

# Filesystems & Disks

CIS 68C1-01

Lecture 4

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# The Filesystem

- Filesystem Components
  - A convention for naming & arranging things
    - A namespace
  - A well-defined set of programming functions
    - API
  - Security Model
  - The code that implements these

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# The Filesystem

- The UNIX file tree may be comprised of one or more separate filesystems
  - Attaching a filesystem is called **mounting**
  - The **mount** command maps a filesystem **onto** an existing directory
  - Filesystems can reside
    - on a local disk
    - on a network
    - in RAM

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# The Filesystem

- The / File Tree Hierarchy
  - Historically not well organized
  - Standard directories
    - Review directory structure on pg. 65 of the text
    - /bin, /sbin, /dev, /etc, /tmp
      - Typically part of the root filesystem
      - Required during boot stage
    - /lib, /usr, /tmp, /var
      - Often separate filesystems

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# The Filesystem

- File Types
  - Regular File
  - Directory
  - Symbolic Link
  - Device
    - Character and Block
  - Named Pipe (FIFO)
  - UNIX Domain Sockets
    - Printing subsystem, X Windows, syslog facility

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# The Filesystem

- Directories
  - A file's name is stored in its parent directory
  - Several names can reference a single file
  - A file can be referenced by any number of directories
  - Each reference is called a **link**

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# The Filesystem

- Links
  - Also called **hard link**
  - Reference to file *by inode*
  - No distinction between links to a file
  - Commonly used to give multiple names to a file
    - Some programs *behave* differently when invoked with a particular name

```
$ ls -li /usr/bin/ypch* /usr/bin/yppass*
97807 /usr/bin/ypchfn
97807 /usr/bin/ypchsh
97807 /usr/bin/yppasswd
```

inode number

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# The Filesystem

- Symbolic Links
  - Also called **soft link** and **symlink**
  - Point to file *by name*
  - Distinct from files they point to
  - Commonly used to create alternate access points

```
$ ls -ld /bin /lib /usr /usr/bin /usr/lib
lrwxrwxrwx 1 root root 9 Aug 27 1998 /bin -> ./usr/bin
lrwxrwxrwx 1 root root 9 Aug 27 1998 /lib -> ./usr/lib
drwxrwxr-x 30 root sys 1024 Jan 1 2000 /usr
drwxrwxr-x 3 root bin 7680 Sep 15 2000 /usr/bin
drwxrwxr-x 42 root bin 10240 Oct 9 20:29 /usr/lib
```

File Type Field  
l=symlink d=directory

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# The Filesystem

- Devices
  - Live in /dev
  - Share a common *interface* (API) with files
  - Two types of devices
    - Block
      - Kernel buffers I/O to increase performance
    - Character
      - Kernel does not buffer I/O
    - Some devices offer both interfaces

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# The Filesystem

- Devices
  - Entries in /dev are *access points* to their respective drivers
    - They are neither the device nor the device driver
  - Major and Minor device numbers
    - Major number tells kernel which driver to use
    - Minor device indicates which device unit
      - Also used in non-standard ways to indicate certain mode of operation for device

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# The Filesystem

- Devices
  - Types, major numbers, and minor numbers

```
$ ls -l /dev/hda2 /dev/hdc /dev/hde /dev/tty
brw-rw---- 1 root   disk    3,  2 Aug 24 2000 /dev/hda2
brw----- 1 cappella disk   22,  0 Aug 24 2000 /dev/hdc
brw-rw---- 1 root   disk   33,  0 Aug 24 2000 /dev/hde
crw-rw-rw- 1 root   root    5,  6 Aug 24 2000 /dev/tty6
```

File Type Field  
c=character, b=block

Major Device  
Number

Minor Device  
Number

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# The Filesystem

- File Permissions
  - User (rwx), Group (rwx), Other (rwx)
  - Permissions on directories
    - r + x required for directory listing
    - w + x allows file creation, deletion, and rename
    - x allows using directory as part of a path
  - Permissions on files
    - r + x required to execute scripts

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# The Filesystem

## • File Permissions

### • Setuid

- Process runs with EUID = program's owner ID
- Allows process to have program file owner's access
- Used by programs such as **su**, **passwd**, and **sendmail**
- Security risk if set on un-trusted program
- *Never* set on shell scripts

```
$ ls -lF /usr/bin/passwd
-r-s--x--x  1 root   root    13536 Jul 12  2000 /usr/bin/passwd*
```

s=setuid in *owner* execute field

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# The Filesystem

## • File Permissions

### • Setgid

- Process runs with EGID = program's group ID
- On directories, causes files to inherit group ID of the parent directory

```
$ ls -ldF /usr/games/freecell /var/ftp/pub
-r-xr-s--x  1 root   games   39692 May 23  11:16 /usr/games/freecell*
drwxr-sr-x  2 root   ftp     4096 Aug 17  2000 /var/ftp/pub/
```

s=setgid in *group* execute field

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# The Filesystem

## • File Permissions

### • Sticky Bit

- Obsolete for files
- On directories, only allows owner of parent directory to rename or delete a file

```
$ ls -ldF /var/tmp
drwxrwxrwt  2 root   root    4096 Oct 13  19:53 /var/tmp/
```

t=sticky in *other* execute field

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# The Filesystem

## • File Permissions

### • umask

- Affects permissions set on new files / directories
- The permissions you do **not** want to give
- Represented in octal notation
- Set a reasonable **umask** value in startup files such as `/etc/csh.login` or `/etc/profile`
  - 077 = no permission for group / others
  - 066 = no read/write permission for group/others
  - 022 = no write permission for group / others
  - 002 = no write permission for others

