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L4/Darwin: Evolving UNIX

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Outline

1. Project Overview
2. BSD on the Mach microkernel
3. Porting Darwin to the L4 microkernel
4. Project Status

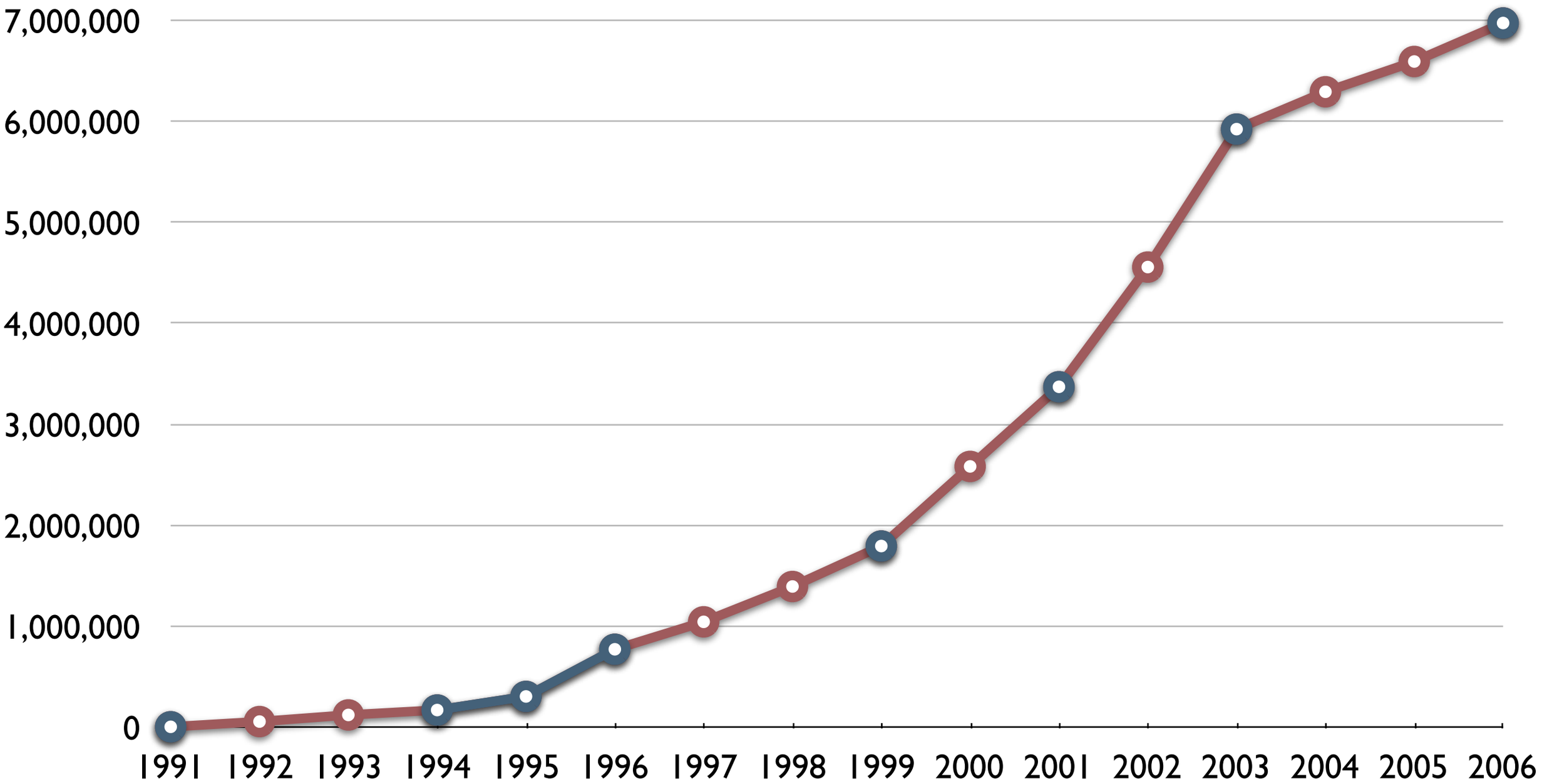
Darbat Overview

- Para-virtualised Darwin kernel
- L4 µ-kernel hypervisor
- Isolated kernel and device drivers
- Standard virtualisation benefits

Why?

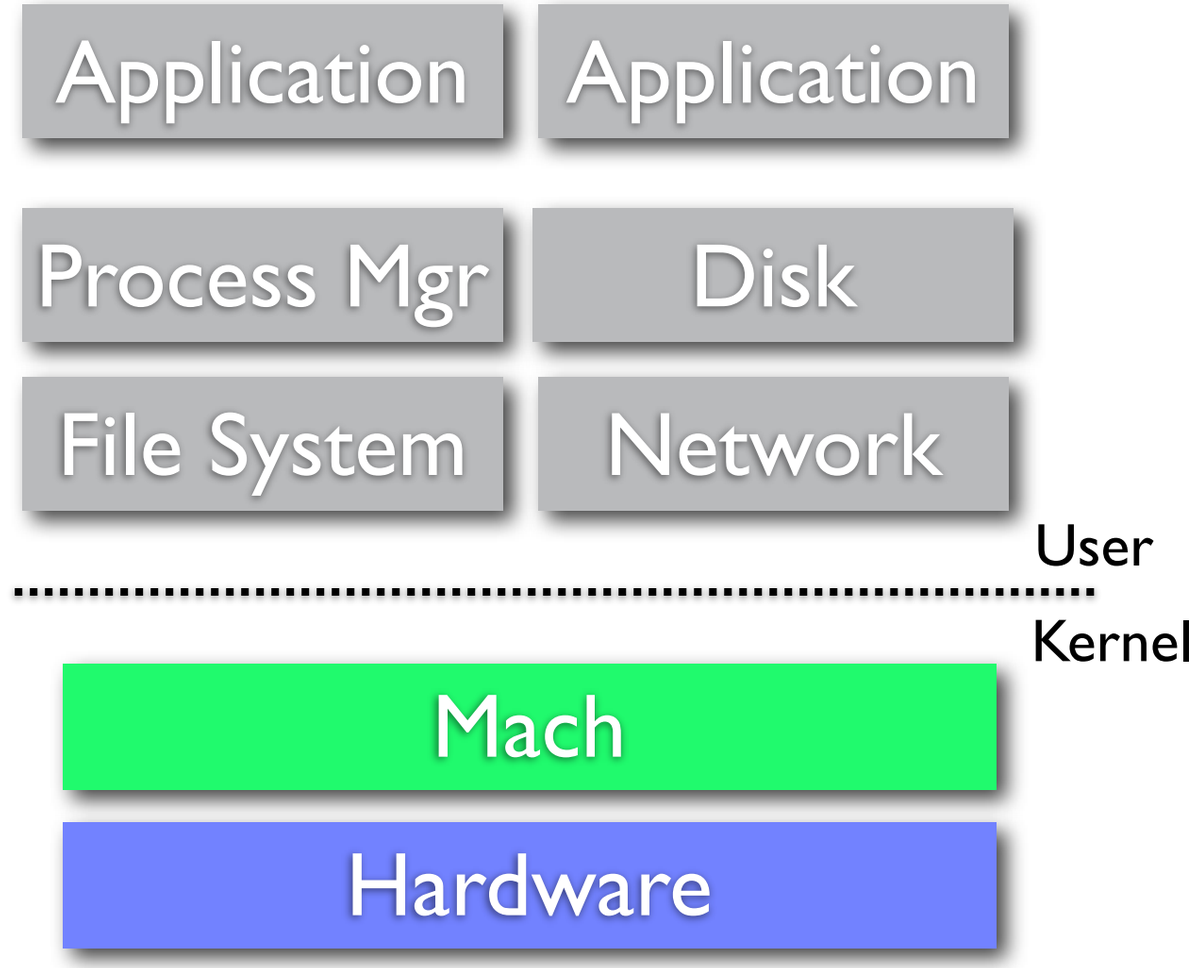
- Virtualisation
- Flexibility
- Robustness
- Code size

Linux Kernel Size (LoC)



