“Prof” Joe's Tutorial on

C Programming for Java & C++ Developers

Joseph Phillips

2017 June 14

What is C?

- Programming language from which the syntax (and some of the mentality) of C++, Java, and C# are based
- The “portable assembly language”
  - No virtual machine here!
  - It does not hide the underlying implementation of datatypes
- A pre-object oriented language
  - It has structures, but think of these as classes:
    - without inheritance
    - no methods, only member vars
    - all member variables are `public`

Why use C?

1) Because you don't want ***No stinkin' virtual machine*** between you and the ***soul*** of the computer (CPU + OS)

2) Because you think you can do a ***faster*** job than:

- the JVM's garbage collector at managing memory
- C++'s virtual tables at figuring out which function to do with a given object at run-time

- Depending on the program (and your coding ability), maybe you can.

C is not so scary!

- Conditionals work pretty-much the same:
  - `if (..) {..}, if(..){..} else{..}`
  - `switch (..) { case ... default }`
- Loops work pretty-much the same:
  - `for(..;..;..)`
  - `do {..} while(..);`
  - `while (..) {..}`
- Functions are simpler: not in classes.
  - Just call them without any `obj.meth()` or `objPtr->meth()`
  - Just say `funct()`

Programming in C (1) (gnu/Linux)

(1) Type in the following program:

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

int  main(int   argc,
          char* argv[]
         )
{
  printf("Hello world!\n");
  return(EXIT_SUCCESS);
}
```

Programming in C (2)

(2) Compile it:

```
$ gcc hello.c -o hello -g
```

(3) Run it:

```
$ ./hello
Hello world!
```

(Yeah, I know. No big surprise . . . but that is a good thing!)

Let's discuss this bad boy (1)

- Header file inclusion:

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

1) Anything beginning with a "**#**" is a command for the pre-processor, not the compiler proper
   - The pre-processor's job is just to get and substitute text (in this case, two header files)

Let's discuss this bad boy (2)

2) C (and C++) distinguish between header (.h) files and source (.c or .cpp) files.

- Header files: tell the compiler "***Oh, this thing might exist. If it does then it has name such-and-such, parameters such-and-such, and return type such-and-such***"
- Source files: tell the compiler "***Here is the actual variable or function that does it. Allocate space, dammit!***"

Let's discuss this bad boy (3)

```
int  main(int   argc,
          char* argv[]
         )
```

- Like in C++ the action commonly starts at **`main()`**.
  - It's just another function. It takes parameters and returns a value.
  - First parameter (**`int argc`**) tells how many command line arguments there are. (It is almost always at least one, **`argv[0]`** tells the process the name of the program being run.)
  - Second parameter (**`char* argv[]`**) is an array of char ptrs that points to each command line argument
  - By convention always called **`argc`** and **`argv`**.

Let's discuss this bad boy (4)

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

- Just call a function without any **`this`** reference/ptr.
  - No **`object.function()`**
  - No **`objectPtr->function()`**
- No classes
- There are “structures” (**`struct`**)
  - Structs' sole purpose is to group member vars
  - Only have member variables, ***no*** methods
  - All member vars are **`public`**.

Let's discuss this bad boy (5)

```
return(EXIT_SUCCESS);
```

- I ***told*** you ***`main()`*** is just another function and returns a value!
  - Returned to OS.
- **`EXIT_SUCCESS`** is the integer **`0`**.
  - Means "***I did what I was supposed to do.***"
- **`EXIT_FAILURE`** is the integer **`1`**.
  - Means "***I encountered a problem, but didn't crash.***"

Let's discuss this bad boy (6)

```
$ gcc hello.c -o hello -g
```

- **gcc** is the GNU C compiler
  - **g++** is the GNU C++ compiler
- **-o hello** means "*Name the output file* ***hello***"
  - If this is missing your program will have name **a.out**
- **-g** means "*Add debugging information*"
  - More about the GNU debugger **gdb** later.
- Many, many more options to ***gcc*** and ***g++***

Let's discuss this bad boy (7)

