Princípios da Computação

The Unix shell

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Shell metacharacters

Shell metacharacters

- Special characters the shell interprets rather than passing to the command.
  - We have already used metacharacters for file substitution:
    - `ls ex*`
    - `ls ?er`
    - `ls [abc]*`

Escaping Metacharacters

- Sometimes those special characters are supposed to be passed to the command: they must *escape* the shell.
  - Use the backslash \ before the character.
    - E.g. `\*` will not interpret the `*` (and a literal `*` is passed to the command)
    - Try `echo *` and `echo \*`
  - Single quotes (`'  '`) protect all characters in between.
  - Double quotes (`"  "`) protect all characters in between, except the backslash (`\`), dollar sign (`$`) and grave accent (`` ` ``).

Bash Metacharacters

- A lot more metacharacters for:
  - Redirecting input/output
  - Expand variables
  - Conditional execution
  - …

Bash Metacharacters

Symbol	Meaning
>	Output redirection
>>	Output redirection (append)
<	Input redirection
<<	Inline input redirection
*	File substitution wildcard; zero or more characters
?	File substitution wildcard; exactly one character
[ ]	File substitution wildcard; any character between brackets
\`cmd\`	Command Substitution
$(cmd)	Command Substitution
|	Pipe commands

Symbol	Meaning
;	Sequence of commands
||	OR conditional execution
&&	AND conditional execution
( )	Group commands, Sequences of Commands
&	Run command in the background
#	Comment
$	Expand the value of a variable
\	Prevent or escape interpretation of the next character
~	User directory
..	Previous directory
.	Current working directory

Redirecting input/output

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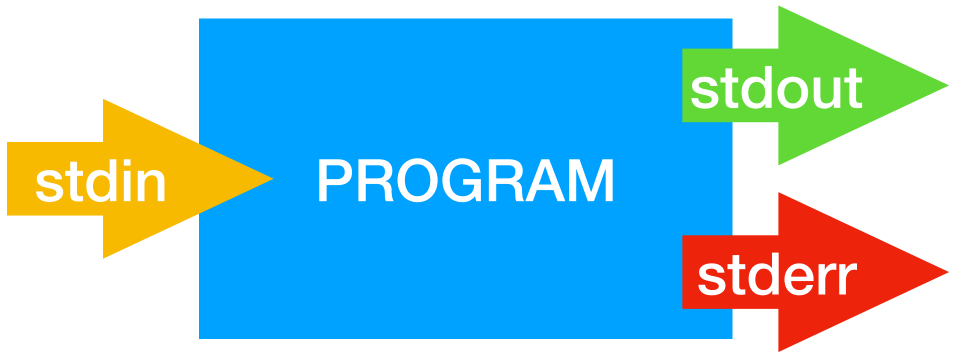
Standard input, output and error

- In Unix, each program has three predefined open streams:
  - standard input (stdin)
  - standard output (stdout)
  - standard error (stderr)



Standard input (stdin)

- *File descriptor: 0*
- The program may read data from this stream…
  - as long as it is programmed to do so.
- Connected to the keyboard, by default.

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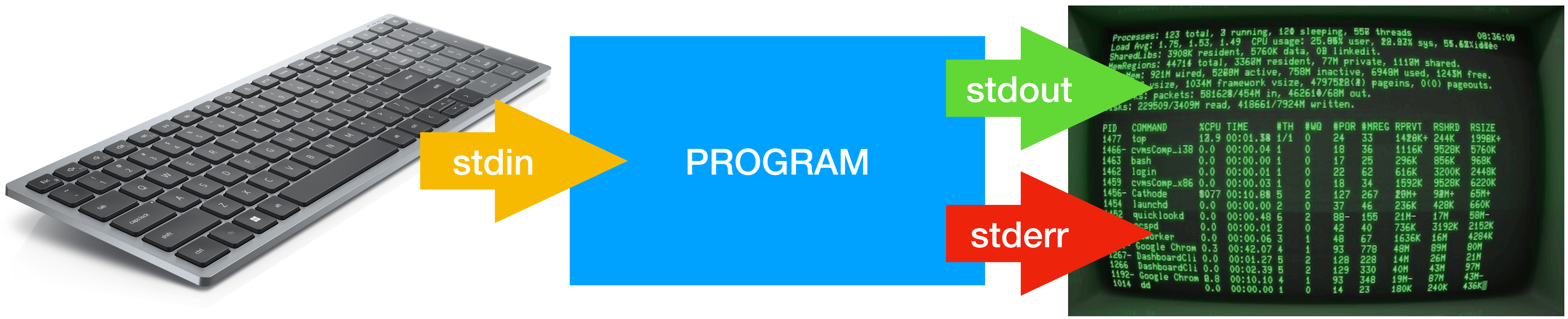
Standard output (stdout)

