ECE 220 Computer Systems & Programming

Lecture 7 – Introduction to C

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C – Higher Level Language

(2018 top programming languages ranked by IEEE Spectrum)

Gives symbolic names to values

- don't need to know which register or memory location

Provides abstraction of underlying hardware

- operations do not depend on instruction set
- example: can write "`a = b * c`", even though LC-3 doesn't have a multiply instruction

Provides expressiveness

- use meaningful symbols that convey meaning
- simple expressions for common control patterns (if-then-else)

Enhances code readability

Safeguards against bugs

- can enforce rules or conditions at compile-time or run-time

Basic C Program

```
/*
 * My first program in C. It will print the value of PI
 * and then exit.
 */
//
#include <stdio.h>
#define PI 3.1416f
int main(){
    float pi = PI;
    printf("pi=%f\n", pi);
    return 0;
}
```

a. Comment
b. Preprocessor directives
c. Main function
d. Variable declaration (type, identifier, scope)
e. I/O
f. Return value
g. Statement termination

Pre-processor directives:

- `#include <stdio.h>`
  - Instructs the pre-processor to copy content of stdio.h (header file) into the source code
  - <stdio.h> and other header files included in <> are located in some well-defined place in the file system known to the compiler
  - Header files located in the current directory or the directory provided to the compiler by the user are enclosed in “”, e.g., “myheader.h”
- `#define PI 3.1416f`
  - Directs the pre-processor to replace all instances of string PI in the file being pre-processed with the value of 3.1416f
- `#ifdef DEBUG`

  `...`

  `#endif`
  - selectively include text in the file based on whether a symbol DEBUG was defined
- `#define min(x, y) (x < y ? x : y)`
  - Allows to define a "macro", sort of like an in-line subroutine

Characteristics of C

C is a **procedural language**

- the program specifies an explicit sequence of steps to follow to produce a result; program is composed of functions (aka subroutines)

C programs are **compiled** rather that interpreted

- a compiler translates a C program into machine code that is directly executable on hardware
- interpreted programs (e.g. MATLAB) are executed by another program, called interpreter

C programs are **statically typed**

- the type of each expression is checked at compile time for type inconsistencies (e.g., `int x = 3.411`)

Compiling a C Program

Preprocessor

- macro substitution
- conditional compilation
- "source-level" transformations
  - ➢ output is still C