```
$ ./hello
```

- Runs our program ***hello***
- The "***./***" before the ***hello*** means "*Run the **hello** program that is in the current directory.*"
  - ***../hello*** means "*Run the **hello** program that is in the directory above the current one.*"

The Mentality of C

- **Be efficient!** (Safety is important, but speed is better)
  - Short-circuiting when computing && and ||
  - No index checking for arrays
- **Be flexible!**
  - C does not have constants true or false. The integer 0 means “false”, any other int means “true”.
- **Functions tells whether or not they succeeded in their return value.**
  - printf() returns -1 on error (rarely checked)
  - Unfortunately there are two standards. Sometimes “0” means “success” and “1” means “failure”. Other times it is the other way around.

Output with printf()

- Output in C with **`printf()`** (“print-formatted”)
  - **`printf("template",expr`**$_1$**`,...expr`**$_n$**`)`**
- Constant formatting:
  - **`printf("\tI just print \"hello\".\n");`**
  - What do these mean? **`\t \" \n`**
- Substitution formatting:
  - **`int i=1;printf("%d %d %d Go!\n",3,1+1,i);`**
  - **`%d`** = decimal integer
  - **`%x %X`** = hexadecimal integer
  - **`%c`** = single char
  - **`%s`** = C-string (*i.e*. pointer to char: **`char*`**)
  - **`%f %g`** = double or floating point
  - **`%p`** = An address (*e.g*. a pointer's value)

But printf()'s man page says:

```
int printf(const char *format, ...);
```

So that means I should write:

```
#include <stdlib.h>
#include <stdio.h>
int main (int argc, char* argv[])
{
  int printf(const char* "Hello world\n");
  return(EXIT_SUCCESS);
}
```

Right?

Your turn!

Write a C program to print the multiplication table from `1*1` to `10*10`

Input with fgets():

- **`fgets(`*`charArrayToWriteInto`*`,`**
  `sizeOfCharArray`*`,`*
  `fileStreamFromWhichToRead``)`

  - Example:

```
char array[64];
printf("Some text? ");
fgets(array,64,stdin);
```

- **`stdin`** is C's **`System.in`** or **`cin`**.

Input with fgets(): Text

- **`fgets()`** places the **`'\n'`** of the enter key in the string
- This removes it:

```
char* cPtr=strchr(text,'\n');
if  (cPtr != NULL)
  *cPtr = '\0';
```

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#define LEN 64

int main ()
{ char* cPtr;
  char name[LEN];
  printf("Name? ");
  fgets(line,LEN,stdin);
  cPtr=strchr(name,'\n');
  if (cPtr!=NULL)
    *cPtr='\0';
  printf("Hello ");
  printf("%s\n",name);
  return(EXIT_SUCCESS);
}
```

Input with fgets(): Numbers

- ***Almost always*** should get any input as string
  - Convert string to integer or float
- `atoi()`:
  - C's `Integer.parseInt()`
  - Instead of throwing exception on error, returns 0
  - `strtol()` is a more modern version
- `atof()`:
  - C's `Double.parseDouble()`
  - Instead of throwing exception on error, returns 0.0
  - `strtod()` is a more modern version

```
#include <stdlib.h>
#include <stdio.h>
#define LEN 64

int main ()
{
  char line[LEN];
  printf("Enter a #: ");
  fgets(line,LEN,stdin);
  int   i = atoi(line);
  float f = atof(line);
  printf("i = %d\n",i);
  printf("f = %g\n",f);
  return(EXIT_SUCCESS);
}
```

Your turn!

Write a program that allows the user to enter a positive integer `n` and writes the multiplication table from `1*1` to `n*n`

Pointers (1)

- Why pointers?
  - In C, except for assignment, there is no way to change a value of a variable.
  - How then would you implement:

```
int i = 10;
int j = 20;
swap(i,j);
```

  - Using pointers! Pass in the addresses of i and j:

```
swap(&i,&j);
```

Pointers (2)

- Addresses:
  - All objects live somewhere in memory
  - Generally given as a hexadecimal number
- Getting addresses: **`&var`**

```
int   i = 10;
char array[10];
printf("i=%d and lives at%p\n",i,&i);
printf("This string constant is known by
its address\n");
strcpy(array,"Hello");
  // a char array name is address too
printf("%s\n",array);
```

Pointers (3)

