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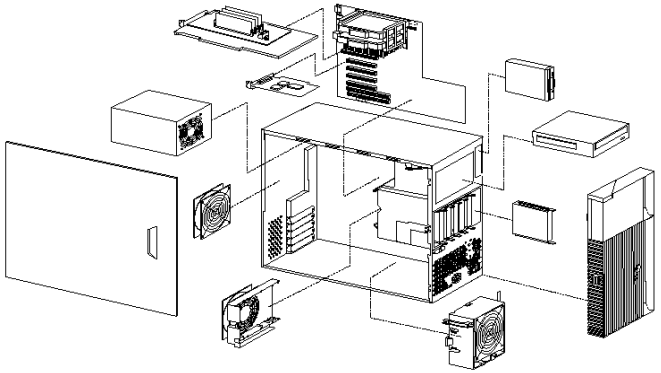
Department of Computer Science and Engineering
School of Science, Engineering & Technology



CSE 317: Computer Organization & Architecture

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Topic 2 – Evolution of Computer

- The First Generation: Vacuum Tubes
- The Second Generation: Transistors
- The Third Generation: Integrated Circuits (IC)
- Later Generations
- Microprocessors vs Microcontrollers
- Embedded Systems

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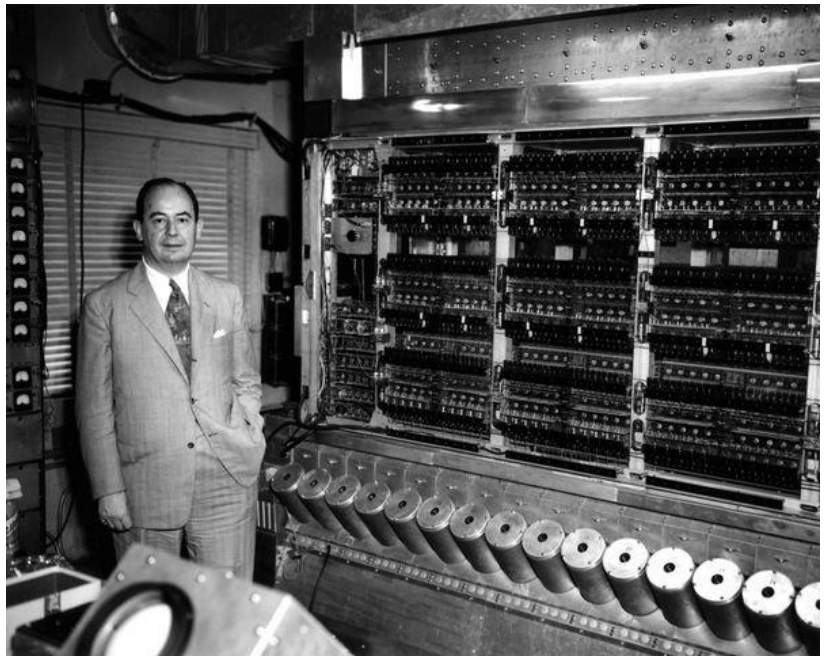
The First Generation: Vacuum Tubes (1944-1955)

- The first generation of computers used vacuum tubes for digital logic elements and memory.

- In 1946, von Neumann and his colleagues began the design of a new stored program computer, referred to as the IAS computer, at the Princeton Institute for Advanced Studies.



