Software I: Utilities and Internals

Lecture 1 – UNIX for Beginners

What is UNIX?

- UNIX is a time-sharing operating system with user-chosen ***shells*** (user interfaces) and one ***kernel*** (operating system core, which allocates and control resources such as CPU time, memory and I/O devices).
- UNIX includes:
  - kernel
  - tools, including compilers, editors, etc.
  - shell, which includes its own programming language

What is LINUX?

- Linux is an open-source operating system, indirectly based on the last public release of UNIX.
- Linux is available in many different versions and different releases and is also closely associated with the GNU project, and through the GNU project has many tools comparable to those found in a UNIX distribution.

History of UNIX

- UNIX was developed at AT&T Bell Labs and is one of the first time-sharing operating systems.
- It was originally developed on a DEC PDP-7 and later redeveloped on a DEC PDP-11 in C, the first operating system written in a high-level language.
- It became popular at colleges and universities and later in the financial industry.

History of Linux

- Andrew Tanenbaum developed MINIX from the last public distribution of UNIX for use with his operating Systems textbook.
- When version 2 of MINIX was released, it was not well adapted for 32-bit processors. This inspired Linus Torsvald to begin work on what became Linux.
- Torsvald welcomed suggestions; this gave way to the community approach to software development that became a hallmark of Linux.

UNIX and Terminals

- Unix is ***full duplex*** – communications between computer and terminal goes in both directions simultaneously and the computer controls terminal display, using a process called **`echo`**.
- Example

```
echo hi there
hi there
```

Control Characters

- Control characters serve a special purpose, performing tasks that one character cannot normally do.
- These include:

RETURN (**^m**)	signifies end of line	**^i**	tab
^d	**EOF** (end of file)	**DELETE**	deletes the character to which the cursor points
^g	rings the bell	**BREAK**	stops a program immediately
^h	backspace		

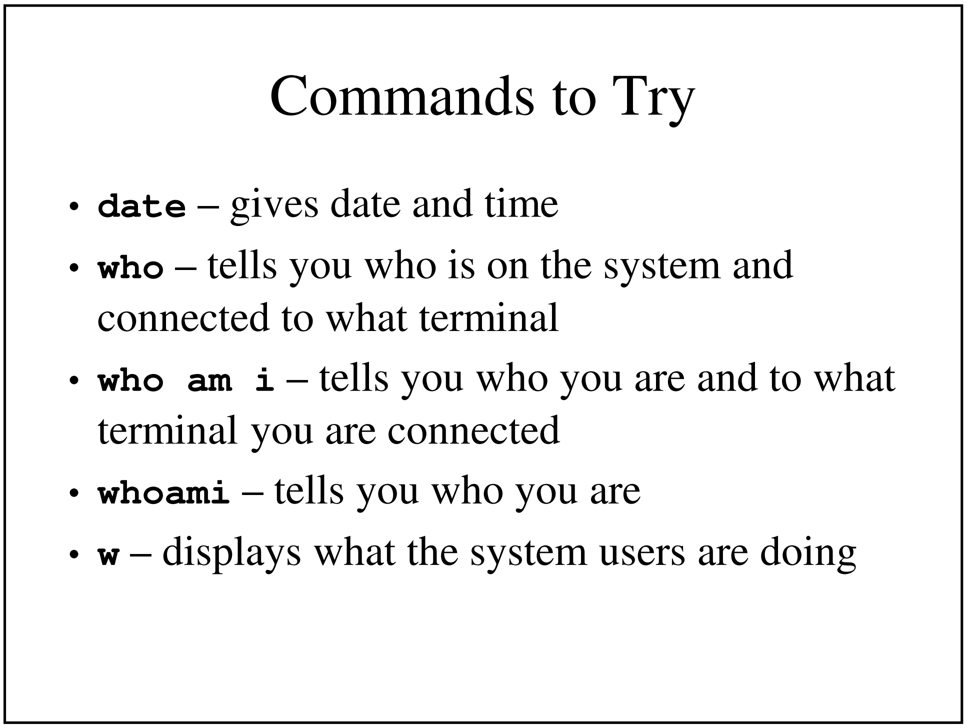
Logging In

motd (message of the day)

```
login: siegfrie
password:
login as: siegfrie
siegfrie@panther.adelphi.edu's password:
Last login: Tue Jun  9 10:05:55 2009 from pool-98-116-196-
   27.nycmny.fios.verizon.net

Welcome to Panther!
If you experience problems or have questions, please contact
   CustomerServices at 516.877.3340, email
   support@adelphi.edu, or visit us in the
Information Commons on the Second Floor of Swirbul Library.

** Reminder: Your Website is
   http://home.adelphi.edu/~siegfried

[SIEGFRIE@panther ~]$
```

