Unix Crash Course

`$ who am i`

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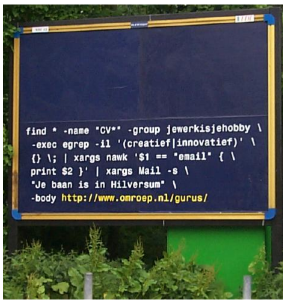
Subjects (before lunch)

- A short history of Unix and Linux
- Structure and philosophy of Unix
- Files and filesystems
- Shell variables and globbing
- Processes and jobs

Subjects (after lunch)

- Networking and the X windowing system
- Shell scripting concepts
- Regular expressions
- **`sed`** and **`awk`**
- Miscelanious (editing and programming)

Mumbo Jumbo?



```
find * -name "CV*" -group jewerkisjehobby \
 -exec egrep -il '(creatief|innovatief)' \
 {} \; | xargs nawk '$1 == "email" { \
 print $2 }' | xargs Mail -s \
 "Je baan is in Hilversum" \
 -body http://www.omroep.nl/gurus/
```

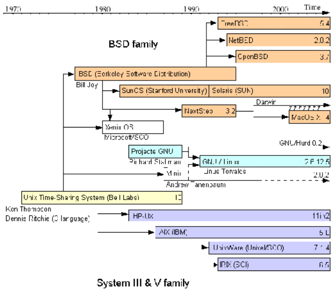
Unix History

- AT&T abandoned MULTICS
- Ken Thompson & Dennis Ritchie developed UNICS on a PDP7
- UNIX ported to Ritchie's C language
- BSD released, many ports followed
- POSIX effort to unify Unices
- GNU project / Linux kernel

Unix History

Ritchie and Thompson working on a PDP11/20 at Bell Labs

Unix History



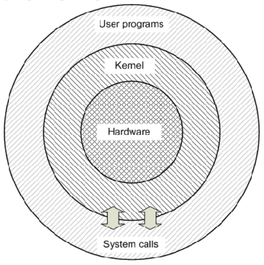
(Gnu/) Linux distros

Unix philosophy

- Everything is a file
- Combine small tools to build your requirement

Unix structure

Unix has an onion-like structure, the hardware is handled by the kernel



Kernel provisions

The kernel provides:

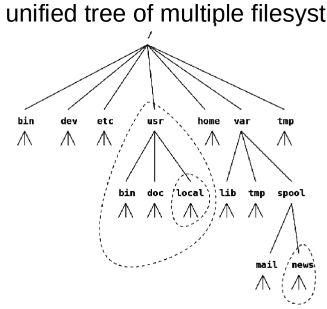
- CPU scheduling of processes
- Accessing hardware
- System calls for user-land programs
- The filesystem
- Privilege separation etc.

Multi-user environment

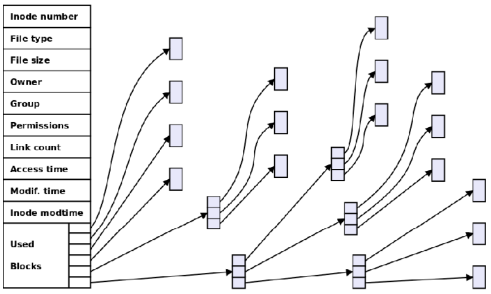
- Unix runs programs from multiple users concurrently, even *interactive* programs
- User identified by numeric id, user name provided for verbosity
- User is member of one or more groups, identified by group id
- Interactive sessions need a TTY for input and output

The filesystem

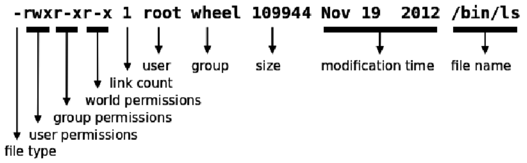
A single unified tree of multiple filesystems



