The C Preprocessor

CSE 303 Lecture #12a

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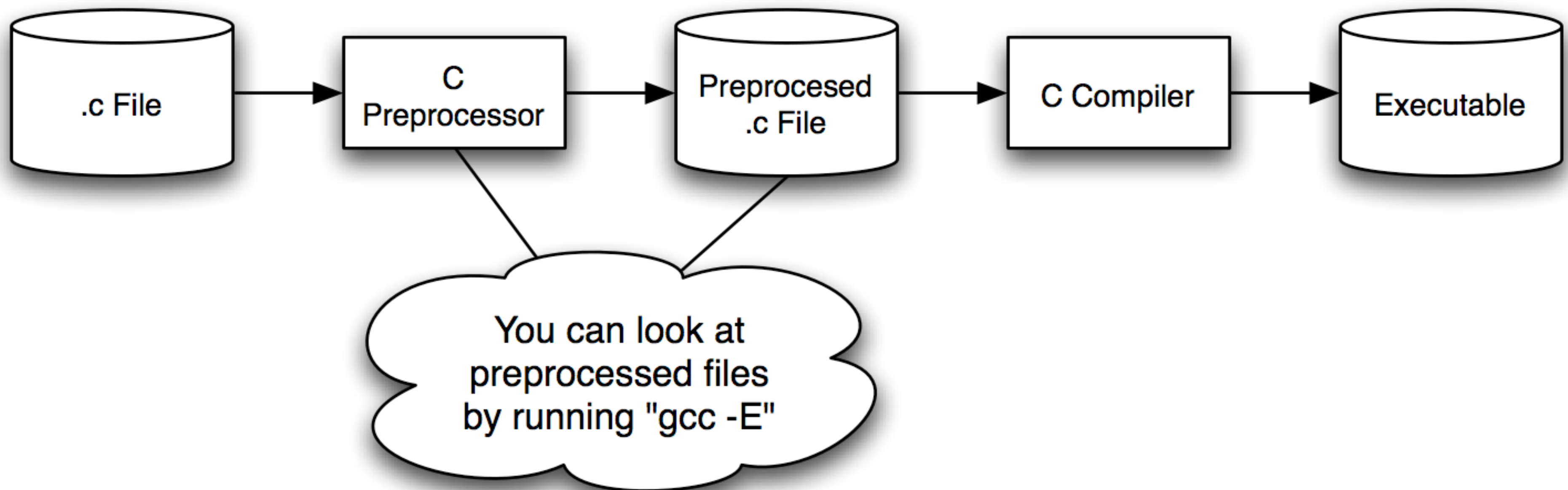
C source files are “preprocessed”



The preprocessor responds to commands

- `#include` …
- `#define` …
- `#ifdef` …
- `#ifndef` …
- …

Simple macros

- `#define foo bar baz buz`
- Replace any occurences of `foo` with "`bar baz buz`"
- Often used to define constants
  - `#define pi 3.14`

Parameterized macros

- `#define PLUS1(x) x+1`
  - Dangerous
- `#define PLUS1b(x) ((x)+1)`
  - Better
- `#define TWICE(x) ((x)+(x))`
  - Problem?

Macros vs Functions

- `#define TWICE(x) ((x)+(x))`
- `int twice(int x) { return x + x; }`
- A: `v=7; w=TWICE(++v);`
- B: `v=7; w=TWICE(v++);`
- C: `v=7; w=twice(v++);`
- D: `v=7; w=twice(++v);`

Macros vs Functions

- `#define TWICE(x) ((x)+(x))`
- `int twice(int x) { return x + x; }`
- A: `v=7; w=TWICE(++v);`
- B: `v=7; w=TWICE(v++);`
- C: `v=7; w=twice(v++);`
- D: `v=7; w=twice(++v);`
- Good rule of thumb: in a macro definition, don’t use an argument more than once

Macros vs. Functions (cont’d)

- Good rule of thumb: don’t use a macro if a function will work just as well
  - Some people think that macros lead to higher performance. You don’t know enough yet to do that level of optimization.
- Good example of a macro that can’t be implemented as a function:
  - `#define NEW_T(t,cnt)`

```
((t*) malloc((cnt)*sizeof(t))
```

File Inclusion

- `#include <file.h>`
  - Search in special directories
- `#include “file.h”`
  - Search in the “current” directory
- When the preprocessor sees an include command, it finds the included file, runs the preprocessor on the file and replaces the include command with the resulting text

Inclusion Problems

- Circular includes
- Multiple inclusions
  - Inefficiency
  - Redeclarations of global variables
  - Redefinitions of functions
- Solution: Conditional compilation

Conditional Compilation

- Very common idiom in header files:

```
#ifndef FOO_H
#define FOO_H
...
  (rest of foo.h)
...
#endif
```

Conditional Debugging

```
#define DEBUG



#ifdef DEBUG
    printf(…);
#else
    don't print
#endif
```

Odds & Ends

- Conditional compilation also useful for manually adapting code to different architectures and operating systems
  - C is a *mostly* portable language

- Preprocessor symbols can also be "`#undef`"ined

Line Numbers

- It is possible to make multi-line macros
- How does the compiler know what line numbers to give in error messages (remember, it only sees the preprocessed file)?
- Answer: there are special "`#line`" directives

printf and scanf

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Input and Output

- `printf` is the standard C function for formatted output
  - `printf(“format string”, v1, v2, …);`
- `scanf` is the standard C function for formatted input
  - `scanf(“format string”, v1, v2, …);`

Format Strings

- Format strings contain special markers, beginning with `%`.
  - `%d` : int
  - `%f` : float, double
  - `%c` : char
  - `%s` : char *, string
  - `%e` : float, double in scientific form

More Formatting

- Padding (width)

  `%12d`

  `%012d`

- Precision

  `%12.4d`

  `%12.6d`

- Left/right justification

  `%12d`

  `%-12d`

- Similar in `%f, %e,` … conversions

scanf

- `scanf` is very similar to `printf`, except people rarely get as creative with the formatting strings
- The expressions following the formatting string must be **pointers** to the appropriate type