Mach

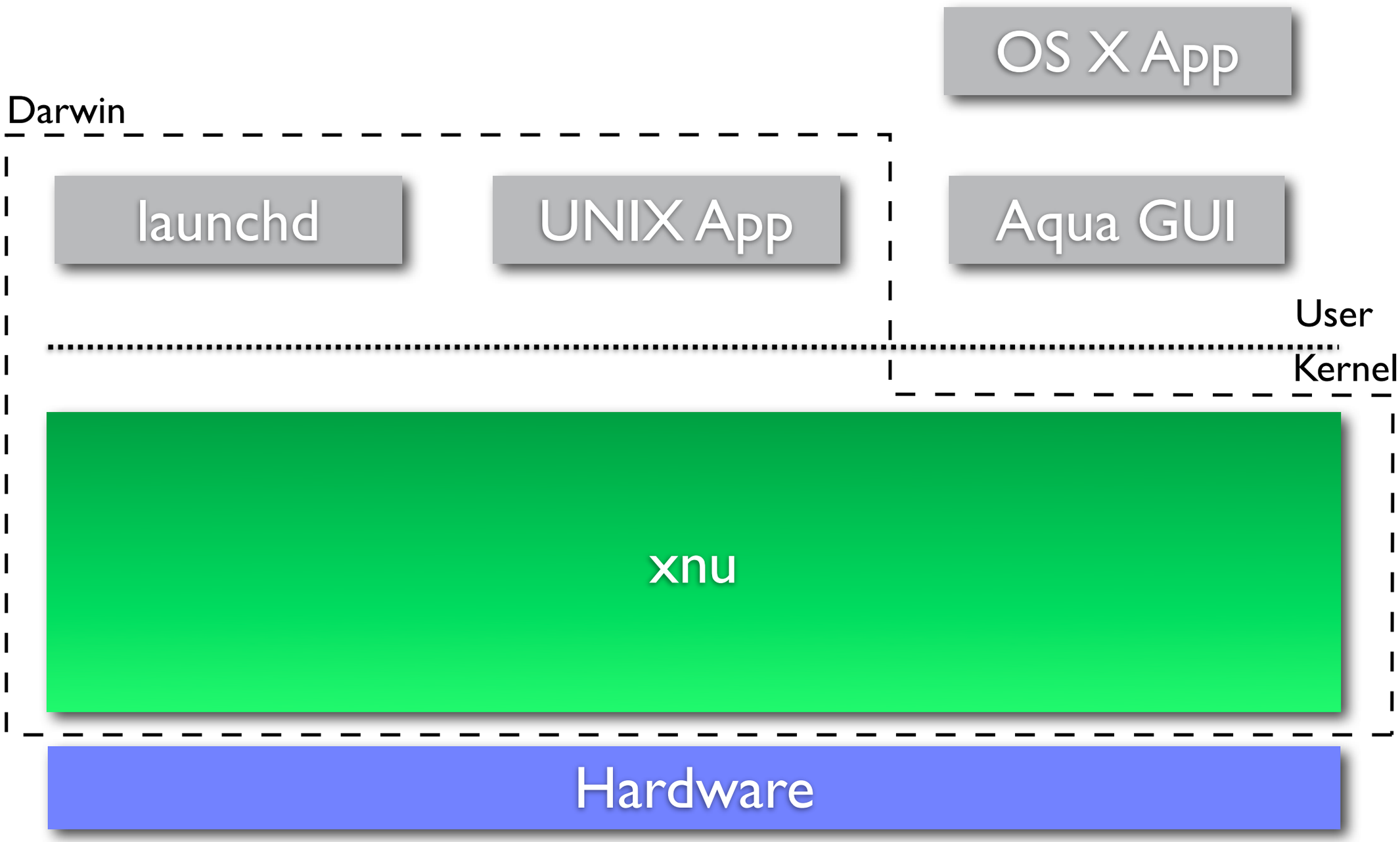
- Once a hot research topic
- Many attempts at BSD on Mach
- Darwin is a monolithic Mach kernel
- Gave microkernels a bad name



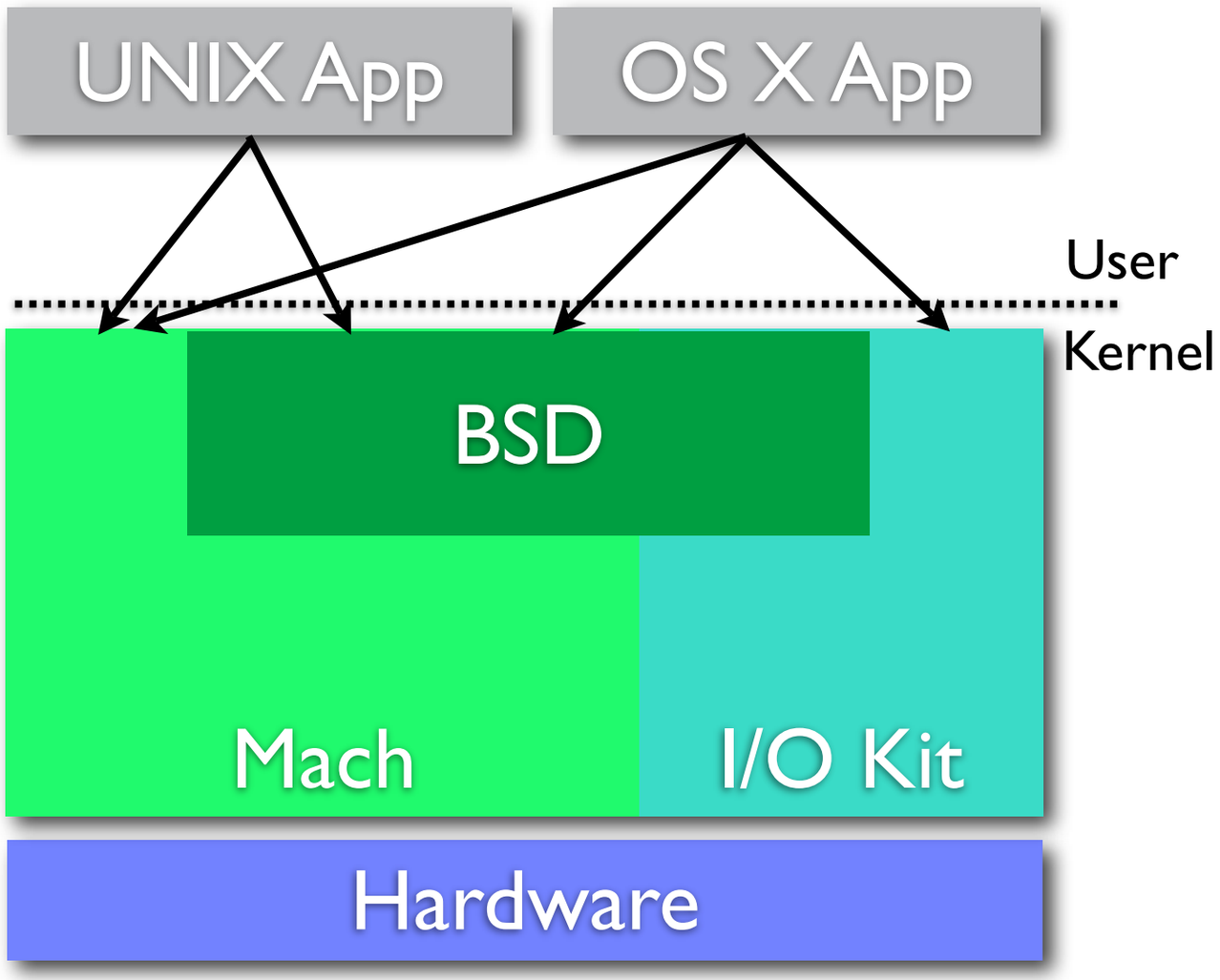
What's in a kernel?

- XML parser
- Decompression algorithms
- Linker
- Network routing
- Device drivers
- Strings

