Concise! GNU Bash

http://talk.jpnc.info/bash_seagl_2016.pdf

an introduction to advanced usage

James Pannacciulli
Systems Engineer at
& Sponsored by (mt) mediatemple

Notes about the presentation:

- This talk assumes you are familiar with basic command line concepts.
- This talk covers **Bash**, not the wealth of CLI utilities available on **GNU/Linux** and other systems.
- This talk assumes a **GNU/Linux** machine, though most everything here should be fairly portable.
- Bash is flexible and fun, don’t forget to enjoy the time you spend using it!

Command Types

File:

External executable file.

Builtin:

Command compiled in as part of Bash.

Keyword:

Reserved syntactic word.

Function:

User definable, named compound command.

Alias:

User definable, simple command substitution.

Getting Help with Bash and with your OS

type:

Determine type of command, list contents of aliases and functions.

help:

Display usage information about Bash builtins and keywords.

apropos:

Search man pages.

man:

System manual.

info:

Advanced manual system primarily used for GNU programs.

General reference commands to get started:

man bash

man man

man -a intro

help

help help

info info

info

Some Useful Definitions

Technical Terms as Defined and Used in Bash Documentation

word Sequence of **characters** considered to be a single unit.

list Sequence of one or more **commands** or **pipelines**.

name A **word** consisting only of alphanumeric characters and underscores. Can not begin with a numeric character.

parameter An **entity** that stores **values**. A *variable* is a parameter denoted by a *name*; there are also *positional* and *special* parameters.

Return Status

Success: Command returns a status of **0**.

Failure: Command returns a **non-zero** status.

- Valid return values range from **0** to **255**.
- The return value of the last command to have executed is captured in the special parameter **$?**.
- Many programs signal different types of failure or error with different return values, which allows us to handle errors programmatically.

List Operators

list0; list1	Execute **list0**, then execute **list1**. Same as separation by newline.
list0 & list1	Execute **list0** in a background subshell and simultaneously execute **list1**.
list0 && list1	Execute **list0**, then execute **list1** only if **list0** returns status 0.
list0 || list1	Execute **list0**, then execute **list1** only if **list0** returns a non-zero status.

Conditionals: if

```
if list0
  then list1
fi
```

Evaluate ***list0***, then evaluate ***list1*** only if ***list0*** returns status ***0***.

```
if list0
  then list1
  else list2
fi
```

Evaluate ***list0***, then evaluate ***list1*** only if ***list0*** returns status ***0***. Otherwise, evaluate ***list2***.

```
if list0
  then list1
  elif list2
    then list3
    else list4
fi
```

Evaluate ***list0***, then evaluate ***list1*** only if ***list0*** returns status ***0***. Otherwise, evaluate ***list2***, then evaluate ***list3*** only if ***list2*** returns status ***0***. Otherwise, evaluate ***list4***.

Tests

[expression]
test expression

Evaluate conditional expression with the **test** builtin (or the analogous **/bin/[** or **/bin/test** commands if specified).

[[expression]]

Evaluate conditional expression with the **[[** keyword.

- Word splitting is **not** performed during any parameter expansion.
- The righthand side of a string comparison (**==**, **!=**) is treated as a **pattern when *not* quoted**, and as a **string when quoted**.
- Regular Expressions may be matched with the **=~** operator.
- Short circuiting logical operators **&&** and **||** can be used to combine condition expressions.

Common Conditional Expressions

*See them all by executing **help test***

[[-e file]]	file **exists**
[[-f file]]	file is a **regular file**
[[-d file]]	file is a **directory**
[[-t fd]]	fd is **open** and refers to a **terminal**
[[file0 -nt file1]]	file0 **is newer than** file1
[[file0 -ef file1]]	file0 **is a hard link to** file1
[[-n string]]	string is **non-empty**
[[-z string]]	string is **empty**
[[string0 == "string1"]]	string0 and string1 are the **same**
[[string0 != "string1"]]	string0 and string1 are **not the same**
[[string == pattern]]	string **matches** pattern
[[string =~ regex]]	string **matches** regular expression

Pattern Matching

Pattern matching is used in Bash for the **[[** *and* **case** *keywords,* **pathname expansion**, *and some types of* **parameter expansion**.

