Information Technology

Computer Architecture

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Review of Lecture 3

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02 IAS machine

03 Registers

Chapter 2

Continue Computer Evolution

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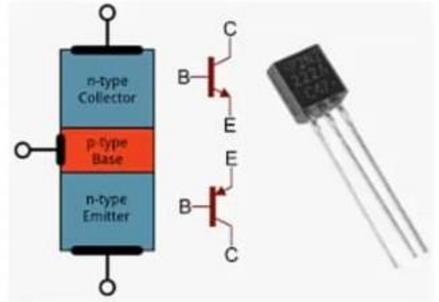
Computer Architecture

After this lecture, we will be able to;

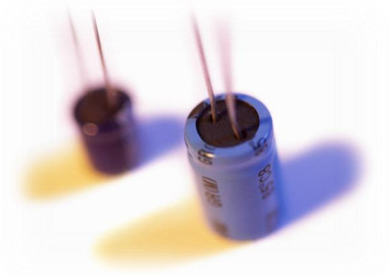
- Know the commercial computers
- Transistors
- Integrated Circuits
- Moore low
- Microprocessor

History of Computers

Second Generation: Transistors

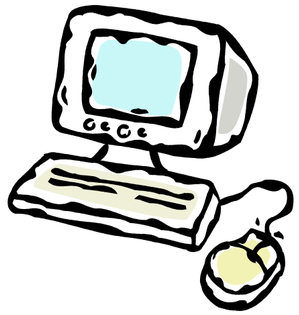


- Was invented at Bell Labs in 1947
- It was not until the late 1950s that fully transistorized computers were commercially available.
- Advantages:
  - Smaller.
  - Cheaper.
  - Dissipates less heat than a vacuum tube.
  - Is a solid-state device made from silicon.



History of Computers

Second Generation: Transistors



- Introduced:
- More complex arithmetic and logic units and control units
- The use of high-level programming languages while the first generation used low-level languages.
- Provision of system software which provided the ability to:
  - Load programs
  - Move data to peripherals
  - Libraries perform common computations, such as iostream library in C++, Scanner library in Java

