Introduction to C

CMSC 104, Spring 2014

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(thanks to John Park for slides)

Introduction to C

Topics

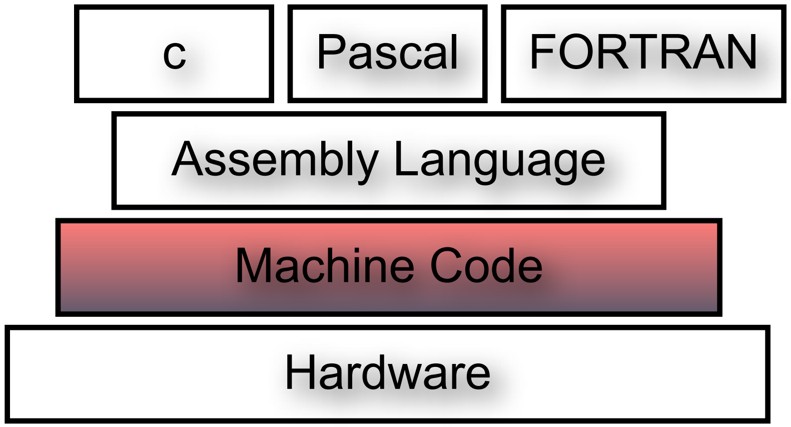
- Brief History of Programming Languages & C
- The Anatomy of a C Program
- Compilation
- Using the gcc Compiler
- 104 C Programming Standards and Indentation Styles

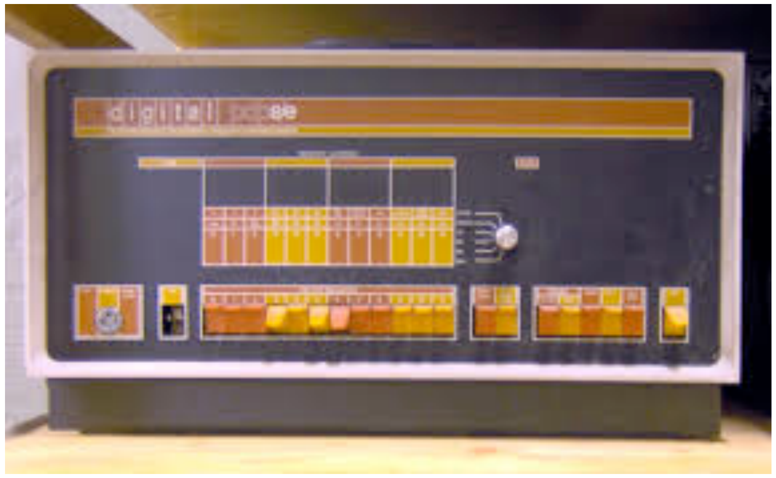
History of Programming Languages & C

- Machine code ("binary")
  - Somehow enter raw sequence of binary patterns

    1011010111001011

    1011010110101010





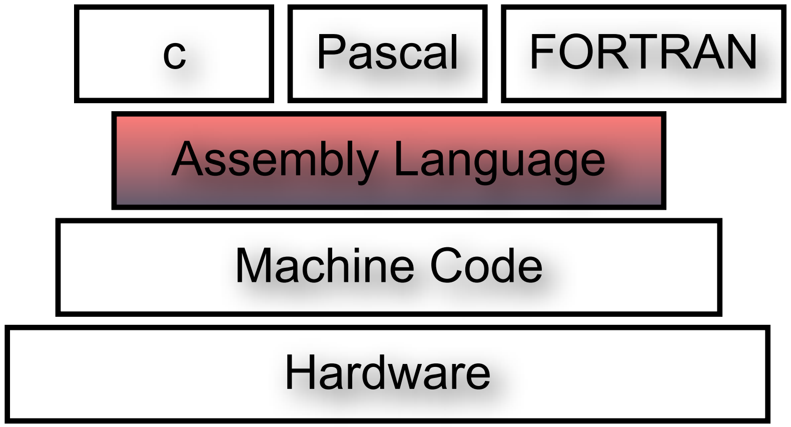
You need machine code just to start this computer up!

(DEC PDP-8)

History of Programming Languages & C

- Assembly language
    - Gave human-friendly syntax to machine code:

```
MOV   1200, R0
SUB   1202, R0
MOV   R0, 1200
```



- Really just short hand for machine code.

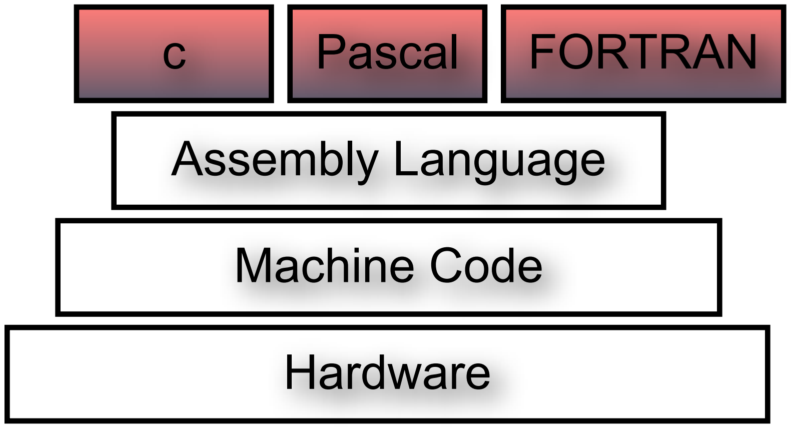
History of Programming Languages & C

- Early high-level languages
  - COBOL

```
SUBTRACT B FROM A GIVING C
MULTIPLY C BY 2 GIVING D
```