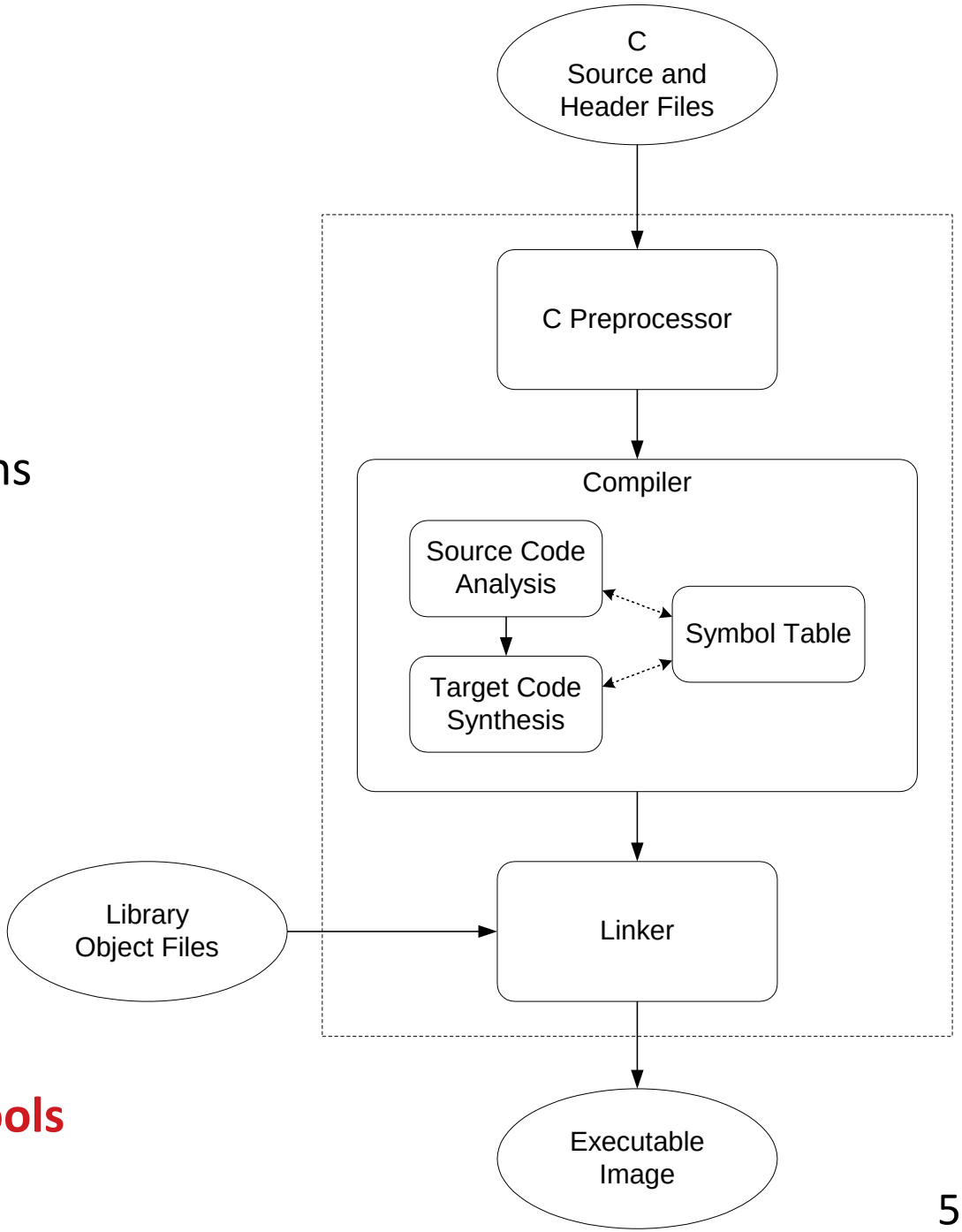
Compiler

- generates object file
  - ➢ machine instructions

Linker

- combine object files (including libraries) into executable image

✓ **gcc compiler – invoke all these tools**



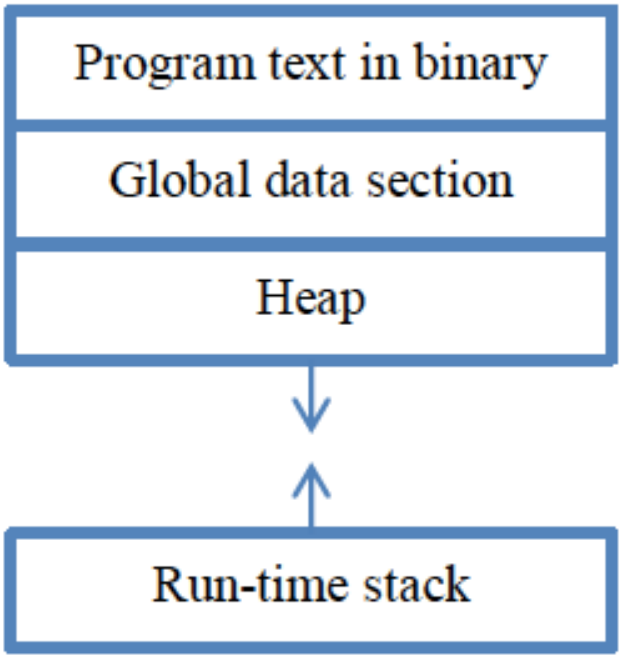
Variables in C

- **int** (long, long long, unsigned), can also use hex representation 0xD
- **float** (double)
- **char** (character)
- **const** (constant qualifier)
- _Bool/bool (true/false-0/1)

Scope: local vs. global

Storage class: static vs. automatic

[Github: Example Codes on local vs. global]



Operators

- Expression vs. Statement
- '=' vs. '=='
- The Assignment Operator (=):
- Arithmetic Operators:
- Order of evaluation:

  precedence -- `x = 2+3*4`

  associativity -- `x = 2+3-4+5`

  parentheses -- `x = a*(b + c)*d/2`
- Logical Operators: _____
- Bitwise Operators: _____
- Relational Operators: _____

Relational and Logical Operators

Relational Operators:

- > less
- >= less or equal
- < more
- <= more or equal
- == equal
- != not equal

Examples

- q = (32 == 80); /*q = 0 */
- q = (x == y);

/* q is 1 if x == y, otherwise q is 0 */

- h = f <= g;

/* h is 1 when f is less than or equal g */

Logical Operators:

- value of 0 is referred to as logically false
- value of 1 is referred to as logically true
- ! - logical NOT
- && logical AND
- || logical OR

Example:

```
y = ( 5 <= x) && (x <= 10)
```

/* true (i.e. 1) if 5 <=x<=10, otherwise false */

Operators (continued)

- Increment/Decrement Operators: ++, -- (post vs. pre)

  example: `x = 4; y = ++x;` vs. `x = 4; y = x++;`

- Special operator (conditional):

  variable = condition ? value_if_true : value_if_false;

  example: `x = (y<z) ? 5 : 7`

- Compound Assignment Operators:

  `a += b;` <--> `a = a + b;`

Expression with multiple operators (Table 12.5 of textbook)

Basic I/O

```
#include <stdio.h>          /* header file for Standard Input Output */
```

- **printf examples**

```
printf("%d is a prime number", 43);
printf("43 + 59 in decimal is %d\n", 43+59);
printf("a+b=%f\n", a+b);
printf("%d+%d=%d\n", a, b, a+b);
```

- **scanf examples**

```
scanf("%c", &nextchar);
scanf("%f", &radius);
scanf(%d %d", &length, &height);
```

Formatting option: %d, %x, %c, %s, %f, \n,

Use "**man**" to look up library functions

C Programming Exercise 1

```
int main(){
/* declare integer variables x, y and z */


/* set x to 5, set y to 3 */


/* increment x by 4 */


/* left shift x by y and then store the result to z */


/* print x, y, and z */

return 0;
}
```

C Programming Exercise 2

```
/*
 * Write a C program to calculate the circumference of a circle when
 * a user inputs the radius.
 */

/* preprocessor directives */


int main(){
    /* declare floating point variables (radius, circumference) */


    /* prompt user to enter a floating point value for radius */
```

```
    /* call scanf to get user input */


    /* calculate the circumference */

    /* print the result */

    /* return out */

}
```