Mac OS X File Systems

Had to give it a shot!

Most ideas come from previous ideas.

Alan Kay

Looking Back

BASIC

UNIX IS MERELY
DEC
CALIFORNIA
MULTICS
WITH NO BALLS

PAÑAL DESECHABLE

Kids

Unix

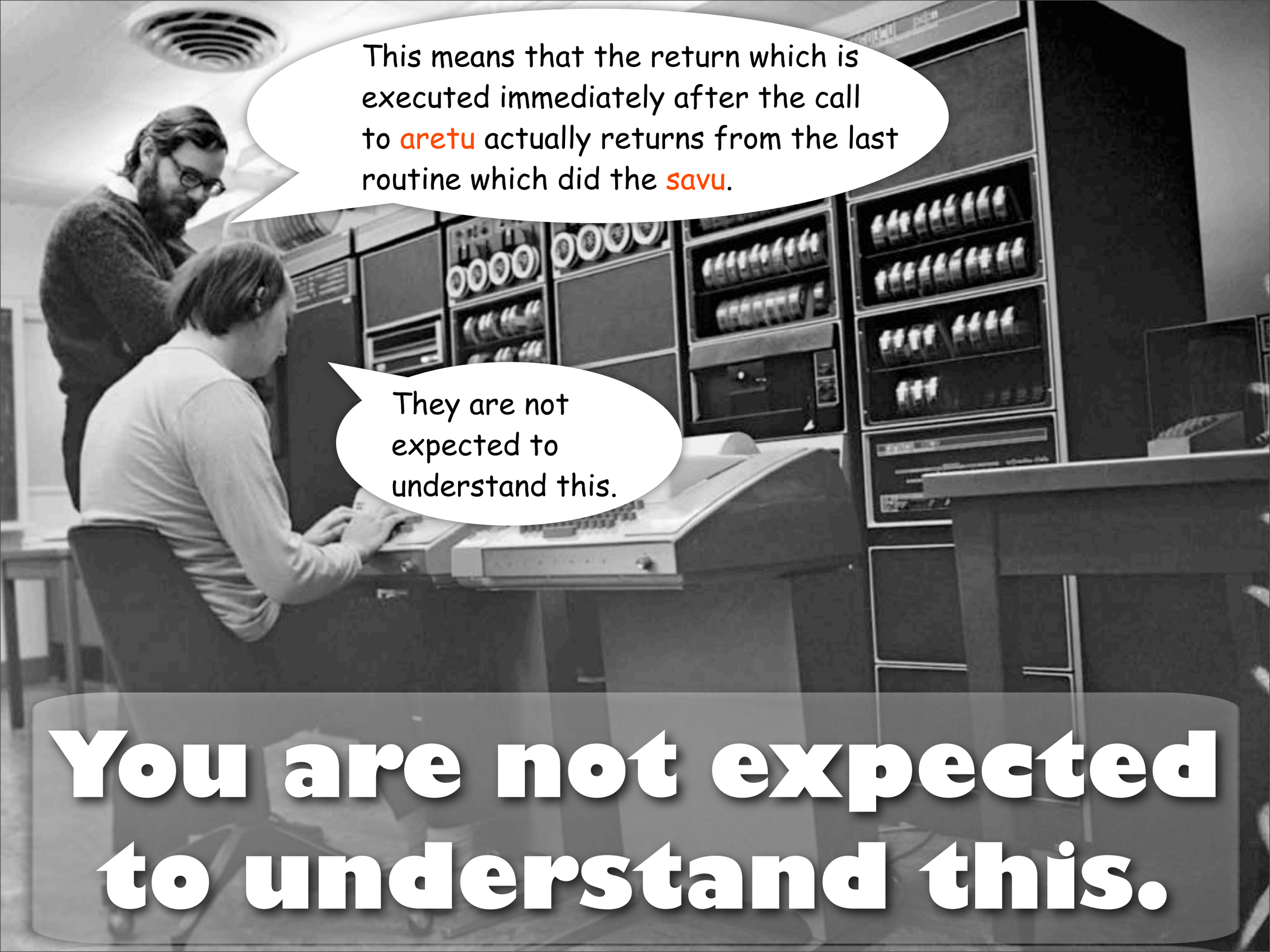
BY DRYPERS

UNISEX

DOBLE ABSORBENCIA
DOBLE BARRERA
