Basic Shell Scripting

Feng Chen
HPC User Services
LSU HPC & LONI
sys-help@loni.org

Louisiana State University
Baton Rouge
September 27, 2023
What have we learned so far?

➢ Introduction to Linux
   – OS used on HPC clusters

➢ HPC User Environment 1
   – LSU and LONI HPC policy
   – Connect to our cluster
   – Use software on HPC

➢ HPC User Environment 2
   – How to submit jobs (PBS/Slurm)
     • Interactive jobs
     • Batch jobs
Outline

• Introduction to Linux Shell
• Shell Scripting Basics
  • Variables/Special Characters
  • Arithmetic Operations
  • Arrays
• Beyond Basic Shell Scripting
  – Flow Control
  – Functions
• Advanced Text Processing Commands (grep, sed, awk)
Linux System Architecture

Diagram showing the layers of a Linux system architecture, with User 1, User 2, and User 3 interacting with the system through the Shell, Kernel, and Hardware layers.
What is a Linux Shell

- An application running on top of the kernel and provides a command line interface to the system
  - Process user’s commands, gather input from user and execute programs
- Types of shell with varied features
  - sh
    - the original Bourne shell.
  - ksh
    - one of the three: Public domain ksh (pdksh), AT&T ksh or mksh
  - bash
    - the GNU Bourne-again shell. It is mostly Bourne-compatible, mostly POSIX-compatible, and has other useful extensions. It is the default on most Linux systems.
  - csh
    - BSD introduced the C shell, which sometimes resembles slightly the C programming language.
  - tcsh
    - csh with more features. csh and tcsh shells are NOT Bourne-compatible.
# Shell Comparison

<table>
<thead>
<tr>
<th>Software</th>
<th>sh</th>
<th>csh</th>
<th>ksh</th>
<th>bash</th>
<th>tcsh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming language</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Shell variables</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Command alias</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Command history</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Filename autocompletion</td>
<td>n</td>
<td>y*</td>
<td>y*</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Command line editing</td>
<td>n</td>
<td>n</td>
<td>y*</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Job control</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
</tr>
</tbody>
</table>

*: not by default

http://www.cis.rit.edu/class/simg211/unixintro/Shell.html
What can you do with a shell?

- Check the current shell you are using
  - `echo $0`
- List available shells on the system
  - `cat /etc/shells`
- Change to another shell
  - `csh`
- Date
  - `date`
- `wget`: get online files
  - `wget https://ftp.gnu.org/gnu/gcc/gcc-7.1.0/gcc-7.1.0.tar.gz`
- Compile and run applications
  - `gcc hello.c -o hello`
  - `./hello`
- What we need to learn today?
  - Automation of an entire script of commands!
  - Use the shell script to run jobs – Write job scripts
Shell Scripting

- Script: a program written for a software environment to automate execution of tasks
  - A series of shell commands put together in a file
  - When the script is executed, those commands will be executed one line at a time automatically
  - Shell script is interpreted, not compiled.

- The majority of script programs are “quick and dirty”, where the main goal is to get the program written quickly
  - May not be as efficient as programs written in C and Fortran
When **NOT** to use Shell Scripting…

- **Selected situations:**
  - Resource-intensive tasks, especially where speed is a factor (sorting, hashing, recursion [2] ...)
  - Procedures involving heavy-duty math operations, especially floating point arithmetic, arbitrary precision calculations, or complex numbers (use C++ or FORTRAN instead)
  - Complex applications, where structured programming is a necessity (type-checking of variables, function prototypes, etc.)
  - Extensive file operations required (Bash is limited to serial file access, and that only in a particularly clumsy and inefficient line-by-line fashion.)
  - Need native support for multi-dimensional arrays, data structures, such as linked lists or trees
  - Need to use libraries or interface with legacy code
Script Example (~/.bashrc)

# .bashrc

# Source global definitions
if [ -f /etc/bashrc ]; then
  . /etc/bashrc
fi

# User specific aliases and functions
export PATH=$HOME/packages/bin:$PATH
export LD_LIBRARY_PATH=$HOME/packages/lib:$LD_LIBRARY_PATH
alias qsubI="qsub -I -X -l nodes=1:ppn=20 -l walltime=01:00:00 -A my_allocation"
alias lh="ls -altrh"
Hello World

#!/bin/bash
# A script example
echo 'Hello World!' # print something

1. #!: "Shebang" line to instruct which interpreter to use. In the current example, bash. For tcsh, it would be: #!/bin/tcsh
2. All comments begin with "#".
3. Print "Hello World!" to the screen.

