CS1101: Lecture 23

The Digital Logic Level: Gates

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Lecture Outline

- A Six-Level Computer
- Gates
- Transistors
- Gates from Transistors
- The Three Simple Gates
- From Three to Five Simple Gates
- Building Computers
- **Reading**: Tanenbaum, Chapter 3, Section 1

A Six-Level Computer

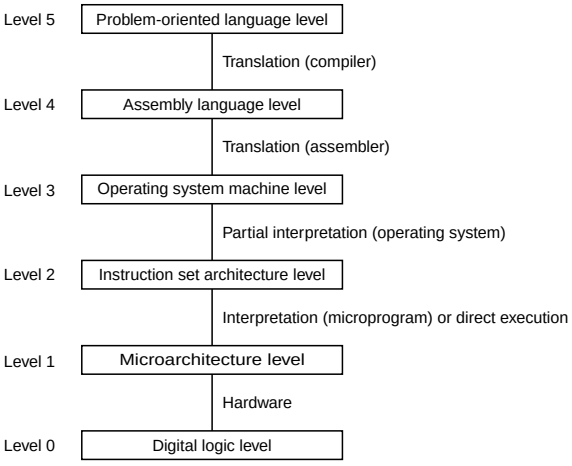


Figure 1-2. A six-level computer.

Introduction

- The Digital Logic Level is at the bottom of our hierarchical model.
- Digital circuits are constructed from a small set of primitive elements
- A special two-valued algebra is used to analyse these circuits
- Boolean Algebra
- So how does it all work?

Gates

- A digital circuit is one in which only two logical values are present – 0 and 1;
- Typically, a signal between 0-1 volts represents a binary 0, a signal between 2-5 volts represents a binary 1,
- Tiny electronic devices, called **gates**, can compute various functions over these two-valued signals;
- These gates form the hardware basis on which all digital computers are built.
- How is a gate implemented?

Transistors

- All modern digital logic rests on the fact that a transistor can be made to operate as a very fast binary switch;
- The transistor has 3 connections to the outside world: the **collector**, the **base** and the **emitter**;
- The input voltage is applied to the base
- When the input voltage is **low**, the transistor voltage is **high**
- When the input voltage is **high**, the transistor voltage is **low**
- Thus, this cirecuit is an **inverter**
- We can build all logic gates with this!!!

Gates from Transistors

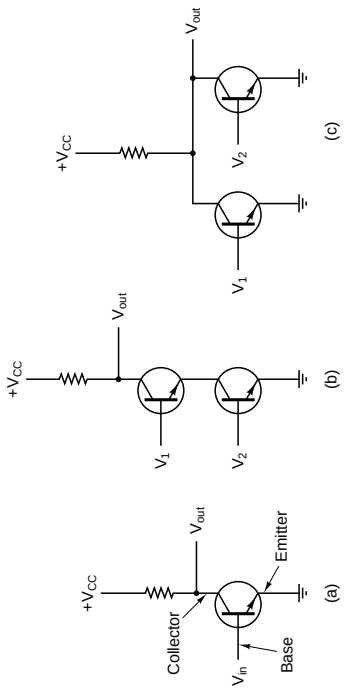
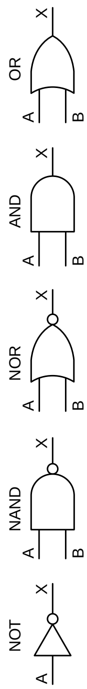


Figure 3-1: (a) A transistor inverter, (b) A NAND gate (c) A NOR gate

The Three Simple Gates

- The circuits given previously form the three simplest gates: NOT, NAND and NOR;
- NOT gates are often called **inverters**
- If we adopt the convention that “high” means logical 1 and “low” means logical 0, we can express the output value as a function of the input values
- Icons for the simplest functions will be presented next.

From Three to Five Simple Gates



(a) NOT

A	X
0	1
1	0

(b) NAND

A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

(c) NOR

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

(d) AND

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

(e) OR

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

Figure 3-2: The symbols and functional behaviour for the five basic gates

Building Computers

- It should be clear that NAND and NOR gates can be built with two transistors, whereas AND and OR gates require three each.
- Thus, many computers are built from NAND and NOR gates rather than the familiar AND and OR gates;
- These gates can have more than two inputs, but seldom have more than 8.