Introduction to Bash scripting language

Day 2

Alessandro Sciarra

Z02 – Software Development Center

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GOETHE UNIVERSITÄT FRANKFURT AM MAIN

AxelKrypton

CRC-TR 211
Strong-interaction matter under extreme conditions

Topics of the day

1. Conditional blocks
2. Loops
3. Choices
4. Colours and cursor movements
5. References and indirect expansion
6. Arrays and associative arrays
7. Input and output
8. Shell options
9. The GNU core utilities and util-linux
10. Ready to script!?

You already know the basics

Yesterday you learnt already almost everything about the core of Bash. Today we will complete ~90% of the picture mostly exploring keywords.

Conditional blocks

The bridge between two continents

Exit code

Every command in Bash terminates with an exit code:

`$?`	Shows the exit code of the last foreground process that terminated It is a 8-bit integer `$?` $\in \{0, \ldots, 255\}$ { Indeed, only the least significant 8 bits count }
`0`	Denotes success
$\neq$`0`	Denotes failure, in general the meaning is up to the command
`1`	Miscellaneous errors
`2`	Misuse of shell builtins
`126`	Command invoked cannot execute
`127`	`"command not found"` error
`128`	Invalid argument to exit
`128 + n`	Fatal error signal `"n"` { For example, `130` means that the script terminated by Control-C }

Which exit code should I use?

Avoid reserved one, be consistent!

The `if` keyword

- Since it is a keyword, it requires a precise syntax (not a surprise)
- It executes a command (or a set of commands) and checks that command's exit code to see whether it was successful
- Different layouts possible, choose a readable one!

```
if␣COMMAND
then
    # COMMAND's exit code was 0
else
    # COMMAND's exit code was different from 0
fi

if␣COMMAND; then
    # COMMAND's exit code was 0
elif␣ANOTHER_COMMAND; then
    # ANOTHER_COMMAND's exit code was 0
else
    # ANOTHER_COMMAND's exit code was different from 0
fi
```

The command in a conditional block

- In principle it can be any command
- There are specifically designed commands to test things:

  `test` or `[` — A normal command that reads its arguments and does some checks with them. The `[` variant requires a `]` as last argument.

  `[[` — A special shell keyword that offers more versatility like pattern matching and regex support

- Multiple commands can be concatenated using control operators `&&` and `||`

Which syntax should I prefer?

Whenever you are making a **Bash** script, you should always use `[[` rather than `[`.
If portability is an issue, e.g. you are writing a **sh**ell script,
you should use `[`, because it is far more portable.

*Since Bash v4.2

The `test` command and its friend `[`

`-e FILE`	True if file exists
`-f FILE`	True if file is a regular file (not a directory or device file)
`-d FILE`	True if file is a directory
`-s FILE`	True if file exists and is not empty
`-z STRING`	True if the string is empty (it's length is zero)
`-n STRING`	True if the string is not empty (it's length is not zero)
`-v VARIABLE`	True if the shell variable is set (has been assigned a value)*

```
$ ls -d */
TeX
$ if [ -d 'TeX' ]; then echo 'YES'; else echo 'NO'; fi
YES
$ if [ -e 'TeX' ]; then echo 'YES'; else echo 'NO'; fi
YES
$ if [ -s 'TeX' ]; then echo 'YES'; else echo 'NO'; fi
YES
$ if [ -f 'TeX' ]; then echo 'YES'; else echo 'NO'; fi
NO
```


Many more tests are supported ⟶ for a complete list refer to the Bash manual v5.2 (section 6.4).

The `test` command and its friend `[`

`STRING = STRING`	True if the first string is identical to the second
`STRING != STRING`	True if the first string is not identical to the second
`STRING \< STRING`	True if the first string sorts before the second
`STRING \> STRING`	True if the first string sorts after the second
`! EXPR`	Inverts the result of the expression (logical NOT)

```
$ aVar="Kal El"
$ bVar="Clark Kent"
$ [ ${aVar} = ${aVar} ]
bash: [: too many arguments
$ if [ "${aVar}" = "${aVar}" ]; then echo 'YES'; else echo 'NO'; fi
YES
$ if [ "${aVar}" \> "${bVar}" ]; then echo 'YES'; else echo 'NO'; fi
YES
$ if [ 319 \< 7 ]; then echo 'YES'; else echo 'NO'; fi
YES # 319 is < than 7 but it is not less than 7...
$ unset aVar bVar
```


Many more tests are supported ⟶ for a complete list refer to the Bash manual v5.2 (section 6.4).

The `test` command and its friend `[`

`INT -eq INT` True if both integers are identical

`INT -ne INT` True if the integers are not identical

`INT -lt INT` True if the first integer is less than the second

`INT -gt INT` True if the first integer is greater than the second

`INT -le INT` True if the first integer is less than or equal to the second

`INT -ge INT` True if the first integer is greater than or equal to the second

```
$ if [ 319 -lt 7 ]; then echo 'YES'; else echo 'NO'; fi
NO
$ if [ 7 -ne 7 ]; then echo 'YES'; else echo 'NO'; fi
NO
$ if [ 7 -eq 7 ]; then echo 'YES'; else echo 'NO'; fi
YES
$ if [ 7 -gt 7 ]; then echo 'YES'; else echo 'NO'; fi
NO
$ if [ 7 -ge 7 ]; then echo 'YES'; else echo 'NO'; fi
YES
```


Many more tests are supported ⟶ for a complete list refer to the Bash manual v5.2 (section 6.4).

The [[keyword

- It supports the tests supported by the `test` and `[` commands*
- String equality (= or ==) and inequality (!=) comparison is changed to pattern matching by default. **Patterns bust be on the right hand side of the (in)equality.** Each quoted part of the pattern is matched literally.
- It does not allow word-splitting of its arguments!
- However, be aware that simple strings still have to be quoted properly
- Few more additional tests supported:

`STRING =~ REGEX`	True if the string matches the regex pattern
`( EXPR )`	Parentheses can be used to change the evaluation precedence
`EXPR && EXPR`	True if both expressions are true (logical AND) { it does not evaluate the second expression if the first already turns out to be false }
`EXPR || EXPR`	True if either expression is true (logical OR) { it does not evaluate the second expression if the first already turns out to be true }

- The alphabetically sorted test operators (< and >) do not need to be escaped

* Except `EXPR -a EXPR` and `EXPR -o EXPR` which should in any case not be used!

The [[keyword

```
$ aVar="Day_1.tex"; bVar='Hello world'
# Pattern matching VS string comparison
$ if [[ ${aVar} = *.tex ]]; then echo 'YES'; else echo 'NO'; fi
YES
$ if [[ *.tex = ${aVar} ]]; then echo 'YES'; else echo 'NO'; fi
NO
$ if [[ ${aVar} = "*.tex" ]]; then echo 'YES'; else echo 'NO'; fi
NO
$ if [[ ${aVar} = Day_?.tex && ${bVar} = [hH]* ]]; then echo 'YES'; else echo 'NO'; fi
YES
# Simple strings still have to be quoted properly!
$ if [[ ${bVar} = Hello world ]]; then echo 'YES'; else echo 'NO'; fi
bash: syntax error in conditional expression
bash: syntax error near `world'
$ if [[ ${bVar} = 'Hello world' ]]; then echo 'YES'; else echo 'NO'; fi
YES # No word splitting occurred!
$ if [[ ${emptyVar} = '' ]]; then echo 'YES'; else echo 'NO'; fi
YES
$ if [ ${emptyVar} = '' ]; then echo 'YES'; else echo 'NO'; fi
bash: [: =: unary operator expected
NO
# Quotes necessary to use test [ command to check for empty variables
$ if [ "${emptyVar}" = '' ]; then echo 'YES'; else echo 'NO'; fi
YES
$ unset aVar bVar
```


* Except `EXPR -a EXPR` and `EXPR -o EXPR` which should in any case not be used!

Control operators

`&&` Used to build AND lists: Run one command only if another exited successfully

```
COMMAND_1 && COMMAND_2
# Equivalent to
if COMMAND_1; then COMMAND_2; fi
```

`||` Used to build OR lists: Run one command only if another exited unsuccessfully

```
COMMAND_1 || COMMAND_2
# Equivalent to
if ! COMMAND_1; then COMMAND_2; fi
```

Do not get overzealous with conditional operators

They can make your script hard to understand and sometimes you need fancy grouping to get your logic right!