IBM 7094 Configuration

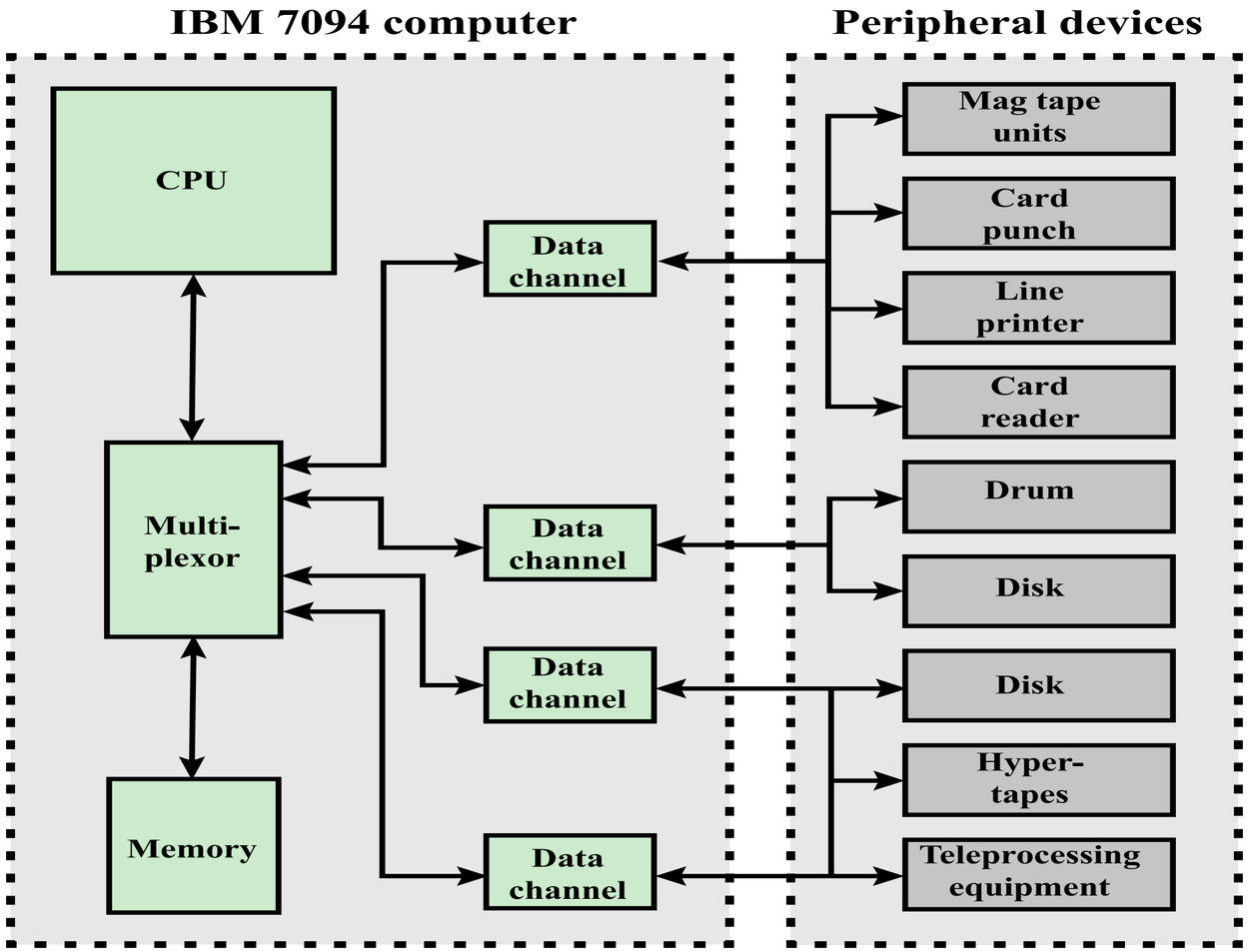
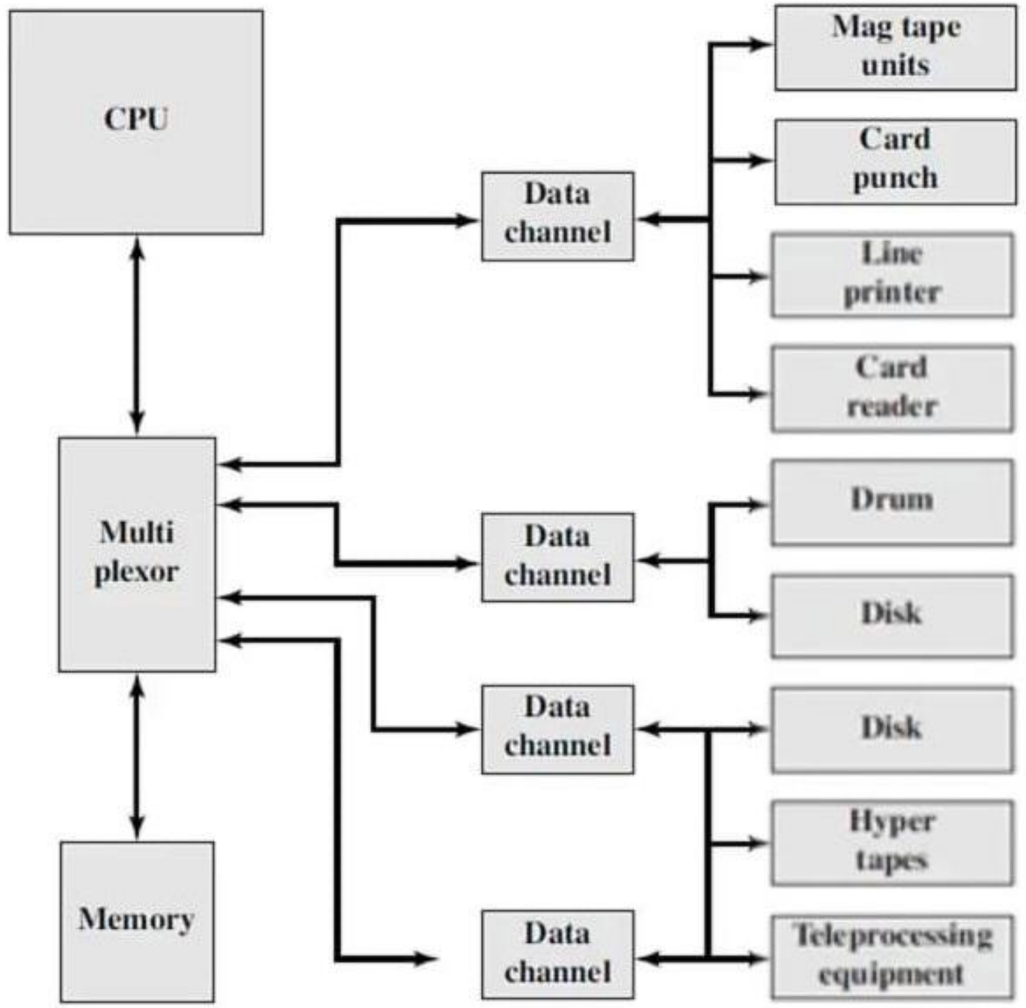


