Advanced Linux

ABiMS

Training Module 2018

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Advanced Linux | Goals

So now you’re **the** Linux gal/guy of the lab. Congrats, colleagues keep coming to you for advice (at best) or for a helping hand (i.e. burden you with chores they can’t take care of themselves).

How do I:

- ~~Get rid of them ?~~ (not an option)
- Extract relevant information from the **myriad humongous** files ?
- Run a **series of commands** and make data **flow** between them ?
- Write **command files** containing lists of commands operating on data files ?

Advanced Linux | Outline

1 A Quick Refresher

2 Redirections & Pipes

3 Slicing ‘n Dicing Files

4 Regular Expressions

5 Awk 101

6 Batch Files 101

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1 A Quick Refresher

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Quick Refresher | CLI Survival Kit

Where am I ?

Quick Refresher | CLI Survival Kit

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```
[stage01@nz~]$ pwd
```

Quick Refresher | CLI Survival Kit

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Which files/directories are located “here” ?

Quick Refresher | CLI Survival Kit

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Which files/directories are located “here” ?

```
[stage01@nz~]$ ls
[stage01@nz~]$ ls .
```

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Which files/dirs are located in /tmp (with full details and hidden files) ?

Quick Refresher | CLI Survival Kit

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Which files/dirs are located in /tmp (with full details and hidden files) ?

```
[stage01@nz~]$ ls -la /tmp
```

Quick Refresher | CLI Survival Kit

Where am I ?

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[stage01@nz~]$ pwd
```

Which files/directories are located “here” ?

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[stage01@nz~]$ ls
[stage01@nz~]$ ls .
```

Which files/dirs are located in `/tmp` (with full details and hidden files) ?

```
[stage01@nz~]$ ls -la /tmp
```

How do I get to `/tmp` (make `/tmp` my current directory) ?

Quick Refresher | CLI Survival Kit

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Which files/directories are located “here” ?

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[stage01@nz~]$ ls
[stage01@nz~]$ ls .
```

Which files/dirs are located in /tmp (with full details and hidden files) ?

```
[stage01@nz~]$ ls -la /tmp
```

How do I get to /tmp (make /tmp my current directory) ?

```
[stage01@nz~]$ cd /tmp
```

Quick Refresher | CLI Survival Kit

How do I create directories `~/foo/bar/baz` ?

Quick Refresher | CLI Survival Kit

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```
[stage01@nz~]$ mkdir -p ~/foo/bar/baz
```

Quick Refresher | CLI Survival Kit

How do I create directories ~/foo/bar/baz ?

```
[stage01@nz~]$ mkdir -p ~/foo/bar/baz
```

How do I copy file quux to ~/foo/bar/baz ?

Quick Refresher | CLI Survival Kit

How do I create directories ~/foo/bar/baz ?

```
[stage01@nz~]$ mkdir -p ~/foo/bar/baz
```

How do I copy file quux to ~/foo/bar/baz ?

```
[stage01@nz~]$ cp quux ~/foo/bar/baz
```

Quick Refresher | CLI Survival Kit

How do I create directories ~/foo/bar/baz ?

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How do I *move* file corge to ~/foo/bar/baz ?

Quick Refresher | CLI Survival Kit

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[stage01@nz~]$ cp quux ~/foo/bar/baz
```

How do I *move* file corge to ~/foo/bar/baz ?

```
[stage01@nz~]$ mv corge ~/foo/bar/baz
```

Quick Refresher | CLI Survival Kit

How do I create directories `~/foo/bar/baz` ?

```
[stage01@nz~]$ mkdir -p ~/foo/bar/baz
```

How do I copy file `quux` to `~/foo/bar/baz` ?

```
[stage01@nz~]$ cp quux ~/foo/bar/baz
```

How do I *move* file `corge` to `~/foo/bar/baz` ?

```
[stage01@nz~]$ mv corge ~/foo/bar/baz
```

How do I copy *directory* `grault` to `~/foo/bar/baz` ?

Quick Refresher | CLI Survival Kit

How do I create directories ~/foo/bar/baz ?

```
[stage01@nz~]$ mkdir -p ~/foo/bar/baz
```

How do I copy file quux to ~/foo/bar/baz ?

```
[stage01@nz~]$ cp quux ~/foo/bar/baz
```

How do I *move* file corge to ~/foo/bar/baz ?

```
[stage01@nz~]$ mv corge ~/foo/bar/baz
```

How do I copy *directory* grault to ~/foo/bar/baz ?

```
[stage01@nz~]$ cp -r grault ~/foo/bar/baz
```

Quick Refresher | CLI Survival Kit

How do I remove (delete forever) file `garply` ?

Quick Refresher | CLI Survival Kit

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```
[stage01@nz~]$ rm garply
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How do I remove directory `waldo` (with all its contents) ?

Quick Refresher | CLI Survival Kit

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```

How do I remove directory `waldo` (with all its contents) ?

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[stage01@nz~]$ rm -rf waldo
```

Quick Refresher | CLI Survival Kit

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How do I remove *empty* directory `fred` ?

Quick Refresher | CLI Survival Kit

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```

How do I remove directory `waldo` (with all its contents) ?

```
[stage01@nz~]$ rm -rf waldo
```

How do I remove *empty* directory `fred` ?

```
[stage01@nz~]$ rmdir fred
```

Quick Refresher | CLI Survival Kit

How do know I what kind of data is stored in file `plugh` ?

Quick Refresher | CLI Survival Kit

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[stage01@nz~]$ file plugh
```

Quick Refresher | CLI Survival Kit

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How do I display the contents of file `xyzzy` (and recover control of the terminal right away) ?

Quick Refresher | CLI Survival Kit

How do know I what kind of data is stored in file plugh ?

```
[stage01@nz~]$ file plugh
```

How do I display the contents of file xyzzy (and recover control of the terminal right away) ?

```
[stage01@nz~]$ cat xyzzy
```

Quick Refresher | CLI Survival Kit

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```

How do I display the beginning (end) of file `thud` ?

CNRS UPMC Station Biologique Roscoff

Abims

Quick Refresher | CLI Survival Kit

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How do I display the beginning (end) of file `thud` ?

```
[stage01@nz~]$ head thud
[stage01@nz~]$ tail thud
```

Quick Refresher | CLI Survival Kit

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How do I page through file `ioofa` ?

Quick Refresher | CLI Survival Kit

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```

How do I page through file `ioofa` ?

```
[stage01@nz~]$ less ioofa
```

Quick Refresher | CLI Survival Kit

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```

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[stage01@nz~]$ cat xyzzy
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How do I display the beginning (end) of file `thud` ?

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[stage01@nz~]$ head thud
[stage01@nz~]$ tail thud
```

How do I page through file `ioofa` ?

```
[stage01@nz~]$ less ioofa
```

How do I edit file `omtg` ?

Quick Refresher | CLI Survival Kit

How do I run program `jimbo` in the background ?

Quick Refresher | CLI Survival Kit

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```
[stage01@nz~]$ jimbo &
```

Quick Refresher | CLI Survival Kit

How do I run program `jimbo` in the background ?

```
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```

How do I relegate already running program `wharty` to the background?

Quick Refresher | CLI Survival Kit

How do I run program `jimbo` in the background ?

```
[stage01@nz~]$ jimbo &
```

How do I relegate already running program `wharty` to the background?

