Environnements et Outils de Développement
Cours 4 — Shell scripting basics

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Outline

Shell and shell script

A shell is a program that sits between yourself and the services offered by the operating system (e.g. running programs).

- shells can be used interactively
  - ▸ with read-eval-print loops
  - ▸ . . . you've done this thousands of times already !
- shells can be programmed
  - ▸ to develop real programs (AKA "scripts")
  - ▸ in a programming language known as shell script
    - ⋆ (in fact, each shell has its own shell scripting language ; we will use the Bash shell—/bin/bash—in these slides)

Scripts are fundamental tools to automate tasks (system administration, development, day-by-day productivity, etc). Learn shell script, love shell script. You will be more productive.

Hello, world!

A simple shell script

#!/bin/bash
echo −n Hello,
echo " World!"

```
$ ls -l hello
-rw-r--r-- 1 zack zack 42 feb 18 11:15 hello
$ cat hello
#!/bin/bash
echo -n Hello,
echo " World!"
$ chmod +x hello
$ ls -l hello
-rwxr-xr-x 1 zack zack 42 feb 18 11:15 hello
$ ./hello
Hello, World!
$
```

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The "API" of general UNIX programs
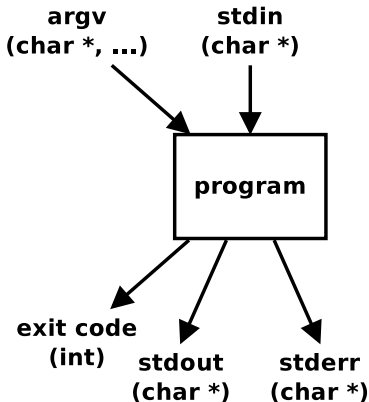
Program execution on UNIX implements a very simple API.

Programs :

- are executed passing command-line arguments (strings)
  - 1st argument = program name
- return a numeric exit code
- read user input via standard input
  - usually : the keyboard
- write "ordinary" output to standard output
  - usually : the screen
- write "extraordinary" output (e.g. error messages) to standard error
  - usually : the screen too

Program execution — examples

```
$ ls
code
main.tex
Makefile
$
```

argv = {"ls"}
exit code = 0   (== 0, i.e. *"everything is fine"*)
stdin = ""
stdout = "code\nmain.tex\nMakefile\n"
stderr = ""

Program execution — examples (cont.)

```
$ ls doesn-t-exist
ls: cannot access doesn-t-exist: No such file or directory
$
```

argv = {"ls", "doesn-t-exist"}
exit code = 2   (!= 0, i.e. *"we've got a problem"*)
stdin = ""
stdout = ""
stderr = "ls : cannot access doesn-t-exist : No such [. . .]\n"

Program execution — examples (cont.)

```
$ cat
foo
foo
bar
bar
baz
baz
CTRL-D
$


argv = {"cat"}
exit code = 0
stdin = "foo\nbar\nbaz\n"
stdout = "foo\nbar\nbaz\n"
stderr = ""
```

Program execution — examples (cont.)

```
$ ./hello one two three
Hello, World!
$
```

argv = {"./hello", "one", "two", "three"}
exit code = 0   (default exit code)
stdin = ""
stdout = "Hello, World !\n"
stderr = ""

Note : hello doesn't *use* its command line arguments, but that didn't stop us from passing them. Other programs will be less forgiving than hello.

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Command composition

Based on the main ingredients of the program execution API—exit codes and standard I/O channels—we can compose shell commands in interesting ways :

conditional execution executing a command only if another one "succeeded" (exit code == 0) or "failed" (exit code != 0)

 redirection using the standard output of a program as the standard input of another one (or diverting stdin/stdout to/from a file)

Conditional execution

- *cmd1* && *cmd2* — execute *cmd2* iff *cmd1* succeeds
- *cmd1* || *cmd2* — execute *cmd2* iff *cmd1* fails

success means : exit code == 0 ; *failure* means : exit code != 0

```
$ ls && echo EUREKA
code
main.tex
Makefile
EUREKA
$ ls doesn-t-exist && echo eureka
ls: cannot access doesn-t-exist: No such file or directory

$ ls doesn-t-exist || echo DOH
ls: cannot access doesn-t-exist: No such file or directory
DOH
$
```

