CS395T: Introduction to Scientific and Technical Computing

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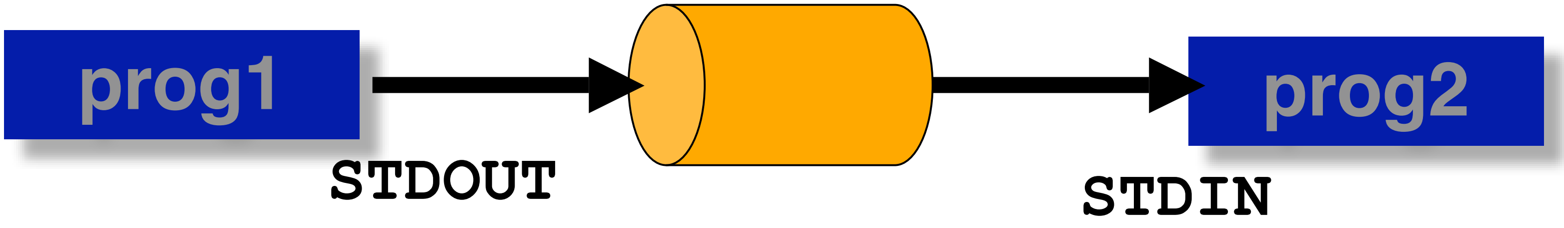
Outline

- Continue with Unix overview
  - Unix pipes
  - Job control
  - Environment Variables
  - Editors
  - Shell Arithmetic
  - Shell scripting

Unix Pipes

- A pipe is a holder for a stream of data
- A Unix **pipeline** is a set of processes chained by their standard streams, so that the output of each process (*stdout*) feeds directly as input (*stdin*) of the next one
- This is handy for using multiple unix commands together to perform a task



Building Commands

- More complicated commands can be built up by using one or more pipes
- Use the "|" character to *pipe* two commands together
- The shell takes care of all the hard work for you
- Example:

```
> cat apple.txt
core
worm seed
jewel

> cat apple.txt | wc
3 4 21
```

Note: the wc command prints the number of newlines, words, and bytes in a file

Job Control

- **The shell allows you to manage *jobs***
  - place jobs in the *background*
  - move a job to the *foreground*
  - suspend a job
  - kill a job
- If you follow a command line with "&", the shell will run the *job* in the background
  - this is you useful if you don't want to wait for the job to complete
  - you can type in a new command right away
  - you can have a bunch of jobs running at once

```
> cat foo | sort | uniq > saved_sort &
```

Background jobs

- Handy for programs you need throughout a session: **`emacs &`**
- For commands that take a lot of time:

```
make all &> make.out &
```

- If the job will run longer than your session:

```
nohup make all &> make.out &
```

Listing Your Jobs

- The command *jobs* will list all background jobs:

```
> jobs
[1] Running  cat foo | sort | uniq >
saved_ls &
```

- The shell assigns a number to each job (in this case, the job number is 1)

Managing Jobs

- You can *kill* the foreground job by pressing ^C (Ctrl-C).
- You can also kill a job in the background using the *kill* command (and the appropriate job index)

```
> kill %1
```

Note: it's important to include the "%" sign to reference a job number.

Moving Jobs between fore/background

- Turn a foreground process into background:
  - Use ^-Z to suspend the command
  - Use the **bg** command to send the job to the background

```
> sleep 60
Suspended
> jobs
[1]  + Suspended                     sleep 60
> bg
[1]    sleep 60 &
> jobs
[1]    Running                       sleep 60
```

- The `fg` command will move a job to the foreground.
  - You give `fg` a job number (as reported by the `jobs` command)

```
> jobs
[1] Stopped         ls -lR > saved_ls &
> fg %1
ls -lR > saved_ls
```

Unix Environment Variables

- Unix shells maintain a list of environment variables which have a unique name and a value associated with them
  - some of these parameters determine the behavior of the shell
  - also determine which programs get run when commands are entered (and which libraries they link against)
  - provide information about the execution environment to programs
- We can access these variables:
  - set new values to customize the shell
  - find out the value of some to help accomplish a task

Environment Variables

- To view environment variables, use the env command

- If you know what you are looking for, you can use your new friend grep:

```
> env | grep PWD
PWD=/home/karl
```

- Use the echo command to print variables; the “$” prefix is required to access the value of the variable:

```
> echo $PWD
/tmp
```

- Can also use environment variables in arbitrary commands:

```
Koomie@canyon--> ls $PWD
foo1  foo2
```

Special Environment Variable: PATH

- Each time you provide the shell a command to execute, it does the following:
  - Checks to see if the command is a built-in shell command
  - If it is not a build-in command, the shell tries to find a program whose name matches the desired command

- How does the shell know where to look on the filesystem?