```
[stage01@nz~]$ wharty
[Ctrl+Z]
(…)
[stage01@nz~]$ bg
```

Quick Refresher | The Ground Rule

When in doubt about running a program :

READ

THE

FINE

MANUAL

```
[stage01@nz~]$ man command
```

Warm up | Configuring The Environment

1. Open a terminal and connect to `nz`

```
[stage01@nz~]$ ssh -Y nz
```

2. Jump to one of the cluster nodes **(nobody runs jobs on nz !)**

```
[stage01@nz~]$ qlogin
```

3. Go to your “project” directory **(don’t work in you home directory !)**

```
[stage01@nz~]$ cdprojet
```

4. Get the course material

```
[stage01@nz~]$ wget https://frama.link/aldata2018
```

5. Unpack the course material

```
[stage01@nz~]$ tar -zxvf aldata2018
```

Advanced Linux | Outline

1 A Quick Refresher

2 **Redirections & Pipes**

3 Slicing ‘n Dicing files

4 Regular Expressions

5 Awk 101

6 Batch Files 101

Redirections & Pipes | Goal

Displaying command output on the terminal has its limitations :

1. Scrolling capacity is finite
2. Difficult to reuse for further processing

The puzzle :

- How do I build the list of files in the current directory matching a specific pattern and modified at a given date ?

Some of the pieces :

- I know how to list the files in the current directory (with `ls`)
- I know how to look for patterns in text files (with `grep`)

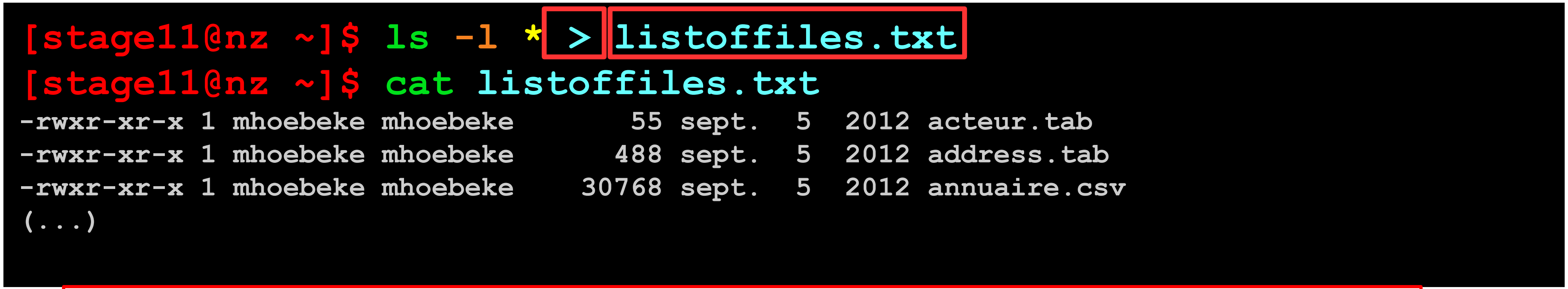
What's missing :

- I don't know how to feed the output of `ls` into `grep`

Redirections & Pipes | Redirections

All programs generate their output into *channels* (special types of files). The terminal is just the default output channel (`stdout` for standard output).
Linux gives us *redirections* to replace the default output channel with a file.

Ex.: Using a redirection to store the output of a command to a file



```
[stage11@nz ~]$ ls -l * > listoffiles.txt
[stage11@nz ~]$ cat listoffiles.txt
-rwxr-xr-x 1 mhoebeke mhoebeke      55 sept.  5  2012 acteur.tab
-rwxr-xr-x 1 mhoebeke mhoebeke     488 sept.  5  2012 address.tab
-rwxr-xr-x 1 mhoebeke mhoebeke   30768 sept.  5  2012 annuaire.csv
(...)
```

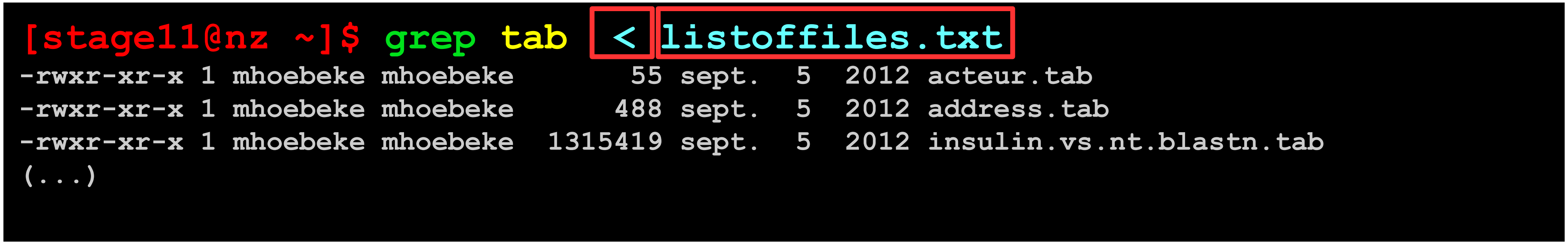
The redirection character **>** added after a command and its arguments and **followed by a filename** will create a file containing the output of the command.

⚠ If the file already exists, it will be overwritten

Redirections & Pipes | Redirections

Programs can read their input from *channels* (special types of files).
There is a default input channel (`stdin` for standard input).
Linux gives us *redirections* to use a file as standard input.

Ex.: Using a redirection to use a file as input for grep using a redirection



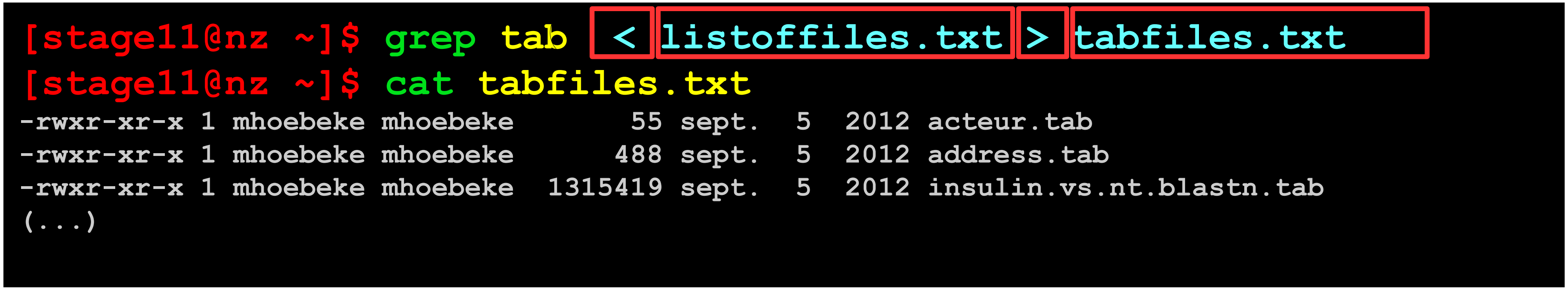
```
[stage11@nz ~]$ grep tab < listoffiles.txt
-rwxr-xr-x 1 mhoebeke mhoebeke       55 sept.  5  2012 acteur.tab
-rwxr-xr-x 1 mhoebeke mhoebeke      488 sept.  5  2012 address.tab
-rwxr-xr-x 1 mhoebeke mhoebeke  1315419 sept.  5  2012 insulin.vs.nt.blastn.tab
(...)
```

The redirection character **<** added after the arguments of a command and **followed by a filename** will use the file as input for reading data instead of `stdin`.

Redirections & Pipes | Redirections

Input and output redirections can be combined.

Ex.: Using a redirection to use a file as input for `grep`, and for storing the result in a file