Mac OS X Architecture

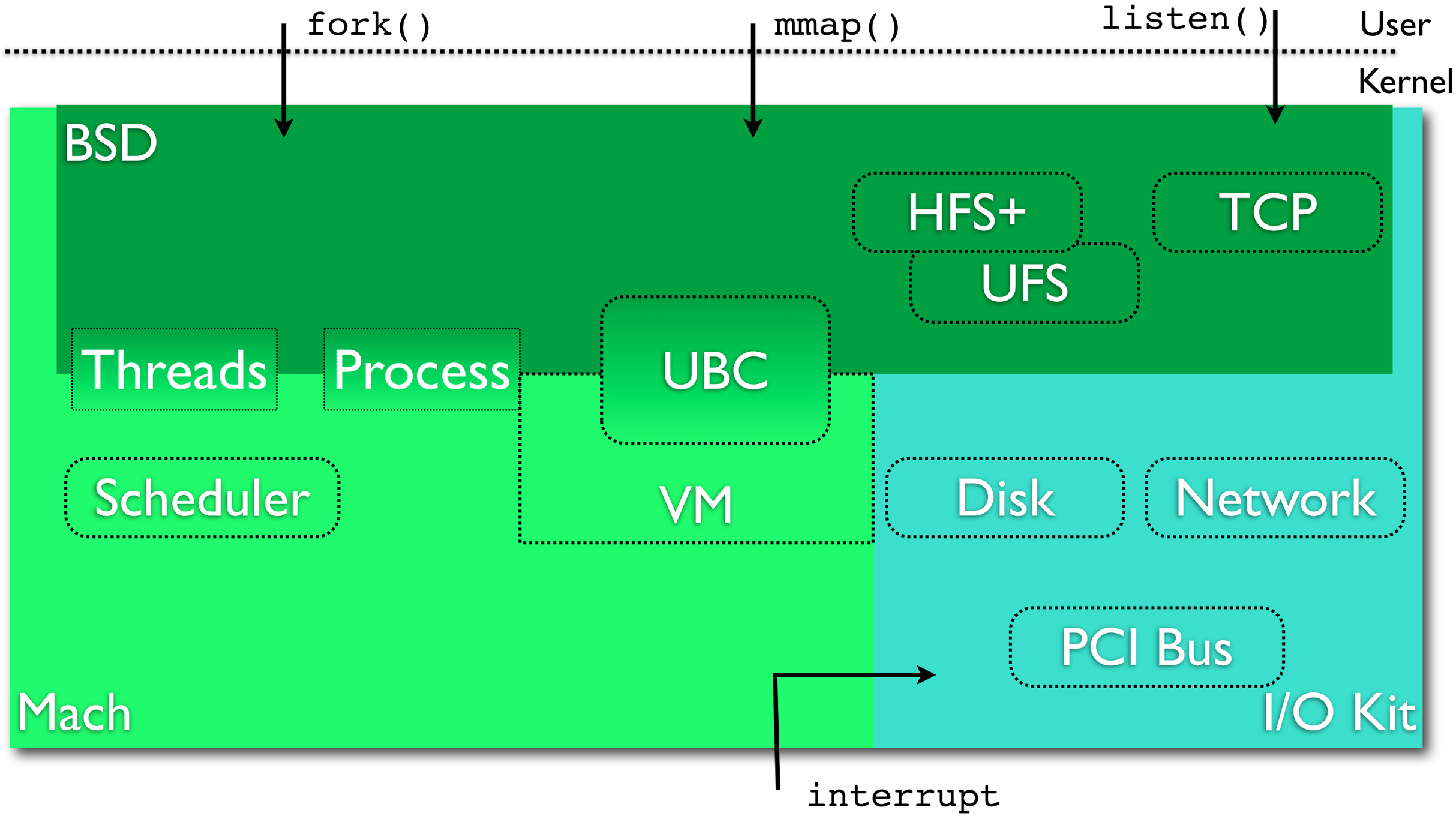


Darwin

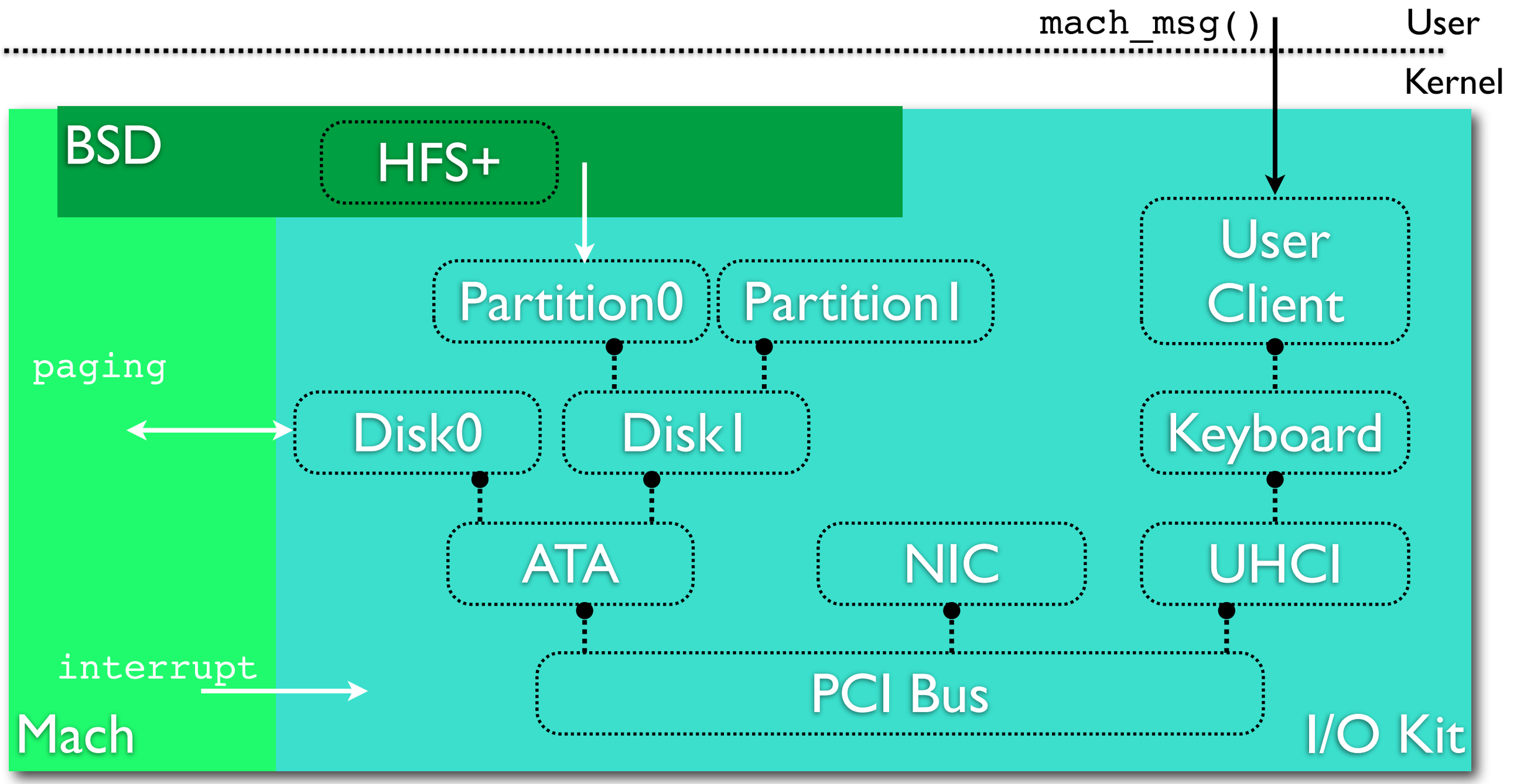


- Unique kernel design
  - Mach 3.0 µ-kernel
  - 4.4 BSD derivative
  - I/O Kit device drivers
- Mac OS X applications
- Full FreeBSD 5 UNIX environment

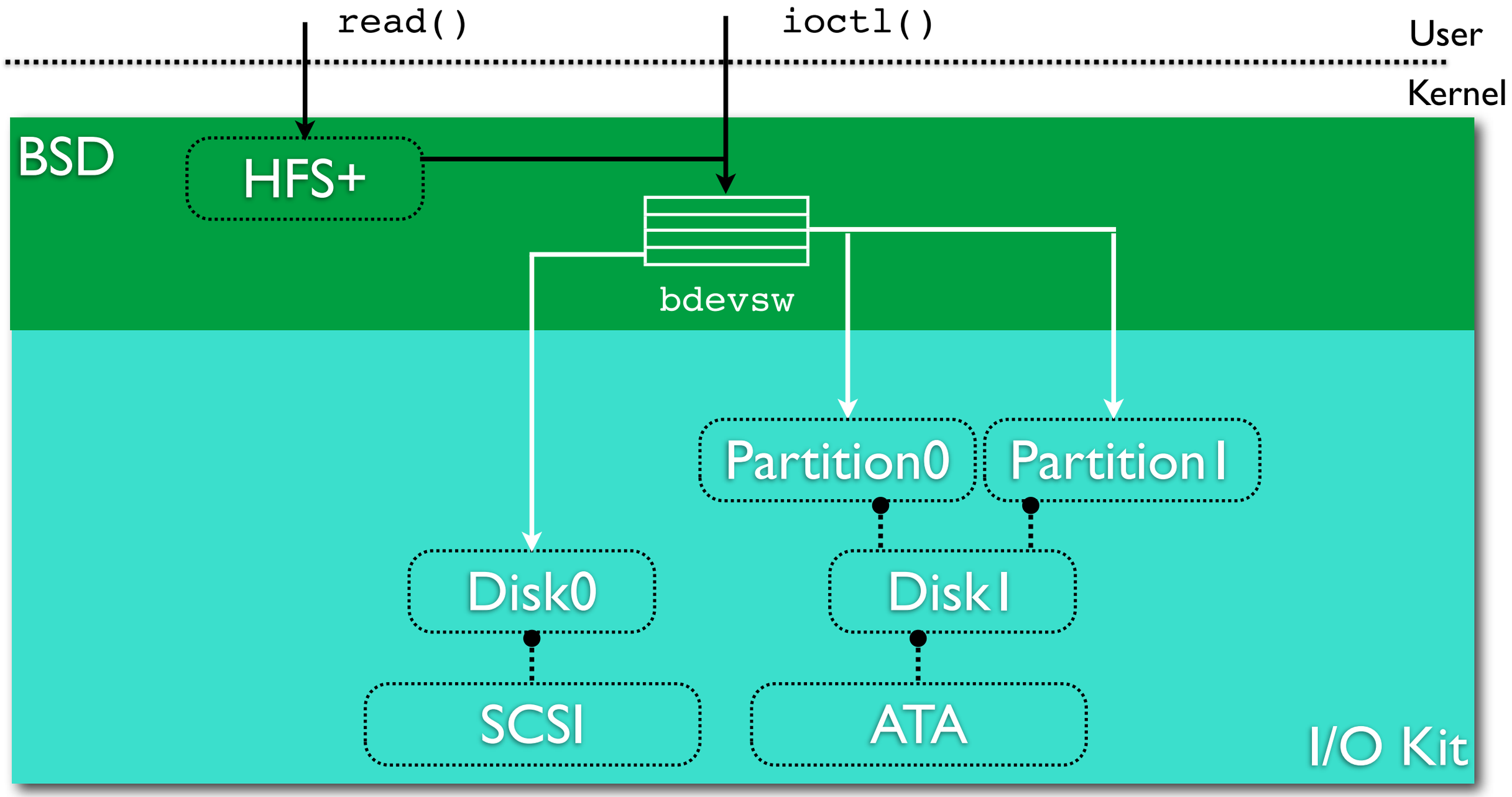
BSD Layer


fork()
mmap()
listen()
User
Kernel
BSD
HFS+
TCP
UFS
Threads
Process
UBC
Scheduler
VM
Disk
Network
PCI Bus
Mach
I/O Kit
interrupt

The I/O Kit


mach_msg()
User
Kernel
BSD
HFS+
Partition0
Partition1
User Client
paging
Disk0
Disk1
Keyboard
ATA
NIC
UHCI
interrupt
PCI Bus
Mach
I/O Kit

