

Outline

- Introduction - history
- Command line basics – getting help
- File system
- Working with files and directories
- More file handling
- The shell revisited
- Monitoring resources

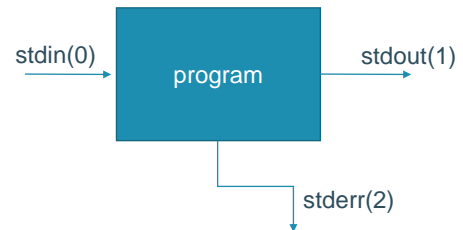
IO redirection



Input / output

- Inputs and outputs of a program are called streams in Linux.
- stdin** (standard input) – stream data going into a program. By default, this is input from the keyboard.
- stdout** (standard output) – output stream where data is written out by a program. By default, this output is sent to the screen.
- stderr** (standard error) – another output stream (independent of stdout) where programs output error messages. By default, error output is sent to the screen.

<https://cvw.cac.cornell.edu/Linux/io>



Redirection

- Redirection is all about files
- Output redirect out from screen to a file
 - This can be done with the redirection operator `>`

```
$ ls -l > ls_out.txt
```
 - Redirection will create the named file if it doesn't exist, or else overwrite the existing file.
- Append with the operator `>>`
 - append instead of rewriting the file


```
$ ls -l >> ls_out.txt
```
- Input redirection
 - Input can also be given to a command from a file instead of typing it in the shell by using the redirection operator `<`

```
$ sort < tabel.dat
```

```

(base) frankvp@KOD-L-000041:~$ ls -l > ls_out.txt
(base) frankvp@KOD-L-000041:~$ cat ls_out.txt
total 85580
drwxr-xr-x 13 frankvp frankvp 4096 Sep 17 2021 LinuxDev
-rwxr-xr-x 1 frankvp frankvp 260948 Nov  8 2020 Linux_basic_for_iridis_v1.pdf
-rwxr-xr-x 1 frankvp frankvp 62341 Jan 31 2020 MOCK_DATA.csv
-rwxr-xr-x 1 frankvp frankvp 62341 Jan 31 2020 MOCK_DATA_r.txt
-rwxr-xr-x 1 frankvp frankvp 76607678 May 16 22:01 Miniconda3-latest-Linux-x86_64.sh
-rwxr-xr-x 1 frankvp frankvp 19787 Apr 28 15:03 Untitled.ipynb
-rwxr-xr-x 1 frankvp frankvp 802 Jul 13 14:08 Untitled2.ipynb
-rwxr-xr-x 1 frankvp frankvp 3201 Jul 13 14:42 Untitled3.ipynb
-rwxr-xr-x 1 frankvp frankvp 137259 Nov  8 2021 WSL-short_intro.pdf.1
-rwxr-xr-x 1 frankvp frankvp 137259 Nov  8 2021 WSL-short_intro.pdf.2
-rwxr-xr-x 1 frankvp frankvp 137259 Nov  8 2021 WSL-short_intro.pdf.3
-rwxr-xr-x 1 frankvp frankvp 137259 Nov  8 2021 WSL-short_intro.pdf.4
-rwxr-xr-x 1 frankvp frankvp 137259 Nov  8 2021 WSL-short_intro.pdf.5
-rwxr-xr-x 1 frankvp frankvp 16096 Nov  8 2021 a.out
-rwxr-xr-x 1 frankvp frankvp 10 Sep 30 2021 blal
-rwxr-xr-x 1 frankvp frankvp 15 Oct  3 2021 blaz
-rwxr-xr-x 1 frankvp frankvp 44 Feb  8 2021 blabla.txt
-rwxr-xr-x 2 frankvp frankvp 4096 Mar 30 11:52 calcul2
-rwxr-xr-x 1 frankvp frankvp 52 Mar 10 2020 cat.txt
-rwxr-xr-x 1 frankvp frankvp 30 Oct  4 2021 cat.txt
-rwxr-xr-x 1 frankvp frankvp 1341 Nov 10 2020 diff-out
-rwxr-xr-x 2 frankvp frankvp 4096 Jul 15 11:40 dir1
-rwxr-xr-x 4 frankvp frankvp 4096 Mar 28 2021 dir180
  