ULTRADELGADO

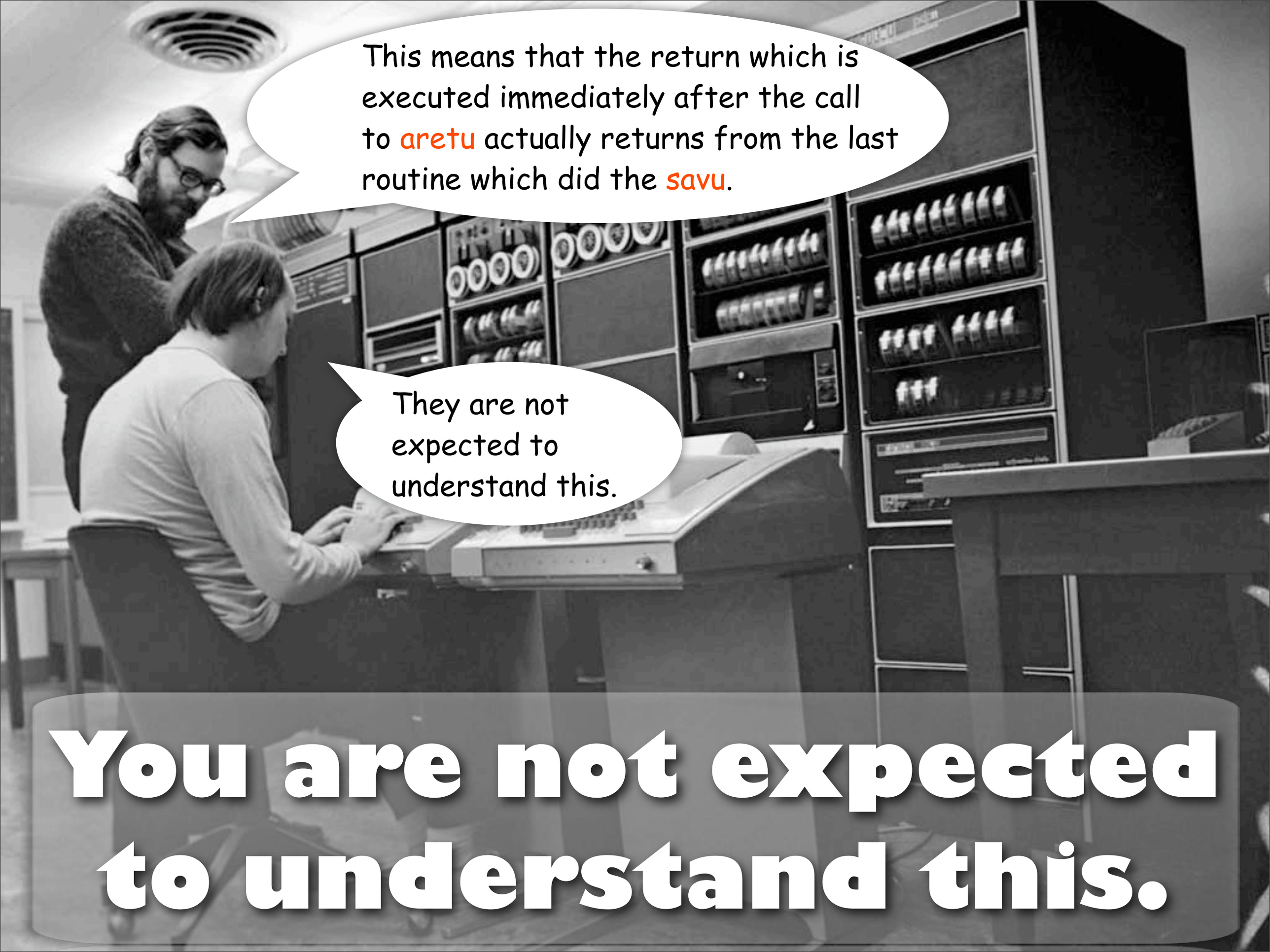
CONTENIDO

14


This means that the return which is executed immediately after the call to aretu actually returns from the last routine which did the savu.
They are not expected to understand this.
You are not expected to understand this.

