

```
#include <stdlib.h>
#include <string.h>
#include <ctype.h>
```

```
#define MAXPAROLA 30
#define MAXRIGA 80
```

```
int main(int argc, char *argv[])
```

```
{
    int freq[MAXPAROLA]; /* vettore di contatori
    delle frequenze delle lunghezze delle parole */
    char riga[MAXRIGA];
    int i, inizio, lunghezza;
    FILE *f;
```

```
for(i=0; i<MAXPAROLA; i++)
    freq[i]=0;
```

```
if(argc != 2)
```

```
{
    fprintf(stderr, "ERRORE, serve un parametro con il nome del file\n");
    exit(1);
}
```

```
f = fopen(argv[1], "r");
if(f==NULL)
```

```
{
    fprintf(stderr, "ERRORE, impossibile aprire il file %s\n", argv[1]);
    exit(1);
}
```

```
while( fgets( riga, MAXRIGA, f ) != NULL )
```



# UNIX/Linux environment

## C programming tools

Stefano Quer, Pietro Laface, and Stefano Scanzio

Dipartimento di Automatica e Informatica

Politecnico di Torino

[skenz.it/os](http://skenz.it/os)

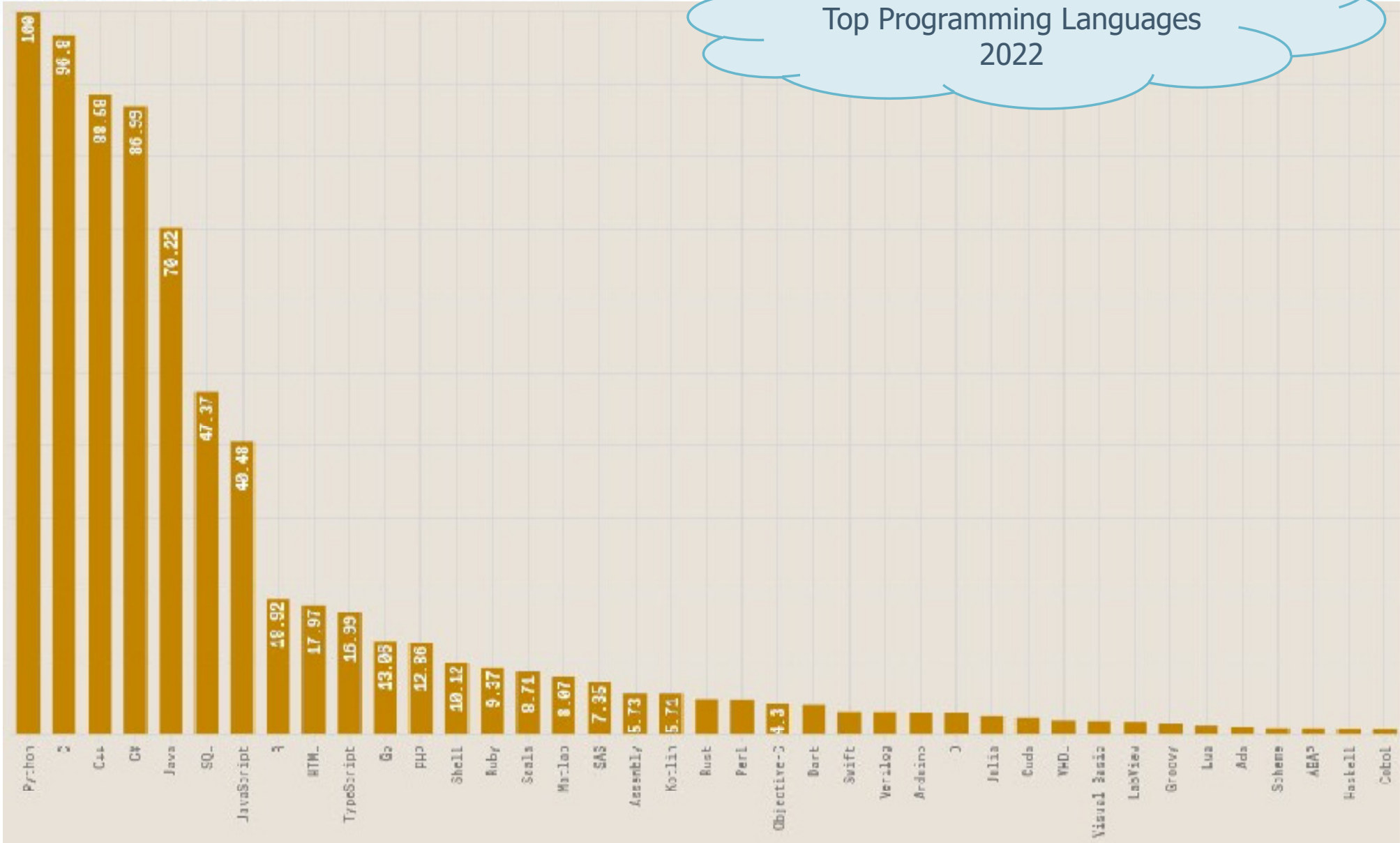
[stefano.scanzio@polito.it](mailto:stefano.scanzio@polito.it)

