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Filesystem Management

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Lecture Topics

- Managing Files and Directories
  - Creating Directories and Files
  - Moving Directories and Files
  - Renaming Directories and Files
  - Copying Directories and Files
  - Deleting Directories and Files
- Finding Files
- Linking Files
- File and Directory Permissions
  - Ownership
  - Managing Permissions
    - Default Permissions
    - Special Permissions
  - Access Control Lists
  - Filesystem Attributes

Creating Directories and Files

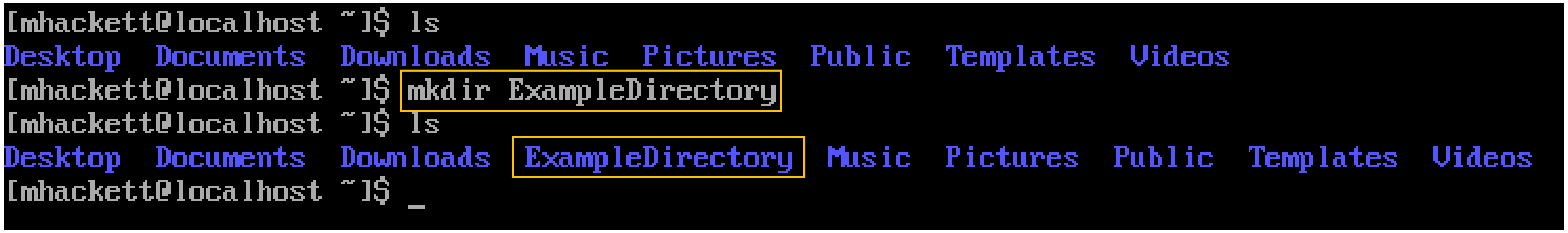
- The command used to **m**a**k**e a **dir**ectory is the **`mkdir`** command.

```
mkdir [argument]
```

- Argument is the directory you wish to create.

Creating Directories and Files

- The command **`mkdir ExampleDirectory`** would create a directory named ExampleDirectory.



```
[mhackett@localhost ~]$ ls
Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Videos
[mhackett@localhost ~]$ mkdir ExampleDirectory
[mhackett@localhost ~]$ ls
Desktop  Documents  Downloads  ExampleDirectory  Music  Pictures  Public  Templates  Videos
[mhackett@localhost ~]$ _
```

- To make a directory in a different location than the current working directory, provide the absolute path.
  - For example: **`mkdir /var/log/ExampleDirectory`**

Creating Directories and Files

- A command that is often used to create new files is the **touch** command.

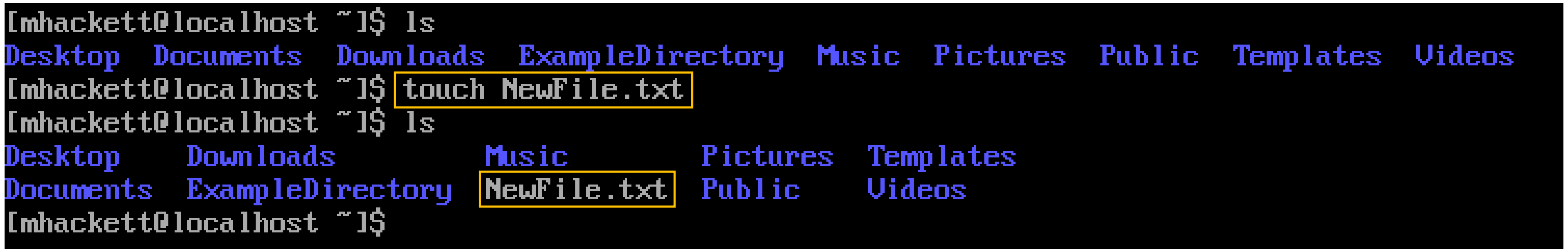
```
touch [argument]
```

- Argument is the file you wish to create.

- The true purpose of the **touch** command is to update the last access date of a file.

Creating Directories and Files

- The command **`touch NewFile.txt`** would create a new (empty) file named NewFile.txt

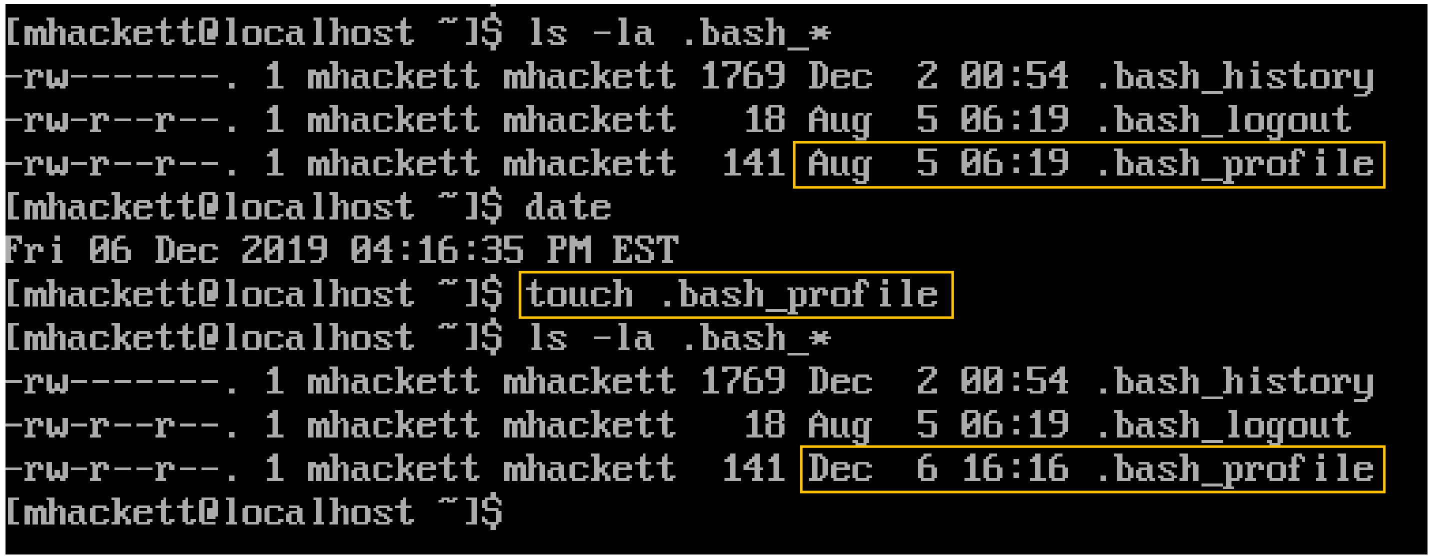


```
[mhackett@localhost ~]$ ls
Desktop  Documents  Downloads  ExampleDirectory  Music  Pictures  Public  Templates  Videos
[mhackett@localhost ~]$ touch NewFile.txt
[mhackett@localhost ~]$ ls
Desktop    Downloads         Music        Pictures  Templates
Documents  ExampleDirectory  NewFile.txt  Public    Videos
[mhackett@localhost ~]$
```

- To create or touch a file in a different location than the current working directory, provide the absolute path.
    - For example: **`touch /var/log/example.log`**

Creating Directories and Files

- If the file already exists, the **`touch`** command will update the last access date of the file.



```
[mhackett@localhost ~]$ ls -la .bash_*
-rw-------. 1 mhackett mhackett 1769 Dec  2 00:54 .bash_history
-rw-r--r--. 1 mhackett mhackett   18 Aug  5 06:19 .bash_logout
-rw-r--r--. 1 mhackett mhackett  141 Aug  5 06:19 .bash_profile
[mhackett@localhost ~]$ date
Fri 06 Dec 2019 04:16:35 PM EST
[mhackett@localhost ~]$ touch .bash_profile
[mhackett@localhost ~]$ ls -la .bash_*
-rw-------. 1 mhackett mhackett 1769 Dec  2 00:54 .bash_history
-rw-r--r--. 1 mhackett mhackett   18 Aug  5 06:19 .bash_logout
-rw-r--r--. 1 mhackett mhackett  141 Dec  6 16:16 .bash_profile
[mhackett@localhost ~]$
```

- (The use of the **`date`** command was simply to display the system's current date and time prior to touching the existing file.)

Moving Directories and Files

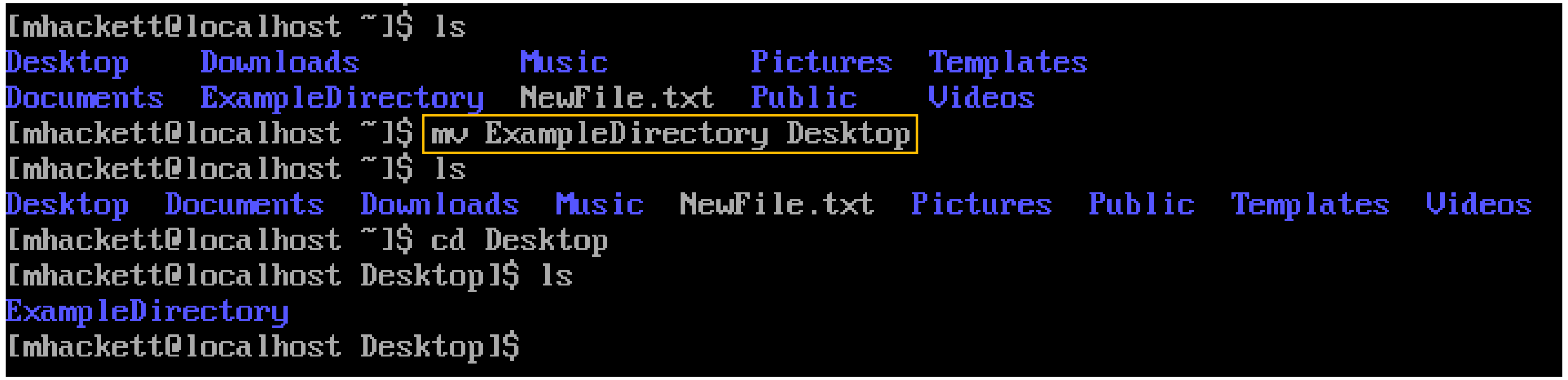
- The command to **m**o**v**e both directories and files is the **`mv`** command.

```
mv [options] source destination
```

- The source is the file or directory to move
- The destination is where the file or directory is to be moved to

Moving Directories and Files

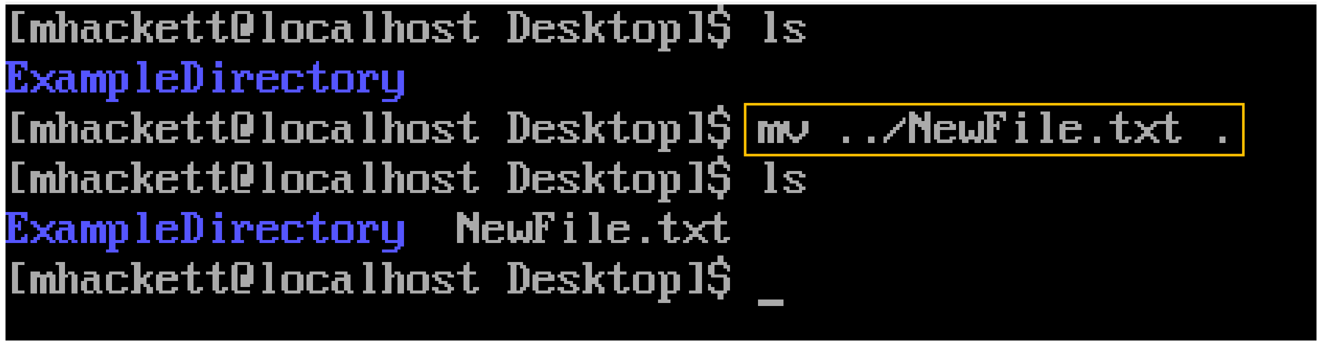
- The command **`mv ExampleDirectory Desktop`** would move the ExampleDirectory directory into the Desktop directory.



```
[mhackett@localhost ~]$ ls
Desktop    Downloads         Music       Pictures  Templates
Documents  ExampleDirectory  NewFile.txt Public    Videos
[mhackett@localhost ~]$ mv ExampleDirectory Desktop
[mhackett@localhost ~]$ ls
Desktop  Documents  Downloads  Music  NewFile.txt  Pictures  Public  Templates  Videos
[mhackett@localhost ~]$ cd Desktop
[mhackett@localhost Desktop]$ ls
ExampleDirectory
[mhackett@localhost Desktop]$
```

Moving Directories and Files

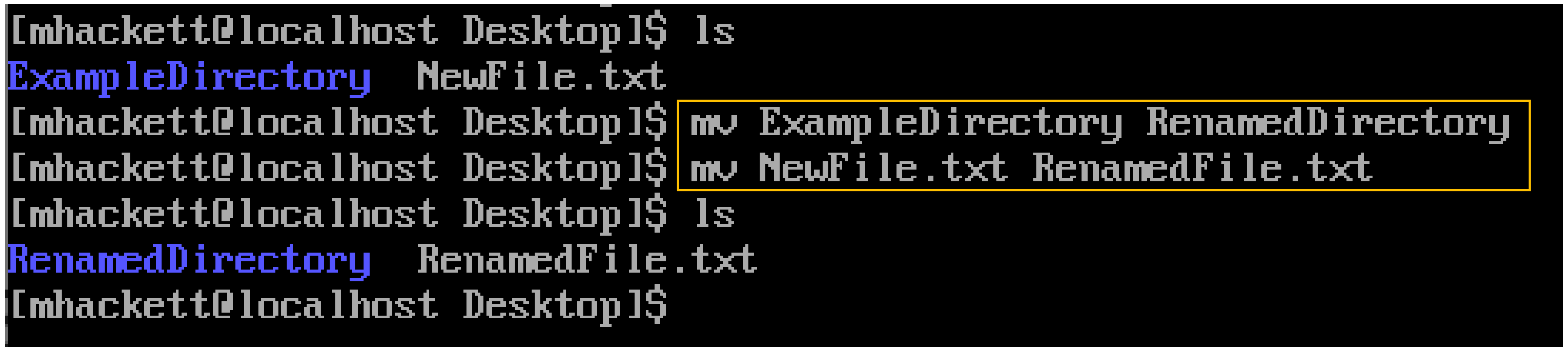
- The command **`mv ../NewFile.txt .`** would move the NewFile.txt file (one directory up) into the current working directory.



```
[mhackett@localhost Desktop]$ ls
ExampleDirectory
[mhackett@localhost Desktop]$ mv ../NewFile.txt .
[mhackett@localhost Desktop]$ ls
ExampleDirectory  NewFile.txt
[mhackett@localhost Desktop]$ _
```

Renaming Directories and Files

- The **`mv`** command is also used to rename a directory or file.



```
[mhackett@localhost Desktop]$ ls
ExampleDirectory  NewFile.txt
[mhackett@localhost Desktop]$ mv ExampleDirectory RenamedDirectory
[mhackett@localhost Desktop]$ mv NewFile.txt RenamedFile.txt
[mhackett@localhost Desktop]$ ls
RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$
```

Copying Directories and Files

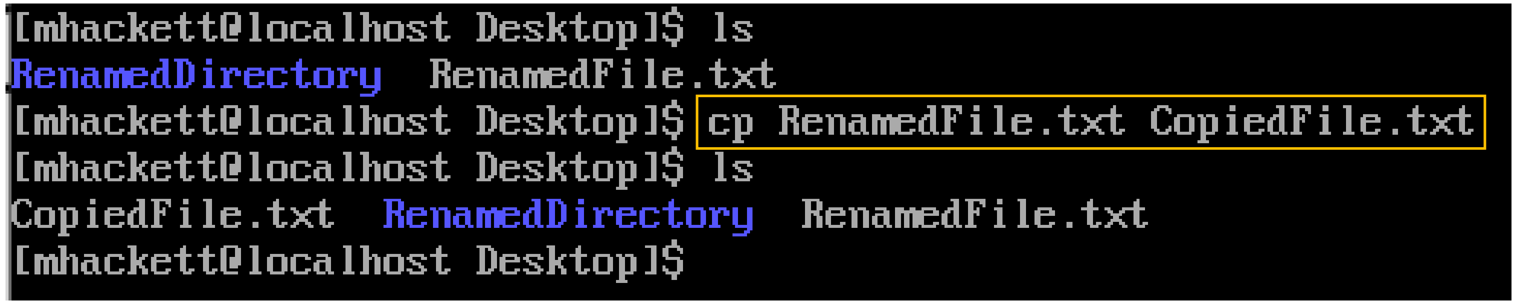
- The command to **c**o**p**y both directories and files is the **`cp`** command.

```
cp [options] source destination
```