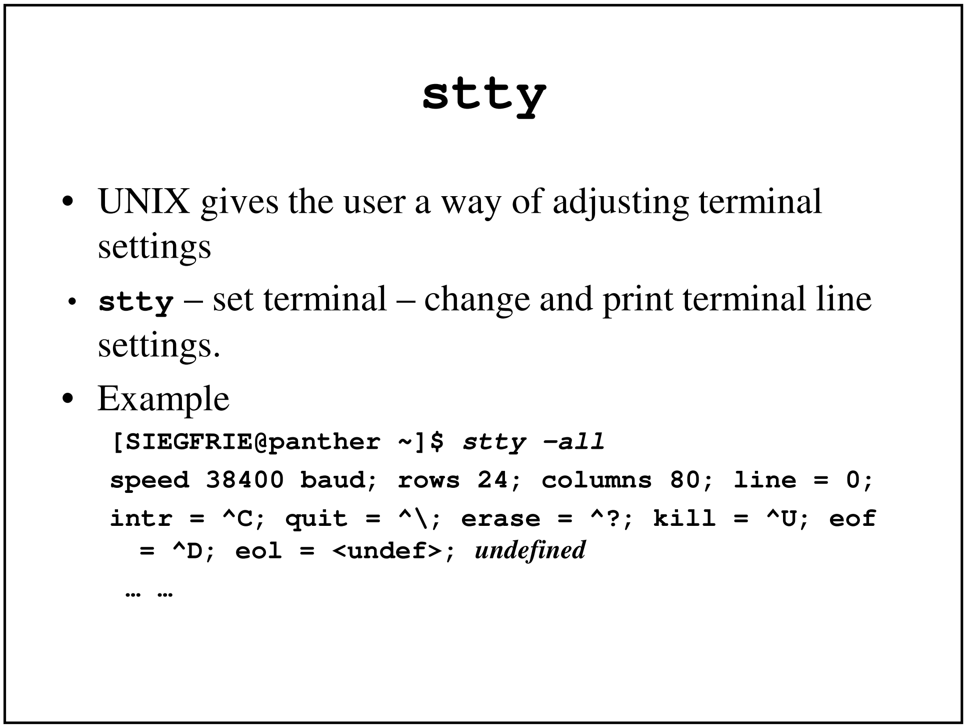
doesn't appear when you type

prompt



Commands to Try

- **`date`** – gives date and time
- **`who`** – tells you who is on the system and connected to what terminal
- **`who am i`** – tells you who you are and to what terminal you are connected
- **`whoami`** – tells you who you are
- **`w`** – displays what the system users are doing



`stty`

- UNIX gives the user a way of adjusting terminal settings
- **`stty`** – set terminal – change and print terminal line settings.
- Example

```
[SIEGFRIE@panther ~]$ stty -all
speed 38400 baud; rows 24; columns 80; line = 0;
intr = ^C; quit = ^\; erase = ^?; kill = ^U; eof
  = ^D; eol = <undef>; undefined
 … …
```

Standard Codes

intr	`^c`	Stops a program
erase	`^h`	backspaces
werase	`^w`	erases last word typed
kill	`^u`	kills the current input line
quit	`^\`	stops the program and saves core in a file
stop	`^s`	pause screen output
start	`^q`	resumes screen output
eof	`^d`	no more data
suspend	`^z`	temporarily stops (i.e., suspends) a program
resume	`^y`	resumes running a program

Type-ahead

- You can type as far ahead as you wish as long as you don't exceed the keyboard buffer's storage capacity.

Stopping A Program

- Programs can be stopped by pressing the **`Break`**, usually the **`^c`**.
- **`^z`** stops a program temporarily. You can restart it by pressing **`^y`** on most systems.

Don't logout without terminating suspended programs!

Logging Out

- You can log out by typing **`logout`** or **`exit`**. If you use the wrong one, the system will let you know.
- On some older systems, you can logout by simply typing **`^d`**.

write

```
$write SIEGFRIE

Message from SIEGFRIE@panther.adelphi.edu on pts/0
  at 13:54 ...
this is a test
this is a test
^d
EOF
[SIEGFRIE@panther ~]$
```

Online manual

- Most UNIX (and Linux) systems have an online manual that can be accessed by typing:

  `man` *commandname*
- Example

  `man who` *– shows the manual page on* **`who`**

  `man man` *– shows the manual page on* **`man`**

Files and File-Oriented Commands

- A great deal of work on the system involves files (data moving into or out of the computer), which makes file-oriented commands particularly important.
- File commands include:
  - **`vi`**, **`ex`**, **`ed`** – file editors
  - **`cat`**, **`pr`** – printing and display commands
  - **`mv`**, **`cp`**, **`rm`** – file manipulation commands
  - **`grep`**, **`sort`**, **`diff`**, **`tail`** - filters

Text editors

- There are 3 text editors that we will concern ourselves with:
  - **`ed`** – the original line-oriented editor
  - **`ex`** – the extended line-oriented editor
  - **`vi`** – visual editor (screen-oriented)

A Sample **ed** Session

```
$ed
a           add text
…
type lots of stuff
…
.           ends adding text
w junk      write text to a file called junk
39          number of characters saved
q           quit
```

Changing A File

```
[SIEGFRIE@panther ~]$ ed junk
junk: No such file or directory
a
To be or not to be
.
a
That is the question
.
p
That is the question
1,$p
To be or not to be
That is the question
```

Changing A File (continued)

```
s/the/The/
1,$p
To be or not to be
That is The question
w
40
q
[SIEGFRIE@panther ~]$
```

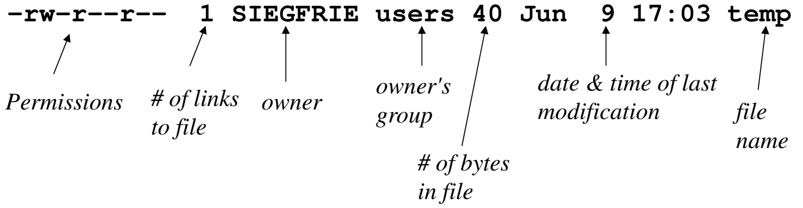
`ls` – Listing Files

```
[SIEGFRIE@panther bbb]$ ls
junk  temp
[SIEGFRIE@panther bbb]$ ls -l
total 8
-rw-r--r--  1 SIEGFRIE users 40 Jun  9 16:49 junk
-rw-r--r--  1 SIEGFRIE users 40 Jun  9 17:03 temp
[SIEGFRIE@panther bbb]$ ls -t
temp  junk
[SIEGFRIE@panther bbb]$ ls -l -t
total 8
-rw-r--r--  1 SIEGFRIE users 40 Jun  9 17:03 temp
-rw-r--r--  1 SIEGFRIE users 40 Jun  9 16:49 junk
[SIEGFRIE@panther bbb]$ ls -lt
total 8
-rw-r--r--  1 SIEGFRIE users 40 Jun  9 17:03 temp
-rw-r--r--  1 SIEGFRIE users 40 Jun  9 16:49 junk
[SIEGFRIE@panther bbb]$
```

ls – l

- **ls -l** – provides a long listing of the files

```
[SIEGFRIE@panther bbb]$ ls -l          long listing
total 8
-rw-r--r--  1 SIEGFRIE users 40 Jun  9 16:49 junk
-rw-r--r--  1 SIEGFRIE users 40 Jun  9 17:03 temp
```