[fchen14@mike1 shelltut]$ ./hello_world.sh # using default /bin/bash
Hello World!
[fchen14@mike1 shelltut]$ bash hello_world.sh # using bash to run the script
Hello World!
Interactive and non-interactive shells

- An interactive shell is one started without non-option arguments, unless -s is specified, without specifying the -c option, and whose input and error output are both connected to terminals or one started with the -i option.
  - The user can interact with the shell from the terminal.
  - e.g., open an interactive shell by typing `bash` or `ssh` from the terminal.
- A shell running a script is always a non-interactive shell.
  - All the same, the script can still access its tty. It is even possible to emulate an interactive shell in a script.

- Test whether you are using an interactive shell using `$-` (prints The current set of options in your current shell.)
  ```bash
  [fchen14@mike1 shelltut]$ echo $-
  himBH
  [fchen14@mike1 shelltut]$ cat checkshell.sh
  #!/bin/bash
  # read value # you can still interact with the script
  echo $-
  [fchen14@mike1 shelltut]$ ./checkshell.sh
  hB
  ```
Subshell

- **Definition:**
  - A subshell is a child process launched by a shell (or shell script).
  - Just as your commands are interpreted at the command-line prompt, similarly does a script batch-process a list of commands.
  - Each shell script running is, in effect, a subprocess (child process) of the parent shell.
- **Two typical examples of starting subshell:**
  - Running a shell script launches a new process, a *subshell*.
  - Type “bash” from an interactive shell
Outline

• Introduction to Linux Shell
• Shell Scripting Basics
  • Variables/Special Characters
  • Arithmetic Operations
  • Arrays
• Beyond Basic Shell Scripting
  • Control flow
  • Functions
• Advanced Text Processing Commands (grep, sed, awk)
Variables

- **Variable names**
  - Must start with a letter or underscore
  - Number can be used anywhere else
  - Do not use special characters such as @, #, %, $
  - Case sensitive
  - Allowed: VARIABLE, VAR1234able, var_name, _VAR
  - Not allowed: 1var, %name, $myvar, var@NAME, myvar-1
- To reference a variable, prepend $ to the name of the variable
- Example: $PATH, $LD_LIBRARY_PATH, $myvar etc.
- When assigning a variable, no space allowed before or after the equal sign. (bash)
Global and Local Variables

- Two types of variables:
  - Global (Environmental) variables
    - Inherited by subshells (child process, see next slide)
    - Provide a simple way to share configuration settings between multiple applications and processes in Linux
    - Using all uppercase letters by convention
    - Example: PATH, LD_LIBRARY_PATH, DISPLAY etc.
    - `printenv/env` list the current environmental variables in your system.
  - Local (shell) variables
    - Only visible to the current shell
    - Not inherited by subshells
Editing Variables

- Assign values to variables

<table>
<thead>
<tr>
<th>Type</th>
<th>sh/ksh/bash</th>
<th>csh/tcsh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell (local)</td>
<td>name=value</td>
<td>set name=value</td>
</tr>
<tr>
<td>Environment (global)</td>
<td>export name=value</td>
<td>setenv name value</td>
</tr>
</tbody>
</table>

- Local (Shell) variables is only valid within the current shell, while environment variables are valid for all subsequently opened shells.

- Example: useful when running a script, where exported variables (global) at the terminal can be inherited within the script.

