

# Tools

“to get a deeper understanding of the language”



Deep C - a 3 day course  
Jon Jagger & Olve Maudal

A glimpse into tools often  
used when developing C

# Exercise: Deep thought, Part I

dt.c

```
#include "dt.h"

int dt_base_value;
#define MULTIPLIER 7
static int dt_answer;

static void run_computer(void)
{
    dt_answer = dt_base_value * MULTIPLIER;
}

int dt_get_answer(void)
{
    run_computer();
    return dt_answer;
}
```

dt.h

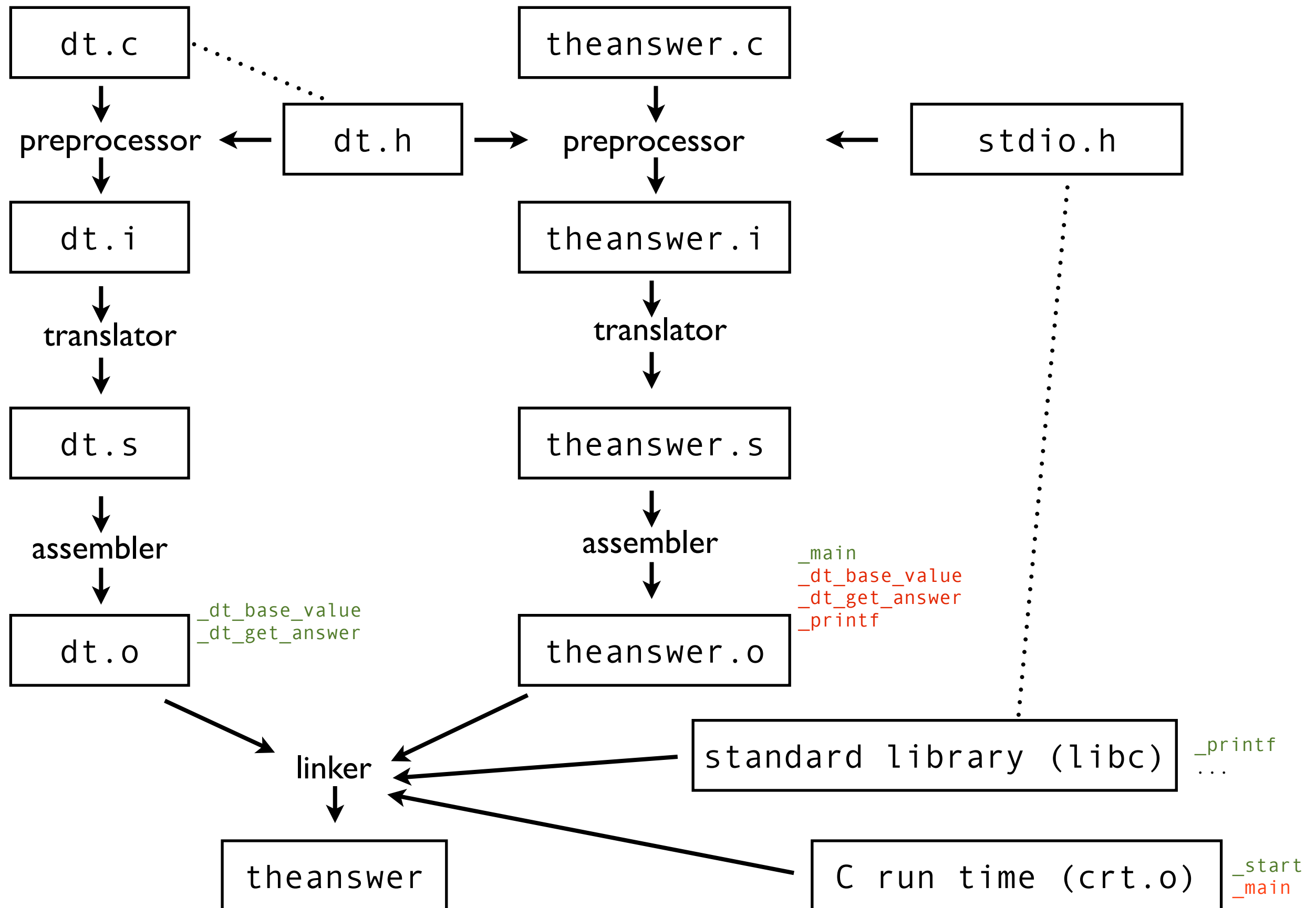
```
extern int dt_base_value;
int dt_get_answer(void);
```

theanswer.c

```
#include "dt.h"
#include <stdio.h>

int main(void)
{
    dt_base_value = 6;
    int answer = dt_get_answer();
    printf("The answer is %d\n",
           answer);
}
```

```
$ cc -c dt.c
$ cc -c theanswer.c
$ cc -o theanswer theanswer.o dt.o
$ ./theanswer
The answer is 42
$
```



