



Unit 5: Memory



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Bibliography

Digital fundamentals.

Thomas Floyd. Prentice-Hall.

- Digital Design.

M. Morris Mano. Prentice-Hall

- Introduction to Digital Logic Design.

John P. Hayes. Addison-Wesley

Basic concepts



- **Memory:** Part of the computer that stores information: instructions and data.

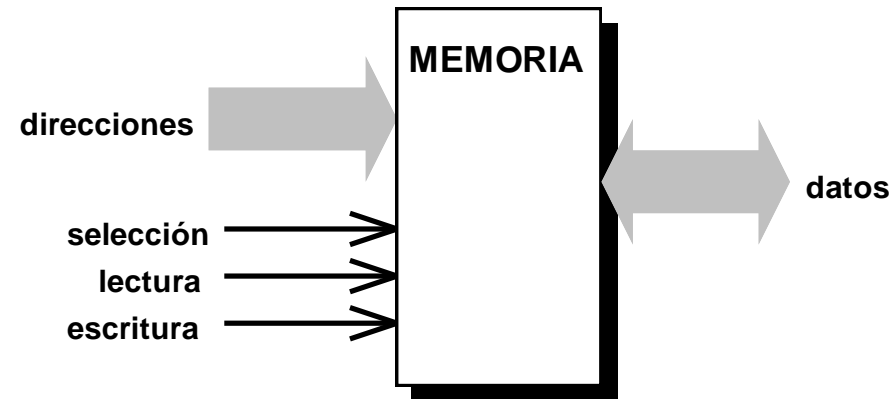
Organization:

- **Address:** Identifies memory position
- **Content:** stored information
- **Memory cell:** Minimum storing element: one bit
- **Word:** group of bits implied in each memory operation (8, 16, 32, 64, ... bits).

It defines data bus size

- **Basic operations:**

- Read (R)
- Write (W)



Characteristic Parameters (I)



➤ **Capacity:** Maximum quantity of information that a memory system can store

▪ Usual measures:

Kilobyte (Kb) = 2^{10} bytes

Megabyte (Mb) = 2^{10} Kb = 2^{20} bytes

Gigabyte (Gb) = 2^{10} Mb = 2^{30} bytes

Terabyte (Tb) = 2^{10} Gb = 2^{40} bytes

➤ **Velocity or access time:** Elapsed time since the moment a memory address is provided until the data contained in it is accessible

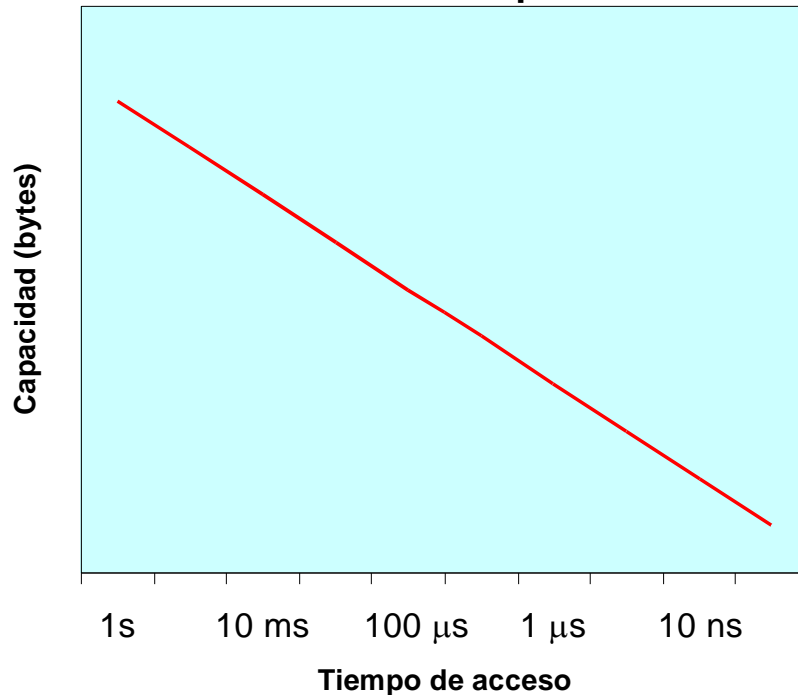
➤ **Memory cycle:** Elapsed time between two consecutive memory accesses.

