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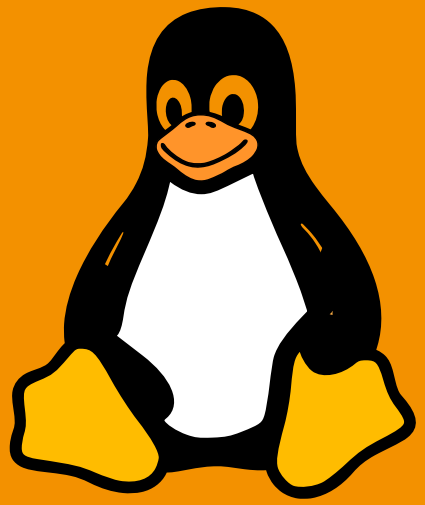
OS 2 – Build



source: iconspng.com

The lecture is based on the work and the documents of Prof. Dr. Ludwig Frank

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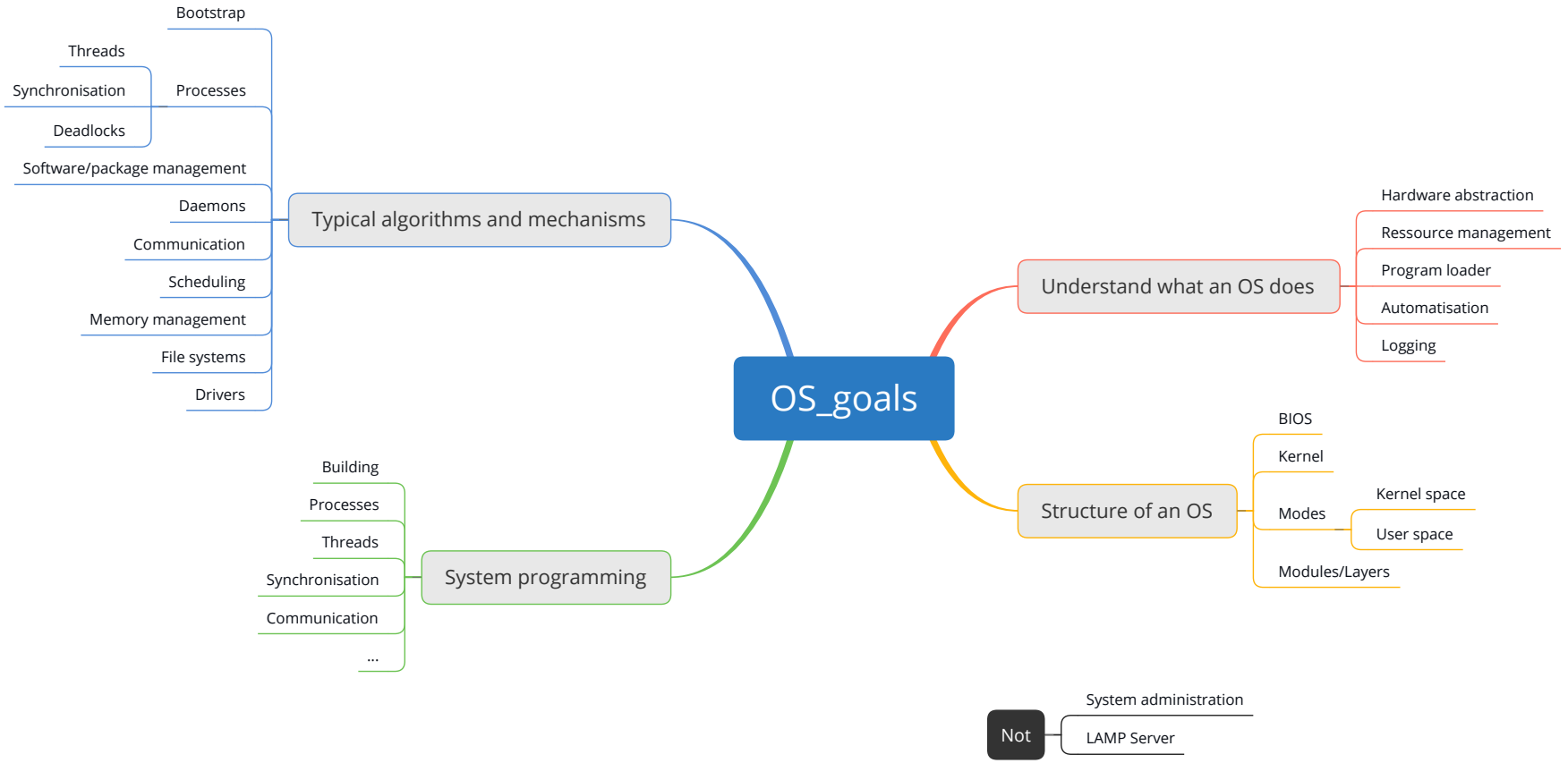
Goal



