Chapter 4:
The Memory System

Objectives

- Basic memory circuits
- Organization of main memory
- Cache memory concept, which shortens the effective memory access time
- Virtual memory mechanism, which increases the apparent size of the main memory
- Magnetic disks, optical disks and magnetic tapes used for secondary storage

Basic Concepts

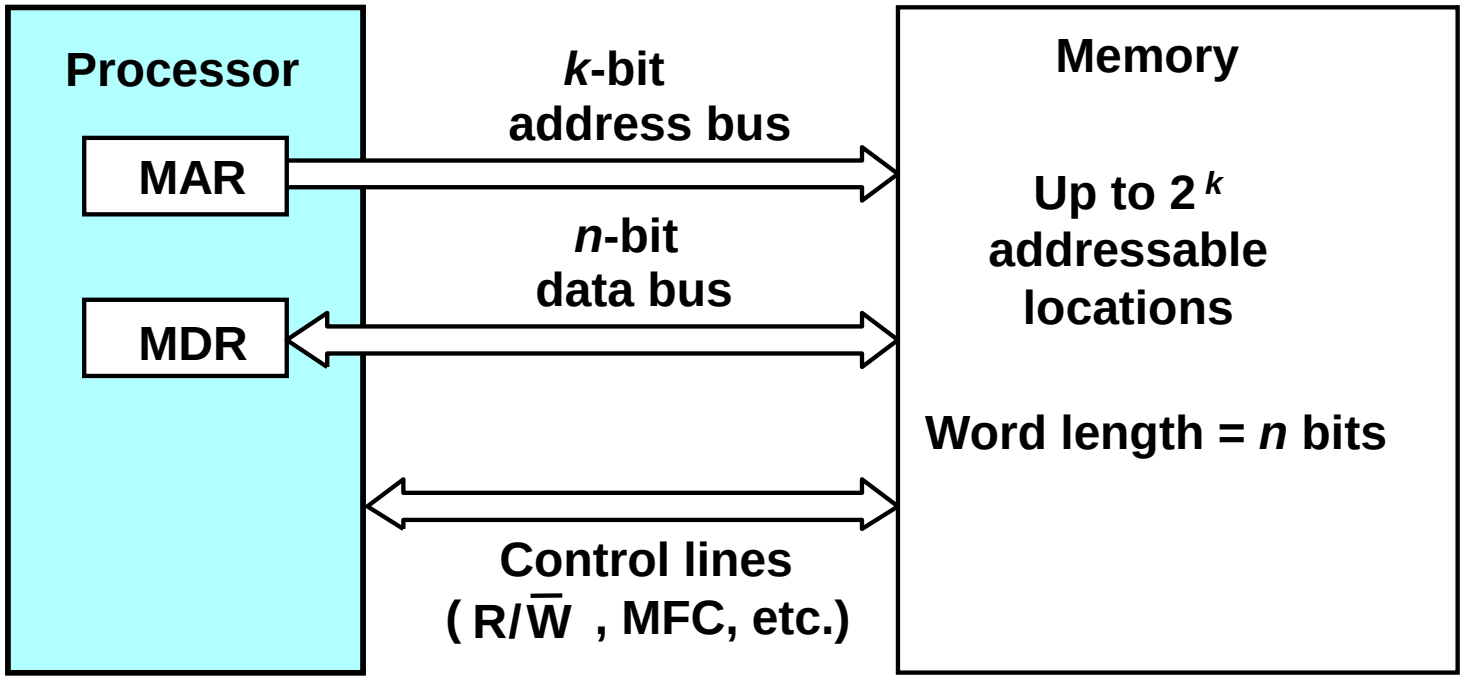


Figure 4.1. Connection of the memory to the processor.

Semiconductor RAM Memories

- Internal Organization of Memory Chips
- Static Memories
- Asynchronous DRAMs
- Synchronous DRAMs
- Structure of larger Memories
- Memory System Considerations
- Rambus Memory

