Introduction to Computing

Lecture 2

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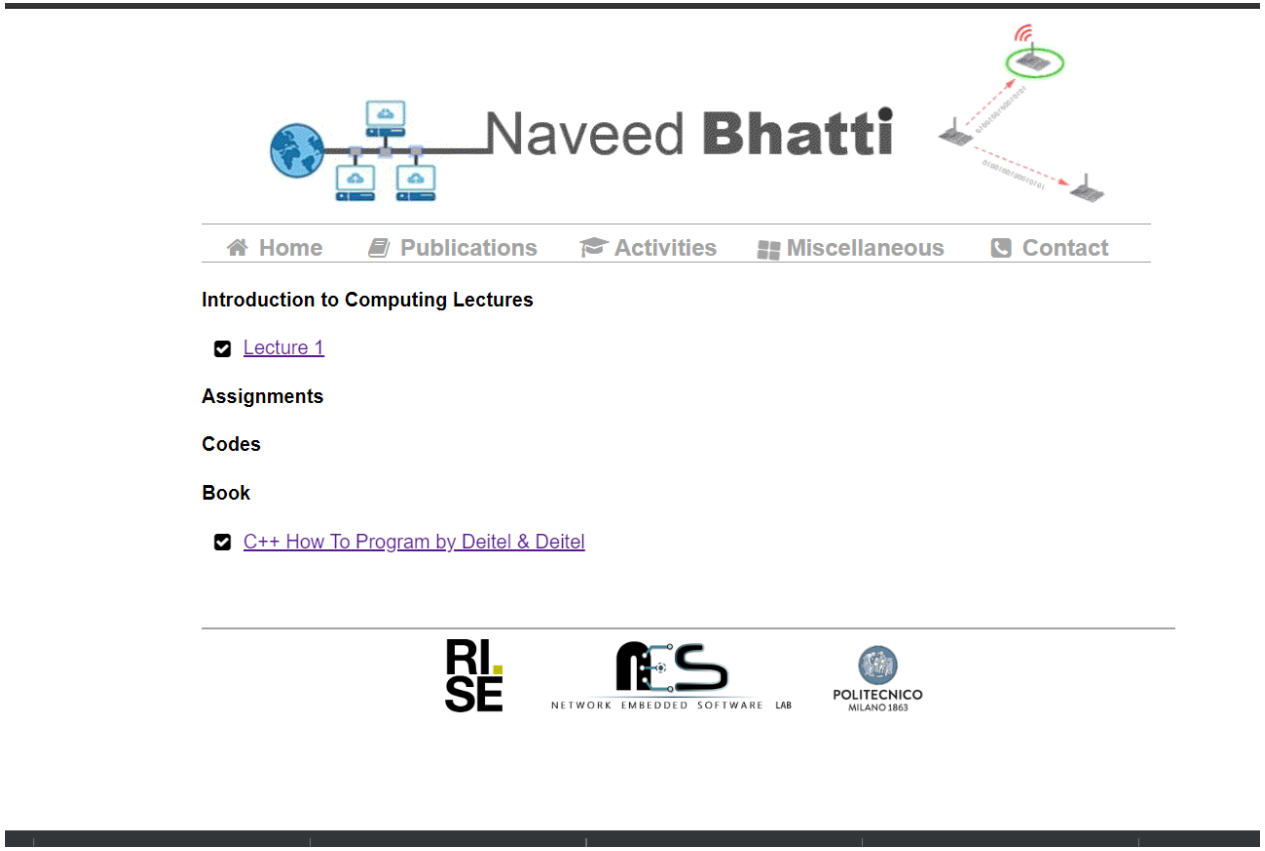
Administrivia

- Weblink is working now



- Google Classroom **Coming Soon**

Before moving to C++ Programming

Number System

(Different Ways To Say How Many)

The “WHY” slide

- Binary numbers
  - All computers work with 0’s and 1’s… so it is like learning alphabets before learning English
- Number systems
  - There are more than one way to express a number in binary. So 1010 could be -2, -5 or -6 and need to know which one.
- Base conversion
  - For convenience, people use other bases (like decimal, hexdecimal) and we need to know how to convert from one to another.

Number (or Numeral) System

*“ A **Number System** is a writing-system for expressing numbers, a mathematical notation for representing numbers of a given set, using symbols in a consistent manner ”*

- **Ideally, a number system will:**
  - Represent a useful **set of numbers** (integers, or rational numbers)
  - Give every number a **unique representation** (or a standard representation)
  - Reflect the **algebraic** and **arithmetic structure** of the numbers

Base/Radix of Number System

“ The number of distinct symbols that can be used to represent numbers in that system ”

- For example, the base for the ***decimal number system*** is **10**, as we use the ten symbols **0,1,2,3,4,5,6,7,8,9** to represent numbers in this system.

Numbering Systems		
System	Base	Digits
Binary	2	0 1
Octal	8	0 1 2 3 4 5 6 7
Decimal	10	0 1 2 3 4 5 6 7 8 9
Hexadecimal	16	0 1 2 3 4 5 6 7 8 9 A B C D E F

Base/Radix of Number System

" The number of distinct symbols that can be used to represent numbers in that system "

- For example, the base for the decimal number system is **10**, as we can use the ten symbols 0,1,2,…,9 to represent numbers in this system.

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Same number will have different representations in different systems.

- **'101' means a hundred and one in decimal**
- **'101' means five, in binary**

Decimal Number System

- The decimal numeral system has **ten** as its base. It is the number system most widely used by modern civilizations.
- This system uses the **10** symbols: **{0,1,2,3,4,5,6,7,8,9}**

10^2 10^1 10^0

179

hundreds tens ones

1x100 7x10 9x1

100 + 70 + 9 = 179

Binary Number System

- The binary numeral system has **two** as its base.
- It is the numerical base used by computers where numbers stored using the on/off logic. The ON and OFF conveniently translate into 1 and 0.
- This system uses the **2** symbols: **{0,1}**

2^2 2^1 2^0

101

four's two's ones

1x4 0x2 1x1

4 + 0 + 1 = 5 5_{10}

Octal Number System

- The octal numeral system (**base eight**) has eight as its base.
- This system uses the **8** symbols: **{0,1,2,3,4,5,6,7,8}**

8^2 8^1 8^0

765

Sixty-fours eights ones

7x64 6x8 5x1

448 + 48 + 5 = 501 501_{10}

Hexadecimal Number System

- The hexadecimal numeral system (**base 16**) has sixteen as its base
- This system uses the **16** symbols: **{0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F}**
- The main advantage of using this numeral system is that it keeps the **representations short**, and hence manageable

$$16^2 \quad 16^1 \quad 16^0$$

F6C

Two-fifty-sixes sixteens ones

15x256 6x16 12x1

3840 + 96 + 12 = 3948 3948_{10}

Conversion to Decimal

Binary -> Decimal

101

$2^2 \quad 2^1 \quad 2^0$

$1x2^2 \quad 0x2^1 \quad 1x2^0$

$4 + 0 + 1 = 5$

Octal -> Decimal

765

$8^2 \quad 8^1 \quad 8^0$

$7x8^2 \quad 6x8^1 \quad 5x8^0$

$448 + 48 + 5 = 501$

Hexa -> Decimal

F6C

$16^2 \quad 16^1 \quad 16^0$

$15x16^2 \quad 6x16^1 \quad 12x16^0$

$3840 + 96 + 12 = 3948$

Exercise

- **Convert following into decimal**

- Binary: **1101110_{2}** **110_{10}**
- Octal: **4675_{8}** **2493_{10}**
- Hexadecimal: **$FF4_{16}$** **4084_{10}**