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# File Hierarchy System

The Linux filesystem hierarchy starts with the **root** represented by a **/** character. Under the root can be found other directories containing task specific files. The hierarchy conforms to a standard called the **Linux File Hierarchy System**.

## Directory Contents

| **Directory** | **Contents** |
|---|---|
| **/bin** | Contains user programs such as ls, cp e.t.c.. |
| **/boot** | Contains bootloader files, kernels and initrd (INItial Ram Disk) files. |
| **/dev** | Contains nodes for accessing all the peripherals and devices connected to the system. The *udev* binary takes care of dynamically creating and deleting the relevant nodes automatically. |
| **/etc** | Contains static configuration files. |
| **/home** | Contains a directory for each registered user of the system except for root. |
| **/lib** | Contains common 32 bit libraries for applications and modules. |
| **/lib64** | Contains common 64 bit libraries for applications and modules. |
| **/lost+found** | Contains damaged file fragments found by the *fsck* command. |
| **/media** | Contains a folder for each of the mounted external file systems (CDRom DVDRom, USB Key e.t.c.). |
| **/mnt** | Contains a folder for each external file system mounted temporarily by root. |
| **/opt** | Contains optional application packages. |
| **/proc** | Contains a virtual file system that documents kernel and process status information as text files. |
| **/root** | The home directory of the root user. |
| **/run** | Replaces the /var/run directory. Note that under Debian 7 and Debian 8 /var/run is a soft link (shorcut) to **/run**. |
| **/sbin** | Contains essential system administration binaires. |
| **/selinux** | Contains a virtual file system used by SELINUX. |
| **/srv** | Contains site specific data **s**e**rv**ed by the system (www,ftp,databases e.t.c.). |
| **/sys** | Contains a virtual file system that describes devices for *udev*. |

| Directory | Contents |
|---|---|
| **/tmp** | Contains the temporary files created by the system and by applications. |
| **/usr** | Contains user commands in */usr/bin*, HOWTOs in */usr/share/doc*, manuals in */usr/share/man* and is the *Secondary Hierarchy* for read-only user data. |
| **/var** | Contains variable files. i.e. files that continually change such as log files and spool files. |

