CH-230-A

Programming in C and C++

C/C++

Lecture 1

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Who am I?

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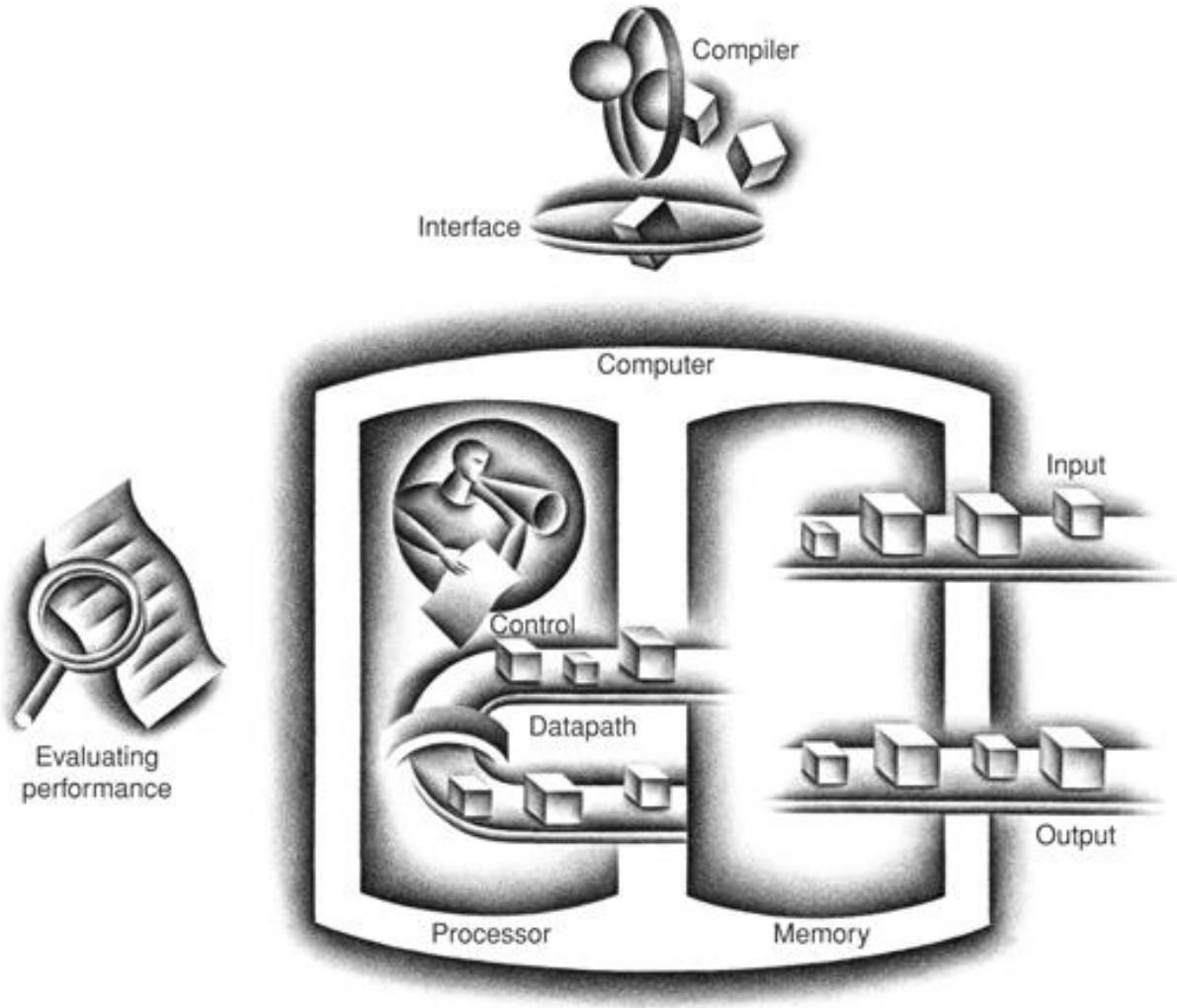
Five Classic Components of the Computer