- *File descriptor: 1*
- Where the program writes the regular output.
- Connected to the monitor, by default.

Standard error (stderr)

- *File descriptor: 2*
- Where the program writes error messages.
- Connected to the monitor, by default.

The standard case



```
Processes: 123 total, 3 running, 120 sleeping, 558 threads                08:36:09
Load Avg: 1.75, 1.53, 1.49  CPU usage: 25.05% user, 20.93% sys, 55.62% idle
SharedLibs: 3908K resident, 5760K data, 0B linkedit.
MemRegions: 44714 total, 3368M resident, 77M private, 1118M shared.
  Mem: 921M wired, 5200M active, 758M inactive, 6940M used, 1243M free.
   vsize, 1034M framework vsize, 4797528(2) pageins, 0(0) pageouts.
  ks: packets: 581628/454M in, 462610/68M out.
 isks: 229509/3409M read, 418661/7924M written.

PID   COMMAND      %CPU TIME     #TH  #WQ  #POR #MREG RPRVT  RSHRD  RSIZE
1477  top          12.9 00:01.38 1/1  0    24   33    1420K+ 244K   1998K+
1466- cvmsComp_i38 0.0  00:00.04 1    0    18   36    1116K  9528K  5760K
1463  bash         0.0  00:00.00 1    0    17   25    296K   856K   968K
1462  login        0.0  00:00.01 1    0    22   62    616K   3200K  2448K
1459  cvmsComp_x86 0.0  00:00.03 1    0    18   34    1592K  9528K  6220K
1456- Cathode      8077 00:10.88 5    2    127  267   20M+   92M+   65M+
1454  launchd      0.0  00:00.00 2    0    37   46    236K   428K   660K
 452  quicklookd   0.0  00:00.48 6    2    88-  155   21M-   17M    58M-
      ocspd        0.0  00:00.01 2    0    42   40    736K   3192K  2152K
      worker       0.0  00:00.06 3    1    48   67    1636K  16M    4284K
      Google Chrom 0.3  00:42.07 4    1    93   778   48M    89M    80M
1267- DashboardCli 0.0  00:01.27 5    2    128  228   14M    26M    21M
1266  DashboardCli 0.0  00:02.39 5    2    129  330   40M    43M    97M
1192- Google Chrom 0.8  00:10.10 4    1    93   348   19M-   87M    43M-
1014  dd           0.0  00:00.00 1    0    14   23    180K   240K   436K
```

Redirecting streams

- Streams can be redirected to files!
  - You may want to feed your program with data from a file.
  - You may want to save output and/or error messages to a file.

Output redirection

- >
  - Redirects all output and errors to a new (empty) file.
- >>
  - Redirects all output and errors, appending to a file.

Output redirection

```
$ ls > my_files.txt
$ cat my_files.txt
Desktop
Documents
Downloads
Library
Movies
Music
Pictures
Public
my_files.txt
$ echo GOODBYE > my_files.txt
$ cat my_files.txt
GOODBYE
$
```

```
$ echo one > numbers.txt
$ cat numbers.txt
one
$ echo two >> numbers.txt
$ cat numbers.txt
one
two
$ echo three >> numbers.txt
$ cat numbers.txt
one
two
three
$
```

Output redirection

- **1>** or **1>>**
  - Redirects only output to a file: new or append, respectively.
- **2>** or **2>>**
  - Redirects only errors to a file: new or append, respectively.

