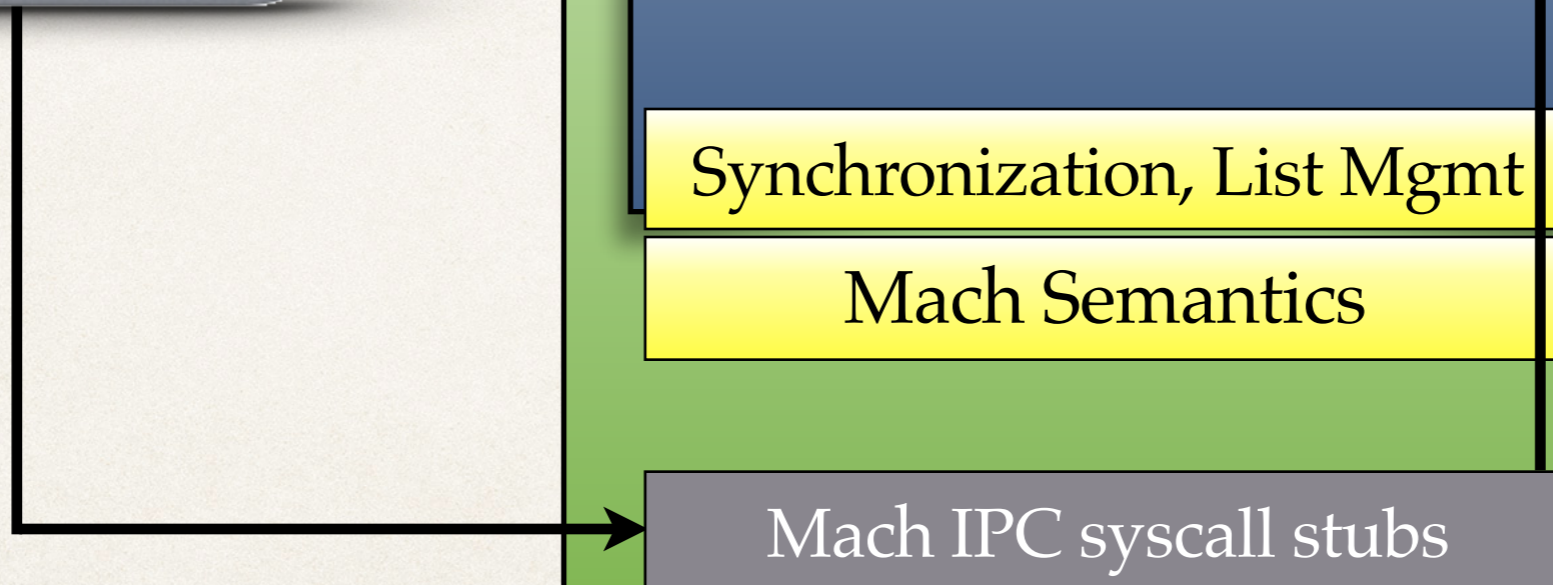
Duct tape



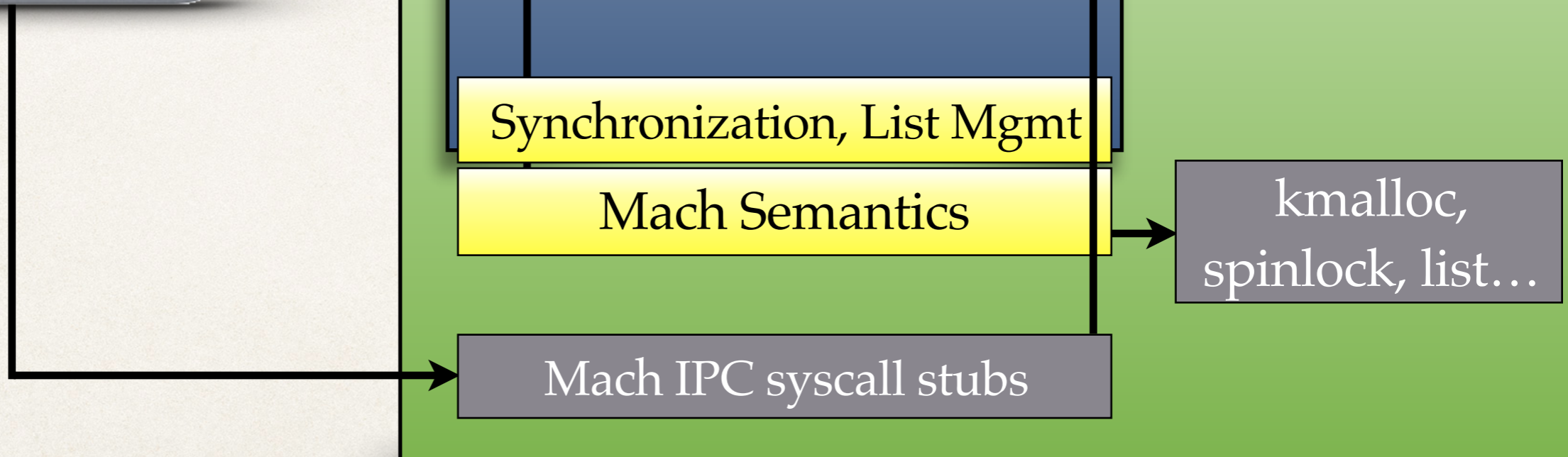
Duct tape



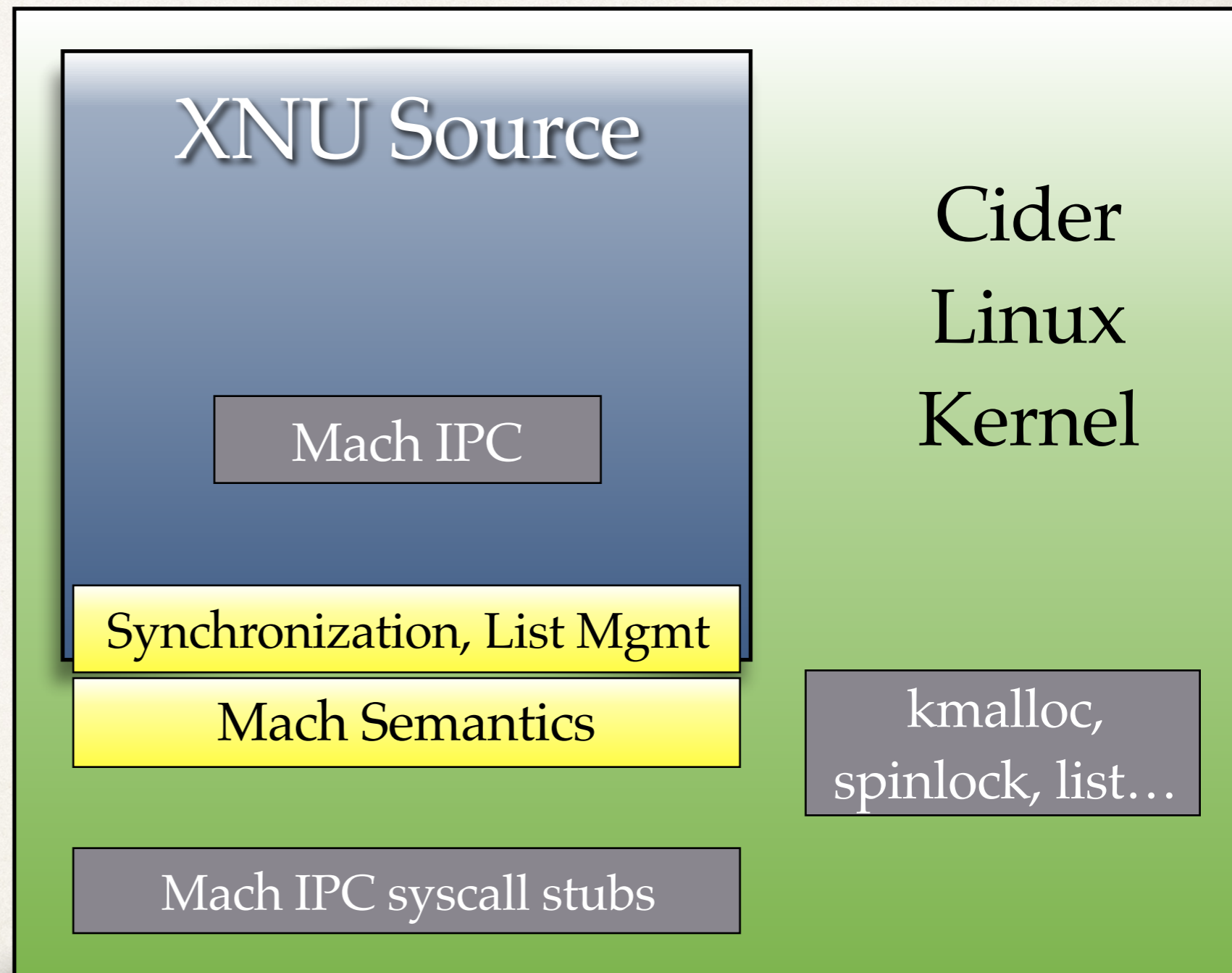
Duct tape



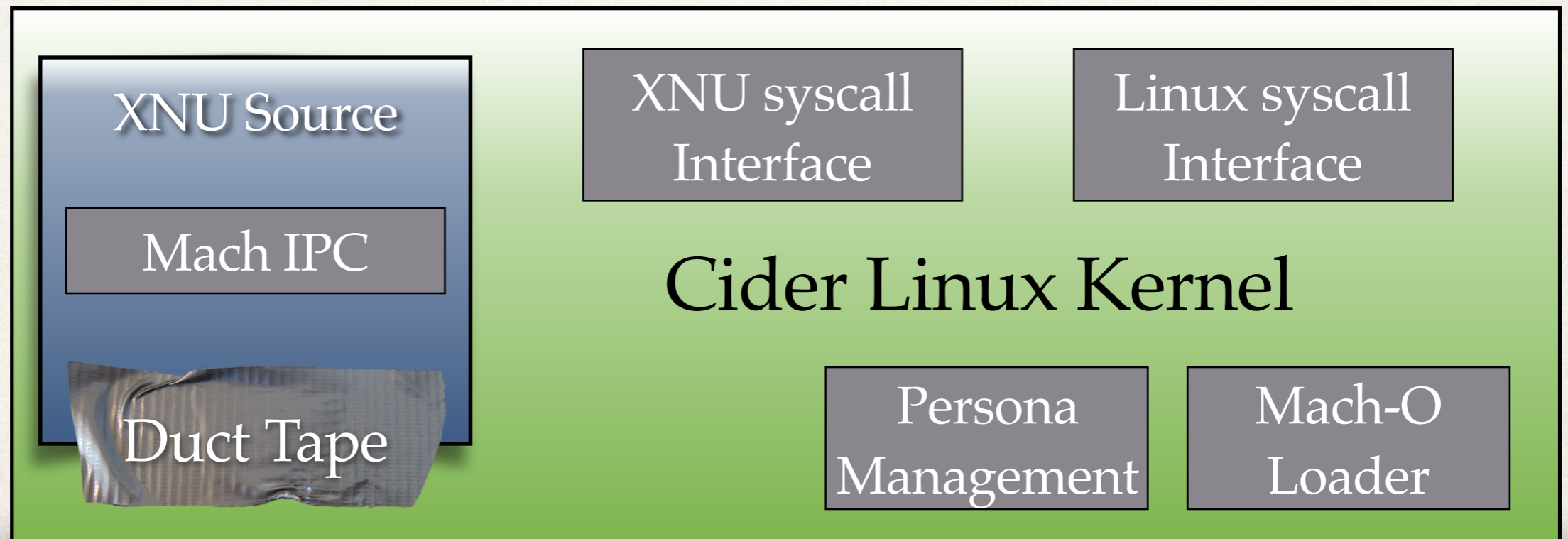
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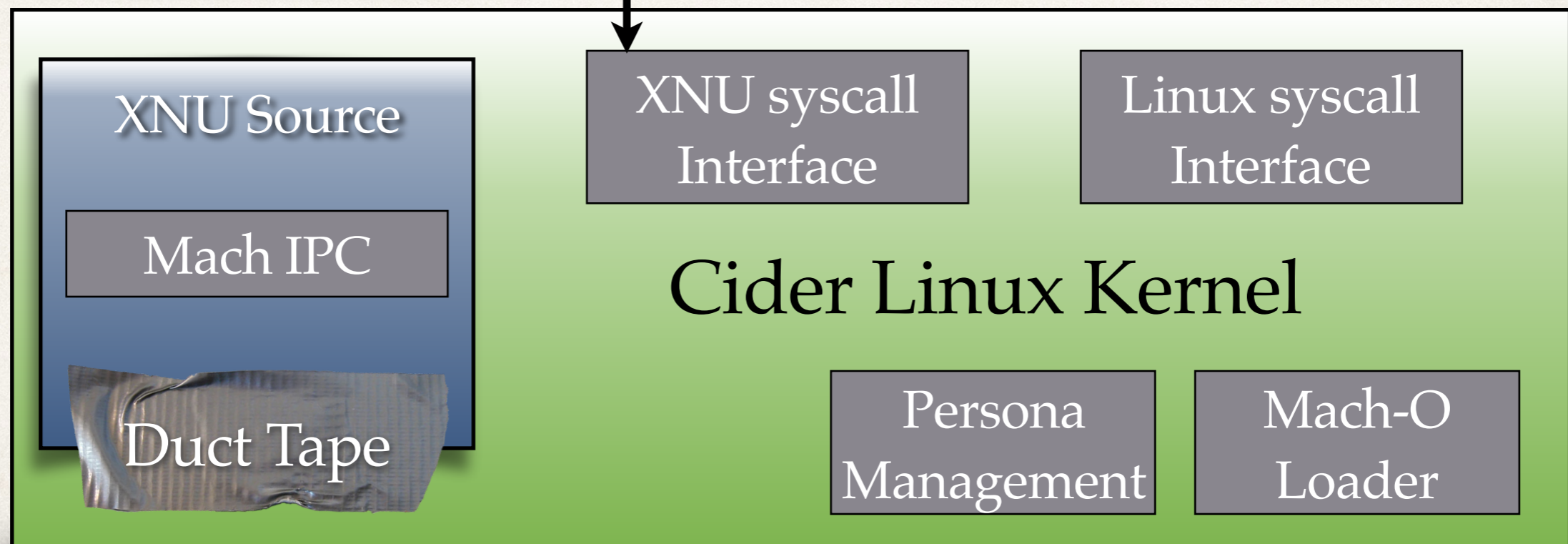
Duct tape