Permissions

# of links to file

owner

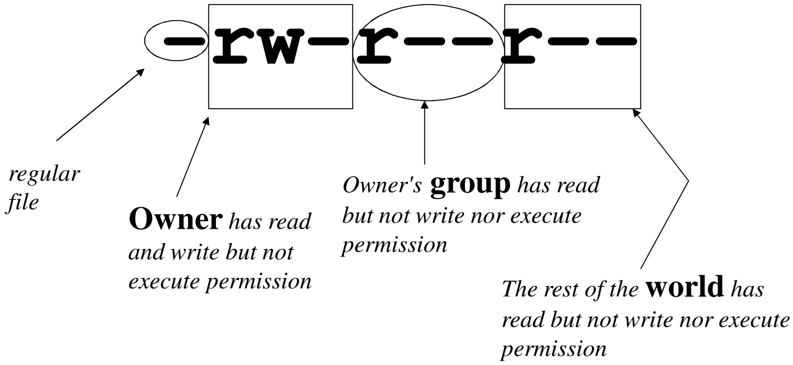
owner's group

# of bytes in file

date & time of last modification

file name

Permission



regular file

Owner *has read and write but not execute permission*

Owner's **group** *has read but not write nor execute permission*

The rest of the **world** *has read but not write nor execute permission*

cat – Displaying a File

```
[SIEGFRIE@panther bbb]$ cat temp
To be or not to be
[SIEGFRIE@panther bbb]$ cat junk
That is The question
[SIEGFRIE@panther bbb]$ cat temp junk
To be or not to be
That is The question
[SIEGFRIE@panther bbb]$
```

pr

- **pr** displays files in format suitable for printing.
- **pr -*n*** display the file in *n*-column format for printing.

- Different systems have different commands for printer access. **lp** is a very common command.

mv, **cp** and **rm**

- **mv** – move (or rename) a file
- **cp** – copy a file
- **rm** – remove (or delete) a file

mv, **cp** and **rm** – An Example

```
[SIEGFRIE@panther bbb]$ ls
junk  temp
[SIEGFRIE@panther bbb]$ mv junk precious
[SIEGFRIE@panther bbb]$ ls
precious  temp
[SIEGFRIE@panther bbb]$ cp precious junk
[SIEGFRIE@panther bbb]$ ls
junk  precious  temp
[SIEGFRIE@panther bbb]$ rm precious
[SIEGFRIE@panther bbb]$ ls
junk  temp
[SIEGFRIE@panther bbb]$
```

Rules Governing File Names

- Older systems may limit names to 14 characters.
- UNIX is case-sensitive; **`junk`**, **`Junk`** and **`JUNK`** are three different files.
- File names should not (but unfortunately can) include unprintable characters (like escape characters) or characters with special meanings.
  - E.g., how would you print the file **`-t`**?

A Few Helpful File Processing Commands

- There are several file processing commands that will become useful:

`wc`	word count
`grep`	general regular expression program – recognizes text within a file.
`sort`	sorts lines of text within a file.
`tail`	prints the last line(s) of text within a file.
`cmp`	compares two files, printing the first pair of lines that differ.
`diff`	compares two files, printing each pair of liens that differ.

wc – Word Count

```
[SIEGFRIE@panther bbb]$ ed
a
Great fleas have little fleas
 upon their backs to bite 'em
And little fleas have lesser fleas
 and so on ad infinitum.
And the great fleas themselves, in turn,
 have greater fleas to go on;
While these again have greater still,
 and great still and so on.
.
w poem
257
```

```
3p
And little fleas have lesser fleas
s/lesser fleas/lesser fleas,/
p
And little fleas have lesser fleas,
w
258
q
[SIEGFRIE@panther bbb]$ wc poem
  8  47 258 poem
[SIEGFRIE@panther bbb]$
```

grep

```
[SIEGFRIE@panther bbb]$ grep fleas poem
Great fleas have little fleas
And little fleas have lesser fleas,
And the great fleas themselves, in turn,
 have greater fleas to go on;

[SIEGFRIE@panther bbb]$ grep -v fleas poem
 upon their backs to bite 'em
 and so on ad infinitum.
While these again have greater still,
 and great still and so on.
```

sort

```
[SIEGFRIE@panther bbb]$ sort poem
 and great still and so on.
And little fleas have lesser fleas,
 and so on ad infinitum.
And the great fleas themselves, in turn,
Great fleas have little fleas
 have greater fleas to go on;
```

cmp

```
[SIEGFRIE@panther bbb]$ cat newpoem
Great fleas have little fleas
 upon their backs to bite them
And little fleas have lesser fleas,
 and so til ad infinitum.
And the great fleas themselves, in turn,
 have greater fleas to go on;
While these again have greater still,
 and great still and so on.

[SIEGFRIE@panther bbb]$ cmp poem newpoem
poem newpoem differ: byte 57, line 2
```

tail

```
[SIEGFRIE@panther bbb]$ tail -1 poem
 and great still and so on.
[SIEGFRIE@panther bbb]$ tail +3 poem
And little fleas have lesser fleas,
 and so on ad infinitum.
And the great fleas themselves, in turn,
 have greater fleas to go on;
While these again have greater still,
 and great still and so on.
[SIEGFRIE@panther bbb]$
```

diff

```
[SIEGFRIE@panther bbb]$ diff poem newpoem
2c2
<  upon their backs to bite 'em
---
>  upon their backs to bite them
4c4
<  and so on ad infinitum.
---
>  and so til ad infinitum.
[SIEGFRIE@panther bbb]$
```

