جامعة الموصل- كلية التربية للعلوم الصرفة- قسم علوم الحاسوب

المرحلة الأولى

تركيب الحاسبة

مدرس المادة النظري :

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مدرس المادة العلمي:

م.م زيد فواز جارالله

- **Computer**: is a machine that can be programmed to carry out sequences of arithmetic or logical operations (computation) automatically. Modern digital electronic computers can perform generic sets of operations known as programs. These programs enable computers to perform a wide range of tasks.

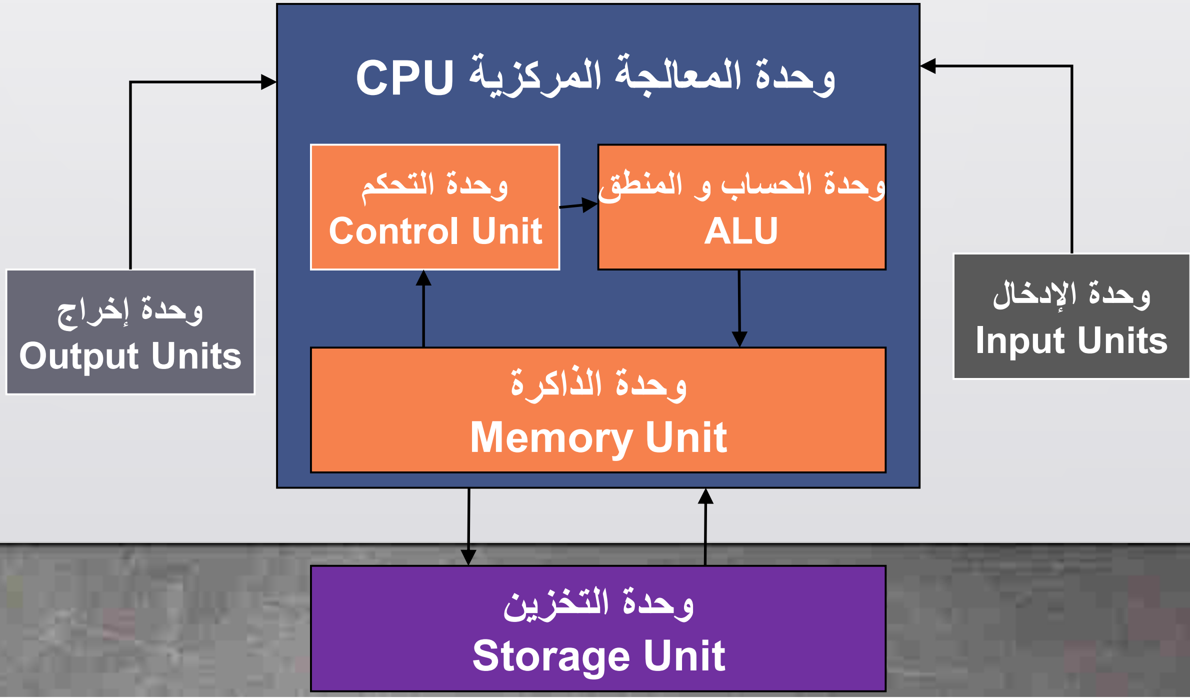
- **Personal Computer(PC):** is a multi purpose microcomputer whose size, capabilities, and price make it feasible for individual use.
- Personal computers are intended to be operated directly by an end user, rather than by a computer expert or technician

Component of Computer

- مكونات الحاسب
  - المكون المادي Hardware
  - المكون البرمجي Software

Hardware Component

1. Processing Unit (CPU)
2. Memory Unit (RAM,ROM)
3. Storage Unit(HDD,SSD)
4. Input Units
5. Output Units



INPUT AND OUTPUT DEVICES

INPUT DEVICES

An input device is anything that puts information inside a computer. Without any input devices a computer would simply be a display device and not allow users to interact with it. It provide means of communication between a computer and outer world. It is also known as peripheral devices because it surround the CPU and memory of a computer system.

TYPES OF INPUT DEVICES

- Keyboard devices
- Point-and-draw devices
- Data scanning devices
- Digitizer
- Electronic Cards Based Devices
- Vision Based devices

KEYBOARD

A 'Keyboard' is a human interface device which is represented as a layout of buttons. Each button, or key, can be used to either input a character to a computer, or to call upon a particular function of the keyboard. The most popular keyboard used today is the 101-keys QWERT Keyboard. Types of Keys in keyboard are:-

- Alphabetic Keys
- Numeric Keys
- Function Keys
- Navigation Keys

Qwerty Keyboard

ESCAPE KEY
A typically cancels a selections of a procedure.

Function keys
Shorcut for spacific tasks. F1, for example, typically display online help

Numeric Keypad
Enter numbers and airthmetic symbols, and control cursur.

Navigation Key
Control the cursur or insertion point on the screen.

Qwerty keyboard

POINT & DRAW DEVICES

A Pointing device is an input device that allows a user to input continuous and multi-dimensional data to a computer. Some of the point and draw devices are:->

- Mouse
- Track Ball
- Joy Stick
- Light Pen
- Touch Screen

1. Mouse

A mouse is a pointing device that functions by detecting two-dimensional motion relative to its supporting surface. A mouse consists of an object held under one of the user's hands, with one or more buttons.

Mechanical Mouse:A mouse that uses a rubber ball that makes contact with wheels inside the unit when it is rolled on a pad of desktop.

Optical Mouse: A mouse that uses light to detect movement. It emits a light and senses its reflection as it is moved. As the user rolls the mouse on a flat surface, the cursor on screen also moves in the same direction.

2. Trackball

A trackball is a pointing device consisting of a ball held by a socket containing sensors to detect a rotation of the ball about two axes-like an upside-down mouse with an exposed protruding ball. The user rolls the ball with the thumb, fingers, or the palm of the hand to move a cursor.

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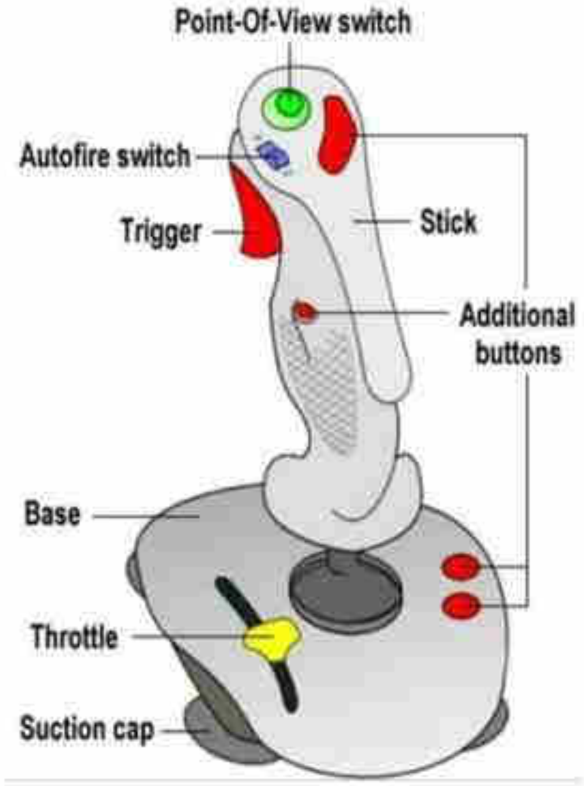
3. Joystick

A joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling. Joysticks usually have one or more push-Buttons.



4. Light Pen

A light pen is a computer input device in the form of a light-sensitive wand used in conjunction with a computer's CRT TV set or monitor. It allows the user to point to displayed objects, or draw on the screen. A light pen is fairly simple to implement. Just like a light gun, a light pen works by sensing the sudden small change in brightness of a point on the screen when the electron gun refreshes that spot.

5. Touch Screen

A touchscreen is a display that can detect the presence and location of a touch within the display area. The term generally refers ta a touch or contact to the display of a device by a finger or hand. It plays an important role in the design of digital appliances such as the personal digital assistant (PDA), mobile phones, and video games.

SCANNERS

A scanner is a device that optically scans images, printed text, handwriting, or an object, and converts it to a digital image. Types of Scanners are:-

1. Image Scanners
   (a) Flatbed scanners
   (b) Handheld scanners
2. OCR(Optical Character recognition)
3. OMR(Optical Mark Reader)
4. Bar code Reader
5. MICR(Magnetic Ink Character Recognition).

A **digital image** is an image composed of picture elements, also known as *pixels*

1. Image Scanner

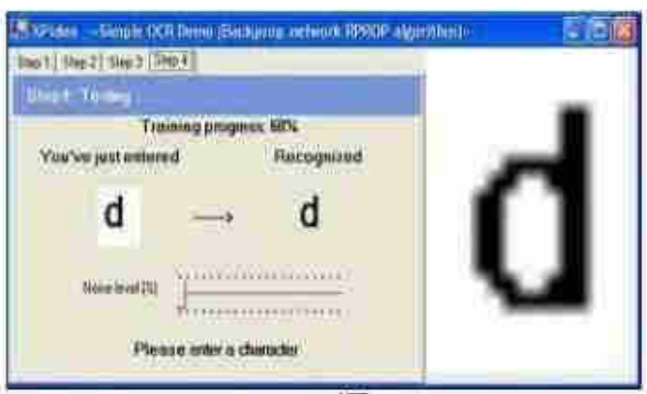
<u>Flatbed Scanners</u>:-A Flate-bed scanner is like a copier machine consisting of a box having a glass plate on its top and a lid that covers the glass plate. Its also called desktop scanners, are the most versatile and commonly used sccaners.

Image Scanner

Handheld Scanners:- A small handheld scanning device used for digitizing images. A scanner that is moved across the image to be scanned by hand is called Handheld scanners. Handheld scanners are small and less expensive.

2.Optical Character Recognition

Optical character recognition, usually abbreviated to OCR, is the mechanical or electronic translation of images of handwritten, typewritten or printed text into machine-editable text. It is used to convert paper books and documents into electronic files. When one scans a paper page into a computer, it produces just an image file, a photo of the page.



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3. Optical Mark Reader

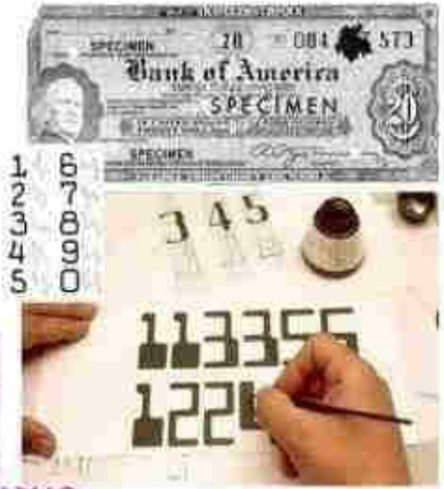
Optical Mark Recognition (also called Optical Mark Reading and OMR) is the process of capturing human-marked data from document forms such as surveys and tests. OMR devices work with a dedicated scanner device that shines a beam of light onto the form paper.

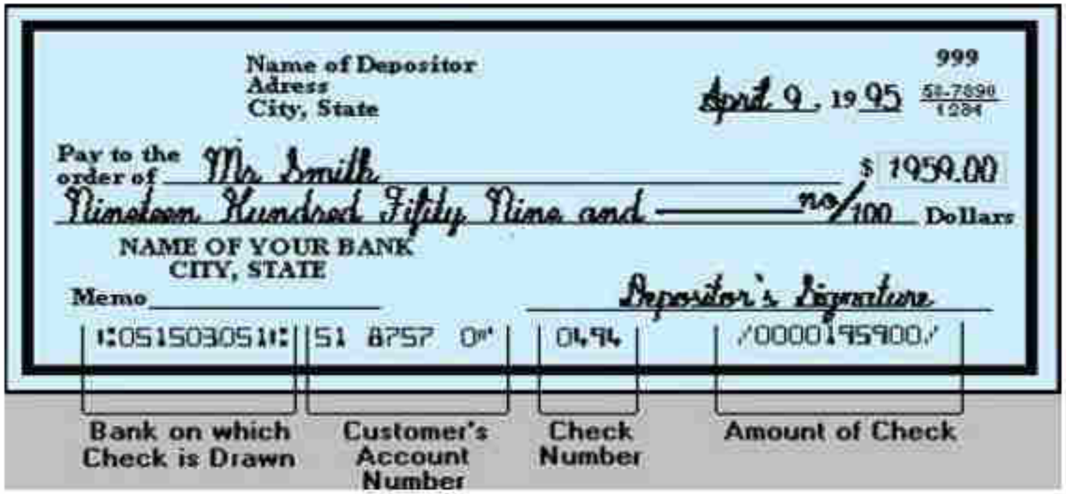
4. Barcode Reader

A barcode reader (or barcode scanner) is an electronic device for reading printed barcodes. Like a flatbed scanner, it consist of a light source, a lens and a light sensor translating optical impulses into electrical ones.

5. Magnetic Ink Character Recognition

Magnetic Ink Character Recognition, or MICR, is an Character recognition technology used primarily by the banking industry to facilitate the processing of cheques. The technology allows computers to read information such as account numbers of printed documents.