Pipeline

cmd1 | cmd2 — execute both *cmd1* and *cmd2*
+ make *cmd1*'s stdout be *cmd2*'s stdin

```
$ ls | wc --lines
3
$ ls | sort --reverse
Makefile
main.tex
code
$ cat /etc/passwd | cut -f 1 -d : | sort
[...]
backup
bin
daemon
games
[...]
root
[...]
$
```
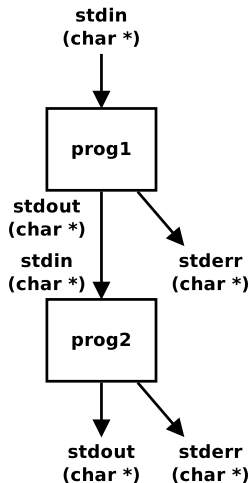
Redirection to/from file

- *cmd* > *file* — execute *cmd*, writing its stdout to *file*
- *cmd* < *file* — execute *cmd*, using *file* as its stdin

```
$ cat < hello
#!/bin/bash
echo -n Hello,
echo " World!"
$ echo "Hello, World!" > test-redir.txt
$ cat test-redir.txt
Hello, World!
$

$ cat < hello | sort --reverse > not-a-script
$ cat not-a-script
echo " World!"
echo -n Hello,
#!/bin/bash
$
```

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Expansions

As a language, shell script has a less clear parsing/execution distinction than many other languages. Instead, evaluation of shell scripts goes through a series of expansions (similar to meta-programming in other languages) that iteratively transform script statements.

- see : Shell Command Language, *The Open Group Base Specifications Issue 6*, IEEE Std 1003.1, 2004 Edition. http://pubs.opengroup.org/onlinepubs/009695399/utilities/xcu_chap02.html

Some expansion phases :

- variable expansion
- wildcard expansion
- arithmetic expansion
- command expansion
- . . .

Variable expansion

```
$ year=2097
$ galaxy="far far away"
$ echo "It's year $year, in galaxy ${galaxy}..."
It's year 2097, in a galaxy far far away...
```

Cmdline arguments can be accessed via special variables $0, $1, ...

```
$ cat hello2
#!/bin/bash
echo "Hello, $1 World!"
$ ./hello2
Hello,  World!
$ ./hello2 wonderful
Hello, wonderful World!
```

Variable expansion

```
$ year=2097
$ galaxy="far far away"
$ echo "It's year $year, in galaxy ${galaxy}..."
It's year 2097, in a galaxy far far away...
```

Cmdline arguments can be accessed via special variables $0, $1, . . .

```
$ cat hello2
#!/bin/bash
echo "Hello, $1 World!"
$ ./hello2
Hello,  World!
$ ./hello2 wonderful
Hello, wonderful World!
```

Exercise : explain the following behavior

```
$ ./hello2 truly wonderful
Hello, truly World!
$ ./hello2 "truly wonderful"
Hello, truly wonderful World!
```

Wildcard expansion

Specific meta-characters, like ∗ and ?, are used as shortcuts for space-separated lists of file names. Collectively, those characters are called wildcards and are subject to wildcard expansion.

- ∗ — any number of (non-/) characters that appear in the name of existing files
- ? — a single character, as above

```
$ ls
auto    code       main.log   main.out   main.pdf.mk   main.tex   main.vrb
build   main.aux   main.nav   main.pdf   main.snm      main.toc   Makefile
$ echo *
auto build code main.aux main.log main.nav main.out main.pdf main.pd
$ echo main.p*
main.pdf main.pdf.mk
$ echo main.t??
main.tex main.toc
$ echo foo*
foo*
```

Arithmetic expansion

$((*expr*)) — evaluate *expr* as an arithmetic expression and expand to its value

```
$ year=2037
$ echo $(( $year + 1 ))
2038
$ year=$(( $year * 2 - 42 ))
$ ls -l $(( $year / 37 )).*
-rw-r--r-- 1 zack zack 5 feb 18 15:42 108.cfg
-rw-r--r-- 1 zack zack 4 feb 18 15:42 108.txt
```

