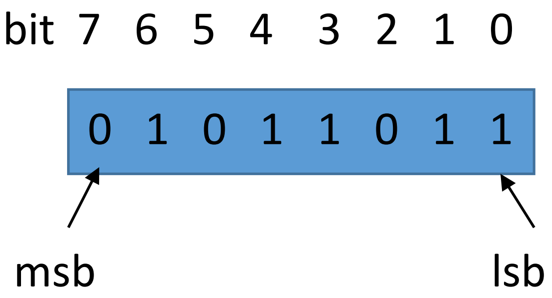
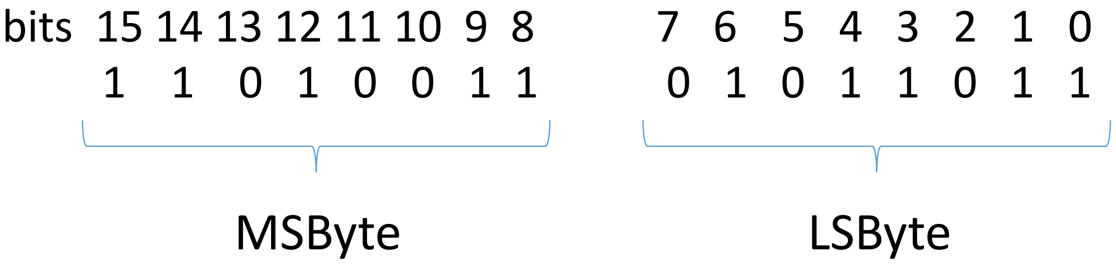
Memory

- Smallest unit of storage is a Bit
- However, smallest addressable unit is a Byte (8 bits)

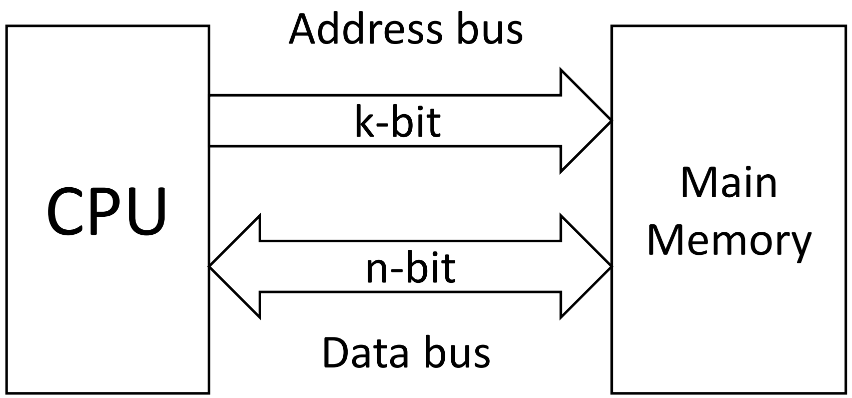


- Most computers permit access of memory through words (16 bits, 32 bits or 64 bits)



