Linux Day 2006

File System

la potenza nasce dall'hard disk

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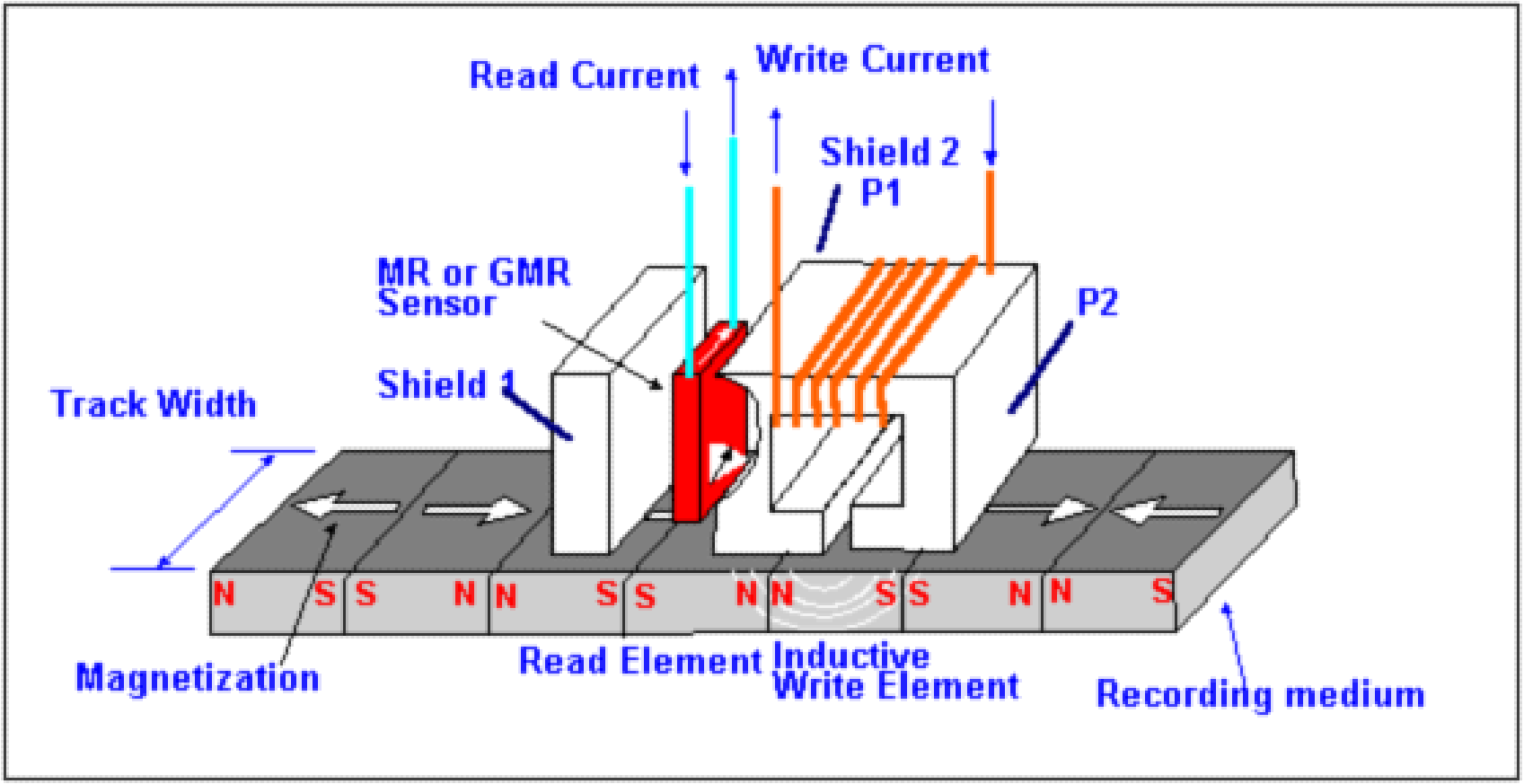
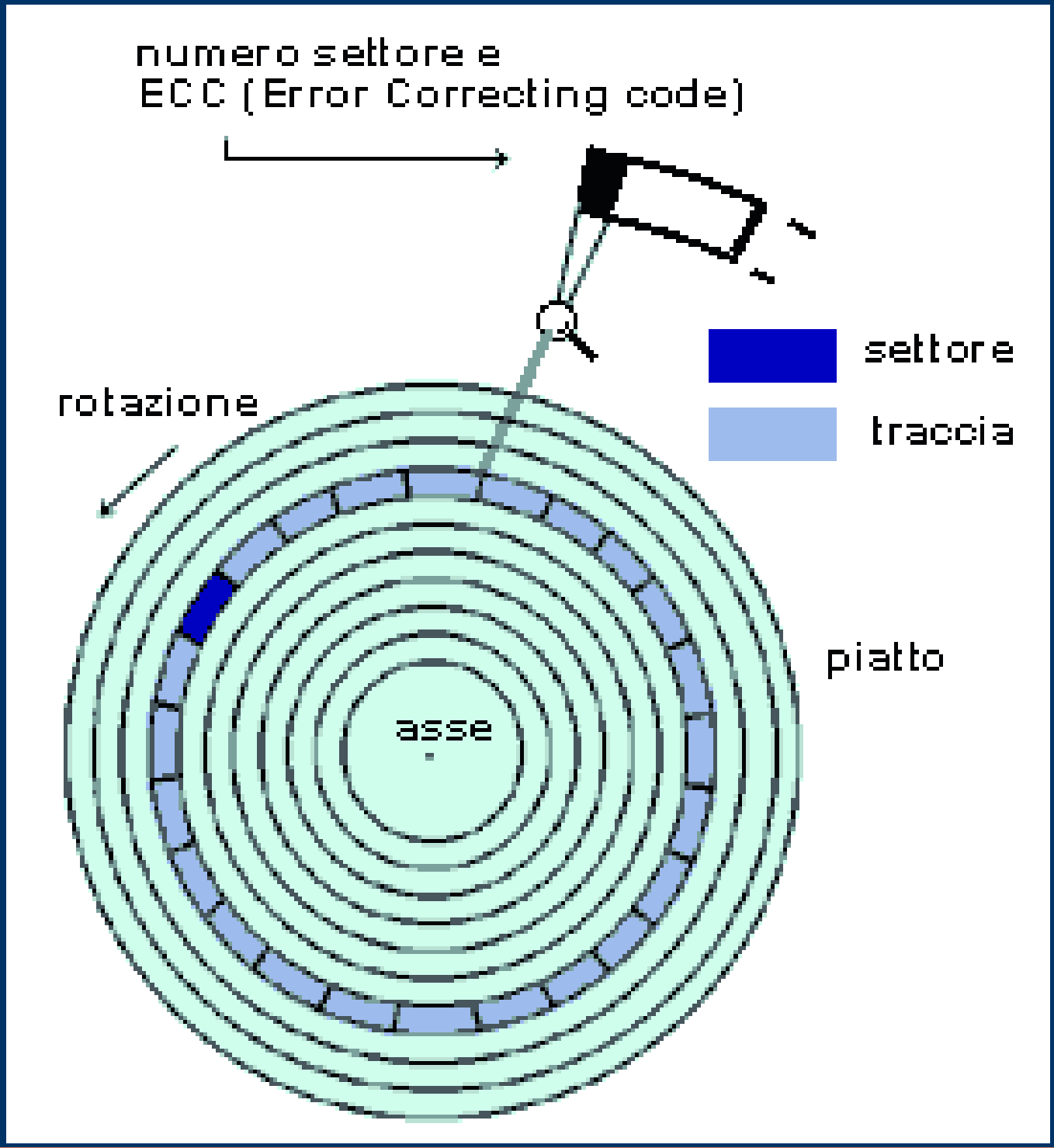