# Programming languages

- ❖ There are more than 200 programming languages
  - Many are practically not used
  - Others have been used mainly in the past
- ❖ There are several classification techniques / taxonomies
  - More used, more loved, more paid, etc.

# Programming languages

IEEE Spectrum  
Top Programming Languages  
2022



# Programming languages

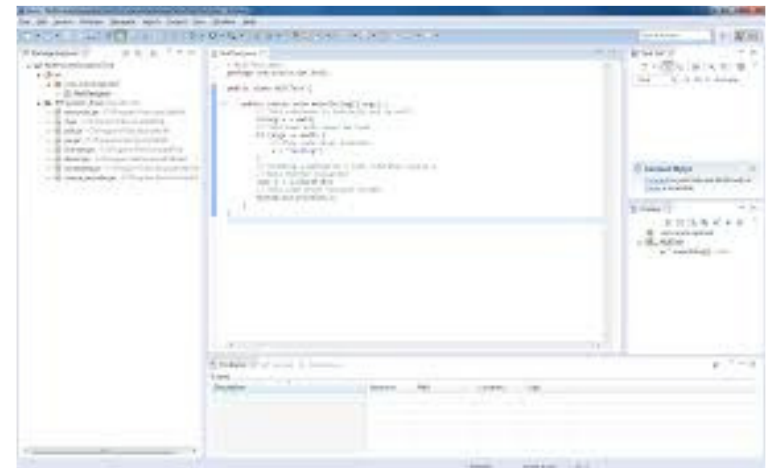
PYPL Index e Stack Overflow  
Settembre 2022

Position	PYPL ranking September 2022	Stack Overflow's Developer Survey 2022
#1	Python	JavaScript
#2	Java	HTML/CSS
#3	JavaScript	SQL
#4	C#	Python
#5	C/C++	TypeScript
#6	PHP	Java
#7	R	Bash/Shell
#8	TypeScript	C#
#9	Go	C++
#10	Swift	PHP



- ❖ Integrated Development Environment (IDE)
  - Single platform to develop projects in different languages
  - They generally provide
    - Text editor, syntax highlighter, customizable interfaces, compiler, code auto-save, version control, debugger, build automation, and deployment.

