bw|HPC – C5

bwHPC Course: (Advanced) Bash Scripting

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How to read the following slides

Abbreviation/Colour code	Full meaning
`$ command -option value`	`$` = prompt of the interactive shell The full prompt may look like: `user@machine:path$` The command has been entered in the interactive shell session
`<integer>` `<string>`	<> = Placeholder for integer, string etc
`foo, bar`	Metasyntactic variables
`${WORKSHOP}`	`/pfs/data1/software_uc1/bwhpc/kit/workshop/2015-09-22`

Sources of this slides?

- http://tldp.org/HOWTO/Bash-Prog-Intro-HOWTO.html (intro)
- http://tldp.org/LDP/abs/html (advanced)
- $ man bash

Why (not) Bash?!

- Great at:
  - managing batch jobs
  - managing external programs
  - invoking entire UNIX command stack & many builtins
- Powerful scripting language
- Portable and version-stable
- Bash almost everywhere installed

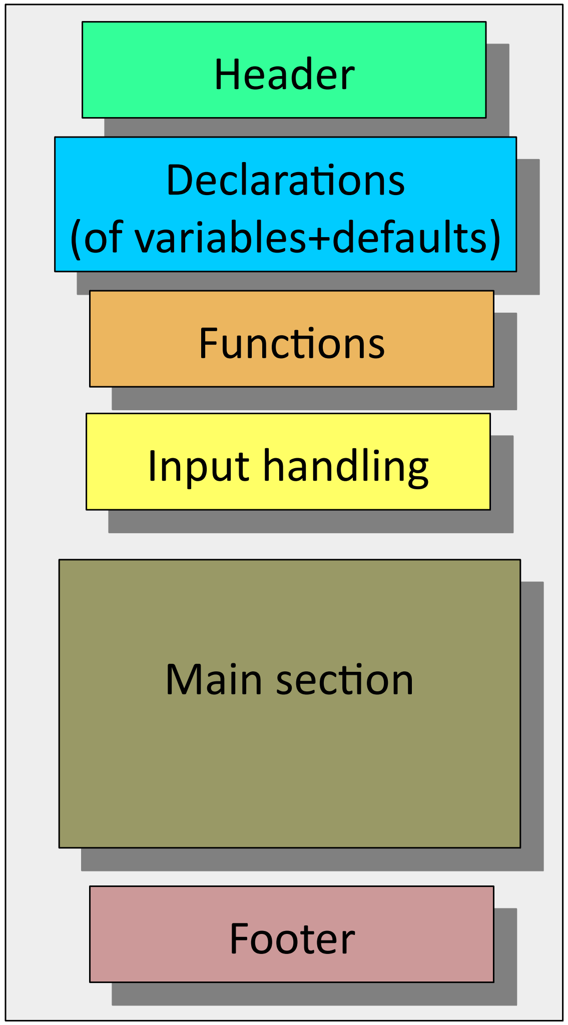
- Less useful when:
  - Resource-intensive tasks (e.g. sorting, recursion, hashing)
  - Heavy-duty math operations
  - Extensive file operations
  - Need for native support of multi-dimensional arrays

Goal

- Be descriptive!
  - Comment your code
    - e.g. via headers sections of script and functions.
  - Decipherable names for variables and functions

- Organise and structure!
  - Break complex scripts into simpler modules

    e.g. use functions
  - Use exit codes
  - Use standardized parameter flags for script invocation.



Header & Line format

- Sha-Bang = '#!'