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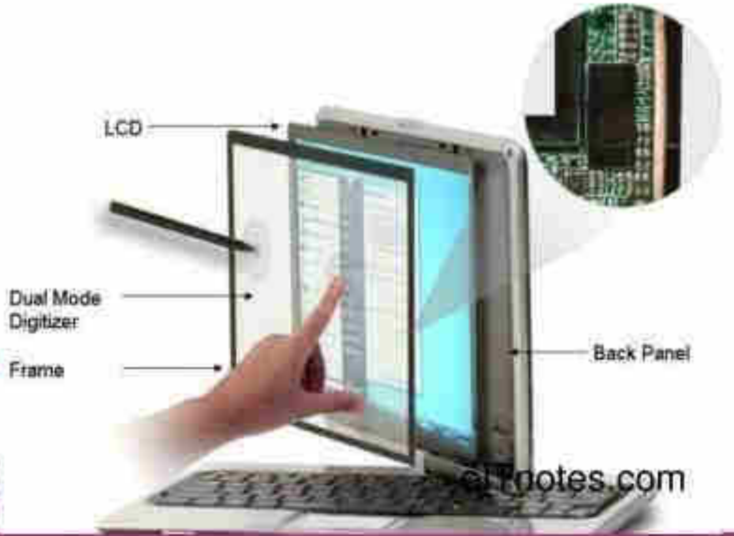
DIGITIZER

Digitizers or digitization is the representation of an object, iamge, sound, document or a signal (usually an analog signal) by a discrete set of its points or samples. The result is called digital representation or, more specifically, a digital image, for the object, and digital form, for the signal. Strictly speaking, digitizer means simply capturing an anolog signal in digital form.



Electronic-Card Reader

A card reader is an input device which help us to read different types of cards. A card reader can read memory card, Debit card, Credit card etc. A memory card reader is a device used for communication with a smart card or flash memory card. The card reader supplies the integrated circuit on the smart card with electricity.

Speech Recognition Device

A voice command device is a device controlled by means of the human voice. By removing the need to use buttons, dials and switches, consumers can easily operate appliances while doing other tasks. Speech recognition converts spoken words or text.

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Vision Input System

It allows computer to accept input just by seeing an object. Input data is normally an object's shape and feature in the form of an image. Today's objective is to investigate the development of a vision system which utilizes or establishes standards. Current focuses in the field include emotion recognition from the face and hand gesture recognition.

OUTPUT DEVICES

An output device is any piece of computer hardware equipment used to communicate the results of data processing carried out by an information processing system (such as a computer) to the outside world.

Types Of Output Devices

- Monitor
- Speaker
- Headphone
- Printer
- Plotter
- Projector

Monitor

- Monitor is a TV like device that display information.
- It can display text as well as graphic images in color or black & white while based on monitor type.
- Monitors are classified on the basis of color and signals.

BASED ON COLOR

Monochrome:- It display two colors, one on the foreground and one on the background. The colors can be black and white, green and black or amber and black.

Gray-scale:- Special type of monochrome monitor capable of displaying different shades of gray.

Multi-Color: They are called RGB monitors, they accept three separate signals-Red, Green and Blue.

A multi-color monitor can display any color.

Based On Signal

Digital monitor: It accepts digital signals rather than analog.
The term digital refers to the type of input received from the video adapter.
Digital monitors are fast and produce clear images.
Eg: Flat-panel display which uses Liquid Crystal Display technology.

Analog monitor: This is the traditional type of color display that has been used for years in televisions.
In reality all monitors based on CRT(Cathode Ray Tube) technology are analog.
The monitor consumes much space.

Sound Card & Speakers

- Sound cards enable the computer to output sound through speakers.

- Speakers are required to listen to music and video CD/DVD sound.
- This also allow us to listen to the computer generated sound.

- Some monitors have built in speakers.

Headphones

- Headphones give sound output from the computer.

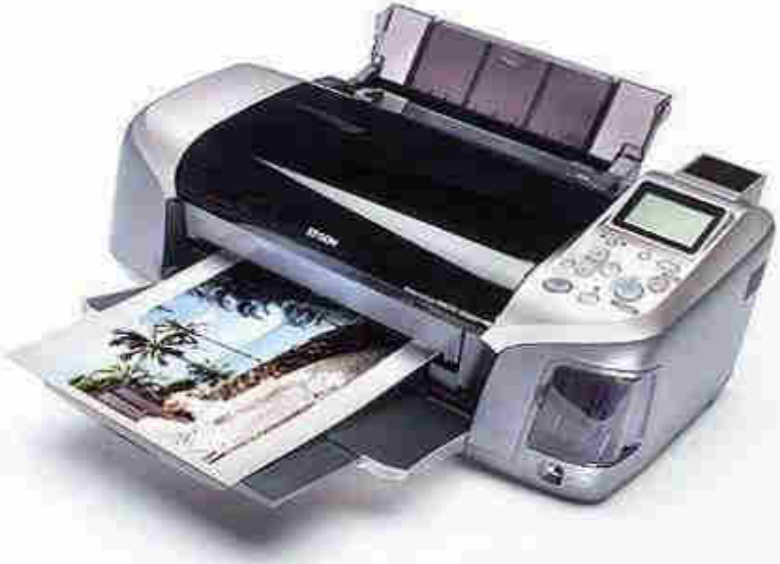
- They are similar to speakers, except they are worn on the ears so only one person can hear the output at a time.

Printer

A printer is a device that prints text or illustrations on paper.

There are many types of printers an they are:

- Daisy-wheel
- Dot-Matrix
- Ink-Jet printer
- Laser
- LED
- Thermal



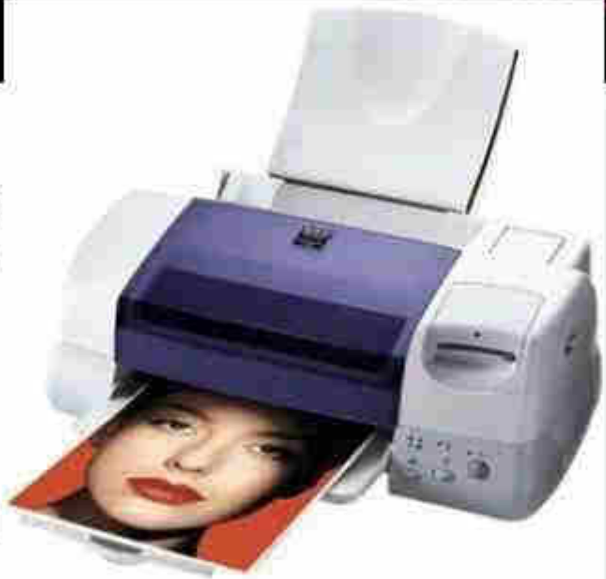
Daisy-Wheel Printer

- It works like a ball head type writer.
- They are printers of letter-quality type.
- It cannot print graphic images.
- They are noisy and slow.

Dot Matrix Printer

- They are the first printers used with personal computers.
- It creates image by striking pins against an ink ribbon.
- By activating these pins in different combinations , printer produce different characters on paper.
- Dot matrix printers are inexpensive and relatively fast.
- Speed of these printers are measured in characters per second(CPS).
- The speed can vary from about 50-500CPS.
- Disadvantage of this printer is its print quality and the loud noise during processing.

Ink Jet Printer



- These printers create image by spraying jet of ink on the paper surface and hence the name.
- The speed of these printers is measured in pages per minute (PPM).
- It produce very high quality printouts on any surface.
- It can be used to get multicolor print outs.
- It provides a resolution of 300 dots per inch.

Advantage & Disadvantage

Advantage:
Since it require smaller mechanical parts, it is popular as portable printers.
It provides an inexpensive way to print full color documents.

Disadvantage:
Per page printing cost of these printers is very high.
They cannot be used to take multiple carbon copies.

Laser Printer

- Laser printer utilizes a laser beam to produce an image and hence the name.
- It is also called page printers.
- Laser printer are expensive.
- Speed is measured in Pages Per Minute or PPM.
- It produce very high quality print and print unlimited variety of fonts.
- It cannot be used to take multiple carbon printouts.

Other Printers

LED Printer

They are similar to laser printer but uses liquid crystals or light emitting diodes rather than a laser.

Thermal Printer

It produce image by pushing electrically heated pins against special heat sensitive paper.
They are inexpensive and are used in calculators and many fax machines.
They produce low quality print.

Plotter

- Plotters are similar to the computer printers.
- It is used to draw pictures on paper based on commands from a computer.
- Plotters differ from printers in that they draw lines using a pen.
- They can produce continuous lines.
- Plotters are used in engineering applications.
- They are more expensive than printers.

PROJECTOR

- A projector is a device that enables an image, such as a computer screen, to be projected onto a flat surface.

- These devices are commonly used in meetings and presentations as they allow for a large image to be shown so everyone in a room can see.

Thank you!

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William Stallings Computer Organization and Architecture 10th Edition

Chapter 1

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Basic Concepts and Computer Evolution

Computer Architecture
Computer Organization

Computer Architecture

- Attributes of a system visible to the programmer
- Have a direct impact on the logical execution of a program

Architectural attributes include:

- Instruction set, number of bits used to represent various data types, I/O mechanisms, techniques for addressing memory

Computer Organization

- The operational units and their interconnections that realize the architectural specifications

Organizational attributes include:

- Hardware details transparent to the programmer, control signals, interfaces between the computer and peripherals, memory technology used

IBM System 370 Architecture

- IBM System/370 architecture
  - Was introduced in 1970
  - Included a number of models
  - New models are introduced with improved technology, but retain the same architecture so that the customer's software investment is protected
  - Architecture has survived to this day as the architecture of IBM's mainframe product line

Structure and Function

- Hierarchical system
  - Set of interrelated subsystems
- Hierarchical nature of complex systems is essential to both their design and their description
- Designer need only deal with a particular level of the system at a time
  - Concerned with structure and function at each level

- Structure
  - The way in which components relate to each other
- Function
  - The operation of individual components as part of the structure

Function

- There are four basic functions that a computer can perform:
  - Data processing
    - Processor
  - Data storage
    - Short-term
    - Long-term
  - Data movement
    - Input-output (I/O) - when data are received from or delivered to a device (peripheral) that is directly connected to the computer
    - Data communications – when data are moved over longer distances, to or from a remote device (e-mail)
  - Control
    - A control unit manages the computer's resources and manages the performance of its functional parts in response to instructions

Structure

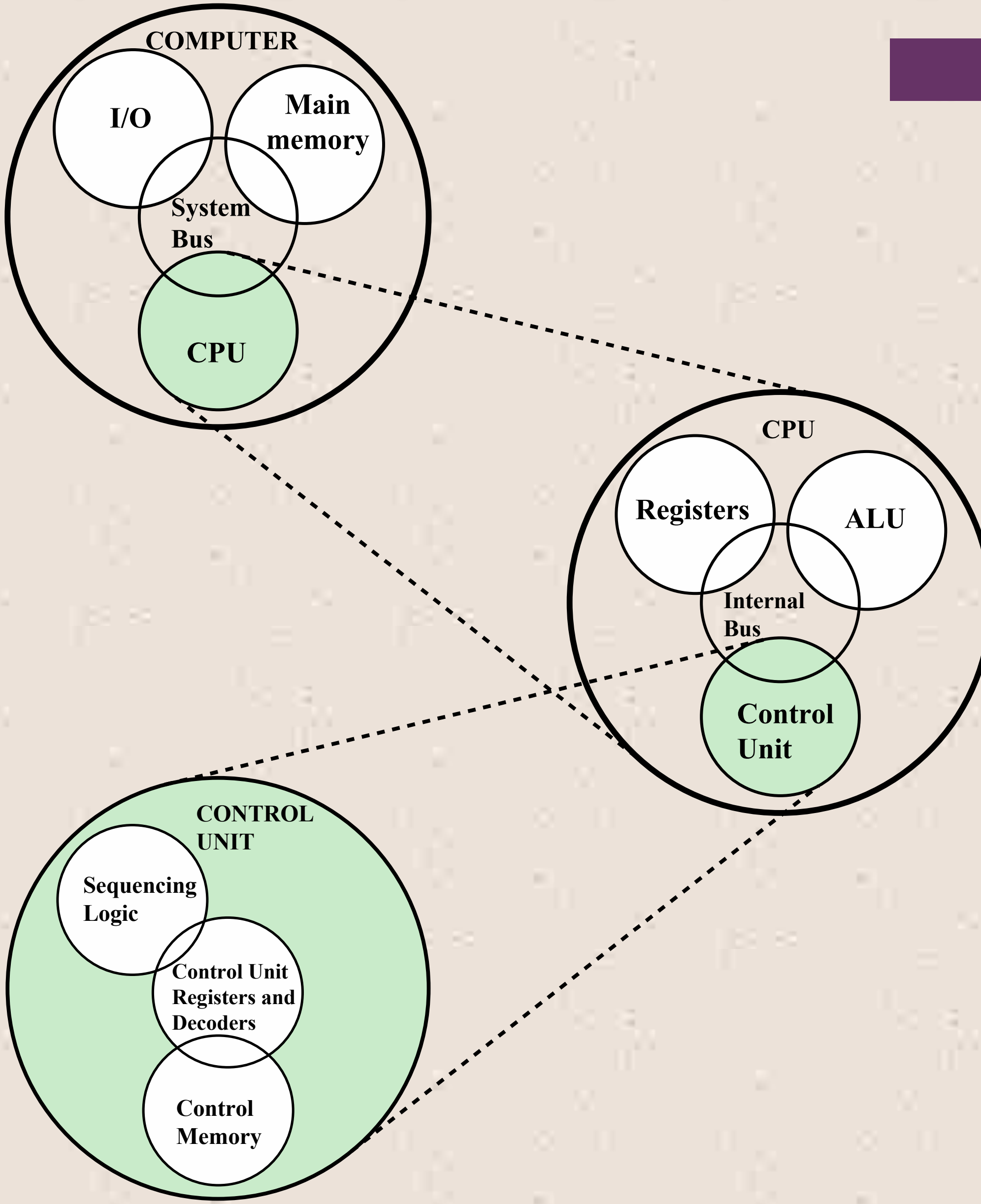

Figure 1.1 A Top-Down View of a Computer

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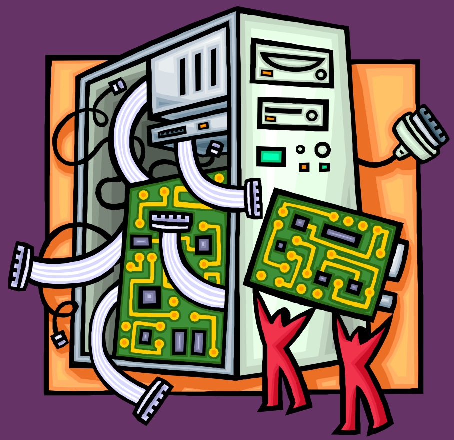
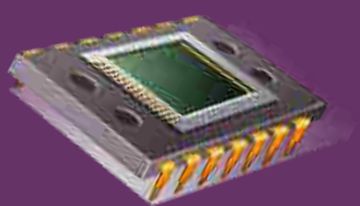
There are four main structural components of the computer:

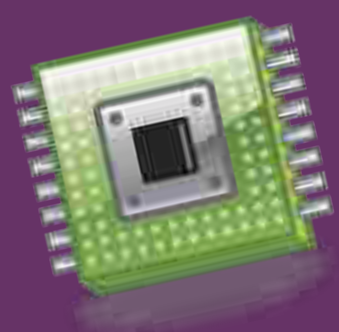


- CPU – controls the operation of the computer and performs its data processing functions
- Main Memory – stores data
- I/O – moves data between the computer and its external environment
- System Interconnection – some mechanism that provides for communication among CPU, main memory, and I/O

CPU

Major structural components:





- Control Unit
  - Controls the operation of the CPU and hence the computer
- Arithmetic and Logic Unit (ALU)
  - Performs the computer's data processing function
- Registers
  - Provide storage internal to the CPU
- CPU Interconnection
  - Some mechanism that provides for communication among the control unit, ALU, and registers

Multicore Computer Structure

- Central processing unit (CPU)
  - Portion of the computer that fetches and executes instructions
  - Consists of an ALU, a control unit, and registers
  - Referred to as a processor in a system with a **single** processing unit
- Core
  - An individual processing unit on a processor chip
  - May be equivalent in functionality to a CPU on a single-CPU system
  - Specialized processing units are also referred to as cores
- Processor
  - A physical piece of silicon containing one or more cores
  - Is the computer component that interprets and executes instructions
  - Referred to as a *multicore processor* if it contains multiple cores

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Cache Memory

- Multiple layers of memory between the processor and main memory
- Is smaller and faster than main memory
- Used to speed up memory access by placing in the cache data from main memory that is likely to be used in the near future
- A greater performance improvement may be obtained by using multiple levels of cache, with level 1 (L1) closest to the core and additional levels (L2, L3, etc.) progressively farther from the core

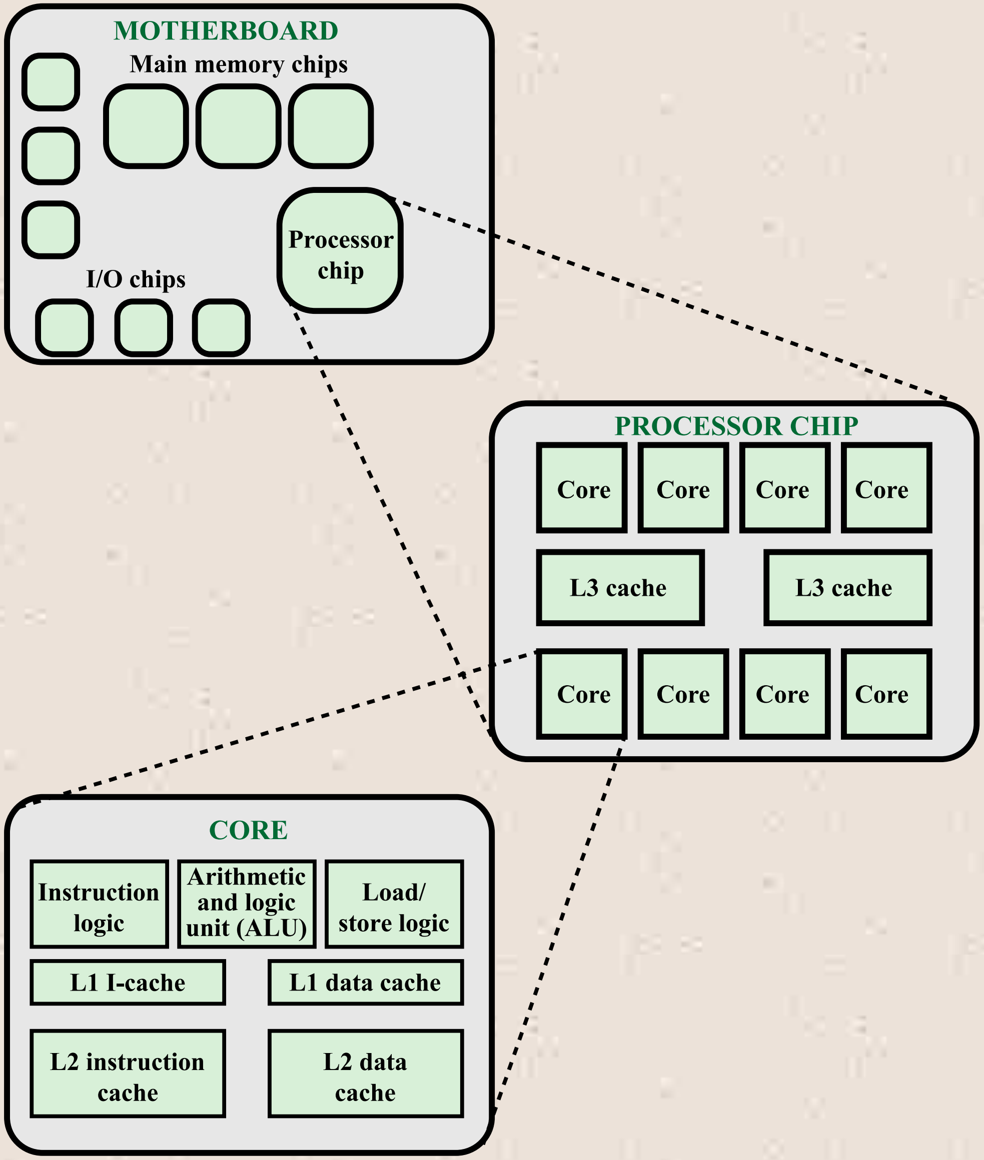

Figure 1.2 Simplified View of Major Elements of a Multicore Computer

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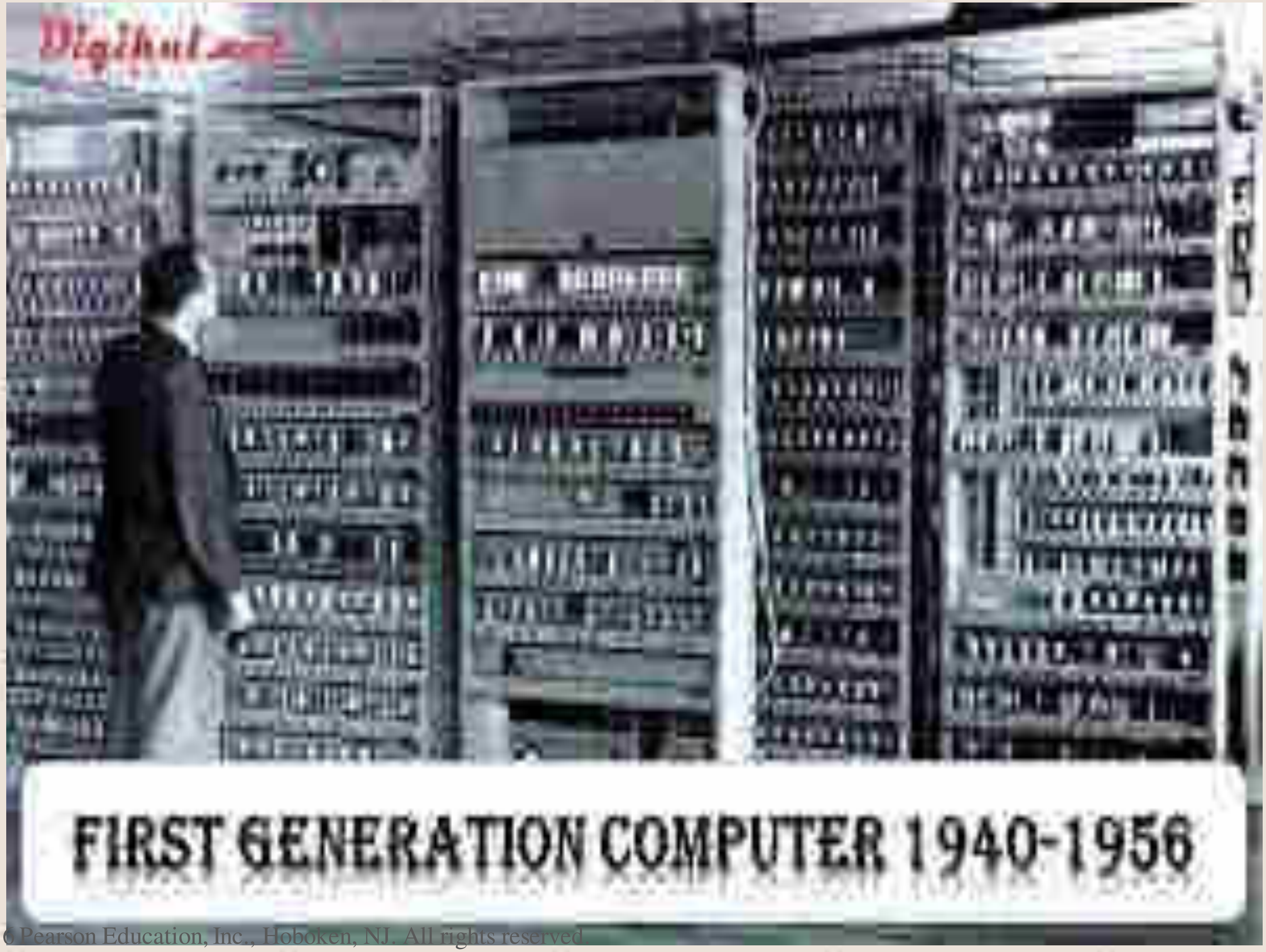
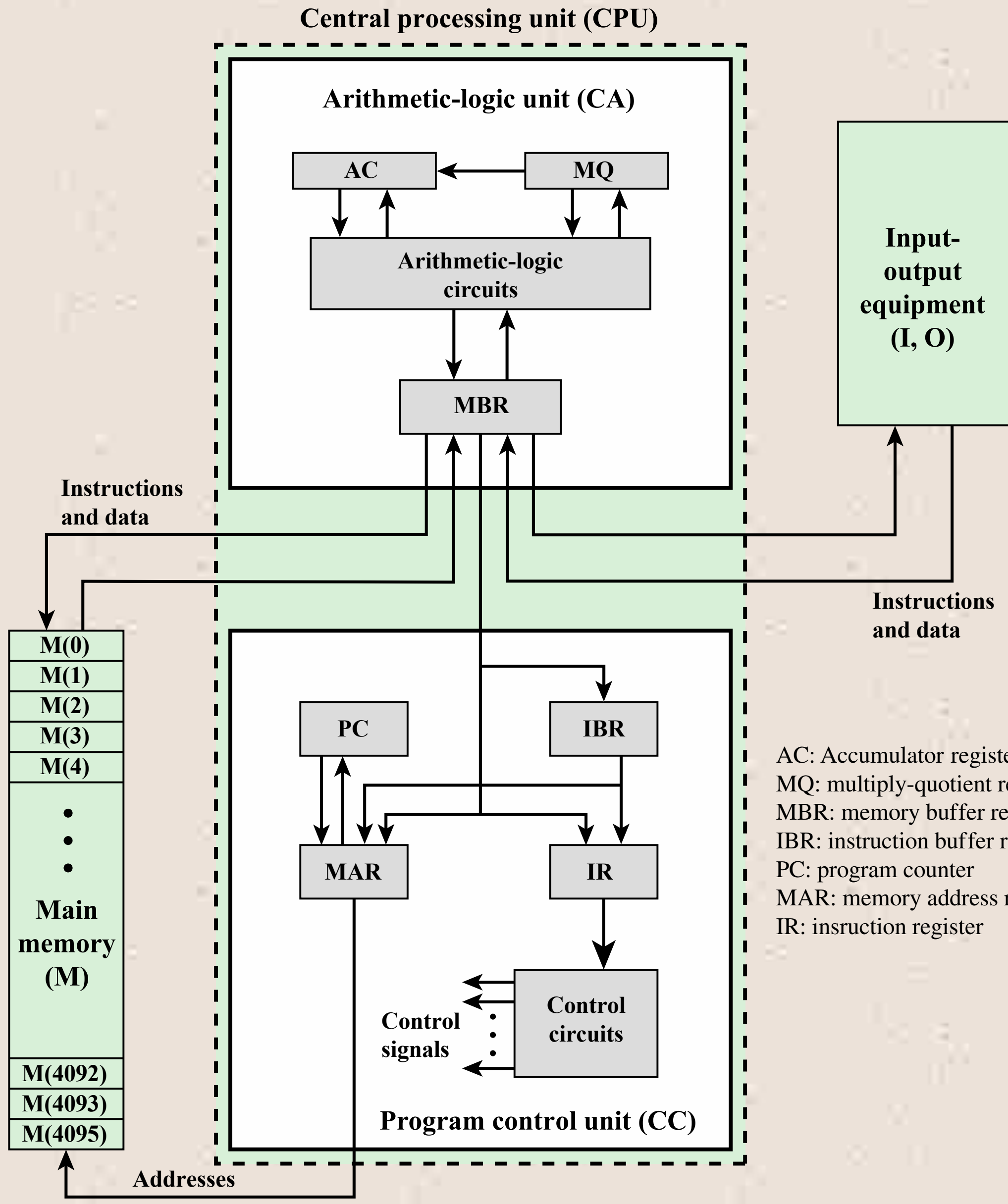
History of Computers

