Lecture 13: The C Preprocessor

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CMPUT 201 - Practical Programming Methodology

Winter 2018

[With material/slides from Guohui Lin, Davood Rafei, and Michael Buro. Most examples taken from K.N. King's book]

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Agenda

- How the preprocessor works

- Categories of directives

- Macro definitions

- Conditional compilation

- Other important directives

Readings

- Textbook Chapter 14 (not all parts covered)

The Preprocessor

Source Code
(hello.c) → **Preprocessing**

Modified C program
↓
Compiling

Assembly code
↓
Assembling

Object code (hello.o)
+
Libraries
↓
Linking → Executable
(hello)

- Is a software that edits a given C program just prior to compilation

- It is part of gcc and a main feature of C (and C++)

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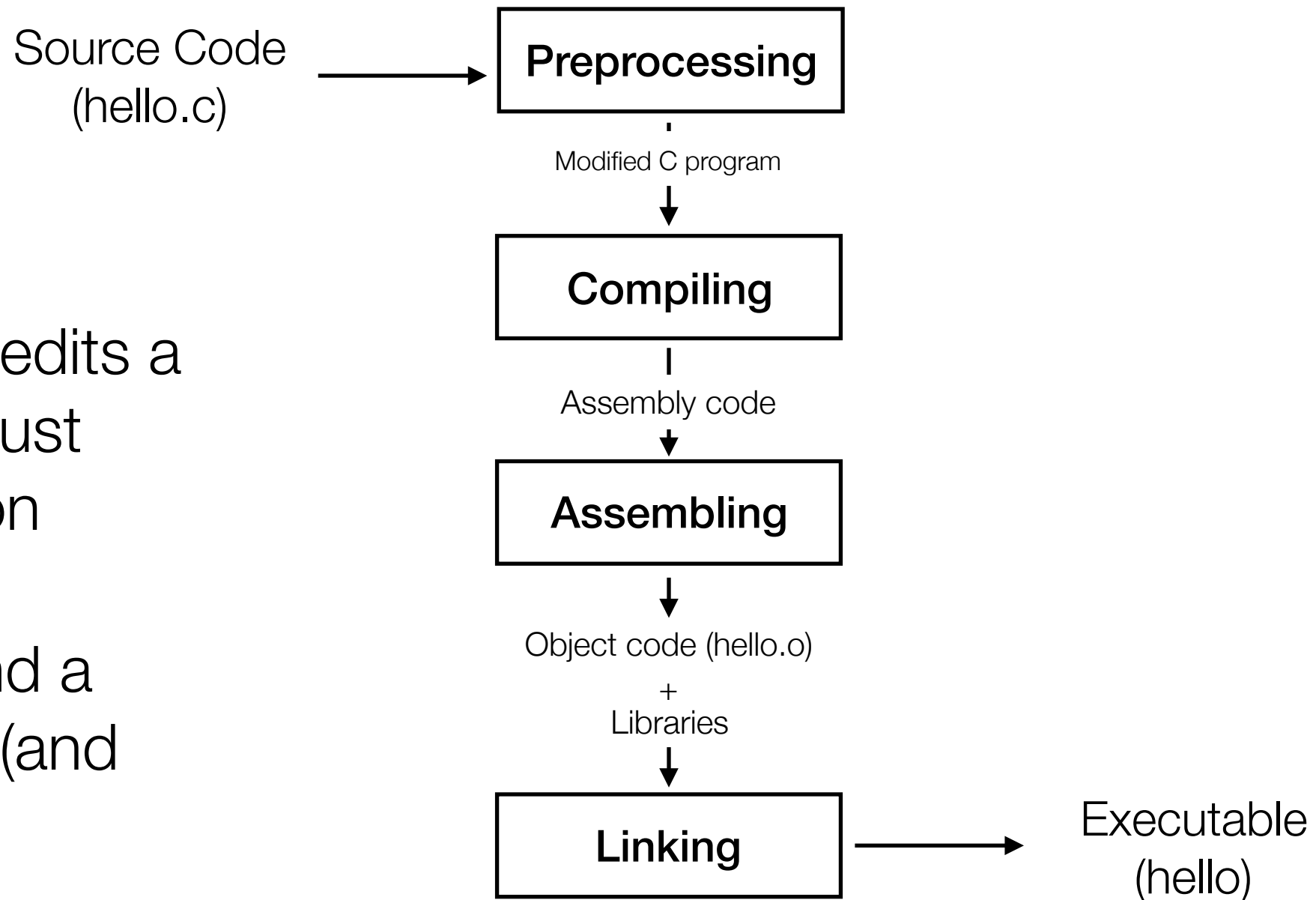
Preprocessor Directives

- The preprocessor only deals with preprocessor directives.

- *Preprocessor directives* start with # and fall into 3 main categories (a few extra ones exist): macro definitions, file inclusion, and conditional compilation

- Examples of preprocessor directives:

  ▸ `#include <stdio.h>`

    - opens the indicated file an includes its contents as part of the file being compiled

  ▸ `#define STR_LEN 80`

    - expands the macro by replacing any occurrence of it with its defined value

- To see what the program looks like after preprocessing, you can use `gcc -E program.c`

demo: demo_preproc.c

Rules for Preprocessor Directives

- Always start with #

- Spaces and tabs in the middle are irrelevant

- A directive ends at the first newline (\n), unless explicitly continued by a \ character

- Directives can appear anywhere in the program and they have an effect from that point on. That said, `#define` and `#include` directives typically appear at the top of the file.