  - FORTRAN

```
S1 = 3.0
S2 = 4.0
H = SQRT((S1 * S1) + (S2 * S2))
```



The Design of C

- C was designed to be:
  - **Efficient**
  - **Close to the machine**
    - I.e., it could directly manipulate the CPU's memory to control hardware-level functions
  - **Structured**
    - A true high-level language with sophisticated control flow, data structures
- C is written in C
  - Although the first compilers were written in assembly language.

Writing C Programs

- A programmer uses a **text editor** to create or modify files containing C code.
  - We will use `emacs` or `nano`
- Code is also known as **source code**.
- A file containing source code is called a **source file**.

A Simple C Program

- Our first program - Hello, world!
- Suppose the file `hello.c` contains the following lines:

```
#include <stdio.h>

int main() {
        printf("hello, world!\n");
}
```

We'll talk about all the parts of the program soon.

Compiling a C Program

- The source file is just a bunch of bytes:

m	a	i	n	(	)	{	\n	\t	p	r	i	n	f	(	“
h	e	l	l	o	,		w	o	r	l	d	“	)	;	\n
}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

- After a C source file has been created, the programmer must invoke the C **compiler** to convert the source code to machine code.
- The machine code can be **executed** (run).

3 Stages of Compilation

Stage 1: **Preprocessing**

- Main purposes:
  - Centralize reused chunks of code
  - Allow “extensions” to the language
  - Make code more portable
- Performed by a program called the **preprocessor**
- Modifies the source code according to **preprocessor directives (preprocessor commands**) embedded in the source code.
- The source code as stored on disk is <u>not</u> modified.
- “Include files” have names of form “*.h”

3 Stages of Compilation (con’t)

Stage 2: **Compilation**

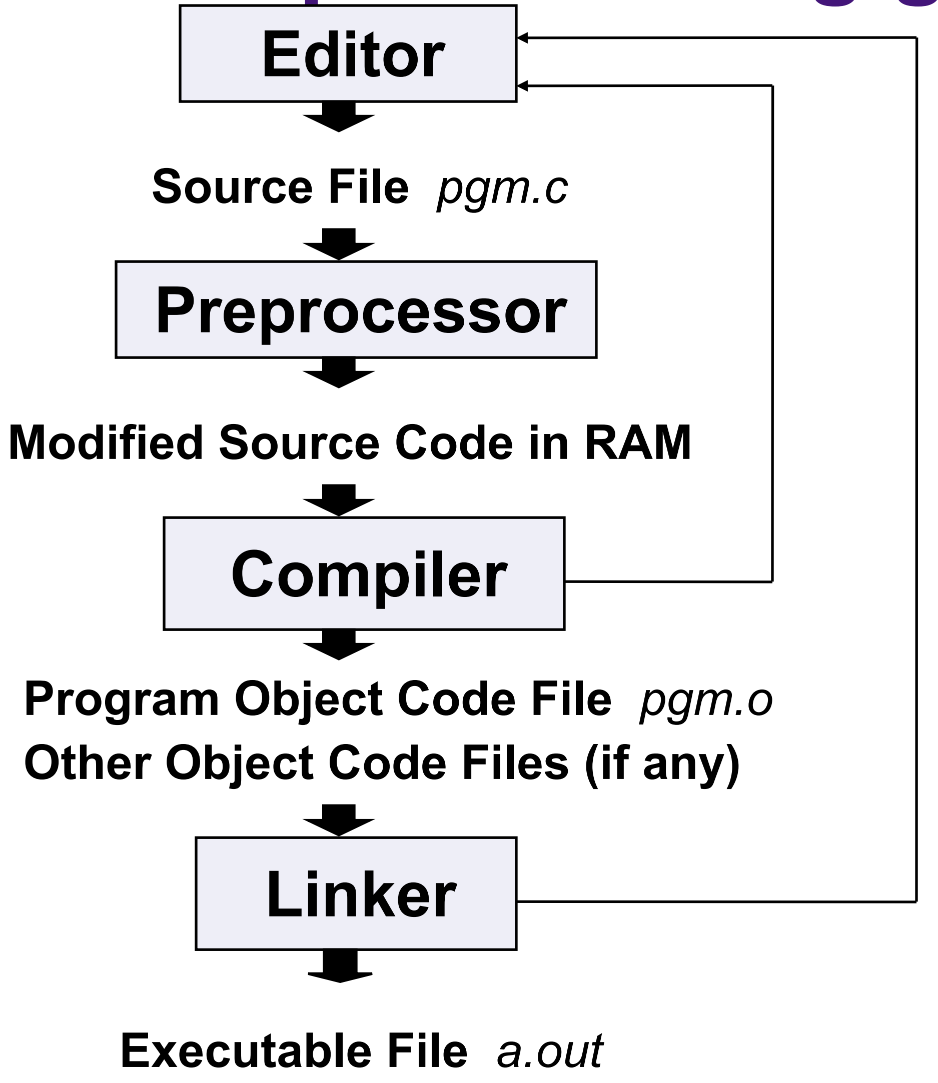
- Performed by a program called the **compiler**
- Translates the preprocessor-modified source code into **object code (machine code)**
- Checks for **syntax errors** and **warnings**
- Saves the object code to a disk file, if instructed to do so.
  - If any compiler errors are received, no object code file will be generated.
  - An object code file will be generated if only warnings, not errors, are received.