First Generation: Vacuum Tubes

- Vacuum tubes were used for digital logic elements and memory
- IAS computer
  - Fundamental design approach was the stored program concept
    - Attributed to the mathematician John von Neumann
    - First publication of the idea was in 1945 for the EDVAC
  - Design began at the Princeton Institute for Advanced Studies
  - Completed in 1952
  - Prototype of all subsequent general-purpose computers

First Generation: Vacuum Tubes





AC: Accumulator register
MQ: multiply-quotient register
MBR: memory buffer register
IBR: instruction buffer register
PC: program counter
MAR: memory address register
IR: insruction register

Figure 1.6 IAS Structure

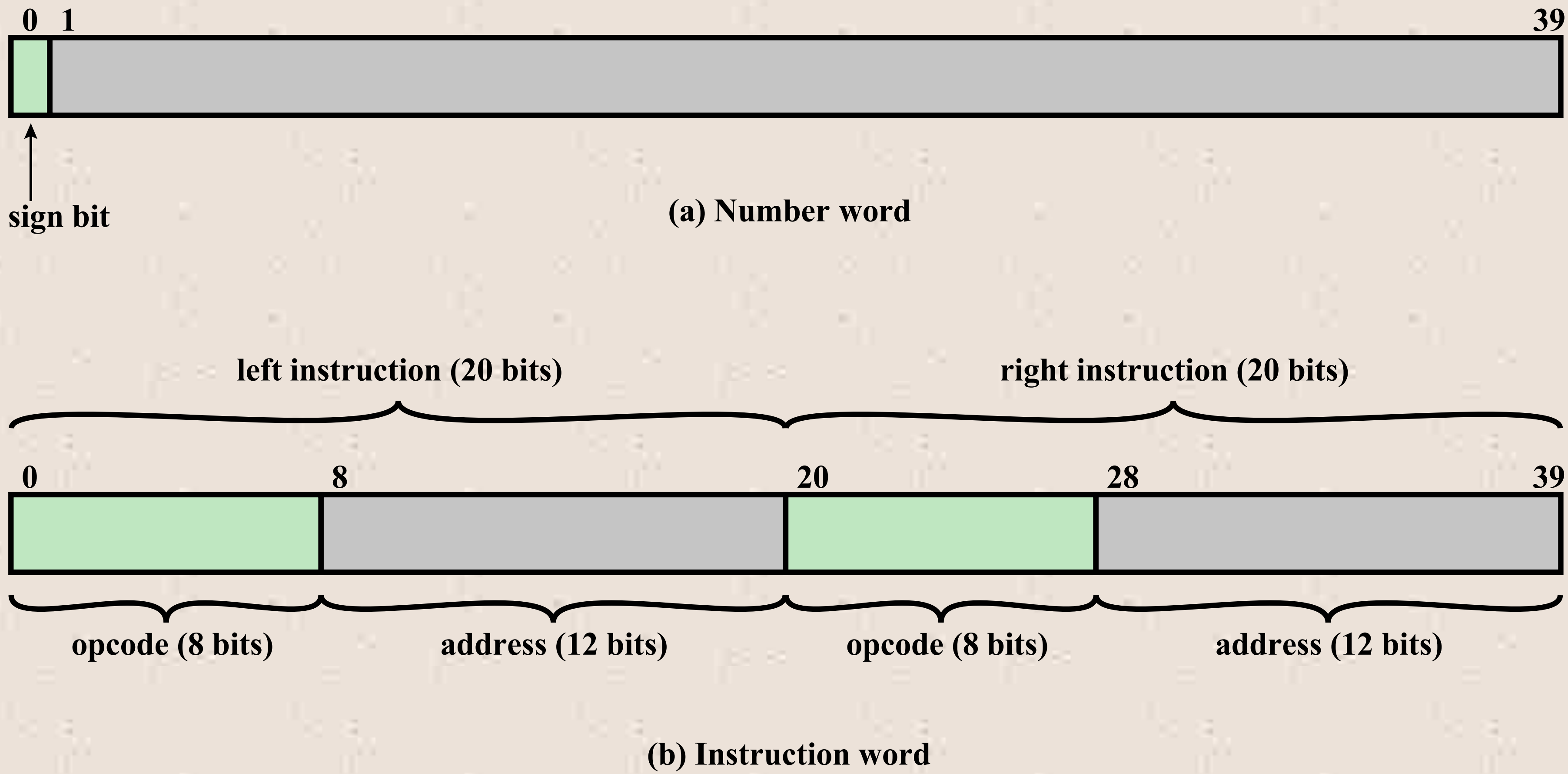


Figure 1.7 IAS Memory Formats

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Registers

Memory buffer register (MBR)	• Contains a word to be stored in memory or sent to the I/O unit • Or is used to receive a word from memory or from the I/O unit
Memory address register (MAR)	• Specifies the address in memory of the word to be written from or read into the MBR
Instruction register (IR)	• Contains the 8-bit opcode instruction being executed
Instruction buffer register (IBR)	• Employed to temporarily hold the right-hand instruction from a word in memory
Program counter (PC)	• Contains the address of the next instruction pair to be fetched from memory
Accumulator (AC) and multiplier quotient (MQ)	• Employed to temporarily hold operands and results of ALU operations

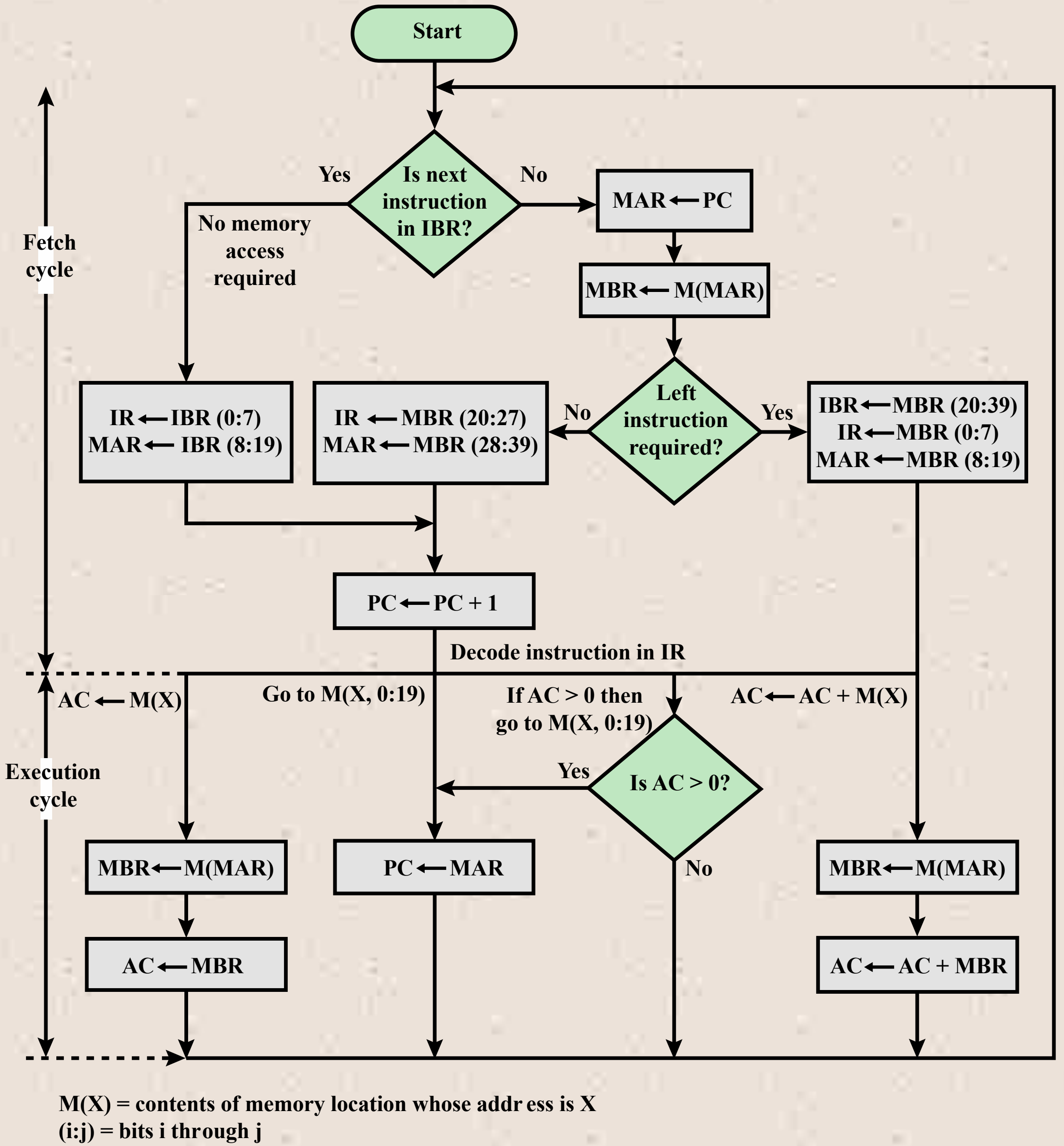

Figure 1.8 Partial Flowchart of IAS Operation

Instruction Type	Opcode	Symbolic Representation	Description
Data transfer	00001010	LOAD MQ	Transfer contents of register MQ to the accumulator AC
	00001001	LOAD MQ,M(X)	Transfer contents of memory location X to MQ
	00100001	STOR M(X)	Transfer contents of accumulator to memory location X
	00000001	LOAD M(X)	Transfer M(X) to the accumulator
	00000010	LOAD –M(X)	Transfer –M(X) to the accumulator
	00000011	LOAD |M(X)|	Transfer absolute value of M(X) to the accumulator
	00000100	LOAD –|M(X)|	Transfer –|M(X)| to the accumulator
Unconditional branch	00001101	JUMP M(X,0:19)	Take next instruction from left half of M(X)
	00001110	JUMP M(X,20:39)	Take next instruction from right half of M(X)
Conditional branch	00001111	JUMP+ M(X,0:19)	If number in the accumulator is nonnegative, take next instruction from left half of M(X)
		JUMP + M(X,20:39)	*If number in the accumulator is nonnegative, take next instruction from right half of M(X)*
Arithmetic	00000101	ADD M(X)	Add M(X) to AC; put the result in AC
	00000111	ADD |M(X)|	Add |M(X)| to AC; put the result in AC
	00000110	SUB M(X)	Subtract M(X) from AC; put the result in AC
	00001000	SUB |M(X)|	Subtract |M(X)| from AC; put the remainder in AC
	00001011	MUL M(X)	Multiply M(X) by MQ; put most significant bits of result in AC, put least significant bits in MQ
	00001100	DIV M(X)	Divide AC by M(X); put the quotient in MQ and the remainder in AC
	00010100	LSH	Multiply accumulator by 2; i.e., shift left one bit position
	00010101	RSH	Divide accumulator by 2; i.e., shift right one position
Address modify	00010010	STOR M(X,8:19)	Replace left address field at M(X) by 12 rightmost bits of AC
	00010011	STOR M(X,28:39)	Replace right address field at M(X) by 12 rightmost bits of AC

Table 1.1

The IAS Instruction Set

(Table can be found on page 17 in the textbook.)