<table>
<thead>
<tr>
<th>With export</th>
<th>Without export</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ export v1=one</td>
<td>$ v1=one</td>
</tr>
<tr>
<td>$ bash</td>
<td>$ bash</td>
</tr>
<tr>
<td>$ echo $v1</td>
<td>$ echo $v1</td>
</tr>
<tr>
<td>→one</td>
<td>→</td>
</tr>
</tbody>
</table>
Global and Local Variables - current shell and subshell

Current Shell
- export VARC=XX
- echo $VARC
- echo $VARS

Sub Shell
- export VARS=YY
- echo $VARC
- echo $VARS

*visible*

*not visible*

Exit the Sub Shell

Type bash or call another script
How to inherit the variables in the script?

- Using the `source` command, it has a synonym in dot “.” (period)
  - Syntax:
    
```
    . filename [arguments]
    source filename [arguments]
    ```
  - The script does not need execute permission in this case. Commands are executed *in the current shell process*, so any changes made to your environment will be visible when the script finishes execution.
  - Executing will run the commands in a new shell process (subshell).

```
[fchen14@mike1 shelltut]$ cat source_var.sh
#!/bin/bash
export myvar="newvalue"
[fchen14@mike1 shelltut]$ bash source_var.sh
[fchen14@mike1 shelltut]$ echo $myvar