Inodes



File permissions



```
-rwxr-xr-x 1 root wheel 109944 Nov 19  2012 /bin/ls
```

user
group
size
modification time
file name
link count
world permissions
group permissions
user permissions
file type

Lab 1

- (page 10, execute **`setup_labs.sh`**)
- `ls -l`
- `cat README`
- `chmod a+r README`
- `ls -l`
- `cat README`

The Shell

- There are various shells available:
  - **sh**: the Bourne shell
  - **csh**: the C shell
  - **ksh**: the Korn shell
  - **tcsh**: the TENEX C shell
  - **bash**: the Bourne-Again shell
  - **zsh**: the Z shell

The Shell

- The shell interprets entered commands Syntax: **`command argument_list`**
- Arguments are separated by white space Certain arguments (usually single characters preceded by a dash change the program's behaviour and are called “options”
- The shell will perform command substitution, variable expansion and globbing and execute the command with modified command line. All these steps depend on quoting.

Frequent commands

```
man
echo
read
ls
cp
mv
ln
rm
pwd
cd
mkdir
rmdir
```

```
chmod
chown
chgrp
umask
cat
head
tail
cut
grep
sed
sort
uniq
```

```
wc
more
date
time
tar
gzip
compress
xargs
tee
expr
awk
find
```

Shell variables

Using shell variables:

```
$ echo $HW
$ HW="Hello, World."
$ echo $HW
Hello, World.
$
```

Export variables to make them visible in a sub-shell:

```
$ export VARIABLE
```

Use curly braces to disambiguate variables:

```
$ echo ${VARIABLE}more_text
```

Special variables

```
$PATH
$MANPATH
$LD_LIBRARY_PATH
$HOME
$USER
$PWD
$SHELL
$PS1
$PS2
```

```
$0
$1 - $9
$#
$*
$@
$?
$$
$!
```

Quoting

Variables expand in double quotes, not in single quotes. Backslashes “escape” a single character:

```
$ HW="Hello, World."
$ echo "$HW"
Hello, World.
$ echo '$HW'
$HW
$ echo \$HW
$HW
$ echo \\$HW
\Hello, World.
$
```

Command substitution

Use “backquotes” for command substitution:

```
$ wc log.`date +%Y%m%d`
      1       8      54 log.20131102
$
```

On modern shells, **`$( )`** is allowed. This enables nesting:

```
bash$ wc log.$(expr $(date +%Y%m%d) – 100)
    630    1616   40744 log.20131002
bash$
```

Globbing

- The asterisk (`*`) expands to *zero* or more characters (e.g. “`ls foo*`”)
- The question mark expands to exactly one character (e.g. “`ls /etc/?asswd`”)
- Characters in square brackets expand to *one* character from the list. Ranges are allowed. (“`ls foo.[abc0-9]`”). Negate the list with an exclamation mark (“`ls foo.[!abc0-9]`”).

Globbing

- On modern shells, the tilde (`~`) expands to the users homedirectory and “`~foo`” to the homedirectory of user “`foo`”
- Globbing is handled by the shell, the executed command doesn't know if globbing occurred
  - Notice that this can cause an error of an oversized argument list

Lab 2

(page 16 – 17)

- File & directory management
- Variable substitution
- Command substitution
- Globbing

Redirection

- Three file descriptors:
  - FD0 is standard input (stdin)
  - FD1 is standard output (stdout)
  - FD2 is standard error (stderr)
- More are available for advanced use
- Redirect output with `>` and input with `<` (e.g. “`command 1> file`” or “`command 0< file`” (FD is optional for stdin and stdout)

Redirection

- Connect file descriptors with `>&` construct: (`command > file 2> &1`)
- `>` overwrites the output file or create a new one, `>>` will append to the file instead
- `<<` is called a “here document” and used in scripts.

