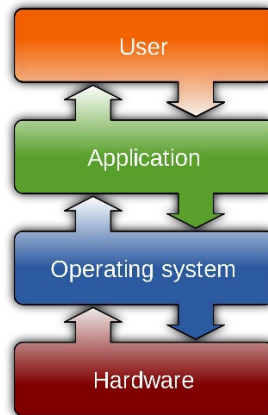


Operating Systems Lab

Lab assignment 1: Unix/Linux Commands and Basic Shell Programming



Objectives

1. To learn Unix/ Linux
2. To use command – line programs
3. To develop sample shell programs

Guidelines

Good knowledge in Unix/Linux based C programming is required for all labs. You are highly encouraged to use command line tools in developing, compiling, and running your programs. You may use editors like vi or gedit and the gcc compiler. This lab is designed to teach you basics of the Linux technical environment, including tools, commands, and shell scripts.

Please pay attention to your coding style and good programming practices, if your program is not worth documenting, it probably is not worth running.¹ Please follow the GNU coding standards available on: https://www.gnu.org/prep/standards/html_node/Writing-C.html.

Unix/ Linux

Linux is a Unix-like operating system, following the design principles of Unix monolithic kernel in process control, cpu scheduling, memory management, file systems, networking, and access to the peripherals. Please read details on <https://en.wikipedia.org/wiki/Linux>.

Unix/ Linux has a culture of distinctive art and powerful design philosophy since its inception in 1969. Software technologies come and go but Unix/ Linux remained dominant and continued to evolve on a wide variety of machines ranging from supercomputers and PCs to handheld devices and embedded networking hardware. The C language is ubiquitous and a central technology of Unix/ Linux. It is very hard to imagine developing applications at the core system level without C. The POSIX, Portable Operating System Standard, the Unix API (Application Programming Interface) is used to write truly portable software that can run across a heterogeneous mix of computers. TCP/IP (which you will learn in this class) and Unix represent the core technologies of the Internet. For more details, see ².

Please install Linux on your laptop computer, either as a bare operating system or as a virtual machine. For

¹ Jonathan Nagler, "Coding Style and Good Computing Practices", *PS: Political Science and Politics*, Volume 28, Issue 3, 1995, pp. 488-492.

² Eric S. Raymond, *The Art of Unix Programming*, Pearson, 2004

details, please check <https://www.linux.com>. If you are using Mac OS, you can use Linux commands in a terminal window, including vi and gcc compiler.

Command-line programs (utilities)

The use of command-line programs is a tradition in Unix/Linux. Commands are executable programs that can run with variety of arguments (options). Command-line options are single letters preceded by a single hyphen, including:

-a: all, -b: buffer, -c: command, -d: debug, -e: execute, -f: file, -l: list, -o: output, -u: user

Some of the basic commands are:

- ls: lists all files and directories (try with options: -a, -al)
- cat: displays file content (try cat file1 file2 > file3)
- mv: moves a file to a new location (try mv file1 file2)
- rm: deletes a file
- cp: copy file
- cmp: compares two files
- man: gives help information on a command
- history: gives a list of past commands
- clear: clear the terminal
- mkdir: creates a new directory
- cd: changes directory
- rmdir: deletes a directory
- chmod: changes the access mode of the specified files to the specified mode
- chown: changes the owner of the specified files to the specified userid
- echo: writes arguments to the standard output (try echo 'Hello World' > myfile)
- df: shows disk usage
- apt-get: install and update packages
- mail -s 'subject' -c 'cc-address' -b 'bcc-address' 'to-address' < filename: sends email with attachment
- chown/ chmod: change ownership/ permission of file or directory
- date: show the current date and time
- ps: displays active processes
- kill: kills process
- grep: searches for pattern in files
- Ctrl+c: halts current command
- Ctrl+z: stops current command and resumes with foreground
- Ctrl+d (exit): logout of current session
- man: displays the manual page of the specified command
- echo: prints on the screen

For more commands, please refer to Linux command quick reference³.

Shell programming (aka scripting)

³ https://www.oreilly.com/openbook/debian/book/appe_01.html

A shell program (aka script) is a text file that contains standard Unix and shell commands. It allows you to execute a series of commands in a shell program simply by running the shell program rather than typing all commands. Shell programs are interpreted not compiled. They are used to automate system administration tasks. In a shell program, you can use

1. comments,
2. variables,
3. conditional commands,
4. repeated actions of commands, and
5. functions.

Bash Born Again Shell is used for this lab. Other Shells are C-Shell – csh, Korn Shell, Bourne Shell – sh, Thomas C-Shell – tcsh.

1. Comments: Use the # character to signify comments. Anything after a # character until the end of the line is considered a comment and is ignored by the shell.