  → at head of file = 1. line only!

```
#!/bin/bash
```

  - Options: e.g. debugging shell):

```
#!/bin/bash -x
```

  - #!/bin/sh → invokes default shell interpreter → mostly Bash
  - If path of bash shell varies:

```
#!/usr/bin/env bash
```

- Line ends with no special character!
  - But multiple statements in one line to be separated by:

`;` Comma

```
$ echo hello; echo World; echo bye
```

Bash Output

- **echo**

  a) trails every output with a „newline“

```
$ echo hello; echo World
hello
World
```

  b) prevent newline:

```
$ echo -n hello; echo World
helloWorld
```

  c) parsing „escape sequences“

```
$ echo -e "hello\nWorld"
hello
World
```

- printf = „enhanced“ echo
  - by default no „newline“ trailing
  - formated output

```
$ printf hello; printf World
helloWorld$
```

```
$ printf "%-9.9s: %03d\n" "Integer" "5"
Integer  : 005
```

Globbing

- = filename expansion
  → recognices and expands „wildcards“
- but this is **not** a Regular Expression interpretion

- wildcards:

*	= any multiple characters
?	= any single character
[]	= to list specific character e.g. list all files starting with a or b `$ ls [a,b]*`
^	= to negate the wildcard match e.g. list all files not starting with a `$ ls [^a]*`

Variables (1)

- Substitution:
  - No spaces before and after '='
  - Brace protect your variables!
  - Values can be generated by commands

```
var1=value
```

```
var2=${var2}
```

```
var2=$(date)
```

- Bash variables are untyped

  → essentially strings,

  → depending on content arithmetics permitted

```
$ a=41; echo $((a+1))
42
```

```
$ a=BB; echo $((a+1))
1
```

→ string has an integer value of 0

- declare/typeset (bash builtin)
  - set variable to integer, readonly, array etc.

```
$ declare -r a=1
$ let a+=1
bash: a: readonly variable
```

```
$ array=( '1 2' 3 4 5)
$ echo ${array[0]}
1 2
```

→ space is separator

Variables (2)

- declare – *cont.*
  - Excursion: store file content in array:
    - a) 1 element per string
    - b) 1 element for whole file
    - c) 1 element per line
  - Identifying variable var:

```
a=( $(< file) )
```

```
a=( "$(< file)" )
```

```
while read -r line; do a+=("${line}") ; done < file
```

```
declare | grep var
```

- Usage only without $ prefix when declare, assign, export, unset

```
declare -i a=41
export a
echo ${a}
unset a
echo ${a}
```

→ use **${}** instead of simply $ to avoid problems manipulating variables

Comments and Quotes

Comments

- at beginning
- at the end
- exception: escaping, quotes, substitution

```
# This line is not executed
```

```
echo 'something' # Comment starts here
```

\ Escape = Quoting mechanism for single characters

```
echo \#
```

' Full Quotes = Preserves all special characters within

```
echo '#'
```

" Partial Quotes = Preserves some of the special characters, but not `${var}`

```
var=42

echo "\${var} = ${var}"
echo '\${var} = ${var}'
```

Manipulation of Variables (1)

Syntax	Does?	Examples

`${#var}`	String length	`$ A='abcdef_abcd'; echo ${#A}`
		`11`

`${var:pos:len}`	Substring extraction:	

	a) via Parameterisation	`$ POS=3; echo ${A:${POS}:2}`
		`de`

	b) Indexing from right	`$ echo ${A:(-2)}`
		`cd`

`${var#sstr}`	Strip shortest match of $sstr from front of $var	`$ sstr=a*b; echo ${A#${sstr}}`
		`cdef_abcd`

`${var%sstr}`	Strip shortest match of $sstr from back of $var	`$ sstr=c*d; echo ${A%${sstr}}`
		`abcdef_ab`

`${var/sstr/repl}`	Replace first match of $sstr with $repl	`$ sstr=ab; rp=AB; echo ${A/${sstr}/${rp}}`
		`ABcdef_abcd`

`${var//sstr/repl}`	Replace all matches of $sstr with $repl	`$ echo ${A//${sstr}/$rp}`
		`ABcdef_ABcd`

`${var/#sstr/repl}`	If $sstr matches frond end, replace by $repl	`$ sstr=a; rp=z_; echo ${A/#${sstr}/${rp}}`
		`z_bcdef_abcd`

`${var/%sstr/repl}`	If $sstr matches back end, replace by $repl	`$ sstr=d; rp=_z; echo ${A/%${sstr}/${rp}}`
		`abcdef_abc_z`

