Bourne-Again SHell and Linux CLI

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Set interpreter: `#!/bin/bash`   Remarks: `# this is comment`

1. Interactive control

Action	`set -o vi`	`set -o emacs`
vi-command mode (C)	Esc	—
Previous/next command in history	j / k	Ctrl+p / Ctrl+n PageUp / PageDown
Automatic fill of file name	Esc Esc	Tab
List of all matches	Esc =	Tab Tab
Horizontal move in command line	h / l	Ctrl+b / Ctrl+f, ← / →
Jump to line begin/end	^ / $	Ctrl+a / Ctrl+e
Backward/forward search in history	/ / ?	Ctrl+r / Ctrl+s
Delete word to the end/begin	dw / db	Esc d / Esc h
Delete text from cursor to the line end/begin	d$ / d^	Ctrl+k / Ctrl+u

1.1. Command line history

- `history`, `fc -l` – display numbered history of commands
- `!`*n* – run command number *n*
- `!`*p* – run last command beginning by *p*
- `!!` – repeat last entered command
- `!!:`*n* – expand *n*-th parameter of last command
- `!$` – expand the last parameter of last command
- `fc` – run defined `$EDITOR` wit last command
- `fc -e vim` *z k* – open `vim` editor with commands from *z* to *k*
- `^old^new` – substitute *old* with *new* in last command
- *program* `` `!!` `` – use output of last command as input

1.2. Help and manuals

- `type -a` *command* – information about command
- `help` *command* – brief help on bash command
- `man` *command*, `info` *command* – detailed help
- `man -k` *key*, `apropos` *key*, `whatis` *key* – find command

2. Debugging

Run a script as: `bash` *option script and its parameters*

- `bash -x` – print commands before execution
- `bash -u` – stop with error if undefined variable is used
- `bash -v` – print script lines before execution
- `bash -n` – do not execute commands

3. Variables, arrays and hashes

- *NAME*`=10` – set value to variable `$NAME`, `${NAME}`
- `export NAME=10, typedef -x NAME` – set as environment variable
- ``D=$(date); D=`date` `` – variable contains output of command `date`
- `env, printenv` – list all environment variables
- `set` – list env. variables, can set bash options and flags `shopt`
- `unset` *name* – destroy variable of function
- `typeset, declare` – set type of variable
- `readonly` *variable* – set as read only
- `local` *variable* – set local variable inside function
- `${!var}`, `eval \$$var` – indirect reference
- `${`*parameter-word*`}` – if *parameter* has value, then it is used, else *word* is used
- `${`*parameter=word*`}` – if *parameter* has no value assing *word*. Doesn't work with `$1`, `$2`, ets.
- `${`*parameter:-word*`}` – works with `$1`, `$2`, etc.
- `${`*parameter?word*`}` – if *parameter* has value, use it; if no display *word* and exit script.
- `${`*parameter+word*`}` – if *parameter* has value, use *word*, else use empty string
- `array=(a b c); echo ${array[1]}` – print ‚b'
- `array+=(d e f)` – append new item/array at the end
- `${array[*]}`, `${array[@]}` – all items of array
- `${#array[*]}`, `${#array[@]}` – number of array items
- `declare -A hash` – create associative array (from version)
- `hash=([key1]=value ["other key2"]="other value")` – store items
- `${hash["other key2"]}`, `${hash[other key2]}` – access
- `${hash[@]}`, `${hash[*]}` – all items
- `${!hash[@]}`, `${!hash[*]}` – all keys

3.1. Strings

- `STRING="Hello"` – indexing: H_0 e_1 l_2 l_3 o_4
- `STRING+=" world!"` – concatenate strings
- `${#string}`, `expr length $string` – string length
- `${string:position}` – extract substring from position
- `${string:position:length}` – extract substr. of length from position
- `${string/substring/substitution}` – substitute first occurrence
- `${string//substring/substitution}` – substitute all
- `${string/%substring/substitution}` – substitute last occurrence
- `${string#substring}` – erase shortest substring
- `${string##substring}` – erase longest substring

3.2. Embedded variables

- `~`, `$HOME` – home directory of current user
- `$PS1`, `$PS2` – primary, secundary user prompt
- `$PWD`, `~+` / `$OLDPWD`, `~-` – actual/previous directory
- `$RANDOM` – random number generator, 0 – 32,767
- `$?` – return value of last command
- `$$` – process id. of current process
- `$!` – process id. of last background command
- `$PPID` – process id. of parent process
- `$-` – display of bash flags
- `$LINENO` – current line number in executed script
- `$PATH` – list of paths to executable commands
- `$IFS` – Internal field separator. List of chars, that delimiter words from input, usually space, tabulator `$'\t'` and new line `$'\n'`.

