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

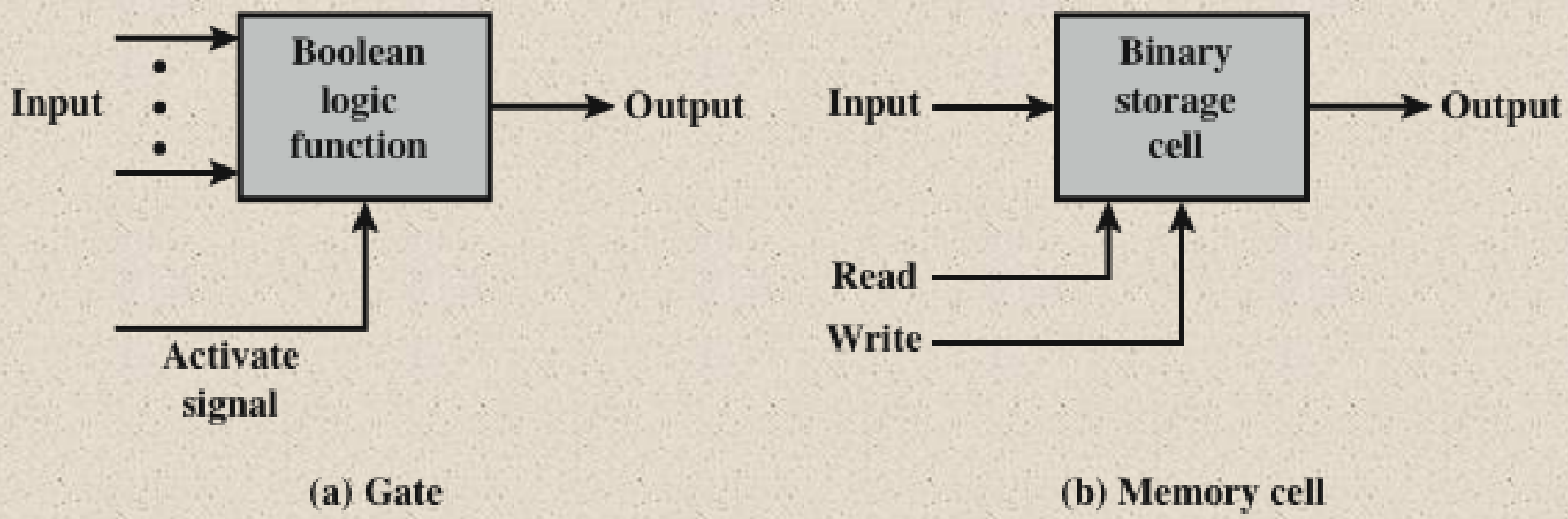

Figure 2.6 Fundamental Computer Elements

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

- 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

Wafer, Chip, and Gate Relationship

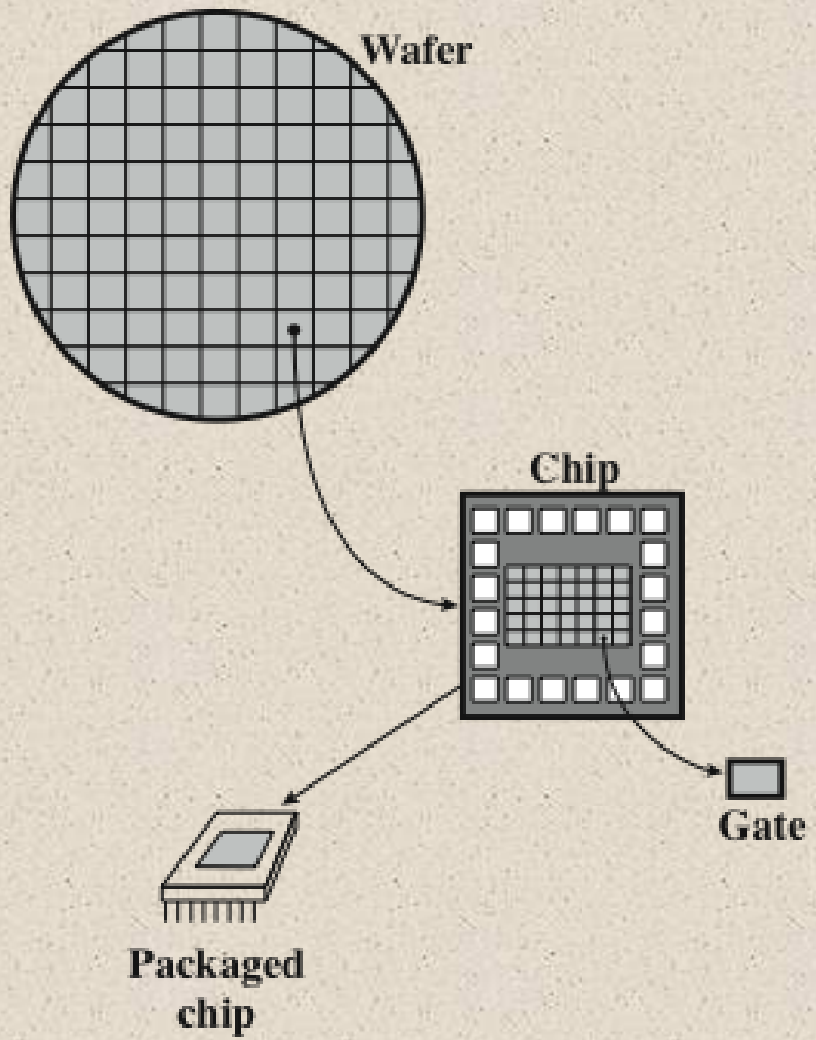

Figure 2.7 Relationship Among Wafer, Chip, and Gate

Chip Growth

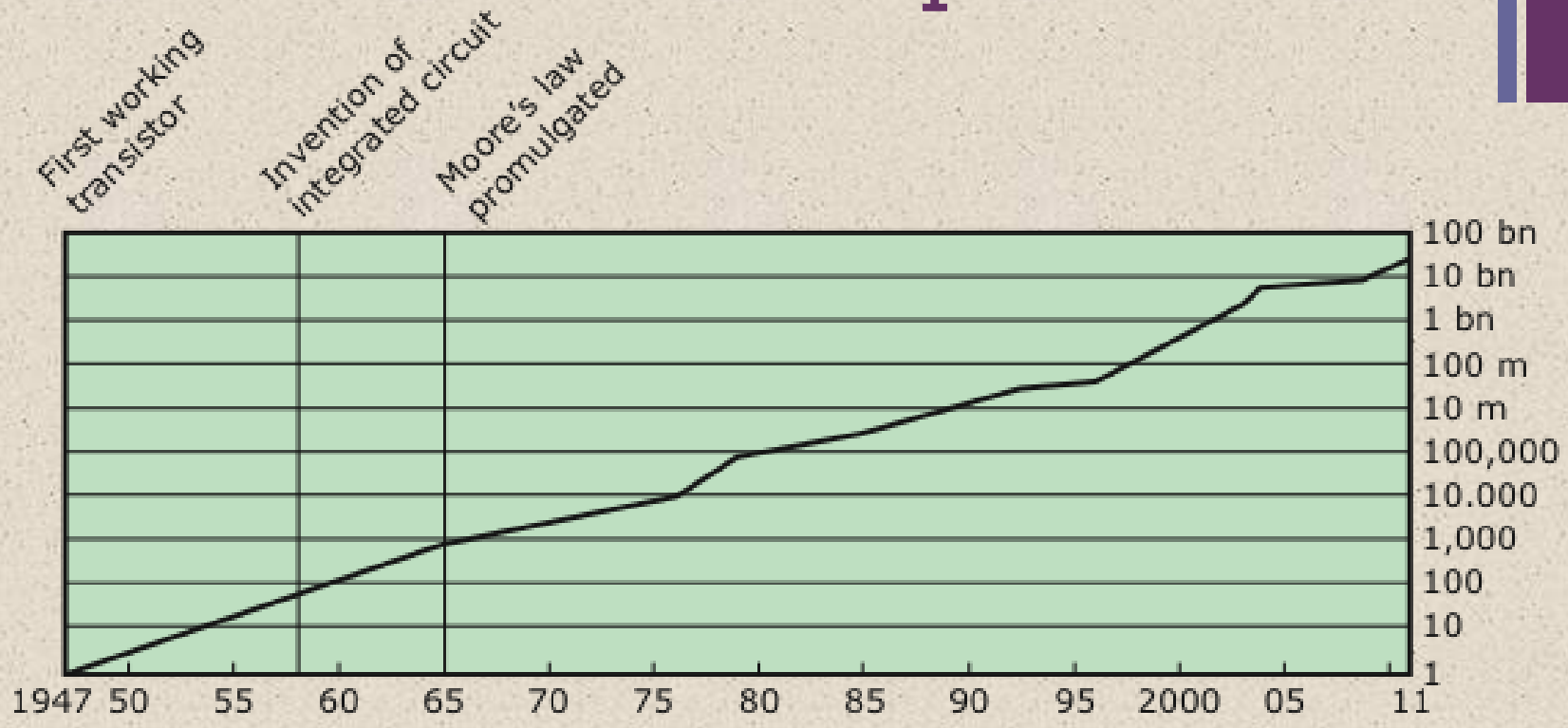

Figure 2.8 Growth in Transistor Count on Integrated Circuits (DRAM memory)

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

- 1964
- Replaced (& not compatible with) 7000 series
- First planned "family" of computers
- Similar or identical instruction sets
- Similar or identical O/S
- Increasing speed
- Increasing number of I/O ports (i.e. more terminals)
- Increased memory size
- Increased cost
- Multiplexed switch structure

