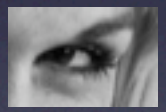
Inside the Mac OS X Kernel

Debunking Mac OS Myths



lucy

28 Dec 2007

Mach

UNIX

microkernel

Open Source

FreeBSD

64 bit

C++

Paul Thurrott's SuperSite for Windows: Apple Mac OS X 10.1 Review

http://www.winsupersite.com/reviews/macosx_puma.asp

Google

Paul Thurrott's SuperSite for Windows

Windows IT Pro

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<< Reviews | Windows | Server | Office | Digital Media | Internet & Networking | Alt. Windows | Xbox 360 | Events

Apple Mac OS X 10.1 Review

My rating:

Related reading

"Tiger" Review

"Panther"

Apple Mac OS X 10.2 "Jaguar" Review

Apple Mac OS X 10.1 Review

Mac OS X vs. Windows XP: Is this what it's come to?

Microsoft

Microsoft SQL Server 2005 delivers 60,359 QphH for the 3-terabyte TPC-H benchmark.

SEE FOR YOURSELF >>

Microsoft SQL Server 2005

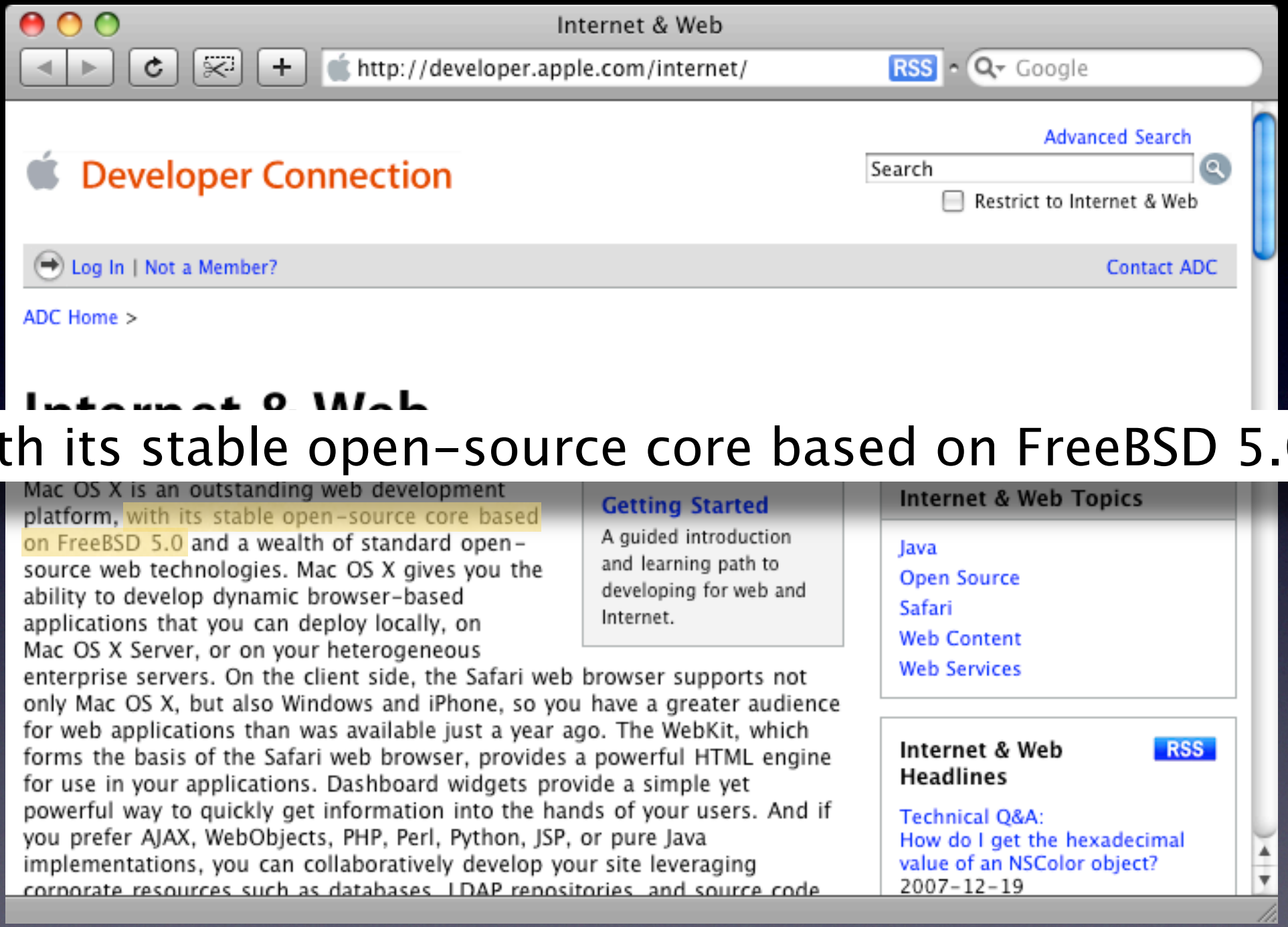
On the Mac, this kernel is called Mach

To the hundreds of millions of Windows users, news about Macintosh enhancements

sweeping improvements the PC world is experiencing with Windows XP. After years of work, Apple has finally released a bulletproof next-generation OS that's as easy to use as it is easy on the eyes. It's called Mac OS X (pronounced ten), and the latest revision—version 10.1—is the first revision that's worthy of your attention, regardless of which OS you currently use.

The parallels between XP on the PC side and OS X on the Mac side are none too subtle. Both OSes are based on a solid core, or kernel, that was previously unavailable to consumers. On the Mac, this kernel is called Mach, and it's based on rock-solid UNIX technology, giving Mac users a break from the system-error bombs that plague older versions of Apple's OS. Both XP and OS X feature a colorful new UI. On the Mac, the UI is called Aqua, an appropriate name given the modulating blue gel-cap buttons and

Paul Thurrott, http://www.winsupersite.com/reviews/macosx_puma.asp



http://developer.apple.com/internet/

Mac OS X for UNIX Users

The power of UNIX with the simplicity of Macintosh.

Features

Open source, UNIX-based foundation

- SMP-optimized kernel based on FreeBSD 5 and Mach 3.0
- 64-bit virtual memory based on the LP64 model

Standards-based networking

- Complete IP-based architecture supporting IPv4, IPv6, and L2TP/IPSec VPN
- Rich zero-configuration discovery and naming via Bonjour and Dynamic DNS
- Interoperable file serving via NFS, AFP, SMB/CIFS, and FTP
- Powerful Apache services (httpd, DAV, PHP)
- Open Directory services built on LDAP and Kerberos for single sign-on

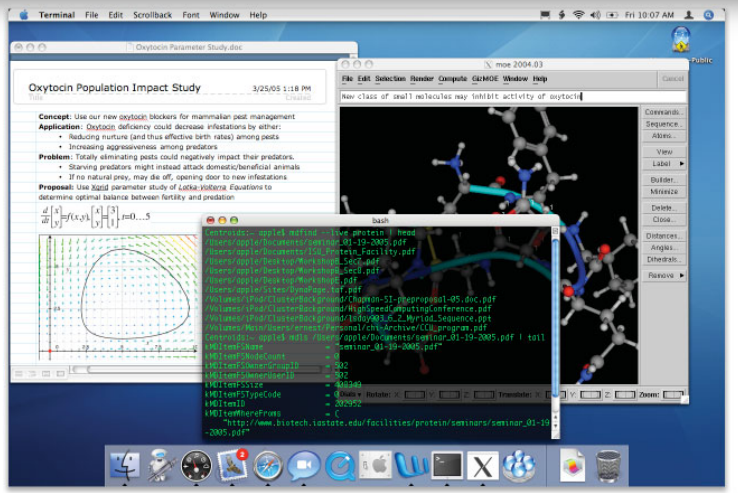
Comprehensive UNIX user environment

- Standards-based graphics built on PDF (Quartz), OpenGL, H.264, and MPEG-4 (QuickTime)
- Xterm-compliant Terminal integrated with Aqua user interface
- Choice of shells (bash, ksh, csh) and scripting languages (Perl, Python, Tcl, Ruby)
- Enhanced with Spotlight searching, Xgrid queuing, and Automator workflows
- Comprehensive UNIX/Linux utilities (emacs, vim, gnutar, make)
- Xcode 2 developer tools with GCC 4.0 for optimized code generation and ISO/IEC 14882:2003 C++ support

Mac OS X version 10.4 Tiger combines a robust and open UNIX-based foundation with the richness and usability of the Mac interface, bringing UNIX technology and 64-bit power to the mass market. Apple has made open source and standards a key part of its strategy to deliver an industrial-strength operating system that is both innovative and easy to use.

There are over 15 million Mac OS X users—scientists, animators, developers, system

emerging generation of UNIX users.



http://images.apple.com/macosx/pdf/MacOSX_UNIX_TB_v2.pdf

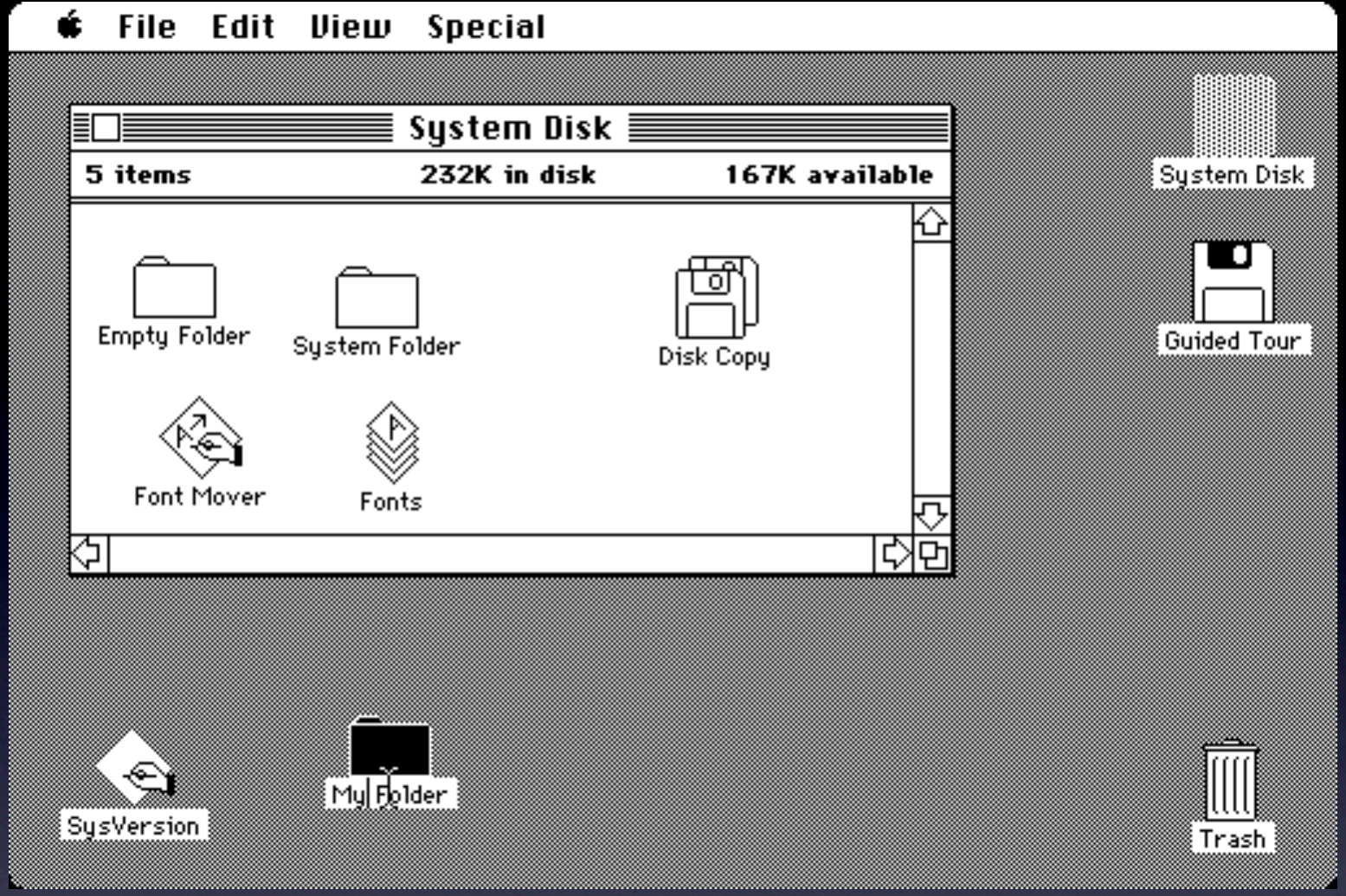
UNIX-based foundation

64 Bit

"Leopard is 64 bit top to bottom."

Steve Jobs, WWDC 2007

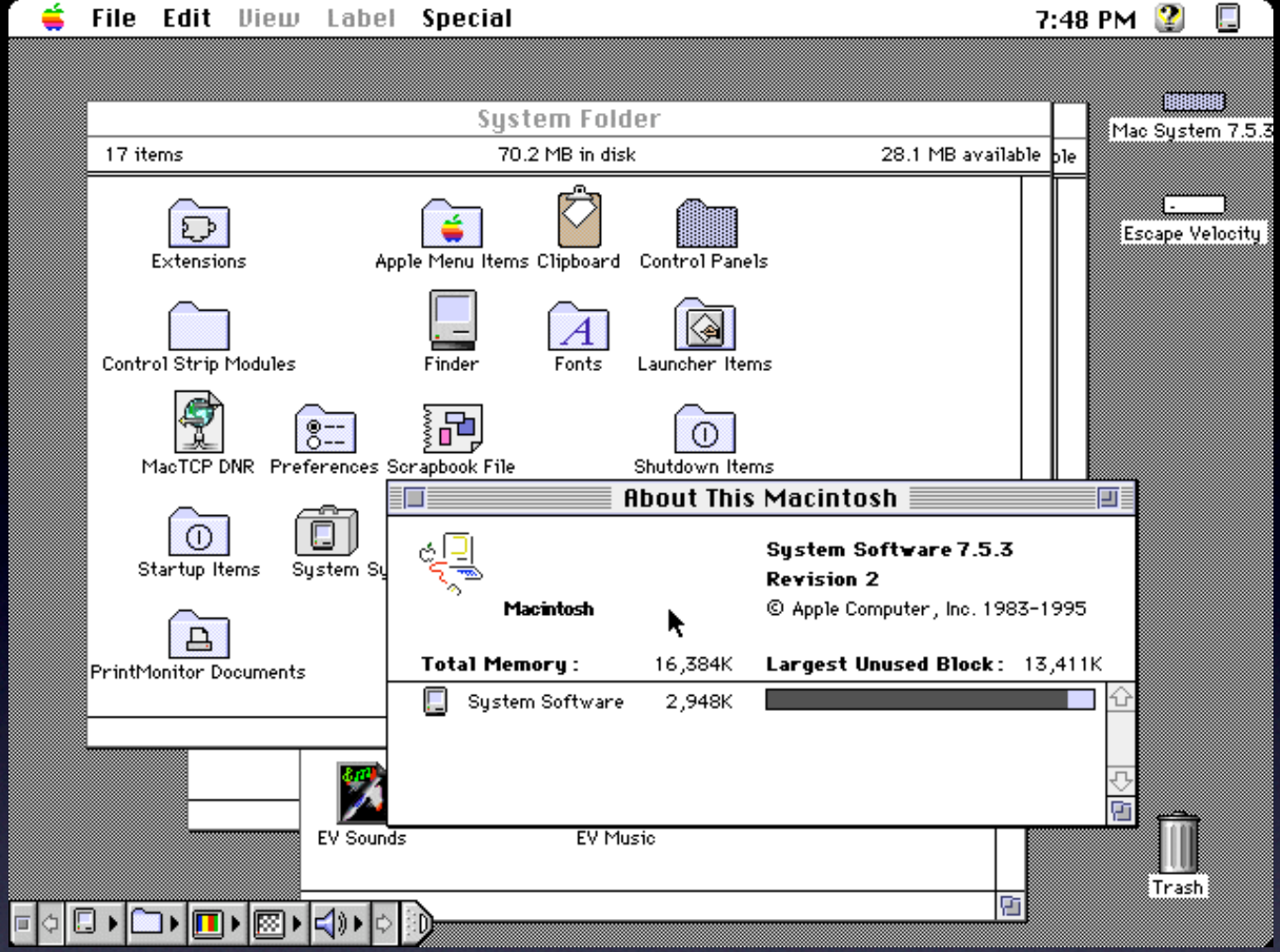
Miles Nordin, http://www.linuxjournal.com/article/6105