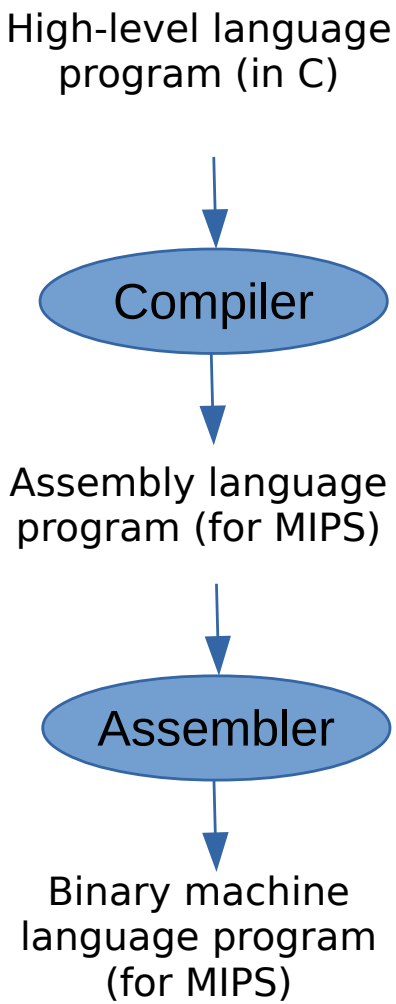


Higher Programming Languages

- Use symbolic names
- Loops, conditions

High-level language program (in C)

```
1  swap(int v[], int k) {
2    int temp;
3    temp = v[k];
4    v[k] = v[k+1];
5    v[k+1] = temp;
6  }
```




```
swap(int v[], int k) {
    int temp;
    temp = v[k];
    v[k] = v[k+1];
    v[k+1] = temp;
}
```

```
swap:
    muli   $2, $5, 4
    add    $2, $4, $2
    lw     $15, 0($2)
    lw     $16, 4($2)
    sw     $16, 0($2)
    sw     $15, 4($2)
    jr     $31
```

```
00000000101000010000000000011000
00000000000011000000110000100001
10001100011000100000000000000000
10001100111100100000000000000100
10101100111100100000000000000000
10101100011000100000000000000100
00000011111000000000000000001000
```

Compiling and Running

- The following command performs compilation and linking
  `$> gcc -o hello hello.c`
- If no compilation errors, an executable called `hello` will be created
- If you do not specify o the executable will be called `a.out`
- To execute the program just type its name
  `$> ./hello`

Comments

- It is highly advisable to insert comments into your programs
- Comments start with the couple of characters
  `/* and end with the couple */` or
  `// this is also a comment`
- Everything between these two couples and after
  `// on the same line is considered to be a comment`
- Comments are ignored by the compiler

Header Files/Libraries

- A header file is a file which contains the description of the resources provided by a library
- Technically it includes the prototypes of the provided functions
- Before using a library you must include the corresponding header file

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

- Issue

  ```
  $> gcc -E -o hello.i hello.c
  ```

  look at the output file `hello.i`

Functions

- A C program is a collection of functions
- A function is a piece of code which can be executed
- Every function has a name
- Functions may return back a value
- Calling a function means to execute the function
- Functions are a wide subject and will be in depth covered in a later lecture

The `main()` Function

- Every C program must have a function called `main()`
- The main function is the logical starting point of the program
- Even if there are 200 functions before ...

```
1  int main() {
2      ...
3      statements...;
4      ...
5  }
```

Escape Characters

- `printf` prints the characters in the string
- If a character is preceded by a `\` character, then it is called an escape character
- Escape characters are printed differently and are used to format the output
- Example: `\n` means new line
- Although you type in two characters, internally they is only one character

Some Escape Characters

Character	Meaning
`\n`	Newline
`\a`	Bell
`\r`	Carriage Return
`\t`	Tabulator
`\b`	Backspace
`\\`	\ (Backslash)
`\“`	“ (Quote)
%% (in the `printf` control string)	% (Percent)

The `return` Keyword

- When the `return` statement is executed, the current function terminates
- In the example the main function, and then the program, terminates
- `return` can provide a value to be returned
- This will be studied when learning functions in detail

The Course of Semicolons

- Every statement must be terminated by a semicolon ;
- Statements:
  - Variable declarations
  - Function calls
  - Assignments
- Practice will help you . . .

