



Chapter 11

Linux

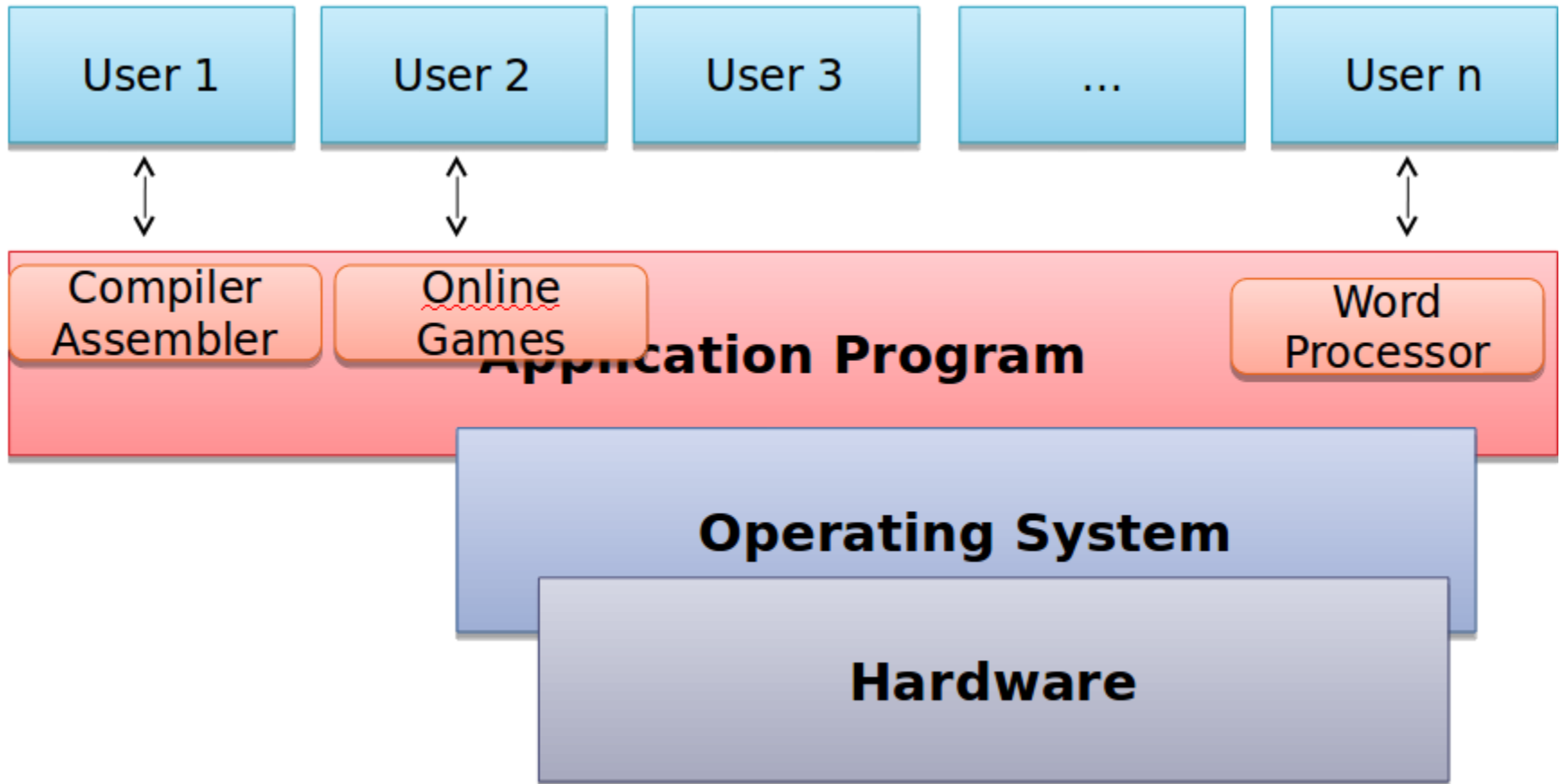
Open Source SW Development
CSE22300



Operating System

- An operating system is the software that **provides the interface between the hardware of a computer system and the applications** programs that are used on it.

Operating System



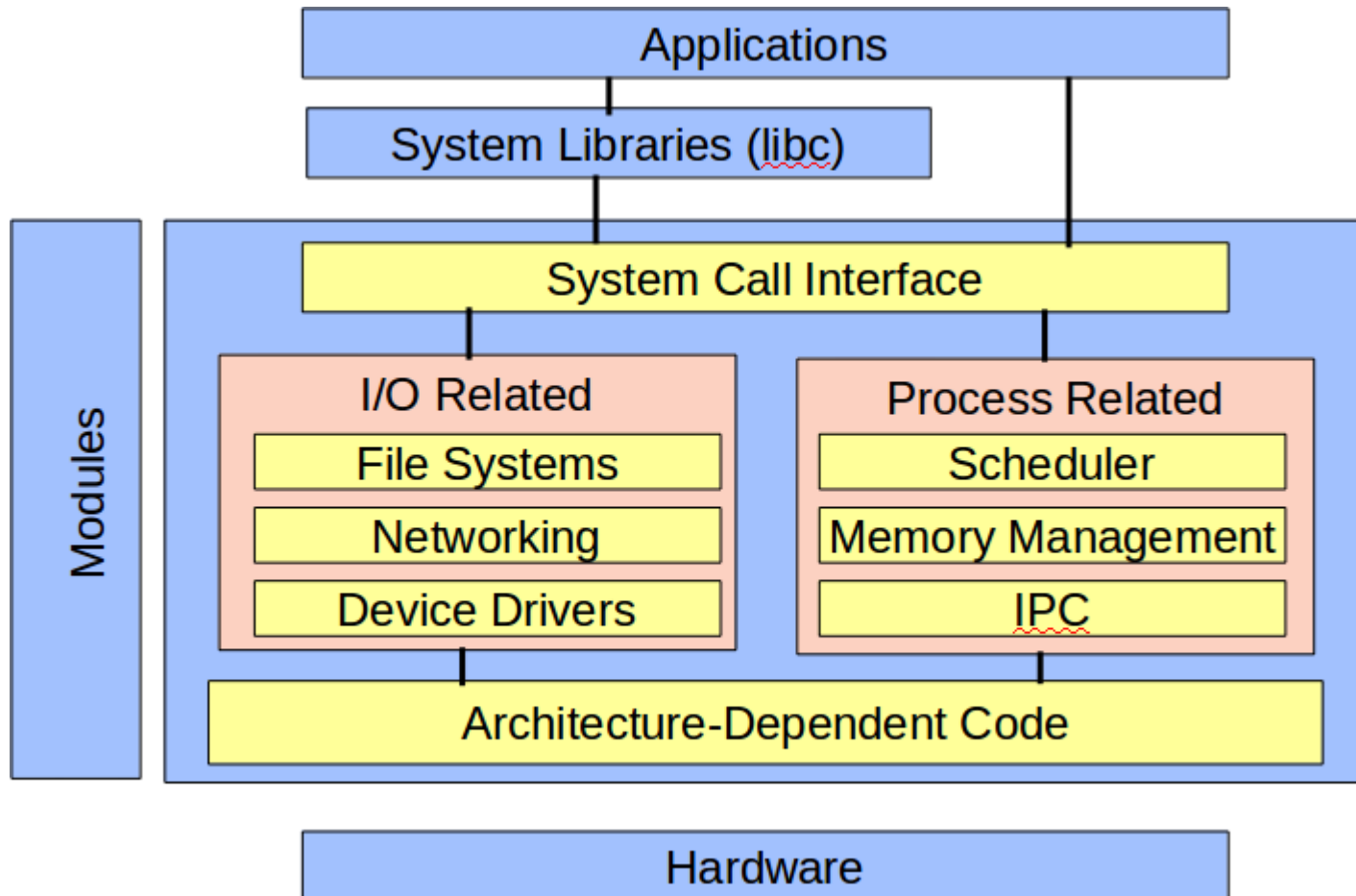
Kernel

- **System monitor**
- **Controls and mediates access to hardware**
- **Implements and supports fundamental abstractions**
 - Processes, files, devices etc
- **Schedules / allocates system resources**
 - Memory, CPU, disk, descriptors, etc
- **Enforces security and protection**
- **Responds to user requests for service**
 - system calls

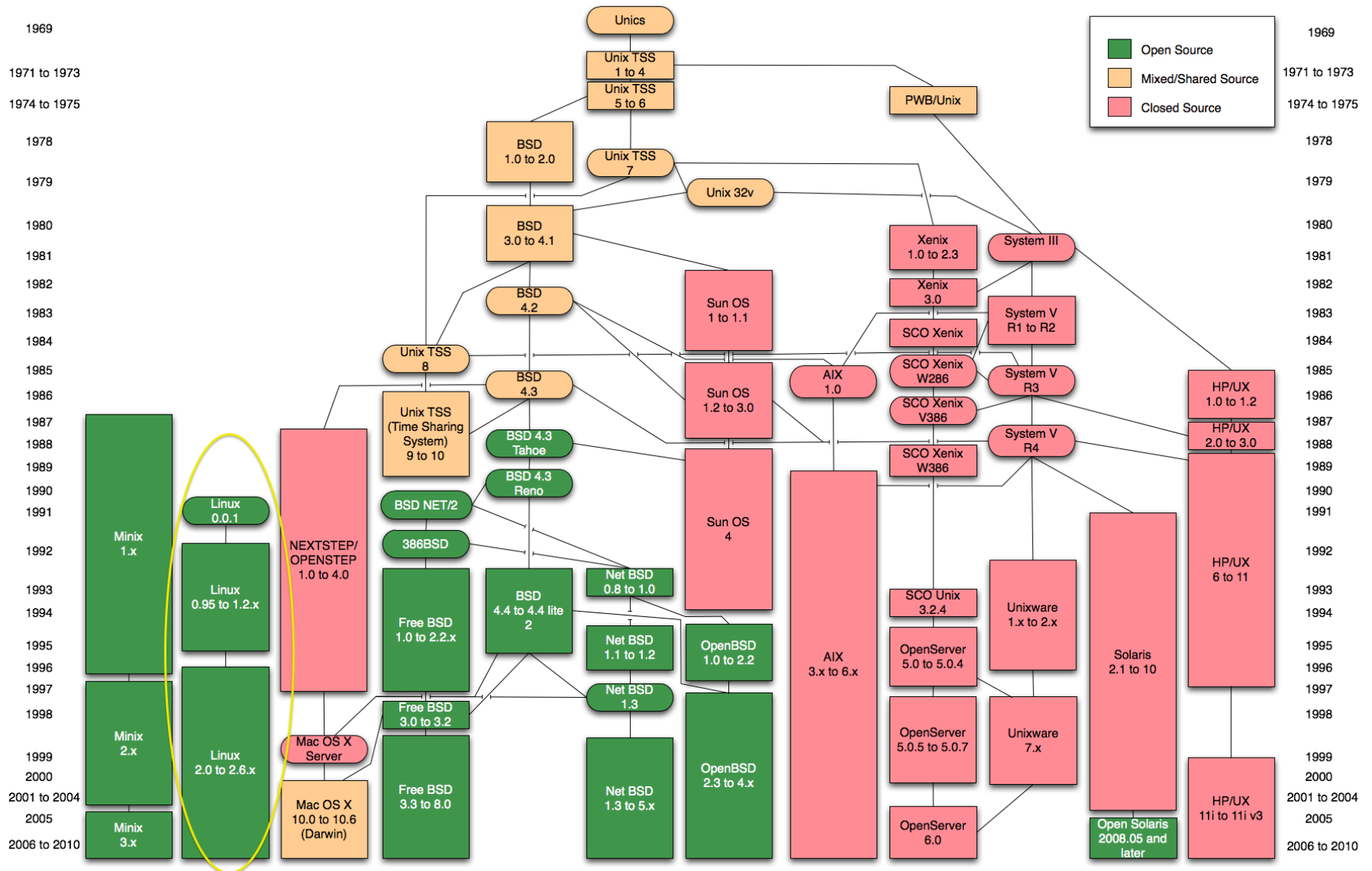
Kernel Design Goal

- **Performance: efficiency, speed.**
 - Utilize resources to capacity with low overhead.
- **Stability: robustness, resilience.**
 - Uptime, graceful degradation.
- **Capability: features, flexibility, compatibility.**
- **Security, protection.**
 - Protect users from each other & system from bad users.
- **Portability.**
- **Extensibility.**

Kernel



UNIX/Linux History



UNIX and Linux

- **Are they the same?**
 - Yes, at least in terms of operating system interfaces
 - Linux was developed independently from Unix
 - Unix is much older (1969 vs. 1991)
- **Scalability and reliability**
 - Both scale very well and work well under heavy load
- **Flexibility**
 - Both emphasize small, interchangeable components
- **Manageability**
 - Remote logins rather than GUI
 - Scripting is integral
- **Security**
 - Due to modular design has a reasonable security model
 - Linux and its applications are not without blame

Why Linux?

- **It's free!**
- **Open Source (modifiability, extensibility, ...)**
- **Works on several platforms**
- **Robustness (after several revisions, and several people working on it)**
- **Widespread Usage**
- **Compatibility with several other platforms.**

Linux Features

- **Monolithic kernel (but well-defined interfaces)**
- **Multi-tasking**
- **Multi-user capability**
- **Multi-processing Support**
- **Architecture Independence (PCs, Alpha, Sparc,...)**
- **Demand loaded executables (on fork, shared address space, and copy-on-write)**
- **4K Pages, demand-paging with memory protection**
- **Dynamic size for disk cache**
- **Shared Libraries (dll)**
- **Support for Posix standard**
- **Several Executables formats**
- **Several File Systems**
- **Several network protocols**

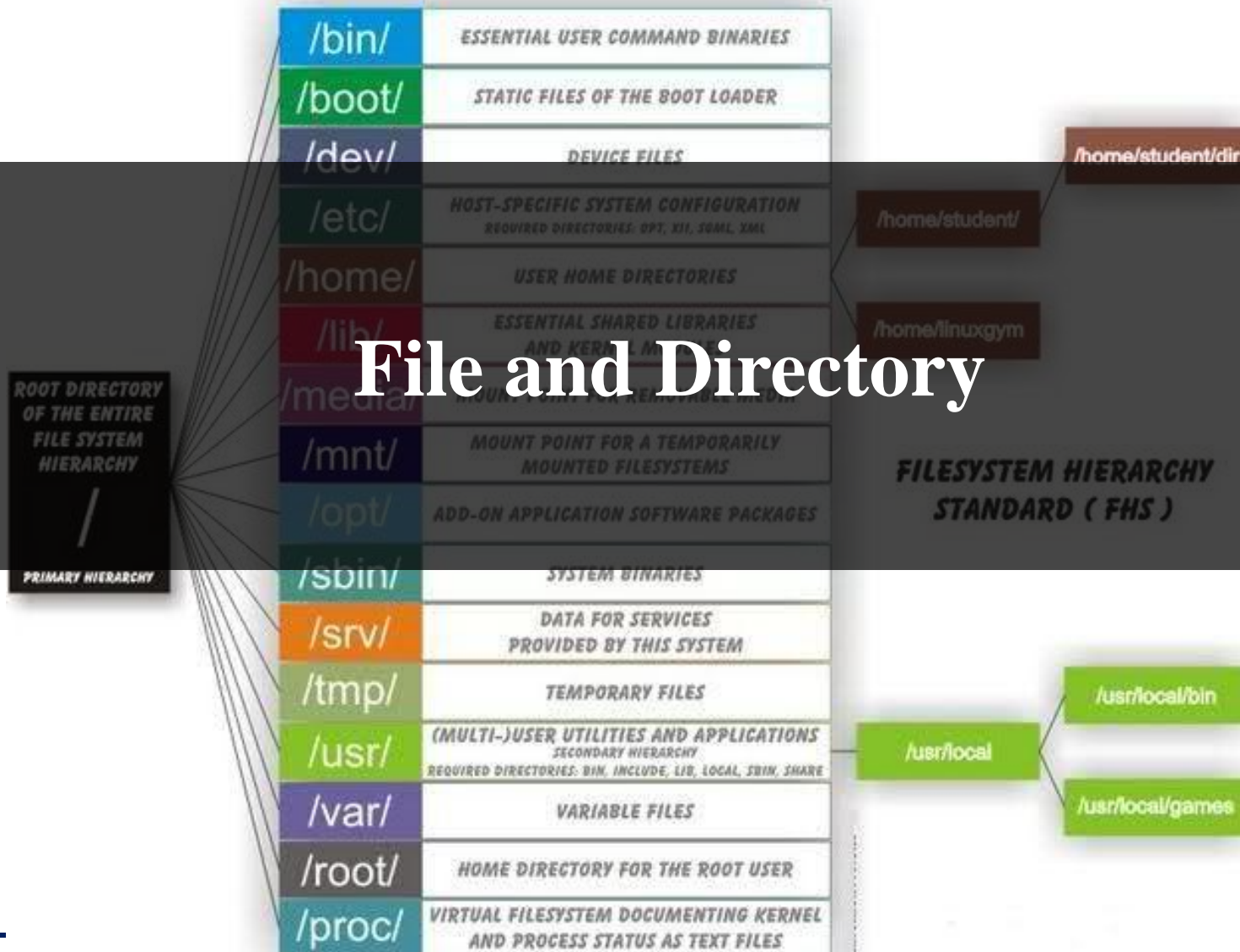
Linux Distribution



Linux Distribution

- **Red Hat**
 - One of the earliest players in the game, Red Hat now position itself strongly in the business market. It has created a community-supported distribution, Fedora Core, which is the choice of many for desktop use.
- **Debian**
 - The most popular community-created distribution. Debian is an excellent choice for server environments. Debian has also been used as the base for many specialist distributions.
- **Ubuntu**
 - Desktop usability, out of the box. Taglined "Linux for human beings," Based on Debian.
- **SUSE**
 - Novell's answer to Red Hat, comes in "enterprise" and a community-based OpenSUSE
- **All Distributions have their respective strengths.**