128 KB
M68K
3.5”
single tasking

Macintosh

1985 1990 1995 2000



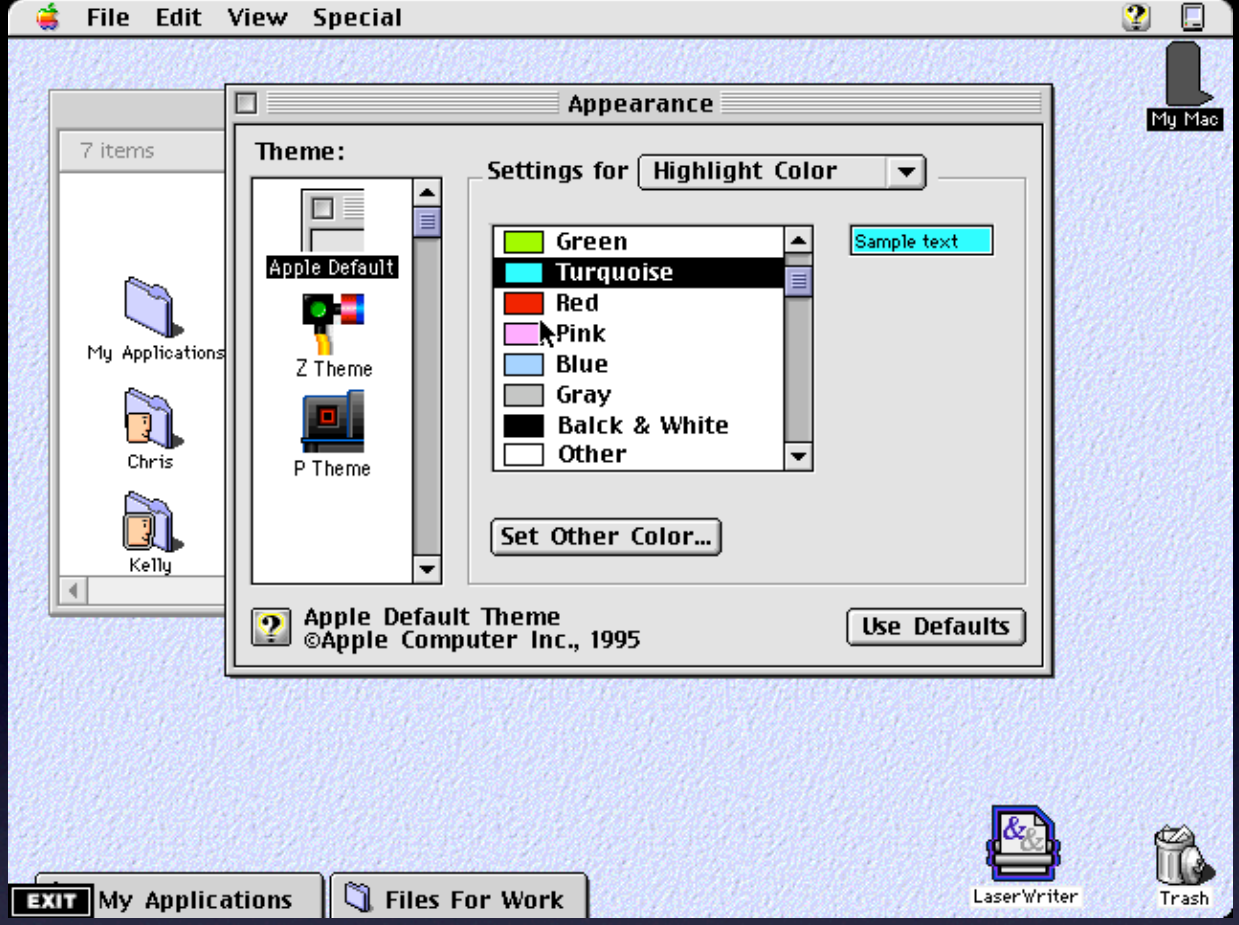
128 KB
M68K
3.5”
single tasking

PowerPC
multitasking

Macintosh

System 7

1985 1990 1995 2000



128 KB
M68K
3.5”
single tasking

Macintosh

PowerPC
multitasking

System 7

Copland ?

1985 1990 1995 2000

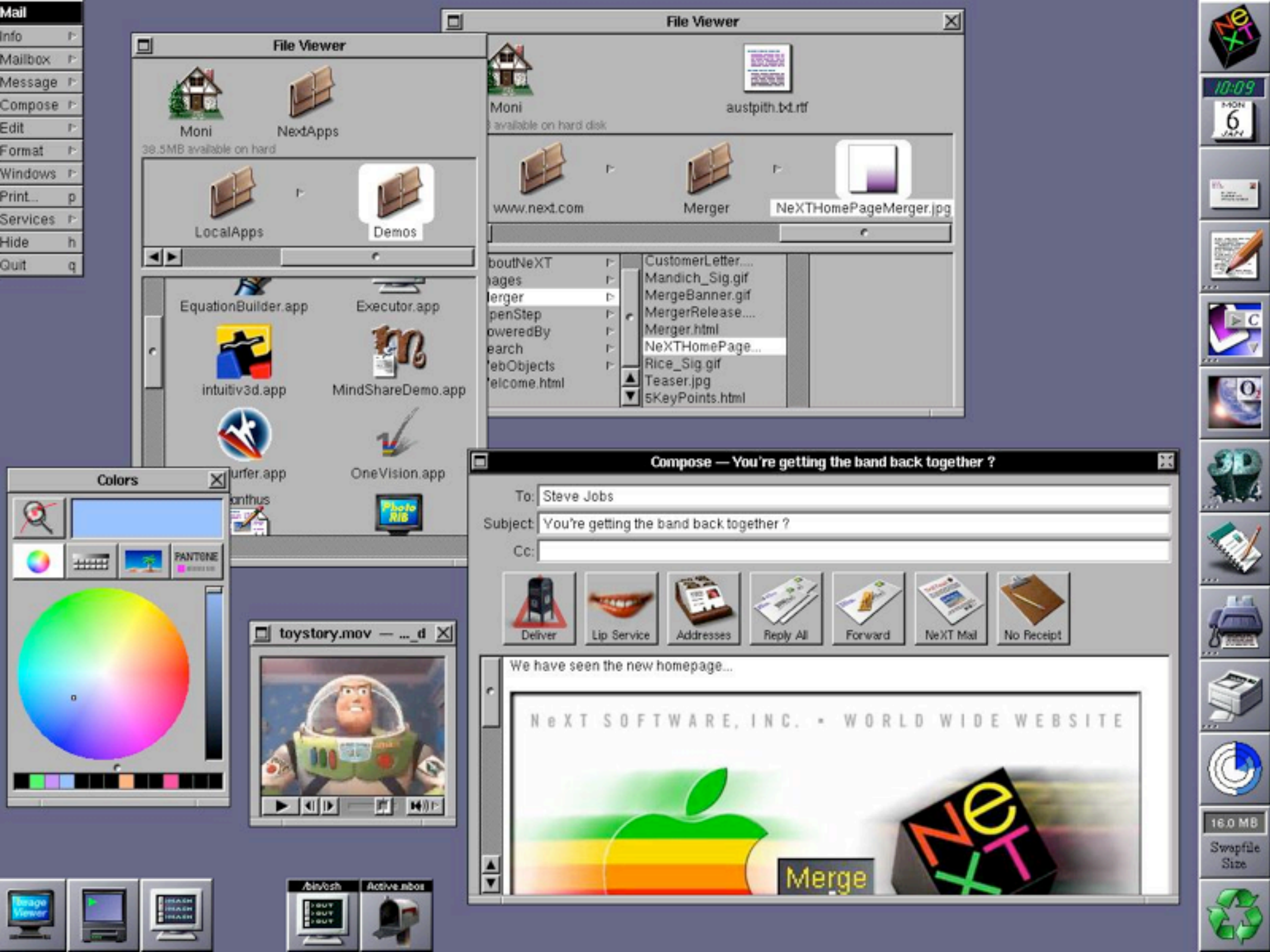
NeXT

Apple

Jobs

Jobs

1985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Info
Mailbox
Message
Compose
Edit
Format
Windows
Print... p
Services
Hide h
Quit q
File Viewer
Moni
NextApps
38.5MB available on hard
LocalApps
Demos
EquationBuilder.app
Executor.app
intuitiv3d.app
MindShareDemo.app
OneVision.app
File Viewer
Moni
austpith.txt.rtf
available on hard disk
www.next.com
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NeXTHomePageMerger.jpg
CustomerLetter....
Mandich_Sig.gif
MergeBanner.gif
MergerRelease....
Merger.html
NeXTHomePage...
Rice_Sig.gif
Teaser.jpg
5KeyPoints.html
Colors
PANTONE
toystory.mov — ..._d
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To: Steve Jobs
Subject: You're getting the band back together ?
Cc:
Deliver
Lip Service
Addresses
Reply All
Forward
NeXT Mail
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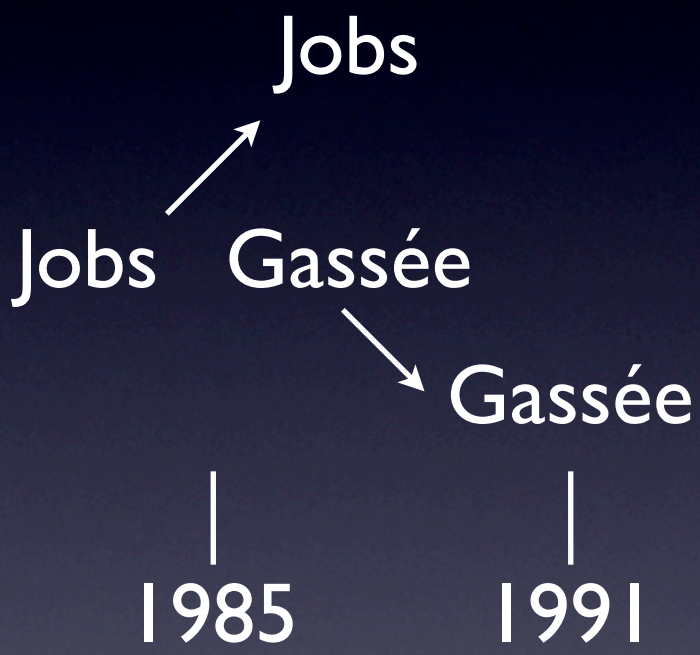
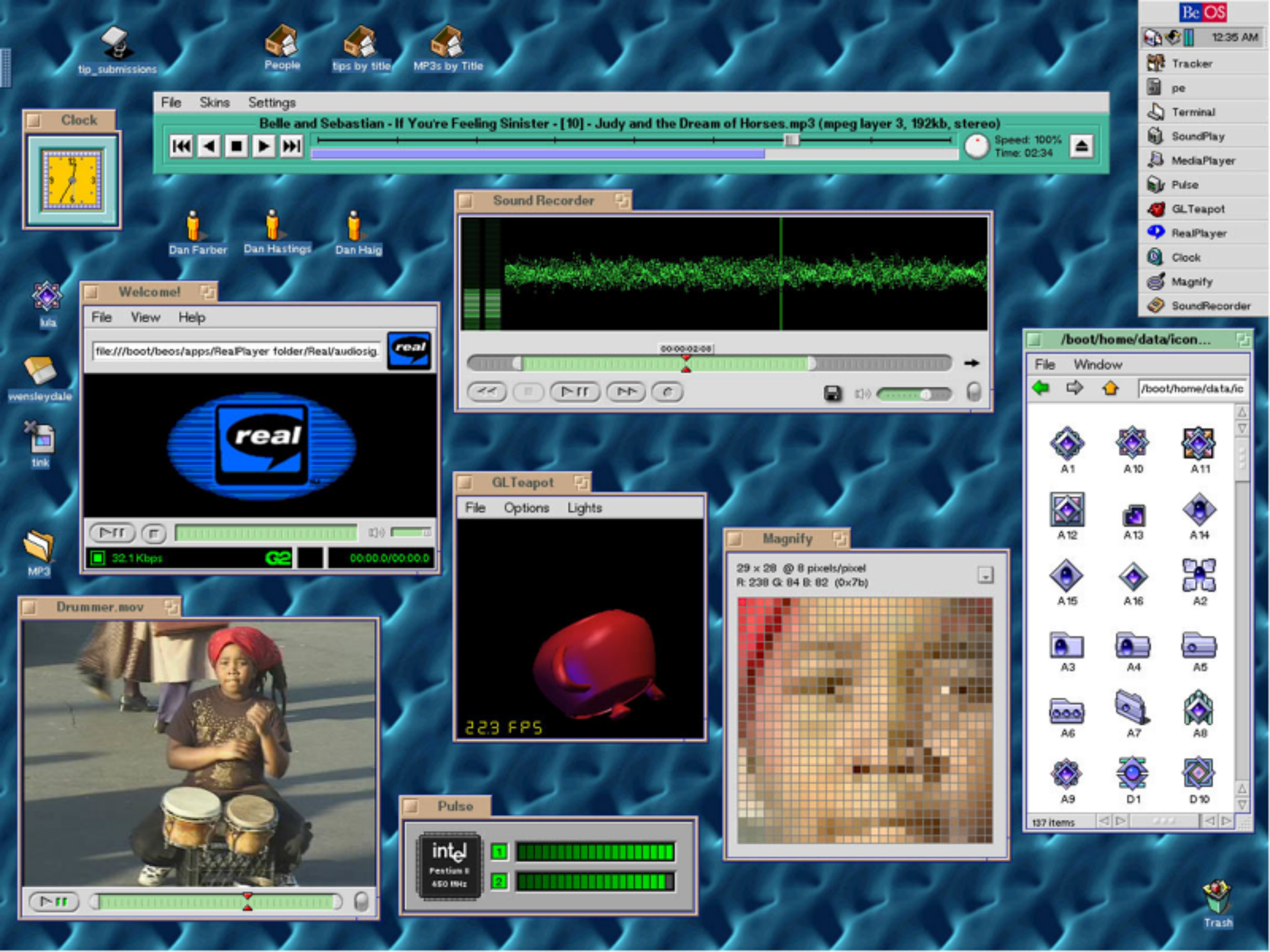
NeXT SOFTWARE, INC. • WORLD WIDE WEBSITE
Merge
10:09
16.0 MB
Swapfile Size