Indentation

- The layout of your program is not important for the compiler
- The program below is correct
- Semicolons are used to determine where a statement ends and where the next starts
- But not only machines will read your programs

```
1    #include <stdio.h>
2    int main(){ printf("Hello\n"); return 0; }
```

- Indent your programs to make them easier to read
- Choose one style and be coherent
- We will look at details of different styles later

Data Types

- A program processes data
- Data can be combined by operators
- The type of a data defines
  - which values can be assumed
  - which operators can be applied
- C is a strongly typed language

Characters

- `char` data type is used to store characters (ASCII code)
- A character is a symbol surrounded by a single quote like `'A'`, `'('` and so on
- C does note provide a string data type
- Strings are dealt as sequences of characters
- Details will follow in later lectures

ASCII Table

32:	48: 0	64: @	80: P	96: `	112: p
33: !	49: 1	65: A	81: Q	97: a	113: q
34: "	50: 2	66: B	82: R	98: b	114: r
35: #	51: 3	67: C	83: S	99: c	115: s
36: $	52: 4	68: D	84: T	100: d	116: t
37: %	53: 5	69: E	85: U	101: e	117: u
38: &	54: 6	70: F	86: V	102: f	118: v
39: '	55: 7	71: G	87: W	103: g	119: w
40: (	56: 8	72: H	88: X	104: h	120: x
41:)	57: 9	73: I	89: Y	105: i	121: y
42: *	58: :	74: J	90: Z	106: j	122: z
43: +	59: ;	75: K	91: [	107: k	123: {
44: ,	60: <	76: L	92: \	108: l	124: |
45: -	61: =	77: M	93:]	109: m	125: }
46: .	62: >	78: N	94: ^	110: n	126: ~
47: /	63: ?	79: O	95: _	111: o	127:

Integers

- Positive or negative numbers without fractional part
  `1, 2, 5, -999, 345302049`
- Maximum and minimum values depend on the system
- The standard does not define this aspect

Floating Point Numbers and Doubles

- Numbers with a fractional part
  `2.3, 3.14, 0.293939`
- `float` used to represent real numbers, they offer just a mere approximation
- `double` uses twice the number of bytes to represent numbers
  - Increased precision
  - Increased memory size
  - Increased time to process

Variables (1)

- A variable is a named location in the computers memory used to store a certain data type
- Variables content vary over time: they can be read or written
- Variables must be declared before use
- Every time you need to store some data in your program a variable is needed
- The type of a variable is fixed
- Variables are created and destroyed on the fly (more in the future)
- The content of a variable is retained as long as the variable is present

Variables (2)

- Have a name
- Carry a type
- Hold a value
- Are located at a specific memory address

Declaring Variables

- To declare a variable there is a fixed syntax
  - First data type and then variable name
  - Variable declarations are statements and must be terminated by a semicolon
- Consider the following:

```
int firstVariable;
```

  - What is the value of `firstVariable`?
  - We do not know, and it cannot be known
  - Variable declaration just reserves enough space for the given type, and ties a name, but does not write anything to memory

Initialization of Variables

- Using a non-initialized variable is a common error
- In C it is possible to declare and initialize a variable at the same time

```
1    int firstVariable = 23;
2    float weight = 3.45;
3    char first = 'A', second = 'B';
```