*****	Matches any string, including null.
?	Matches any single character.
[character class]	Matches any one of the characters enclosed between **[** and **]**.

[^...] matches the complement (any character not in the class)

[x-z] matches the range of characters from **x** to **z**

[[:*class***:]]** matches according to these POSIX classes:

alnum alpha ascii blank cntrl digit graph lower print punct space

Conditionals: case

```
case word in
    pattern0)
        list0;;
    pattern1 | pattern2)
        list1;;
esac
```

Match **word** against each **pattern** sequentially. When the first match is found, evaluate the **list** corresponding to that match and stop matching.

The **|** (pipe) character between two patterns entails a match if either pattern matches (*inclusive* ***OR***).

Parameters

Positional Parameters: **$1 $2 $3 $4 $5 $6 $7 $8 $9 ${10} ...**

Parameters passed to salient command, encapsulating **words** on the command line as **arguments**.

Special Parameters: **$* $@ $# $- $$ $0 $! $? $_**

Parameters providing **information** about positional parameters, the current shell, and the previous command.

Variables: name=*string*

Parameters which may be **assigned values** by the user. There are also some special shell variables which may provide information, toggle shell options, or configure certain features.

For variable assignment, "**=**" must **not** have adjacent spaces.

Parameter Expansion: Conditionals

(check if variable is unset, empty, or non-empty)

	unset param	param=""	param="**gnu**"
${param-*default*}	default	–	gnu
${param=*default*}	*name=default*	–	gnu
${param+*alternate*}	–	alternate	alternate
${param?*error*}	error	–	gnu
Treat empty as unset:			
${param:-*default*}	default	default	gnu
${param:=*default*}	*name=default*	*name=default*	gnu
${param:+*alternate*}	–	–	alternate
${param:?*error*}	error	error	gnu

Parameter Expansion: Substrings

param="**mandrake**"

Extraction:

offset of **3**, length of **2**

${param:*offset*}

drake

${param:*offset*:*length*}

dr

Removal from left edge:

pattern is '***a**'

${param#*pattern*}

ndrake

${param##*pattern*}

ke

Removal from right edge:

pattern is '**a***'

${param%*pattern*}

mandr

${param%%*pattern*}

m

Parameter Expansion: Pattern Substitution

param="**ubuntu**"

Substitution: pattern is '**u?**', string is '**X**'

${param/*pattern*/*string*} **X**untu

${param//*pattern*/*string*} **XX**tu

Substitute at left edge: pattern is '**u**', string is '**X**'

${param/**#***pattern*/*string*} **X**buntu

Substitute at right edge:

${param/**%***pattern*/*string*} ubunt**X**

Parameter Expansion:

Indirection, Element Listing, and Length

name0="**name1**"; name1="**hello**";
array=(**gnu not unix**)

Indirect expansion:

${**!**name0}

hello

List names matching prefix "pa":

${**!**na*} or "${**!**na@}"

name0 name1

List keys in array:

${**!**array[*]} or "${**!**array[@]}"

0 1 2

Expand to length:

${**#**name0}

5

${**#**array}

3

Indexed Arrays

Assign an array by elements:

```
array=( zero one two "three and more" )
```

Add an element to an array:

```
array+=( "four and beyond" )
```

Recreate array with spaces in elements as underscores:

```
array=( "${array[@]// /_}" )
```

Recreate array only with elements from index 2 to 4:

```
array=( "${array[@]:2:3}" )
```

Print element at index 1 of array (second element):

```
echo "${array[1]}"
```

Print array indexes:

```
echo ${!array[@]}
```

Associative arrays (`array[key]=value`) may be created in Bash 4 and greater with `declare -A array`.

Arithmetic Expressions

((math and stuff))

name++	increment name after evaluation
name--	decrement name after evaluation
++name	increment name before evaluation
--name	decrement name before evaluation

- + * / % ** <= >= < > == != && ||

- Can be used as a test, **returning 0** if the comparison, equality, or inequality is **true**, or if the calculated **number is not zero**.
- Can provide in-line expansion when used like command substitution – **$((** *math* **))**.
- Bash does not natively support floating point.

