NILE UNIVERSITY OF NIGERIA

CPE 301

COMPUTER ORGANIZATION

&

ARCHITECTURE

Dr. Nyangwarimam Obadiah Ali
Associate Professor
Computer Engineering Department
RM 223, Congo House
ali.obadiah@nileuniversity.edu.ng

NILE UNIVERSITY OF NIGERIA
HONORIS UNITED UNIVERSITIES

Lecture 1

INTRODUCTION TO COMPUTER ARCHITECTURE AND ORGANIZATION

INTRODUCTION

A Computer is a tool for solving problems in several fields such as scientific, research, administration, manufacturing etc. Its basic ability is to perform arithmetic calculations.

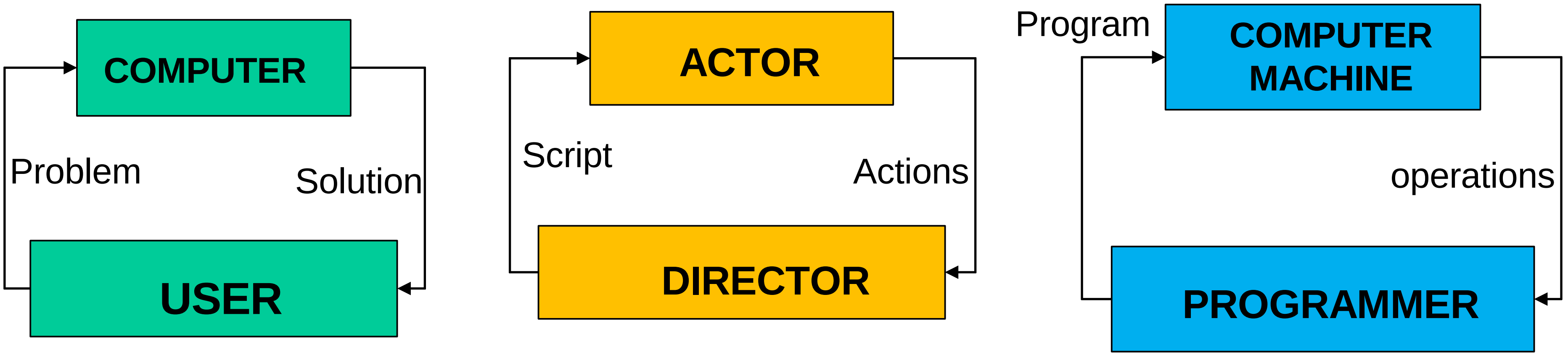


FIG 1. The User and Computer

COMPUTER ARCHITECTURE & ORGANIZATION

COMPUTER ARCHITECTURE **refers to those attributes of a system visible to a programmer or those attributes that have a direct impact on the logical execution of a program. Examples of architectural attributes include the instruction set, the number of bits used to represent various data types (e.g. numbers and characters), Input/output mechanisms and techniques for addressing memory.**

COMPUTER ORGANIZATION **refers to the operational units and their interconnections that realize the architectural specifications. Examples of 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**

COMPUTER STRUCTURE & FUNCTION

■■ ***Structure: The way in which the components are interrelated.***

■■ ***Function: The operation of each individual component as part of the structure.***

In general terms, there are only four basic functions that a computer can perform:

1. Data processing

2. Data storage

3. Data movement

4. Control

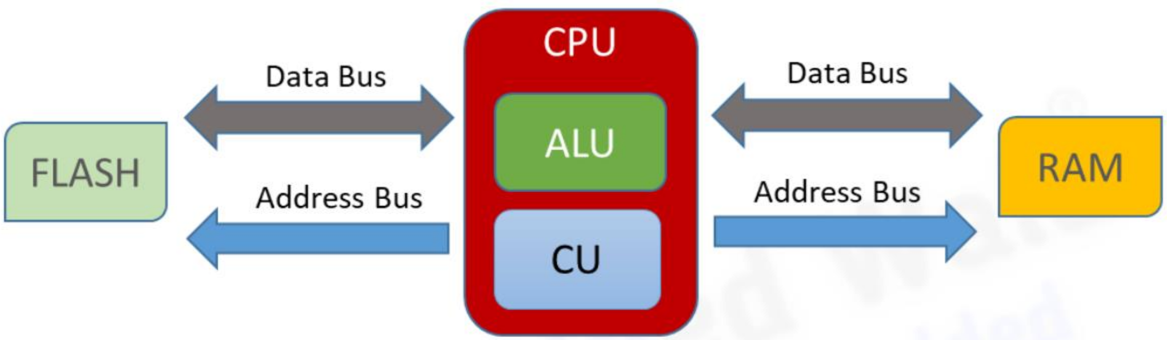
There are four main structural components:

1. Central processing unit (CPU)

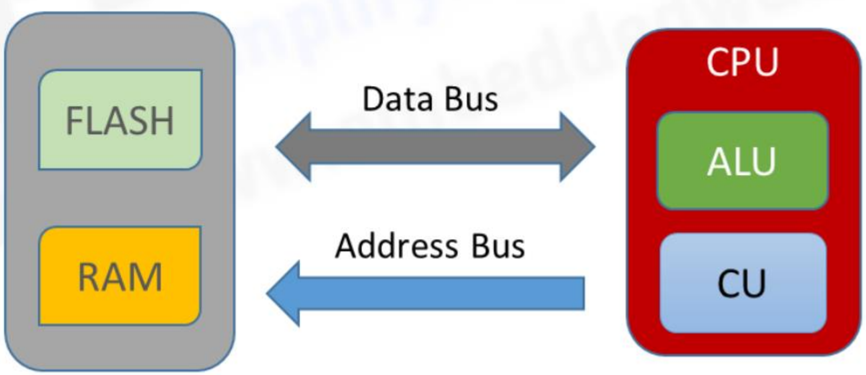
2. Main memory: Stores data.

3. Input/Output

4. System interconnection



Harvard Architecture

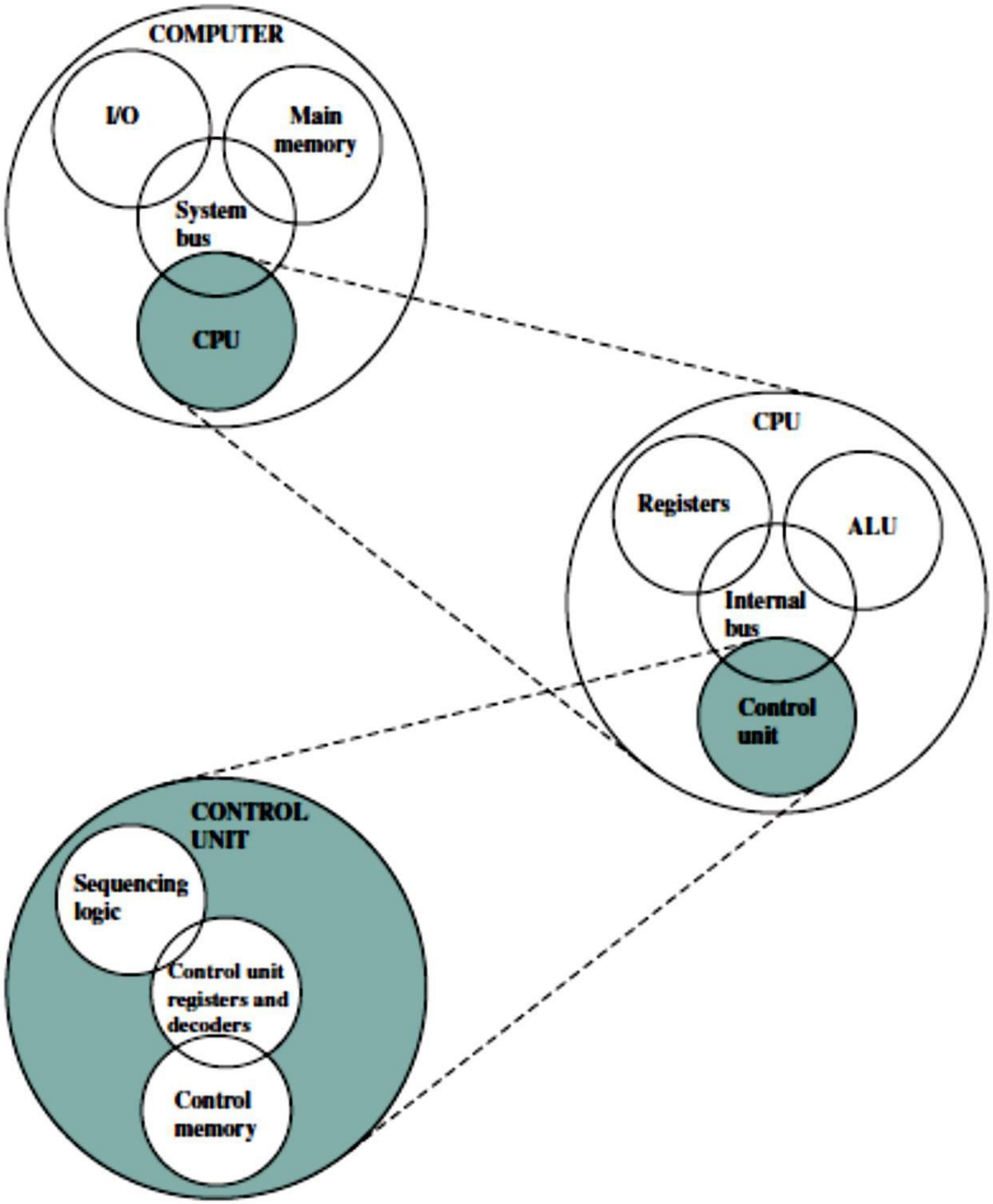


Von-Neumann Architecture

VON NEUMANN ARCHITECTURE
VERSUS
HARVARD ARCHITECTURE

VON NEUMANN ARCHITECTURE	HARVARD ARCHITECTURE
It is a theoretical design based on the stored-program computer concept.	It is a modern computer architecture based on the Harvard Mark I relay-based computer model.
It uses same physical memory address for instructions and data.	It uses separate memory addresses for instructions and data.
Processor needs two clock cycles to execute an instruction.	Processor needs one cycle to complete an instruction.
Simpler control unit design and development of one is cheaper and faster.	Control unit for two buses is more complicated which adds to the development cost.
Data transfers and instruction fetches cannot be performed simultaneously.	Data transfers and instruction fetches can be performed at the same time.
Used in personal computers, laptops, and workstations.	Used in microcontrollers and signal processing.

COMPUTER STRUCTURE



Control unit: Controls the operation of the CPU and hence the computer.
Arithmetic and logic unit (ALU): Performs the computer's data processing functions.
Registers: Provides storage internal to the CPU.
CPU interconnection: Some mechanism that provides for communication among the control unit, ALU, and registers.

COMPUTER history summary

Table 1.2 Computer Generations

Generation	Approximate Dates	Technology	Typical Speed (operations per second)
1	1946–1957	Vacuum tube	40,000
2	1957–1964	Transistor	200,000
3	1965–1971	Small- and medium-scale integration	1,000,000
4	1972–1977	Large scale integration	10,000,000
5	1978–1991	Very large scale integration	100,000,000
6	1991–	Ultra large scale integration	>1,000,000,000

