OVERVIEW OF MICROCOMPUTER SYSTEMS
Course Outline

- Part I: Computer organization
- Part II: Assembly Language

Diagram:
- Hardware: Processor, Memory, I/O system
- Software: Operating System (Unix; Windows 9x), Compiler, Assembler
- Instruction Set Architecture
- Digital Design, Circuit Design, transistors, IC layout

Application (Netscape)
Outline

• Introduction to Computer Organization
• The components of a microcomputer system
• Memory Types
• CPU
• I/O Ports
• Explanation of Terms
• Evolution of the Microprocessor
Introduction

- **Computer architecture:** refers to those attributes of a system visible to a programmer or, put another way, those attributes that have a direct impact on the logical execution of a program.

- **Computer organization** refers to the operational units and their interconnections that realize the architectural specifications. 
  Examples of architectural attributes include:
  - The instruction set,
  - The number of bits used to represent various data types (e.g., numbers, characters),
  - I/O mechanisms,
  - and techniques for addressing memory.

Organizational attributes include those hardware details transparent to the programmer, such as control signals; interfaces between the computer and peripherals; and the memory technology used.
Introduction

• A **computer**: is a complex system; contemporary computers contain millions of elementary electronic components.

• **Hierarchical system** is a set of interrelated subsystems, each of the latter, in turn, hierarchical in structure until we reach some lowest level of elementary subsystem.

• At each level, the designer is concerned with structure and function:
  • **Structure**: The way in which the components are interrelated
  • **Function**: The operation of each individual component as part of the structure
Introduction

• Function:
• in general there are four basic functions:
1. Data processing
2. • Data storage
3. • Data movement
4. • Control
Introduction

• Structure:
• There are four main structural components:
  • **Central processing unit (CPU):** Controls the operation of the computer and performs its data processing functions; often simply referred to as processor.
  • **Main memory:** Stores data.
  • **I/O:** Moves data between the computer and its external environment.
  • **System interconnection:** Some mechanism that provides for communication among CPU, main memory, and I/O. A common example of system interconnection is by means of a **system bus**, consisting of a number of conducting wires to which all the other components attach.
Historical Background
The First Generation: Vacuum Tubes

ENIAC - background

- Electronic Numerical Integrator And Computer
- Eckert and Mauchly
- University of Pennsylvania
- Started 1943
- Finished 1946
  - Too late for war effort
- Used until 1955
- Decimal (not binary)
- 20 accumulators of 10 digits
- Drawback: Programmed manually by switches and plugging and unplugging cables.
Historical Background
The First Generation: Vacuum Tubes
von Neumann/Turing

- Stored Program concept
- Main memory storing programs and data
- ALU operating on binary data
- Control unit interpreting instructions from memory and executing
- Input and output equipment operated by control unit
- Princeton Institute for Advanced Studies
  - IAS
- Completed 1952
Historical Background
The First Generation: Vacuum Tubes

IAS - details

- 1000 x 40 bit words
  - Binary number
  - 2 x 20 bit instructions
- Set of registers (storage in CPU)
  - Memory Buffer Register
  - Memory Address Register
  - Instruction Register
  - Instruction Buffer Register
  - Program Counter
  - Accumulator
  - Multiplier Quotient
Historical Background
The First Generation: Vacuum Tubes
Commercial Computers

- 1947 - Eckert-Mauchly Computer Corporation
- UNIVAC I (Universal Automatic Computer)
- US Bureau of Census 1950 calculations
- Became part of Sperry-Rand Corporation
- Late 1950s - UNIVAC II
  - Faster
  - More memory
Historical Background
The First Generation: Vacuum Tubes

IBM

- Punched-card processing equipment
- 1953 - the 701
  - IBM’s first stored program computer
  - Scientific calculations
- 1955 - the 702
  - Business applications
- Lead to 700/7000 series
Historical Background
The Second Generation: Transistors

- Replaced vacuum tubes
- Smaller
- Cheaper
- Less heat dissipation
- Solid State device
- Made from Silicon (Sand)
- Invented 1947 at Bell Labs
- William Shockley et al.
Historical Background
The Third Generation: Integrated Circuits
Microelectronics

• Means: Literally - “small electronics”

• Tow fundamental types of components:
  
  1- gates: is a device that implements a simple Boolean or logical function, such as IF $A$ AND $B$ ARE TRUE THEN $C$ IS TRUE
  
  2- memory cells: is a device that can store one bit of data

• By interconnecting large numbers of these fundamental devices, we can construct a computer.