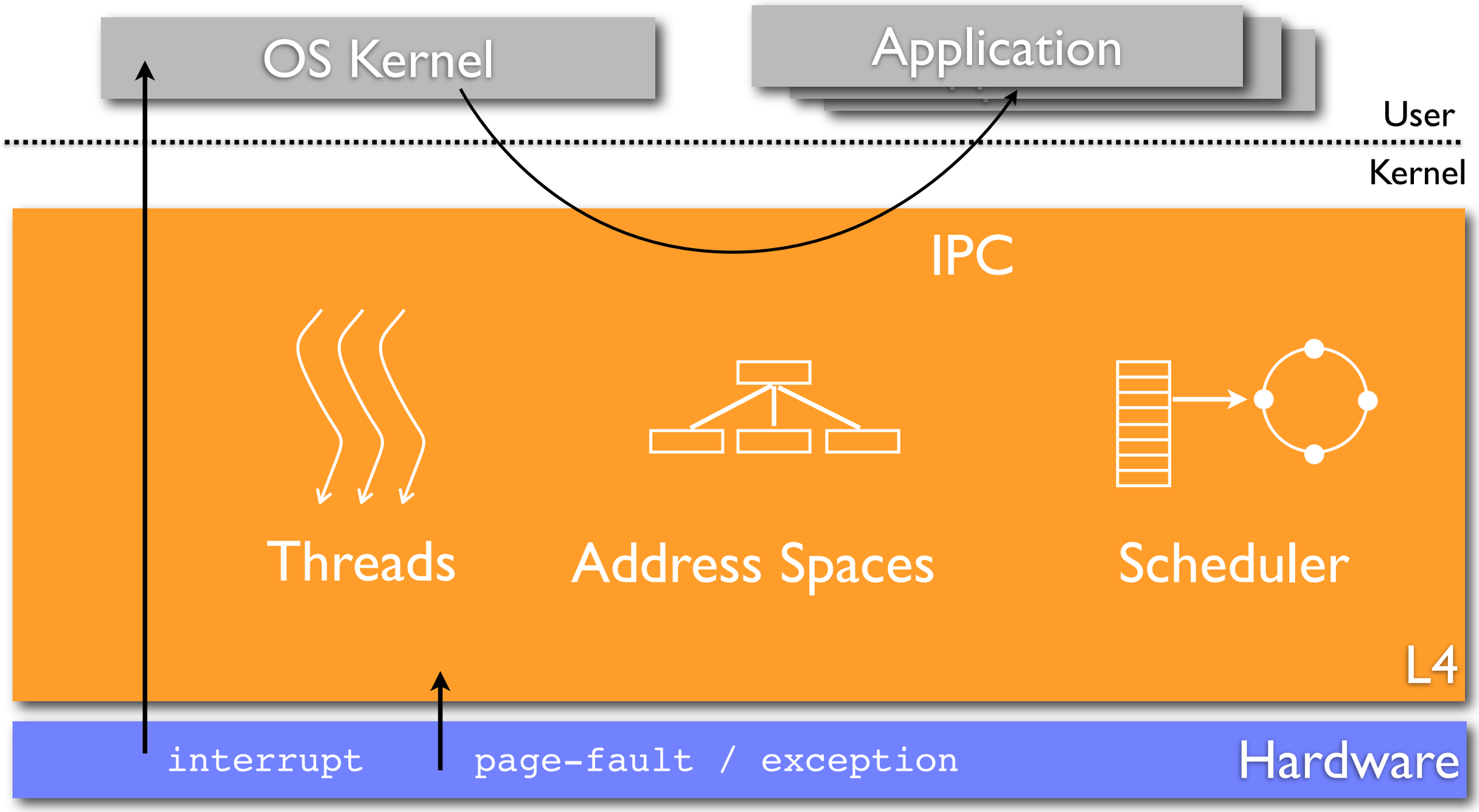
BSD and I/O Kit



L4

- 2nd generation u-kernel
- Learn from mistakes of Mach
- Pay attention to cache, TLB, complexity
- Make microkernels work
- 10-20x performance improvement over Mach

L4 µ-kernel



★not to scale

Darbat

- Decompose Darwin kernel
- Tackle complexity problem
- Add flexibility
- Maintain (or improve) performance
- All with binary compatibility