4. Script command line parameters

- `$0`, `${0}` – name of script/executable
- `$1` to `$9`, `${1}` to `${255}` – positional command line parameters
- `PAR=${1:?"Missing parameter"}` – error when `${1}` is not set
- `PAR=${1:-default}` – when `${1}` is not set, use *default* value
- `$#` – number of command line parameters (argc)
- `${!#}` – the last command line parameter
- `$*` – expand all parameters, `"$*"` = `"$1 $2 $3..."`
- `$@` – expand all parameters, `"$@"` = `"$1" "$2" "$3"...`
- `$_` – last parameter of previous command
- `shift` – rename arguments, `$2` to `$1`, `$3` to `$2`, etc.; lower counter `$#`
- `xargs` *command* – read stdin and put it as parameters of *command*

4.1. Read options from command line

```
while getopts "a:b" opt; do case $opt in
    a) echo a = $OPTARG ;;
    b) echo b ;;
    \?) echo "Unknown parameter!" ;;
esac; done
shift $(($OPTIND - 1)); echo "Last: $1"
```

5. Control expressions

- `(`*commands*`)`, `$(`*commands*`)`, `` ` ``*commands*`` ` ``, `{`*commands;*`}` – run in subshell
- `$(`*program*`)`, `` ` ``*program*`` ` `` – output of program replaces command
- `test`, `[ ]` – condition evaluation:
  - numeric comparison: `a -eq` *b* ...$a=b$, `a -ge` *b* ...$a \geq b$, `a -gt` *b* ...$a > b$, `a -le` *b* ...$a \leq b$, `a -lt` *b* ...$a < b$
  - file system: `-d` *file* is directory, `-f` *file* exists and is not dir., `-r` *file* exists and is readable, `-w` *file* exists and is writable, `-s` *file* is non-zero size, `-a` *file* exists
  - logical: `-a` and, `-o` or, `!` negation
- `[[ ]]` – comparison of strings, equal `=`, non-equal `!=`, `-z` *string* is zero sized, `-n` *string* is non-zero sized, `<`, `>` lexical comparison
- `[` *condition* `] && [` *condition* `]`
- `true` – returns 0 value
- `false` – returns 1 value
- `break` – terminates executed cycle
- `continue` – starts new iteration of cycle
- `eval` *parameters* – executes parameters as command
- `exit` *value* – terminates script with return value
- `.` *script*, `source` *script* – reads and interprets another script
- `:` *argument* – just expand argument or do redirect
- `alias` *name='commands'* – expand *name* to commands
- `unalias` *name* – cancel alias
- `if [` *condition* `]; then` *commands*;
`elif [` *condition* `]; then` *commands*;
`else` *commands*`; fi`
- `for` *variable* `in` *arguments*`; do` *commands;* `done`
  - `{a..z}` – expands to `a b c` ...`z`
  - `{`*i..n..s*`}` – sequence from *i* to *n* with step *s*
  - `\"{a,b,c}\"` – expands to `"a" "b" "c"`
  - `{1,2}{a,b}` – expands to `1a 1b 2a 2b`
  - `seq` *start step end* – number sequence
- `for((i=1; i<10; i++)); do` *commands;* `done`
- `while` *returns true*`; do` *commands;* `done`
- `until [` *test returns true* `]; do` *commands;* `done`
- `case $prom in value`$_1$`) commands ;;`
`value`$_2$`) commands ;; *) implicit. commands ;;`
`esac`
- Function definition: `function` *name ()* `{`*commands*`; }`
- `return` *value* – return value of the function
- `declare -f` *function* – print function declaration