- Comments can appear on the same line as the directive

Conditional Compilation

- *Conditional compilation* is the inclusion or exclusion of a section of program text depending on the outcome of a test performed by the preprocessor

Conditional Compilation:
`#if` **and** `#if defined()`

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```
int i = 3;
#if DEBUG
printf("DEBUG: Value of i is %d\n", i);
#endif /* DEBUG */
i++;
```

Conditional Compilation: `#if` **and** `#if defined()`

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int i = 3;
#if DEBUG
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#endif /* DEBUG */
i++;
```

Code between the #if and #endif will not be included for compilation unless DEBUG has the a non-zero value. E.g.:
`#define DEBUG 1`
`#define DEBUG 10`

Conditional Compilation:
`#if` and `#if defined()`

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Code between the #if and #endif will not be included for compilation unless DEBUG has the a non-zero value. E.g.:
```
#define DEBUG 1
#define DEBUG 10
```

```
int i = 3;
#if defined(DEBUG)
printf("DEBUG: Value of i is %d\n", i);
#endif /* DEBUG */
i++;
```

Conditional Compilation:
`#if` **and** `#if defined()`

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Code between the #if defined(..) and #endif will not be included for compilation unless DEBUG has been explicitly defined somewhere (regardless of its value). E.g.:
```
#define DEBUG
```

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```

Code between the #if defined(..) and #endif will not be included for compilation unless DEBUG has been explicitly defined somewhere (regardless of its value). E.g.:
```
#define DEBUG
```

```
int i = 3;
#if INT_MAX < 1000
…
#endif /* INT_MAX */
i++;
```

Conditional Compilation: #if and #if defined()

```
int i = 3;
#if DEBUG
printf("DEBUG: Value of i is %d\n", i);
#endif /* DEBUG */
i++;
```

Code between the #if and #endif will not be included for compilation unless DEBUG has the a non-zero value. E.g.:
```
#define DEBUG 1
#define DEBUG 10
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```

```
int i = 3;
#if INT_MAX < 1000
…
#endif /* INT_MAX */
i++;
```

can also check for values, rather than just Boolean expressions

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Conditional Compilation: `#ifdef,` `#ifndef, #else, #elif`

```
int i = 3;
#ifdef DEBUG
printf("DEBUG: Value of i is %d\n", i);
#endif /* DEBUG */
i++;
```

```
int i = 3;
#ifndef DEBUG
printf("Production message %d\n", i);
#else
printf("Production message: Initialized program\n");
#endif /* DEBUG */
i++;
```

```
#if defined(WIN32)
…
#elif defined (MAC_OS)
..
#elif defined (LINUX)
…
#endif
```

Conditional Compilation: `#ifdef,` `#ifndef, #else, #elif`

Behaves similar to #if defined(..). Code between the #ifdef and #endif will not be included for compilation unless DEBUG has been explicitly defined somewhere (regardless of its value). E.g.:
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```
#if defined(WIN32)
…
#elif defined (MAC_OS)
..
#elif defined (LINUX)
…
#endif
```

Conditional Compilation: `#ifdef, #ifndef, #else, #elif`

Behaves similar to #if defined(..). Code between the #ifdef and #endif will not be included for compilation unless DEBUG has been explicitly defined somewhere (regardless of its value).
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printf("Production message %d\n", i);
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printf("Production message: Initialized program\n");
#endif /* DEBUG */
i++;
```

Can test whether something is ***undefined*** and can also have else parts

```
#if defined(WIN32)
…
#elif defined (MAC_OS)
..
#elif defined (LINUX)
…
#endif
```

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Conditional Compilation: `#ifdef,` `#ifndef, #else, #elif`

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int i = 3;
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```

Can test whether something is **undefined** and can also have else parts

```
#if defined(WIN32)
…
#elif defined (MAC_OS)
..
#elif defined (LINUX)
…
#endif
```

Can use cascaded "if-else" directives. This is especially useful to write code that is portable to several machines or works with several compilers, for example.

Default Values

```
#ifndef BUFFER_SIZE
#define BUFFER_SIZE 10
#endif
```

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```
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This is similar to the structure you have seen when defining header files. When this structure is used with header files, it is called an *#include guard* or a *header guard*. We will talk more about this next class.

How to Define a Macro

- So how do we define the macros we check for in #if defined, #ifdef etc.?

- We can define (or actually un-define) them in the program itself, before the check happens. E.g.:

  ▸ `#define DEBUG`

  ▸ `#define SIZE 10`

  ▸ `#undef DEBUG`

- Or we can define them from outside the program by providing them during compilation

(Un-)Defining Macros During Compilation

- `-D name`

  ‣ Predefine name as a macro, with definition 1

  ‣ e.g.,: `gcc -Wall -std=c99 -DDEBUG -D 64BIT -o test test.c`

- `-D name=definition`

  ‣ contents of definition are processed as if you had a #define name (definition)

  ‣ e.g., `gcc -Wall -std=c99 -D MAX_SIZE=1000 -o test test.c`

- `-U name`

  ‣ e.g., `gcc -Wall -std=c99 -UDEBUG -o test test.c`

demo: preproc.c

The `#error` Directive

```
#ifndef BUFFER_SIZE
#error BUFFER_SIZE must be defined
#endif
```

- Encountering #error indicates a serious problem and causes the compilation to terminate (well, technically it causes the preprocessing stage to terminate)

```
#if defined (WIN32)
…
#elif defined (MAC_OS)
…
#elif defined (LINUX)
…
#else
#error No operating system specified
#endif
```