CSE 303
Lecture 8

Intro to C programming

read *C Reference Manual*
pp. Ch. 1, 2.2 - 2.4, 2.6, 3.1, 5.1, 7.1 - 7.2, 7.5.1 - 7.5.4, 7.6 - 7.9, Ch. 8;
Programming in C Ch. 1-6

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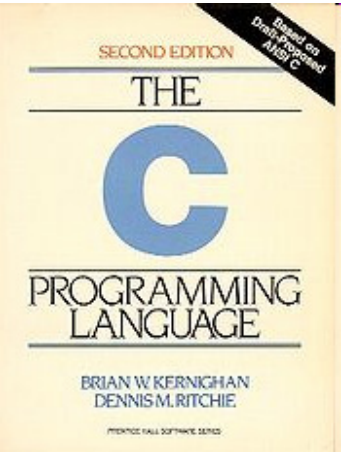
Lecture summary

- History and characteristics of C
- major C language features
  - differences between C and Java
- basic console input and output (`printf` and `scanf`)
- Our learning objectives in C:
  - procedural programming
  - deeper understanding of program compilation and execution
  - learn details of memory management
  - debugging skills
  - software development strategies

History



- created in 1972 by Dennis Ritchie of Bell Labs to accompany the Unix operating system
  - latest version standard: "C99" (1999)

- designed for creating system software (programs close to the OS that talk directly to hardware)
  - also designed to be hardware-independent (portable)
  - C is also used to develop high-level applications

- currently the 1st or 2nd most widely used language worldwide

- based on ALGOL; has influenced the designs of many languages
  - C++, Java, C#, Perl, PHP, JavaScript, Objective-C, D, ...

Characteristics of C

- fairly similar basic syntax and semantics to Java
  - `if/else`, `for`, `while`, `int`, `double`, `{} [] () ; +- */% ++`
- much smaller provided standard library / API than Java
- more low-level (more work for programmer, less for compiler)
- procedural (not object-oriented)
  - C (essentially) does not have objects as we know them
  - *verb*`(`*noun*`);` rather than *noun*`.`*verb*`();`

- more unsafe (an incorrect program can cause more damage)
  - C programs have more direct access to the system / hardware

First C program

```
#include <stdio.h>

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

- Kernighan and Ritchie started the convention that the first program you show in a new language should be one that prints "Hello, world!"

Dissecting Hello World

```
#include <stdio.h>


int main(void) {

  printf("Hello, world!\n");

  return 0;

}
```

like `import` in Java;
links the program to
the standard I/O library
(includes `printf` function)

the `main` function header;
you don't need to say `public static`
because these are the default in C

`main` returns an `int` error code to the OS
(0 on success, > 0 on failure)

like `println` in Java
(actually more like
`System.out.printf`);
prints output to console

Second C program

```c
/* Computes greatest common divisor (GCD) with Euclid's algorithm. */
#include <stdio.h>

int main(int argc, char** argv) {
  int a, b, temp, r;

  printf("Please enter two positive integers: ");
  scanf("%d %d", &a, &b);

  if (b > a) {
    temp = a;
    a = b;
    b = temp;
  }

  while ((r = a % b) != 0) {
    a = b;
    b = r;
  }

  printf("The GCD is %d.\n", b);
  return 0;
}
```

Compiling/running

command	description
`gcc`	GNU C compiler

- to compile a program, type:

  `gcc -o` ***`target source`***`.c`

  (where ***target*** is the name of the executable program to build)

  - the compiler builds an actual executable file, not a `.class` like Java
  - example: `gcc -o hi hello.c`

- to run your program, just execute that file
  - example: `./hi`

gcc options (partial)

option	description
`-W`	level of warnings to display (common usage: `-Wall` for all warnings)
`-o`	output executable file name (if omitted, compiles to file `a.out`)
`-g`	generates information for debugger tools

- most common usage for this course:

```
gcc -g -Wall -o target source.c
```

  - the warnings from `-Wall` will protect us from unwise idioms

printf

function	description
`printf`	prints formatted output to console

```
printf("format string", parameters);
```

- A format string contains *placeholders* to insert parameters into it:
  - `%d` or `%i` an integer
  - `%lf` a double ('long floating-point')
  - `%s` a string
  - `%p` a pointer (seen later)