Naming Variables

- Give variables meaningful names
  - Avoid too short or too long names
  - There are exceptions for loop variables (`i`, `j`, `k`, `m`)
- Rules:
  - First character must be a letter or the underscore
  - The remaining characters can be letters, numbers and underscores
  - No spaces are allowed
- A variable cannot have the same name as C keywords

Naming Variables: Example

- These are valid identifiers

```
1        int firstVariable;
2        float _startingWithUnderscore;
3        char _99adsfq_743m_;
```

- These are not valid identifiers

```
1        int first Variable;
2        float 945_temperature;
3        char float;
4        int some%data;
```

Types Size: An Example

Data type	Size (in bytes)
`char`	1
`short int`	2
`int`	4
`long int`	4 or 8
`float`	4
`double`	8
`long double`	12 or 16

Modifiers

- C provides some modifiers that apply to the basic data types
- The `long` modifier can be applied to the `int` and `double` data types
- The `signed` and `unsigned` modifiers can be applied to `int` and `char` data types
- The `short` modifier can be applied to the `int` data type
- Modifiers must be put before the data type
- If the data type is `int`, it may (but should not) be omitted

```
1    unsigned int modifiedVariable;
2    long double somevar;
3    unsigned unsignedVariable;
```

Operators

- Operators perform mathematical or logical operations on data
- Can be roughly divided in arithmetic, relational and logical operators
- Apparently an easy subject, but there are many subtle details to know

Arithmetic Operators

Operator	Integer	Floating point
+	3 + 5 = 8	3.4 + 1.2 = 4.6
-	89 - 2 = 87	9.9 - 1.1 = 8.8
*	22 * 2 = 44	1.2 * 3.4 = 4.08
/	48 / 4 = 12	4.5 / 1.2 = 3.752
% (modulo)	49 % 4 = 1	n/a

Assignment Operator

- The assignment operator = is used to write data to variables
- `lvalue = rvalue`
- `lvalue` is what is on the left
- `rvalue` is what is on the right
  - Could be a variable, a constant, or an expression

Example

```
1  int main() {
2      int first = 4, second = 5;
3      int sum, difference;
4      int product;
5      product = first * second;
6      sum = first + second;
7      difference = first - second;
8      return 0;
9  }
```

- Note that this is a valid C program even if it does not print any of its results
- Modify the program, to print the results

Shorthand Operators

- The following patterns are very common

```
1        int x = 32, y = 50;
2        x = x + 10;
3        y = y * 3;
```

- To shorten the notation, it is possible to use the following abbreviations

```
1        +=        x += 10;        x = x + 10;
2        -=        x -= 10;        x = x - 10;
3        *=        x *= 10;        x = x * 10;
4        /=        x /= 10;        x = x / 10;
5        %=        x %= 10;        x = x % 10;
```

The Control String of `printf`

- The general syntax is the following

```
printf("control string", arg1, arg2, ...);
```

- The control string specifies:
  - Which characters have to be printed,
  - How variables have to be formatted,
  - Number of decimal places, their type, etc.
- Note that `printf` accepts a variable number of arguments

Specification of the base

- When printing integers it is possible to specify which base should be used for their representation

Specification	**System**
%o	Octal
%d	Decimal
%x	Hexadecimal

Formatting Integer Numbers

- It is possible to specify how many digits should be used while printing an integer

```
1     int a = 145;
2     printf("The value is %6d\n", a);
```

- This will print three spaces and then 145 (i.e., 6 places for a three digits number)
- If the number of digits is too small, it will be ignored

```
1       int a = 145;
2       printf("The value is %2d\n", a);
```

- This will print 145 over 3 places

The Precision Modifier

- The precision modifier is written `.number`
- For floating point numbers it controls the number of digits printed after the decimal point

  ```
  printf("%.3f", 1.2);
  ```

  will print 1.200
- If the number provided has more precision than is given, it will rounded

  ```
  printf("%.3f", 1.2348);
  ```

  will display as 1.235