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Goal

OS::Build

- Build on command line
- ELF
- Makefile
- Autotools

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Build (one step)

A simple hello world

```
1 #include <stdlib.h> //EXIT_SUCCESS
2 #include <stdio.h>  //printf
3
4 int main(int argc, char const* argv[])
5 {
6     printf("hello world\n");
7     return EXIT_SUCCESS;
8 }
```

Build and execute on command line

```
gcc -o hello_world main.c #build (compile + link)
./hello_world             #execute
```

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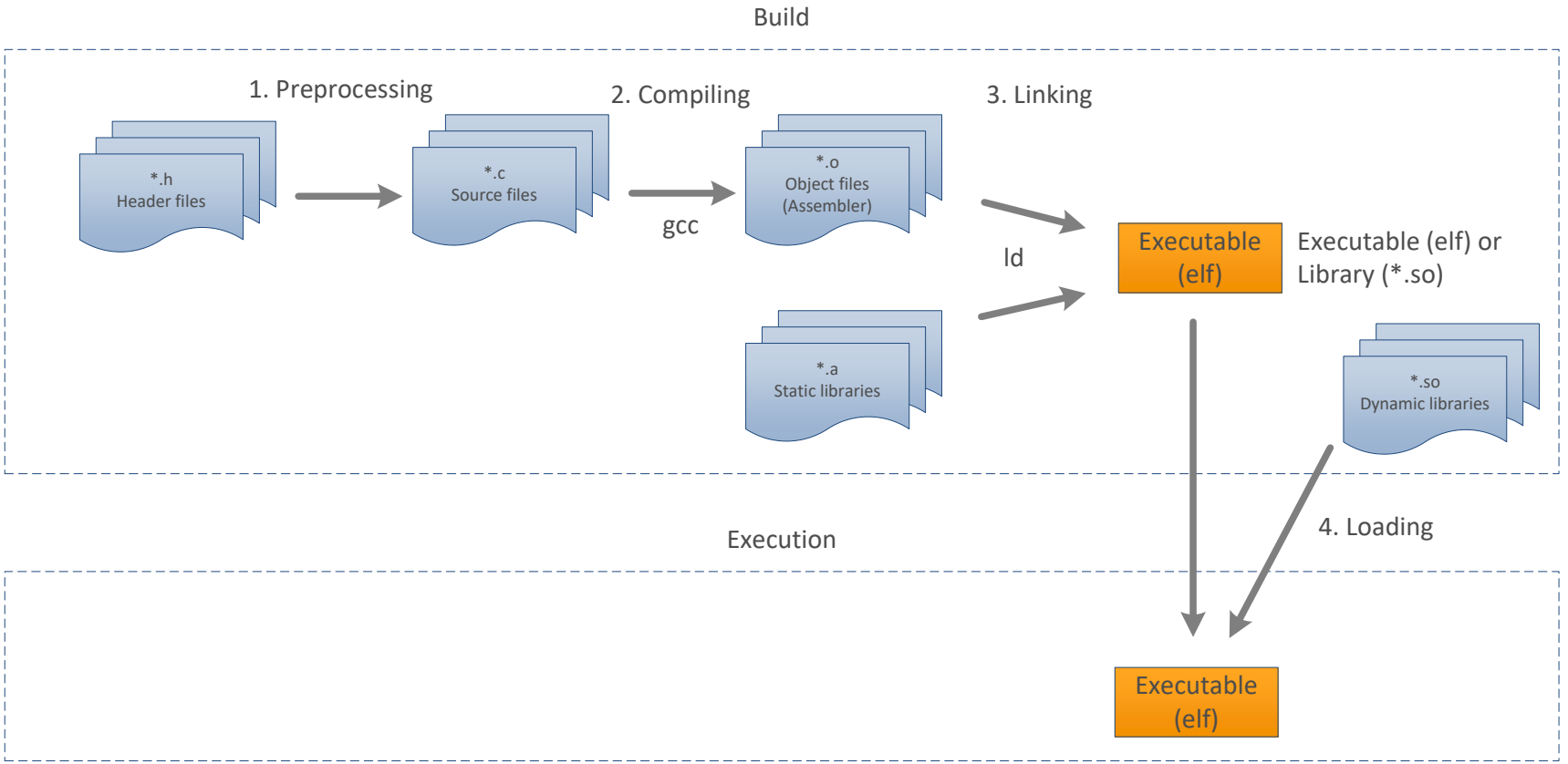
Build process



