

CS 241: Systems Programming

Lecture 8. Introduction to C

Fall 2019

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Standardization

1972 - Traditional C (Dennis Ritchie)

1978 - K&R C

1983 - ANSI C committee formed

1989 - committee adopted standard C89 (ANSI C)

- ▶ Adds in the standard library, etc.

1990 - ISO adopts C89 as international standard

1995 - Adopted two “Technical Corrigenda” and an “Amendment” to form C95

- ▶ Mostly new library functions for multibyte and wchar

1999 - More extensive revisions create C99

- ▶ Inline funcs, new data types, C++ style comments, variable len arrays

2011 - C11 approved adding features like multithreading, atomic operations, type-generic macros, Unicode support, etc.

Hello, World!

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

```
int main(void) {  
    printf("Hello world!\n");  
    return 0;  
}
```

Jobs of a Compiler

Inputs

- ▶ C program file and options
- ▶ Libraries

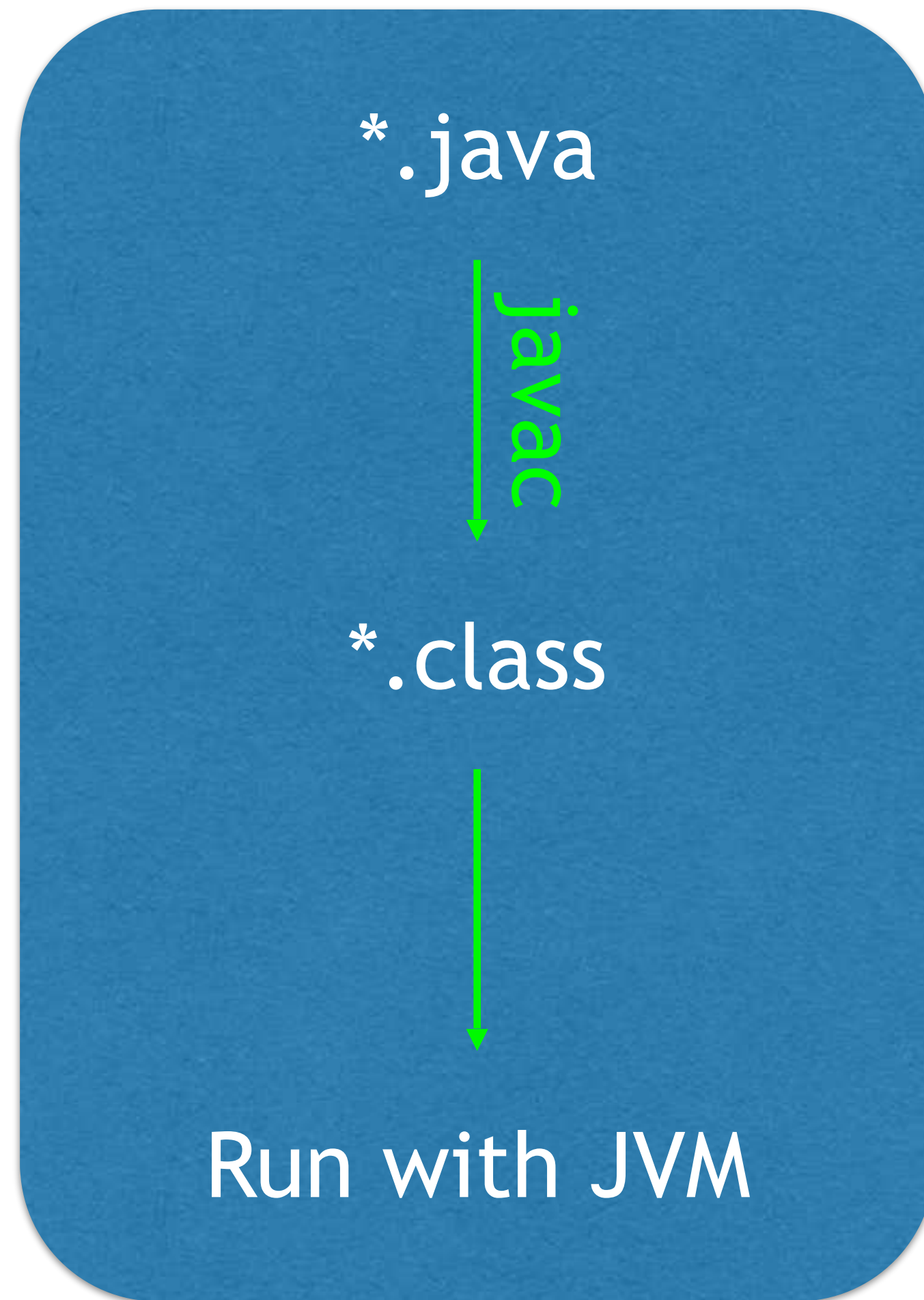
Compilation phases

- ▶ Preprocessing
- ▶ Compilation
- ▶ Linking

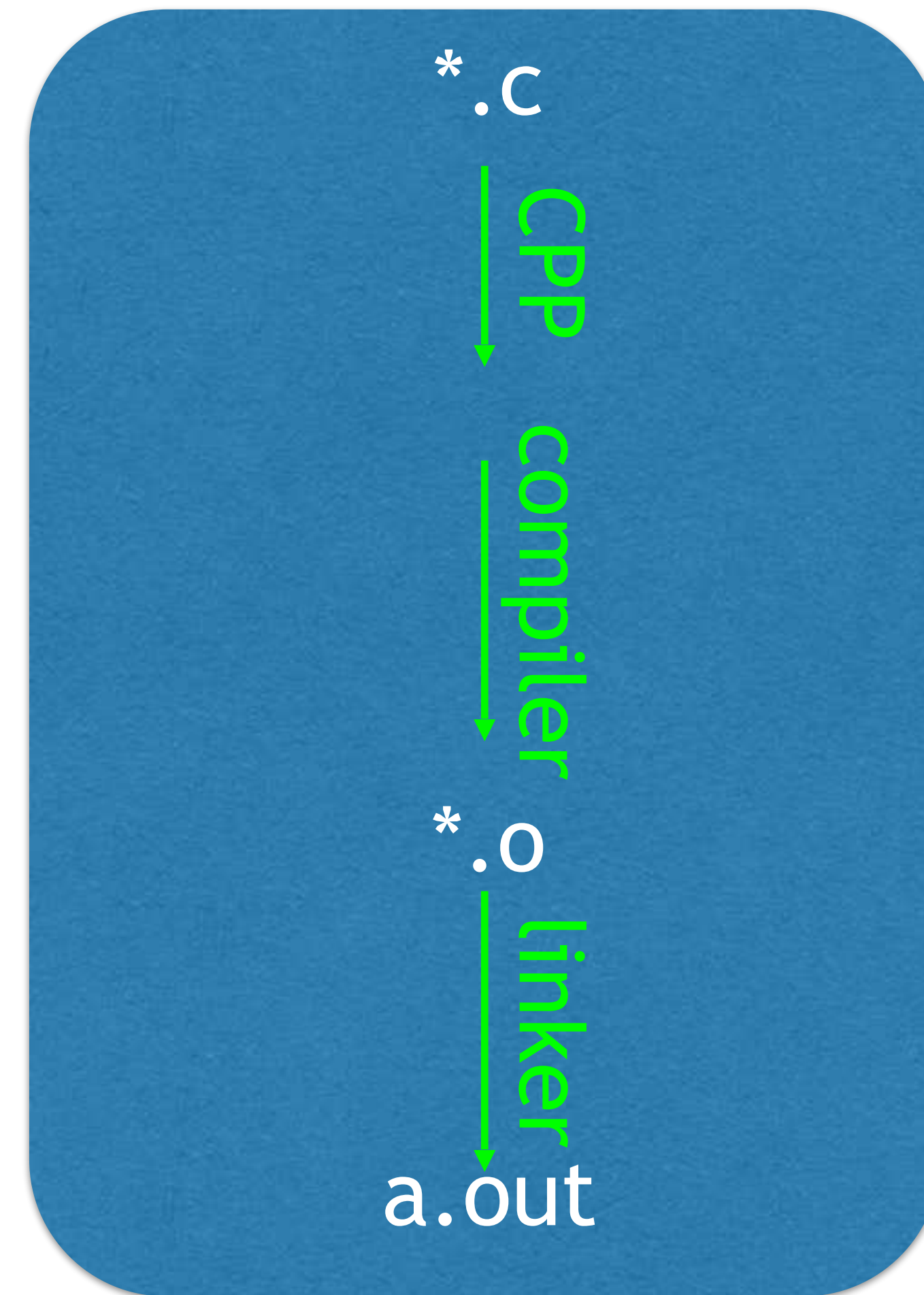
Outputs

- ▶ Executable
- ▶ Warnings and errors

Compilation



Java Model



C Model

C Preprocessor Directives

`#include` — literal inclusion of a file

- ▶ `#include <foo.h>`
- ▶ `#include "foo.h"`

`#define foo bar` — literal replacement of “foo” with “bar”