Command Summary

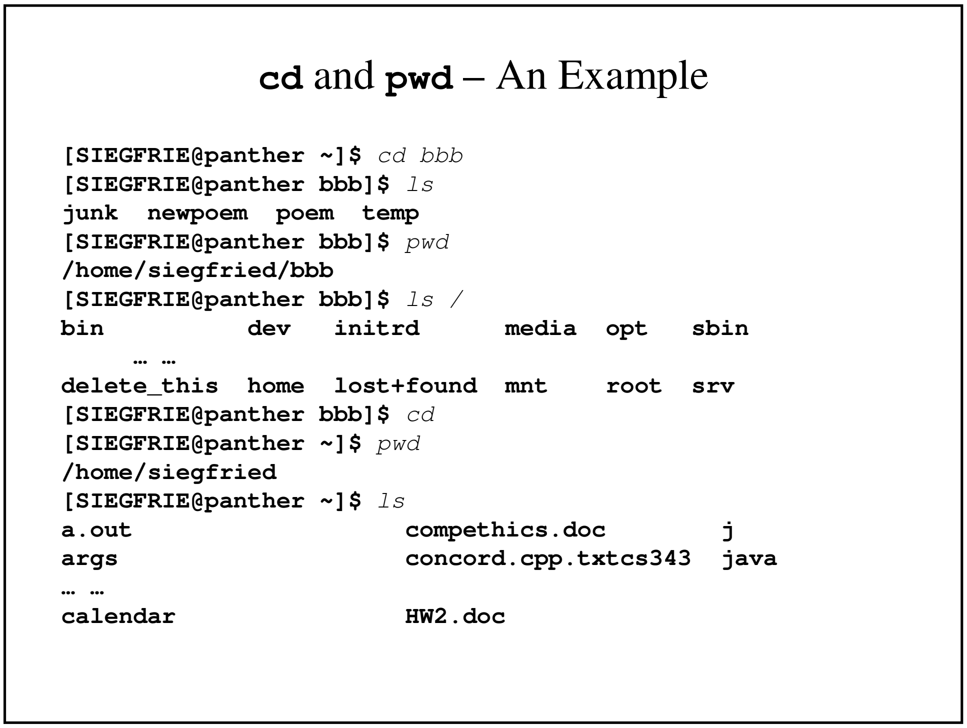
`ls`	list filenames in current directory
`ls` *filenames*	lists only these files
`ls -t`	lists in reverse chronological order
`ls -l`	long listing
`ls -u`	list by last time used
`ls -r`	list in reverse order
`ed` *filename*	edit a file listed by name
`cp` *file1 file2*	copy *file1* to *file2*
`mv` *file1 file2*	move (or rename) *file1* to *file2*
`rm` *filenames*	delete these files

Command Summary

`cat` *filename(s)*	display file contents
`pr` *filename(s)*	display and format file contents
`pr` *–n filename(s)*	display and format file contents in *n* columns
`pr -m` *filename(s)*	display files side by side
`wc` *filename(s)*	count words and bytes for these files
`wc -l` *filename(s)*	count lines for these files
`grep` *pattern filename(s)*	print lines containing the pattern
`grep -v` *pattern filename(s)*	print lines not containing the pattern
`cmp` *file1 file2*	print line of first difference
`diff file1` *file2*	print each pair of differing lines

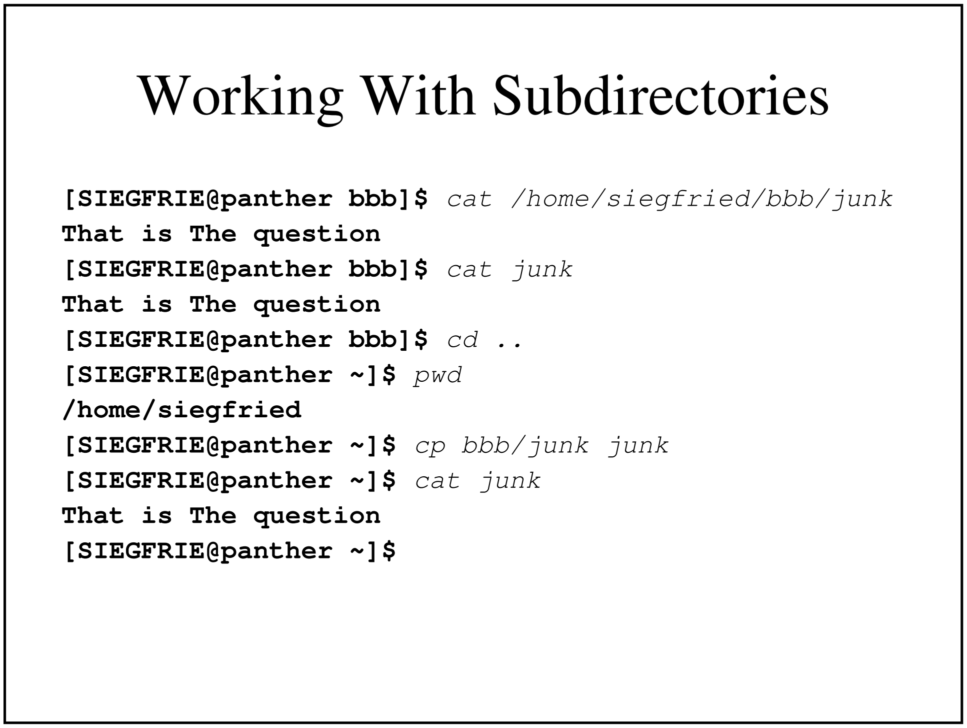
Directories

- The system knows how to distinguish between different files with the same name by recognizing that they are listed in ***different directories***.
- Each user has his/her own directory, which can be divided into subdirectories by the user.
- You can use the **`cd`** (***c***hange ***d***irectory) command to switch between different directories and **`pwd`** (***p***rint ***w***orking ***d***irectory) to display the current directory being used.