UNIX

The most important role of UNIX is to provide a file system.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UNIX

The most important
Everything is a file.
provide a file system.

User Program

User

Kernel

System Calls

System Call Layer

The File System

User Program

User

Kernel

System Calls

System Call Layer

Which?

File System 1

File System 2

User Program

User

Kernel

System Calls

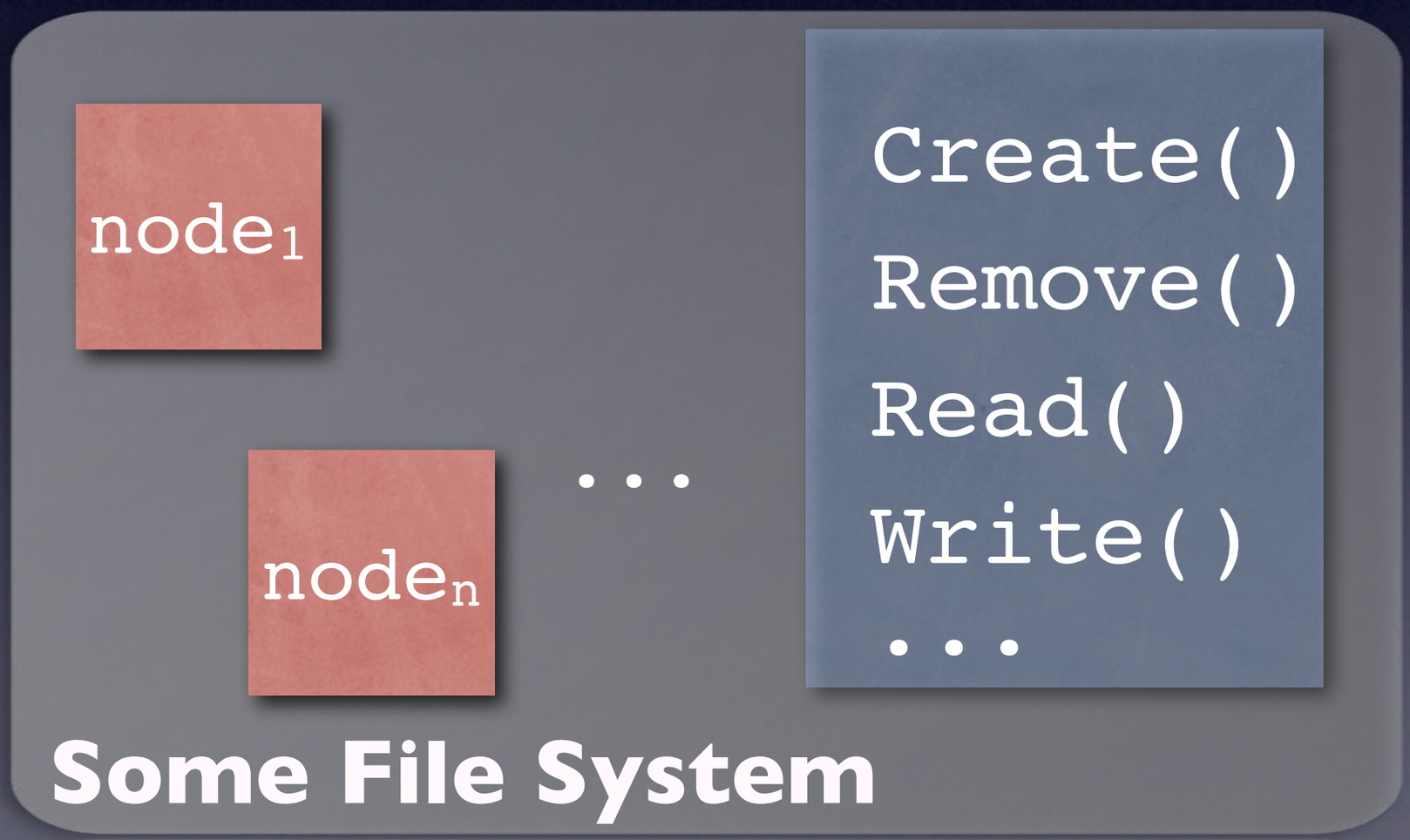
System Call Layer

Which?