```
[stage11@nz ~]$ grep tab < listoffiles.txt > tabfiles.txt
[stage11@nz ~]$ cat tabfiles.txt
-rwxr-xr-x 1 mhoebeke mhoebeke       55 sept.  5  2012 acteur.tab
-rwxr-xr-x 1 mhoebeke mhoebeke      488 sept.  5  2012 address.tab
-rwxr-xr-x 1 mhoebeke mhoebeke  1315419 sept.  5  2012 insulin.vs.nt.blastn.tab
(...)
```

Redirections & Pipes | Pipes

Pipes **can be used to directly channel `stdout` from one command into `stdin` of the next command**

Ex.: Using a pipe to `grep` for a pattern in the output of `ls`

```
[stage11@nz ~]$ ls -l | grep tab
-rwxr-xr-x 1 mhoebeke mhoebeke       55 sept.  5  2012 acteur.tab
-rwxr-xr-x 1 mhoebeke mhoebeke      488 sept.  5  2012 address.tab
-rwxr-xr-x 1 mhoebeke mhoebeke  1315419 sept.  5  2012 insulin.vs.nt.blastn.tab
(...)
```

The pipe symbol | is placed after the arguments of the first command and before the second command.

Series of commands can be linked with pipes.

```
[stage11@nz ~]$ ls -l | grep tab | grep -v insulin
-rwxr-xr-x 1 mhoebeke mhoebeke       55 sept.  5  2012 acteur.tab
-rwxr-xr-x 1 mhoebeke mhoebeke      488 sept.  5  2012 address.tab
(...)
```

Redirections & Pipes | Tips

There is a special channel, `stderr` (for standard error), different from `stdout`, where commands write error messages when necessary.
By default stderr is also the terminal output...

Ex.: Redirecting `stdout` only will still generate error messages on the terminal.

```
[stage11@nz ~]$ ls -lR /home/fr2424 > /tmp/lsfr2424.txt
ls: cannot open directory /home/fr2424/administration/bmasse: Permission denied
ls: cannot open directory /home/fr2424/administration/carou: Permission denied
ls: cannot open directory /home/fr2424/administration/hmignot: Permission denied
(...)
```

The redirection of `stderr` is possible by adding the `>&` redirection symbol after a command's arguments.

```
[stage11@nz ~]$ ls -lR /home/fr2424 > /tmp/lsfr2424.txt >& /tmp/lserrors.txt
[stage11@nz ~]$ cat /tmp/lserrors.txt
ls: cannot open directory /home/fr2424/administration/bmasse: Permission denied
ls: cannot open directory /home/fr2424/administration/carou: Permission denied
ls: cannot open directory /home/fr2424/administration/hmignot: Permission denied
(...)
```

Redirections & Pipes | Tips

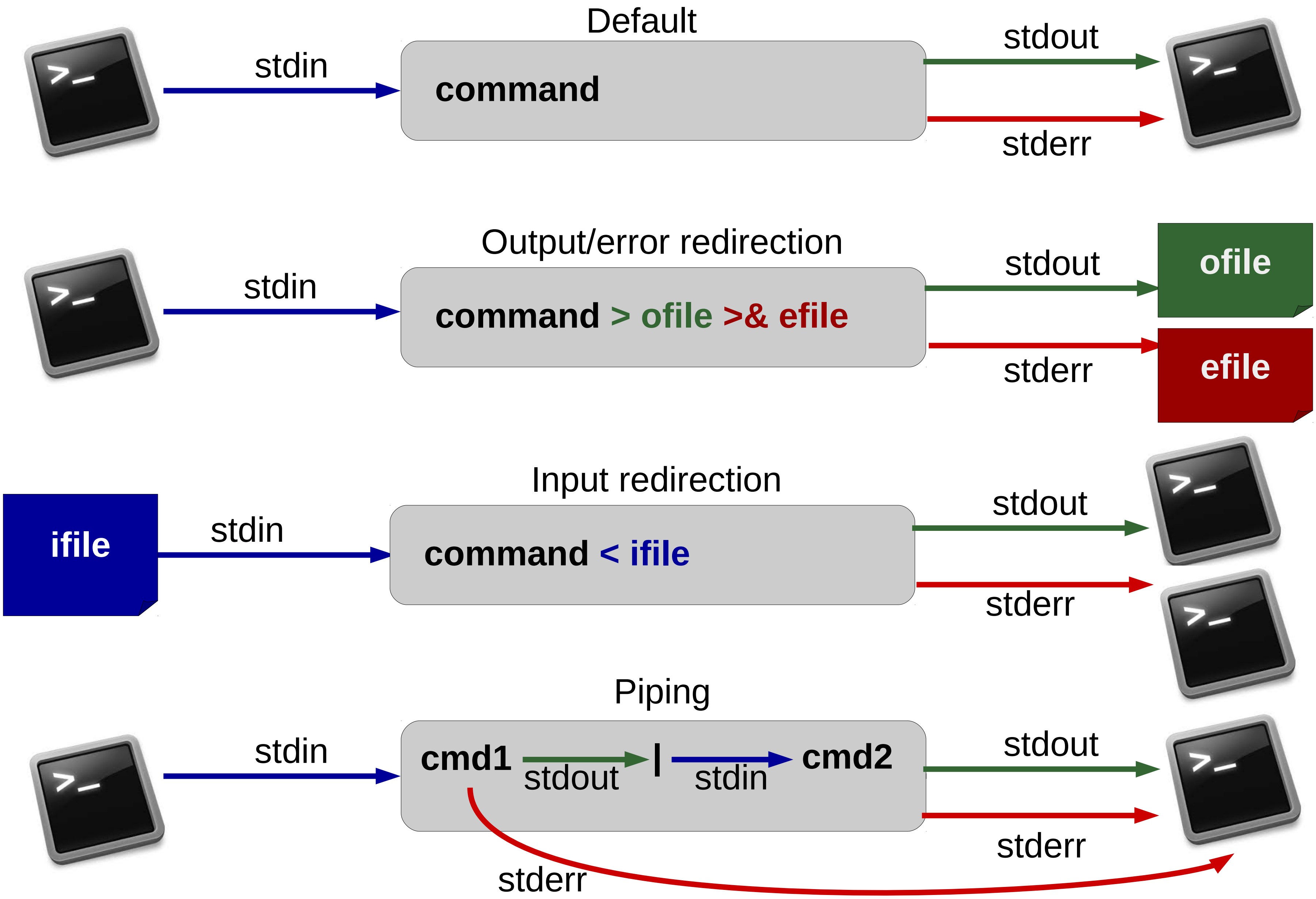
To ignore what's generated on an output channel (stdout or stderr), it can be redirected to a special file : /dev/null.

```
[stage11@nz ~]$ ls -lR /home/fr2424 > /tmp/lsfr2424.txt >& /dev/null
[stage11@nz ~]$
```

To redirect an output channel (stdout or stderr) to an already existing file without overwriting its contents, the redirect append (>>) symbol can be used.