File and Directory



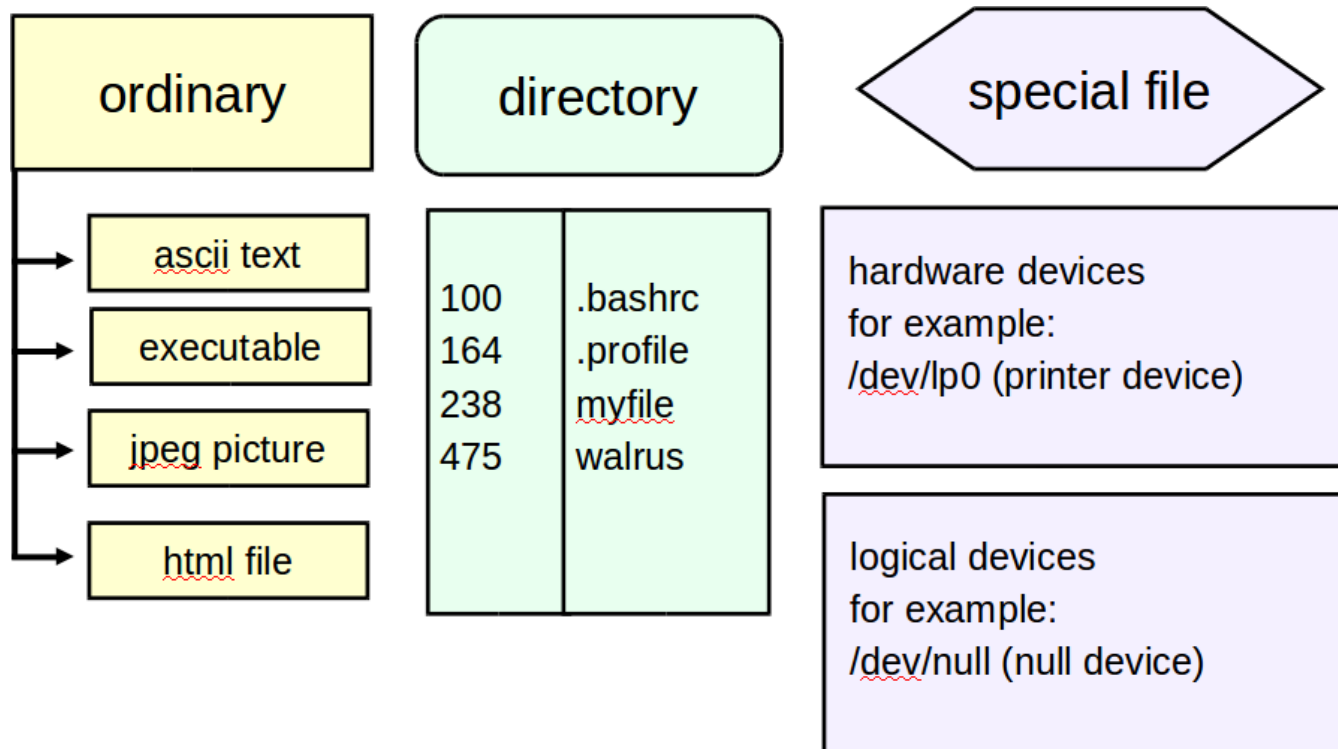
Filesystem

- **Filesystem**
 - How are data stored in storage?
 - How do users access the data?
 - Data organization, files and directories
- **Filesystem types**
 - Disk FS: ext3, ext4, FAT, FAT32 & NTFS
 - Network FS: Samba & NFS
 - Flash FS: JFFS2
 - Special FS: proc FS

File

- **File**

- A collection of data
- A stream of characters or a “byte stream”



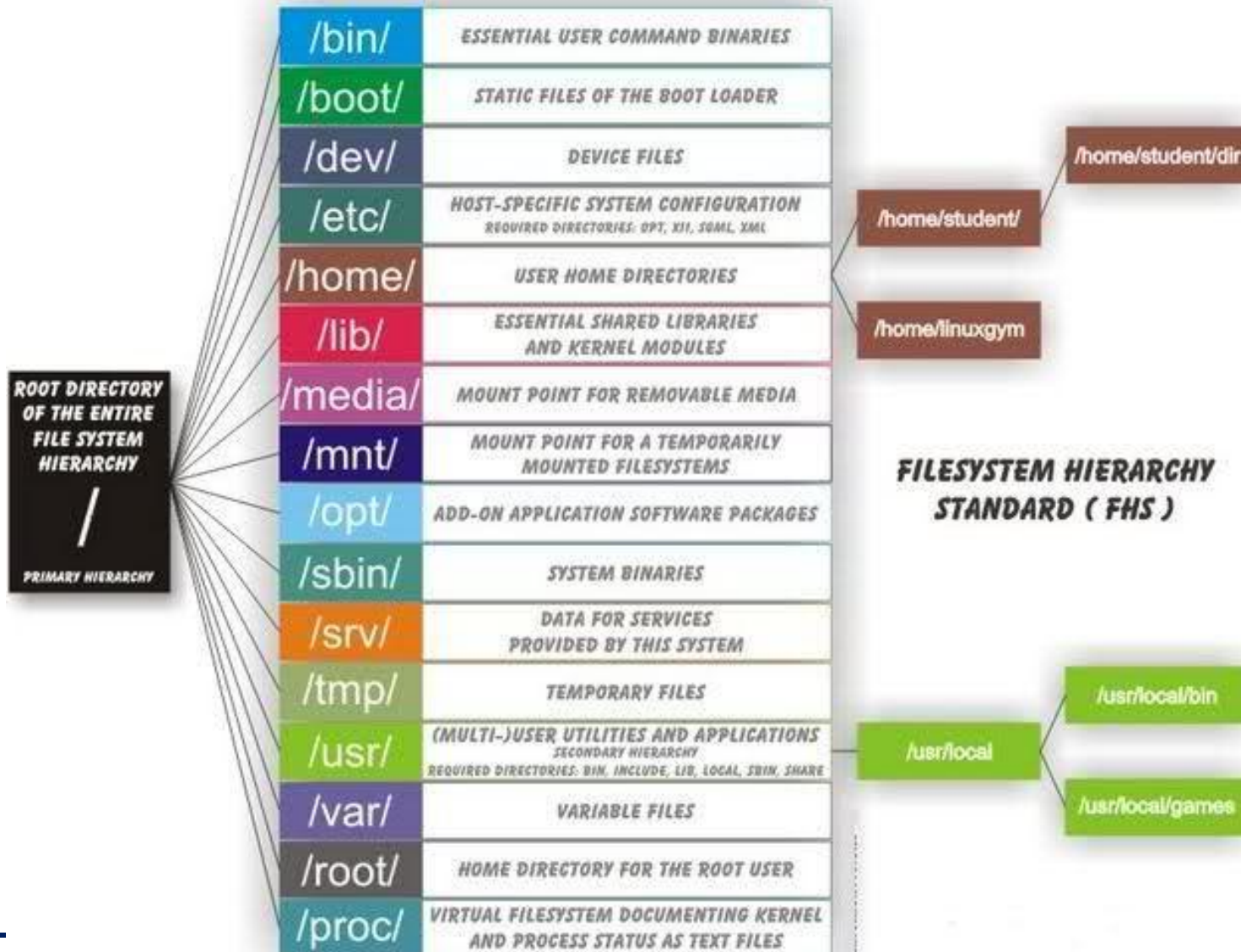
Filenames

- **Should be descriptive of the content**
- **Should use only alphanumeric characters:**
 - UPPERCASE, lowercase, number, @, _
- **Should not contain shell metacharacters**
 - * ? > < / ; & ! | \ ` ' " [] () { }
- **Should not begin with + or - sign**
- **Case sensitive**
- **Hidden if the first character is a . (period)**
- **Can have a maximum of 255 characters**

Directory Structure

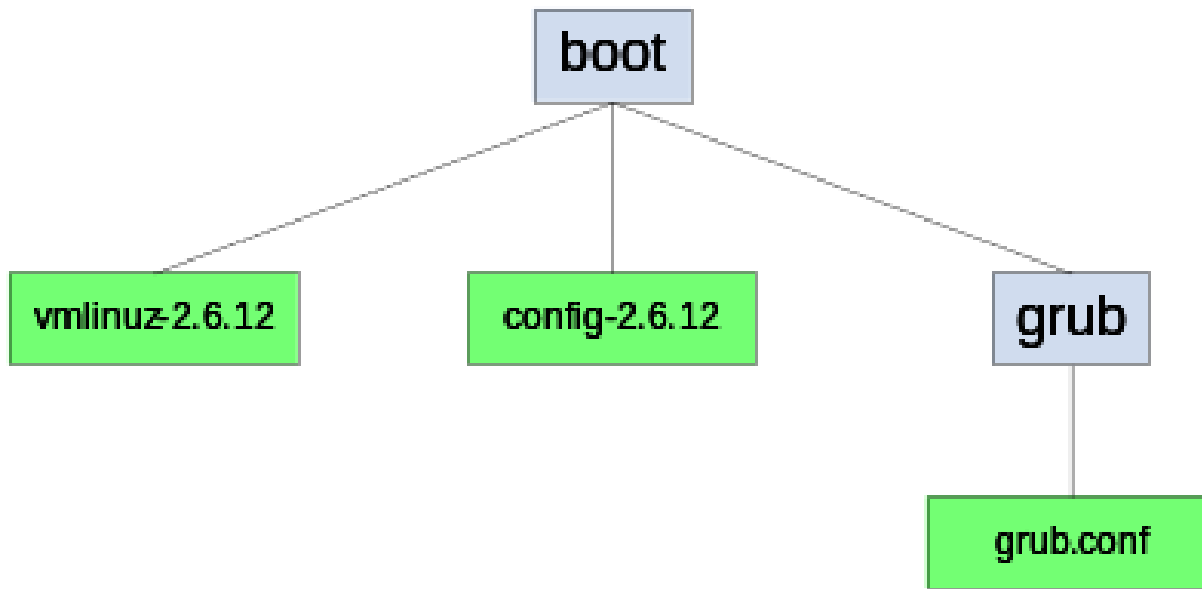
- **All Linux directories are contained in one, virtual, unified filesystem.**
- **Physical devices are mounted on mount points:**
 - Floppy disks
 - Hard disk partitions
 - CD-ROM drives
- **No drive letters like A:, C:, ...**

Linux Directory



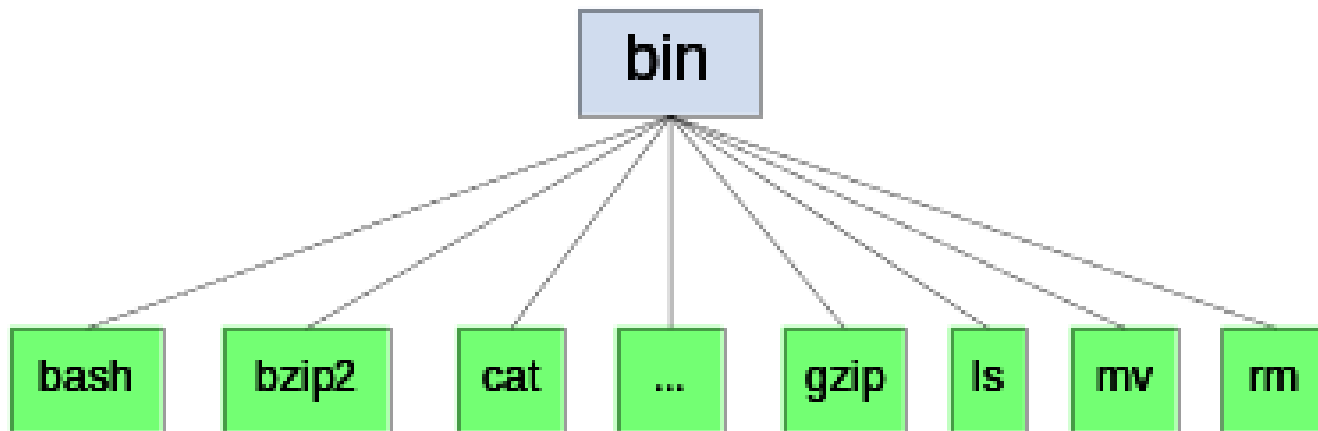
Directory : Boot

- **Linux kernel**
- **Boot loader configuration**
- **If you lost boot**
 - You cannot boot your OS



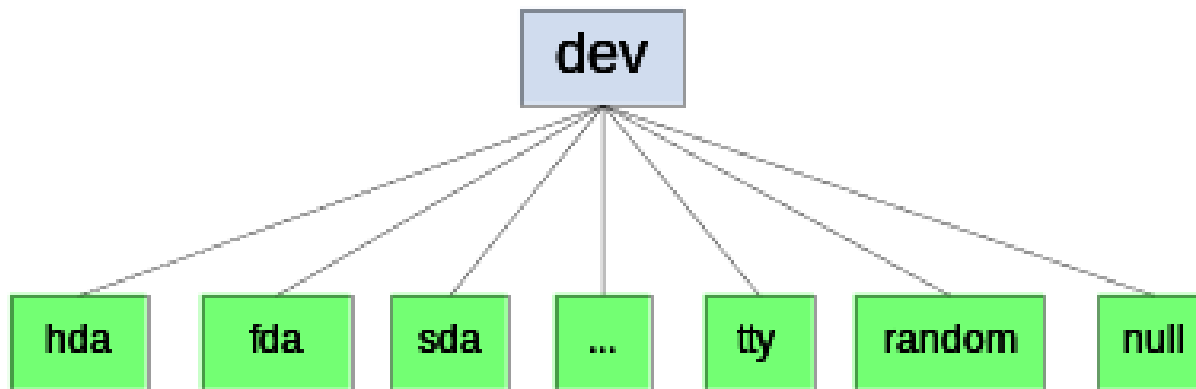
Directory : Bin

- **Essential programs**
- **Need for system startup**
- **Basic commands for**
 - Navigating in filesystem
 - File management



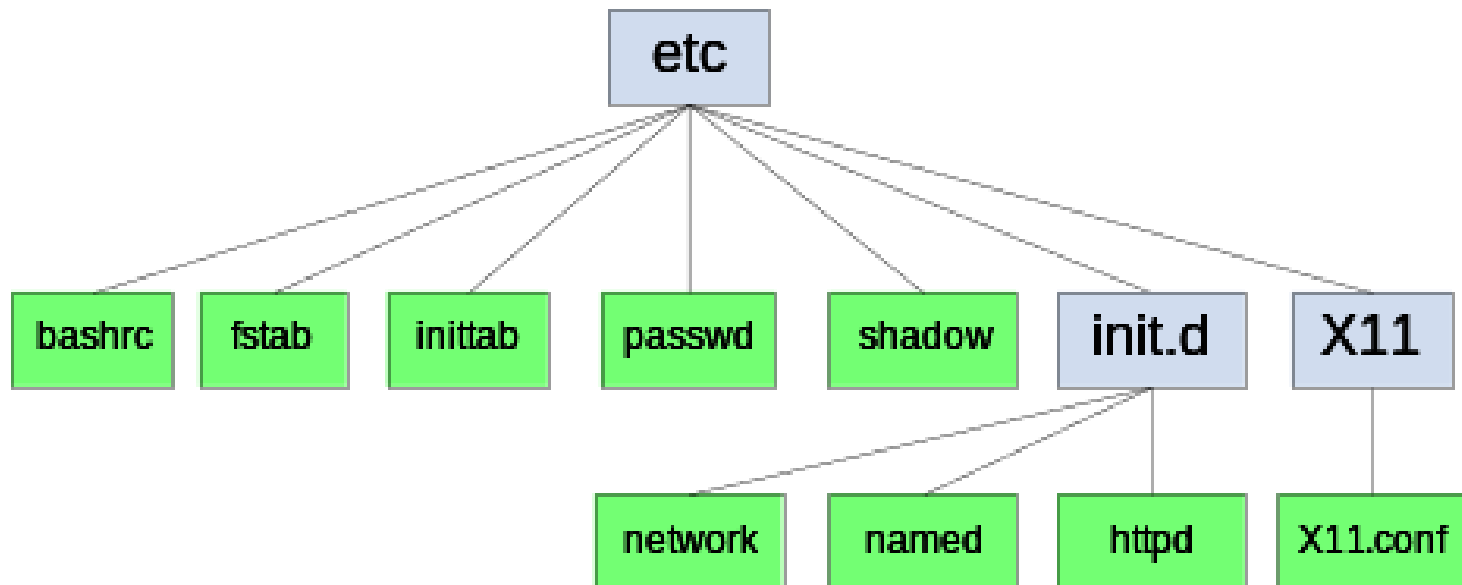
Directory : dev

- **Everything is file**
 - Hardware components (devices) are file
 - Hard disk
 - Key board
- **All device files are here**
- **Direct interaction with device driver**
 - Open the device file
 - Read & Write



Directory : etc

- **System configuration directory**
 - Similar with the registry in Windows
- **All configuration file are text files**
 - You can view and edit it manually