- The source is the file or directory to copy
- The destination is where the file or directory is to be copied to

Copying Directories and Files

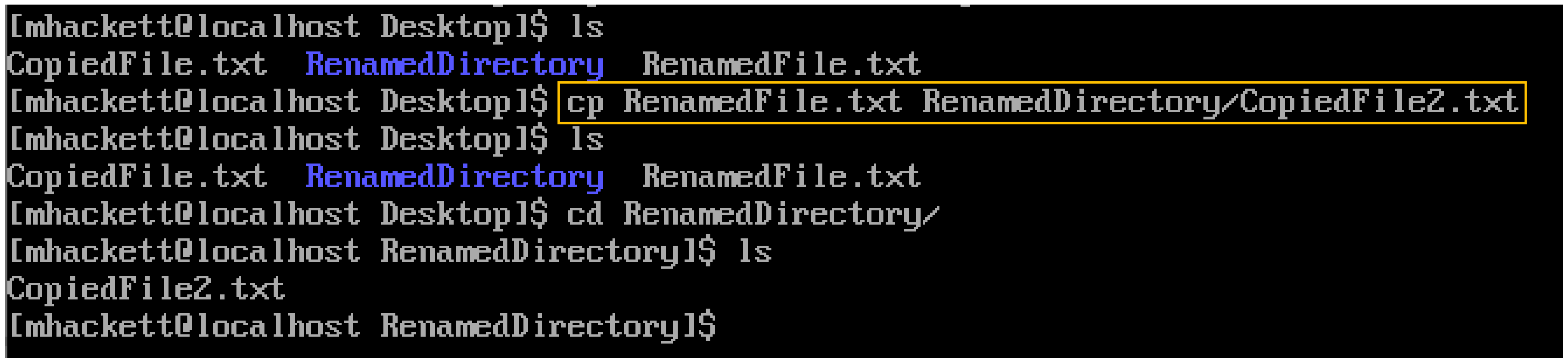
- The command **`cp RenamedFile.txt CopiedFile.txt`** would copy the RenamedFile.txt to a file (in the same working directory) named CopiedFile.txt



```
[mhackett@localhost Desktop]$ ls
RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$ cp RenamedFile.txt CopiedFile.txt
[mhackett@localhost Desktop]$ ls
CopiedFile.txt  RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$
```

Copying Directories and Files

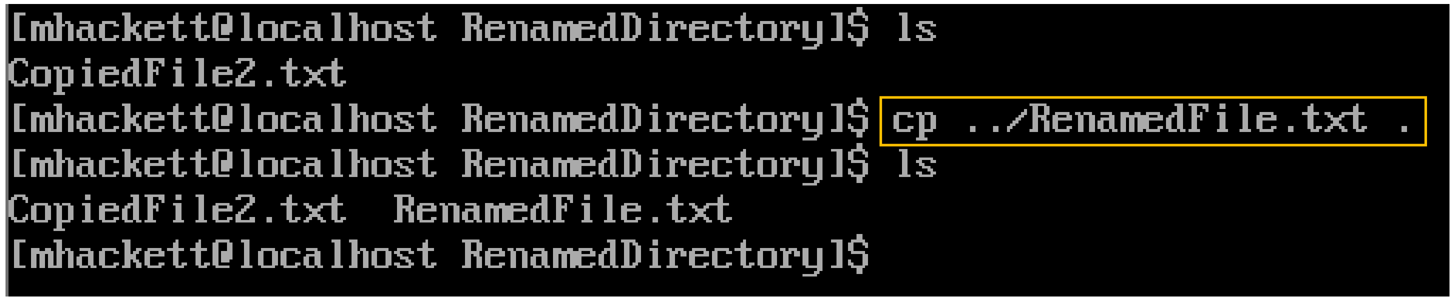
- The command
  `cp RenamedFile.txt RenamedDirectory/CopiedFile2.txt`
  would copy the RenamedFile.txt to a file named CopiedFile.txt in the RenamedDirectory directory



```
[mhackett@localhost Desktop]$ ls
CopiedFile.txt  RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$ cp RenamedFile.txt RenamedDirectory/CopiedFile2.txt
[mhackett@localhost Desktop]$ ls
CopiedFile.txt  RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$ cd RenamedDirectory/
[mhackett@localhost RenamedDirectory]$ ls
CopiedFile2.txt
[mhackett@localhost RenamedDirectory]$
```

Copying Directories and Files

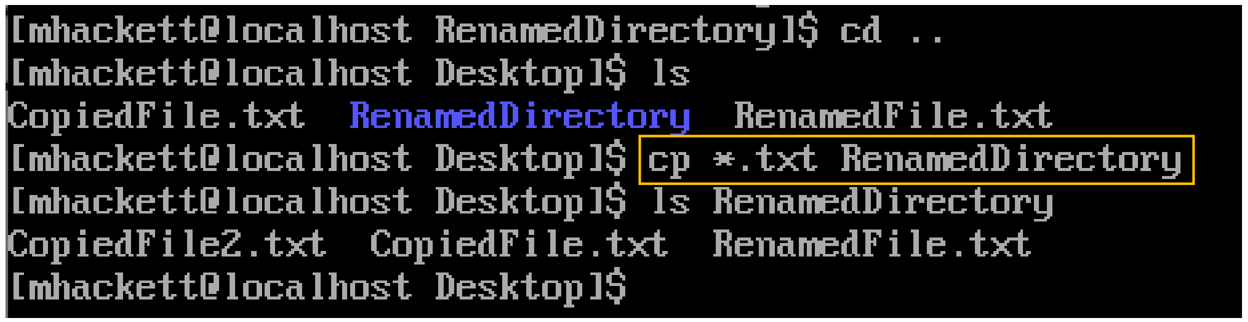
- The command **`cp ../RenamedFile.txt .`** would copy the RenamedFile.txt to a file to the current working directory.



```
[mhackett@localhost RenamedDirectory]$ ls
CopiedFile2.txt
[mhackett@localhost RenamedDirectory]$ cp ../RenamedFile.txt .
[mhackett@localhost RenamedDirectory]$ ls
CopiedFile2.txt  RenamedFile.txt
[mhackett@localhost RenamedDirectory]$
```

Copying Directories and Files

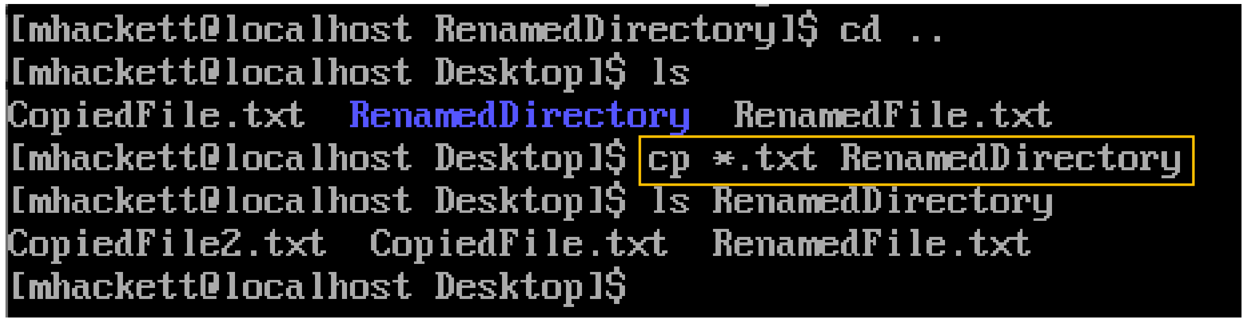
- The command **`cp *.txt RenamedDirectory`** would copy the any files that end with .txt at the current working directory into the RenamedDirectory directory.



```
[mhackett@localhost RenamedDirectory]$ cd ..
[mhackett@localhost Desktop]$ ls
CopiedFile.txt  RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$ cp *.txt RenamedDirectory
[mhackett@localhost Desktop]$ ls RenamedDirectory
CopiedFile2.txt  CopiedFile.txt  RenamedFile.txt
[mhackett@localhost Desktop]$
```

Copying Directories and Files

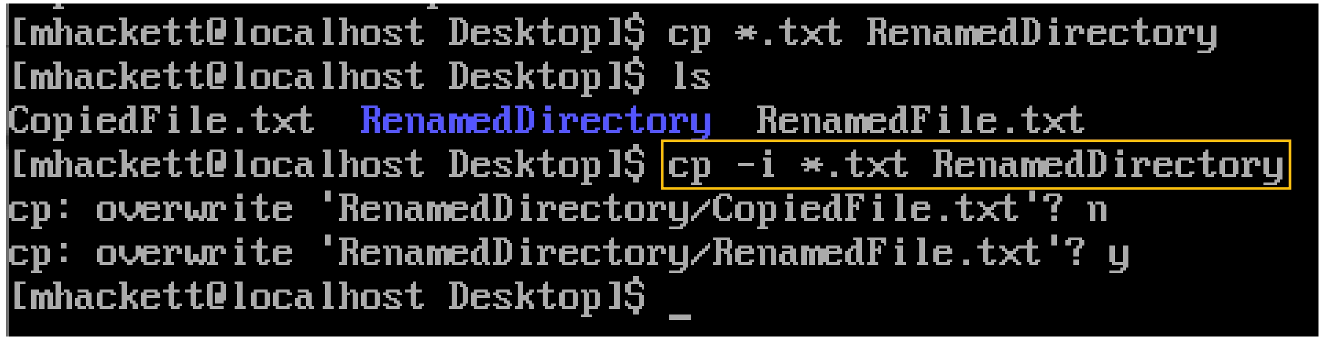
- Notice the command did not prompt us before overwriting the existing RenamedFile.txt that already existed in the RenamedDirectory directory.



```
[mhackett@localhost RenamedDirectory]$ cd ..
[mhackett@localhost Desktop]$ ls
CopiedFile.txt  RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$ cp *.txt RenamedDirectory
[mhackett@localhost Desktop]$ ls RenamedDirectory
CopiedFile2.txt  CopiedFile.txt  RenamedFile.txt
[mhackett@localhost Desktop]$
```

Copying Directories and Files

- To prompt before overwriting, use the **`-i`** option with the **`cp`** command.
  - **`-i`** is interactive mode

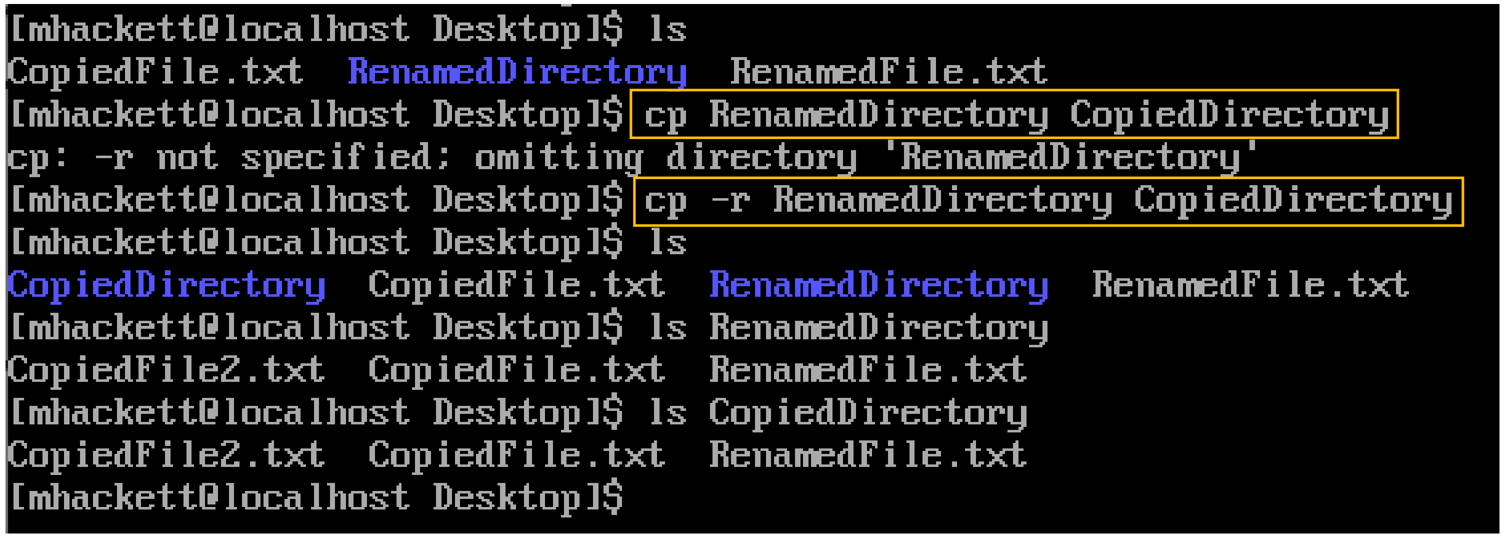


```
[mhackett@localhost Desktop]$ cp *.txt RenamedDirectory
[mhackett@localhost Desktop]$ ls
CopiedFile.txt  RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$ cp -i *.txt RenamedDirectory
cp: overwrite 'RenamedDirectory/CopiedFile.txt'? n
cp: overwrite 'RenamedDirectory/RenamedFile.txt'? y
[mhackett@localhost Desktop]$ _
```

- The **`-i`** option also works with the **`mv`** command to prompt before overwriting existing files.

Copying Directories and Files

- When copying a *directory*, the **-r** option must be used.
  - **-r** (or **-R**) is the recursive option, which means all contents in the directory will be copied.



```
[mhackett@localhost Desktop]$ ls
CopiedFile.txt  RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$ cp RenamedDirectory CopiedDirectory
cp: -r not specified; omitting directory 'RenamedDirectory'
[mhackett@localhost Desktop]$ cp -r RenamedDirectory CopiedDirectory
[mhackett@localhost Desktop]$ ls
CopiedDirectory  CopiedFile.txt  RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$ ls RenamedDirectory
CopiedFile2.txt  CopiedFile.txt  RenamedFile.txt
[mhackett@localhost Desktop]$ ls CopiedDirectory
CopiedFile2.txt  CopiedFile.txt  RenamedFile.txt
[mhackett@localhost Desktop]$
```

Deleting Directories and Files

- The command to **rem**ove files is the **rm** command.

```
rm [options] [arguments]
```

- The **rm** command (with the **-r** option) is used to remove non-empty directories.