Arithmetic expansion

$((*expr*)) — evaluate *expr* as an arithmetic expression and
expand to its value

```
$ year=2037
$ echo $(( $year + 1 ))
2038
$ year=$(( $year * 2 - 42 ))
$ ls -l $(( $year / 37 )).*
-rw-r--r-- 1 zack zack 5 feb 18 15:42 108.cfg
-rw-r--r-- 1 zack zack 4 feb 18 15:42 108.txt
```

Exercise
list the expansion phases that the commands above go through

Command substitution

- $(*cmd*) — executes *cmd* and substitute the $(cmd) string with cmd's stdout before continuing execution
- `*cmd*` — same (but harder to nest)

```
$ date
Mon Feb 18 15:49:31 CET 2013
$ date +%s
1361198971
$ now=$(date +%s)
$ echo $now
1361198971
$ date -d @1361198971
Mon Feb 18 15:49:31 CET 2013

$ one_week_later=$(date -d @$(( $(date +%s) + 60*60*24*7 )))
$ echo $one_week_later
Mon Feb 25 15:54:22 CET 2013
```

(see date(1) for a simpler way to do the same)

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If/then/else

- if *cmd1* ; then *cmd2* ; else *cmd3* ; fi — execute *cmd1* then, depending on its exit code, execute either *cmd2* (*cmd1* succeeded) or *cmd3* (*cmd1* failed)
- multiline syntax :

```
if cmd1 ; then
    cmd2
else
    cmd3
fi
```

Note : as it happened for conditional composition, it is the exit code of the guard that determines which branch is executed not, e.g., its stdout/stderr.

test

The `test` program is very useful in if/then/else guards. Some noteworthy usages :

- `test -f file` — true (i.e. exit code == 0) if *file* exists
- `test -z string` — true if *string* is the empty string
- `test s1 = s2` — true if *s1* and *s2* are equal as strings
- `test x -lt y` — true if *x* is smaller (**l**ess **t**han) *y*, when interpreted as integers
    - other integer comparison operators : `-eq`, `-ne`, `-ge`, `-gt`, `-le`

Tip

`!` *cmd* — logically negate the exit code of *cmd*

test — examples

```
$ test -f annoying-file.txt && rm annoying-file.txt
$ ! test -f file-i-need.txt && echo foo > file-i-need.txt



$ cat hello3
#!/bin/bash
if test -z "$1" ; then
    echo "Usage: hello3 MESSAGE"
    exit 1
fi
echo "Hello, $1 World!"
$ ./hello3
Usage: hello3 MESSAGE
$ ./hello3 wonderful
Hello, wonderful World!
```

test — examples (cont.)

```
$ cat debug
#!/bin/bash
debug="yes"
if test "$debug" = "yes" ; then echo "D: enter script" ; fi
echo "Hello, World!"
if test "$debug" = "yes" ; then echo "D: exit script" ; fi
$ ./debug
D: enter script
Hello, World!
D: exit script
```

test — examples (cont.)

```
$ cat debug
#!/bin/bash
debug="yes"
if test "$debug" = "yes" ; then echo "D: enter script" ; fi
echo "Hello, World!"
if test "$debug" = "yes" ; then echo "D: exit script" ; fi
$ ./debug
D: enter script
Hello, World!
D: exit script
```

Always add quotes around test operands ! I.e. don't do this :

```
if test $debug = "yes" ; then echo "D: enter script" ; fi
```

Why ?

test — examples (cont.)

```
$ cat debug
#!/bin/bash
debug="yes"
if test "$debug" = "yes" ; then echo "D: enter script" ; fi
echo "Hello, World!"
if test "$debug" = "yes" ; then echo "D: exit script" ; fi
$ ./debug
D: enter script
Hello, World!
D: exit script
```

Always add quotes around test operands! I.e. don't do this :

```
if test $debug = "yes" ; then echo "D: enter script" ; fi
```

Because :   (exercise : explain why the error happens)

```
$ debug=""
$ if test $debug = "yes" ; then echo "D: enter script" ; fi
-bash: test: =: unary operator expected
```

A nicer syntax for `test`

Hack

- `/usr/bin/[` — is a symbolic link (i.e. an alias) to `test`
- `]` can be safely added at the end of `test`'s expressions

What gives?