Manipulation of Arrays

Syntax	Does?	Examples

`${#array[@]}`	Number of elements	`$ dt=( $(date) ); echo ${#dt[@]}`
		`6`

`${array[@]:p1:p2}`	Print elements from no. **p1** to **p2**:	`$ echo ${dt[@]:1:2}`
		`Feb 25`

`${array[@]#sstr}`	Strip shortest match of $sstr from front of all elements of Array	`$ sstr=W*d; echo ${dt[@]#${sstr}}`
		`Feb 25 10:18:22 CET 2015`

- Adding elements to an array:

  a) at the end:

```
$ dt+=( "AD" )
$ echo ${dt[@]}
Wed Feb 25 17:18:22 CET 2015 AD
```

  b) in-between

```
$ dt=( ${dt[@]:0:2} ':-)' ${dt[@]:2}} )
$ echo ${dt[@]}
Wed Feb 25 :-) 17:18:22 CET 2015
```

Output & Input Redirection (1)

Syntax	Does?	Examples
`exe > log`	Standard output (stdout) of application exe is (over)written to file log	`$ date > log; cat log`
`exe >> log`	Standard output (stdout) of application exe is append to file log	`$ date >> log; cat log`
`exe 2> err`	Standard output (stderr) of application exe is (over)written to file err	`$ date 2> err; cat err`
`exe 2>> log`	Standard output (stderr) of application exe is append to file log	`$ date 2>> err; cat err`
`exe >> log 2>&1`	Redirects stderr to stdout	`$ date >> log 2>&1`

`exe1 | exe2`	Passes stdout of exe1 to standard input (stdin) of exe2 of next command	`# Print stdout & stderr to screen and then append both to file`
		 `$ date 2>&1 | tee -a log`

`exe < inp`	Accept stdin from file inp	`$ wc -l < file`

Output & Input Redirection (2)

- Take care of order when using redirecting
  - e.g:

```
ls -yz >> log 2>&1
```

→ Stdout redirected to file
→ Stderr redirected to file redirectd stdout

```
ls -yz 2>&1 >> log
```

→ Stderr redirected to stdout (channel)
→ Stdout redirected to file

- Suppressing stderr

```
ls -yz >> log 2>/dev/null
```

Usage? Keep variable empty when error occurs,

→ e.g. number of files with extension log

```
list_logs="$(ls *.log 2>/dev/null)"
```

Output & Input Redirection (3)

- Redirection of „all“ output in shell script to one user file

  → generalise = define variable

```
#!/bin/bash

log="blah.log"
err="blah.err"

echo "value 1" >> ${log} 2>> ${err}
command >> ${log} 2>> ${err}
```

  → or use exec

```
#!/bin/bash

exec > "blah.log" 2> "blah.err"

echo "value 1"
command
```

→ all stdout and stderr after 'exec' will be written to blah.log and blah.err resp.

Manipulation of Variables (2)

- Example:

```
${WORKSHOP}/exercises/bash/var_manipulation.sh
```

```
#!/bin/bash

## Purpose: Define automatic output names for executables

exe="binary.x"

## Assume: $exe contains extension .x or .exe etc
sstr=".*"
log="${exe%${sstr}}.log"  ## replace extension with .log
err="${exe%${sstr}}.err"  ## replace extension with .err

## Define command: echo and run
echo "${exe} >> ${log} 2>> ${err}"
${exe} >> ${log} 2>> ${err}
```

Expansion of Variables

Syntax	Does?	Examples

`${var-${def}}`	If $var not set, set value of $def	`$ unset var; def=new; echo ${var-${def}}`
		`new`

`${var:-${def}}`	If $var not set or *is empty*, set value of $def	`$ var=''; def=new; echo ${var:-${def}}`
		`new`
		`# Output name for interactive and MOAB`
		`jobID=${MOAB_JOBID:-${BASHPID}}`

`${var:?${err}}`	If $var not set or *is empty,* print $err and abort script with exit status of 1	`$ var=''; err='ERROR - var not set'`
		`$ echo ${var:?${err}}`
		`bash: var: ERROR - var not set`