➤ **Bit cost:** Total memory cost divided by its capacity in bits

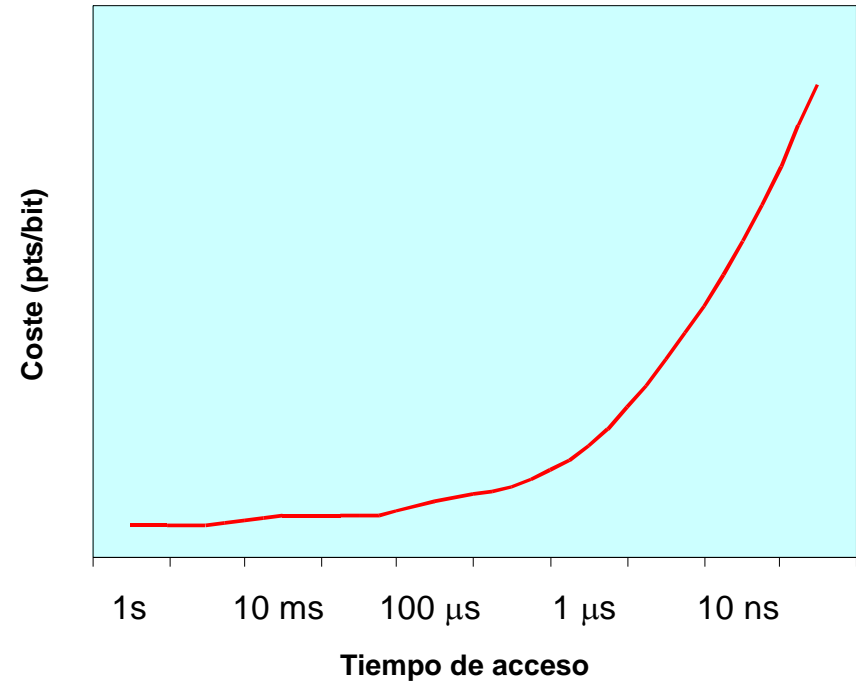
Characteristic Parameters (II)



Comparativa
velocidad/capacidad



Comparativa
velocidad/coste

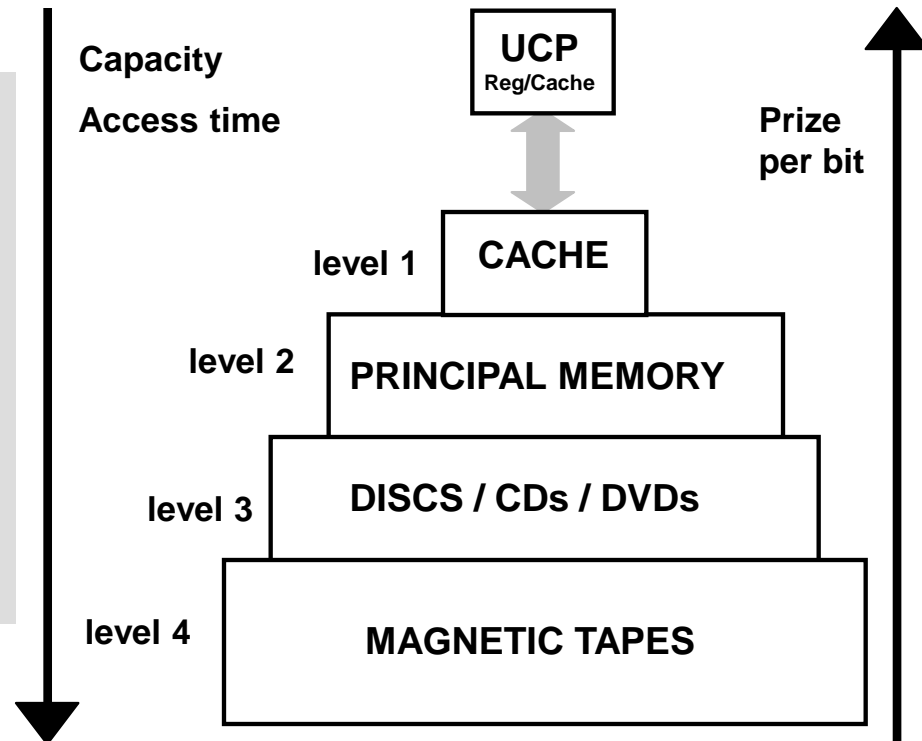


Memory hierarchy



Hierarchy:

- CPU registers
- Internal cache
- External cache
- Principal memory (RAM)
- External/secondary storing devices (Hard Discs, CDs, DVDs, pen drive, magnetic tapes, etc...)