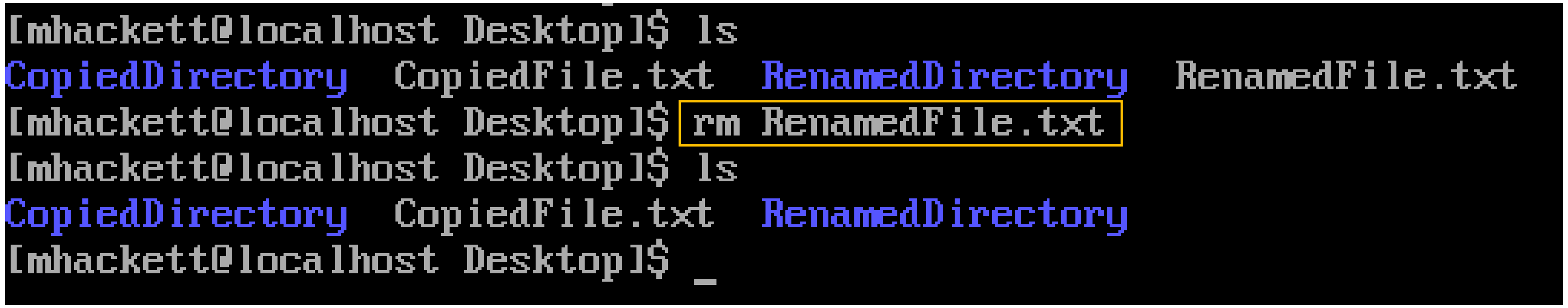
```
rm -r [arguments]
```

- The **rmdir** command is used to remove empty directories.

```
rmdir [options] [arguments]
```

Deleting Directories and Files

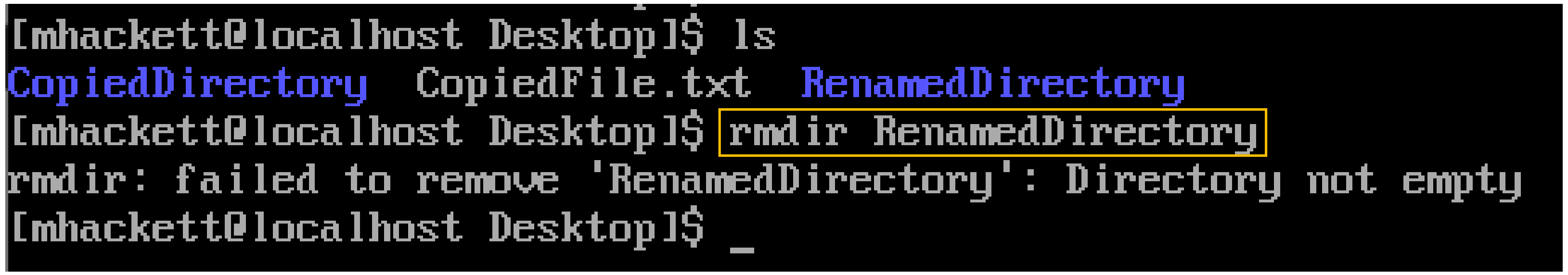
- The command **`rm RenamedFile.txt`** would delete the RenamedFile.txt file in the current working directory.



```
[mhackett@localhost Desktop]$ ls
CopiedDirectory  CopiedFile.txt  RenamedDirectory  RenamedFile.txt
[mhackett@localhost Desktop]$ rm RenamedFile.txt
[mhackett@localhost Desktop]$ ls
CopiedDirectory  CopiedFile.txt  RenamedDirectory
[mhackett@localhost Desktop]$ _
```

Deleting Directories and Files

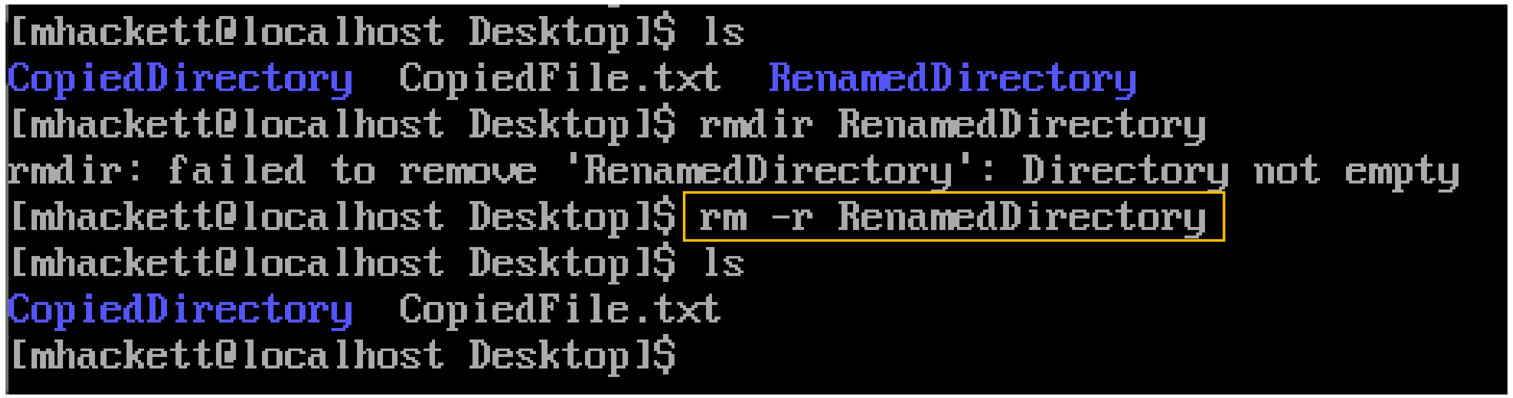
- The command **`rmdir RenamedDirectory`** would *attempt* to delete the RenamedDirectory directory in the current working directory.
  - This will not work for non-empty directories.



```
[mhackett@localhost Desktop]$ ls
CopiedDirectory  CopiedFile.txt  RenamedDirectory
[mhackett@localhost Desktop]$ rmdir RenamedDirectory
rmdir: failed to remove 'RenamedDirectory': Directory not empty
[mhackett@localhost Desktop]$ _
```

Deleting Directories and Files

- The **`rm -r`** command and option is used to remove non-empty directories.



```
[mhackett@localhost Desktop]$ ls
CopiedDirectory  CopiedFile.txt  RenamedDirectory
[mhackett@localhost Desktop]$ rmdir RenamedDirectory
rmdir: failed to remove 'RenamedDirectory': Directory not empty
[mhackett@localhost Desktop]$ rm -r RenamedDirectory
[mhackett@localhost Desktop]$ ls
CopiedDirectory  CopiedFile.txt
[mhackett@localhost Desktop]$
```

Finding Files

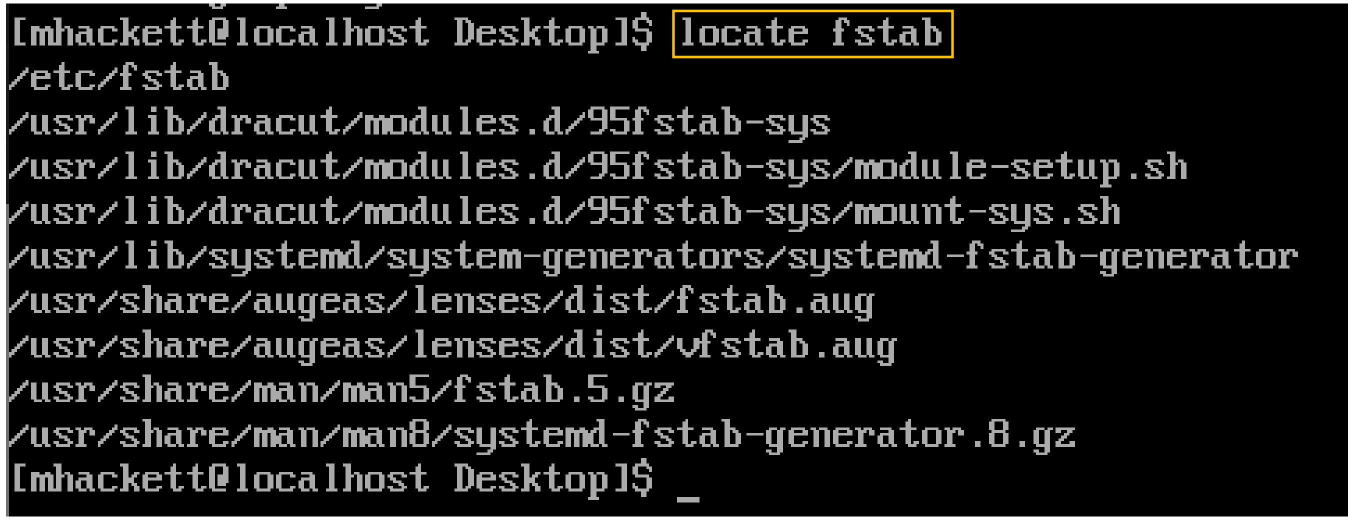
- When searching for files, there are different commands for different types of searches.
- To search the *entire* filesystem for a file based on its name, the locate command is used.

```
locate [argument]
```

- The argument is the name (or partial name) of the file.

Finding Files

- The command **`locate fstab`** would search the entire filesystem for files that contain “fstab” in its name and display the results.



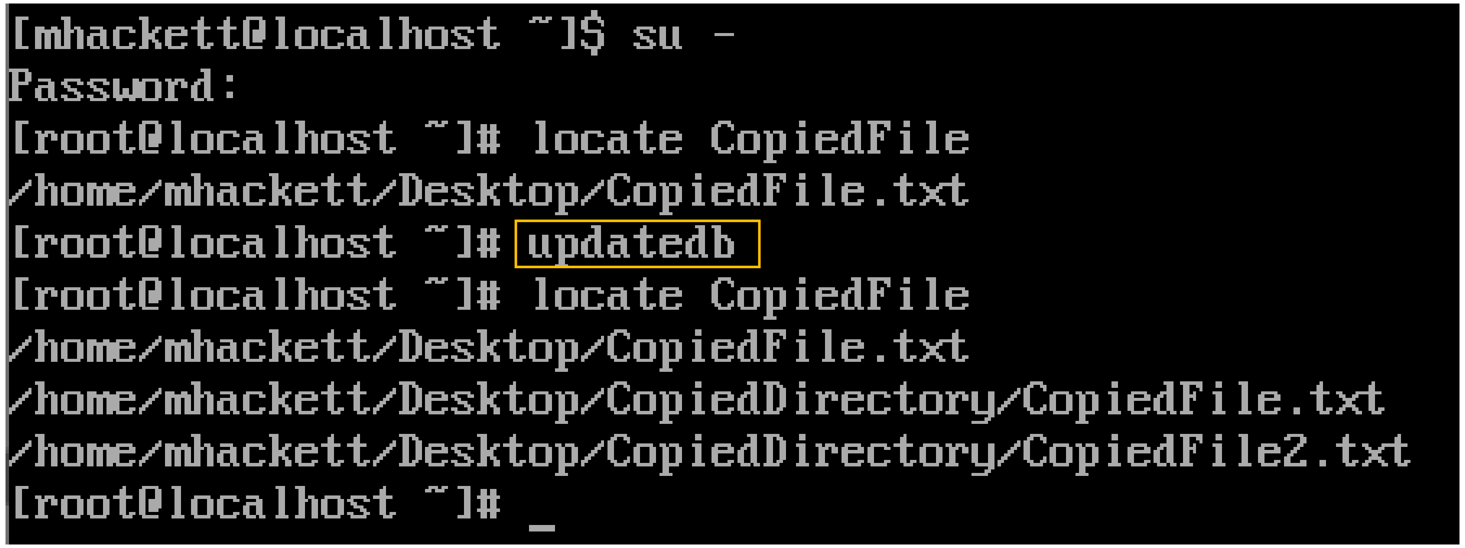
```
[mhackett@localhost Desktop]$ locate fstab
/etc/fstab
/usr/lib/dracut/modules.d/95fstab-sys
/usr/lib/dracut/modules.d/95fstab-sys/module-setup.sh
/usr/lib/dracut/modules.d/95fstab-sys/mount-sys.sh
/usr/lib/systemd/system-generators/systemd-fstab-generator
/usr/share/augeas/lenses/dist/fstab.aug
/usr/share/augeas/lenses/dist/vfstab.aug
/usr/share/man/man5/fstab.5.gz
/usr/share/man/man8/systemd-fstab-generator.8.gz
[mhackett@localhost Desktop]$ _
```

Finding Files

- The **`locate`** command maintains a database of files in the filesystem.
  - Actual database file is /var/lib/mlocate/mlocate.db

- As files are added and removed, the database needs to be updated.
  - This is done automatically once a day.
  - To manually update the database, run the **`updatedb`** command as the root user.

Finding Files



```
[mhackett@localhost ~]$ su -
Password:
[root@localhost ~]# locate CopiedFile
/home/mhackett/Desktop/CopiedFile.txt
[root@localhost ~]# updatedb
[root@localhost ~]# locate CopiedFile
/home/mhackett/Desktop/CopiedFile.txt
/home/mhackett/Desktop/CopiedDirectory/CopiedFile.txt
/home/mhackett/Desktop/CopiedDirectory/CopiedFile2.txt
[root@localhost ~]# _
```

Finding Files

- Another command for searching for files is the **`find`** command.

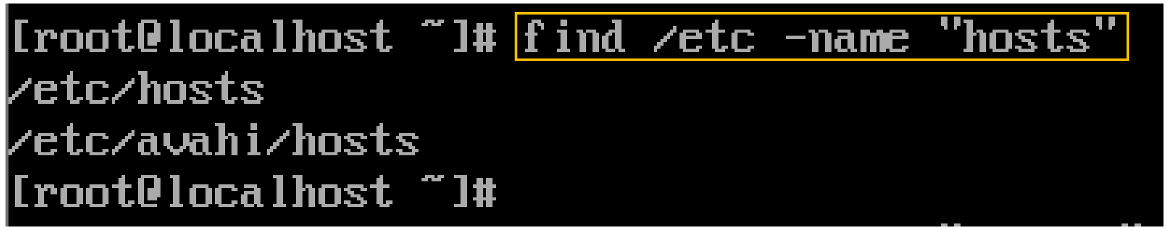
  ```
  find start [options] argument
  ```

  - The start is the directory to begin the search.
  - The options specify the type of criteria.
  - The argument is the criteria for the search.

- It is slower than **`locate`**, but is more versatile.
  - Slower because it doesn’t maintain a database of files like **`locate`** does

Finding Files

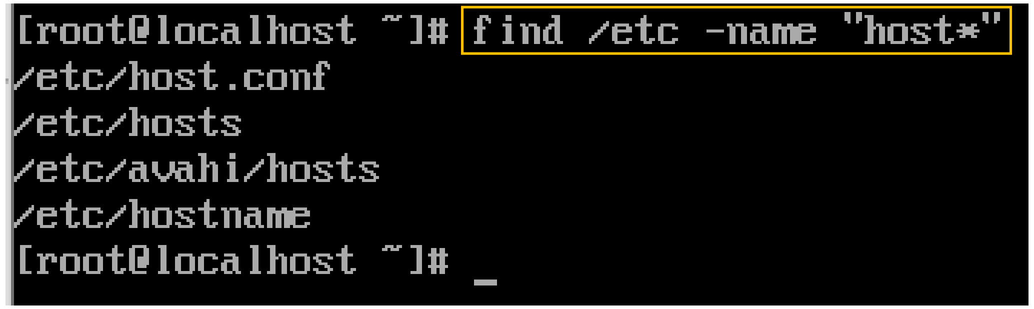
- The command **`find /etc -name "hosts"`** would search the entire etc directory for files that contain “hosts” in its name and display the results.



```
[root@localhost ~]# find /etc -name "hosts"
/etc/hosts
/etc/avahi/hosts
[root@localhost ~]#
```

Finding Files

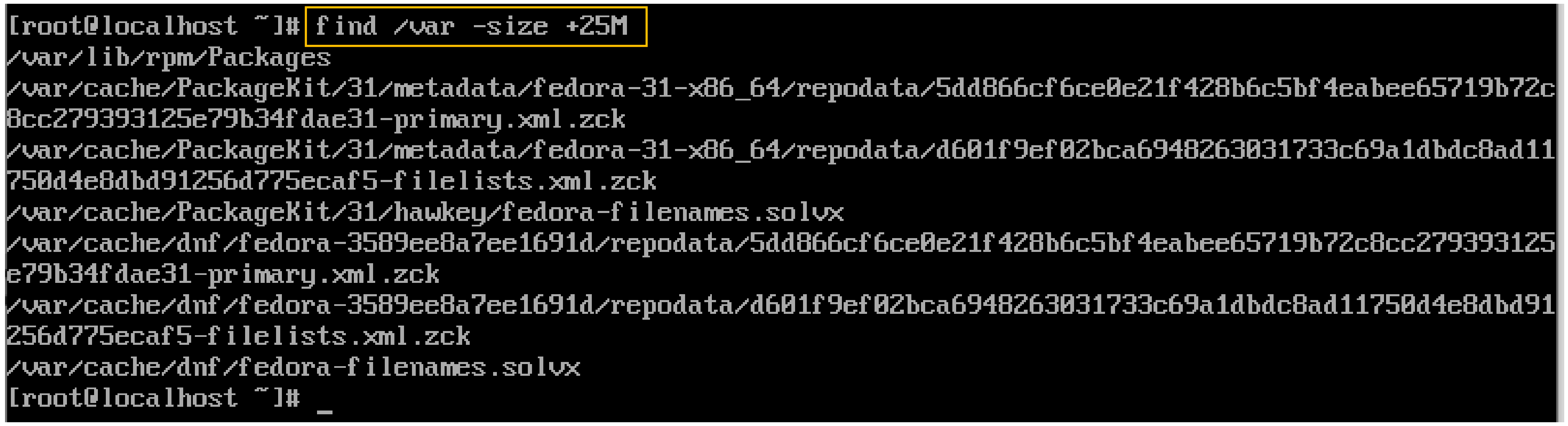
- The command **`find /etc -name "host*"`** would search the entire etc directory for files that begin with “host” followed by any characters and display the results.



```
[root@localhost ~]# find /etc -name "host*"
/etc/host.conf
/etc/hosts
/etc/avahi/hosts
/etc/hostname
[root@localhost ~]# _
```

Finding Files

- The command **`find /var -size +25M`** would search the entire var directory for files larger than 25 megabytes.



```
[root@localhost ~]# find /var -size +25M
/var/lib/rpm/Packages
/var/cache/PackageKit/31/metadata/fedora-31-x86_64/repodata/5dd866cf6ce0e21f428b6c5bf4eabee65719b72c
8cc279393125e79b34fdae31-primary.xml.zck
/var/cache/PackageKit/31/metadata/fedora-31-x86_64/repodata/d601f9ef02bca6948263031733c69a1dbdc8ad11
750d4e8dbd91256d775ecaf5-filelists.xml.zck
/var/cache/PackageKit/31/hawkey/fedora-filenames.solvx
/var/cache/dnf/fedora-3589ee8a7ee1691d/repodata/5dd866cf6ce0e21f428b6c5bf4eabee65719b72c8cc279393125
e79b34fdae31-primary.xml.zck
/var/cache/dnf/fedora-3589ee8a7ee1691d/repodata/d601f9ef02bca6948263031733c69a1dbdc8ad11750d4e8dbd91
256d775ecaf5-filelists.xml.zck
/var/cache/dnf/fedora-filenames.solvx
[root@localhost ~]# _
```

- See the manual for **`find`** (enter **`man find`**) for additional criteria.