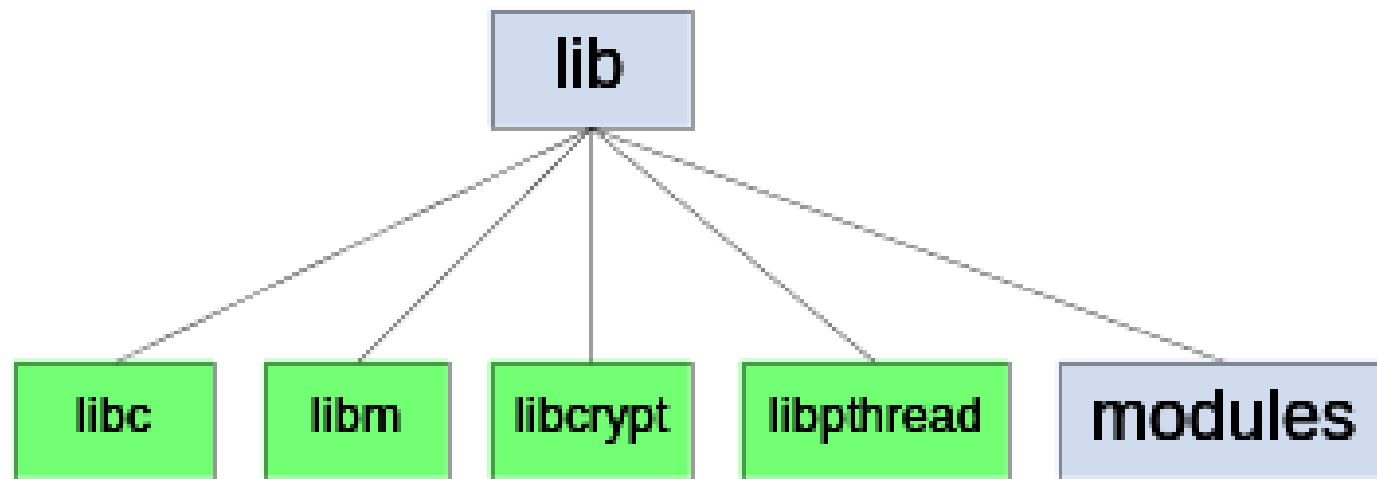


Directory : home

- **Home directory of user**
- **Each user has a directory**
 - **/home/user01**
 - **/home/user02**
- **All files of user are stored here**

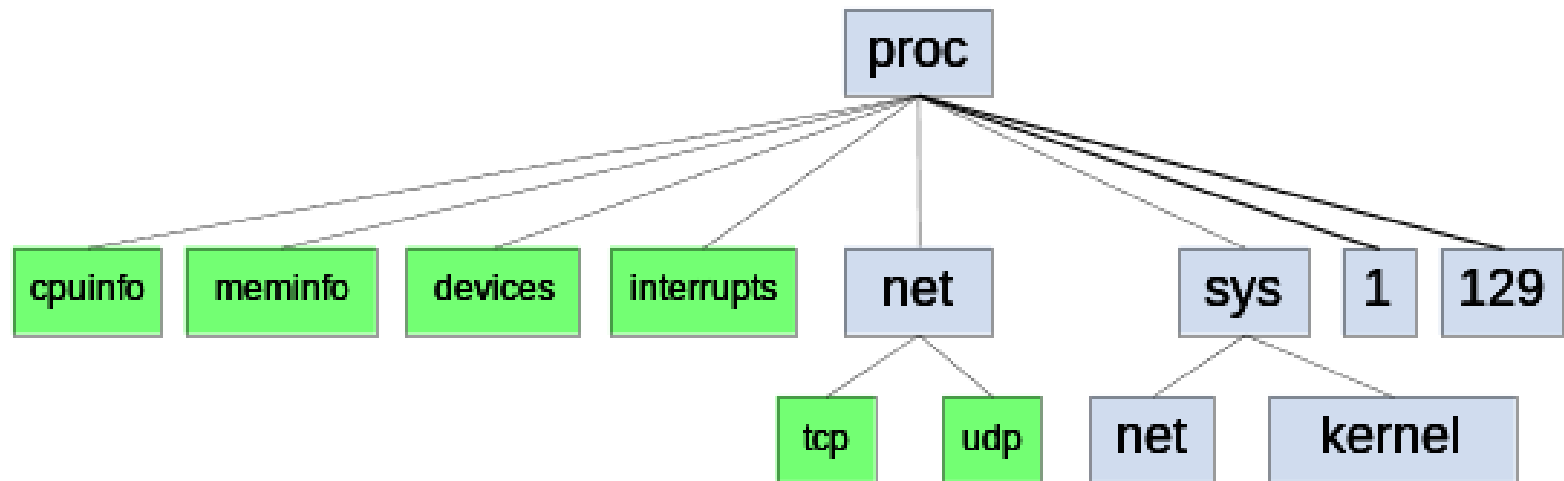
Directory : lib

- **Programs need libraries**
 - Dynamically linked libraries
- **Programmers need libraries**
- **All essential libraries are here**
 - Needed for system startup



Directory : proc

- **Kernel's interface**
 - Kernel pseudo-directory
- **Special directory**
 - It is **NOT** a directory on hard disk
- **Kernel Configuration**
- **Kernel State monitoring**

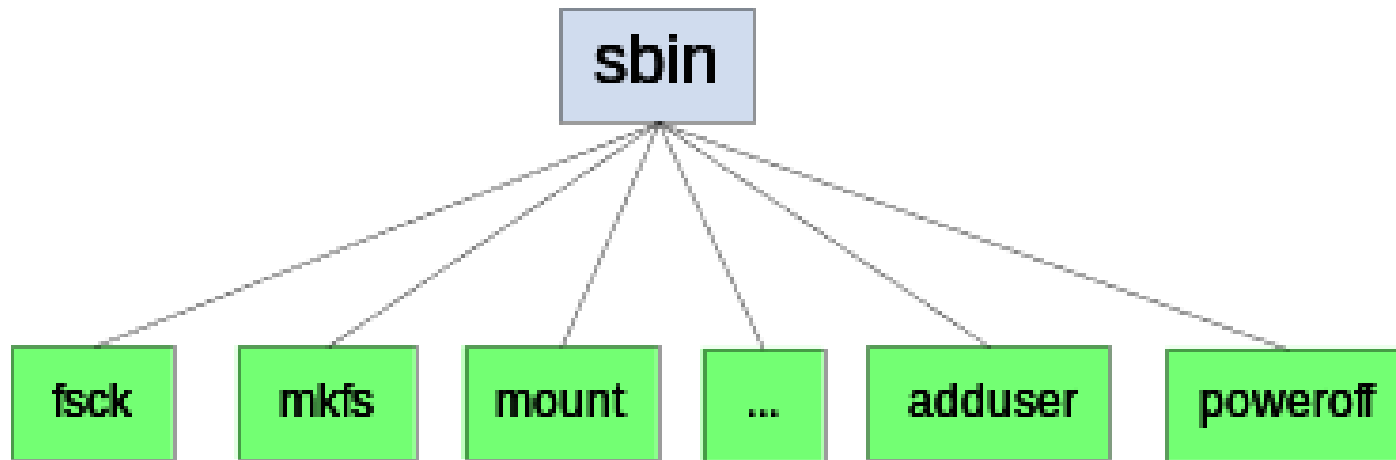


Directory : root

- **Home directory of root**
- **Don't confuse**
 - / is the “root of Filesystem”
 - root is the name of system admin
 - /root is home directory of root

Directory : sbin

- **System configuration programs**
 - Format hard disk
 - Manage hardware
- **Only “root” can run the programs**

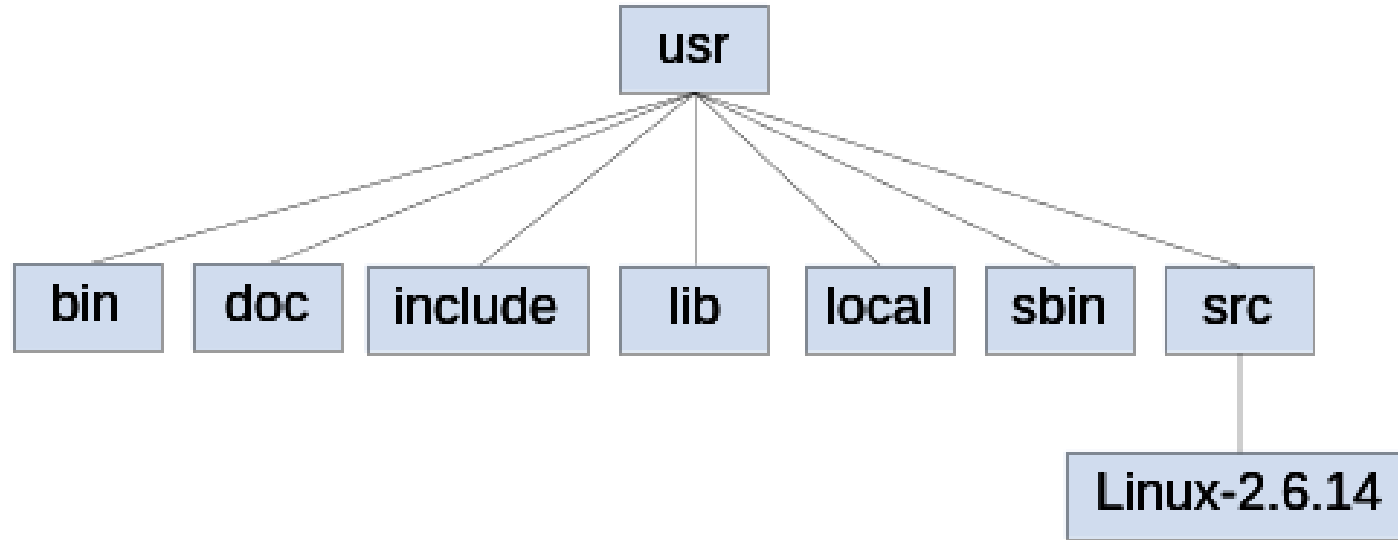


Directory : tmp

- **Temporary directory**
- **All temp files are created by programs**
- **Your temp files**
- **It is emptied regularly**

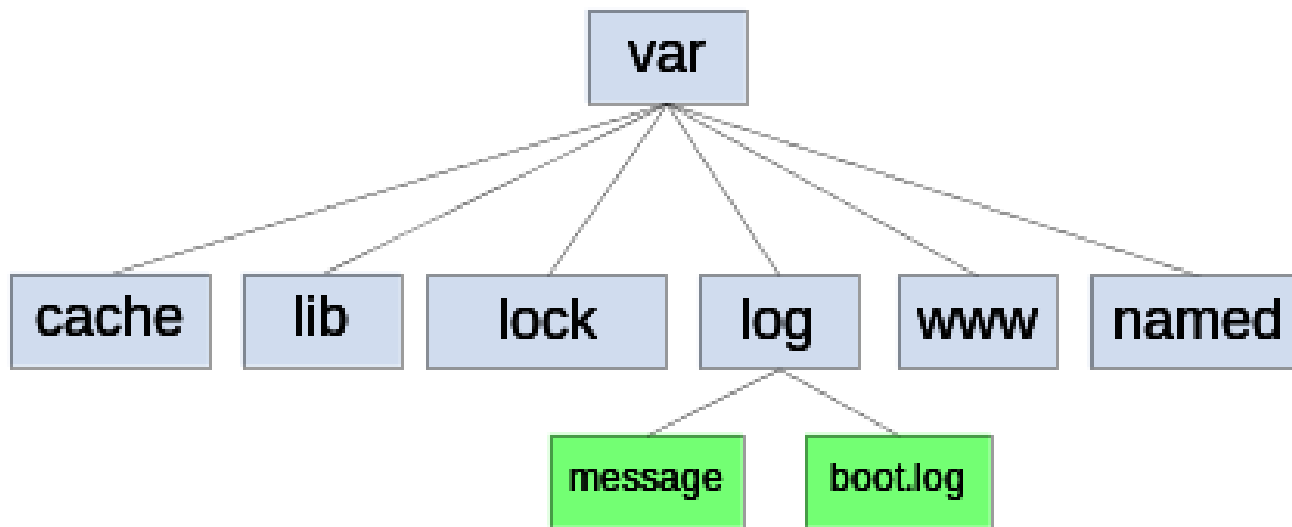
Directory : usr

- **Secondary hierarchy**
- **Very useful programs**
 - We usually use them
 - compiler, tools
- **Are not essential for system startup**



Directory : var

- The variable directory
- All dynamic files
- User cannot change the files



Permission

Owner			Group			All		
r	w	x	r	w	x	w	w	x

Legend

r = 'read access' (1 = yes, 0 = no)

w = 'write access' (1 = yes, 0 = no)

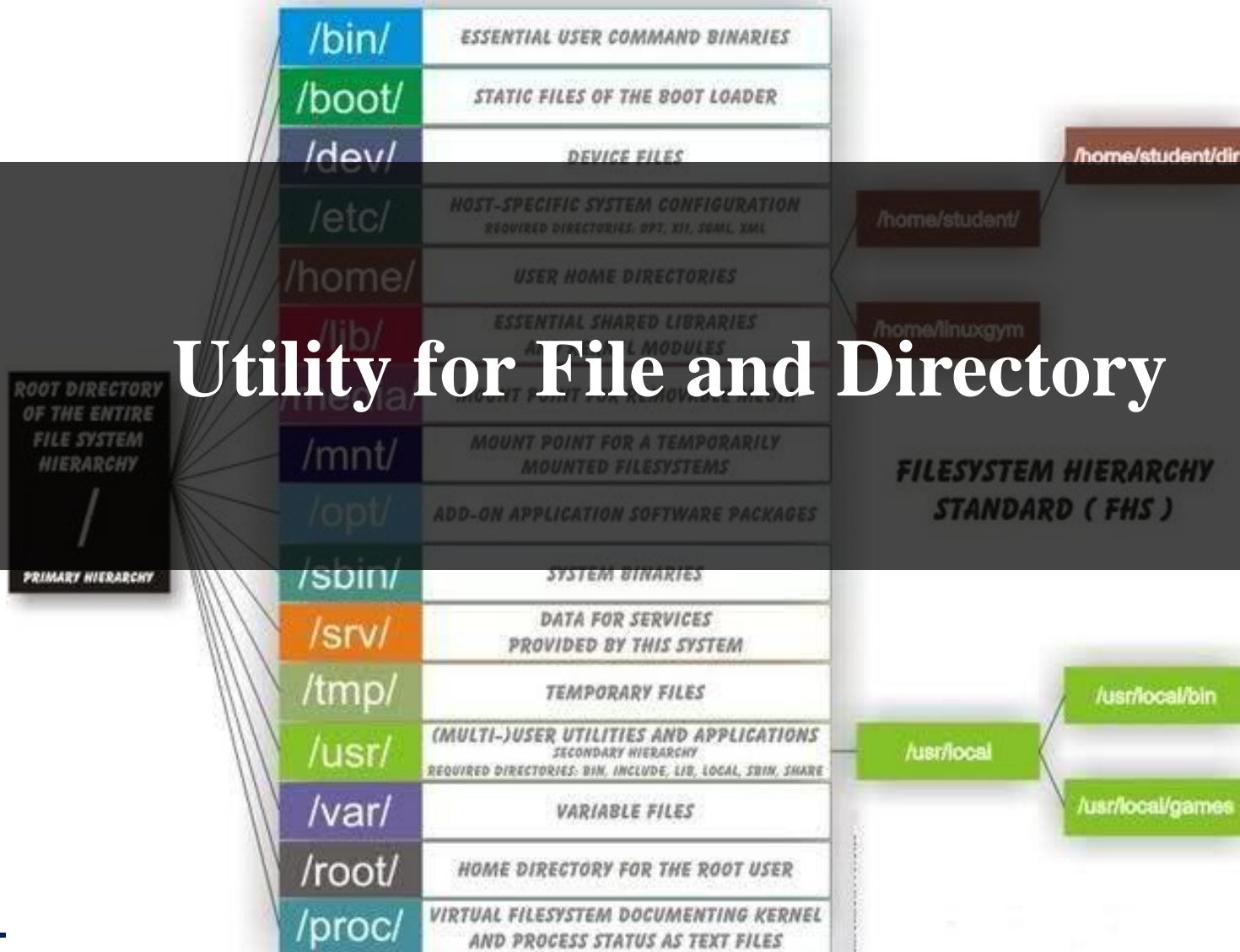
x = 'execute access' (1 = yes, 0 = no)