Main Memory

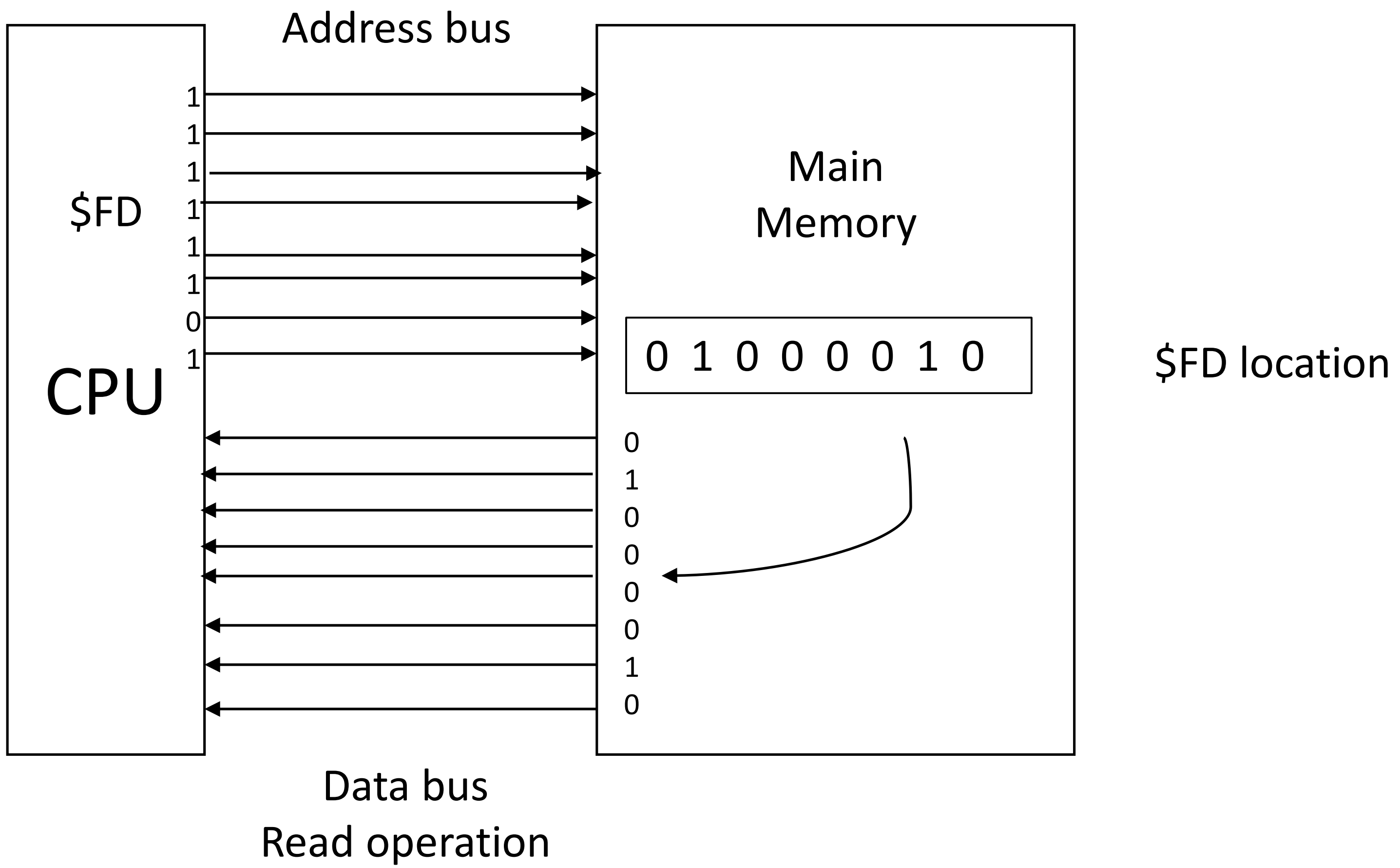
- System Bus connects major computer components – CPU, Memory, I/O



- Main Memory stores both program instructions and data.
- CPU puts the memory location that should be accessed on the address bus with width *k*, (each wire carries a 1 or a 0). The contents of that location are transferred via the data bus.
- Typically memory addresses will range from 0 to 2^k- 1 distinct values
- A 16 bit address *(k* = 16*)* provides $2^{16} = 65536$ (64K) addressable locations.
- Memory is organized so that a group of *n* bits are stored or retrieved in a single operation.
- Group of *n* bits is referred to as a *word*, and *n* is called the *word length.*