## Directory Structure

```
trainee@debian6:/$ ls -l
total 92
drwxr-xr-x   2 root root  4096  6 déc.   2014 bin
drwxr-xr-x   3 root root  4096  6 déc.   2014 boot
drwxr-xr-x  15 root root  3120 25 août  16:51 dev
drwxr-xr-x 121 root root 12288  4 juil. 15:05 etc
drwxr-xr-x   3 root root  4096 24 avril  2011 home
lrwxrwxrwx   1 root root    28 24 avril  2011 initrd.img -> boot/initrd.img-2.6.32-5-686
drwxr-xr-x  12 root root 12288  6 déc.   2014 lib
drwx------   2 root root 16384 24 avril  2011 lost+found
drwxr-xr-x   3 root root  4096 24 avril  2011 media
drwxr-xr-x   2 root root  4096 14 déc.   2010 mnt
drwxr-xr-x   4 root root  4096  4 déc.   2011 opt
dr-xr-xr-x 128 root root     0  4 juil. 14:34 proc
drwx------  11 root root  4096  7 déc.   2014 root
drwxr-xr-x   2 root root  4096  6 déc.   2014 sbin
drwxr-xr-x   2 root root  4096 21 juil.  2010 selinux
drwxr-xr-x   2 root root  4096 24 avril  2011 srv
drwxr-xr-x  12 root root     0  4 juil. 14:34 sys
drwxrwxrwt  10 root root  4096 25 août  16:34 tmp
drwxr-xr-x  10 root root  4096 24 avril  2011 usr
drwxr-xr-x  14 root root  4096 24 avril  2011 var
lrwxrwxrwx   1 root root    25 24 avril  2011 vmlinuz -> boot/vmlinuz-2.6.32-5-686
```

```
trainee@debian7:/$ ls -l
```

```
total 84
drwxr-xr-x   2 root root  4096 juin  26 16:06 bin
drwxr-xr-x   3 root root  4096 juin  26 16:09 boot
drwxr-xr-x  14 root root  3160 juil.  4 16:36 dev
drwxr-xr-x 133 root root 12288 juil.  4 16:36 etc
drwxr-xr-x   3 root root  4096 juin  26 15:42 home
lrwxrwxrwx   1 root root    32 juin  26 15:35 initrd.img -> /boot/initrd.img-3.2.0-4-686-pae
lrwxrwxrwx   1 root root    28 juin  26 15:35 initrd.img.old -> /boot/initrd.img-3.2.0-4-486
drwxr-xr-x  15 root root  4096 juin  26 16:01 lib
drwx------   2 root root 16384 juin  26 15:35 lost+found
drwxr-xr-x   3 root root  4096 juil. 15  2014 media
drwxr-xr-x   2 root root  4096 juil.  7  2014 mnt
drwxr-xr-x   2 root root  4096 juil. 15  2014 opt
dr-xr-xr-x 131 root root     0 juin  26 16:17 proc
drwx------   4 root root  4096 juil.  4 15:14 root
drwxr-xr-x  20 root root   880 juil.  4 16:36 run
drwxr-xr-x   2 root root  4096 juin  26 16:07 sbin
drwxr-xr-x   2 root root  4096 juin  10  2012 selinux
drwxr-xr-x   2 root root  4096 juil. 15  2014 srv
drwxr-xr-x  13 root root     0 juin  26 16:17 sys
drwxrwxrwt   9 root root  4096 juil.  4 16:17 tmp
drwxr-xr-x  10 root root  4096 juin  26 15:39 usr
drwxr-xr-x  12 root root  4096 juin  26 15:39 var
lrwxrwxrwx   1 root root    28 juin  26 15:39 vmlinuz -> boot/vmlinuz-3.2.0-4-686-pae
lrwxrwxrwx   1 root root    24 juin  26 15:39 vmlinuz.old -> boot/vmlinuz-3.2.0-4-486
```

```
trainee@debian8:/$ ls -l
total 84
drwxr-xr-x   2 root root  4096 juin  28 16:31 bin
drwxr-xr-x   3 root root  4096 juin  28 16:31 boot
drwxr-xr-x  17 root root  3080 juil. 23 17:04 dev
drwxr-xr-x 125 root root 12288 août  27 12:18 etc
drwxr-xr-x   3 root root  4096 juin  28 16:30 home
lrwxrwxrwx   1 root root    33 juin  28 16:26 initrd.img -> /boot/initrd.img-3.16.0-4-686-pae
lrwxrwxrwx   1 root root    29 juin  28 16:26 initrd.img.old -> /boot/initrd.img-3.16.0-4-586
drwxr-xr-x  18 root root  4096 juin  28 16:31 lib
drwxr-xr-x   2 root root  4096 juin   6 17:07 live-build
drwx------   2 root root 16384 juin  28 16:26 lost+found
drwxr-xr-x   3 root root  4096 juin   6 16:32 media
drwxr-xr-x   2 root root  4096 juin   6 16:32 mnt
drwxr-xr-x   3 root root  4096 juin  28 16:38 opt
dr-xr-xr-x 138 root root     0 juin  28 16:41 proc
drwx------   2 root root  4096 juin  28 16:35 root
drwxr-xr-x  24 root root   820 août  27 12:18 run
drwxr-xr-x   2 root root  4096 juin  28 16:39 sbin
drwxr-xr-x   2 root root  4096 juin   6 16:32 srv
dr-xr-xr-x  13 root root     0 juin  28 16:41 sys
drwxrwxrwt  12 root root  4096 juil. 23 16:17 tmp
drwxr-xr-x  10 root root  4096 juin  28 16:29 usr
drwxr-xr-x  11 root root  4096 juin  28 16:29 var
lrwxrwxrwx   1 root root    29 juin  28 16:29 vmlinuz -> boot/vmlinuz-3.16.0-4-686-pae
lrwxrwxrwx   1 root root    25 juin  28 16:29 vmlinuz.old -> boot/vmlinuz-3.16.0-4-586
```

## File Types

The three major file types under Linux are :

- Ordinary files,
- Directories,
- Special files or Devices.

Note that :

- Ordinary files can be anything from text files to binaries.
- The length of a file name is limited to 225 characters, including the file extension.

- Linux is case sensitive.
- If a file name starts with a dot (**.**), it is a hidden file.