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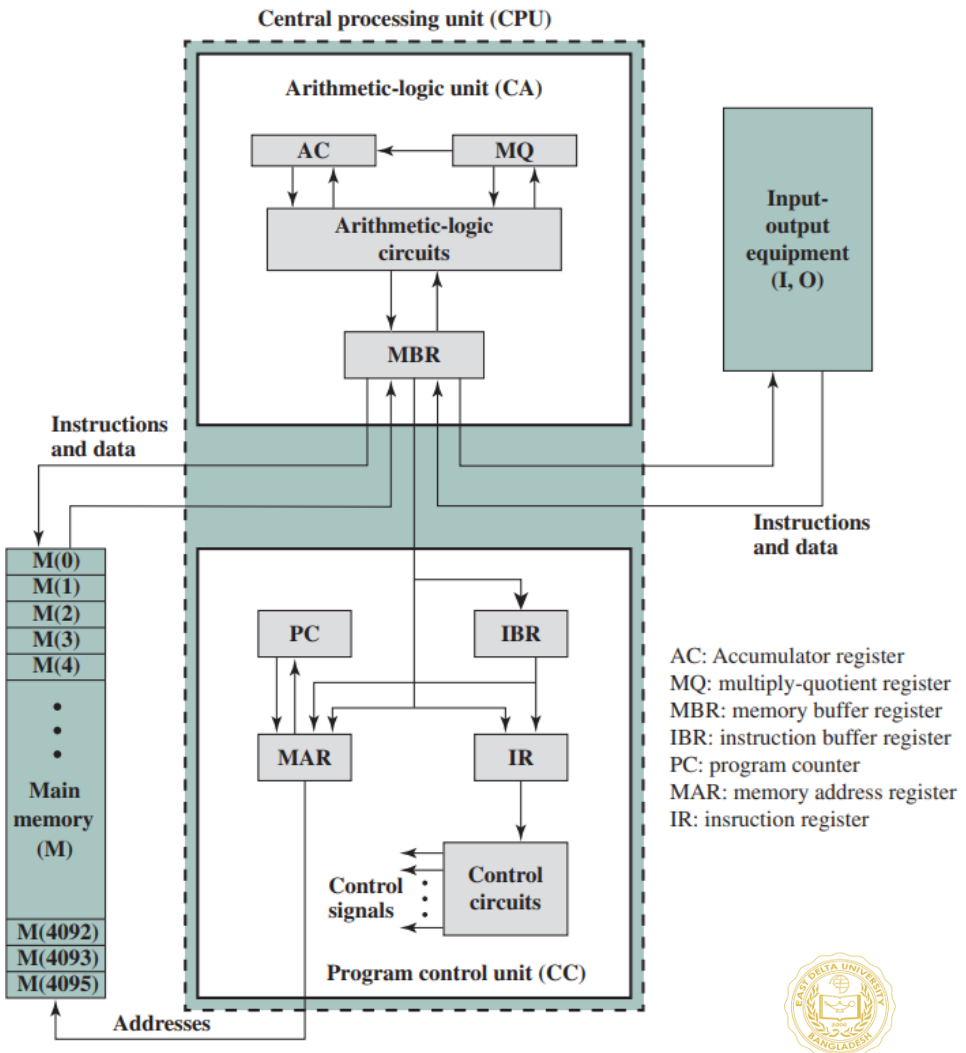
The First Generation: Vacuum Tubes

- A main memory, which stores both data and instructions.
- An arithmetic and logic unit (ALU) capable of operating on binary data.
- A control unit, which interprets the instructions in memory and causes them to be executed.
- Input/output (I/O) equipment operated by the control unit.



