Registers and Memory

CSIM601251

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Outline

- Register
- Memory
- Memory Unit
- Read/Write Operations
- Memory Arrays

Note: These slides are taken from Aaron Tan's slide

Registers

- N-bit register:
  - N flip-flops, possibly with added combinational gates that perform data-processing task
  - Capable of storing n bits of binary information
- Counter:
  - A register that goes through a predetermined sequence of states upon the application of clock pulse
- Register and Counter are sequential functional blocks that are used extensively in the design of digital systems

D Flip-Flops Register

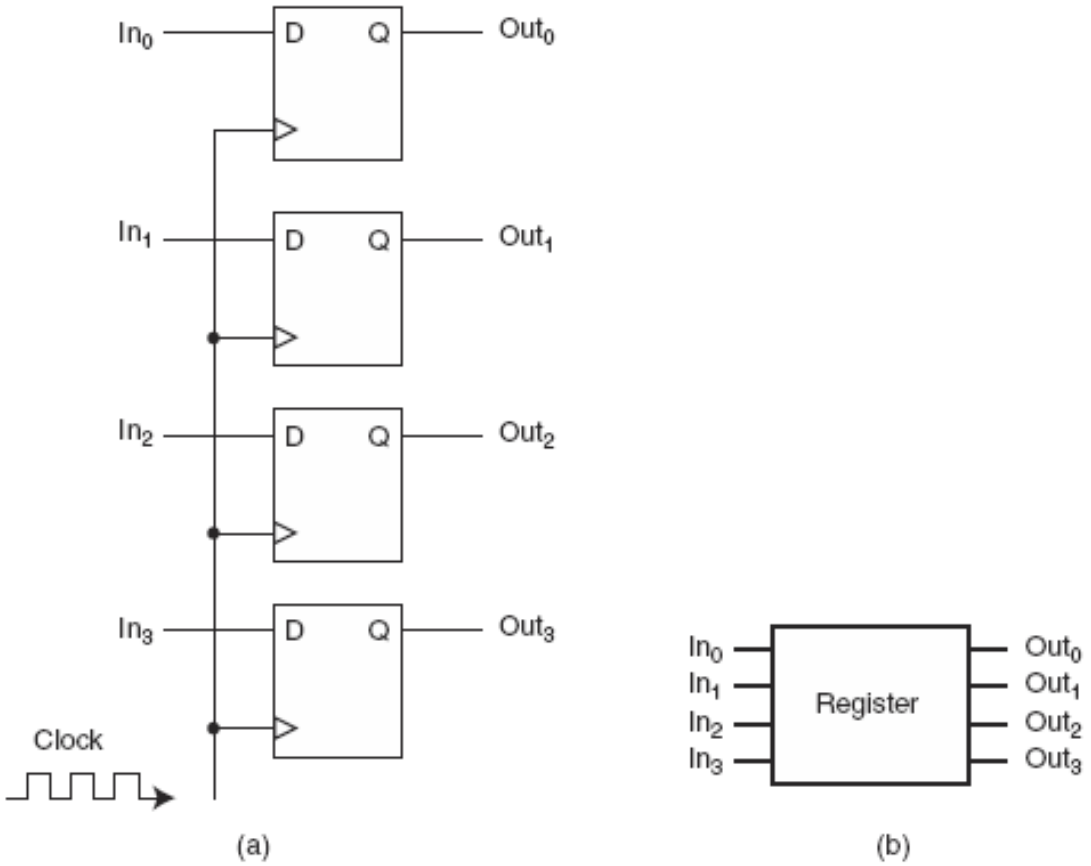

FIGURE 3.23 **a) A 4-Bit Register**
b) A Block Diagram for a 4-Bit Register

Binary Counters

- Counters are sequential circuits that cycle through some states.
- They can be implemented using flip-flops.
- 0000, 0001, 0010, 0011……..
  - Lower bit is complemented each time
  - Whenever it changes state from 1 to 0, the bit to the left is complemented
  - Each of the other bits changes state from 0 to 1 when all bit to the right are equal to 1