3 Stages of Compilation (con’t)

Stage 3: **Linking**

- Combines the program object code with other object code to produce the executable file.
- The other object code can come from the **Run-Time Library**, other libraries, or object files that you have created.
- Saves the executable code to a disk file. On the Linux system, that file is called **a.out**.
    - If any linker errors are received, no executable file will be generated.

Program Development Using gcc


Editor
Source File *pgm.c*
Preprocessor
Modified Source Code in RAM
Compiler
Program Object Code File *pgm.o*
Other Object Code Files (if any)
Linker
Executable File *a.out*

A Simple C Program

```c
/* Filename: hello.c
 * Author:Brian Kernighan & Dennis Ritchie
 * Date written:  ?/?/1978
 * Description: This program prints the
 * greeting "Hello, World!"
 */
#include  <stdio.h>
int main()
{
     printf("Hello, World!\n");
     return 0;
}
```

Anatomy of a C Program

```
program header comment

preprocessor directives (if any)

int main ( )
{
    statement(s)
    return 0 ;
}
```

Program Header Comment

- A **comment** is descriptive text used to help a *reader* of the program understand its content.
- All comments must begin with the characters /* and end with the characters */
    - These are called **comment delimiters**
- Program header comment always comes first.
- Look at the class web page for the required contents of our header comment.

Preprocessor Directives

- Lines that begin with a # in column 1 are called **preprocessor directives (commands)**.
- Example: the `#include <stdio.h>` directive causes the preprocessor to include a copy of the standard input/output header file `stdio.h` at this point in the code.
- This header file was included because it contains information about the `printf()` function that is used in this program.

int main ( )

- Every program must have a **function** called **main**. This is where program execution begins.
- `main()` is placed in the source code file as the first function for readability.
- The **reserved word** `int` indicates that `main()` **returns** an integer value.
- The parentheses following “main” indicate that it is a function.

The Function Body

- A left brace or curly bracket ({) begins the **body** of every function. A corresponding right brace (}) ends the function body.
- The style is to place these braces on separate lines in column 1 and to indent the entire function body 3 to 4 spaces.

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

- This line is a C **statement**.
- It is a **call** to the function `printf()` with a single **argument (parameter)**, namely the **string** "`Hello, World!\n`".
- Even though a string may contain many characters, the string itself should be thought of as a single quantity.
- Notice that this line ends with a semicolon. All statements in C end with a semicolon.

return 0 ;

- Because function `main()` returns an integer value, there must be a statement that indicates what this value is.
- The statement

```
return 0;
```

indicates that `main()` returns a value of zero to the operating system.

- A value of 0 indicates that the program successfully terminated execution.
- Do not worry about this concept now. Just remember to use the statement.

Another C Program

```c
/*****************************************
** File: message.c
** Author: Joe Student
** Date: 9/15/06
** Section: 0101
** E-mail: jstudent22@umbc.edu
**
** This program prints a cool message to
** the user.
*****************************************/
```

Another C Program (con’t)

```
#include <stdio.h>
int main()
{
   printf(“Programming in CMSC104 is\nfun. “) ;
   printf(“C is a really cool language!\n”) ;
   return 0 ;
}
```

What will the output be?

Using the C Compiler at UMBC

- Invoking the compiler is system dependent.
  - At UMBC, we have two C compilers available, **cc** and **gcc**.
  - For this class, we will use the gcc compiler as it is the compiler available on the Linux system.

Invoking the gcc Compiler

At the prompt, type

```
gcc -Wall program.c -o program.out
```

where *`program.c`* is the C program source file.

- `-Wall` is an option to turn on all compiler **warnings** (best for new programmers).

The Result :   a.out

- If there are no errors in `pgm.c`, this command produces an **executable file**, which is one that can be executed (run).
- If you do not use the "`-o`" option, the compiler names the executable file `a.out` .
- To execute the program, at the prompt, type

```
program.out
```

- Although we call this process "compiling a program," what actually happens is more complicated.

Good Programming Practices

- C programming standards and indentation styles are available on the 104 course Web page.
- You are expected to conform to these standards for <u>all</u> programming projects in this class and in CMSC 201. (This will be part of your grade for each project!)
- The program just shown conforms to these standards, but is uncommented (we'll discuss commenting your code later).
- Subsequent lectures will include more "Good Programming Practices" slides.