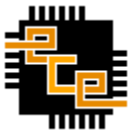
ECE364
Software Engineering Tools Lab

Lecture 1

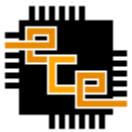
Bash I



Outline

Programming the Bash Shell (Part 1)

- Preliminaries
- Variables
- Math
- Branching
- Script I/O
- Looping
- Simple Text Operations

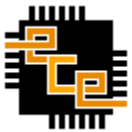


The Shell

- The shell is a program that interfaces users with the operating system

- The Graphical Shell
  - Point an click on things, sometimes you need to use the keyboard

- The Command Line Shell
  - Interactive mode: type commands at the prompt
  - Batch mode: run a multiple commands in a shell script

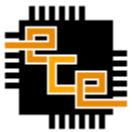


The Shell (2)

- What does the shell do? (Bash Manual 3.1.1)*

1. Read input from: a file, a string, or a user terminal
2. Break input into words and operators.
3. Parse tokens into simple & compound commands.
4. Perform shell expansions.
5. Execute commands.
6. Wait for commands to complete and collect exit codes.

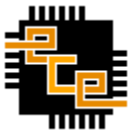
*http://www.gnu.org/software/bash/manual/bashref.html#Shell-Operation



The Shell (3)

- A shell script should start with a special line:
  - `#! /absolute/path/to/the/shell`
  - This line indicates what shell program the OS should run
  - Allows a script to be run no matter what shell you are currently using

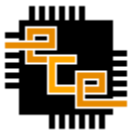
- Some common shells include:
  - `#! /bin/sh` Bourne Shell
  - `#! /bin/ksh` KornShell
  - `#! /bin/bash` Bourne-Again Shell (Bash)
  - `#! /bin/csh` C-Shell
  - `#! /bin/tcsh` TC-Shell



Return Codes

- When a command terminates it returns a numeric value called the return code
  - Recall returning and integer at the end of your main() function in C
  - A return value of zero indicates successful termination

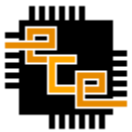
- The `exit <n>` command terminates the current script with a return value `<n>`
  - **Always** end your script with an exit command!



Running Bash Scripts

- A bash shell script can be run by providing it to the bash executable program explicitly:
  - `bash MyScript.sh <arg1> <arg2> …`

- If the shell script contains a #! line then that shell will be invoked using the specified program
  - `./MyScript.sh <arg1> <arg2> …`
  - You will need execute permissions to run your script



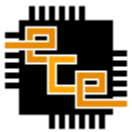
Commands in Bash

- Commands must be separated from one another with a semicolon or newline

```
Cmd1; Cmd2; Cmd3
Cmd4
Cmd5
```

- If your line gets too long you can continue on the next line by adding a \ (backslash)

```
Cmd6 With a very long set of command arguments \
that span multiple \
lines
```

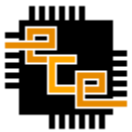


Commands in Bash (2)

- Some commands are built-in to the shell, others may be external shell scripts or programs

- When Bash executes your command it will first see if it is a built-in command
  - If not, it will attempt to execute your command as an external program

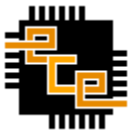
- Commands in bash can always be entered manually at the command prompt
  - Even complicated commands like `for` or `if`!



Commenting Bash Scripts

- Comments are denoted by a the pound sign #
  - Each line of a comment must start with #

- Bash will ignore comments when running commands in your script
  - The #! line is the exception

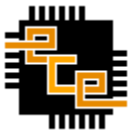


Debugging Bash Scripts

- Debugging features are controlled by providing additional arguments to the shell program
  - `bash [options] ./MyScript.sh`
  - `#! /bin/bash [options]`

Option	Description
`-n`	Check the script for syntax errors but do not execute any commands
`-x`	Prints out commands as they are executed

- The `-x` option is especially useful for observing what commands are executed as your script runs
  - Often easier then littering your code with print statements



Variables in Bash

- To assign and declare a variable:

```
VAR_NAME=value
```

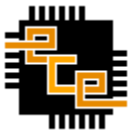
- To access the variable:

```
$VAR_NAME
```
or
```
${VAR_NAME}
```

- Some Examples:

```
Var1=7
Var2=Hello!
Var3=$Var1          # Var3=7
Var4=${Var2}        # Var4=Hello!
```

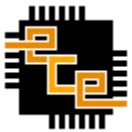
NOTE: NO WHITESPACE BETWEEN THE EQUAL SIGN!