- The **`PATH`** variable tells the shell where to search for programs (non built-in commands)

Special Environment Variable: PATH

- Example PATH Definition:

```
-> echo $PATH
/home/karl/bin/krb5:/opt/intel/compiler70/ia32/bi
n:/home/karl/bin:/usr/local/apps/mpich/icc/bin:/u
sr/kerberos/bin:/usr/local/bin:/bin:/usr/bin:/usr
/X11R6/bin
```

- The **`PATH`** is a list of directories delimited by colons (":“)
  - It defines a list and *search order*
  - Directories specified earlier in the **`PATH`** take precedent; once the matching command is found, the search terminates

- You can add more search directories to your PATH by changing the shell startup files
  - `BASH: export PATH="$PATH":/home/karl/bin`
  - `TCSH: set path = (/home/karl/bin $path)`

Other Important Variables

PWD	*current working directory*
MANPATH	*determines where to find man pages*
HOME	*home directory of user*
MAIL	*where your email is stored*
TERM	*what kind of terminal you have*
PRINTER	*specifies the default printer name*
EDITOR	*used by many applications to identify your choice of editors (eg. vi or emacs)*
LD_LIBRARY_PATH	*specifies a search path for dynamic runtime libraries*

Setting Environment Variables

- The syntax for setting Unix environment variables depends on your shell:
  - **BASH**: use the *export* command
    ```
    > export PRINTER=scully
    > echo $PRINTER
    scully
    ```
  - **TCSH**: use the *setenv* command
    ```
    > setenv PRINTER mulder
    > echo $PRINTER
    mulder
    ```

- Note: environment variables that you set interactively are only available in your current shell
  - If you spawn a new shell (or login again), these settings will be lost
  - To make permanent changes, you should alter the login scripts that affect your particular shell (eg. *.login, .profile, .cshrc, etc...)*

Modules on TACC computers

- TACC machines control software through the ‘module’ command, which changes the environment.
- module load mkl ; env | grep MKL
- module unload mkl

Text Editors

Text Editors

- For programming, we need to make use of available Unix text editors
- The two most popular and available editors are *vi* and *emacs*
- You should familiarize yourself with at least one of the two (*and this let's you enter into the editor wars which is a never-ending debate in the programming community)*
- We will have very short introductions to each....

Brief history of Unix text editors

- **`ed`** : line mode editor
- **`ex`** : extended version of **`ed`**
- **`vi`** : full screen version of **`ex`**
- **`emacs`** : extremely powerful, nothing like the above
- **`ed/ex/vi`** share lots of syntax, which also comes back in **`sed/awk`**: useful to know.

Vi Overview

- Fundamental thing to remember about vi is that it has two different modes of operation:
  - *Insert* Mode
  - *Command* mode
- The *insert* mode puts anything typed on the keyboard into the current file
- The *command* mode allows the entry of commands to manipulate text. These commands are usually one or two characters long, and can be entered with few keystrokes
- Note that vi starts out in the *command* mode by default

Vi Overview

- Quick Start Commands
  - > **vi**
  - Press i to enable insert mode
  - Type text (*use arrow keys to move around*)
  - Press Esc to enable command mode
  - Press :w <filename> to save the file
  - Press :q to exit vi

Useful vi commands

- :q! – exit without saving the document. Very handy for beginners
- :wq – save and exit
- / <string> – search within the document for text. n goes to next result
- dd – delete the current line
- yy – copy the current line
- p – paste the last cut/deleted line
- :1 – goto first line in the file
- :$ - goto last line in the file
- $ – end of current line, ^ – beginning of line
- % – show matching brace, bracket, parentheses

Additional vi References

- http://www.eng.hawaii.edu/Tutor/vi.html
- http://staff.washington.edu/rells/R110/
- Vi Commands Reference card: http://tnerual.eriogerg.free.fr/vimqrc.pdf

Emacs Overview

- Programmer friendly modes for common languages (C/C++, Fortran, shell scripts, etc)
- Different from vi in that emacs has only one-main mode
- Lots of commands and extremely customizable (using LISP)
- Includes some very sophisticated features if you take the time to learn them:
  - Compile your executables within emacs
  - Interact with your revision control process (eg. CVS)
  - Control RPM software builds
  - Debug your application using gdb

Emacs Overview

- *> emacs myfile opens myfile for editing*
- *Type whatever text you like (use arrow keys to navigate)*
- *C-x C-s (control + x, control + s) – saves the file*
- C-g exits the current command
- C-x u - Undo
- *C-x C-c exit after saving*

Additional Emacs References

- http://www.lib.uchicago.edu/keith/tcl-course/emacs-tutorial.html
- http://www.stolaf.edu/people/humke/UNIX/emacs-tutorial.html
- Emacs includes its own on-line tutorial; to run issue the following:
  - *> emacs*
  - Then, enter “C-h t”, to invoke the on-line emacs tutorial (*that’s a “Control-h”, followed by a “t”*)