Control operators

```
# The use of control operators is handy in simple cases
[[ ${PATH} ]] && echo 'PATH variable set and non empty!'
# Mostly they are used in script
rm file || echo 'Could not delete file!'
mkdir TeX && cd TeX
source AuxiliaryOps.bash || exit 1
# Avoid complicated one-liners which might easily be wrong!
grep -q goodword "${file}" && ! grep -q badword "${file}"
    && rm "${file}" || echo "Couldn't delete: ${file}"
```

What happens if the first `grep` fails (sets the exit status to 1)?

Do not get overzealous with conditional operators

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Control operators

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# Avoid complicated one-liners which might easily be wrong!
grep -q goodword "${file}" && ! grep -q badword "${file}"
    && rm "${file}" || echo "Couldn't delete: ${file}"
```

What happens if the first `grep` fails (sets the exit status to 1)?

```
grep -q goodword "${file}" && ! grep -q badword "${file}"
    && { rm "${file}" || echo "Couldn't delete: ${file}"; }
```

Do not get overzealous with conditional operators

They can make your script hard to understand and sometimes you need fancy grouping to get your logic right!

Regular expressions in Bash

- Regular expressions are similar to Glob Patterns, but not for filename matching
- Since v3.0, Bash supports the =~ operator to the `[[` keyword
- This operator matches the string that comes before it against the regular expression pattern that follows it and it returns
  - `0` when the string matches the pattern
  - `1` If the string does not match the pattern
  - `2` In case the pattern's syntax is invalid
- Bash uses the Extended Regular Expression dialect
  - POSIX standard
  - The Premier website about Regular Expressions
- Regular Expression patterns that use capturing groups (parentheses) will have their captured strings assigned to the `BASH_REMATCH` variable (array) for later retrieval

Regular expressions in Bash

```
$ echo "${LANG}"
en_GB.utf8
$ langRegex='(..)_(..)'
$ if [[ ${LANG} =~ ${langRegex} ]]
> then
>     echo "Your country code (ISO 3166-1-alpha-2) is ${BASH_REMATCH[2]}."
>     echo "Your language code (ISO 639-1) is ${BASH_REMATCH[1]}."
> else
>     echo "Your locale was not recognised"
> fi
Your country code (ISO 3166-1-alpha-2) is GB.
Your language code (ISO 639-1) is en.
```

General remarks

- The best way to always be compatible is to put your regex in a variable and expand that variable in `[[` without quotes, as we showed above.
- The pattern matching achieved by the `=` and `!=` operators can be achieved using regex: Find your way!

The syntax `"${BASH_REMATCH[1]}"`, e.g. how to use an array variable, will be discussed in detail at a later point.

Loops

Ice cave in the Breiðamerkurjökull

Conditional loops

Often we need to repeat things: Copy and paste is not the solution!

`while` Repeat as long as a command is executed successfully (exit code is 0)

`until` Repeat as long as a command is executed unsuccessfully (exit code is not 0)

`for` It comes in two versions

- to iterate over a list
- to iterate over an integer index as in C

Which one should be used?

There will nearly always be multiple approaches to solving a problem. The test of your skill soon won't be about solving a problem as much as about how best to solve it.

While instead of until

The `until` loop is barely ever used, if only because it is pretty much exactly the same as `while !`

The `while` and `until` keywords

```
while COMMAND; do
    # Body of the loop: entered if COMMAND's exit code = 0
done

until COMMAND; do
    # Body of the loop: entered if COMMAND's exit code ≠0
done
```

- Testing command like `[` or preferably `[[` are often used
- Infinite loops can be achieved using the builtins `true`, `false` and `:`
- Use the `continue` builtin to skip ahead to the next iteration of a loop without executing the rest of the body
- use the `break` builtin to jump out of the loop and continue with the script after it
- Both `continue` and `break` accept an optional integer to act on nested loops

The `while` and `until` keywords

```
$ until false; do    # while true; do    # while :; do
>   echo "Infinite loop"
>   sleep 3
> done
Infinite loop
Infinite loop
^C    # Press CTRL-C
```

```
# An example of countdown...
$ deadline=$(date -d "8 seconds" +'%s'); \
> now=$(date +'%s'); \
> while [[ $((deadline - now)) -gt 0 ]]; do
>   echo "$((deadline - now)) seconds to BOOM!"
>   sleep 3
>   now=$(date +'%s')
> done; echo 'BOOOOOM!!'
8 seconds to BOOM!
5 seconds to BOOM!
2 seconds to BOOM!
BOOOOOM!!
```


The condition of the `while` loop should rather be written using arithmetic evaluation `((...))`, which we discuss tomorrow.

The `while` and `until` keywords

```
$ i=0; \
> while [[ ${i} -lt 5 ]]; do
>   j=0
>   while [[ ${j} -le 5 ]]; do
>     if [[ ${j} -le ${i} ]]; then
>       printf "$((i+j)) "
>       j=$((j+1))
>     else
>       printf '\n'
>       i=$((i+1))
>       continue 2
>     fi
>   done
> done
0
1 2
2 3 4
3 4 5 6
4 5 6 7 8
```


In the snippet above arithmetic evaluation `((...))`, which we discuss tomorrow, should be used instead of `[[ ... ]]` and to increment variables.

The `for` keywords

```
for VARIABLE in WORDS; do
    # Body of the loop: VARIABLE set to WORD
done

for (( EXPR1; EXPR2; EXPR3 )) # Expressions can be empty
    # Body of the loop
done
```

- In the second form,
  1. it starts by evaluating the first arithmetic expression;
  2. it repeats as long as the second arithmetic expression is successful;
  3. at the end of each loop evaluates the third arithmetic expression.
- Bash takes the characters between `in` and the end of the line and
  - it splits them up into words;
  - this splitting is done on spaces and tabs, just like argument splitting;
  - if there are any unquoted substitutions, they will be word-split as well (using `IFS`).

The for keywords

```
$ for (( ; 1; )); do echo "Infinite loop"; sleep 1; done
Infinite loop
Infinite loop
^C    # Press CTRL-C
```

```
$ for index in {0,1}{0,1}; do
>   echo "${index} in base 2 is $(( 2#${index})) in base 10"
> done; unset index
00 in base 2 is 0 in base 10
01 in base 2 is 1 in base 10
10 in base 2 is 2 in base 10
11 in base 2 is 3 in base 10
```

```
# BAD code!

$ for file in $(ls *.mp3); do    # AAAARGH!
>   rm "$file"
> done; unset file
```

The `for` keywords

Bad code:

```
$ ls
Happy birthday.mp3
$ for file in $(ls *.mp3); do    # AAAARGH!
>   rm "$file"
> done; unset file
rm: cannot remove `Happy': No such file or directory
rm: cannot remove `birthday.mp3': No such file or directory
```

You want to quote it, you say?

The `for` keywords

Bad code:

```
$ ls
Happy birthday.mp3
$ for file in $(ls *.mp3); do    # AAAARGH!
>   rm "$file"
> done; unset file
rm: cannot remove `Happy': No such file or directory
rm: cannot remove `birthday.mp3': No such file or directory
```

You want to quote it, you say?

```
$ ls
Happy birthday.mp3   Hello.mp3
$ for file in "$(ls *.mp3)"; do    # AAAARGH!
>   rm "$file"
> done; unset file
rm: cannot remove `Happy birthday.mp3   Hello.mp3': No such
    file or directory
```

So, what do we do?

The `for` keywords

Use globs!

Bash **does** know that it is dealing with filenames, and it **does** know what the filenames are, and as such it can split them up nicely!