JK Flip-Flops Counter

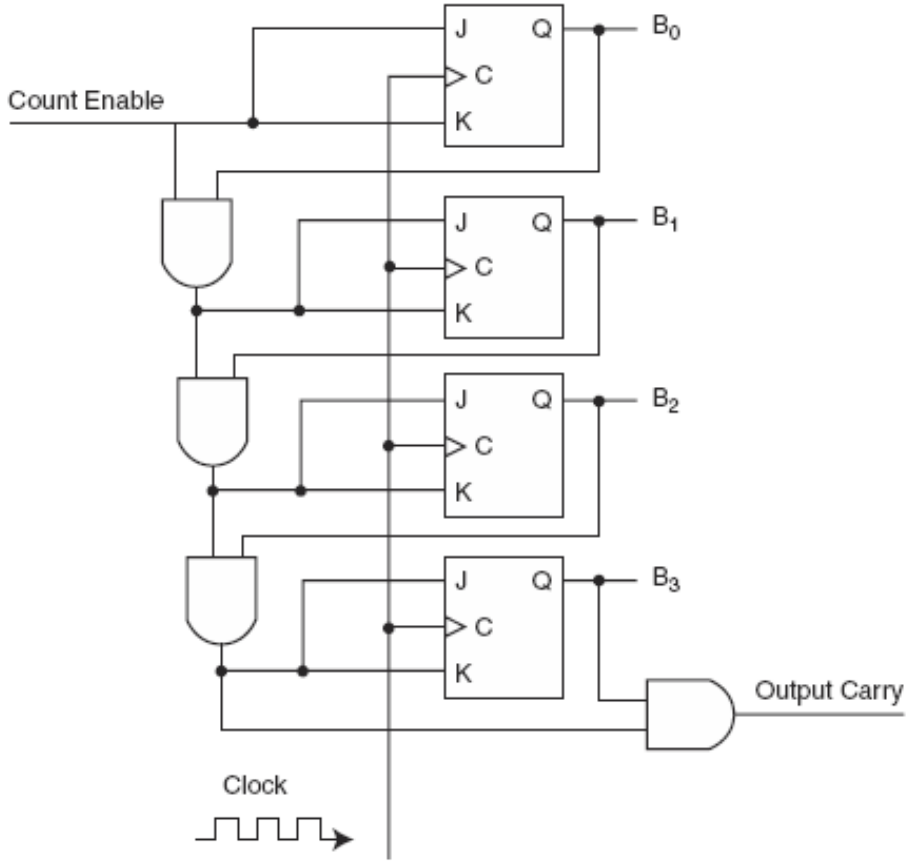

FIGURE 3.24 **A 4-Bit Synchronous Counter Using JK Flip-Flops**

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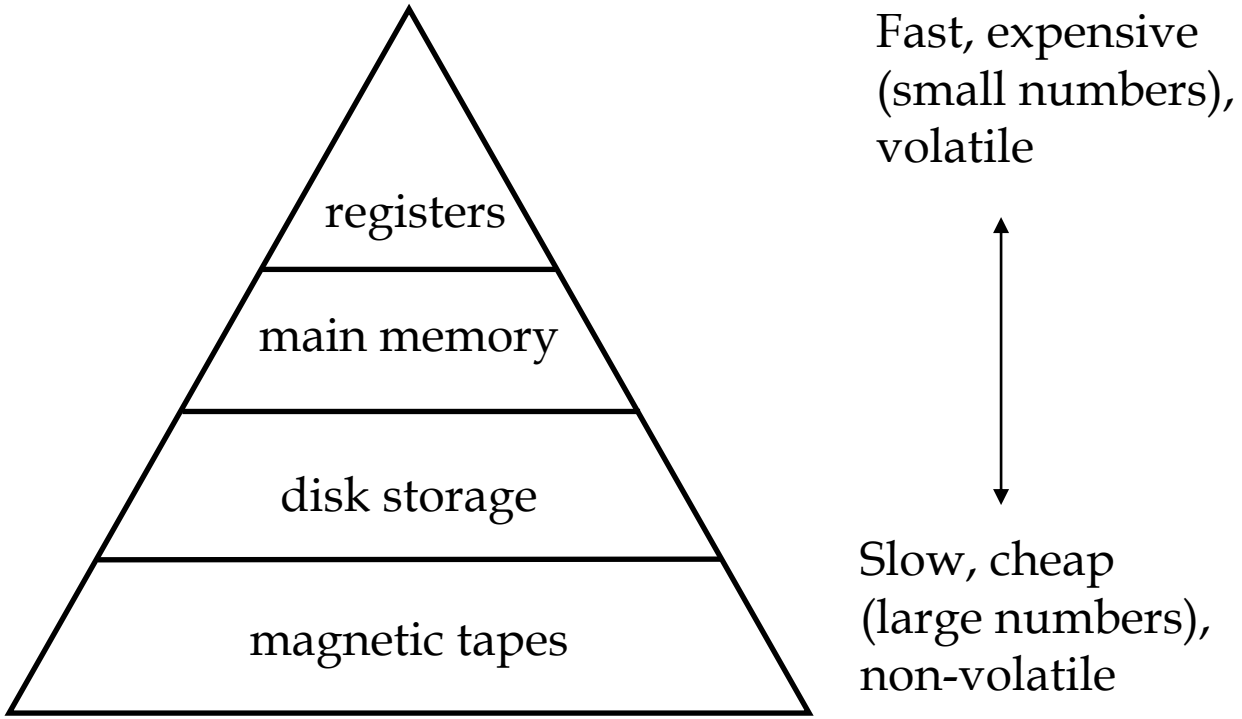
Memory (1/4)

