Shell Programming

Put distinctive simple tools together to accomplish your goal…

hwlin1414

Outline

- Variable pre-operations
- args, argc in Shell Scripts
- Arithmetic and Logics
  - Test commands
- Control Structures: if-else, switch-case, for/while loops
- Input/output: Read from screen
- Defining Functions & Parsing Arguments
- Error Handling and Debug tool (sh -x)
- A Shell Script Sample: Failure Detection on Servers

- Appendix: Regular Expression
- Appendix B: sed and awk

Bourne Shell

- We use Bourne Shell in this slide.

  - `% echo $SHELL`
  - `/usr/local/bin/bash`

  - `% sh`
  - `$`

Executable script

- Shebang
  - `#!/bin/sh`
  - `#!/bin/bash`
  - `#!/usr/local/bin/bash`
  - `#!/usr/bin/env bash`
- Execution
  - `$ sh test.sh`
  - `$ chmod a+x test.sh`
  - `$ ./test.sh`

Shell variables (1)

❑ Assignment

	Bourne Shell	C Shell
Local variable	`my=test`	`set my=test`
Global variable	`export my`	`setenv my test`

- Example:
  - 
    - `$ export PAGER=/usr/bin/less`
  - 
    - `% setenv PAGER /usr/bin/less`
  - 
    - `$ current_month=`date +%m``
  - 
    - `% set current_month =`date +%m``

Shell variables (2)

- Declaration is needed!

There are two ways to call variable…

"${var}"… why? I

- Access
  - % echo "$PAGER"
  - % echo "${PAGER}"
- Use {} to avoid ambiguity
  - % temp_name="haha"
  - % temp="hehe"
  - % echo $temp
    - hehe
  - % echo $temp_name
    - haha
  - % echo ${temp}_name
    - hehe_name
  - % echo ${temp_name}
    - haha

More clear…

Shell variable operator (1)

※ BadCond == !GoodCond

BadCond : var is not set or the value is null
GoodCond : var is set and is not null

operator	description
${var:=value}	If !GoodCond, use the value and assign to var
${var:+value}	If GoodCond, use value instead else null value is used but not assign to var
${var:-value}	If !GoodCond, use the value but not assign to var
${var:?value}	If !GoodCond, **print** value and shell exits

Print → stderr

The command stops immediately

"Parameter Expansion" in sh(1)

Shell variable operator (2)

❑Ex:

```
#!/bin/sh

var1="haha"
echo "01" ${var1:+"hehe"}
echo "02" ${var1}
echo "03" ${var2:+"hehe"}
echo "04" ${var2}
echo "05" ${var1:="hehehe"}
echo "06" ${var1}
echo "07" ${var2:="hehehe"}
echo "08" ${var2}
echo "09" ${var1:-"he"}
echo "10" ${var1}
echo "11" ${var3:-"he"}
echo "12" ${var3}
echo "13" ${var1:?"hoho"}
echo "14" ${var1}
echo "15" ${var3:?"hoho"}
echo "16" ${var3}
```

❑Result:

```
01 hehe
02 haha
03
04
05 haha
06 haha
07 hehehe
08 hehehe
09 haha
10 haha
11 he
12
13 haha
14 haha
hoho
16
```

Shell variable operator (3)

operator	description
${#var}	String length
${var#pattern}	Remove the smallest prefix
${var##pattern}	Remove the largest prefix
${var%pattern}	Remove the smallest suffix
${var%%pattern}	Remove the largest suffix

These operators do not change var. value…

```
#!/bin/sh

var="Nothing happened end closing end"

echo ${#var}
echo ${var#*ing}
echo ${var##*ing}
echo ${var%end*}
echo ${var%%end*}
```

Results:

```
32
happened end closing end
end
Nothing happened end closing
Nothing happened
```

Predefined shell variables

Similar to C program's "Int main(argc, args)" – **arguments of program**, e.g. ls –a ~

