



Fundamentos de Sistemas Operativos / Sistemas de Operação

(Academic year 2022-2023)

Lab guide

Guide #04

The bash scripting language

Summary

Shell scripting using bash.

Exercise 1 *Familiarization with common Unix/Linux commands and builtin bash commands.*

1. Command **man** shows a description page for the command passed as argument. Use it to see the role of commands. It follows a list of common ones: **ls**, **mkdir**, **rmdir**, **pwd**, **rm**, **mv**, **cat**, **echo**, **less**, **head**, **tail**, **find**, **cp**, **diff**, **wc**, **sort**, **grep**, **sed**, **tr**, **cut**, **paste**, **chmod**, **stat**, **history**, ...
 2. Commands usually have switches/options that allow you to change their default behavior. Explore some of the **ls** command options: **-l**, **-a**, **-lh**, **-R**, **-lt**, **-ltr**, ...
 3. In general, commands correspond to executable programs, but there are some that are builtin functions of the command interpreter. Command **cd** is one of them. To see a list of such commands, execute the builtin command **help**. To see a description of a given builtin command, execute **help** followed by its name, as, for instance, **help cd**.
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Exercise 2 *Redirecting input and output.*

Many commands receive input from the standard input (usually the keyboard) and deliver output to the standard output (usually the terminal display window). Error messages are usually and preferably sent to the standard error (also usually the terminal display window). However, it is possible to change this default behaviour.

1. Operators **>** and **>>** redirect the standard output to a given file, the former creating a new file, the latter appending to the end of an existing one. The following sequence of commands illustrates their use.

```
echo ola           # message "ola" is sent to the terminal display window
echo ola > z        # message "ola" is sent to file "z",
                   # any previous content of "z" being deleted
echo ola >> z       # message "ola" is appended to the end of file "z";
                   # file "z" is created if it does not exist
```

2. Operators **2>** and **2>>** redirects the standard error to a given file. The following sequence of commands illustrates its use.

```
rm -f zzz          # to guarantee file "zzz" does not exist
cat zzz            # an error message is sent to the terminal display window
cat zzz 2> z        # the error message is sent to file "z",
                   # any previous content of "z" being deleted
cat z              # to check the error message is there
cat zzz 2>> z       # the error message is appended to the end of file "z"
cat z              # Why are there 2 error messages in file "z"?
cat zzz > z         # the error message is sent to the terminal display window. Why?
```

3. Operator `|` redirects the standard output of a command to the standard input of the following, an operation known as the piping of commands. The following sequence of commands illustrates its use.

```
# the following command sends to the terminal display window
# the contents of file "/etc/passwd"
cat /etc/passwd

# the following command piping sends to the terminal display window
# the number of lines of file "/etc/passwd"
cat /etc/passwd | wc -l
```

4. Operators `2>&1` and `>&2` (or `1>&2`) redirect the standard error to the standard output and the standard output to the standard error, respectively. The following sequence of commands illustrates their use.

```
rm -f zzz                # to guarantee zzz does not exist
# in the following command, the standard error was not redirect
cat zzz > err
# in the following command, the standard error was redirect
# to the same file the standard output was
cat zzz > err 2>&1
cat err                  # to check the error message is there
# in the following command, the standard output was not redirect
cat /etc/passwd 2> z
# in the following command, the standard output was redirect
# to the same file the standard error was
cat /etc/passwd 2> z >&2
cat z                    # to check the it
```

Exercise 3 Using special characters.

1. Analysing the result of the execution of the following sequence of commands, try to understand the meaning of characters `*` and `?`

```
mkdir dir1
cd dir1
touch a a1 a2 a3 a11 b b1 b11 b12 b21 # to create some files
ls
ls a*
ls *1
ls a?
ls b??
ls b?*
ls *
```

2. Analysing the result of the execution of the following sequence of commands, try to understand the meaning of characters `[` and `]`

```
touch a a1 a2 a3 a11 b b1 b11 c c11 # to create some files
ls
ls [ac]
ls [a-c]
ls [a-c]?
ls [ab]*
```

3. Character `\` can be used to disable the special meaning of the character following it. The following sequence of commands illustrates its use.

```
touch a1 a2 a3 a4 a22    # to create some files
echo a*
echo a\*
echo a?
echo a\?
echo a\[
echo a\\
```

4. Characters `'` and `"` can be used to disable the special meaning of a sequence of characters. The following sequence of commands illustrates their use.

```
touch a1 a2 a3 a4 a22    # create some files
echo a*
echo "a*"
echo 'a*'
```

Exercise 4 Declaring and using variables.