Internal Organization of Memory Chips

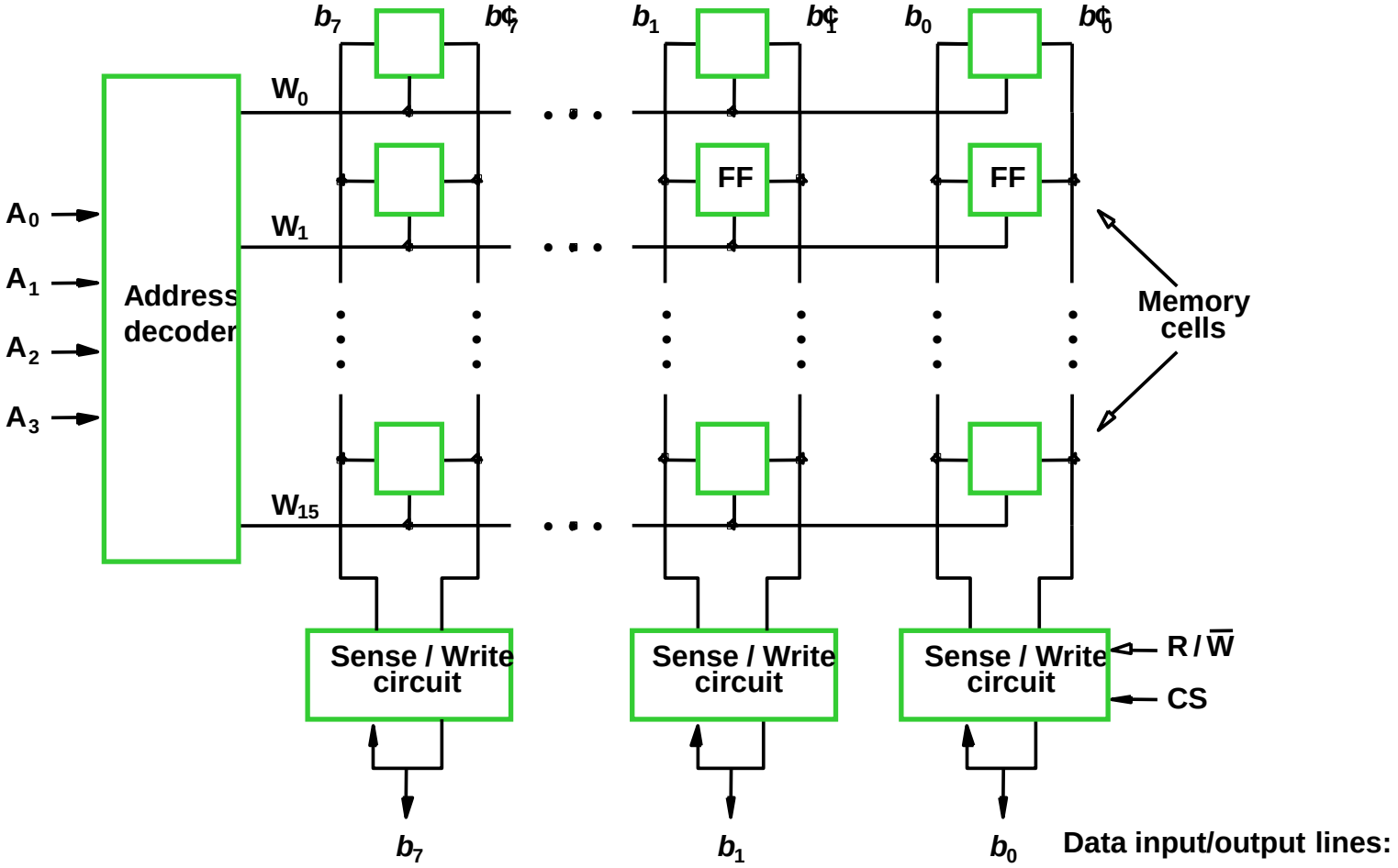


Figure 4.2. Organization of bit cells in a memory chip.

small (very) example (128 bit chip) 16 words of 8 bits each (16 x 8)