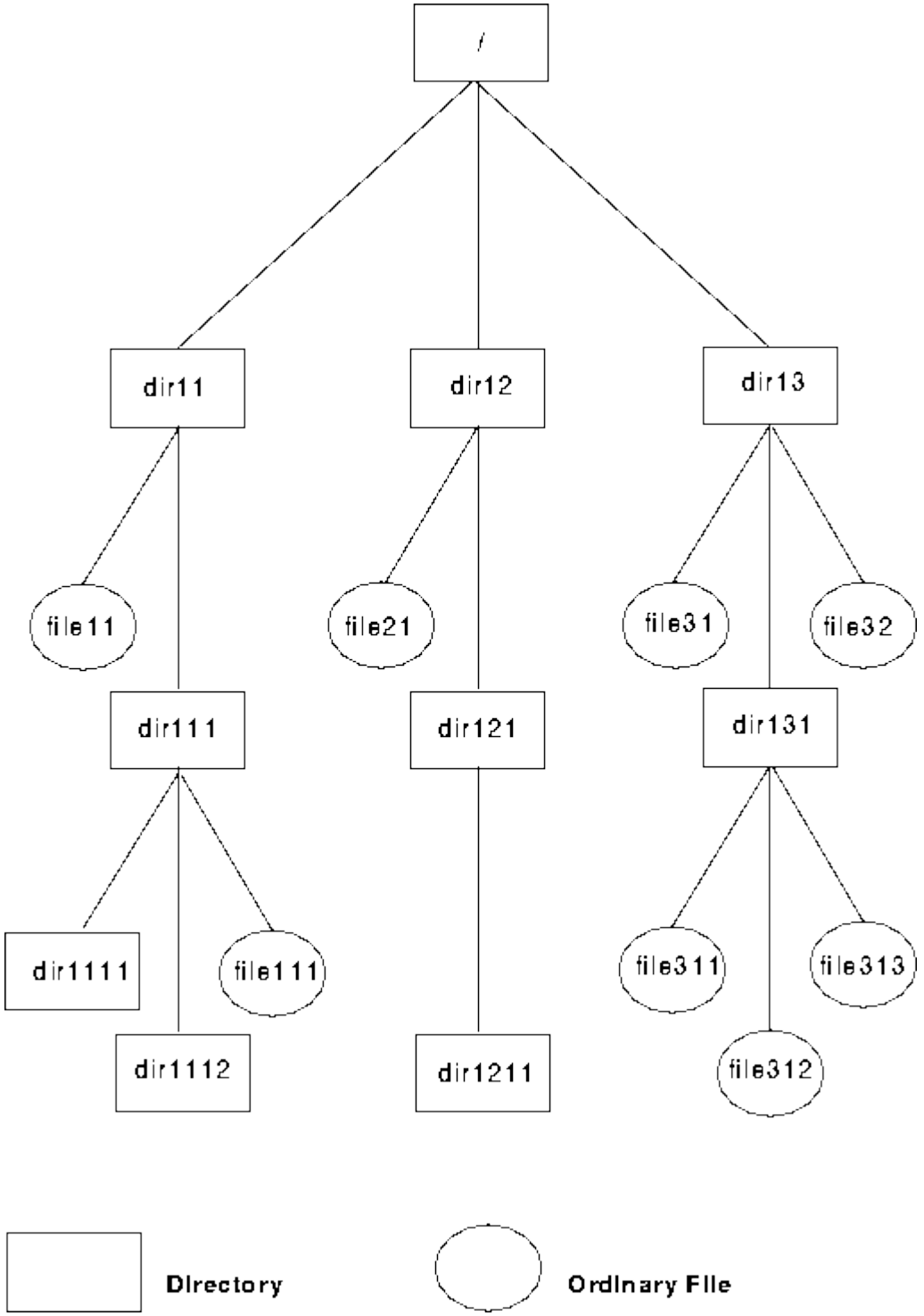
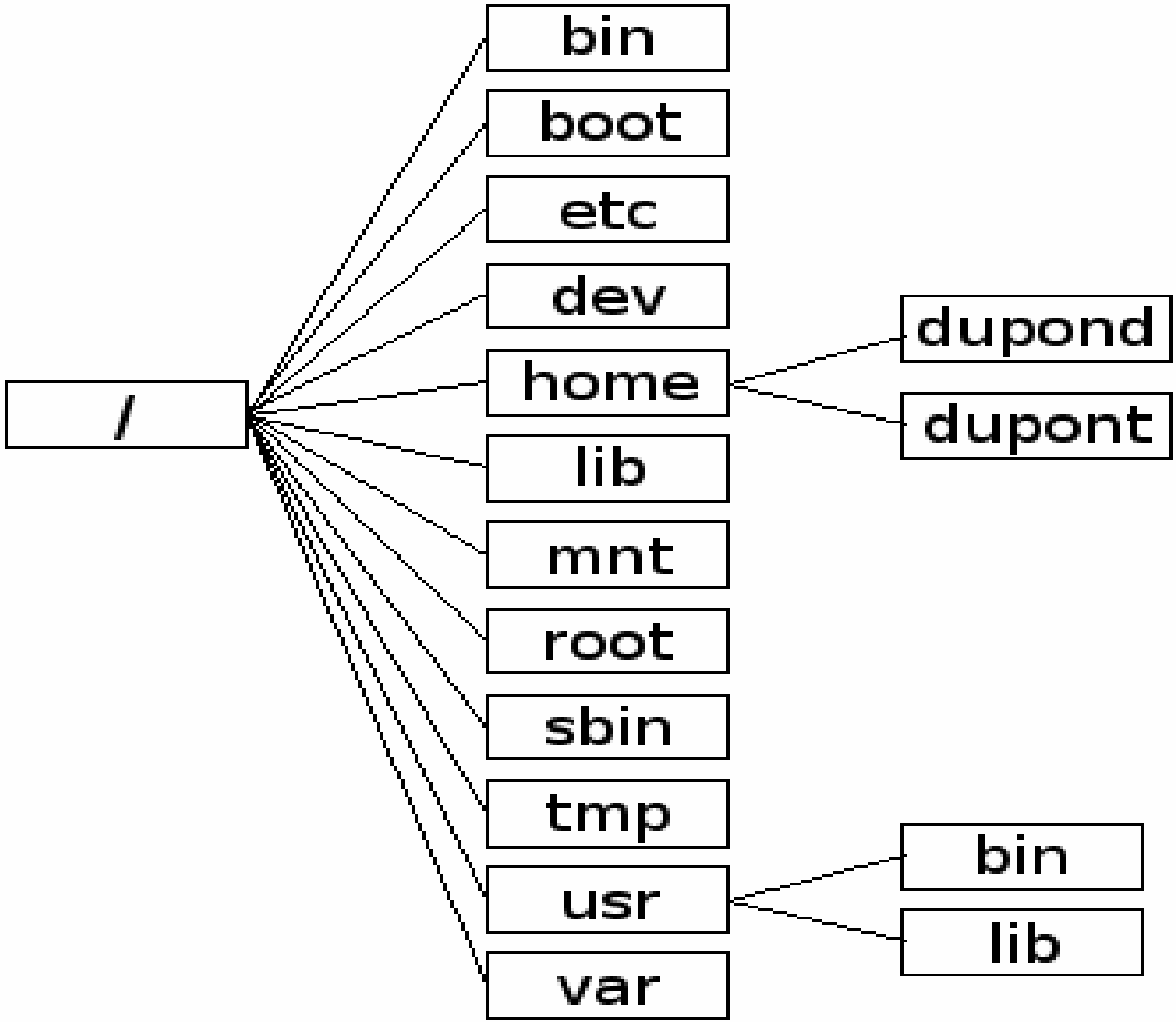
Cover Mounting Holes
(Cover not shown)
Base Casting
Spindle
Slider (and Head)
Actuator Arm
Actuator Axis
Actuator
Case
Mounting
Holes
Platters
Ribbon Cable
(attaches heads
to Logic Board)
SCSI Interface
Connector
Jumper Pins
Jumper
Power
Connector
Tape Seal



