CIS 1.0
Computing: the Nature, Power and Limits

Topic 8, Stored Program Concept: Hardware View
[Reed, Chapter 14]
Program Concept

- Hardwired systems are inflexible
- General purpose hardware can do different tasks, given correct control signals
- Instead of re-wiring, supply a new set of control signals
What is a Program?

- A sequence of steps
- For each step, an arithmetic or logical operation is done
- For each operation, a different set of control signals is needed.
Function of Control Unit

- For each operation a unique code is provided
  - e.g. ADD, MOVE
- A hardware segment accepts the code and issues the control signals
- We have a computer!
The Computer

- Storage
- Processing

Peripherals

Communication Lines
The Computer: Top-Level Structure
The Central Processing Unit (CPU)
Components of CPU

- **ALU (Arithmetic/Logic Unit):** circuitry for arithmetic/logic operation
- **CU (Control Unit):**
  - Requests instruction from memory
  - Decodes the instruction
  - Executes the instruction
- **Registers:** hold data for future use by ALU
- **Bus:** circuits connecting CPU and main memory
Von Neumann architecture
• What is store in memory?
  – Data
  – Instructions

• How is data stored in memory used?
  – Take 1st #  A
  – Take 2nd #  B
  – Add A, B via ALU
  – Save in A
  – Save A in Result
How Program is Executed?

1. A user writes a program in high-level programming languages
2. Translated into machine code
3. The *binary code* is loaded in memory with data
   when user launched the program
4. Two special registers in CPU
   - *Program counter (PC)*: the address of the next instruction in memory
   - *The instruction register (IR)*: holds the instruction currently executing.
How Program is Executed? –cont’

5. Control unit cycles thru the following:
   – Fetches instruction (pointed by PC) into IR
   – Increments PC to point to next instruction
   – CU decodes the instruction in IR into circuitry actions
   – CU executes the instruction by activating circuitry actions, until the end of program

   Jump: PC points to a place not in order, that makes “loop” possible (loop: repeating of a set of instructions)

   Millions of instructions could be executed in less than a second.
CPU Cycle

- The Path that data follows within the CPU, traveling along buses from registers to the ALU and then back to registers, is known as the CPU datapath.

- A single rotation around the CPU datapath is referred to as a CPU datapath cycle, or CPU Cycle.
CPU Speed!

- We define CPU speed as measuring the number of basic instructions that a CPU can carry out in one second.
- Since each instruction requires a single CPU cycle to execute, we can infer that a CPU’s speed is equal to the number of CPU cycles that occur per second.
- For example, an 800-MHz CPU can perform 800 million CPU cycles per second, whereas a 1.7-GHz CPU can perform 1.7 billion CPU cycles per second.
- Don’t compare CPU solely on speed😊
Facts

- In practice, transferring data between main memory and the CPU takes much longer than executing a single CPU cycle. (Use of Cache memory)

- For a modest 33% increase in CPU speed in going from a 2.4 GHz CPU to a 3.2 GHz CPU, you pay almost three and a half times more money!
Reference