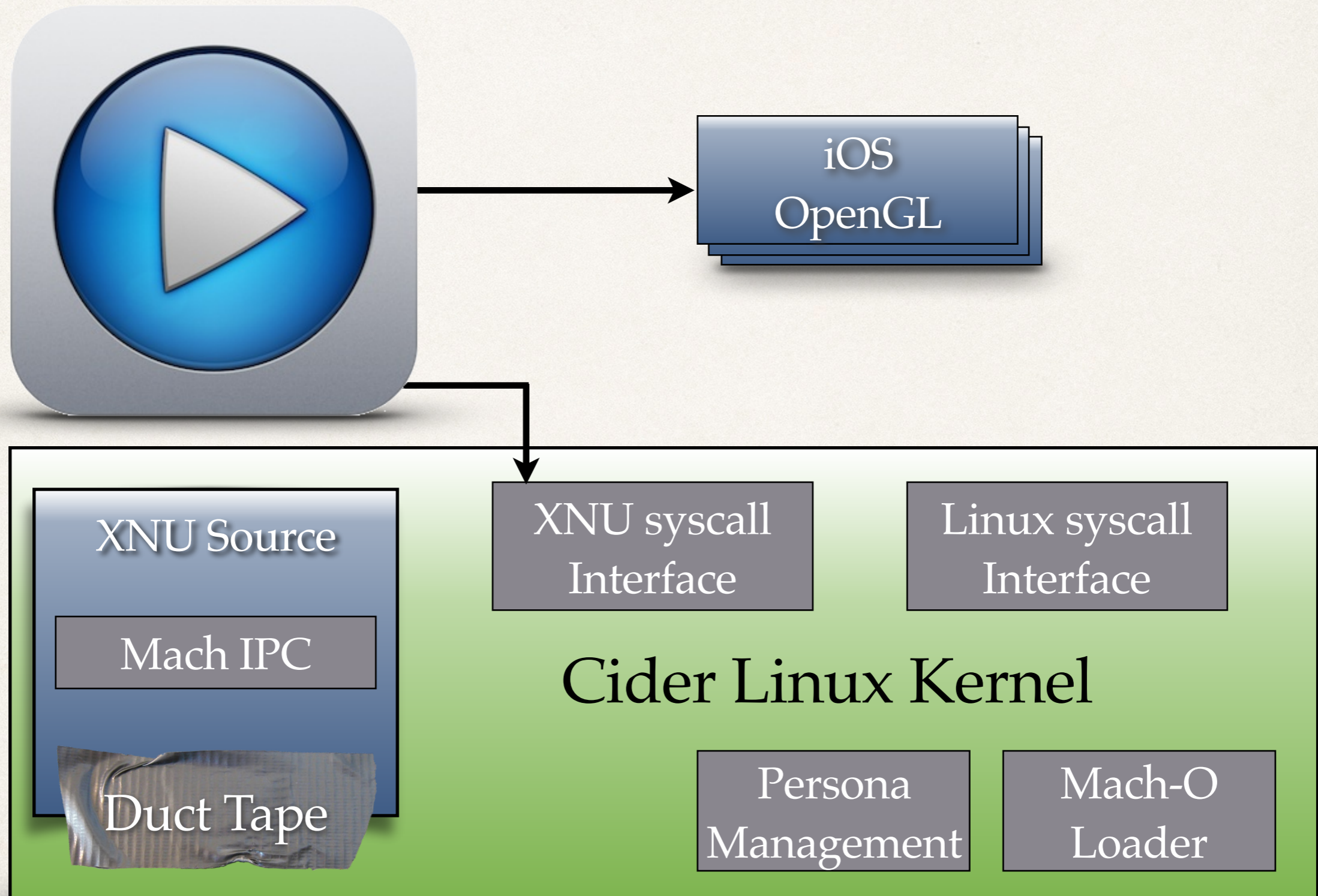
Cider : OS Compatibility



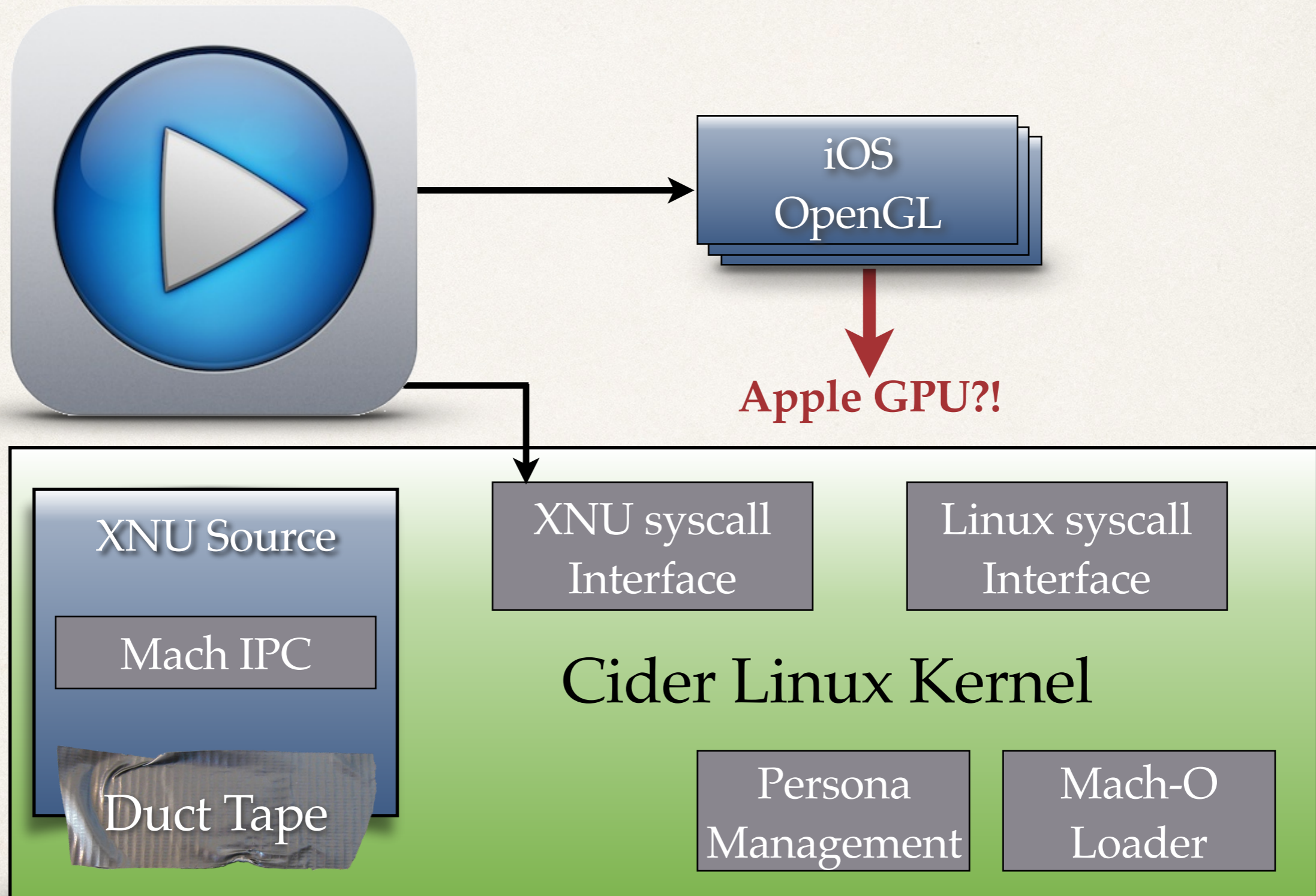
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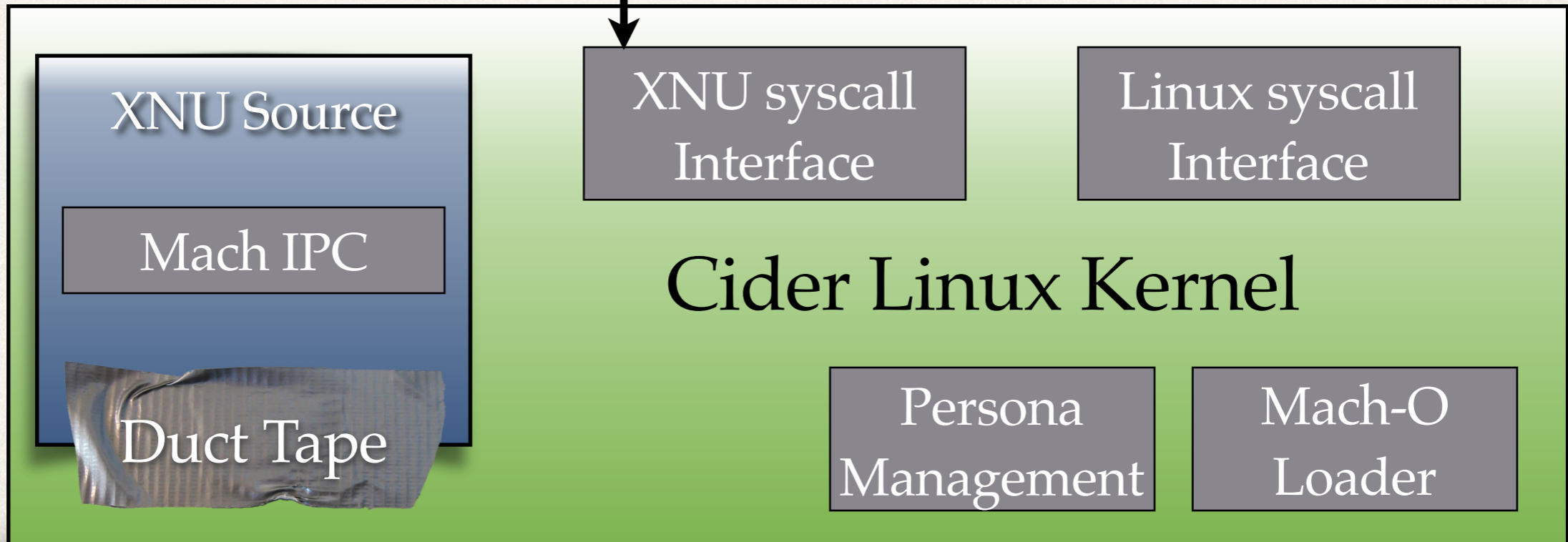
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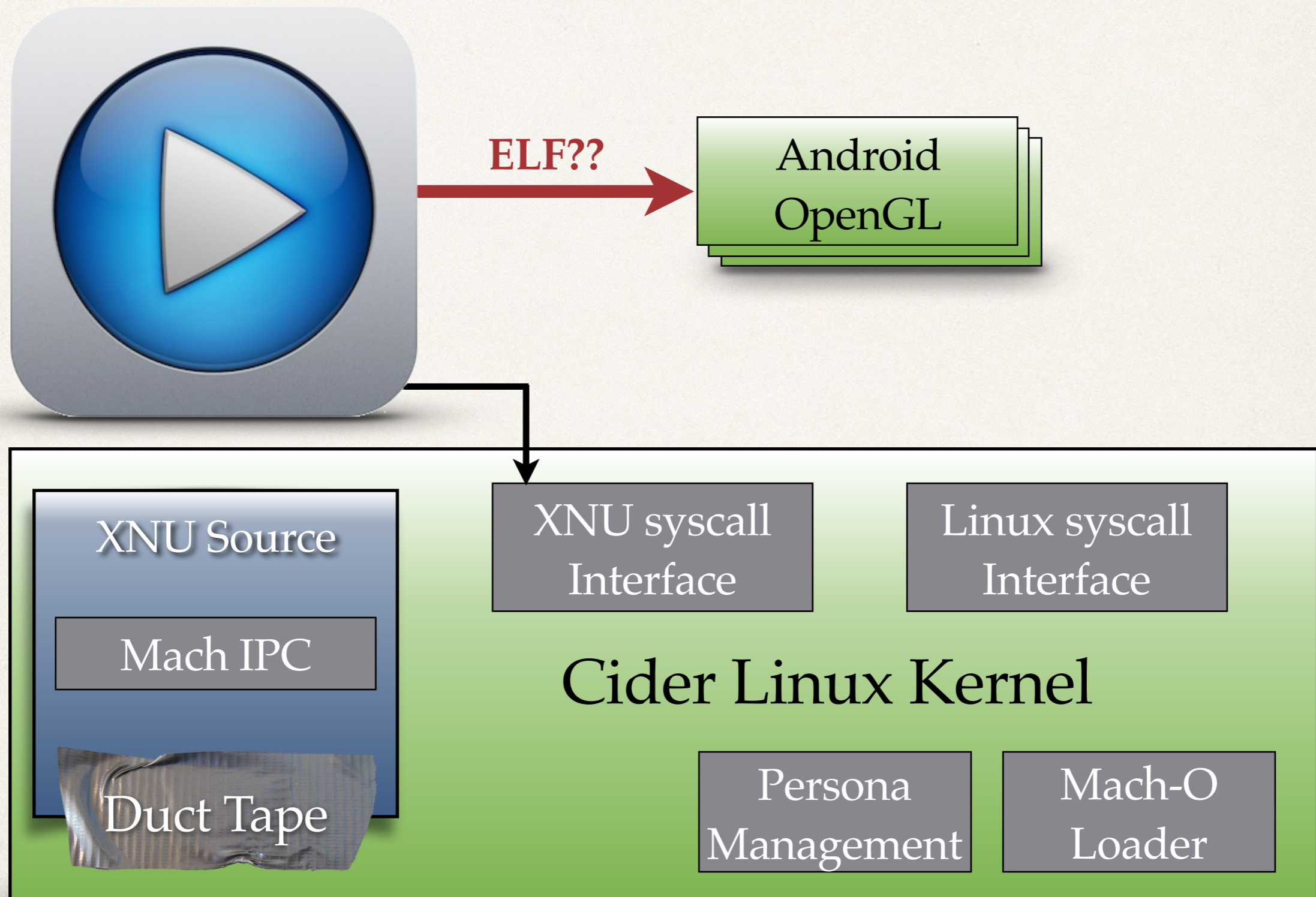
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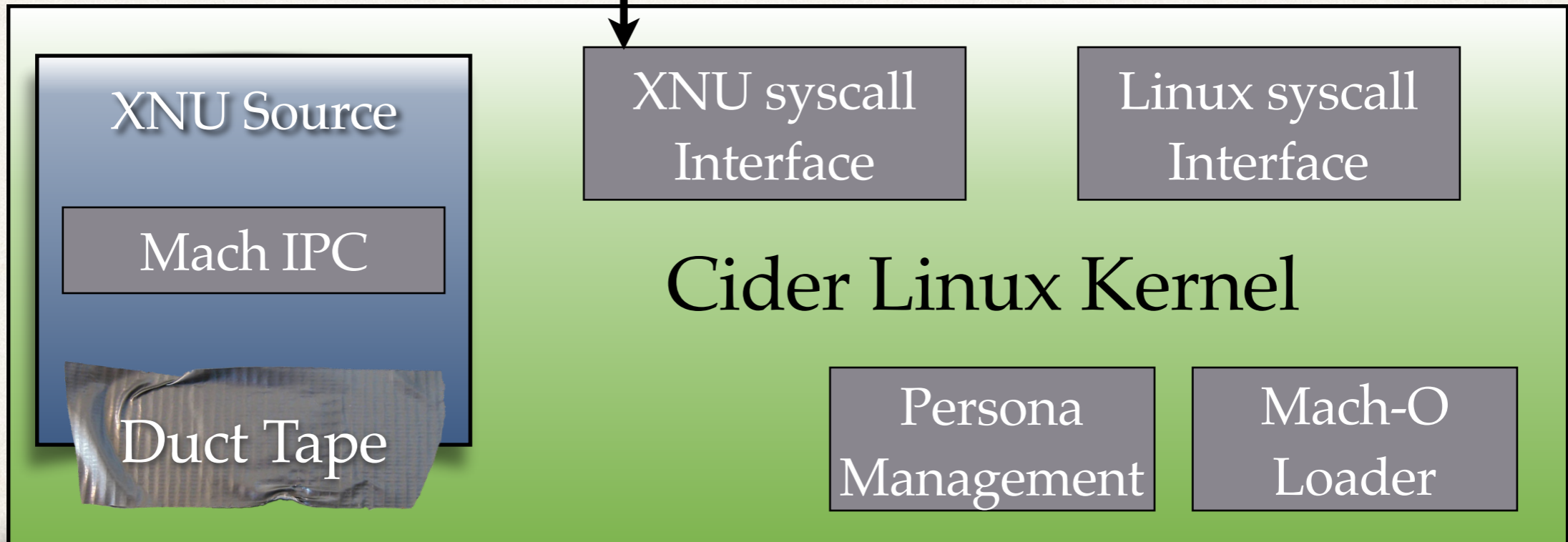
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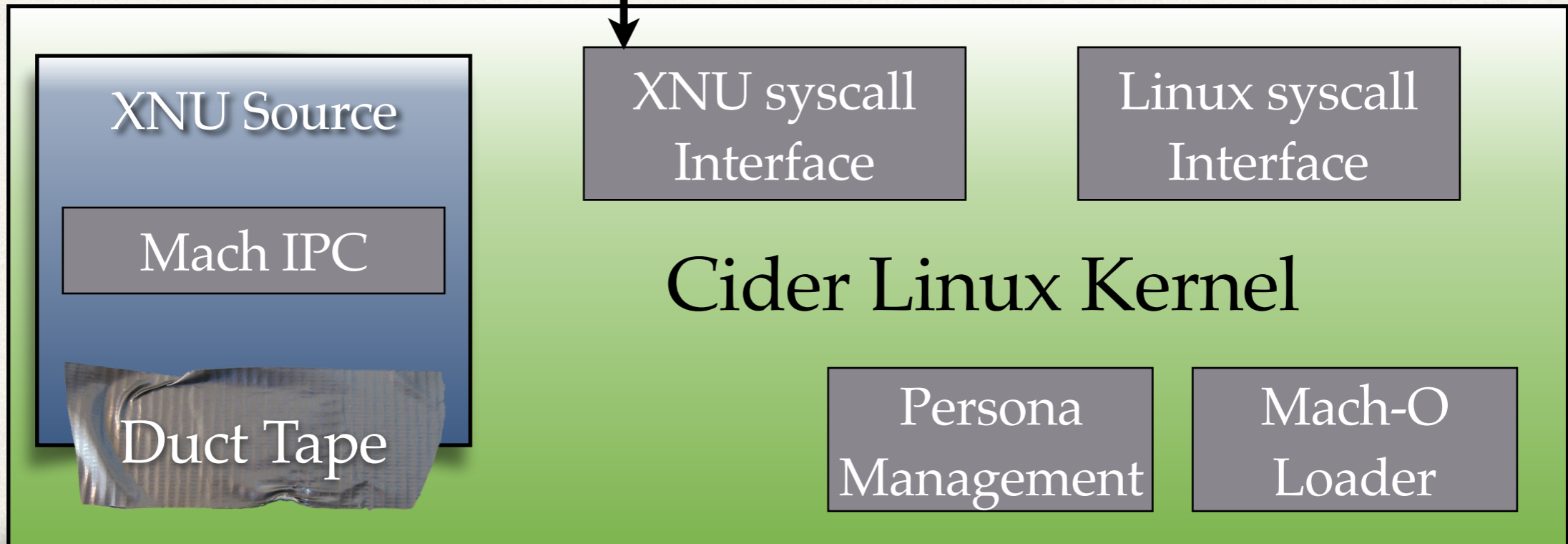
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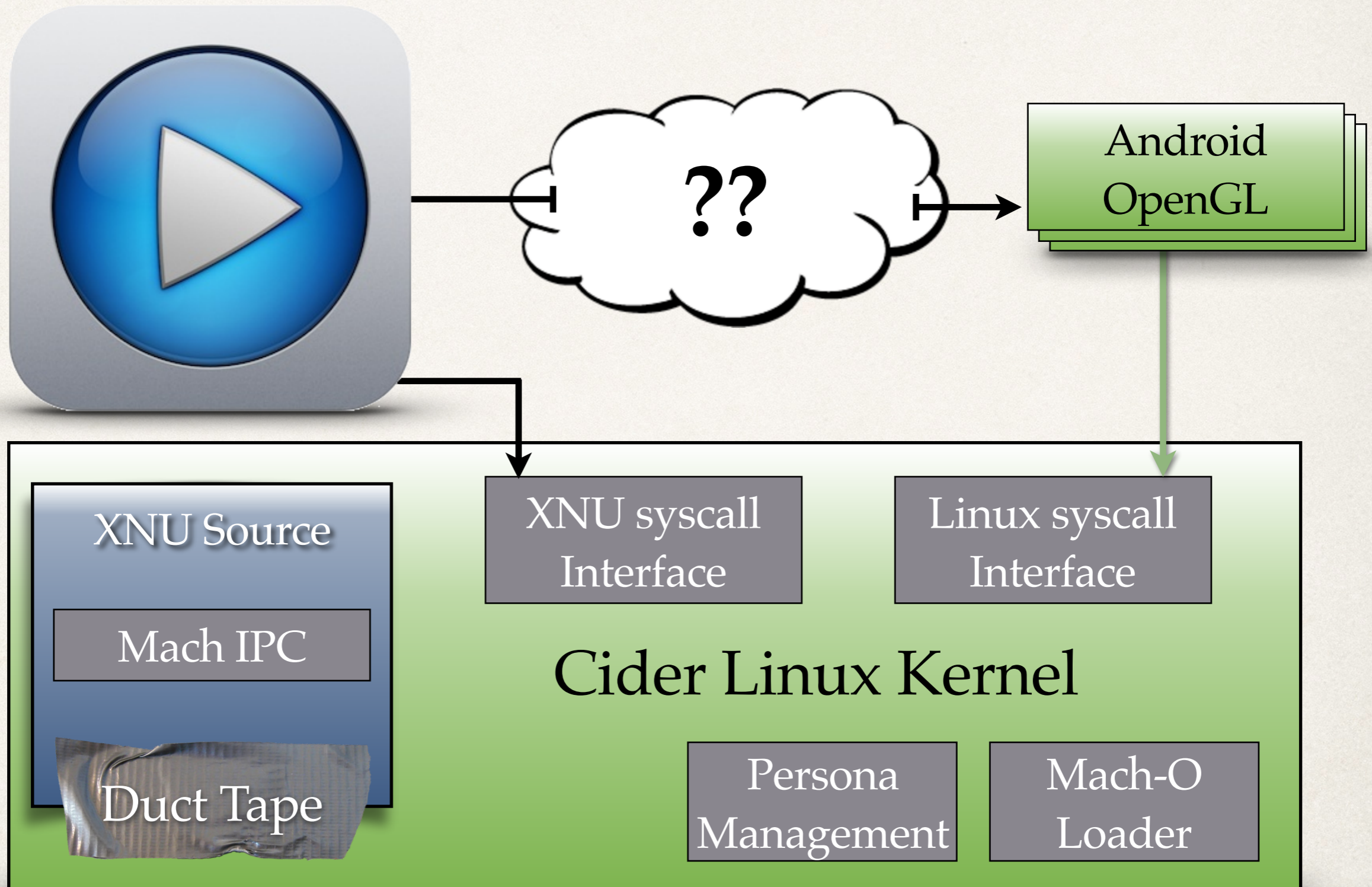
Android
OpenGL