Pipes

- A pipe connects stdout of a command to stdin of the next
  This is central to the Unix philosophy, i.e. create small but powerful tools and connect them
  Example:
  `ls /tmp | wc -l`
- stderr can't be piped alone, only with stdout

`tee` and `xargs`

- Two commands used a lot with pipes: **`tee`** and **`xargs`**. Examples:
- Save log output and count entries:
```
grep 10.1.2.3 /var/log/apache/access.log \
| tee /tmp/rogueclient.txt | wc -l
```
- Search for text in files that are less than 4 days old:
```
find /var/log -mtime -4 -print | xargs \
grep -l 'kernel error'
```

Grouping

Combine stdout of multiple commands with **`()`** or **`{}`**. Parentheses work in sub-shell, braces in current shell:

```
$ echo Foo ; echo Bar | wc
Foo
      1       1       4
$ { echo Foo ; echo Bar ;} | wc
      2       2       8
$ (echo Foo ; echo Bar) | wc
      2       2       8
$
```

Lab 3

(page 19)

- Redirection and piping

Forking

- The shell will start a “child process”. The command will be executed in this process.
- After the child exits, it signals the “parent”.
- Changed environment in child is not visible in the parent (variables, current directory)
- Parent variables should be “exported” to be visible in the child (**`export VARNAME`**)
- Executing a shell in current process is called “sourcing” (**`. scriptfile`**)

Processes

- Every process has a “process id”
- Use **`ps`** to retrieve information of processes
- Use **`kill`** to send processes a signal
  Some signals (e.g. **`SIGINT`**) are handled by the program, others (e.g. **`SIGKILL`**) are handled by the kernel

Jobs

- A process can be started in the background by appending an ampersand (**`&`**) to the CL
- A program is suspended by sending it a **`SIGSTOP`** (e.g. by pressing **`CTRL-Z`**)
- **`jobs`** gives a list of all suspended and backgrounded processes
- **`fg`** and **`bg`** continue running a process in the foreground or background respectively (job id may be appended with **`%`** sign

Scheduling

- Run a program unattended later with **`at`**:

```
echo "find /tmp -mtime +30 | xargs rm -f"\
| at 20:08 tomorrow
```

- Schedule regularly with **`cron`**. Syntax:

```
min hou dom mon dow command [arguments]
```

  Example:

```
5 * * 3,6 2 echo foo >> /tmp/myfile
```

Shell Initialization

- The shell will source files on login or other startup.
  - **`sh`**, **`ksh`**: **`/etc/profile`**, **`$HOME/.profile`** (on login)
  - **`bash`**: **`/etc/profile`**, **`$HOME/.bash_profile`**, **`$HOME/.profile`** (on login)
    `/etc/bash.bashrc`, **`$HOME/.bashrc`** (interactive)

Lunch

See you in an hour

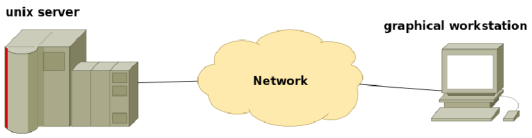
Networking

- Interactive shells and file sharing can be started from networked hosts
- Common tools:
  - **`telnet`**
  - **`ftp`**
  - “rsh” tools (**`rsh`**, **`rlogin`**, **`rcp`**)
  - secure shell suite (**`ssh`**, **`scp`**, **`sftp`**)
- Pseudo-TTY's are assigned to interactive networked shells

The X Windowing System

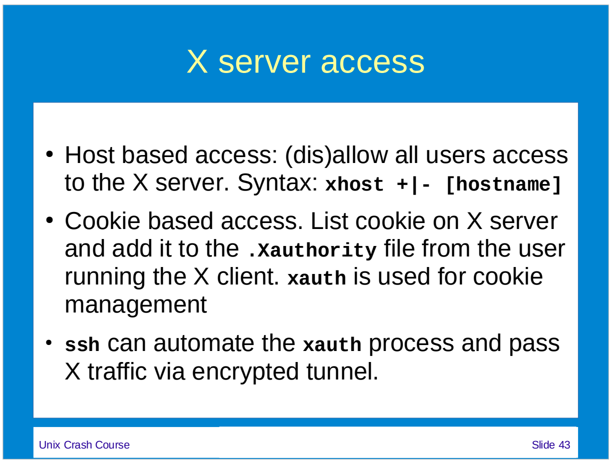
- The standard Unix GUI (X) is networked based. Consists of an “*X server*” (which can display graphics and handle keyboard and mouse) and an “*X client*” (a program requesting graphical output.
- The X server is identified by the **`$DISPLAY`** variable (e.g. **`myscreen.example.com:0.0`**)