History of Computers
Second Generation: Transistors

- Smaller
- Cheaper
- Dissipates less heat than a vacuum tube
- Is a *solid state device* made from silicon
- Was invented at Bell Labs in 1947
- It was not until the late 1950's that fully transistorized computers were commercially available

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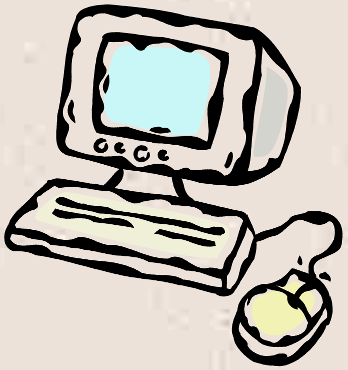
Second Generation Computers

- Introduced:
  - More complex arithmetic and logic units and control units
  - The use of high-level programming languages
  - Provision of *system software* which provided the ability to:
    - Load programs
    - Move data to peripherals
    - Libraries perform common computations



Second Generation Computers

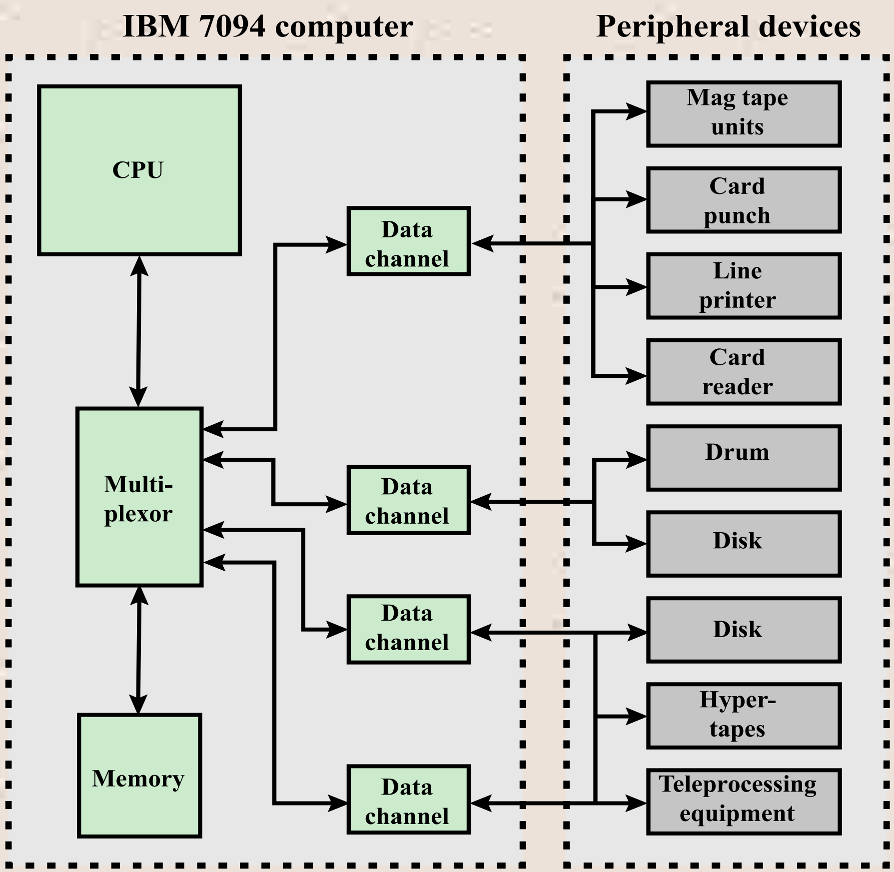


Figure 1.9 An IBM 7094 Configuration

+ Second Generation Computers

- Data channel:
  - Several differences from the IAS computer are worth noting. The most important of these is the use of data channels. A data channel is an independent I/O module with its own processor and instruction set
  - In a computer system with such devices, the CPU does **not execute** detailed I/O instructions. Such instructions are stored in a main memory to be executed by a **special-purpose processor** in the data channel itself.
  - The CPU initiates an I/O transfer by sending a control signal to the data channel, instructing it to execute a sequence of instructions in memory. The data channel performs its task independently of the CPU and signals the CPU when the operation is complete.

- Multiplexor:

Which is the central termination point for data channels, the CPU, and memory. The multiplexor schedules access to the memory from the CPU and data channels, allowing these devices to act independently.

History of Computers

Third Generation: Integrated Circuits

- 1958 – the invention of the integrated circuit
- *Discrete component*
  - Single, self-contained transistor
  - Manufactured separately, packaged in their own containers, and soldered or wired together onto masonite-like circuit boards
  - Manufacturing process was expensive and cumbersome
- The two most important members of the third generation were the IBM System/360 and the DEC PDP-8

Microelectronics

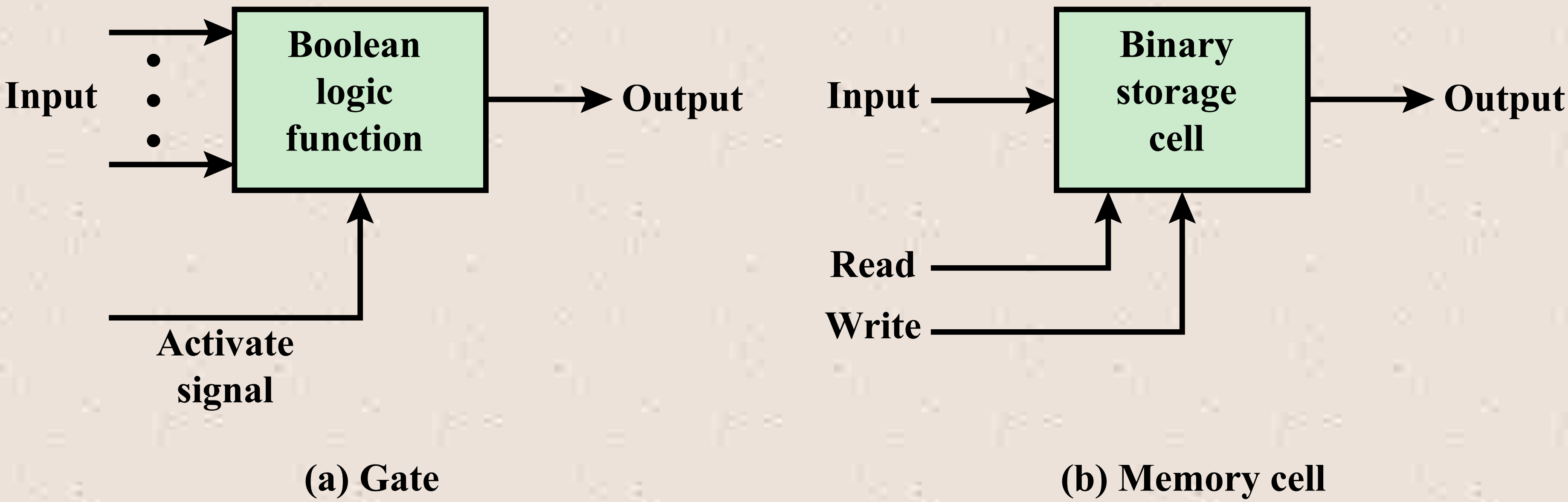
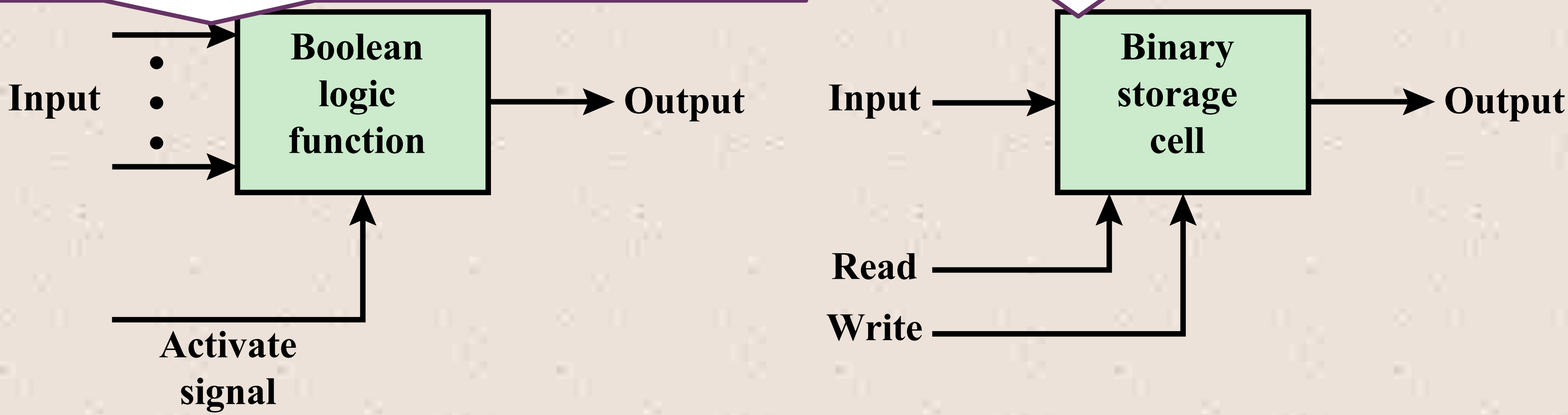


Figure 1.10 Fundamental Computer Elements

A gate is a device that implements a simple Boolean or logical function, such as IF *A AND B ARE TRUE* THEN *C IS TRUE (AND gate). Such devices are called gates because they control* data flow in much the same way that canal gates control the flow of water

The memory cell is a device that can store one bit of data; that is, the device can be in one of two stable states at any time



(a) Gate

(b) Memory cell

Figure 1.10 Fundamental Computer Elements

Integrated Circuits

- Data storage – provided by memory cells
- Data processing – provided by gates
- Data movement – the paths among components are used to move data from memory to memory and from memory through gates to memory
- Control – the paths among components can carry control signals

• **Control:** The paths among components can carry control signals. For example,
a gate will have one or two data inputs plus a control signal input that activates
the gate. When the control signal is ON, the gate performs its function on the
data inputs and produces a data output. Similarly, the memory cell will **store**
the bit that is on its input lead when the WRITE control signal is ON and will
place the bit that is in the cell on its output lead when the READ control signal
is ON.

Integrated Circuits

- Data storage – provided by memory cells
- Data processing – provided by gates
- Data movement – the paths among components are used to move data from memory to memory and from memory through gates to memory
- Control – the paths among components can carry control signals

- A computer consists of gates, memory cells, and interconnections among these elements
- The gates and memory cells are constructed of simple digital electronic components
  - Exploits the fact that such components as transistors, resistors, and conductors can be fabricated from a semiconductor such as silicon
  - Many transistors can be produced at the same time on a single wafer of silicon
  - Transistors can be connected with a processor metallization to form circuits

Figure 1.11 depicts the key concepts in an integrated circuit. A thin **wafer** of silicon is divided into a matrix of small areas, each a few millimeters square. The identical circuit pattern is fabricated in each area, and the wafer is broken up into **chips.** Each chip consists of many gates and/or memory cells plus a number of input and output attachment points. This chip is then packaged in housing that protects it and provides pins for attachment to devices beyond the chip. A number of these packages can then be interconnected on a printed circuit board to produce larger and more complex circuits.