COMPUTER history summary

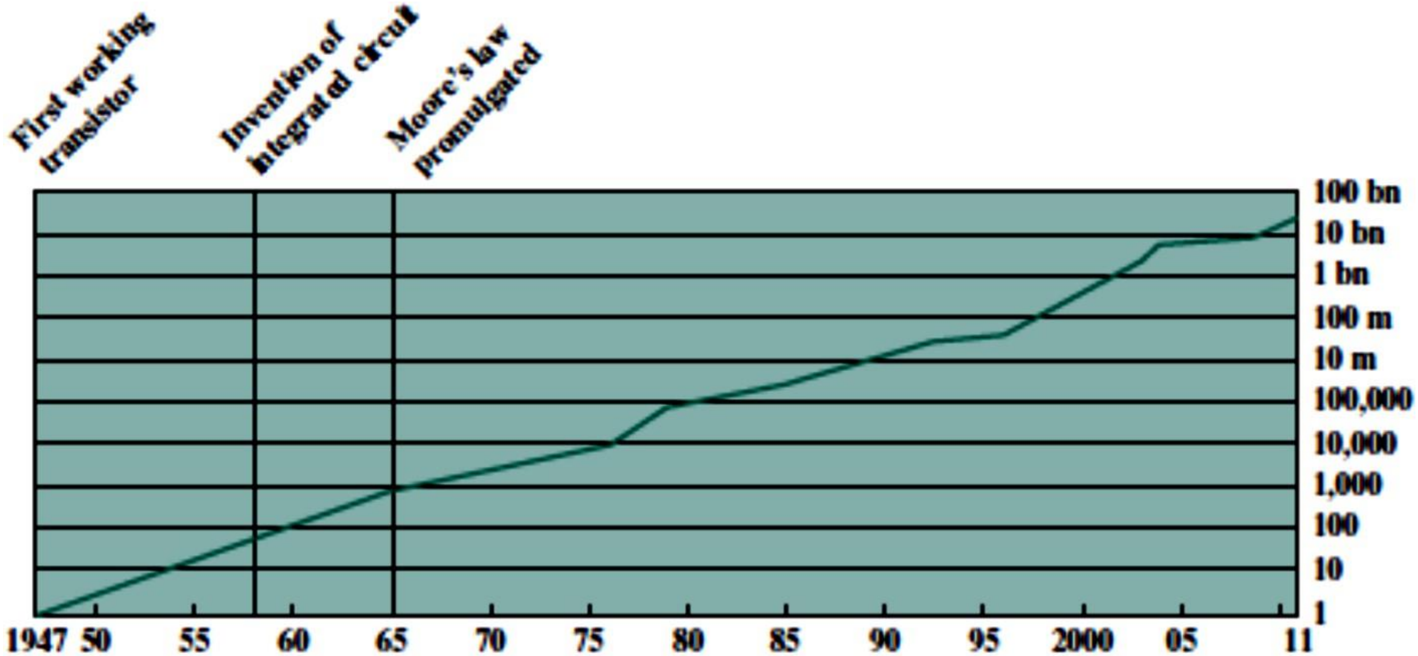


Figure 1.12 Growth in Transistor Count on Integrated Circuits

COMPUTER PROCESSOR INTEL X86 EVOLUTION

(d) Recent Processors

	Pentium III	Pentium 4	Core 2 Duo	Core i7 EE 4960X
Introduced	1999	2000	2006	2013
Clock speeds	450–660 MHz	1.3–1.8 GHz	1.06–1.2 GHz	4 GHz
Bus width	64 bits	64 bits	64 bits	64 bits
Number of transistors	9.5 million	42 million	167 million	1.86 billion
Feature size (nm)	250	180	65	22
Addressable memory	64 GB	64 GB	64 GB	64 GB
Virtual memory	64 TB	64 TB	64 TB	64 TB
Cache	512 kB L2	256 kB L2	2 MB L2	1.5 MB L2/15 MB L3
Number of cores	1	1	2	6

The x86 provides an excellent illustration of the advances in computer hardware over the past 35 years. The 1978 8086 was introduced with a clock speed of 5 MHz and had 29,000 transistors. A six-core Core i7 EE 4960X introduced in 2013 operates at 4 GHz, a speedup of a factor of 800, and has 1.86 billion transistors, about 64,000 times as many as the 8086. Yet the Core i7 EE 4960X is in only a slightly larger package than the 8086 and has a comparable cost.

COMPUTER PROCESSOR EVOLUTION

■■ Pentium: With the Pentium, Intel introduced the use of superscalar techniques, which allow multiple instructions to execute in parallel.

■■ Pentium Pro: The Pentium Pro continued the move into superscalar organization begun with the Pentium, with aggressive use of register renaming, branch prediction, data flow analysis, and speculative execution.

■■ Pentium II: The Pentium II incorporated Intel MMX technology, which is designed specifically to process video, audio, and graphics data efficiently.

■■ Pentium III: The Pentium III incorporates additional floating-point instructions: The Streaming SIMD Extensions (SSE) instruction set extension added 70 new instructions designed to increase performance when exactly the same operations are to be performed on multiple data objects. Typical applications
are digital signal processing and graphics processing.

■■ Pentium 4: The Pentium 4 includes additional floating-point and other enhancements for multimedia.11

■■ Core: This is the first Intel x86 microprocessor with a dual core, referring to the implementation of two cores on a single chip.

■■ Core 2: The Core 2 extends the Core architecture to 64 bits. The Core 2 Quad provides four cores on a single chip. More recent Core offerings have up to 10 cores per chip. An important addition to the architecture was the Advanced Vector Extensions instruction set that provided a set of 256-bit, and then 512-bit, instructions for efficient processing of vector data.

EMBEDDED SYSTEMS

The term embedded system refers to the use of electronics and software within a product, as opposed to a general- purpose computer, such as a laptop or desktop system.