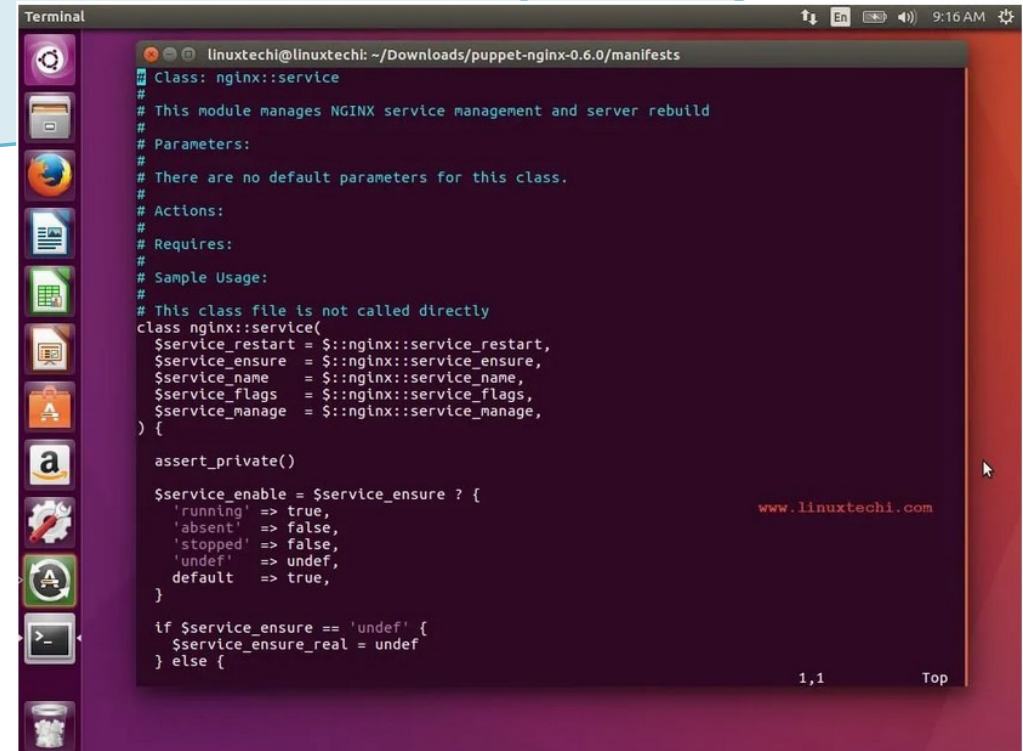
<https://www.geeksforgeeks.org/7-best-ides-for-c-c-plus-plus-developers-in-2022/>  
Settembre 2022



Tool	Comments
Eclipse	Written in JAVA and developed by IBM. It supports C, C++, C#, Java, Javascript, COBO; Perl, Python, etc.
Visual Studio	Written in C++ and developed by Microsoft. It supports C, C++, C#, CSS, Go, HTML, Java, JavaScript, Python, PHP, TypeScript and other.
NetBeans	Free open source, developed by Apache Software Foundation. Recommended for students or beginners and C/C++
<u>CLion</u>	Developed by JetBrains for programmers in C++, best cross-platform platform (macOS, Linux, Windows integrated with Cmake); it supports Kotlin, Python, Swift, etc.
Code::Blocks	Open-source C/C++ IDE developed using wxWidgets, a toolkit GUI; it supports C, C++ e Fortran
CodeLite	Free and open-source for C++; one of the best IDE for code refactoring; supported by Windows and Mac
QtCreator	It requires commercial license for its complete version; it is supported by Windows, Linux, and macOS

- ❖ An editor permits to write textual files (possibly containing programs)

<https://www.linuxtechi.com/top-10-text-editors-for-linux-desktop/>  
Settembre 2022



The screenshot shows a terminal window with a dark background and light-colored text. The prompt is `linuxtechi@linuxtechi: ~/Downloads/puppet-nginx-0.6.0/manifests`. The file content is a Puppet class definition for `nginx::service`. The class includes comments about its purpose and parameters, followed by a class definition block with various service management attributes like `$service_restart`, `$service_ensure`, `$service_name`, `$service_flags`, and `$service_manage`. It also includes an `assert_private()` function and a conditional block for `$service_ensure`. The terminal window has a sidebar on the left with various application icons and a status bar at the bottom showing `1,1` and `Top`.

```
linuxtechi@linuxtechi: ~/Downloads/puppet-nginx-0.6.0/manifests
class nginx::service
#
# This module manages NGINX service management and server rebuild
#
# Parameters:
#
# There are no default parameters for this class.
#
# Actions:
#
# Requires:
#
# Sample Usage:
#
# This class file is not called directly
class nginx::service {
  $service_restart = $::nginx::service_restart,
  $service_ensure   = $::nginx::service_ensure,
  $service_name     = $::nginx::service_name,
  $service_flags    = $::nginx::service_flags,
  $service_manage   = $::nginx::service_manage,
}

  assert_private()

  $service_enable = $service_ensure ? {
    'running' => true,
    'absent'  => false,
    'stopped' => false,
    'undef'   => undef,
    default   => true,
  }

  if $service_ensure == 'undef' {
    $service_ensure_real = undef
  } else {

