“Prof” Joe's Tutorial on

C Programming for Java & C++ Developers

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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
  - 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 objects
  - 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 <u>current</u> directory.*"
  - **`../hello`** means "*Run the* ***`hello`*** *program that is in the directory <u>above</u> 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)

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
- `atof()`:
  - C's `Double.parseDouble()`
  - Instead of throwing exception on error, returns 0.0

```
#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 (0)

- Declaring pointers: *`Type* typePtr`*

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

- Getting addresses: `&var`

```
int i = 10;
printf("i=%d and lives at%p\n",i,&i);
```

- Putting it together:

```
int i = 10;
int*  intPtr  = &i;
const char* charPtr = "string const";
```

Pointers (00)

- 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.

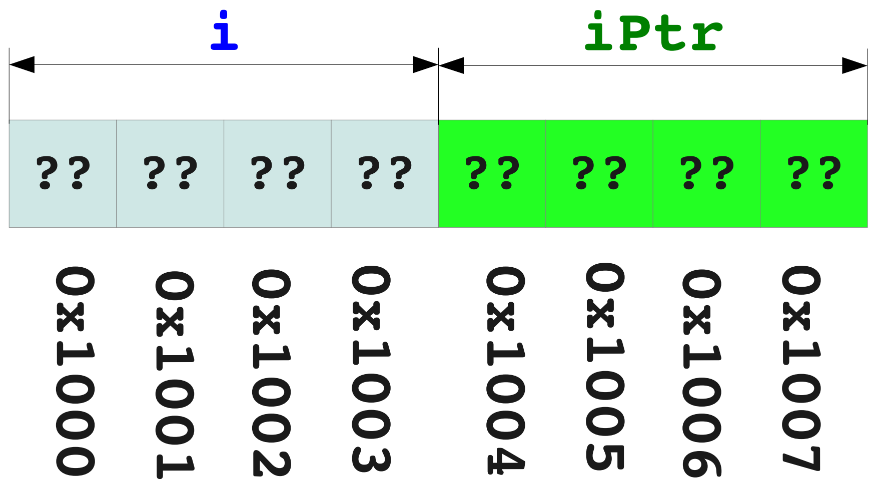
```
 #include <stdlib.h>
#include <stdlib.h>

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

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

Pointers (1)

(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 (2)

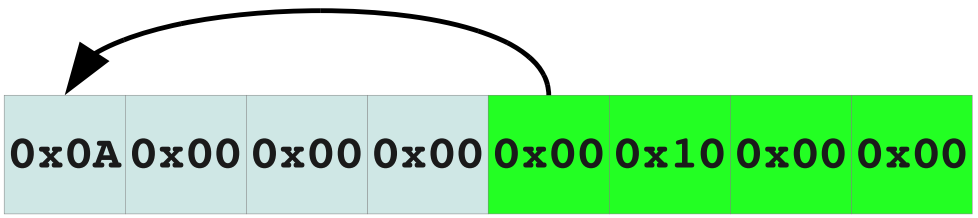
(2) `i = 10;`

0x0A	0x00	0x00	0x00	??	??	??	??

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

Pointers (3)

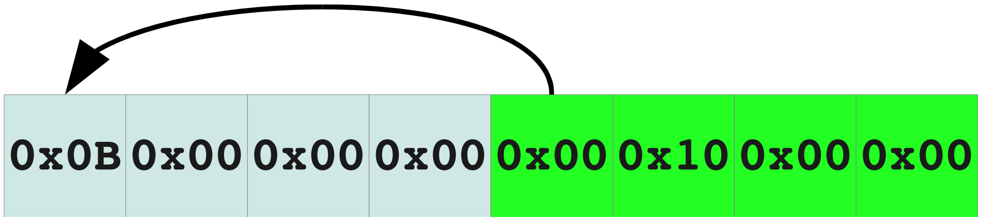
(3) `iPtr = &i;`



- 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 (4)

(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 (5)

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

0x0B	0x00	0x00	0x00	0x00	0x10	0x00	0x00

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

Pointers (6)

- 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)

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

// Solution 1: reorder

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

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

```c
#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");
}
```