[fchen14@mike1 shelltut]$ source source_var.sh
[fchen14@mike1 shelltut]$ echo $myvar
newvalue
```
List of Some Environment Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PATH</td>
<td>A list of directory paths which will be searched when a command is issued</td>
</tr>
<tr>
<td>LD_LIBRARY_PATH</td>
<td>colon-separated set of directories where libraries should be searched for first</td>
</tr>
<tr>
<td>HOME</td>
<td>indicate where a user's home directory is located in the file system.</td>
</tr>
<tr>
<td>PWD</td>
<td>contains path to current working directory.</td>
</tr>
<tr>
<td>USER</td>
<td>Current logged in user's name</td>
</tr>
<tr>
<td>OLDPWD</td>
<td>contains path to previous working directory.</td>
</tr>
<tr>
<td>TERM</td>
<td>specifies the type of computer terminal or terminal emulator being used</td>
</tr>
<tr>
<td>SHELL</td>
<td>contains name of the running, interactive shell.</td>
</tr>
<tr>
<td>PS1</td>
<td>default command prompt</td>
</tr>
<tr>
<td>PS2</td>
<td>Secondary command prompt</td>
</tr>
<tr>
<td>HOSTNAME</td>
<td>The systems host name</td>
</tr>
<tr>
<td>DISPLAY</td>
<td>Network name of the X11 display to connect to, if available.</td>
</tr>
</tbody>
</table>
Quotations

• Single quotation
  – Enclosing characters in single quotes (’) preserves the literal value of each character within the quotes. A single quote may not occur between single quotes, even when preceded by a backslash.

• Double quotation
  – Enclosing characters in double quotes (") preserves the literal value of all characters within the quotes, with the exception of ‘$’, ‘\’, ‘‘

• Back “quotation?”
  – Command substitution (``) allows the output of a command to replace the command itself, enclosed string is executed as a command, almost the same as $( )
Quotation - Examples

[fchen14@mike1 ~]$ str1='echo $USER'
[fchen14@mike1 ~]$ echo "$str1"
echo $USER
[fchen14@mike1 ~]$ str2="echo $USER"
[fchen14@mike1 ~]$ echo "$str2"
echo fchen14
[fchen14@mike1 ~]$ str3=`echo $USER`
[fchen14@mike1 ~]$ echo "$str3"
fchen14
[fchen14@mike1 ~]$ str3=$(echo $USER)
[fchen14@mike1 ~]$ echo "$str3"
fchen14

Always use double quotes around variable substitutions and command substitutions: "$foo", "$\{foo\}"

Basic Shell Scripting
# Start a comment line.

$ Indicate the name of a variable.

\ Escape character to display next character literally

{} Enclose name of variable

; Command separator. Permits putting two or more commands on the same line.

;; Terminator in a case option

. “dot” command, equivalent to `source` (for bash only)

| Pipe: use the output of a command as the input of another one

> Redirections (0<: standard input; 1>: standard out; 2>: standard error)
## Special Characters (2)

<table>
<thead>
<tr>
<th>Character</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>?</code></td>
<td>Exit status for the last command, 0 is success, failure otherwise</td>
</tr>
<tr>
<td><code>$$</code></td>
<td>Process ID variable.</td>
</tr>
<tr>
<td><code>[</code></td>
<td>Test expression, eg. if condition</td>
</tr>
<tr>
<td><code>[[ ]]</code></td>
<td>Extended test expression, more flexible than <code>[ ]</code></td>
</tr>
<tr>
<td><code>$[ ]</code>, <code>$(( ))</code></td>
<td>Integer expansion</td>
</tr>
<tr>
<td>`</td>
<td></td>
</tr>
</tbody>
</table>
Outline

- Introduction to Linux Shell
- Shell Scripting Basics
  - Variables/Special Characters
  - Arithmetic Operations
- Beyond Basic Shell Scripting
  - Arrays
  - Flow Control
  - Functions
- Advanced Text Processing Commands (grep, sed, awk)
## Integer Arithmetic Operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition</td>
<td>+</td>
</tr>
<tr>
<td>Subtraction</td>
<td>-</td>
</tr>
<tr>
<td>Multiplication</td>
<td>*</td>
</tr>
<tr>
<td>Division</td>
<td>/</td>
</tr>
<tr>
<td>Exponentiation</td>
<td>** (bash only)</td>
</tr>
<tr>
<td>Modulo</td>
<td>%</td>
</tr>
</tbody>
</table>
Integer Arithmetic Operations

- $((...))$ or $[...]$ commands
  - $x=$((1+2))$  # Addition, suggested
  - echo $[$x*$x$]  # Multiplication, deprecated

- let command:
  - let c=$x+$x  # no space
  - let c=x+x  # you can omit the $ sign
  - let c="x + x"  # can have space
  - let c+=1 or let --c  # C-style increment operator

- expr command:
  - expr 10 / 2  # division, space required
  - expr 5 \* 4  # multiplication, space required

Note: Bash is picky about spaces!
Floating-Point Arithmetic Operations

GNU basic calculator (bc) external calculator

- Add two numbers
  ```
  echo "3.8 + 4.2" | bc
  ```

- Divide two numbers and print result with a precision of 5 digits:
  ```
  echo "scale=5; 2/5" | bc
  ```

- Convert between decimal and binary numbers
  ```
  echo "ibase=10; obase=2; 10" | bc
  ```

- Call bc directly:
  ```
  bc <<< "scale=5; sqrt(2)"
  ```
Outline

• Introduction to Linux Shell
• Shell Scripting Basics
  – Variables
  – Quotations
  – Arithmetic Operations
  – Arrays
• Beyond Basic Shell Scripting
  – Flow Control
  – Command Line Arguments
  – Functions
• Advanced Text Processing Commands (grep, sed, awk)
Arrays Operations (1)

- Initialization
  
  ```bash
  my_array=("Alice" "Bill" "Cox" "David")
  my_array[0]="Alice";
  my_array[1]="Bill"
  ```

- Bash supports one-dimensional arrays
  - Index starts at 0
  - No space around `="`

- Reference an element
  ```bash
  ${my_array[i]}  # must include curly braces {}  
  ```

- Print the whole array
  ```bash
  ${my_array[@]}
  ```

- Length of array
  ```bash
  ${#my_array[@]}
  ```
Array Operations (2)

• Add an element to an existing array
  • `my_array=(first ${my_array[@]})`
  • `my_array="${my_array[@]}" last`
  • `my_array[4]="Nason"

• Copy the current array to a new array
  • `new_array=${my_array[@]}

• Concatenate two arrays
  • `two_arrays=${my_array[@]} ${new_array[@]}"`
Array Operations (3)

• Delete the entire array
  • unset my_array

• Delete an element to an existing array
  • unset my_array[0]
Outline

• Introduction to Linux Shell
• Shell Scripting Basics
  – Arrays
  – Arithmetic Operations
• Beyond Basic Shell Scripting
  – Flow Control
  – Functions
• Advanced Text Processing Commands
  (grep, sed, awk)
Flow Control

• Shell scripting languages execute commands in sequence similar to programming languages such as C and Fortran
  – Control constructs can change the order of command execution
• Control constructs in bash
  – Conditionals:
    ➢ if-then-else
    ➢ Switches: case
  – Loops: for, while, until
if statement

- if/then construct test whether the exit status of a list of commands is 0, and if so, execute one or more commands