Bitmap-example: 110-100-100

Octal representation: 0644

ASCII-representation: rw-r--r--

Utility for File and Directory



Utility : pwd

- **Print Working Directory**
- **Find out what your current working directory**

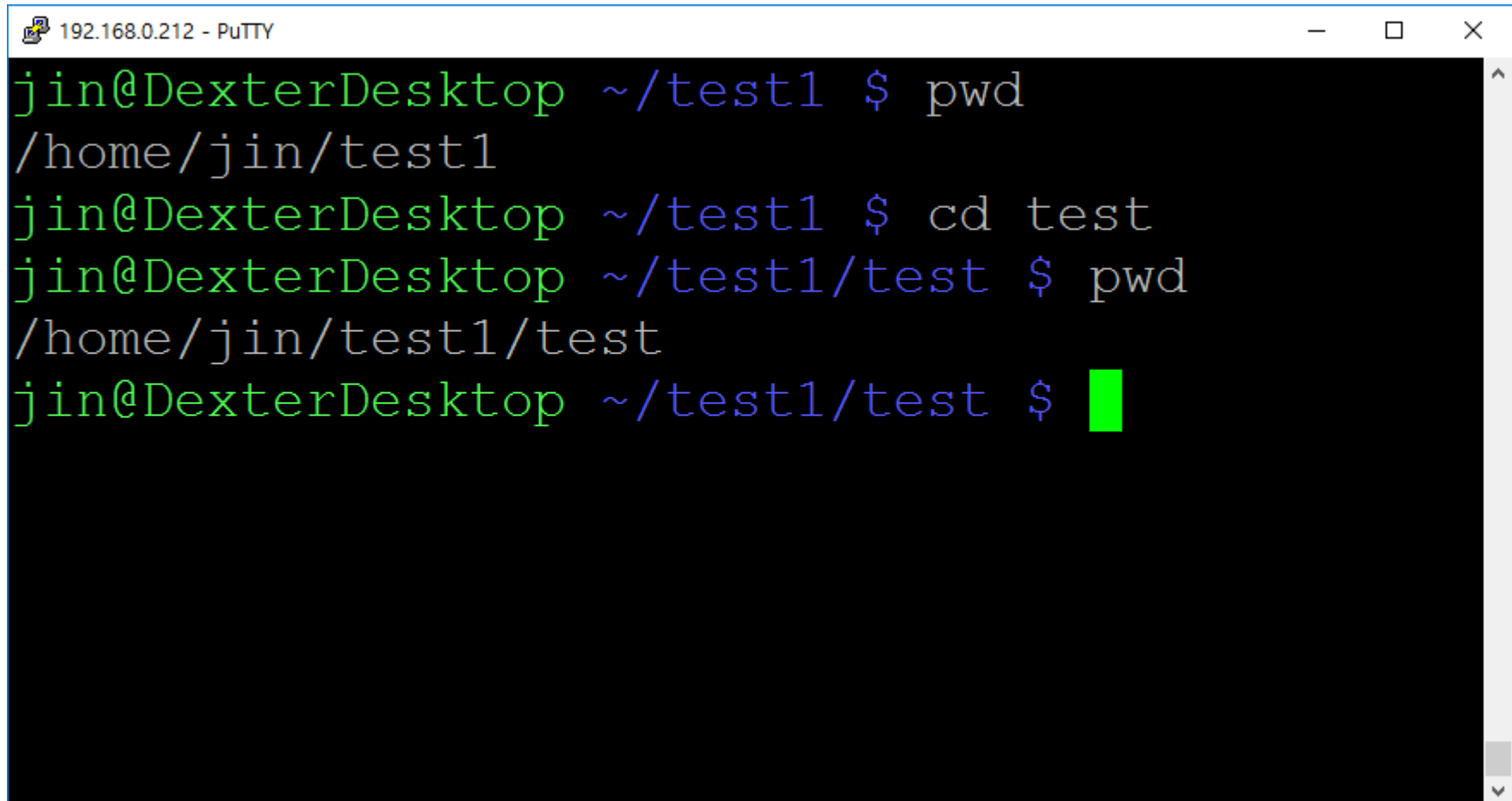


The screenshot shows a PuTTY terminal window titled "192.168.0.212 - PuTTY". The terminal displays the following sequence of commands and output:

```
jin@DexterDesktop ~ $ pwd
/home/jin
jin@DexterDesktop ~ $ pwd
/home/jin
jin@DexterDesktop ~ $ pwd
/home/jin
jin@DexterDesktop ~ $
```

Utility : cd

- Change Directory

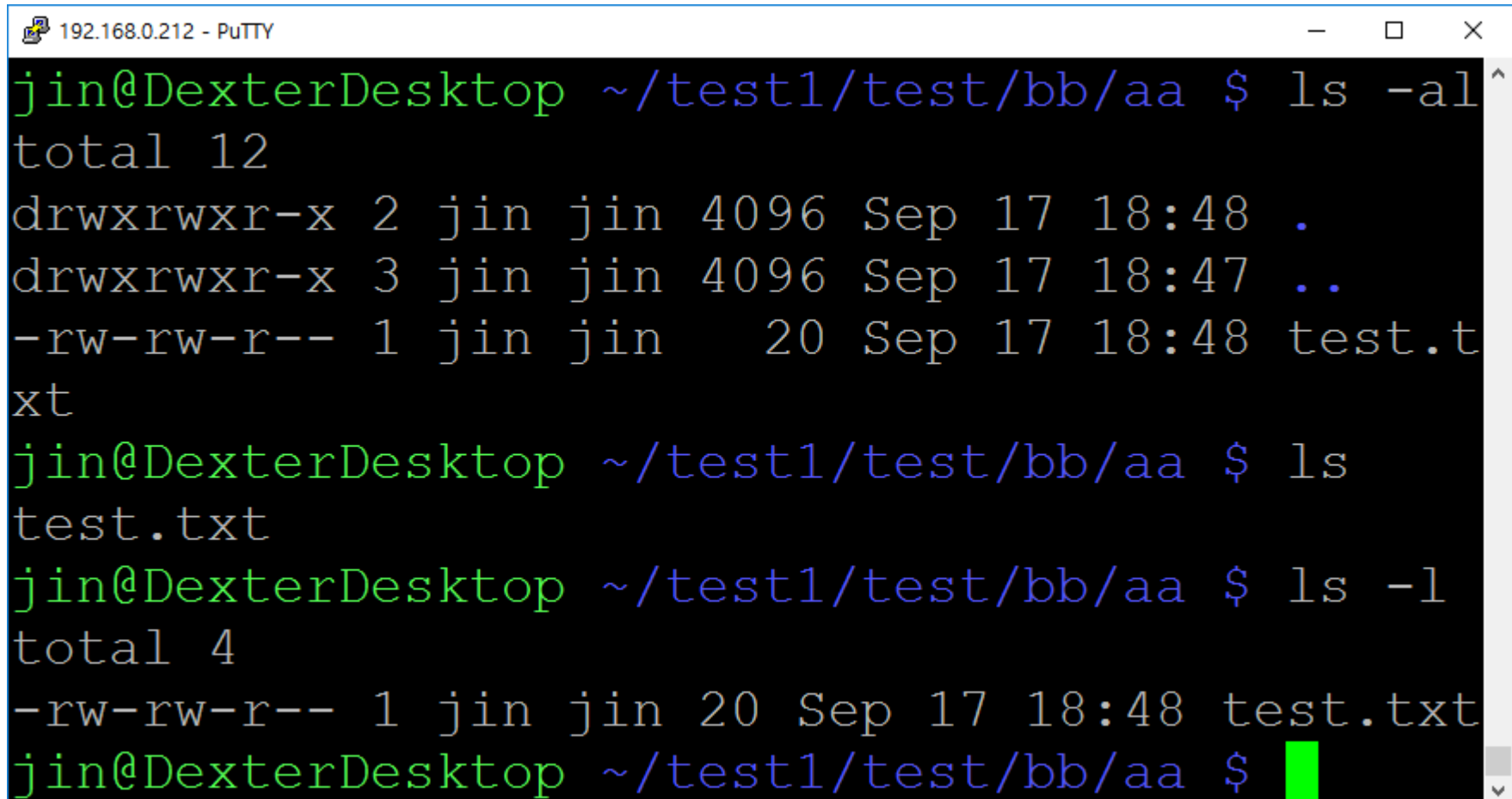


A screenshot of a PuTTY terminal window titled "192.168.0.212 - PuTTY". The terminal shows a user named "jin" at a host named "DexterDesktop". The user is in the directory "~/test1" and runs the command "pwd", which outputs "/home/jin/test1". Then, the user runs "cd test", and the prompt changes to "~/test1/test". Running "pwd" again outputs "/home/jin/test1/test". The terminal ends with the prompt "jin@DexterDesktop ~/test1/test \$" followed by a red cursor block.

```
jin@DexterDesktop ~/test1 $ pwd
/home/jin/test1
jin@DexterDesktop ~/test1 $ cd test
jin@DexterDesktop ~/test1/test $ pwd
/home/jin/test1/test
jin@DexterDesktop ~/test1/test $
```

Utility : ls

- List contents of a directory



The screenshot shows a PuTTY terminal window titled "192.168.0.212 - PuTTY". The user is at the prompt "jin@DexterDesktop ~/test1/test/bb/aa" and has entered the command "ls -al". The output shows the contents of the directory, including the current directory ".", the parent directory "..", and a file named "test.txt". The permissions for each entry are listed on the left, followed by the number of links, the owner, the group, the size in bytes, the date and time of last modification, and the file name.

```
jin@DexterDesktop ~/test1/test/bb/aa $ ls -al
total 12
drwxrwxr-x 2 jin jin 4096 Sep 17 18:48 .
drwxrwxr-x 3 jin jin 4096 Sep 17 18:47 ..
-rw-rw-r-- 1 jin jin 20 Sep 17 18:48 test.txt

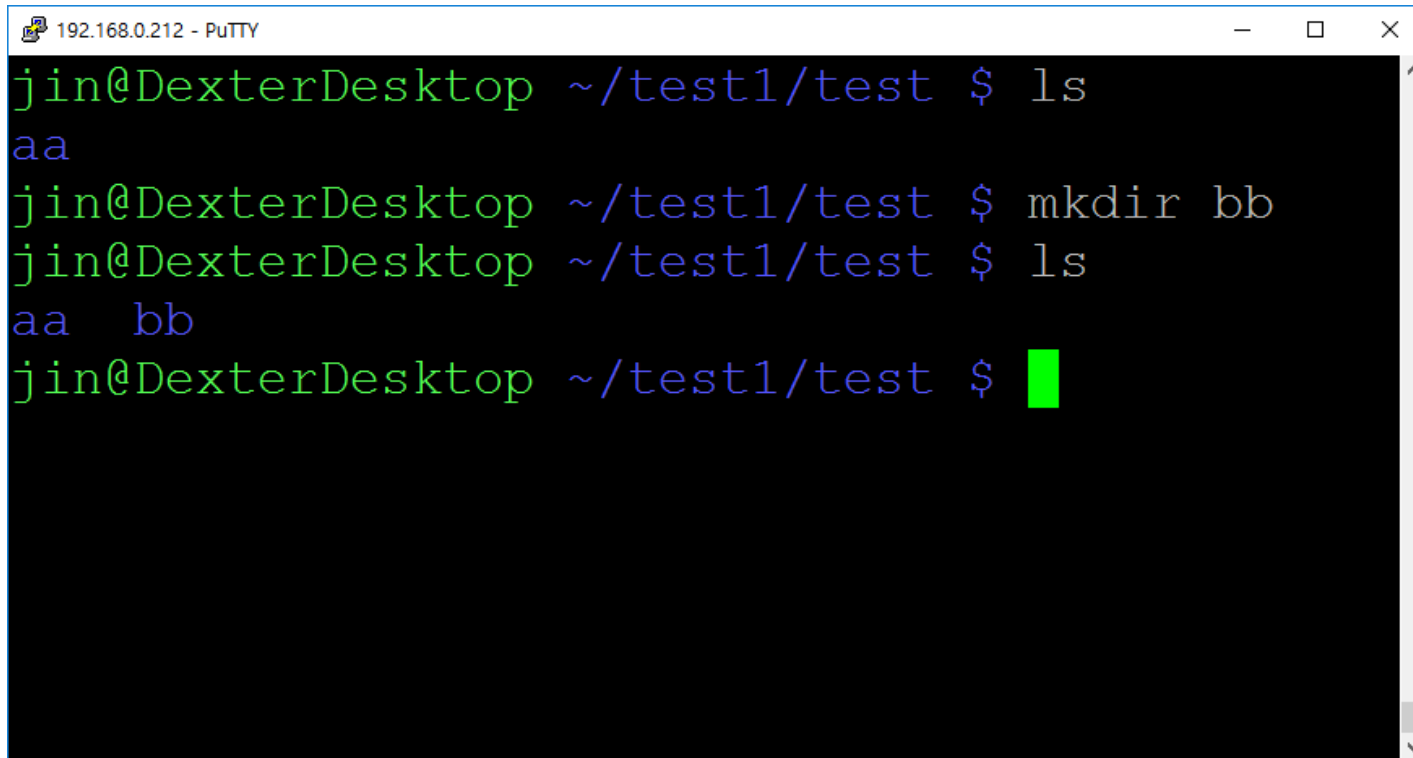
jin@DexterDesktop ~/test1/test/bb/aa $ ls
test.txt

jin@DexterDesktop ~/test1/test/bb/aa $ ls -l
total 4
-rw-rw-r-- 1 jin jin 20 Sep 17 18:48 test.txt

jin@DexterDesktop ~/test1/test/bb/aa $
```

Utility : mkdir

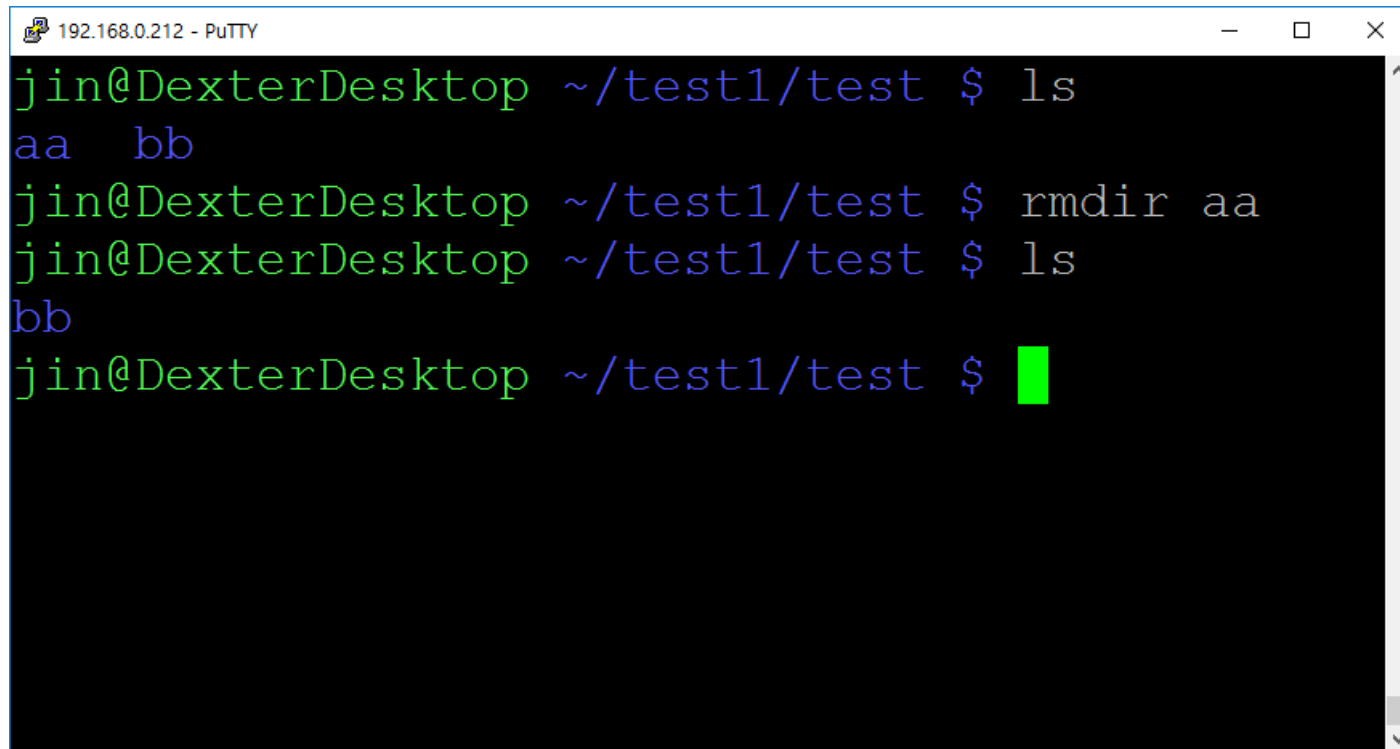
- **mkdir command:** creates new directories
- **Arguments specify directory's absolute or relative pathname**

A terminal window titled '192.168.0.212 - PuTTY' with standard window controls. The terminal shows a user 'jin' at 'DexterDesktop' in the directory '~/test1/test'. The user runs 'ls' and sees 'aa'. Then they run 'mkdir bb' and run 'ls' again to see 'aa' and 'bb'. The prompt is then followed by a red cursor.

```
jin@DexterDesktop ~/test1/test $ ls
aa
jin@DexterDesktop ~/test1/test $ mkdir bb
jin@DexterDesktop ~/test1/test $ ls
aa  bb
jin@DexterDesktop ~/test1/test $
```

Utility : rmdir

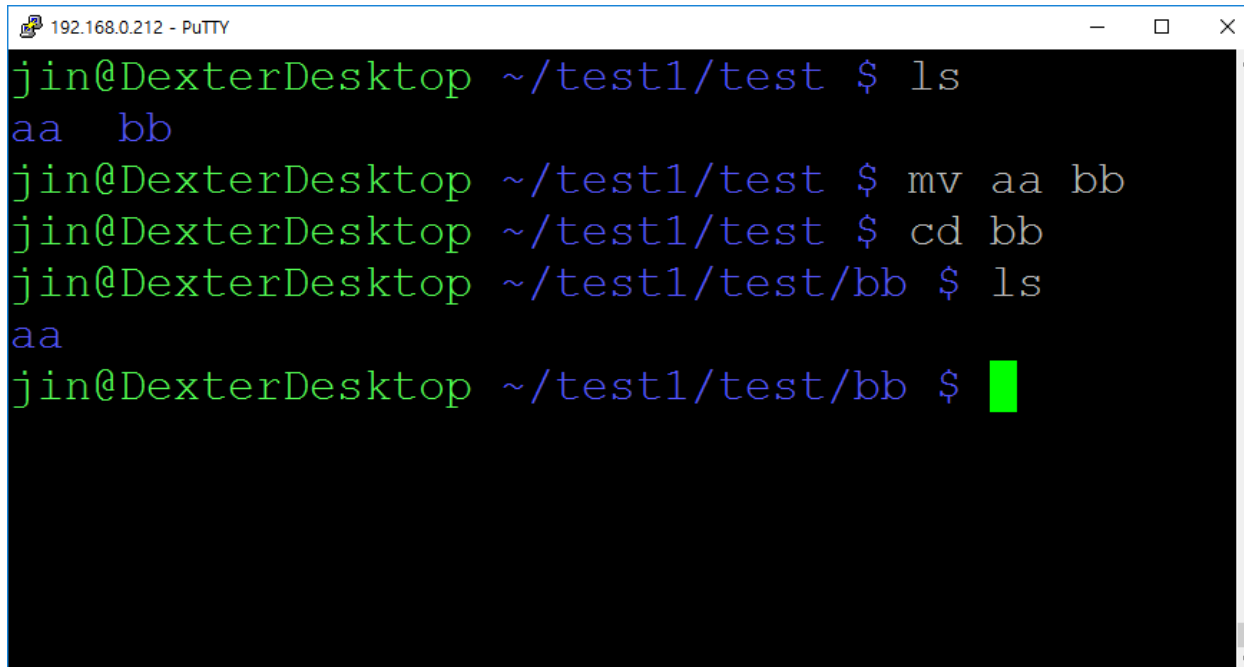
- **Removes directories**
 - Arguments are a list of files
 - Cannot be used to remove directory full of files