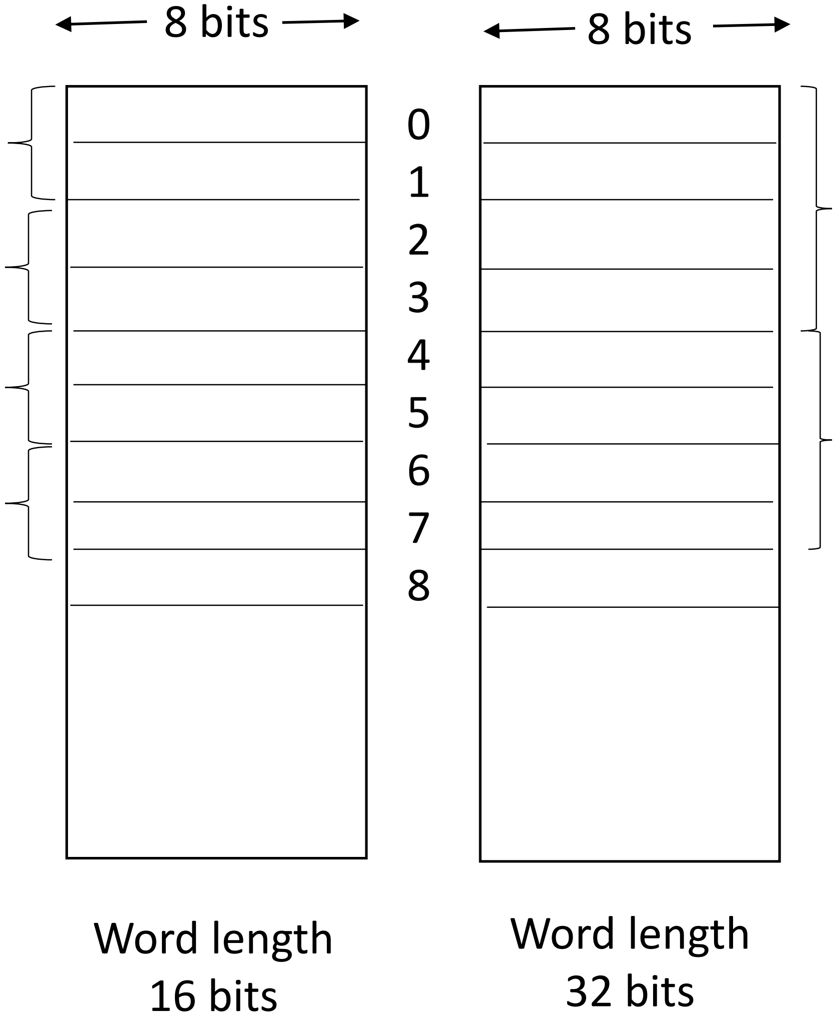
Main Memory

- Internally data is always represented in binary, although Hex is more readable



Memory Addressing

- Successive addresses refer to successive byte locations in memory.
- Byte locations have addresses 0, 1, 2, ….
- If word length of the machine is 16 bits, successive words are located at addresses 0, 2, 4, ….(these even addresses are also called word boundary)
- If word length of the machine is 32 bits (long word), successive words are located at addresses 0, 4, 8, ….
- Words must be accessed at their word boundaries, otherwise exception occurs
- Some machines allow long words to be accessed at even addresses – address 0 for bytes at locations 0,1,2,3 – address 2 for bytes at locations 2,3,4,5



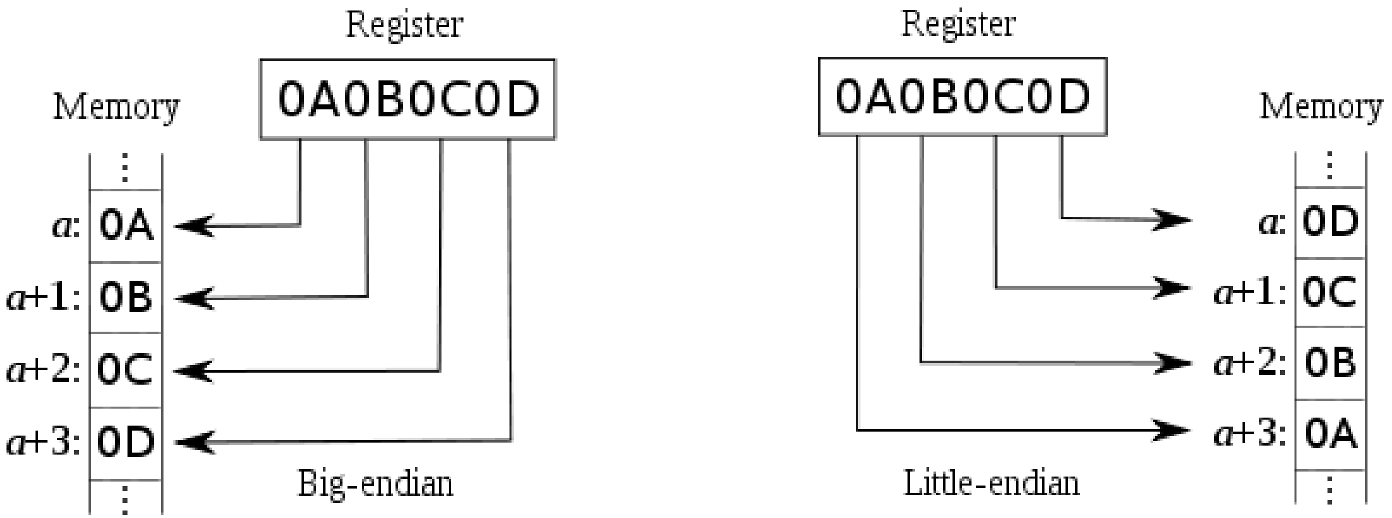
Big-Endian and Little-Endian

Big-Endian:

- Lower memory address correspond to MSByte
- Address of word is defined as address of MSByte

Little-Endian:

- Lower memory address correspond to LSByte
- Address of word is defined as address of LSByte



Memory Capacity

Capacity (C): number of bytes that can be stored in a memory (KB, MB, GB)

