

COMP26020 Programming Languages and Paradigms Part 1: C Programming

Modular Compilation

Modular Compilation

- Large programs: need to organise the code in several source files
 - [Redis's src folder](#)
 - [Linux](#) kernel sources (59000 C source files for v6.11!)
- **How to break up the program code into different files representing well-isolated compilation units?**
 - Modular compilation, covered in this slide deck

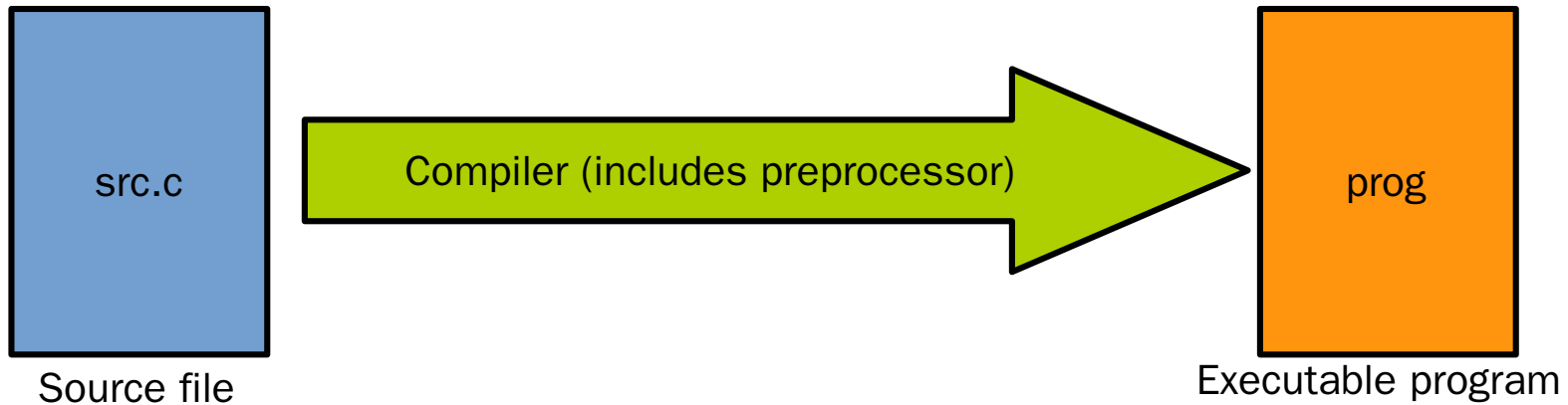
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- **How to break up the program code into different files representing well-isolated compilation units?**
 - Modular compilation, covered in this slide deck
- Also, can't run `gcc <59K source files>` each time we do a small update to one or a few source files
- **How to automate efficiently the build process?**
 - Automated compilation, covered in the next slide deck

A Closer Look at the Compilation Phase

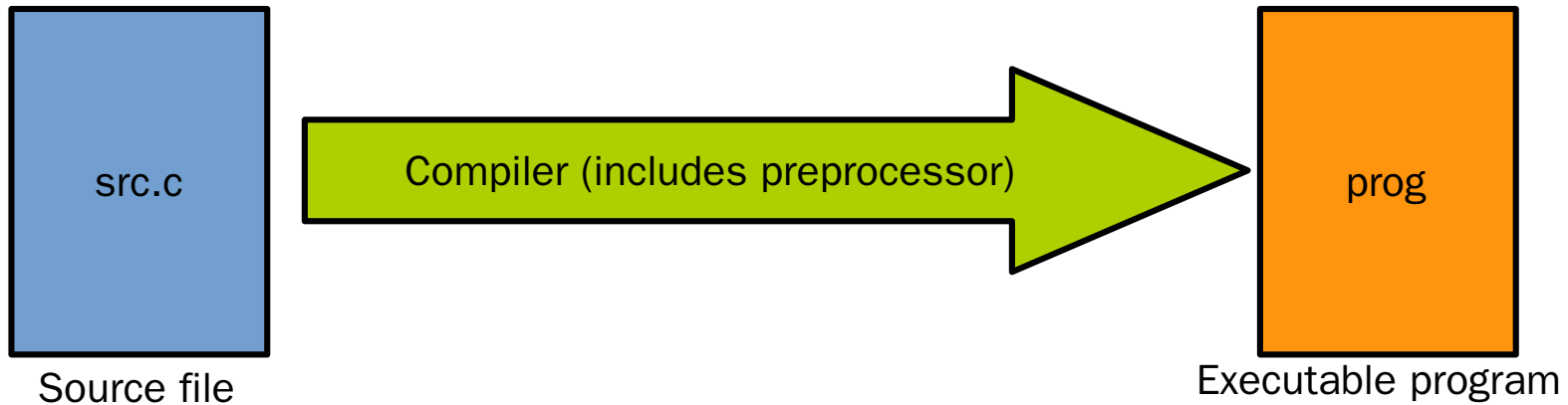
A Closer Look at the Compilation Phase

```
gcc src.c -o prog
```



