Design of Digital Circuits
Summary

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Chapter 1

From Zero to One

1.1 Managing Complexity

Abstraction: The levels of abstraction for an electronic computer:

- **physics:** The motion of electrons
- **electronic devices:** Transistors which have connection points (terminals) and can be modeled by the relationship between voltage and current as measured at each terminal.
- **analog circuits:** Devices which are assembled to create components such as amplifiers. They input and output a continuous range of voltages
- **Digital circuits:** e.g logic gates restrict the voltages to descrete ranges which we use to indicate 0 and 1.
- **Microarchitecture:** Links the logic and architecture levels of abstraction. Microarchitecture involves combining logic elements to execute the instructions defined by the architecture-
- **Architecture:** Describes the computer from the programmers perspective. A particular architecture can be implemented by one of many different microarchitectures.
- **Operating system:** Handles low-level details such as accessing a hard drive or managing memory.
- **Application software:** Uses the facilities provided by the operating system to solve a problem for the user.

Discipline: the act of intentionally restricting your design choices so that you can work more productively at a higher level of abstraction.

The Three- Y's:

- **Hierarchy:** involves dividing a system into modules then further subdividing each of these modules until the pieces are easy to understand
- **Modularity:** states that the modules have well-defines functions and interfaces so that they connect together easily without unanticipated side effects
- **Regularity:** seeks uniformity among the modules. Common modules are reused many times, reducing the number of distinct modules that must be designed

1.2 Digital Abstraction:

Discrete-valued variables: Variables with a finite number of distinct values. Most electronic computers use a binary representation in which a high voltage indicates a 1 and a low voltage indicates a 0. The amount of information D in a descrete valued variable with N distinct states is measured in units of bits as:

$$D = log_2 N \text{ bits}$$

hence a binary variable conveys $log_2 2 = 1$ bit of information

1.3 Number Systems

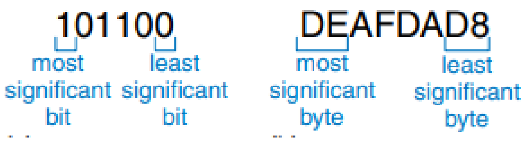
Binaray Numbers: Bits represent one of two values 0 or 1 and are joined together to form binary numbers. Each column of a binary number has twice the weight of the previous column, hence they are base 2 (the base is denoted as subscript e.g 10110_2).

Hexadecimal Numbers: groups of four bits i.e base 16. Hexadecimal numbers use the digits 0 to 9 along with the letters A to F

Hexadecimal Digit	Decimal Equivalent	Binary Equivalent
0	0	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

Bytes,Nibbles,etc: A group of eight bits is called a byte. The size of objects stored in computer memories is measured in bytes rather than bits. A group of four bits, is called a nibble i.e one hexadecimal digit stores one nibble. Microprocessors handle data in chunks called words which the size of depends on the architecture of the microprocessor (64 bit processors indicate that they operate on 64-bit words)

Most/Least significant bit (lsb/msb): Within a group of bits in the 1's column is called the lsb and the bit at the other end is called the msb



Estimating Powers of Two:

- $2^{10} \approx 10^3$
- $2^{20} \approx 10^6$
- $2^{30} \approx 10^9$

Binary Addition

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Figure 1.8 Addition examples showing carries: (a) decimal (b) binary