Variables in Bash (2)

- Before each command is executed, any variables are replaced with their current value, even in strings
  - Called variable substitution
  - Run your script with the –x shell debug option to see

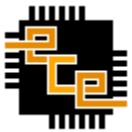
```
> foovar=42

> echo foovar  # $ needed to substitute
foovar         # foovar looks like a string

> echo $foovar # becomes “echo 42”
42
```



Variables in Bash (3)

- Curly braces are optional when all you want is a simple variable substitution
- Sometimes you must use them to disambiguate between a variable name and adjacent characters in a string
- You should aim to improve readability.

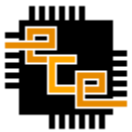
```
> number=10
> echo “There are $numbers of people”
There are  of people
> echo “There are ${number}s of people”
There are 10s of people
```



Special Variables in Bash

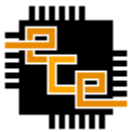
- Set by Bash automatically and can not be assigned directly

`$#`	Number of command line arguments to the script
`$@`	All the command line arguments to the script
`$0`	The relative path to your script (includes its name)
`$$`	Current process ID number
`$?`	Return code from last executed command
`$1 to $N`	The Nth command line parameter
`$RANDOM`	A random integer value



Bash Math

- Bash supports basic math on integers
- Use `let` or `(( … ))` to isolate mathematical statements
  - You will get syntax errors if you forget this!
  - You can exclude $ from variable names in arithmetic evaluation
- Operators: `+, -, *, /, <<, >>, %`



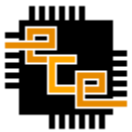
Integer Math Example

- The let command indicates a mathematical expression

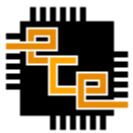
```
let a=66+11          # a is 77
let b=$a*2           # b is 154
let c=5/2            # c is 2
let d=(a-c)*6        # d is 450
```

- Alternatively you can enclose the mathematical expression in double parenthesis `((…))`

```
((a=66+11))          # a is 77
((b=$a*2))           # b is 154
((c=5/2))            # c is 2
((d=(a-c)*6))        # d is 450
```



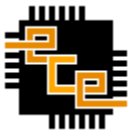
Demo: Basics



Conditional Testing

- Bash has several flavors conditional tests
  - Arithmetic Tests – Compare numbers
  - File Tests – Check properties of files
  - String Tests – Compare string values

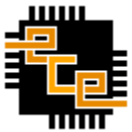
- Syntax for each test command varies depending on the flavor of test



Conditional Testing (2)

- When a command completes it will set the return value variable: `$?`
  - A return value of 0 indicates: success/true
  - A non-zero return value indicates: failure/false
  - This is opposite to programming languages!

- Any conditional test preformed in Bash is checking the return value of a command

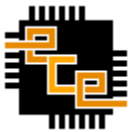


Conditional Testing (3)

```
(( 5 == 5 ))              # is 5 == 5?
echo $?

[[ -e /etc/passwd ]]      # does the file exist?
echo $?

[[ -z “Nope” ]]           # is the string empty?
[[ “foo” != “bar” ]]      # this will overwrite $? !!!
echo $?
```

The above commands will produce the output:

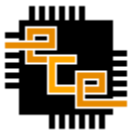
```
0 0 0
```



Conditional Testing (4)

- Any conditional test may be inverted using the not operator (`!`) before the test expression

```
(( ! 5 == 5 ))
[[ ! -e /etc/passwd ]]
[[ ! -z “Nope” ]]
```