- Memory stores programs and data.
- Definitions:
  - 1 byte = 8 bits
  - 1 word: in multiple of bytes, a unit of transfer between main memory and registers, usually size of register.
  - 1 KB (kilo-bytes) = 2^{10} bytes; 1 MB (mega-bytes) = 2^{20} bytes; 1 GB (giga-bytes) = 2^{30} bytes; 1 TB (tera-bytes) = 2^{40} bytes.
- Desirable properties: fast access, large capacity, economincal cost, non-volatile.
- However, most memory devices do not posess all these properties.

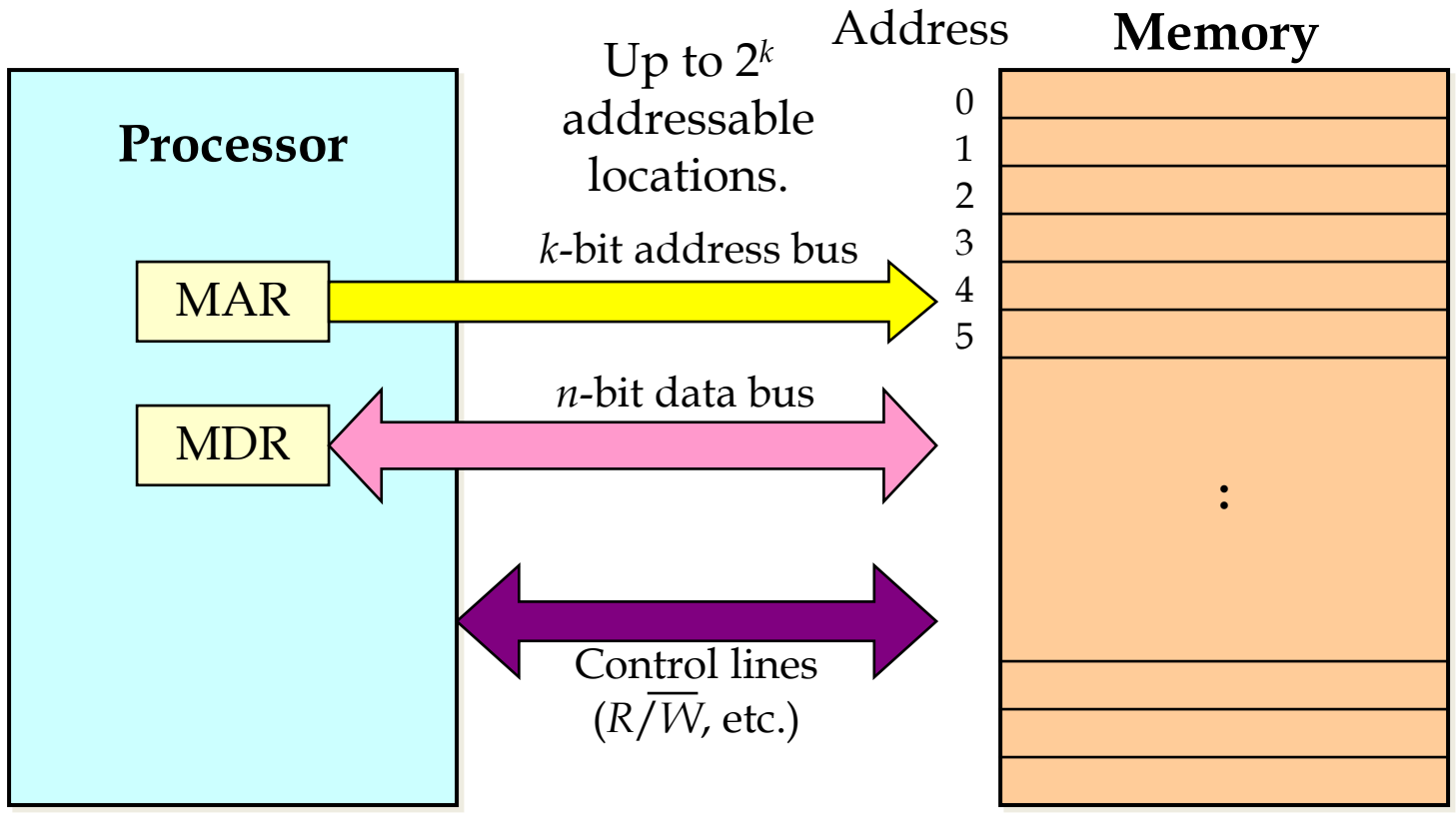
Memory (2/4)