The X Windowing System



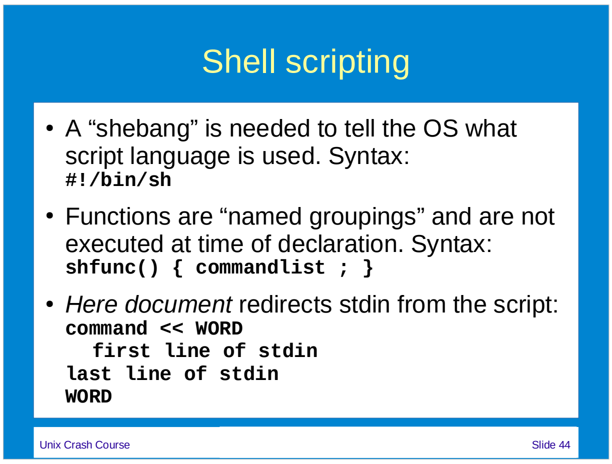
X clients:
- window manager
- graphical toolkit
- GUI program

X server:
- graphical rendering
- font rendering
- keyboard & mouse handling



X server access

- Host based access: (dis)allow all users access to the X server. Syntax: `xhost +|- [hostname]`
- Cookie based access. List cookie on X server and add it to the `.Xauthority` file from the user running the X client. `xauth` is used for cookie management
- `ssh` can automate the `xauth` process and pass X traffic via encrypted tunnel.



Shell scripting

- A “shebang” is needed to tell the OS what script language is used. Syntax:

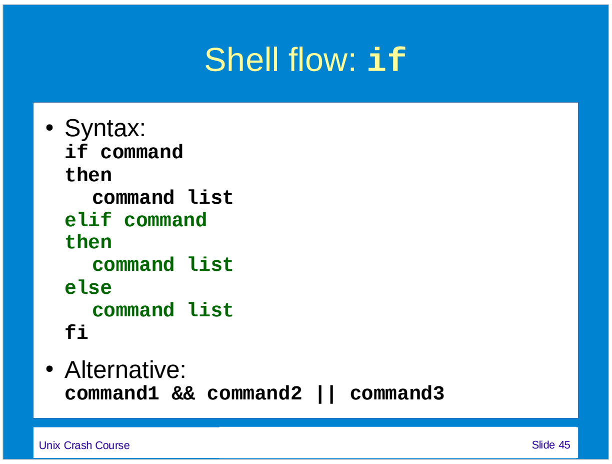
```
#!/bin/sh
```

- Functions are “named groupings” and are not executed at time of declaration. Syntax:

```
shfunc() { commandlist ; }
```

- *Here document* redirects stdin from the script:

```
command << WORD
  first line of stdin
last line of stdin
WORD
```



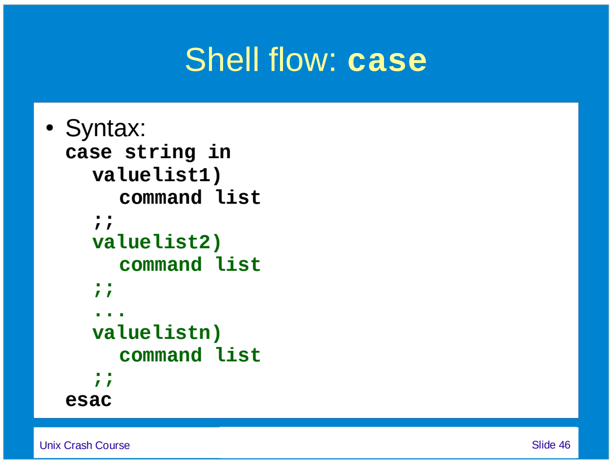
Shell flow: **`if`**

- Syntax:

```
if command
then
  command list
elif command
then
  command list
else
  command list
fi
```