A terminal window titled "192.168.0.212 - PuTTY" with standard window controls. The terminal shows a user 'jin' at 'DexterDesktop' in the directory '~/test1/test'. The user runs 'ls', showing 'aa' and 'bb'. Then they run 'rmdir aa'. Finally, they run 'ls' again, showing only 'bb'. The prompt is currently at the end of the last line.

```
jin@DexterDesktop ~/test1/test $ ls
aa  bb
jin@DexterDesktop ~/test1/test $ rmdir aa
jin@DexterDesktop ~/test1/test $ ls
bb
jin@DexterDesktop ~/test1/test $
```

Utility : mv

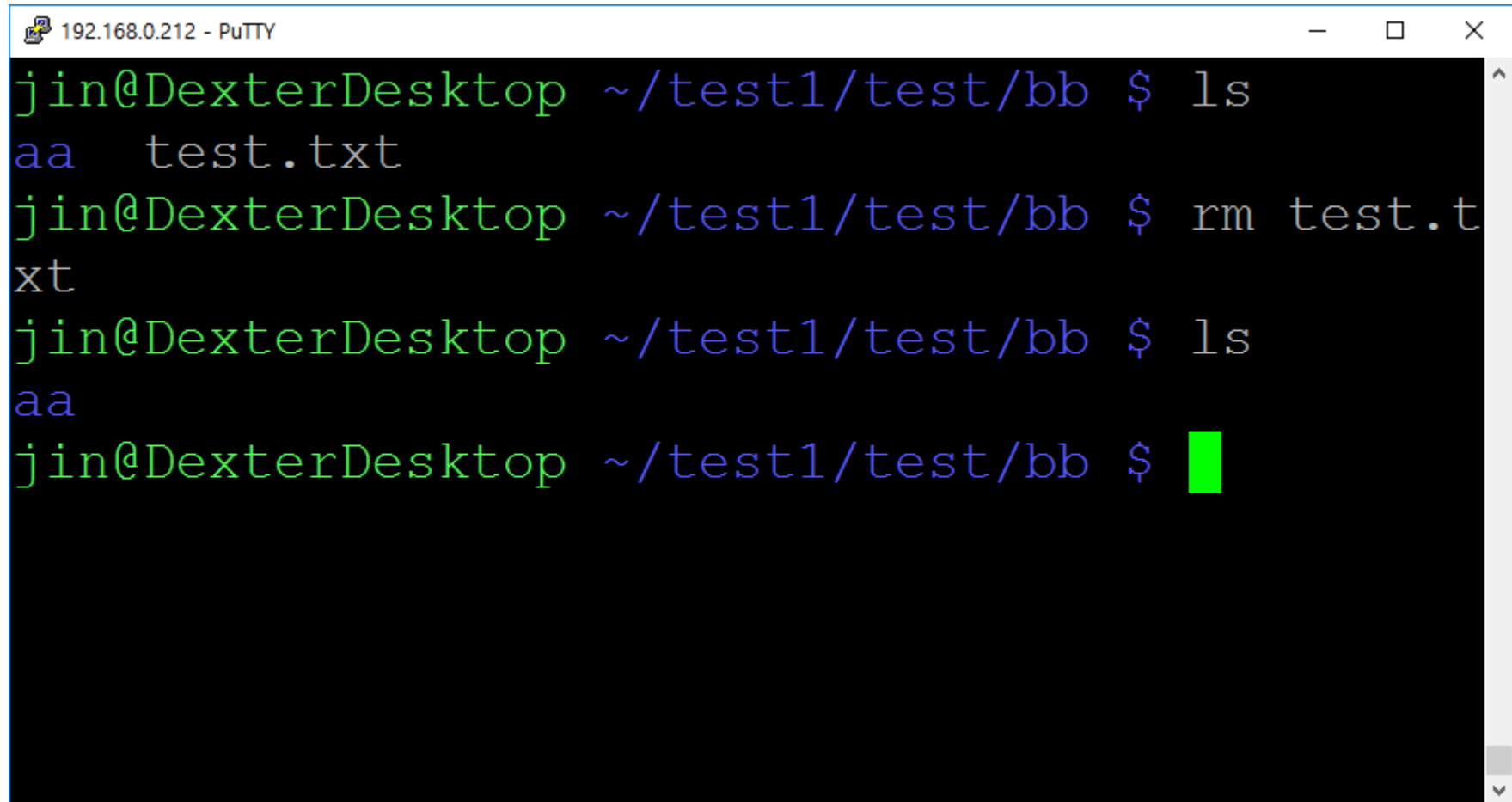
- Moves files
- Minimum of two arguments:
 - Source file/directory (may specify multiple sources)
 - Target file/directory
- Also used to rename files or directories



```
192.168.0.212 - PuTTY
jin@DexterDesktop ~/test1/test $ ls
aa  bb
jin@DexterDesktop ~/test1/test $ mv aa bb
jin@DexterDesktop ~/test1/test $ cd bb
jin@DexterDesktop ~/test1/test/bb $ ls
aa
jin@DexterDesktop ~/test1/test/bb $
```

Utility : rm

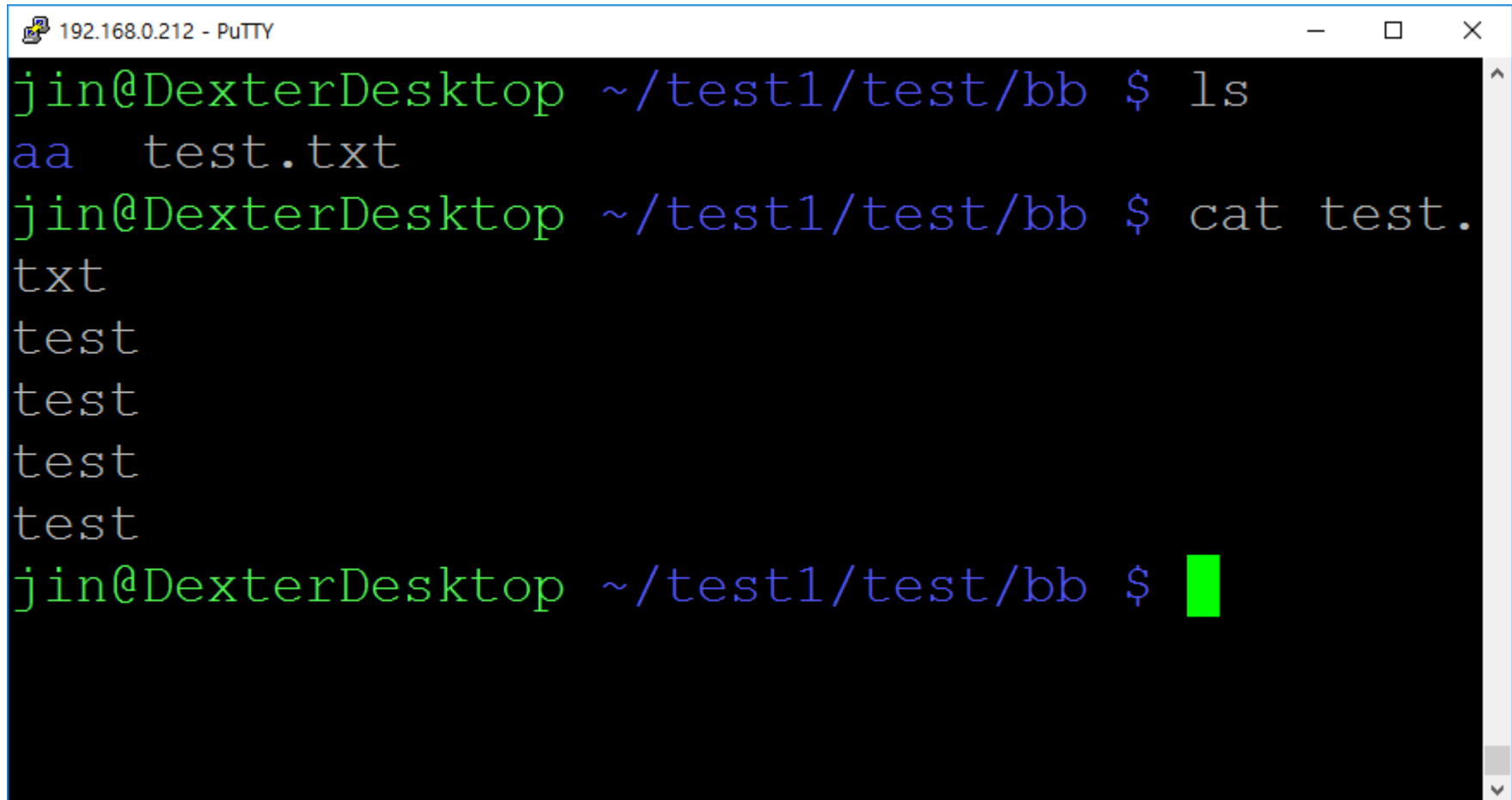
- **Removes files**
 - Arguments are a list of files



```
192.168.0.212 - PuTTY
jin@DexterDesktop ~/test1/test/bb $ ls
aa  test.txt
jin@DexterDesktop ~/test1/test/bb $ rm test.t
xt
jin@DexterDesktop ~/test1/test/bb $ ls
aa
jin@DexterDesktop ~/test1/test/bb $
```


Utility : cat

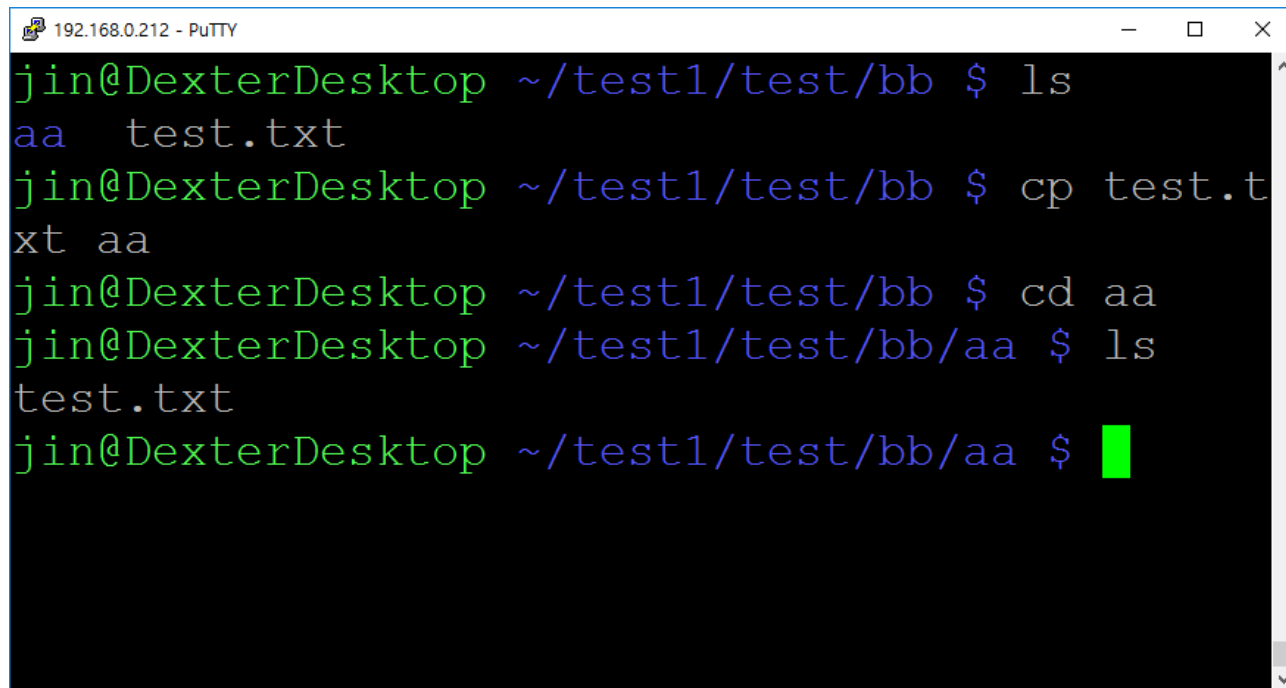
- Prints contents of file

A terminal window titled "192.168.0.212 - PuTTY" with standard window controls. The prompt is "jin@DexterDesktop ~/test1/test/bb \$". The first command is "ls", which outputs "aa test.txt". The second command is "cat test.txt", which outputs "test" four times on separate lines. The prompt is then shown again with a red cursor.

```
jin@DexterDesktop ~/test1/test/bb $ ls
aa test.txt
jin@DexterDesktop ~/test1/test/bb $ cat test.
txt
test
test
test
test
jin@DexterDesktop ~/test1/test/bb $
```

Utility : cp

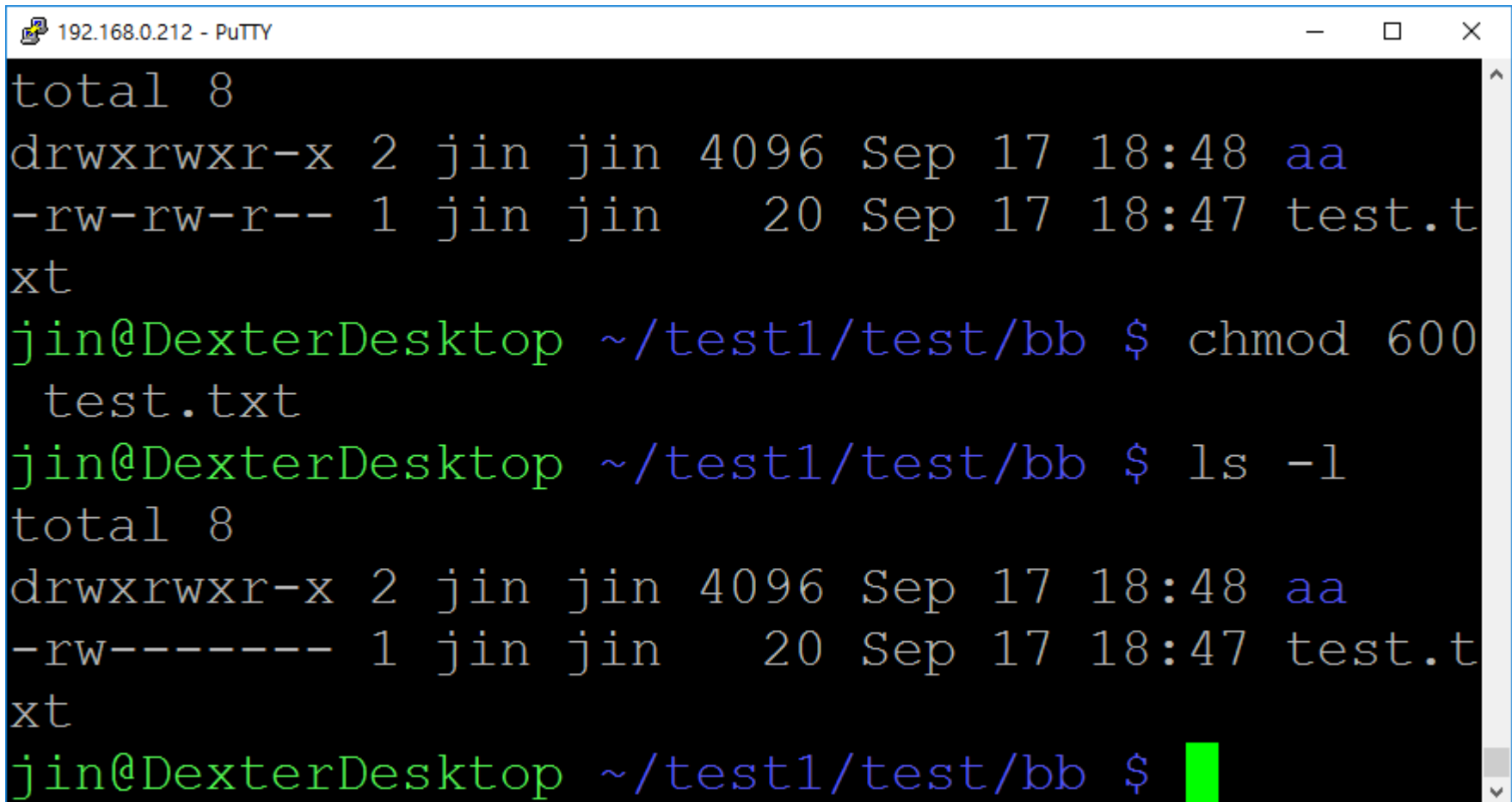
- **Copies files**
 - **Recursive:** referring to itself and its own contents
 - **Recursive copy command** copies the directory and all subdirectories and contents
 - **Use `-r` option**