```
$ ls
Happy birthday.mp3   Hello.mp3
$ for file in *.mp3; do    # GOOD code
>   rm "$file"
> done; unset file
```

Do not be tempted

You might argue that, if there are no spaces in filenames, then you would have no troubles. But would you throw in the air a sharp knife trying to catch it afterwards, just because if you do not touch the blade it would be safe?

Choices

The Skaftafell natural park: Svartifoss

The `case` keyword

Completely equivalent to a `if-elif-else-fi` construct, but often handy:

```
case WORD in
    [ [(] pattern [| pattern]...) command-list ;;]...
esac
```

- The command-list corresponding to the first pattern that matches word is executed
- The match is performed according Pattern Matching rules
- The `|` is used to separate multiple patterns
- The `)` operator terminates a pattern list
- A list of patterns and an associated command-list is known as a **clause**

Before matching is attempted:

WORD undergoes { tilde expansion, parameter expansion, command substitution, arithmetic expansion, quote removal } Pattern undergoes

Using `;&` or `;;&` instead of `;;` allows to execute the command list or to test the patterns of the next clause, respectively.

The `case` keyword

Completely equivalent to a `if-elif-else-fi` construct, but often handy:

```
case WORD in
    [ [(] pattern [| pattern]...) command-list ;;]...
esac
```

```
case ${LANG} in
    en* )
        echo 'Hello!' ;;
    fr* )
        echo 'Salut!' ;;
    de* )
        echo 'Hallo!' ;;
    it* )
        echo 'Ciao!' ;;
    es* )
        echo 'Hola!' ;;
    C | POSIX )
        echo 'Hello World!' ;;
    *)
        echo 'I do not speak your language.' ;;
esac
```


Using ;& or ;;& instead of ;; allows to execute the command list or to test the patterns of the next clause, respectively.

The `select` keyword

A convenient statement for generating a menu of choices that the user can choose from:

```
select NAME in WORDS; do
    # Body with commands -> break needed to terminate
done
```

- The list of words following `in` is expanded, generating a list of items
- The set of expanded words is printed on the standard error, each preceded by a number
- If the `in WORDS` is omitted, the positional parameters are printed, as if `in "$@"`
- The `PS3` prompt is then displayed and a line is read from the standard input:
  - If the line consists of a number corresponding to one of the displayed words, then the value of `NAME` is set to that word
  - If the line is empty, the words and prompt are displayed again
  - Any other value read causes `NAME` to be set to null
  - The line read is saved in the variable `REPLY`
- It is good practice not to `break` if the user typed something meaningless!

The `select` keyword

A convenient statement for generating a menu of choices that the user can choose from:

```
select NAME in WORDS; do
    # Body with commands -> break needed to terminate
done
```

```
$ select file in *; do
>     echo "You picked \"${file}\" (${REPLY})"
>     break
> done
1) Day_1.tex
2) Day_2.tex
3) Day_3.tex
#? 2
You picked "Day_2.tex" (2)
$ echo "After select: \"${file}\" (${REPLY})"
After select: "Day_2.tex" (2)
$ unset file
```

The `select` keyword

A convenient statement for generating a menu of choices that the user can choose from:

```
select NAME in WORDS; do
    # Body with commands -> break needed to terminate
done
```

```
$ select file in *; do
>     echo "You picked \"${file}\" (${REPLY})"
>     break;
> done
1) Day_1.tex
2) Day_2.tex
3) Day_3.tex
#? dlfagfdsu
You picked "" (dlfagfdsu)
$ echo "After select: \"${file}\" (${REPLY})"
After select: "" (dlfagfdsu)
$ unset file
```

It is always important to **validate the answer**!

The `select` keyword

A convenient statement for generating a menu of choices that the user can choose from:

```
select NAME in WORDS; do
    # Body with commands -> break needed to terminate
done
```

```
$ select file in *; do
>     if [[ ${file} != '' ]]; then  # GOOD PRACTICE
>         echo "You picked \"${file}\" (${REPLY})"
>         break;
>     fi
> done; unset file
1) Day_1.tex
2) Day_2.tex
3) Day_3.tex
#? dlfagfdsu
#? dgasdf
#? 4
#? 231345134
#? 2
You picked "Day_2.tex" (2)
```

Colours and cursor movements

Icebergs on the beach of the Jökursárlón

Colours and formatting in the terminal

A good reference

- Most terminals are able to display colours and formatted texts using escape sequences
- Your script can benefit from using colours (e.g. errors, warnings, info)
- You might run into compatibility problems (not really) Compatibility list
- The `echo` command has a `-e` option to enable the parsing of the escape sequences
- The `printf` command parses escape sequences

Escape sequences

`<Esc>[FormatCodem`

- The `<Esc>` character can be obtained with any of the following syntaxes:
  - `\e`
  - `\033`
  - `\x1B`
- The `FormatCode` is an integer and different ones can be combined using semi-colons

The colors can vary depending of the terminal configuration!

Colours and format codes

`<Esc>[FormatCodem`

0	Reset, all attributes off
1	Bold (or increased intensity)
2	Faint (decreased intensity)
3	Italic { not widely supported, sometimes treated as inverse }
4	Underline
5 or 6	Slow/Rapid Blink
7	Swap foreground and background colours
8	Hidden (useful for passwords)
2{1..8}	Reset second digit format (e.g. 24 to stop underlining)*
30 to 37	Set foreground colour } 8 colours
40 to 47	Set background colour
38;5;{0..255}	Set foreground colour } 256 colours
48;5;{0..255}	Set background colour
90 to 97	Set bright foreground colour } 16 colours
100 to 107	Set bright background colour

* GNOME Terminal 3.28 (VTE 0.52), debuting in Ubuntu 18.04 LTS, adds support for a few more styles. Use code 22 to unbold since 21 is double underline!

Colours and format codes

```
$ echo "Default \e[31mRed\e[0m"
Default \e[31mRed\e[0m
$ echo -e "Default \e[31mRed\e[0m"
Default Red
$ echo -e "Default \e[91mLight Red\e[0m"
Default Light Red
$ echo -e "Default \e[46mCyan\e[0m"
Default Cyan
$ echo -e "Default \e[106mLight Cyan\e[0m"
Default Light Cyan
$ echo -e "Default \e[1mBold\e[0m"
Default Bold
$ echo -e "Default \e[4mUnderlined\e[0m"
Default Underlined
$ echo -e "Default \e[4m\e[91mUnderlined\e[0m"
Default Underlined
$ echo -e "Default \e[4;91mUnderlined\e[0m"
Default Underlined
$ printf "Default \e[4;91mUnderlined\e[24m still red\e[0m Default"
Default Underlined still red Default
$ echo -e "\e[40;38;5;82m Hello \e[30;48;5;82m World \e[0m"
 Hello  World
```


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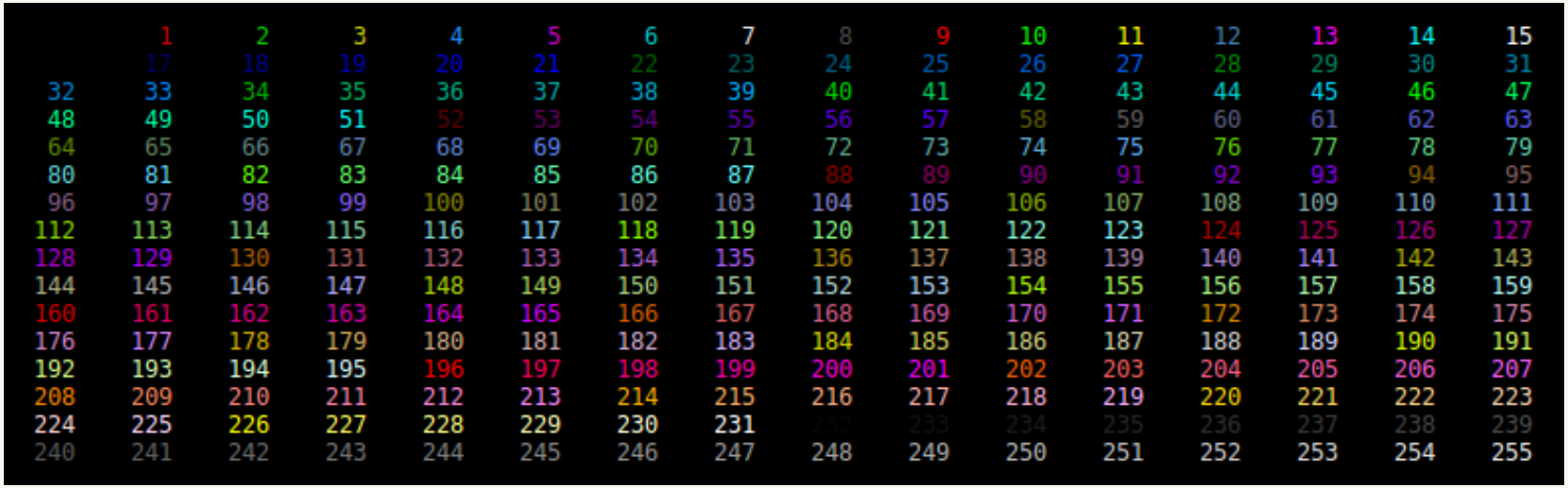
Colours and format codes

```
$ for fgbg in 38; do  # 38 48 to get also background
>     for color in {0..255}; do
>         printf "\e[${fgbg};5;%sm  %3s  \e[0m" ${color} ${color}
>         if [[ $(((color + 1) % 16)) -eq 0 ]]; then
>             echo
>         fi
>     done
>     echo
> done
```



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Defining variables for colour codes