- Alternative:

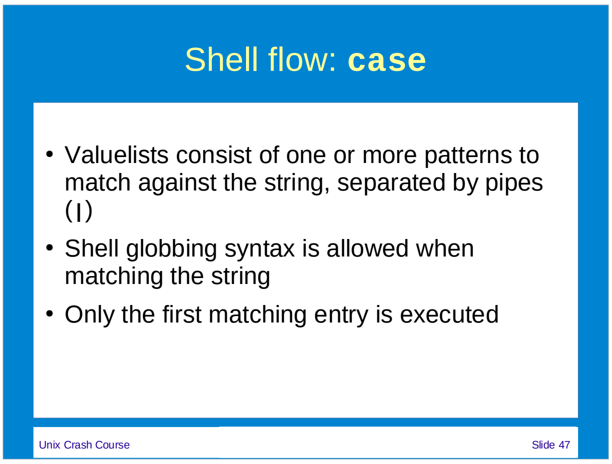
```
command1 && command2 || command3
```



Shell flow: **`case`**

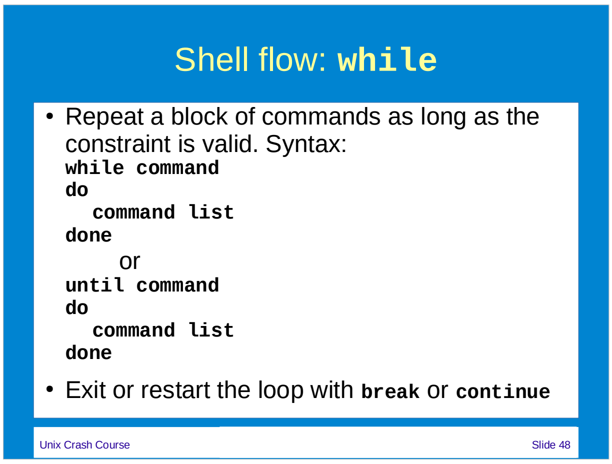
- Syntax:

```
case string in
  valuelist1)
    command list
  ;;
  valuelist2)
    command list
  ;;
  ...
  valuelistn)
    command list
  ;;
esac
```



Shell flow: **`case`**

- Valuelists consist of one or more patterns to match against the string, separated by pipes (|)
- Shell globbing syntax is allowed when matching the string
- Only the first matching entry is executed



Shell flow: **`while`**

- Repeat a block of commands as long as the constraint is valid. Syntax:

```
while command
do
  command list
done
```

or

```
until command
do
  command list
done
```

- Exit or restart the loop with `break` or `continue`

Shell flow: `for`

- Repeat a loop a number of times while assigning a value to a variable. Syntax:

```
for VAR in value-list
do
  command list
done
```

- The value-list consists of whitespace-separated values.
- `break` and `continue` are valid in `for` loops.
- Bash allows a C-like syntax:
  `for ((expr1;expr2;expr3)) ; do list ; done`

`test`

- The `test` command is used very often for flow control. The syntax is:
  `test expression` or
  `[ expression ]`
- Expressions can be tested for strings, numbers or files.

`test` examples

`[ "$VAR" = foo ]` - Test string equality

`[ -z "$VAR" ]` - Test `$VAR` as empty string

`[ "$VAR" -lt 12 ]` - Numeric comparison

`[ -d foo ]` - Is `foo` a directory

`[ expression1 -a expression2 ]` - Logical AND

`[ expression1 -o expression2 ]` - Logical OR

`[ ! expression ]` - Logical NOT

Lab 4

(page 28)

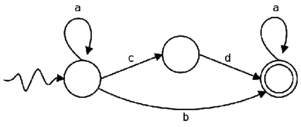
Create a small script with multiple names.