cd and **pwd** – An Example

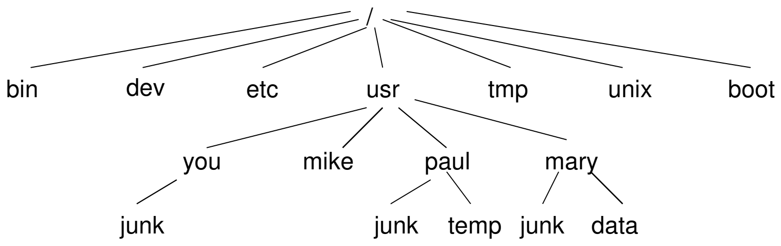
```
[SIEGFRIE@panther ~]$ cd bbb
[SIEGFRIE@panther bbb]$ ls
junk  newpoem  poem  temp
[SIEGFRIE@panther bbb]$ pwd
/home/siegfried/bbb
[SIEGFRIE@panther bbb]$ ls /
bin          dev   initrd      media  opt   sbin
     … …
delete_this  home  lost+found  mnt    root  srv
[SIEGFRIE@panther bbb]$ cd
[SIEGFRIE@panther ~]$ pwd
/home/siegfried
[SIEGFRIE@panther ~]$ ls
a.out                   compethics.doc        j
args                    concord.cpp.txtcs343  java
… …
calendar                HW2.doc
```



Working With Subdirectories

```
[SIEGFRIE@panther bbb]$ cat /home/siegfried/bbb/junk
That is The question
[SIEGFRIE@panther bbb]$ cat junk
That is The question
[SIEGFRIE@panther bbb]$ cd ..
[SIEGFRIE@panther ~]$ pwd
/home/siegfried
[SIEGFRIE@panther ~]$ cp bbb/junk junk
[SIEGFRIE@panther ~]$ cat junk
That is The question
[SIEGFRIE@panther ~]$
```

A Sample File System



More Work With Subdirectories

```
[SIEGFRIE@panther home]$ ls /bin
alsaunmute     date           grep      mkdir
  … …
gettext        mailx          rm          tracepath
[SIEGFRIE@panther home]$ ls /usr/bin
[                       4odb
4rdf                    4ss
… …
ktip                    znew
ktradertest             zsoelim
[SIEGFRIE@panther home]$ /bin/date
Wed Jun 10 10:40:44 EDT 2009
[SIEGFRIE@panther home]$ /bin/who
-bash: /bin/who: No such file or directory
[SIEGFRIE@panther home]$
```

Creating and Deleting Subdirectories

```
[SIEGFRIE@panther bbb]$ mkdir book
[SIEGFRIE@panther bbb]$ cd book
[SIEGFRIE@panther book]$ pwd
/home/siegfried/bbb/book
[SIEGFRIE@panther book]$ cd
[SIEGFRIE@panther ~]$ pwd
/home/siegfried
[SIEGFRIE@panther ~]$ ls bbb
book  junk  newpoem  poem  temp
[SIEGFRIE@panther ~]$ rmdir bbb/book
[SIEGFRIE@panther ~]$ ls bbb
junk  newpoem  poem  temp
[SIEGFRIE@panther ~]$
```

The Shell

- The shell is another name for the command interpreter, which runs all the commands that we type in a session on a UNIX (or Linux) system.
- It provides 3 benefits:
  - File name shorthands - a whole bunch of files specified using wild card characters, can be specified at one.
  - Input-output redirection – a file can replace either keyboard or screen or both.
  - You can personalize your environment.

Shorthands

- Imagine that every chapter section is a separate file **`ch1.1`**, **`ch1.2`**, **`ch1.3`**, … **`ch2.1`**, **`ch2.2`**

  We can print them by typing

  ```
  pr ch1.1 ch1.2 ch1.3 … ch2.1 ch2.2
  ```

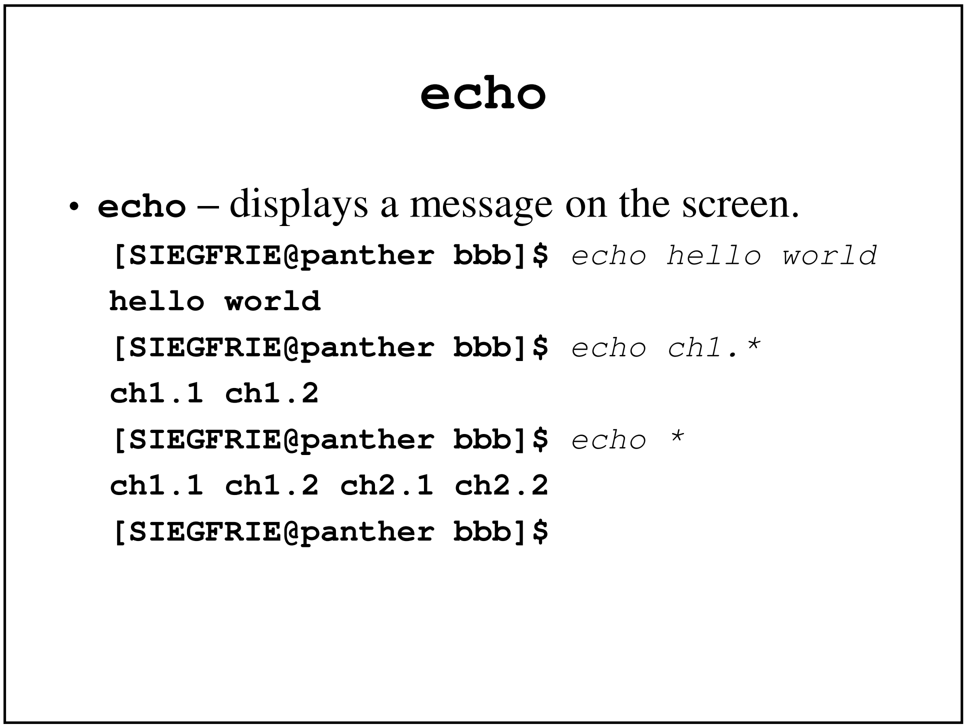
or

```
pr ch*
```

- **`wc ch1.*`** gives us a count of characters, words and lines for all the sections of chapter 1.