- Environment Variables
- Other useful variables:

sh	description
$#	Number of positional arguments
$0	Command name
$1, $2, ..	Positional arguments
$*	List of positional arguments (useful in for loop)
$?	Return code from last command
$$	Process number of current command (pid)
$!	Process number of last background command

Usage of $* and $@

- The difference between $* and $@
  - $* : all arguments are formed into a long string
  - $@ : all arguments are formed into separated strings

- Examples: test.sh

```
for i in "$*" ;  do
    echo $i
done

% test.sh 1 2 3
1 2 3
```

```
for i in "$@" ;  do
    echo $i
done

% test.sh 1 2 3
1
2
3
```

test command

Checking things for us… e.g. file status, statements

- test(1)
  - test expression
  - [expression]
  - Test for: file, string, number

- Test and return 0 (true) or 1 (false) in $?
  - `% test -e News ; echo $?` → $? To obtain the return code
    - If there exist the file named "News"
  - `% test "haha" = "hehe" ; echo $?`
    - Whether "haha" **equal** "hehe"
  - `% test 10 -eq 11 ; echo $?`
    - Whether 10 **equal** 11

Details on the capability of test command – File test

- -e file
  - True if file exists (regardless of type)
- -s file
  - True if file exists and has a size greater than zero
- -b file
  - True if file exists and is a block special file
- -c file
  - True if file exists and is a character special file
- -d file
  - True if file exists and is a directory
- -f file
  - True if file exists and is a regular file
- -p file
  - True if file is a named pipe (FIFO)
- -L file
  - True if file exists and is a symbolic link
- -S file
  - True if file exists and is a socket
- -r file
  - True if file exists and is readable
- -w file
  - True if file exists and is writable
- -x file
  - True if file exists and is executable
- -u file
  - True if file exists and its set user ID flag is set
- -g file
  - True if file exists and its set group ID flag is set
- -k file
  - True if file exists and its sticky bit is set
- -O file
  - True if file exists and its owner matches the effective user id of this process
- -G file
  - True if file exists and its group matches the effective group id of this process
- file1 -nt file2
  - True if file1 exists and is newer than file2
- file1 -ot file2
  - True if file1 exists and is older than file2
- file1 -ef file2
  - True if file1 and file2 exist and refer to the same file

Hard links to same file..

Details on the capability of test command – String test

- -z string
  - True if the length of string is zero
- -n string
  - True if the length of string is nonzero
- string
  - True if string is not the null string
- s1 = s2
  - True if the strings s1 and s2 are identical
- s1 != s2
  - True if the strings s1 and s2 are not identical
- s1 < s2
  - True if string s1 comes before s2 based on the binary value of their characters
- s1 > s2
  - True if string s1 comes after s2 based on the binary value of their characters

Details on the capability of test command – Number test

- n1 -eq n2 ==, !=, >, <, >=, <= fashion does not apply here…
  - True if the integers n1 and n2 are algebraically equal
- n1 -ne n2
  - True if the integers n1 and n2 are not algebraically equal
- n1 -gt n2
  - True if the integer n1 is algebraically greater than the integer n2
- n1 -ge n2
  - True if the integer n1 is algebraically greater than or equal to the integer n2
- n1 -lt n2
  - True if the integer n1 is algebraically less than the integer n2
- n1 -le n2
  - True if the integer n1 is algebraically less than or equal to the integer n2

test command – combination

- ! expression
  - True if expression is false.
- expression1 -a expression2
  - True if both expression1 and expression2 are true.
- expression1 -o expression2
  - True if either expression1 or expression2 are true.
  - The -a operator has higher precedence than the -o operator.
- (expression)
  - True if expression is true

test command – in script

- test command short format using [] or ()
  - % test "haha" = "hehe" ; echo $?

```
if [ "haha" = "hehe" ] ; then
        echo “haha equals hehe”
else
        echo “haha doesn’t equal hehe”
fi
```

expr command

```
# AND - OR – NOT
$ [ 1 -eq 2 ] || [ 1 -eq 1 ] ;
echo $?
0

$ [ 1 -eq 1 ] || [ 1 -eq 2 ] ;
echo $?
0

$ [ 1 -eq 1 ] && [ 1 -eq 2 ] ;
echo $?
1

$ [ 1 -eq 2 ] && [ 1 -eq 1 ] ;
echo $?
1

$ ! [ 1 -eq 2 ] ; echo $?
0

$ [ 1 -eq 2 ] ; echo $?
1
```