Alter the behaviour depending on the name.

Remember: the name of the script is stored in the variable **`$0`**

Regular expressions

- Recognise the language of strings that can be expressed with a *state transition diagram*



a*(b|cd)a*

- Used extensively in Unix, e.g. **`ed`**, **`grep`**, **`vi`**, **`awk`**, **`perl`**, **`python`**, etc.

Regular expressions

- **`abc`** – Concatenated characters are recognized as such
- **`.`** – The dot is a placeholder for any character
- **`*`** – The asterisk represents *zero* or more repetitions of the previous character
- **`[abc0-9]`** – A single character in the brackets is recognized, **`0-9`** is a range
- **`[^abc0-9]`** – A caret as first bracketed character negates the list.

Regular expressions

- `^` and `$` bind to the empty string at the beginning and end of a line respectively
- `\<` and `\>` bind to the empty string at the beginning and end of a line respectively
- `\|` is the logical OR between two regexps
- `\(` and `\)` can be used to group part of a regexp that can be referenced as `\n`, where n is the number of the `n`th grouping.

Extended regexps

- The `?` recognizes zero or one repetitions of the previous character or group
- The `+` recognizes one or more repetitions
- `{n,m}` recognizes at least `n` and at most `m` repetitions. Either `n` or `m` is optional. A single `n` recognizes exactly `n` repetitions.
- The characters `(`, `)` and `|` are not escaped in extended regexps

sed

- `sed` is a *stream editor*. It will change the text of stdin or the file(s) in the arguments and send the result to stdout.
- A `sed` command can be preceded by a range definition. If the range is omitted, all lines are submitted to the command.
- Lines that are unaffected by either the range or the command are printed verbatim to stdout.

sed

- The range takes the form of `a,b` where both `a` and `b` can be either a line number or a regexp indicating the first line where the regexp matches.
- Example: the command
  ```
  1,/^$/d
  ```
  will delete all text from the first line to the first empty line.
- Multiple commands are grouped in braces (`{}`) with each command on a separate line.

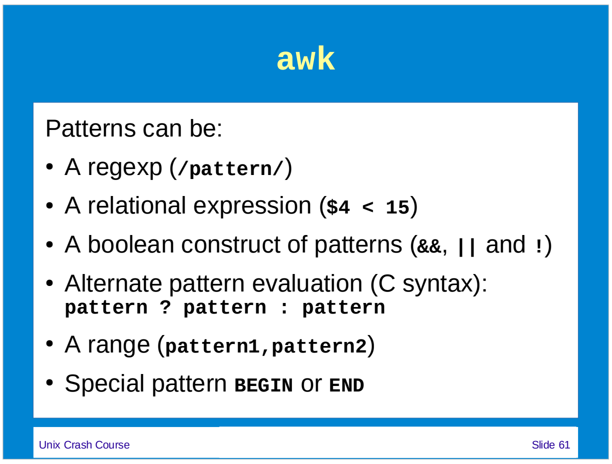
sed

Some common sed commands:

- Substitute: `s/regexp/newtext/flags`
  `\n` and `&` references are available in RHS
- Delete: `/regexp/d`
- Append: *`atext`* or insert *`itext`*.
  A single range token is mandatory. Newlines must be escaped with a backslash (\)
- Transliterate: `y/fromchars/tochars/`
  Replace all occurences from LHS with corresponding character from RHS