Output redirection

```
$ my_program 1> output.txt 2>> my_errors.log
$
```

Redirects output to the new (empty) file output.txt

Appends error messages to file my_errors.log

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Input redirection

- <
  - The content of a file is redirected to the stdin of a command.
- <<
  - The command line arguments are directed to the stdin of a command.

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Input redirection

```
$ cat numbers.txt
one
two
three
$ sort < numbers.txt
one
three
two
$ sort < numbers.txt > sorted_numbers.txt
```

Pipes

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Piping streams between commands

- The output stream of a command can be piped into the input stream of other command.
    - The pipe symbol **|** is placed between commands, connecting the output stream of the first to the input stream of the next command.
    - Example: **`command 1 | command2 | command3`**
- Both programs are running at the same time.
    - Output of the first command is immediately sent to the next command in the pipeline.

Pipes

```
$ ls -l /bin | more
total 9584
-rwxr-xr-x  2 root  wheel   134240  2 Set 08:35 [
-r-xr-xr-x  1 root  wheel  1326752  2 Set 08:35 bash
-rwxr-xr-x  1 root  wheel   135408  2 Set 08:35 cat
-rwxr-xr-x  1 root  wheel   136960  2 Set 08:35 chmod
-rwxr-xr-x  1 root  wheel   152800  2 Set 08:35 cp
-rwxr-xr-x  2 root  wheel  1153408  2 Set 08:35 csh
-rwxr-xr-x  1 root  wheel   307248  2 Set 08:35 dash
-rwxr-xr-x  1 root  wheel   168032  2 Set 08:35 date
-rwxr-xr-x  1 root  wheel   185088  2 Set 08:35 dd
-rwxr-xr-x  1 root  wheel   151440  2 Set 08:35 df
-rwxr-xr-x  1 root  wheel   133952  2 Set 08:35 echo
-rwxr-xr-x  1 root  wheel   235296  2 Set 08:35 ed
-rwxr-xr-x  1 root  wheel   134800  2 Set 08:35 expr
-rwxr-xr-x  1 root  wheel   133952  2 Set 08:35 hostname
-rwxr-xr-x  1 root  wheel   134352  2 Set 08:35 kill
-r-xr-xr-x  1 root  wheel  2598896  2 Set 08:35 ksh
-rwxr-xr-x  1 root  wheel   394848  2 Set 08:35 launchctl
-rwxr-xr-x  2 root  wheel   134736  2 Set 08:35 link
-rwxr-xr-x  2 root  wheel   134736  2 Set 08:35 ln
-rwxr-xr-x  1 root  wheel   187120  2 Set 08:35 ls
-rwxr-xr-x  1 root  wheel   134128  2 Set 08:35 mkdir
-rwxr-xr-x  1 root  wheel   135552  2 Set 08:35 mv
-More-
```

Environment variables

Environment variables

- Environment variables store information about
  - the shell session,
  - the working environment, and
  - user defined data.

Global and local variables

- Global variables are visible from the shell, but also from any program running inside the shell.
  - Usually store useful session data.
- Local variables are visible only from the shell.
  - User defined variables are local.