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Build (separate steps: compile + link)

A simple hello world

```c
#include <stdlib.h> //EXIT_SUCCESS
#include <stdio.h>  //printf

int main(int argc, char const* argv[])
{
    printf("hello world\n");
    return EXIT_SUCCESS;
}
```

Build and execute on command line

```
gcc -c main.c              #compile main.c into main.o
gcc -o hello_world main.o  #link main.o + deps into hello_world
./hello_world              #execute
```

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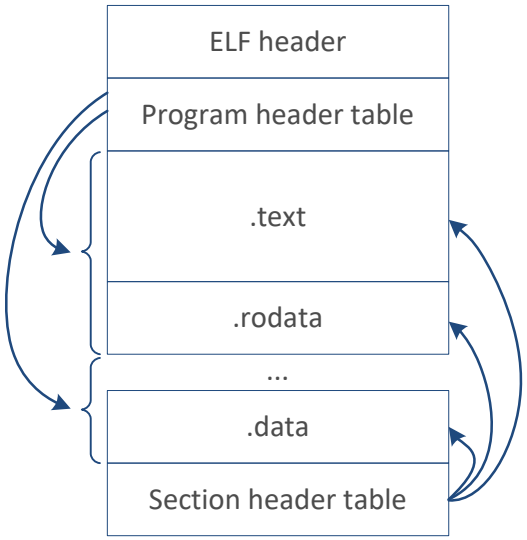
ELF – Executable and Linking Format



Part	Description
ELF header	Describes the files organization
Program header table	Information to create a process image
Section/Segment	Information like: instructions, data, symbol table, relocation information, ...
.text	- Executable instruction for program
.rodata	- Read-only data
.data	- Global tables, variables, etc.
.bss	- Uninitialized arrays and variables
.comment & .note	- Comments from the compiler/linker
.stab & .stabstr	- Debugging symbols & similar information
.symtab	- Symbol table
...	
Section header table	Locations for the sections

More details:
- `https://manpages.debian.org/stretch/manpages/elf.5.en.html`
- `http://www.skyfree.org/linux/references/ELF_Format.pdf`

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Common commands for ELFs

```
1  #!/bin/bash
2
3  strings hello_world     #List all printable strings in a
4                          #binary file.
5
6  ldd hello_world         #List all shared libraries on which
7                          #the object binary depends.
8
9  nm hello_world          #List all symbols from the object file.
10 strip hello_world       #Delete the symbol table information.
11
12 #Display detailed information from object files.
13 objdump -t hello_world #Display symbols
14 objdump -d hello_world #Display disassembly
15
16 readelf -a hello_world #Display information about an ELF
17                         #object file.
```

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Second example

main.c

```c
#include <stdlib.h>         //EXIT_SUCCESS
#include <stdio.h>          //printf
#include "mathfunctions.h" //int_add

int main(int argc, char const* argv[])
{
    int a = 3, b = 4;

#ifdef USE_SPECIAL_ADD
    printf("use special add\n");
    int result = int_add(a, b);
#else
    int result = a + b;
#endif

    printf("%d + %d = %d\n", a, b, result);
    return EXIT_SUCCESS;
}
```

mathfunctions.h

```c
#ifndef MATH_FUNCTIONS_H
#define MATH_FUNCTIONS_H

/*!
 * Adds two integers a, b.
 */
int int_add(int a, int b);

#endif
```

mathfunctions.c

```c
#include "mathfunctions.h"

int int_add(int a, int b){
    return a + b;
}
```

build: `gcc -D USE_SPECIAL_ADD -o simple_prog mathfunctions.c main.c`

Any problems?

What is the problem with building on the shell with raw `gcc` command?