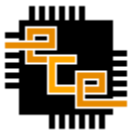
Conditional Testing (5)

- Multiple tests can be combined using AND (`&&`) and OR (`||`) operators

```
(( 5 == 5 && 6 == 6 ))
[[ ! -f /etc/passwd || -d /etc ]]
[[ ! -z $input && $input < "foo" ]]
```

- If you need to mix test flavors the operators can be placed outside of the parenthesis or brackets

```
(( 5 == 5 )) && [[ ! -d /etc ]]
```

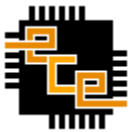


Arithmetic Test Expressions

Expression	Description
`x == y`	True if x **is equal to** y
`x != y`	True if x **is not equal to** y
`x < y`	True if x **is less than** y
`x > y`	True if x **is greater than** y
`x <= y`	True if x **is less than or equal to** y
`x >= y`	True if x **is greater than or equal to** y

Example Usage:

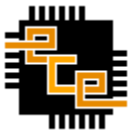
```
(( $var_y <= $var_z ))    (( 5 != 9 ))
```



File Testing

- A significant part of many shell scripts is devoted to file tests
  - Does a file exist?
  - Is a file readable? writable? executable?
  - Is the file a directory?
  - Is the file empty?

- In practice you should always perform the appropriate file tests before operating on files

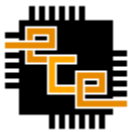


File Testing Expressions

Expression	Description
`-e <file>`	True if <file> **exists**
`-f <file>`	True if <file> **is a regular file**
`-d <file>`	True if <file> **is a directory**
`-r <file>`	True if <file> **is readable**
`-w <file>`	True if <file> **is writable**
`-x <file>`	True if <file> **is executable**
`-s <file>`	True if <file> **exists and is not empty**

Example Usage:

```
[[ -e $my_file ]]    [[ ! -x /bin/bash ]]
```

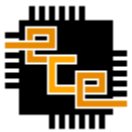


String Test Expressions

Expression	Description
`-z <str>`	True if <str> **is empty**
`-n <str>`	True if <str> **is not empty**
`<str1> = <str2>`	True if <str1> **is equal to** <str2>
`<str1> != <str2>`	True if <str1> **is not equal to** <str2>
`<str1> < <str2>`	True if <str1> **is lexicographically ordered before** <str2>
`<str1> > <str2>`	True if <str1> **is lexicographically ordered after** <str2>

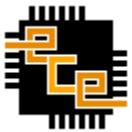
Example Usage:

```
[[ -z $input ]][[ “foo” < “bar” ]]
```



`if` Command

```
if <command/conditional test>
then
     <commands>
elif <command/conditional test>
then
     <commands>
else
     <commands>
fi
```



`if` Command (2)

```
if gcc file.c
then
      echo “You code compiles!”
else
      echo “Try again…”
fi

if [[ -d $filename ]]
then
      echo “The file is a directory!”
elif [[ -f $filename ]]
      echo “The file is a regular file!”
fi
```

`if` Command (3)

```
read –p “Enter a number: “ num
if (( $number < 10 ))
then
     printf “The number %d is too small!\n” $num
elif [[ -f /numbers/${num} ]]
then
     printf “The number %d already exists!\n” $num
else
     echo “$num” > /numbers/${num}
fi
```

`if` On A Single Line

```
[[ $DEBUG == "YES" ]] && save_output
```

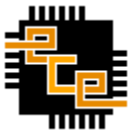
Is equivalent to:

```
if [[ $DEBUG == "YES" ]]
then
    save_output
fi
```

```
[[ -e mydir ]] || mkdir mydir
```

Is equivalent to:

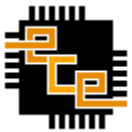
```
if [[ ! -e mydir ]]
then
    mkdir mydir
fi
```