## The mount command

In order to be able to use external file systems, such as a CDRom or DVDRom, Linux needs to be informed of their availability. This is accomplished by using the **mount** command:

```
# mount /dev/<special_file> /mnt/<directory_name> [Enter]
```

where **/dev/<special_file>** is the file system to mount and **/mnt/<directory_name>** is the target directory where the mounted file system will be available to the system. The directory **/mnt/<directory_name>** must exist prior to using the **mount** command.

In the case where the **mount** command is used without options, the current mounted file systems are shown:

```
root@debian6:~# mount
/dev/sda1 on / type ext3 (rw,errors=remount-ro)
tmpfs on /lib/init/rw type tmpfs (rw,nosuid,mode=0755)
proc on /proc type proc (rw,noexec,nosuid,nodev)
sysfs on /sys type sysfs (rw,noexec,nosuid,nodev)
udev on /dev type tmpfs (rw,mode=0755)
tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev)
devpts on /dev/pts type devpts (rw,noexec,nosuid,gid=5,mode=620)
fusectl on /sys/fs/fuse/connections type fusectl (rw)
binfmt_misc on /proc/sys/fs/binfmt_misc type binfmt_misc (rw,noexec,nosuid,nodev)
```

```
root@debian7:~# mount
sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime)
proc on /proc type proc (rw,nosuid,nodev,noexec,relatime)
udev on /dev type devtmpfs (rw,relatime,size=10240k,nr_inodes=127976,mode=755)
devpts on /dev/pts type devpts (rw,nosuid,noexec,relatime,gid=5,mode=620,ptmxmode=000)
tmpfs on /run type tmpfs (rw,nosuid,noexec,relatime,size=103420k,mode=755)
```

```
/dev/disk/by-uuid/0f1cdb0c-8bd7-45ec-8d99-064292047bdb on / type ext4 (rw,relatime,errors=remount-
ro,user_xattr,barrier=1,data=ordered)
tmpfs on /run/lock type tmpfs (rw,nosuid,nodev,noexec,relatime,size=5120k)
tmpfs on /run/shm type tmpfs (rw,nosuid,nodev,noexec,relatime,size=597180k)
rpc_pipefs on /var/lib/nfs/rpc_pipefs type rpc_pipefs (rw,relatime)
binfmt_misc on /proc/sys/fs/binfmt_misc type binfmt_misc (rw,nosuid,nodev,noexec,relatime)
```

```
root@debian8:~# mount
sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime)
proc on /proc type proc (rw,nosuid,nodev,noexec,relatime)
udev on /dev type devtmpfs (rw,relatime,size=10240k,nr_inodes=126281,mode=755)
devpts on /dev/pts type devpts (rw,nosuid,noexec,relatime,gid=5,mode=620,ptmxmode=000)
tmpfs on /run type tmpfs (rw,nosuid,relatime,size=206376k,mode=755)
/dev/sda1 on / type ext4 (rw,relatime,errors=remount-ro,data=ordered)
securityfs on /sys/kernel/security type securityfs (rw,nosuid,nodev,noexec,relatime)
tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev)
tmpfs on /run/lock type tmpfs (rw,nosuid,nodev,noexec,relatime,size=5120k)
tmpfs on /sys/fs/cgroup type tmpfs (ro,nosuid,nodev,noexec,mode=755)
cgroup on /sys/fs/cgroup/systemd type cgroup
(rw,nosuid,nodev,noexec,relatime,xattr,release_agent=/lib/systemd/systemd-cgroups-agent,name=systemd)
pstore on /sys/fs/pstore type pstore (rw,nosuid,nodev,noexec,relatime)
cgroup on /sys/fs/cgroup/cpuset type cgroup (rw,nosuid,nodev,noexec,relatime,cpuset)
cgroup on /sys/fs/cgroup/cpu,cpuacct type cgroup (rw,nosuid,nodev,noexec,relatime,cpu,cpuacct)
cgroup on /sys/fs/cgroup/devices type cgroup (rw,nosuid,nodev,noexec,relatime,devices)
cgroup on /sys/fs/cgroup/freezer type cgroup (rw,nosuid,nodev,noexec,relatime,freezer)
cgroup on /sys/fs/cgroup/net_cls,net_prio type cgroup (rw,nosuid,nodev,noexec,relatime,net_cls,net_prio)
cgroup on /sys/fs/cgroup/blkio type cgroup (rw,nosuid,nodev,noexec,relatime,blkio)
cgroup on /sys/fs/cgroup/perf_event type cgroup (rw,nosuid,nodev,noexec,relatime,perf_event)
tmpfs on /etc/machine-id type tmpfs (ro,relatime,size=206376k,mode=755)
systemd-1 on /proc/sys/fs/binfmt_misc type autofs
(rw,relatime,fd=22,pgrp=1,timeout=300,minproto=5,maxproto=5,direct)
hugetlbfs on /dev/hugepages type hugetlbfs (rw,relatime)
mqueue on /dev/mqueue type mqueue (rw,relatime)
debugfs on /sys/kernel/debug type debugfs (rw,relatime)
```

```
fusectl on /sys/fs/fuse/connections type fusectl (rw,relatime)
rpc_pipefs on /run/rpc_pipefs type rpc_pipefs (rw,relatime)
tmpfs on /run/user/119 type tmpfs (rw,nosuid,nodev,relatime,size=103188k,mode=700,uid=119,gid=127)
tmpfs on /run/user/1000 type tmpfs (rw,nosuid,nodev,relatime,size=103188k,mode=700,uid=1000,gid=1000)
```