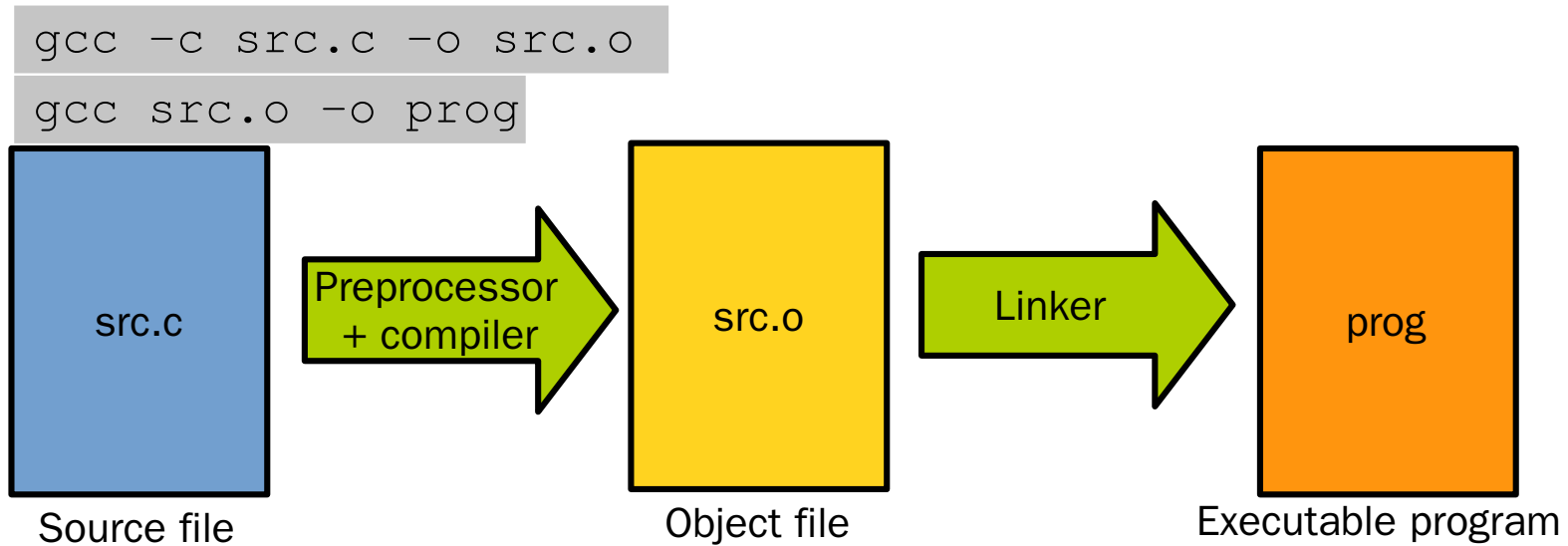
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```