  ```bash
  if [ condition ]; then
      Do something
  elif [ condition 2 ]; then
      Do something
  else
      Do something else
  fi
  ```

- Strict spaces between condition and the brackets (bash)
- `[[ condition ]]` extended test construct is the more versatile Bash version of `[ condition ]`, generally safer to use.
# File Operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>bash</th>
</tr>
</thead>
<tbody>
<tr>
<td>File exists</td>
<td>if [ -e test ]</td>
</tr>
<tr>
<td>File is a regular file</td>
<td>if [ -f test]</td>
</tr>
<tr>
<td>File is a directory</td>
<td>if [ -d /home ]</td>
</tr>
<tr>
<td>File is not zero size</td>
<td>if [ -s test ]</td>
</tr>
<tr>
<td>File has read permission</td>
<td>if [ -r test ]</td>
</tr>
<tr>
<td>File has write permission</td>
<td>if [ -w test ]</td>
</tr>
<tr>
<td>File has execute permission</td>
<td>if [ -x test ]</td>
</tr>
</tbody>
</table>
## Integer Comparisons

<table>
<thead>
<tr>
<th>Operation</th>
<th>Bash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal to</td>
<td><code>if [ 1 -eq 2 ]</code></td>
</tr>
<tr>
<td>Not equal to</td>
<td><code>if [ $a -ne $b ]</code></td>
</tr>
<tr>
<td>Greater than</td>
<td><code>if [ $a -gt $b ]</code></td>
</tr>
<tr>
<td>Greater than or equal to</td>
<td><code>if [ 1 -ge $b ]</code></td>
</tr>
<tr>
<td>Less than</td>
<td><code>if [ $a -lt 2 ]</code></td>
</tr>
<tr>
<td>Less than or equal to</td>
<td><code>if [ $a -le $b ]</code></td>
</tr>
</tbody>
</table>
## String Comparisons

<table>
<thead>
<tr>
<th>Operation</th>
<th>bash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal to</td>
<td>if [ $a == $b ]</td>
</tr>
<tr>
<td>Not equal to</td>
<td>if [ $a != $b ]</td>
</tr>
<tr>
<td>Zero length or null</td>
<td>if [ -z $a ]</td>
</tr>
<tr>
<td>Non zero length</td>
<td>if [ -n $a ]</td>
</tr>
</tbody>
</table>
# Logical Operators

<table>
<thead>
<tr>
<th>Operation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>! (NOT)</td>
<td>if [ ! -e test ]</td>
</tr>
<tr>
<td>&amp;&amp; (AND)</td>
<td>if [ -f test ] &amp;&amp; [ -s test ]</td>
</tr>
</tbody>
</table>
|           | if [[ -f test && -s test ]]
|           | if ( -e test && ! -z test ) |
| || (OR)   | if [ -f test1 ] || [ -f test2 ] |
|           | if [[ -f test1 || -f test2 ]]

Basic Shell Scripting

39
if condition examples

Example 1:
read input
if [ $input == "hello" ]; then
    echo hello;
else echo wrong ;
fi

Example 2
touch test.txt
if [ -e test.txt ]; then
    echo "file exist"
elif [ ! -s test.txt ]; then
    echo "file empty"
fi

What happens after
echo "hello world" >> test.txt
Loop Constructs

• A loop is a block of code that iterates a list of commands as long as the loop control condition stays true

• Loop constructs
  for, while and until
for loop examples

Example 1:
for arg in `seq 1 4`
do
echo $arg;
touch test.$arg
done

How to delete test files using a loop?
rm test.[1-4]

Example 2:
for file in `ls /home/$USER`
do
cat $file
done
While Loop

- The `while` construct test for a condition at the top of a loop and keeps going as long as that condition is true.
- In contrast to a `for` loop, a `while` is used when loop repetitions is not known beforehand.