```
[stage11@nz ~]$ ls *.tab > fileswithcolumns.txt
[stage11@nz ~]$ wc -l fileswithcolumns.txt
5 fileswithcolumns.txt
[stage11@nz ~]$ ls *.csv >> fileswithcolumns.txt
[stage11@nz ~]$ wc -l fileswithcolumns.txt
7 fileswithcolumns.txt
```

Redirections & Pipes | Summary



Default

stdin

command

stdout

stderr

Output/error redirection

stdin

command > ofile >& efile

stdout

ofile

stderr

efile

Input redirection

ifile

stdin

command < ifile

stdout

stderr

Piping

stdin

cmd1 stdout | stdin cmd2

stdout

stderr

stderr

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Slicing ‘n Dicing | Foreword

**Beware when copying text files from foreign systems, especially from the MS-DOS family tree (including the Windows offspring).
Format differences can bite real hard.**

A typical symptom of format discrepancy is :

```
[stage01@nz~]$ ./phyml-mpi-multi.sh
-bash: ./phyml-mpi-multi.sh: /bin/sh^M: bad interpreter:
No such file or directory
```

Doh ! A DOS line terminator !

The cause of the disease :
- Linux/Unix uses a single character to signal “newline” \n (line feed).
- DOS-ish systems use two : \r (carriage return) and \n.

And the cure relies on the `dos2unix` command :

```
[stage01@nz~]$ dos2unix ./phyml-mpi-multi.sh
```

Slicing 'n Dicing | Extracting Lines

Remember `grep` ?

The **`grep`** command takes two arguments : a ***pattern*** and a ***file name*** ; it displays every line of the file matching the pattern.

```
[stage11@nz ~]$ grep ">" insulin.fas
>gi|163659904|ref|NM_000618.3| Homo sapiens insulin-like growth factor 1 (somatomedin C) (IGF1),
transcript variant 4, mRNA
(...)
```

`grep` has loads of options, among which the most common are :
`-i` (ignore upper/lower case differences),
`-v` (display lines ***not*** matching the pattern),
`-c` (display the line count instead of the actual lines),
`-r` (recursively examine the contents of the **directory** given as second argument).

```
[stage11@nz ~]$ grep -r -c -i TRANSCRIPT .
./insulin_vs_nt.blast:144
./acteur.csv:0
./insulin.fas:5
```

Slicing 'n Dicing | Extracting Lines

Contextual grep

When the relevant information spans several lines, **`grep`** can give contextual information.

With the **`-A`** ***`n`*** option, **`grep`** displays for each matching line, the *n* **following** lines (A : after)

```
[stage11@nz ~]$ grep -A 1 ">" insulin.fas
>gi|163659904|ref|NM_000618.3| Homo sapiens insulin-like growth factor 1 (somatomedin C) (IGF1),
transcript variant 4, mRNA
TTTTGTAGATAAATGTGAGGATTTTCTCTAAATCCCTCTTCTGTTTGCTAAATCTCACTGTCACTGCTAA
--
>gi|163659900|ref|NM_001111284.1| Homo sapiens insulin-like growth factor 1 (somatomedin C) (IGF1),
transcript variant 2, mRNA
GCATACCTGCCTGGGTGTCCAAATGTAACTAGATGCTTTCACAAACCCCACCCACAAAGCAGCACATGTT
--
(...)
```

With the **`-B`** ***`n`*** option, **`grep`** displays for each matching line, the ***n*** **preceding** lines (B: before)

With the **`-C`** ***`n`*** option, **`grep`** displays for each matching line, the ***n*** **surrounding** lines (C: context)

```
[stage11@nz ~]$ grep -C 3 TIGR01365 iprscan.xml
        <category>Biological Process</category>
        <description>biosynthetic process</description>
      </classification>
      <match id="TIGR01365" name="serC_2: phosphoserine aminotransferase" dbname="TIGRFAMs">
        <location start="29" end="400" score="2.1e-214" status="T" evidence="HMMTigr" />
      </match>
    </interpro>
(...)
```

Slicing 'n Dicing | Extracting Columns

The `cut` command takes an option describing how to extract columns (aka fields) and an argument with the name of the file containing *tabular* (columns are separated by **<TAB>** characters).

Ex. : extracting the first column of a file using the `-f 1` syntax.

```
[stage11@nz ~]$ cut -f 1 acteur.tab
Chuck
Sylvester
Steven
(...)
```

Ex. : extracting the second and third columns of a file using the `-f 2,3` syntax.

```
[stage11@nz ~]$ cut -f "2,3" acteur.tab
Norris    72
Stallone  66
Seagal    61
(...)
```

Ex. : extracting **all but** the second and third columns of a file using the `--complement` option.

```
[stage11@nz ~]$ cut --complement -f "2,3" acteur.tab
Chuck
Sylvester
Steven
(...)
```

Ex. : using the `-d` syntax to specify the field delimiter.

```
[stage11@nz ~]$ cut -d ";" -f 2 annuaire.csv
Clio
Brice
Mathilde
(...)
```

Slicing ‘n Dicing | Sorting Files

The **sort** command is used to sort files. It takes a filename as argument and options allow to specify sort fields and/or sort types.

Ex. : alphabetically sorting the lines of a file

```
[stage11@nz ~]$ sort pop_ville.tab
Paris     4193031
Roscoff   3705
Tokyo     13010279
```

Ex. : alphabetically sorting the lines of a file using a specific field (**-k** option)

```
[stage11@nz ~]$ sort -k 2 pop_ville.tab
Tokyo     13010279
Roscoff   3705
Paris     4193031
```

Ex. : numerically sorting the lines of a file using a specific field (**-n** option)

```
[stage11@nz ~]$ sort -n -k 2 pop_ville.tab
Roscoff   3705
Paris     4193031
Tokyo     13010279
```

Ex. : reversing the sort order with the **-r** option

```
[stage11@nz ~]$ sort -r -n -k 2 pop_ville.tab
Tokyo     13010279
Paris     4193031
Roscoff   3705
```

Slicing ‘n Dicing | Managing Occurrences

The **`uniq`** command is used to remove consecutive identical lines in a file. **On a sorted file, it removes all repeated lines.**

```
[stage11@nz ~]$ wc -l condition1_sorted.go
44 condition1_sorted.go
[stage11@nz ~]$ uniq condition1_sorted.go
GO:0000166      nucleotide binding
GO:0003824      catalytic activity
GO:0005488      binding
… [11 lines total]
```

`uniq` can also be used to count occurrences with the **`-c`** option:

```
[stage11@nz ~]$ uniq -c condition1_sorted.go
      2 GO:0000166  nucleotide binding
      1 GO:0003824  catalytic activity
      7 GO:0005488  binding
(...)
```

or to extract unique occurrences with the **`-u`** option:

```
[stage11@nz ~]$ uniq -u condition1_sorted.go
GO:0003824      catalytic activity
GO:0005623      cell
GO:0006810      transport
GO:0008152      metabolic process
```

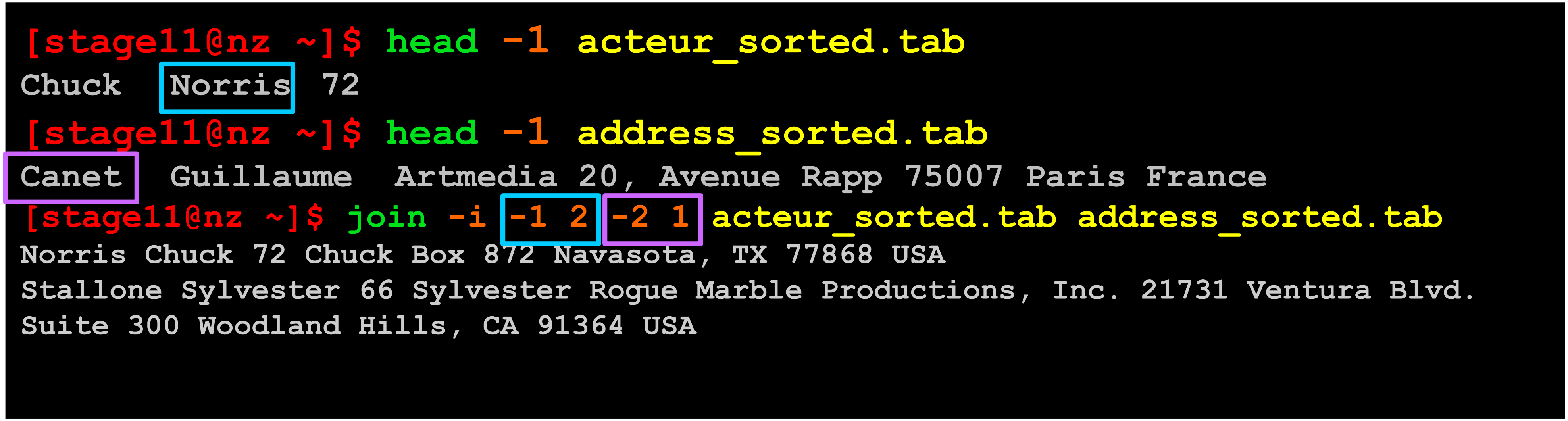
Slicing 'n Dicing | Merging Tabular Data

The `join` command is used merge two files **having a *sorted* column in common**.
It is used as follows :

```
join -1 n -2 m file1 file2
```

where :

- in `-1 n : n` is the position of the common column in `file1`
- in `-2 m : m` is the position of the common column in `file2`



```
[stage11@nz ~]$ head -1 acteur_sorted.tab
Chuck   Norris  72
[stage11@nz ~]$ head -1 address_sorted.tab
Canet   Guillaume  Artmedia 20, Avenue Rapp 75007 Paris France
[stage11@nz ~]$ join -i -1 2 -2 1 acteur_sorted.tab address_sorted.tab
Norris Chuck 72 Chuck Box 872 Navasota, TX 77868 USA
Stallone Sylvester 66 Sylvester Rogue Marble Productions, Inc. 21731 Ventura Blvd.
Suite 300 Woodland Hills, CA 91364 USA
```

The `-i` option can be added to ignore case differences in key column values

Slicing 'n Dicing | Simple Text Substitutions

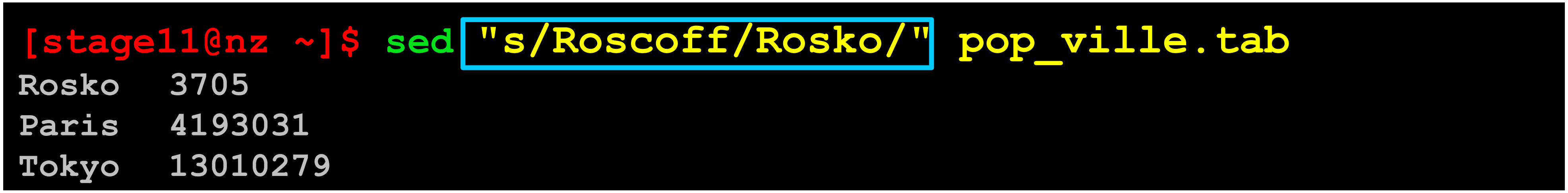
The **`sed`** command is the swiss army-knife for performing manipulation on the contents of (text) files. Its basic usage looks like :

`sed "`*`operation`*`" [file]`

Where :

- *`operation`* : recipe(s) describing operations to perform on the contents (substitute, delete, paste…)
- **`file`** : the file to act upon (optional : remember how pipes work ?)

Ex. : Simple text substitution



```
[stage11@nz ~]$ sed "s/Roscoff/Rosko/" pop_ville.tab
Rosko   3705
Paris   4193031
Tokyo   13010279
```

`s/Roscoff/Rosko/`

`s` : the **substitute** operation

`Roscoff` : the text we want to replace

`Rosko` : the replacement text

Written like this :
- **case sensitive** (roscoff ≠ Roscoff)
- only the **first occurrence** of a line is replaced

Slicing 'n Dicing | Simple Text Substitutions

Ex. : Field delimiter substitution

```
[stage11@nz ~]$ sed "s/\t/;/g" acteur.tab
Chuck;Norris;72
Sylvester;Stallone;66
Steven;Seagal;61
```

`s/\t/;/g`

`s` : the **substitute** operation

`\t` : the text we want to replace = the TAB character

`;` : the replacement text

`g` : a **flag** to indicate global substitution (all occurrences of the line)

The **`i` flag** can be used to ignore uppercase/lowercase differences on the pattern to match

Slicing 'n Dicing | Simple Text Substitutions

Ex. : Using locations to operate on specific line ranges

```
[stage11@nz ~]$ sed "2,3s/\t/;/g" acteur.tab
Chuck   Norris  72
Sylvester;Stallone;66
Steven;Seagal;61
```

`2,3s/\t/;/g`

`2,3` : only apply the (substitution) operation on lines 2 to 3

Having fun with **`sed`**

Ex. : Using the delete operator

```
[stage11@nz ~]$ sed "2d" acteur.tab
Chuck   Norris  72
Steven  Seagal  61
```

Ex. : Combining operators : pasting & replacing

```
[stage11@nz ~]$ sed "2p; s/Sylvester/Sly/" acteur.tab
Chuck   Norris  72
Sylvester   Stallone    66
Sly Stallone    66
Steven  Seagal  61
```

Exercises

- Extract the actors last names from **`acteur.tab`**

- Order the actors in **`acteur.tab`** by (increasing) age

- Replace the TAB character in **`acteur.tab`** with a semicolon (;). Store the result in **`acteur.csv`**

Exercises

- Extract the actors last names from **`acteur.tab`**

```
[stage11@nz ~]$ cut -f 2 acteur.tab
Norris
Stallone
Seagal
```

- Order the actors in **`acteur.tab`** by (increasing) age

```
[stage11@nz ~]$ sort  -n -k 3 acteur.tab
Steven  Seagal  61
Sylvester   Stallone    66
Chuck   Norris  72
```

- Replace the TAB character in **`acteur.tab`** with a semicolon (;). Store the result in **`acteur.csv`**

```
[stage11@nz ~]$ sed "s/\t/;/g" acteur.tab > acteur.csv
```

Exercises

Using the `annuaire.csv` file

- Sort the file using the **team** column (6th)
- Extract the **name** (1st), **firstname** (2nd), **unit** (5th) and **team** (6th) columns
- Only keep people belonging to the **umr7144** unit.
- Store the result in file `annuaire_umr7144.csv`

All this using a single command line

Exercises

TIMTOWDI

```
[stage11@nz ~]$ grep "umr7144" annuaire.csv | cut -d ";" -f "1,2,5,6" |
sort -k 4 -t ";" > annuaire_umr7144.csv
```

```
[stage11@nz ~]$ sort -k 6 -t ";" annuaire.csv | grep "umr7144" | cut -d ";"
-f "1,2,5,6"  > annuaire_umr7144.csv
```

```
[stage11@nz ~]$ cut -d ";" -f "1,2,5,6" annuaire.csv | sort -k 4 -t ";" |
grep "umr7144" > annuaire_umr7144.csv
```

Exercises

Using the `condition2.go` file

- Determine the most frequent GO **number** (not the complete identifier, i.e. *0395853* in GO:*0395853*)

All this using a single command line

TIMTOWDI