Demo: Conditional Testing

Brace Expansion

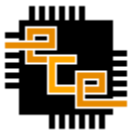
- A sequence of elements like a1, a2, a3, … z1, z2, z3 can be generated using brace expansion
  - `{1..10}` `# 1 2 3… 10`
  - `{a..e}` `# a b c d e`
  - `{a..z}{1..3}` `# a1 a2 a3…z1 z2 z3`
  - `ee364{a..f}{1..9}` `# ee364a1 ee364a2…`
  - `a{b,C,5}f` `# abf aCf a5f`
  - `{1,2}x{a..b}` `# 1xa 1xb 2xa 2xb`



Globs (Pathname Expansion)

- A glob is a pattern that expands to match file names

`*`	Matches everything
`*.foo`	Matches strings ending in .foo
`ee364*`	Matches strings starting with ee364
`*bar*`	Matches string containing “bar”
`*.[ch]`	Matches strings ending in .c or .h
`?`	Matches any single character
`JK[0-9]???`	Matches JK followed by any 0-9 digit and three other characters. Ex: `JK4x2z` or `JK87bb`

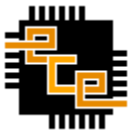


Globs (2)

- Globs are expanded into a list of file names that match the glob

- Examples:

```
ls *.c

cat ee364*.log

rm -f accounts/ee364???/Lab*/*.bash
```

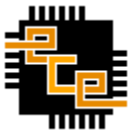


Globs (3)

- If no files match a glob the string will not be expanded!

- Example:

```
cat *junk_dsfsfsdfsf
cat: *junk_dsfsfsdfsf: No such file or directory
```

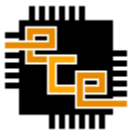


Globs (4)

- Brace expansion can be combined with globs to form even more complex patterns

- Example:

```
ls /pics/*.{jpg,png,gif}

# Same as above
ls /pics/*.jpg /pics/*.png /pics/*.gif
```



`echo` Command

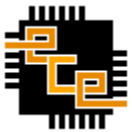
- `echo [options] [string]`
  - Prints a string to standard output (the terminal)

Option	Meaning
`-n`	Disable the automatic newline
`-e`	Treat `\` as an escaping character

```
> age=23
> echo "You are ${age} years old."
You are 23 years old
```

```
> echo "Hello \name"
Hello \name
```

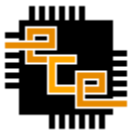
```
> echo -e "Hello \name"
Hello
ame
```



`printf` Command

- Useful when you need to format output
  - Uses the same format string e.g. %s %d…
  - Arguments are separated by a space
  - No automatic newline

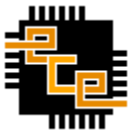
```
printf "Magic number is %d\n"  $RANDOM
printf "My name is %s\n" Goldfarb
printf "Pi = %1.2f e = %1.2f\n" 3.14159 2.71828
```



`read` Command

- `read [-p prompt] [variable]`
- Reads a single line from standard input into a variable

```
echo –n “Enter a line of text:”
read aLineOfText
echo “You entered: “ $aLineOfText

read –p “How old are you? “ age
echo “You are $age years old”

echo “Press [ENTER] to continue…”
read
```



`read` Command (2)

- The read command can populate more then one variable
  - e.g. `read First Second Third Rest`
  - Each variable will contain a word of text
  - The last variable will get remaining contents of the line

`for` Command

- The `for` command executes a loop over a set of elements in a list
  - **A list can be anything separated by whitespace**

```
for <var> in <list>
do
  <…commands…>
done
```

- A more C-like `for` command syntax is also allowed:

```
for ((<pre-cond>; <cond>; <iter-step>))
do
  <…commands…>
done
```

`for` Command (2)

```
for I in 1 2 3 4 5
do
   echo -n ${I}
done
```

```
for I in {1..5}
do
   echo -n ${I}
done
```

```
for (( I=1; I < 6; I++ ))
do
   echo -n ${I}
done
```

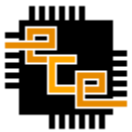
All three result in the same output:

```
12345
```

`for` Command (3)