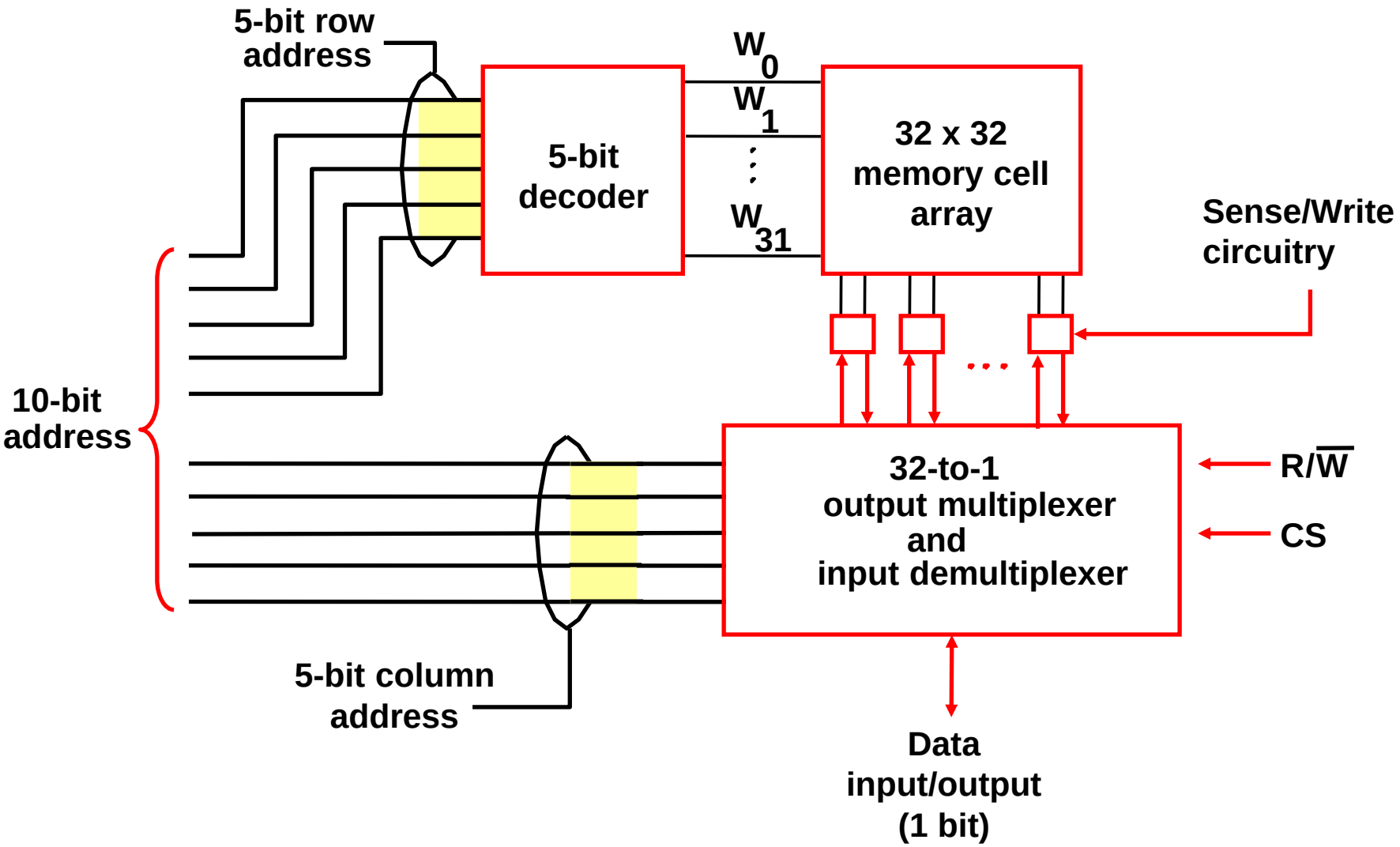


Figure 4.3. Organization of a 1K × 1 memory chip.