- Memory hierarchy



Memory (3/4)

- Data transfer

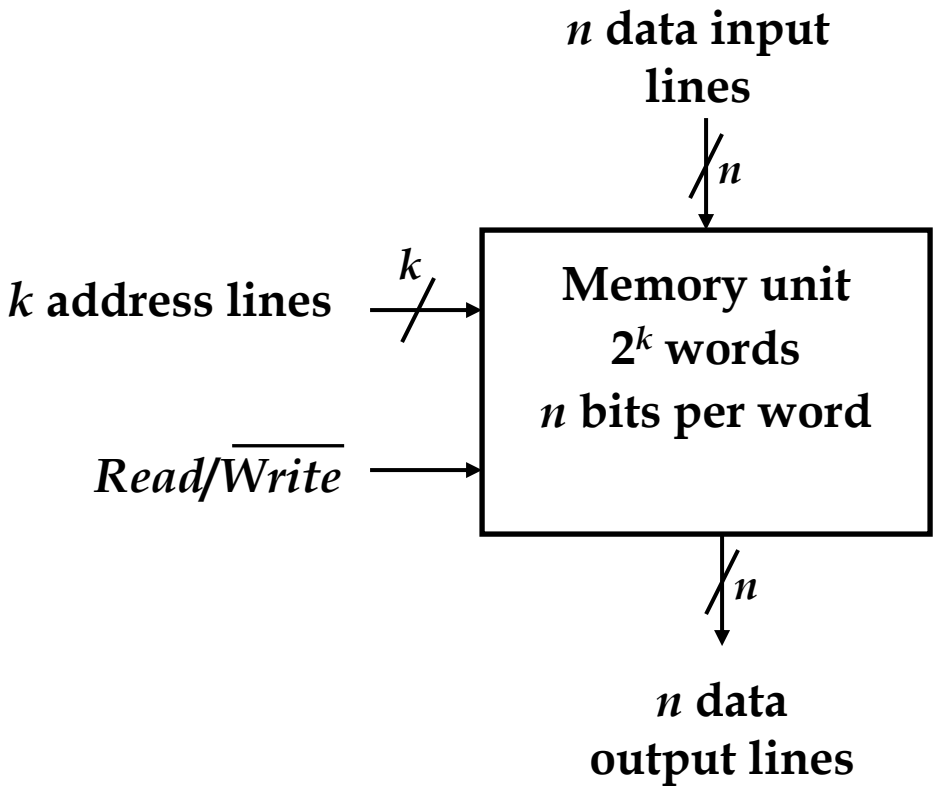


Memory (4/4)