- For Byte Organized memory,

$$C = 2^k \text{ bytes}$$

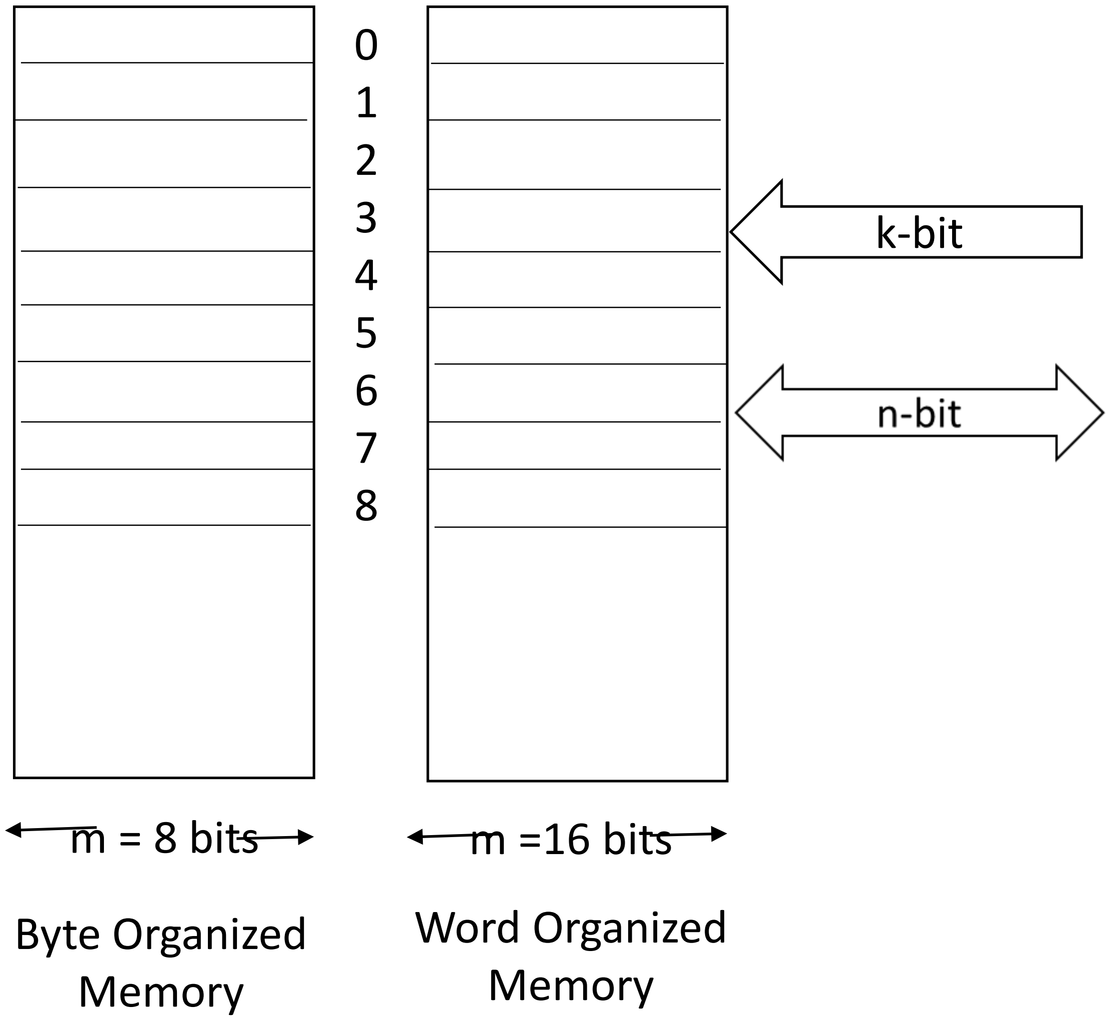
since there are 2^k locations and each location is a byte

- For Word Organized memory,

$$C = 2^k \times 2 \text{ bytes}$$

since there are 2^k locations and each location is 2 bytes

- In general, $C = 2^k \times \frac{m}{8}$ bytes
- Ex: If C = 1MB = 2^{20} bytes, what is k for a byte organized memory?



Semiconductor Memory Types

Memory Type	Category	Erasure	Write Mechanism	Volatility
RAM, Random-access memory	Read–write memory	Electrically	Electrically	Volatile
ROM, Read-only memory	Read-only memory	Not possible	Masks	Nonvolatile
PROM, programmable ROM			Electrically	
EPROM, Erasable PROM	Read-mostly memory	UV light		
EEPROM, electrically erasable PROM		Electrically		

Memory Address Map for Microprocomputer

Component	Hexadecimal address	Address bus 10	9	8	7	6	5	4	3	2	1
RAM 1	0000–007F	0	0	0	x	x	x	x	x	x	x
RAM 2	0080–00FF	0	0	1	x	x	x	x	x	x	x
RAM 3	0100–017F	0	1	0	x	x	x	x	x	x	x
RAM 4	0180–01FF	0	1	1	x	x	x	x	x	x	x
ROM	0200–03FF	1	x	x	x	x	x	x	x	x	x