Arithmetic Expansion

```
echo $(( 1 + 2 ))     3


a=8                          // a=8
a=$(( $a + 9 ))              // a=17
a=$(( $a + 17 ))             // a=34
a=$(( $a + 9453 ))           // a=9487
echo $a                      9487
```

if-then-else structure

```
if [ test conditions ] ; then
      command-list
Elif [ test contitions ] ; then
      command-list
else
      command-list
fi
```

switch-case structure (1)

```
case $var in
    value1)
        action1
    ;;
    value2)
        action2
    ;;
    value3|value4)
        action3
    ;;
    *)
        default-action
    ;;
esac
```

```
case $sshd_enable in
    [Yy][Ee][Ss])
        action1
    ;;
    [Nn][Oo])
        action2
    ;;
    *)
        ???
    ;;
esac
```

For loop

```
for var in var1 var2 …; do
        action
done
```

```
a=“”
for var in `ls`; do
        a=“$a $var”
done
echo $a
```

While loop

```
while […] ; do
      action
done

break
continue
```

Read from stdin

```
#!/bin/sh
echo -n "Do you want to 'rm -rf /'  (yes/no)? "
read answer
case $answer in
    [Yy][Ee][Ss])
        echo "Hahaha"
    ;;
    [Nn][Oo])
        echo "No~~~"
    ;;
    *)
        echo "removing..."
    ;;
esac
```

Create tmp file/dir

- `TMPDIR=`mktemp -d tmp.XXXXXX``
- `TMPFILE=`mktemp ${TMPDIR}/tmp.XXXXXX``
- `echo "program output" >> ${TMPFILE}`

functions (1)

- Define function

```
function_name ( ) {
   command_list
}
```

- Removing function definition

```
unset function_name
```

- Function execution

```
function_name
```

- Function definition is local to the current shell

※ Define the function before first use…

functions (2) - scoping

```
func () {
        # global variable
        echo $a
        a="hello"
}
a="5566"

func
echo $a

Result:
5566
hello
```

```
func () {
        # global variable
        local a="hello"
        echo $a
}
a="5566"

func
echo $a

Result:
hello
5566
```

functions (3) - arguments check

```
func () {
        if [ $# -eq 2 ] ; then
                echo $1 $2
        else
                echo “Wrong”
        fi
}
func
func hi
func hello world

Result:
Wrong
Wrong
hello world
```

functions (4) - return value

```
func () {
        if [ $# -eq 2 ] ; then
                return 0
        else
                return 2
        fi
}
func
echo $?
func hello world
echo $?

Result:
2
0
```

Parsing arguments

- Use getopt (recommended)

```
#!/bin/sh

while getopts abcf: op ; do
    echo "${OPTIND}-th arg“

    case $op in
        a|b|c)
            echo "one of ABC" ;;
        f)
            echo $OPTARG ;;
        *)
            echo "Default" ;;
        esac
done
```

```
$ ./test.sh -a -b -c -f gg
2-th arg
one of ABC
3-th arg
one of ABC
4-th arg
one of ABC
6-th arg
gg
```