**Important** : Note that with Debian 6 the default filesystem is **ext3** whereas with Debian 7 and Debian 8 the default filesystem is **ext4**. Please see the unit **Managing Disks, Swap Space and Filesystems** for further coursework concerning ext3 and ext4 filesystems.

## Command Line Switches

The following switches can be used with the mount command:

```
root@debian8:~# mount --help

Usage:
 mount [-lhV]
 mount -a [options]
 mount [options] [--source] <source> | [--target] <directory>
 mount [options] <source> <directory>
 mount <operation> <mountpoint> [<target>]

Options:
 -a, --all               mount all filesystems mentioned in fstab
 -c, --no-canonicalize   don't canonicalize paths
 -f, --fake              dry run; skip the mount(2) syscall
 -F, --fork              fork off for each device (use with -a)
 -T, --fstab <path>      alternative file to /etc/fstab
 -h, --help              display this help text and exit
 -i, --internal-only     don't call the mount.<type> helpers
 -l, --show-labels       lists all mounts with LABELs
 -n, --no-mtab           don't write to /etc/mtab
 -o, --options <list>    comma-separated list of mount options
 -O, --test-opts <list>  limit the set of filesystems (use with -a)
 -r, --read-only         mount the filesystem read-only (same as -o ro)
 -t, --types <list>      limit the set of filesystem types
     --source <src>      explicitly specifies source (path, label, uuid)
     --target <target>   explicitly specifies mountpoint
 -v, --verbose           say what is being done
 -V, --version           display version information and exit
 -w, --rw, --read-write  mount the filesystem read-write (default)

 -h, --help     display this help and exit
 -V, --version  output version information and exit

Source:
 -L, --label <label>     synonym for LABEL=<label>
 -U, --uuid <uuid>       synonym for UUID=<uuid>
 LABEL=<label>           specifies device by filesystem label
 UUID=<uuid>             specifies device by filesystem UUID
 PARTLABEL=<label>       specifies device by partition label
 PARTUUID=<uuid>         specifies device by partition UUID
 <device>                specifies device by path
 <directory>             mountpoint for bind mounts (see --bind/rbind)
 <file>                  regular file for loopdev setup

Operations:
 -B, --bind              mount a subtree somewhere else (same as -o bind)
 -M, --move              move a subtree to some other place
 -R, --rbind             mount a subtree and all submounts somewhere else
 --make-shared           mark a subtree as shared
 --make-slave            mark a subtree as slave
 --make-private          mark a subtree as private
 --make-unbindable       mark a subtree as unbindable
 --make-rshared          recursively mark a whole subtree as shared
 --make-rslave           recursively mark a whole subtree as slave
 --make-rprivate         recursively mark a whole subtree as private
 --make-runbindable      recursively mark a whole subtree as unbindable

For more details see mount(8).
```