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# Disks

- Disk Interfaces - IDE
  - ATA-2 (EIDE), ATA-3, Ultra-ATA, ATA-4, ATA-5
  - 2 disks per channel, 2 channels per system
    - Primary master/slave, Secondary master/slave
  - ATAPI Interface
    - Allows non-ATA devices using EIDE channel
      - CD-ROM, CD-Recordable, CD-RW, DVD, tape drives, super-floppy drives (ZIP, LS-120)
    - Requires ATAPI driver

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# Disks

- Disk Interfaces
  - SCSI
    - SCSI-1, SCSI-2 (fast, wide), SCSI-3
    - Controller is not usually built into typical PCs
      - Requires external SCSI controller
        - Known as SCSI bus adapter or host bus adapter
    - Often BIOS does not know about SCSI
      - Requires host bus adapter driver to boot from SCSI device
    - Technically superior to IDE

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# Disks

- Adding a Disk
  - Install and connect hardware
  - Create device nodes in /dev
  - Format disk
  - Partition disk
  - Create filesystem within partitions
  - Setup mounting
  - Setup swapping

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# Disks

- Setting up Device Entries
  - Adding new device nodes
    - **mknod** utility
      - Must know the **major** / **minor** device numbers
    - MAKEDEV script/utility
    - Very OS-specific
  - Most device entries are already made
  - Check the permissions on /dev entries

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# Disks

- **Formatting**
  - Writes address and timing information, and maps bad sectors
  - Also called *low-level* formatting
    - Not the same as the Window's *Format* command
  - Today disks are factory pre-formatted
    - Avoid reformatting unless absolutely required
    - IDE drives not designed for re-formatting
      - Software may be available from vendor to re-format
    - SCSI drives format themselves in response to a command

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# Disks

- **Partitioning**
  - Disks must be partitioned before use
  - Sub-divides a disk into smaller pieces
  - IDE drives can have at most either
    - 4 **primary** partitions, or
    - 3 **primary** partitions + 1 **extended** partition
      - **Extended** partition can further reference many **logical** partitions

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- **Partitioning**
  - The **fdisk** utility is used to partition a disk
    - The **cfdisk** utility is also available on Linux
  - Common Linux partitions
    - root – minimally contains files necessary to boot
    - swap – required for virtual memory
    - user – home directories, data files, source code
    - home – sometimes used for home directories

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# Disks

- **Partitioning**
  - Careful partition planning is essential ...
    - for optimal performance
    - to provide ample storage space
    - for performing backups
    - to avoiding filling the root filesystem
    - allow for redundancy
    - for storing crash dumps if system panics

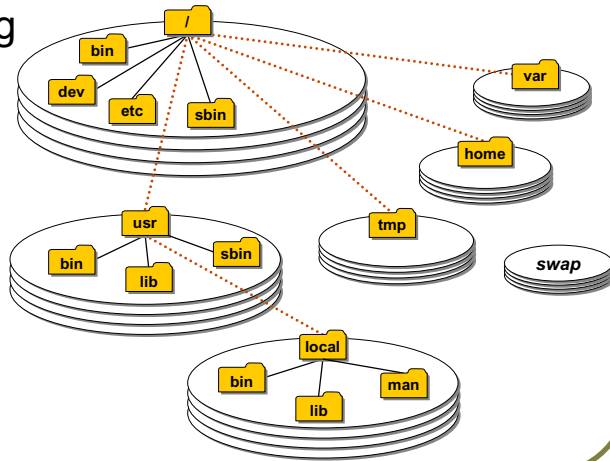
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# Disks

## Partitioning



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# Disks

## ● Creating a Filesystem

### ● The ext2 filesystem

- Very efficient - based on BSD Fast Filesystem
- **Inode table**
  - Table that keeps track of files
  - Fixed size - cannot be changed once created
- **Superblocks**
  - Superblock is master record for filesystem
  - Backup superblocks are created for safety
    - Always a backup at block 32

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# Disks

## ● Creating a Filesystem

- **mkfs** creates a filesystem within a partition
  - Creates **lost+found** directory used by **fsck**
- Linux device nodes for hard disks
  - IDE
    - `/dev/hd[a-h][partition_number]`
  - SCSI
    - `/dev/sd[a-p][partition_number]`

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# Disks

## ● Setting up automatic mounting

- Mount filesystems to make them available
  - Manually mount new filesystem first to test
- **/etc/fstab**
  - Contains information about filesystems
    - Device node, mount point, file system type, mount options, dump frequency, and fsck order
  - Add entry to cause automatic mounting at boot
  - Read by **mount**, **umount**, **swapon**, and **fsck**

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## Disks

- Setting up Swap Partition
  - Must initialize a swap partition with **mkswap** prior to use
  - Add entry into **/etc/fstab**
  - Do not run **fsck** on swap partitions

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## Disks

- Checking a Filesystem
  - The **fsck** command checks filesystem integrity and fixes inconsistencies
  - It runs automatically at boot time
  - Skips filesystem check if it is marked **clean**
    - No guarantee the filesystem is clean however
    - Should periodically force a clean

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## Disks

- Checking a Filesystem
  - Cannot always automatically fix all problems
    - Requires manual execution
    - Places unfixable files in **lost+found**
  - Always check root filesystem
    - in single-user mode
    - before others are checked or mounted
  - Rerun **fsck** until there are no errors
  - Do not boot multi-user with corrupted root

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