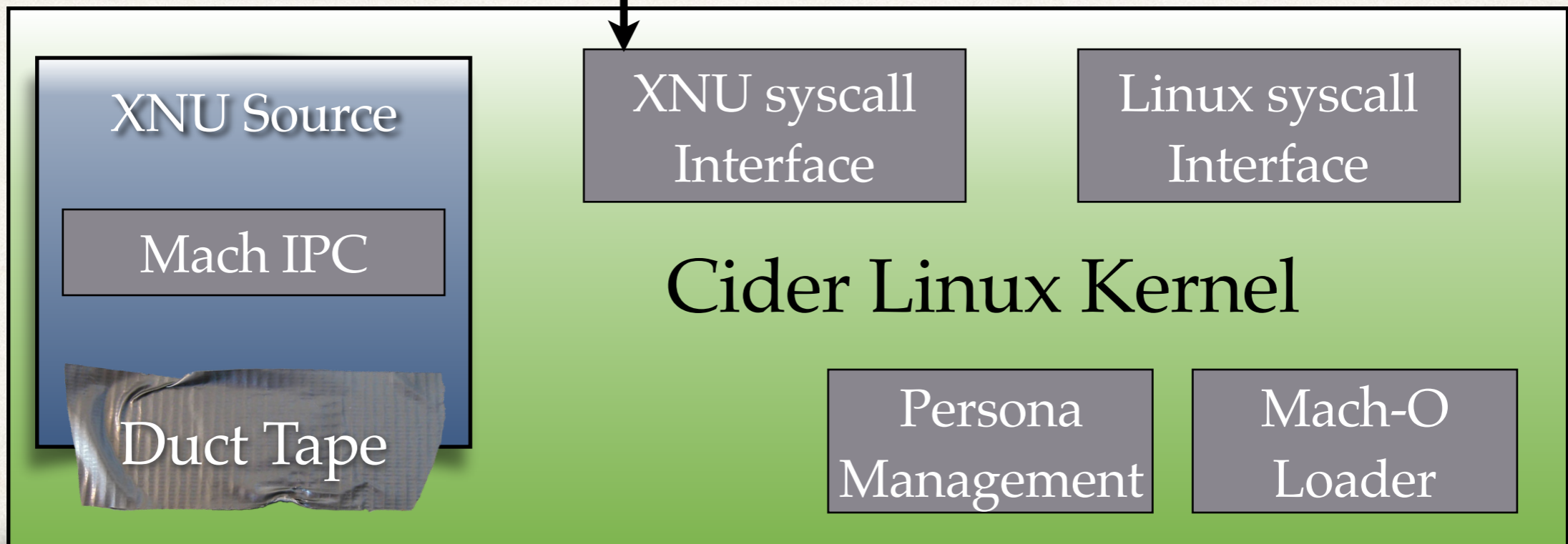
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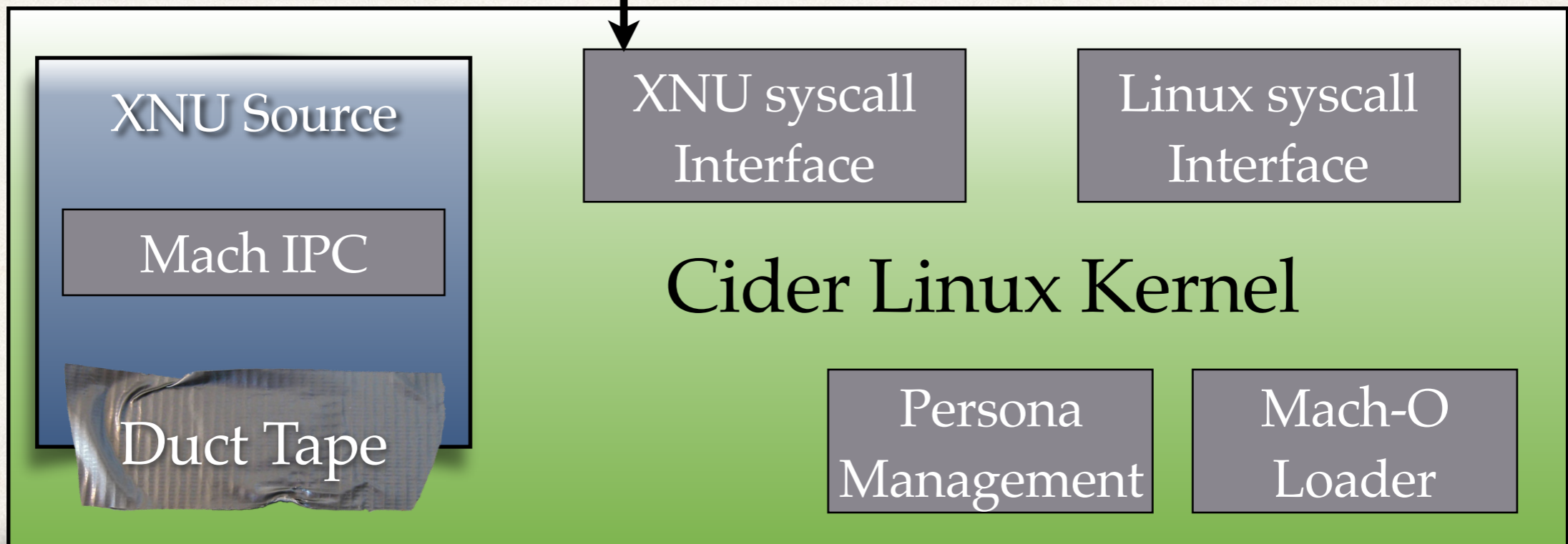
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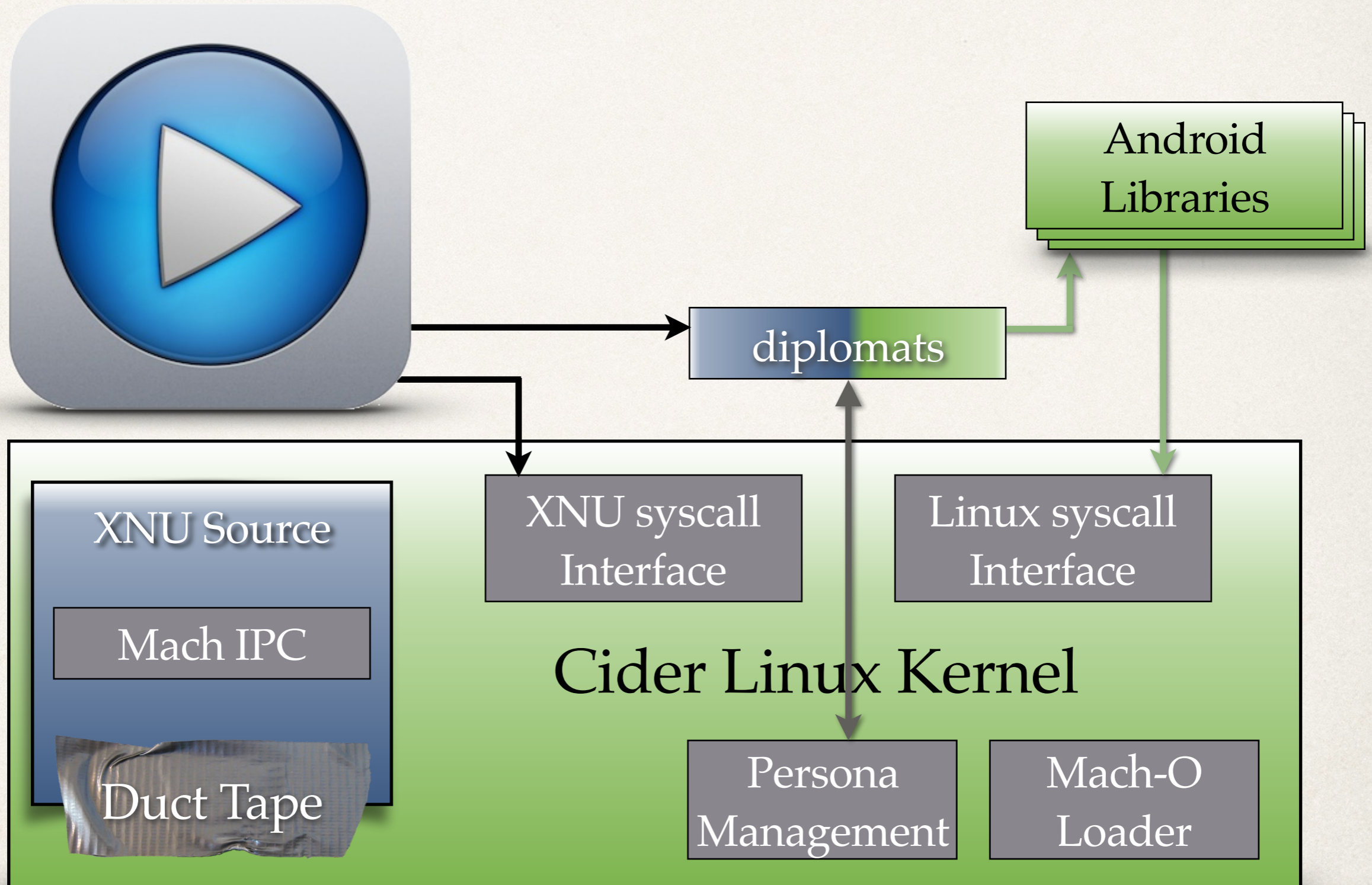
Diplomats