1. Variables are supported in `bash`. The assignment of a value to a variable is done using the syntax `<id>=<value>`, where `<id>` represents the name of the variable and `<value>` the value to be assigned. The value of a variable can be retrieved using the syntax `${<id>}`, where `<id>` represents the name of the variable. If no confusion arises, the braces can be omitted. The following sequence of commands illustrates their use.

```
x=abc
xx=0123456789
echo ${x}
echo $x
echo ${xx}
echo $xx
echo ${x}x
echo x${x}
touch a1 a2 a3 a4 a22    # create some files
z=a*
ls $z
```

2. In the previous exercise, when the special characters were presented, characters `"` and `'` seem to be equivalent. Try to understand how they differ executing and analysing the following sequence of commands.

```
v=a*                                # a* is not expanded in assignment
echo $v
echo "$v"
echo '$v'
```

3. There are functions to manipulate the value of variables. The following sequence of commands illustrates the use of the substring and substitute functions.

```
x=0123456789
echo ${x:2:4}
echo ${x/123/ccc}
```

4. Use the manpage of `bash` (`man bash`) to see other possible manipulations of variables.
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Exercise 5 Declaring and using functions.

1. Functions are supported in `bash`. The following sequence of commands illustrates the declaration and use of a function.

```
# the following code declares function x
x()
{
    ls -l
}
# the following code uses the function x previously defined
x
x | wc -l
```

2. Functions can accept arguments. Variables `$1`, `$2`, ..., `$*`, `$@` and `$#` can be used to access them.

```
y()
{
    echo $#      # the number of arguments
    echo $1      # the first argument
    echo $2      # the second argument
    echo $*      # the list of all arguments
    echo $@      # idem
    echo "$*"    # idem
    echo "$@"    # idem
}
y a bb ccc dddd eeeee
y a "b b" ccc "dd dd" eeeee
```

Exercise 6 Grouping commands.

1. Characters `{ e }` can be used to group commands. In the following example, the output of a group of commands is redirected to a file.

```
{
    ls
    echo =====
    ls
} > z
cat z
```

2. Characters (`e`) can also be used to group commands. In the following example, the output of a group of commands is redirected to a file.

```
(
    ls
    echo =====
    ls
) > z
cat z
```

3. The difference between them is that in the second case the execution happens in a new instance of the bash. The following bash code shows the differences. Pay attention to the successive values of variable `zzz`.

```
zzz=abc
echo $zzz
{
    echo "This takes place in the same bash instance"
    zzz=xpto
    echo $zzz
}
echo $zzz
echo =====
zzz=abc
echo $zzz
(
    echo "This takes place in a new bash instance"
    zzz=xpto
    echo $zzz
)
echo $zzz          # the assignment within !()! 'got lost'
```

Exercise 7 *The conditional if construction.*

1. Commands have a return value, that, in C/C++ programs, corresponds to the argument of the `return` instruction of the `main` function or to the argument of the `exit` function. The `bash` saves this return value in variable `$?`. Execute the following sequence of commands to see it.

```
ls
echo $?
rm -f zzz      # to guarantee file zzz does not exist
echo $?
test -f zzz
echo $?
touch zzz     # to guarantee file zzz exists
test -f zzz
echo $?
```

2. The value of `$?` is used by `bash` as a boolean value, 0 representing `true` and other values representing `false`. The following sequence of commands illustrates a use of the `if .. then .. [else ..] fi` construction.

```
touch zzz      # to guarantee file zzz exists
if test -f zzz
then
    echo "File zzz exists"
else
    echo "File zzz does not exist"
fi
check()
{
    if test -f $1
    then
        echo -e "\e[33mFile zzz exists\e[0m"
    else
        echo -e "\e[31mFile zzz does not exist\e[0m"
    fi
}
touch zzz      # to guarantee file zzz exists
check zzz
rm -f zzz      # to guarantee file zzz does not exist
check zzz
```

3. Function `test` can be called using brackets.

```
check()
{
    if [ -f $1 ]
    then
        echo -e "\e[33mFile zzz exists\e[0m"
    else
        echo -e "\e[31mFile zzz does not exist\e[0m"
    fi
}
touch zzz      # to guarantee file zzz exists
check zzz
rm -f zzz      # to guarantee file zzz does not exist
check zzz
```

4. Operator `!` is the logical not.

```
rm -f zzz      # to guarantee file zzz does not exist
if ! test -f zzz
then
    echo "File zzz does not exist"
fi
```