Finding Files

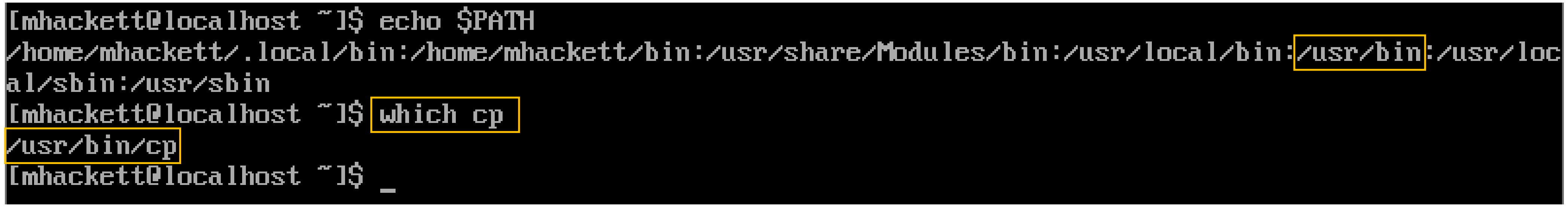
- The **`which`** command searches locations specified in the user's PATH environment variable.

```
which argument
```

  - The argument is the name of the file or program.

Finding Files

- The command **`which cp`** would search only the user's PATH for files or programs named "cp"
  - The $PATH is displayed to illustrate where the **`which`** command will search.



```
[mhackett@localhost ~]$ echo $PATH
/home/mhackett/.local/bin:/home/mhackett/bin:/usr/share/Modules/bin:/usr/local/bin:/usr/bin:/usr/loc
al/sbin:/usr/sbin
[mhackett@localhost ~]$ which cp
/usr/bin/cp
[mhackett@localhost ~]$ _
```

Finding Files

- A command similar to the **`which`** command is the **`type`** command.

  ```
  type argument
  ```

  - The argument is the name of the file or program.

- If there were more than one result of the **`which`** command, the **`type`** command would only display the first result.

Finding Files

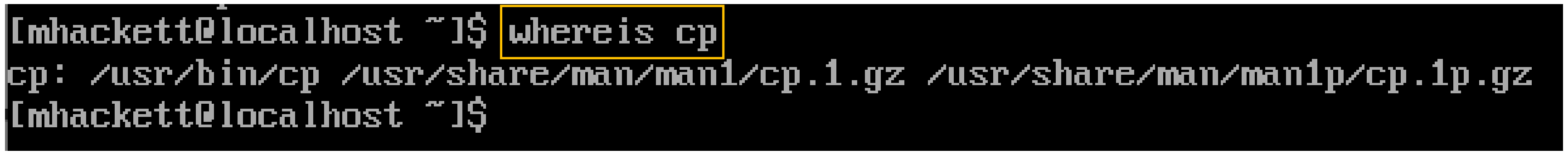
- The **`whereis`** command displays the location of the file or program (searches only the directories in the user's PATH) and any associated manual files.

  ```
  whereis argument
  ```

  - The argument is the name of the file or program.

Finding Files

- The command **`whereis cp`** would search only the user's PATH for files or programs named "cp" and its associated manual files.



```
[mhackett@localhost ~]$ whereis cp
cp: /usr/bin/cp /usr/share/man/man1/cp.1.gz /usr/share/man/man1p/cp.1p.gz
[mhackett@localhost ~]$
```

Linking Files

- The filesystem, structurally, has three main sections
  - The **superblock** which contains (among other things) the number of inodes and size of data blocks.
  - The **inode table** contains a table of **i**nformation **node**s which each describe a file or directory in the filesystem. Each inode has a unique identification number.
    - inodes store information about their files and directories like its size, permissions, ownership, etc.
  - The **data blocks** (or **allocation units**) contain the actual data of files.

- When a file or directory is deleted, only its inode is deleted.

Linking Files

- A file is **hard linked** when it shares the same inode as another file.
    - They share the same inode number and data blocks.

- Hard linked files must all reside in the same filesystem.

Linking Files

- A file is **soft linked** when it simply points another file.
  - The proper term is **symbolically linked** or a “**symlink**”
  - They do not share the same inode number and data blocks.

- Soft linked files do not need to all reside in the same filesystem.

Linking Files

- The **`ln`** command is used to create both hard **lin**ks and symlinks

```
ln [options] source link
```

- To create a hard link, no options are needed:

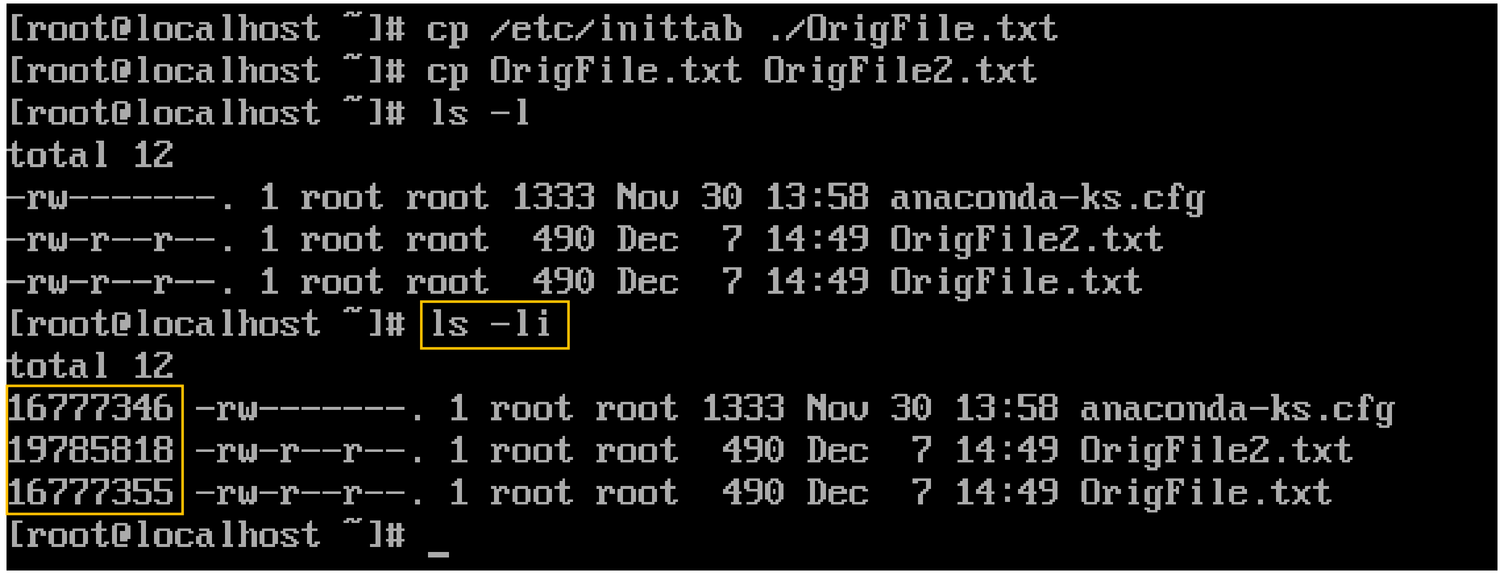
```
ln origFile.txt origFileLink.txt
```

- To create a symlink, use the **`-s`** option:

```
ln -s origFile.txt origFileLink.txt
```

Linking Files

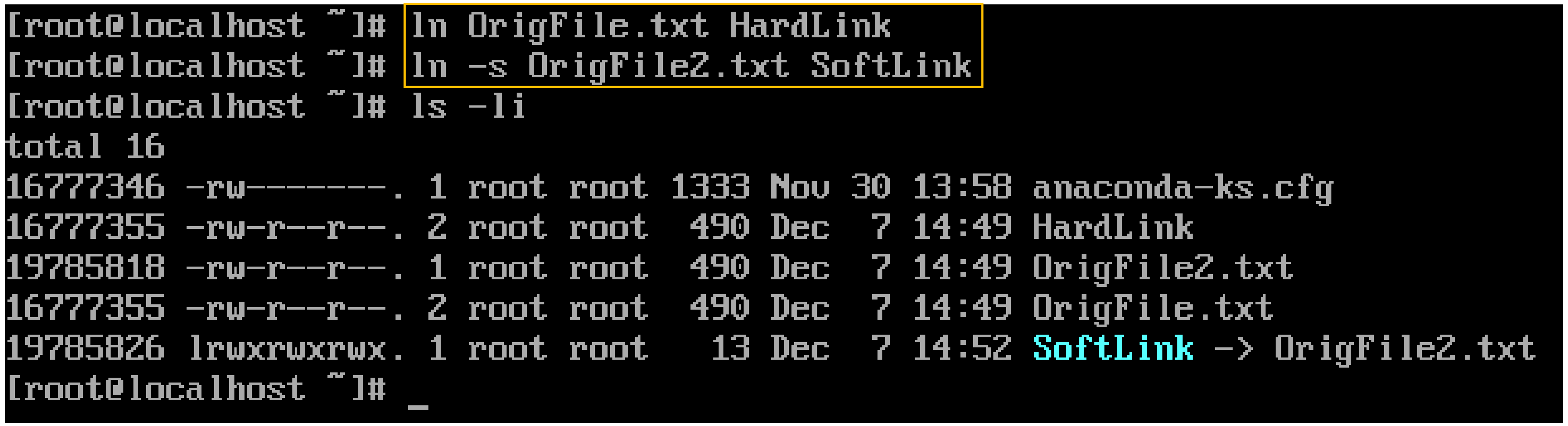
- To include inode numbers in a listing, use the **`-i`** option with the **`ls`** command:



```
[root@localhost ~]# cp /etc/inittab ./OrigFile.txt
[root@localhost ~]# cp OrigFile.txt OrigFile2.txt
[root@localhost ~]# ls -l
total 12
-rw-------. 1 root root 1333 Nov 30 13:58 anaconda-ks.cfg
-rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile2.txt
-rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile.txt
[root@localhost ~]# ls -li
total 12
16777346 -rw-------. 1 root root 1333 Nov 30 13:58 anaconda-ks.cfg
19785818 -rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile2.txt
16777355 -rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile.txt
[root@localhost ~]# _
```

Linking Files

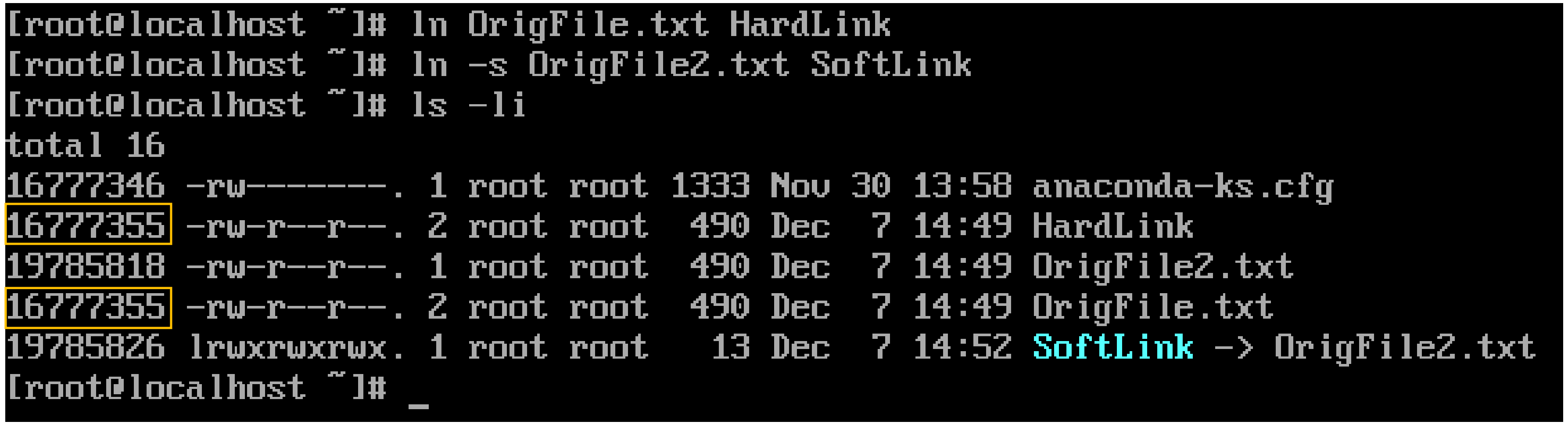
- Examples of creating hard links and symlinks:



```
[root@localhost ~]# ln OrigFile.txt HardLink
[root@localhost ~]# ln -s OrigFile2.txt SoftLink
[root@localhost ~]# ls -li
total 16
16777346 -rw-------. 1 root root 1333 Nov 30 13:58 anaconda-ks.cfg
16777355 -rw-r--r--. 2 root root  490 Dec  7 14:49 HardLink
19785818 -rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile2.txt
16777355 -rw-r--r--. 2 root root  490 Dec  7 14:49 OrigFile.txt
19785826 lrwxrwxrwx. 1 root root   13 Dec  7 14:52 SoftLink -> OrigFile2.txt
[root@localhost ~]# _
```

Linking Files

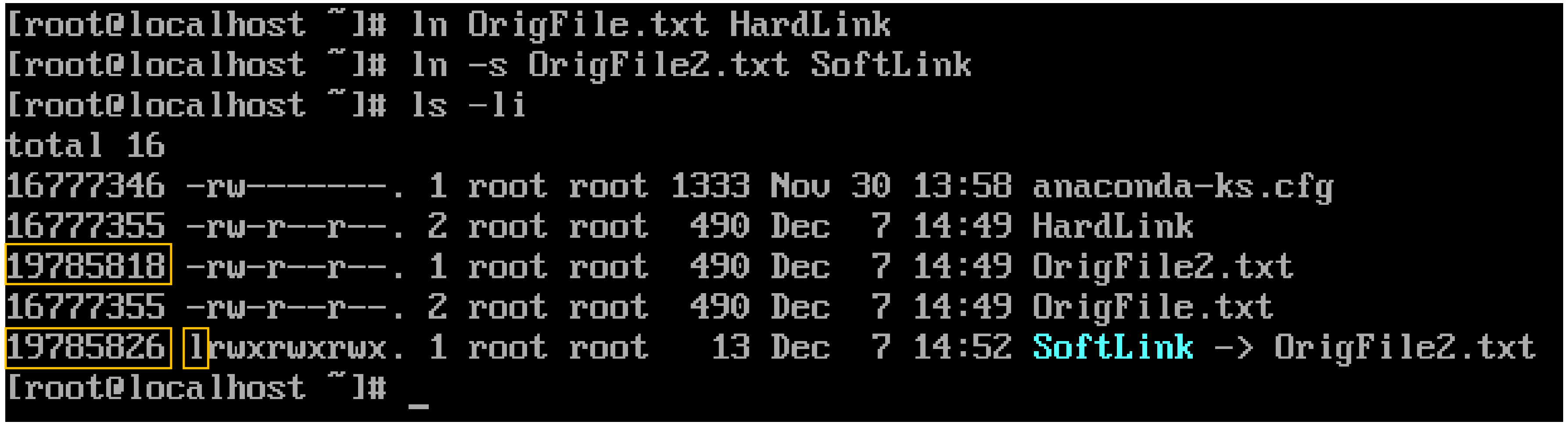
- Notice the hard linked file shares the same inode number:



```
[root@localhost ~]# ln OrigFile.txt HardLink
[root@localhost ~]# ln -s OrigFile2.txt SoftLink
[root@localhost ~]# ls -li
total 16
16777346 -rw-------. 1 root root 1333 Nov 30 13:58 anaconda-ks.cfg
16777355 -rw-r--r--. 2 root root  490 Dec  7 14:49 HardLink
19785818 -rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile2.txt
16777355 -rw-r--r--. 2 root root  490 Dec  7 14:49 OrigFile.txt
19785826 lrwxrwxrwx. 1 root root   13 Dec  7 14:52 SoftLink -> OrigFile2.txt
[root@localhost ~]# _
```