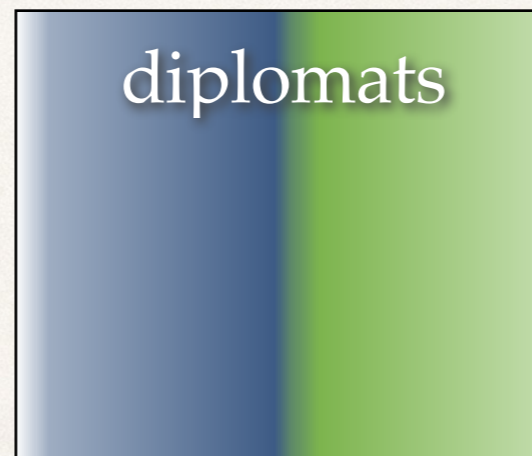
diplomats



Diplomats



Diplomats



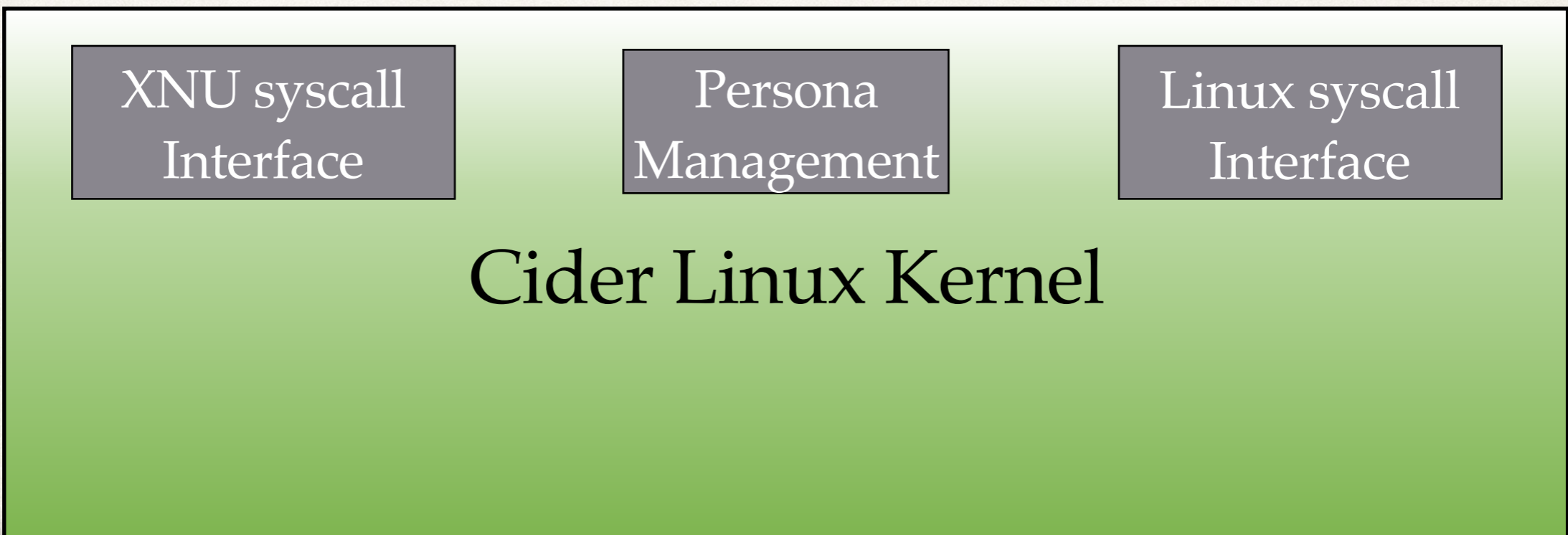
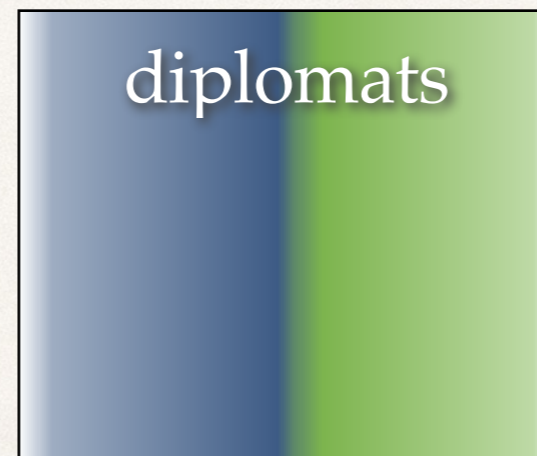
XNU syscall
Interface

Persona
Management

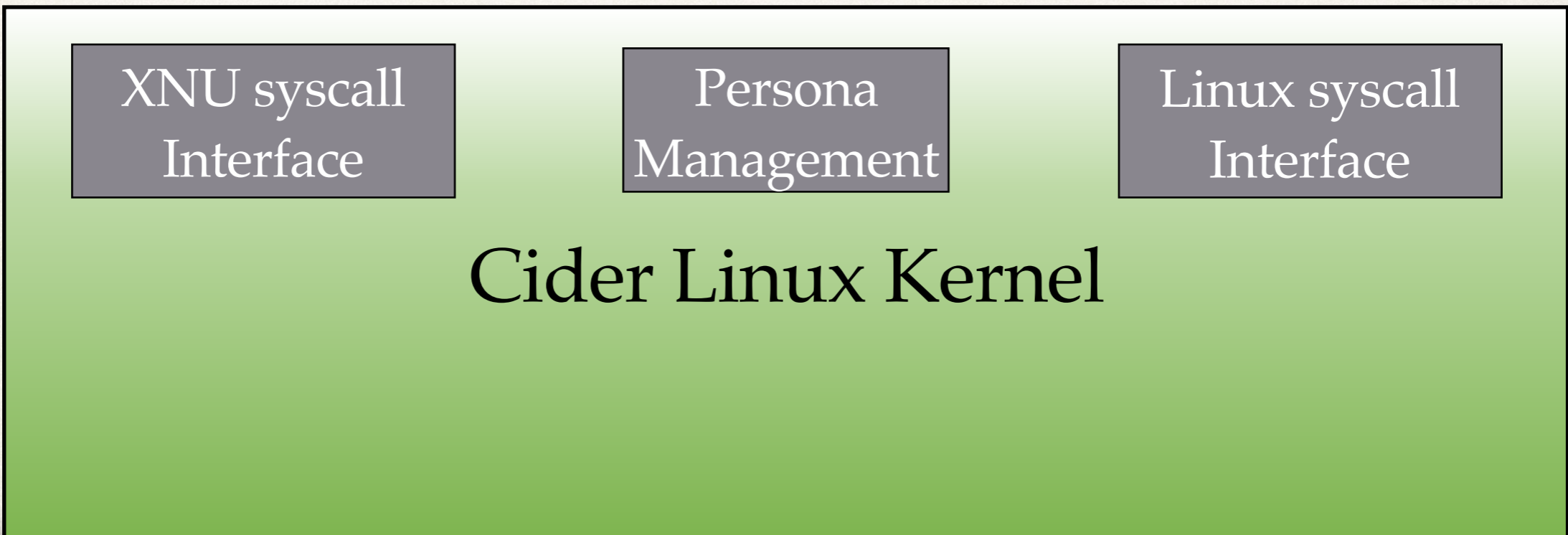
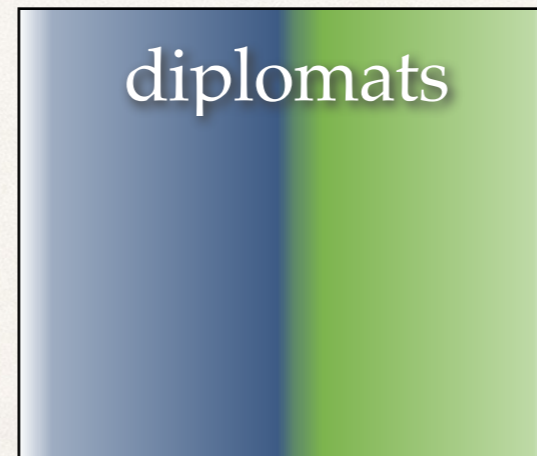
Linux syscall
Interface

Cider Linux Kernel

Diplomats

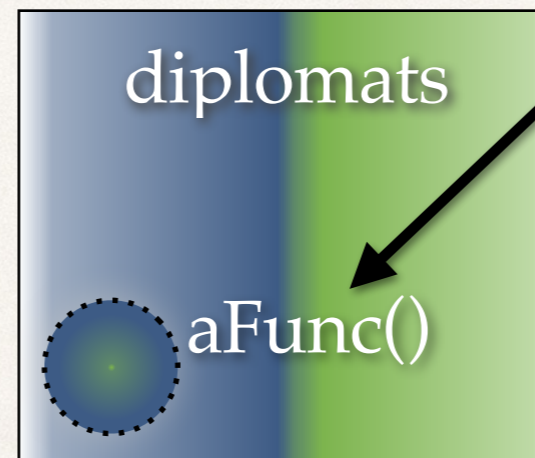


Diplomats



Diplomats

iOS App links against
diplomats - not iOS symbols!



XNU syscall
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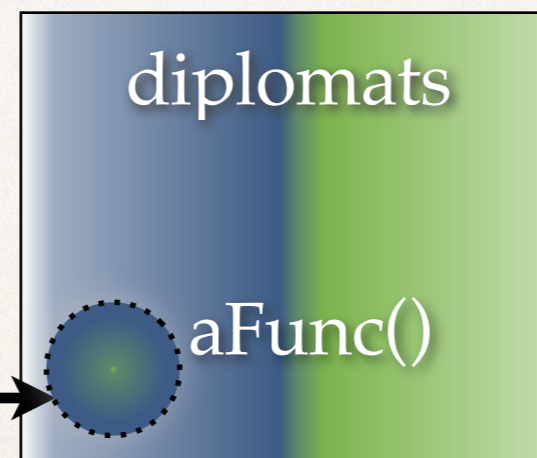
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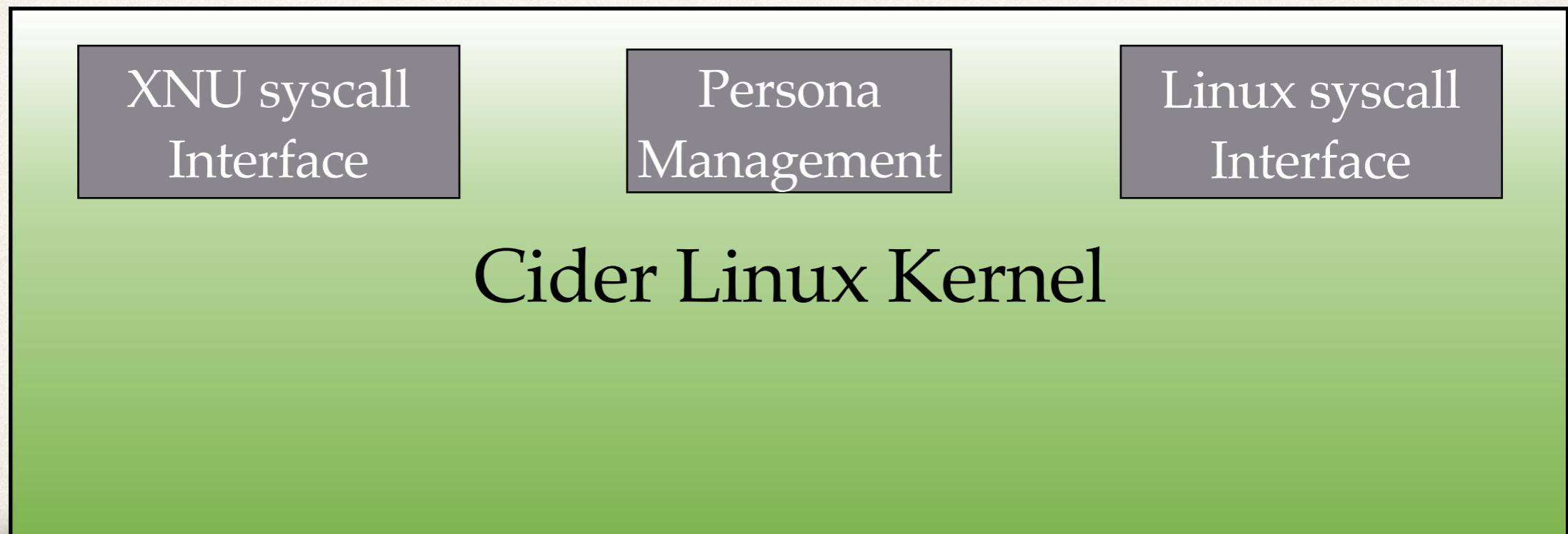
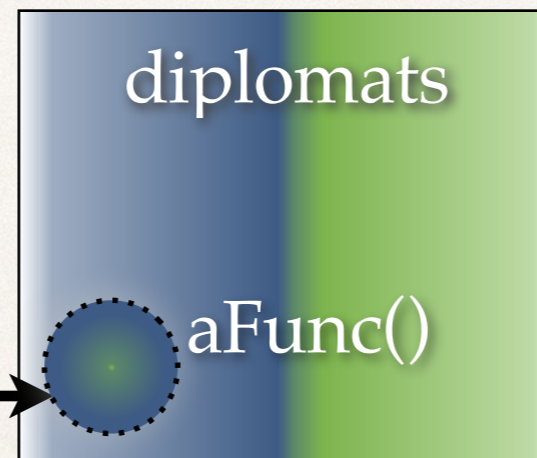
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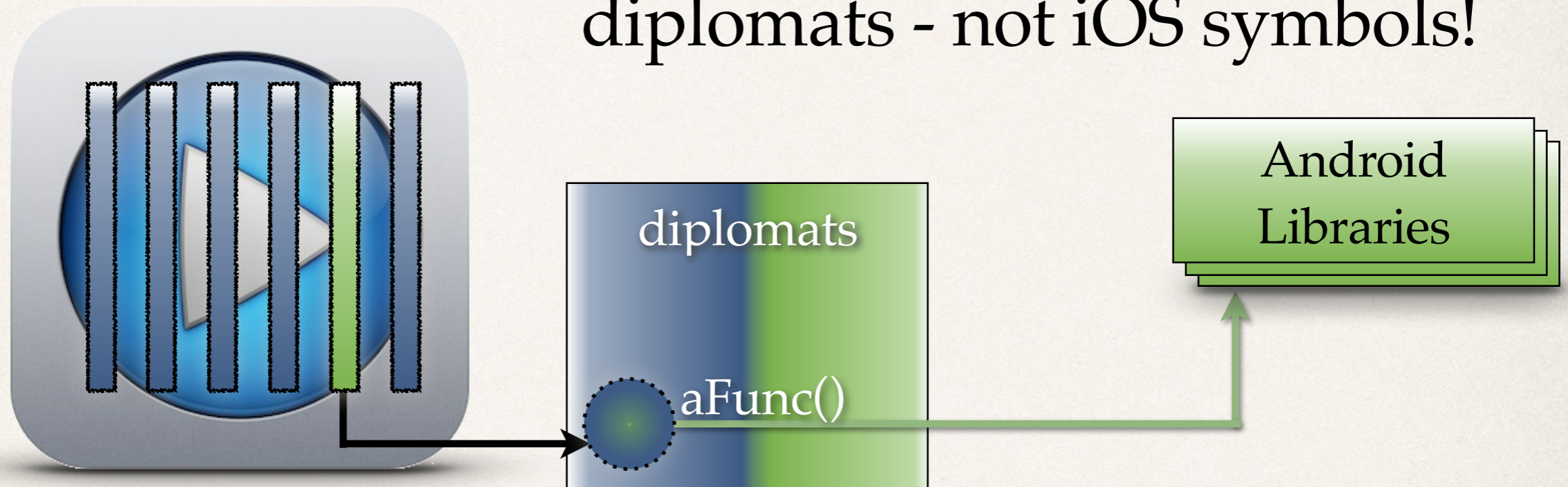
Diplomats