- The list of a for loop can also be globs/brace expansions for iterating over files

```
# With globs
for File in *.c
do
   # Print all C source files
   lp -dSOME_PRINTER $File
done

# With brace expansion and globs
for File in /students/ee364{a..f}*.c
do
   # Compile all student files
   cc -Wall -lm -O3 -o${File}.o ${File}
done
```



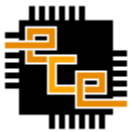
Loop Control Commands

`continue`

- Used to skip to the next iteration of the inner-most loop

`break`

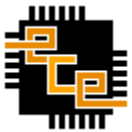
- Used to end the execution of the inner-most loop



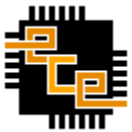
Command Line Arguments

- What if we want to loop through the command line arguments?
  - Easy `$@` is a list of arguments

```
for arg in $@
do
   echo $arg
done
```



Demo: Loops



`while` Command

- Run a set of commands until a conditional test or command returns a non-zero value (false)

```
while gcc student_file.c
do
    echo “Student code still compiles!”
    inject_errors student_file.c
done

while (( $RANDOM % 10 != 0 ))
do
    echo “Still no luck!”
done
```

`while` Command (2)

- The read command is typically used with a while loop to process lines of text

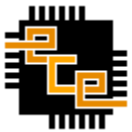
```
while read line
do
  echo "$line"
done < $1 # Redirect into the loop!
```

- `$1` will be redirected into standard input of the while command which will execute read until all lines are read
- Note the placement of the redirect at the ***END*** of the while command

`while` Command (3)

- Like the conditional tests `[[…]]` and `((…))` other command tests can be inverted with a `!` Operator

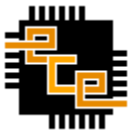
```
while ! gcc student_file.c
do
    echo "Student still has bugs!"
    correct_errors student_file.c
done
```



`shift` Command

- Left shifts the parameters on the command line by `n` (default `n = 1`) places

- The `$0` parameter is NEVER shifted



`shift` Command (2)

```
echo '$0 -- ' $0
echo '$# -- ' $#
X=0
while (( $# != 0 ))
do
  ((X=X+1))
  echo "\"\$${X}\" was $1"
  shift
done
```

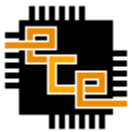
Example usage:

```
$ parameters q "1 2 3" xyz
$0 -- ./parameters
$# -- 3
"$1" was q
"$2" was 1 2 3
"$3" was xyz
```

`cat` Command

- `cat [option] [files]`
- Concatenates and prints the contents of each file
  - Standard input is used if no files are provided
  - A hyphen (`-`) may be used as one of the files to indicate standard in as an additional source of input

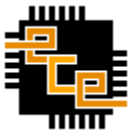
Option	Description
`-n`	Include line numbers for each line
`-s`	Remove extra empty lines so that there is at most one empty line between two non-empty lines
`-b`	Include line numbers of non-empty lines



`head` Command

- `head [option] [files]`
- Prints the beginning each file specified
  - Standard input is used if no files are provided

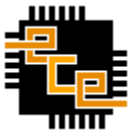
Option	Description
`-n <N>`	Displays the first `<N>` lines
`-n -<N>`	Displays all but the last `<N>` lines
`-c <N>`	Displays the first `<N>` characters/bytes



`tail` Command

- `tail [option] [files]`
- Prints the end (tail) each file specified
  - Standard input is used if no files are provided

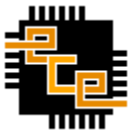
Option	Description
`-n <N>`	Displays the last `<N>` lines
`-n +<N>`	Displays all lines starting at line `<N>`
`-c <N>`	Displays the last `<N>` characters
`-c +<N>`	Displays all characters starting at the `<N>`th character



`wc` Command

- `wc [options] [files]`
- Counts the number of lines in one or more files
  - Standard input is used if no files are provided

Option	Description
`-w`	Count the number of words in each file
`-l`	Count the number of lines in each file
`-c`	Count the number of characters in each file



Demo: File Content Printing