# Exercise: Deep thought, Part 2

```
dt.c
#include "dt.h"

int dt_base_value;
static int dt_answer;

static void run_computer(int multiplier)
{
    dt_answer = dt_base_value * multiplier;
}

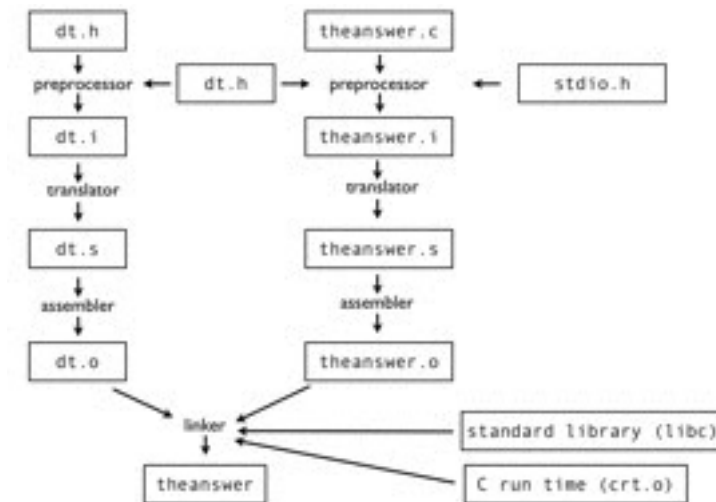
void dt_init(void)
{
    dt_base_value = 6;
}

int dt_compute_answer(void)
{
    run_computer(7);
    return dt_answer;
}

dt.h
void dt_init(void);
int dt_compute_answer(void);

theanswer.c
#include <stdio.h>
#include "dt.h"

int main(void)
{
    dt_init();
    int answer = dt_compute_answer();
    printf("The answer is %d\n",
          answer);
}
```



```
$ cc -E dt.c >dt.i
$ cat dt.i
$ cc -S dt.i
$ cat dt.s
$ cc -c dt.s
$ nm dt.o
```

```
$ cc -c -save-temps theanswer.c
$ ls theanswer.*
$ nm theanswer.o
```

```
$ ld -lc -o theanswer dt.o theanswer.o /usr/lib/crt1.o
$ ./theanswer
The answer is 42
```

# Exercise: Deep thought, Part 3

dt.c	dt.h
<pre>#include "dt.h"  int dt_base_value; static int dt_answer;  static void run_computer(int multiplier) {     dt_answer = dt_base_value * multiplier; }  void dt_init(void) {     dt_base_value = 6; }  int dt_compute_answer(void) {     run_computer(7);     return dt_answer; }</pre>	<pre>void dt_init(void); int dt_compute_answer(void);</pre>
	<pre>theanswer.c  #include &lt;stdio.h&gt; #include "dt.h"  int main(void) {     dt_init();     int answer = dt_compute_answer();     printf("The answer is %d\n",         answer); }</pre>

```
$ cc -g -o theanswer dt.c theanswer.c
$ gdb theanswer
(gdb) run
(gdb) break run_computer
(gdb) run
(gdb) set dt_base_value = 8
(gdb) cont
(gdb) disassemble run_computer
(gdb) set disassembly-flavor intel
(gdb) disassemble run_computer
(gdb) help
(gdb) quit
```

# include test seam

- [-iquote folder] adds a new #include ".." folder
- [-isystem folder] adds a new #include "<...>" folder

```
CFLAGS += -iquote ./local_seam
CFLAGS += -isystem ./system_seam

target: ...
    @gcc -v $(CFLAGS) ... -o $@
```

makefile

↓  
verbose

```
#include ".." search starts here:
./local_seam
#include <...> search starts here:
./system_seam
/usr/lib/gcc/x86_64-linux-gnu/4.8/include
/usr/local/include
/usr/lib/gcc/x86_64-linux-gnu/4.8/include-fixed
/usr/include/x86_64-linux-gnu
/usr/include
End of search list.
```