2. Variables: Use letters, numbers, and the underscore to define variable names in a shell program. The assigned values to variables are stored internally as strings. To use a variable, precede the name with \$. The shell provides the following pre-defined shell variables that may be used to pass parameters to a shell script.

\$0	the name of the shell program
\$1 thru \$9	the first thru to ninth parameters
\$#	the number of parameters
\$*	all parameters passed represented as a single word with individual parameters separated
@	all the parameters passed with each parameter as a separate word
?	hold the exit status of the previous command
\$\$	the process id of the current process
PATH	the value of the PATH environment variable
HOME	the full path name of your home directory
USER	your user name
PWD	the current directory path

3. Conditional commands: Use if keyword for a conditional statement in either of the following arrangements:

```
if expression
then
command-list
fi
```

```
if expression
then
command-list
elif expression
command-list2
fi
```

```
if expression
then
command-list1
else
command-list2
fi
```

case keyword can also be used to execute one of several lists of statements depending on the value of a variable.

Expressions (Boolean):

- Relational operators:
-eq, -ne, -gt, -ge, -lt, -le

- File operators:
 - f *file* True if *file* exists and is not a directory
 - d *file* True if *file* exists and *is* a directory
 - s *file* True if *file* exists and has a size > 0
- String operators:
 - z *string* True if the length of *string* is zero
 - n *string* True if the length of *string* is nonzero
 - s1* = *s2* True if *s1* and *s2* are the same
 - s1* != *s2* True if *s1* and *s2* are different
 - s1* True if *s1* is not the null string
- Compound comparison:
 - a And
 - o Or
 - ! Not

The other type of conditional command supported by the shell is the **case** command. The **case** command allows the user to compare a single value against multiple values and when a match is found execute the associated command list.

4. Repeated actions of commands: The Bash shell provides three repeated action commands: for, while, and until as follows:

for variable in word1 word2 word3 ... wordn

do

command-list

done

while command

do

command-list

done

until command

do

command-list

done

5. Functions: shell functions are generally defined in a file as:

```
name () {
    commands;
}
e.g.
add () {
    echo $[ $1 + $2 ]
}
```

Important notes:

- Shell programming is not good in numerical computation, but use can still use some mathematical expressions by using the keyword `expr`, e.g. `i='expr $i+1'` or you may close expressions in brackets, e.g. `i=$((10-3))`
- Use `#!/bin/bash` as the first line of a shell program to define the path of the command interpreter.
- Use `chmod +x <program_name>` to make a shell program executable, then run either using `sh <program_name>`, or `./<program_name>`
- Shell metacharacters are:
 - '...' takes without interpreting contents
 - "..." takes after processing `$`, ``` and `\`
 - \ escape, for example `\c` takes character `c`
 - '...' runs enclosed command and replace with output

Sample shell program

Demonstrate each of the following steps to get a grade on this part of the lab assignment
Step 1. Write the following shell program using vi, emacs, or an editor of your choice.

#Sample shell programs for Lab assignment

```
#!/bin/bash
echo Executing $0
echo $(/bin/ls | wc -l) files
wc -l $(/bin/ls)
echo "HOME=$HOME"
echo "USER=$USER"
echo "PATH=$PATH"
echo "PWD=$PWD"
echo "\$\$"=$$
user=`whoami`
numusers=`who | wc -l`
echo "Hi $user! There are $numusers users logged on."
if [ $user = "lam" ]
then
    echo "Now you can proceed!"
else
    echo "Check who logged in!"
    exit 1
fi

response="Yes"
while [ $response != "No" ]
do
    echo "Enter height of rectangle: "
    read height
    echo "Enter width of rectangle: "
    read width
    area=`expr $height \* $width`
    echo "The area of the rectangle is $area"

    echo "Would you like to repeat for another rectangle [Yes/No]?"
    read response
done
```

Step 2. Run the shell program by typing `./lab1` When it runs without errors or warnings, be sure to make a copy of the source file.

Step 3. Add to the program in Step 1. so that you can also compute the area of a circle, then demonstrate steps 1 – 3.

When your program runs without errors or warnings, make a copy of the source file.

Questions: What linux system are you using? Did you experience any difficulties with this lab task?

Requirements to complete the lab

1. Show the correct execution of the shell programs.
2. Submit your answers to questions.
3. Submit the source code for all your programs.

Be sure to retain copies of your source text files. You will want these for study purposes and to resolve any grading questions (should they arise).

Please start each program/ text with a descriptive block that includes minimally the following information:

```
# Name: <your name>
# Date: <date> (due date of this lab)
# Title: Lab1 - task
# Description: This program computes ... <you should
# complete an appropriate description here.>
```

Introduction to Operating Systems