Brace Expansion

Arbitrary Word Generation

String generation:

prefix{*ab*,*cd*,*ef*}suffix

Sequence generation:

prefix{*x*..*y*}suffix

Bash can complete a list of files into nested brace expansion format with the **ESC-{** key combination. All key bindings may be displayed with **bind -P**.

Sequencing by specified increment (Bash 4+):

prefix{*x*..*y*..*incr*}suffix

Brace expansion may be **nested** and **combined**.

The **prefix** and **suffix** are optional.

Compound Commands

Iteration:

Continuously loop over **list** of commands delineated by the keywords **do** and **done**.

while until for select

Conditionals:

Execute **list** of commands only under certain conditions.

if case

Command groups:

Grouped **list** of commands, sharing any external redirections and whose return value is that of the **list**.

(list) { list; }

While and Until Loops

(Typically) iterate based on an external resource

while list0; do list1; done

Execute **list0**; if **success**, execute **list1** and repeat.
Continue until **list0** returns a **non-zero** status (*fails*).

until list0; do list1; done

Execute **list0**; if **failure**, execute **list1** and repeat.
Continue until **list0** returns a status of **0** (*succeeds*).

The following construct is incredibly handy for processing lines of text: **while read**

For and Select Loops

Iterate based on command line arguments

for name in words; do list; done

During each iteration, assign **name** the value of the next **word**, then execute **list**. Repeat until all **words** have been exhausted.

initialization *condition* *afterthought*

for ((expr0 ; expr1 ; expr2)); do list; done

Evaluate **expr0**, then loop over **((expr1)) || break; { list; ((expr2)); }** – that is to say execute **list** only if **expr1** returns **non-zero** status (*fails*), evaluating **expr2** after each iteration. The expressions are evaluated as *arithmetic expressions*, and the **list** as a regular command list.

select name in words; do list; done

Create a menu with each **word** as an item. When the user makes a selection, **name** is assigned the value of the selected **word**, **REPLY** is assigned the **index** number of the selection, and **list** Is executed.

Command Groups

Treat group as single unit for redirection or branching

Subshell:

Evaluate **list** of commands in a **subshell**, meaning that its environment is distinct from the current shell and its parameters are contained.

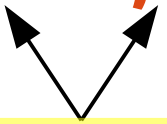
The **righthand side** of a **pipe** is *always* a **subshell**.

(list)

Group command:

Evaluate **list** of commands in the **current shell**, sharing the current shell's environment and parameter scope.

{ list; }



The **spaces** and **trailing semicolon** are *obligatory*.

Redirection

Controlling the input, output, error, and other streams

list > file Overwrite/create **file** with **output** from **list**

list >> file Append/create **file** with **output** from **list**

list < file Feed **file** to **list** as **input**

list0 | list1 Use **output** from **list0** as **input** to **(list1)**

- If not specified, **fd 1** (**STDOUT**) is assumed when redirecting output.
- Alternative file descriptors may be specified by **prepending** the **fd number**, e.g. **2> file** to redirect **fd 2** (**STDERR**) to a file.
- To redirect *to* a file descriptor, prepend '**&**' and the fd number, e.g. **2>&1** to redirect **STDERR** to the *current target during parsing* for **STDOUT**.

Command and Process Substitution

Command substitution:

Replace the **command substitution** **in-line** with the **output** of its **subshell**. Turns *output* into *arguments*.

$(*list***)**

Process substitution:

Replace the **process substitution** with a **file descriptor** which is connected to the input or output of the **subshell**. Allows *commands* in **list** to act as a *file*.

>(*list***)** **<(***list***)**

Functions

Functions are compound commands which are defined in the current shell and given a function name, which can be called like other commands.

func.name () compound_cmd

Assign **compound_cmd** to function named **func.name**.

func.name () compound_cmd [>,<,>>] file

Assign **compound_cmd** to function named **func.name**; function will always redirect to (**>**), from (**<**), or append to (**>>**) the specified file. Multiple file descriptors may be specified, for instance: ***>out.file 2>err.log***.

Session Portability

Import elements from current session into a distinct local or remote session.

```
sudo bash -c “
$(declare -p parameters;
  declare -f functions)
code and stuff”
```

Import **parameters** and **functions** into **root** shell, then run **code and stuff**.

```
ssh remote_host “
$(declare -p parameters;
  declare -f functions)
code and stuff”
```

Import **parameters** and **functions** into **remote** shell, then run **code and stuff**.