Magnetic recording process.


numero settore e
ECC (Error Correcting code)
settore
traccia
rotazione
piatto
asse


/
dir11
dir12
dir13
file11
file21
file31
file32
dir111
dir121
dir131
dir1111
file111
file311
file313
dir1112
dir1211
file312
Directory
Ordinary File


/
bin
boot
etc
dev
home
lib
mnt
root
sbin
tmp
usr
var
dupond
dupont
bin
lib

UNIX File System

A UFS volume is composed of the following parts:

* a few blocks at the beginning of the partition reserved for boot blocks (which must be initialized separately from the filesystem)
* a superblock, containing a magic number identifying this as a UFS filesystem, and some other vital numbers describing this filesystem's geometry and statistics and behavioral tuning parameters
* a collection of cylinder groups. Each cylinder group has the following components:
    - a backup copy of the superblock
    - a cylinder group header, with statistics, free lists, etc, about this cylinder group, similar to those in the superblock
    - a number of inodes, each containing file attributes
    - a number of data blocks

Inodes are numbered sequentially. The first several inodes are reserved for historical reasons, followed by the inode for the root directory.

Directory files contain only the list of filenames in the directory and the inode associated with each file. All file metadata is kept in the inode.

FAT

	FAT12	FAT16	FAT32
Developer	Microsoft		
Full Name	File Allocation Table		
	(12-bit version)	(16-bit version)	(32-bit version)
Introduced	1977 (Microsoft Disk BASIC)	July 1988 (MS-DOS 4.0)	August 1996 (Windows 95 OSR2)
Structures			
Directory contents	Table		
File allocation	Linked List		
Bad blocks	Cluster tagging		
Limits			
Max file size	32 MiB	2 GiB	4 GiB
Max number of files	4,077	65,517	268,435,437
Max filename size	8.3, or 255 characters when using LFNs		
Max volume size	32 MiB	2 GiB	4 GiB with some implementations
	2 TiB		
Features			
Dates recorded	Creation, modified, access		
Date range	January 1, 1980 - December 31, 2107		
Forks	Not natively		
Attributes	Read-only, hidden, system, volume label, subdirectory, archive		
Permissions	No		
Transparent compression	Per-volume, Stacker, DoubleSpace, DriveSpace		No
Transparent encryption	Per-volume only with DR-DOS		No