```bash
read counter
while [ $counter -ge 0 ]
  do let counter--
    echo $counter
done
```
Until Loop

• The `until` construct test a condition at the top of a loop, and stops looping when the condition is met (opposite of `while` loop)

```bash
read counter
until [ $counter -lt 0 ]
do let counter--
   echo $counter
done
```
Switching Constructs - bash

- The `case` constructs are technically not loops since they do not iterate the execution of a code block

```bash
#!/bin/sh
echo "Please talk to me ..."
while :
do
    read INPUT_STRING
case $INPUT_STRING in
    hello)
        echo "Hello yourself!"
    ;;
    bye)
        echo "See you again!"
        break
    ;;
    *)
        echo "Sorry, I don't understand"
    ;;
esac
Done
echo "That's all folks!"
```
Outline

• Introduction to Linux Shell
• Shell Scripting Basics
• Beyond Basic Shell Scripting
  – Arithmetic Operations
  – Arrays
  – Flow Control
  – Functions
• Advanced Text Processing Commands (grep, sed, awk)
Functions

- A function is a code block that implements a set of operations. Code reuse by passing parameters,
- Syntax:

  ```
  function_name () {
    command...
  }
  ```

- By default all variables are global.
- Modifying a variable in a function changes it in the whole script.
- Create a local variables using the `local` command, which is invisible outside the function