Memory Technologies

RAM *Random Access Memory (volatile, read/write)*

- SRAM – Static RAM
- DRAM - Dynamic RAM
 - SDRAM - Synchronous Dynamic RAM

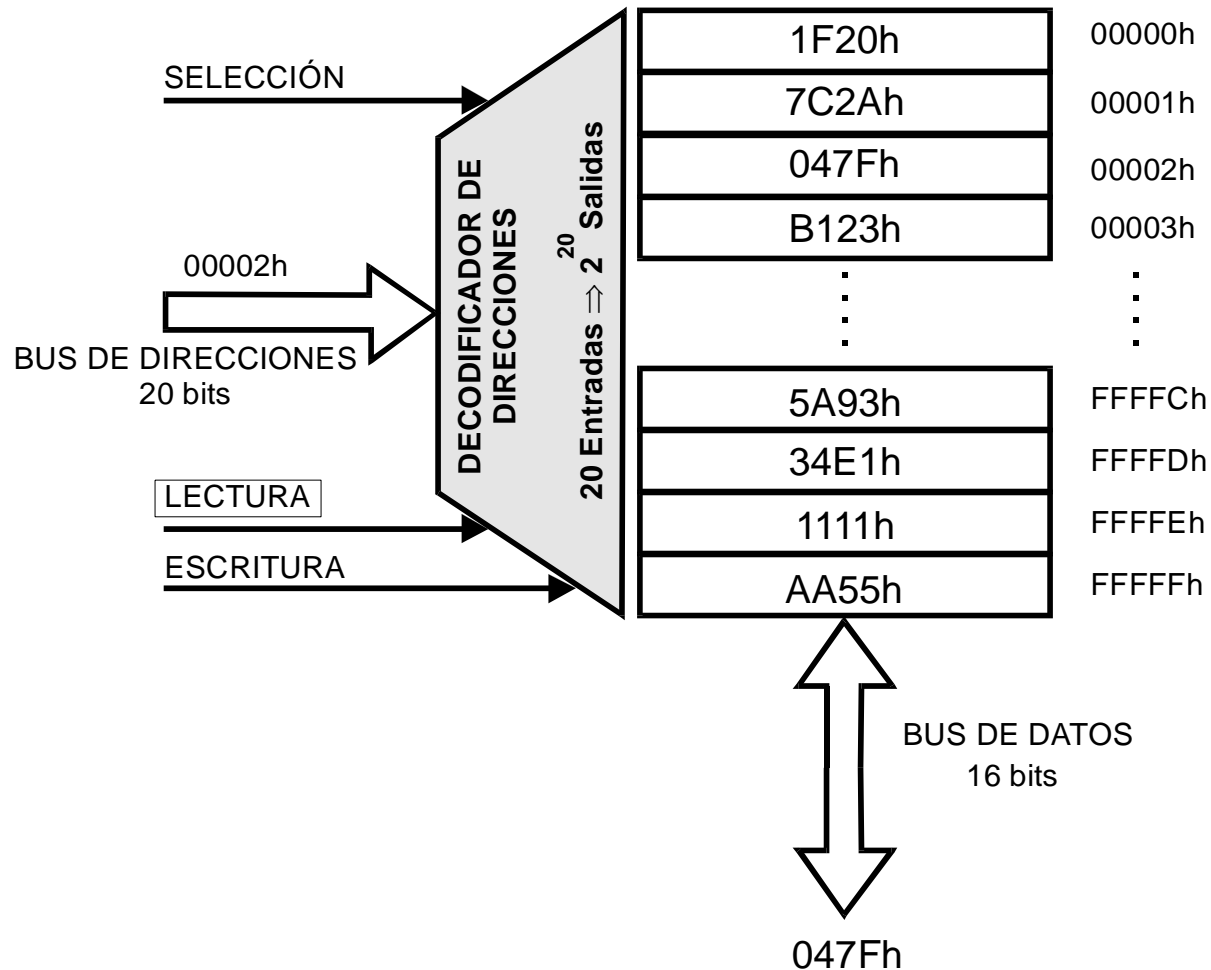
ROM *Read Only Memory (non-volatile, only read)*

- PROM - *Programmable ROM* –
- EPROM - *Erasable PROM*
- EEPROM - *Electrically EPROM* –

FLASH – (non-volatile, only read/write). Pen drives, cameras....