```
# Reset
Default='\033[0m'
# Regular Colors
Black='\033[0;30m'
Red='\033[0;31m'
Green='\033[0;32m'
Yellow='\033[0;33m'
Blue='\033[0;34m'
Magenta='\033[0;35m'
Cyan='\033[0;36m'
White='\033[0;37m'                    # Or you can wait to
# Bold                                # learn about functions
Bold='\033[1m'                        # and create your way!
BBlack='\033[1;30m'
BRed='\033[1;31m'
BGreen='\033[1;32m'
BYellow='\033[1;33m'
BBlue='\033[1;34m'
BMagenta='\033[1;35m'
BCyan='\033[1;36m'
BWhite='\033[1;37m'                 # ...and so on and so forth!
```

Cursor movements

In the same spirit of colours, the terminal cursor position can be moved:

`<Esc>[<L>;<C>H`	Puts the cursor at line `L` and column `C`
`<Esc>[<L>;<C>f`	Puts the cursor at line `L` and column `C`
`<Esc>[<N>A`	Move the cursor up N lines
`<Esc>[<N>B`	Move the cursor down N lines
`<Esc>[<N>C`	Move the cursor forward N columns
`<Esc>[<N>D`	Move the cursor backward N columns
`<Esc>[2J`	Clear the screen, move to (0,0)
`<Esc>[K`	Erase to end of line
`<Esc>[s`	Save cursor position
`<Esc>[u`	Restore cursor position

The `tput` command is a kind of wrapper for everything we learnt in this section → Starting point . It is the way to go when portability matters!

Cursor movements

Use your imagination to take advantage of this functionality:

```
$ while true; do
>     printf "     $(date) \n\e[1A"
>     sleep 1
> done
^C   Thu 11 Jul 18:07:26 CEST 2019 # Stop it with CTRL-C

# Here a crazy progress bar:
$ while true; do
>     printf '\e[s'
>     printf '%0.s=' $(seq 1 $(bc -l <<< "$RANDOM/32767*100"))
>     sleep 0.2
>     printf '\e[u\e[K'  # Use \r instead of saving cursor
> done
======================^C # Stop it with CTRL-C

$ printf 'You will never see my ${password}... MUAHAHA!\r\e[K'
$
```


The `tput` command is a kind of wrapper for everything we learnt in this section → Starting point . It is the way to go when portability matters!

References and indirect expansion

The geyser Strokkur: 25-35m high every ~10 minutes

The nameref attribute

Introduced in 2014, Bash v4.3.0

Reference: `declare -n reference`
The variable is a reference to another variable

- It allows variables to be manipulated indirectly
- Whenever the `reference` variable
  - is referenced, assigned to, unset,
  - or has its attributes modified (other than using or changing the **nameref** attribute itself),

  the operation is performed on the variable specified by the `reference`'s value!

```
$ aVar='Hello'; echo "${aVar}"
Hello
$ declare -n bVar='aVar'; echo "${bVar}"
Hello
$ bVar='Goodbye'; echo "${aVar}"
Goodbye
$ declare +n bVar; echo "${bVar}"
aVar
$ unset aVar bVar
```

The nameref attribute

Introduced in 2014, Bash v4.3.0

Think before using indirection

Putting variable names or any other bash syntax inside parameters is frequently done incorrectly and in inappropriate situations to solve problems that have better solutions. **It violates the separation between code and data**, and as such puts you on a slippery slope toward bugs and security issues. Indirection can make **your code less transparent and harder to follow**.

Normally, in bash scripting, you won't need indirect references at all. Generally, people look at this for a solution when they don't understand or know about Bash Arrays or haven't fully considered other Bash features such as functions.

Greg's Wiki

Sometimes you might need it

A **nameref** is commonly used within shell functions to refer to a variable whose name is passed as an argument to the function.

Indirect expansion

An alternative to use the **nameref** attribute

- It is about using the content of a variable as name of a different variable
- It is a particular case of parameter expansion: `${!parameter}`
  - Bash uses the value formed by expanding `parameter` as the new parameter
  - this is then expanded and that value is used in the rest of the expansion

```
$ aVar='Hello'; bVar='aVar'
$ echo "bVar contains \"${bVar}\" which contains \"${!bVar}\""
bVar contains "aVar" which contains "Hello"
$ unset aVar bVar
```

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```
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$ echo "bVar contains \"${bVar}\" which contains \"${!bVar}\""
bVar contains "aVar" which contains "Hello"
$ unset aVar bVar
```

- If a `*` or a `@` is put at the end of parameter, the behaviour changes!

`${!prefix@}`
`"${!prefix@}"`
`${!prefix*}`
} Expands to the names of variables whose names begin with `prefix` as single word

`"${!prefix*}"` ⟶ As above, but words are separated by the first character of the `IFS`

Indirect expansion

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```
1 $ aVar='Hello'; bVar='aVar'
2 $ echo "bVar contains \"${bVar}\" which contains \"${!bVar}\""
3 bVar contains "aVar" which contains "Hello"
4 $ unset aVar bVar
```

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`"${!prefix*}"` ⟶ As above, but words are separated by the first character of the `IFS`

You will hardly need this!

Arrays and associative arrays

A baby moulin on the Breiðamerkurjökull

Motivation

- **Strings** are without any doubt the most used parameter "type"
- They are also the most **misused** parameter "type", though!
- Strings hold **just one** element!
- Capturing a list in a string is very often plain wrong, even if it might work...
- A parameter contains just one string of characters, no matter the meaning of them
- If you put multiple filenames in a string, maybe to iterate over them at a later point, which delimiter would you use?
- Is there a delimiter that is not accepted to be part of a filename? Mmmh...

```
# This does NOT work in the general case
$ files=$(ls ~/*.jpg); cp ${files} /backups/     # BAD code!
```

Array

An array is a numbered list of strings: It maps integers to strings.

For filenames in Linux, there are usually almost no restrictions, apart from / and \0, you are allowed to use anything.

Creating an array

`array=(...)` The most used syntax: space separated list in parenthesis

```
array=(one two "three and four") # Equivalent to:
array=([0]=one [1]=two [2]="three and four")
# Sparse array perfectly legal!
array=([0]=First [11]=Middle [23]=Last)
```

`array[n]=` Setting single elements works for undeclared variable, too

```
array[0]=First
array[11]=Middle
array[23]=Last
```

`declare -a array` Rarely used but possible

```
declare -a array  # Because of declare,
array=One         # equivalent to array[0]=One, AVOID!
array[1]=Two
```

`array+=(...)` Concatenate r.h.s. array to l.h.s. array

The command `read -a array` allows to store what has been read in an array.

Storing filenames into an array

Take home message

If you want to fill an array with filenames, then you'll probably want to use **globs** in there!

```
$ files=(~/"My Photos"/*.jpg)
```

- Here we quoted the `"My Photos"` part because it contains a space
- If we hadn't quoted it, Bash would have split it up into

  ```
  files=('~/My' 'Photos/'*.jpg)
  ```

  which is obviously not what we want!
- We quoted **only** the part that contained the space: We cannot quote the `~` or the `*`
- If we do, they'll become literal and Bash won't treat them as special characters anymore!

Storing filenames into an array

Take home message

If you want to fill an array with filenames, then you'll probably want to use **globs** in there!

```
# Please, really, use globs instead of commands!

$ files=$(ls)       # BAD, BAD, BAD!
$ files=($(ls))     # STILL BAD!

# So, how should you do?

$ files=(*)         # GOOD!
```

Globs know about files

Using glob patterns is possible to create an array with filenames in different entries!

Accessing array's content (I)

Definition, single elements and length

`declare -p array` It prints the definition of the variable { not so useful in scripts }

```
$ declare -p array
declare -a array='([0]="one" [1]="two and four")'
```

`${array[n]}` It retrieves the n-th element { no error if entry missing in array }

```
$ echo "${array[1]}"; echo "_${array[3156]}_"
two and four

__
$ echo "${array[0+1]}" # [...] is an arithmetic context
two and four
```

`${#array[@]}` It retrieves the length of the array { same as `${#array[*]}` }

```
$ echo "${#array[@]}"; array[7]=Hello; echo "${#array[@]}";
2  # Quoting the expansion does not change anything!
3
$ echo "${#array[7]}"; echo "${#array[-1]}";
5
5  # What does this mean?
```


Curly braces in parameter expansions accessing arrays are mandatory.

Accessing array's content (II)

All elements at once

`"${array[@]}"` Bash replaces this syntax with each element properly quoted

```
$ printf '%s\n' "${array[@]}"
one
two and four
Hello
```

`"${array[*]}"` expands to a `IFS`-first-character-separated list of the array entries

```
$ IFS=':'; printf '%s\n' "${array[*]}"; unset IFS
one:two and four:Hello
```

Unquoted `${array[@]}` and `${array[*]}` let word splitting kick in!