6. Redirections and pipes

- `0` stdin/input, `1` stdout/output, `2` stderr/error output
- `>` *file* – redirection, create new file or truncate it to zero size
- `>>` *file* – append new data at the end of file
- *command*$_1$`<<<`*command*$_2$ – ouput from 2nd to stdin of 1st
- *command* `<` *file* – read stdin from file
- `tee` *file* – read stdin, writes to file and to stdout
- *command* `2>` *file* – redirect error messages to file
- `exec 1> >(tee -a log.txt)` – redirect stdout also to file
- `2>&1` – merge stderr and stdout
- `exec 3<>/dev/tcp/`*addr/port* – create descriptor for network read/write
- `exec 3>&-` – close descriptor
- *command* `> /dev/null 2>&1` – suppress all output
- `n> n>> n>&m` – operation redirect for descriptors *n, m*
- `mkfifo` *name* – make a named pipe, it can be written and read as file
- *command*$_1$ `|` *command*$_2$ – pipe, connection between processes
- *command* `2>&1 | ...` – can be shortened to *command* `|& ...`
- `${PIPESTATUS[0]}`, `${PIPESTATUS[1]}` – retvals before and after pipe
- `read` *parameters* – read input line and separate it into parameters

6.1. Input for interactive programs (here documents)

```
./program <<  EOF      ./program <<-'EOF' # suppress tabulators
Input1                 Input1
Input2                 Input2
EOF                    EOF
```

6.2. Process file line by line

```
cat file.txt | (while read L; do echo "$L"; done)
```

7. Evaluating mathematical expressions

- `let` *expression*, `expr` *expression*, `$((`*expression*`))`, `$((`*expression1, expression2*`))`, `$[`*expression*`]`
- Numeric systems: *base*`#`*number*; hexa `0xABC`, octal `0253`, binary `2#10101011`
- Operators: `i++`, `++i`, `i--`, `--i`, `+`, `-`; `**` power, `*`, `/`, `%` remainder; logical: `!` neg., `&&` and, `||` or; binary: `~`, `&`, `|`; `<<`, `>>` shifts; assignment: `= *= /= %= += -= <>= &= ^= |= >>= <<=`; relations: `< <= > >=`
- `factor` *n* – factorize *n* into primes
- Floating point operations: `echo "scale=10; 22/7" | bc`

8. Screen output

- `echo "text"` – print text, `echo *` print all files in current dir
- `echo -e "text"` – interpret escape-sequences (`\t` tab., `\a` beep, `\f` new page, `\n` new line), `-n`, `\c` suppressing `\n`, `\x`*HH* hex-byte, `\`*nnn* oct. byte, `\u03B1` „α" (U+03B1) in UTF-8
- `stty` – change and print terminal line settings
- `tty` – print name of terminal connected to stdout
- `printf` *format values* – format output
- `printf -v` *variable form. val.* – form. output into variable
  - % [flags][width][.precision][length]specifier
  - Specifier: `%u`, `%d`, `%i` decimal; `%E`, `%f` float, `%x`, `%X` hex; `%o` octal, `%s` string, `%%` char %
  - Width: *n* prints at least *n* chars, spaces from right, 0*n* print at least *n* chars, zeros from left, `*` width specified in preceding parameter
  - Precision: min. number of digits, digits after decimal point, number of printed chars, `*` number of chars given by preceding parameter
  - Flags: `-` left-justify, `+` prints number with sign `+/-`
- `printf "%d" \'A` – display ASCII code of char "A" (65)
- `printf \\$(printf '%03o' 65)` – print char given by ASCII code
- `tput` *action* – terminal dependent action
- `reset`, `tput sgr0`, `tset` – reset terminal, cancel attributes
- `clear`, `tput clear` – clear screen