NeXT

Apple

Be

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tips by title
MP3s by Title
Clock
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Speed: 100%
Time: 02:34
Dan Farber
Dan Hastings
Dan Haig
Sound Recorder
Welcome!
File View Help
file:///boot/beos/apps/RealPlayer folder/Real/audiosig
real
32.1 Kbps
G2
00:00.0/00:00.0
lula
wensleydale
tink
MP3
GLTeapot
File Options Lights
223 FPS
Drummer.mov
Magnify
29 x 28 @ 8 pixels/pixel
R: 238 G: 84 B: 82 (0x7b)
Pulse
intel
Pentium II
450 MHz
/boot/home/data/icon...
File Window
/boot/home/data/ic
A1
A10
A11
A12
A13
A14
A15
A16
A2
A3
A4
A5
A6
A7
A8
A9
D1
D10
137 items
BeOS
12:35 AM
Tracker
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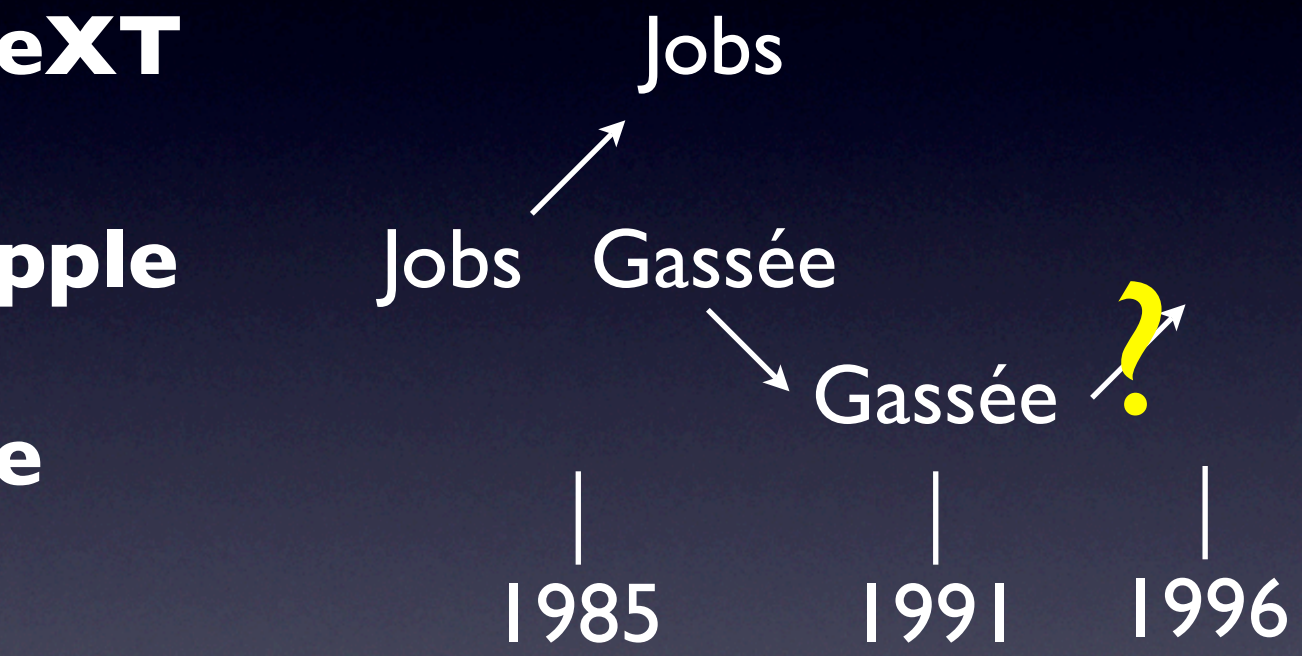
Terminal
SoundPlay
MediaPlayer
Pulse
GLTeapot
RealPlayer
Clock
Magnify
SoundRecorder
Trash

NeXT

Apple

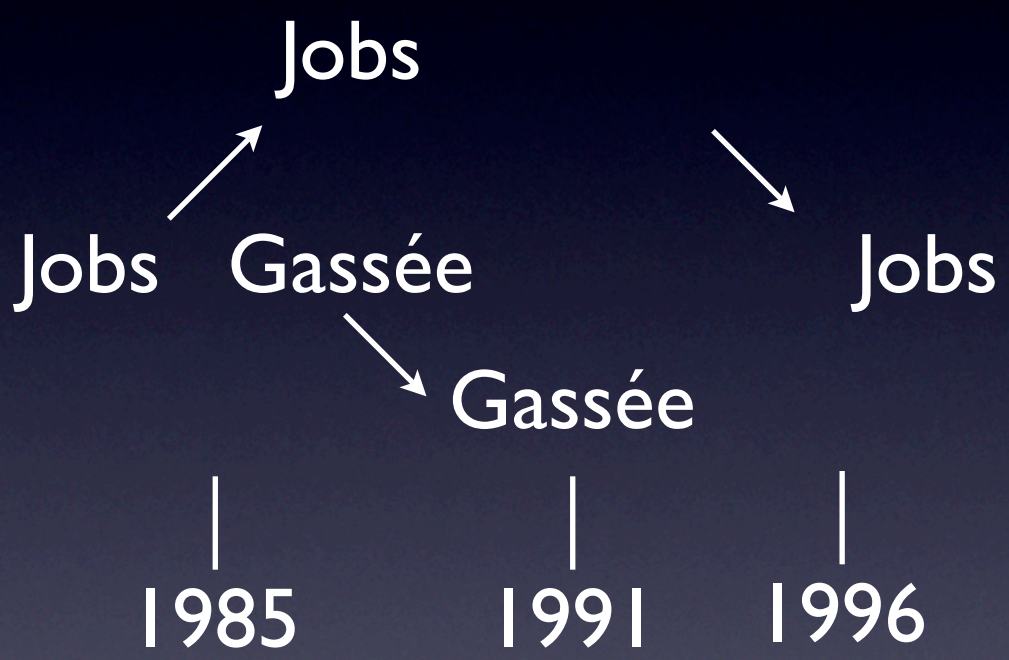
Be



NeXT

Apple

Be



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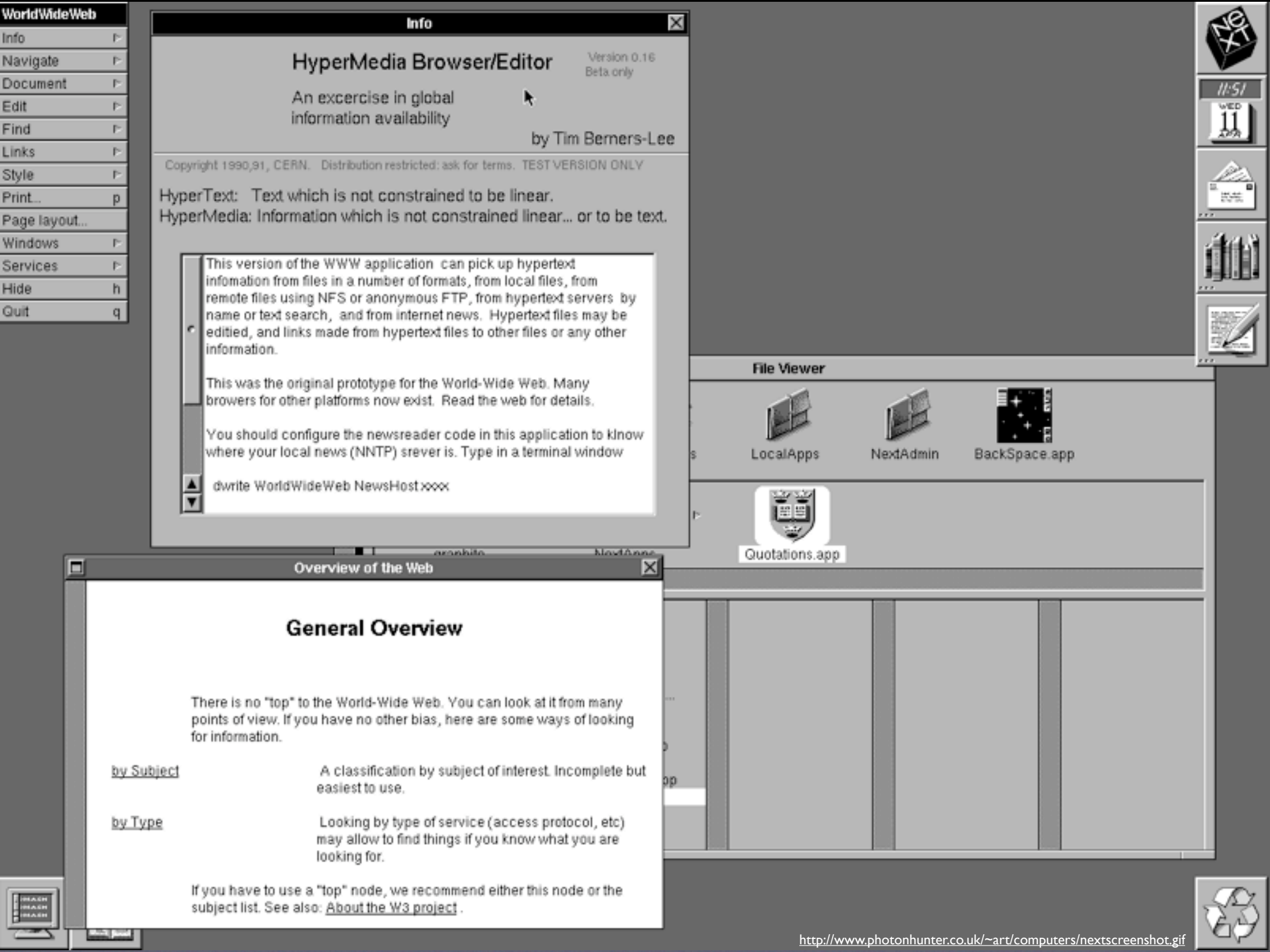
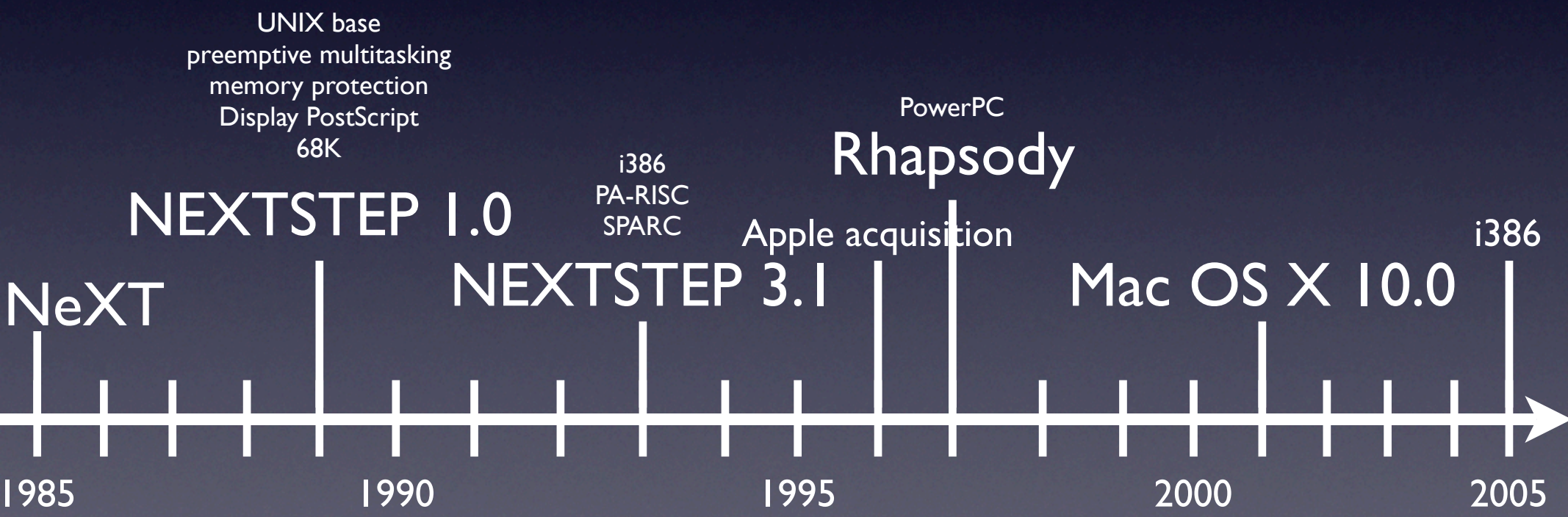


http://www.photonhunter.co.uk/~art/computers/nextscreenshot.gif

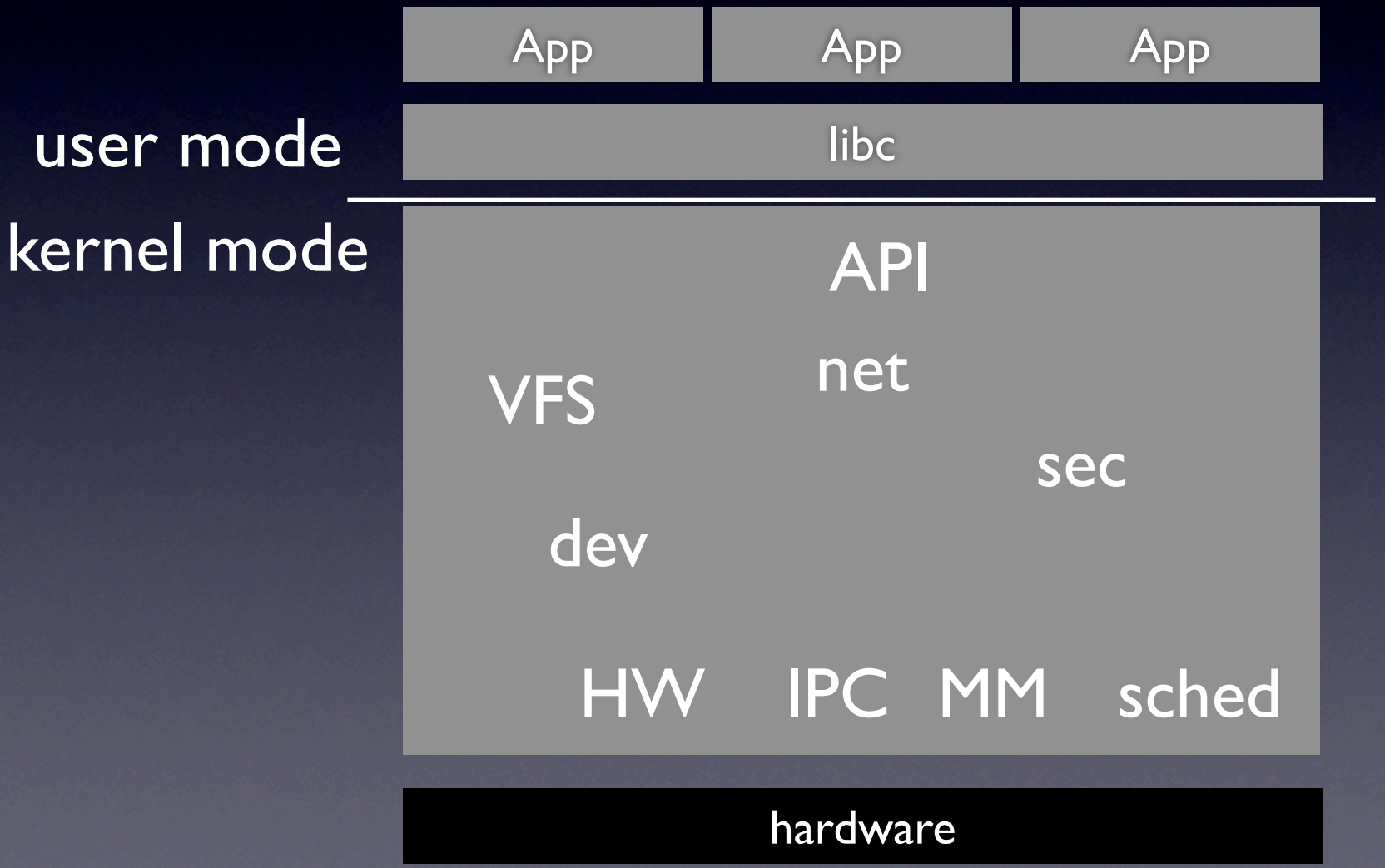
NEXTSTEP


UNIX base
preemptive multitasking
memory protection
Display PostScript
68K
i386
PA-RISC
SPARC
PowerPC
Rhapsody
NEXTSTEP 1.0
Apple acquisition
i386
NeXT
NEXTSTEP 3.1
Mac OS X 10.0
1985
1990
1995
2000
2005