A terminal window titled '192.168.0.212 - PuTTY' with standard window controls. It shows a series of commands and their outputs in a shell. The user 'jin' is at 'DexterDesktop'. The path is '~/test1/test/bb'. The first command 'ls' lists 'aa' and 'test.txt'. The second command 'cp test.txt aa' copies the file. The third command 'cd aa' changes the directory. The fourth command 'ls' lists 'test.txt'. The prompt is currently at '~/test1/test/bb/aa \$' with a red cursor.

```
jin@DexterDesktop ~/test1/test/bb $ ls
aa  test.txt
jin@DexterDesktop ~/test1/test/bb $ cp test.txt aa
jin@DexterDesktop ~/test1/test/bb $ cd aa
jin@DexterDesktop ~/test1/test/bb/aa $ ls
test.txt
jin@DexterDesktop ~/test1/test/bb/aa $
```

Utility : chmod

- Change the file permission



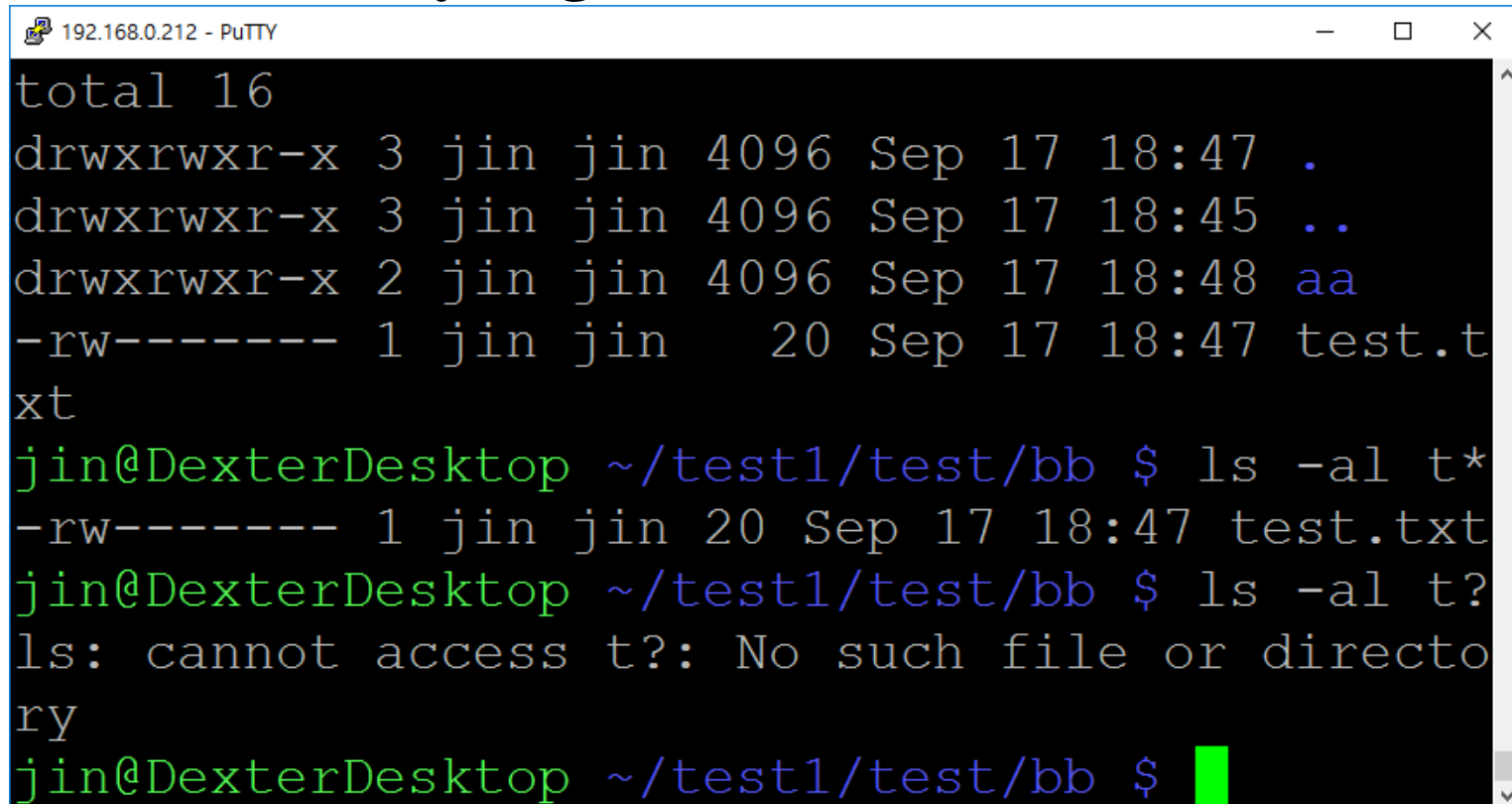
The screenshot shows a PuTTY terminal window titled "192.168.0.212 - PuTTY". The terminal output is as follows:

```
total 8
drwxrwxr-x 2 jin jin 4096 Sep 17 18:48 aa
-rw-rw-r-- 1 jin jin 20 Sep 17 18:47 test.txt
jin@DexterDesktop ~/test1/test/bb $ chmod 600
test.txt
jin@DexterDesktop ~/test1/test/bb $ ls -l
total 8
drwxrwxr-x 2 jin jin 4096 Sep 17 18:48 aa
-rw----- 1 jin jin 20 Sep 17 18:47 test.txt
jin@DexterDesktop ~/test1/test/bb $
```

The terminal shows the initial permissions of the file 'test.txt' as '-rw-rw-r--'. The user 'jin' then runs the command 'chmod 600 test.txt'. After running the command, the user runs 'ls -l' to verify the change. The permissions for 'test.txt' are now '-rw-----', indicating that only the owner (jin) has read and write permissions, and no permissions are granted to the group or others.

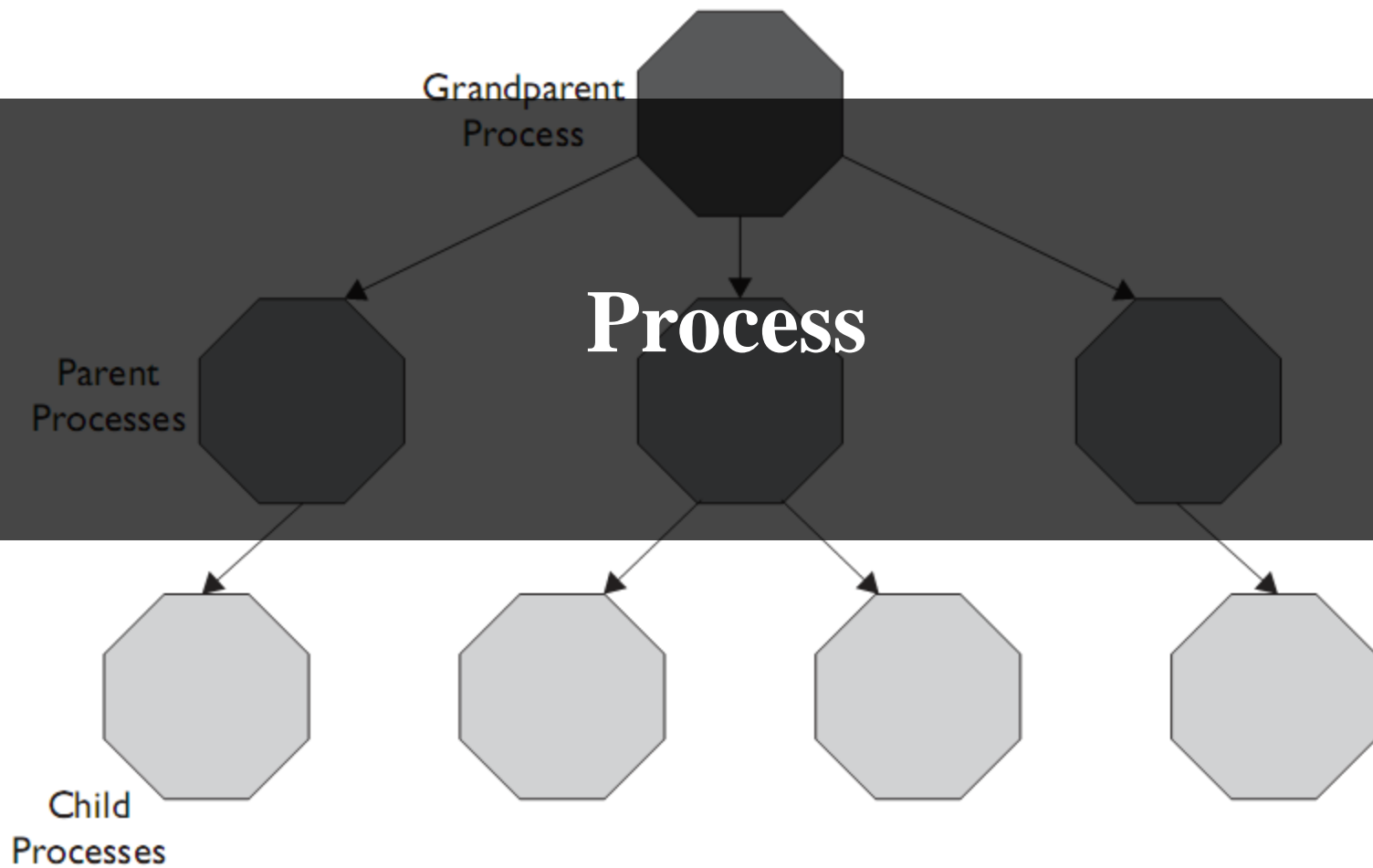
Metacharacter

- *** = Matches any sequence of zero or more characters, except for "." (a dot) at the beginning of a filename.**
- **? = Matches any single character.**



The screenshot shows a PuTTY terminal window titled "192.168.0.212 - PuTTY". The terminal output displays the results of a file listing command, showing permissions, owner, group, size, date, and filename. The files listed are ".", "..", "aa", and "test.txt". Below this, the user runs the command `ls -al t*`, which lists "test.txt". Then, the user runs `ls -al t?`, which results in an error message: "ls: cannot access t?: No such file or directory". The terminal prompt is `jin@DexterDesktop ~/test1/test/bb $`.

```
total 16
drwxrwxr-x 3 jin jin 4096 Sep 17 18:47 .
drwxrwxr-x 3 jin jin 4096 Sep 17 18:45 ..
drwxrwxr-x 2 jin jin 4096 Sep 17 18:48 aa
-rw----- 1 jin jin  20 Sep 17 18:47 test.txt
jin@DexterDesktop ~/test1/test/bb $ ls -al t*
-rw----- 1 jin jin 20 Sep 17 18:47 test.txt
jin@DexterDesktop ~/test1/test/bb $ ls -al t?
ls: cannot access t?: No such file or directory
jin@DexterDesktop ~/test1/test/bb $
```



Process

- **The kernel considers each program running to be a process**
- **A process lives as it executes, with a lifetime that may be short or long**
- **A process is said to die when it terminates**
- **The kernel identifies each process by a number known as a process id (PID)**

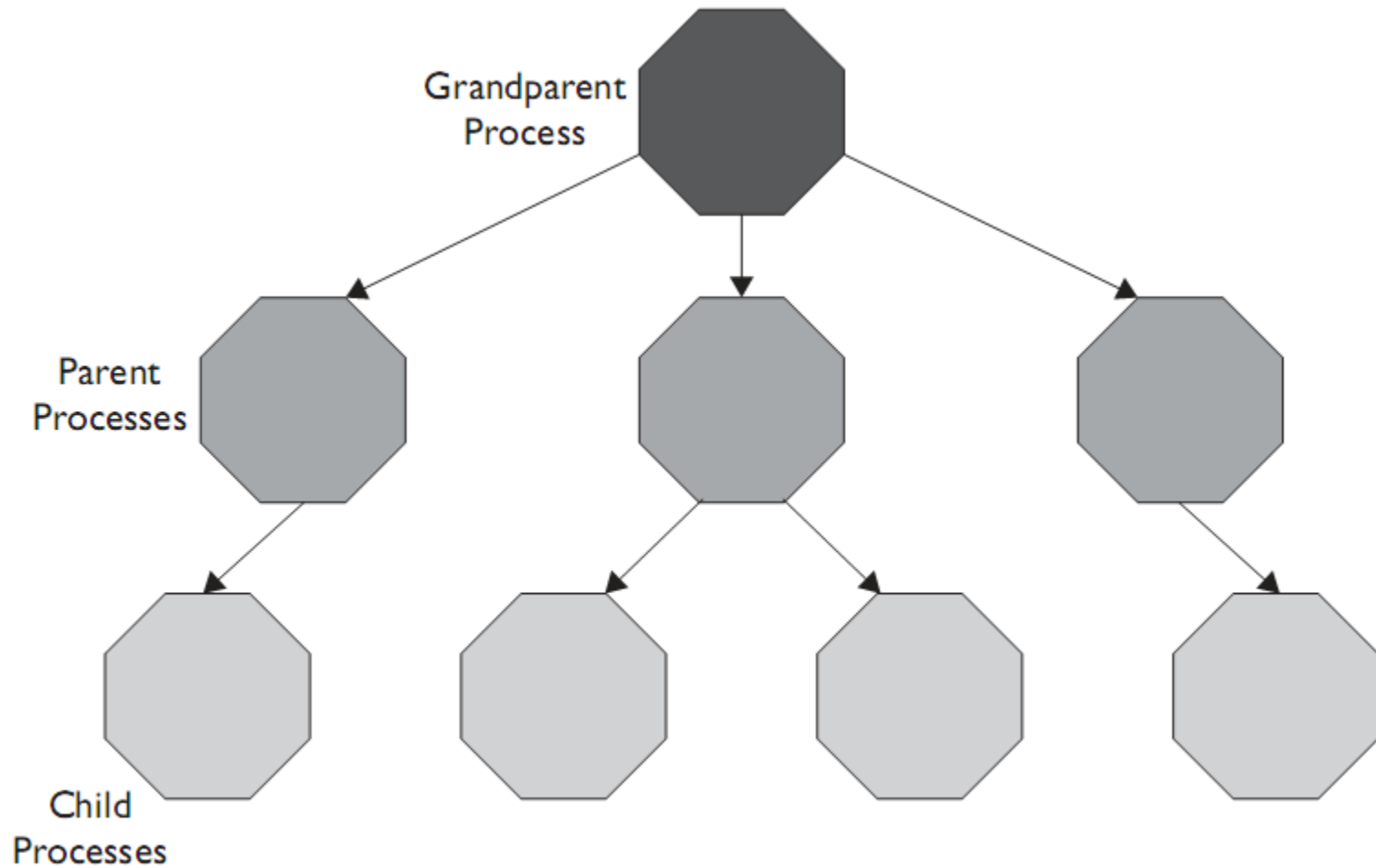
Type of Process

- **Init**
 - The parent of all processes.
- **User Processes**
 - Created by the end user
- **System processes or daemons**
 - Web server, an FTP server, a file service such as Samba, a print service such as CUPS, a logging service, and so on.