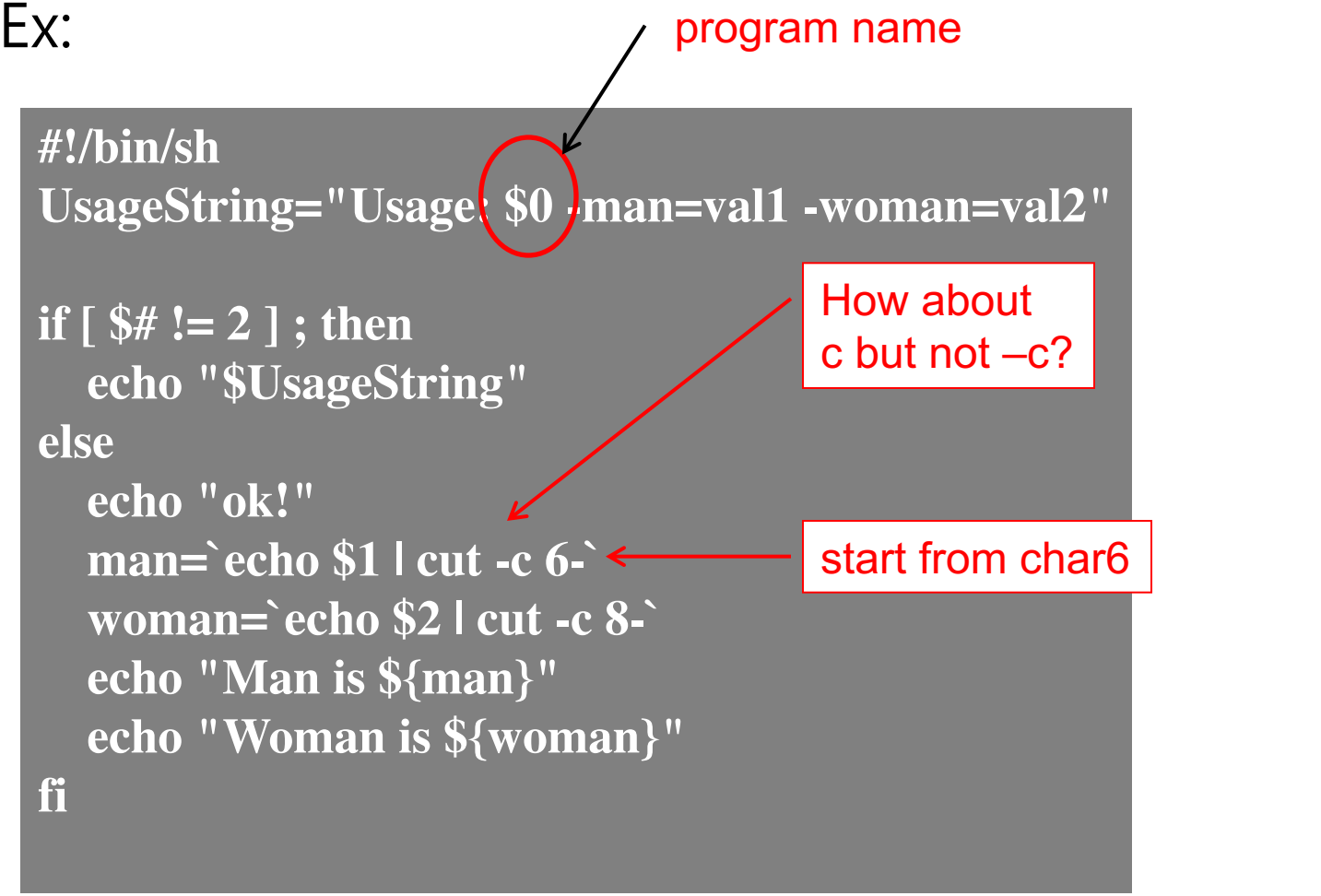
":" means additional arg.
$OPTARG: content of arguments
$OPTIND: index of arguments

Handling Error Conditions

- Internal error ← program crash
  - Caused by some command's failing to perform
    - User-error
      - Invalid input
      - Unmatched shell-script usage
    - Command failure
- External error ← signal from OS
  - By the system telling you that some system-level event has occurred by sending signal

Handling Error Conditions – Internal Error

- Ex:



→ Handling the errors yourself…

Handling Error Conditions – External Error (1)

- Using trap in Bourne shell
  - trap [command-list] [signal-list]
    - Perform command-list when receiving any signal in signal-list