5. Operators `&&` and `||` are simplified conditional constructions.

```
touch zzz      # to guarantee file zzz exists
test -f zzz && echo "File zzz exists"
rm -f zzz      # to guarantee file zzz does not exist
test -f zzz || echo "File zzz does not exist"
```

Exercise 8 *The multiple choice case construction.*

1. The `case` construction allows branching based on patterns, as is illustrated by the following code.

```
z()
{
    case $# in
        0) echo "No arguments were given";;
        1) echo "One argument was given";;
        2|3) echo "Two or three arguments were given";;
        *) echo "More than three arguments were given";;
    esac
}
z
z aa
z aa bb
z aa bb cc
z aa bb cc dd
z aa bb cc dd ee
```

The double `;;` is used to end a branch. The `|` in a pattern defines an alternative. The `` means any value. In the previous code, being the last, it represents the otherwise values.*

Exercise 9 *The repetitive for construction.*

1. The `for` construction allows for iteration through a list of values. Next code appends a prefix to the name of all files in the current directory whose names start with an `a`.

```
touch a1 a2 a77 abc b1 c12 ddd    # create some files
ls
prefix="_a_"
for f in a*
do
    echo "changing the name of \"$f\""
    mv $f $prefix$f
done
ls
```

The following code creates and uses a function that iterates through all files passed as arguments.

```
f1()
{
    for file in $*
    do
        echo "==== $file =====" > $file
    done
}

f1 abc xpto zzz
cat xpto
cat abc
cat zzz
```

Exercise 10 *The repetitive while and until constructions.*

1. In the following code, functions `f2` e `f3` are equivalent to function `f1` of the previous exercise.

```
f2()
{
    while [ $# -gt 0 ]
    do
        echo "==== $1 =====" > $1
        shift
    done
}

f3()
{
    until [ $# -eq 0 ]
    do
        echo "==== $1 =====" > $1
        shift
    done
}

rm -f abc xpto zzz    # to guarantee they do not exist
f2 abc xpto zzz
cat xpto
cat abc
cat zzz
f3 abc xpto zzz
cat xpto
cat abc
cat zzz
```

Exercise 11 *Script files.*

1. You can create a file whose contents is a program in **bash** (or a program in any other scripting language). To execute it, you can pass its name as an argument to the **bash** command or change its permissions to include execution. Such program are usually called shell scripts. Use your favorite text editor to create the file `myscript`, with the following contents.

```
#!/bin/bash
# The previous line (comment) tells the operating system that
#   this script is to be executed by bash
#
# This script selects and sorts the lines of a given file,
#   except the first 5 and the last 5.
#
if [ $# -ne 1 ]
then
    echo "A single argument is mandatory" 1>&2
    exit 1
fi

if ! [ -f $1 ]
then
    echo "Given argument ($1) is not a regular file" 1>&2
    exit 1
```



```
fi

head -n -5 $1 | tail -n +6 | sort
```

2. In the following code, the previous script is called through the `bash`.

```
bash myscript
bash myscript xpto abc for testing
rm -f abc      # to guarantee it does not exist
bash myscript abc
# create a file for testing
seq -w 100 -3 2 > xpto
bash myscript xpto
```

3. In the following code, permissions are changed to include execution and thus the script can be called directly. Actually, the code is executed within a new `bash`, implicitly called.

```
chmod +x myscript
./myscript xpto
```

Exercise 12 Bash supports both indexed and associative arrays.

1. The indices of an indexed array do not need to be contiguous and can not be negative. The following code shows the use of an indexed array.

```
a[1]=aaa
echo ${a[1]}
declare -a a[2]=bbb # can also be used
a[4]=ddd
a[2+3]=eee          # integer arithmetic expression are allowed
echo ${a[*]}         # the list of elements in the array
echo ${#a[*]}        # the number of elements in the array
echo ${!a[*]}        # the list of indices used in the array

# iterate through the list of elements
for v in ${a[*]}
do
    echo $v
done

# iterate through the list of indices
for i in ${!a[*]}
do
    echo "a[$i] = ${a[$i]}"
done
```

2. Associative arrays need to be declared explicitly. The following code illustrates its declaration and use.

```
declare -A arr
arr["homem"]=man
arr["papel"]=paper
arr["olá"]=hello
arr["lição"]=lesson
echo ${arr[*]}          # the list of elements in the array
echo $#arr[*]          # the number of elements in the array
echo ${!arr[*]}        # the list of indices used in the array
for i in ${!arr[*]}
do
    echo "The translation of \"${i}\" is \"${arr[$i]}\""
done
```