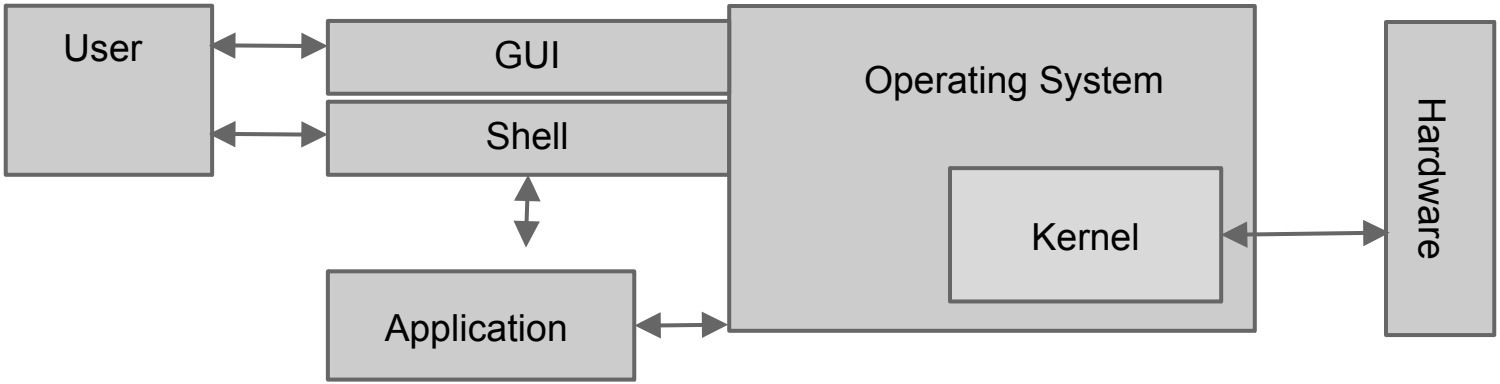
A Gentle Introduction to Bash

Advanced Programming for Scientific Computing
2015-2016

What is a shell?



a UNIX shell program is a command interpreter that enables the user to interact with application software, the operating system (OS), and with the Kernel that controls Hardware (HW).

sh a.k.a "Bourne Shell" was the default Unix shell of Unix Version 7

bash "Bourne Again Shell" is the GNU shell. On GNU/Linux and most modern UNIX-like systems `/bin/sh` is a *symlink* to `/bin/bash`

bash is Free Software, it is a compatible and standard conforming extension to **sh**.

What bash stands for?

Bash stands for: Bourne Again Shell. A homage to Stephen Bourne, the inventor of the original shell for Unix.

It is now the default Unix shell of for all unix-based systems, including Linux and MAC-OS.

It is largely compatible with the original shell sh. It is a command interpreter and a scripting language

Possible alternatives:

Maybe someone wants to try other shells. A major alternative to the bash shell is the C-shell (csh), or the “vanilla” shell (sh). You may change shell by simply typing its name and even change the default shell for your sessions.

In-built commands and shell commands

There are two types of commands. The in-build ones and the others. The in-buld commands are directly executed by the shell, the others shell commands are normal executables (scripts or compiled programs), usually residing in /bin.

From the user point of view there is normally little difference, so you should not be worried about it, but you should only remind this two important facts:

- Only in-built command may change environmental variables of the current session. For instance cd (change directory) is an in-build command becouse has to change the environmental variable PWD (print working directory). Use the env or printenv (not in-built) command to have a list of the current environmental variables.
- Information on in-built commands is obtained with the command help. That for other commands with the command man (manual) or info

In conclusion, don't worry about the difference, but be aware of the existence of the two type of commands, and in particular that only in-built commands may change the environmental variables.

Bash as command line interpreter

When logging-in to a computer on a console or via a terminal emulator, the the OS starts a **`bash`** process in *interactive* mode.

```
Last login: Fri Jan 16 18:56:00 2015 from tosca.mate.polimi.it
(default)carlo@mox33 ~ $
```

the prompt

Enter a command, then press `enter`. The command is *interpreted* and executed then the shell waits to read a new command.