gcc src.c -o prog
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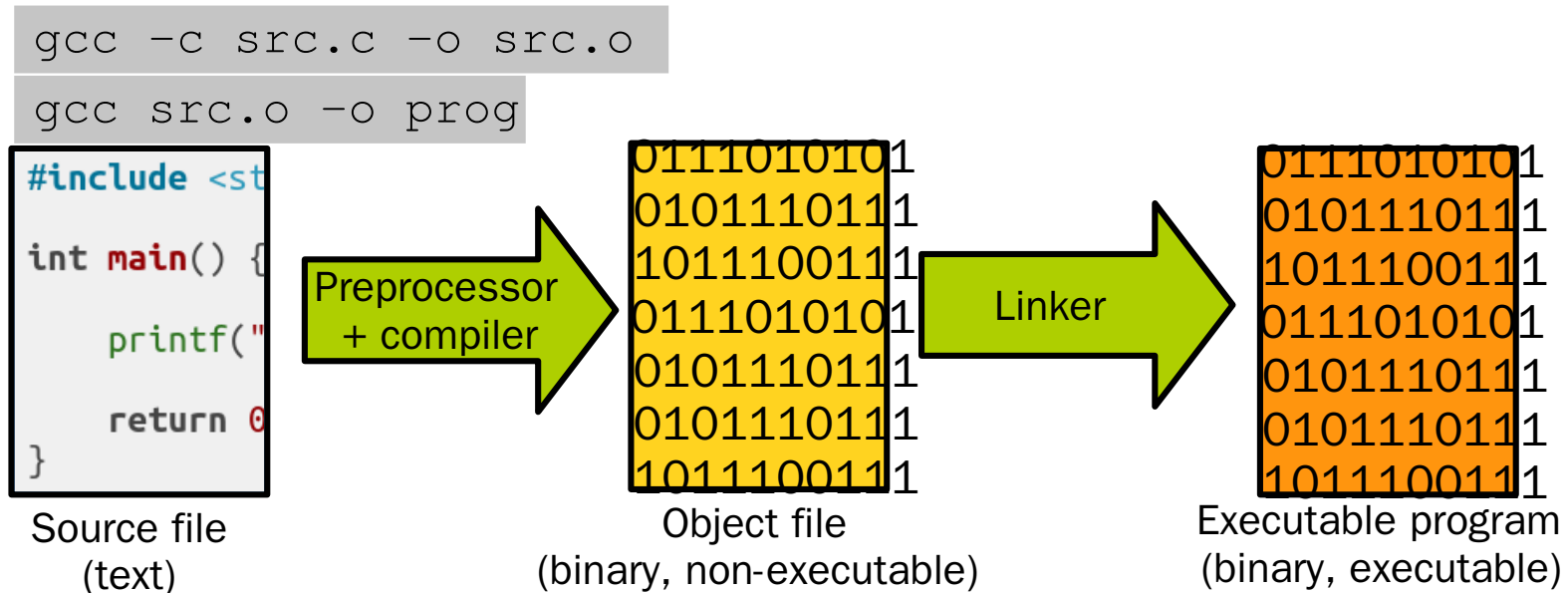