Figure 1.9 An IBM 7094 Configuration

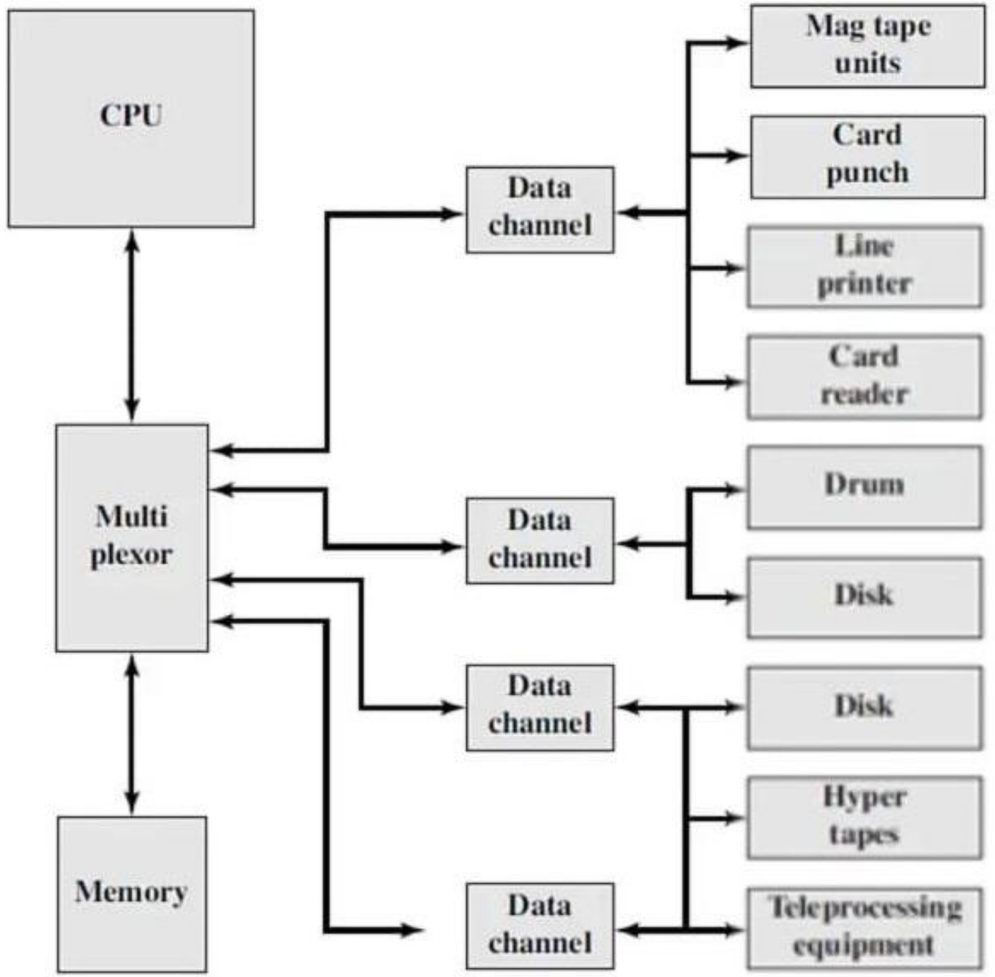
IBM 7094 Configuration

- A data channel is an independent I/O module with its own processor and its own 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



IBM 7094 Configuration

- 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.
- This arrangement relieves the CPU of a considerable processing burden