iOS App links against diplomats - not iOS symbols!



Diplomats

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XNU syscall
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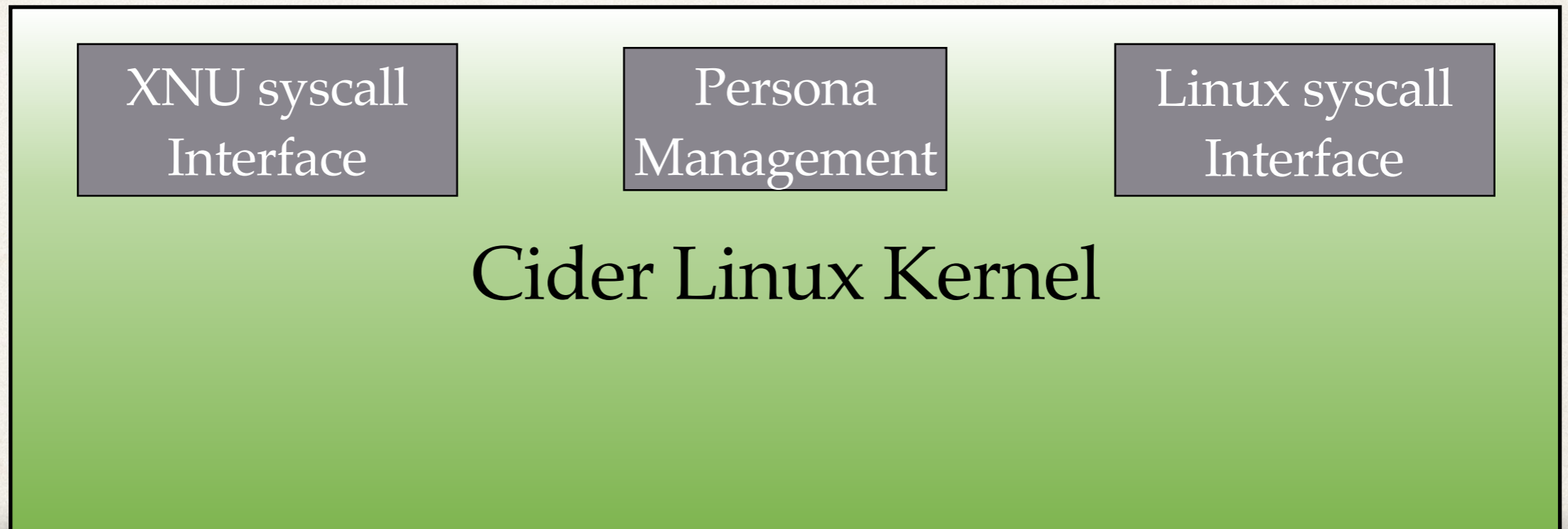
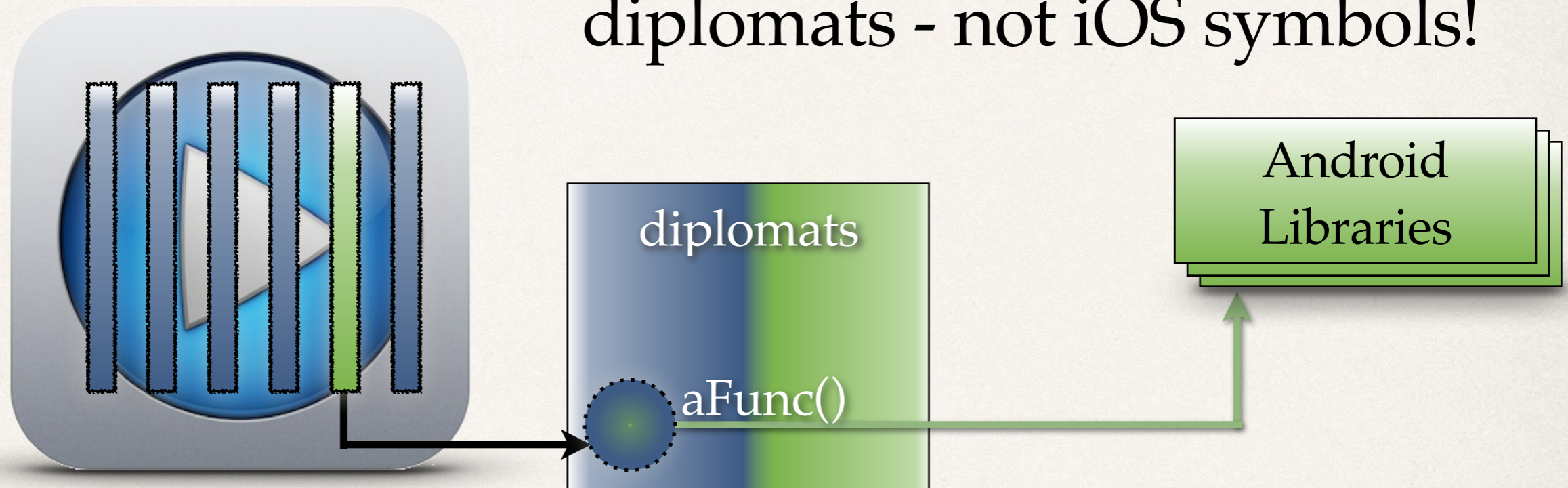
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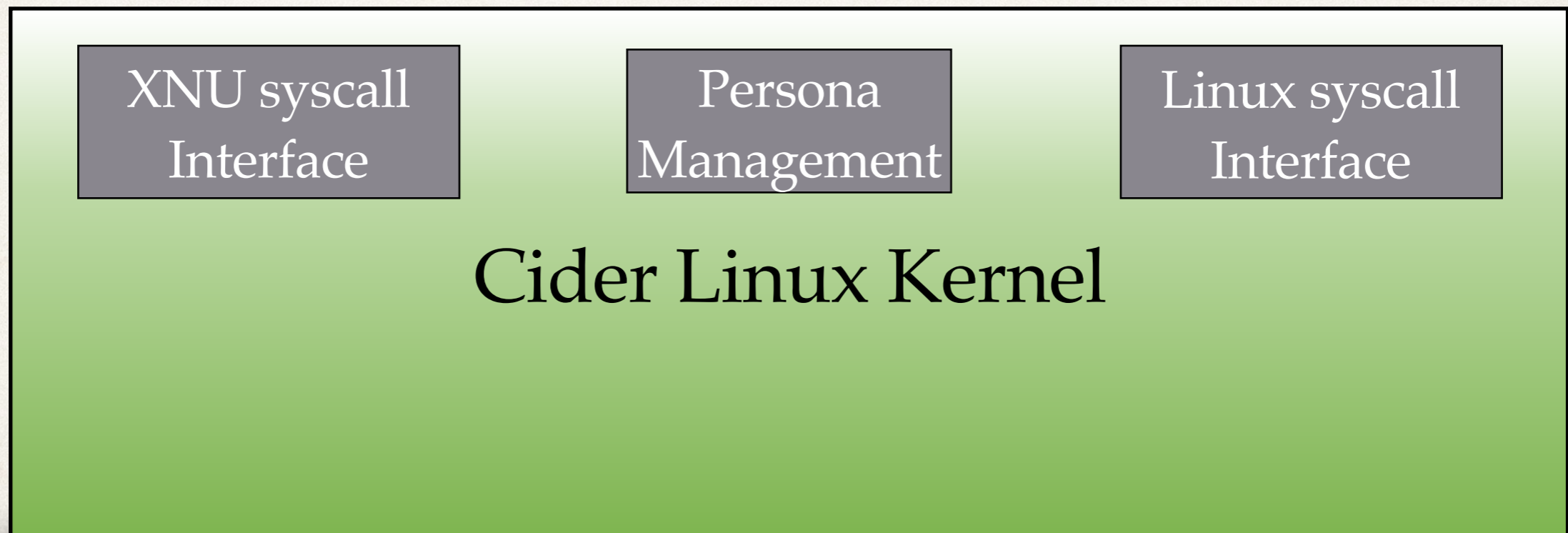
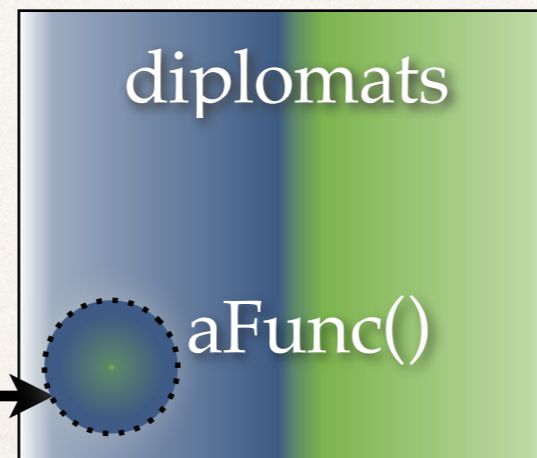
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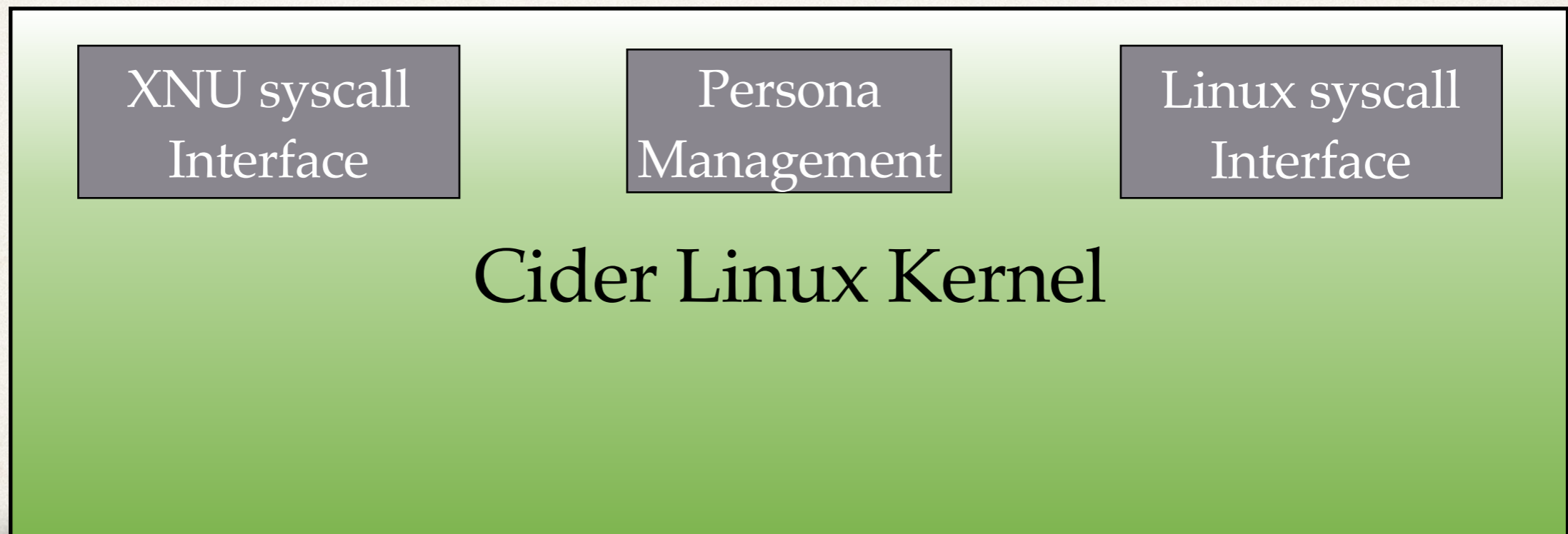
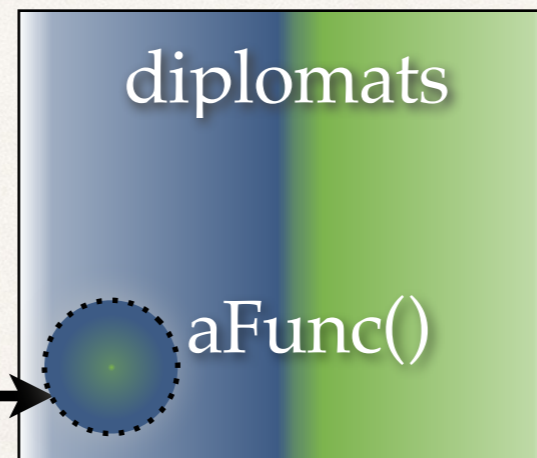
Diplomats

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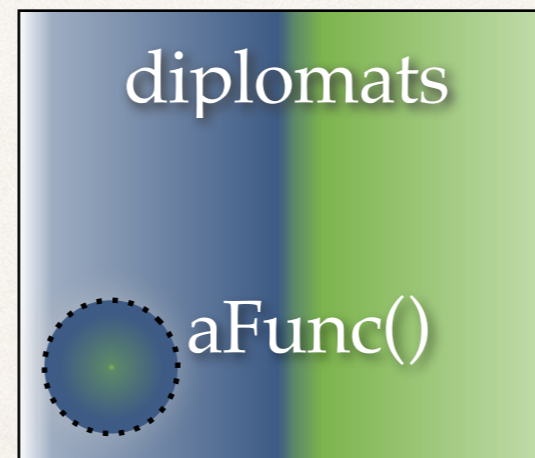
Diplomats

iOS App links against diplomats - not iOS symbols!