Actually things are still a little bit more complicated 🤪

A Closer Look at the Compilation Phase



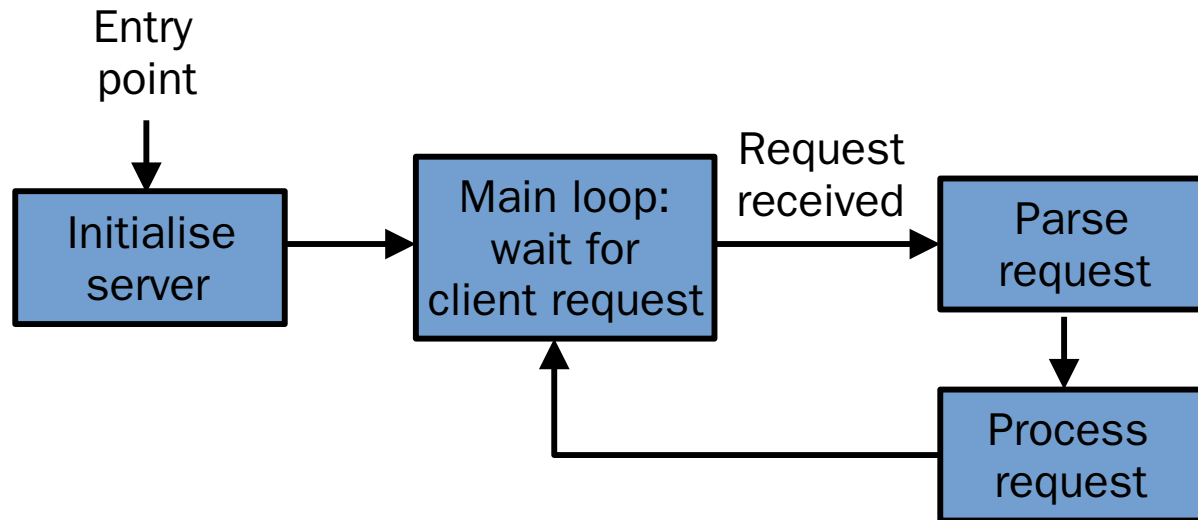
A Closer Look at the Compilation Phase



Breaking Down the Program into Modules

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- Consider a hypothetical server application working as follows:



Breaking Down the Program into Modules

- Server implemented into 3 `.c` source files, also named **modules**:

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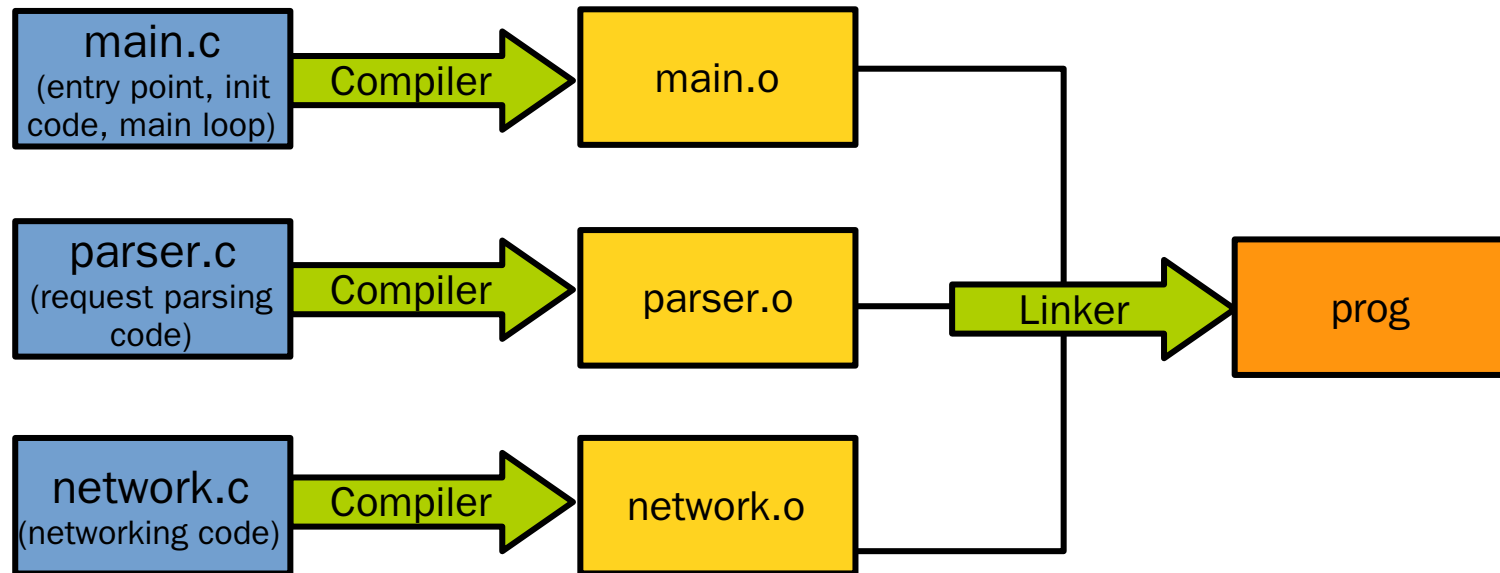
main.c
(entry point, init
code, main loop)

parser.c
(request parsing
code)

network.c
(networking code)