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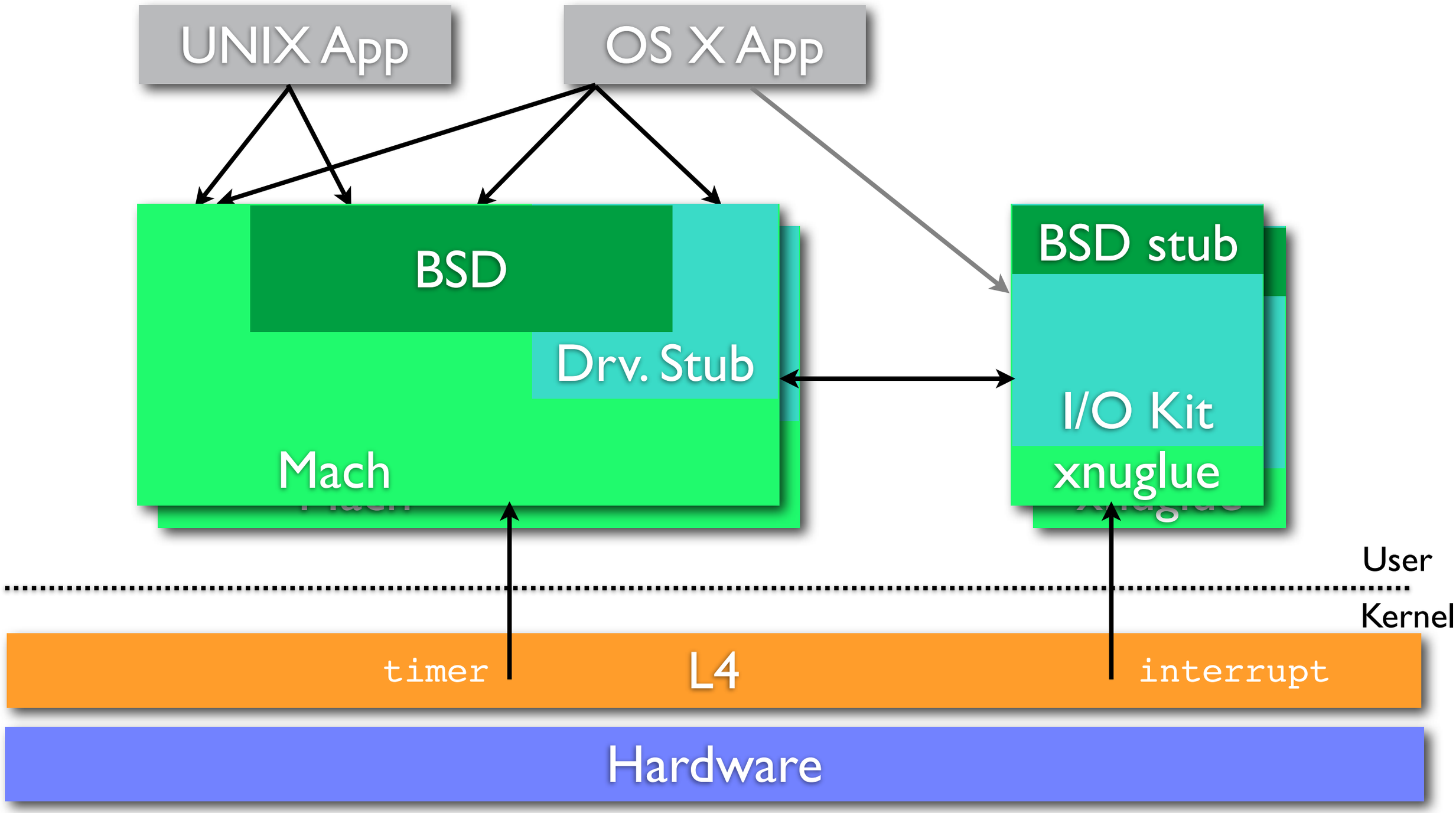
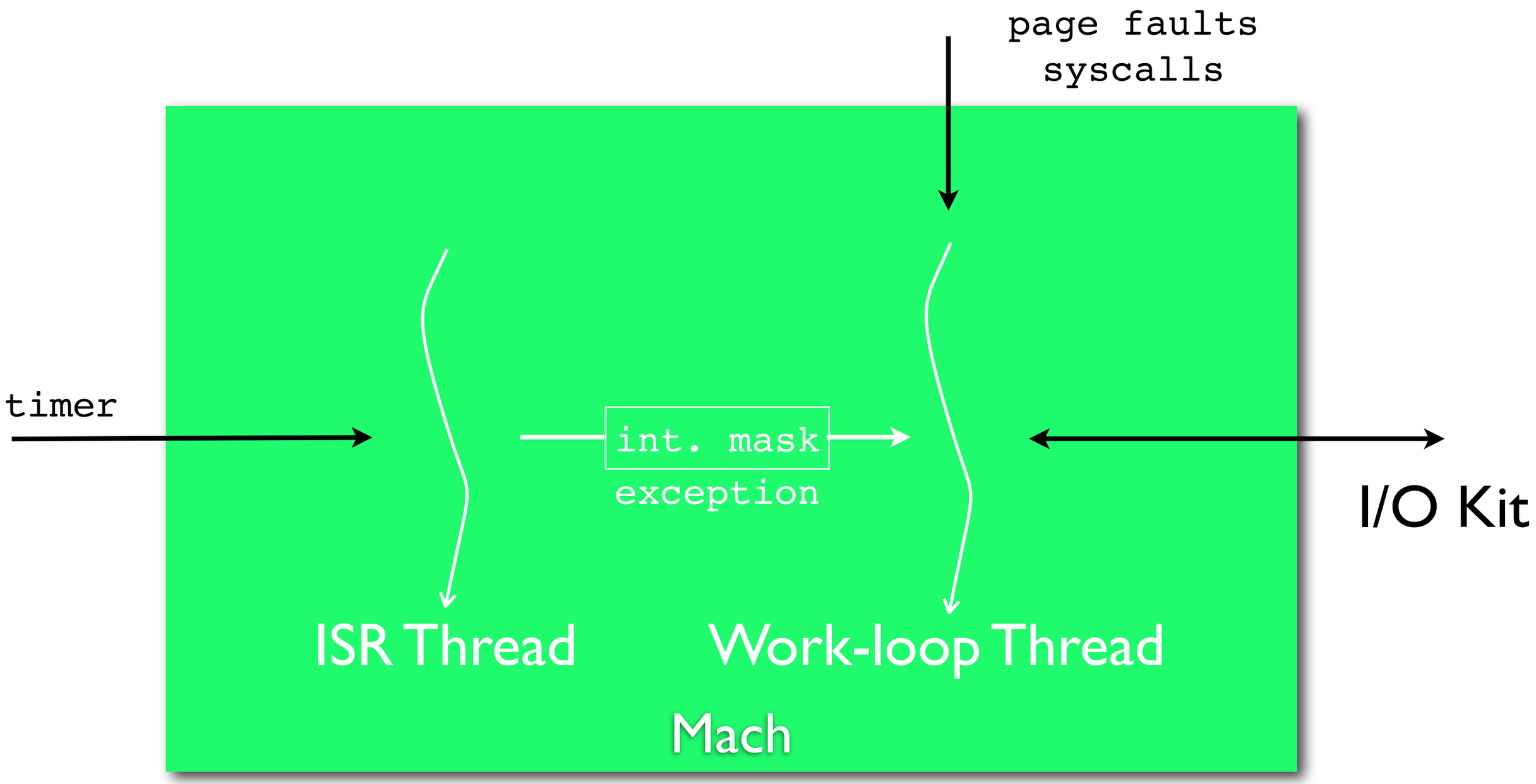
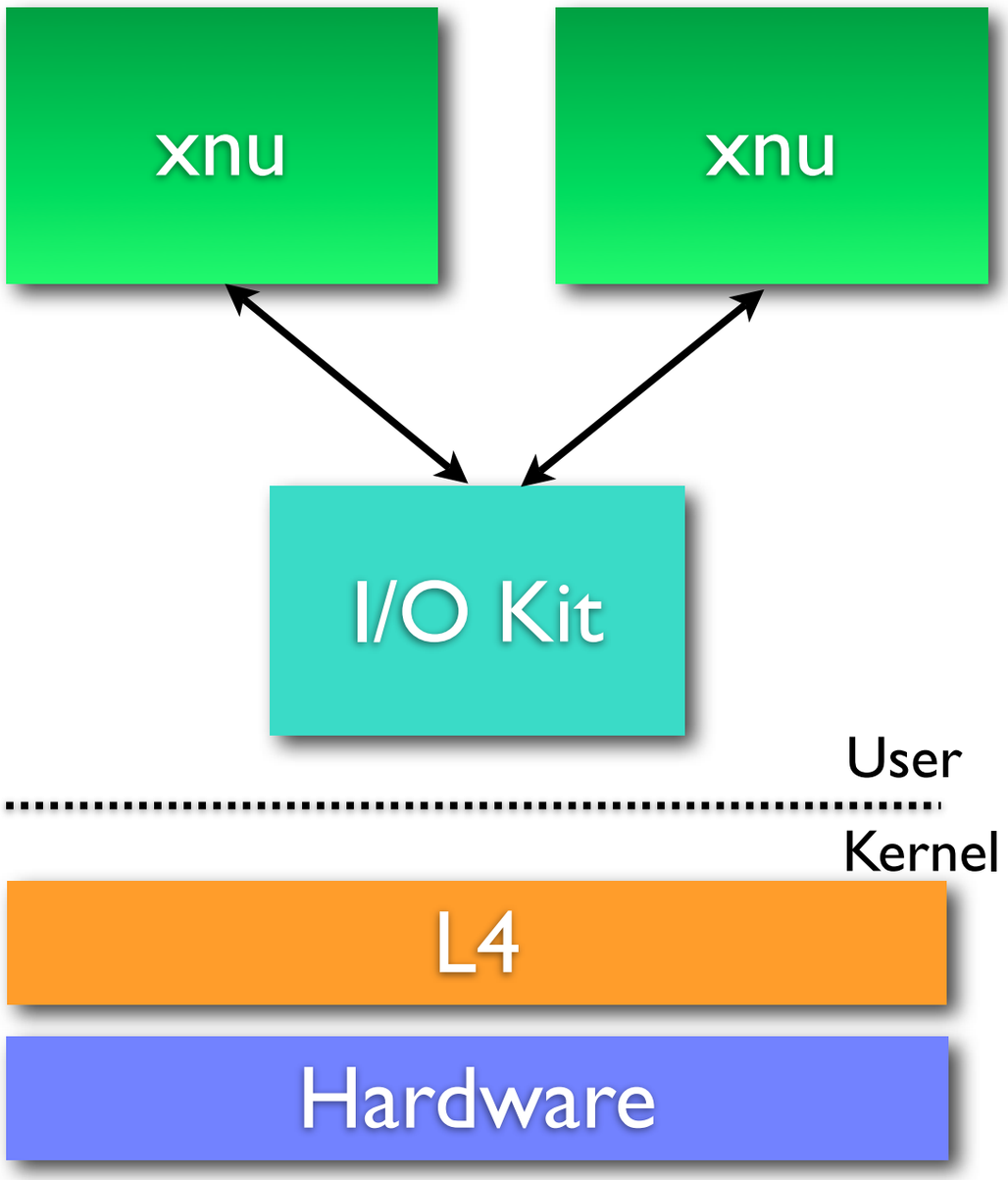
Darbat Model



XNU on L4


page faults
syscalls
timer
int. mask
exception
I/O Kit
ISR Thread
Work-loop Thread
Mach

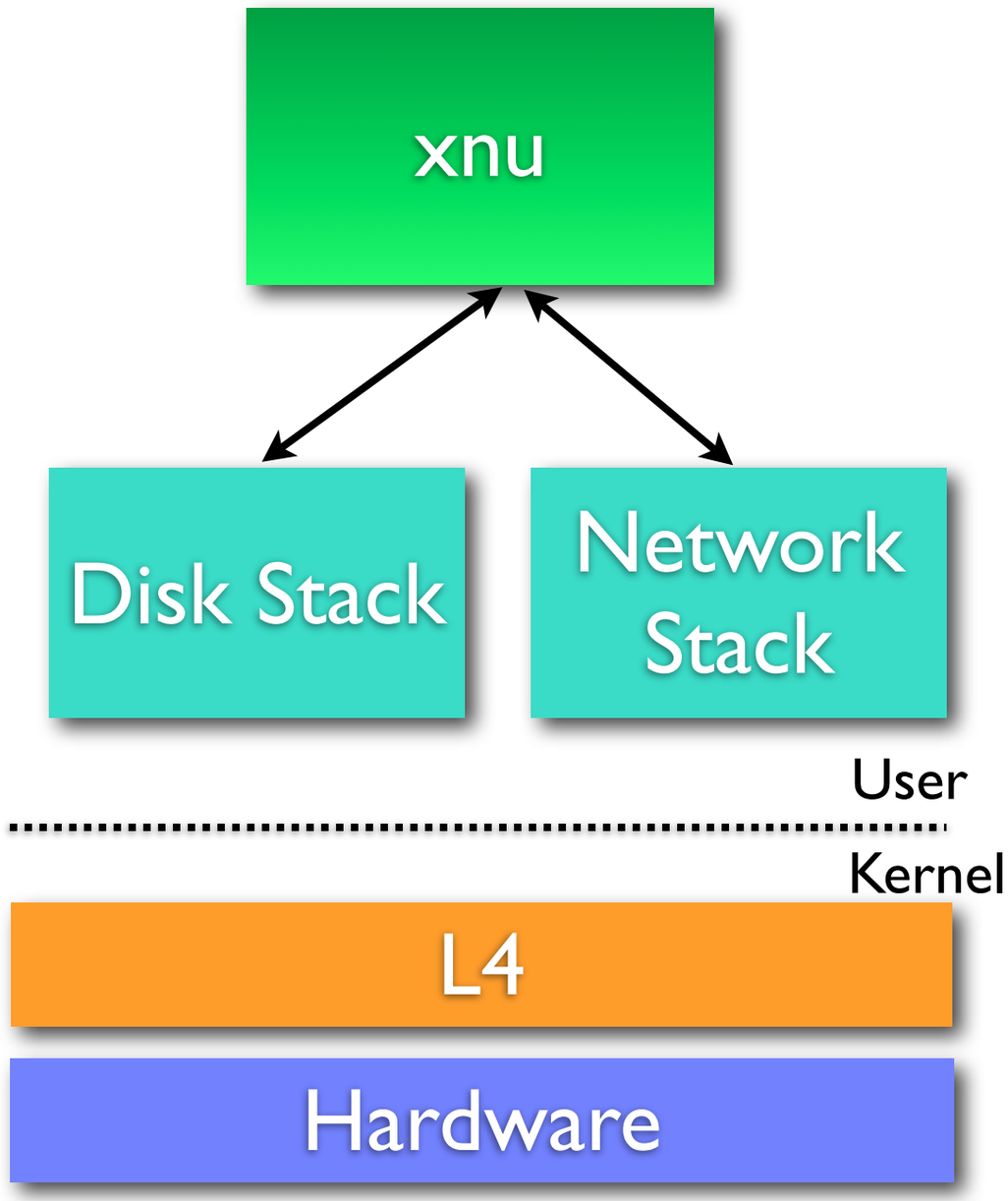
Server Consolidation



- Multiple OS instances
- Kernel support
- Simplified driver model

Crashable Drivers

- Drivers crash
  - Holding locks
  - Hogging resources
- Can isolate drivers
  - and keep performance
- Some devices still critical