Exit & Exit Status

- Exit terminates a script
- Every command returns an exit status
  - successfull = 0
  - non-successfull > 0 (max 255)
- $? = the exit status of last command executed (of a pipe)

```
ls -xy; echo $?
2
```

- Special meanings (avoid in user-specified definitions):

1 =	Catchall for general errors
2 =	Misuse of shell builtins
126 =	Command invoked cannot execute (e.g. /dev/null)
127 =	"command not found"
128 + n =	Fatal error signal "n" (e.g. kill -9 of cmd in shell returns 137)

(Conditional) Tests

```
if condition1 ; then
   do_if_cond1_true/0
elif condition2 ; then
   do_if_cond2_true/0
else
   do_the_default
fi
```

condition	Does?	Examples

`(( ))`	Arithmetic evaluation	`$ if (( 2 > 0 )) ; then echo yes ; fi`
		`yes`

`[ ]`	Part of (file) test builtin, arithmetic evaluation only with `-gt`, `-ge`, `-eq`, `-lt`, `-le`, `-ne`	`$ if [ 2 -gt 0 ] ; then echo yes ; fi`
		`yes`
		`$ # existance of file`
		`$ if [ -e "file" ] ; then echo yes ; fi`

`[[ ]]`	Extented test builtin; allows usage of `&&`, `||`, `<`, `>`	`$ a=8; b=9`
		`$ if [[ ${a} < ${b} ]]; then echo $? ; fi`
		`0`

Typical File Tests

- (not) exists:
```
if [ ! -e "file" ] ; then echo "file does not exist" ; fi
```
- file is not zero:
```
[ -s "file" ] && (echo "file greater than zero")
```
- file is directory:
```
[ -d "file" ] && (echo "This is a directory")
```

- readable:
- writeable:
- executable:
```
[ -r "file" ]

[ -w "file" ]

[ -x "file" ]
```

- newer that file2:
```
[ "file" -nt "file2" ]
```

- Pitfalls when using variables:

wrong:
```
$ unset file_var; if [ -e ${file_var} ] ; then echo "yes" ; fi
yes
```

right:
```
$ unset file_var; if [ -e "${file_var}" ] ; then echo "yes" ; fi
```

for Loops

```
for arg in list
   do
    command
done
```

- Iterates command(s) until all arguments of *list* are passed
- *list* may contain globbing wildcards

- Example

```
#!/bin/bash

## Purpose: Loop over generated integer sequence
counter=1
for i in {1..10} ; do
   echo "loop no. ${counter}: ${i}"
   let counter+=1
done
```

while Loops

```
while condition
   do
    command
done
```

- Iterates command(s) as long as *condition* is true (or exit status 0)
- Allows indefinite loops

- Example

```
#!/bin/bash

## Purpose: Loop until max is reached
max=10
i=1
while (( ${max} >= ${i} )) ; do
   echo "${i}"
   let i+=1
done
```

Positional parameters

= Arguments passed to the script from the command line

Special variable	Meaning, notes
`$0`	Name of script itself
`$1, $2, $3`	First, second, and third argument
`${10}`	10th argument, but: `$10 = $1 + 0`
`$#`	Number of arguments
`$*`	List of all arguments as one single string
`$@`	List of all arguments, each argument separately quoted

- **Example:**

  Show differences between

  `${*}` and `${@}`

```
echo "Number PPs: ${#}"

i=1
for PP in "${@}" ; do
   printf "%3.3s.PP: %s\n" "${i}" "${PP}"
   let i+=1
done

i=1
for PP in "${*}" ; do
   printf "%3.3s.PP: %s\n" "${i}" "${PP}"
   let i+=1
done
```

`${WORKSHOP}/exercises/bash/special_var_01.sh`

Conditional evaluation - case

```
case variable in
    condition1)
        do_if_cond1_true/0
        ;;
    *)
        do_the_default
        ;;
esac
```