problemi - FAT32

- **Scalability:** The largest volume size supported by FAT32 on-disk structures is 2 terabytes. Windows 2000 and later versions further limit the size of a volume that can be formatted with FAT32 to 32 GB. Because the maximum size of a file on FAT32 is limited to 32 bits, it cannot be used to store files larger than 4 GB.
- **Data transfer limitations:** FAT does not provide support for alternate data streams, other than the default data stream. Copying data from an NTFS or UDF volume, which supports alternate data streams, to a FAT volume can cause data that is stored in the named streams to be lost. This makes FAT unsuitable for transferring data from an NTFS or UDF volume that contains named steams.
- **No incremental-write support:** FAT requires its metadata structures to be overwritten in place during updates to the metadata. Because of this, FAT cannot be used on incremental-write removable media, such as CD-R and DVD-R.
- **No defect management support:** FAT does not provide a mechanism for defect management at the file system level. The FAT file system expects the underlying hardware to manage and remap defective blocks on the media. It does, however, support marking some allocation units as "bad" to prevent their use by the file system. FAT cannot be used on removable rewritable media, such as CD-RW, DVD-RW, and DVD+RW. This is because these media types do not support defect management in the hardware layer.
- **Performance and recoverability:** FAT does not provide clustering of metadata on the disk. The metadata is typically scattered all over the volume. This scattering of metadata causes performance degradation during runtime and also impacts the ability of the operating system to recover corrupted data.

NTFS

Developer	Microsoft
Full name	New Technology File System
Introduced	July 1993 (Windows NT 3.1)
Partition identifier	0x07 (MBR) EBD0A0A2-B9E5-4433-87C0-68B6B72699C7 (GPT)

Structures

Directory contents	B+ tree
File allocation	Bitmap/Extents
Bad blocks	Bitmap/Extents

Limits

Max file size	16 TiB with current implementation (16 EiB architecturally)
Max number of files	4,294,967,295 (232-1)
Max filename size	255 characters
Max volume size	256 TiB with current implementation (16 EiB architecturally)
Allowed characters in filenames	any character except '\0' (NULL) and '/[1]

Features

Dates recorded	Creation, modification, POSIX change, access
Date range	January 1, 1601 - May 28, 60056
Forks	Yes
Attributes	Read-only, hidden, system, archive
File system permissions	ACLs
Transparent compression	Per-file, LZ77 (Windows NT 3.51 onward)
Transparent encryption	Per-file,DESX (Windows 2000 onward),Triple DES (Windows XP onward), AES (Windows XP Service Pack 1, Windows Server 2003 onward)
Supported operating systems	Windows NT family (Windows NT 3.1 to Windows NT 4.0, Windows 2000, Windows XP, Windows Server 2003, Windows Vista

Ext2

Developer	Rémy Card
Full name	Second extended file system
Introduced	January 1993 (Linux)

Structures

File allocation	I-nodes

Limits

Max file size	2 TiB
Max number of files	1018
Max filename size	255 characters
Max volume size	16 TiB
Allowed characters in filenames	Any byte except NUL and '/'

Features

Forks	yes
Attributes	
File system permissions	POSIX
Transparent compression	Yes (optional)
Transparent encryption	No
Supported operating systems	Linux, BSD, Windows (through an IFS), MacOS

ReiserFS

Developer	Namesys
Full name	ReiserFS
Introduced	2001 (Linux 2.4.1)

Structures	
Directory contents	B+ tree
File allocation	Bitmap [1]

Limits	
Max file size	8TiB
Max number of files	232 (~4 billion)
Max volume size	16TiB
Allowed characters in filenames	All bytes except NUL and '/'

Features	
Dates recorded	modification (mtime), metadata change (ctime), access (atime)
Date range	December 14, 1901 - January 18, 2038
Forks	Extended attributes
File system permissions	Unix permissions, ACLs and arbitrary security attributes
Transparent compression	No
Transparent encryption	No
Supported operating systems	Linux

Developer Stephen Tweedie (ext3 design and implementation), Rémy Card (original ext2 design and implementation), Theodore Ts'o (tools and improvements), Andreas Gruenbacher (xattrs and ACLs), Andreas Dilger (online resizing), et al
Full name Third extended file system
Introduced November 2001 (Linux 2.4.15)

Ext3

Structures
Directory contents Table, Tree
File allocation bitmap (free space), table (metadata)
Bad blocks Table
Limits
Max file size 16GiB – 2TiB
Max number of files Variable[1]
Max filename size 255 bytes
Max volume size 2TiB – 32TiB
Allowed characters in filenames All bytes except NUL and '/'
Features
Dates recorded modification (mtime), attribute modification (ctime), access (atime)
Date range December 14, 1901 - January 18, 2038
Forks Yes
Attributes No-atime, append-only, synchronous-write, no-dump, h-tree (directory), immutable, journal, secure-delete, top (directory), allow-undelete
File system permissions Unix permissions, ACLs and arbitrary security attributes (Linux 2.6 and later)
Transparent compression No
Transparent encryption No (provided at the block device level)
Supported operating systems GNU/Linux, BSD, Windows (through an IFS