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VM Aware Scheduling

priority

Application

Application

Application

Application

Application

xnu

xnu

xnu

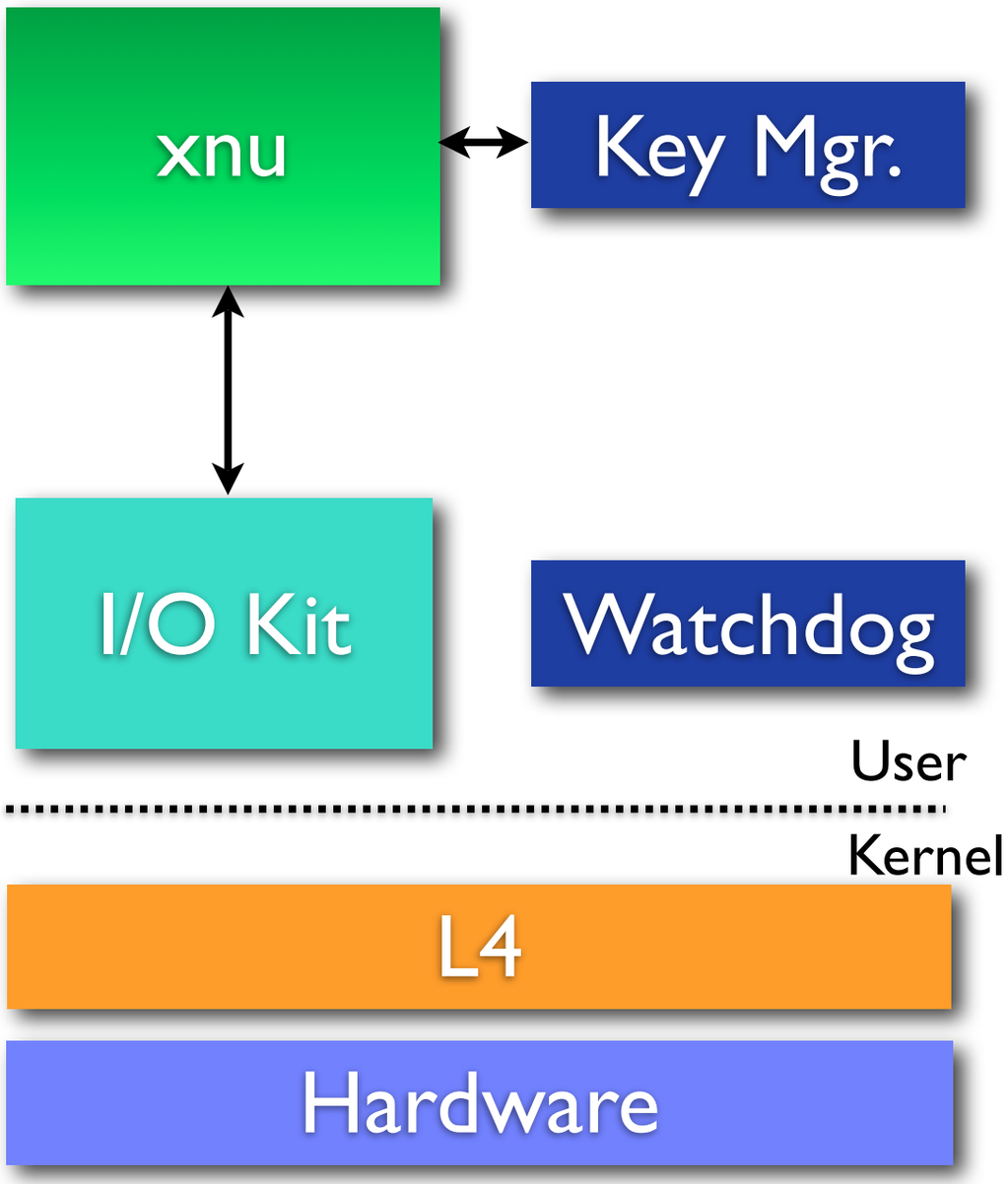
User

Kernel

L4

Hardware

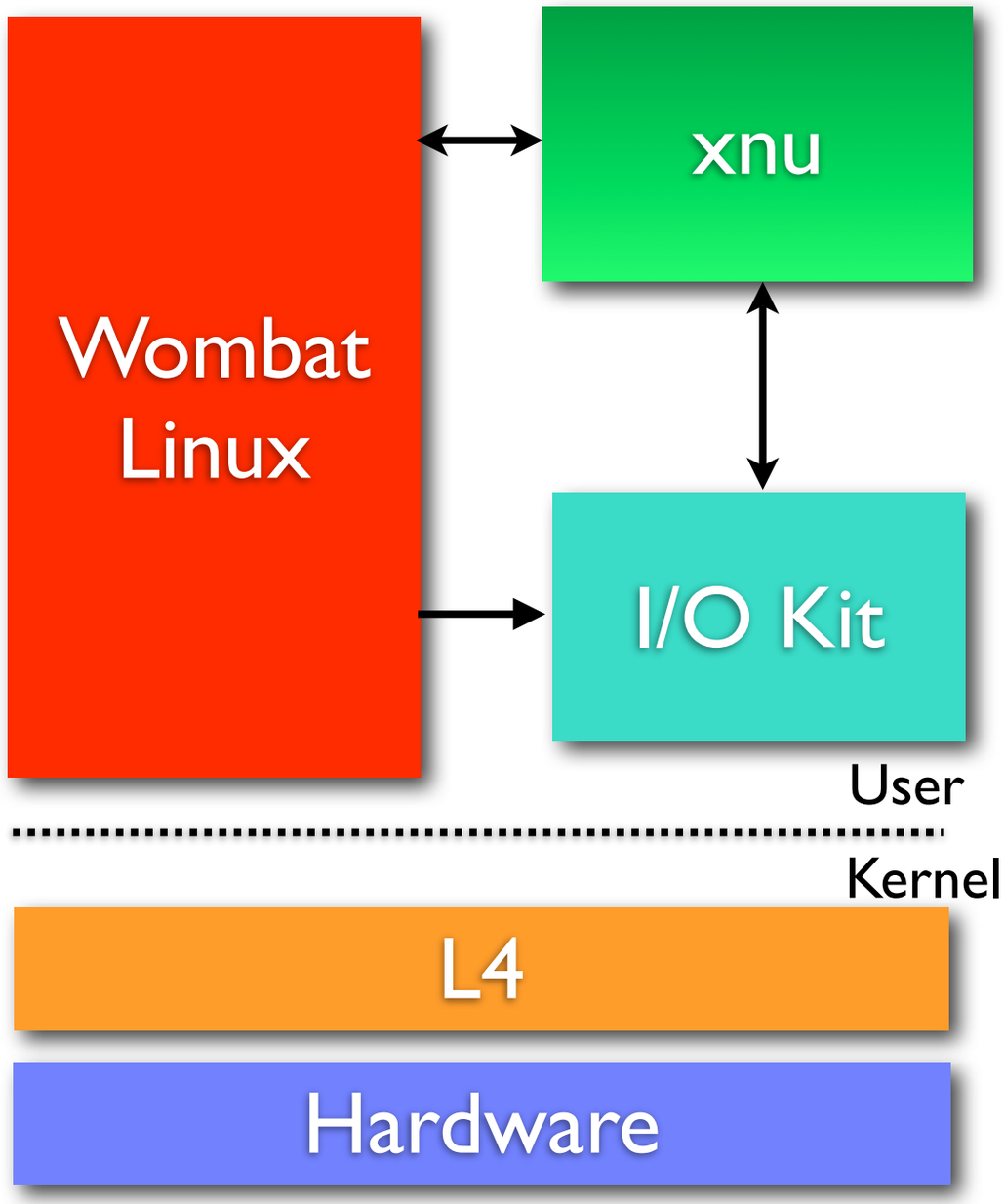
Reliable Servers



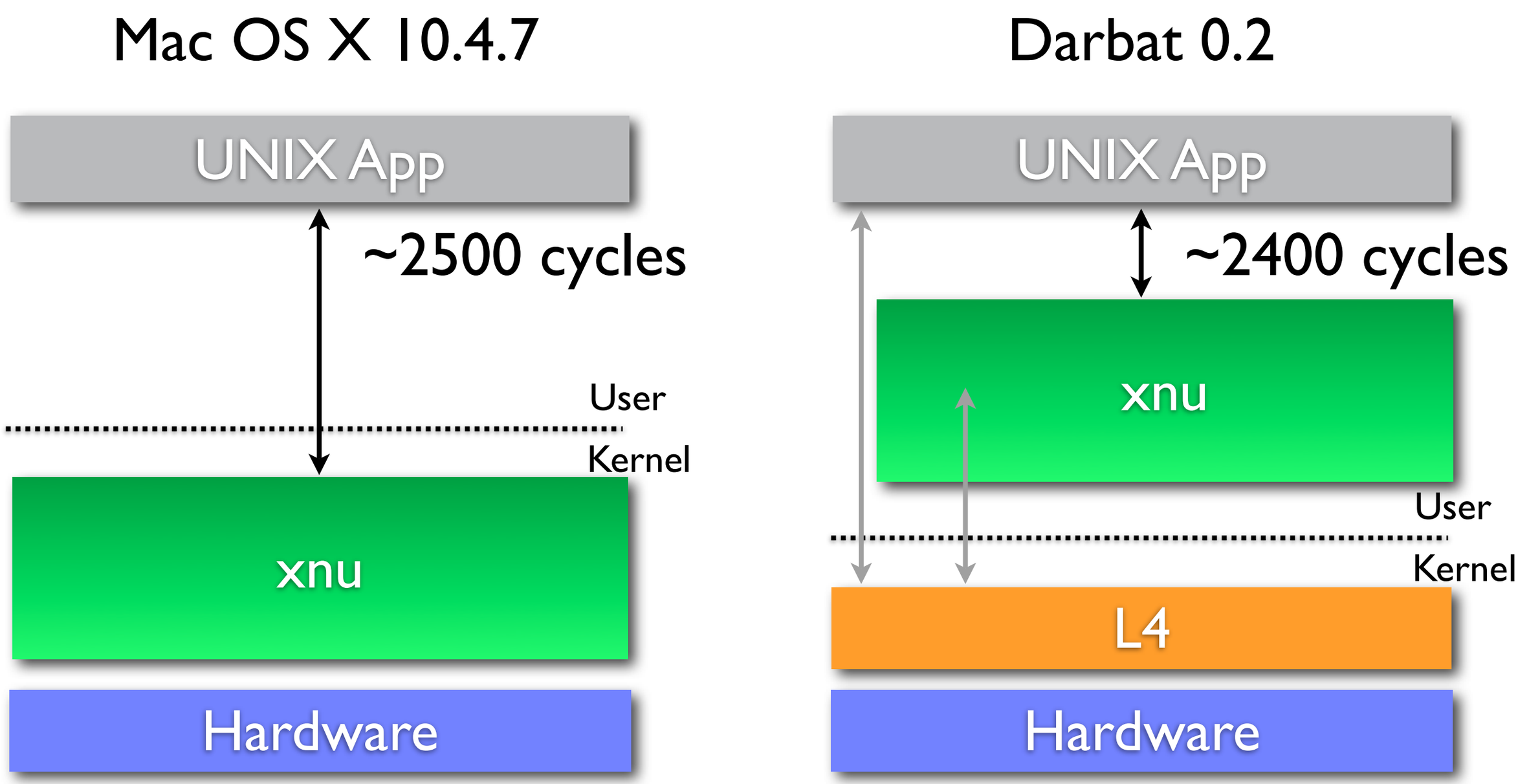
- Microkernel is very resilient
- Protect data from 3rd party modules