awk

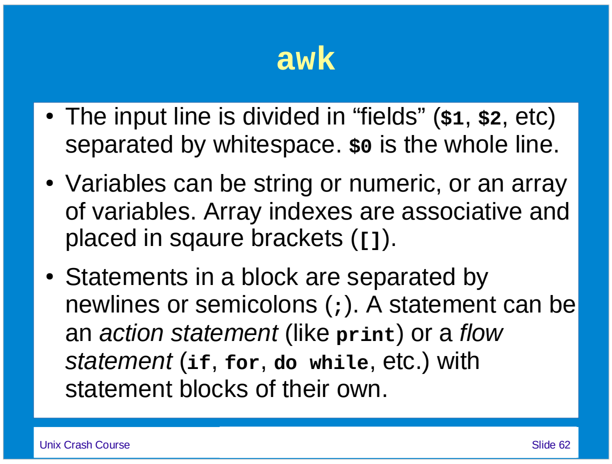
- All commands consist of an optional pattern followed by a block of statements in braces:
  ```
  pattern { statements }
  pattern { statements }
  ...
  ```
- All lines that pass the `pattern` constraint are subjected to the statements
- The `BEGIN` and `END` patterns indicate statements that are executed before and after reading the input respectively



awk

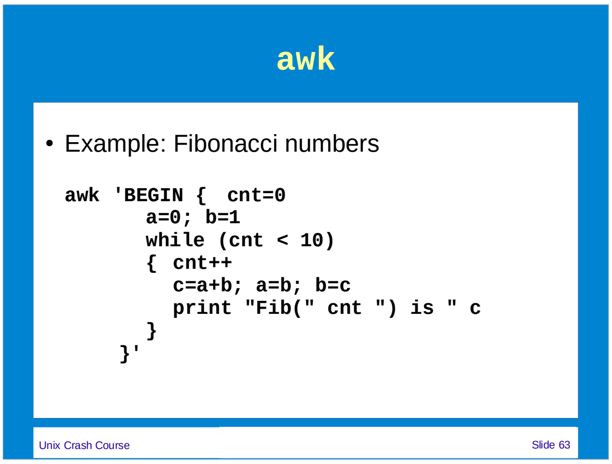
Patterns can be:

- A regexp (`/pattern/`)
- A relational expression (`$4 < 15`)
- A boolean construct of patterns (`&&`, `||` and `!`)
- Alternate pattern evaluation (C syntax): `pattern ? pattern : pattern`
- A range (`pattern1,pattern2`)
- Special pattern `BEGIN` or `END`



awk

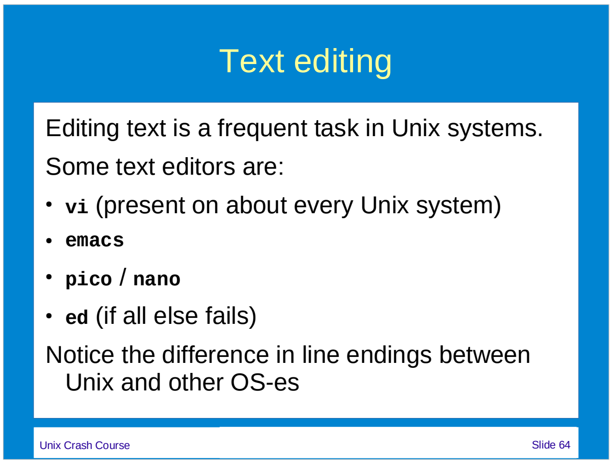
- The input line is divided in “fields” (`$1`, `$2`, etc) separated by whitespace. `$0` is the whole line.
- Variables can be string or numeric, or an array of variables. Array indexes are associative and placed in sqaure brackets (`[]`).
- Statements in a block are separated by newlines or semicolons (`;`). A statement can be an *action statement* (like `print`) or a *flow statement* (`if`, `for`, `do while`, etc.) with statement blocks of their own.



awk

- Example: Fibonacci numbers

```
awk 'BEGIN {  cnt=0
      a=0; b=1
      while (cnt < 10)
      {  cnt++
         c=a+b; a=b; b=c
         print "Fib(" cnt ") is " c
      }
   }'
```