```

## Editor

Tool	Comments
<b><u>VIM</u></b>	VI Improved. Default editor UNIX/Linux; present everywhere. Difficult but widely configurable.
<b>Geany</b>	Editor for Linux desktop integrable with the development tool GTK+
<b>Sublime</b>	Text editor and development environment. It supports different languages (automatic markup)
<b>Brackets</b>	Produced by ADOBE in 2014 for Linux. Developed with HTML; CSS and JavaScript. Light.
<b><u>Gedit</u></b>	Default editor for the GNOME desktop. Simple user interface. Light.
<b><u>VS Code</u></b>	Visual Studio Code, Microsoft, for Windows, UNIX/Linux, Mac. Very powerfull and usefull editor.
<b>Nano</b>	Similar to the editor Pico, released in 2000, but with several additional features. It allows only a «line interface»
<b><u>Emacs</u></b>	One of the older Linux editors; developed by Richard Stallmann ( <a href="https://youtu.be/jUibaPTXSHk">https://youtu.be/jUibaPTXSHk</a> ), funder of GNU. Completely developed in LISP and C.



## Editor: Vim (Vi)

### ❖ Text editor

- Present in all BSD and Unix systems (and also in embed systems)
- Developed since 1976
- Last version (8.1) in 2018

### ❖ Base version (Vi)

- Is not functional for extensive file editing
- Very useful if other editors cannot be used, or give some problem
  - e.g., remote editing

## Editor: Vim (Vi)

- ❖ Expanded and improved over time
  - Vim = VI Improved
  - In the newer versions can be used for editing large projects
    - Multi-level undo, multi-window, multi-buffer, etc
    - On-line help, syntax highlighting, etc.
- ❖ Together with emacs, it is one of the protagonists of the "war of the editors"
- ❖ Extensions allow to increase editor features

## Editor: Vim (Vi)

- ❖ Run with the command
  - `vi filename`
- ❖ It provides different operating modes
  - **Command Mode**
    - Cursor positioned in the text
    - The keyboard is used to issue commands
  - **Input Mode**
    - Text insertion mode
    - The keyboard is used to insert the text
  - **Directive Mode**
    - Cursor positioned on the last line of the video
    - The keyboard is used for control directives

# Editor: Vim (Vi)

Command Mode	Command
Cursor movements	←, ↑, →, ↓ (h, j, k, l)
Insert Mode (from the cursor)	i
Insert Mode (at the beginning of the line)	I
Append Mode (from the cursor)	a
Append Mode (at the end of the line)	A
Overwrite Mode	R
Pass (return) to Command Mode	esc (key)
Delete a row	dd
Delete a single character	x

Also  
0-g  
n-g

Also  
n-dd  
n-x

Documentation

Local help : man vim

Online resources: <http://www.vim.org/docs.php>

Resources in PDF: <ftp://ftp.vim.org/pub/vim/doc/book/vimbook-OPL.pdf>

## Editor: Vim (Vi)

### Command Mode (continue)

### Command

Insert last deletion

P

Delete a character

X

Cancel the last operation (undo)

u

Restore the last change (redo)

Ctrl-r

### Directive Mode

### Command

Pass to Directive Mode (last line)

:

Show line numbers

:set nu

Save the file

:w!, :w fileName

Exit without saving the latest changes

:q!