Usag: trap "[commands]" list of signals looking for…

```
trap "rm tmp*; exit0" 1 2 3 14 15
```

```
trap "" 1 2 3
```

Ignore signal 1 2 3

Handling Error Conditions – External Error (2)

#	Name	Description	Default	Catch	Block	Dump core
1	SIGHUP	Hangup	Terminate	☑	☑	⊘
2	SIGINT	Interrupt (^C)	Terminate	☑	☑	⊘
3	SIGQUIT	Quit	Terminate	☑	☑	☑
9	SIGKILL	Kill	Terminate	⊘	⊘	⊘
10	SIGBUS	Bus error	Terminate	☑	☑	☑
11	SIGSEGV	Segmentation fault	Terminate	☑	☑	☑
15	SIGTERM	Soft. termination	Terminate	☑	☑	⊘
17	SIGSTOP	Stop	Stop	⊘	⊘	⊘
18	SIGTSTP	Stop from tty (^Z)	Stop	☑	☑	⊘
19	SIGCONT	Continue after stop	Ignore	☑	⊘	⊘

Debugging Shell Script

Debug tools in sh…

❑Ex:

```
#!/bin/sh -x

var1="haha"
echo "01" ${var1:+"hehe"}
echo "02" ${var1}
echo "03" ${var2:+"hehe"}
echo "04" ${var2}
echo "05" ${var1:="hehehe"}
echo "06" ${var1}
echo "07" ${var2:="hehehe"}
echo "08" ${var2}
echo "09" ${var1:-"he"}
echo "10" ${var1}
echo "11" ${var3:-"he"}
echo "12" ${var3}
echo "13" ${var1:?"hoho"}
echo "14" ${var1}
echo "15" ${var3:?"hoho"}
echo "16" ${var3}
```

Debug mode

❑Result:

```
+ var1=haha
+ echo 01 hehe
01 hehe
+ echo 02 haha
02 haha
+ echo 03
03
+ echo 04
04
+ echo 05 haha
05 haha
+ echo 06 haha
06 haha
+ echo 07 hehehe
07 hehehe
+ echo 08 hehehe
08 hehehe
+ echo 09 haha
09 haha
+ echo 10 haha
10 haha
+ echo 11 he
11 he
+ echo 12
12
+ echo 13 haha
13 haha
+ echo 14 haha
14 haha
hoho
```

Debug msgs.
print out the
substitution results…

Useful tools

- head
- tail
- grep
- find
- ps
- xargs

Shell Script Examples

check alive (1)

- ping
  - /sbin/ping –c 3 bsd1.cs.nctu.edu.tw

```
PING bsd1.cs.nctu.edu.tw (140.113.235.131): 56 data bytes
64 bytes from 140.113.235.131: icmp_seq=0 ttl=60 time=0.472 ms
64 bytes from 140.113.235.131: icmp_seq=1 ttl=60 time=0.473 ms
64 bytes from 140.113.235.131: icmp_seq=2 ttl=60 time=0.361 ms

--- bsd1.cs.nctu.edu.tw ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max/stddev = 0.361/0.435/0.473/0.053 ms
```

check alive (2)

```
#!/bin/sh
# [Usage] isAlive.sh ccbsd1

Usage="[Usage] $0 host"
temp="$1.ping"
Admin="liuyh"
count="20"

if [ $# != 1 ] ; then
  echo $Usage
else
  /sbin/ping -c ${count:=10} $1 | /usr/bin/grep 'transmitted' > $temp
  Lost=`awk –F" " '{print $7}' $temp | awk –F"%" '{print $1}' `

  if [ ${Lost:=0} -ge 50 ] ; then
    mail –s  "$1 failed" $Admin < $temp
  fi
  /bin/rm $temp
fi
```

default 10 times

Grep “tran…”

wrtie to the temp file

- awk on $temp using space as delimeter
- How many % packet loss?

