

Lecture 23 – Memory architecture 1

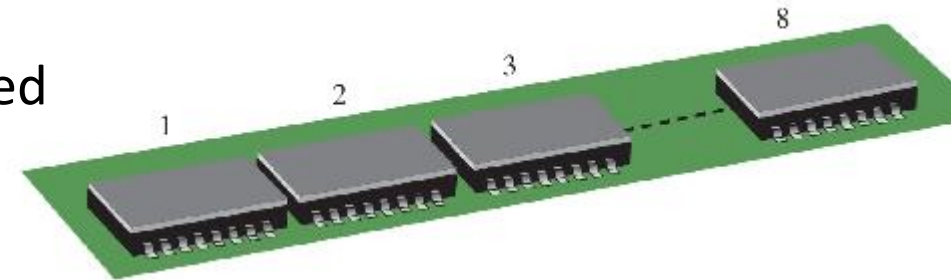
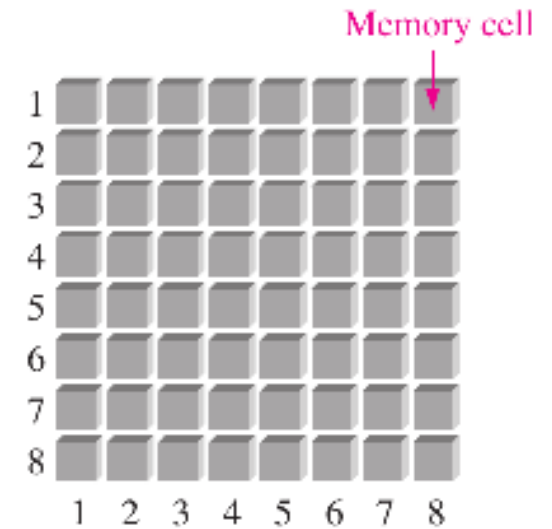
Chapter 7

Memory

- Two major types of semiconductor memories are **random-access memory (RAM)** and **read-only memory (ROM)**.
- RAM is a type of memory in which all contents are accessible in an equal amount of time and can be selected in any order for a read or write operation.
 - RAM has both read and write capability.
 - RAMs lose stored data when the power is turned off, they are *volatile memories*.
- ROM is a type of memory in which data are stored permanently or semi-permanently.
 - Data can be read from a ROM, but there is no write operation as in the RAM.
 - The ROM, like the RAM, is a random-access memory but the term RAM traditionally means a random-access read/write memory
 - Because ROMs retain stored data even if power is turned off, they are *nonvolatile* memories.

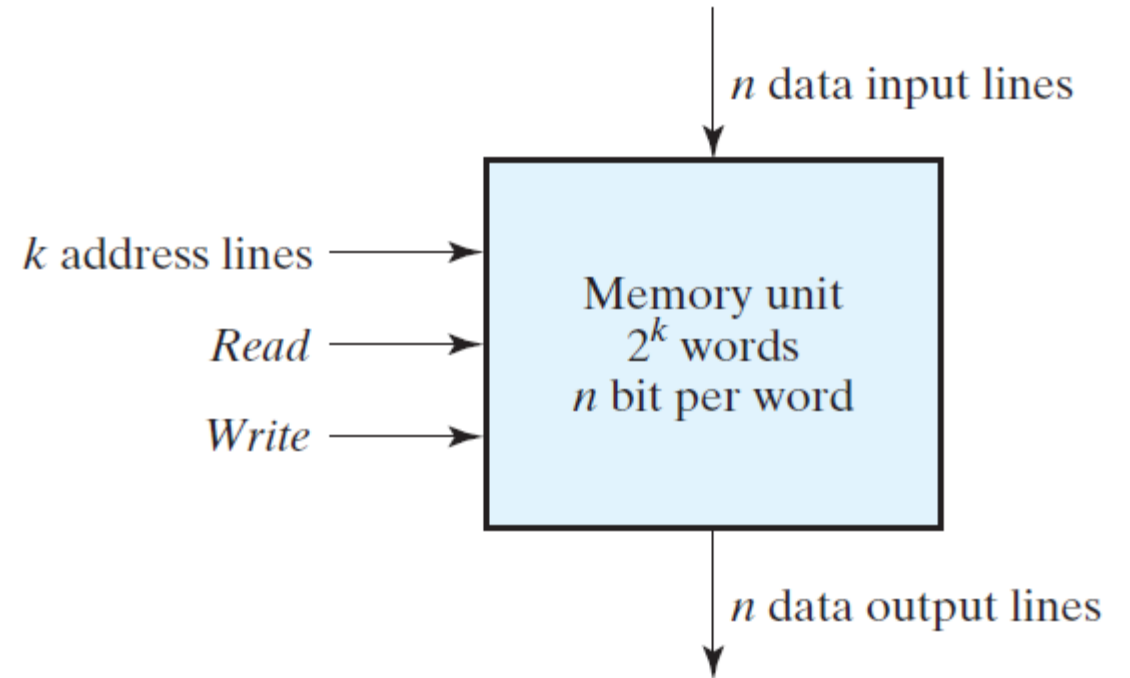
Random Access Memory (RAM)