Seeing global variables

- Commands **`env`** and **`printenv`** display the session global variables.

```
$ printenv
[...]
SHELL=/bin/bash
HOME=/Users/johnny
LOGNAME=johnny
USER=johnny
PATH=/usr/local/bin:/usr/bin:/bin:/usr/sbin:/sbin
PWD=/Users/johnny
OLDPWD=/Users/johnny
LANG=pt_PT.UTF-8
$
```

Seeing local variables

- Command **set** displays all (global and local) variables.

```
$ set
(...)
SHELL=/bin/bash
HOME=/Users/johnny
LOGNAME=johnny
USER=johnny
PATH=/usr/local/bin:/usr/bin:/bin:/usr/sbin:/sbin
PWD=/Users/johnny
OLDPWD=/Users/johnny
LANG=pt_PT.UTF-8
(...)
my_var='This is my local var.'
$
```

Setting a user defined variable

- Assign a value to a variable using the = symbol.
    - No spaces are allowed around the = symbol!!!

```
$ my_word=Hello
$ my_sentence="Hi there"
$ set
(...)
my_sentence='Hi there'
my_word='This is my local var.'
$
```

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Using a variable

- Variables can be used on command lines.
- The value stored in the variable is obtained using the **$** symbol (variable expansion).

```
$ echo $my_sentence I am $USER
Hi there I am johnny
$ ls /Users/johnny/docs
PRCMP_assignment3.pdf
PRCMP_assignment4.pdf
$ ls $HOME/docs
PRCMP_assignment3.pdf
PRCMP_assignment4.pdf
$
```

Name	Value
my_sentence	Hi there
HOME	/Users/home/johnny
USER	johnny

Promoting a variable to global

- The export command makes a variable global.

```
$ export DOCS_DIR=$HOME/docs
$ printenv
(...)
DOCS_DIR=/Users/johnny/docs
(...)
$
```

Conditional execution

Exit status

- When a program ends, it informs the shell about its exit status.
- The exit status is an integer:
    - 0 (zero) means SUCCESS
    - Any other value means FAILURE
- The exit status of the last command can be accessed in the variable **`$?`**
    - Try **`echo $?`**

Conditional execution

- The exit status can determine the execution of the next program.
- **&&** executes the next program if the previous succeeded
- **||** executes the next program if the previous failed.

```
$ true && echo OK || echo FAILED
OK
$ false && echo OK || echo FAILED
FAILED
$
```

```
$ true
$ echo $?
0
$ false
$ echo $?
1
$
```

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Conditional execution

```
$ ls && echo OK || echo FAILED
docs    numbers.txt     letters.txt
OK
$ ls no_file_here && echo OK || echo FAILED
ls: no_file_here: No such file or directory
FAILED
$
```

A more useful example. What is it supposed to do?

```
$ mkdir $HOME/docs && mv $HOME/Downloads/*.pdf $HOME/docs
$
```

Job control

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Foreground jobs

- When you launch a program, it runs in the foreground.
  - The shell loads the program and suspends, waiting for the program to finish.
  - When the program ends, the shell returns.
- However, it is possible to launch a program running in the background…

Background jobs

- When a program is launched in the background, the shell does not suspend, returning immediately.
- To launch a program in the background, the **&** symbol is added at the end of the command line.

Background jobs

- The command should not be interactive!
  - No keyboard input, no output for the monitor!
- Great for programs that run for a long time.

```
$ git clone git://git.kernel.org/pub/scm/.../linux.git my-linux &
[1] 34451
$
```

Job 1, with identifier 34451 started.

The shell returns immediately.

Run command in the background

List jobs in the background

- The **`jobs`** command lists the uncompleted jobs.

```
$ jobs
[1]    running    git clone ...
[2]  - running    vlc -I dummy -q ...
[3]  + running    my_
$
```

Switching between foreground and background

- **CTRL-Z** interrupts (suspends) the job in the foreground.
- The **`bg`** command puts a suspended job to run in the background.
- The **`fg`** command puts a suspended job to run in the foreground.

Switching between foreground and background

```
$ sleep 60
^Z
bash: suspended  sleep 60
$ jobs
[1]  + suspended  sleep 60
$ bg %1
[1]  + continued  sleep 60
$ jobs
[1]  + running    sleep 60
$ fg %1
[1]  + running    sleep 60
```

Pressing CTRL-Z suspends the job running in the foreground.

Job %1 (number 1) continues running in the background.

Job %1 is promoted to run in the foreground.

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