Unix tool: sed

- Stream editor: editor commands applied to an input file or stream, giving an output stream

```
%% cat 123
1 one
2 word
3 is is
4 enough
5 words
%% sed s/word/picture/ 123
1 one
2 picture
3 is is
4 enough
5 pictures
%% sed 2,4s/word/picture/ 123
1 one
2 picture
3 is is
4 enough
5 words
%% sed -e 's/word/picture/' -e 's/is$/often/' 123
1 one
2 picture
3 is often
4 enough
5 pictures
%%
```

Unix tool: awk

- Pattern/action pairs, applied successively to each line

```
[albook:~/tst] %% cat awk.in
C from file1.f
        subroutine foo
        call something
        end
C from file2.f
        subroutine bar
        call something(else)
        end
```

```
%% awk '{print $0}' awk.in
C from file1.f
        subroutine foo
        call something
        end
C from file2.f
        subroutine bar
        call something(else)
        end
%% awk '{print $1}' awk.in
C
subroutine
call
end
C
subroutine
call
end
%% awk '/subroutine/ {print $2}' awk.in
foo
bar
```

Awk programs

```
%% awk '/subroutine/ {count=count+1 ; print "Subroutine " count ":" $2}' \
       awk.in
Subroutine 1:foo
Subroutine 2:bar
%% awk '/^C from/ {file=$3} \
       /subroutine/ {count=count+1 ; \
                     print "Subroutine " count ":" $2 ", from file " file}' \
       awk.in
Subroutine 1:foo, from file file1.f
Subroutine 2:bar, from file file2.f
```

Unix Scripting

- Scripting is “easy” - you just place all the Unix commands in a file as opposed to typing them interactively

- Handy for automating certain tasks:
  - staging your scientific applications
  - performing limited post-processing operations
  - any repetitive operations on files, etc...

- Shells provide basic control syntax for looping, if constructs, etc...

Unix Scripting

- Shell scripts must begin with a specific line to indicate which shell should be used to execute the remaining commands in the file:
  - BASH:
    ```
    #!/bin/bash
    ```
  - TCSH
    ```
    #!/bin/tcsh
    ```
- Comment lines can be included if they start with #
- In order to run a shell-script, it must have execute permission. Consider the following script:

```
> cat hello.sh
#!/bin/bash
echo “hello world”

> ./hello.sh
./hello.sh: Permission denied.

> chmod 700 hello.sh
> ./hello.sh
hello world
```

Unix Scripting: Arithmetic Operations

- Simple arithmetic syntax depends on the shell:
  - **TCSH**

    ```
    set i1=10
    set j1=3
    @ k1 = $i1 + $j1   # Note space between @ and k1
    echo "The sum of $i1 and $j1 is $k1”
    ```

  - BASH

    ```
    i1=2
    j1=6
    k1=$(($i1*$j1))
    echo "The multiple of $i1 and $j1 is $k1”
    ```

- Note, you can also use the `expr` command (for both shells). For example:
  - **TCSH:** `set z=`expr $i1 + $j1``
  - **BASH:** `z=`expr $i1 + $j1``

consult man page on
`expr` ***for more details***

Unix Scripting: Conditionals

- **Syntax for conditional expressions depends on your choice of shell:**

- **BASH (general format):**

```
if [ condition_A ]; then
        code to run if condition_A true
elif [ condition_B ]; then
        code to run if condition_A false and
        condition_B true
else
        code to run if both conditions false
fi
```

- **TCSH (general format):**

```
if (condition) then
    commands
else if (other condition) then
    commands
else
    commands
endif
```

Unix Scripting: String Comparisons

• string1 = string2	Test identity
• string1 !=string2	Test inequality
• -n string	the length of *string* is nonzero
• -z string	the length of *string* is zero

BASH Example:

```
today="monday"
if [ "$today" = "monday" ] ; then
    echo "today is monday"
fi
```

TCSH Example:

```
set today="friday"
if ( "$today" != "monday” )  then
    echo "today is not monday"
endif
```

BASH Integer Comparisons

int1 –eq int2	Test identity
int1 –ne int2	Test inequality
int1 –lt int2	Less than
int1 –gt int2	Greater than
int1 –le int2	Less than or equal
int1 –ge int2	Greater than or equal

BASH Example:

```
x=13
y=25
if [ $x -lt $y ]; then
  echo “$x is less than $y"
fi
```

TCSH Integer Comparisons

int1 < int2	Less than
int1 > int2	Greater than
int1 <= int2	Less than or equal
int1 >= int2	Greater than or equal
int1 == int2	Equal to
int1 != int2	Not equal to