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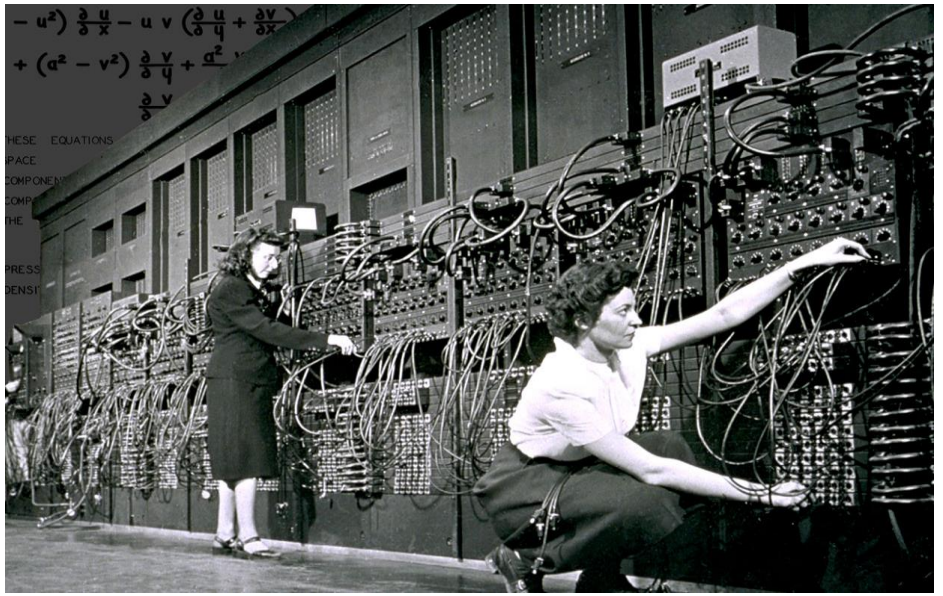
The First Generation: Vacuum Tubes

ENIAC: Electronic Numerical Integrator and Computer

- Decimal (not binary)
- 20 accumulators of 10 digits
- Programmed manually by switches
- 18,000 vacuum tubes
- 30 tons
- 15,000 square feet
- 140 kW power consumption
- 5,000 additions per second



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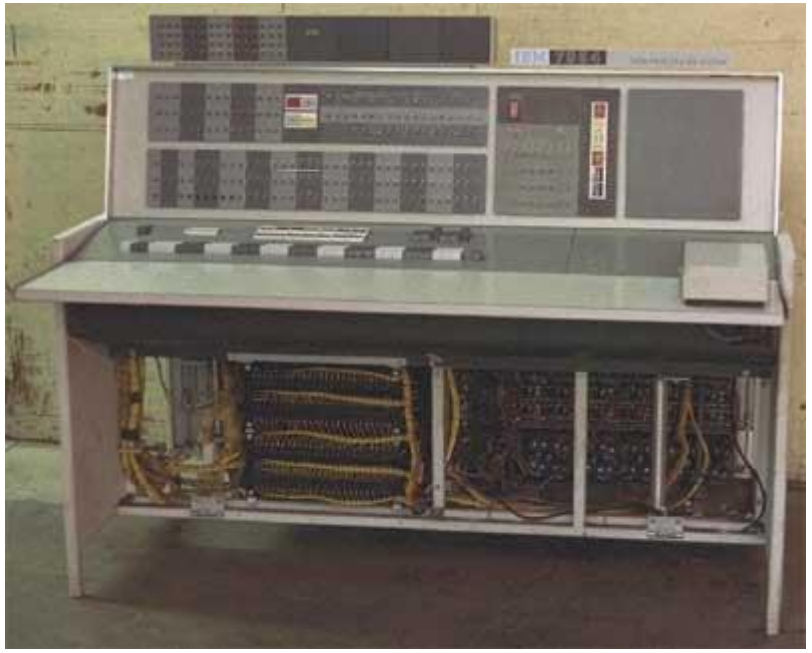
The Second Generation: Transistors (1956-1964)

- The first major change in the electronic computer came with the replacement of the vacuum tube by the transistor. The transistor, which is smaller, cheaper, and generates less heat than a vacuum tube, can be used in the same way as a vacuum tube to construct computers.

- The transistor was invented at Bell Labs in 1947 and by the 1950s had launched an electronic revolution.



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The Second Generation: Transistors (1956-1964)

The main features of second generation are –

- Use of transistors
- Reliable in comparison to first generation computers
- Smaller size as compared to first generation computers
- Generated less heat as compared to first generation computers
- Consumed less electricity as compared to first generation computers
- Faster than first generation computers
- Still very costly
- AC required
- Supported machine and assembly languages

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The Second Generation: Transistors (1956-1964)

- Some computers of this generation were –

- IBM 1620
- IBM 7094
- CDC 1604
- CDC 3600
- UNIVAC 1108

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The Third Generation: Integrated Circuits (1965-1975)

- A single, self-contained transistor is called a discrete component. Throughout the 1950s and early 1960s, electronic equipment was composed largely of discrete components—transistors, resistors, capacitors, and so on.