```
$ printf '%s\n' ${array[@]} # The same with ${array[*]}
one
two
and
four
Hello
```

Accessing array's content (III)

All indices

`"${!array[@]}"` Bash replaces this syntax with the indices of the entries that are set

```
$ printf '%d\n' "${!array[@]}"
0
1
7
```

`"${!array[*]}"` expands to a `IFS`-first-character-separated list of the array indices

```
$ IFS=':'; printf '%s\n' "${!array[*]}"; unset IFS
0:1:7
```

In any case, prefer quoted versions!

Unquoted `${!array[@]}` and `${!array[*]}` let word splitting kick in.
This, for **normal** arrays, is harmless, since indices are just integers.

Iterating over array elements

- Depending on the needs you can iterate over the elements or the indices in the array
- When iterating over the **elements**, 99% of the time you will need `"${array[@]}"`
- When iterating over the **indices**, 99% of the time you will need `"${!array[@]}"`
- To implicitly iterate over arrays is possible using different commands (e.g. `printf`, `cp`)

```
$ array=(one "two and four")
$ for entry in "${array[@]}"; do
>     echo "${entry}"
> done
one
two and four
$ for index in "${!array[@]}"; do
>     echo "array[${index}]=${array[index]}"
> done                                  # ↳  arithmetic context,
array[0]=one                            #     no ${} needed
array[1]=two and four
$ unset entry index
# Coming back to motivation: GOOD code!
$ files=(~/*.jpg); cp "${files[@]}" /backups/
```

Deleting arrays or array elements

- To delete an element of an array, pass it to the `unset` builtin

```
$ array=({a..e}); unset 'array[2]' 'array[3]'
$ for index in "${!array[@]}"; do
>     echo "array[${index}]=${array[index]}"
> done; unset 'index'
array[0]=a
array[1]=b
array[4]=e
```

- If you pass the name of an array to `unset`, the whole array will be unset!

```
$ array=({a..c})
$ for index in "${!array[@]}"; do
>     echo "array[${index}]=${array[index]}"
> done; unset 'index'
array[0]=a
array[1]=b
array[2]=c
$ unset 'array'
$ echo "_${array[@]}_ -> ${#array[@]} entries"
__ -> 0 entries
```

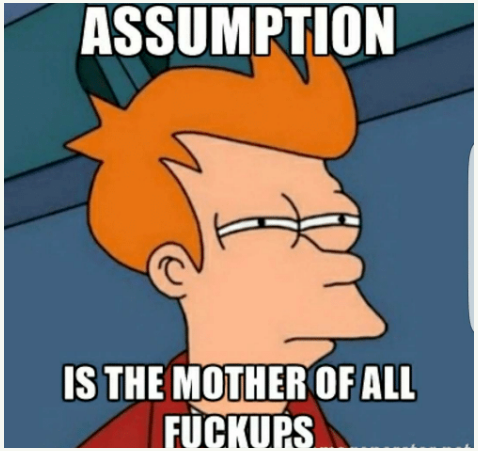
Deleting arrays or array elements: A sneaky trap

Do not forget to **quote your variable** to avoid file pattern matching!

```
$ a=(file{1..3})
$ ls
a0   Day_1.tex   Day_1.pdf
$ a0='Hello'
$ printf '%s\n' "${a[@]}"
file1
file2
file3
$ echo "${a0}"
Hello
$ unset a[0] # <--- BAD, BAD, BAD CODE!
$ printf '%s\n' "${a[@]}"
file1   # Wait! I unset the first element, didn't I?
file2
file3
$ echo "_${a0}_"
__                  # Is it clear what happened?
```


In doubt, always quote the variable passed to `unset`. Using either the `-v` or `-f` option is also encouraged!

Sparse arrays



Arrays might be sparse!

- Don't assume that your indices are sequential
- If the index values matter, always iterate over the indices { instead of making assumptions about them... }
- If you loop over the values instead, don't assume anything about indices
- In particular, don't assume that just because you're currently in the first iteration of your loop, that you must be on index 0...

If you need a non-sparse array, just make it such!

```
$ array=("${array[@]}")
```

Associative arrays

Since Bash v4.0 (2009)

- An associative array is a map of strings to strings
- It has to be **explicitly declared** as such via `declare -A`
- Since keys are strings, they might contain spaces!
  ⇒ Iterating over keys requires quotes: `"${!array[@]}"`

```
$ declare -A dict
$ dict[Apartment]="Die Wohnung"
$ declare -p dict
declare -A dict='([Apartment]="Die Wohnung" )'
$ dict[Water]="Das Wasser"
$ for key in "${!dict[@]}"; do
>     printf 'EN: %20s -> DE: %s\n' "${key}" "${dict[$key]}"
> done
EN:                Water -> DE: Das Wasser
EN:            Apartment -> DE: Die Wohnung
$ echo "${#dict[@]}"; unset dict
2
$ echo "${#dict[@]}"
0
```

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  ⇒ Iterating over keys requires quotes: `"${!array[@]}"`

```
$ declare -A dict
$ dict[Die Wohnung]="Apartment"
$ dict[Das Wasser]="Water"
$ for key in ${!dict[@]}; do    # AAAAAARGH!
>     printf 'DE: %20s -> EN: _%s_\n' "${key}" "${dict[$key]}"
> done
DE:                  Die -> EN: __
DE:              Wohnung -> EN: __
DE:                  Das -> EN: __
DE:               Wasser -> EN: __
$ echo "${#dict[@]}"; unset -v 'dict[Das Wasser]'
2
$ echo "${#dict[@]}"; unset -v 'dict'
1
```

Associative arrays: Remarks

Since Bash v4.0 (2009)

- The order of both keys and elements of an associative array is unpredictable
  ⇒ They are **not** well suited to store lists that need to be processed in order
- If you use a parameter as key of an associative array, you must use the $ sign
  ⇒ Indeed, it makes sense: The name of the parameter might simply be a valid key

```
$ declare -A array
$ index=1; for entry in one two three four five six; do
>     array[${entry}]=$((index++))
> done
$ echo "${array[@]}"
4 1 5 6 2 3
$ echo "${!array[@]}"
four one five six two three
$ unset 'array' 'entry' 'index'
```

Associative arrays: Remarks

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- The order of both keys and elements of an associative array is unpredictable
  ⇒ They are **not** well suited to store lists that need to be processed in order
- If you use a parameter as key of an associative array, you must use the $ sign
  ⇒ Indeed, it makes sense: The name of the parameter might simply be a valid key

```
10 $ indexed=("one" "two")  index=0  key="foo"
11 $ declare -A associative=([foo]=bar [alpha]=omega)
12 $ echo "${indexed[$index]}"
13 one
14 $ echo "${indexed[index]}"
15 one
16 $ echo "${indexed[index + 1]}"
17 two
18 $ echo "${associative[$key]}"
19 bar
20 $ echo "_${associative[key]}_"
21 __
22 $ echo "_${associative[key + 1]}_"
23 __
24 $ unset 'indexed' 'associative' 'index' 'key'
```

The power of parameter expansion on arrays (I)

- Arrays are very flexible, because they are well integrated with the other shell expansions
- Any parameter expansion can be carried out on individual array elements
- Parameter expansions can equally well apply to an entire array!
- To use parameter-expansion manipulations on all array entries, use `[@]` and `[*]`
- It is critical that these special expansions are properly quoted

```
$ array=(alpha beta gamma)
$ echo "${array[-1]:2:2}"    # Substring of last entry
mm
$ echo "${array[@]#a}"       # Chop 'a' from the beginning
lpha beta gamma
$ echo "${array[@]%a}"       # Chop 'a' from the end
alph bet gamm
$ echo "${array[@]//a/_}"    # Substitute all 'a' by '_'
_lph_ bet_ g_mm_
$ echo "${array[@]/#a/_}"    # Substitute 'a' by '_' at start
_lpha beta gamma
$ echo "${array[@]/%a/_}"    # Substitute 'a' by '_' at end
alph_ bet_ gamm_
```

The power of parameter expansion on arrays (I)

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- It is critical that these special expansions are properly quoted