TCSH Example:

```
set x=13
set y=25
if ( $x < $y ) then
  echo “$x is less than $y"
endif
```

Unix Scripting: Common File Tests

• -d file	Test if file is a directory
• -f file	Test if file is not a directory
• -s file	Test if the file has non zero length
• -r file	Test if the file is readable
• -w file	Test if the file is writable
• -x file	Test if the file is executable
• -o file	Test if the file is owned by the user
• -e file	Test if the file exists

BASH Example:

```
if [ -f foo ]; then
  echo "foo is a file"
fi
```

TCSH Example:

```
if ( -d foo.dir ) then
  echo "foo.dir is a directory"
endif
```

Unix Scripting: For loops

- These are useful when you want to run the same command in sequence with different options
- *sh* example:

```
 for VAR in test1 test5 test7b finaltest; do
   runmycode $VAR > $VAR.out
 done
```

- *csh* example:

```
 foreach VAR ( test1 test5 test7b finaltest )
   runmycode $VAR > $VAR.out
 end
```

- *sh* one-liner (note `seq` is not standard):

```
for i in `seq 1 5`; do echo $i; done
1
2
3
4
5
```

Quoting in Unix

- We've seen that some metacharacters are treated special on the command line: `* ?`

- What if we don't want the shell to treat these as special - we really mean `*`, not all the files in the current directory

- To turn off special meaning - surround a string with double quotes:

```
> echo here is a star "*“
here is a star *
```

Use of Quotes

- You have to be careful with the use of different styles of quotes in your commands or scripts

- They have different functions:
  - Double quotes inhibit wildcard replacement only
  - Single quotes inhibit wildcard replacement, variable substitution and command substitution
  - Back quotes cause command substitution

Double Quotes

- Double quotes around a string turn the string in to a *single* command line parameter:

```
> ls
fee file? foo
> ls "foo fee file?"
ls: foo fee file?: No such file or
directory
```

- Double quotes only inhibit wildcards; use \ to escape special characters:

```
 > echo “This is a quote \" “
This is a quote “
```

Single Quotes

- Single quotes are similar to double quotes, but they also inhibit variable substitution and command substitution
- Means that special characters do not have to be escaped:

```
> echo 'This is a quote \" '
This is a quote \"
```

Back Quotes

- If you surround a string with back quotes, the string is replaced with the result of running the command in back quotes:

```
> echo `ls`
foo fee file?

> echo "It is now `date` and OU is still
questionable”
It is now Tue Sep 19 11:24:25 CDT 2006 and OU
is still questionable
```

More Quote Examples

- Some Quoting Examples:

```
$ echo Today is date
Today is date
$ echo Today is `date`
Today is Thu Sep 19 12:28:55 EST 2002
$ echo ”Today is `date`”
Today is Thu Sep 19 12:28:55 EST 2002
$ echo ’Today is `date`’
Today is `date`
```

“ “ = double quotes
‘ ‘ = single quotes
` ` = back quotes

Command-Line Parsing

- To build generic shell scripts, consider using command-line arguments to provide the inputs you need internally (syntax again depends on the choice of shell)

- Syntax:
  - $# *refers to the number of command-line arguments*
  - $0 *refers to the name of the calling command*
  - $1, $2, ..., $N *refers to the Nth argument*
  - $* *refers to all command-line parameters*

```
echo "Calling command is:        $0"
echo "Total # of arguments is:    $#"
echo "A list of all arguments is: $*"
echo "The 2nd argument is:        $2"
```

```
> ./foo.sh texas rose bowl
Calling command is:         ./foo.sh
Total # of arguments is:    3
A list of all arguments is: texas rose bowl
The 2nd argument is:        rose
```

In tcsh, you can also reference individual arguments with $argv: eg. $1 = $argv[1]

More UNIX Commands for Programmers

man –k	Search man pages by topic
time	How long your program took to run
date	print out current date/time
test	Compare values, existence of files, etc
tee	Replicate output to one or more files
diff	Report differences between two files
sdiff	Report differences side-by-side
wc	Show number of lines, words in a file
sort	Sort a file line by line
gzip	Compress a file
gunzip	Uncompress it
strings	Print out ASCII strings from a (binary)
ldd	Show shared libraries program is linked to
nm	Show detailed info about a binary obj
tar	Archiving utility
uniq	Remove duplicate lines from a sorted file
which	Show full path to a command
file	Determine file type

References/Acknowledgements

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- Advanced Bash-Scripting Guide, http://db.ilug-bom.org.in/Documentation/abs-guide/
- TCSH Reference, http://www.tcsh.org/tcsh.html/top.html
- **Unix in a Nutshell**, A. Robbins, O'Reilly Media, 2006.