The Third Generation: Integrated Circuits (1965-1975)

- The period of third generation was from 1965-1971. The computers of third generation used Integrated Circuits (ICs) in place of transistors. A single IC has many transistors, resistors, and capacitors along with the associated circuitry.

- The IC was invented by Jack Kilby. This development made computers smaller in size, reliable, and efficient. In this generation remote processing, time-sharing, multiprogramming operating system were used. High-level languages (FORTRAN-II TO IV, COBOL, PASCAL PL/1, BASIC, ALGOL-68 etc.) were used during this generation.

The Third Generation: Integrated Circuits (1965-1975)

The main features of third generation are –

- IC used
- More reliable in comparison to previous two generations
- Smaller size
- Generated less heat
- Faster
- Lesser maintenance
- Costly
- AC required
- Consumed lesser electricity
- Supported high-level language

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The Third Generation: Integrated Circuits (1965-1975)

Some computers of this generation were –

IBM-360 series
Honeywell-6000 series
PDP (Personal Data Processor)
IBM-370/168
TDC-316

Later Generations

- largescale integration (LSI), more than 1,000 components can be placed on a single integrated circuit chip. Very-large-scale integration (VLSI) achieved more than 10,000 components per chip, while current ultra-large-scale integration (ULSI) chips can contain more than one billion components.

- Microprocessors: A breakthrough was achieved in 1971, when Intel developed its 4004. The 4004 was the first chip to contain all of the components of a CPU on a single chip: The microprocessor was born.

- The 4004 can add two 4-bit numbers and can multiply only by repeated addition

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Later Generations

The main features of fourth generation are –

- VLSI/ULSI technology used
- Very cheap
- Portable and reliable
- Use of PCs
- Very small size
- Pipeline processing
- No AC required
- Concept of internet was introduced
- Great developments in the fields of networks
- Computers became easily available

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Later Generations

- Intel 8008 introduced in 1972 was the first 8-bit microprocessor and was almost twice as complex as the 4004.

- Intel 8080 was introduced In 1974 which was the first general-purpose microprocessor. Whereas the 4004 and the 8008 had been designed for specific applications

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

(b) 1980s Processors

	80286	386TM DX	386TM SX	486TM DX CPU
Introduced	1982	1985	1988	1989
Clock speeds	6–12.5 MHz	16–33 MHz	16–33 MHz	25–50 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

(c) 1990s Processors

	486TM SX	Pentium	Pentium Pro	Pentium II
Introduced	1991	1993	1995	1997
Clock speeds	16–33 MHz	60–166 MHz,	150–200 MHz	200–300 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

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Evolution of Intel Microprocessors