Enter the on-line help

:help

Learn Vim (from Google): Vim Adventures <https://vim-adventures.com/>



## Editor: emacs

### ❖ Free text editor

- Emacs = Editor MACroS
- Developed since 1976
- Last version (26.2) in 2019
- Initially developed by Richard Stallman  
[https://en.wikipedia.org/wiki/Richard\\_Stallman](https://en.wikipedia.org/wiki/Richard_Stallman)

### ❖ Preferred by many advanced programmers: powerful, extensible, flexible

### ❖ Various versions, but the most popular are

- GNU Emacs
- Xemacs = next generation Emacs

**Editor: emacs**

## ❖ Available for

- GNU, GNU/Linux
- FreeBSDm, NetBSD, OpenBSD
- Mac OS X
- MS Windows
- Solaris

## Editor: emacs

### ❖ Advantages

- Many features, more powerful than the simple text editor
- Fully customizable
- Fast execution of complex operations

### ❖ Disadvantages

- Slow learning curve
- Written in Lisp

## Editor: emacs

### ❖ Base commands available through

#### ➤ Menu

#### ➤ Character sequences

- Control commands: control + character (c-key)
- Meta commands: alt + character (m-key)

Documentation

Local help : man emacs

Online resources : <http://www.gnu.org/software/emacs/manual/emacs.html>

Resources in PDF: <http://www.gnu.org/software/emacs/maannual/pdf/emacs.pdf>

# Compiler and Debugger

## ❖ Compiler

- GCC
- G++
- Makefile
- Configure

## ❖ Debugger

- GDB



# Compiler: gcc

## ❖ Open-Source GNU project

- gcc compiler and linker
- Supports C and C++

Documentation

Local help : `man gcc`

Online resources : <http://www.gnu.org>

## ❖ Command syntax

### ➤ `gcc <options> <arguments>`

- Options: list of flags that control the compiler and the linker; there are options for compilation only, for linker only, or both
- Arguments: list of files that gcc reads and process depending on the given options

# Examples

- ❖ Compilation of a set of files that produces the corresponding object files
  - `gcc -c file1.c`
  - `gcc -c file2.c`
  - `gcc -c main.c`
- ❖ Link of the object files produces the executable file
  - `gcc -o myexe file1.o file2.o main.o`
- ❖ Compilation and linking with a single command
  - `gcc -o myexe file1.c file2.c main.c`

# gcc options

## ❖ Most common options

### ➤ -c file

- Compilation only

### ➤ -o file

- Specifies the executable name; generally indicates the name of the final executable (after the link operation)

### ➤ -g

- gcc does not produce optimized code, but inserts additional information useful for debugging (see gdb)

### ➤ -Wall

- Output a warning for all possible code errors

# gcc options

Do not insert spaces

## ➤ -Idir

- Specify further directories where searching header files
- More than one directory can be specified (-Idir1 – Idir2 ...)

## ➤ -lm

- Specifies to use the math library

## ➤ -Ldir

- Specifies the search directories for pre-existing libraries to be linked

## Example 1

```
gcc -Wall -g -I. -I/myDir/subDir -o myexe \  
myMain.c \  
fileLib1.c fileLib2.c file1.c \  
file2.c file3.c -lm
```

- ❖ Compilation of many source files, followed by linking and creation of the executable file
  - Multi-row command
  - Provides "All Warnings"
  - Debug option (i.e., do not optimize code)
  - Find the header files in two directories
  - Links the math library



# Makefile

- ❖ Support tools for the development of complex projects
- ❖ Developed since 1998
- ❖ Made up of utilities
  - Makefile
  - Make
- ❖ Provides a convenient tool to automate the compilation and linker steps
- ❖ Help
  - `man make`

First scripting language used in this course

Extremely flexible instrument, but its main strength is the verification of dependencies

# Makefile

## ❖ Makefile has two main aims

- Automatically perform repetitive tasks
- Avoid (re)doing unnecessary tasks
  - by verifying the file **dependencies** and **modification times** (e.g., **re-compile** only the **files** that have been **modified** since the previous make command)

## ❖ Two phases

- Write a makefile file
  - A text file similar to a script (shell script or other)
- The Makefile file is interpreted with the **make** utility
  - This way you can compile and link

## Make options

- ❖ **Make** can be executed using different options
  - Does not execute, just displays the commands
    - -n
  - Ignores possible errors and proceeds with the next commands
    - -i, --ignore-errors
  - Output debug information during the execution
    - -d
  - --debug=[options]
    - Options: a = print all info, b = basic info, v = verbose = basic + other, i = implicit = verbose + other