- A memory unit stores binary information in groups of bits called *words*.
- The data consists of n lines (for n-bit words). Data input lines provide the information to be stored (*written*) into the memory, while data output lines carry the information out (*read*) from the memory.
- The address consists of k lines which specify which word (among the 2^k words available) to be selected for reading or writing.
- The control lines *Read* and $\overline{Write}$ (usually combined into a single control line *Read*/$\overline{Write}$) specifies the direction of transfer of the data.

Memory Unit

- Block diagram of a memory unit:



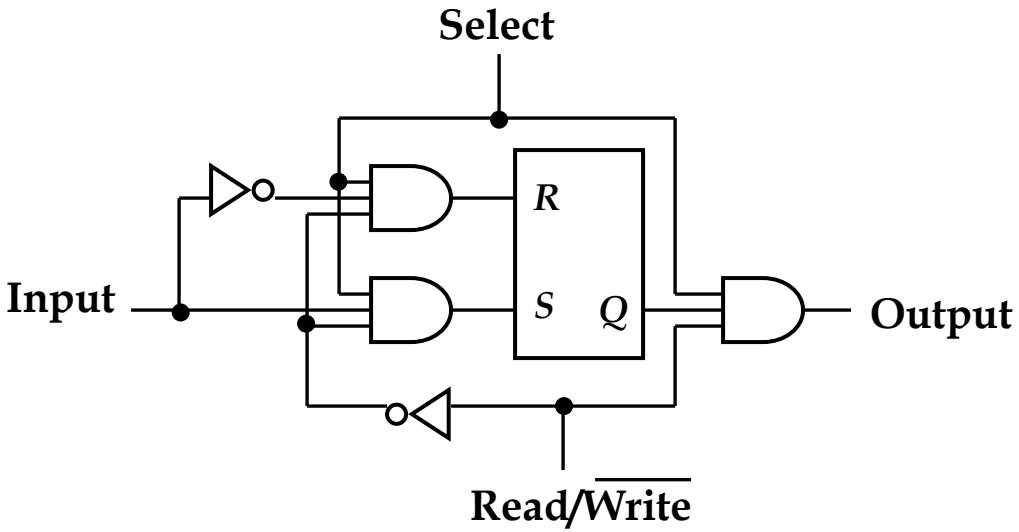
Read/Write Operations

- Write operation:
  - Transfers the address of the desired word to the address lines.
  - Transfers the data bits (the word) to be stored in memory to the data input lines.
  - Activates the *Write* control line (set *Read/$\overline{Write}$* to 0).
- Read operation:
  - Transfers the address of the desired word to the address lines.
  - Activates the *Read* control line (set *Read/$\overline{Write}$* to 1).

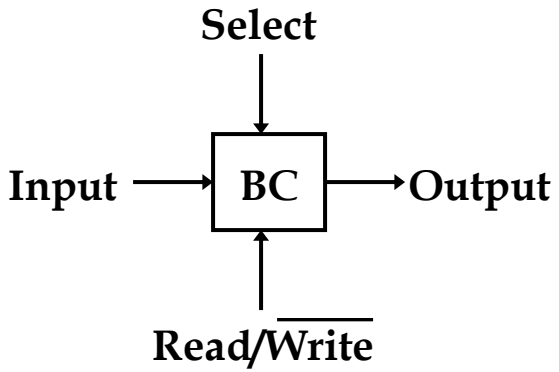
Memory Enable	*Read/$\overline{Write}$*	Memory Operation
0	X	
1	0	
1	1	

Memory Cell

- Two types of RAM
  - Static RAMs use flip-flops as the memory cells.
  - Dynamic RAMs use capacitor charges to represent data. Though simpler in circuitry, they have to be constantly refreshed.
- A single memory cell of the static RAM has the following logic and block diagrams:



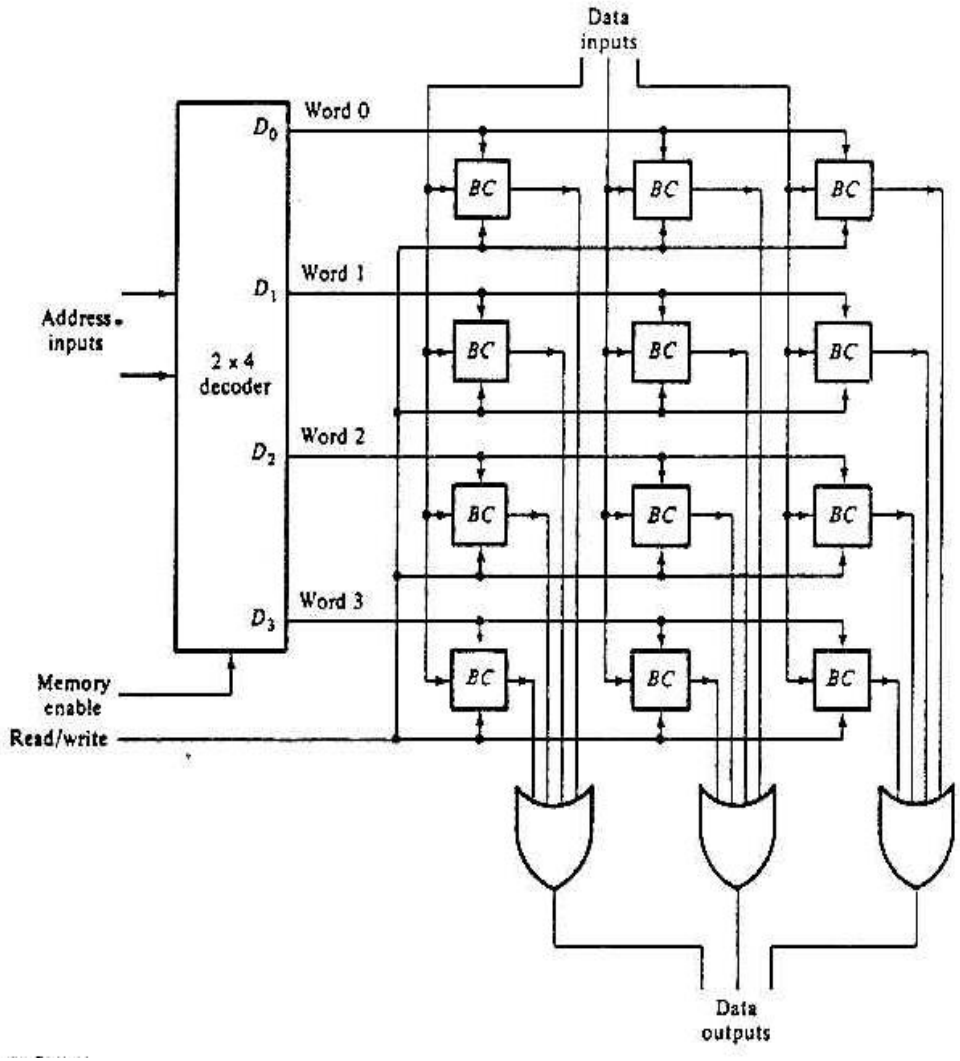
Logic diagram



Block diagram

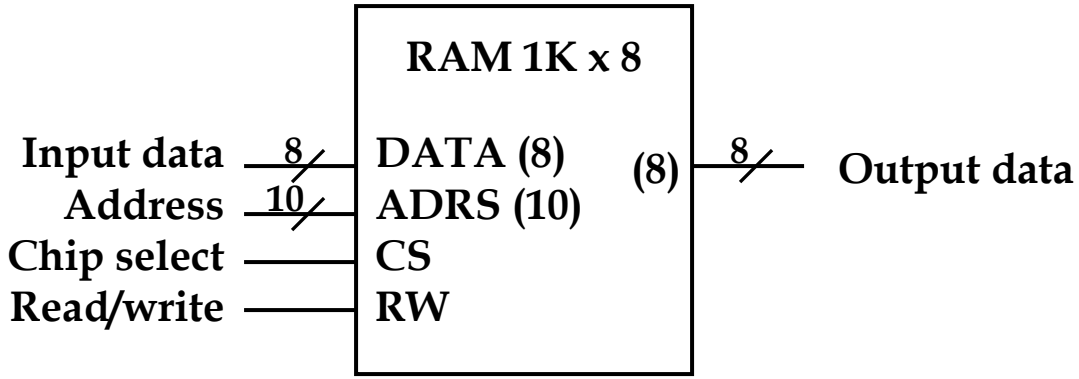
Memory Arrays (1/4)