- Ensure reliable execution of code
- Cheaper software solutions

Heterogeneous Systems

- L4 is OS (everything?) agnostic
  - Linux
  - *BSD
- Share devices
- Share file systems



System Call Performance



mach_msg null operation

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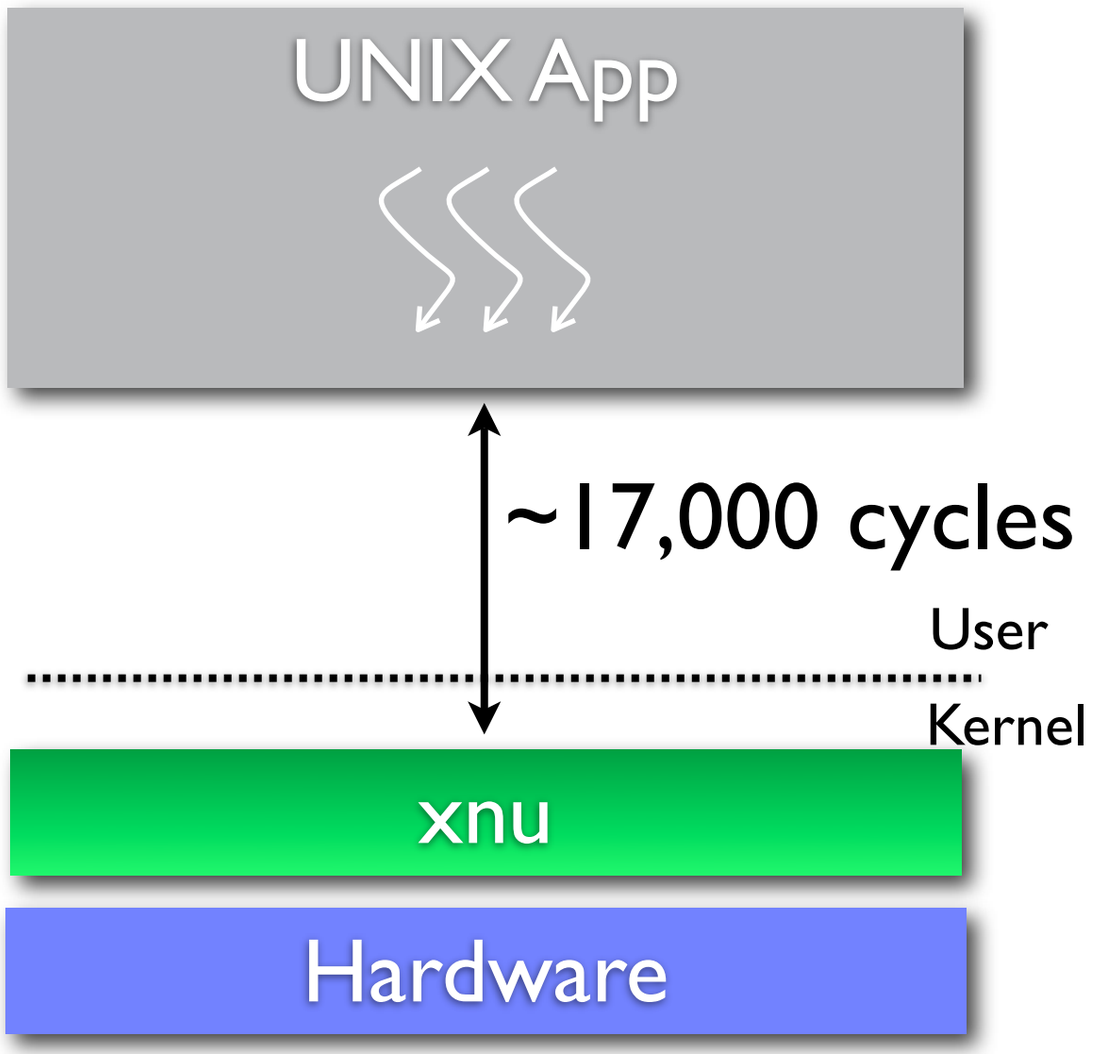
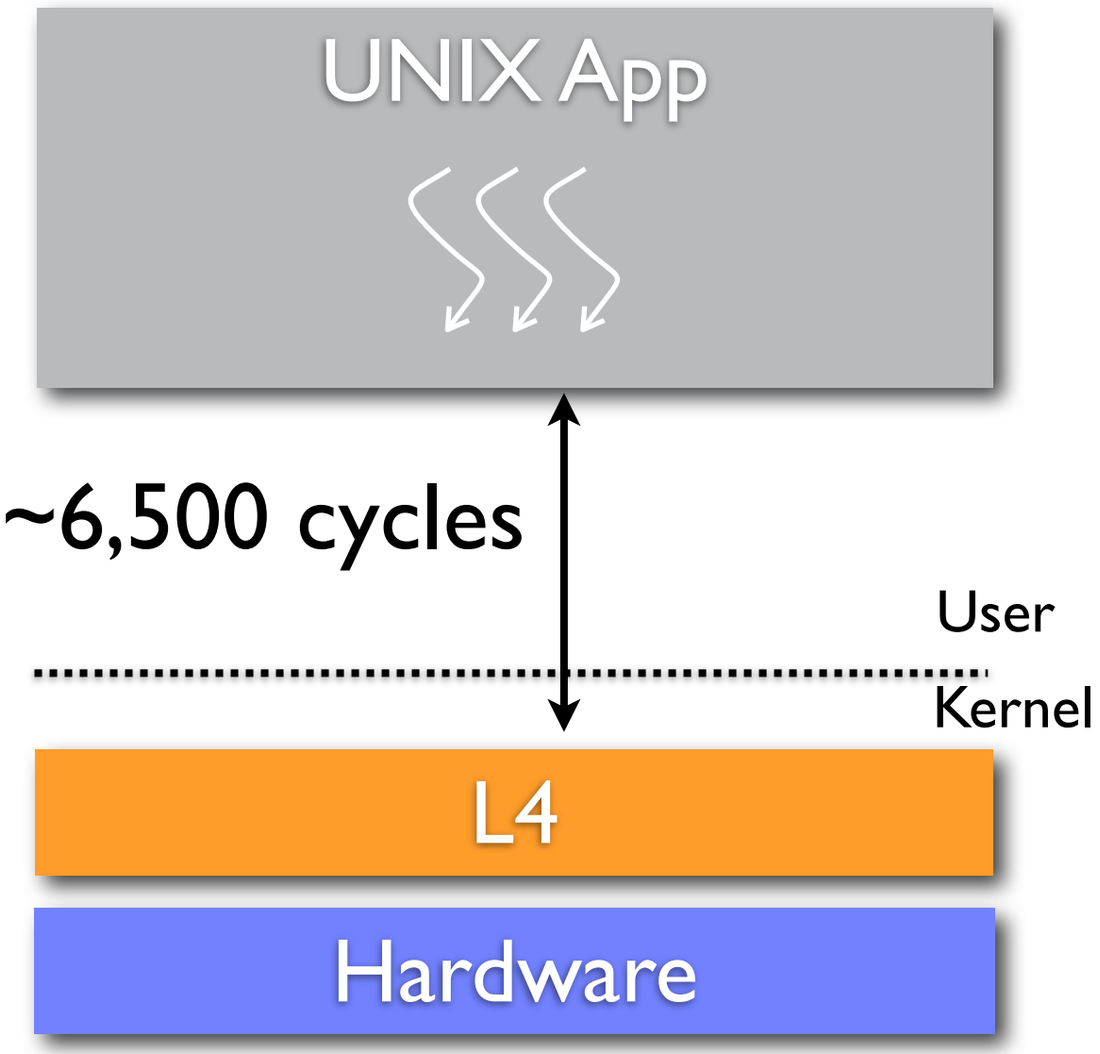
In-task Synchronisation