```
$ echo "${array[@]/#/prefix_}"  # Add prefix to all entries
prefix_alpha prefix_beta prefix_gamma
$ echo "${array[@]/%/_suffix}"  # Add suffix to all entries
alpha_suffix beta_suffix gamma_suffix
$ echo "${array[@]^^}"          # Capitalise all characters
ALPHA BETA GAMMA
$ echo "${array[3]?Third entry is unset}"
bash: array[3]: Third entry is unset
$ echo "${array[3]=delta}"
delta
$ echo "${array[@]^}"
Alpha Beta Gamma Delta
$ unset 'array'
```

The power of parameter expansion on arrays (II)

Since Bash v5.1 and v5.2 a couple of new expansions offer more flexibility with arrays:

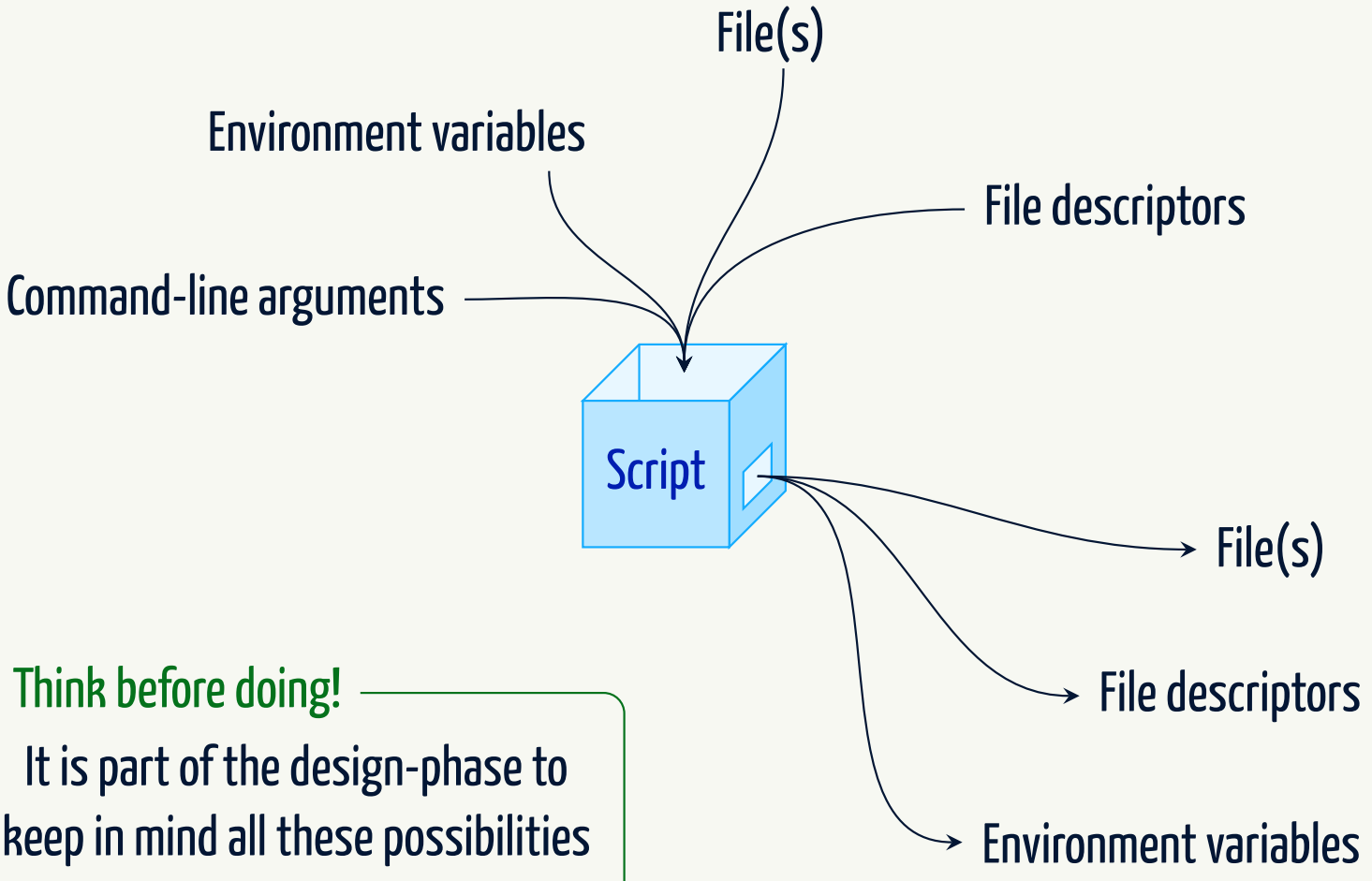
```
# ${var@K} introduced in v5.1 -- ${var@k} introduced in v5.2
$ array=(alpha "beta gamma" delta)
$ echo "${array[@]@K}"  # Possibly quoted key-value pairs
0 "alpha" 1 "beta gamma" 2 "delta"
$ echo "${array[@]@k}"  # Separate words after word splitting
0 alpha 1 beta gamma 2 delta
$ unset 'array'
```

```
$ declare -A array=([Hi]="Ciao" [Bye Bye]="Ciao")
$ echo "${array[@]@K}"
"Bye Bye" "Ciao" Hi "Ciao"
$ echo "${array[@]@k}"
Bye Bye Ciao Hi Ciao
# Also other v5.1 operators can be used on array values
$ echo "${array[@]@U}"  # All lowercase letters capitalised
CIAO CIAO
# Acting directly on indeces is not possible in one statement
$ echo "${!array[@]@U}"
-bash: Ciao Ciao: invalid variable name
$ unset 'array'
```

Input and output

The Krisuvikurberg cliffs at the sunset

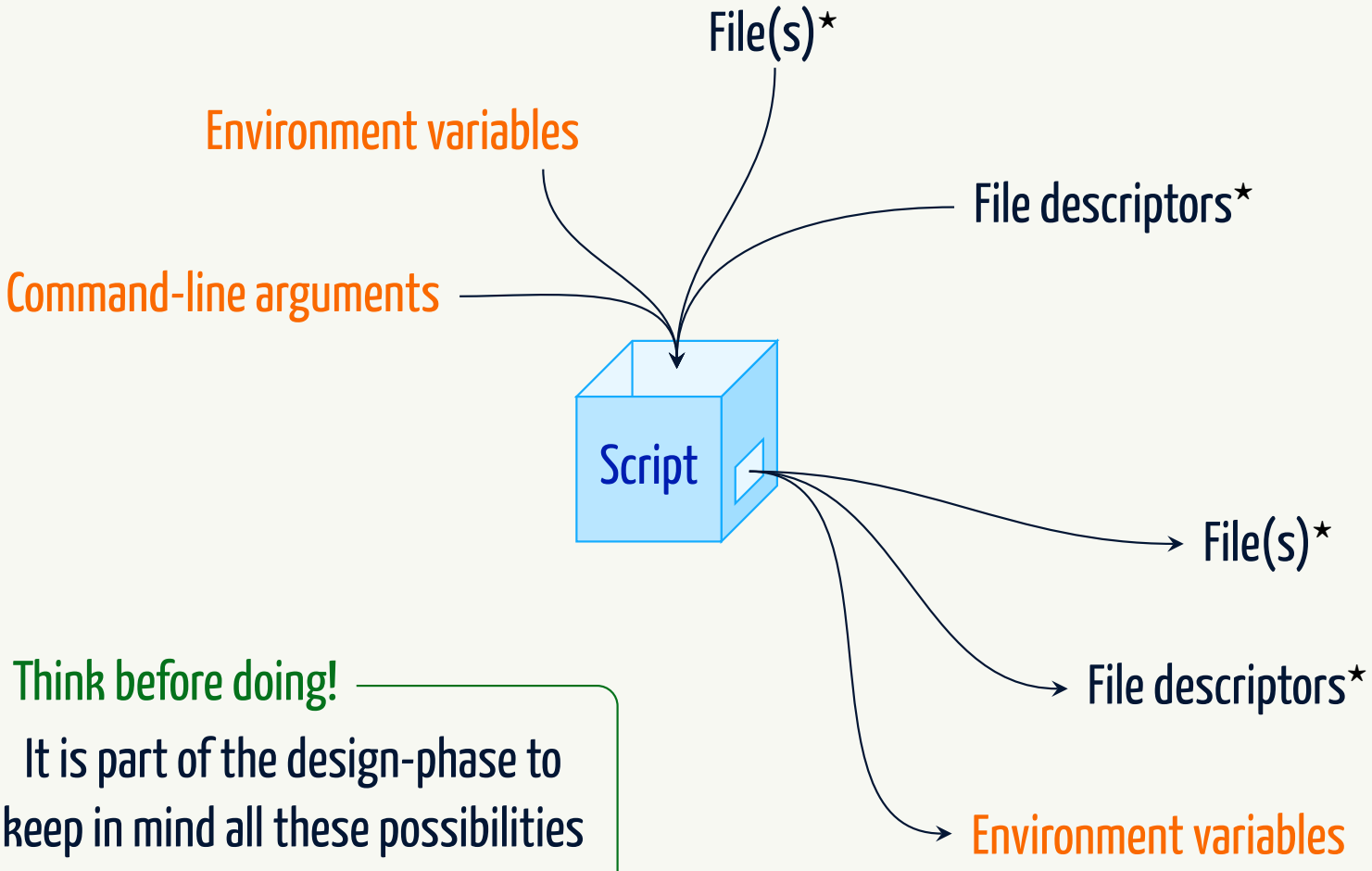
The Bash script flow



Think before doing!

It is part of the design-phase to keep in mind all these possibilities and take advantage of them.

The Bash script flow



Think before doing!

It is part of the design-phase to keep in mind all these possibilities and take advantage of them.

* We will discuss all these in detail tomorrow.

Command-line parameters

- They are accessible via `$1`, `$2`, etc.
- After the 9th one, you need curly braces: `${10}`, `${11}`, etc.
- It is possible to refer to all of them via `$@` and `$*`
- When you refer to all of them, especially to pass them over, use `"$@"`
  → the double quotes are crucial to preserve the parameters without splitting them!
- The `shift` bulit-in is remarkably handy when parsing command-line parameters
  → it destroys `$1` and it maps `$2` into `$1`, `$3` into `$2` and so on