Shorthands – An Example

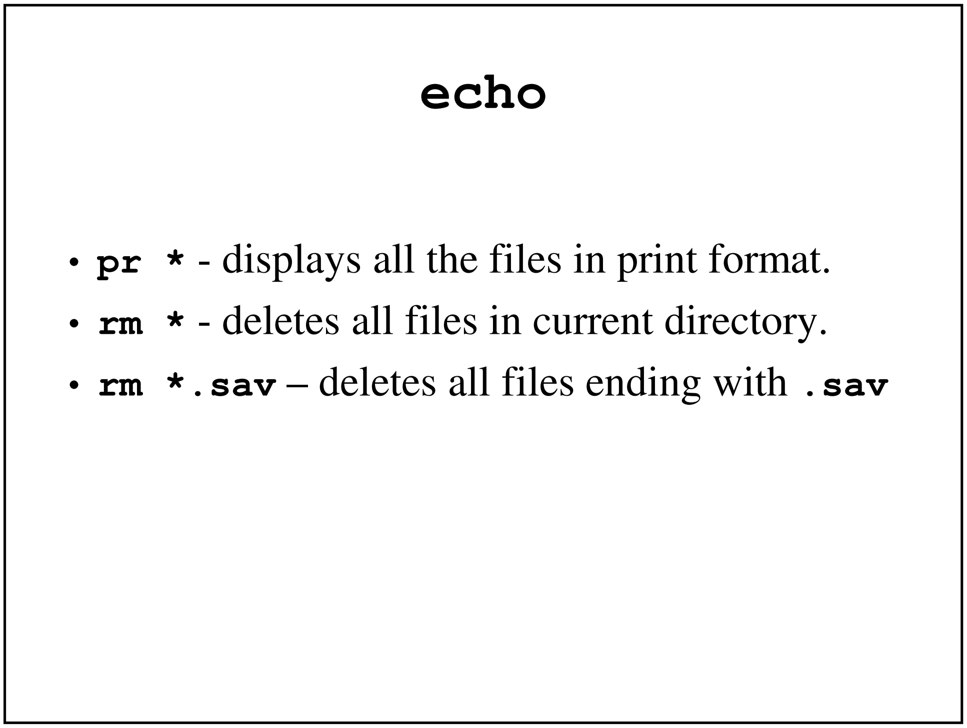
```
[SIEGFRIE@panther bbb]$ wc ch*
  1   4  21 ch1.1
  8  47 260 ch1.2
  8  47 258 ch2.1
  1   6  19 ch2.2
 18 104 558 total
[SIEGFRIE@panther bbb]$
```



echo

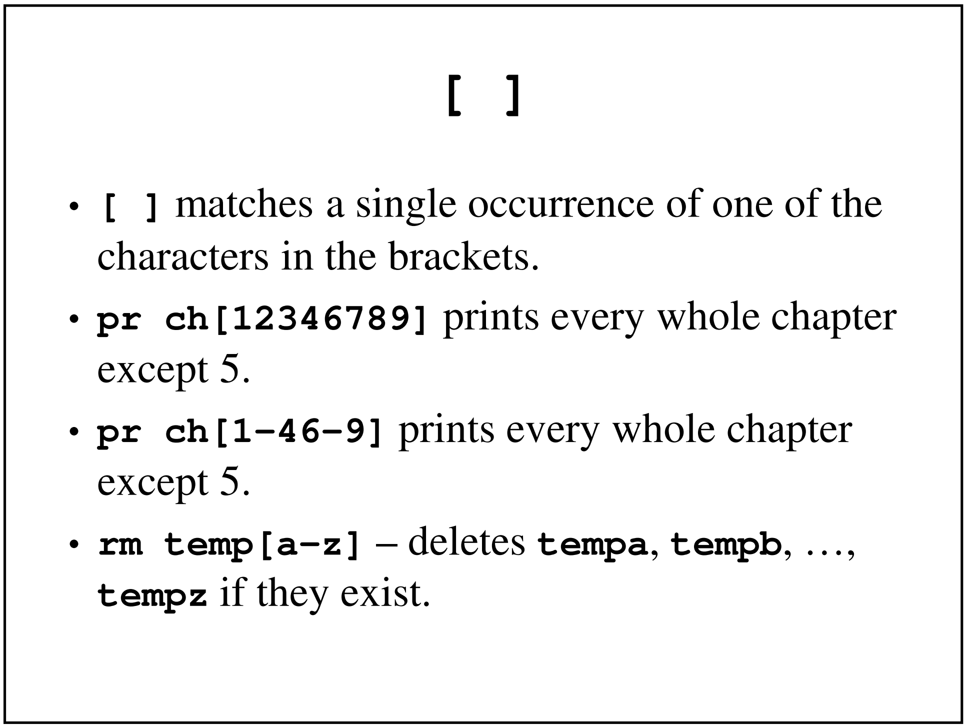
- **echo** – displays a message on the screen.

```
[SIEGFRIE@panther bbb]$ echo hello world
hello world
[SIEGFRIE@panther bbb]$ echo ch1.*
ch1.1 ch1.2
[SIEGFRIE@panther bbb]$ echo *
ch1.1 ch1.2 ch2.1 ch2.2
[SIEGFRIE@panther bbb]$
```