History of Computers

Third Generation: Integrated Circuits

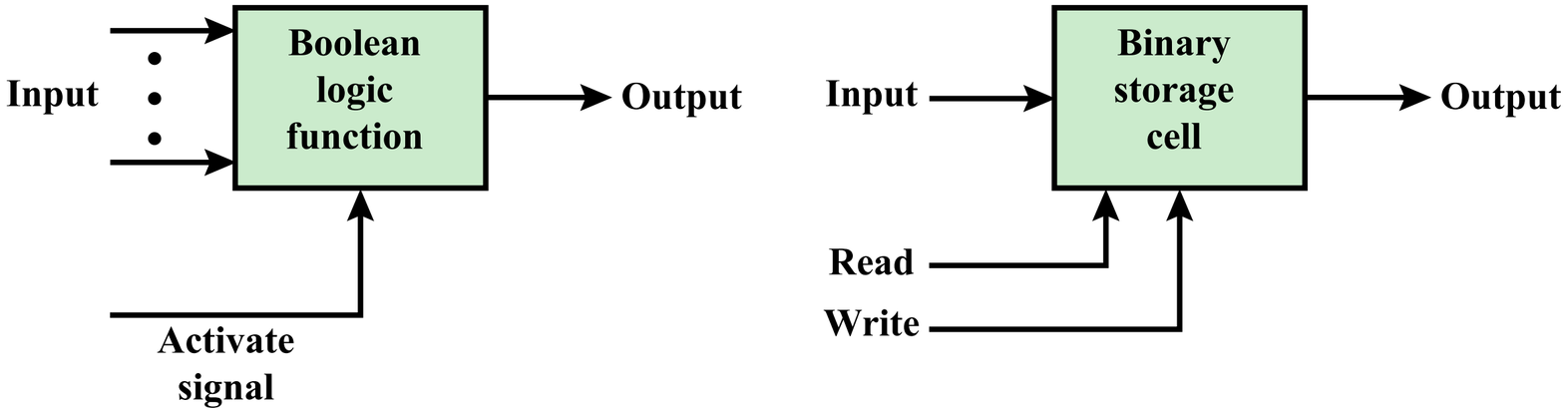


- 1958 – the invention of the integrated circuit
- Discrete component
  - Single, self-contained transistor
  - Manufactured separately, packaged in their own containers, and soldered or wired together onto Masonite-like circuit boards
  - Manufacturing process was expensive and cumbersome
- The two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

History of Computers

Third Generation: Integrated Circuits

Logical operation: AND, OR, NOT, XOR, XNOR, NAND, NOR



(a) Gate (b) Memory cell

Figure 1.10 Fundamental Computer Elements

Integrated Circuits

- Data storage – provided by memory cells
- Data processing – provided by gates (011 OR 100 = 111)
- 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