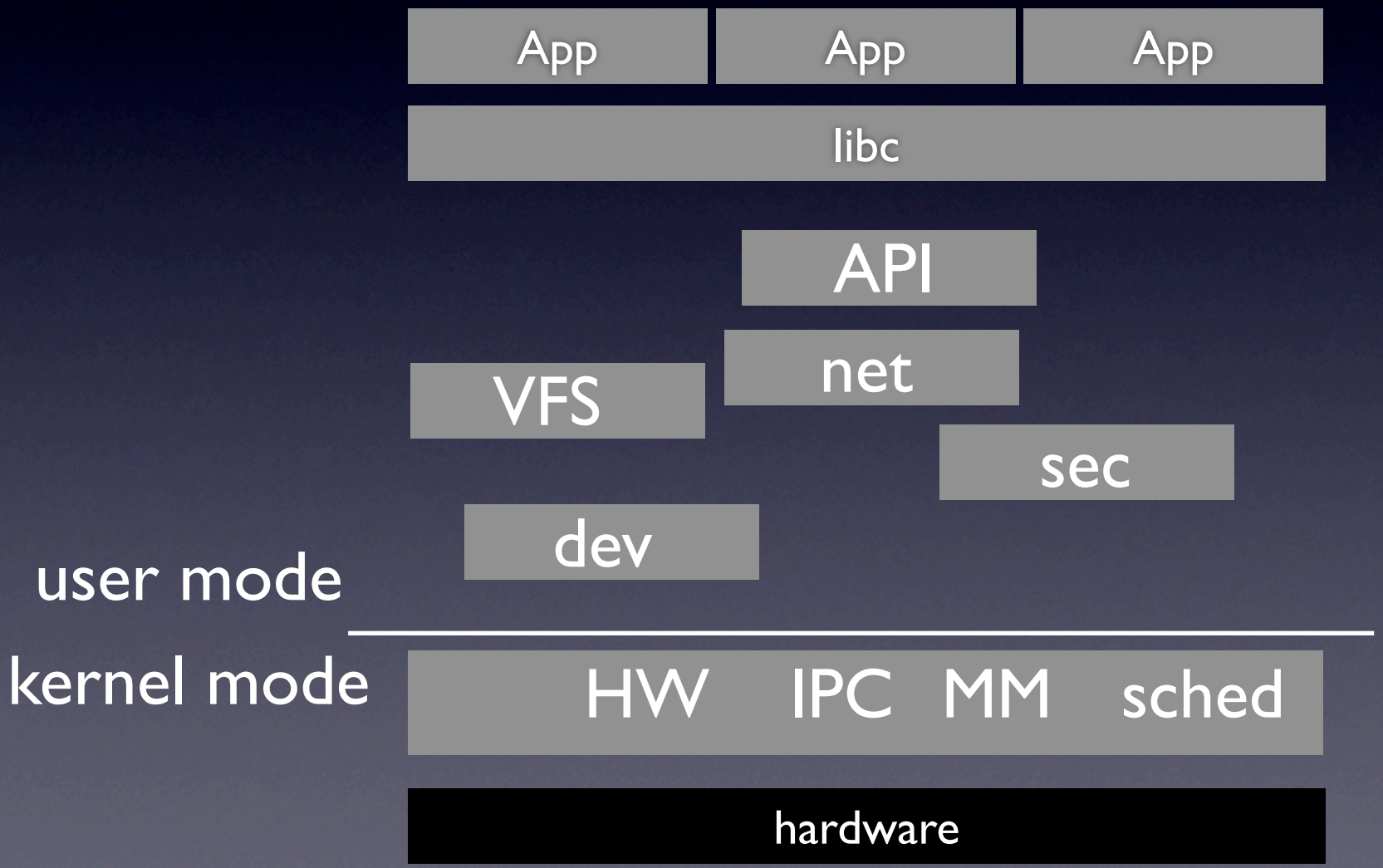
XNU

X is not UNIX

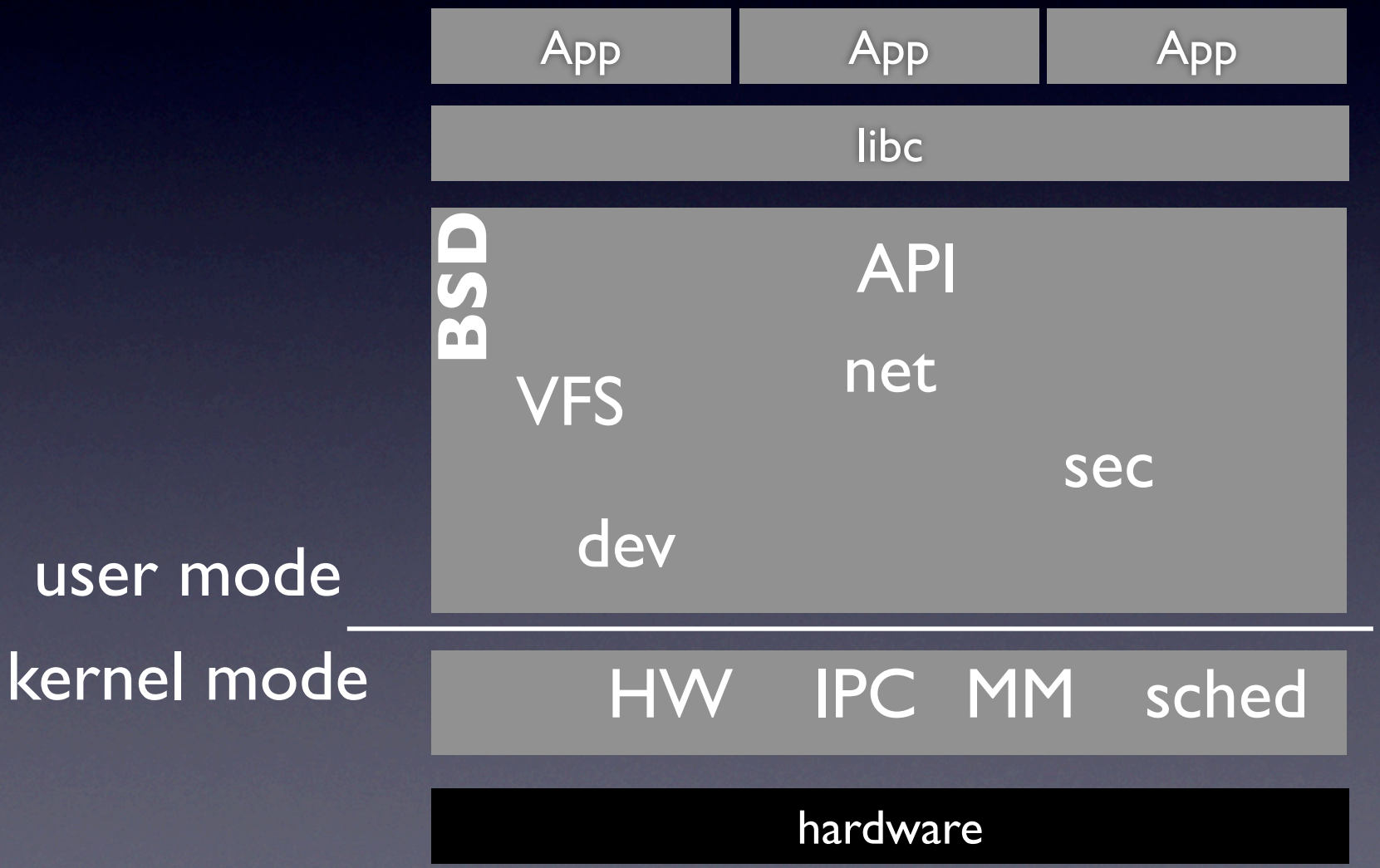
Monolithic Kernel



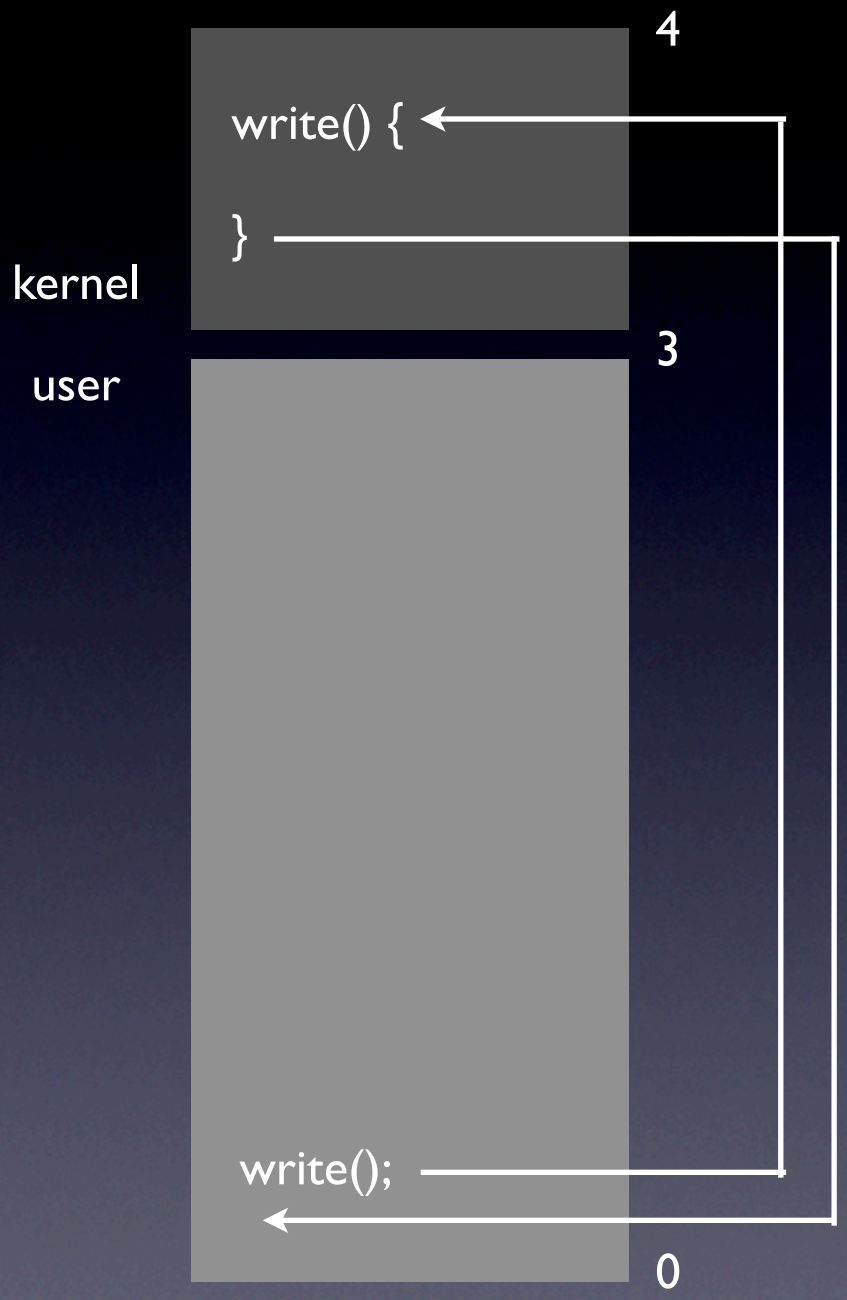
Microkernel



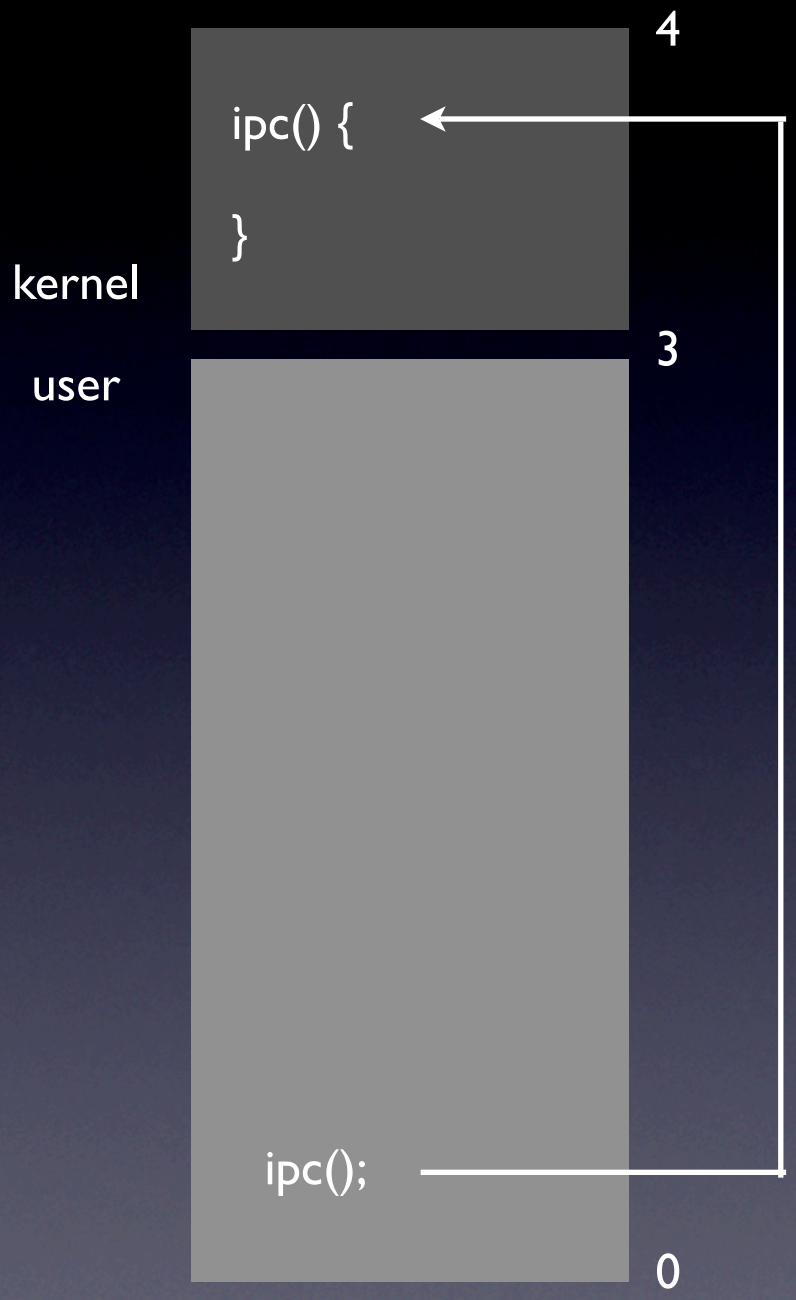
BSD Single Server



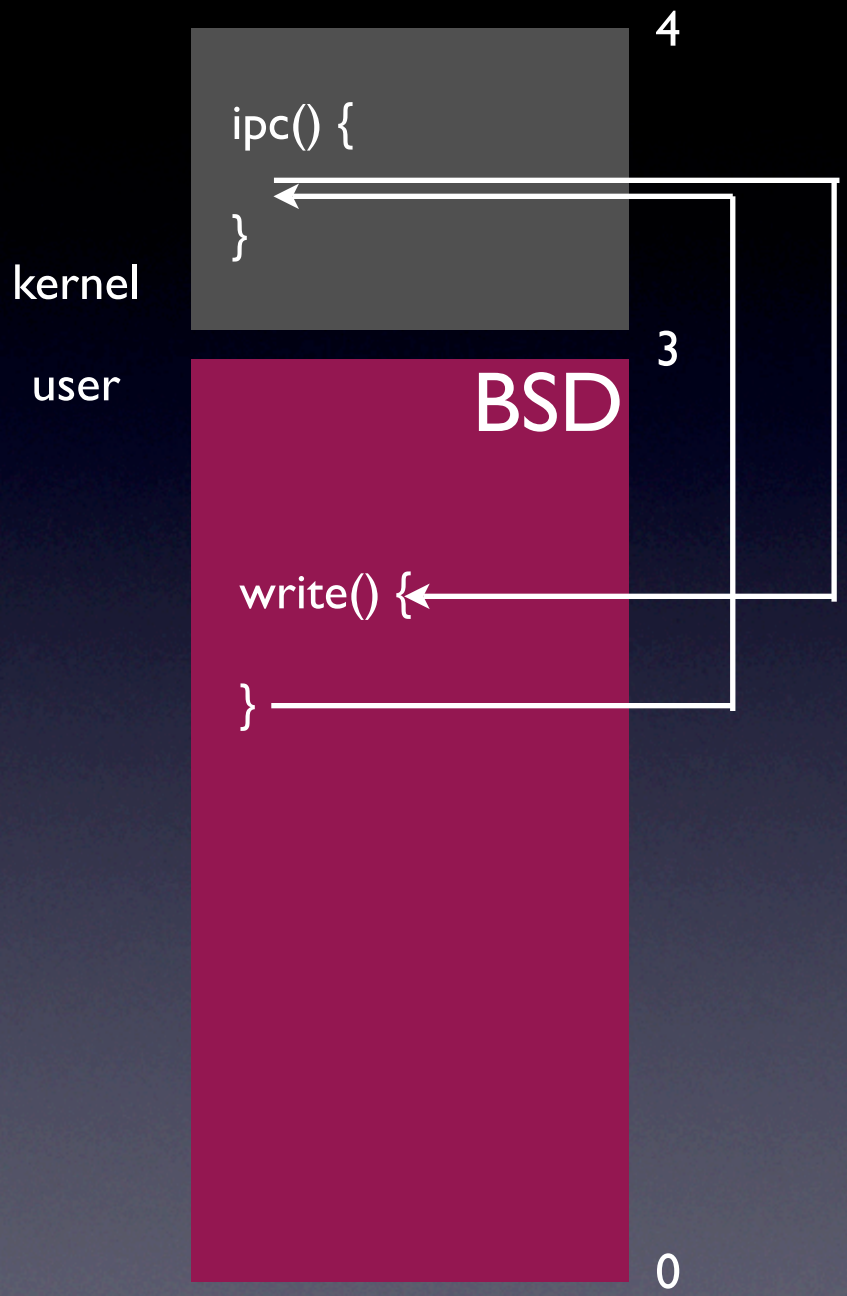
monolithic



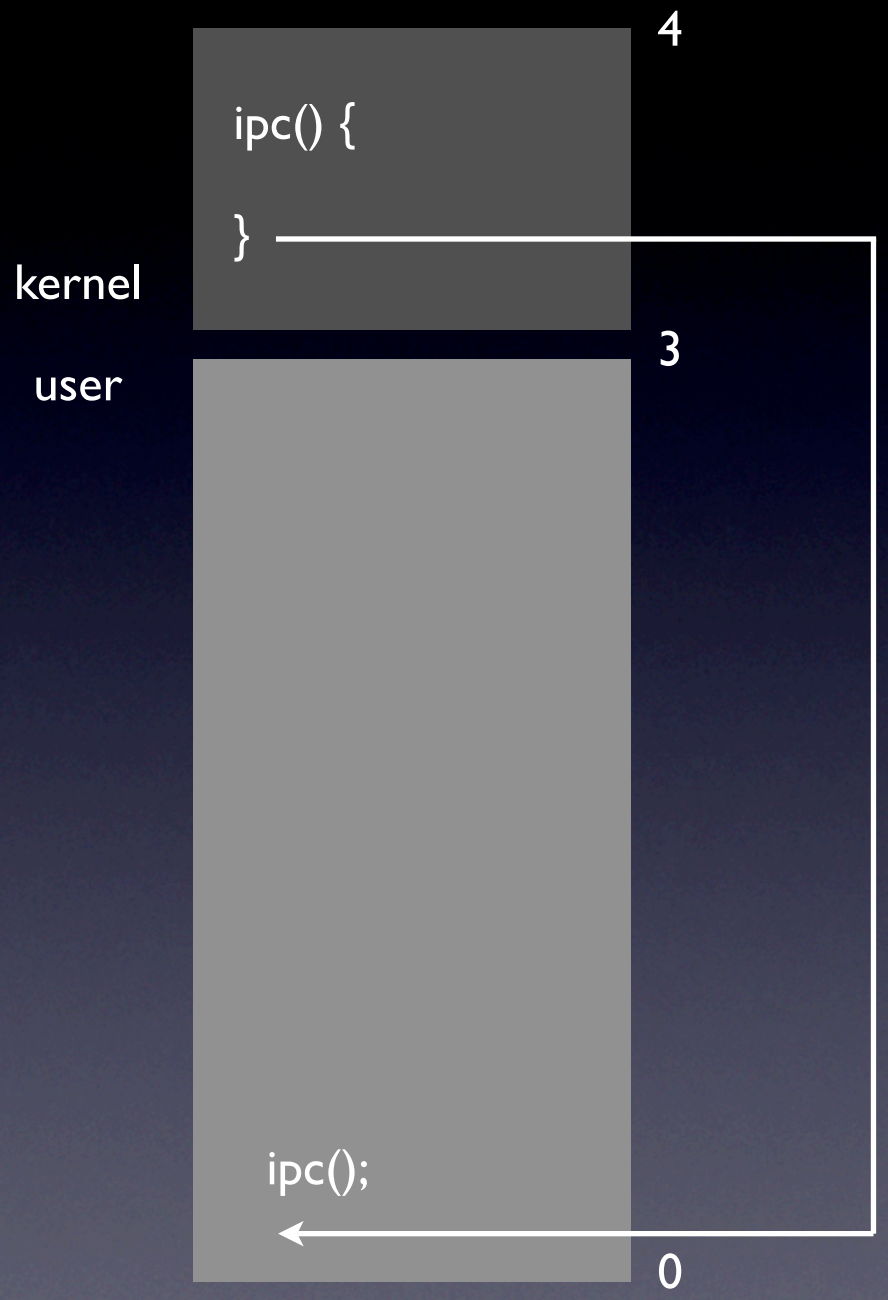
microkernel



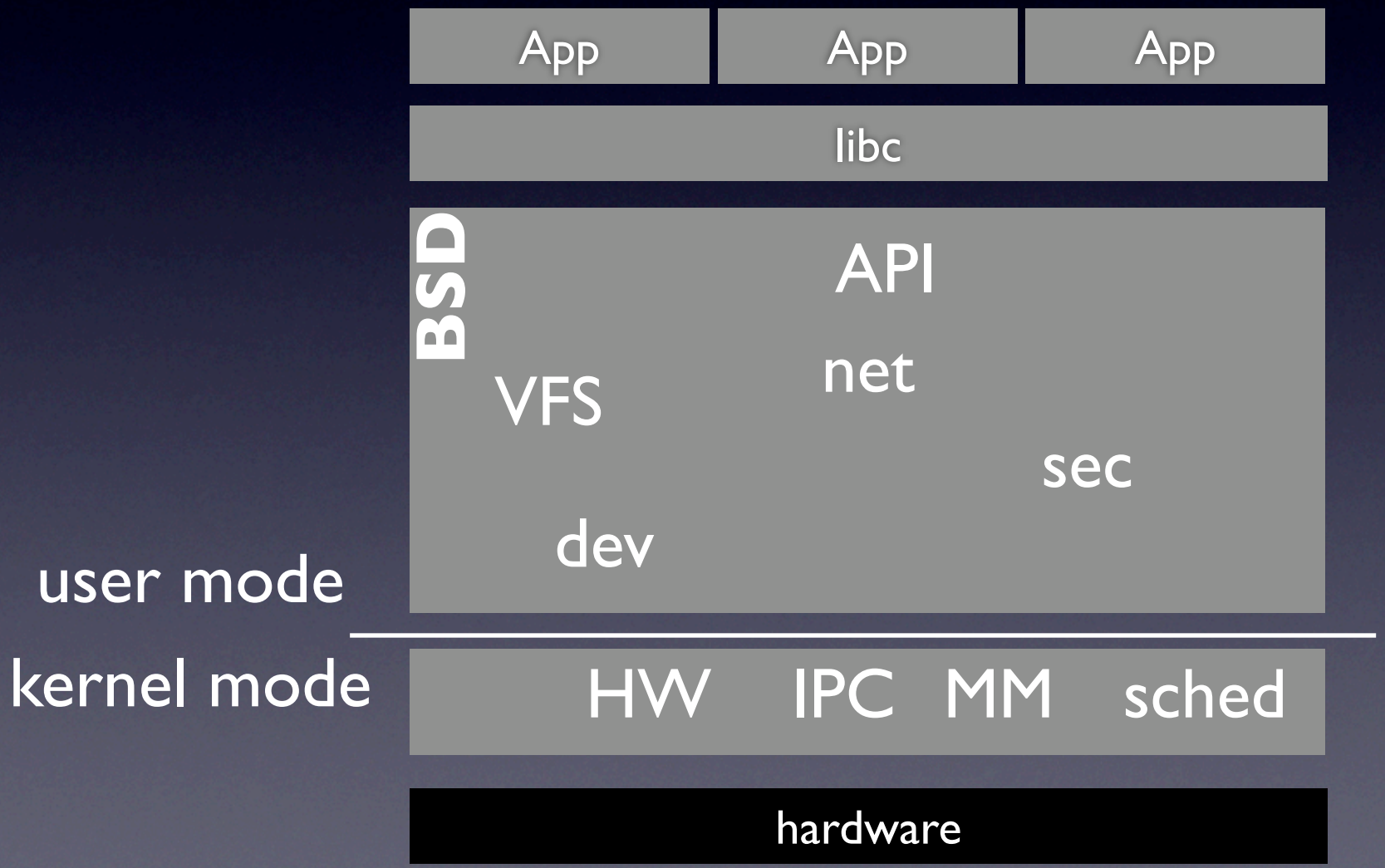