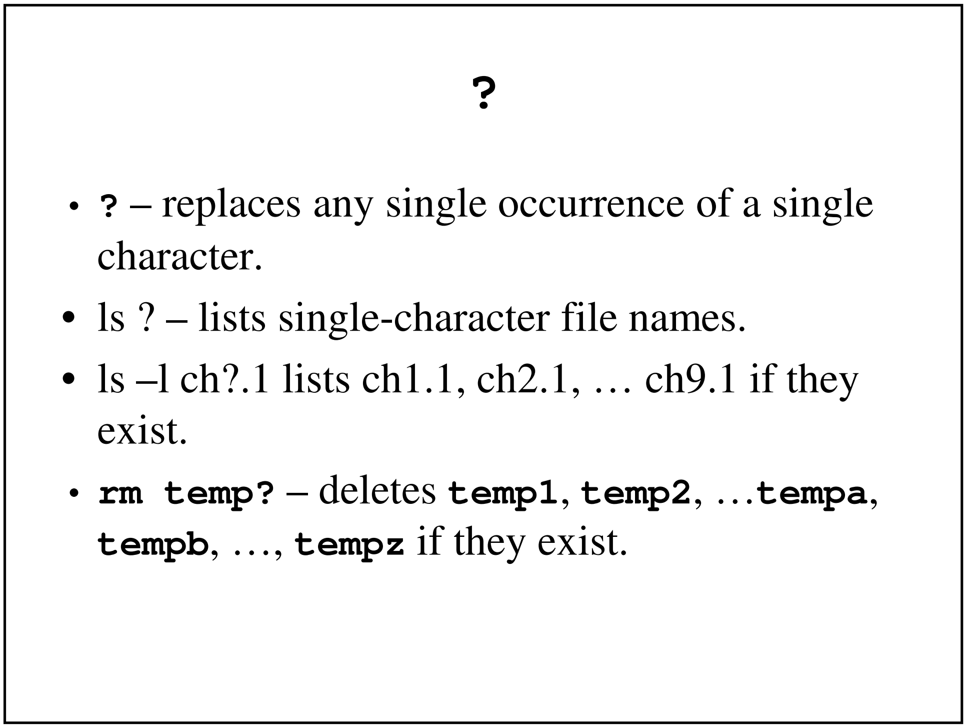
echo

- **pr *** - displays all the files in print format.
- **rm *** - deletes all files in current directory.
- **rm *.sav** – deletes all files ending with **.sav**



[ ]

- **[ ]** matches a single occurrence of one of the characters in the brackets.
- **pr ch[12346789]** prints every whole chapter except 5.
- **pr ch[1-46-9]** prints every whole chapter except 5.
- **rm temp[a-z]** – deletes **tempa**, **tempb**, …, **tempz** if they exist.



?

- **?** – replaces any single occurrence of a single character.
- ls ? – lists single-character file names.
- ls –l ch?.1 lists ch1.1, ch2.1, … ch9.1 if they exist.
- **rm temp?** – deletes **temp1**, **temp2**, …**tempa**, **tempb**, …, **tempz** if they exist.

Final Word on Metacharacters

- All file names must exist for the metacharacters to be used:

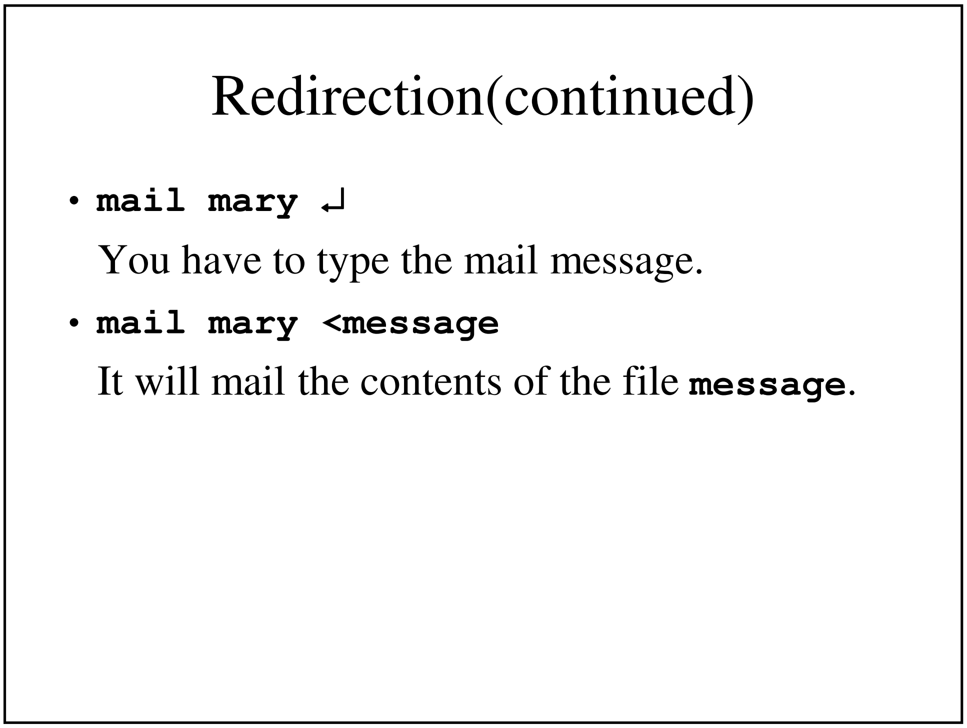
```
mv      ch.* chapter.*
```

Won’t work because the `chapter` files don't already exist.

- Metacharacters also can match other names in the path, e.g., `usr/*/calendar`.
- How do you use a file name that has a metachracter in it?
- `ls '?'` or `ls \?`

Redirection

- Redirection replaces standard input (or standard output) with a file.
- `ls` – lists the files in the directory on the screen.
- `ls > filelist` – creates a file containing the directory listing
- `cat f1 f2 f3 >temp` – places the files' contents in a file called temp. If the file already exists, it is overwritten.
- `cat f1 f2 f3 >temp` – places the files' contents in a file called temp. If the file already exists, the output is placed at the end.