```





Redirection

- Error Redirection

- Normal or standard output (stdout), will not affect stderr (separate stream).
- Use the redirection operator 2>

```
$ ls non-existing* 2> ls_err.txt
```

- Trash any data

- /dev/null is a special file that is used to trash any data that is redirected to it. Any output that is sent to /dev/null is discarded.

```
$ ls > /dev/null
```

- See also: <https://www.tecmint.com/linux-io-input-output-redirection-operators/>

Pipes



Pipes

- Piping is all about processes
- Pipes (also referred to as pipelines) can be used to direct the output of one command to the input of another.
The Shell arranges it so that the standard output of one command is fed to another command
- use the | key on the keyboard
- `$ ls -l | less`
 - the output of the ls command is piped into the less program
 - compare with `$ ls -l > less` (the output of the ls command is saved in a file with the name less)

pipes

- Key feature of the unix philosophy
(https://en.wikipedia.org/wiki/Unix_philosophy)
 - Write programs that do one thing and do it well.
 - Write programs to work together.
 - Write programs to handle text streams, because that is a universal interface.

Redirection revisited: tee

- Show and Save Output
- When redirecting output to a file, nothing is shown on the screen.
- To have the output go to both a file and the screen, use the `tee` command

- Syntax, use it with a pipe

```
[command] | tee [options] [filename]
```

```
$ ls -al | tee ls_out.txt
```

- Option `-a`: append (instead of overwriting)

```
$ ls -al | tee -a ls_out.txt
```

Command chaining

Command chaining

- `;` makes it possible to run, several commands in a single go and the execution of command occurs sequentially.
- `&&` (AND Operator) will execute the second command only, if the execution of first command SUCCEEDS, i.e., the exit status of the first command is 0.
- `||` (OR Operator) will execute the second command only if the execution of first command fails, i.e., the exit status of first command is '1'.

Command	What does it?
<i>cmd1 ; cmd2</i>	Run <i>cmd1</i> then <i>cmd2</i>
<i>cmd1 && cmd2</i>	Run <i>cmd2</i> if <i>cmd1</i> is successful
<i>cmd1 cmd2</i>	Run <i>cmd2</i> if <i>cmd1</i> is not successful
<i>cmd &</i>	Run <i>cmd</i> in a subshell

(very) Basic shell scripting

Basic steps

1. **Create a file using** an editor(Nano). Name script file with extension **.sh**
2. **Start** the script with **#!/bin/bash**
3. Write some code.
4. Save the script file
5. For **executing** the script type: **bash filename.sh**

Linux variables

- Variables are a way of passing information from the shell to programs
- 2 categories:
 - shell variables.
 - shell variables apply only to the current instance of the shell and are used to set short-term working conditions;
 - environment variables
 - environment variables reach further, and those are set at login are valid for the duration of the session.

<https://projects.ncsu.edu/hpc/Documents/unixtut/unix8.html>

<https://linuxize.com/post/how-to-set-and-list-environment-variables-in-linux/>

environment

- The shell environment is configured through a variety of variables called *environment variables*. This environment tells the shell and your various tools how to behave.
- `env`: prints out the environment in its current state, listing all environment variables.
- `SHELL`, `HOME`, and `PATH` are built-in shell variables.
- Any variable can be declared to the shell by typing
`MYVAR=something`
 - Convention: declare shell variable in capitals.
 - The variable can then be used in bash commands or scripts by inserting `$MYVAR`. If you want to insert the variable inside a string, this can be done by `${MYVAR}` with the beginning and ending portions of the string on either side. For example:

```
$ DATAPATH=/home/jolo/Project
$ ls $DATAPATH
$ cp newdatafile.txt ${DATAPATH}/todaysdatafile.txt
$ ls $DATAPATH
```

<https://cvw.cac.cornell.edu/Linux/envvars>

<https://linuxize.com/post/how-to-set-and-list-environment-variables-in-linux/>

environment

- `PATH` stores a list of directory paths which the shell searches when you issue a command.
- view this list with `echo $PATH`.
- If the command you issue is not found in any of the listed paths (having been added either by the OS, a system administrator, or you), then the shell will not be able to execute it, since it is not found in any of the directories in the `PATH` environment variable. You can change the directories in the list using the `export` command. To add directories to your path, you can use:
 - `$ export PATH=$PATH:/path/to/new/command`
 - The `:` joins directories in the path variable together.
 - If you wanted to completely replace the list with a different path:
 - `$ export PATH=/path/to/replacement/directory`
 - Please keep in mind that the previous list will be erased.
- <https://cvw.cac.cornell.edu/Linux/envvars>