- Declaring pointers: ***Type* typePtr***

```
int*      intPtr;
char*     charPtr;
MyClass*  myClassPtr;
```

Pointers (4)

- Putting it together:

```
int i = 10;
int*  intPtr  = &i;
char          array[10];
const char*cPtr;

// All of these are legal
cPtr = array;
cPtr = &array[0];
cPtr  = "string const";
// C-strings end with the \0 character
// Which is automatically added to string
consts
```

Pointers (5)

- **Dereferencing**:
  - A fancy term that just means "***follow the pointer to the object***"

```
printf("i = %d = %d\n",i,*intPtr);

//  What does this do?
for  (cPtr = "string const";
      *cPtr != '\0';
      cPtr++
     )
   printf("%c",*cPtr);

printf("\n",*cPtr);
```

Your turn!

- Write the swap function so that this will work:

```
int i = 10;
int j = 20;
swap(&i,&j);
printf("Now i = 20 = %d and j = 10 = %d\n",
       i,j
      );
```

Pointers (6)

- All a pointer is a variable that holds the address of an object (like another var)

  (Ain't so scary, is it? :)

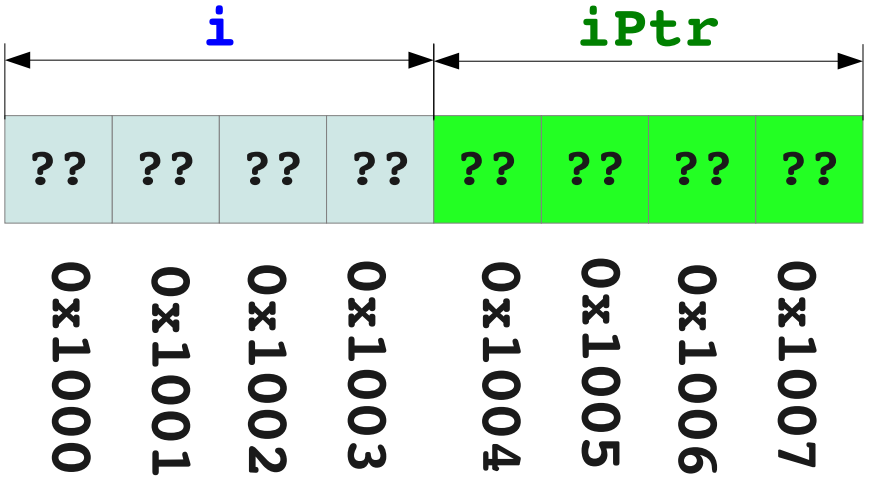
- Consider the simple program to the right
  - It increments variable **i** using a pointer from 10 to 11, and prints it.

```
 #include <stdlib.h>
#include <stdlib.h>

int main()
{
  int  i;
  int* iPtr;

  i    = 10;
  iPtr = &i;
  (*iPtr)++;
  printf("%d\n",i);
  return(EXIT_SUCCESS);
}
```

Pointers (7)

(1)

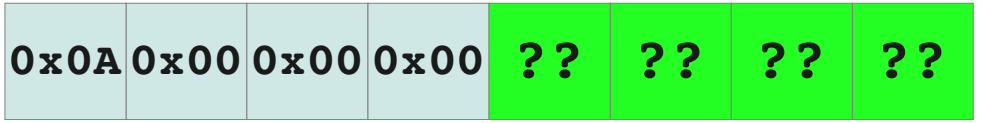
```
int  i;
int* iPtr;
```



- The act of declaring the variables makes the compiler write code that allocates space for them
  - Assume 32-bit architecture (4 bytes per var)
  - Assume little-endian byte ordering

Pointers (8)

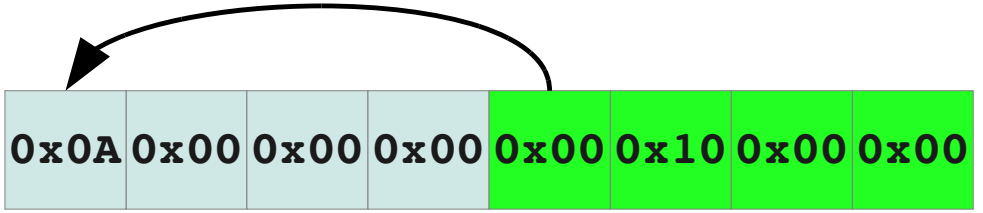
(2) `i = 10;`



- Assigning 10 to **`i`** places **`0x0A`** (= **`10`** decimal) in the first byte of **`i`**.
  - ***Remember***: little endian byte ordering