(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

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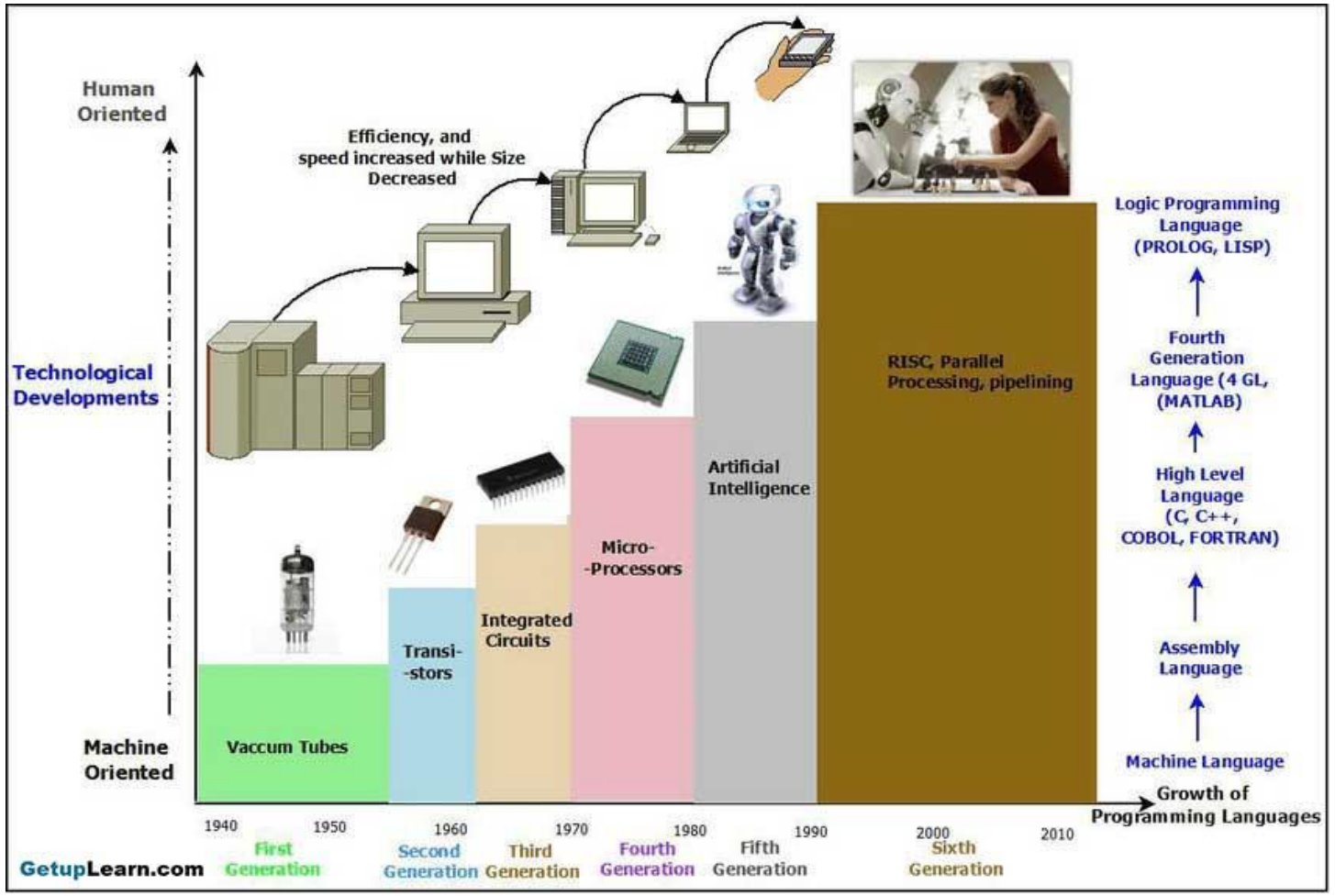
Evolution of Computer



Evolution of Computer: Speed

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

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Microprocessors vs Microcontrollers

- **Microprocessor** consists of a CPU and several supporting chips that supply the memory, serial interface, inputs and outputs, timers, and other necessary components.

- **Microcontroller** is that it incorporates all of the necessary computing components onto a single chip. The CPU, memory, interrupt controls, timer, serial ports, bus controls, I/O peripheral ports, and any other necessary components are all present on the same chip and no external circuits are required.