Mail and del. $temp

Appendix A: Regular Expression

pattern matching

Regular Expression (1)

- Informal definition
  - Basis:
    - A single character "a" is a R.E.
  - Hypothesis
    - If r and s are R.E.
  - Inductive
    - Union: r + s is R.E
      - Ex: a + b
    - Concatenation: rs is R.E.
      - Ex: ab
    - Kleene closure: r* is R.E.
      - Ex: a*

Regular Expression (2)

- Pattern-matching
  - Special operators

operator	Description
.	Any single character
[]	Any character in []
[^]	Any character not in []
^	start of a line
$	end of a line
*	zero or more
?	zero or one
+	one or more
{m,n}	At least m times and at most n times
{m,}	At least m times.
{m}	Exactly m times.
\	Escape character

Regular Expression (3)

- Examples
  - r.n
    - Any 3-character string that start with r and end with n
      - r1n, rxn, r&n will match
      - r1xn, axn will not match
  - ..Z..
    - Any 5-character strings that have Z as 3rd character
      - aeZoo, 12Zos will match
      - aeooZ, aeZoom will not match
  - r[a-z]n
    - Any 3-character string that start with r and end with n and the 2nd character is an alphabet
      - rxn will match
      - r1n, r&n will not match

Regular Expression (4)

- Examples
  - ^John
    - Any string starts with John
      - John Snow -> will match
      - Hi John -> will not match
  - [En][Nn][Dd]$
    - Any string ends with any combination of "end"
  - [A-Za-z0-9]+
    - String of characters

Regular Expression (5)

- Utilities using RE
  - grep
  - awk
  - sed
  - find
- Different tools, different RE
  - BRE (Basic)
  - ERE (Extended)
  - PCRE (Perl Compatible)
  - https://en.wikipedia.org/wiki/Regular_expression#Standards

Appendix B: sed and awk

Details on using sed and awk…

sed – Stream EDitor (1)

- sed(1)
  - sed –e “command” –e “command”… file
  - sed –f script-file file
    - Sed will (1) read the file line by line and (2) do the commands, then (3) output to stdout
    - e.g. sed -e '1,10d' -e 's/yellow/black/g' yel.dat
- Command format
  - [address1[,address2]]function[argument]
    - From address 1 to address 2
    - Do what action
- Address format
  - n ➔ line number
  - /R.E./ ➔ the line that matches R.E

sed – Stream EDitor (2)

- Example of address format
  - `sed -e 10d`
  - `sed -e /man/d`
  - `sed -e 10,100d`
  - `sed -e 10,/man/d`
    - Delete line from line 10 to the line contain "man"

sed – Stream EDitor
Function: substitution (1)

- substitution
  - Syntax

    s/pattern/replace/flags
  - Flags
    - N: Make the substitution only for the N'th occurrence
    - g: replace all matches
    - p: print the matched and replaced line
    - w: write the matched and replaced line to a file

sed – Stream EDitor
Function: substitution (2)

- Ex:
  - sed –e ‘s/liuyh/LIUYH/2’ file
  - sed –e ‘s/liuyh/LIUYH/g’ file
  - sed –e ‘s/liuyh/LIUYH/p’ file
  - sed –n –e ‘s/liuyh/LIUYH/p’ file
  - sed –e ‘s/liuyh/LIUYH/w wfile’ file

file
I am jon
I am john
I am liuyh
I am liuyh
I am nothing

sed – Stream EDitor
Function: delete

- delete
  - Syntax:
    [address]d
- Ex:
  - `sed -e 10d`
  - `sed -e /man/d`
  - `sed -e 10,100d`
  - `sed -e 10,/man/d`

sed – Stream EDitor
Function: append, insert, change

- append, insert, change
  - Syntax:

[address]a\	[address]i\	[address]c\
text	text	text

- insert → insert before the line
- change → replace whole line

- Ex:
  - sed –f sed.src file

sed.src

```
/liuyh/i \
Meet liuyh, Hello
```

file

```
I am jon
I am john
I am liuyh
I am liuyh
I am nothing
```

Results:

```
I am jon
I am john
Meet liuyh, Hello
I am liuyh
Meet liuyh, Hello
I am liuyh
I am nothing
```