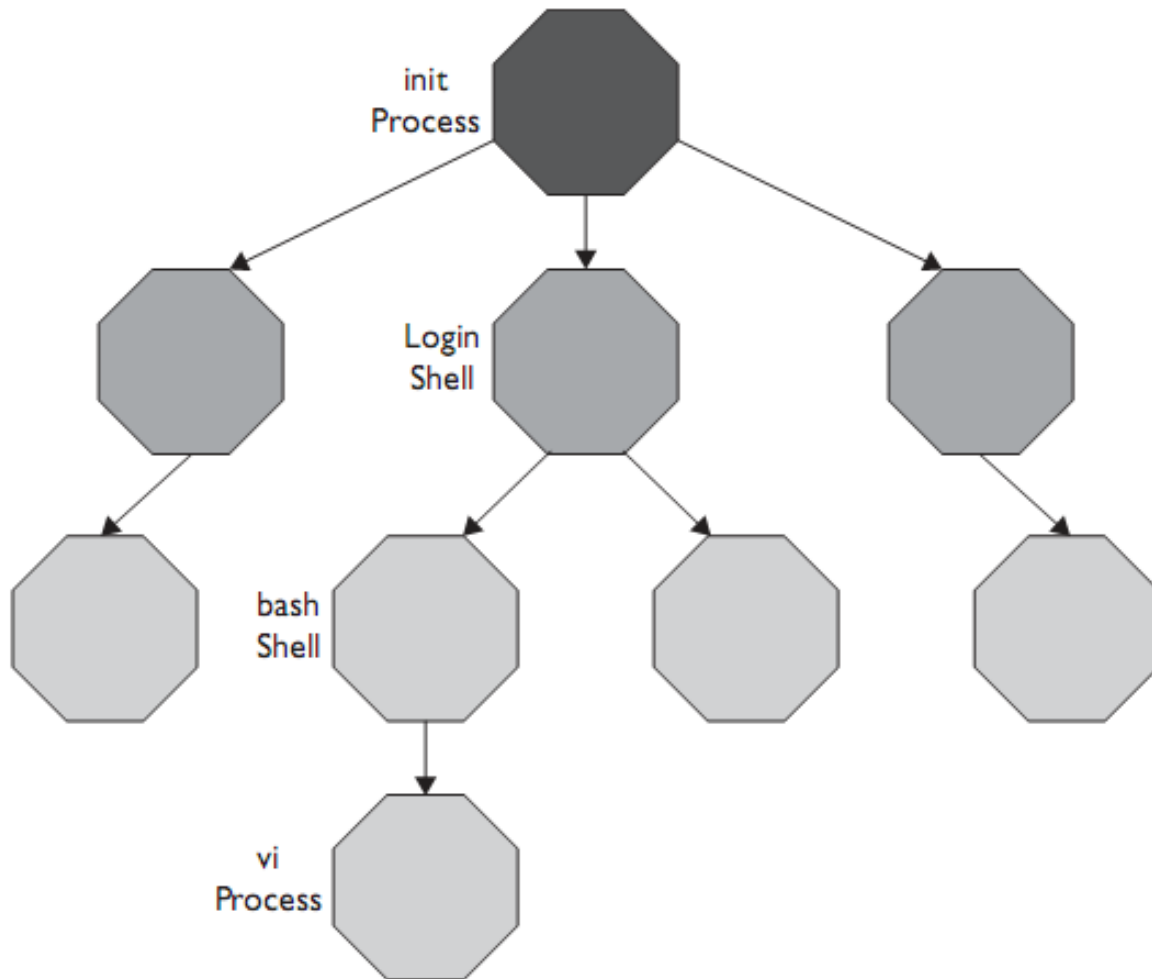
Attribute of Process

- **PID**
 - process ID, an integer.
- **PPID**
 - parent process ID, an integer.
- **TTY**
 - the terminal to which the process is connected.
- **RUID**
 - Real user ID. The user issuing the command.
- **RGID**
 - real group owner. The group of the user who started the process

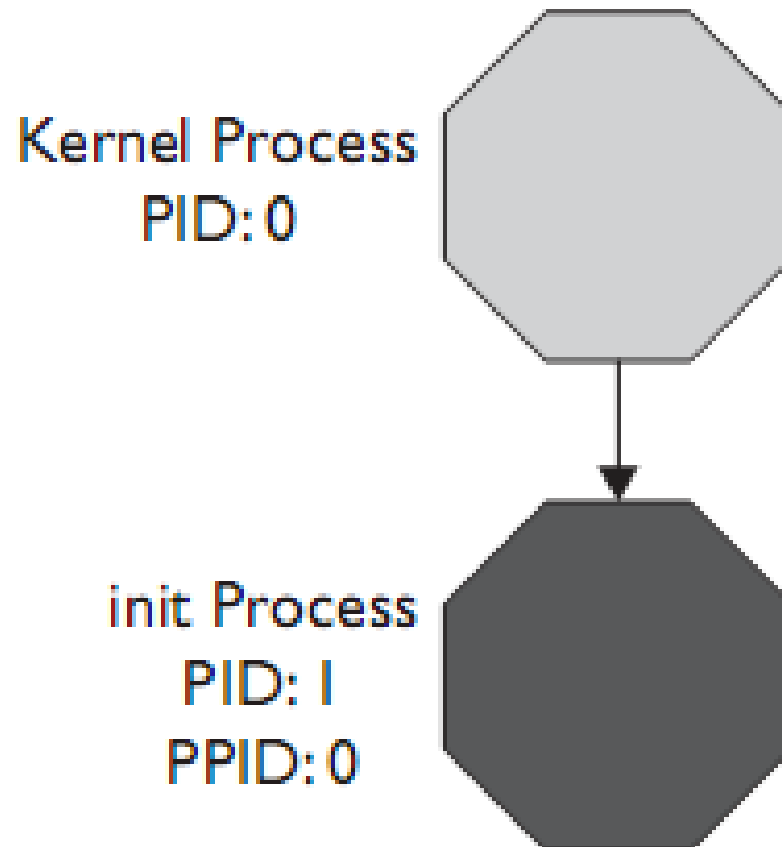
The Heredity of Linux Processes

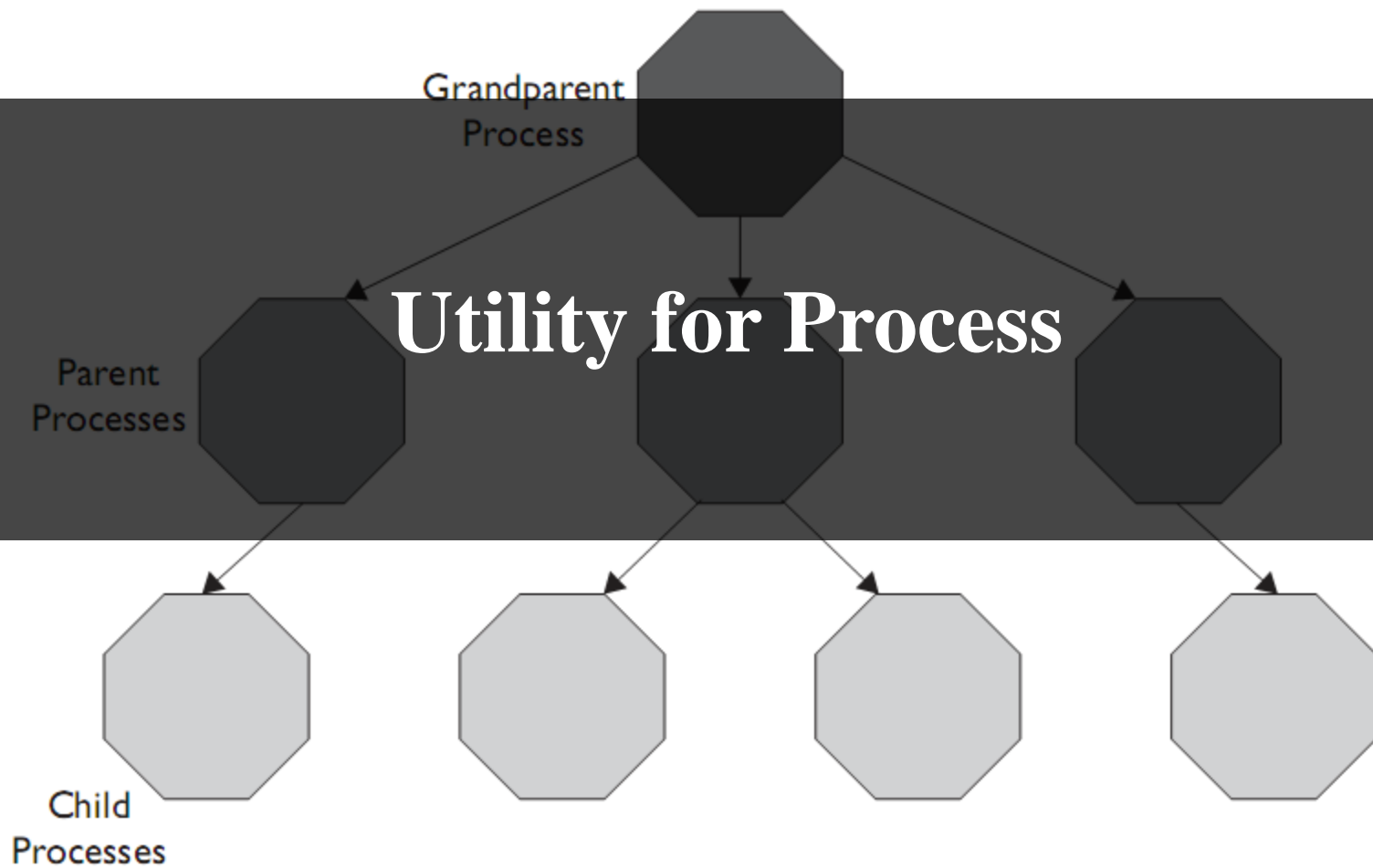


The Heredity of Linux Processes



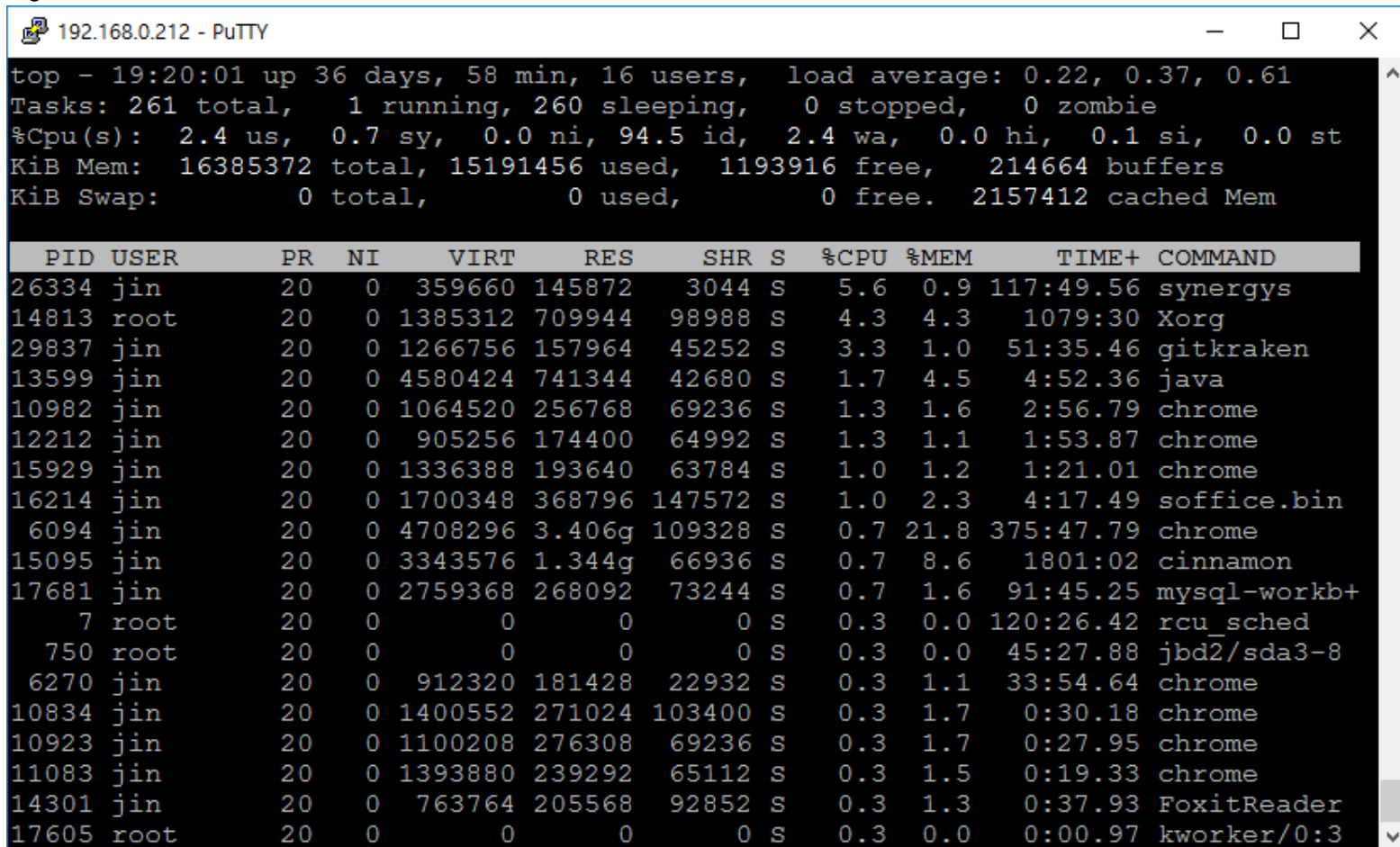
Parent Process ID





Utility : top

- Display a dynamic real-time view of a running system.



```
top - 19:20:01 up 36 days, 58 min, 16 users,  load average: 0.22, 0.37, 0.61
Tasks: 261 total,  1 running, 260 sleeping,  0 stopped,  0 zombie
%Cpu(s):  2.4 us,  0.7 sy,  0.0 ni, 94.5 id,  2.4 wa,  0.0 hi,  0.1 si,  0.0 st
KiB Mem: 16385372 total, 15191456 used, 1193916 free,  214664 buffers
KiB Swap:  0 total,  0 used,  0 free. 2157412 cached Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
26334	jln	20	0	359660	145872	3044	S	5.6	0.9	117:49.56	synergys
14813	root	20	0	1385312	709944	98988	S	4.3	4.3	1079:30	Xorg
29837	jln	20	0	1266756	157964	45252	S	3.3	1.0	51:35.46	gitkraken
13599	jln	20	0	4580424	741344	42680	S	1.7	4.5	4:52.36	java
10982	jln	20	0	1064520	256768	69236	S	1.3	1.6	2:56.79	chrome
12212	jln	20	0	905256	174400	64992	S	1.3	1.1	1:53.87	chrome
15929	jln	20	0	1336388	193640	63784	S	1.0	1.2	1:21.01	chrome
16214	jln	20	0	1700348	368796	147572	S	1.0	2.3	4:17.49	soffice.bin
6094	jln	20	0	4708296	3.406g	109328	S	0.7	21.8	375:47.79	chrome
15095	jln	20	0	3343576	1.344g	66936	S	0.7	8.6	1801:02	cinnamon
17681	jln	20	0	2759368	268092	73244	S	0.7	1.6	91:45.25	mysql-workb+
7	root	20	0	0	0	0	S	0.3	0.0	120:26.42	rcu_sched
750	root	20	0	0	0	0	S	0.3	0.0	45:27.88	jbd2/sda3-8
6270	jln	20	0	912320	181428	22932	S	0.3	1.1	33:54.64	chrome
10834	jln	20	0	1400552	271024	103400	S	0.3	1.7	0:30.18	chrome
10923	jln	20	0	1100208	276308	69236	S	0.3	1.7	0:27.95	chrome
11083	jln	20	0	1393880	239292	65112	S	0.3	1.5	0:19.33	chrome
14301	jln	20	0	763764	205568	92852	S	0.3	1.3	0:37.93	FoxitReader
17605	root	20	0	0	0	0	S	0.3	0.0	0:00.97	kworker/0:3

Utility : ps

- Report a snapshot of the current processes.

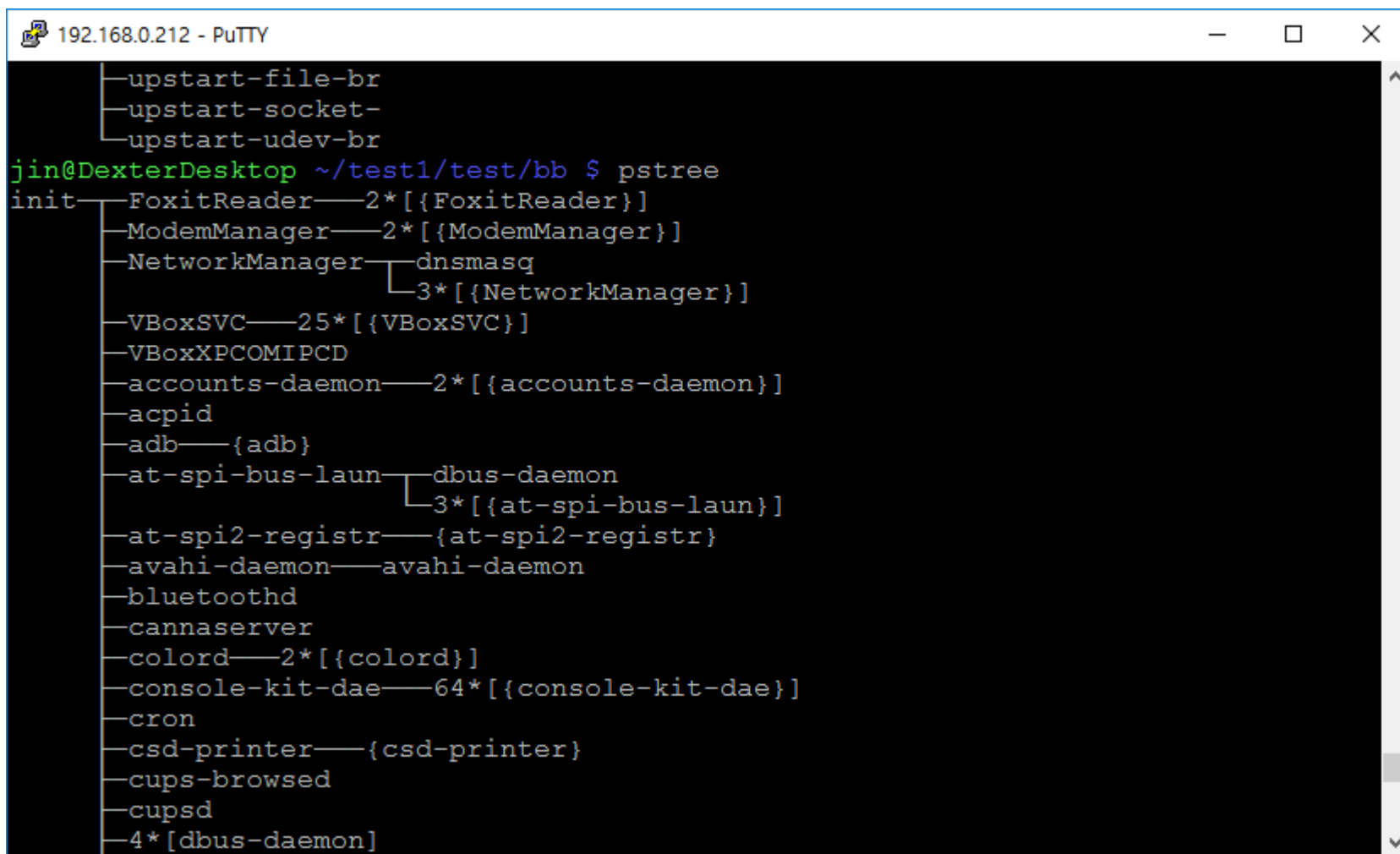
```
192.168.0.212 - PuTTY
PID TTY          TIME CMD
17117 pts/3        00:00:00 bash
17715 pts/3        00:00:00 ps
jin@DexterDesktop ~/test1/test/bb $ ps u
```

USER	PID	%CPU	%MEM	VSZ	RSS	TTY	STAT	START	TIME	COMMAND
jin	1631	0.0	0.0	48668	1068	pts/22	S+	Sep12	0:02	ssh -L 3312:kiwi
jin	1843	0.0	0.0	25200	3416	pts/7	Ss+	Sep12	0:00	bash
jin	14333	0.0	0.0	25216	3432	pts/11	Ss	Sep13	0:00	bash
jin	14424	0.0	0.0	51164	2688	pts/11	S+	Sep13	0:00	vi redzone.csv
jin	15570	0.0	0.0	25212	3420	tty2	S	Aug17	0:00	-bash
jin	15737	0.0	0.0	45984	4004	tty2	S+	Aug17	0:34	ssh -L 3307:kiwi
jin	15752	0.0	0.0	25116	3320	tty3	S	Aug17	0:00	-bash
jin	15777	0.0	0.0	44568	1056	tty3	S+	Aug17	0:21	ssh -L 3308:kiwi
jin	15792	0.0	0.0	25116	3320	tty4	S+	Aug17	0:00	-bash
jin	16541	0.0	0.0	25124	3300	pts/14	Ss+	Sep13	0:00	bash
jin	17074	0.0	0.0	25124	6752	pts/2	Ss+	18:37	0:00	bash
jin	17117	0.0	0.0	25196	6912	pts/3	Ss	18:38	0:00	-bash
jin	17716	0.0	0.0	19672	2824	pts/3	R+	19:21	0:00	ps u
jin	18364	0.0	0.0	25120	3288	pts/6	Ss+	Sep08	0:00	bash
jin	18699	0.0	0.0	25124	3332	pts/12	Ss+	Sep09	0:00	bash
jin	20500	0.0	0.0	25128	3336	pts/22	Ss	Sep01	0:00	bash
jin	21830	0.0	0.0	25124	3328	pts/13	Ss+	Sep13	0:00	bash
jin	21883	0.0	0.0	25124	3328	pts/15	Ss+	Sep13	0:00	bash
jin	22027	0.0	0.0	25120	3328	pts/17	Ss+	Sep08	0:00	bash
jin	22862	0.0	0.0	25140	3344	pts/16	Ss+	Sep08	0:00	bash