Linking Files

- Notice the symlinks do not share the same inode number:

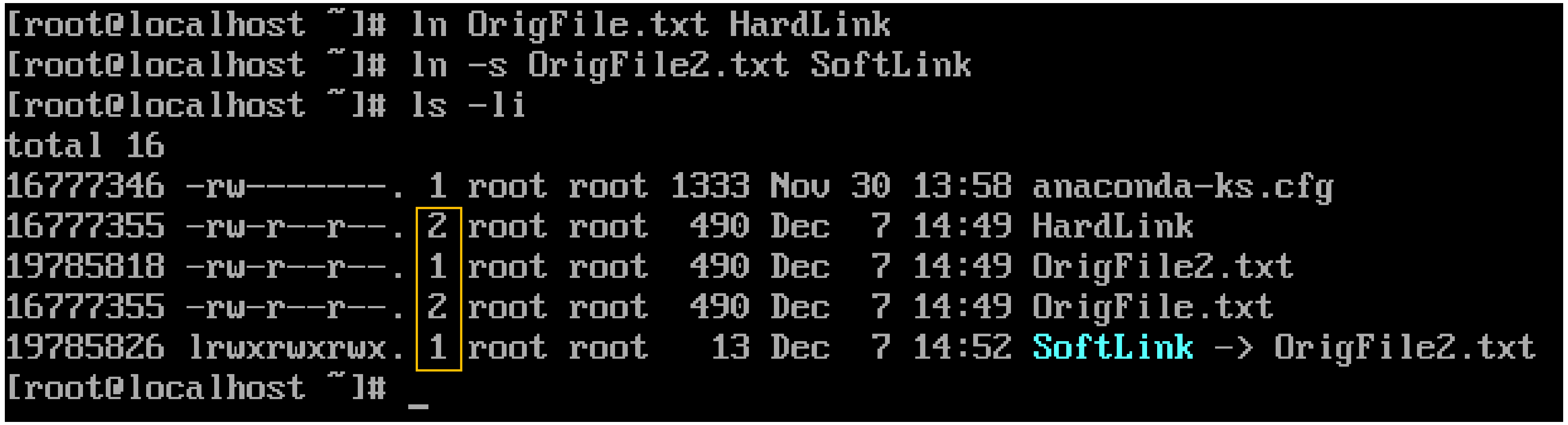


```
[root@localhost ~]# ln OrigFile.txt HardLink
[root@localhost ~]# ln -s OrigFile2.txt SoftLink
[root@localhost ~]# ls -li
total 16
16777346 -rw-------. 1 root root 1333 Nov 30 13:58 anaconda-ks.cfg
16777355 -rw-r--r--. 2 root root  490 Dec  7 14:49 HardLink
19785818 -rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile2.txt
16777355 -rw-r--r--. 2 root root  490 Dec  7 14:49 OrigFile.txt
19785826 lrwxrwxrwx. 1 root root   13 Dec  7 14:52 SoftLink -> OrigFile2.txt
[root@localhost ~]# _
```

- Just before the file's mode (discussed shortly and mentioned in a previous lecture), an l indicates a symlink

Linking Files

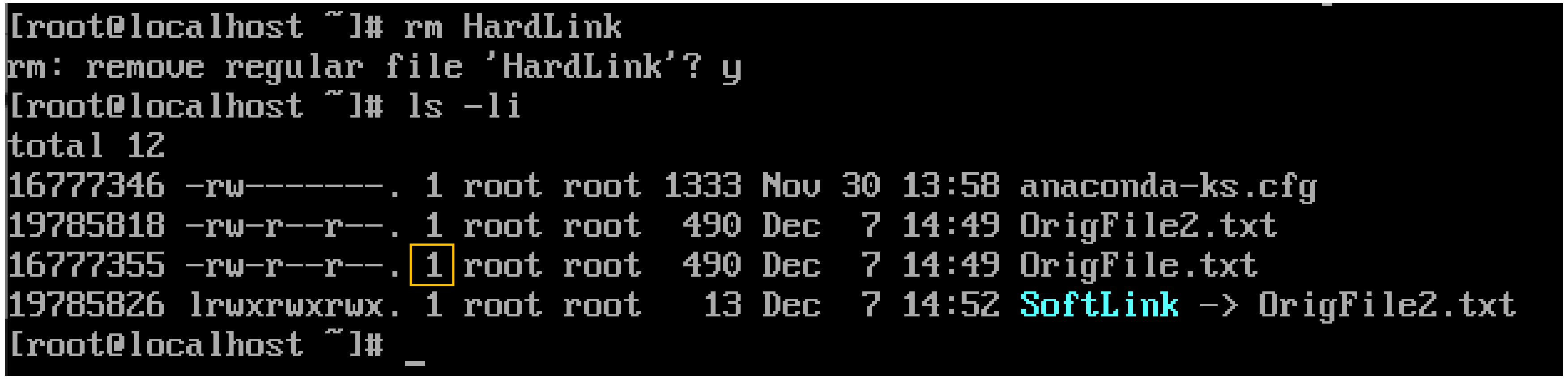
- Also note the link counts for each file:
  - Symlinks do not increase the link count



```
[root@localhost ~]# ln OrigFile.txt HardLink
[root@localhost ~]# ln -s OrigFile2.txt SoftLink
[root@localhost ~]# ls -li
total 16
16777346 -rw-------. 1 root root 1333 Nov 30 13:58 anaconda-ks.cfg
16777355 -rw-r--r--. 2 root root  490 Dec  7 14:49 HardLink
19785818 -rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile2.txt
16777355 -rw-r--r--. 2 root root  490 Dec  7 14:49 OrigFile.txt
19785826 lrwxrwxrwx. 1 root root   13 Dec  7 14:52 SoftLink -> OrigFile2.txt
[root@localhost ~]# _
```

Linking Files

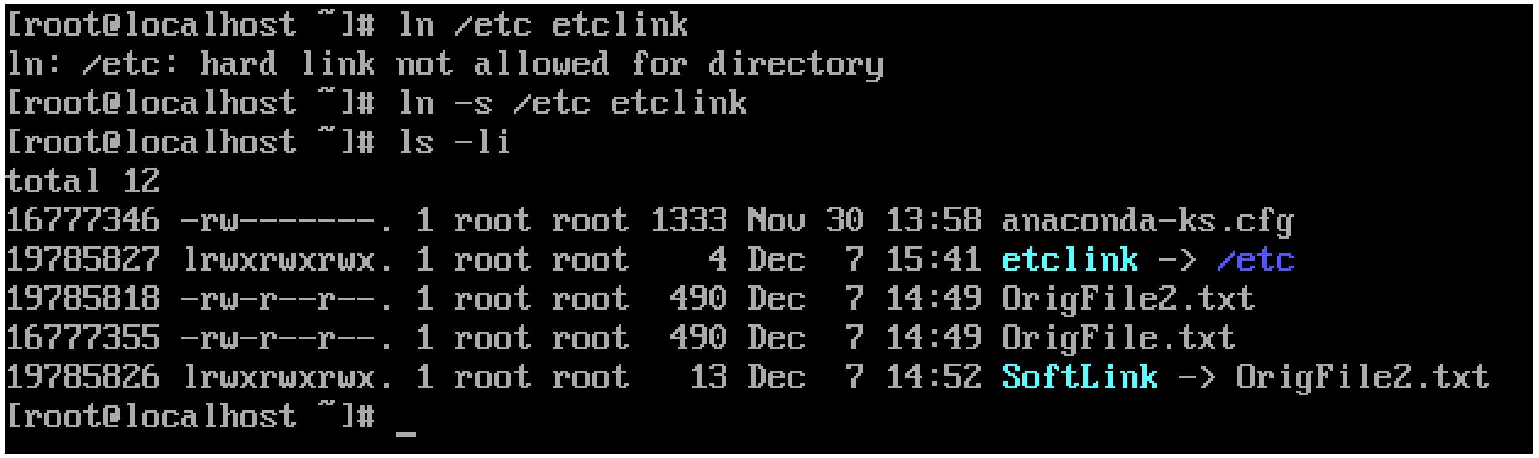
- Deleting a link will update the link count:



```
[root@localhost ~]# rm HardLink
rm: remove regular file 'HardLink'? y
[root@localhost ~]# ls -li
total 12
16777346 -rw-------. 1 root root 1333 Nov 30 13:58 anaconda-ks.cfg
19785818 -rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile2.txt
16777355 -rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile.txt
19785826 lrwxrwxrwx. 1 root root   13 Dec  7 14:52 SoftLink -> OrigFile2.txt
[root@localhost ~]# _
```

Linking Files

- Another important distinction:
  - Directories cannot be hard linked
  - Directories can be symbolically linked



```
[root@localhost ~]# ln /etc etclink
ln: /etc: hard link not allowed for directory
[root@localhost ~]# ln -s /etc etclink
[root@localhost ~]# ls -li
total 12
16777346 -rw-------. 1 root root 1333 Nov 30 13:58 anaconda-ks.cfg
19785827 lrwxrwxrwx. 1 root root    4 Dec  7 15:41 etclink -> /etc
19785818 -rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile2.txt
16777355 -rw-r--r--. 1 root root  490 Dec  7 14:49 OrigFile.txt
19785826 lrwxrwxrwx. 1 root root   13 Dec  7 14:52 SoftLink -> OrigFile2.txt
[root@localhost ~]# _
```

File and Directory Permissions

- Every user is identified by their username and a group membership.
  - Users can be members of multiple groups.

- Access to resources like files and directories depends on the resource’s **permissions**.
  - Access is granted based on the resource’s owner and group ownership.

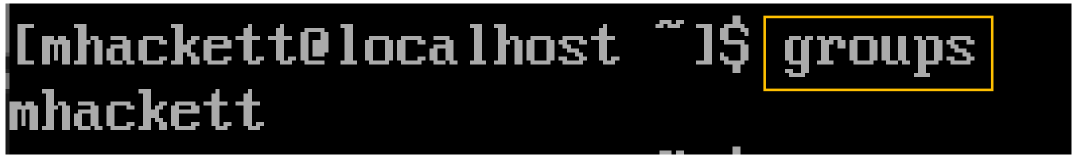
Ownership

- When a user creates files and directories, the file or directory is created with
  - The user as the owner
  - The user’s primary group as the group owner

- The **groups** command will list the current user’s group membership.
  - The first group listed is the user’s primary group
  - Most users will have a primary group that is identical to their username

Ownership

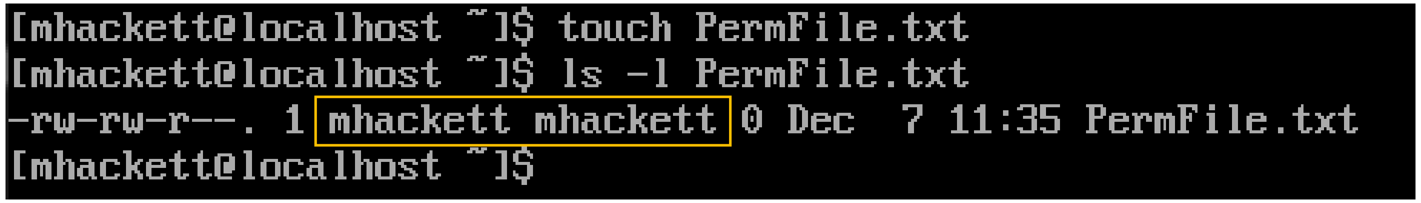
- Currently, this user account is only a member of one group.
  - We'll see how to add a user to additional groups in a later lecture.



```
[mhackett@localhost ~]$ groups
mhackett
```

Ownership

- When creating a new file (or directory) we see that the default ownership is the user that created it and their primary group.



```
[mhackett@localhost ~]$ touch PermFile.txt
[mhackett@localhost ~]$ ls -l PermFile.txt
-rw-rw-r--. 1 mhackett mhackett 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$
```

Ownership

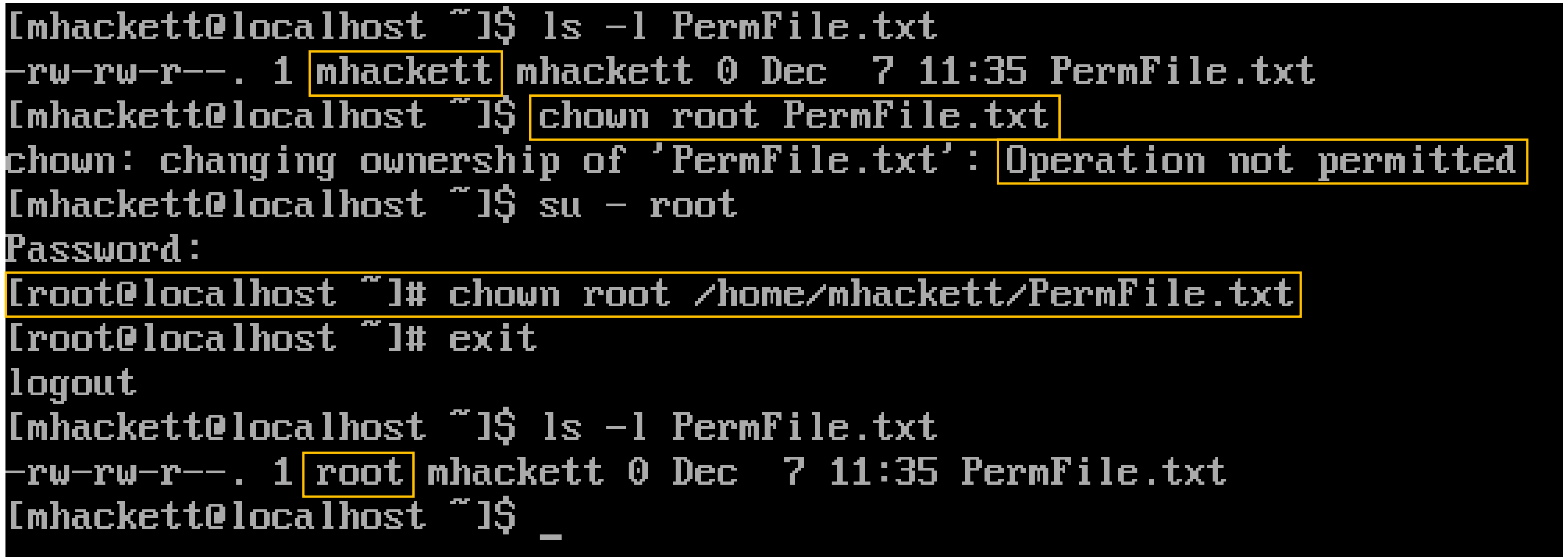
- The command to **ch**ange **own**ership of a file or directory is the **chown** command.

  chown [options] ***username*** **[files or directories]**

- Only the root user or current owner* can change the resource's ownership
  - *(Unless the current owner does not have access/permission to use the chown command; discussed later)

Ownership

- Changing ownership of PermFile.txt from mhackett to the root user:



```
[mhackett@localhost ~]$ ls -l PermFile.txt
-rw-rw-r--. 1 mhackett mhackett 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$ chown root PermFile.txt
chown: changing ownership of 'PermFile.txt': Operation not permitted
[mhackett@localhost ~]$ su - root
Password:
[root@localhost ~]# chown root /home/mhackett/PermFile.txt
[root@localhost ~]# exit
logout
[mhackett@localhost ~]$ ls -l PermFile.txt
-rw-rw-r--. 1 root mhackett 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$ _
```

Ownership

- To change a directory’s owner, the syntax is the same:

  `chown` ***`newowner directory`***

- To change a directory’s owner and change the owner of everything in it, use the **`-R`** (recursive) option:

  `chown -R` ***`newowner directory`***

Ownership

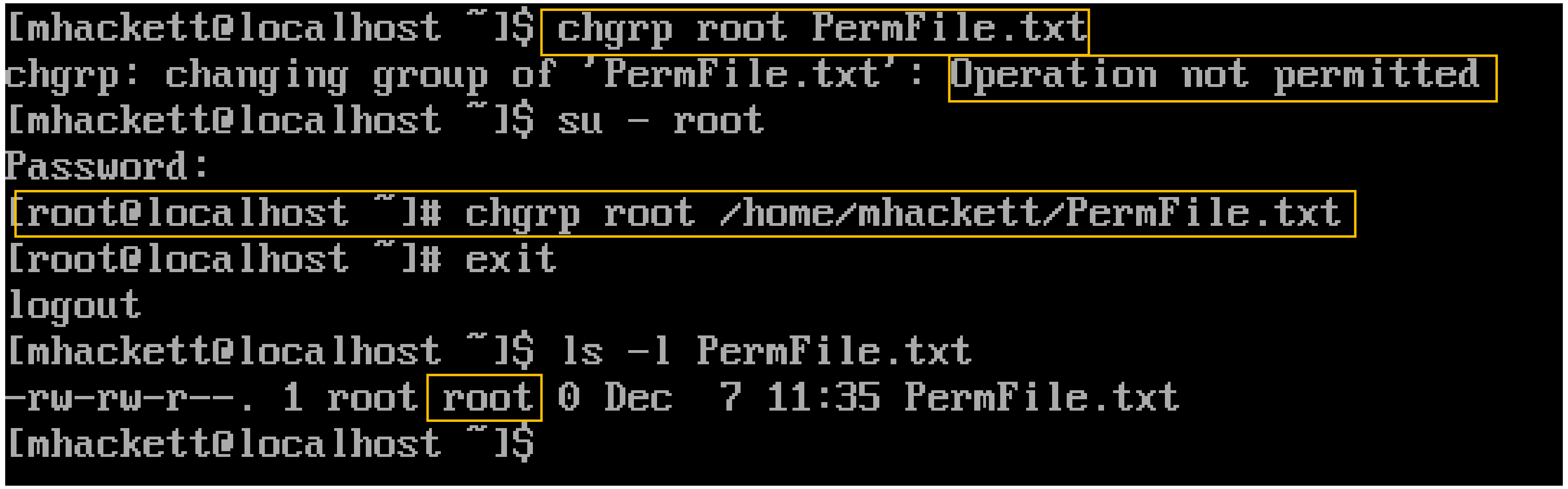
- The command to **ch**ange **gr**ou**p** ownership of a file or directory is the **chgrp** command.

```
chgrp [options] username [files or directories]
```

- Only the root user, current owner*, or a group member* can change the resource's group ownership
  - *Can only change the group to a group that the owner or group member belongs to

Ownership

- Changing group ownership of PermFile.txt from the mhackett to the root group:
    - (mhackett is not a member of the root group)



```
[mhackett@localhost ~]$ chgrp root PermFile.txt
chgrp: changing group of 'PermFile.txt': Operation not permitted
[mhackett@localhost ~]$ su - root
Password:
[root@localhost ~]# chgrp root /home/mhackett/PermFile.txt
[root@localhost ~]# exit
logout
[mhackett@localhost ~]$ ls -l PermFile.txt
-rw-rw-r--. 1 root root 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$
```

Ownership

- To change a directory's group ownership, the syntax is the same:

  chgrp ***newgroup directory***

- To change a directory's group ownership and change the group ownership of everything in it, use the **-R** (recursive) option:

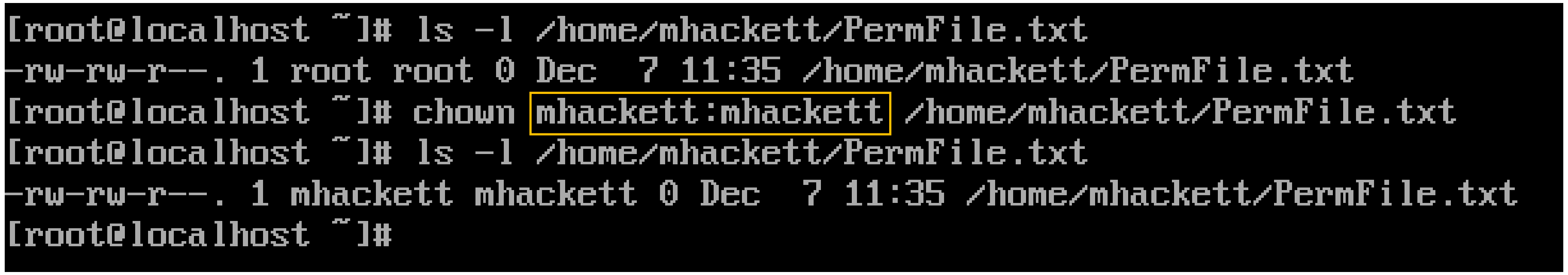
  chgrp -R ***newgroup directory***

Ownership

- The **chgrp** command will only work with existing groups.
- Creating new groups is a topic covered in a later lecture.

Ownership

- The **chown** command can be used to change both owner and group at the same time.
  chown [options] ***username*****:*****group*** **[files or directories]**



```
[root@localhost ~]# ls -l /home/mhackett/PermFile.txt
-rw-rw-r--. 1 root root 0 Dec  7 11:35 /home/mhackett/PermFile.txt
[root@localhost ~]# chown mhackett:mhackett /home/mhackett/PermFile.txt
[root@localhost ~]# ls -l /home/mhackett/PermFile.txt
-rw-rw-r--. 1 mhackett mhackett 0 Dec  7 11:35 /home/mhackett/PermFile.txt
[root@localhost ~]#
```

Managing Permissions

- Every file and directory has a set of permissions called its **mode**
- The mode is broken down into three main groups:
    - User (owner) permissions
    - Group permissions
    - Other (everyone else) permissions

- Each group is given some combination (or none) of the following permissions:
    - Read Permission
    - Write Permission
    - Execute Permission

Managing Permissions

- Read Permission
  - For files: Allows opening and reading the file
  - For directories: Allows listing the contents of the directory (requires execute permission)
- Write Permission
  - For files: Allows opening, reading, and editing the file
  - For directories: Allows adding and removing to/from the directory (requires execute permission)
- Execute Permission
  - For files: Allows executing the file (if it is a program or script)
  - For directories: Allows entering the directory and to work with its contents.

Managing Permissions

- The structure of a file or directory’s mode:
  - - means the permission is not granted

$$\underbrace{\underbrace{\overbrace{\texttt{r}}^{\text{Read}}\overbrace{\texttt{w}}^{\text{Write}}\overbrace{\texttt{x}}^{\text{Execute}}}_{\text{User (Owner)}}\underbrace{\texttt{rw-}}_{\text{Group}}\underbrace{\texttt{r--}}_{\text{Other (Everyone else)}}}_{\textbf{Mode}}$$

Managing Permissions

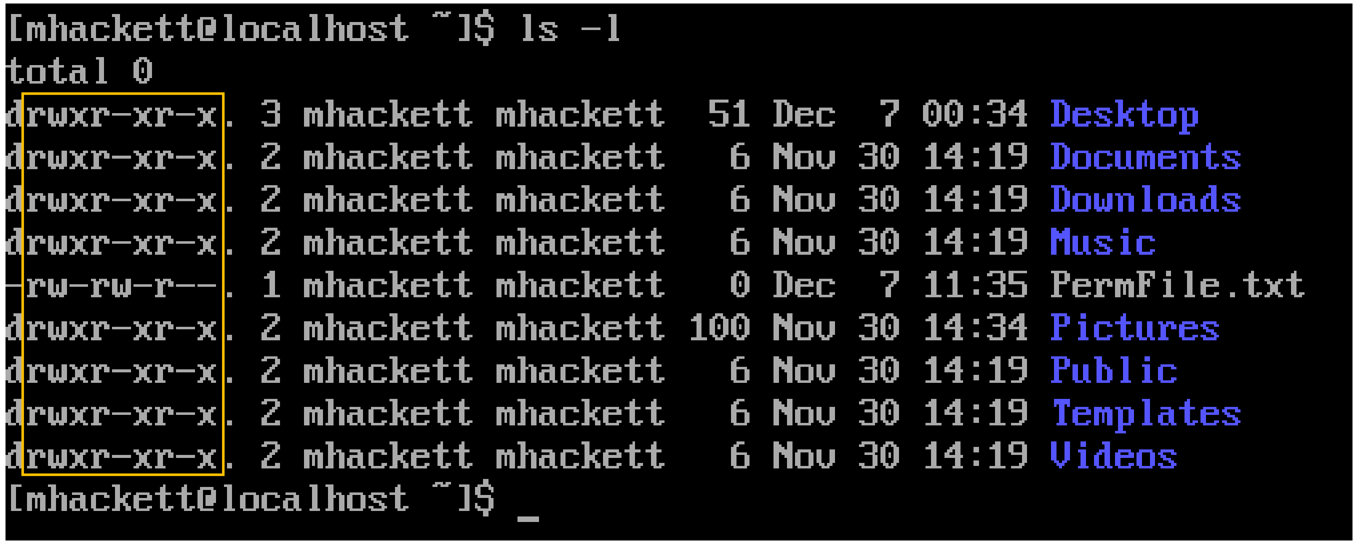
- A file or directory with these permissions would permit the following:

$$\underbrace{\texttt{rwx}}_{\text{User (Owner)}}\underbrace{\texttt{rw-}}_{\text{Group}}\underbrace{\texttt{r--}}_{\text{Other (Everyone else)}}$$

  - User: Read, Write, and Execute Permission
  - Group: Read and Write Permission
  - Other: Read Permission

Managing Permissions

- The modes of files and directories can be viewed with the **`ls -l`** command:



```
[mhackett@localhost ~]$ ls -l
total 0
drwxr-xr-x. 3 mhackett mhackett  51 Dec  7 00:34 Desktop
drwxr-xr-x. 2 mhackett mhackett   6 Nov 30 14:19 Documents
drwxr-xr-x. 2 mhackett mhackett   6 Nov 30 14:19 Downloads
drwxr-xr-x. 2 mhackett mhackett   6 Nov 30 14:19 Music
-rw-rw-r--. 1 mhackett mhackett   0 Dec  7 11:35 PermFile.txt
drwxr-xr-x. 2 mhackett mhackett 100 Nov 30 14:34 Pictures
drwxr-xr-x. 2 mhackett mhackett   6 Nov 30 14:19 Public
drwxr-xr-x. 2 mhackett mhackett   6 Nov 30 14:19 Templates
drwxr-xr-x. 2 mhackett mhackett   6 Nov 30 14:19 Videos
[mhackett@localhost ~]$ _
```

Managing Permissions

- To **ch**ange a file or directory's **mod**e, the chmod command is used.

  ```
  chmod [options] file/directory
  ```

- The options are the criteria for the mode.

Managing Permissions

- Criteria categories:
  - **u** (User)
  - **g** (Group)
  - **o** (Other)
  - **a** (All- User, Group, and Other)
- Criteria operations:
  - **+** (Adds a permission)
  - **-** (Removes a permission)
  - **=** (Sets permissions exactly to)
- Criteria permissions:
  - **r** (Read)
  - **w** (Write)
  - **x** (Execute)

Managing Permissions

- Examples:

```
chmod g+x somefile.txt
```

  - Would add executable permission to the group

```
chmod u+w,o+x somefile.txt
```

  - Would add write permission to the owner and executable permission to others

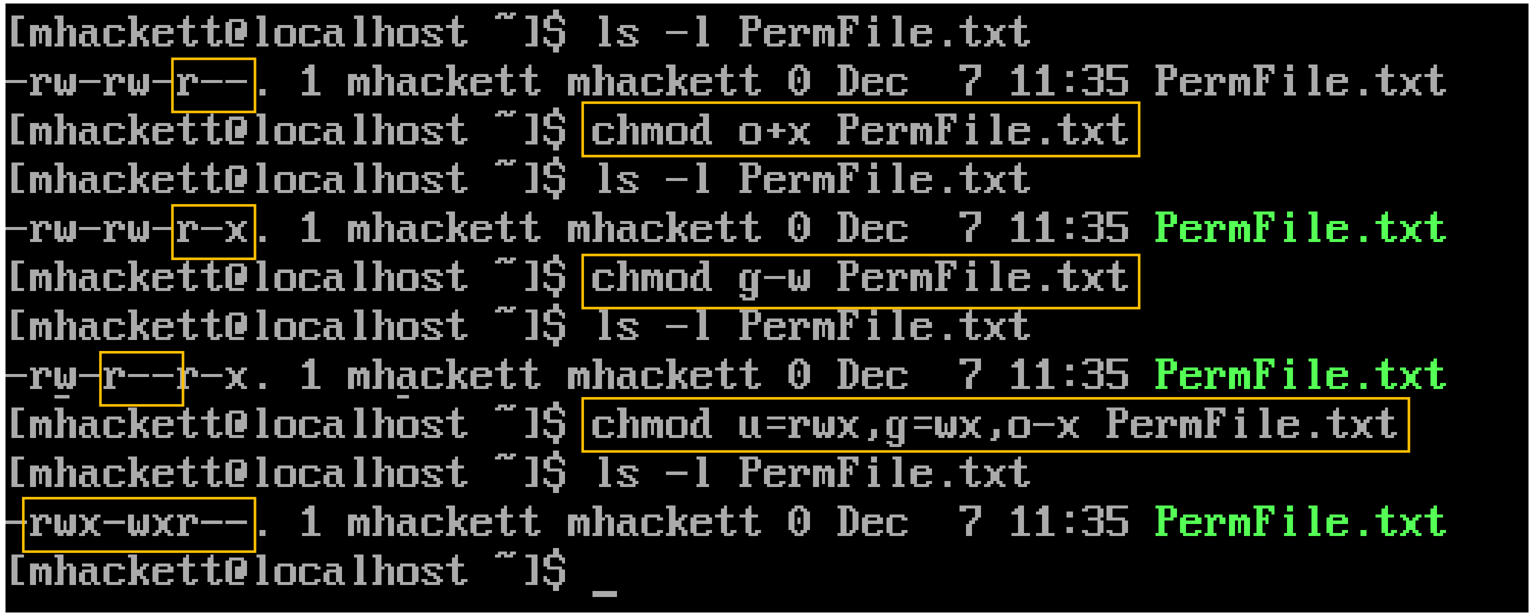
```
chmod o-w somefile.txt
```

  - Would remove write permission from the group

```
chmod u=rwx,g=rw,o-x somefile.txt
```

  - Would set read, write, and execute permission to the owner, read and write permission to the group, and remove execute permissions from others

Managing Permissions



```
[mhackett@localhost ~]$ ls -l PermFile.txt
-rw-rw-r--. 1 mhackett mhackett 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$ chmod o+x PermFile.txt
[mhackett@localhost ~]$ ls -l PermFile.txt
-rw-rw-r-x. 1 mhackett mhackett 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$ chmod g-w PermFile.txt
[mhackett@localhost ~]$ ls -l PermFile.txt
-rw-r--r-x. 1 mhackett mhackett 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$ chmod u=rwx,g=wx,o-x PermFile.txt
[mhackett@localhost ~]$ ls -l PermFile.txt
-rwx-wxr--. 1 mhackett mhackett 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$ _
```

Managing Permissions

- File permissions can also be set using numeric (octal) values.
  - Read = 4
  - Write = 2
  - Execute = 1

$$\underbrace{\underbrace{\overbrace{\texttt{r}}^{4}\overbrace{\texttt{w}}^{2}\overbrace{\texttt{x}}^{1}}_{4+2+1=\mathbf{7}}\underbrace{\texttt{rw-}}_{4+2+0=\mathbf{6}}\underbrace{\texttt{r--}}_{4+0+0=\mathbf{4}}}_{\textbf{Mode = 764}}$$

Managing Permissions

- Eight possible combinations:

rwx	4+2+1 = **7**
rw-	4+2+0 = **6**
r-x	4+0+1 = **5**
r--	4+0+0 = **4**
-wx	0+2+1 = **3**
-w-	0+2+0 = **2**
--x	0+0+1 = **1**
---	0+0+0 = **0**