microkernel



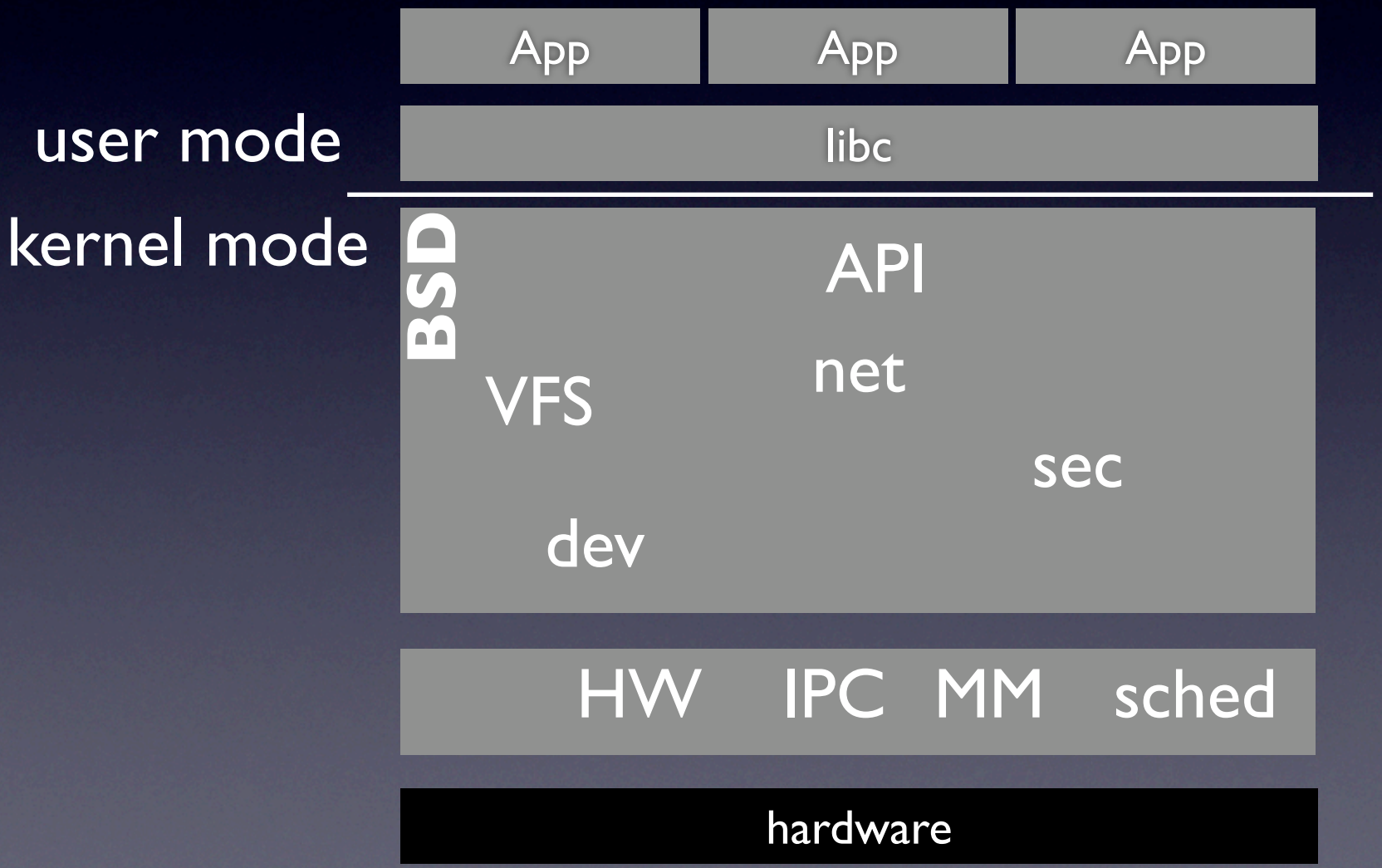
microkernel



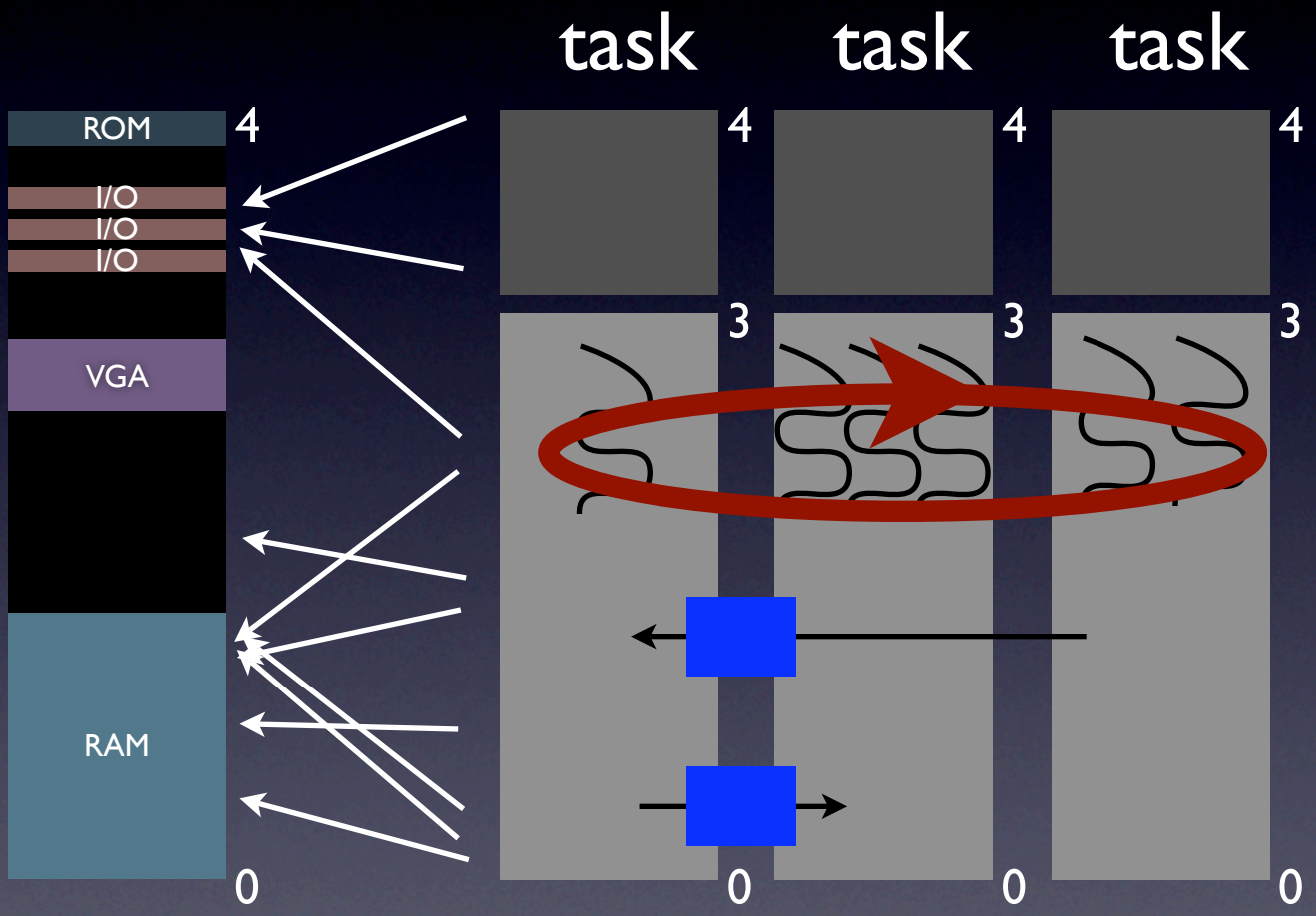
BSD Single Server



Co-location

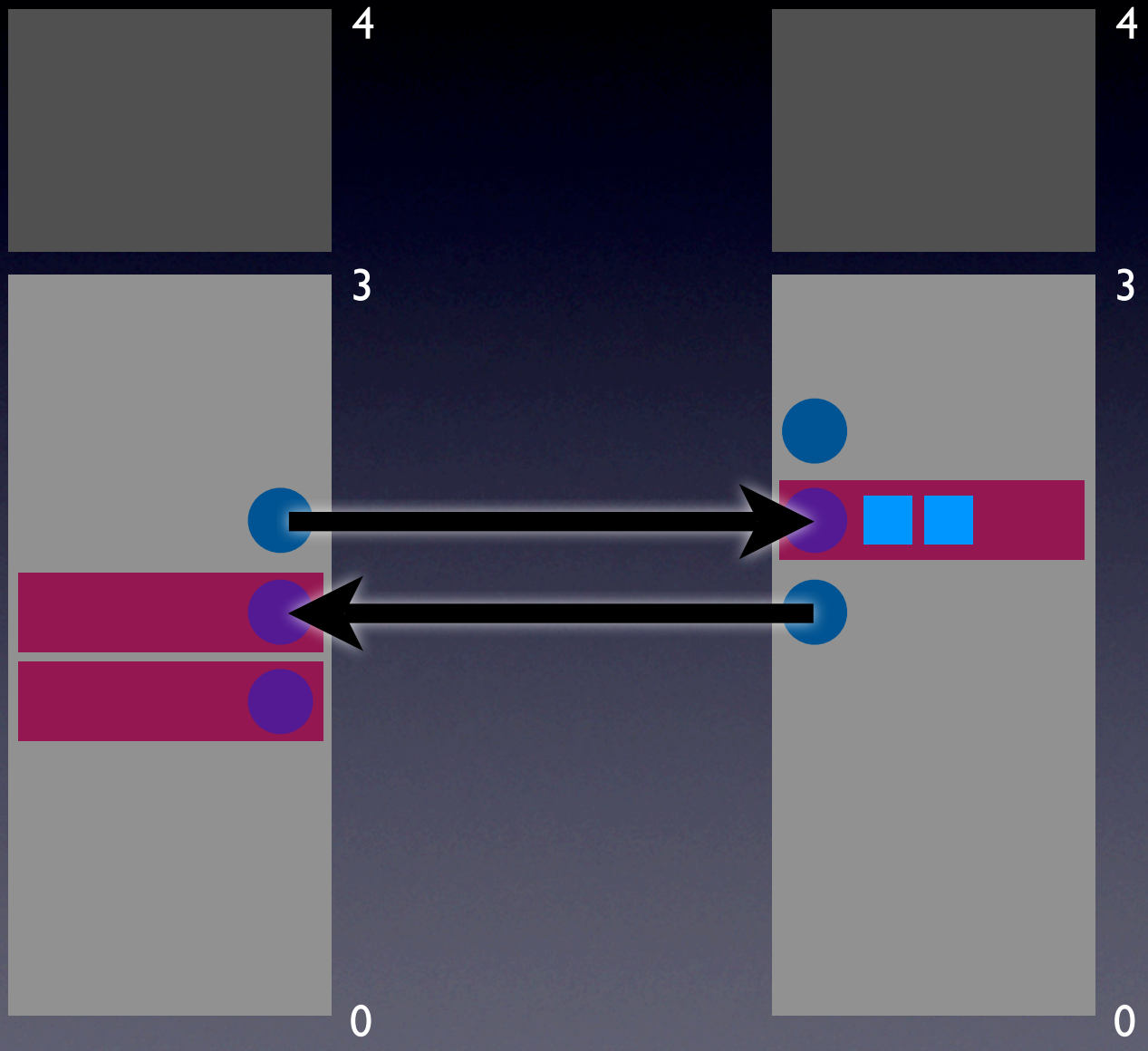

App
App
App
user mode
libc
kernel mode
BSD
API
net
VFS
sec
dev
HW
IPC
MM
sched
hardware

Mach

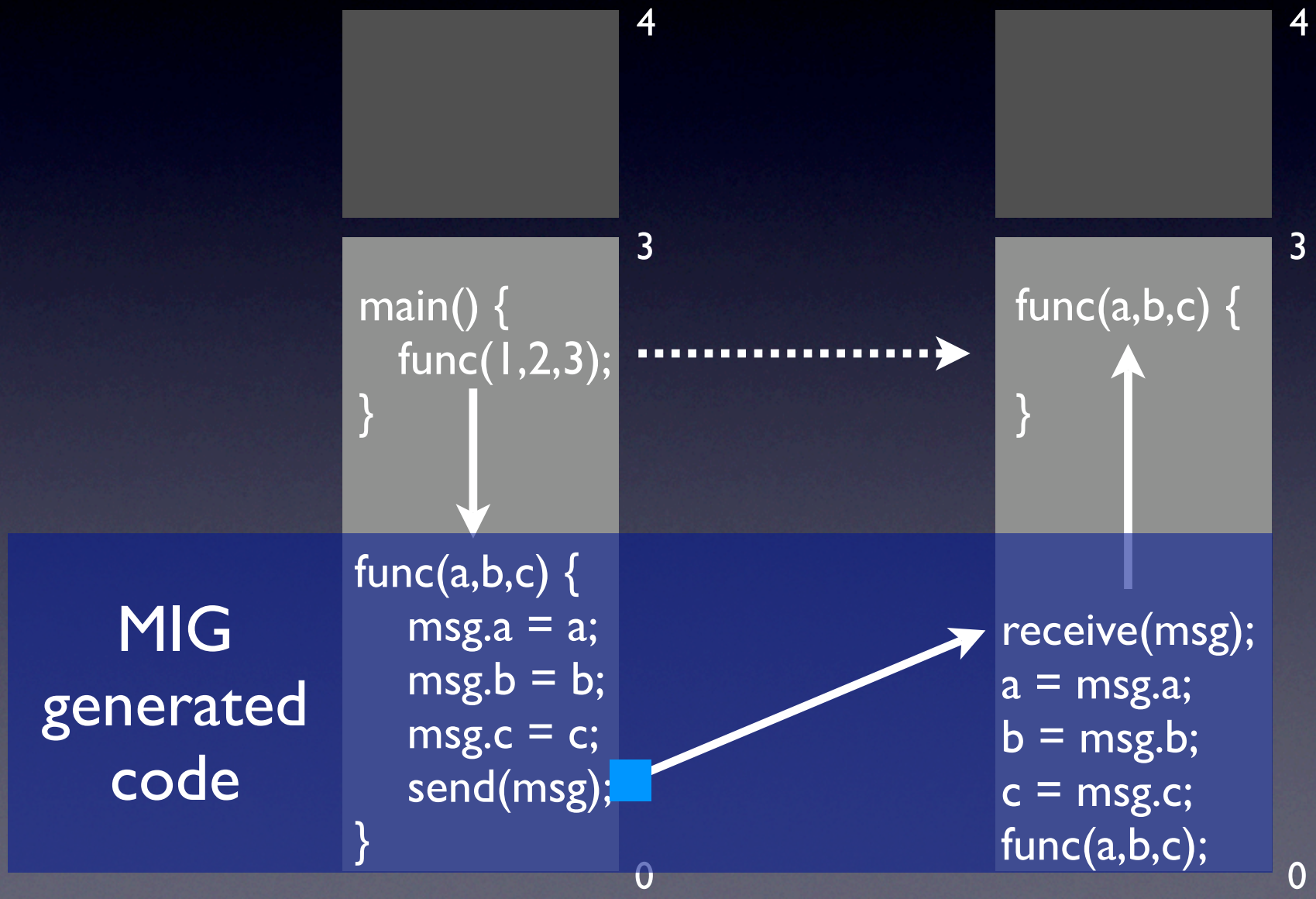


- memory management
- scheduling
- inter-process communication