ReiserFS

	3.5	3.6
max number of files	2^{32} - 3 => 4 Gi - 3	2^{32} - 3 => 4 Gi - 3
max number files a dir can have	518701895, but in practice this value is limited by hash function. r5 hash allows about 1 200 000 file names without collisions	2^{32} - 4 => 4 Gi - 4 but in practice this value is limited by hash function. r5 hash allows about 1 200 000 file names without collisions
max file size	2^{31} - 1 => 2 Gi - 1	2^{60} - bytes => 1 Ei, but page cache limits this to 8 Ti on architectures with 32 bit int
max number links to a file	2^{16} => 64 Ki	2^{32} => 4 Gi
max filesystem size	2^{32} (4K) blocks => 16 Ti	2^{32} (4K) blocks => 16 Ti

XFS

Developer	Silicon Graphics Inc.
Full name	XFS
Introduced	1994 (IRIX v5.3)

Structures	
Directory contents	B+ trees
File allocation	extent based

Limits	
Max file size	9 exabytes
Max number of files	
Max filename size	255 bytes
Max volume size	9 exabytes
Allowed characters in filenames	All bytes except NUL

Features	
Dates recorded	Yes
Forks	Yes (called extended attributes)
File system permissions	Yes
Transparent compression	No
Transparent encryption	No (provided at the block device level)
Supported operating systems	IRIX, Linux, FreeBSD

Reiser4

Developer	Namesys
Full name	ReiserFS 4
Introduced	2004 (Linux)

Structures	
Directory contents	Dancing B*-tree

Limits	
Max file size	8TiB on x86

Allowed characters in filenames	All bytes except NUL and '/'

Features	
Dates recorded	modification (mtime), metadata change (ctime), access (atime)
Date range	64-bit timestamps[1]
Forks	Extended attributes
Attributes	
File system permissions	Unix permissions, ACLs and arbitrary security attributes
Transparent compression	Version 4.1 (beta)
Transparent encryption	Version 4.1 (beta)
Supported operating systems	Linux

Internal JFS (potential) limits

JFS

JFS is a full 64-bit file system. All of the appropriate file system structure fields are 64-bits in size. This allows JFS to support both large files and partitions.

File system size

The minimum file system size supported by JFS is 16 Mbytes. The maximum file system size is a function of the file system block size and the maximum number of blocks supported by the file system meta-data structures. JFS will support a maximum file size of 512 terabytes (with block size 512 bytes) to 4 petabytes (with block size 4 Kbytes).

File size

The maximum file size is the largest file size that virtual file system framework supports. For example, if the frame work only supports 32-bits, then this limits the file size.

Developer IBM

Ext4

Developer	Mingming Cao, Dave Kleikamp, Alex Tomas, Andrew Morton, others
Full name	Fourth extended file system
Introduced	October 10, 2006 (Linux 2.6.19-rc2)

Structures

Directory contents	Table, Tree
File allocation	bitmap (free space), table (metadata)
Bad blocks	Table

Limits

Max volume size	1024 PiB

Features

Supported operating systems	Linux

Benchmarking Filesystems

COMPUTER: Dell Optiplex GX1
CPU: Pentium III 500MHZ
RAM: 768MB
SWAP: 2200MB
CONTROLLER:
Maxtor Promise ATA/133 TX2 - IN PCI SLOT #1

DRIVES USED:
1] **Seagate 400GB ATA/100 8MB CACHE 7200RPM**
2] Maxtor 61.4GB ATA/66 2MB CACHE 5400RPM