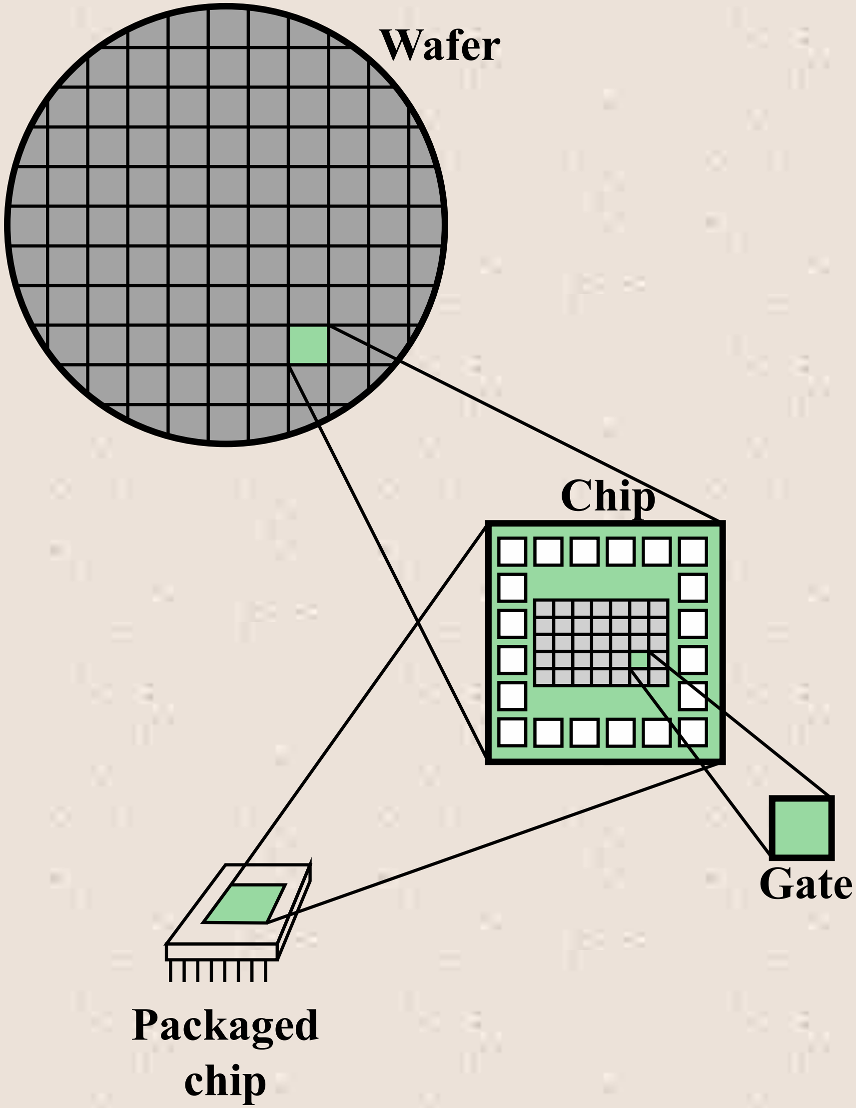


Figure 1.11 Relationship Among Wafer, Chip, and Gate

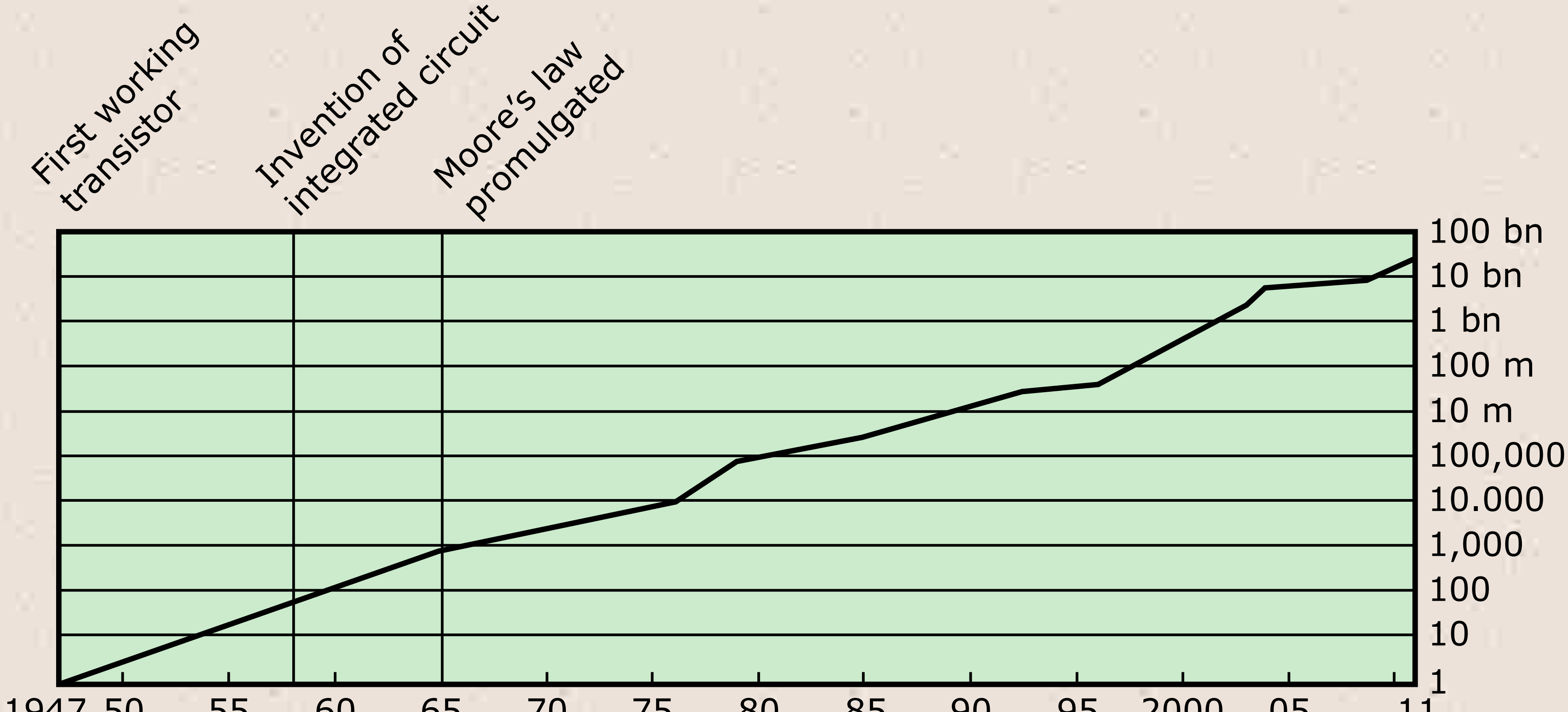


Figure 1.12 Growth in Transistor Count on Integrated Circuits (DRAM memory)

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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

Moore's Law

1965; Gordon Moore – co-founder of Intel

Observed number of transistors that could be put on a single chip was doubling every year

The pace slowed to a doubling every 18 months in the 1970's but has sustained that rate ever since

Consequences of Moore's law:

- **The cost of computer logic and memory circuitry has fallen at a dramatic rate**
- **The electrical path length is shortened, increasing operating speed**
- **Computer becomes smaller and is more convenient to use in a variety of environments**
- **Reduction in power and cooling requirements**
- **Fewer interchip connections**

IBM System/360

- By 1964, IBM had a firm grip on the computer market with its 7000 series of machines. In that year, IBM announced the System/360, a new family of computer products. Although the announcement itself was no surprise, it contained some unpleasant news for current IBM customers: the 360 product line was incompatible with older IBM machines. Thus, the transition to the 360 would be difficult for the current customer base

- This was a bold step by IBM, but one IBM felt was necessary to break out of some of the constraints of the 7000 architecture and to produce a system capable of evolving with the new integrated circuit technology

- The architecture remains to this day the architecture of IBM's mainframe computers

- The models were compatible in the sense that a program written for one model should be capable of being executed by another model in the series, with only a difference in the time it takes to execute

+

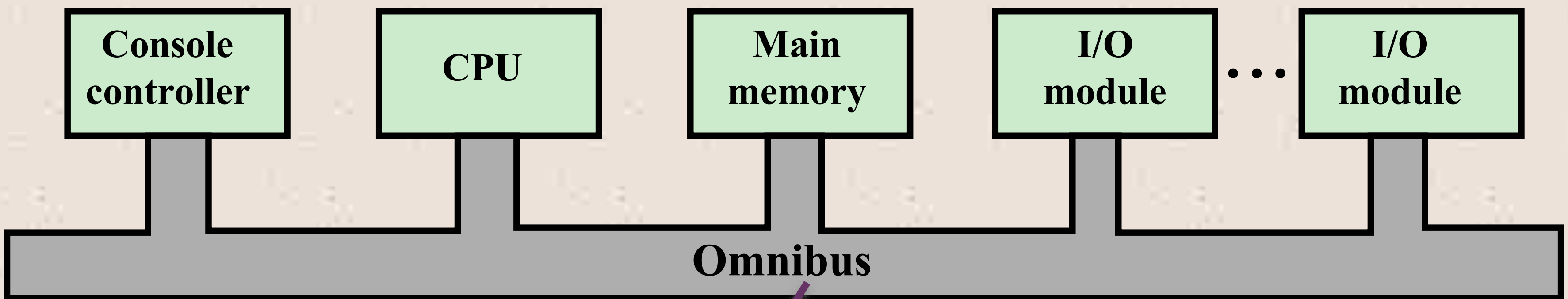
The concept of a family of compatible computers was both novel and extremely successful. A customer with modest requirements and a budget to match could start with the relatively inexpensive Model 30. Later, if the customer's needs grew, it was possible to upgrade to a faster machine with more memory without sacrificing the investment in already-developed software. The **characteristics of a family** are as follows:

- Similar or identical instruction set
- Similar or identical operating system
- Increasing speed
- Increasing cost
- Increasing number of I/O ports
- Increasing memory size
- Multiplexed Switch structure

DEC PDP-8

- 1964
- First minicomputer
- Did not need air conditioned room
- Small enough to sit on a lab bench
- $16000
- $100k+for IBM 360
- Embedded applications & OEM (original equipment manufacture)
- Bus structure (earlier multiplexer)

+ PDP-8



consists of 96 separate signal paths, used to carry control, address, and data signals. Because all system components share a common set of signal paths, their use can be controlled by the CPU. This architecture is highly flexible, allowing modules to be plugged into the bus to create various configurations.

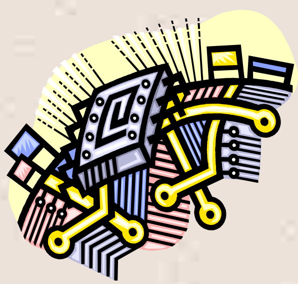
Figure 1.13 PDP-8 Bus Structure

Later Generations

LSI
Large Scale Integration

VLSI
Very Large Scale Integration

ULSI
Ultra Large Scale Integration



Semiconductor Memory
Microprocessors

Semiconductor Memory

In 1970 Fairchild produced the first relatively capacious semiconductor memory

Chip was about the size of a single core	Could hold 256 bits of memory	Non-destructive	Much faster than core

In 1974 the price per bit of semiconductor memory dropped below the price per bit of core memory

There has been a continuing and rapid decline in memory cost accompanied by a corresponding increase in physical memory density	Developments in memory and processor technologies changed the nature of computers in less than a decade

Since 1970 semiconductor memory has been through 13 generations

Each generation has provided four times the storage density of the previous generation, accompanied by declining cost per bit and declining access time

+

Microprocessors

- The density of elements on processor chips continued to rise
  - More and more elements were placed on each chip so that fewer and fewer chips were needed to construct a single computer processor
- 1971 Intel developed 4004
  - First chip to contain all of the components of a CPU on a single chip
  - Birth of microprocessor
- 4-bit microprocessor
- 1972 Intel developed 8008
  - First 8-bit microprocessor
- 1974 Intel developed 8080
  - First general purpose microprocessor
  - Faster, has a richer instruction set, has a large addressing capability

Microprocessor speed

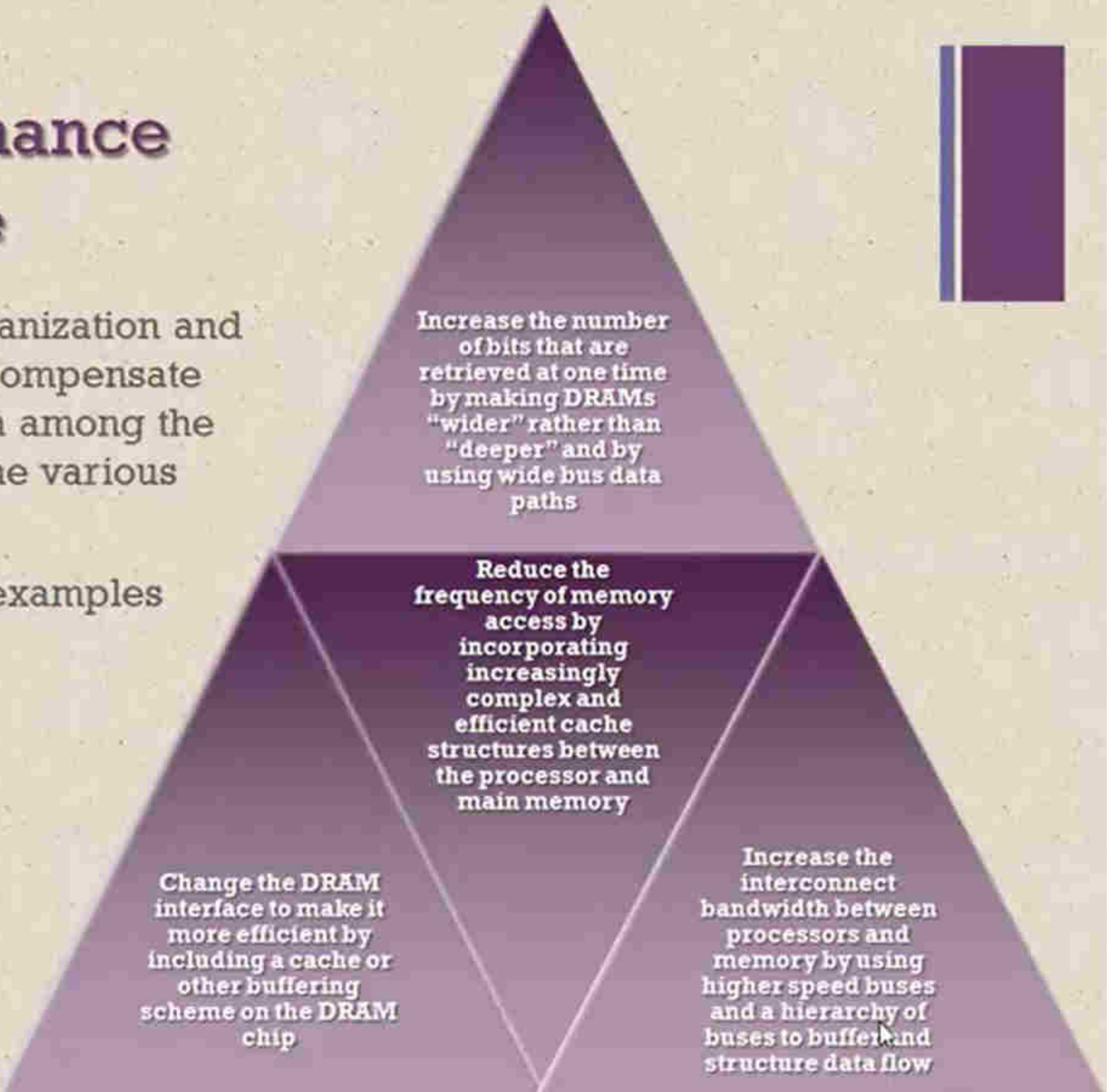
Techniques built into contemporary processors include:

Pipelining	•Processor moves data or instructions into a conceptual pipe with all stages of the pipe processing simultaneously
Branch prediction	•Processor looks ahead in the instruction code fetched from memory and predicts which branches, or groups of instructions, are likely to be processed next
Data flow analysis	•Processor analyzes which instructions are dependent on each other's results, or data, to create an optimized schedule of instructions
Speculative execution	•Using branch prediction and data flow analysis, some processors speculatively execute instructions ahead of their actual appearance in the program execution, holding the results in temporary locations, keeping execution engines as busy as possible
On board cache	
On board L1 & L2 cache	

Performance Balance

Performance Balance

- Adjust the organization and architecture to compensate for the mismatch among the capabilities of the various components
- Architectural examples include:



I/O Devices

- Peripherals with intensive I/O demands
- Large data throughput demands
- Processors can handle this
- Problem moving data
- Solutions:
- Caching
- Buffering
- Higher-speed interconnection buses
- More elaborate bus structures
- Multiple-processor configuration's

Evolution of Intel Microprocessors

	4004	8008	8080	8086	8088
Introduced	1971	1972	1974	1978	1979
Clock speeds	108 kHz	108 kHz	2 MHz	5 MHz, 8 MHz, 10 MHz	5 MHz, 8 MHz
Bus width	4 bits	8 bits	8 bits	16 bits	8 bits
Number of transistors	2,300	3,500	6,000	29,000	29,000
Feature size (µm)	10	8	6	3	6
Addressable memory	640 Bytes	16 KB	64 KB	1 MB	1 MB

(a) 1970s Processors

Evolution of Intel Microprocessors

	80286	386TM DX	386TM SX	486TM DX CPU
Introduced	1982	1985	1988	1989
Clock speeds	6 MHz - 12.5 MHz	16 MHz - 33 MHz	16 MHz - 33 MHz	25 MHz - 50 MHz
Bus width	16 bits	32 bits	16 bits	32 bits
Number of transistors	134,000	275,000	275,000	1.2 million
Feature size (µm)	1.5	1	1	0.8 - 1
Addressable memory	16 MB	4 GB	16 MB	4 GB
Virtual memory	1 GB	64 TB	64 TB	64 TB
Cache	—	—	—	8 kB

(b) 1980s Processors

Evolution of Intel Microprocessors

	486TM SX	Pentium	Pentium Pro	Pentium II
Introduced	1991	1993	1995	1997
Clock speeds	16 MHz - 33 MHz	60 MHz - 166 MHz,	150 MHz - 200 MHz	200 MHz - 300 MHz
Bus width	32 bits	32 bits	64 bits	64 bits
Number of transistors	1.185 million	3.1 million	5.5 million	7.5 million
Feature size (µm)	1	0.8	0.6	0.35
Addressable memory	4 GB	4 GB	64 GB	64 GB
Virtual memory	64 TB	64 TB	64 TB	64 TB
Cache	8 kB	8 kB	512 kB L1 and 1 MB L2	512 kB L2

(c) 1990s Processors

Evolution of Intel Microprocessors

	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

(d) Recent Processors

+ The Evolution of the Intel x86 Architecture

- Two processor families are the Intel x86 and the ARM architectures
- Current x86 offerings represent the results of decades of design effort on complex instruction set computers (CISCs)
- An alternative approach to processor design is the reduced instruction set computer (RISC)
- ARM architecture is used in a wide variety of embedded systems and is one of the most powerful and best-designed RISC-based systems on the market

Highlights of the Evolution of the Intel Product Line:

8080

- World's first general-purpose microprocessor
- 8-bit machine, 8-bit data path to memory
- Was used in the first personal computer

8086

- A more powerful 16-bit machine
- Wider data path and larger registers
- Has an instruction cache, or queue, that prefetches a few instructions before they are executed
- The first appearance of the x86 architecture
- The 8088 was a variant of this processor and used in IBM's first personal computer (securing the success of Intel

80286

- Extension of the 8086 enabling addressing a 16-MB memory instead of just 1MB

80386

- Intel's first 32-bit machine
- First Intel processor to support multitasking meaning it could run multiple programs at the same time.