- Logic construction of a 4×3 RAM (with decoder and OR gates):



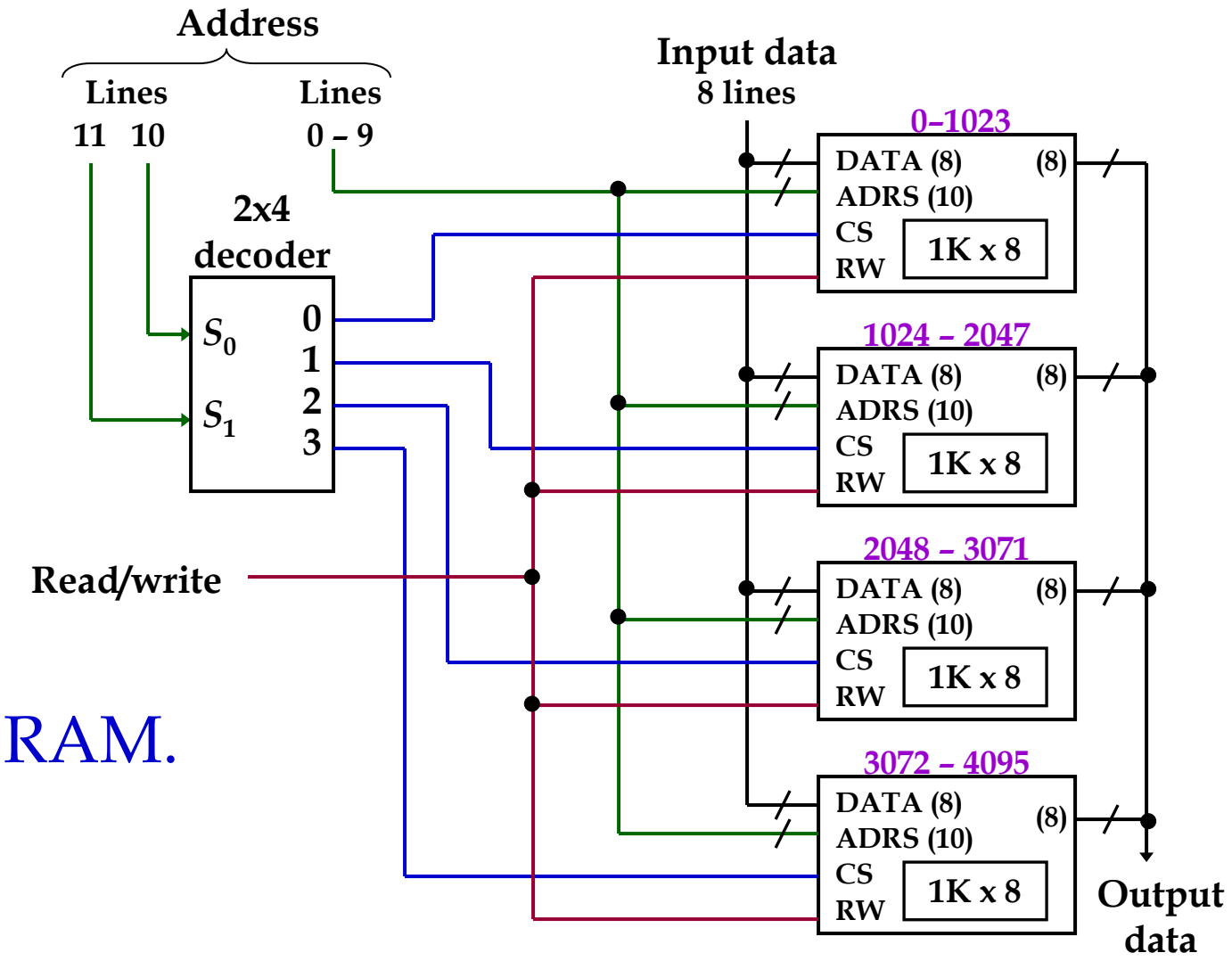
Memory Arrays (2/4)