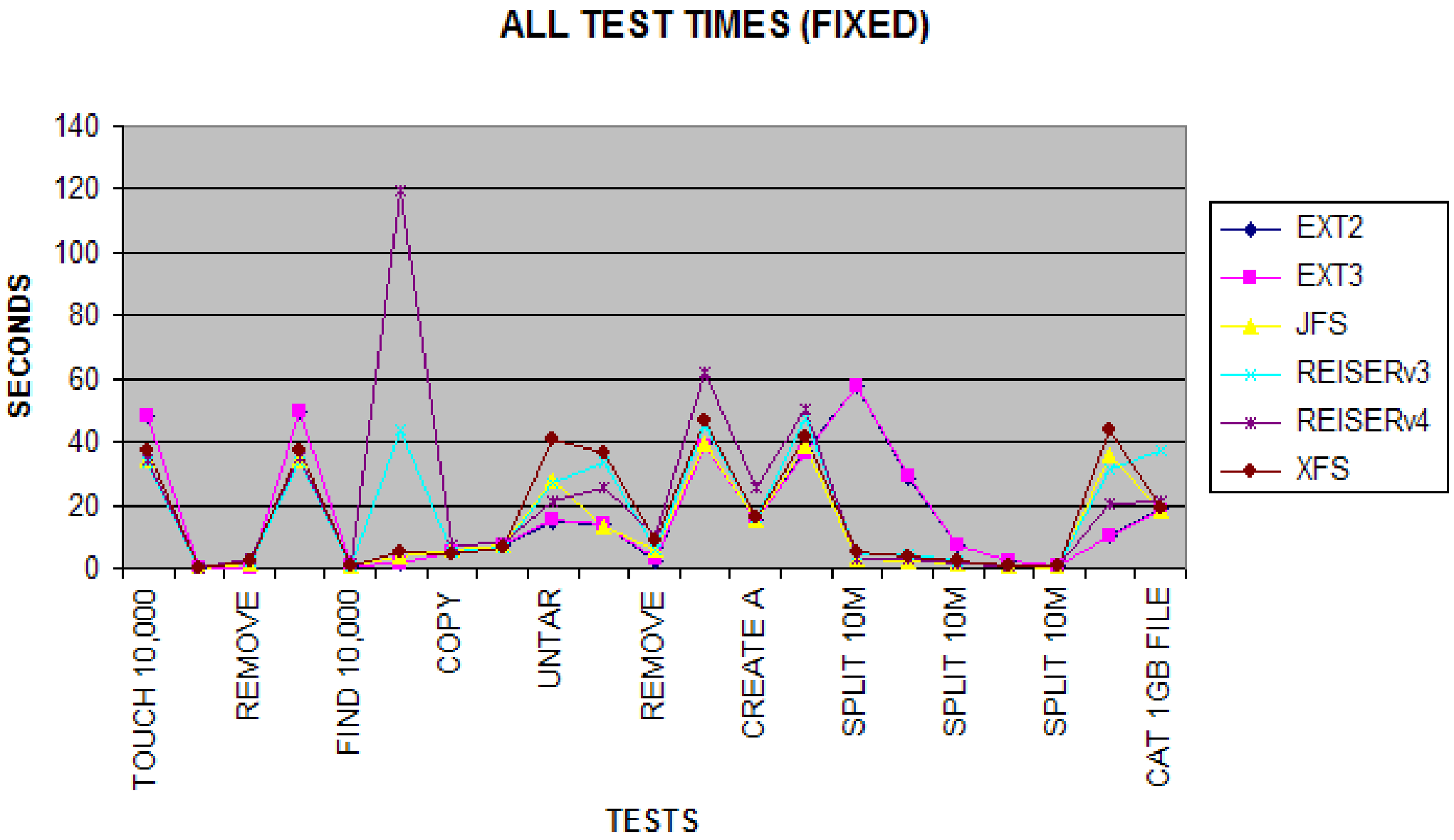
DRIVE TESTED: The Seagate 400GB.