FS_1 FS_2 FS_3 ... FS_n

User

Kernel



User

Kernel

User Program

System Call Layer

VNOP_CREATE()
VNOP_REMOVE()
VNOP_READ()
VNOP_WRITE()
...

v_1 ... v_n ... v_{n+1} ... v_{n+m}

Vnode/VFS

h_1 ... h_n

hfs_create()
hfs_remove()
hfs_read()
hfs_write()
...

HFS+

u_1 ... u_m

ufs_create()
ufs_remove()
ufs_read()
ufs_write()
...

UFS

File Systems

HFS+

HFS

UF

AFP

SMB/CIFS

NFS

cddafs

devfs

fdesc

Many File Systems

UDF

WebDAV

ISO9660

FTP

FS

NTFS

MS-DOS

deadfs

fifofs

specfs

synthfs

union

volfs

ZFS

Malloc/Free Abstraction

No partitions (just storage pool)

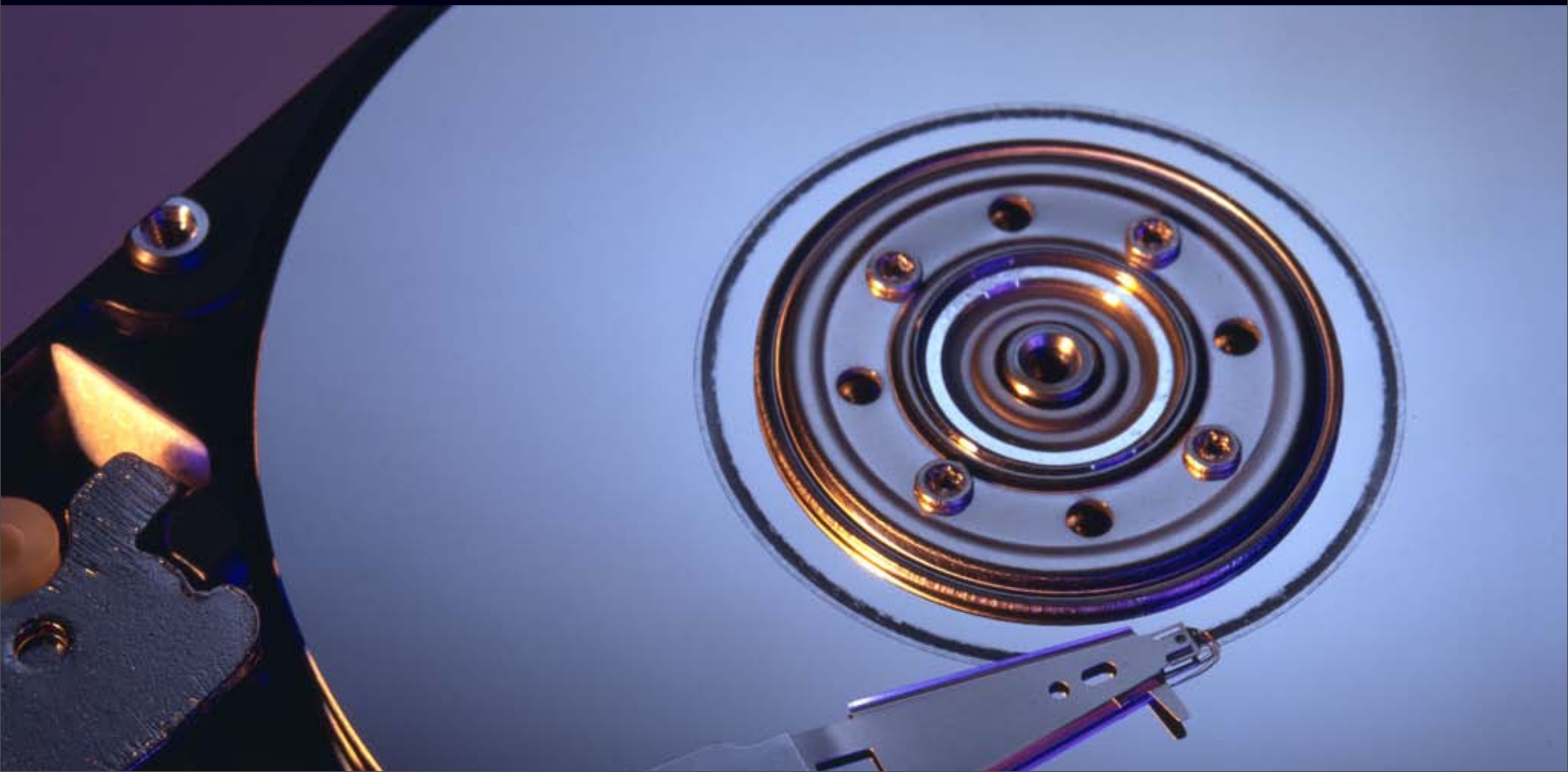
Automatically grows/shrinks

Pool's storage shared across file systems

Transactional (no journal, no fsck)

Copy-on-write, checksummed

Inside HFS+

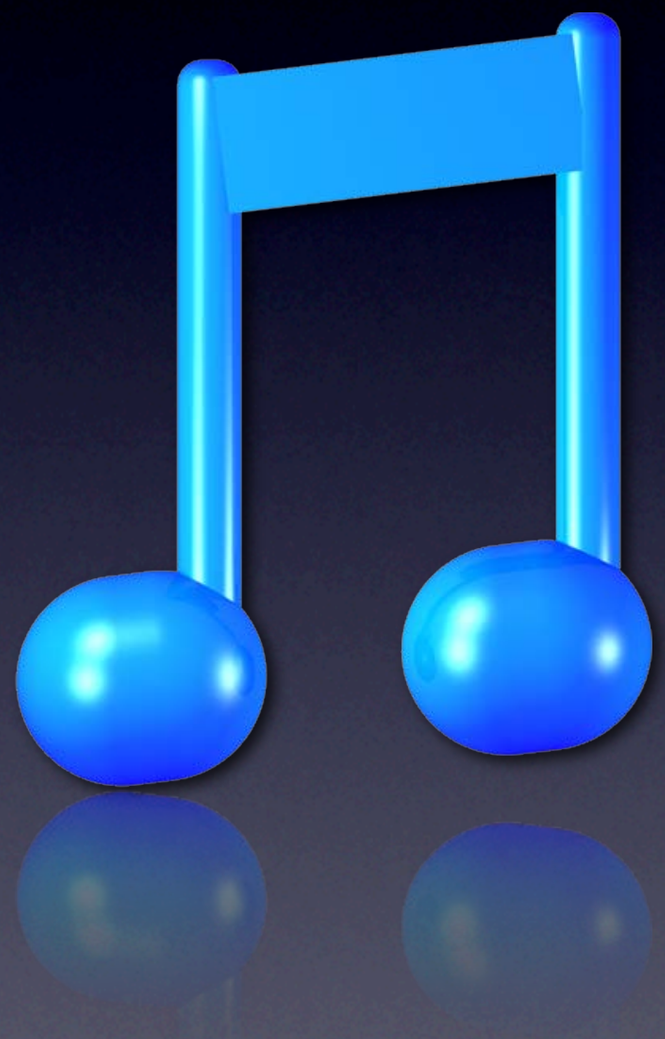


```
$   sudo hfsdebug -f -t 10
...
# Top 10 Files with the Most Extents

1              632          183.10    2163846
Macintosh HD:/.Spotlight-V100/.store.db

2              618          187.24    2163845
Macintosh HD:/.Spotlight-V100/store.db
...

Out of 2252467 non-zero data forks total,
2252128 (99.98 %) have no fragmentation.
```

```
$   sudo hfsdebug -0 | sort -n +1
# Free Contig Starting@   Ending@    Space
...
101813        0x2e1097b   0x2e2972f 397.71MB
127220        0x48f0c     0x67fff   496.95MB
238304        0x2dca9cd   0x2e04cac 930.88MB
```

```
$   sudo hfsdebug -m
...
next allocation search at block = 0x2c0f7d6
next unused catalog node ID     = 4042316
file system write count         = 138418087
...
```

Demos



http://osxbook.com/software/hfsdebug/

File System

Activity

Carbon App

Cocoa App

X11 App

"Terminal" Commands

Cocoa

NSFileManager

Carbon

Carbon File Manager

User

Kernel

BSD Interfaces (libSystem)

Vnode/VFS Layer

HFS+

UFS

...