## The /etc/fstab file

In the case where the **mount** command is used with the **-a** option, all mount points specified in the **/etc/fstab** file are mounted:

```
root@debian6:~# cat /etc/fstab
# /etc/fstab: static file system information.
#
# Use 'blkid' to print the universally unique identifier for a
# device; this may be used with UUID= as a more robust way to name devices
# that works even if disks are added and removed. See fstab(5).
#
# <file system> <mount point>   <type>  <options>       <dump>  <pass>
proc            /proc           proc    defaults        0       0
# / was on /dev/sda1 during installation
UUID=a42a1ddd-14bc-4dde-a537-e6c1b984a782 /               ext3    errors=remount-ro 0       1
# swap was on /dev/sda5 during installation
UUID=e21d8931-21ca-4ab3-9fbb-bd71657b312e none            swap    sw              0       0
```

```
root@debian7:~# cat /etc/fstab
# /etc/fstab: static file system information.
#
# Use 'blkid' to print the universally unique identifier for a
# device; this may be used with UUID= as a more robust way to name devices
# that works even if disks are added and removed. See fstab(5).
#
```

```
# <file system> <mount point>   <type>  <options>       <dump>  <pass>
# / was on /dev/sda1 during installation
UUID=0f1cdb0c-8bd7-45ec-8d99-064292047bdb /               ext4    errors=remount-ro 0       1
# swap was on /dev/sda5 during installation
UUID=ae5f67d1-6fad-487e-ad41-d53992a75755 none            swap    sw              0       0
```

```
root@debian8:~# cat /etc/fstab
# /etc/fstab: static file system information.
#
# Use 'blkid' to print the universally unique identifier for a
# device; this may be used with UUID= as a more robust way to name devices
# that works even if disks are added and removed. See fstab(5).
#
# <file system> <mount point>   <type>  <options>       <dump>  <pass>
# / was on /dev/sda1 during installation
UUID=0ac29bda-b6bb-41c2-b47a-03fecb95bc87 /               ext4    errors=remount-ro 0       1
# swap was on /dev/sda5 during installation
UUID=fa3153a5-5ef4-46fe-9115-d3773a06d283 none            swap    sw              0       0
```

## Understanding the /etc/fstab file

Each line in **/etc/fstab** has 6 fields :

| **Field 1** | **Field 2** | **Field 3** | **Field 4** | **Field 5** | **Field 6** |
|---|---|---|---|---|---|
| Special file or UUID or Virtual File System | Mount Point | Filesystem Type | Comma separated list of options | Used by the dump command ( 1 = dump, 0 or empty = do not dump ) | The order in which the *fsck* command checks the disks/partitions at boot time |

The **UUID** ( *Universally Unique Identifier* ) is a randomly generated 128 bit string that is automatically generated by the system when a filesystem is created on the partition.

### Mountpoint Options

The most important mount point options are as follows:

| Option | Filesystem | Description | Default Value |
|---|---|---|---|
| defaults | All | Use default options: rw, suid, dev, exec, auto, nouser, and async. | N/A [1] |
| auto/noauto | All | Do or do not mount when “mount -a” is given. | auto |
| rw/ro | All | Mount the filesystem read-write/read-only. | rw |
| suid/nosuid | All | Allow/disallow set-user-identifier or set-group-identifier bits to take effect. | suid |
| dev/nodev | All | Interpret/do not interpret character or block special devices on the filesystem. | dev |
| exec/noexec | All | Permit/do not permit execution of binaries. | exec |
| sync/async | All | All I/O to the filesystem should be done synchronously/asynchronously. | async |
| user/nouser | All | Allow/disallow a user to mount. The mount point is read from the /etc/fstab file. Only the user that mounted the filesystem can unmount it. | N/A |
| users | All | Allow every user to mount and unmount the filesystem. | N/A |
| owner | All | Allow device owner to mount. | N/A |
| atime/noatime | POSIX | Do not use noatime feature, then the inode access time is controlled by kernel defaults/Do not update inode access times on this filesystem | atime |
| uid=value | Non-Linux filesystems | Set the owner of the root of the filesystem. | root |
| gid=value | Non-Linux filesystems | Set the group of the root of the filesystem. | N/A |
| umask=value | Non-Linux filesystems | Set the umask. The default is the umask of the current process. The value is given in octal. | N/A |
| dmask=value | Non-Linux filesystems | Set the umask applied to directories only. The value is given in octal. | Current processes' umask |
| fmask=value | Non-Linux filesystems | Set the umask applied to regular files only. The value is given in octal. | Current processes' umask |

# The umount command

To unmount a file system, you need to use the **umount** command. For example:

```
# umount /mnt/target_directory [Entrée]
```