A nicer syntax for `test`

Hack
- `/usr/bin/[` — is a symbolic link (i.e. an alias) to `test`
- `]` can be safely added at the end of `test`'s expressions

```
if [ -z "$1" ] ; then
    echo "Usage: hello3 MESSAGE"
    exit 1
fi

if [ "$debug" = "yes" ] ; then
    echo "D: enter script"
fi

if ! [ -f "$datafile" ] ; then
    echo "init:0" > "$datafile"
fi
```

- see `test(1)` manpage for more details

grep — the swiss army knife of text search

grep *regexp file*... — search all given *file*s for lines that matches the regular expression *regexp*

- output matching lines on stdout
- exit code is 0 iff at least one matching line is found

- you know regular expressions already !
- see regex(7) manpage for the actual syntax

grep — examples

```
$ cat hamburger.txt
bread
lettuce
tomato
meat
cheddar
bacon
bread

$ grep '^b' hamburger.txt
bread
bacon
bread
$ grep 'd$' hamburger.txt
bread
bread
$ grep '[ht]' hamburger.txt
lettuce
tomato
meat
cheddar
```

grep — examples (cont.)

```
$ cat onion-check
#!/bin/bash
recipe="hamburger.txt"
if ! grep --quiet '^onions$' "$recipe" ; then
    echo "Oops! no onions..."
    echo "onions" >> "$recipe"
    echo "Fixed! Onions are now safely(?) back in"
fi

$ ./onion-check
Oops! no onions...
Fixed! Onions are now safely(?) back in
$ grep onion hamburger.txt
onions
$ ./onion-check
$
```

Alternative (and more cumbersone) check :

```
if ! [ -z "$(grep '^onions$' $recipe)" ] ; then
```

For/foreach loops

- for *var* in *list*...; do *cmd*; done — loop over *list*...,
  binding at each iteration *var* to the current value. At each
  iteration, execute *cmd* (that usually uses $var to reference *var*).
- multiline syntax

  ```
  for var in list ... ; do
      cmd
  done
  ```

Pure for loops can be built using command substitution and the seq
program :

```
$ for i in `seq 1 5` ; do echo $i ; done
1
2
3
4
5
```

For/foreach loops — example

```
$ cat explain-recipe
#!/bin/bash
if [ -z "$1" ] ; then echo "Usage: $0 RECIPE" ; exit 1 ; fi
recipe="$1"
step="0"
for ingredient in $(cat $recipe) ; do
    step=$(( $step + 1 ))
    echo "step #${step}: add $ingredient"
done
echo "All done: congratulations!"

$ ./explain-recipe hamburger.txt
step #1: add bread
step #2: add lettuce
step #3: add tomato
step #4: add meat
step #5: add cheddar
step #6: add bacon
step #7: add bread
All done: congratulations!
```

While loops

- while *cmd1* ; do *cmd2* ; done — execute *cmd2* repeatedly, as long as *cmd1* succed (usual semantics : test first, then execute)
- multiline syntax

  ```
  while cmd1 ; do
      cmd2
  done
  ```

```
i=$1
fact=1
while [ $i -gt 0 ] ; do
   fact=$(( $fact * $i ))
   i=$(( $i - 1 ))
done
echo $fact
```

While true...

Tip

The program true does nothing and return a 0 exit code.
It can then be used to write infinite loops.

```
$ while true ; do echo "I'm bored" ; done
I'm bored
I'm bored
I'm bored
I'm bored
I'm bored
I'm bored
I'm bored
I'm bored
I'm bored
I'm bored
[...]
```

While/read loops

read *var* — read a line from stdin and store it in variable *var*

Poor men's cat :

```
$ while read line ; do echo $line ; done
foo
foo
bar
bar
baz
baz
CTRL-D
$
```

References

📄 Mendel Cooper
Advanced Bash-Scripting Guide : An in-depth exploration of the art of shell scripting
http://tldp.org/LDP/abs/html/

📄 Arnold Robbins and Nelson H.F. Beebe
Classic Shell Scripting
O'Reilly Media, 2005.

📄 GNU
bash(1) manual page
http://man.cx/bash