80486

- Introduced the use of much more sophisticated and powerful cache technology and sophisticated instruction pipelining
- Also offered a built-in math coprocessor which offloading complex math operations from the main CPU.

Highlights of the Evolution of the Intel Product Line:

Pentium

- Intel introduced the use of superscalar techniques, which allow multiple instructions to execute in parallel(multiple pipeline)

Pentium Pro

- Continued the move into superscalar organization with aggressive use of register renaming, branch prediction, data flow analysis, and speculative execution

Pentium II

- Incorporated Intel MMX technology, which is designed specifically to process video, audio, and graphics data efficiently

Pentium III

- Incorporated additional floating-point instructions which perform arithmetic and logical operations on values in floating-point registers
- 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

Pentium 4

- Includes additional floating-point and other enhancements for multimedia

Core

- First Intel x86 micro-core referring to the implementation of two cores on a single chip.

Core 2

- Extends the Core architecture to 64 bits
- 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

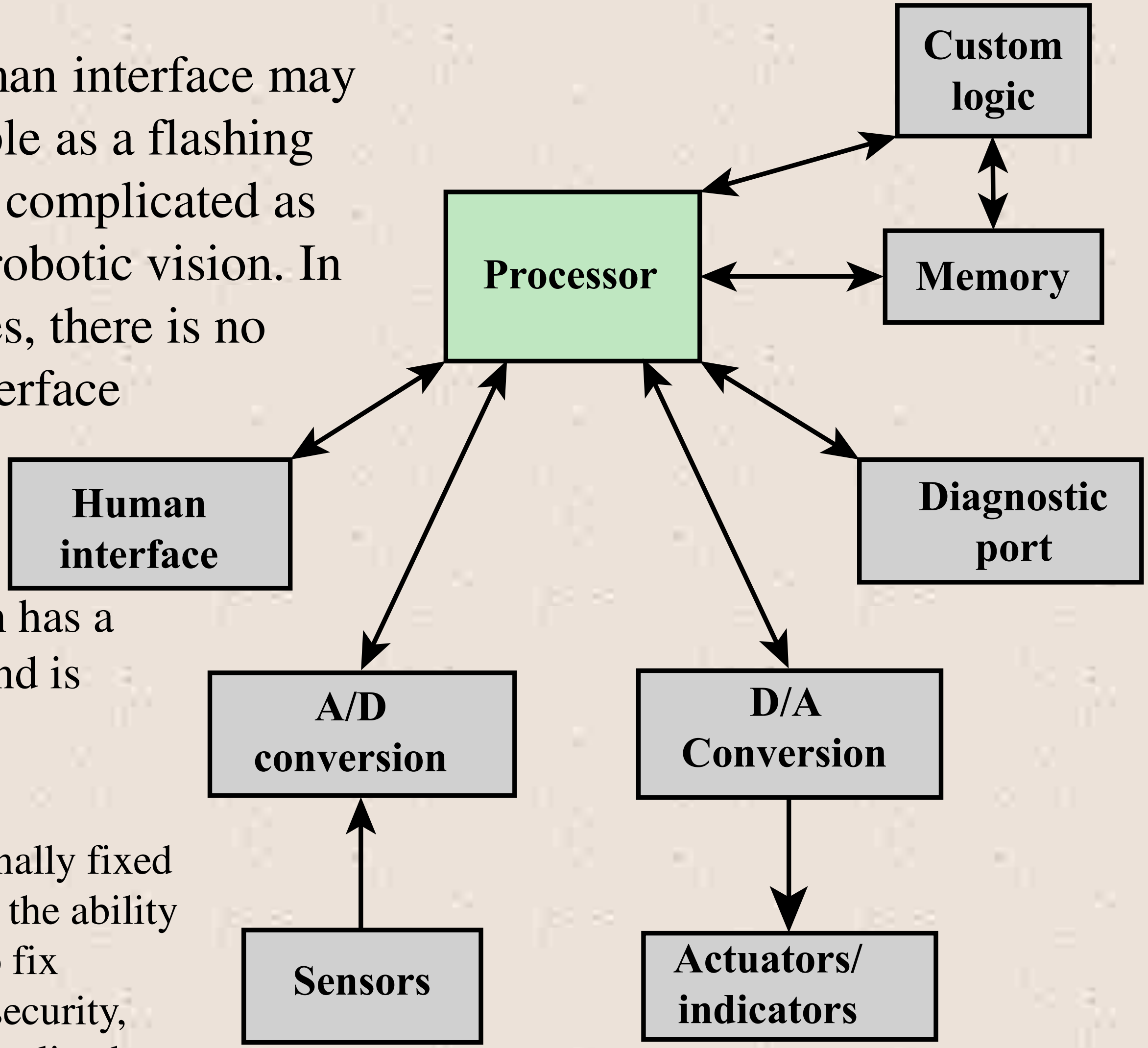
Embedded Systems

- A combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a dedicated system are part of a larger system or product, as in the case of an antilock braking system in a car.
- Embedded systems are special-purpose computers built into devices not generally considered to be computers
- The use of electronics and software within a product
- Billions of computer systems are produced each year that are embedded within larger devices
- Today many devices that use electric power have an embedded computing system
- Often embedded systems are tightly coupled to their environment
  - This can give rise to real-time constraints imposed by the need to interact with the environment
    - Constraints such as required speeds of motion, required precision of measurement, and required time durations, dictate the timing of software operations
  - If multiple activities must be managed simultaneously this imposes more complex real-time constraints

+ Table 2.7 Examples of Embedded Systems and Their Markets [NOER05]

Market	Embedded Device
Automotive	Ignition system Engine control Brake system
Consumer electronics	Digital and analog televisions Set-top boxes (DVDs, VCRs, Cable boxes) Personal digital assistants (PDAs) Kitchen appliances (refrigerators, toasters, microwave ovens) Automobiles Toys/games Telephones/cell phones/pagers Cameras Global positioning systems
Industrial control	Robotics and controls systems for manufacturing Sensors
Medical	Infusion pumps Dialysis machines Prosthetic devices Cardiac monitors
Office automation	Fax machine Photocopier Printers Monitors Scanners

2.The human interface may be as simple as a flashing light or as complicated as real-time robotic vision. In many cases, there is no human interface



3.The diagnostic port may be used for diagnosing the system that is being controlled

4.Software often has a fixed function and is specific to the application

5.Even with nominally fixed function software, the ability to field upgrade to fix bugs, to improve security, and to add functionality, has become very important for embedded system

1.Embedded systems often interact (sense, manipulate, and communicate) with external world through sensors and actuators

Figure 1.14 Possible Organization of an Embedded System

The Internet of Things (IoT)

- Term that refers to the expanding interconnection of smart devices, ranging from appliances to tiny sensors
- Is primarily driven by deeply embedded devices
- Requirements to build an IoT system:
  - Information technology (IT)
    - PCs, servers, routers, firewalls, and so on, bought as IT devices by enterprise IT people and primarily using wired connectivity
  - Operational technology (OT)
    - Machines/appliances with embedded IT built by non-IT companies, such as medical machinery, SCADA, process control, and kiosks, bought as appliances by enterprise OT people and primarily using wired connectivity
  - Personal technology
    - Smartphones, tablets, and eBook readers bought as IT devices by consumers exclusively using wireless connectivity and often multiple forms of wireless connectivity
  - Sensor/actuator technology
    - Single-purpose devices bought by consumers, IT, and OT people exclusively using wireless connectivity, generally of a single form, as part of larger systems
- It is the fourth generation that is usually thought of as the IoT and it is marked by the use of billions of embedded devices

Embedded Operating Systems

- There are two general approaches to developing an embedded operating system (OS):
  - Take an existing OS and adapt it for the embedded application
  - Design and implement an OS intended solely for embedded use

Application Processors versus Dedicated Processors

- Application processors
  - Defined by the processor's ability to execute complex operating systems
  - General-purpose in nature
  - An example is the smartphone – the embedded system is designed to support numerous apps and perform a wide variety of functions
- Dedicated processor
  - Is dedicated to one or a small number of specific tasks required by the host device
  - Because such an embedded system is dedicated to a specific task or tasks, the processor and associated components can be engineered to reduce size and cost

Microcontroller

- Also called a “computer on a chip,” billions of microcontroller units are embedded each year in myriad products from toys to appliances to automobiles. For example, a single vehicle can use 70 or more microcontrollers. Typically, especially for the smaller, less expensive microcontrollers, they are used as dedicated processors for specific tasks. For example, microcontrollers are heavily utilized in automation processes. By providing simple reactions to input, they can control machinery, turn fans on and off, open and close valves, and so forth. They are integral parts of modern industrial technology and are among the most inexpensive ways to produce machinery that can handle extremely complex functionalities.

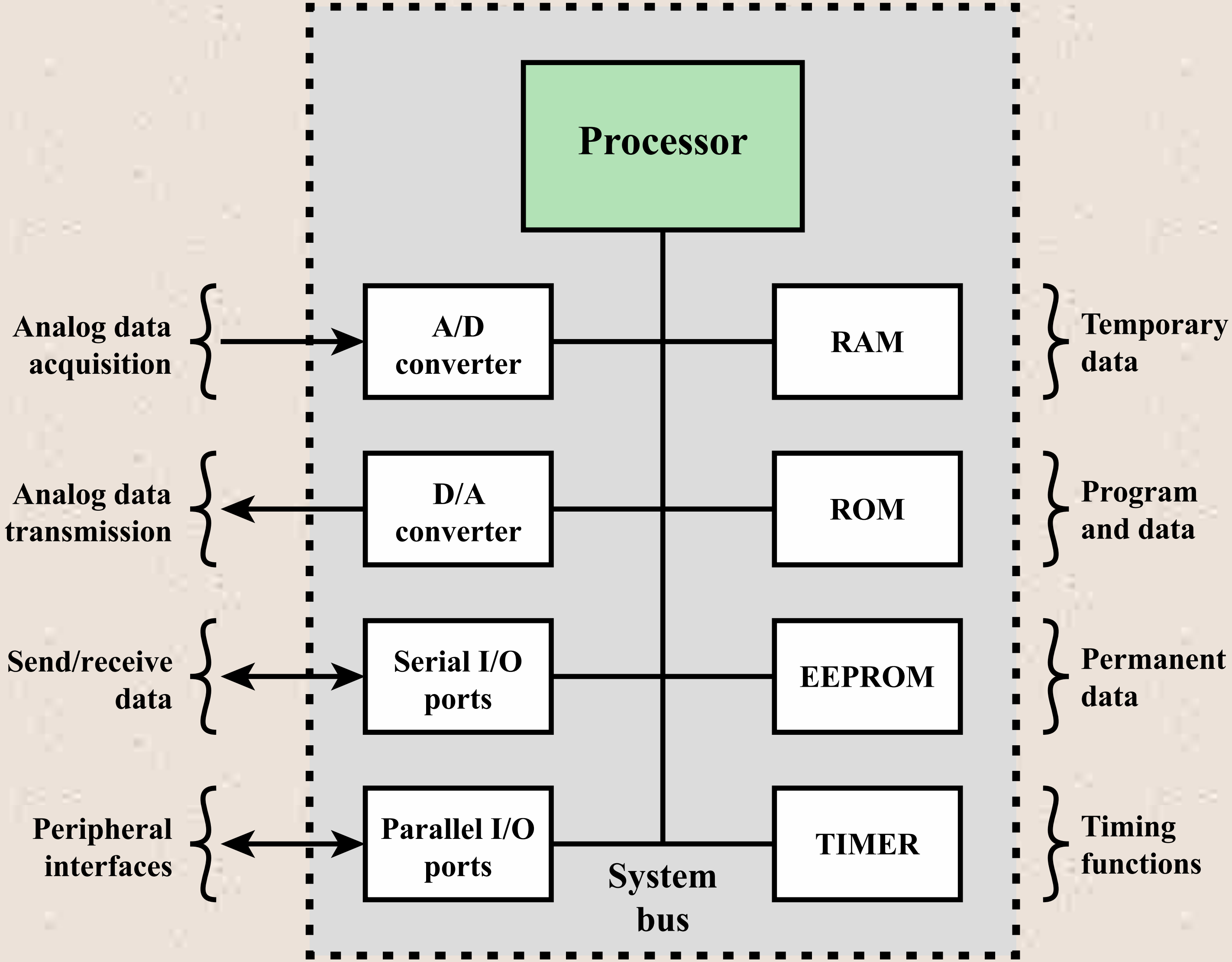


Figure 1.15 Typical Microcontroller Chip Elements

Microprocessor vs Microcontroller

- 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, as shown in Figure 1.2, include multiple cores and a substantial amount of cache memory.