## Command Line Switches

The following switches can be used with the umount command:

```
trainee@debian8:~$ umount --help

Usage:
 umount [-hV]
 umount -a [options]
 umount [options] <source> | <directory>

Options:
 -a, --all               unmount all filesystems
 -A, --all-targets       unmount all mountpoints for the given device in the
                           current namespace
 -c, --no-canonicalize   don't canonicalize paths
 -d, --detach-loop       if mounted loop device, also free this loop device
     --fake              dry run; skip the umount(2) syscall
 -f, --force             force unmount (in case of an unreachable NFS system)
 -i, --internal-only     don't call the umount.<type> helpers
 -n, --no-mtab           don't write to /etc/mtab
 -l, --lazy              detach the filesystem now, clean up things later
 -O, --test-opts <list>  limit the set of filesystems (use with -a)
 -R, --recursive         recursively unmount a target with all its children
 -r, --read-only         in case unmounting fails, try to remount read-only
 -t, --types <list>      limit the set of filesystem types
 -v, --verbose           say what is being done

 -h, --help     display this help and exit
 -V, --version  output version information and exit

For more details see umount(8).
```

# Unix File Systems

Each file system contains the following :

- superblock
- inodes
- data blocks

## Superblock

The superblock contains :

- the block size,
- the size of the file system,
- the number of mounts for the file system,
- a pointer to the root of the file system,
- pointers to the free inodes,
- pointers to free data blocks.

Linux maintains multiple redundant copies of the superblock in every file system.

For example, to view the primary and backup superblock locations on ext filesystems, use the following command:

```
root@debian8:~# mount | grep ext
/dev/sda1 on / type ext4 (rw,relatime,errors=remount-ro,data=ordered)
root@debian8:~# dumpe2fs /dev/sda1 | grep -i superblock
dumpe2fs 1.42.12 (29-Aug-2014)
  Primary superblock at 0, Group descriptors at 1-1
```

```
     Backup superblock at 32768, Group descriptors at 32769-32769
     Backup superblock at 98304, Group descriptors at 98305-98305
     Backup superblock at 163840, Group descriptors at 163841-163841
     Backup superblock at 229376, Group descriptors at 229377-229377
     Backup superblock at 294912, Group descriptors at 294913-294913
     Backup superblock at 819200, Group descriptors at 819201-819201
     Backup superblock at 884736, Group descriptors at 884737-884737
     Backup superblock at 1605632, Group descriptors at 1605633-1605633
```

To repair an ext file system using a backup superblock use the following command :

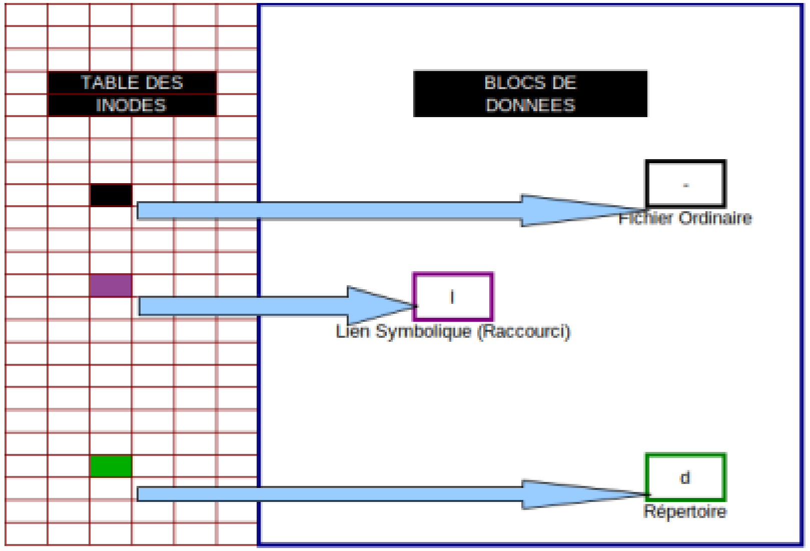
```
# e2fsck -f -b 32768 /dev/sda1 [Enter]
```

## Inodes

Each file is represented by an **inode**. An inode contains the following information:

- the file type : **-**, **d**, **l**, **b**, **c**, **p**, **s**,
- file permissions, for example : **rwx rw- r--**,
- the number of hard links,
- the UID of the file creator or the current UID attributed by the **chown** command,
- the GID of the creating process or the current GID attributed by the **chgrp** command,
- the file size in bytes,
- the date of the last modification of the file's inode content : **ctime**,
- the date of the last modification of the file contents : **mtime**,
- the date of the last access : **atime**,
- allocation addresses that point to the data blocks used by the file.