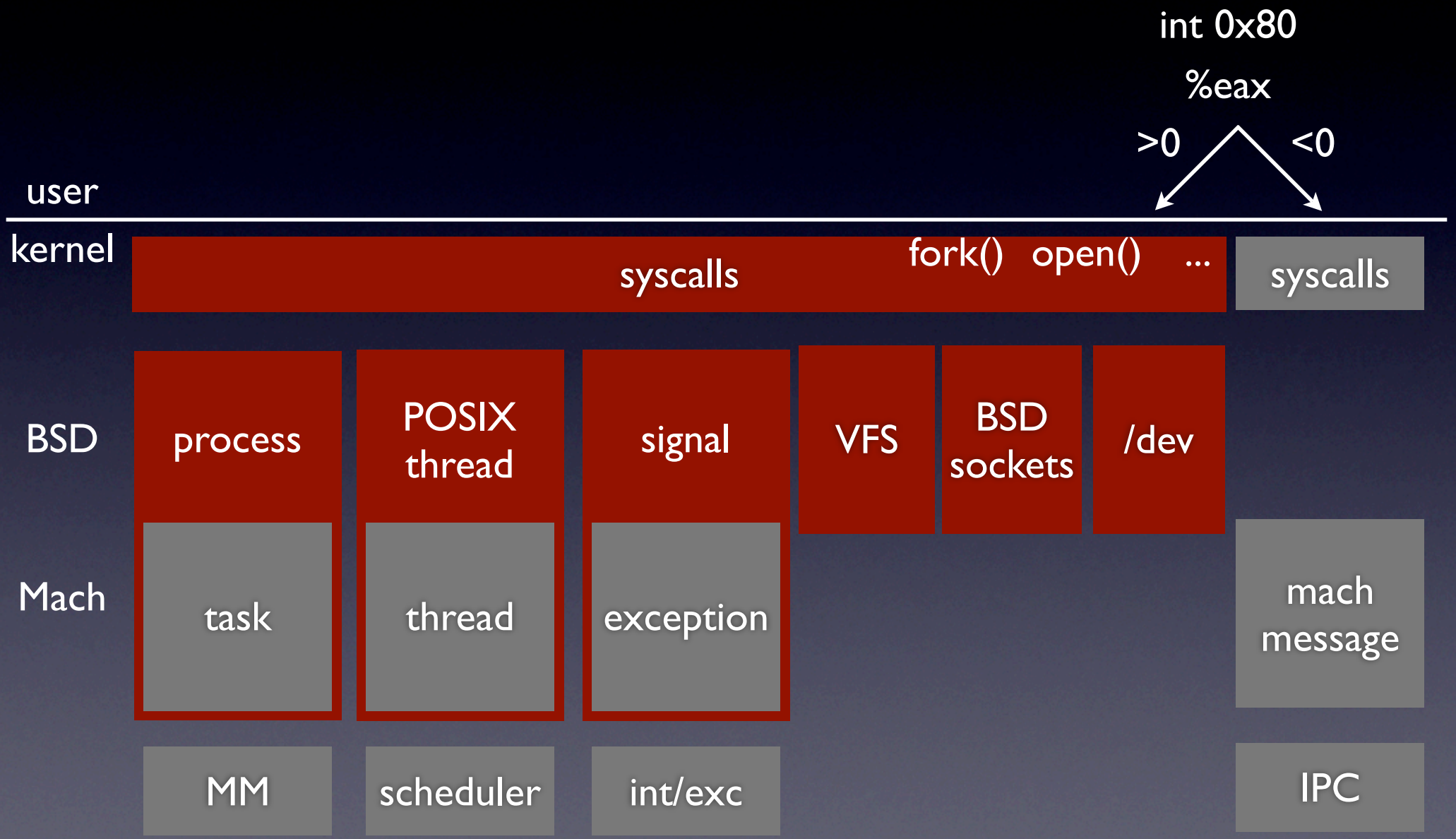
Mach IPC



Mach Interface Generator (MIG)



Mach + BSD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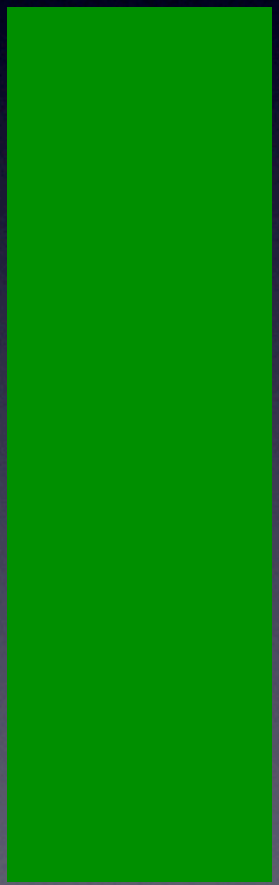
%eax
>0
<0
user
kernel
syscalls
fork()
open()
...
syscalls
BSD
process
POSIX thread
signal
VFS
BSD sockets
/dev
Mach
task
thread
exception
mach message
MM
scheduler
int/exc
IPC