Managing Permissions

- Examples:

```
chmod 777 somefile.txt
```

  - Would result in a mode of rwxrwxrwx

```
chmod 742 somefile.txt
```

  - Would result in a mode of rwxr---w-

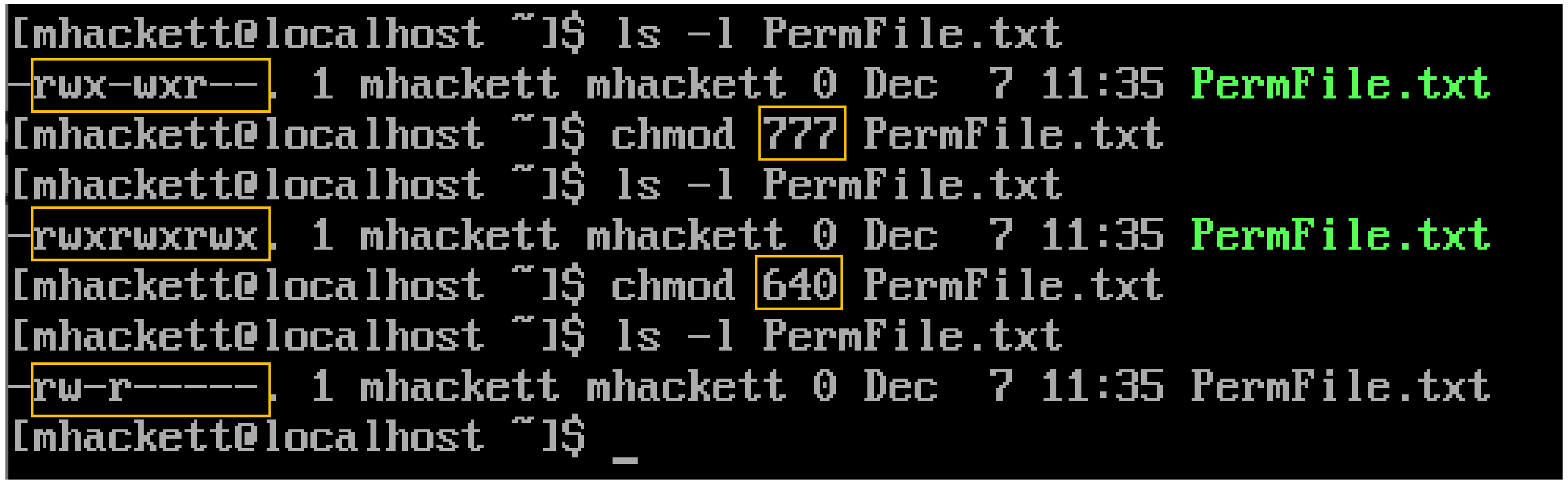
```
chmod 000 somefile.txt
```

  - Would result in a mode of ---------

```
chmod 640 somefile.txt
```

  - Would result in a mode of rw-r-----

Managing Permissions



```
[mhackett@localhost ~]$ ls -l PermFile.txt
-rwx-wxr--. 1 mhackett mhackett 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$ chmod 777 PermFile.txt
[mhackett@localhost ~]$ ls -l PermFile.txt
-rwxrwxrwx. 1 mhackett mhackett 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$ chmod 640 PermFile.txt
[mhackett@localhost ~]$ ls -l PermFile.txt
-rw-r-----. 1 mhackett mhackett 0 Dec  7 11:35 PermFile.txt
[mhackett@localhost ~]$ _
```

Default Permissions

- By default, files are created with the following permissions:

  rw-rw-rw-

- By default, directories are created with the following permissions:

  rwxrwxrwx

- A special variable on the system called the **u**ser **mask** (**`umask`**) immediately takes away permissions from newly created files and directories.

Default Permissions

- A common umask is 022
  - This specifies nothing is taken away from the owner, write permission is removed from the group, and write permission is removed from everyone else

Default Permissions

- New Files (umask is 022):

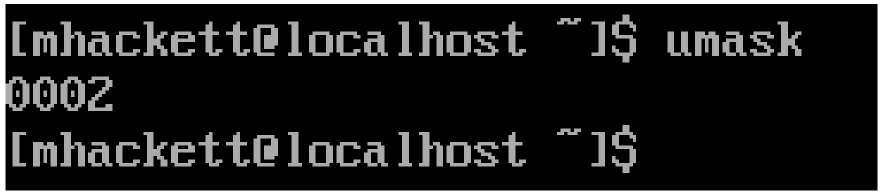
rw-rw-rw-	6 6 6
	-0 -2 -2
rw-r--r--	**6 4 4**

- New Directories (umask is 002):

rwxrwxrwx	7 7 7
	-0 -2 -2
rwxr-xr-x	**7 5 5**

Default Permissions

- To view the system's current user mask, enter the **umask** command.

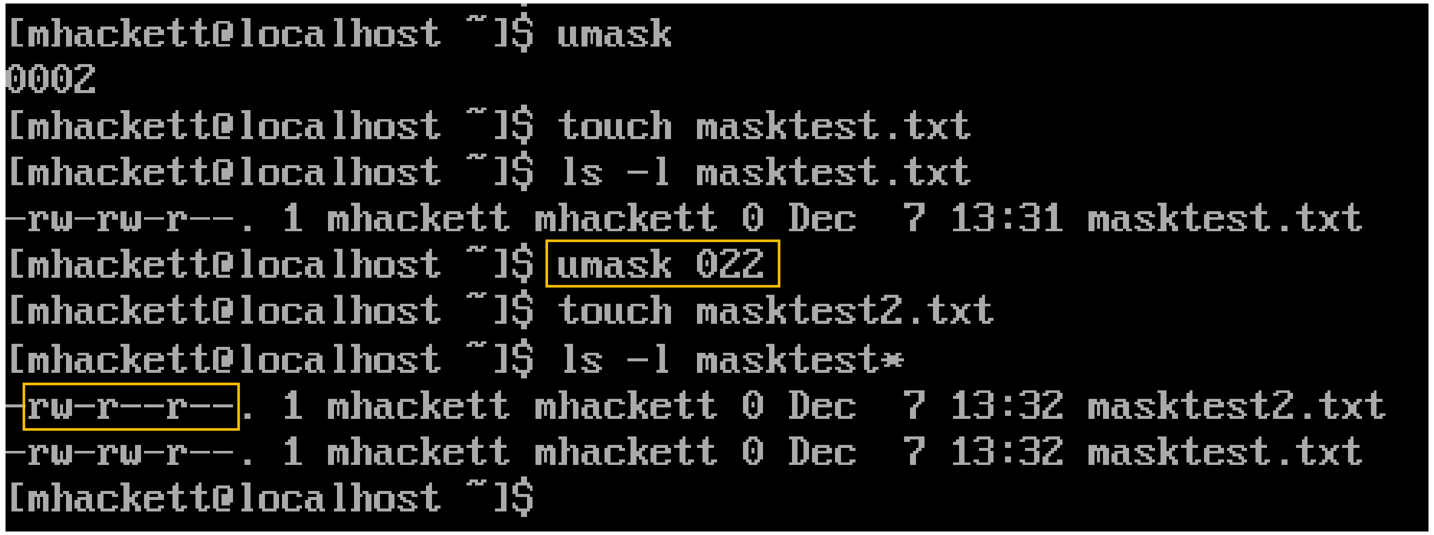


```
[mhackett@localhost ~]$ umask
0002
[mhackett@localhost ~]$
```

- On this system, write permission for other users is the only thing removed from new files and directories.
- The last slides showed only three numbers for the user mask
  - The first digit is used for a special type of permission discussed shortly.

Default Permissions

- Changing the user mask:



```
[mhackett@localhost ~]$ umask
0002
[mhackett@localhost ~]$ touch masktest.txt
[mhackett@localhost ~]$ ls -l masktest.txt
-rw-rw-r--. 1 mhackett mhackett 0 Dec  7 13:31 masktest.txt
[mhackett@localhost ~]$ umask 022
[mhackett@localhost ~]$ touch masktest2.txt
[mhackett@localhost ~]$ ls -l masktest*
-rw-r--r--. 1 mhackett mhackett 0 Dec  7 13:32 masktest2.txt
-rw-rw-r--. 1 mhackett mhackett 0 Dec  7 13:32 masktest.txt
[mhackett@localhost ~]$
```

Special Permissions

- Read, write, and execute are the regular permissions for files.

- There are three more special permissions:
  - SUID (Set User ID)
  - SGID (Set Group ID)
  - Sticky bit

Special Permissions

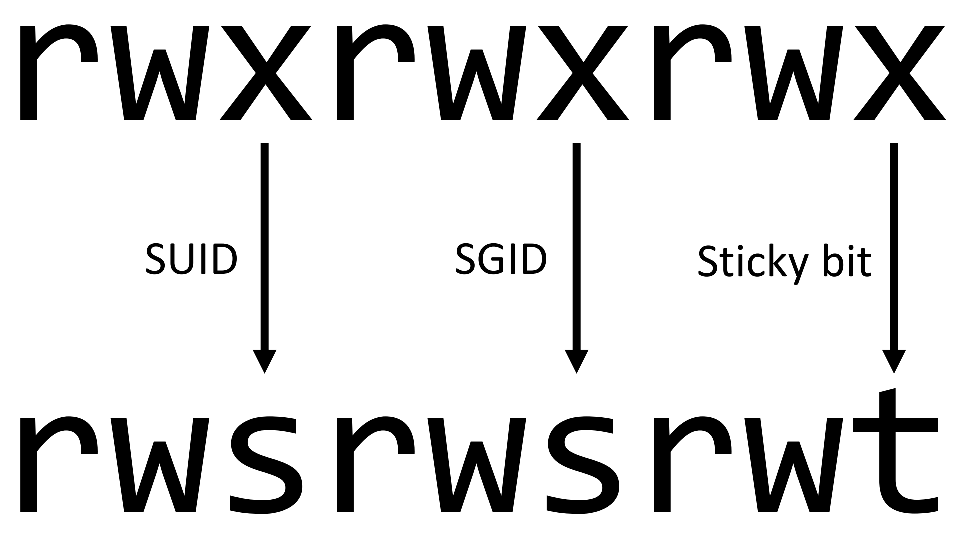
- When SUID is set for a file, the user temporarily becomes the file’s owner when the file is executed.
  - No effect on directories
- When SGID is set for a file, the user temporarily becomes a member of the file’s group ownership when the file is executed.
  - For directories, new files created will have the user as the owner, but will have the *directory’s* group ownership

Special Permissions

- When used on a directory, the sticky bit allows users to write to directory but only delete files they own.
- The sticky bit, in the past, was used to lock files in memory.
  - Today, the sticky bit is only used for directories.

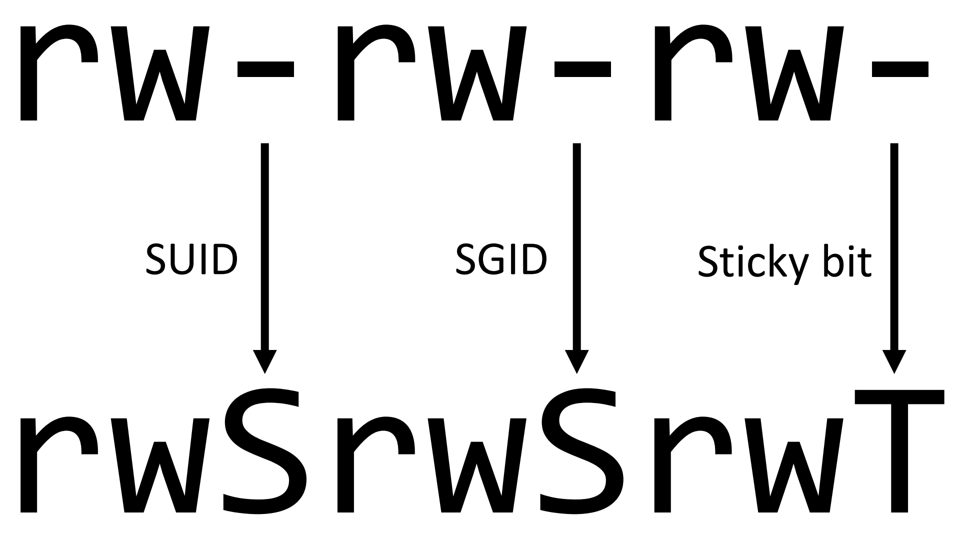
Special Permissions

- Special permissions are seen in file or directory’s mode:



Special Permissions

- If execute permission is not enabled, they appear as capital letters:



```
rw-rw-rw-
```

```
rwSrwSrwT
```

Special Permissions

- Special permissions are set using numeric (octal) values.
  - SUID = 4
  - SGID = 2
  - Sticky bit = 1

Special Permissions

- Eight possible combinations:

(SUID SGID Stickybit)

sst	4+2+1 = **7**
ss-	4+2+0 = **6**
s-t	4+0+1 = **5**
s--	4+0+0 = **4**
-st	0+2+1 = **3**
-s-	0+2+0 = **2**
--t	0+0+1 = **1**
---	0+0+0 = **0**

Special Permissions

- Set by providing a fourth number to the **`chmod`** command.
    - The special permissions is the first number

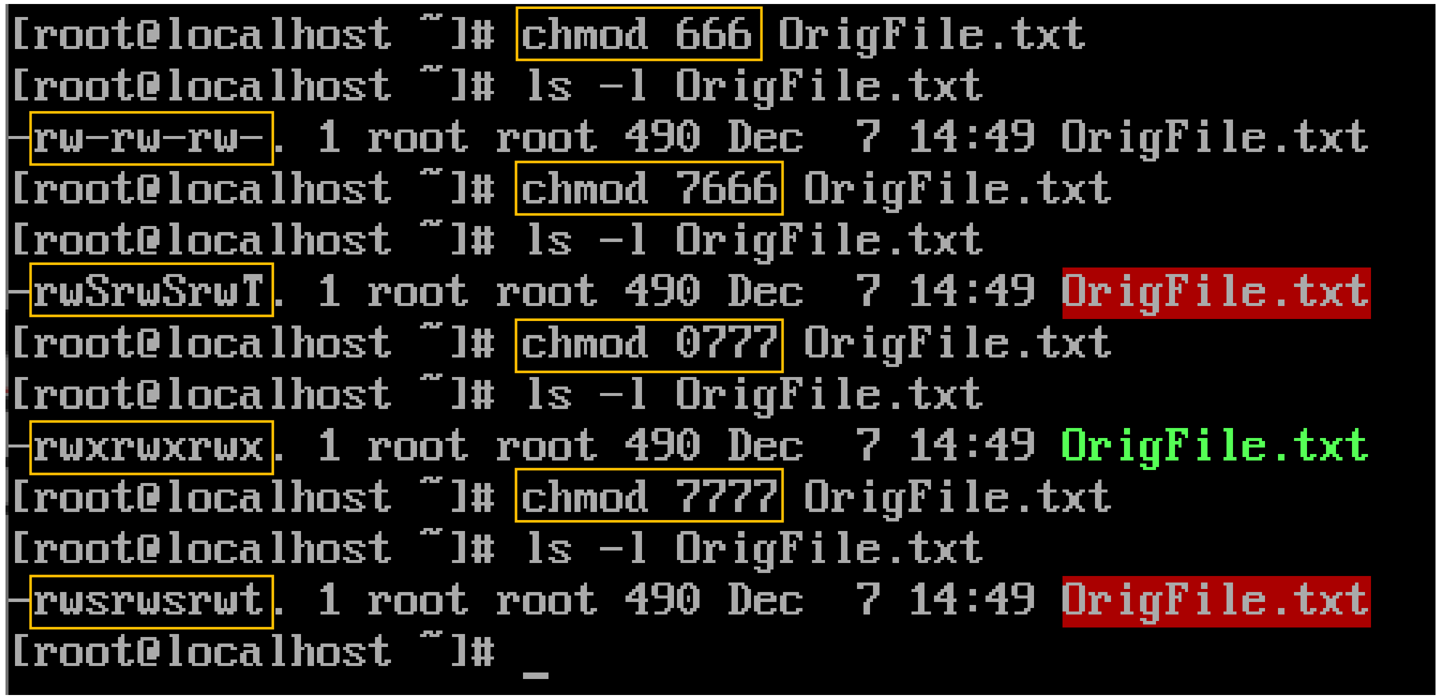
```
chmod 641 somedirectory
```

- Results in rw-r----x

```
chmod 5641 somedirectory
```

- 5 = SUID and Sticky bit are enabled
- Results in rwSr----t
    - S because owner execute permission is disabled
    - t because all execute permission is enabled

Special Permissions



```
[root@localhost ~]# chmod 666 OrigFile.txt
[root@localhost ~]# ls -l OrigFile.txt
-rw-rw-rw-. 1 root root 490 Dec  7 14:49 OrigFile.txt
[root@localhost ~]# chmod 7666 OrigFile.txt
[root@localhost ~]# ls -l OrigFile.txt
-rwSrwSrwT. 1 root root 490 Dec  7 14:49 OrigFile.txt
[root@localhost ~]# chmod 0777 OrigFile.txt
[root@localhost ~]# ls -l OrigFile.txt
-rwxrwxrwx. 1 root root 490 Dec  7 14:49 OrigFile.txt
[root@localhost ~]# chmod 7777 OrigFile.txt
[root@localhost ~]# ls -l OrigFile.txt
-rwsrwsrwt. 1 root root 490 Dec  7 14:49 OrigFile.txt
[root@localhost ~]# _
```

Access Control Lists

- An **Access Control List** (**ACL**) is a list of additional users or groups that you can assign permissions to for a file or directory.