## Makefile options

- ❖ The command **make** can take as argument a source file (Makefile), with name different than standard ones
  - The **make** command executes by default
    - the file **makefile** if it exists
    - Or the file **Makefile** if the file makefile does not exist
  - **-f <fileName> (or --file <fileName>)**
    - Allows you to execute the Makefile with name <fileName>
    - `make --file <fileName>`
    - `make --file=<fileName>`
    - `make -f <fileName>`

# Makefile format

Tabulation character

```
target: dependency  
    <tab>command
```

## ❖ A Makefile includes

### ➤ Empty lines

- They are ignored

### ➤ Lines starting with "#"

- They are comments, and consequently ignored

### ➤ Lines that specify rules

- Each rule specifies a target, some dependencies, and actions; it can occupy one or more lines
- Very long lines can be splitted by inserting the "\" character at the end of the line



# Makefile format

```
target: dependency
<tab>command
```

- ❖ When a Makefile is executed (with the command `make`)
  - The default behavior is to execute the first rule
    - i.e., the first target in the file
  - If more targets are specified, the desired target can be passed as an argument to `make`
    - `make <targetName>`
    - `make -f <myMakefile> <targetName>`

# Makefile format

- ❖ A makefile consists of "rules" like this:

```
target: dependency  
    <tab>command
```

- ❖ Each rule includes

- Target Name

- Usually the name of a file
- Sometimes the name of an action (which is named "phony" target)

- dependency list that must be verified to execute the target

- Command, or list of commands

- Each command is preceded by a mandatory **TAB** character, **invisible** but necessary

## Example 1: Single target

```
target:
<tab>gcc -Wall -o myExe main.c -lm
```

Notice: TAB

### ❖ Specifies

- A single target with name **target**
- The target does not have dependencies

### ❖ Executing the Makefile

- The **target** is executed
- Since the target does not have dependencies, the execution of the target corresponds to the execution of the compilation command

## Example 2: Multiple targets

```
project1:  
    <tab>gcc -Wall -o project1 myFile1.c  
  
project2:  
    <tab>gcc -Wall -o project2 myFile2.c
```

- ❖ The Makefile specifies more rules
  - Need to choose which is the target to execute
  - The default consists in the execution of the first target
- ❖ Executing the command
  - **make**
    - The target project1 is executed
  - **make project2**
    - The target project2 is executed

## Example 3: Multiple targets and actions

target:

```
<tab>gcc -Wall -o my \
<tab>  main.c \
<tab>  bst.c list.c queue.c stack.c
<tab>cp my /home/myuser/bin
```

Command on  
more rows

clean:

```
<tab>rm -rf *.o *.txt
```

### ❖ Specify more rules

- Rules have no dependencies
- The first target executes two commands (gcc and cp)
  - This first target is executed with the commands
    - make
    - make target

## Example 3: Multiple targets and actions

target:

```
<tab>gcc -Wall -o my \  
<tab>  main.c \  
<tab>  bst.c list.c queue.c stack.c  
<tab>cp my /home/myuser/bin
```

Command on  
more rows

clean:

```
<tab>rm -rf *.o *.txt
```

- The second target removes all the files with extension .o and all the files with extension .txt
  - This second target is executed with the command
    - make clean



## Example 4: dependencies

```
target: file1.o file2.o
<tab>gcc -Wall -o myExe file1.o file2.o

file1.o: file1.c myLib1.h
<tab>gcc -Wall -g -I./dirI -c file1.c

file2.o: file2.c myLib1.h myLib2.h
<tab>gcc -Wall -g -I./dirI -c file2.c
```

- ❖ Execution of multiple targets in the presence of dependencies
  - It checks if target dependencies are more recent than the current target
  - In this case, dependencies are performed before the execution of the current target
  - This process iterates recursively