For example:



Execute the following command:

```
root@debian8:~# ls -ld /dev/console /dev/sda1 /etc /etc/passwd
crw-------   1 root root  5, 1 Aug 18 11:29 /dev/console
brw-rw----   1 root disk  8, 1 Aug 18 11:29 /dev/sda1
drwxr-xr-x 121 root root 12288 Aug 18 11:29 /etc
-rw-r--r--   1 root root  2094 May  1 20:32 /etc/passwd
```

The first character of each line indicates the file type:

- **-** - an ordinary file,
- **d** - a directory,
- **l** - a symbolic link,
- **b** - a bloc type peripheral,
- **c** - a character type peripheral,
- **p** - a named pipe for communication between processes,
- **s** - a network socket.

To see the inode numbers, execute the previous command with, in addition, the **-i** option:

```
root@debian8:~# ls -ldi /dev/console /dev/sda1 /etc /etc/passwd
 5601 crw-------   1 root root  5, 1 Aug 18 11:29 /dev/console
 6890 brw-rw----   1 root disk  8, 1 Aug 18 11:29 /dev/sda1
38995 drwxr-xr-x 121 root root 12288 Aug 18 11:29 /etc
52831 -rw-r--r--   1 root root  2094 May  1 20:32 /etc/passwd
```

### Data Blocks

File data is stored in data blocks. In the case of a directory, the data block contains a table referencing the inodes and the names of the contents of the directory.

The name of the file is stored in the parent directory's data block and not in the inode. This means that a file can be referenced by one or more different names. To add a name to a data block, you need to create what is called a **hard link**.

### Hard (Physical) Links

A hard link is created by using the **ln** command.

```
root@debian8:~# cd /tmp; mkdir inode; cd inode; touch file1; ls -ali
total 8
140612 drwxr-xr-x  2 root root 4096 Aug 18 13:28 .
130564 drwxrwxrwt 10 root root 4096 Aug 18 13:28 ..
140613 -rw-r--r--  1 root root    0 Aug 18 13:28 file1
```

**file1** shows an inode number of **140613** and a single name, indicated by the number **1** in the third column:

```
140613 -rw-r--r--  1 root root    0 Aug 18 13:28 file1
```

now create the hard link and check the result:

```
root@debian8:/tmp/inode# ln file1 file2
```

```
root@debian8:/tmp/inode# ls -ali
total 8
140612 drwxr-xr-x  2 root root 4096 Aug 18 13:29 .
130564 drwxrwxrwt 10 root root 4096 Aug 18 13:28 ..
140613 -rw-r--r--  2 root root    0 Aug 18 13:28 file1
140613 -rw-r--r--  2 root root    0 Aug 18 13:28 file2
```

Now you can see two lines, one for file1 and a second for file2:

```
140613 -rw-r--r--  2 root root    0 Aug 18 13:28 file1
140613 -rw-r--r--  2 root root    0 Aug 18 13:28 file2
```

**file1** and **file2** are referenced by the same inode. As a result the number of names has been increased to two in the thrid column.

**Important** - Hard links cannot be created across file system boundaries. A hard link can only be created if the source file exists.

## Soft (Symbolic) Links

A soft link is a shortcut to a file or directory. A soft link is created using the same **ln** command with the **-s** option.

```
root@debian8:/tmp/inode# ln -s file1 file3
root@debian8:/tmp/inode# ls -ali
total 8
140612 drwxr-xr-x  2 root root 4096 Aug 18 13:36 .
130564 drwxrwxrwt 10 root root 4096 Aug 18 13:28 ..
140613 -rw-r--r--  2 root root    0 Aug 18 13:28 file1
140613 -rw-r--r--  2 root root    0 Aug 18 13:28 file2
140614 lrwxrwxrwx  1 root root    5 Aug 18 13:36 file3 -> file1
```

Note here that the soft link is referenced by a separate inode.

**Important** - A soft link can be created across file system boundaries and can be created even when the source file does not exist.

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</html>

[1] Not Applicable