`bash` built-in commands:

```
(default)carlo@mox33 ~ $ help
GNU bash, version 4.1.2(1)-release (x86_64-redhat-linux-gnu)
These shell commands are defined internally.  Type `help' to see this list.
Type `help name' to find out more about the function `name'.
Use `info bash' to find out more about the shell in general.
Use `man -k' or `info' to find out more about commands not in this list.
```

Main bash commands

cd	Change directory	rm -r	Remove recursively files in a directory (use with care)
ls	List directory	mkdir	Create a directory
ls -l	Long list	rmdir	Delete an empty directory
ls -a	Show also hidden files (starting with .)	grep	Find the occurrence of a string in a file
rm	Remove a file	find	Find a specific file
rm -f	Force removal	cat	See the content of a file
more	See the content of a file page by page	locate	Locates a file (faster than find)
less	A better version of more	mv	Move a file (used also to change file name)

Shell commands

`bash` is a full-fledged interpreted programming language

shell commands may contain

- conditionals
  `if, test, case, [ … ]`
- cycles
  `for, while, until`
- arithmetic expressions
  `let, (( … ))`

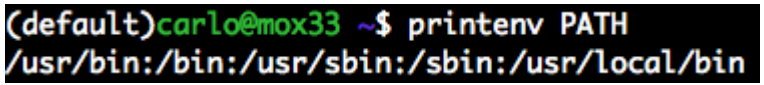
example :

```
select pippo in `ls`; file $pippo; done
```

Starting an application

To start a (binary) executable type the name of the file and press enter.

Command line options are passed to the application as `(int argc, char **argv)`
The OS consists of the Kernel plus many small utility provided as separate executables
If a *directory* is in the `$PATH` then one does not need to type the full *path. If the file is in the current directory you must use ./programname to launch it (unless the current dir is in the PATH).*



man and info

`help` works for shell built-in commands
to get info for a command that is installed as a separate executable use `man`

```
$ man ls
```

some complex applications provide a more detailed manual that can be read usin `info`

```
info latex
```

```
info octave
```

if a detailed manual is not available `info` still displays manpages

to search manpages use

```
man -k string
```

Environment variables

Environment variables are used to set options for the behaviour of the shell or other applications
List environment variables:

```
tosca.mate.polimi.it > env
HOSTNAME=tosca.mate.polimi.it
TERM=xterm-256color
SHELL=/bin/bash
HISTSIZE=1000
SSH_CLIENT=10.48.137.75 63111 22
SSH_TTY=/dev/pts/4
USER=carlo
LS_COLORS=
```

Set, print, unset value of a variable

```
tosca.mate.polimi.it > export PIPPO=cane
tosca.mate.polimi.it > printenv PIPPO
cane
tosca.mate.polimi.it > echo $PIPPO
cane
tosca.mate.polimi.it > unset PIPPO
tosca.mate.polimi.it > printenv PIPPO
tosca.mate.polimi.it >
```

“$” indicates *variable expansion*

```
tosca.mate.polimi.it > echo PIPPO e"'" un $PIPPO
PIPPO e' un cane
```

Return values

Each command executed returns a ‘return value’

```
$ cat pippo.c
int main (int argc, char
**argv)
{ return 0;}
$ gcc -o pippo pippo.c
$ ./pippo
$ echo $?
0
```

```
$ cat topolino.c
int main (int argc, char **argv)
{ return 2;}
$ gcc -o topolino topolino.c
$ ./topolino
$ echo $?
2
```

```
$ cat pluto.c
int main (int argc, char **argv)
{ return -1;}
$ gcc -o pluto pluto.c
$ ./pluto
$ echo $?
255
```

- ‘$?’ is a special variable containing the return value of the last executed command
- There is a convention that 0 indicates success, nonzero indicates failure

In Linux, Unix and other POSIX-compatible systems, the wait system call sets a *status* value of type int packed as a bitfield with various types of child termination information. If the child terminated by exiting (as determined by the WIFEXITED macro; the usual alternative being that it died from an uncaught signal), SUS specifies that the low-order 8 bits of the exit status can be retrieved from the status value using the WEXITSTATUS macro in wait.h; As such, POSIX-compatible exit statuses are restricted to values 0-255, the range of an unsigned 8-bit integer.