Breaking Down the Program into Modules

- Server implemented into 3 `.c` source files, also named **modules**:



```
gcc -c main.c -o main.o
gcc -c parser.c -o parser.o
gcc -c network.c -o network.o
gcc main.o network.o parser.o -o prog
```

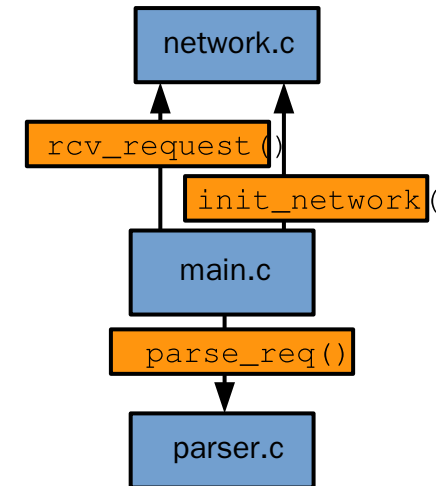
```
# build main.o
# build parser.o
# build network.o
# link prog
```

Breaking Down the Program into Modules

- Each module (.c source file) exposes an **interface** callable from the other source files
 - Should be **as small as possible** to hide internal code/data

Breaking Down the Program into Modules

- Each module (.c source file) exposes an **interface** callable from the other source files
 - Should be **as small as possible** to hide internal code/data
- Assume the following interactions:
 - Server starts, `main.c` calls `init_network()` implemented in `network.c` to init. networking
 - `main.c` then runs the main sever loop:
 - Calls `rcv_request()` implemented in `network.c` to wait for the next request
 - When received, calls `parse_req()` implemented by `parser.c` to process the request
 - Rince and repeat



Header File for Modular Compilation

- There is generally 1 header file per module, **defining its interface**.
- Can be included in several `.c` files so **must contain only declarations**
 - Function prototypes, struct/typedefs/enums declarations, variable declarations
 - **No definitions** (i.e. function body/global variable initialisation)
- For example `network.h`:

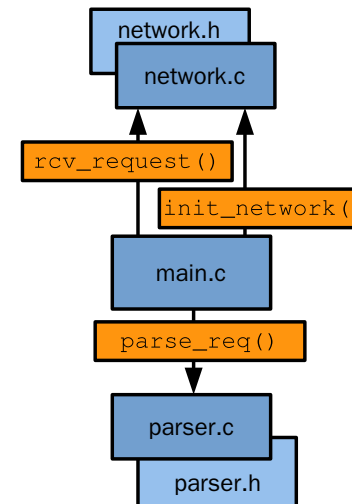
```
#ifndef NETWORK_H // include guard
#define NETWORK_H

typedef struct {
    int id;
    char content[128];
} request;

void init_network();
int rcv_request(request *r);

#endif /* NETWORK_H */
//
```

[16-modular-compilation/network.h](#)



Breaking Down the Program into Modules

- network.c:

```
/* std includes here */
#include "network.h"

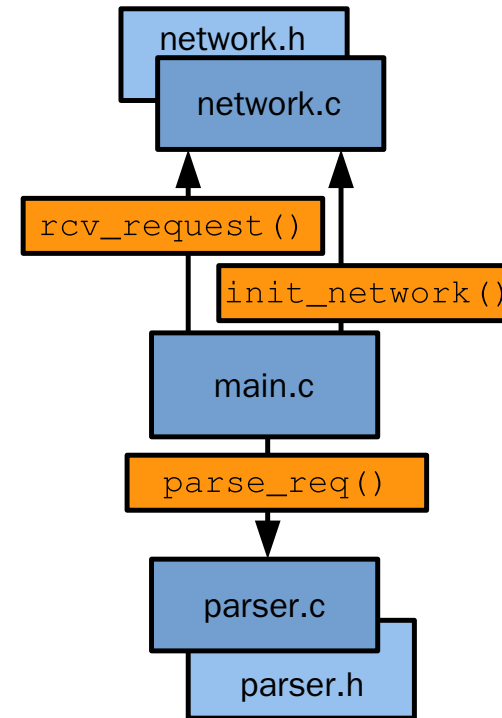
// this function and variable are internal
// so they are not declared in network.h
// the keyword static force their use
// to be only within the network.c file
static void generate_request(request *r);
static int request_counter = 0;

void init_network() {
    /* init code here ... */
}

int rcv_request(request *r) {
    generate_request(r);
    /* ... */
}

static void generate_request(request *r) {
    /* ... */
}
```