- analog to switch in C/C++
- to simplify multiple if/then/else
- each condition block ends with double semicolon
- If a condition tests true:

    a) commands in that block are executed

    b) case block terminates

Processing Input without getopts

- Combining: Positional parameter + case + while

```
${WORKSHOP}/exercises/bash/proc_input.sh
```

```
#!/bin/bash

## Purpose: Processing positional parameters

while (( ${#} > 0 )) ; do
   case "${1}" in

      ## script option: -h
      -h) echo "${1}: This option is for HELP"   ;;

      ## script option: -i + argument
      -i) echo "${1}: This option contains the argument ${2}"
          shift ;;


      ## default
       *) echo "${1}: This is non-defined PP"    ;;
   esac
   ## Shifting positional parameter one to the left: $1 <-- $2 <-- $3
   shift
done
```

Lifetime of Variables (1)

- Script execution:
  - assigned variables only known during runtime
  - assigned variables not known in „slave“ scripts until „exported“
  - Example:

```
${WORKSHOP}/exercises/bash/master_parse_var.sh
${WORKSHOP}/exercises/bash/slave_get_var.sh
```

```
#!/bin/bash

## Purpose: Demonstrate parsing of assigned variables

var1="Non-exported value of var1"
export var2="Exported value of var2"
slave_sh="./slave_get_var.sh"

## check if $slave_sh is executable for user
echo "${0}: \$var1 = $var1"
echo "${0}: \$var2 = $var2"
if [ -x "${slave_sh}" ] ; then
   "${slave_sh}"
fi
```

- But: export of variables in script to interactive shell session only via:

```
$ source script.sh
```

(compare ~/.bashrc)

Lifetime of Variables (2)

- Environmental variables

  a) can be read in e.g. `my_workDIR=${PWD}`

  b) during script changed, example:

```
...
## Purpose: Demonstrating effects on environmental variables

## Changing it during runtime
export HOME="new_home_dir"
echo "${0}: \${HOME} = ${HOME}"
...
```

`${WORKSHOP}/exercises/bash/env_var.sh`

```
$ echo ${HOME}; ./env_var.sh; echo ${HOME}
/home/kit/scc/ab1234
./env_var.sh: ${HOME} = new_home_dir
/home/kit/scc/ab1234
```

awk & sed: Command substitution

- **awk**

  → full-featured text processing language with a syntax reminiscent of C

  → use for complicated arithmetics or text or RE processing

  - Examples:

    a) logarithm of variable:

    ```
    a=10; echo ${a} | awk '{print log($1)}'
    ```

    b) first column reformated:

    ```
    awk '{printf "%20.20s\n",$1}' file
    ```

  - One-liners: http://awk.info/?OneLiners

- **sed**

  → non-interactive stream editor

  → use for deleting blank or commented lines etc

  - Example: delete all blank lines of a file:

    ```
    sed '/^$/d' file
    ```

  - One-liners: http://sed.sourceforge.net/sed1line.txt

Functions (1)

```
function my_name ()
{
    commands
}
```

- Stores a series of commands for ***later*** or ***repeative*** execution
- Functions are called by writing the name
- **Like scripts:** functions handle positional parameters
- Example:

`${WORKSHOP}/exercises/bash/fct_01.sh`

```
#!/bin/bash

## Purpose: Demonstrating features of functions

## Add to printf command a common string
function my_printf ()
{
   printf "${0}: $(date): ${@}"
}

my_printf "Hello World\n"
```

Functions (2)

- **`local`** variables: values do not exist outside function, example:

```
#!/bin/bash
## Purpose: Demonstrating features of functions

var1="global value"

## Function: assign to global var1 temporarily a local value
function locally_mod_var ()
{
   local var1=${1}
   if [ -z "${var1}" ] ; then
      return 1
   fi
   echo "fct: local \${var1} = ${var1}"
   var1="new value in fct"
   echo "fct: local \${var1} = ${var1}"
}

echo "main: global \${var1} = ${var1}"
locally_mod_var "${var1}"
echo "main: global \${var1} = ${var1}"
```

`${WORKSHOP}/exercises/bash/fct_02.sh`

- **`return`**: Terminates a function, optionally takes integer = „exit status of the function“

Thank you for your attention!

Regular Expression matching