```
int x = 3;
int y = 2;
printf("(%d, %d)\n", x, y);   // (3, 2)
```

printf continued

- A placeholder can specify the parameter's *width* or *precision*:
  - `%8d` an integer, 8 characters wide, right-aligned
  - `%-8d` an integer, 8 characters wide, left-aligned
  - `%.4f` a real number, 4 digits after decimal
  - `%6.2f` a real number, 6 total characters wide, 2 after decimal

  - Examples:

```
int age = 45;
double gpa = 1.2345678;

printf("%8d %7.3f\n", age, gpa);
printf("%8.2f %.1f %10.5f", gpa, gpa, gpa);
```

  - Output:

```
      45   1.234
1.23 1.2    1.23457
```

Same as Java

- general syntax for statements, control structures, function calls
- types `int`, `double`, `char`, `long`
  - type-casting syntax
- expressions, operators, precedence

```
+ - * / % ++ --
= += -= *= /= %=
< <= == != > >= && || !
```

- scope (within set of { } braces)
- comments: `/* ... */`, `//` (// not officially legal until C99)

Mostly the same as Java

- variables
  - can be used without being initialized (!)
  - must be declared at the start of a function or block *(changed in C99)*
- `for` loops
  - variable cannot be declared in the loop header
- `if/else` statements, `while` and `do/while` loops
  - there is no `boolean` type *(changed in C99)*
  - any type of value can be used as a test
  - 0 means `false`, every other number means `true`
- parameters / returns
  - C has certain features for values vs. references ("pointers")

Very different from Java

- Strings
  - very clunky to use in C; essentially just arrays of characters
  - are not objects; do not contain methods (external string functions)

- I/O to console and files
  - no `Scanner`; must use input functions such as `scanf`
  - console I/O different than file I/O

- errors and exceptions
  - C has no `try/catch` and does not represent errors as objects
  - errors are usually returned as integer *error codes* from functions
  - crashes are mostly called "segmentation faults" and are evil

Also very different

- arrays
  - are just bare contiguous blocks of memory
  - have no methods and do not know their own length (!)
- objects
  - C doesn't have them
  - closest similar feature: `struct` (a set of fields; no methods)
- memory management
  - most memory that you consume, you must explicitly *free* afterward
- API and provided libraries
  - C doesn't have very many, compared to Java
  - you must write many things yourself (even data structures)

scanf

function	description
`scanf`	reads formatted input from console

`scanf("format string", variables);`

- uses same syntax for formatted strings, placeholders as `printf`
  - `doubles` use `%lf` ('long float')

- must precede each variable with an & (address-of operator)

```
int x;
int y;
printf("Type your x and y values: ");
scanf("%d %d", &x, &y);
```

scanf continued

- `scanf` returns the number of values successfully read
  - can be examined to see whether the reading was successful

- if # of variables listed doesn't match # of format placeholders:
  - *too many variables*: later ones ignored
  - *too few variables*: program crashes!

- string can be complex to match a specific input pattern

```
int x;
int y;
printf("What is your (x, y) point?\n");
scanf("My point is (%d, %d)", &x, &y);
```

Exercise

- Write a C program that makes change:
  - prompts the user for an amount of money
  - reports the number of pennies, nickels, dimes, quarters, and dollars

- Example:

```
Amount of money? 17.93
Pennies :   2
Nickels :   1
Dimes   :   1
Quarters:   3
Dollars :  17
```

Exercise solution

```
#include <stdio.h>

int main(void) {
    int pennies = 0, nickels = 0, dimes = 0, quarters = 0, dollars;
    double money;

    printf("Amount of money? ");
    scanf("%lf", &money);
    dollars = (int) money;
    pennies = (int) (money * 100) % 100;

    while (pennies >= 25) {
        pennies -= 25;
        quarters++;
    }
    while (pennies >= 10) {
        pennies -= 10;
        dimes++;
    }
    while (pennies >= 5) {
        pennies -= 5;
        nickels++;
    }

    printf("Pennies : %3d\n", pennies);
    printf("Nickels : %3d\n", nickels);
    printf("Dimes   : %3d\n", dimes);
    printf("Quarters: %3d\n", quarters);
    printf("Dollars : %3d\n", dollars);
    return 0;
}
```