```
$ set -- Hello my "nice world"
$ printf '%s\n' "$@"
Hello
my
nice world
$ printf '%s\n' $@   # <-- Probably, AAAAARGH!
Hello
my
nice
world
```

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  → it destroys `$1` and it maps `$2` into `$1`, `$3` into `$2` and so on

```
$ echo "$1"; shift
Hello
$ echo "$1"; shift
my
$ echo "$1"; shift
nice world
$ echo _"$1"_
__
$ set -- Hello my "nice world"; shift 2; echo "$1"
nice world
```

Environment variables (I)

- Every program inherits certain information from its parent process { resources, privileges and restrictions }
- One of those resources is a set of variables called Environment Variables
- Traditionally, environment variables have names that are all capital letters, such as `PATH`
- When you run a command in Bash, you have the option of specifying a temporary environment change which only takes effect for the duration of that command
- This is done by putting `VAR=value` in front of the command

```
1 $ ls /tpm
2 ls: cannot access '/tpm': No such file or directory
3 $ LANGUAGE=de_DE.utf-8 ls /tpm  # 🔗Read more about LANGUAGE
4 ls: Zugriff auf '/tpm' nicht möglich: Datei oder
      Verzeichnis nicht gefunden
5 $ VERBOSE=1 make
```

Good practice

Don't use all-capital variable names in your scripts, unless they are environment variables. Use lower-case or mixed-case variable names, to avoid accidents.

Environment variables (II)

- In a script, you can use environment variables just like any other variable

```
if [[ ${EDITOR} ]]; then
    ${EDITOR}
else
    emacs
fi
```

- To change the environment for your child processes to inherit, use the `export` builtin

```
export PATH=${HOME}/.local/bin:${PATH}
```

Remember!

The tricky part here is that your environment changes are **only inherited by your descendants**. You can't change the environment of a program that is already running, or of a program that you don't run.

...mmmh, and if I needed it?

Side remark: The first snippet is a verbose way of the simpler `${EDITOR:-emacs}` expansion.

Environment variables (III)

- Sourcing a script, will execute it in the current environment/shell

```
$ cat script.bash
#!/bin/sh
cd /tmp
$ pwd; ./script.bash; pwd
/home/sciarra/Documents
/home/sciarra/Documents
$ pwd; source script.bash; pwd # 'source' as '.'
/home/sciarra/Documents
/tmp
```

Indeed, this is what you do e.g. when you add code in the `${HOME}/.bashrc` file

Splitting a large script in several files

Although a script should not be huge, it is important sometimes to split it into pieces for handier development. This can be done using the `source` builtin, delegating to the main (executable) script to source all secondary files. We will come back to this point when we introduce functions.

Shell options

The Þingvellir national park seen from above

Modifying the shell behaviour

- There are some shell features that can be activated, if needed
- There are two builtins that are responsible for that:

  `set` associated to the `SHELLOPTS` environment variable

  `shopt` associated to the `BASHOPTS` environment variable

Why two?

Historically, the `set` command was used to turn options on and off. As the number of options grew, `set` became more difficult to use because options are represented by single letter codes. As a result, Bash provides the `shopt` (shell option) command to turn options on and off by name instead of a letter. You can set certain options only by letter. Others are available only under the `shopt` command.

This makes finding and setting a particular option a confusing task.

Linux Shell Scripting with Bash

- The `set` builtin allows you to also set positional parameters → it can be very handy!

Modifying the shell behaviour

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- There are two builtins that are responsible for that:

  `set` associated to the `SHELLOPTS` environment variable

  `shopt` associated to the `BASHOPTS` environment variable

Gilles says...

As far as I know, the `set -o` options are the ones that are inherited from other Bourne-style shells (mostly `ksh`), and the `shopt` options are the ones that are specific to bash. There's no logic that I know of.

Well, there are `set -o` options like `posix`, `physical`, `interactive-comments` that are not in `ksh`, and `shopt` ones that are in other shells including `ksh` for some like `login_shell` or `nullglob`. Like you say, there's no logic. It was probably the idea at the start (that `SHELLOPTS` would be the standard ones, and `BASHOPTS` the bash specific ones), but that got lost along the way, and now it just ends up being annoying and a UI design fiasco.

...Stéphane comments

The `set` builtin

🔗Bash manual v5.2 section 4.3.1

- Without arguments, `set` displays the names and values of all shell variables/functions.
- When options are supplied, they set or unset shell attributes.
- Using + rather than – causes these options to be turned off.
- The `set` options can also be used upon invocation of the shell.
- The current set of options may be found in `$-`.
- The remaining N arguments are positional parameters and are assigned, in order, to `$1`, `$2`, ..., `$N`. The special parameter `#` is set to N.
- If you want to set positional arguments that start by a dash, you need to use `--`.

The `set` builtin

Bash manual v5.2 section 4.3.1

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- The current set of options may be found in `$-`.
- The remaining N arguments are positional parameters and are assigned, in order, to `$1`, `$2`, ..., `$N`. The special parameter `#` is set to N.
- If you want to set positional arguments that start by a dash, you need to use `--`.

```
$ echo $-; set -u; echo $-; set +u; echo $-
himBHs
himuBHs
himBHs
$ echo $#; set -- -s --long; echo $#; echo "$@"
0
2
-s --long
```

Some among the many available options (I)

`-o noglob` It is the equivalent to `-f`.
Disable filename expansion (globbing).

`-o noclobber` It is the equivalent to `-C`.
Prevent output redirection from overwriting existing files.

`-o noexec` It is the equivalent to `-n`.
Read commands but do not execute them. { This may be used to check a script for syntax errors. }

`-o nounset` It is the equivalent to `-u`.
Treat unset variables and parameters other than the special parameters @ or * as an error when performing parameter expansion. An error message will be written to the standard error, and a non-interactive shell will exit.

`-o pipefail` If set, the return value of a pipeline is the value of the last (rightmost) command to exit with a non-zero status, or zero if all commands in the pipeline exit successfully. This option is disabled by default.

For debug purposes you might also be interested in the `xtrace` option, equivalent to `-x`.

Some among the many available options (I)

`-o errexit` It is the equivalent to `-e`.
Roughly speaking, this option makes the shell exit immediately when a command returns a non-zero status. This is not always true, though.

`-o errtrace` It is the equivalent to `-E`.

`-o functrace` It is the equivalent to `-T`.

An attempt to simplify error handling

We will come back to these options and discuss them in detail. Although setting `-e` enables a nice feature, it also switches on lots of drawbacks that often need special handling.

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To me it actually seems like...

...a nice try!

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The `shopt` builtin

🔗 Bash manual v5.2 section 4.3.2

```
shopt [-pqsu] [-o] [optname ...]
```

- `-s` Enable (set) each `optname`.
- `-u` Disable (unset) each `optname`.
- `-q` No output; the return status indicates whether the `optname` is set or unset.
  { If multiple `optname` arguments are given with `-q`, the return status is zero if all optnames are enabled; non-zero otherwise. }
- `-p` A list of all settable options is displayed, with an indication of whether or not each is set; if `optnames` are supplied, the output is restricted to those options.
  { Without options the behaviour of `shopt` is the same as with the `-p` option }
- `-o` Restricts `optname` to be one of values of the `-o` option of the `set` builtin.