- A memory unit is a collection of storage cells, together with associated circuits needed to transfer information into and out of a device
- The architecture of memory is such that information can be selectively retrieved from any of its internal locations
- The time it takes to transfer information to or from any desired random location is always the same—hence the name *random-access memory*, abbreviated **RAM**
- In contrast, the time required to retrieve information that is stored on magnetic tape, optical disks, etc, depends on the location of the data
- A memory unit stores binary information in groups of bits called *words*
- A word in memory is an entity of bits that move in and out of storage as a unit
- Most computer memories use words that are multiples of 8 bits in length
- The capacity of a memory unit is usually stated as the total number of bytes that the unit can store



Random Access Memory (RAM)

- Communication between memory and its environment is achieved through **data input and output lines, address selection lines, and control lines** that specify the direction of transfer
- The n data input lines provide the information to be stored in memory, and the n data output lines supply the information coming out of memory
- The k address lines specify the particular word chosen among the many available
- The two control inputs specify the direction of transfer desired: The **Write** input causes binary data to be transferred into the memory, and the **Read** input causes binary data to be transferred out of memory
- The **address lines** select one particular word

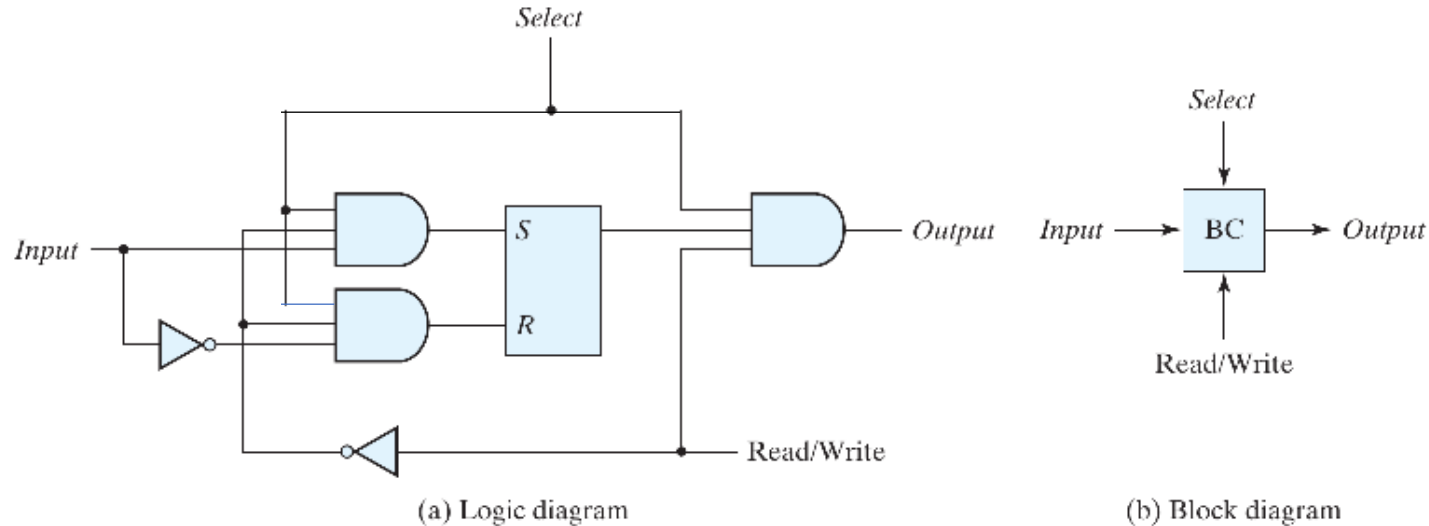


Random Access Memory (RAM)

- Consider, for example, a memory unit with a capacity of 1K words of 16 bits each
- Since $1\text{K} = 1,024 = 2^{10}$ and 16 bits constitute two bytes, we can say that the memory can accommodate $2,048 = 2\text{Kb}$
- The words are recognized by their decimal address from 0 to 1,023
- The equivalent binary address consists of 10 bits
- A word in memory is selected by its binary address
- *When a word is read or written, the memory operates on all 16 bits as a single unit*

Memory address		Memory content
Binary	Decimal	
0000000000	0	1011010101011101
0000000001	1	1010101110001001
0000000010	2	0000110101000110
	⋮	⋮
1111111101	1021	1001110100010100
1111111110	1022	0000110100011110
1111111111	1023	1101111000100101

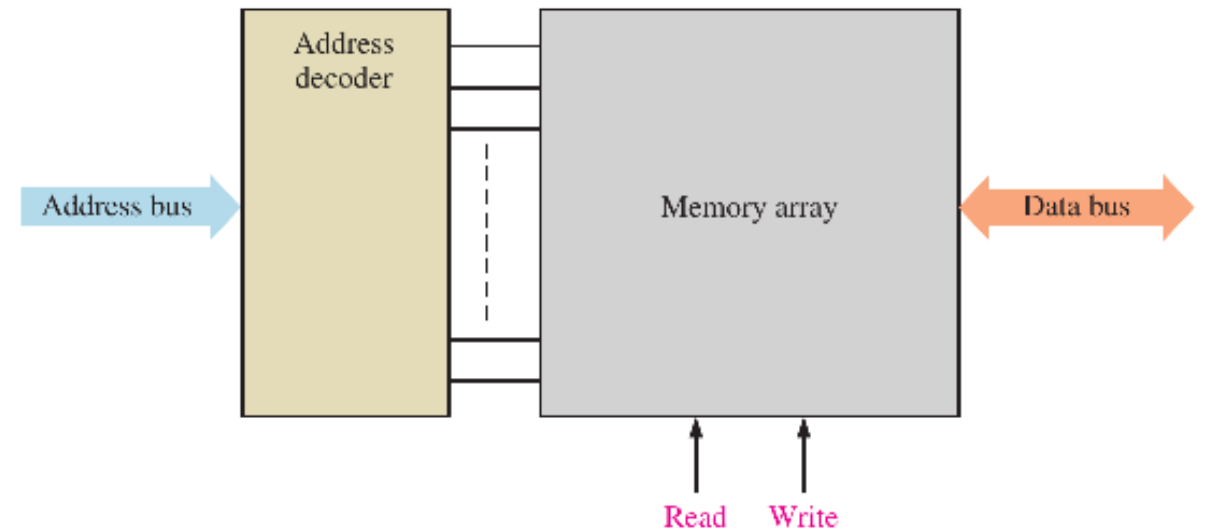
Random Access Memory (RAM) – internal structure



- The internal construction of a RAM of m words and n bits per word consists of $m * n$ binary storage cells and associated decoding circuits for selecting individual words
- The binary storage cell (SR latch) is the basic building block of a memory unit
- The storage part of the cell is modeled by an SR latch with associated gates to form a D latch
- *Note that this is not a D flip-flop*