NFS

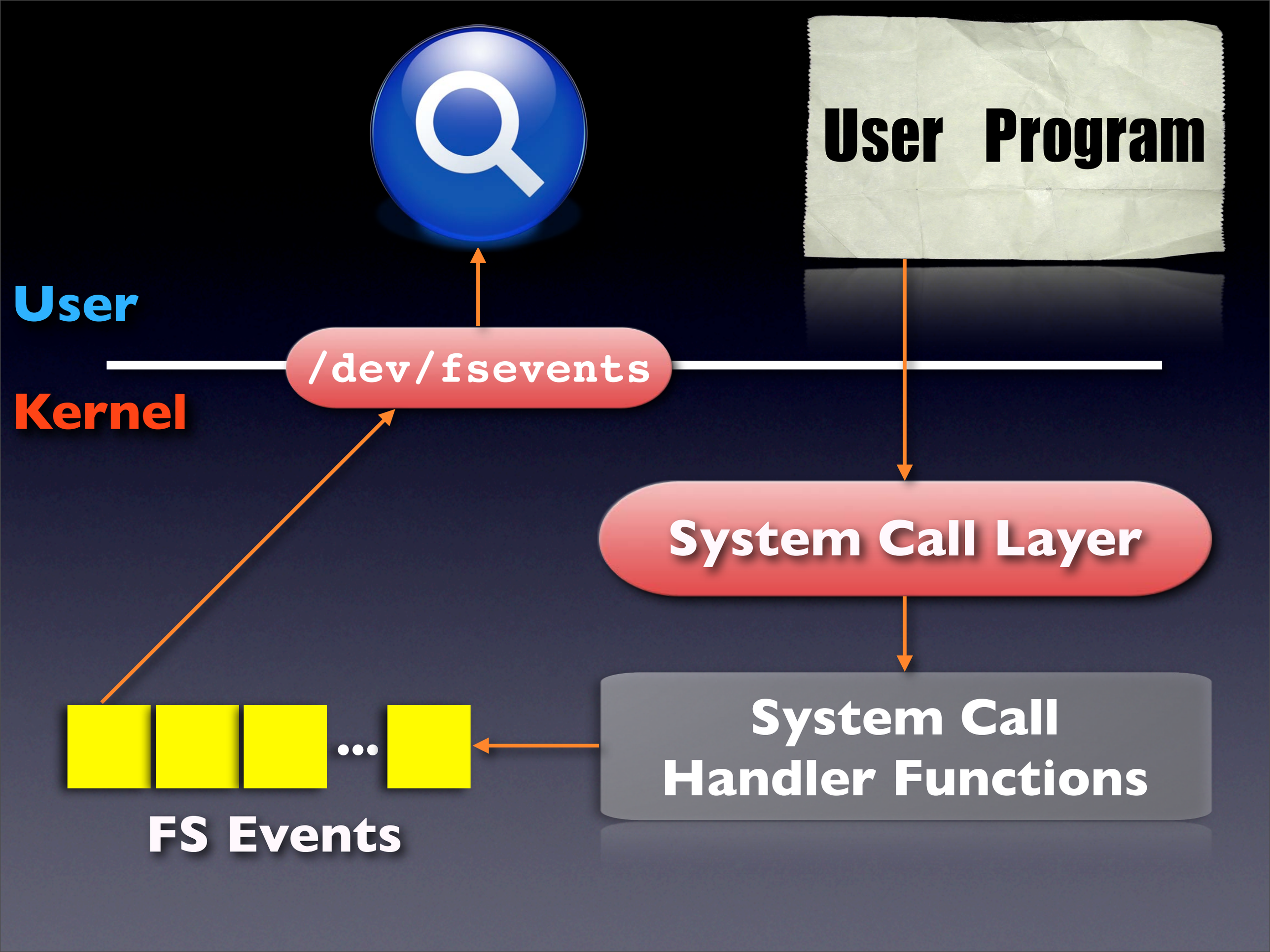
Monitoring
File System Activity

fsevents

Kauth

kdebug

DTrace (Leopard onwards)