• These can be manufactured on a semiconductor. e.g. silicon wafer
Historical Background

Later Generations

• After third generation less general agreement on defining generations of computers

• Later generations based on advances in integrated circuit technology.
Summary: Generations of Computer

- Vacuum tube - 1946-1957
- Transistor - 1958-1964
- Small scale integration - 1965 on
  - Up to 100 devices on a chip
- Medium scale integration - to 1971
  - 100-3,000 devices on a chip
- Large scale integration - 1971-1977
  - 3,000 - 100,000 devices on a chip
- Very large scale integration - 1978 -1991
  - 100,000 - 100,000,000 devices on a chip
- Ultra large scale integration – 1991 -
  - Over 100,000,000 devices on a chip
Components of a microcomputer system

- The Control Unit and the Arithmetic and Logic Unit constitute the Central Processing Unit.
- Data and instructions need to get into the system and results out:
  - Input/output
- Temporary storage of code and results is needed:
  - Main memory
Computer Components: Top Level View

PC = Program counter
IR = Instruction register
MAR = Memory address register
MBR = Memory buffer register
I/O AR = Input/output address register
I/O BR = Input/output buffer register
Memory Connection

- Receives and sends data
- Receives addresses (of locations)
- Receives control signals
  - Read
  - Write
  - Timing
Memory Types

• **Random Access Memory (RAM):** allows data and instructions to be accessed randomly from any memory location (address). Primary storage.
  • Volatile - lost when power is turned off
• **Read Only Memory (ROM):** usually contains programs that help the computer system operate:
  • can only be read: cannot be written to or altered by the user (usually)
  • ROM is not volatile
CPU Connection

- Reads instruction and data
- Writes out data (after processing)
- Sends control signals to other units
- Receives (& acts on) interrupts
Input/Output Connection (1)

• Similar to memory from computer’s viewpoint

• Output
  • Receive data from computer
  • Send data to peripheral

• Input
  • Receive data from peripheral
  • Send data to computer
Input/Output Connection(2)

- Receive control signals from computer
- Send control signals to peripherals
  - e.g. spin disk
- Receive addresses from computer
  - e.g. port number to identify peripheral
- Send interrupt signals (control)
Buses

• There are a number of possible interconnection systems
• Single and multiple BUS structures are most common
• e.g. Control/Address/Data bus (PC)
• e.g. Unibus (DEC-PDP)
What is a Bus?

- A communication pathway connecting two or more devices
- Usually broadcast
- Often grouped
  - A number of channels in one bus
  - e.g. 32 bit data bus is 32 separate single bit channels
- Power lines may not be shown
Data Bus

• Carries data
  • Remember that there is no difference between “data” and “instruction” at this level

• Width is a key determinant of performance
  • 8, 16, 32, 64 bit
Address bus

- Identify the source or destination of data
- e.g. CPU needs to read an instruction (data) from a given location in memory
- Bus width determines maximum memory capacity of system
  - e.g. 8080 has 16 bit address bus giving 64k address space
Control Bus

- Control and timing information
  - Memory read/write signal
  - Interrupt request
  - Clock signals
Bus Interconnection Scheme
Introduction to Microprocessor

Explanation of Terms

• An **Address** is a pattern of 0’s and 1’s that represents a specific location in memory or a particular I/O device.