```
jin@DexterDesktop ~/test1/test/bb $
```

Utility : pstree

- Display a tree of processes

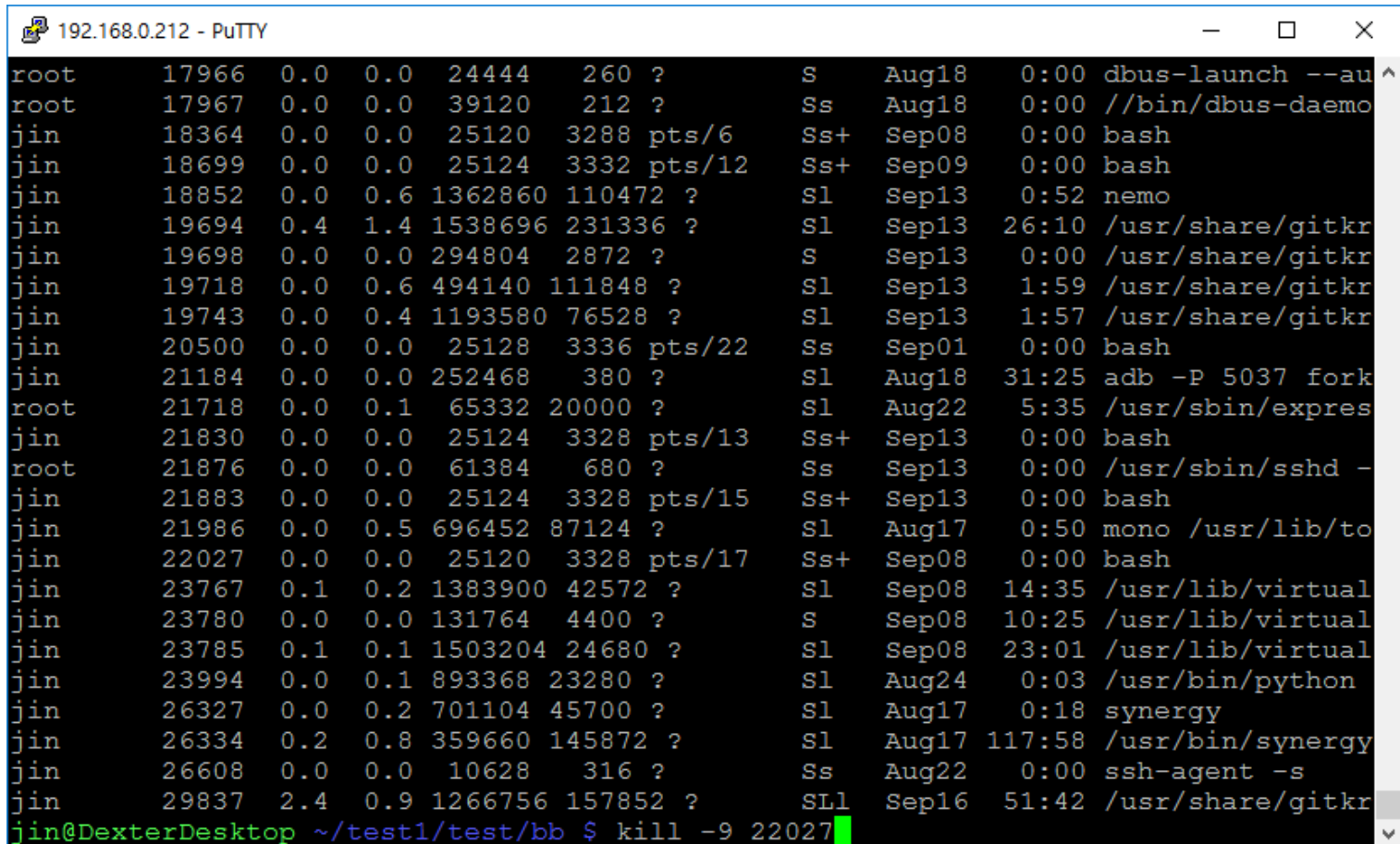


The screenshot shows a terminal window titled "192.168.0.212 - PuTTY". The user is logged in as "jin" on a machine named "DexterDesktop". The current directory is "~/test1/test/bb". The user has executed the command "pstree", which displays a hierarchical tree of running processes. The root process is "init", which has several children, including "FoxitReader", "ModemManager", "NetworkManager", "VBoxSVC", "VBoxXPCOMIPCD", "accounts-daemon", "acpid", "adb", "at-spi-bus-laun", "at-spi2-registr", "avahi-daemon", "bluetoothd", "cannaserver", "colord", "console-kit-dae", "cron", "csd-printer", "cups-browsed", "cupsd", and "dbus-daemon". Each process is followed by a count of its instances in square brackets.

```
192.168.0.212 - PuTTY
jin@DexterDesktop ~/test1/test/bb $ pstree
init--FoxitReader--2*[{FoxitReader}]
init--ModemManager--2*[{ModemManager}]
init--NetworkManager--dnsmasq
                        3*[{NetworkManager}]
init--VBoxSVC--25*[{VBoxSVC}]
init--VBoxXPCOMIPCD
init--accounts-daemon--2*[{accounts-daemon}]
init--acpid
init--adb--{adb}
init--at-spi-bus-laun--dbus-daemon
                        3*[{at-spi-bus-laun}]
init--at-spi2-registr--{at-spi2-registr}
init--avahi-daemon--avahi-daemon
init--bluetoothd
init--cannaserver
init--colord--2*[{colord}]
init--console-kit-dae--64*[{console-kit-dae}]
init--cron
init--csd-printer--{csd-printer}
init--cups-browsed
init--cupsd
init--4*[{dbus-daemon}]
```

Utility : kill

- Send a signal to a process.
- **kill -9** : sends a termination signal



192.168.0.212 - PuTTY

```
root      17966  0.0  0.0  24444   260 ?        S      Aug18   0:00 dbus-launch --au ^
root      17967  0.0  0.0   39120   212 ?        Ss     Aug18   0:00 //bin/dbus-daemo
jin       18364  0.0  0.0   25120  3288 pts/6    Ss+    Sep08   0:00 bash
jin       18699  0.0  0.0   25124  3332 pts/12   Ss+    Sep09   0:00 bash
jin       18852  0.0  0.6  1362860 110472 ?        Sl     Sep13   0:52 nemo
jin       19694  0.4  1.4  1538696 231336 ?        Sl     Sep13  26:10 /usr/share/gitkr
jin       19698  0.0  0.0   294804   2872 ?        S      Sep13   0:00 /usr/share/gitkr
jin       19718  0.0  0.6   494140  11848 ?        Sl     Sep13   1:59 /usr/share/gitkr
jin       19743  0.0  0.4   1193580  76528 ?        Sl     Sep13   1:57 /usr/share/gitkr
jin       20500  0.0  0.0   25128   3336 pts/22   Ss     Sep01   0:00 bash
jin       21184  0.0  0.0   252468    380 ?        Sl     Aug18  31:25 adb -P 5037 fork
root      21718  0.0  0.1    65332  20000 ?        Sl     Aug22   5:35 /usr/sbin/expres
jin       21830  0.0  0.0   25124   3328 pts/13   Ss+    Sep13   0:00 bash
root      21876  0.0  0.0    61384    680 ?        Ss     Sep13   0:00 /usr/sbin/sshd -
jin       21883  0.0  0.0   25124   3328 pts/15   Ss+    Sep13   0:00 bash
jin       21986  0.0  0.5   696452  87124 ?        Sl     Aug17   0:50 mono /usr/lib/to
jin       22027  0.0  0.0   25120   3328 pts/17   Ss+    Sep08   0:00 bash
jin       23767  0.1  0.2  1383900  42572 ?        Sl     Sep08  14:35 /usr/lib/virtual
jin       23780  0.0  0.0   131764   4400 ?        S      Sep08  10:25 /usr/lib/virtual
jin       23785  0.1  0.1   1503204  24680 ?        Sl     Sep08  23:01 /usr/lib/virtual
jin       23994  0.0  0.1   893368  23280 ?        Sl     Aug24   0:03 /usr/bin/python
jin       26327  0.0  0.2   701104  45700 ?        Sl     Aug17   0:18 synergy
jin       26334  0.2  0.8   359660 145872 ?        Sl     Aug17 117:58 /usr/bin/synergy
jin       26608  0.0  0.0    10628    316 ?        Ss     Aug22   0:00 ssh-agent -s
jin       29837  2.4  0.9  1266756 157852 ?        SLl    Sep16  51:42 /usr/share/gitkr
jin@DexterDesktop ~/test1/test/bb $ kill -9 22027
```


Utility : command &

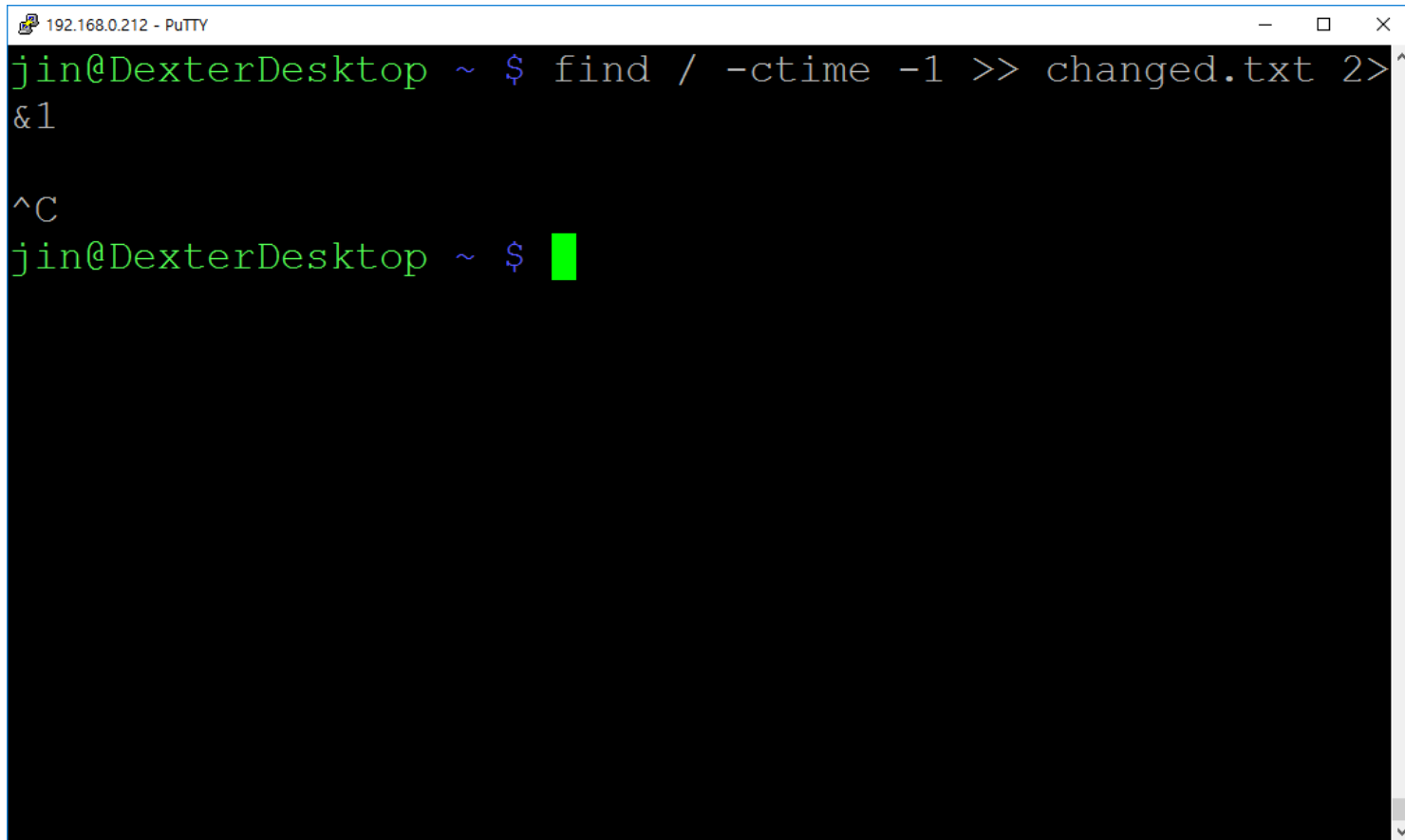
- **command &**
 - Run command in the background.
- **find / -ctime -1 > changed-file-list.txt 2>&1**
- **find / -ctime -1 > changed-file-list.txt 2>&1 &**



```
192.168.0.212 - PuTTY
jin@DexterDesktop ~ $ find / -ctime -1 >> changed.txt 2>^
&1 &
[1] 17885
jin@DexterDesktop ~ $
jin@DexterDesktop ~ $
jin@DexterDesktop ~ $
jin@DexterDesktop ~ $
[1]+  Exit 1                  find / -ctime -1 >> change
d.txt 2>&1
jin@DexterDesktop ~ $
```

Utility : Ctrl + C

- **Ctrl + C**
 - Terminate a process running in the foreground.



The screenshot shows a PuTTY terminal window titled "192.168.0.212 - PuTTY". The prompt is "jin@DexterDesktop ~ \$". The user has entered the command "find / -ctime -1 >> changed.txt 2> ^&1" and pressed Enter. The prompt returns. The user then presses Ctrl+C, which is shown as "^C". The prompt returns again, followed by a redacted area (a solid black rectangle).

```
192.168.0.212 - PuTTY
jin@DexterDesktop ~ $ find / -ctime -1 >> changed.txt 2> ^&1
jin@DexterDesktop ~ $ ^C
jin@DexterDesktop ~ $ [REDACTED]
```

Utility : Ctrl + Z

- **Ctrl + Z**
 - Suspend a process running in the foreground.



The screenshot shows a PuTTY terminal window titled "192.168.0.212 - PuTTY". The user 'jin' is at the 'DexterDesktop' prompt. They have entered the command `find / -ctime -1 >> changed.txt 2>&1`. After pressing Ctrl+Z, the terminal shows `^Z` followed by `[1]+ Stopped find / -ctime -1 >> change`. The prompt returns to `jin@DexterDesktop ~ $` with a green cursor.

```
192.168.0.212 - PuTTY
jin@DexterDesktop ~ $ find / -ctime -1 >> changed.txt 2>&1
^Z
[1]+  Stopped                  find / -ctime -1 >> change
d.txt 2>&1
jin@DexterDesktop ~ $ █
```

Utility : bg

- **bg**
 - **Reactivate a suspended program in the background.**



```
192.168.0.212 - PuTTY
jin@DexterDesktop ~ $ find / -ctime -1 >> changed.txt 2>&1
^Z
[1]+  Stopped                  find / -ctime -1 >> change
d.txt 2>&1
jin@DexterDesktop ~ $ bg
[1]+ find / -ctime -1 >> changed.txt 2>&1 &
jin@DexterDesktop ~ $
```

Utility : fg

- **fg**
 - Place a job in the foreground, and make it the current job.



```
192.168.0.212 - PuTTY
jin@DexterDesktop ~ $ find / -ctime -1 >> changed.txt 2>&1 &
[3] 17917
jin@DexterDesktop ~ $ fg
find / -ctime -1 >> changed.txt 2>&1
[3]-  Exit 1                  find / -ctime -1 >> change
d.txt 2>&1
jin@DexterDesktop ~ $
```