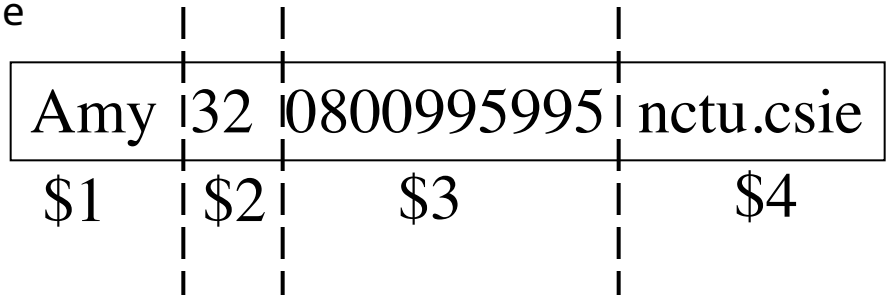
sed – Stream EDitor
Function: print

- print
  - Syntax:
    [addr1, addr2]p
- Ex:
  - sed -n -e '/^liuyh/p' Print out the lines that begins with liuyh

-n: By default, each line of input is echoed to the standard output after all of the commands have been applied to it. The -n option suppresses this behavior.

awk

- awk(1)
  - `awk [-F fs] [ 'awk_program' | -f program_file] [data_file ……]`
    - awk will read the file line by line and evaluate the pattern, then do the action if the test is true
    - Ex:
      - `awk '{print "Hello World"}' file`
      - `awk '{print $1}' file`



- Program structure
  - `pattern { action }`
  - missing pattern means always matches
  - missing { action } means print the line

awk – Pattern formats

- pattern formats
  - Regular expression
    - `awk '/[0-9]+/ {print “This is an integer” }'`
    - `awk '/[A-Za-z]+/ {print “This is a string” }'`
    - `awk '/^$/ {print “this is a blank line.”}'`
  - BEGIN
    - before reading any data
      - `awk ' BEGIN {print “Nice to meet you”}'`
  - END
    - after the last line is read
      - `awk ' END {print “Bye Bye”}'`

awk – action format

- Actions
  - Print
  - Assignment
  - if(expression) statement [; else statement2]
    - `awk ' { if( $2 ~ /am/ ) print $1}' file`
  - while(expression) statement
    - `awk 'BEGIN {count=0} /liuyh/ {while (count < 3) {print count;count++}}' file`
    - `awk 'BEGIN {count=0} /liuyh/ {while (count < 3) {print count;count++};count=0}' file`
  - for (init ; test ; incr) action
    - `awk '{for (i=0;i<3;i++) print i}' file`

var usage: no need for "$"

reset count after printing

awk – built-in variables (1)

- $0, $1, $2, ...
  - Column variables
- NF
  - Number of fields in current line
- NR
  - Number of line processed
- FILENAME
  - the name of the file being processed
- FS
  - Field separator, set by -F
- OFS
  - Output field separator

awk – built-in variables (2)

- Ex:
  - awk ‘BEGIN {FS=“:”} /liuyh/ {print $3}’ /etc/passwd
    - 1002
  - awk 'BEGIN {FS=":"} /^liuyh/{print $3 $6}' /etc/passwd
    - 1002/home/liuyh
  - awk 'BEGIN {FS=":"} /^liuyh/{print $3 " " $6}' /etc/passwd
    - 1002 /home/liuyh
  - awk 'BEGIN {FS=":" ;OFS="=="} /^liuyh/{print $3 ,$6}' /etc/passwd
    - 1002==/home/liuyh

Reference

- awk(1)
- sed(1)
- http://www.grymoire.com/Unix/Awk.html
- http://www.grymoire.com/Unix/Sed.html
- https://en.wikipedia.org/wiki/Regular_expression