User Program
User
/dev/fsevents
Kernel
System Call Layer
System Call
Handler Functions
FS Events

VFS Layer

File Systems

File Execution

`vnode_authorize()`

Kauth Layer

No Listeners

Have Listeners

Call Each Listener

Result

Kernel

fs__usage

latency

sc__usage

User

Kernel

Kdebug Trace Buffer

```
KERNEL_DEBUG*()
```

Kernel Code

Modifying
File System Activity

Permissions and ACLs

Kauth

Storage Filter Scheme

User Program

User

Write

Read

Kernel

...

Filter

Device Services

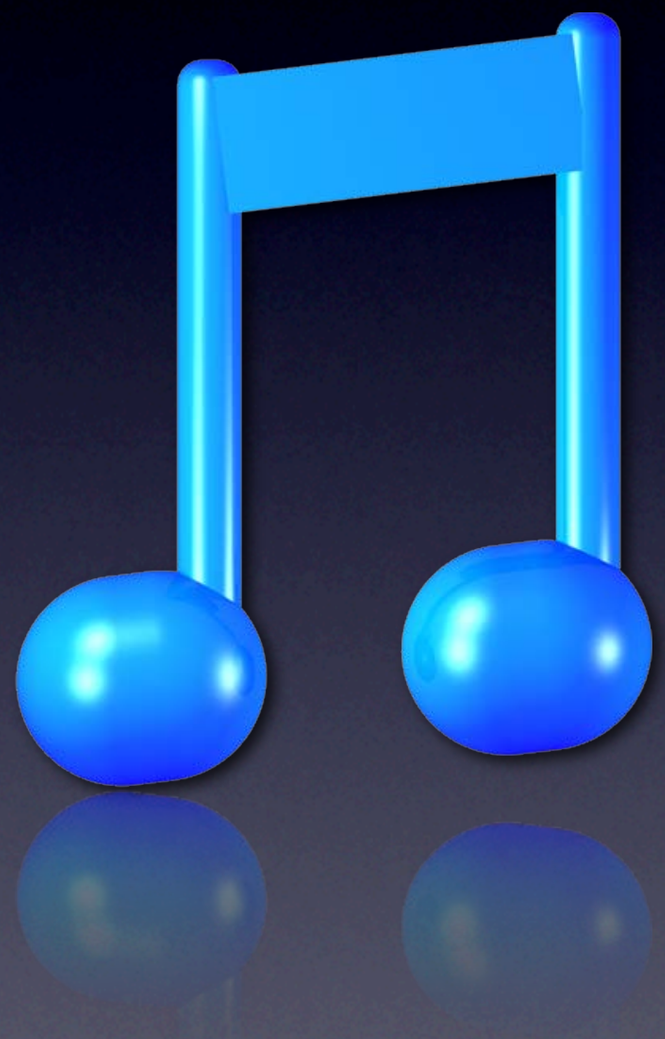
Transport Services

Physical Interconnect

Your Kernel Extension

Device

Demos



Hosting

File System Activity

FTP FS

NFS Server

User Program

User

Kernel

NFS Protocol

NFS Client

mount_webdav

User Program

Local Cache

User

Kernel

Custom Protocol
(AF_UNIX Socket)

WebDAV
VFS
Kernel
Extension

Hosting

File System Activity

Difficult.

Until Today.