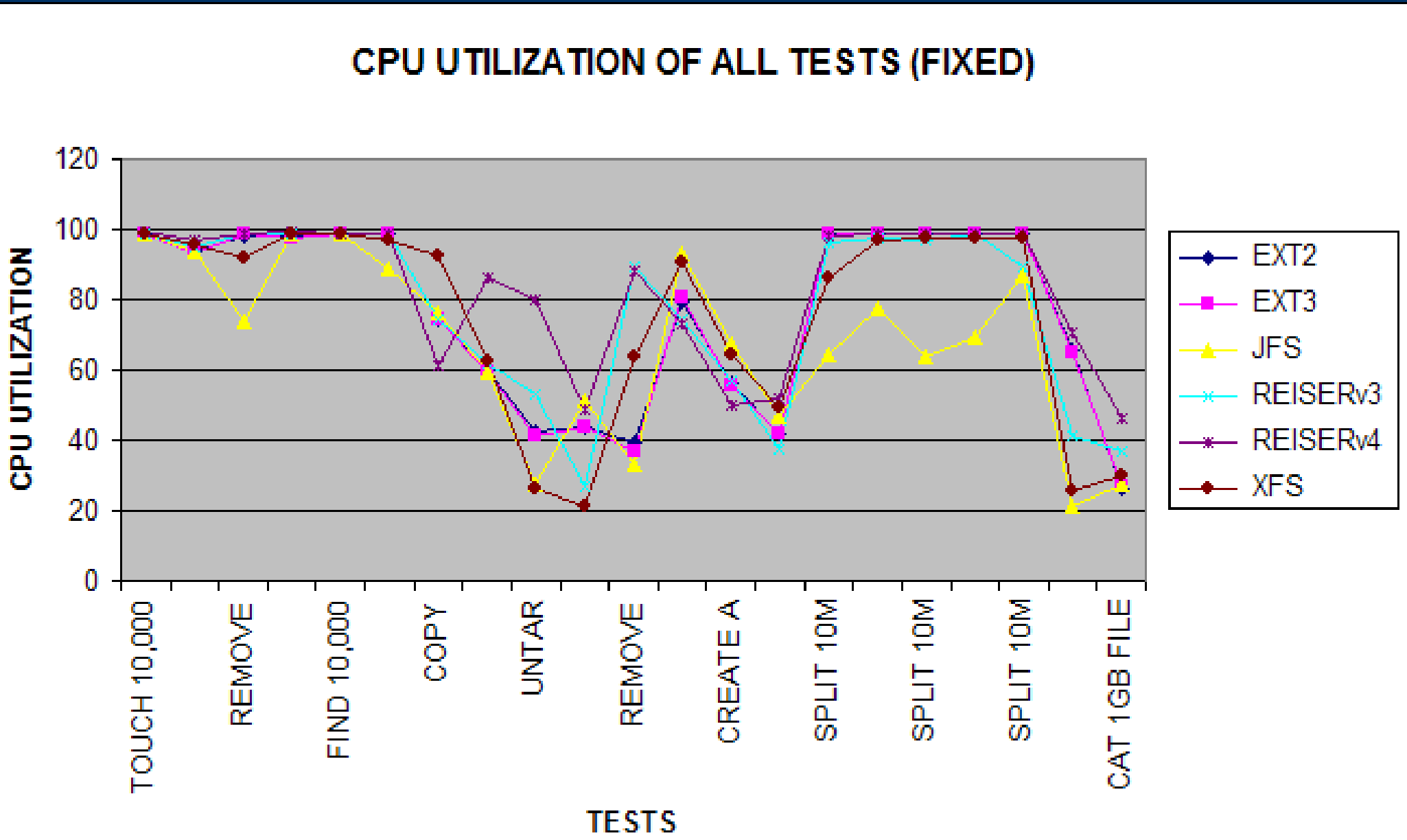
Benchmarking Filesystems

LIBC VERSION: 2.3.5
KERNEL: linux-2.6.14.4
COMPILER USED: gcc-4.0.3
EXT2: e2fsprogs-1.38/sbin/mkfs.EXT2
EXT3: e2fsprogs-1.38/sbin/mkfs.EXT3
JFS: jfsutils-1.1.8/sbin/mkfs.jfs
REISERFSv3: reiserfsprogs-3.6.19/sbin/mkreiserfs
REISERFSv4: reiser4progs-1.0.5/sbin/(Used patch reiser4-for-2.6.14-1.patch w/ libaal-1.0.5 + reiser4progs-1.0.5)
XFS: xfsprogs-2.6.36/sbin/mkfs.xfs

Benchmarking Filesystems

001] Create 10,000 files with touch in a directory.
002] Run 'find' on that directory.
003] Remove the directory.
004] Create 10,000 directories with mkdir in a directory.
005] Run 'find' on that directory.
006] Remove the directory containing the 10,000 directories.
007] Copy kernel tarball from other disk to test disk.
008] Copy kernel tarball from test disk to other disk.
009] Untar kernel tarball on the same disk.
010] Tar kernel tarball on the same disk.
011] Remove kernel source tree.
012] Copy kernel tarball 10 times.
013] Create 1GB file from /dev/zero.
014] Copy the 1GB file on the same disk.
015] Split a 10MB file into 1000/1024/2048/4096/8192 byte pieces.
016] Copy kernel source tree on the same disk.
017] Cat a 1GB file to /dev/null.


ALL TEST TIMES (FIXED)
SECONDS
140
120
100
80
60
40
20
0
TOUCH 10,000
REMOVE
FIND 10,000
COPY
UNTAR
REMOVE
CREATE A
SPLIT 10M
SPLIT 10M
SPLIT 10M
CAT 1GB FILE
TESTS
EXT2
EXT3
JFS
REISERv3
REISERv4
XFS


CPU UTILIZATION OF ALL TESTS (FIXED)
CPU UTILIZATION
120
100
80
60
40
20
0
TOUCH 10,000
REMOVE
FIND 10,000
COPY
UNTAR
REMOVE
CREATE A
SPLIT 10M
SPLIT 10M
SPLIT 10M
CAT 1GB FILE
TESTS
EXT2
EXT3
JFS
REISERv3
REISERv4
XFS

DOMANDE?

Grazie per
l'attenzione ed a
voi la parola