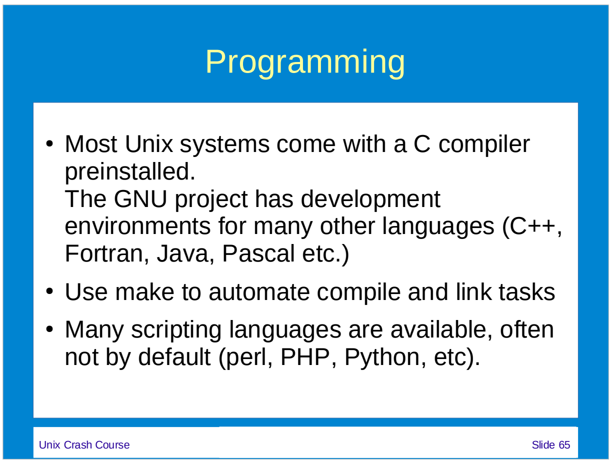
Text editing

Editing text is a frequent task in Unix systems.

Some text editors are:

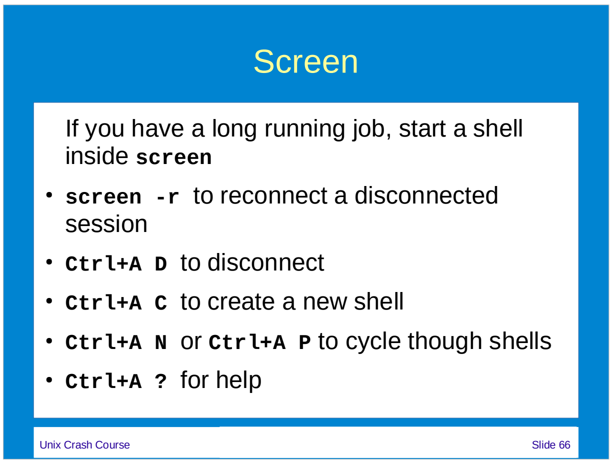
- `vi` (present on about every Unix system)
- `emacs`
- `pico` / `nano`
- `ed` (if all else fails)

Notice the difference in line endings between Unix and other OS-es



Programming

- Most Unix systems come with a C compiler preinstalled.
  The GNU project has development environments for many other languages (C++, Fortran, Java, Pascal etc.)
- Use make to automate compile and link tasks
- Many scripting languages are available, often not by default (perl, PHP, Python, etc).



Screen

If you have a long running job, start a shell inside `screen`

- `screen -r` to reconnect a disconnected session
- `Ctrl+A D` to disconnect
- `Ctrl+A C` to create a new shell
- `Ctrl+A N` or `Ctrl+A P` to cycle though shells
- `Ctrl+A ?` for help

Mumbo Jumbo Revisited

```
find * -name "CV*" -group jewerkisjehobby \
 -exec egrep -il '(creatief|innovatief)' \
 {} \; | xargs nawk '$1 == "email" { \
 print $2 }' | xargs Mail -s \
 "Je baan is in Hilversum" \
 -body http://www.omroep.nl/gurus/
```

Mumbo Jumbo Corrected

```
find * -name "CV*" -group jewerkisjehobby \
| xargs egrep -il '(creatief|innovatief)' \
| xargs nawk '$1 == "email" { print $2 }' \
| while read addr ; do \
echo http://www.omroep.nl/gurus | Mail -s \
"Je baan is in Hilversum" $addr ; done
```

Try it yourself

ubuntu
linux for human beings

- Download an Ubuntu ISO image from: https://ubuntu.com/
- This is a bootable DVD/USB image that you can try on a PC or Mac without overwriting an existing OS ... and it's FREE! (both types)
- Or use it to create a bootable USB or include it as an image on Ventoy (https://ventoy.net/)

^D

Thank you for your interest.

This presentation will be available online at
`https://unix.hamal.nl/`