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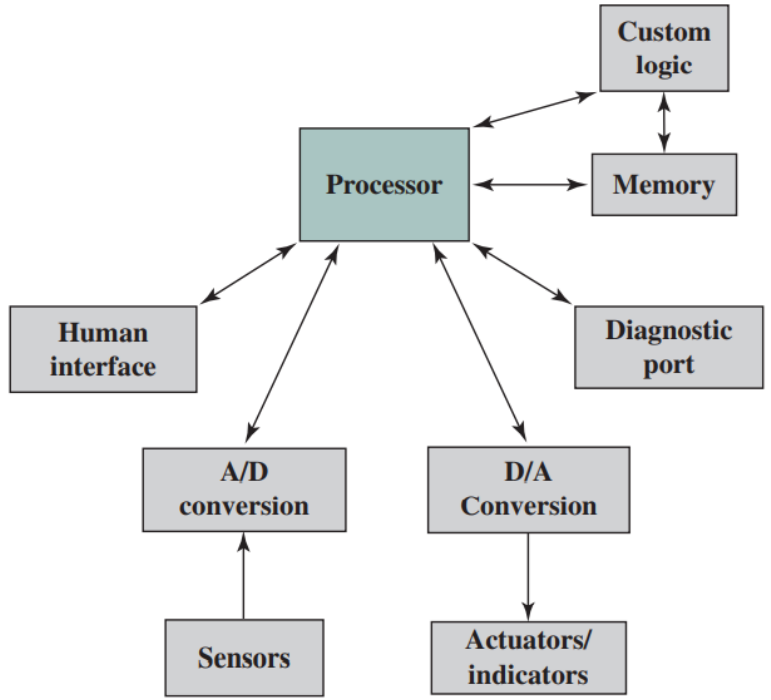
Embedded System

- 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.

- 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) and numerous types of sensors and actuators in automated systems.

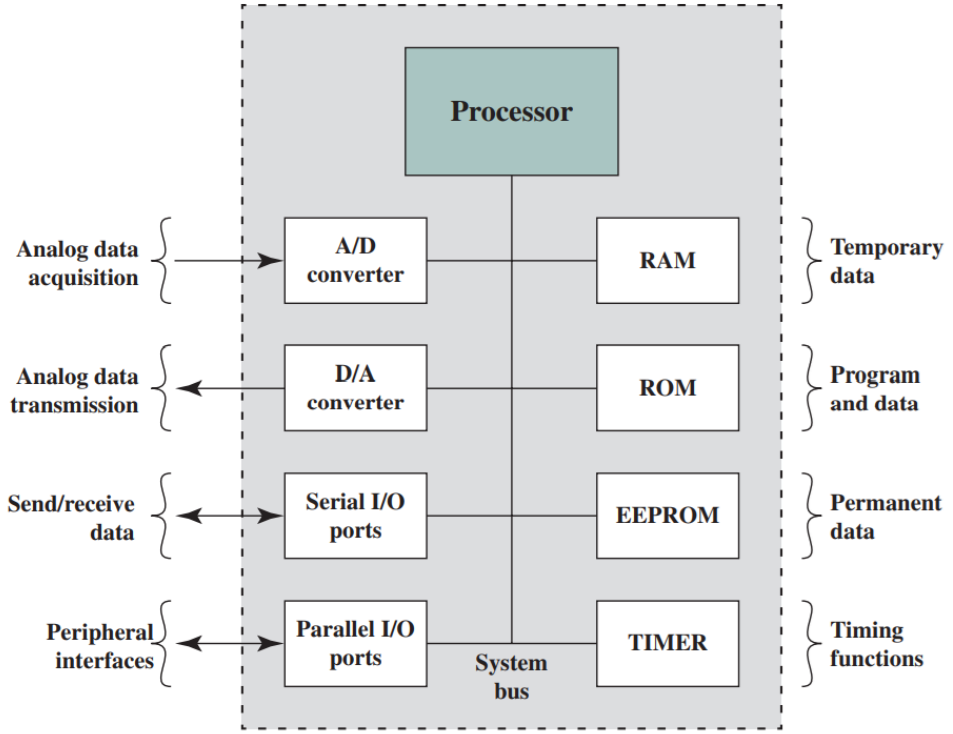
- Often, embedded systems are tightly coupled to their environment.



Embedded System

- The Internet of things (IoT) is a term that refers to the expanding interconnection of smart devices, ranging from appliances to tiny sensors.

- 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



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