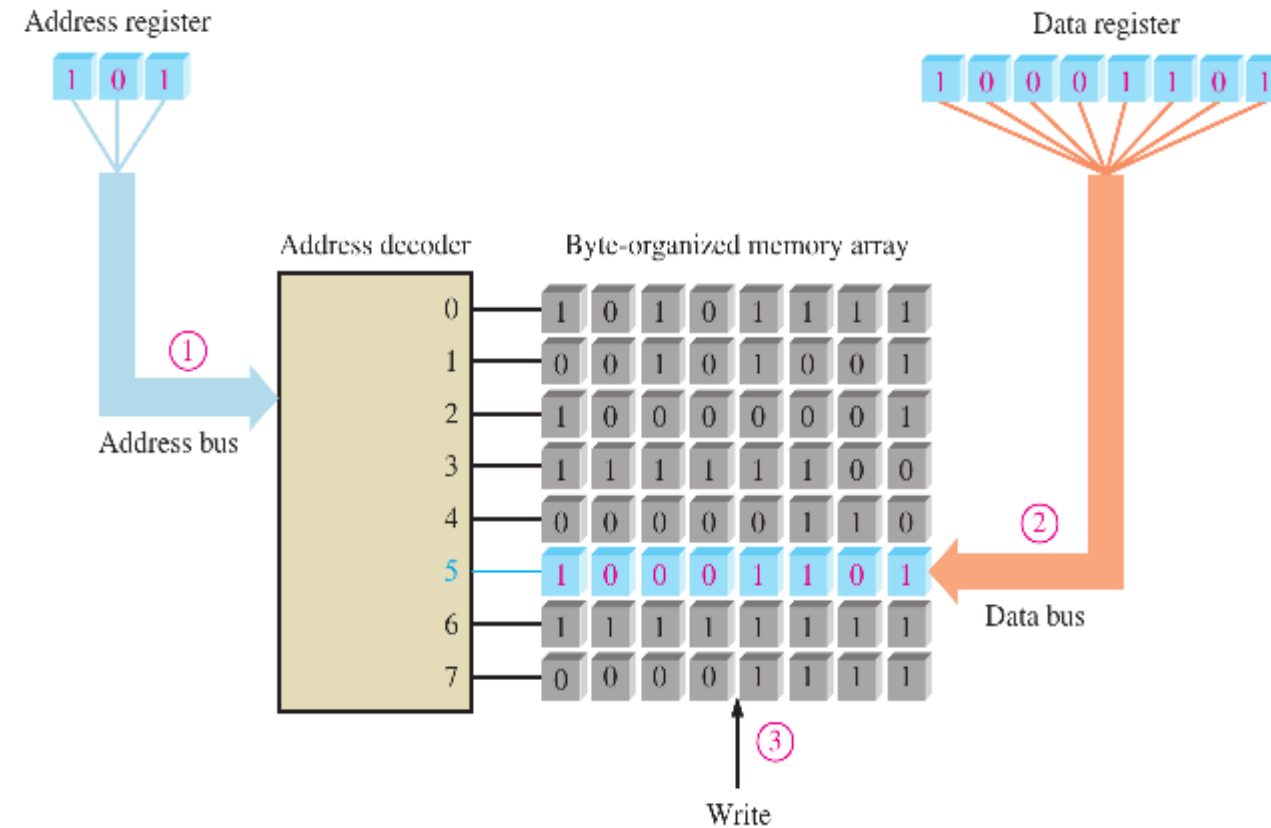
Write and Read operations

- The two operations that RAM can perform are the write and read operations
- The write signal specifies a transfer-in operation and the read signal specifies a transfer-out operation
- On accepting one of these control signals, the internal circuits inside the memory provide the desired operation