MacFUSE

Source of Data

Your File System

libfuse

User Program

User

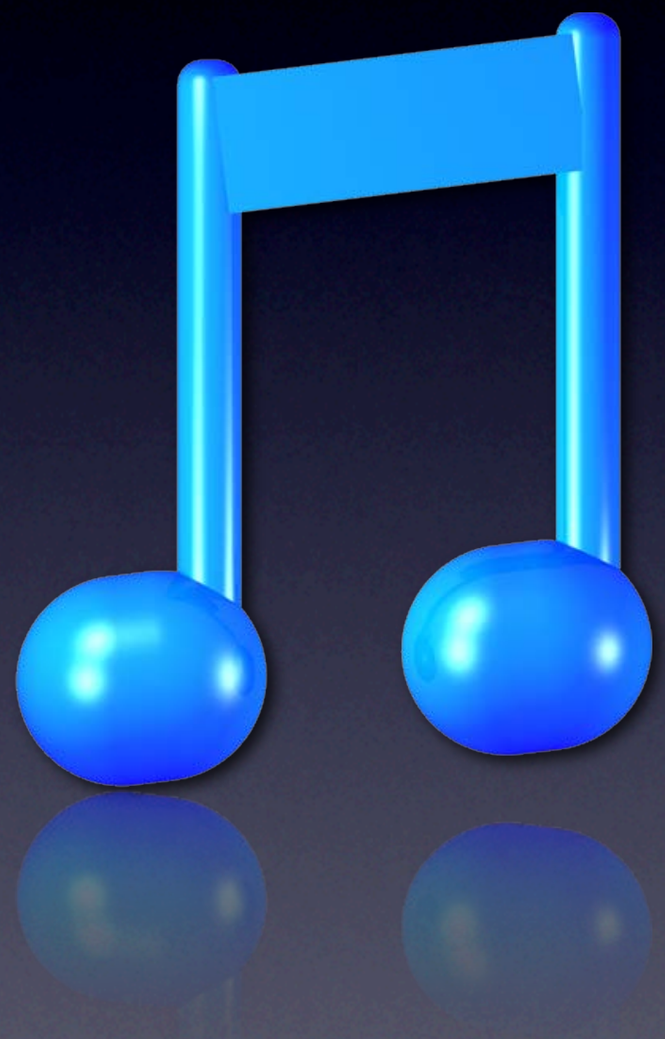
Kernel

/dev/fuse

MacFUSE VFS

ferrisfuse
FuseFTP
unpackfs
FUSE&DPAP
LAFS
gphoto2-fuse-fs
beaglefs
wdfs
OpenomyFS
gitfs
spgmfs
compFUSED
fuse_adfs
Bluetooth
FUR
BlogFS
FlickrFS
fuseiso
Logic
rarfs
LoggedFS
obexfs
RelFS
SMBNetFS
ntfs-3g
fsfip
sshfs
GmailFS
DBToy
ZFS
LZOlayer
FSFS
PhoneBook
GfarmFS
NOOFS
ntfsmount
Grifi
afpfs-ng
Captive NTFS
Fusedav
mcachefs
FUSECompres
playlistfs
hierfs
wikifuse
fusedaap
owfs
yacufs
cddfs
fusecram
fusepak
unionfs-fuse
Clustered RAID
TagsFS
KIO Fuse Gateway
CopyFS
usmb
SMB for FUSE
fuse-dbfs
encfs
Lkarmafs
Cromfs
FunionFS
MountIo
HTTP-FUSE
rofs
BitTorrent
ltspfs
GSpaceFS
ELFI
MythTVfs
CvsFS
Apretujado
GnomeVFS2FUSE
mediamax-fuse
TrackerFS
unFS
httpfs
FUSEPod
Run-Time-Access
djmount
wadfs
FUSE::DBI
gcfuse
Hyppocampus
WikipediaFS
SieFS
GlusterFS
User-Level Versioning
Afuse
dereferencefs
CryptoFS
DVDfs
FUFS
mysqlfs
LUFS Bridge
fdmsfs
archivemount
9pfuse
CurlFtpFS
localfs
mp3fs
Offline Media Content DB

Demos



What's Being Released

MacFUSE VFS kernel extension

Mac OS X patch for libfuse

Mac OS X patch for sshfs

A Universal Binary tarball

http://code.google.com/p/macfuse

Thanks

FUSE Developers on Linux and FreeBSD

Google

My Team

You

Q/A