- An array of RAM chips: memory chips are combined to form larger memory.
- A 1K × 8-bit RAM chip:



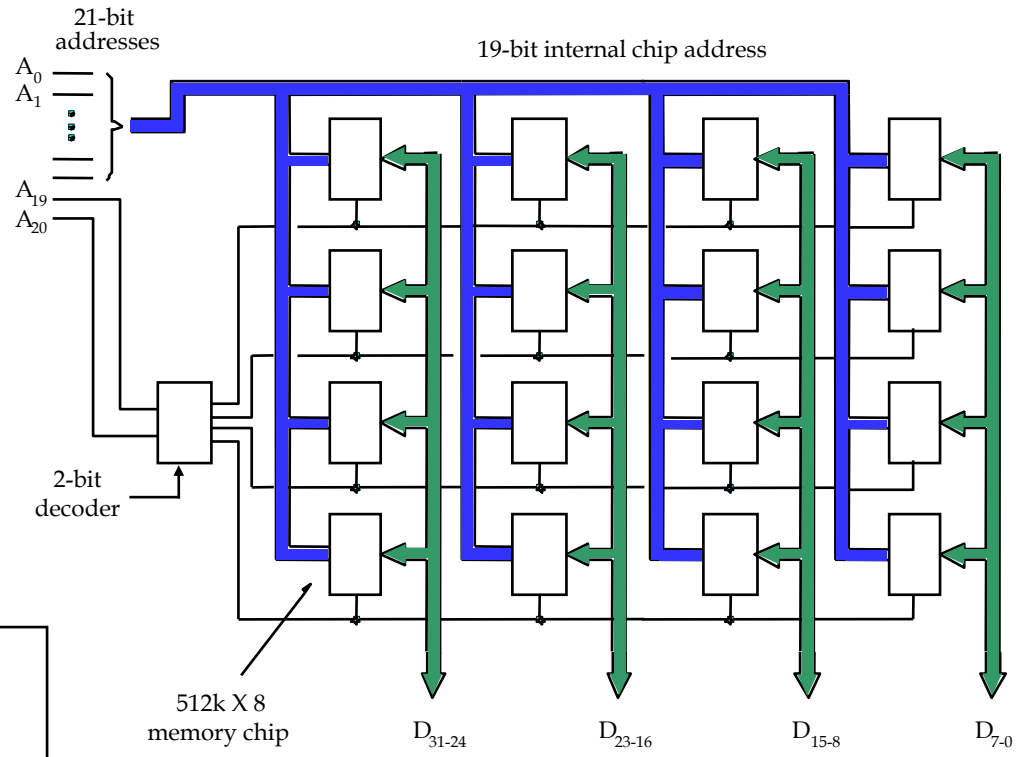
Block diagram of a 1K x 8 RAM chip

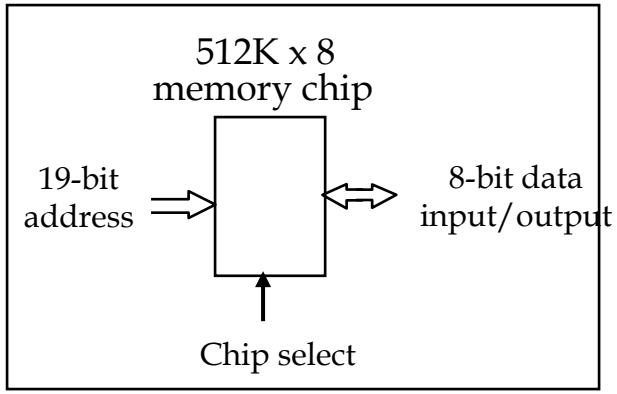
Memory Arrays (3/4)



- 4K × 8 RAM.

Memory Arrays (4/4)





- $2M \times 32$ memory module
  - Using $512K \times 8$ memory chips.