```
[stage11@nz ~]$ sort condition2.go | uniq -c | sort -k 1 -n | tail -1 | cut
-f 1 | cut -f 2 -d ":"
```

```
[stage11@nz ~]$ sort condition2.go | uniq -c | sort -k 1 -r -n | head -1 |
cut -f 1 | cut -f 2 -d ":"
```

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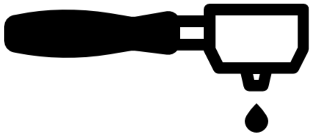
Regular Expressions | A Definition

A regular expression, regex or regexp is, in theoretical computer science and formal language theory, a sequence of characters that define a search pattern. Usually this pattern is then used by string searching algorithms for "find" or "find and replace" operations on strings.



Wikipedia
The Free Encyclopedia

A **sequence of characters** that define a **search pattern**

Two types of constraints define the pattern :

- **The very nature of the characters : letters / digits / space or punctuation**
- **The sequential organization of the characters : the position(s) they are allowed to occupy in the sequence**

Some real world examples :

- A (french domestic) phone number (i.e. 07 45 12 96 43) => a sequence of **5 groups** of **2 digits** each, separated by a **space character**.
- A DNA sequence coding for a (bacterial) protein => a series of **letters chosen from {a,t,g,c}** grouped by **triplets**, where the **first and last triplet** belong to two **specific subsets** of all possible triplets.

Regular Expressions | Character Classes

		grep	sed
`[0-9]`	Digits	✓	✓
`[a-z]`	Lowercase Letter	✓	✓
`[A-Z]`	Uppercase Letter	✓	✓
`[a-zA-Z]`	Alphabetic character	✓	✓
`[0-9a-zA-Z]`	Alphanumeric character	✓	✓
`[\t_]`	Space Character	✓	✓
`.`	Any character	✓	✓
`[^ATGC]`	Any character **except** ATGC	✓	✓

A sample pattern for a phone number :

```
[0-9][0-9][\t_][0-9][0-9][\t_][0-9][0-9][\t_][0-9][0-9][\t_][0-9][0-9]
```

Regular Expressions | Occurrences

		grep / sed -r	sed
`?`	Zero or one occurrence	✓	✗
`+`	At least one occurrence	✓	✗
`*`	Zero or more occurrences	✓	✓
`{2}`	Exactly two occurrences	✓	✗
`{2,5}`	From two to five occurrences	✓	✗
`{2,}`	At least two occurrences	✓	✗
`{,5}`	At most five occurrences	✓	✗

A sample pattern for a phone number including occurrence operators :

```
[0-9]{2}[\t_][0-9]{2}[\t_][0-9]{2}[\t_][0-9]{2}[\t_][0-9]{2}
```

Regular Expressions | Special characters

		grep / sed -r	sed
^	The beginning of a line	✓	✓
$	The end of a line	✓	✓
|	The “or” operator	✓	✗
(and)	The grouping operator	✓	✓
\	The “despecializing” character	✓	✓

A sample pattern for a single phone number on a line using grouping :

```
^([0-9]{2}[\t_]){4}[0-9]{2}$
```

A sample pattern to search for amounts in dollars with optional cents:

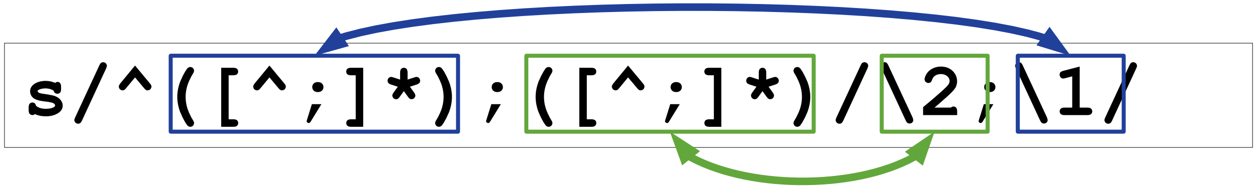
```
\$[0-9]+(\.[0-9]+)?
```

Regular Expressions | Using sed with REs

Patterns with regular expressions can be used when using `sed` for substitutions.

Each of the matches between parentheses can be referenced in the replacement string.

Ex.: swapping the first two columns in a CSV file using semi-colons



```
s/^([^;]*);([^;]*)/\2;\1/
```

`^` : anchor to the beginning of the line
`[^;]*` : the contents of a field (any character except a semi-colon)
`\1` : a reference to the first pattern between ()
`\2` : a reference to the second pattern described between ()

When using `sed`, with regular expressions use option `-r`

Regular Expressions | Using grep with REs

Recommendation : use egrep (extended grep) instead of grep

egrep has better support for regular expressions

Ex.: Looking for phone numbers in the **annuaire.csv** file.

```
[stage11@nz ~]$ egrep --color "([0-9]{2} ){4}[0-9]{2}" annuaire.csv
Boye;Aurelien;aurelien.boye{AT}sb-roscoff.fr;02 98 29 23 23;fr2424;lbm
Czerwinska;Urszula;urszula.czerwinska{AT}sb-roscoff.fr;02 98 29 23 23;fr2424;lbm
Divoux;Jordane;jordane.divoux{AT}sb-roscoff.fr;02 98 29 23 23;fr2424;lbm
(...)
```

Exercises

Using the `patelles_roscoff.tab` file

- Find all the pierced limpets (1 in the third column)

Exercises

Using the **`patelles_roscoff.tab`** file

- Find all the pierced limpets (1 in the third column)

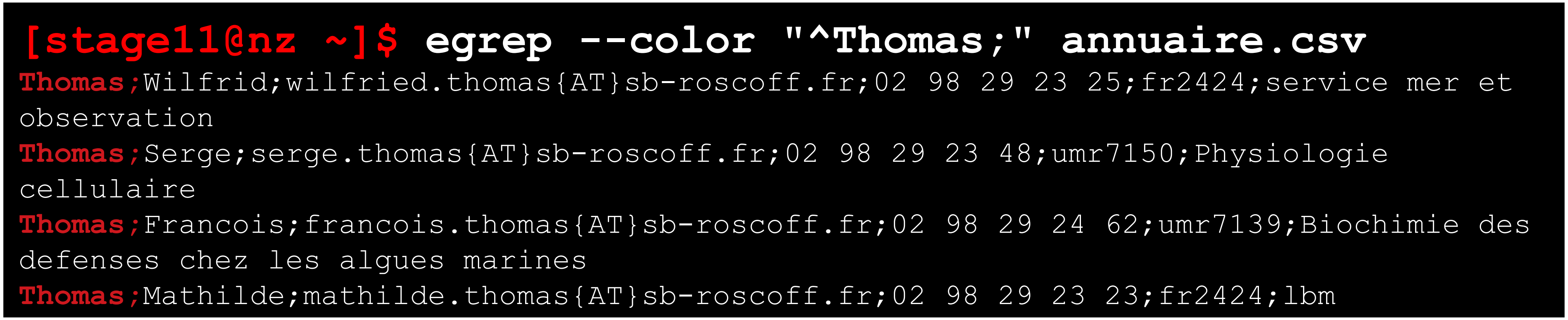
```
[stage11@nz ~]$ egrep --color "1$" patelles_roscoff.tab
43,9     17,1     1
42,8     15,8     1
47,4     22,6     1
(...)
```

Using the **`annuaire.csv`** file

- Find all the persons whose last name is Thomas

Using the **annuaire.csv** file

- Find all the persons whose last name is Thomas