Drivers

driver.c



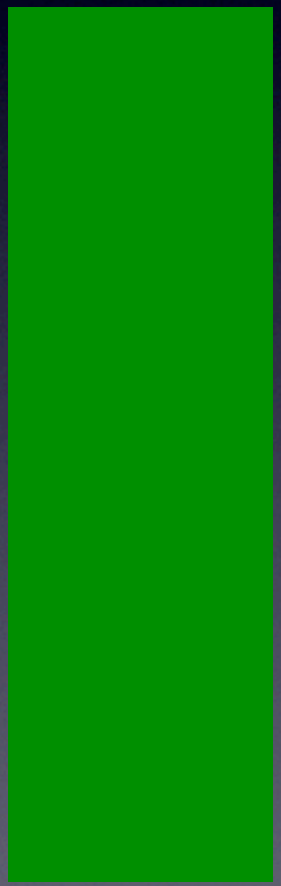
driver2.c

Drivers

driver.c

I/O-Kit

generic.cc



special.cc

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ACard68xxM.kext	Aug 22, 2007, 10:33 PM	176 KB	Kernel Extension
ACard671xSCSI.kext	Aug 22, 2007, 10:32 PM	184 KB	Kernel Extension
ACard6280ATA.kext	Aug 22, 2007, 10:33 PM	156 KB	Kernel Extension
ACard6885M.kext	Aug 22, 2007, 10:33 PM	192 KB	Kernel Extension
ACard67162.kext	Aug 22, 2007, 10:32 PM	188 KB	Kernel Extension
ALF.kext	Oct 10, 2007, 6:48 AM	160 KB	Kernel Extension
Apple_iSight.kext	Oct 10, 2007, 6:46 AM	100 KB	Kernel Extension
Apple02Audio.kext	Oct 10, 2007, 6:49 AM	936 KB	Kernel Extension
Apple16X50Serial.kext	Oct 10, 2007, 6:44 AM	380 KB	Kernel Extension
AppleACPIPlatform.kext	Oct 10, 2007, 6:45 AM	640 KB	Kernel Extension
AppleAD741x.kext	Oct 10, 2007, 6:43 AM	68 KB	Kernel Extension
AppleADBButtons.kext	Oct 10, 2007, 6:47 AM	100 KB	Kernel Extension
AppleADBKeyboard.kext	Oct 10, 2007, 6:45 AM	120 KB	Kernel Extension
AppleADBMouse.kext	Oct 10, 2007, 6:46 AM	172 KB	Kernel Extension
AppleADM103x.kext	Oct 10, 2007, 6:48 AM	64 KB	Kernel Extension
AppleADT746x.kext	Oct 10, 2007, 6:48 AM	64 KB	Kernel Extension
AppleAHCIPort.kext	Oct 10, 2007, 6:47 AM	228 KB	Kernel Extension
AppleAirPort.kext	Oct 10, 2007, 6:47 AM	408 KB	Kernel Extension
AppleAltiVecDVDDriver.bundle	Oct 12, 2007, 3:51 AM	224 KB	Bundle
AppleAPIC.kext	Oct 10, 2007, 6:43 AM	56 KB	Kernel Extension
AppleBacklight.kext	Sep 24, 2007, 4:14 AM	120 KB	Kernel Extension
AppleBlower.kext	Oct 10, 2007, 6:45 AM	60 KB	Kernel Extension
AppleBMC.kext	Oct 10, 2007, 6:52 AM	192 KB	Kernel Extension
AppleCore99NVRAM.kext	Oct 10, 2007, 6:45 AM	56 KB	Kernel Exte
AppleCPUThermo.kext	Oct 10, 2007, 6:44 AM	64 KB	Kernel Ext
AppleDallasDriver.kext	Oct 10, 2007, 6:50 AM	64 KB	Kernel Exte
AppleEFIRuntime.kext	Oct 10, 2007, 6:47 AM	140 KB	Kernel Exte
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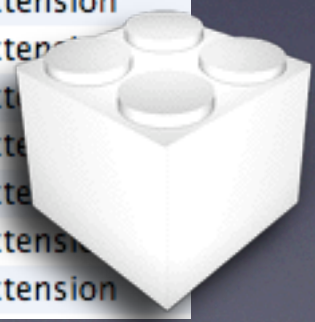
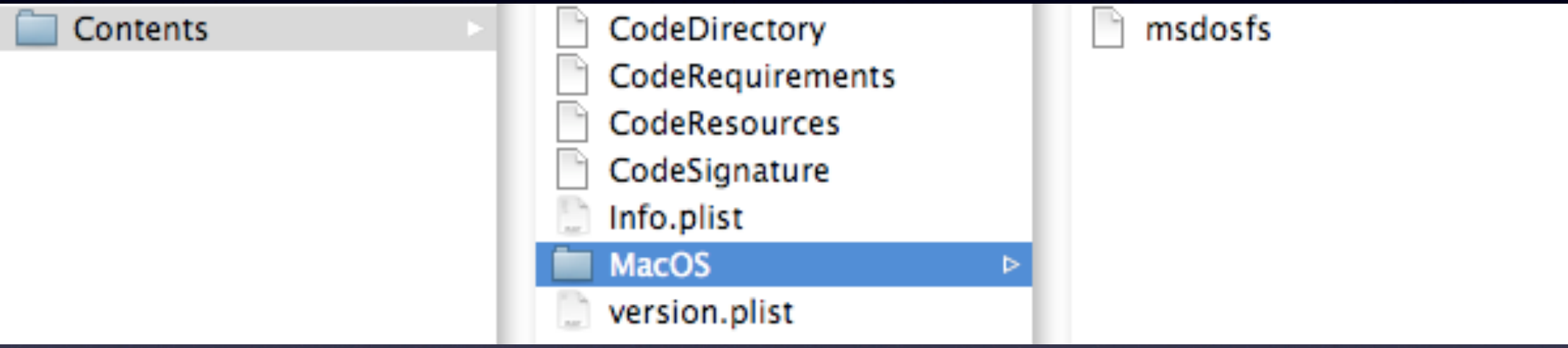
AppleFCU.kext	Oct 10, 2007, 6:47 AM	80 KB	Kernel Extension




Contents
CodeDirectory
CodeRequirements
CodeResources
CodeSignature
Info.plist
MacOS
version.plist
msdosfs

```
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	<key>CFBundleInfoDictionaryVersion</key>
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	<key>CFBundleName</key>
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	<key>CFBundleSignature</key>
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	<dict/>
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		<key>com.apple.kpi.mach</key>
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```

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        <key>com.apple.kpi.mach</key>
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        <key>com.apple.kpi.unsupported</key>
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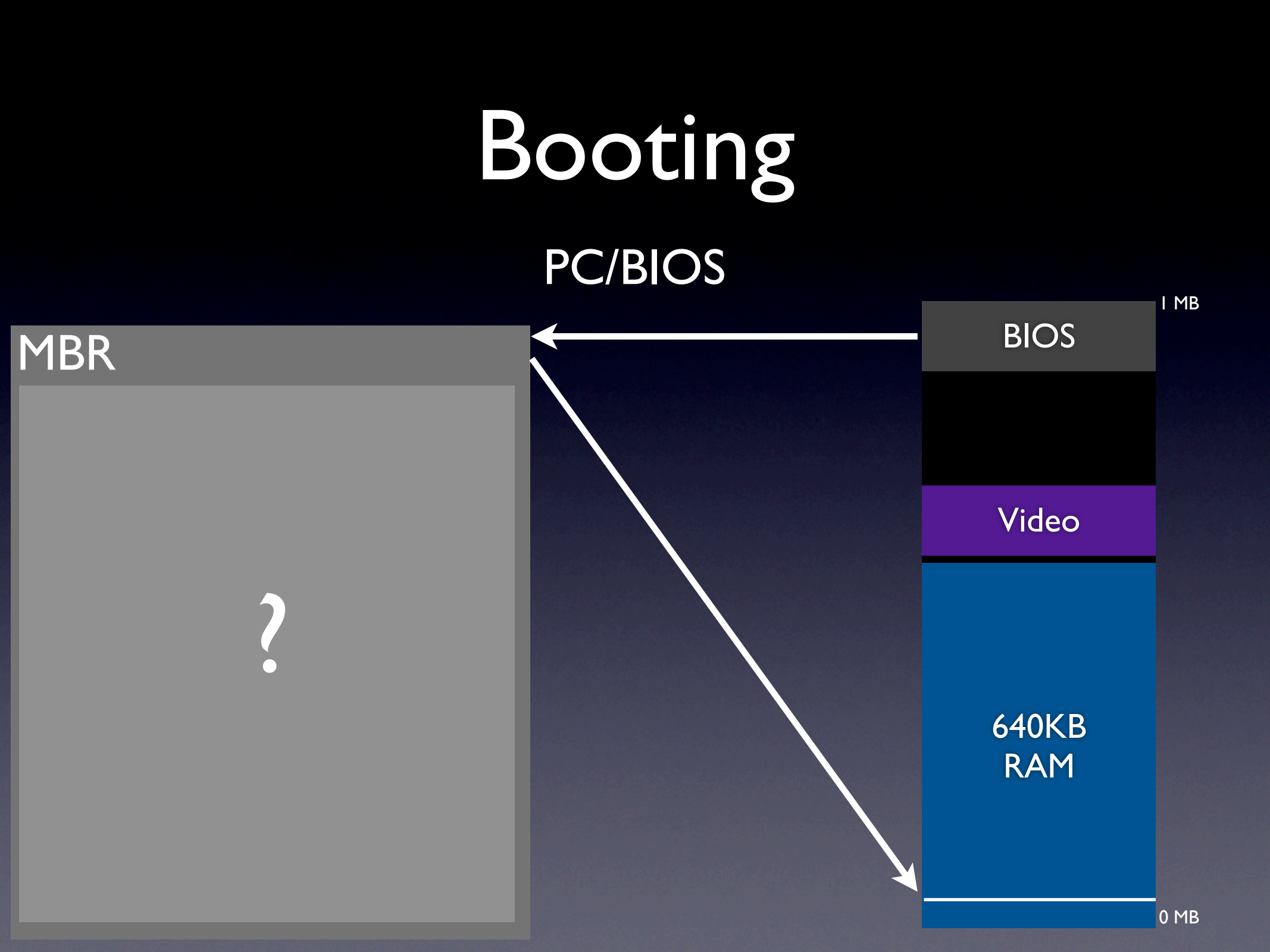
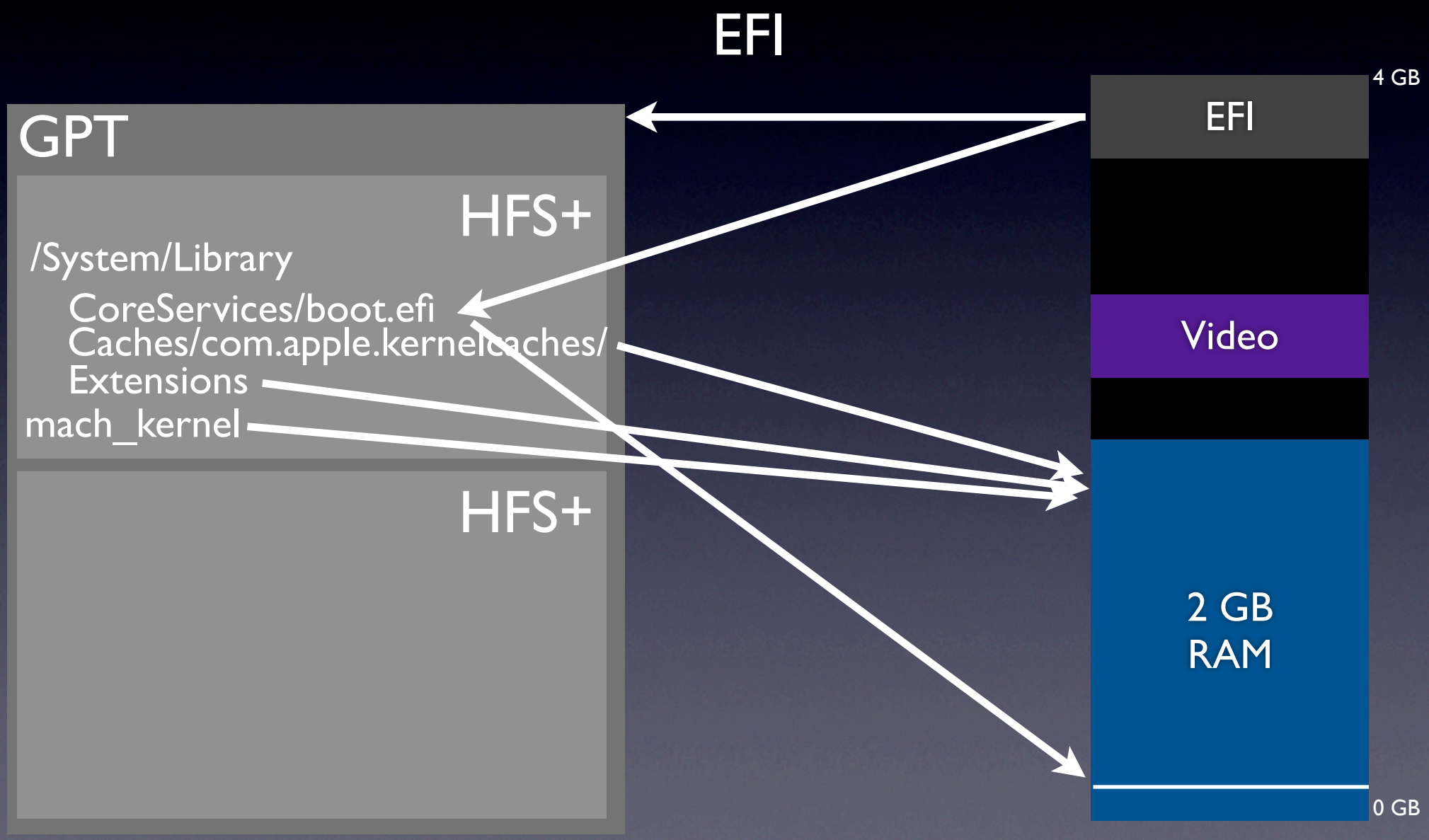
    </dict>
```

Info.plist

Booting



Booting


EFI
GPT
HFS+
/System/Library
CoreServices/boot.efi
Caches/com.apple.kernelcaches/
Extensions
mach_kernel
HFS+
4 GB
EFI
Video
2 GB
RAM
0 GB

http://clc.its.psu.edu/Labs/Mac/Resources/blastimageconfig/images/SigBuild/Intel-Sig-BootPicker.JPG

Mach-O

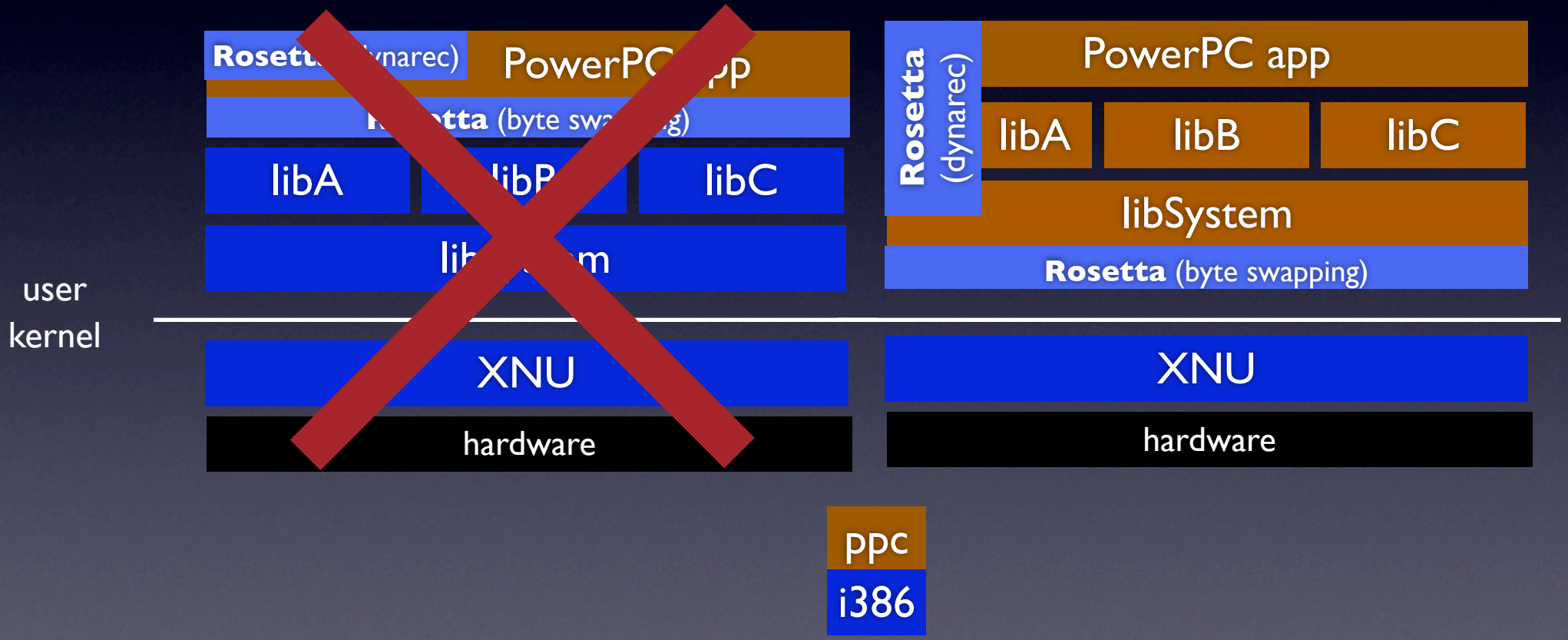
```
$ file libSystem.dylib
libSystem.dylib: Mach-O universal binary with 4 architectures
libSystem.dylib (for architecture ppc7400):    Mach-O dynamically linked shared library ppc
libSystem.dylib (for architecture ppc64):      Mach-O 64-bit dynamically linked shared library ppc64
libSystem.dylib (for architecture i386):       Mach-O dynamically linked shared library i386
libSystem.dylib (for architecture x86_64):     Mach-O 64-bit dynamically linked shared library x86_64
```