Types of devices with embedded systems are almost too numerous to list.

Examples include cell phones, digital cameras, video cameras, calculators, microwave ovens, home security systems, washing machines, lighting systems, thermostats, printers, various automotive systems (e.g., transmission control, cruise control, fuel injection, anti-lock brakes, and suspension systems), tennis rackets, toothbrushes, and numerous types of sensors and actuators in automated systems.

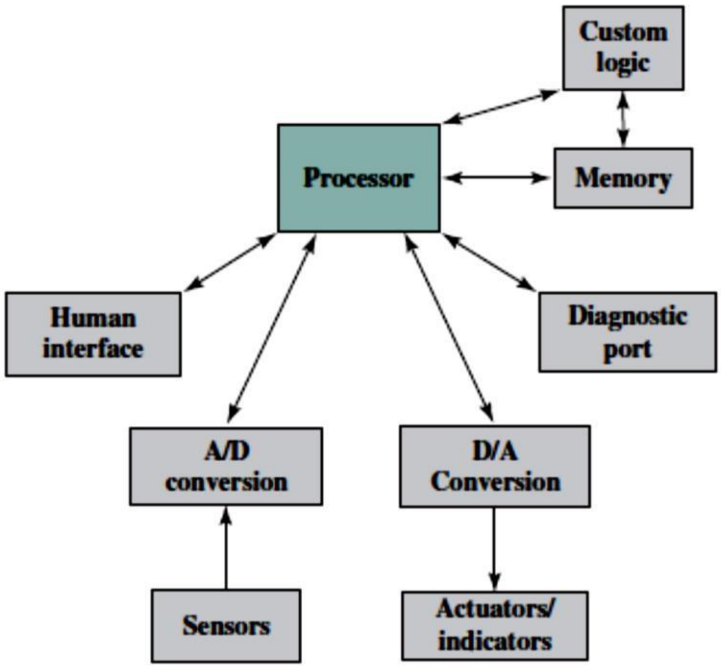


Figure 1.14 Possible Organization of an Embedded System

Microprocessors versus Microcontrollers

As we have seen, early microprocessor chips included registers, an ALU, and some sort of control unit or instruction processing logic. As transistor density increased, it became possible to increase the complexity of the instruction set architecture, and ultimately to add memory and more than one processor. Contemporary microprocessor chips include multiple cores and a substantial amount of cache memory.

A microcontroller chip makes a substantially different use of the logic space available. A microcontroller is a single chip that contains the processor, non-volatile memory for the program (ROM), volatile memory for input and output (RAM), a clock, and an I/O control unit. The processor portion of the microcontroller has a much lower silicon area than other microprocessors and much higher energy efficiency.

Microprocessor Speed

Year by year, the cost of computer systems continues to drop dramatically, while the performance and capacity of those systems continue to rise equally dramatically.

Today's laptops have the computing power of an IBM mainframe from 10 or 15 years ago.

Anything that gets in the way of that smooth flow undermines the power of the processor.

Accordingly, while the chipmakers have been busy learning how to fabricate chips of greater and greater density, the processor designers must come up with

ever more elaborate techniques for feeding the monster. Among the techniques built into contemporary processors are the following:

Microprocessor Speed

Pipelining: The execution of an instruction involves multiple stages of operation, including fetching the instruction, decoding the opcode, fetching operands, performing a calculation, and so on. Pipelining enables a processor to work simultaneously on multiple instructions by performing a different phase for each of the multiple instructions at the same time. The processor overlaps operations by moving data or instructions into a conceptual pipe with all stages of the pipe processing simultaneously. For example, while one instruction is being executed, the computer is decoding the next instruction. This is the same principle as seen in an assembly line.

Branch prediction: The processor looks ahead in the instruction code fetched from memory and predicts which branches, or groups of instructions, are likely to be processed next. If the processor guesses right most of the time, it can prefetch the correct instructions and buffer them so that the processor is kept busy.

Microprocessor Speed

Superscalar execution: This is the ability to issue more than one instruction in every processor clock cycle. In effect, multiple parallel pipelines are used.

Data flow analysis: The processor analyzes which instructions are dependent on each other's results, or data, to create an optimized schedule of instructions. In fact, instructions are scheduled to be executed when ready, independent of the original program order. This prevents unnecessary delay.