- **declare** can list parameters and functions from the current shell, or can set parameter attributes.
- When **sourcing** or **interpolating** Bash code, be mindful of shell options which affect parsing, such as *extglob*, if the code relies on that syntax.

Example code from the talk

```
true
echo $?

false
echo $?

true && echo true

false || echo false

if fgrep -qi gentoo /etc/os-release
then
  echo "gentoo"
else
  echo "not gentoo :-/"
fi

[[ -n "much content!" ]]

[[ -z "wow!" ]]
```

Example code from the talk

```
[[ -e /etc ]] && echo exists
[[ -f /etc ]] && echo regular file
[[ -d /etc ]] && echo directory

[[ -t 0 ]]

[[ -t 0 ]] < /etc/os-release

if [[ "abc" == "abc" ]]
then
  echo "yep"
else
  echo "nope"
fi

if [[ "abc" == "c" ]]
then
  echo "yep"
else
  echo "nope"
fi
```

Example code from the talk

```
if [[ "abc" == *c ]]
then
  echo "yep"
else
  echo "nope"
fi

[[ "seagl 2016" == [a-z]*[^[:digit:]] ]]

[[ "seagl 2016" == [a-z]*[[:digit:]] ]]
```

Example code from the talk

```
case one in
  o)
    echo 'o'
  ;;
  o?e)
    echo 'o?e'
  ;;
  o*)
    echo 'o*'
  ;;
  *)
    echo 'nope'
  ;;
esac

set -- one two "three four" five
printf "%s\n" "\$1: $1" "\$2: $2" "\$3: $3" "\$4: $4" "\$5: $5" "\$#: $#"\
  "\$*: $*" "\$@: $@"

param=gnu; echo "${param:-default value for expansion}"
```

Example code from the talk

```
unset param; echo "${param:-default value for expansion}"

echo "${param:?a nifty custom error string}"

echo "${PATH:+yes you have a PATH, great job}"

echo "${BASH_VERSION:0:1}"

echo "${PATH##*:}"

echo -e "${PATH//:/\\n}"

param=PATH; printf "%s\n\n" "\$param: ${param}"\
  "\${!param}: ${!param}" "\${!param%%:*}: ${!param%%:*}"

echo ${!BASH*}

echo "${#PATH}"

array=( zero one two "three and more" )
printf "%s\n" "${array[@]}"
```

Example code from the talk

```
array+=( "four and beyond" )
printf "%s\n" "${array[@]}"

array=( "${array[@]// /_}" )
printf "%s\n" "${array[@]}"

array=( "${array[@]:2:3}" )
printf "%s\n" "${array[@]}"

echo ${!array[@]}

echo $(( 3 + 11 ))

(( 3 >= 5 ))

(( 0 ))

echo $(( i++ ))

echo bash{,e{d,s},ful{,ly,ness},ing}
```

Example code from the talk

```
echo {1..5}{0,5}%

echo {10..55..5}%

echo {g..z..7}

touch testfile && cp -v testfile{,.bak}

man{,}

while read var1 var2
do
  echo $var2 $var1
done

count=0
until (( ++count > 3 ))
do
  echo $count
done
```

Example code from the talk

```
for i in one two "three four"
do
  echo "_-_-_-$i-_-_-_"
done

for (( i=0 ; i<5 ; i++ ))
do
  echo $i
done

((i=0))
while :
do
  ((i < 5)) || break
  { echo $i; ((i++)); }
done

select choice in one two "three four"
do
  echo "$REPLY : $choice"
done
```

Example code from the talk

```
for file in *
do
  echo "$(stat -c"%a %A" "$file") $(md5sum "$file")"
done

ls -1 | while read file
do
    echo "$(stat -c"%a %A" "$file") $(md5sum "$file")"
done

select file in *
do
  stat "$file"
  break
done

unset x
(x=hello; echo "x: $x")
echo "x: $x"
```