Mac OS X 10.4.7



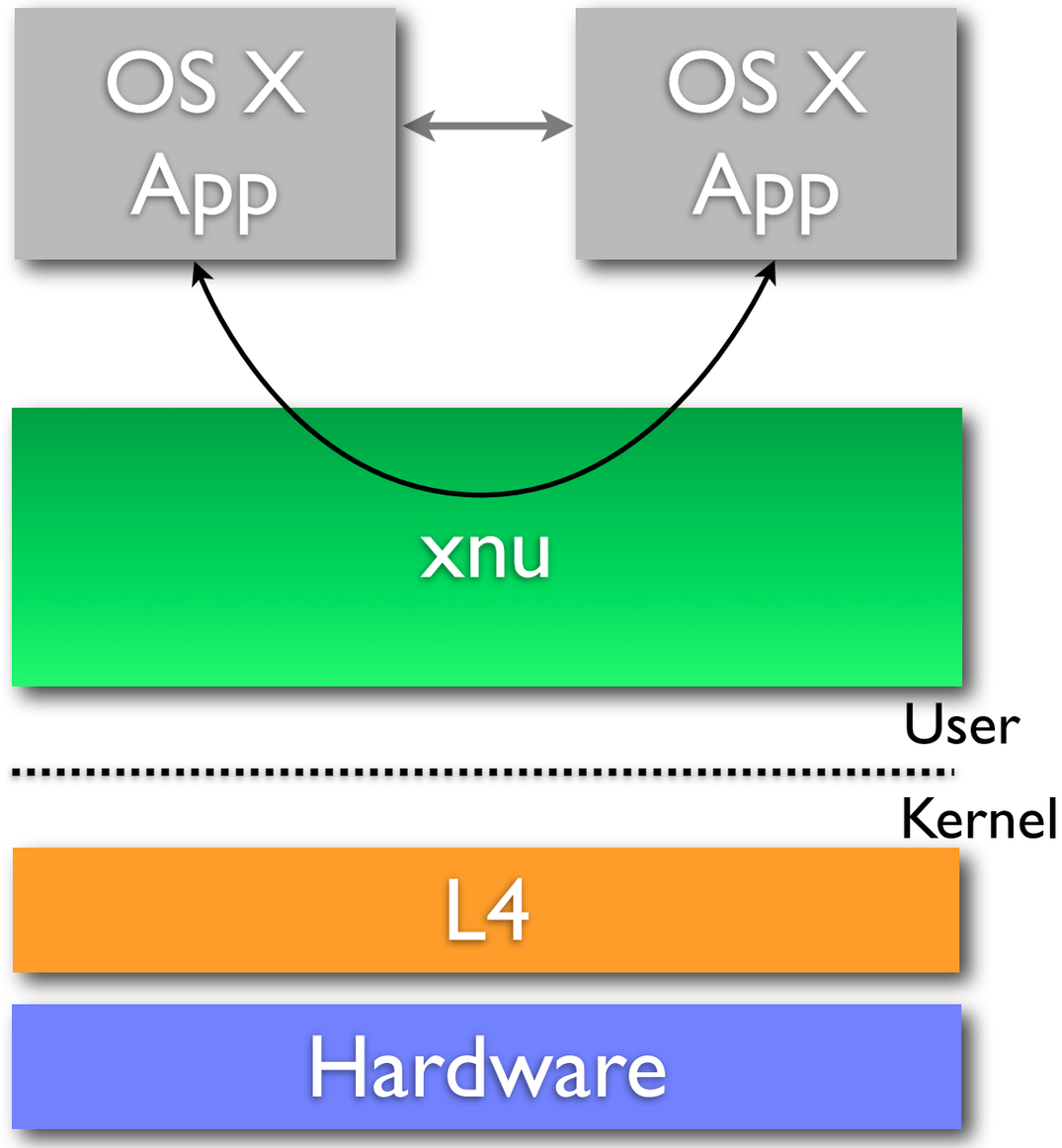
Darbat



pthreads synchronisation

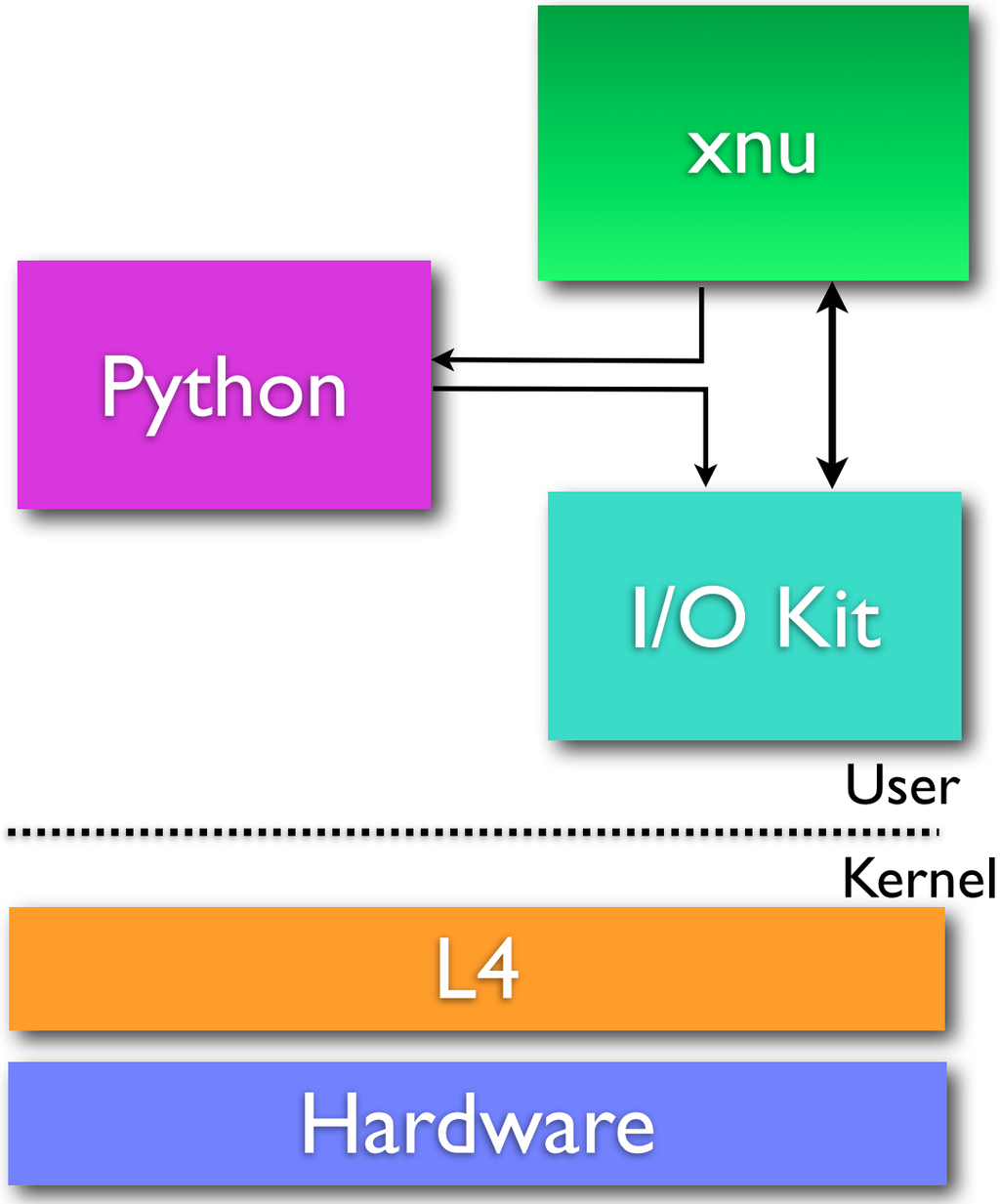
IPC Optimisation

- L4 IPC is a subset of Mach IPC
- Applications rely on Mach semantics
- Optimisation for some messages



Kernel Scripting

- Sometimes you just need a hack
- In-kernel scripts get messy
- Scheduling and locks are a pain
- Don't compromise the whole system



Lessons So Far

- Darwin modularity
- Binary compatibility
- Mac OS X has bugs
- Performance
- Debugging

Future Work?

- Further decomposition
- Improved xnu and I/O Kit bindings
- Usable system!
- Experiment with features
- System benchmarks

Summary

- UNIX kernels are feature-packed
- L4 is one option to address this problem
- Extend UNIX kernel to meet modern usage

Questions?