~~/usr/lib~~
~~/usr/lib64~~

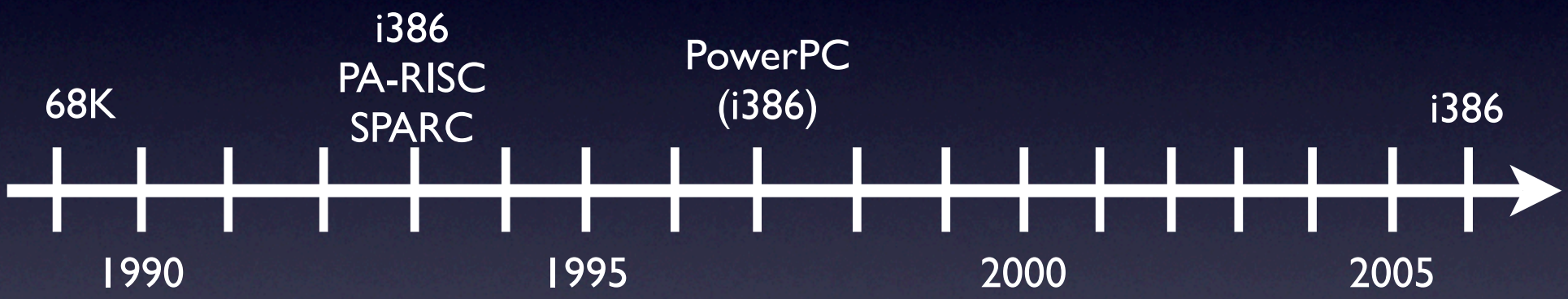
~~C:\WINDOWS\SYSTEM~~
~~C:\WINDOWS\SYSTEM32~~
~~C:\WINDOWS\SYSTEM64~~

```
$ file /mach_kernel
/mach_kernel: Mach-O universal binary with 2 architectures
/mach_kernel (for architecture i386):Mach-O executable i386
/mach_kernel (for architecture ppc): Mach-O executable ppc
```

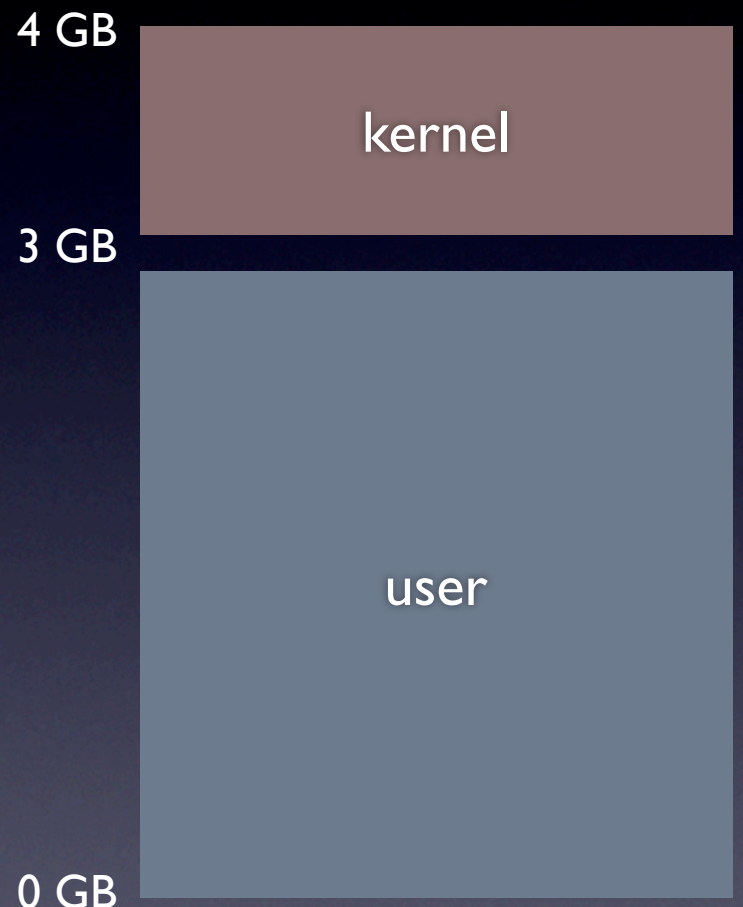
Rosetta


Rosetta (dynarec)
PowerPC app
Rosetta (byte swapping)
libA
libB
libC
libSystem
user
kernel
XNU
hardware
ppc
i386

Architectures

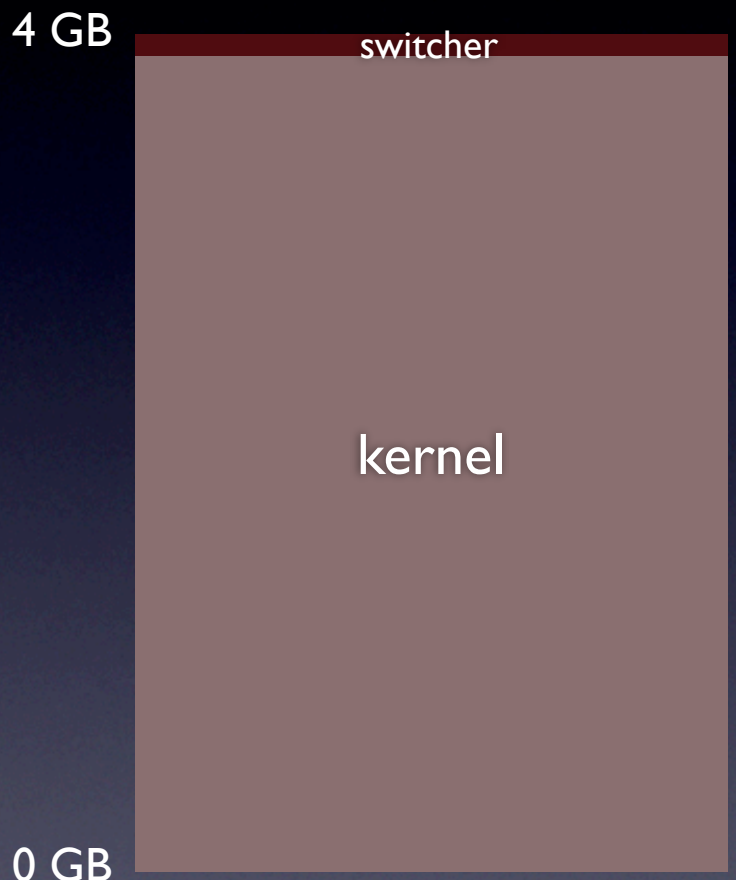


3/1 Split



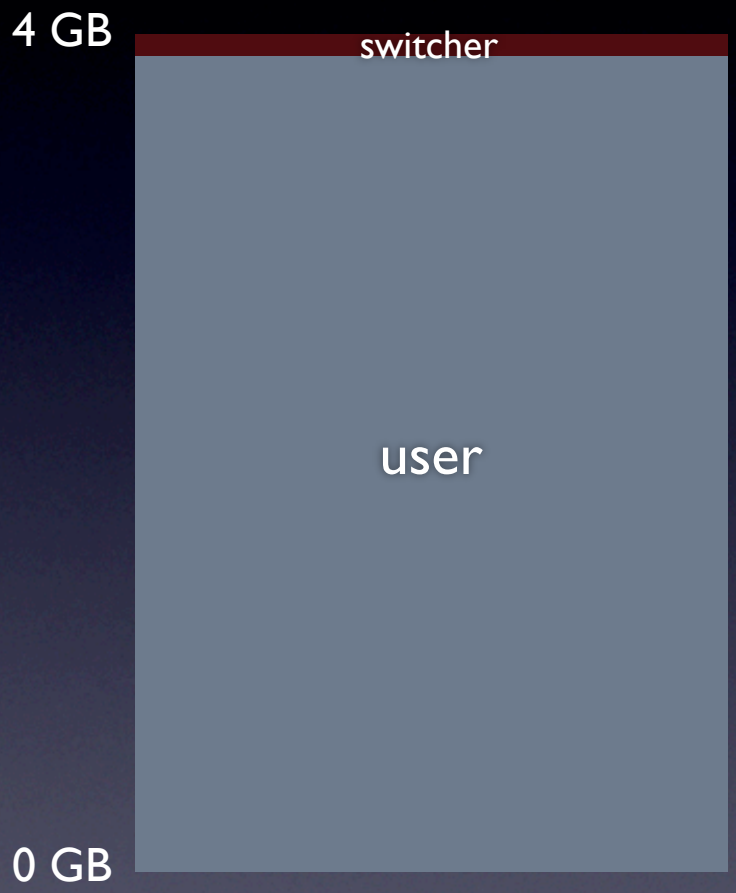
Windows, Linux, ...

4/4 Split



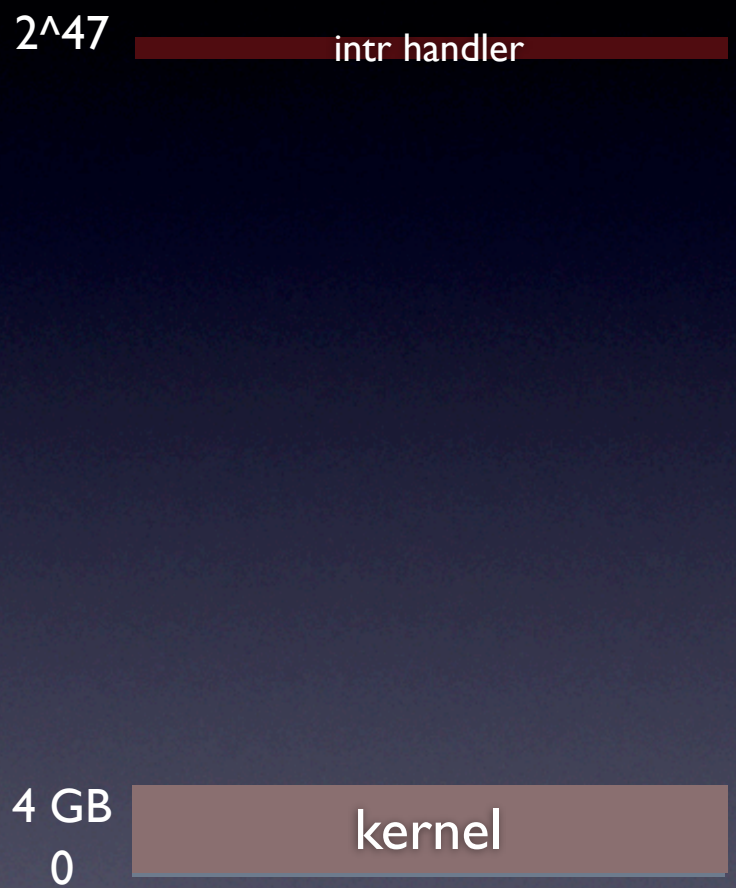
Mac OS X Intel

4/4 Split



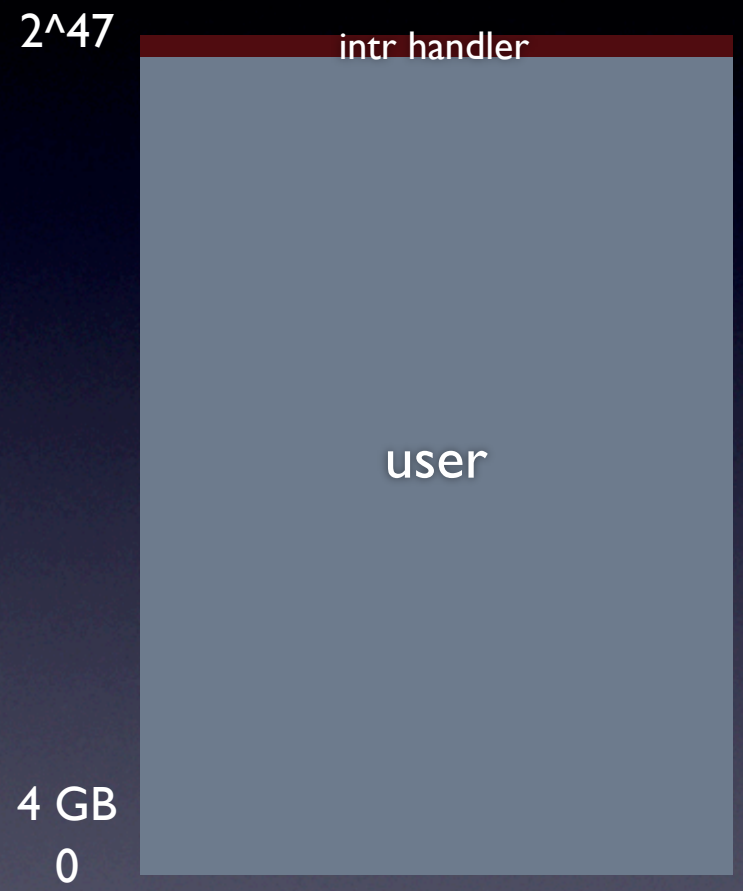
Mac OS X Intel

x86_64



x86_64

x86_64



iPhone

- ARM
- Custom Bootloader
- No real KEXTs
- Kernel Cache

Darwin Releases

Download or browse the Darwin source code releases from the links below.

Mac OS X (Darwin) Releases		
Mac OS X 10.5	Darwin 9.0	Source (PPC & x86)
Mac OS X 10.4.10	Darwin 8.10	Source (PPC) Source (x86)
Mac OS X 10.4.9	Darwin 8.9	Source (PPC) Source (x86)
Mac OS X 10.4.8	Darwin 8.8	Source (PPC) Source (x86)
Mac OS X 10.4.7	Darwin 8.7	Source (PPC) Source (x86)
Mac OS X 10.4.6	Darwin 8.6	Source (PPC)

Developer Tools Releases	
August 2006 Developer Tools Xcode Tools 2.4	Source
May 2006 Developer Tools Xcode Tools 2.3	Source
November 2005 Developer Tools Xcode Tools 2.2	Source
June 2005 Developer Tools Xcode Tools 2.1	Source
November 2004 GCC Update	Source
August 2004 Developer Tools Xcode Tools 1.5	Source

shell_cmds-116	Other	.tar.gz
smb-344	Other	.tar.gz
srm-6	Other	.tar.gz
stmalloc-4	APSL	.tar.gz
subversion-16	Other	.tar.gz
sudo-28	Other	.tar.gz
svk-9	Other	.tar.gz
swig-4	Other	.tar.gz
syslog-64	APSL	.tar.gz
system_cmds-431	APSL	.tar.gz
system_config-49	APSL	.tar.gz
tcl-64	Other	.tar.gz
tcp_wrappers-18	Other	.tar.gz
tcpdump-23	Other	.tar.gz
tcsh-60	Other	.tar.gz
texi2html-5	Other	.tar.gz
texinfo-17	Other	.tar.gz
text_cmds-68	APSL	.tar.gz
tidy-13	Other	.tar.gz
top-37	APSL	.tar.gz
usertemplate-65	APSL	.tar.gz
uucp-10	Other	.tar.gz
vim-34	Other	.tar.gz
webdavfs-252	APSL	.tar.gz
wxWidgets-11	Other	.tar.gz
xar-28	Other	.tar.gz
xelf-1	Other	.tar.gz
xnu-1228	APSL	.tar.gz
zip-9	Other	.tar.gz
zlib-18	Other	.tar.gz
zsh-48	Other	.tar.gz

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Version 2.0 - August 6, 2003

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What Makes XNU Great

What Makes XNU Great

#8

dtrace

What Makes XNU Great

#7
kernel cache

What Makes XNU Great

#6

Separation between Mach, BSD, I/O-Kit

What Makes XNU Great

#5
POSIX Conformance

What Makes XNU Great

#4

Mach Message API

What Makes XNU Great

#3
I/O-Kit

What Makes XNU Great

#2
Stable KEXT ABI

What Makes XNU Great

#1
Universal Binaries

Buzzwords

again

Mach

- The Mac OS X kernel is not “Mach”.
- The Mac OS X kernel is XNU.
- XNU consists of Mach, BSD and I/O-Kit.

Microkernel

- The OS X kernel is not a microkernel.
- The Mach codebase can be used as a microkernel.
- XNU is a monolithic kernel.
- BSD and most drivers are in kernel mode.

FreeBSD Kernel

- The Mac OS X kernel is not based on the FreeBSD kernel.
- XNU contains some FreeBSD code.

C++

- XNU is not written in C++.
- I/O-Kit is written in Embedded C++.
- Mach and BSD are written in C.

64 bit

- The Mac OS X kernel is not 64 bit.
- It supports 64 bit user land applications.
- The kernel code is 32 bit with tiny 64 bit parts for user support.

Open Source

- The Mac OS X kernel and most of the UNIX bits are Open Source.
- But there is no live repository.
- Some code is missing.
- But it can be compiled into a working system.

- Mac OS X is “UNIX”.
- But only since Leopard.
- It passed the POSIX Conformance Test.
- It may use the “UNIX” trademark.
- It does not contain AT&T UNIX code.

Awesome

- But Mac OS X is awesome.
- That's a fact.

lucy