CSC 4304 - Systems Programming
Fall 2010

Lecture - II

Basics of C Programming

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Summary of Last Class

- Basics of UNIX:
  - logging in , changing password
  - text editing with vi, emacs and pico
  - file and directory operations
  - file/dir permissions and changing them
  - process monitoring and manipulation

C vs. Java

- C is procedural, not object oriented
  - C has no objects, interfaces or packages
  - A program only consists of functions and data
- C is compiled, not interpreted
  - Translated directly to assembly language
  - Faster, less portable and very hard to debug.
- C has no array bounds, null pointer or cast checks
  - You have to detect and handle all problems yourself
- C has no garbage collector
  - You have to do all of the memory management yourself

C vs. Java *(cont.)*

- C has pointers
  - Similar to Java references but...
  - ...they can be used in calculations (pointer arithmetic)
  - Allows you to use the location of data in computations (not just the value)
  - Useful, powerful and a debugging nightmare!

- Compared to Java, C is a low-level language
  - You can and must do everything yourself
  - Suitable for low-level software like device-drivers, communication libraries, operating systems, etc.

- You can implement anything in C!
  - No limits!

C vs. Java *(cont.)*

- A Java program consists of:
  - Several classes, one class per file.
  - A main method in one of these classes.
  - External class libraries (jar files).

- A C program consists of:
  - Several functions in any number of files.
  - A main function in one of these files.
  - Possibly some header files.
  - External libraries with their own header files.

C can be quite complex

- This program computes and prints the first 800 decimals of PI:

```
---
#include <stdio.h>
long a=10000,b,c=2800,d,e,f[2801],g;
int main(){
 for(;b-c;)f[++b]=a/5;
 for(;d=0,g=c*2;c-=14,printf("%.4d",e+d/a),e=d%a)
     for(b=c;d+=f[b]*a,f[b]=d%--g,d/=g--,--b;d*=b);
}
---
```

Basic C Program

```
main()
{

}
```

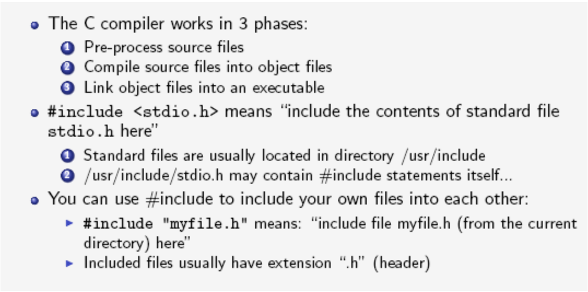
Basic C Program: Print to stdout

```
#include <stdio.h>

main()
{
    printf("Hello, CSC4304 Class!\n”);
}
```

Basic C Program: Print to stdout

```
#include <stdio.h>

main()
{
    printf("Hello, CSC4304 Class!\n");
}

---
gcc prog1.c            ==> a.out
gcc prog1.c -o prog1  ==> prog1
make prog1             ==> prog1
```

Header Files



- The C compiler works in 3 phases:
  1. Pre-process source files
  2. Compile source files into object files
  3. Link object files into an executable
- `#include <stdio.h>` means “include the contents of standard file `stdio.h` here”
  1. Standard files are usually located in directory /usr/include
  2. /usr/include/stdio.h may contain #include statements itself...
- You can use #include to include your own files into each other:
  - `#include "myfile.h"` means: “include file myfile.h (from the current directory) here”
  - Included files usually have extension “.h” (header)

Read argument and print

```
#include <stdio.h>

// take arguments from stdin
main(int argc, char* argv[])
{
    printf("Hello, %s!\n", argv[1]);
}
```

Read argument and print

```
#include <stdio.h>

main(int argc, char* argv[])
{
        if (argc < 2){
                printf("Usage: %s <your name>\n", argv[0]);
        }
        else{
                printf("Hello, %s!\n", argv[1]);
        }
}
```

Read from stdin and print

```
#include <stdio.h>

main()
{
     char name[64];
     printf("What's your name?");
     scanf("%s", name);
     printf("Hello, %s!\n", name);
}
```