Diplomats

iOS App links against
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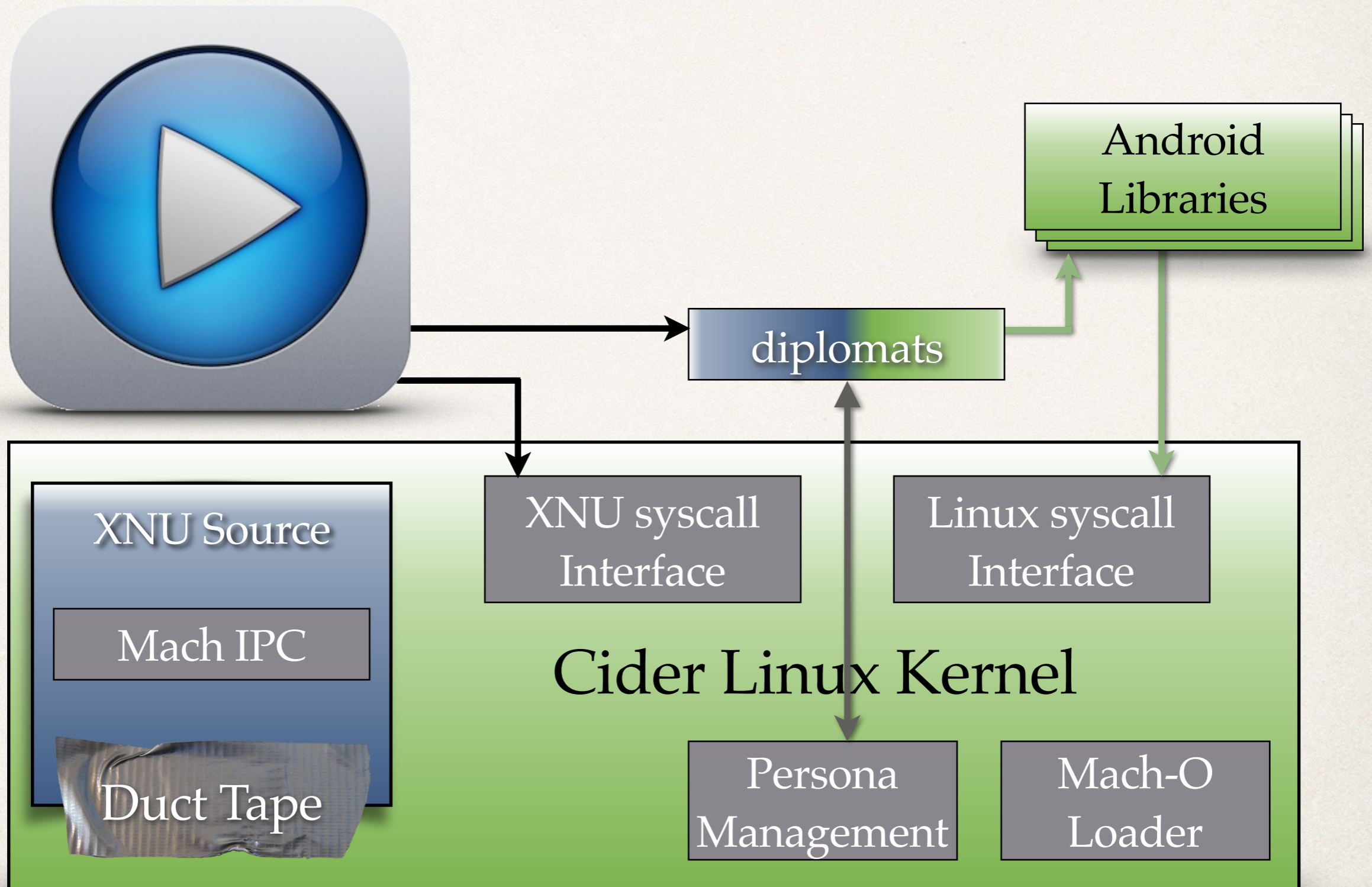


XNU syscall
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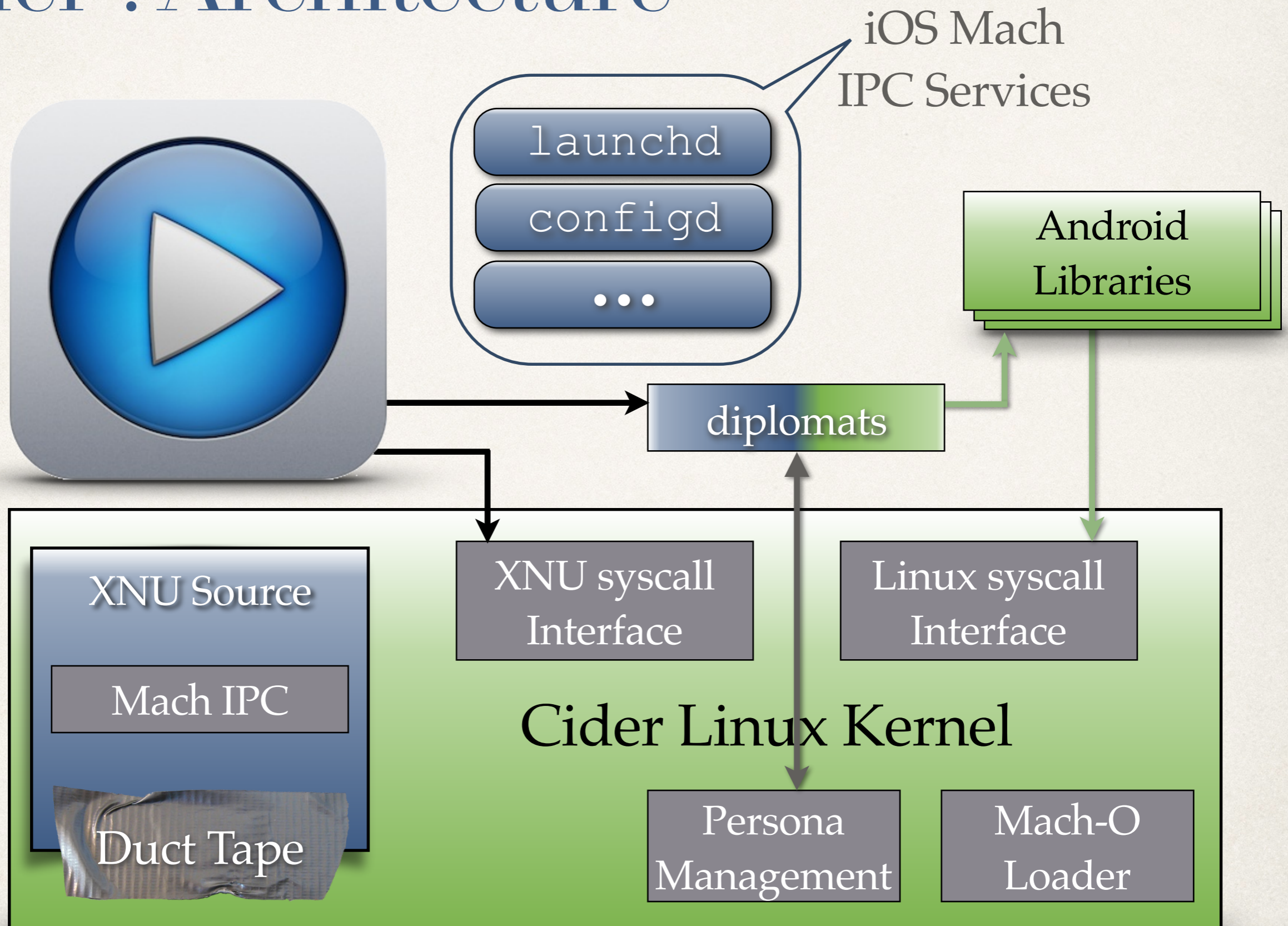
Persona
Management

Linux syscall
Interface

Cider Linux Kernel



Cider : Architecture



Cider: Prototype

Cider: Prototype

❖ Nexus 7 (Tegra)



Cider: Prototype

iOS Apps!

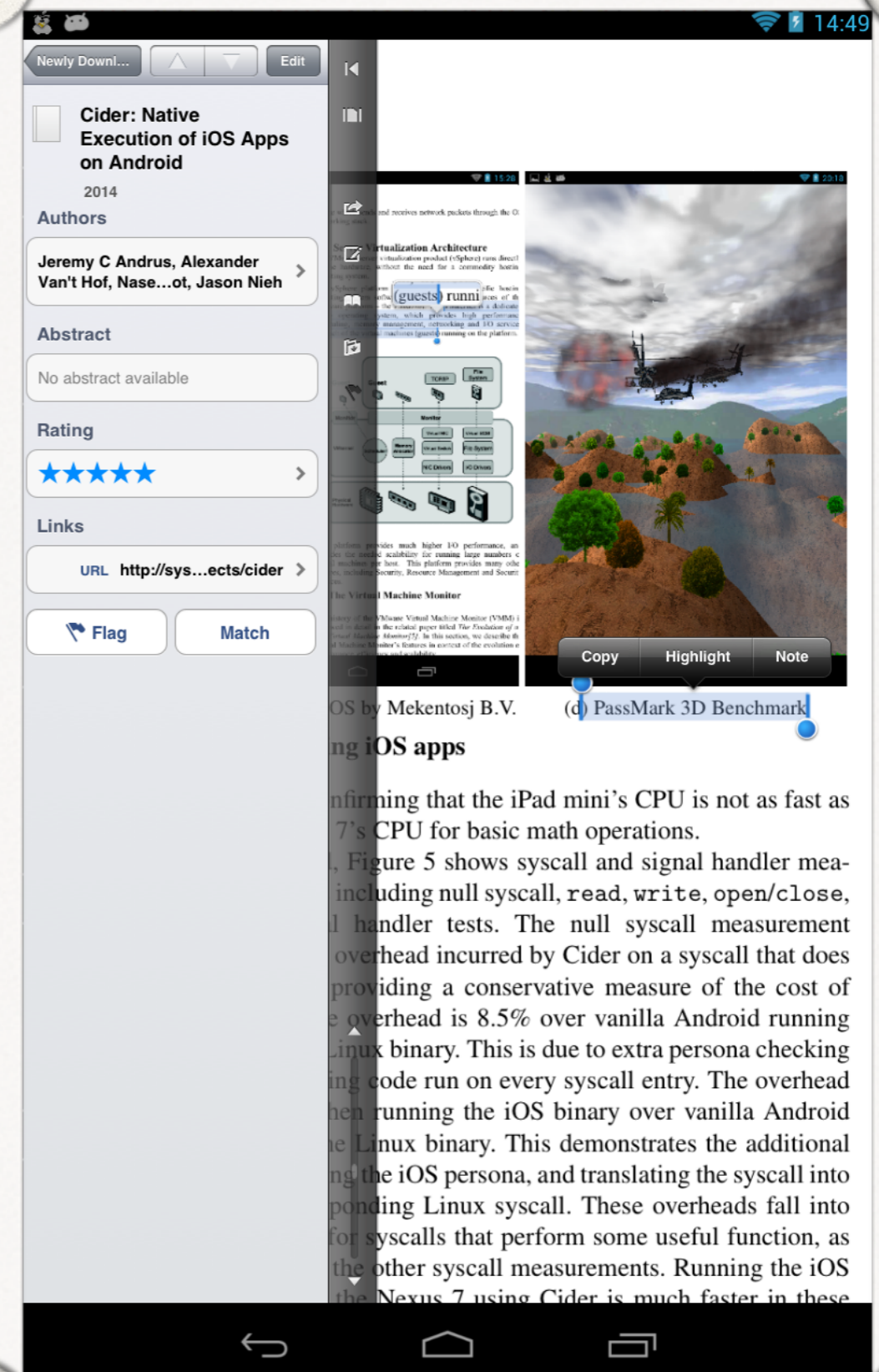
❖ Nexus 7 (Tegra)

→ Integrated iOS app launch

Android Apps!