Example code from the talk

```
unset x
{ x=hello; echo "x: $x"; }
echo "x: $x"

printf "%s\n" ${RANDOM:1:2} ${RANDOM:1:2} ${RANDOM:1:2} | sort -n

man bash                        |\
tr [[:space:]] "\n"             |\
tr [[:upper:]] [[:lower:]]      |\
grep -v "^[[:space:]]*$"        |\
sort                            |\
uniq -c                         |\
sort -n                         |\
tail -$(( ${LINES:-16} - 1 ))

echo b; echo a | sort

{ echo b; echo a; } | sort

echo "what a wonderful example" > awesome.txt
cat < awesome.txt
```

Example code from the talk

```
filename="file_$(date +%F)"
echo "$(date +%s)" > "$filename"
sleep 1s
echo "$(date +%s)" >> "$filename"

printf "%s\n"\
  "$filename: $(wc -l "$filename" | cut -d" " -f1) lines"\
  ""\
  "$(<"$filename")"

echo "$(echo "$(echo "$(echo "$(ps wwf -s $$)")")")"
echo this `echo quickly \`echo gets \\\`echo very \\\\\\\`echo
extremely \\\\\\\\\\\\\\\`echo ridiculous\\\\\\\\\\\\\\\`\\\\\\\`\\\`\``

wc -c <(echo "$PATH")
wc -c < <(echo "$PATH")

printf "%s\n" one two "three four" |\
  tee >(tac) >(sleep 1; cat) >/dev/null |\
  cat
```

Example code from the talk

```
var=$(
printf "%s\n" one two "three four" |\
  tee >(tac) >(sleep 1; cat) >/dev/null
)
echo "$var"

unset array
while read; do
  array+=( "$REPLY" )
done
declare -p array

unset array
# WILL NOT WORK
printf "%s\n" one two "three four" |\
  while read; do
    array+=( "$REPLY" )
  done
declare -p array
```

Example code from the talk

```
unset array
while read
do
  array+=( "$REPLY" )
done < <(printf "%s\n" one two "three four")
declare -p array

diff -wyW85\
  <(echo "${examples[((I - 2))]}")\
  <(echo "${examples[((I - 1))]}") |\
    highlight --syntax bash -O xterm256  -s rootwater

words ()
# print each word on new line
for word
do
  echo "$word"
done
```

Example code from the talk

```
rev_chars ()
# reverse characters by word
for charlist
do local word
  while (( ${#charlist} ))
  do
    echo -n "${charlist:(-1)}"
    charlist="${charlist:0:(-1)}"
  done
  (( ++word == ${#@} )) &&\
    echo ||\
    echo -n "${IFS:0:1}"
done

rev_words ()
# reverse/print each word on new line
for word
do
  echo "$(rev_chars "$word")"
done
```

Example code from the talk

```
memtop ()
# list top consumers of memory on the system (...slowly)
{
 {
  echo "_PID_ _Name_ _Mem_"
  for pid in /proc/[0-9]*
   do
    printf "%s " \
     "${pid##*/}" \
     "$(<$pid/comm)" \
     "$(pmap -d "${pid##*/}" |\
       tail -1 |\
       { read a b c mem d
         echo $mem; })"
    echo
   done |\
   sort -nr -k3 |\
   head -$((${LINES:-23} - 3))
 } |\
 column -t
} 2>/dev/null
```

Example code from the talk

```
random_word ()
{
  local word= count=1;
  while :; do
    word=$(tr -dc 'a-z' < /dev/urandom | head -c ${1:-4})
    grep -qi "\<$word\>" /usr/share/dict/cracklib-small && {
      echo $count: $word
      return 0
    } || (( count++ ))
  done
}

for i in {1..4}
  do
    docker run -d gentoo_ssh /usr/sbin/sshd -D
  done
```

Example code from the talk

```
for container in $(
  docker inspect -f "{{ .NetworkSettings.IPAddress }}" $(docker ps -q))
  do
    printf "%s\n" "$container: $(
      ssh -o StrictHostKeyChecking=no -i ~/.ssh/docker.id_rsa $container \
        "$(declare -f random_word); random_word" )"
  done
```

A Few Good Links

- http://www.gnu.org/software/bash/
- http://tiswww.case.edu/php/chet/bash/NEWS
- http://tldp.org/LDP/abs/html/index.html
- http://wiki.bash-hackers.org/doku.php
- http://git.jpnc.info/parssh/