  ```
  local var=value
  local varName
  ```
Pass Arguments to Bash Scripts

- Note the difference between the arguments passed to the script and the function.
- All parameters can be passed at runtime and accessed via $1, $2, $3..., add {} when >=10
- $0: the shell script name
- Array variable called FUNCNAME contains the names of all shell functions currently in the execution call stack.
- $* or @: all parameters passed to a function
- $#: number of positional parameters passed to the function
- $?: exist code of last command
- $$: PID of current process
Function example

#!/bin/bash

func_add () # define a simple function
{
    local x=$1 # 1st argument to the function
    local y=$2 # 2nd argument to the function
    result=$(( x + y ))
    # echo "result is: " $result
}

a=3; b=4
echo "a = $a, b = $b"
result="nothing"
echo "result before calling the function is: " $result
func_add $a $b # note this is arguments to the function
echo "result by passing function arguments is: " $result
func_add $1 $2 # note this is command line arguments
echo "result by passing command line arguments is: " $result
Outline

• Introduction to Linux Shell
• Shell Scripting Basics
  – Variables/Special Characters
  – Arithmetic Operations
  – Arrays
• Beyond Basic Shell Scripting
  – Flow Control
  – Functions
• Advanced Text Processing Commands (grep, sed, awk)
Advanced Text Processing Commands

- grep
- sed
- awk
One slide about Regular Expression

• What are Regular Expressions (regex)?
  o They describe patterns in strings
  o These patterns can be used to modify strings
  o Invented by Stephen Cole Kleene
  o Idea of RegEx dates back to the 1950s
• Today, they come in different “flavors”
• PCRE, POSIX Basic & Extended RegEx, ECMA RegEx and loads more!
• Examples:
Regex examples

- **Anchors** - ^ and $
  - `^The` matches any string that starts with The
  - `end$` matches a string that ends with end
  - `^The end$` exact string match (starts and ends with The end)
  - `roar` matches any string that has the text roar in it

- **Quantifiers** - * + ? and {}
  - `abc*` matches a string that has ab followed by zero or more c
  - `abc+` matches a string that has ab followed by one or more c
  - `abc?` matches a string that has ab followed by zero or one c
  - `abc{2}` matches a string that has ab followed by 2 c
  - `abc{2,}` matches a string that has ab followed by 2 or more c
  - `abc{2,5}` matches a string that has ab followed by 2 up to 5 c

- **OR operator** - | or [ ]
  - `a(b|c)` matches a string that has a followed by b or c
  - `a[bc]` same as previous
grep & egrep

- **grep**: Unix utility that searches a pattern through either information piped to it or files.
- **egrep**: extended grep, same as `grep -E`
- **zgrep**: compressed files.

**Usage**: `grep <options> <search pattern> <files>

**Options**:

- `-i`  
  ignore case during search
- `–r, –R`  
  search recursively
- `–v`  
  invert match i.e. match everything except pattern
- `–l`  
  list files that match pattern
- `–L`  
  list files that do not match pattern
- `–n`  
  prefix each line of output with the line number within its input file.
- `–A num`  
  print num lines of trailing context after matching lines.
- `–B num`  
  print num lines of leading context before matching lines.
grep Examples

• Search files containing the word `bash` in current directory
  
  ```bash
  grep bash *
  ```

• Search files NOT containing the word `bash` in current directory
  
  ```bash
  grep -v bash *
  ```

• Repeat above search using a case insensitive pattern match and print line number that matches the search pattern
  
  ```bash
  grep -iN bash *
  ```

• Search files not matching certain name pattern
  
  ```bash
  ls | grep -vi fun
  ```
grep Examples

100  Thomas  Manager    Sales       $5,000
200  Jason   Developer   Technology $5,500
300  Raj     Sysadmin    Technology $7,000
500  Randy   Manager    Sales       $6,000

• grep OR

grep 'Man\|Sales' employee.txt
  ->  100  Thomas  Manager    Sales       $5,000
      300  Raj     Sysadmin    Technology $7,000
      500  Randy   Manager    Sales       $6,000

• grep AND

grep -i 'sys.*Tech' employee.txt
  ->  100300  Raj     Sysadmin    Technology $7,000
sed

- "stream editor" to parse and transform information – information piped to it or from files
- line-oriented, operate one line at a time and allow regular expression matching and substitution.
- substitution command
### sed commands and flags

<table>
<thead>
<tr>
<th>Flags</th>
<th>Operation</th>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>-e</td>
<td>combine multiple commands</td>
<td>s</td>
<td>substitution</td>
</tr>
<tr>
<td>-f</td>
<td>read commands from file</td>
<td>g</td>
<td>global replacement</td>
</tr>
<tr>
<td>-h</td>
<td>print help info</td>
<td>p</td>
<td>print</td>
</tr>
<tr>
<td>-n</td>
<td>disable print</td>
<td>i</td>
<td>ignore case</td>
</tr>
<tr>
<td>-V</td>
<td>print version info</td>
<td>d</td>
<td>delete</td>
</tr>
<tr>
<td>-r</td>
<td>use extended regex</td>
<td>G</td>
<td>add newline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>w</td>
<td>write to file</td>
</tr>
<tr>
<td></td>
<td></td>
<td>x</td>
<td>exchange pattern with hold buffer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>h</td>
<td>copy pattern to hold buffer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>;</td>
<td>separate commands</td>
</tr>
</tbody>
</table>

*Basic Shell Scripting*
sed Examples

#!/bin/bash

# My First Script

echo "Hello World!"
sed Examples (2)

- Delete blank lines from a file

```bash
sed '/^$/d' hello.sh
```

```bash
#!/bin/bash
# My First Script
echo "Hello World!"
```

- Delete line \texttt{n} through \texttt{m} in a file

```bash
sed '2,4d' hello.sh
```

```bash
#!/bin/bash
echo "Hello World!"
```
sed Examples (1)

- **Add flag** `-e` **to carry out multiple matches.**

```bash
cat hello.sh | sed -e 's/bash/tcsh/g' -e 's/First/Second/g'  
#!/bin/tcsh  
# My Second Script  
echo "Hello World!"
```

- **Alternate form**