- ▶ Useful for symbolic constants (and other things)
- ▶ Use UPPERCASE for constants
 - Usually these are at the top of the file

Difference between "" and <>

2 A preprocessing directive of the form

```
# include <h-char-sequence> new-line
```

searches a sequence of implementation-defined places for a header identified uniquely by the specified sequence between the < and > delimiters, and causes the replacement of that directive by the entire contents of the header. How the places are specified or the header identified is implementation-defined.

Difference between "" and <>

3 A preprocessing directive of the form

```
# include "q-char-sequence" new-line
```

causes the replacement of that directive by the entire contents of the source file identified by the specified sequence between the " delimiters. **The named source file is searched**

for in an implementation-defined manner. If this search is not supported, or if the search fails, the directive is reprocessed as if it read

```
# include <h-char-sequence> new-line
```

with the identical contained sequence (including > characters, if any) from the original directive.

Consider the two files header_file.h and source_file.c shown to the right.

What is the value of x after the first line of main?

- A. 10
- B. 12
- C. 20

```
// In header_file.h
#define BAR 10
#define FOO BAR+1

// In source_file.c
#include "header_file.h"
int main(void) {
    int x = FOO * 2;
    /* ... */
}
```

- D. 22
- E. It's an error

Functions

```
/* Function declaration.  
 * - No return value.  
 * - Has three parameters, parameter names are optional.  
 * - Ends with a semicolon.  
 */
```

```
void foo(int x, float y, char z);
```

```
/* Function definition.  
 * - Must match declaration.  
 * - Parameter names are not optional.  
 * - Body of function wrapped in { }.  
 */
```

```
void foo(int x, float y, char z) {  
    /* ... */  
}
```

Main function

```
// The main function is where execution begins.  
// - Returns an int, 0 is success, 1-127 are failure.  
// - Takes 0, 2, or implementation-defined number of parameters.  
// - argc is the number of command line parameters.  
// - argv points to an array of command line parameters.  
int main(void) { /* ... */ }  
int main(int argc, char **argv) { /* ... */ } // Use this one.  
int main(int argc, char **argv, char **envp) { /* ... */ }
```

Command line parameters

```
1 // stdio.h contains printf's declaration.
2 #include <stdio.h>
3
4 // argc is like Bash's $# (but off-by-one)
5 // argv[0] is like $0
6 // argv[1], ..., argv[argc-1] is like $1, $2 ...
7 int main(int argc, char **argv) {
8     for (int idx = 0; idx < argc; ++idx) {
9         // %d means print an integer,
10        // %s means print a string
11        printf("%d: %s\n", idx, argv[idx]);
12    }
13    return 0;
14 }
```

Command line parameters

```
$ ./arguments 'First argument' second third etc.  
0: ./arguments  
1: First argument  
2: second  
3: third  
4: etc.
```

Basic types

class	systematic name	other name
integers	_Bool	bool
	unsigned char	
	unsigned short	
	unsigned int	unsigned
	unsigned long	
	unsigned long long	
	[un]signed char	
	signed char	
	signed short	short
	signed int	signed or int
	signed long	long
	signed long long	long long
floating point	float	
	double	
	long double	
	float _Complex	float complex
	double _Complex	double complex
	long double _Complex	long double complex

Integer type sizes

`sizeof(type)` is the number of bytes a variable of `type` has

`1 = sizeof(char) ≤ sizeof(short) ≤ sizeof(int)`
`≤ sizeof(long) ≤ sizeof(long long)`

`sizeof(type) = sizeof(signed type) = sizeof(unsigned type)`

`sizeof(bool)` is implementation defined

A byte isn't always 8 bits! (But it is on most systems.)

On a system where `sizeof(unsigned short)` is 2 (and bytes are 8 bits), the maximum value of an unsigned short is 0xFFFF (or 65535). Consider

```
unsigned short x = 0xFFFF;  
unsigned short y = 1;  
unsigned short z = x + y;
```

What value does `z` have after this code runs?

- A. 0
- B. 0xFFFF (65535)
- C. 0x10000 (65536)
- D. It depends on the compiler
- E. It's a runtime error.

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