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Makefile example (1)

Makefile

```
1  #target for the whole program
2  simple_prog: main.o mathfunctions.o
3      gcc -o simple_prog main.o mathfunctions.o
4
5  #target for the main file
6  main.o: main.c
7      gcc -c main.c -D USE_SPECIAL_ADD
8
9  #target for the mathfunctions file
10 mathfunctions.o: mathfunctions.c mathfunctions.h
11     gcc -c mathfunctions.c
12
13 ## syntax:
14 #target: depends_on_file_or_target
15 #    command
16
17 #Behavior: if depends_on has changed, the command is executed
```

Build:

```
make
```

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Makefile example (2)

Makefile

```
1  CC=gcc
2
3  #target for the whole program
4  simple_prog: main.o mathfunctions.o
5      $(CC) -o simple_prog main.o mathfunctions.o
6
7  #target for the main file
8  main.o: main.c
9      $(CC) -D USE_SPECIAL_ADD -c main.c
10
11 #target for the mathfunctions file
12 mathfunctions.o: mathfunctions.c mathfunctions.h
13     $(CC) -c mathfunctions.c
```

Build:

```
make
```

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Makefile example (3)

Makefile

```
1  CC=gcc
2  CFLAGS=-DUSE_SPECIAL_ADD
3
4  #target for the whole program
5  simple_prog: main.o mathfunctions.o
6      $(CC) $(CFLAGS) -o simple_prog main.o mathfunctions.o
7
8  #target for the main file
9  main.o: main.c
10     $(CC) $(CFLAGS) -c main.c
11
12 #target for the mathfunctions file
13 mathfunctions.o: mathfunctions.c mathfunctions.h
14     $(CC) $(CFLAGS) -c mathfunctions.c
```

Build:

```
make
```

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Makefile example (4)

Makefile

```
1  #variables
2  CC=gcc
3  CFLAGS=-I. -D USE_SPECIAL_ADD
4  DEPS = mathfunctions.h
5  OBJ = main.o mathfunctions.o
6
7  #targets
8  %.o: %.c $(DEPS)
9      $(CC) -c -o $@ $< $(CFLAGS)
10
11 simple_prog: $(OBJ)
12     $(CC) -o $@ $^ $(CFLAGS)
13
14 #.PHONY are targets that have no dependencies
15 .PHONY: clean
16 clean:
17     rm -f *.o
```

Build:

```
make
```

Parallel build:

```
make -j
```

Clean:

```
make clean
```

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Any problems with Makefiles?

What are the problems with Makefiles?