Pointers (9)

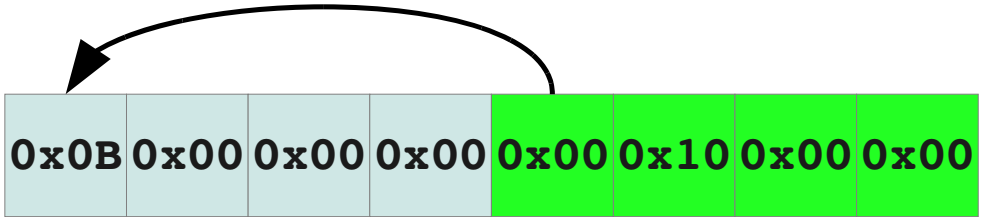
(3) `iPtr = &i;`



- Assigning the address of **`i`** (**`&i`** in C notation) to **`iPtr`** puts where **`i`** lives in **`iPtr`**.
  - **`i`** lives at **`0x1000`**, so **`iPtr`** now holds **`0x00001000`**.
  - We say "**`iPtr`** points to **`i`**" Drawing the arrow helps too.

Pointers (10)

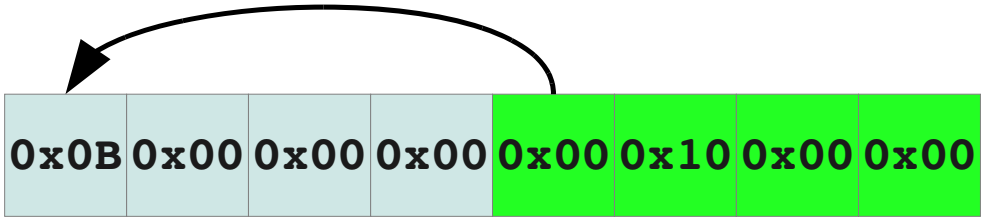
(4) `(*iPtr)++;`



- **`*iPtr`** "dereferences" **`iPtr`**. This just means "***Follow the pointer to the object***".
- Thus **`(*iPtr)++`** means the same thing as **`i++`**
  - **`i`** goes from **`10`** (**`0x0A`**) to **`11`** (**`0x0B`**).
- Must say **`(*iPtr)++`**.
  - **`*iPtr++`** means "Return the thing to which **`iPtr`** points, and make **`iPtr`** point to the next object".
  - Thus, **`iPtr`** would change to **`0x1004`** instead of **`i`** changing to **`11`**.

Pointers (11)

(5) `printf("%d",i);`



- When we print **`i`** after doing **`(*iPtr)++`** we get **`i`**'s new value: **`11`** (**`0x0B`**).

Pointers (12)

- No legally-accessible object is allowed at address **`NULL`** (generally integer **`0`**).
- **`NULL`** is a nice marker for "***This pointer has not been initialized, or has no legal value.***"

```
#include <stdlib.h>
#include <stdlib.h>

// What will I do?

int main()
{
  int* iPtr;

  iPtr = NULL;
  printf("%d\n",*iPtr);
  return(EXIT_SUCCESS);
}
```

Functions (1)

- C compilers want to know about functions before they are called:

```
#include <stdlib.h>
#include <stdlib.h>

//Compiler will complain:

int main()
{
  foo();
  return(EXIT_SUCCESS);
}

void foo ()
{
  printf("Hello world!\n");
}
```

Functions (2)

```
#include <stdlib.h>
#include <stdlib.h>

// Solution 1: reorder

void foo ()
{
  printf("Hello world!\n");
}

int main()
{
  foo();
  return(EXIT_SUCCESS);
}
```

```
#include <stdlib.h>
#include <stdlib.h>

// Soln 2: declare before use

extern void foo();

int main()
{
  foo();
  return(EXIT_SUCCESS);
}

void foo ()
{
  printf("Hello world!\n");
}
```