Write operation

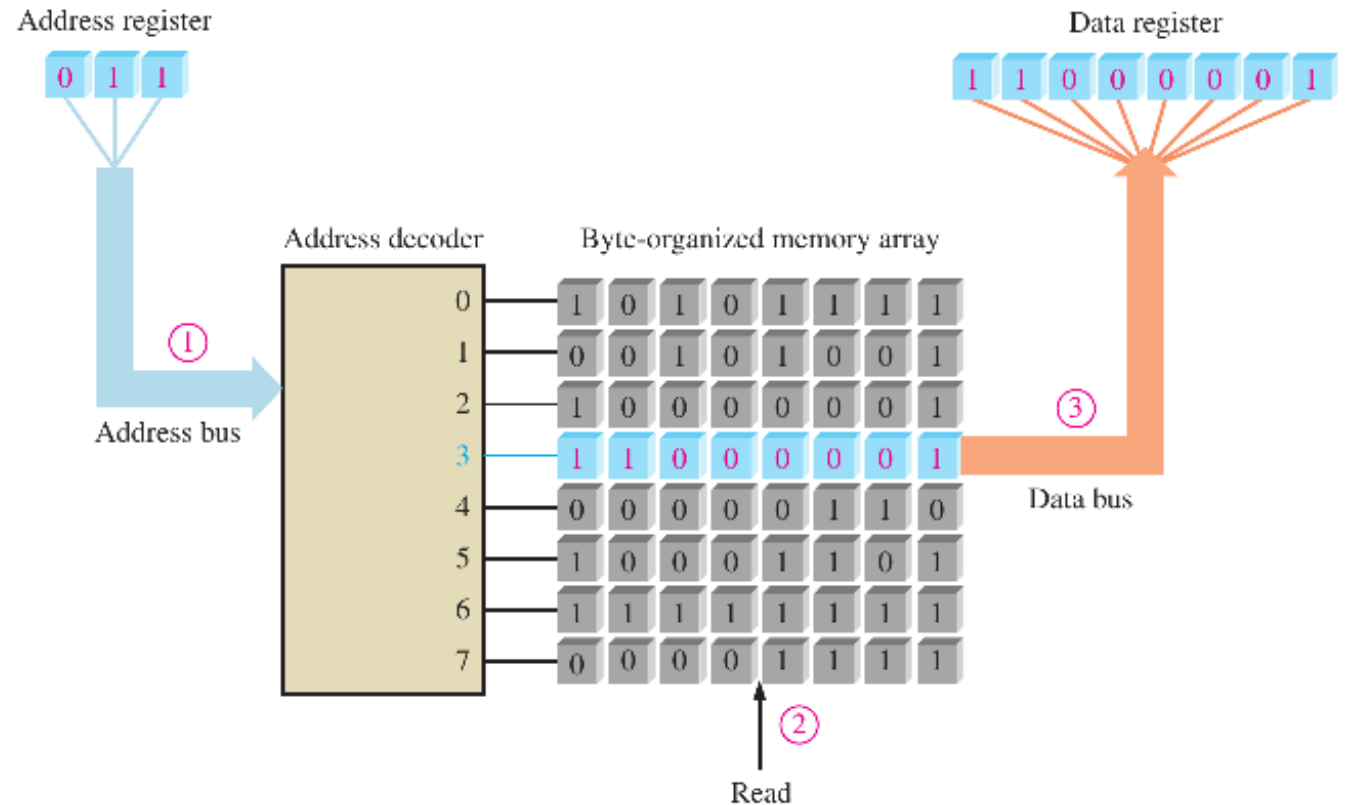
- The steps that must be taken for the purpose of transferring a new word to be stored into memory are as follows:
 1. Apply the binary address of the desired word to the address lines.
 2. Activate the *write* input.
 3. Apply the data bits that must be stored in memory to the data input lines.
- The memory unit will then take the bits from the input data lines and store them in the word specified by the address lines



- ① Address code 101 is placed on the address bus and address 5 is selected.
- ② Data byte is placed on the data bus.
- ③ Write command causes the data byte to be stored in address 5, replacing previous data.

Read operation

- The steps that must be taken for the purpose of transferring a stored word out of memory are as follows:
1. Apply the binary address of the desired word to the address lines
 2. The data shows up on the output lines after a certain delay from the application of the stable address (selecting the word)



- (1) Address code 011 is placed on the address bus and address 3 is selected.
- (2) Read command is applied.
- (3) The contents of address 3 is placed on the data bus and shifted into data register. The contents of address 3 is not erased by the read operation.