```
1 $ shopt extglob nullglob
2 extglob            on
3 nullglob           off
4 $ shopt -p extglob
5 shopt -s extglob
```

Some among the many available options (II)

Here focusing on those about globbing

`dotglob` If set, Bash includes filenames beginning with a `.` in the results of filename expansion.

{ The filenames `.` and `..` must always be matched explicitly, even if `dotglob` is set }

`extglob` If set, the extended pattern matching features (described yesterday) are enabled.

`failglob` If set, patterns which fail to match filenames during filename expansion result in an expansion error.

`globstar` If set, the pattern `**` used in a filename expansion context will match all files and zero or more directories and subdirectories. If the pattern is followed by a `/`, only directories and subdirectories match. { This option exists since bash v4.0. }

`nullglob` If set, Bash allows filename patterns which match no files to expand to a null string, rather than themselves.

Some among the many available options (II)

Here focusing on those about globbing

```
$ ls -a
.  ..  .hiddenFile  dir1  file1.c  file2.dat  file3.txt
# Example of dotglob
$ shopt -s dotglob; echo *
.hiddenFile dir1 file1.c file2.dat file3.txt
$ shopt -u dotglob; echo *
dir1 file1.c file2.dat file3.txt
# Example of failglob
$ shopt -s failglob; echo *.pdf  # echo is not executed!
bash: no match: *.pdf
$ shopt -u failglob; echo *.pdf
*.pdf
# Example of nullglob
$ shopt -s nullglob; echo *.pdf

$ shopt -u nullglob; echo *.pdf
*.pdf
```

Some among the many available options (II)

Here focusing on those about globbing

```
$ ls -a
.  ..  .hiddenFile  dir1  file1.c  file2.dat  file3.txt
$ ls -a dir1/
.  ..  dir2  file4.c
$ ls -a dir1/dir2/
.  ..  file5.c
# Example of globstar
$ shopt -u globstar; echo **
dir1 file1.c file2.dat file3.txt
$ shopt -s globstar; echo **
dir1     dir1/dir2  dir1/dir2/file5.c  dir1/file4.c
file1.c  file2.dat  file3.txt
$ echo **/
dir1/ dir1/dir2/
$ echo **/*.c
dir1/dir2/file5.c dir1/file4.c file1.c
$ echo **.c  # ATTENTION: Equivalent to  *.c/*.c/*.c/...
file1.c
```

Some among the many available options (II)

Here focusing on those about globbing

```
36 # Example of extglob -> We saw it already yesterday!
37 $ shopt -s extglob
38 $ echo !(*.c|*.dat)
39 dir1 file3.txt
40 $ shopt -u extglob
```

Some among the many available options (II)

Here focusing on those about globbing

```
36 # Example of extglob -> We saw it already yesterday!
37 $ shopt -s extglob
38 $ echo !(*.c|*.dat)
39 dir1 file3.txt
40 $ shopt -u extglob
```

In a script to be sourced it is good practice remember whether extglob was originally set:

```
shopt -q extglob; extglobSet=$?
# set extglob if it wasn't originally set
[[ ${extglobSet} -ne 0 ]] && shopt -s extglob
# ...
# unset extglob if it wasn't originally set
[[ ${extglobSet} -ne 0 ]] && shopt -u extglob
```

If you do not do so, you might change the shell behaviour where your script will be sourced!

An important remark about options affecting the parser

Some options affect the parser behaviour!

Some options changes the way certain characters are parsed. It is necessary to have a newline (not just a semicolon) between e.g. `shopt -s extglob` and any subsequent commands to use it. You cannot enable such options inside a compound command that uses them, because the entire block is parsed before the `shopt` is evaluated. Note that the typical function body (or an `if`-clause) is a compound command.

This is also why **you cannot run** (when `extglob` is previously unset)

```
# WRONG as one-liner
shopt -s extglob; ls !(*.txt)
```

but must have a newline between the two commands.

Which options affect the parser behaviour is unfortunately not documented, but `extglob` is for sure the most relevant one.

The GNU core utilities and util-linux

Walking on the Breiðamerkurjökull

They are not part of bash but they naturally interact with it

GNU coreutils

The GNU Core Utilities are the basic file, shell and text manipulation utilities of the GNU operating system. These are the core utilities which are expected to exist on every operating system.

The util-linux package

util-linux is a standard package distributed by the Linux Kernel Organization for use as part of the Linux operating system.

If you are interested in exploring how the GNU core utilities are designed, there is an amazing project → Decoded: GNU coreutils

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What should I do here?!

The v9.4 GNU coreutils manual from September 2023 has 295 pages and there are 98 available commands. There are more than 100 commands in the **util-linux** package.

Don't panic. Discover, read the manuals and **learn when you need it!**

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GNU coreutils

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arch	cut	false	logname	od	runcon	tee	uptime
base64	date	fmt	ls	paste	seq	test	users
basename	dd	fold	md5sum	pathchk	shred	timeout	vdir
cat	df	groups	mkdir	pinky	shuf	touch	wc
chcon	dir	head	mkfifo	pr	sleep	tr	who
chgrp	dircolors	hostid	mknod	printenv	sort	true	whoami
chmod	dirname	hostname	mktemp	printf	split	truncate	yes
chown	du	id	mv	ptx	stat	tsort	
chroot	echo	install	nice	pwd	stdbuf	tty	
cksum	env	join	nl	readlink	stty	uname	
comm	expand	kill	nohup	realpath	sum	unexpand	
cp	expr	link	nproc	rm	tac	uniq	
csplit	factor	ln	numfmt	rmdir	tail	unlink	

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cat	df	groups	mkdir	pinky	shuf	touch	wc
chcon	dir	head	mkfifo	pr	sleep	tr	who
chgrp	dircolors	hostid	mknod	printenv	sort	true	whoami
chmod	dirname	hostname	mktemp	printf	split	truncate	yes
chown	du	id	mv	ptx	stat	tsort	
chroot	echo	install	nice	pwd	stdbuf	tty	
cksum	env	join	nl	readlink	stty	uname	
comm	expand	kill	nohup	realpath	sum	unexpand	
cp	expr	link	nproc	rm	tac	uniq	
csplit	factor	ln	numfmt	rmdir	tail	unlink	

The highlighted commands are those that have been touched at least ones during the lecture (some more are discovered in the exercises).

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Some GNU core utilities

Cheat-sheet

`basename`	Strip directory and, optionally, a suffix from filenames.
`comm`	Compare two sorted files line by line.
`dirname`	Print a filename with its last non-slash component and trailing slashes removed.
`expand`	Convert tabs to spaces.
`fmt`	Reformat each paragraph in the file(s), writing to standard output.
`fold`	Wrap each input line to fit in specified width.
`ln`	Make links between files.
`nl`	Write each input file to standard output, with line numbers added.
`realpath`	Print the resolved absolute file name.
`tac`	Write each input file to standard output in a reversed order (last line first).
`uniq`	Report, omit or count repeated lines in a file
`unexpand`	Convert spaces to tabs.

Some commands from the util-linux package

The project is available on GitHub and a list of the commands on Wikipedia

- This package is much more OS oriented.
- Just have a look to it if you are curious, otherwise the following will be enough!

You can do better than that!

At the end of this lecture you will have learnt to implement even more flexible versions of the following commands. To know they exist might still be handy in some occasions, though.

`cal`	Display a calendar and the date of Easter.
`column`	Format the input into multiple columns.
`getopt`	Parse command options.
`rename`	Rename the specified files by replacing the first occurrence of an expression in their name by a replacement.

There might be an issue on your OS, since the package **bsdmainutils** is providing column in Debian and **util-linux** will not ship column as long as **bsdmainutils** does.

Ready to script!?

Yoda meditating in the Jökursárlón

Writing scripts

Google Shell Style Guide

- Is it a Bash script? Take advantage of it! { Use a proper shebang! }
- You learnt all flow constructs, keep them in mind
- Use meaningful, lower-case (or mixed-case) variable names!
- Does your script accept command line options? Implement a `-h` option!
- Does your scripts takes files on the command line? Implement the `--` mechanism.
- If environment variables affect the script behaviour, document it
- Do you need to set particular shell options? Make a note for maintenance!
- Do the error messages get printed to the standard error?
- Take advantage of colours, if needed
- Do not make assumptions, be paranoid
- Use (associative) arrays for collections
- Avoid unnecessary pipes, use herestrings!
- Is the script getting large? Split it! { More tomorrow with functions }
- ...