- ACLs allow you to specify permissions to a file or directory for one user or group (in addition to the owner and owning group) instead of an entire group or everyone else.

Access Control Lists

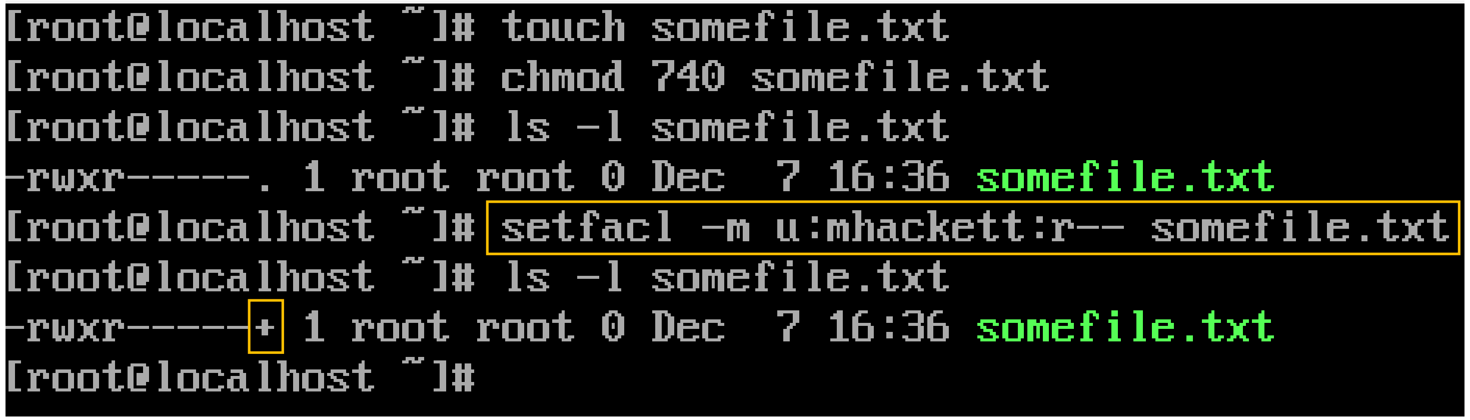
- To update or **set** a **f**ile's **a**ccess **c**ontrol **l**ist, the **`setfacl`** command is used.
  - Used for files and directories

```
setfacl [options] [criteria] file/directory
```

- The **`-m`** option is used to modify a file or directory's ACL
- The syntax for user criteria is **`u:name:permissions`**
- The syntax for group criteria is **`g:name:permissions`**

Access Control Lists

- The command **`setfacl -m u:mhackett:r-- somefile.txt`** would give the user mhackett read permission (but not write and execute) to somefile.txt
  - Note the **+** symbol that indicates the presence of additional permissions

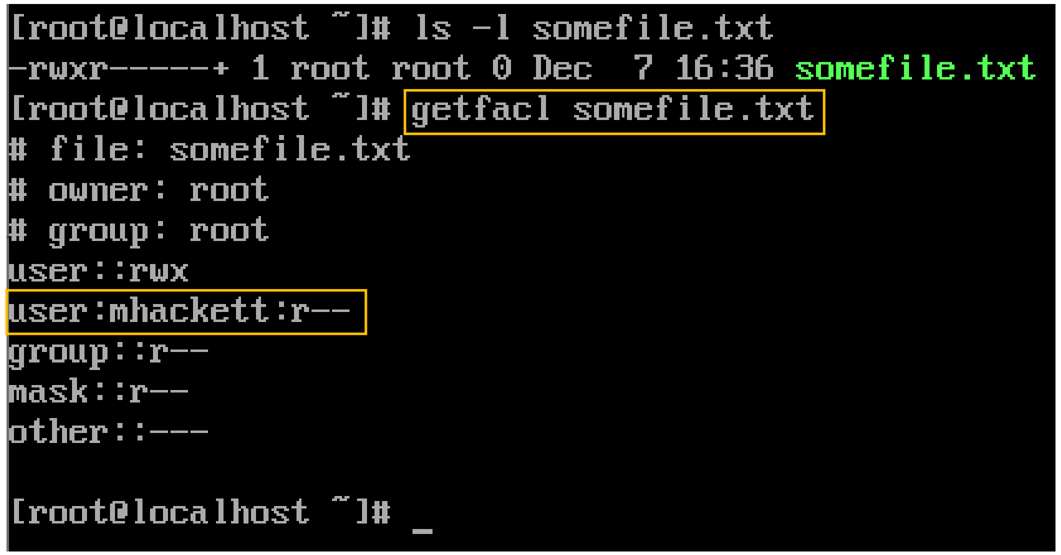


```
[root@localhost ~]# touch somefile.txt
[root@localhost ~]# chmod 740 somefile.txt
[root@localhost ~]# ls -l somefile.txt
-rwxr-----. 1 root root 0 Dec  7 16:36 somefile.txt
[root@localhost ~]# setfacl -m u:mhackett:r-- somefile.txt
[root@localhost ~]# ls -l somefile.txt
-rwxr-----+ 1 root root 0 Dec  7 16:36 somefile.txt
[root@localhost ~]#
```

Access Control Lists

- To view or **get** a **f**ile's **a**ccess **c**ontrol **l**ist, the **`getfacl`** command is used.
  - Used for files and directories

`getfacl file/directory`

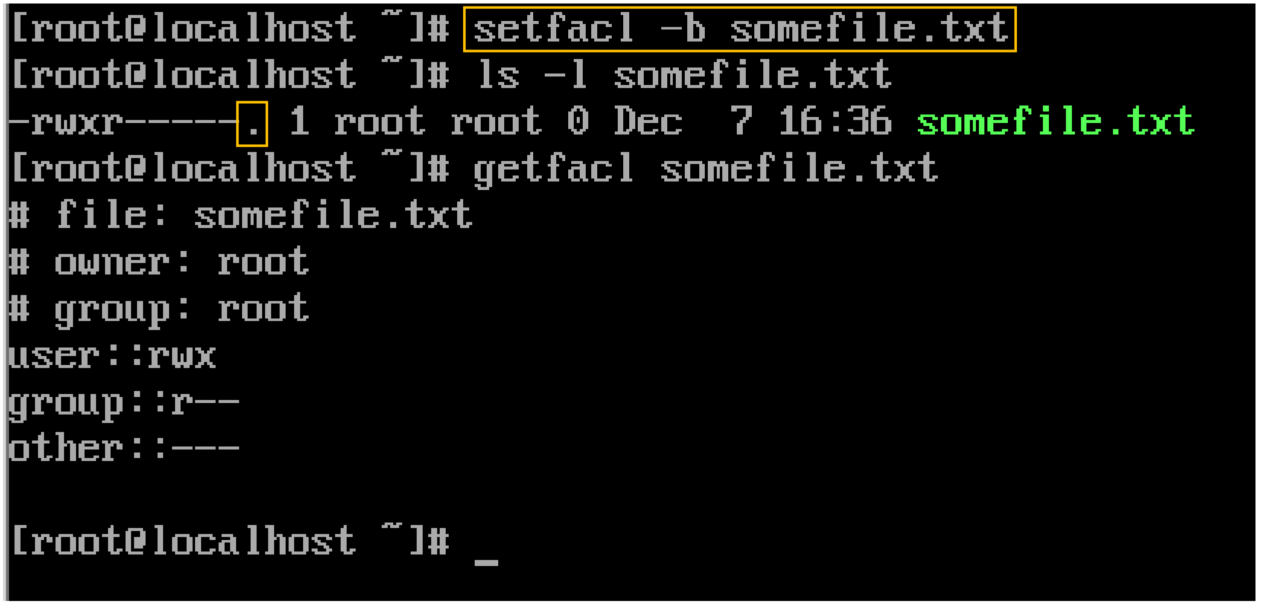


```
[root@localhost ~]# ls -l somefile.txt
-rwxr-----+ 1 root root 0 Dec  7 16:36 somefile.txt
[root@localhost ~]# getfacl somefile.txt
# file: somefile.txt
# owner: root
# group: root
user::rwx
user:mhackett:r--
group::r--
mask::r--
other::---

[root@localhost ~]# _
```

Access Control Lists

- To remove all additional permissions in the ACL, use the **`-b`** option with the **`setfacl`** command.



```
[root@localhost ~]# setfacl -b somefile.txt
[root@localhost ~]# ls -l somefile.txt
-rwxr-----. 1 root root 0 Dec  7 16:36 somefile.txt
[root@localhost ~]# getfacl somefile.txt
# file: somefile.txt
# owner: root
# group: root
user::rwx
group::r--
other::---

[root@localhost ~]# _
```

Filesystem Attributes

- Files and directories can have attributes that work outside of the standard permissions.

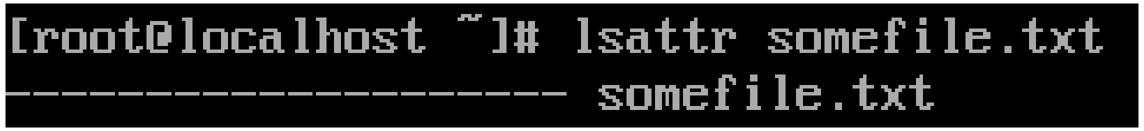
- The attributes are filesystem dependent.
  - Types of filesystems were briefly discussed in a previous lecture.
  - The next lecture goes more in depth on types of filesystems.

Filesystem Attributes

- To **lis**t a file or directory's **attr**ibutes, the **`lsattr`** command is used.

  `lsattr file/directory`

- The example below shows this file has no attributes set.



```
[root@localhost ~]# lsattr somefile.txt
---------------------- somefile.txt
```

Filesystem Attributes

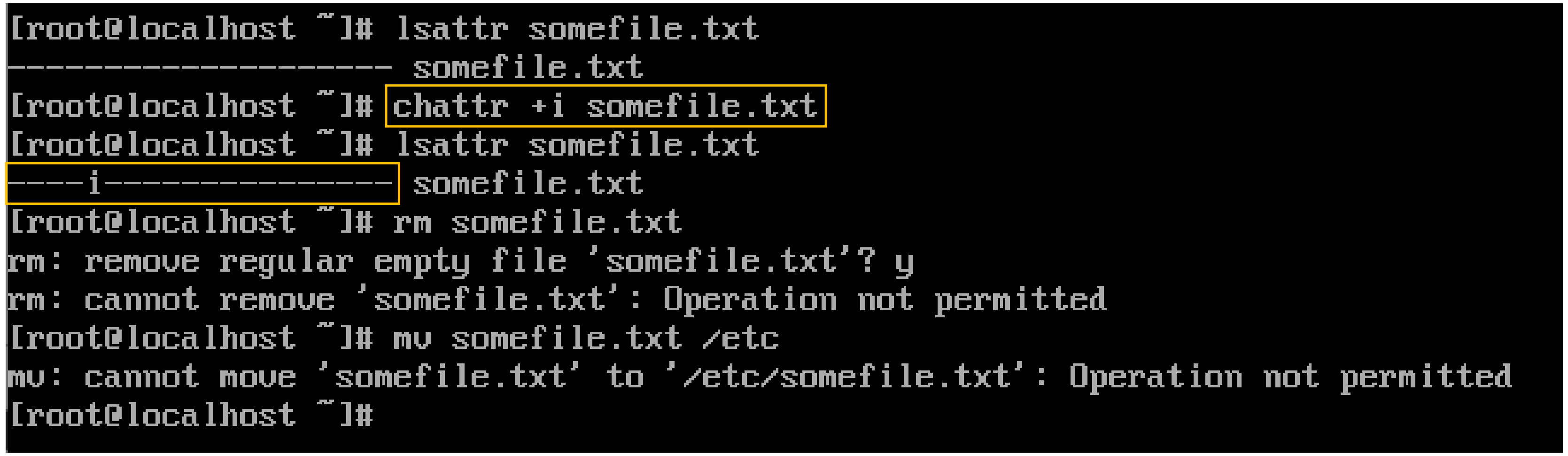
- To **ch**ange a file or directory's **attr**ibutes, the **`chattr`** command is used.

```
chattr [criteria] file/directory
```

- We won't cover every attribute, just the **immutable** attribute.
  - This prevents a file or directory from being changed or deleted by anyone.
  - Use **`man  chattr`** for details about additional attributes in the chattr user manual.

Filesystem Attributes

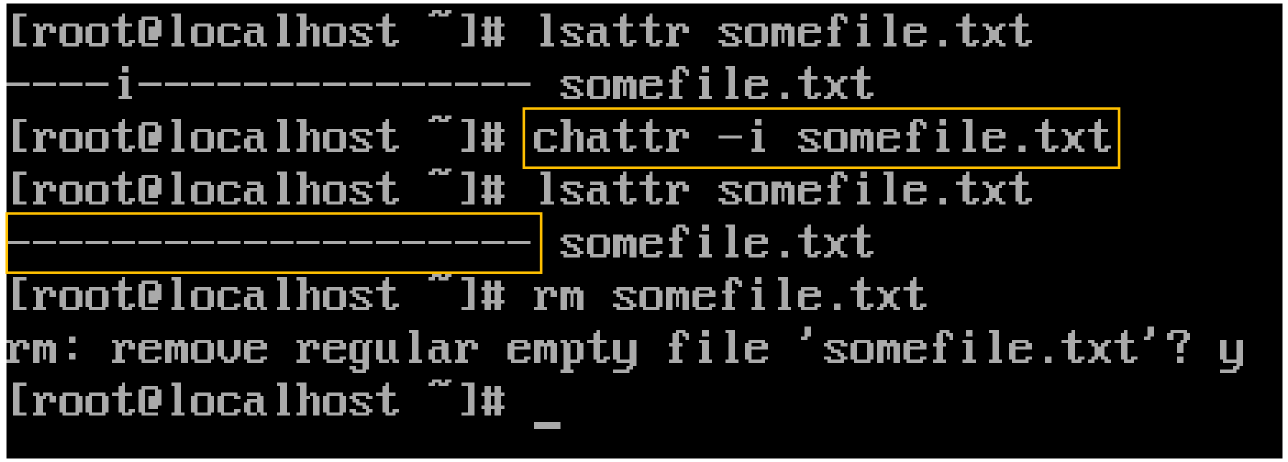
- The command **`chattr +i somefile.txt`** would add the immutable attribute to somefile.txt.
  - Not able to be modified, moved, or deleted



```
[root@localhost ~]# lsattr somefile.txt
-------------------- somefile.txt
[root@localhost ~]# chattr +i somefile.txt
[root@localhost ~]# lsattr somefile.txt
----i--------------- somefile.txt
[root@localhost ~]# rm somefile.txt
rm: remove regular empty file 'somefile.txt'? y
rm: cannot remove 'somefile.txt': Operation not permitted
[root@localhost ~]# mv somefile.txt /etc
mv: cannot move 'somefile.txt' to '/etc/somefile.txt': Operation not permitted
[root@localhost ~]#
```

Filesystem Attributes

- The command **`chattr -i somefile.txt`** would remove the immutable attribute to somefile.txt.
  - Able to be modified, moved, or deleted again



```
[root@localhost ~]# lsattr somefile.txt
----i---------------- somefile.txt
[root@localhost ~]# chattr -i somefile.txt
[root@localhost ~]# lsattr somefile.txt
--------------------- somefile.txt
[root@localhost ~]# rm somefile.txt
rm: remove regular empty file 'somefile.txt'? y
[root@localhost ~]# _
```