IBM System/360

Table 2.4 Characteristics of the System/360 Family

Characteristic	Model 30	Model 40	Model 50	Model 65	Model 75
Maximum memory size (bytes)	64K	256K	256K	512K	512K
Data rate from memory (Mbytes/sec)	0.5	0.8	2.0	8.0	16.0
Processor cycle time μs)	1.0	0.625	0.5	0.25	0.2
Relative speed	1	3.5	10	21	50
Maximum number of data channels	3	3	4	6	6
Maximum data rate on one channel (Kbytes/s)	250	400	800	1250	1250

Table 2.4 Characteristics of the System/360 Family

DEC PDP-8

- 1964
- First minicomputer (after miniskirt!)
- Did not need air conditioned room
- Small enough to sit on a lab bench
- $16,000
- $100k+ for IBM 360
- Embedded applications & OEM
- BUS STRUCTURE

DEC PDP-8

Table 2.5
Evolution of the PDP-8

Model	First Shipped	Cost of Processor + 4K 12-bit Words of Memory ($1000s)	Data Rate from Memory (words/μsec)	Volume (cubic feet)	Innovations and Improvements
PDP-8	4/65	16.2	1.26	8.0	Automatic wire-wrapping production
PDP-8/5	9/66	8.79	0.08	3.2	Serial instruction implementation
PDP-8/1	4/68	11.6	1.34	8.0	Medium scale integrated circuits
PDP-8/L	11/68	7.0	1.26	2.0	Smaller cabinet
PDP-8/E	3/71	4.99	1.52	2.2	Omnibus
PDP-8/M	6/72	3.69	1.52	1.8	Half-size cabinet with fewer slots than 8/E
PDP-8/A	1/75	2.6	1.34	1.2	Semiconductor memory; floating-point processor

Table 2.5 Evolution of the PDP-8

DEC - PDP-8 Bus Structure

- IBM used the central-switched
- architecture on its 700/7000 and 360
- systems.
- PDP-8 used a structure that is now
- virtually universal for

microcomputers: The bus structure.

- The PDP-8 bus, called the Omnibus,

consists of 96 separate signal paths,

- used to carry control, address, and data signals.

DEC - PDP-8 Bus Structure

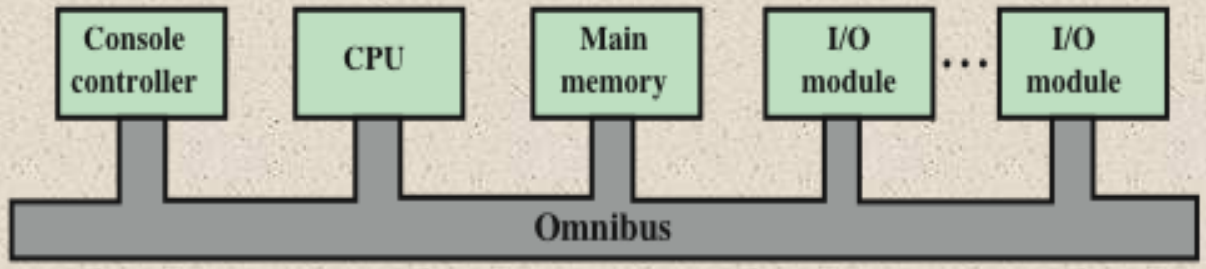

Figure 2.9 PDP-8 Bus Structure

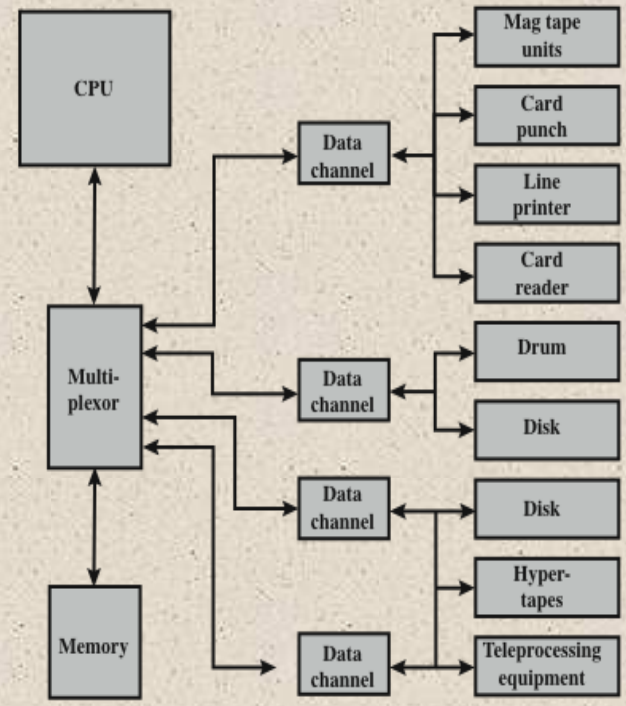

Figure 2.5 An IBM 7094 Configuration