Basic Data Types

- Basic Types
  - char : character - 1 byte
  - short: short integer - 2 bytes
  - int: integer - 4 bytes
  - long: long integer - 4 bytes
  - float: floating point - 4 bytes
  - double - double precision floating point - 8 bytes
- Formatting Template
  - %d: integers
  - %f: floating point
  - %c: characters
  - %s: string
  - %x: hexadecimal
  - %u: unsigned int

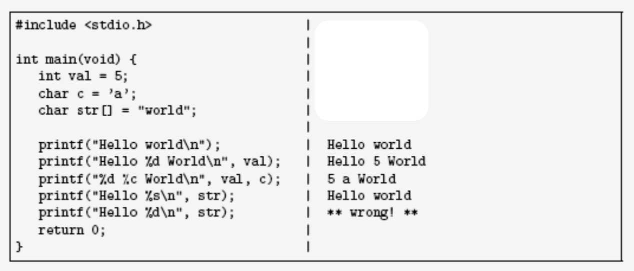
Test Size of Data Types

```
#include <stdio.h>

main()
{
    printf("sizeof(char): %d\n", sizeof(char));
    printf("sizeof(short): %d\n", sizeof(short));
    printf("sizeof(int): %d\n", sizeof(int));
    printf("sizeof(long): %d\n", sizeof(long));
    printf("sizeof(float): %d\n", sizeof(float));
    printf("sizeof(double): %d\n", sizeof(double));
}
```

Formatting

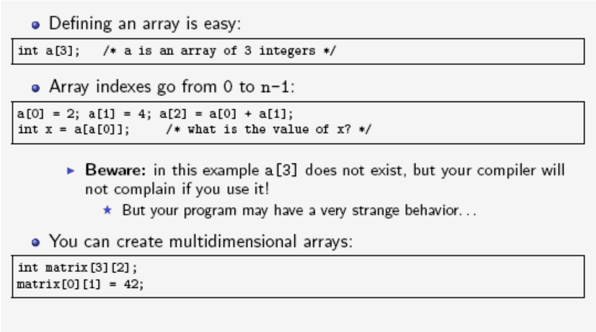
```
#include <stdio.h>

main()
{
       char var1;
       float f;

       printf(" Enter a character:");
       scanf("%c", &var1);
       printf("You have entered character:%c \n ASCII value=%d \n
                Address=%x\n", var1, var1, &var1);


       printf(" And its float value would be: %.2f\n", (float)var1);
}
```

Formatting *(cont.)*



```
#include <stdio.h>                          |
                                            |
int main(void) {                            |
   int val = 5;                             |
   char c = 'a';                            |
   char str[] = "world";                    |
                                            |
   printf("Hello world\n");                 |  Hello world
   printf("Hello %d World\n", val);         |  Hello 5 World
   printf("%d %c World\n", val, c);         |  5 a World
   printf("Hello %s\n", str);               |  Hello world
   printf("Hello %d\n", str);               |  ** wrong! **
   return 0;                                |
}                                           |
```

Arrays



- Defining an array is easy:

```
int a[3];   /* a is an array of 3 integers */
```

- Array indexes go from 0 to `n-1`:

```
a[0] = 2; a[1] = 4; a[2] = a[0] + a[1];
int x = a[a[0]];     /* what is the value of x? */
```

  - **Beware:** in this example `a[3]` does not exist, but your compiler will not complain if you use it!
    - But your program may have a very strange behavior. . .

- You can create multidimensional arrays:

```
int matrix[3][2];
matrix[0][1] = 42;
```

Strings

- A string is an array of characters:

```
char hello[15]="Hello, world!\n";
```

- Unlike in Java, you must decide in advance how many characters can be stored in a string.
  - You cannot change the size of the array afterwards
- Beware: strings are always terminated by a NULL character: '\0'
  - For example, "Hello" is string of 6 characters:

H	e	l	l	o	\0

Manipulating Arrays

- You cannot copy an array into another directly
  - You must copy each element one at a time

```
int a[3] = {12,24,36};
int b[3];

b = a;     /* This will NOT work! */

b[0]=a[0];
b[1]=a[1];
b[2]=a[2]; /* This will work */
```