Processing commands

sort

Command	Options	What does it?
sort		Sort anyfile lexicographically
	-n	Sort in numeric order
	-r	sort things in reverse order
	-R	Re-arrange the lines of the input randomly

- sort is the tool to sort a file. Sorting by itself isn't that useful, but it is an important pre-requisite to a lot of other tasks.
- Note: -R can be useful for developing a large number of test cases.
- File: sort_demo.sh
- See also:
<https://shapedshed.com/unix-sort/>

tr

Command	Options	Common usage	What does it?
tr		tr SET1 [SET2]	it will replace each character in SET1 with each character in the same position in SET2. When SET2 is shorter than SET1, the tr command will, by default, repeat the last character of SET2
	-t		truncate SET1 to the length of SET2:
	-s		Squeeze, remove repeated instances of a character
	-d	tr -d SET1	delete characters in SET1.
	-c	tr -c SET1	search for a complement of SET1. i.e. searching for the inverse of SET1.

Translate, a tool that can:

- convert character case
- squeeze repeating characters
- delete specific characters
- do basic text replacement
- File: tr_demo.sh

WC

Command	Options	Common usage	What does it?
WC		wc anyfile	print newline, word, and byte counts for anyfile
	-c		print byte counts
	-m		print character counts
	-w		print word counts
	-l		print newline counts

- A tool that to obtain word counts and line counts.
- Line counts are usually a measure for counting a number of elements.
- File: wc_demo.sh

uniq

Command	Options	Common usage	What does it?
uniq		uniq anyfile	the default behaviour is to discard duplicate lines
	-c		count number of occurrences
	-d		only print duplicate lines
	-u		only print unique lines
	-i		ignore case

- Tool to detect the adjacent duplicate lines and also deletes the duplicate lines.
- Note: uniq is not able to detect the duplicate lines unless they are adjacent to each other, therefore it is often seen in a pipe coupled with sort.
Or simply use sort -u instead of uniq command
- File: uniq_demo.sh

comm

Command	Options	Common usage	What does it?
comm		comm file1 file2	compare two (sorted) files line by line column 1: only in file1 column 2: only in file 2 column 3: in file1 and file2
	-1		suppress column 1
	-2		suppress column 2
	-3		suppress column 3
	--		Output a summary
	total		

- comm compares each and every line of the files and displays the unique lines and common lines of the files in separate columns

Slicing and glueing files

- Slice rowlike (horizontal)
 - split
 - cat
- Slice columnlike (vertical)
 - cut
 - paste

split

Command	Options	Common usage	What does it?
split		split filename me prefix	split filename and prefix is the name you wish to give the small output files
	-b		the number of bytes in each of the smaller files.
	-l		the number of lines of the smaller files (default is 1,000).
	-n		the number of parts to split the original file

- Split a file into smaller chunks
- Specify in what way the file needs to be cut
- File: split_demo.sh

cat

- concatenate files together into a larger file

Command	Options	Common usage	What does it?
cat		cat file1 file2 filen	display the content of multiple files
	-s		Omit the empty lines
	-n		display the line number of file content

cut

- extracts a column of columns of information from a file (usually delimited)
- File: cut_demo.sh

Command and cut	Options	Common usage	What does it?
			cut option filename
	-d	cut -d ',' -f 1 filename	specify a delimiter to use instead of the default TAB delimiter
	-f	cut -f n cut -f n1-n2 cut -f n1,n2,n3	a specified field, a field set, or a field range
	-b	cut -b n cut -b n1-n2 cut -b n1,n2,n3	cut by byte position cut by byte position range cut by byte position list
	-c	cut -c n cut -c n1-n2	Similar to b, but by character position, some characters take more than a byte for the representation
	--output-delimiter	cut -c n1,n2,n3 --output-delimiter=@	Add a custom delimiter for output

paste

Command	Options	Common usage	What does it?
paste			
	-d	paste -d ',' file1 file2 file3	specify a delimiter to use instead of the default TAB delimiter. A list of delimiters can be specified
	-s	paste -s file1 file2 file3	It reads all the lines from a single file and merges all these lines into a single line with each line separated by tab.