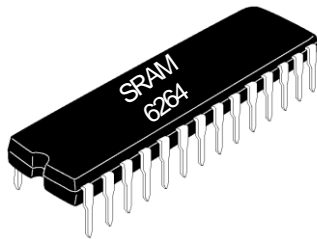
Principal Memory: structure (I)



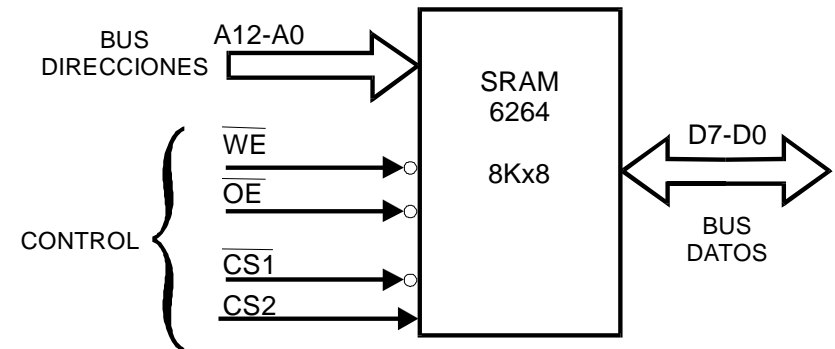
Principal Memory: structure (II)



Example: static RAM 8Kx8



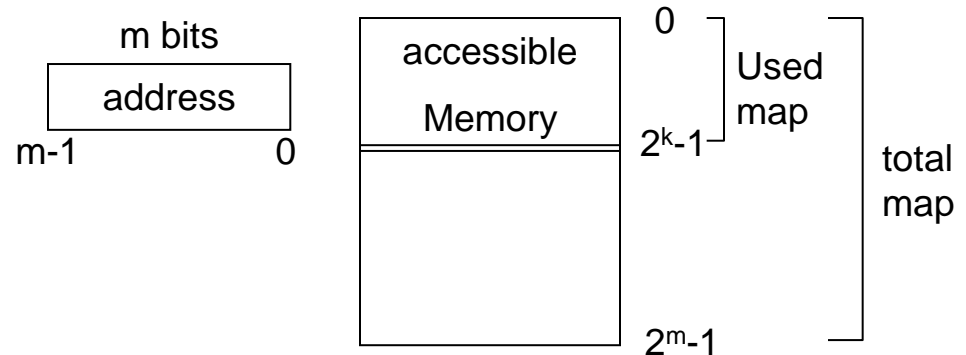
| | | | |
|-----------------|------|----|-------------------|
| NC | □ 1 | 28 | □ V _{CC} |
| A12 | □ 2 | 27 | □ \overline{WE} |
| A7 | □ 3 | 26 | □ CS2 |
| A6 | □ 4 | 25 | □ A8 |
| A5 | □ 5 | 24 | □ A9 |
| A4 | □ 6 | 23 | □ A11 |
| A3 | □ 7 | 22 | □ \overline{OE} |
| A2 | □ 8 | 21 | □ A10 |
| A1 | □ 9 | 20 | □ CS1 |
| A0 | □ 10 | 19 | □ D7 |
| D0 | □ 11 | 18 | □ D6 |
| D1 | □ 12 | 17 | □ D5 |
| D2 | □ 13 | 16 | □ D4 |
| V _{SS} | □ 14 | 15 | □ D3 |



Memory map (I)

Memory map

- Organization and structure of the addressable space in a computer
- It is determined by the quantity of addresses and the size of the content of each address (word size)
 - Size of address bus, m , determines number of addresses, 2^m
 - Size of data bus, n , generally equals the size of the content of each address (word)

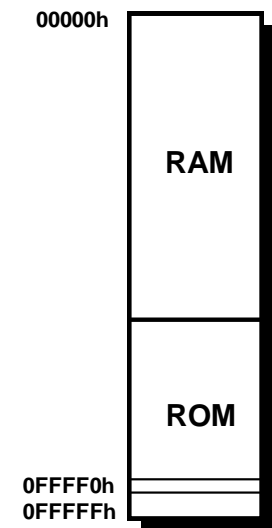


Memory map amplification

- Generally a processor is not equipped with all the memory it can address.