Manipulating Strings

- There are standard function to manipulate strings:
  - `strcpy(destination, source)` will copy string **source** into string **destination**:

```
char a[15] = "Hello, world!\n";
char b[15];
strcpy(b,a);
```

☞ Attention: `strcpy` does **not** check that **destination** is large enough to accomodate **source**.

```
char c[10];
strcpy(c,a);  /* This will get you in BIG trouble */
```

Manipulating Strings *(cont.)*

- Instead of `strcpy` **it is always better to use** `strncpy`:
  - `strncpy` takes one more parameter to indicate the maximum number of characters to copy:

```
char a[15] = "Hello, world!";
char c[10];
strncpy(c,a,9);   /* Why 9 instead of 10? */
```

Comparison Operators

- The following operators are defined for basic data types:

```
if (a == b) { ... }
if (a != b) { ... }
if (a <  b) { ... }
if (a <= b) { ... }
if (a >  b) { ... }
if (a >= b) { ... }
if ((a==b) && (c>d)) {...}  /* logical AND */
if ((a==b) || (c>d)) {...}  /* logical OR */
```

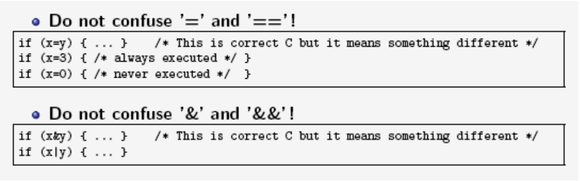
- There is no boolean type in C. We use integers instead:
  - 0 means FALSE
  - Any other value means TRUE

```
int x;
if (x)  {...}          /* Equivalent to: if (x!=0) {...} */
if (!x) {...}          /* Equivalent to: if (x==0) {...} */
```

Example

```
#include <stdio.h>

main()
{
	int x = 5;
	int y = 3;

	if (x=y){
		printf("x is equal to y, x=%d, y=%d\n", x, y);
	}
	else{
		printf("x is not equal to y, x-axes=%d, y=%d\n", x, y);
	}

}
```

Classical Bugs



- Do not confuse '=' and '=='!

```
if (x=y) { ... }    /* This is correct C but it means something different */
if (x=3) { /* always executed */ }
if (x=0) { /* never executed */  }
```

- Do not confuse '&' and '&&'!

```
if (x&y) { ... }    /* This is correct C but it means something different */
if (x|y) { ... }
```

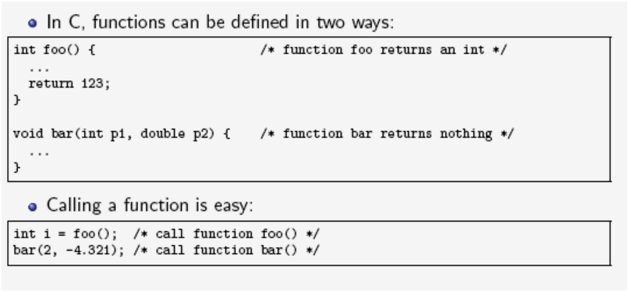
Exercise:

- (7 & 8)   vs (7 && 8)
- (7 | 8)   vs (7 || 8)

Loops

```
while (x>0){
…
}

do{
…
} while (x>0);

for (x=0; X<3;x++) {…}
```

Functions



- In C, functions can be defined in two ways:

```
int foo() {                     /* function foo returns an int */
  ...
  return 123;
}

void bar(int p1, double p2) {   /* function bar returns nothing */
  ...
}
```

- Calling a function is easy:

```
int i = foo();  /* call function foo() */
bar(2, -4.321); /* call function bar() */
```

Exercises

1. Write a program which defines an integer, a float, a character and a string, then displays their values and their sizes on screen. /*use the sizeof() function*/

2. Write a program which computes and displays fib(n), where n is a parameter taken from command line:

fib(0) = 0, fib(1) = 1
If n > 1 then fib(n) = fib(n - 1) + fib(n - 2)

Summary

- C Basics
  - C vs Java
  - Writing to stdout
  - Taking arguments
  - Reading from stdio
  - Basic data types
  - Formatting
  - Arrays and Strings
  - Comparison Operators
  - Loops
  - Functions

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