9. Process management

- *command* `&` – run *command* in background
- `prog`$_1$ `&&` `prog`$_2$ – run prog$_2$, if prog$_1$ ends with success
- `prog`$_1$ `||` `prog`$_2$ – rub prog$_2$, if prog$_1$ ends with error
- Ctrl+z – stop process (SIGSTOP)
- `bg` / `fg` – run last stopped process in background/foreground
- `jobs` – list processes running in background
- `exec` *command* – shell is replaced by *command*
- `wait` – wait for end of background tasks
- `top` – watch CPU, memory, system utilization
- `ps -xau` – list processes and users, `ps -xaf, pstree` tree listing
- `pgrep` *process*, `pidof` *process* – get PID by name of process
- `nice -n` *p command* – priority *p* od −20 (max.) to 19 (min.)
- `renice -n` *p* `-p` *pid* – change priority of running process
- `kill -s` *k n* – send signal *k* to proces id. *n*, 0, 1 SIGHUP; 2 SIGINT Ctrl+c; 3 SIGQUIT; 9 SIGKILL; 15 SIGTERM; 24 SIGSTOP
- `trap '`*command*`' signals` – run command when signal received
- `killall` *name* – send signals to process by name
- `nohup` *command* `&` – command will continue after logout
- `time` *command* – print time of process execution
- `times` – print user and system time utilization in current shell
- `watch -n` *s command* – every *s* seconds run command
- `timeout` *N command* – quit *command* after *N* seconds

10. Time and process planning

- `date` – print date, `date --date=@`*unix_time*
- `date +"%Y%m%d %H:%M:%S %Z"` – format to `20130610 13:39:02 CEST`
- `cal` – display calendar
- `crontab -e` – edit crontab, `-l` list, format *min hour date month day command*, `* * * * * command` run every minute, `1 * * * * command` 1st min of every hour
- `at, batch, atq, atrm` – queue, examine or delete jobs for later execution

11. File operations

File name wildchars: `?` a char; `*` zero or more chars; `[`*set*`]` one or more given chars, interval `[0-9]` `[a-z]`, `[A-Z]`; `[!`*set*`]`, `[^`*set*`]` none of chars.

- `ls` – list directory, `ls -la`, `vdir` all files with info
- `tree` – display hierarchy tree of directories
- `file` *file* – determine file by its magic number
- `lsattr, chattr` – list and change file attributes for ext2,3
- `umask` – define permission mask for new file
- `pwd (-P)` – logical (physical) path to current directory
- `cd directory` – change directory, `cd` jump to `$HOME`, `cd -` to `$OLDPWD`
- `dirs` – list stack of directories
- `pushd` *directory* – store *directory* to stack
- `popd` – set top stack directory as actual directory
- `cp` *source target* – copy file
- `ln -s` *source link* – create a symbolic link
- `mkdir`, `rmdir` – create, remove directory
- `rm` *file*, `rm -r -f` *directory*, `unlink` – delete
- `touch` *file* – create file, set actual time to existing file
- `du -h` – display space usage of directories
- `stat` *file* – file statistics, `stat --format=%s` size
- `basename` *name suffix* – remove path or suffix
- `dirname` */path/to/file* – print only path
- `repquota` – summarize quotas for a filesystem
- `mktemp` – create file with unique name in `/tmp`

12. Work with file content

- `cat` – concatenate files and print them to stdout
- `cat > file` – create file, end with Ctrl+d
- `mapfile A < file` – store stdin into array `$A`
- `tac` – like `cat`, but from bottom to top line
- `more`, `less` – print by pages, scrollable
- `od`, `hexdump -C`, `xxd` – print in octal, hex dump
- `wc` – get number of lines `-l`, chars `-n`, bytes `-c`, words `-w`
- `head/tail` – print begin/end, `tailf, tail -f` wait for new lines
- `split`, `csplit` – split file by size, content
- `sort` – `-n` numerical, `-r` reverse, `-f` ignore case
- `uniq` – omit repeated lines, `-d` show only duplicates
- `sed -e '`*script*`'` – stream editor, script `y/ABC/abc/` replaces A, B, C for a, b, c; `s/regexp/substitution/`
- `tr` *a b* – replace char *a* for *b*
- `tr '[a-z]' '[A-Z]' < file.txt` – change lowercase to uppercase
- `awk '/pattern/ {action }'` *file* – process lines containing pattern
- `cut -d` *delimiter* `-f` *field* – print column(s)
- `cmp` *file1 file2* – compare files and print first difference
- `diff, diff3, sdiff, vimdiff` – compare whole files
- `dd if=`*in* `of=`*out* `bs=`*k* count=*n* – read *n* blocks of *k* bytes
- `strings` – show printable strings in binary file
- `paste` *file*$_1$ *file*$_2$ – merge lines of files
- `rev` – reverse every line