- combine files as columns into 1 file
- File: paste_demo.sh

wget



- Instead of downloading files from your browser, just copy and paste their URL and download them with `wget`
- main features
 - http and ftp support
 - Can resume interrupted downloads
 - Can download entire sites or at least check for bad links
 - Very useful in scripts or when no graphics are available (system administration, embedded systems)
- `$ wget -v https://github.com/franklbvp/linuxintro/blob/master/docs/WSL-short_intro.pdf`
- `https://bioinformaticsworkbook.org/dataAcquisition/fileTransfer/downloading-files-via-wget.html#gsc.tab=0`

The grep command

- **G**lobal **r**egular **e**xpression **p**rint
- Grep is used to search text files with **regular expressions (regex)**.
 - It prints the lines matching the given pattern in a text file.
 - If no file is given, grep will recursively search the given pattern in the files in current directory
 - regex is different from wildcards!

Regular expressions for grep command

Expression	Description	Example
*	0+ repeats of preceding character string or regex	12*3 matches "13", "123", "1223"
.	any single char (grep)	c.t matches "cat", "cut" or "cot"
?	0+ of proceeding chars	ma?ke matches "make", "mke"
^	appears at beginning	^he matches "hello", "hell", "help", "he is a boy"
\$	appears at end	^he matches "hello", "hell", "help", "he is a boy"
[nnn]	match any character in this set. - defines ranges (e.g. [a-z] is any lowercase letter), ^ means "not"	[abc] matches "a", "b" or "c" in the string "abc". a[^b]c matches "aec", "acc", "adc", but not "abc"



The grep command

- `$ grep <pattern> <files>`
Scans the given files and displays the lines which match the given pattern.
- `$ grep error *.log`
Displays all the lines containing error in the *.log files
- `$ grep -i error *.log`
Same, but case insensitive
- `$ grep -ri error .`
Same, but recursively in all the files in the current directory and its subdirectories
- `$ grep -v info *.log`
Outputs all the lines in the files except those containing info.
- <http://www.thegeekstuff.com/2009/03/15-practical-unix-grep-command-examples/>



More commands

- `$ sleep 60`
Waits for 60 seconds
(doesn't consume system resources).
- `$ date`
Returns the current date. Useful in scripts to record when commands started or completed.



time

- Helpful command for doing simple benchmarking
- Run your scripts along with **time** command, and compare the execution time.
- Example:

```
$ time ls
real 0m2.304s (actual elapsed time)
user 0m0.449s (CPU time running program code)
sys 0m0.106s (CPU time running system calls)
```



time

- $\text{real} = \text{user} + \text{sys} + \text{waiting}$
waiting = I/O waiting time + idle time (running other tasks)
- real or total or elapsed (wall clock time)
 - is the time from start to finish of the call. It is the time from the moment you hit the Enter key until the moment the command is completed.
- user
 - amount of CPU time spent in user mode.
- system or sys
 - amount of CPU time spent in kernel mode.

optional

Root and Sudo

- The **root** user (superuser) on any system is the administrative account with the highest level of permissions and access (administrator user on Windows). By default, most Linux systems have a single root account when installed and user accounts have to be set up. The root account has a UID of 0, and the system will treat any user with a UID of 0 as root.
- If you have access to a root account on any Linux system, best practice is to **only** use this account when the privileges are needed to perform your work (such as installing packages)
- The home directory of the root user is actually located at /root.
- The program **sudo** allows users to run commands with the equivalent privileges of another user. The default privileges selected are the root user's, but any user can be selected.
- A user with sudo privileges can run commands with root privileges without logging in as root (must enter user's password) by putting sudo in front the command.
- The first user account created on some Linux distributions is given sudo privileges by default, but most distributions require you to specifically give sudo privileges to a user. (edit /etc/sudoers)

<https://cww.cac.cornell.edu/Linux/optional>

<https://ubuntu.com/tutorials/command-line-for-beginners#7-the-command-line-and-the-superuser>