## Example 4: dependencies

```
target: file1.o file2.o
<tab>gcc -Wall -o myExe file1.o file2.o

file1.o: file1.c myLib1.h
<tab>gcc -Wall -g -I./dirI -c file1.c

file2.o: file2.c myLib1.h myLib2.h
<tab>gcc -Wall -g -I./dirI -c file2.c
```

- ❖ Target has file1.o and file2.o as dependencies
  - rule file1.o is checked
    - If file1.c (or myLib1.h) is more recent than file1.o, this rule (i.e., the gcc command) is executed
    - Otherwise this rule is not executed
  - The same is done for the file2.o rule
  - At the end the target is executed **if necessary**

Action name  
("phony" target)

## Example 4: dependencies

```
target: file1.o file2.o  
    <tab>gcc -Wall -o myExe file1.o file2.o
```

...

File name

```
file2.o: file2.c myLib1.h myLib2.h  
    <tab>gcc -Wall -g -I./dirI -c file2.c
```

- ❖ If the target is not a file name, it is a "phony" target that should always be executed
- ❖ To be sure that is always executed
  - **.PHONY : target**

Regardless the existence of a file with the same name and more recent than dependencies

## Implicit rules and modularity

- ❖ There exist very powerful rules for improving modularity and make more efficient the writing of makefiles
  - Use of macros
  - Use of implicit rules
    - The dependence between .o and .c is automatic
    - The dependence between .c and .h is automatic
    - Recursive dependencies are analyzed automatically
    - etc.

## Example 5: Macro

```
CC=gcc
FLAGCS=-Wall -g
SRC=main.c bst.c list.c util.c
```

Definition of macro:  
macro=name  
(with or without spaces)

```
project: $(SRC)
<tab>$ (CC) $ (FLAGS) -o project $ (SRC) -lm
```

Use of the macro:  
\$(macro)

### ❖ Macro allows to define

#### ➤ Symbols

- Compilers, compilation flags, etc.

#### ➤ Lists

- Object files, executables, directories, etc.

## Example 6: Multi-Folder

```
CC=gcc
FLAGCS=-Wall -g
SDIR=source
HDIR=header
ODIR=obj
```

The macro `$@`  
copies the current  
"target name"

The macro `$^` copies the  
list of files reported in the  
list of dependencies

```
project: $(ODIR)/main.o $(ODIR)/bst.o
<tab>$(CC) $(FLAGS) -o $@ $^
```

```
$(ODIR)/main.o: $(SDIR)/main.c $(HDIR)/main.h
<tab>$(CC) $(FLAGS) -c $^
```

```
$(ODIR)/bst.o: $(SDIR)/bst.c $(HDIR)/bst.h
<tab>$(CC) $(FLAGS) -c $^
```

The macro `$<` would copy the  
first file reported in the list of  
dependencies



## Debugger: gdb

- ❖ Software package used to analyze the behavior of another program in order to identify and eliminate errors (bugs)
- ❖ GNU debugger **`gdb`** is available for almost all Operating Systems
- ❖ It can be used
  - As a "stand-alone" tool
    - Particularly inconvenient use
  - Integrated with many editors (e.g., emacs)
  - Embedded in some graphical IDE
- ❖ Abbreviate form of commands can be given

# Debugger: gdb

Action	Command
Execution commands	<code>run (r)</code> <code>next (n)</code> <code>next &lt;NumberOfSteps&gt;</code> <code>step (s)</code> <code>step &lt;NumberOfSteps&gt;</code> <code>stepi (si)</code> <code>finish (f)</code> <code>continue (c)</code>
Breakpoint commands	<code>info break</code> <code>break (b), ctrl-x-blank</code> <code>break LineNumber</code> <code>break FunctionName</code> <code>break fileName:LineNumber</code> <code>disable BreakpointNumber</code> <code>enable BreakpointNumber</code>

# Debugger: gdb

Action	Command
Print commands	print (p) print expression display expression
Stack operations	down (d) up (u) Info args Info locals
Code listing commands	list (l) list LineNumber list FirstLine, LastLine
Miscellaneous commands	file fileName exec filename kill

<http://darkdust.net/files/GDB%20Cheat%20Sheet.pdf>