- A microcontroller chip makes a substantially different use of the logic space available. Figure 1.15 shows in general terms the elements typically found on a microcontroller chip. As shown, 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

- Microcontrollers come in a range of physical sizes and processing power. Processors range from 4-bit to 32-bit architectures. Microcontrollers tend to be much slower than microprocessors, typically operating in the MHz range rather than the GHz speeds of microprocessors. Another typical feature of a microcontroller is that it does not provide for human interaction. The microcontroller is programmed for a specific task, embedded in its device, and executes as and when required in addition is less expensive than microprocessor

+ Deeply Embedded Systems

- Subset of embedded systems
- Has a processor whose behavior is difficult to observe both by the programmer and the user
- Uses a microcontroller rather than a microprocessor
- Is not programmable once the program logic for the device has been burned into ROM
- Has no interaction with a user
- Dedicated, single-purpose devices that detect something in the environment, perform a basic level of processing, and then do something with the results
- Often have wireless capability and appear in networked configurations, such as networks of sensors deployed over a large area
- The Internet of things depends heavily on deeply embedded systems
- Typically have extreme resource constraints in terms of memory, processor size, time, and power consumption

ARM

- Refers to a processor architecture that has evolved from RISC design principles and is used in embedded systems
- Family of RISC-based microprocessors and microcontrollers designed by ARM Holdings, Cambridge, England
- Chips are high-speed processors that are known for their small die size and low power requirements
- Probably the most widely used embedded processor architecture and indeed the most widely used processor architecture of any kind in the world
- Acorn RISC Machine/Advanced RISC Machine

+

RISC VS CISC

Parameter	RISC	CISC
Instruction types	Simple	Complex
Number of instructions	Reduced (30-40)	Extended (100-200)
Duration of an instruction	One cycle	More cycles (4-120)
Instruction format	Fixed	Variable
Instruction execution	In parallel (pipeline)	Sequential
Addressing modes	Simple	Complex
Instructions accessing the memory	Two: Load and Store	Almost all from the set
Register set	multiple	unique
Complexity	In compiler	In CPU (micro-program)

Cloud Computing

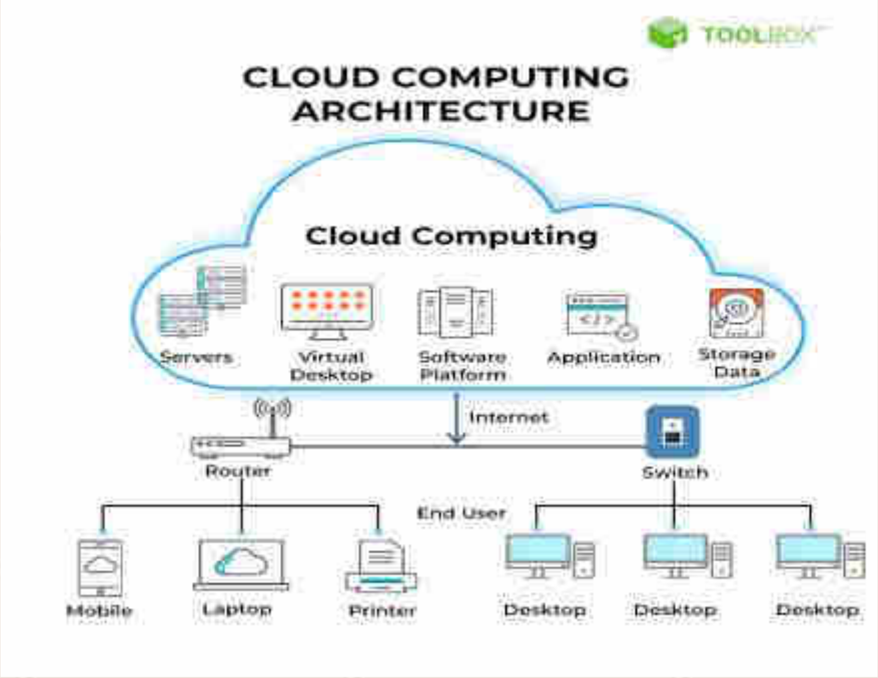
- Cloud computing is a general term for the delivery of hosted computing services and IT resources over the internet with pay–as-you-go pricing. Users can obtain technology services such as processing power, storage and databases from a cloud provider, eliminating the need for purchasing, operating and maintaining on-premises physical data centres and servers

- A cloud can be private, public or a hybrid. A public cloud sells services to anyone on the internet. A private cloud is a proprietary network or a data center that supplies hosted services to a limited number of people, with certain access and permissions settings. A hybrid cloud offers a mixed computing environment where data and resources can be shared between both public and private clouds. Regardless of the type, the goal of cloud computing is to provide easy, scalable access to computing resources and IT services.

- Cloud infrastructure involves the hardware and software components required for the proper deployment of a cloud computing model. Cloud computing can also be thought of as utility computing or on-demand computing.

+ How does cloud computing work

- Cloud computing lets client devices access rented computing resources, such as data, analytics and cloud applications over the internet. It relies on a network of remote data centers, servers and storage systems that are owned and operated by cloud service providers. The providers are responsible for ensuring the storage capacity, security and computing power needed to maintain the data users send to the cloud



Steps are involved in cloud computing

1. An internet network connection links the front end -- the accessing client device, browser, network and cloud software applications -- with the back end, which consists of databases, servers, operating systems and computers.

2. The back end functions as a repository, storing data accessed by the front end.

3. A central server manages communications between the front and back ends. It relies on protocols to facilitate the exchange of data. The central server uses both software and middleware to manage connectivity between different client devices and cloud servers.

4. Typically, there's a dedicated server for each application or workload

5. Backup for data is available

Cloud Networking

- Refers to the networks and network management functionality that must be in place to enable cloud computing
- One example is the provisioning of high-performance and/or high-reliability networking between the provider and subscriber
- The collection of network capabilities required to access a cloud, including making use of specialized services over the Internet, linking enterprise data center to a cloud, **and using firewalls and other network security** devices at critical points to enforce access security policies

Cloud Storage

- Subset of cloud computing
- Consists of database storage and database applications hosted remotely on cloud servers
- Enables small businesses and individual users to take advantage of data storage that scales with their needs and to take advantage of a variety of database applications without having to buy, maintain, and manage the storage assets

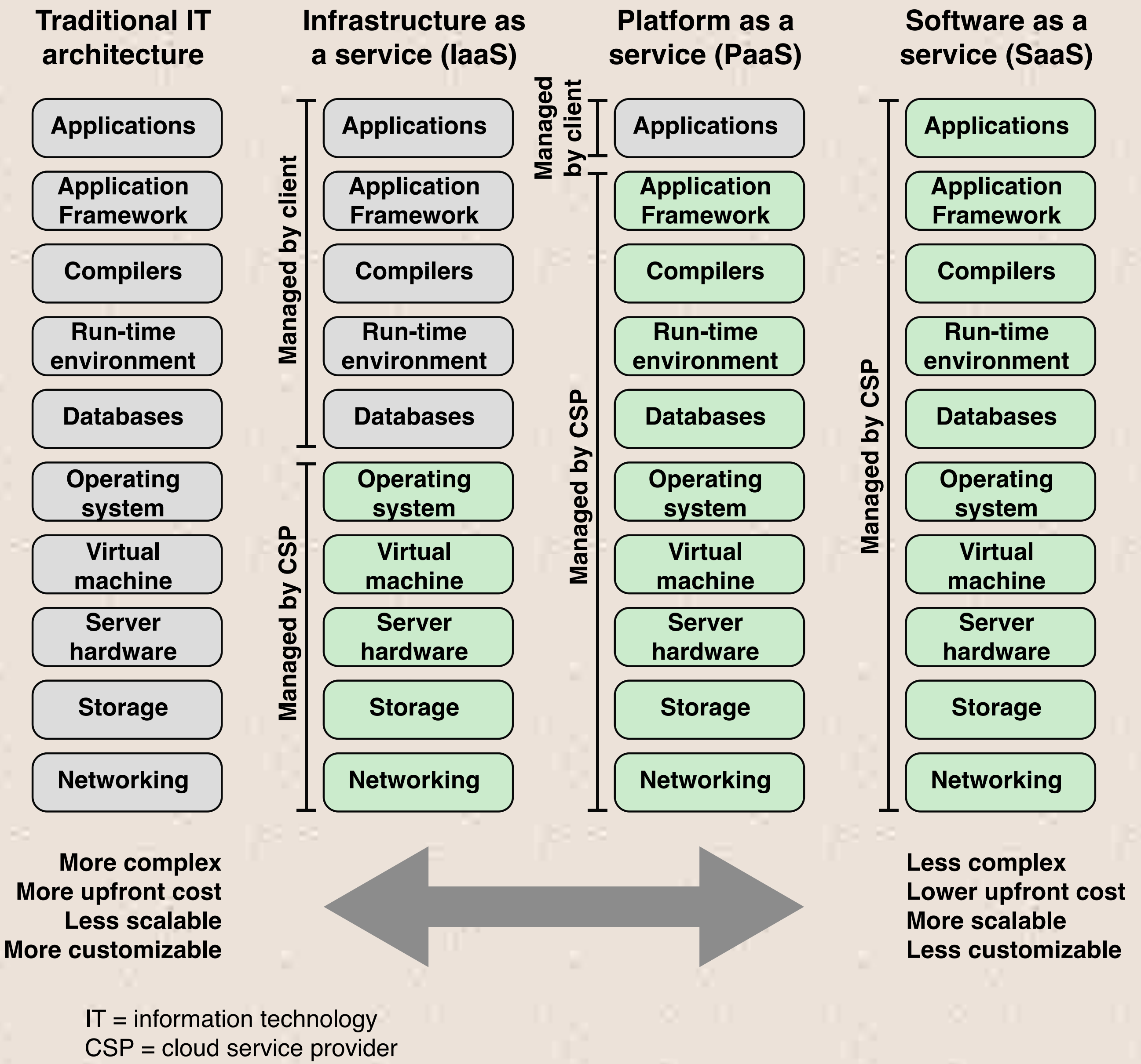


Figure 1.17 Alternative Information Technology Architectures

SaaS

- Software as a service (SaaS) As the name implies, a SaaS cloud provides service to customers in the form of software, specifically application software, running on and accessible in the cloud. SaaS follows the familiar model of Web services, in this case applied to cloud resources. SaaS enables the customer to use the cloud provider's applications running on the provider's cloud infrastructure. The applications are accessible from various client devices through a simple interface such as a Web browser. Instead of obtaining desktop and server licenses for software products it uses, an enterprise obtains the same functions from the cloud service. SaaS saves the complexity of software installation, maintenance, upgrades, and patches. Examples of services at this level are **Gmail, Google's e-mail service**, and **google Drive**, which help firms keep track of their customers.

- Common subscribers to SaaS are organizations that want to provide their employees with access to typical office productivity software, such as document management and email. Individuals also commonly use the SaaS model to acquire cloud resources. Typically, subscriber use specific applications on demand. The cloud provider also usually offers data-related features such as automatic **backup and data sharing between subscribers.**

PaaS

- Platform as a service (PaaS) A PaaS cloud provides service to customers in the form of a platform on which the customer's applications can run. PaaS enables the customer to deploy onto the cloud infrastructure containing **customer- created or acquired applications**. A PaaS cloud provides useful software building blocks, plus a number of development tools, such as programming languages, run- time environments, and other tools that assist in deploying new applications. In effect, PaaS is an operating system in the cloud. **PaaS is useful for an organization that wants to develop new or tailored applications while paying for the needed computing resources only as needed and only for as long as needed**. Google App Engine and the Salesforce1 Platform from Salesforce.com are examples of PaaS.

+

IaaS

- Infrastructure as a service (IaaS) With IaaS, the customer has access to the underlying cloud infrastructure. IaaS provides virtual machines and other abstracted hardware and operating systems, which may be controlled through a service application programming interface (API). IaaS offers the customer processing, storage, networks, and other fundamental computing resources so that the customer is able to deploy and run arbitrary software, which can include operating systems and applications. IaaS enables customers to combine basic computing services, such as number crunching and data storage, to build highly adaptable computer systems. Examples of IaaS are Amazon Elastic Compute Cloud (Amazon EC2) and Windows Azure.

+ # Summary

Chapter 1

Basic Concepts and Computer Evolution

- Organization and architecture
- Structure and function
- Brief history of computers
  - The First Generation: Vacuum tubes
  - The Second Generation: Transistors
  - The Third Generation: Integrated Circuits
  - Later generations
- The evolution of the Intel x86 architecture
- Cloud computing
  - Basic concepts
  - Cloud services
- Embedded systems
  - The Internet of things
  - Embedded operating systems
  - Application processors versus dedicated processors
  - Microprocessors versus microcontrollers
  - Embedded versus deeply embedded systems
- ARM architecture
  - ARM evolution
  - Instruction set architecture
  - ARM products