STDOUT STDERR STDIN

```
$ cat pippo.cc
#include <iostream>
int main (int argc, char **argv)
{
  std::cout << "this is the standard output strem"
            << std::endl;
  std::cerr << "this is the standard error stream"
            << std::endl;
  return 0;
}
$ g++ -o pippo pippo.cc
$ ./pippo
this is the standard output strem
this is the standard error stream
```

```
$ ./pippo 2> /dev/null
this is the standard output strem

$ ./pippo 1> /dev/null
this is the standard error stream

$ ./pippo > /dev/null 2>&1
$

 $ ./pippo  > pippo.txt 2>&1
 $ cat pippo.txt
this is the standard output strem
this is the standard error stream
```

Redirection

stdout to file

```
echo “something” > filename
```

stderr to file

```
./pippo 2> filename
```

stdout to stderr

```
./pippo 2> filename 1>&2
```

stderr to stdout

```
./pippo > filename 2>&1
```

stderr and stdout to file

```
/pippo &> filename
```

Piping

You can redirect the STDOUT/STDERR of a program to another program:

```
$ ls
pippo      pippo.c        pippo.cc    pippo.txt
$ ls | grep txt
pippo.txt
$
```

the “piping” can include multiple stages

```
$ $ ls | grep txt | sed 's/txt/png/g'
pippo.png
```

Saving STDOUT into a variable

$(command) and `command` expand to the output of command

```
$ for filename in `ls | grep txt`
do
  echo "change name of ${filename} to $(basename $filename .txt).ascii"
done

change name of pippo.txt to pippo.ascii
```

The output can be assigned to a variable:

```
export NEWNAME=$(basename pippo.txt .txt).ascii
```

or

```
export NEWNAME=`basename pippo.txt '.txt'`
```

Initialization files

Global configuration files

```
/etc/profile
/etc/bashrc
```

User configuration files

```
~/.bash_profile
~/.profile
~/.bashrc
```

hint : to avoid confusion set one file as a *symlink* to the other so you have only one startup file to debug.

Scripts

Scripts are text files containing a list of shell commands

```
tosca.mate.polimi.it > cat helloworld
echo 'Hello, World!'

tosca.mate.polimi.it > bash helloworld
Hello, World!
```

Scripts can be made *executable* using a shebang

```
tosca.mate.polimi.it > cat helloworld
#!/bin/sh
echo 'Hello, World!'

tosca.mate.polimi.it > chmod u+x helloworld
tosca.mate.polimi.it > ./helloworld
Hello, World!
tosca.mate.polimi.it >
```

Bash functions

```
!/bin/bash
# BASH FUNCTIONS CAN BE DECLARED IN ANY ORDER
function function_B {
	echo Function B.
}
function function_A {
	echo $1
}
function function_D {
	echo Function D.
}
function function_C {
	echo $1
}
```

```
# FUNCTION CALLS
# Pass parameter to function A
function_A "Function A."
function_B
# Pass parameter to function C
function_C "Function C."
function_D
```

Variables in scripts

```
#!/bin/bash
#Define bash global variable
#This variable is global and can be used anywhere in this bash script
VAR="global variable"
function bash {
#Define bash local variable
#This variable is local to bash function only
local VAR="local variable"
echo $VAR
}
echo $VAR
bash
# Note the bash global variable did not change
# "local" is bash reserved word
echo $VAR
```

More resources

GNU Bash Website

Wikipedia page about Bash

Bash Programming HOWTO

Advanced Bash Scripting guide

Bash Guide for Beginners