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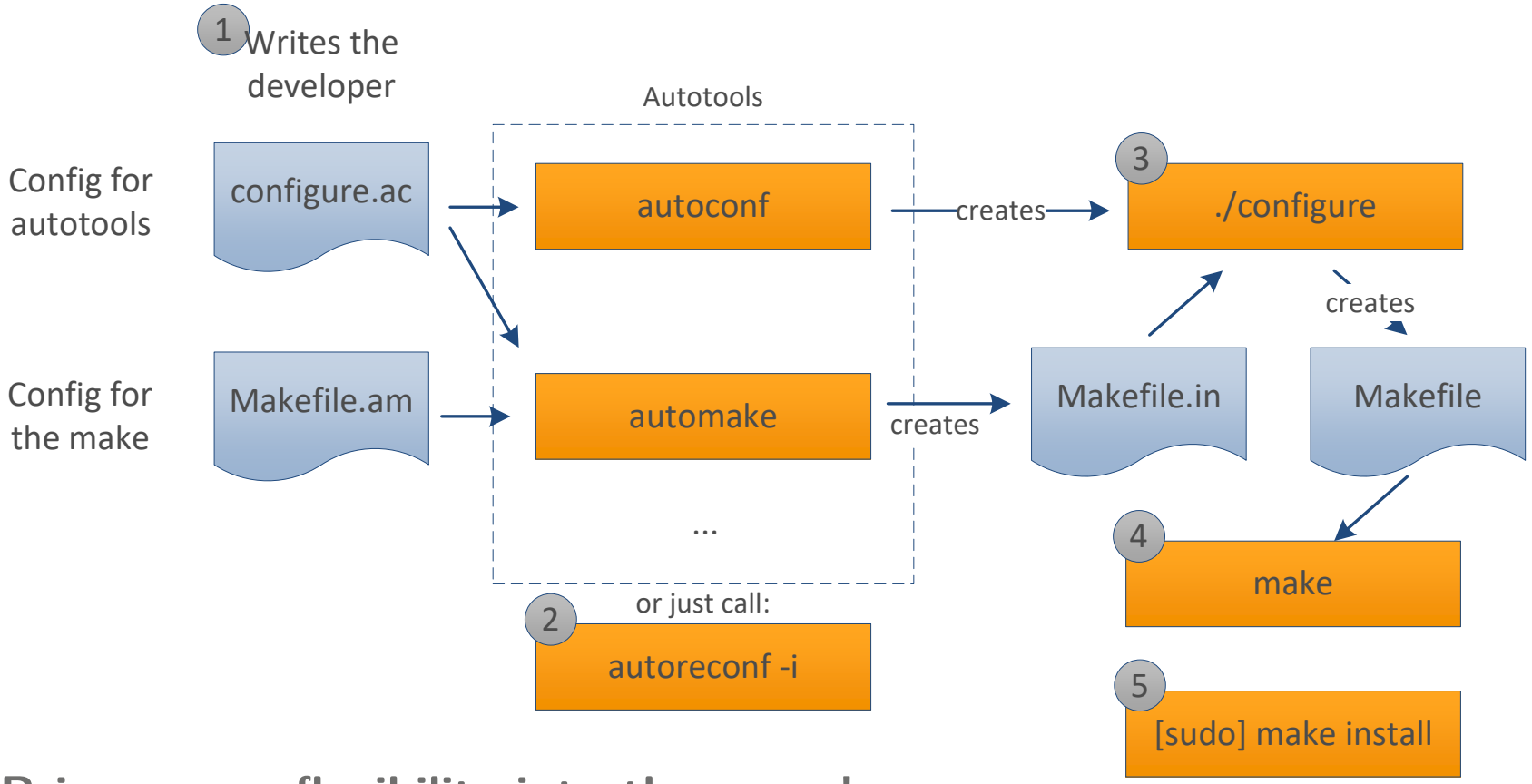
Autotools



Brings more flexibility into the game!

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Autotools: configure example

configure.ac

```
1  AC_PREREQ([2.69])
2  AC_INIT([simple_prog], [1.0], [florian.kuenzner@th-rosenheim.de])
3  AC_CONFIG_HEADERS([config.h])
4
5  # Configure to use build-aux for auxilary files
6  AC_CONFIG_AUX_DIR([build-aux])
7
8  # Checks for programs.
9  AC_PROG_CC
10
11 # Checks for header files.
12 AC_CHECK_HEADERS([stdlib.h])
13
14 # Init automake
15 AM_INIT_AUTOMAKE([1.11 -Wall -Werror])
16
17 # Configure creates Makefile
18 AC_CONFIG_FILES([Makefile])
19
20 AC_OUTPUT
```

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Autotools: make example

Makefile.am

```
1  #target binary
2  bin_PROGRAMS = simple_prog
3
4  #sources
5  simple_prog_SOURCES = main.c mathfunctions.c
6
7  #compiler flags
8  simple_prog_CFLAGS = -DUSE_SPECIAL_ADD
9
10 #manpage
11 man_MANS = simple_prog.1
```

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Autotools: manpage example

simple_prog.1

```
1  .\" Manpage for simple_prog
2  .\" Contact florian.kuenzner@th-rosenheim.de to correct errors or
3  .TH man 7 "14 Septenber 2018" "1.0" "simple_prog man page"
4  .SH NAME
5  simple_prog \- do something useful
6  .SH SYNOPSIS
7  simple_prog
8  .SH DESCRIPTION
9  simple_prog is a program that does something useful.
10 .SH OPTIONS
11 The simple_prog does not take any options.
12 .SH BUGS
13 No known bugs.
14 .SH AUTHOR
15 Florian Künzner (florian.kuenzner@th-rosenheim.de)
```

View: `man ./simple_prog.1`

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Autotools: usage example

```
1  #initialise the build system
2  autoreconf -i
3
4  #create the Makefile
5  ./configure
6
7  #make
8  make -j
9
10 #install
11 sudo make install
12
13 #uninstall
14 sudo make uninstall
15
16 #clean
17 make clean
```

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Any problems with autotools?

Are there still problems with the build?

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Summary and outlook

Summary

- Build on command line
- ELF
- Makefile
- Autotools

Outlook

- Software management
- Create own packages
- Flatpak