```bash
sed 's/bash/tcsh/g; s/First/Second/g' hello.sh  
#!/bin/tcsh  
# My Second Script  
echo "Hello World!"
```

- **The default delimiter is slash (/), can be changed**

```bash
sed 's:/bin/bash:/bin/tcsh:g' hello.sh  
#!/bin/tcsh  
# My First Script  
echo "Hello World!"
```
sed Examples (4)

- Replace-in-place with a backup file
  
  ```
  sed -i.bak '/First/Second/i' hello.sh
  ```

- echo with sed
  
  ```
  $ echo "shell scripting" | sed "s/[si]/?/g"
  $ hell ?cr?pt?ng
  
  $ echo "shell scripting 101" | sed "s/[0-9]/#/g"
  $ shell scripting ###
  ```
**awk**

- The **awk** text-processing language is useful for tasks such as:
  - Tallying information from text files and creating reports from the results.
  - Adding additional functions to text editors like "vi".
  - Translating files from one format to another.
  - Creating small databases.
  - Performing mathematical operations on files of numeric data.
- **awk** has two faces:
  - It is a utility for performing simple text-processing tasks, and
  - It is a programming language for performing complex text-processing tasks.
How Does awk Work

- `awk` reads the file being processed line by line.
- The entire content of each line is split into columns with space or tab as the delimiter.
- `$0` Print the entire line
- `$1, $2, $3, ...` for each column (if exists)
- `NR` number of records (lines)
- `NF` number of fields or columns in the current line.
- By default the field delimiter is space or tab. To change the field delimiter use the `-F<delimiter>` command.
awk Syntax

awk pattern {action}
pattern decides when action is performed

Actions:
• Most common action: print
• Print file dosum.sh:
  awk '{print $0}' dosum.sh
• Print line matching files in all .sh files in current directory:
  awk '/bash/{print $0}' *.sh
uptime
11:18am up 14 days 0:40, 5 users, load average: 0.15, 0.11, 0.17

uptime | awk '{print $0}'
11:18am up 14 days 0:40, 5 users, load average: 0.15, 0.11, 0.17

uptime | awk '{print $1,NF}'
11:18am 12

uptime | awk '{print NR}'
1

uptime | awk -F, '{print $1}'
11:18am up 14 days 0:40

for i in $(seq 1 3); do touch file${i}.dat ; done
for i in file* ; do
> prefix=$(echo $i | awk -F. '{print $1}')
> suffix=$(echo $i | awk -F. '{print $NF}')
> echo $prefix $suffix $i; done

file1.dat file1.dat
file2.dat file2.dat
file3.dat file3.dat
Awk Examples

• Print list of files that are bash script files

```bash
awk '/^#!\!/bin/\bash/{print $0, FILENAME}' *
```

→  #!/bin/bash Fun1.sh
    #!/bin/bash fun_pam.sh
    #!/bin/bash hello.sh
    #!/bin/bash parm.sh

• Print extra lines below patterns

```bash
awk '/sh/ {print; getline; print}' <hello.sh
```

#!/bin/bash
More about grep, sed and awk

➢ grep:

➢ sed:

➢ awk:
What have we learned so far?

Introduction to Linux
  OS used on HPC clusters

HPC User Environment 1
  LSU and LONI HPC policy
  Connect to our cluster
  Use Software on HPC

HPC User Environment 2
  How to submit jobs (PBS/Slurm)
    Interactive jobs
    Batch jobs
Getting Help

- User Guides
  - LSU HPC: http://www.hpc.lsu.edu/docs/guides.php#hpc
  - LONI: http://www.hpc.lsu.edu/docs/guides.php#loni
- Documentation: http://www.hpc.lsu.edu/docs
- Archived tutorials: http://www.hpc.lsu.edu/training/archive/tutorials.php
- Contact us
  - Email ticket system: sys-help@loni.org
  - Telephone Help Desk: 225-578-0900