• Typical **8-bit** microprocessors have 16 address lines

• These 16 lines can produce unique 16-bit patterns from 0000000000000000 to 1111111111111111, representing 65,536 ($2^{16} = 65,536$) different address combinations.
Introduction to Microprocessor
Explanation of Terms

- **Addressing mode** is the manner in which the microprocessor determines the operand (data) and destination addresses during execution of an instruction.

- **An Arithmetic-logic unit (ALU)** is a digital circuit that performs arithmetic and logic operations on two n-bit digital words.

- **Bit** is an abbreviation for the term binary digit. A binary digit can have only two values, 0 and 1,
Introduction to Microprocessor
Explanation of Terms

• **Word size** refers to the number of bits that can be processed simultaneously by the basic arithmetic circuits of a microprocessor.

➢ A number of bits taken as a group in this manner is called a word.

• For example, a 32-bit microprocessor can process a 32-bit word, a 16-bit microprocessor can process a 16-bit word.

• **8086** is a 16-bit microprocessor can process a 16-bit word
Introduction to Microprocessor
Explanation of Terms

• A **bus** consists of a number of conductors (wires) organized to provide a means of communication among different elements in a microprocessor system.

• **Cache Memory** is a high-speed, directly accessible, relatively small, semiconductor read/write memory block used to store data/instructions that the microprocessor may need in the immediate future.
Introduction to Microprocessor

Explanation of Terms

- The **instruction set** of a microprocessor is a list of commands that the microprocessor is designed to execute.

- **Pipelining** is a technique that overlaps instruction fetch (instruction read) with execution.

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Microprocessor Data Types

- **Fundamental Data Types:**
  - Bytes (8 bit)
  - words (2 bytes)
  - double words (4 bytes)
  - Quad words (8 bytes)
Introduction To Microprocessors:

Evolution of microprocessors:

**Intel**

- **1971 - 4004**
  - First microprocessor
  - All CPU components on a single chip
  - 4 bit
- **Followed in 1972 by 8008**
  - 8 bit
  - Both designed for specific applications
- **1974 - 8080**
  - Intel’s first general purpose microprocessor
Introduction To Microprocessors: New Approach – Multiple Cores

- Multiple processors on single chip
  - Large shared cache
- Within a processor, increase in performance proportional to square root of increase in complexity
- If software can use multiple processors, doubling number of processors almost doubles performance
- So, use two simpler processors on the chip rather than one more complex processor
- With two processors, larger caches are justified
  - Power consumption of memory logic less than processing logic
Introduction To Microprocessors:
Evolution of microprocessors

• x86 Evolution (1)

• 8080
  • first general purpose microprocessor
  • 8 bit data path
  • Used in first personal computer – Altair
• 8086 – 5MHz – 29,000 transistors
  • much more powerful
  • 16 bit
  • instruction cache, prefetch few instructions
  • 8088 (8 bit external bus) used in first IBM PC
• 80286
  • 16 Mbyte memory addressable
  • up from 1Mb
• 80386
  • 32 bit
  • Support for multitasking
• 80486
  • sophisticated powerful cache and instruction pipelining
  • built in maths co-processor
Introduction Microprocessors: Evolution of microprocessors

- **X86 Evolution (2)**
  - Pentium
    - Superscalar
    - Multiple instructions executed in parallel
  - Pentium Pro
    - Increased superscalar organization
    - Aggressive register renaming
    - branch prediction
    - data flow analysis
    - speculative execution
  - Pentium II
    - MMX technology
    - graphics, video & audio processing
  - Pentium III
    - Additional floating point instructions for 3D graphics
Evolution (3)

- Pentium 4
  - Note Arabic rather than Roman numerals
  - Further floating point and multimedia enhancements
- Core
  - First x86 with dual core
- Core 2
  - 64 bit architecture
- Core 2 Quad – 3GHz – 820 million transistors
  - Four processors on chip
That’s all for Today!!

Text Book:
COMPUTER ORGANIZATION AND ARCHITECTURE
(Chapter 1.2.3)