RAM and ROM positions

- Example: Simplified memory map of 8086 micro processor

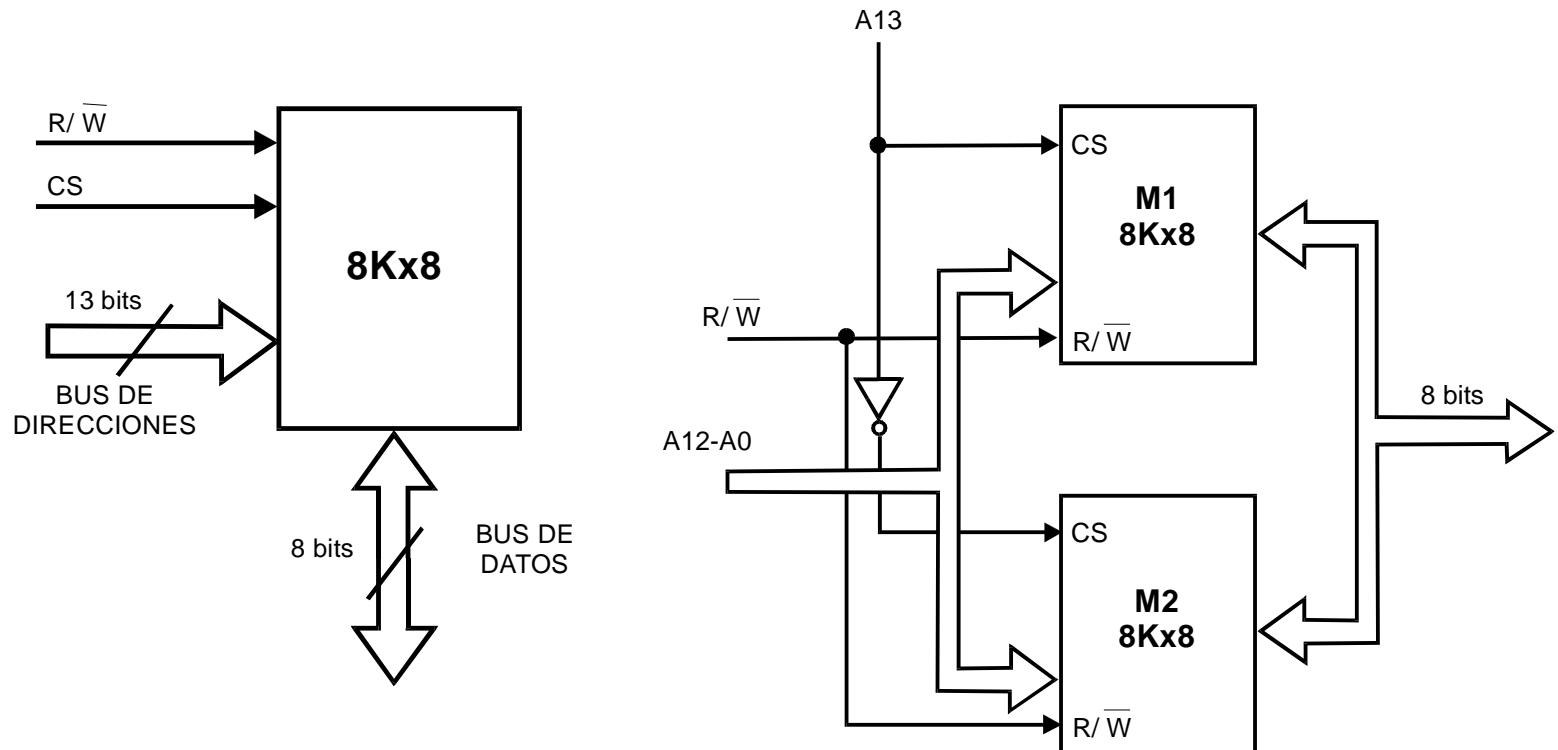


Memory map (II)

Example of capacity amplification (number of addresses):

Use more memory chips to increase number of addresses – ie of accessible words

Built a 16Kx8 memory system with 8Kx8 chips



Memory map (III)

Example of word size amplification:

Use more memory chips to increase the size of the content of each memory position (word size)

Built a 8Kx16 memory system with 8Kx8 chips