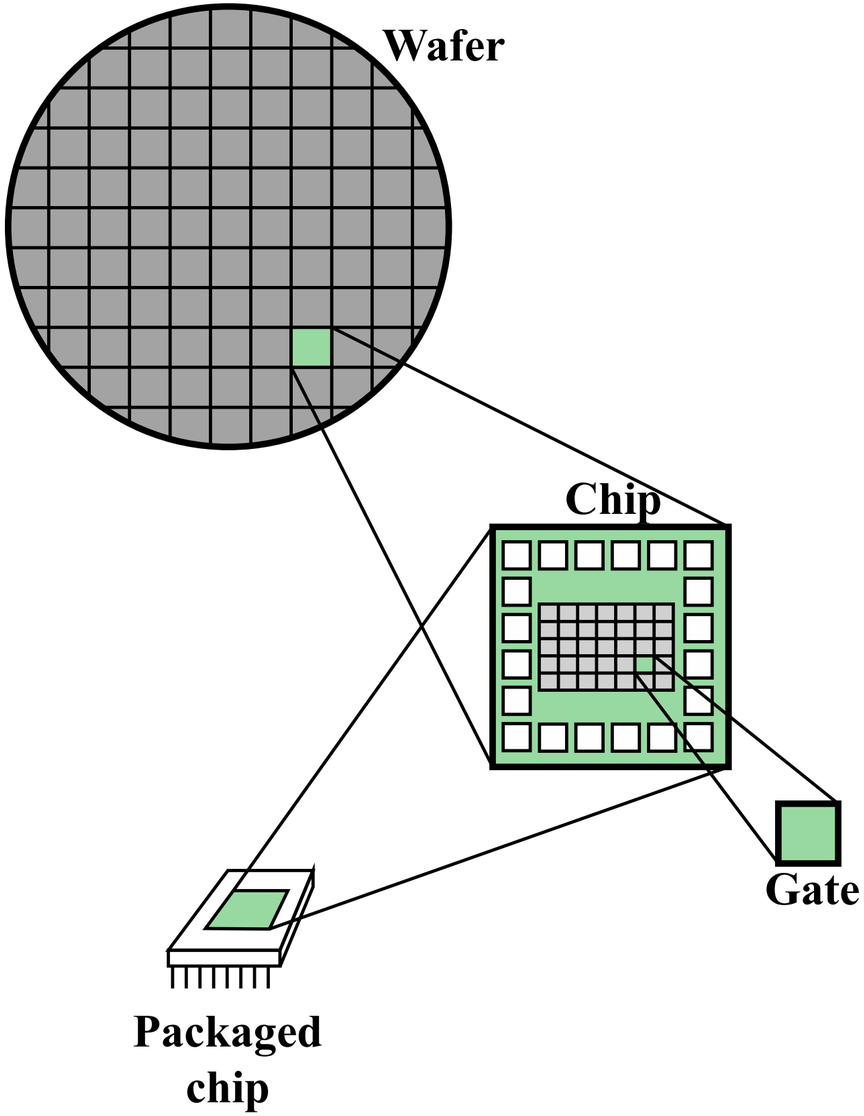


Figure 1.11 Relationship Among Wafer, Chip, and Gate

History of Computers

IC Complexity Classification

- **Small Scale Integrated Circuit (SSI)**
  - It describes fixed-function ICs that have up to ten equivalent gate circuits on a single chip, and they include basic gates and flip-flops
- **Medium-scale integration (MSI)**
  - It describes integrated circuits that have from 10 to 100 equivalent gates on a chip. They include logic functions such as encoders, decoders, counters, registers, multiplexers, arithmetic circuits, small memories, and others
- **Large-scale integration (LSI)**
  - It is a classification of ICs with complexities of from more than 100 to 10,000 equivalent gates per chip, including memories.

History of Computers

IC Complexity Classification

- **Very large-scale integration (VLSI)**
  - It describes integrated circuits with complexities of from more than 10,000 to 100,000 equivalent gates per chip
- **Ultra-large-scale integration (ULSI)**
  - 100,000 - 100,000 ,000 devices on a chip
  - It describes very large memories, larger microprocessors, and larger single-chip computers. Complexities of more than 100,000 equivalent gates per chip are classified as ULSI

History of Computers

Moore low

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

History of Computers

IBM System/360

- Announced in 1964
- Product line was incompatible with older IBM machines
- Was the success of the decade and cemented IBM as the overwhelmingly dominant computer vendor
- The architecture remains to this day the architecture of IBM's mainframe computers
- Was the industry's first planned family of computers
  - 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

Family Characteristics

Similar or identical instruction set

Similar or identical operating system

Increasing speed

Increasing number of I/O ports

Increasing memory size

Increasing cost

DEC PDP-8

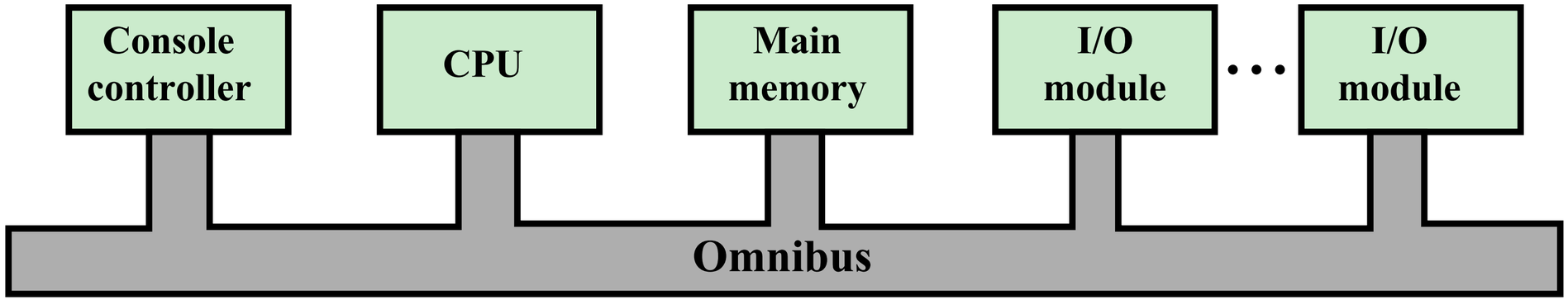


Figure 1.13 PDP-8 Bus Structure

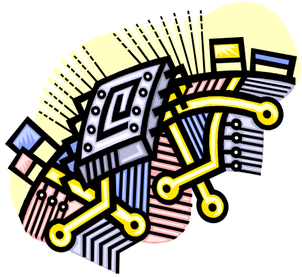
Table 1.2
Computer Generations

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

Later Generations

LSI
Large
Scale
Integration

VLSI
Very Large-
Scale
Integration



Semiconductor Memory
Microprocessors

ULSI
Ultra Large
Scale
Integration

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 the microprocessor

- 1972 Intel developed 8008
  - First 8-bit microprocessor

- 1974 Intel developed the 8080
  - First general-purpose microprocessor
  - Faster, has a richer instruction set, and has a large addressing capability



Evolution of Intel Microprocessors

3.2 GHz = 3.2 billion , 3.2 MHz=3.2 million, 3.2 KHz= 3200
Cycle per second

	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

Thank You

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