```
[stage11@nz ~]$ egrep --color "^Thomas;" annuaire.csv
Thomas;Wilfrid;wilfried.thomas{AT}sb-roscoff.fr;02 98 29 23 25;fr2424;service mer et
observation
Thomas;Serge;serge.thomas{AT}sb-roscoff.fr;02 98 29 23 48;umr7150;Physiologie
cellulaire
Thomas;Francois;francois.thomas{AT}sb-roscoff.fr;02 98 29 24 62;umr7139;Biochimie des
defenses chez les algues marines
Thomas;Mathilde;mathilde.thomas{AT}sb-roscoff.fr;02 98 29 23 23;fr2424;lbm
```

Using the **`annuaire.csv`** file

- Find all the persons whose first name is Thomas

Using the **annuaire.csv** file

- Find all the persons whose first name is Thomas

```
[stage11@nz ~]$ egrep --color "^[^;]*;Thomas;" annuaire.csv
Broquet;Thomas;thomas.broquet{AT}sb-roscoff.fr;02 98 29 23
12;umr7144;Diversite et connectivite dans le paysage marin cotier
```

Using the `condition2.go` file

- Determine the most frequent GO **number** (not the complete identifier)

All this using a single command line including `sed` and a regular expression for the last stage

Exercises

Using the **`condition2.go`** file

- Determine the most frequent GO **number** (not the complete identifier)

All this using a single command line including `sed` and a regular expression for the last stage

```
[stage11@nz ~]$ sort condition2.go | uniq -c | sort -k 1,1 -
n | tail -n 1 | sed -r "s/^.*GO:([0-9]{7}).*$/\1/"
0003824
```

For the foolhearted : using the **`nr.fsa`** file

- Generate a two column file containing the access number (4th field of ID lines) and the organism name (between square brackets [])

For the foolhearted : using the **`nr.fsa`** file

- Generate a two column file containing the access number (4th field of ID lines) and the organism name (between square brackets [])

```
[stage11@nz ~]$ grep ">" nr.fsa | sed -r "s/^>gi\|.*\|.*\|([A-Z]{2}_[0-9]*\.[0-9]*)\|.*\[(.*)\].*$/\1\t\2/"
YP_005877138.1   Lactococcus lactis subsp. lactis IO-1
XP_642131.1  Dictyostelium discoideum AX4
XP_642837.1  Dictyostelium discoideum AX4
(…)
```

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Awk 101 | What's Awk ?

AWK is a **pattern scanning** and **processing language**

pattern scanning : why bother, we already master **`grep`** and **`sed`** !

processing language : aren't we better off learning Python or R then ?

AWK fits in nicely for straightforward to moderately complex

line-oriented processing tasks.

- ✓ **computations can be carried out on field values**
- ✓ **conditions can be checked before generating output**
- ✓ **programs can be stored in files for later reuse**
- ✓ **easy to use in pipe-based command-lines**

Awk 101 | Basic Command-Line Structure

The **`awk`** command-line is built as follows :

```
awk '{ instructions }' [file]
```

Where :
- ***`instructions`*** *:* recipe(s) describing operations to perform on the contents (substitute, delete, paste…)
- **`file`** *:* the file to act upon (optional : remember how pipes work ?)

- **`awk`** splits each input line in **fields** named **`$1, $2, $3`** etc..
- The special **`$0`** field **includes the whole line**.

- The **last field** of a line is stored in **`$NF`**
- The **penultimate field** of a line is stored in **`$(NF-1)`** etc...

- The **number of fields** of a line is stored in **`NF`** **(no dollar sign !)**
- The **current line number** in the input file is stored in **`NR`** **(no dollar sign !)**

Awk 101 | Instructions

The **print** instruction is used to generate output :

```
awk '{ print $0; }'[file]
```

Prints each line of the input stream to the output stream (!)

```
[stage11@nz ~]$ awk  '{ print $2,$3 }' acteur.tab
Norris 72
Stallone   66
Seagal 61
(...)
```

Ex. : using **awk** to display the second and third columns of a file with added text.

```
[stage11@nz ~]$ awk '{ print $2" is "$3" years old." }' acteur.tab
Norris is 72 years old.
Stallone is 66 years old.
Seagal is 61 years old.
(...)
```

Awk 101 | Conditional Output

A predicate can determine if output will be generated for a given input line :

```
awk ' predicate { instructions }' [file]
```

Predicates most often verify conditions on one or more fields of the input line.

Predicates can use comparison operators :

- **==** (equality), and **!=** (inequality)
- **<** (smaller), **<=** (smaller or equal), **>** (greater), **>=** (greater or equal)

Ex. : using **awk** to display veteran actors.

```
[stage11@nz ~]$ awk ' $NF >=65 { print $1" "$2 }' acteur.tab
Chuck Norris
Sylvester
(...)
```

Awk 101 | Conditional Output

Predicates can use regular expression operators :

- **~ */regexp/*** : matches a regular expression
- **!~ */regexp/*** : doesn’t match a regular expression

Ex. : using **awk** with regular expressions to display actors whose name starts with “S”

```
[stage11@nz ~]$ awk ' $2 ~ /^S.*/ { print $1" "$2 }' acteur.tab
Sylvester Stallone
Steven Seagal
(...)
```

Predicates can use arithmetic operators :

- **+, -, *, / , %**

Ex. : using **awk** with arithmetic operators to display actors with odd ages

```
[stage11@nz ~]$ awk ' $NF % 2 != 0 { print $0 }' acteur.tab
Steven Seagal 61
(...)
```

Awk 101 | Conditional Output

Predicates can use logical operators to combine terms:

- ***term1 && term2*** : true if both **term1** and **term2** evaluate as true
- ***term1 || term2*** : true **term1** or **term2** (or both) evaluate as true

Ex. : using **awk** with arithmetic operators to display actors with evenages and who are over 70

```
[stage11@nz ~]$ awk ' $NF % 2 == 0  && $NF > 70 { print $0 }' acteur.tab
Chuck Norris 72
(...)
```

CNRS UPMC
Station Biologique
Roscoff

Awk 101 | BEGIN and END blocks

Two specially named blocks can be used to carry out instructions :

- Before the line processing loop : **`BEGIN`** block
- After all the lines have been processed **`END`** block

Ex. : using **`BEGIN`** to print output column headers

```
[stage11@nz ~]$ awk ' BEGIN { print "First Name\tLast Name\tAge" }
{ print $0 }' acteur.tab
First name    Last Name   Age
Chuck  Norris 72
Sylvester Stallone  66
(...)
```

Awk 101 | Using Variables

Variables can be used in each block to store processing results.

Ex. : using variables to compute the average age of the actors.