# test seams

- suppose I want to test a scenario where `getaddrinfo()` fails

message.c

```
#include "message.h"
#include <netdb.h> // getaddrinfo();
...

int send_message(const char * msg, size_t size)
{
    struct addrinfo hints =
    {
        .ai_family = AF_UNSPEC,
        .ai_socktype = SOCK_STREAM,
        .ai_flags = AI_PASSIVE
    };
    const char * port = "3490";
    struct addrinfo * serv_info;
    int rv = getaddrinfo(NULL, port, &hints, &serv_info);
    → if (rv != 0) ←
    {
        fputs("getaddrinfo: ", stderr);
        fputs(gai_strerror(rv), stderr);
        fputc('\n', stderr);
        return EXIT_FAILURE;
    }
    ...
}
```



# fake function test seam

- a test can `#include` the source and selected fake functions

test\_send\_message/getaddrinfo\_failure\_prints\_gai\_diagnostic\_to\_stderr.c

```
#include "message.c"

...
int getaddrinfo(const char * host_name, const char * server_name,
               const struct addrinfo * hints, struct addrinfo ** result)
{
    ...
    return 42; // force failure ←
}

int main(void)
{
    const char message[] = "Hello, world";
    int rv = send_message(message, sizeof message);
    assert(rv == EXIT_FAILURE);
    assert(...);
    assert(...);
}
```

# fake function test seam

- the excellent FFF\* makes writing fakes very easy

test\_send\_message/getaddrinfo\_failure\_prints\_gai\_diagnostic\_to\_stderr.c

```
#include "message.c"
#include "fff.h"
...
FAKE_VALUE_FUNC(int, getaddrinfo, const char *, const char *,
                  const struct addrinfo *, struct addrinfo **)
FAKE_VALUE_FUNC(int, fputs, const char *, FILE *)
...
int main(void)
{
    ...
    getaddrinfo_fake.return_val = EAI_AGAIN;

    const char message[] = "Hello, world";
    int rv = send_message(message, sizeof message);
    assert(rv == EXIT_FAILURE);
    assert(getaddrinfo_fake.call_count == 1);
    assert(fputs_fake.call_count == 2);
    assert(strcmp("getaddrinfo: ", fputs_fake.arg0_history[0]) == 0);
    assert(fputs_fake.arg1_history[0] == stderr);
    assert(strcmp(gai_strerror(getaddrinfo_fake.return_val),
                  fputs_fake.arg0_history[1]) == 0);
    assert(fputs_fake.arg1_history[1] == stderr);
    ...
}
```

\*Fake Function Framework: <https://github.com/meekrosoft/fff>

# link time test seam

- use `-Wl,--wrap=func` to redirect func to `__wrap_func`
- only works *across* translation units

```
target: dependencies
    @gcc -Wl,--wrap=getaddrinfo ... -o $@
```

makefile

test\_send\_message/getaddrinfo\_failure\_prints\_gai\_diagnostic\_to\_stderr.c

```
#include "message.h"
...
int __wrap_getaddrinfo(const char * host_name, const char * server_name,
                      const struct addrinfo * hints, struct addrinfo ** result)
{
    ...
    return 42;
}

int main(void)
{
    const char message[] = "Hello, world";
    int rv = send_message(message, sizeof message);
    assert(rv == EXIT_FAILURE);
    assert(...);
    assert(...);
}
```

## link time test seam

- simply link to a different object file

# run time test seam

- using function pointers

```
#include "..."  
  
struct netdb_api  
{  
    int (*getaddrinfo)(const char *, const char *,  
                       const struct addrinfo *, struct addrinfo **);  
    ...  
};  
  
extern const struct netdb_api netdb;
```

```
#include "message.h"  
#include "netdb_api.h"  
  
int send_message(const char * msg, size_t size)  
{  
    ...  
    const char * port = "3490";  
    struct addrinfo * serv_info;  
    int rv = netdb.getaddrinfo(NULL, port, &hints, &serv_info);  
    if (rv != 0)  
    {  
        fputs("getaddrinfo: ", stderr);  
        fputs(gai_strerror(rv), stderr);  
        fputc('\n', stderr);  
        return EXIT_FAILURE;  
    }  
    ...  
}
```

# run time test seam

- using function pointers

```
#include "message.h"
...
int fake_getaddrinfo(
    const char * host_name, const char * server_name,
    const struct addrinfo * hints, struct addrinfo ** result)
{
    ...
    return 42; // force failure
}

int main(void)
{
    const char message[] = "Hello, world";
    netdb.getaddrinfo = fake_getaddrinfo;
    int rv = send_message(message, sizeof message);
    assert(rv == EXIT_FAILURE);
    assert(...);
    assert(...);
}
```

# Summary

- hello world!
- behaviour
- vocabulary of the language
- preprocessor, translator, assembler, linker
- standard library and C run-time
- test seams, e.g. fake functions
  - linker wrapping
  - function pointers

TODO: profiling