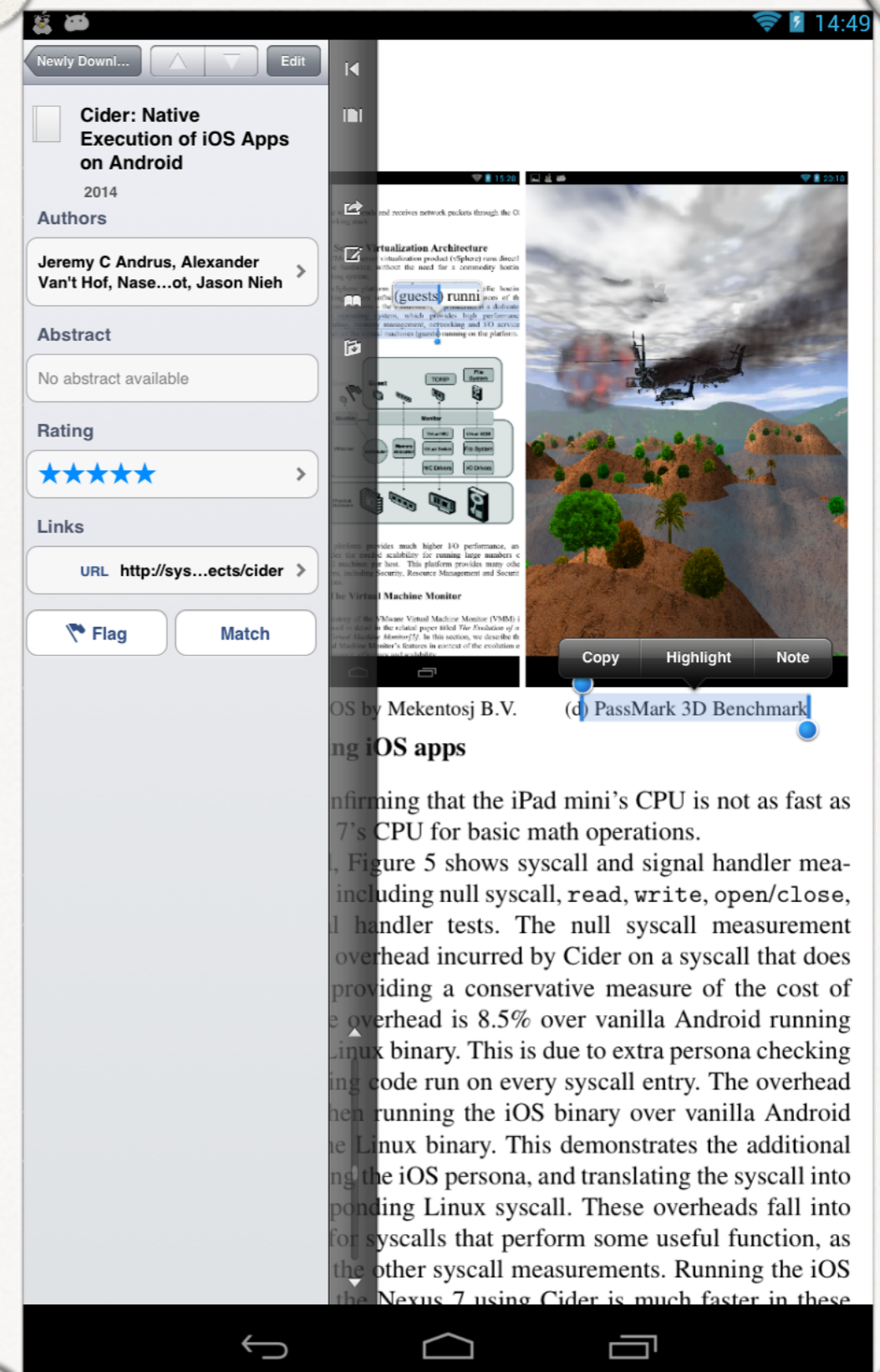
Cider: Prototype



Cider: Prototype

❖ Nexus 7 (Tegra)

- ➔ Full multi-touch support
- ➔ OpenGL for 2D / 3D graphics



Cider: Experimental Results

Cider: Experimental Results

- ❖ PassMark benchmark application

Cider: Experimental Results

- ❖ PassMark benchmark application
- ❖ Android App
 - ➔ Stock Nexus 7
 - ➔ Cider

Cider: Experimental Results

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- ❖ iOS App
 - ➔ Cider
 - ➔ iPad mini

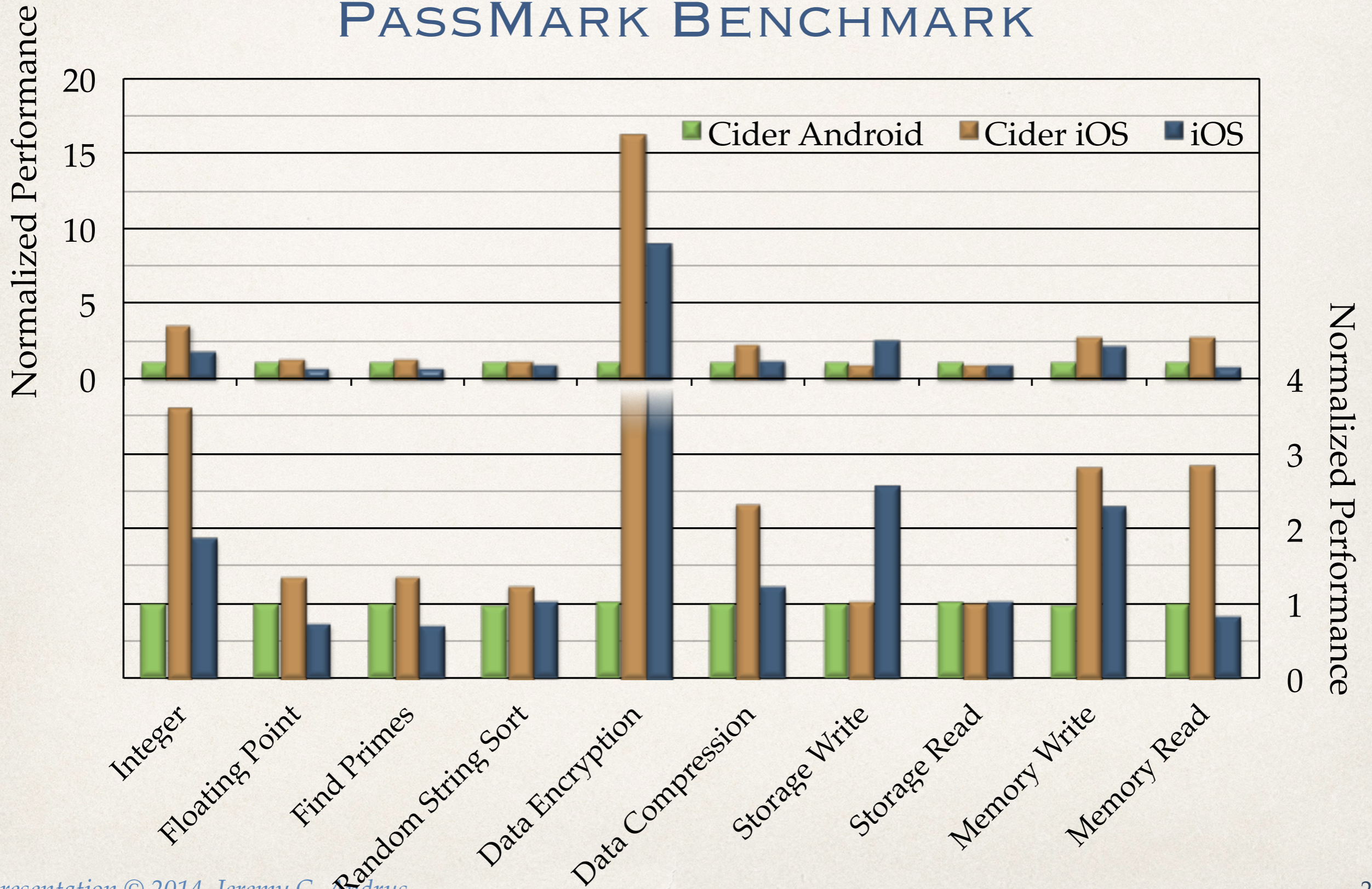
Cider: Experimental Results

Cider: Experimental Results

PASSMARK BENCHMARK

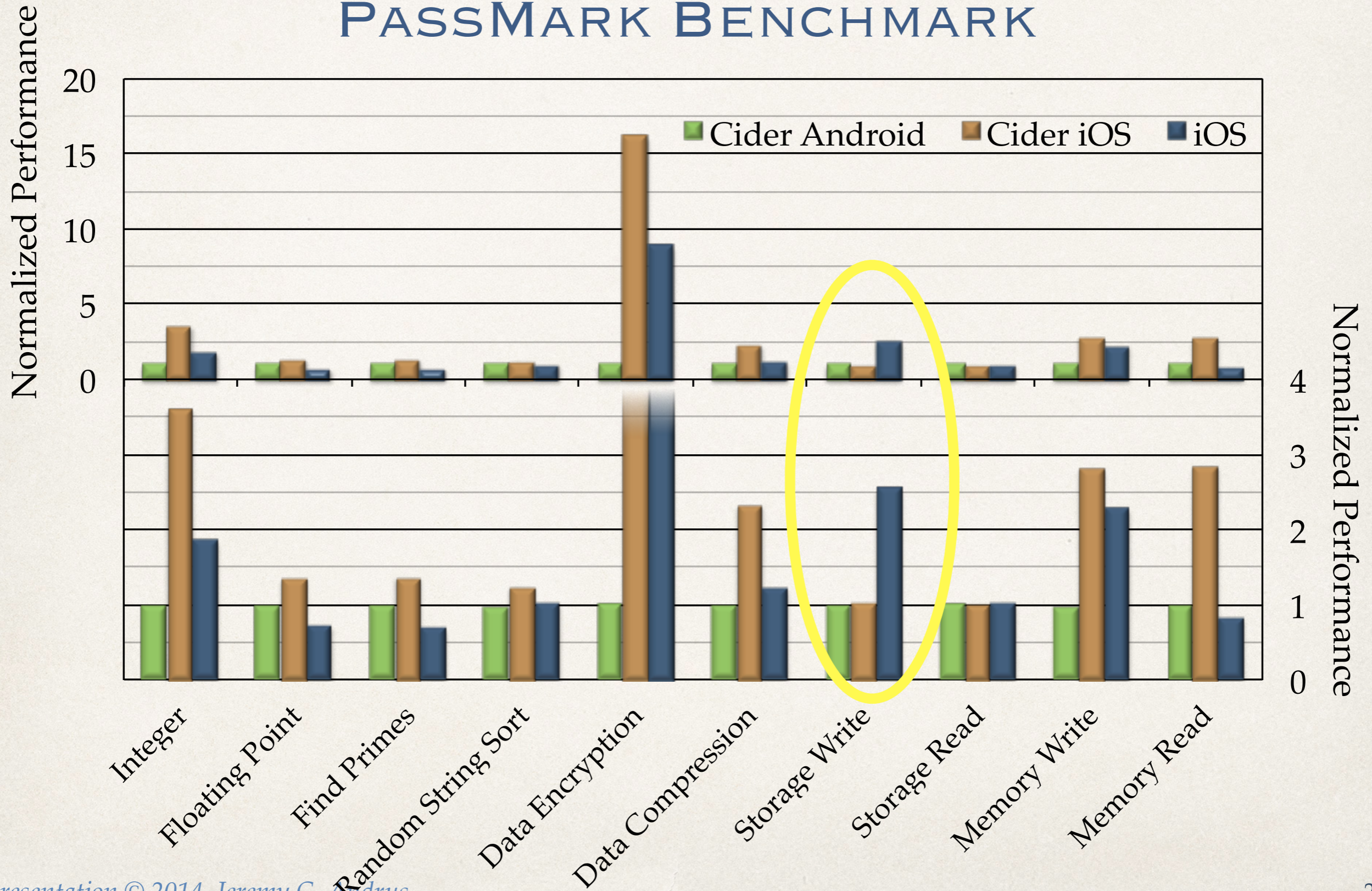
Cider: Experimental Results

PASSMARK BENCHMARK



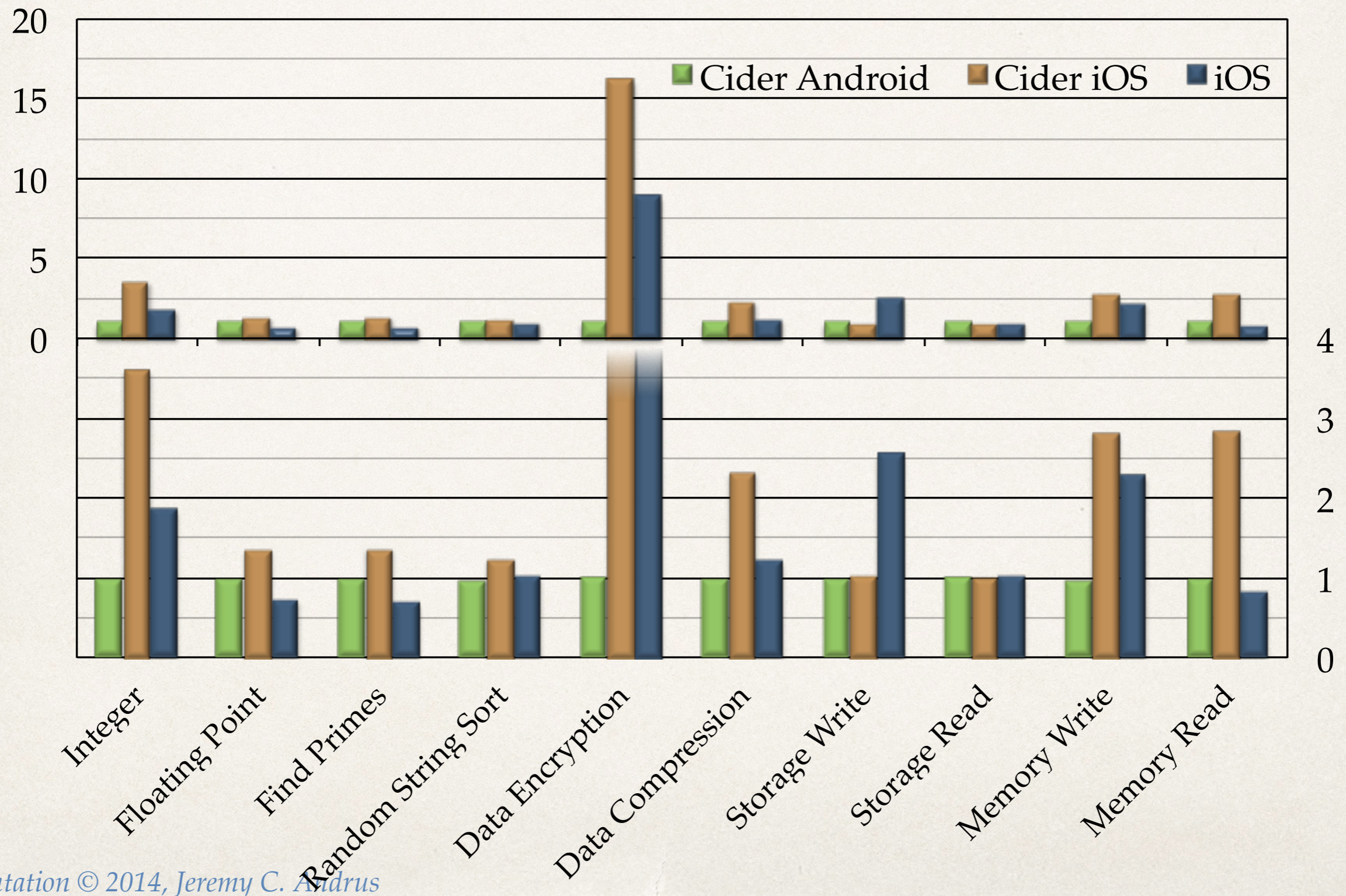
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PASSMARK BENCHMARK