```
[stage11@nz ~]$ awk ' BEGIN { total = 0 }  { total=total+
$3 } END { print "Average age "total/NR} ' acteur.tab
Average age 66.3333
(...)
```

Some functions that can be used with variables :

- **`length(s)`** : number of characters in **`s`**
- **`toupper(s)`** : transform **`s`** to uppercase letters
- **`tolower(s)`** : transform **`s`** to lowercase letters
- **`sub(r,s,t)`** : replace every match of regexp **`r`** with string **`s`** in **`t`**
- **`split(s,a,d)`** : split string **`s`** using delimiter **`d`** and store the result in array **`a`**

- **`int(n)`** : compute the integer part of **`n`**
- **`log(n)`** : compute the logarithm part of **`n`**
- **`sqrt(n)`** : compute the square root of **`n`**

Awk 101 | Tips

Specifying the field delimiter

```
awk -F ';' 'predicate { instructions }' [file]
```

Using awk with a file containing the instructions :

```
awk -f myawkprogram.txt [file]
```

Exercises

Using the **`patelles_roscoff.tab`** file

- Find all the pierced limpets :
  - using **`awk`** with an arithmetic operator predicate
  - using **`awk`** with a regular expression operator predicate

Using the `patelles_roscoff.tab` file

- Find all the pierced limpets :
  - using **awk** with an arithmetic operator predicate
  - using **awk** with a regular expression operator predicate

```
[stage11@nz ~]$ awk '$NF == 1 { print $0}' patelles_roscoff.tab
43,9      17,1      1
42,8      15,8      1
47,4      22,6      1
(...)
```

```
[stage11@nz ~]$ awk '$0 ~ /^.*1$/ { print $0}' patelles_roscoff.tab
43,9      17,1      1
42,8      15,8      1
47,4      22,6      1
(...)
```

Using the **annuaire.csv** file

- Find all the persons whose last name is Thomas (using **awk** obviously)

Exercises

Using the **annuaire.csv** file

- Find all the persons whose last name is Thomas (using **awk** obviously)

```
[stage11@nz ~]$ awk -F ';' ' $1 == "Thomas" { print $0}' annuaire.csv
Thomas;Wilfrid;wilfried.thomas{AT}sb-roscoff.fr;02 98 29 23 25;fr2424;service mer et
observation
Thomas;Serge;serge.thomas{AT}sb-roscoff.fr;02 98 29 23 48;umr7150;Physiologie
cellulaire
(...)
```

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Using Batch Files | Why ?

What’s a batch file ?

- Level 0 : A text file with a series of commands
- Level 1 : Level 0 + with input parameters to configure the command execution
- Level 2 : Level 1 + control structures (conditionals, loops)
- Level 3 : Level 2 + functions

Why use batch files ?

- Level 0 : To avoid tediously retyping complex commands
- Level 1 : To reuse series of commands with different parameter sets
- Level 2 : To make batch execution more robust
- Level 3 : Because for command-line based tasks it beats programming languages

Using Batch Files | How ?

Your most basic batch file

Ex. : writing a batch file to display the most recent files in directory **/tmp**

```
1 [stage11@nz ~]$ cat > ./tmpsmostrecent.sh
2 ls -lat | head -5
  [Ctrl^D]
3 [stage11@nz ~]$ chmod +x ./tmpsmostrecent.sh
4 [stage11@nz ~]$ ./tmpsmostrecent.sh
  total 104
  drwxrwxrwt. 12 root       root        57344 Nov 26 14:25 .
  drwxr-xr-x   2 stage11    stage        4096 Nov 26 14:25 1279165.1.qlogin.q
  (...)
```

1 Create an empty file using **cat** and **stdin**
2 Type the commands you want in your batch file and finish with [Ctrl^D]
3 Make the file executable using **chmod**
4 Run your batch file

Using Batch Files | Choosing the Shell

Rationale : leaving the choice of the shell to the system might (sometimes) lead to ***minor incompatibilities*** when ***copying batch files*** to other environments.

Rule of thumb : always start your batch scripts with the following line :

```
#!/usr/bin/env bash
```

`#!` (or she-bang) : tells the system that your file is a (batch) script needing an interpreter

`/usr/bin/env bash` tells the system the interpreter is the bash version configured in your environment

Using Batch Files | Argument Passing

The canonical command-line structure also applies to batch files

```
./mybatch.sh arg1 arg2 arg3...argn
```

```
#!/usr/bin/env bash

# hello.bash :
# A simple batch file writing its first argument to stdout

echo "Hello $1"
```

```
[stage11@nz ~]$ ./hello.bash Guru
Hello Guru
```

The special variable `$0` matches the command name (i.e the name of the batch file)
The special variable `$*` matches the whole set of arguments

Exercises

- Write a batch file listing the most recent files of a directory.
- The name of the directory and the number of files to be displayed are passed as arguments to the batch file.

Exercises

- Write a batch file listing the most recent files of a directory.
- The name of the directory and the number of files to be displayed are passed as arguments to the batch file.

```
#!/usr/bin/env bash

# mostrecent.bash :
# A simple batch file displaying the most recent files in
# a directory
# Usage : mostrecent.bash directoryname numberofiles

ls -lat $1 | head -n $2
```

Using Batch Files | Basic Loops

The loop structure is used to apply a series of commands to a sequence of words :

```
for <word> in <wordlist> ; do

    # use ${<word>} in various commands

done
```

```
#!/usr/bin/env bash

# dispargs.bash :
# A simple batch file using  the for loop to enumerate its
# arguments

for userarg in $* ; do
    echo "The next argument is ${userarg}"
done
```

```
[stage11@nz ~]$ ./dispargs.bash Gnu is Not Unix
The next argument is Gnu
The next argument is is
The next argument is Not
The next argument is Unix
```

Using Batch Files | Looping over Files

A frequent use case of loops is to apply a series of commands on files in a directory, relying on **ls** to retrieve the file list as in :

```
files=$(ls <directory>)

for file in ${files} ; do

    # use ${file} for useful stuff

done
```

The **$(<commands>)** construction, runs the **<commands>** and returns what they write to **stdout**

```
#!/usr/bin/env bash

# protect.bash :
# A simple batch file to write-protect the contents of a directory
# given as argument argument

files=$(ls $1)

for file in ${files} ; do
    chmod -w ${file}
done
```

Exercises

- Write a batch file taking a file extension and directory name as arguments and displaying : the owner, the size and the filename.

Exercises

- Write a batch file taking a file extension and directory name as arguments and displaying : the owner, the size and the filename.

```
#!/usr/bin/env bash

# customls.bash :
# A simple batch file displaying some info about files
# with a given extension in a specific directory
# Usage : customls.bash extension directoryname

files=$(ls $2/*.$1)
for file in ${files} ; do
   ls -l ${file} | awk '{print $3,$5,$NF}'
done
```

Exercises

- Write a batch file using **`annuaire.csv`** to generate a file with two columns : the name of the lab and the number of members of the lab.
- Hint : generate temporary files with the members of each lab.

Exercises

```
#!/usr/bin/env bash

# catcount.bash :
# A batch file generating a file with the number lines for
# each different value of a given column in the input file.

# Usage : catcount.bash inputcsvfile categorycolumn outputfile

csvfile=$1
rm -f /tmp/categories_*/csv
# Stage 1 : generate the intermediate files for each category
for line in $(sed 's/ /#/g' ${csvfile}) ; do
    lab=$(echo ${line} | cut -d ";" -f $2)
    echo ${line} | sed 's/#/ /g' >> /tmp/categories_${lab}.csv
done

# Stage 2 : count the lines in the intermediate files
rm -f $2
for labfile in $(ls /tmp/categories_*.csv) ; do
    lab=$(echo ${labfile} | sed -r 's/^.*_([a-z0-9]+)\.csv$/\1/')
    members=$(wc -l ${labfile} | awk '{print $1}')
    echo "${lab} ${members}" >> $3
done
```

Thank you for your patience and your tenacity