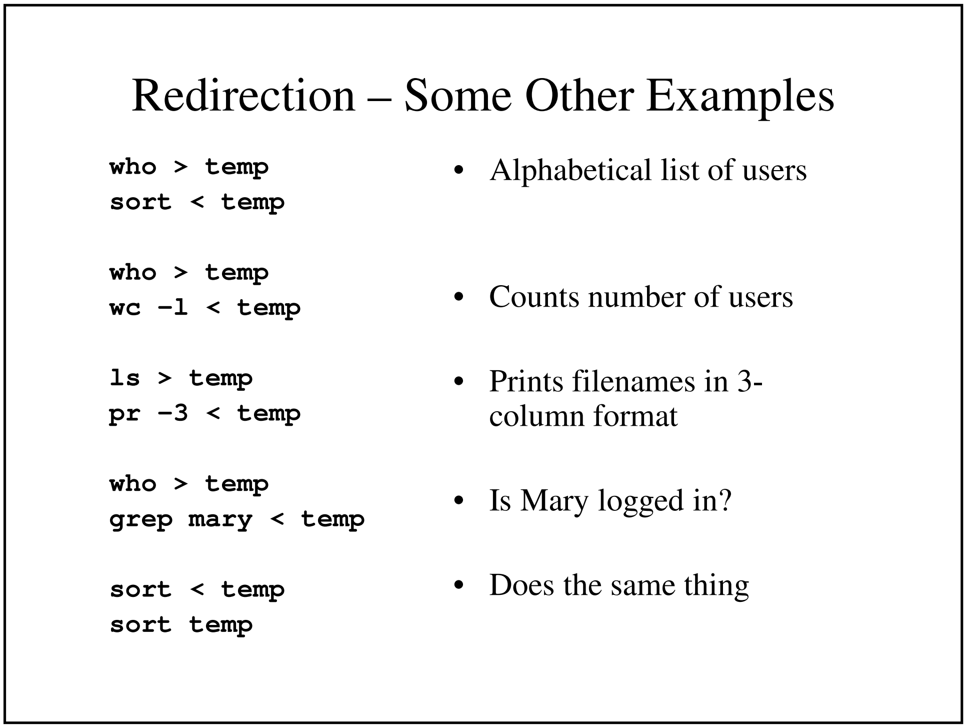


Redirection(continued)

- **`mail mary`** ↲

  You have to type the mail message.
- **`mail mary <message`**

  It will mail the contents of the file **`message`**.



Redirection – Some Other Examples

`who > temp`
`sort < temp`
	• Alphabetical list of users

`who > temp`
`wc -l < temp`
	• Counts number of users

`ls > temp`
`pr -3 < temp`
	• Prints filenames in 3-column format

`who > temp`
`grep mary < temp`
	• Is Mary logged in?

`sort < temp`
`sort temp`
	• Does the same thing

Using **`sort`** Without A File

```
[SIEGFRIE@panther bbb]$ sort
def
ijk
abc
^d
abc
def
ijk
[SIEGFRIE@panther bbb]$
```

Pipes

- We don’t need to use temporary files the way we did before.

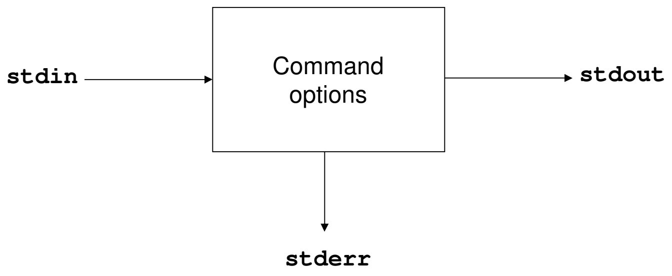
```
who | sort
who | wc -l
ls | wc -l
ls | pr -3
who | grep mary
```

- Any program reading the keyboard and displaying on the screen can use a pipe (`|`)"

```
who | grep mary | wc -l
```

How many times did Mary log in?

Normal Flow of Data



stdin

Command options

stdout

stderr

Processes

- A process is the act of running a program
- Proper use of the shell will allow you to run 2 processes with one command:

```
[SIEGFRIE@panther bbb]$ date;who
Wed Jun 10 19:11:11 EDT 2009
SIEGFRIE pts/0        Jun 10 10:07 (pool… … .net)
[SIEGFRIE@panther bbb]$
```

Background Processes

- Proper use of the shell will allow you to run 2 processes concurrently:

Run in the background

```
[SIEGFRIE@panther bbb]$wc ch* > wc.out &
[1] 12909
[SIEGFRIE@panther bbb]$ cat wc.out
  1   4  21 ch1.1
  8  47 260 ch1.2
  8  47 258 ch2.1
  1   6  19 ch2.2
 18 104 558 total
[1]+  Done                    wc ch* >wc.out
[SIEGFRIE@panther bbb]$
```

Pipes and Background Processes

```
pr ch* | lp &
6951
$wait
kill -9 6944
```

Applies to the whole pipe

Waits until all the processes are finished

Kills the lp process

ps

- **ps** – process status

```
[SIEGFRIE@panther bbb]$ ps ag
  PID TTY      STAT   TIME COMMAND
 6660 tty1     Ss+    0:00 /sbin/mingetty tty1
 6661 tty2     Ss+    0:00 /sbin/mingetty tty2
 6662 tty3     Ss+    0:00 /sbin/mingetty tty3
 6663 tty4     Ss+    0:00 /sbin/mingetty tty4
 6664 tty5     Ss+    0:00 /sbin/mingetty tty5
 6665 tty6     Ss+    0:00 /sbin/mingetty tty6
12115 pts/0    Ss     0:00 -bash
12944 pts/0    R+     0:00 ps ag
[SIEGFRIE@panther bbb]$
```

Creating Processes

- Processes can create processes.
- If a process is running, in the background when you log out, it will terminate unless you wrote **nohup** (no hang-up).

```
nohup command &
```

- Output is saved in the file nohup.out

nice *expensive-command* – cuts the process's priority