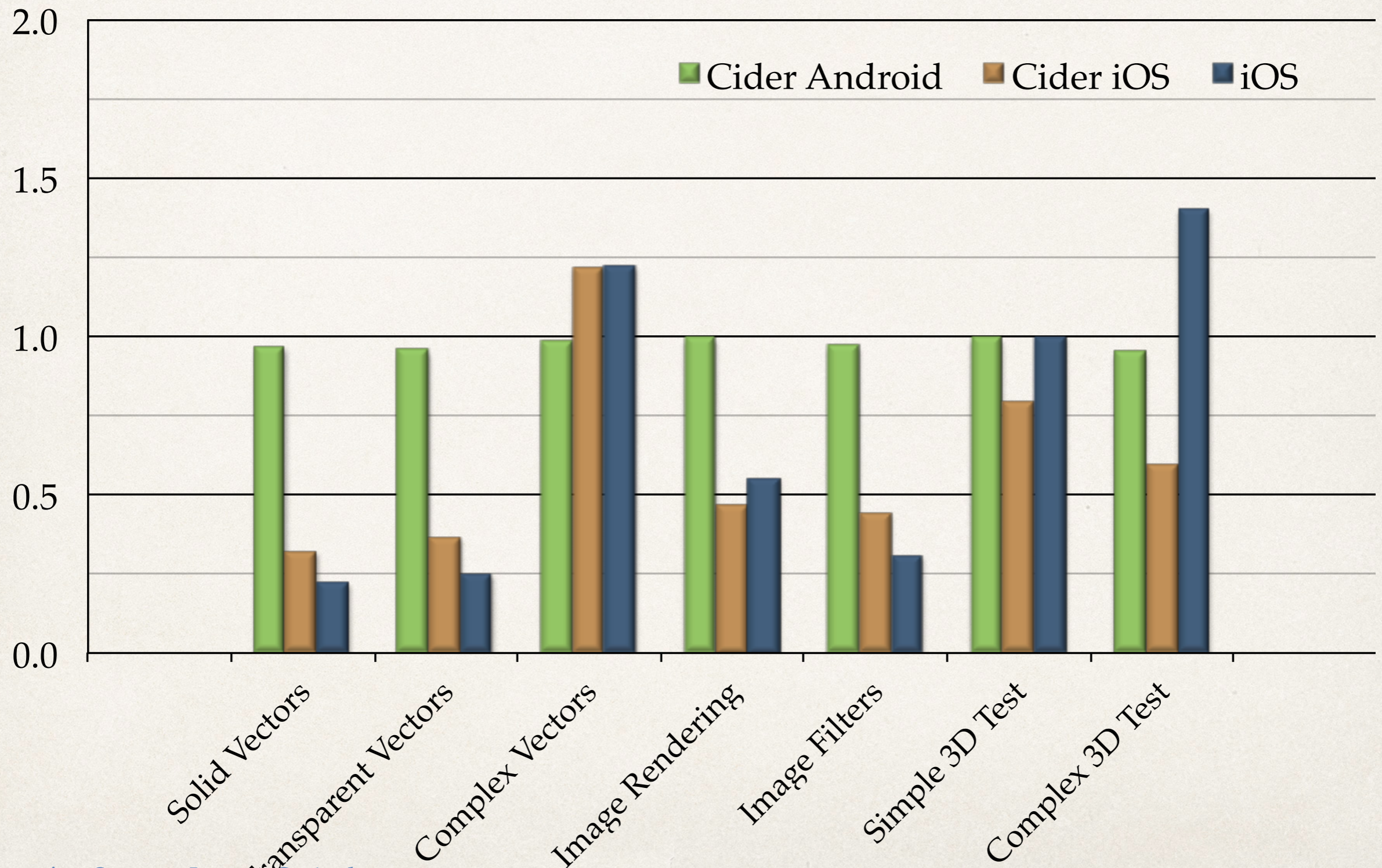
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PASSMARK BENCHMARK



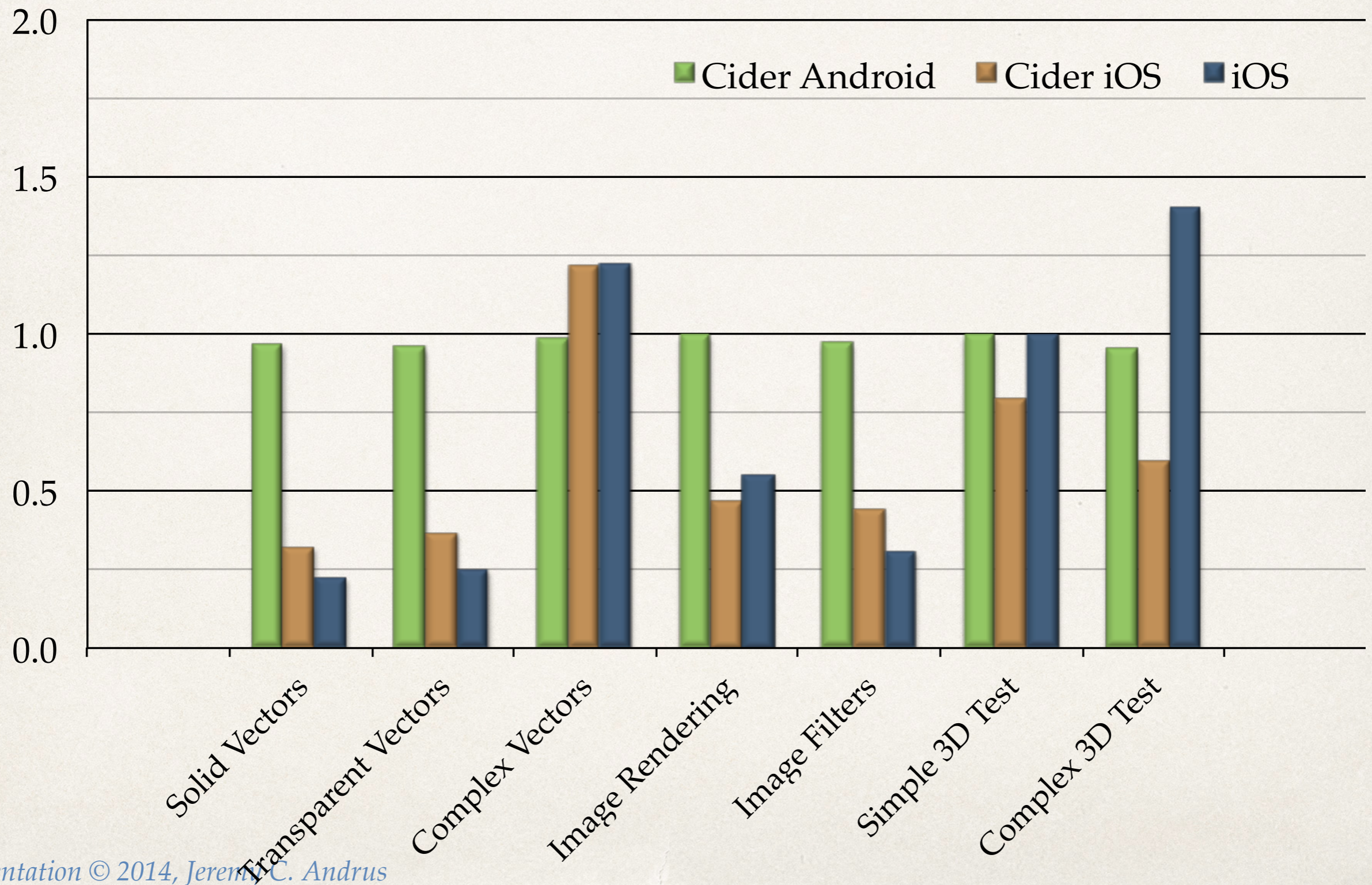
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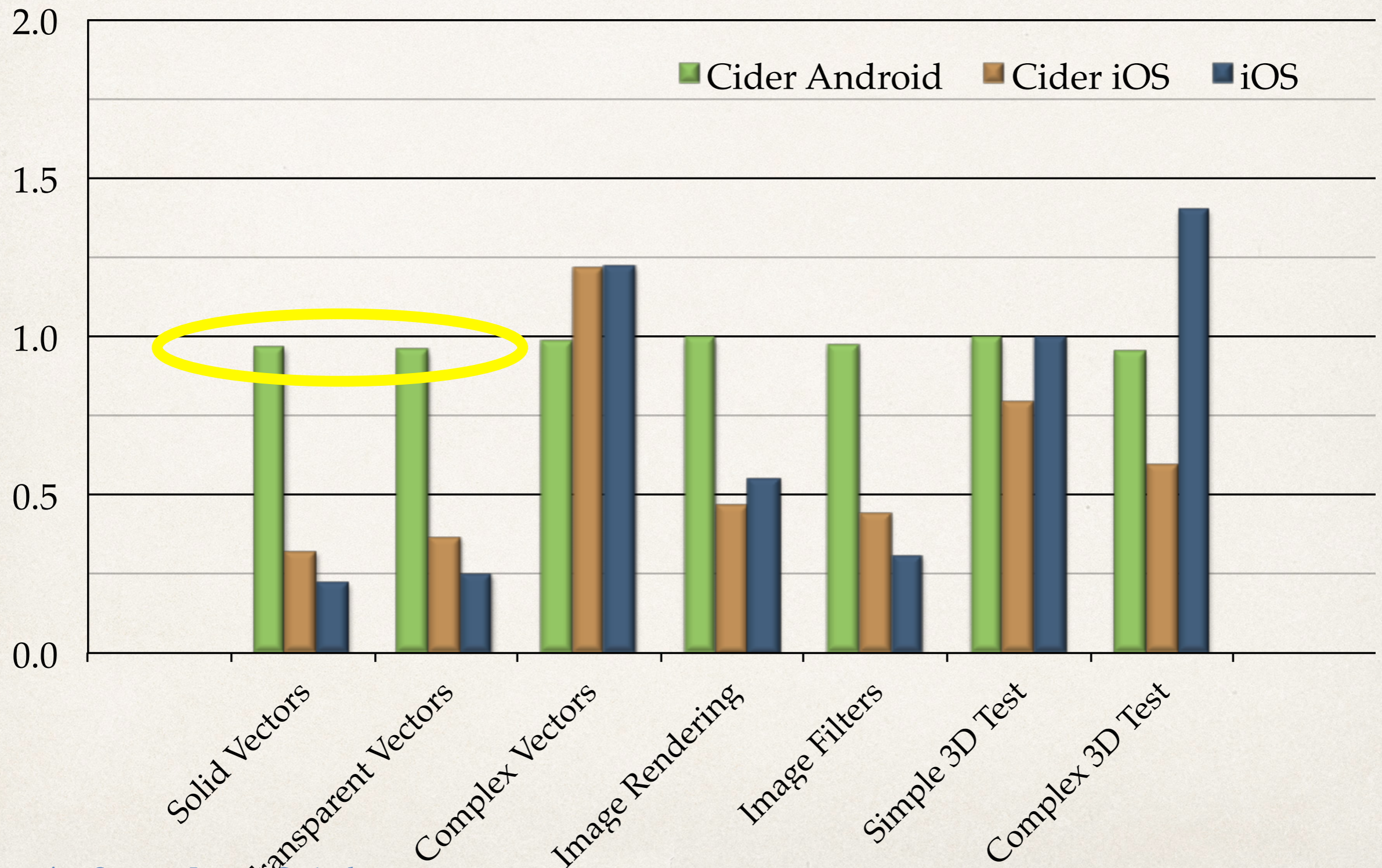
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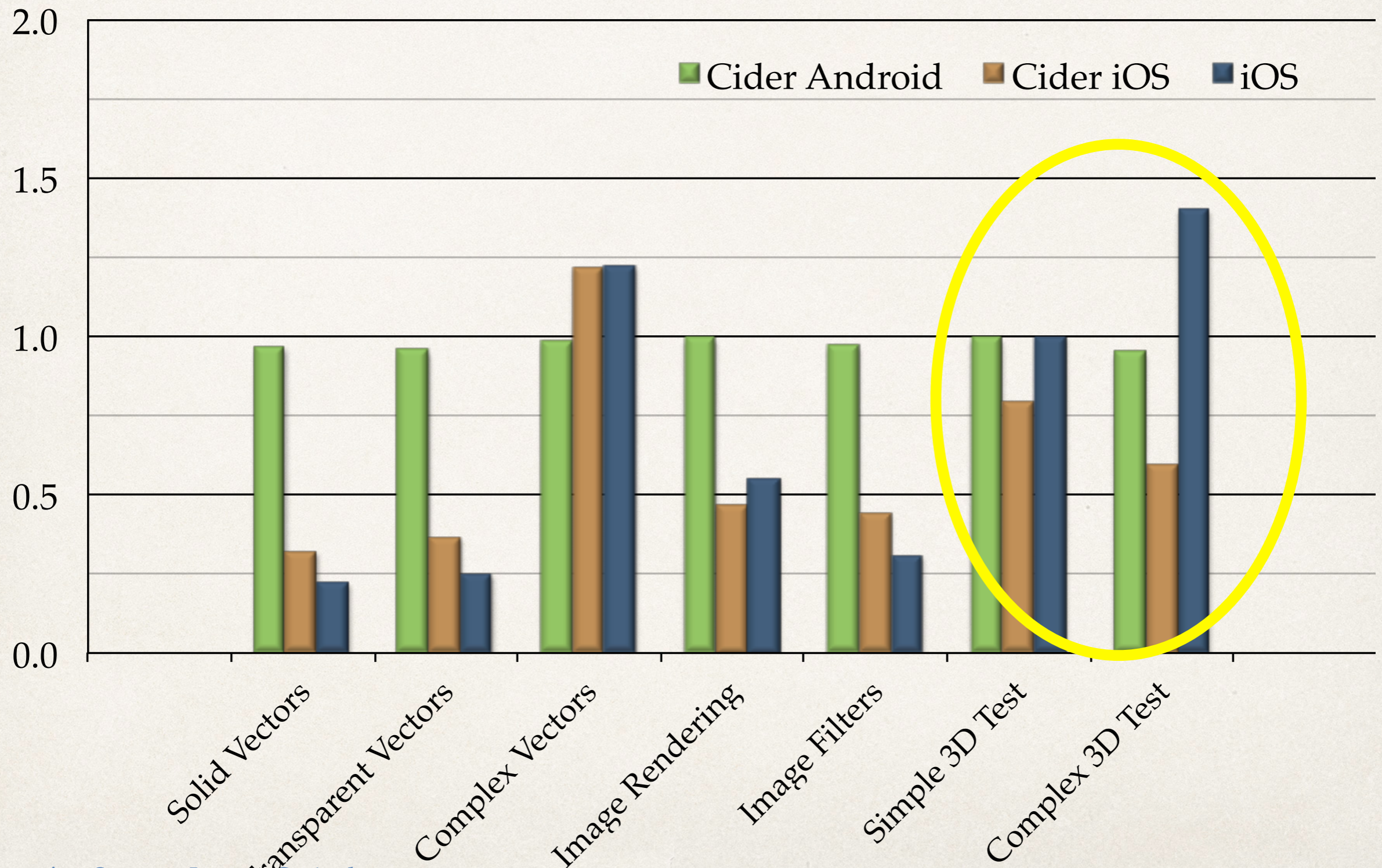
Cider: Experimental Results

PASSMARK BENCHMARK



Cider: Experimental Results

PASSMARK BENCHMARK



Conclusion

- ❖ Direct execution of unmodified iOS apps



Conclusion

- ❖ Direct execution of unmodified iOS apps
 - ➔ Per-thread Personas
 - ➔ Duct Tape
 - ➔ Diplomats





<http://systems.cs.columbia.edu/projects/cider>

Logo design by: Steve Lovelace (<http://steve-lovelace.com/>)

Thank You



<http://systems.cs.columbia.edu/projects/cider>

Logo design by: Steve Lovelace (<http://steve-lovelace.com/>)