[16-modular-compilation/network.c](#)



Breaking Down the Program into Modules

- `parser.h`:

```
#ifndef PARSER_H
#define PARSER_H

/* needed for the definition of request: */
#include "network.h"

void parse_req(request *r);

#endif
```

[16-modular-compilation/parser.h](https://github.com/16-modular-compilation/parser.h)

- `parser.c`:

```
#include <stdio.h>

#include "parser.h"

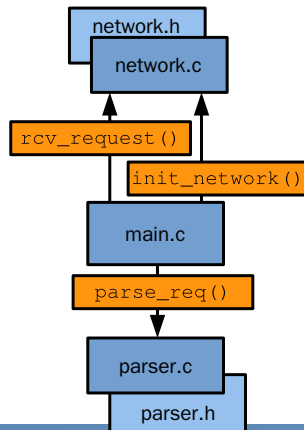
static void internal1(request *r);
static void internal2(request *r);

void parse_req(request *r) {
    internal1(r);
    internal2(r);
}

static void internal1(request *r) {
    /* ... */
}

static void internal2(request *r) {
    /* ... */
}
```

[16-modular-compilation/parser.c](https://github.com/16-modular-compilation/parser.c)



Breaking Down the Program into Modules

- `main.c`:

```
#include "network.h"
#include "parser.h"

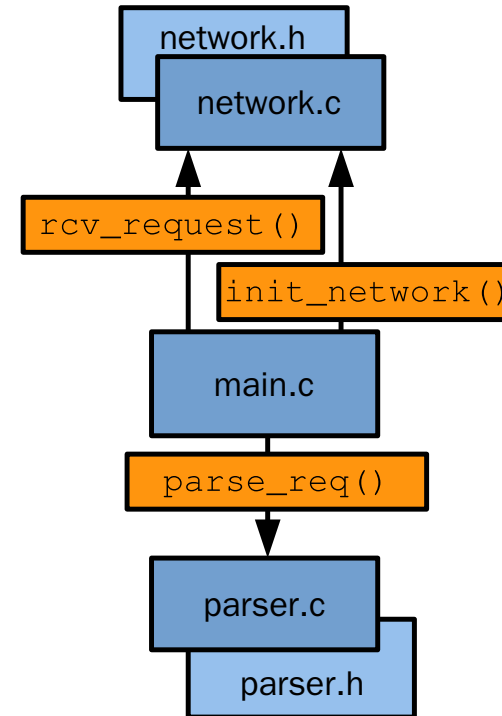
int main(int argc, char **argv) {
    request req;

    /* call functions from network module */
    init_network();
    rcv_request(&req);

    /* call function from parser module */
    parse_req(&req);

    /* ... */
}
```

[16-modular-compilation/main.c](#)



Compile & Test

```
# Compile the .c source files, in no particular order:
$ gcc -c main.c -o main.o
$ gcc -c parser.c -o parser.o
$ gcc -c network.c -o network.o

# Link the final executable:
$ gcc main.o parser.o network.o -o prog

# Launch it
$ ./prog
```

Summary

- **Modular Compilation:** breaking down a program's sources into multiple header `.h` files and source `.c` files
 - Proper source organisation is important for medium/large programs
 - Export using header files only the interface supposed to be used from outside the module
-

Feedback form: <https://bit.ly/3lInZ8h>