13. Search

- `whereis, which` – find path to command
- `grep` – `-i` ignore case, `-n` print line number, `-v` display everything except pattern, `-E` extended regexp
- `locate` *file* – find file
- `find` *path* `-name 'file*'` – search for *file**
- `find` *path* `-exec grep` *text* `-H {}\;` – find file containing *text*

14. Users and permissions

- `whoami, who am i` – tell who I am :)
- `w, who, users, pinky, finger` – list connected users
- `last / lastb` – history successful / unsuccessful logins
- `logout`, Ctrl+d – exit shell
- `su` *login* – change user to *login*
- `sudo` – run command as other user
- `su -` *login* `-c '`*command*`'` – run one command as *login*
- `id` *login*, `groups` *login* – show user details
- `useradd, userdel, usermod` – create, delete, edit user
- `groupadd, groupdel, groupmod` – create, delete, edit group
- `passwd` – change password
- `pwck` – check integrity of `/etc/passwd`
- `chown` *user:group file* – change owner, `-R` recursion
- `chgrp` *group file* – change group of file
- `chmod` *permissions file* – change permissions in octal of user, group, others; `444=-r--r--r--`, `700=-rwx------`, `550=-r-xr-x---`
- `runuser` *login* `-c "`*command*`"` – run command as user

15. System utilities

- `uname -a` – name and version of operating system
- `uptime` – how long the system has been running
- `fuser` – identify processes using files or sockets
- `lsof` – list open files
- `sync` – flush file system buffers
- `chroot` *dir command* – run command with special root directory
- `strace,ltrace` *program* – show used system/library calls
- `ldd` *binary* – show library dependencies

15.1. Disk partitions

- `df` – display free space
- `mount` – print mounted partitions
- `mount -o remount -r -n /` – change mount read only
- `mount -o remount -w -n /` – change mount writeable
- `mount -t iso9660 cdrom.iso /mnt/dir -o loop` – mount image
- `mount -t cifs \\\\server\\ftp /mnt/adr -o user=a,passwd=b`
- `umount` *partition* – unmount partition
- `fdisk -l` – list disk devices and partitions
- `blkid` – display attributes of block devices
- `tune2fs` – change ext2/3/4 filesystem parameters
- `mkfs.ext2`, `mkfs.ext3` – build file-system
- `hdparm` – set/read parameters of SATA/IDE devices

15.2. System utilization

- `ulimit -l` – print limits of system resources
- `free`, `vmstat` – display usage of physical, virt. memory
- `lspci`, `lsusb` – list PCI, USB devices
- `dmesg` – display messages from kernel
- `sysctl` – configure kernel parameters at runtime
- `dmidecode` – decoder for BIOS data (DMI table)
- `init`, `telinit` – command `init` to change runlevel
- `runlevel`, `who -r` – display current runlevel

16. Networking

- `hostname` – display computer hostname
- `ping` *host* – send ICMP ECHO_REQUEST
- `dhclient eth0` – dynamically set `eth0` configuration
- `host, nslookup` *host/adr* – DNS query
- `dig` – get record from DNS
- `whois` *domain* – finds owner of domain or network range
- `ethtool eth0` – change HW parameters of network interface `eth0`
- `ifconfig` – display network devices, device configuration
- `ifconfig eth0 add 10.0.0.1 netmask 255.255.255.0`
- `ifconfig eth0 hw ether 01:02:03:04:05:06` – change MAC address
- `route add default gw 10.0.0.138` – set network gateway
- `route -n`, `netstat -rn` – display route table
- `netstat -tlnp` – display processes listening on ports
- `arp` – display ARP table
- `iptables -L` – display firewall rules
- `tcpdump -i eth0 'tcp port 80'` – display HTTP communication
- `tcpdump -i eth0 'not port ssh'` – all communication except SSH
- `ssh user@hostname` *command* – run command remotely
- `mail -s "subject" address` – send email to address
- `wget -e robots=off -r -L http://`*path* – mirror given page