Static Memories

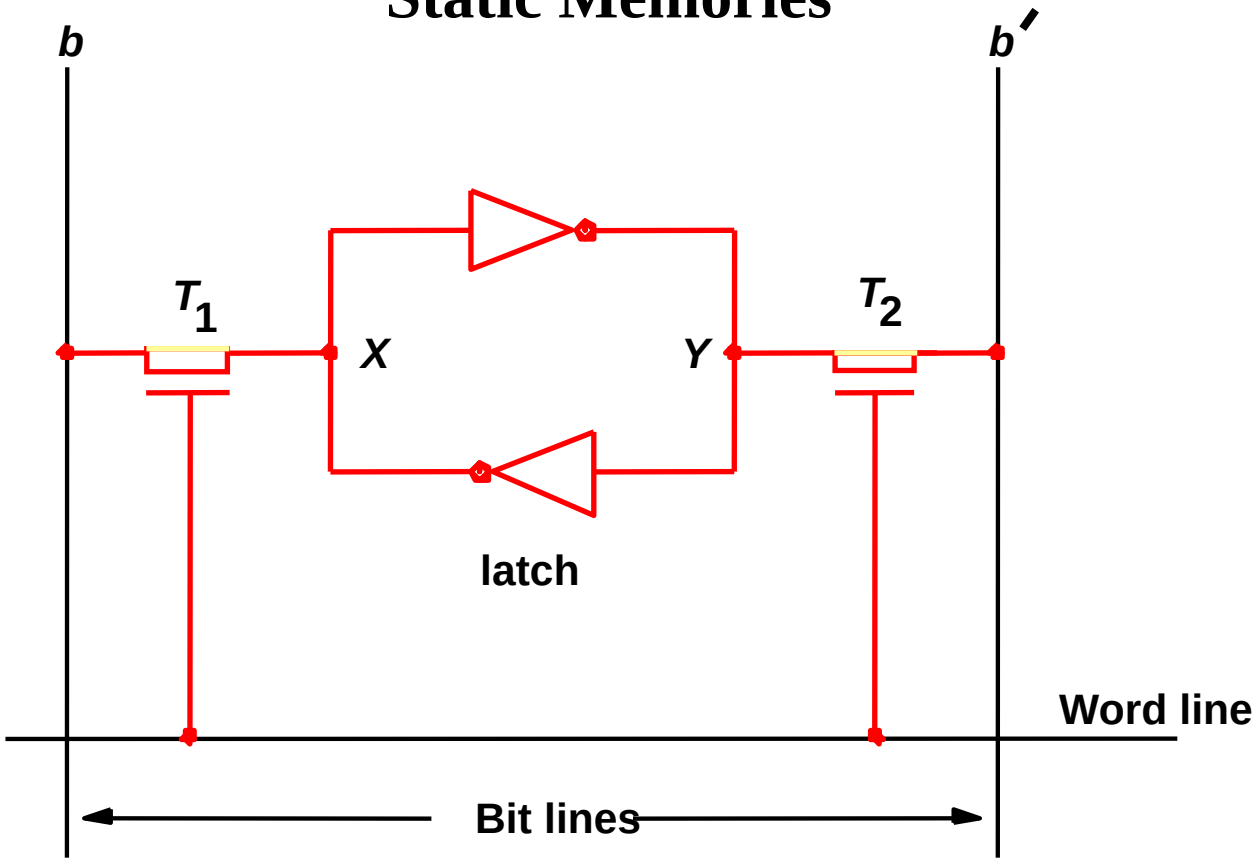


Figure 4.4. A static RAM cell.

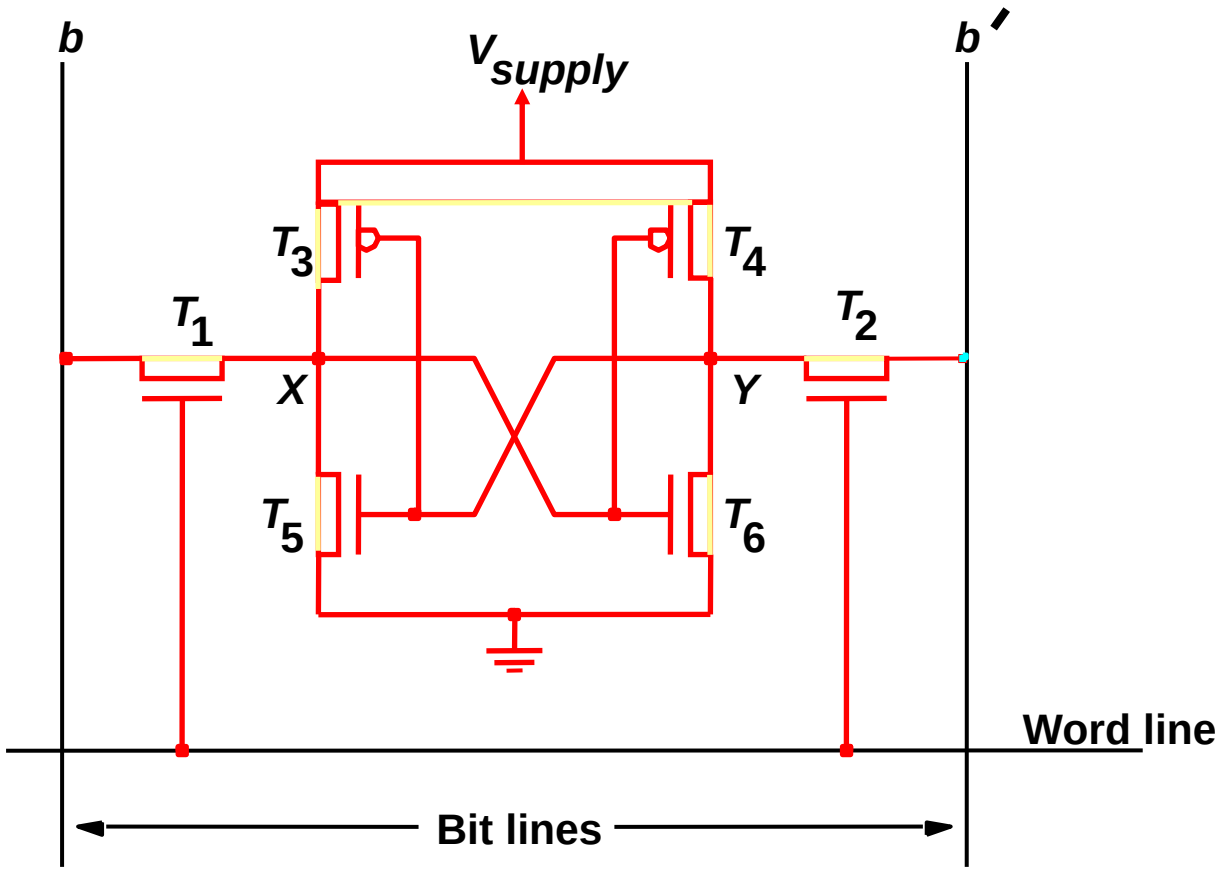


Figure 5.5. An example of a CMOS memory cell.

Asynchronous DRAMs

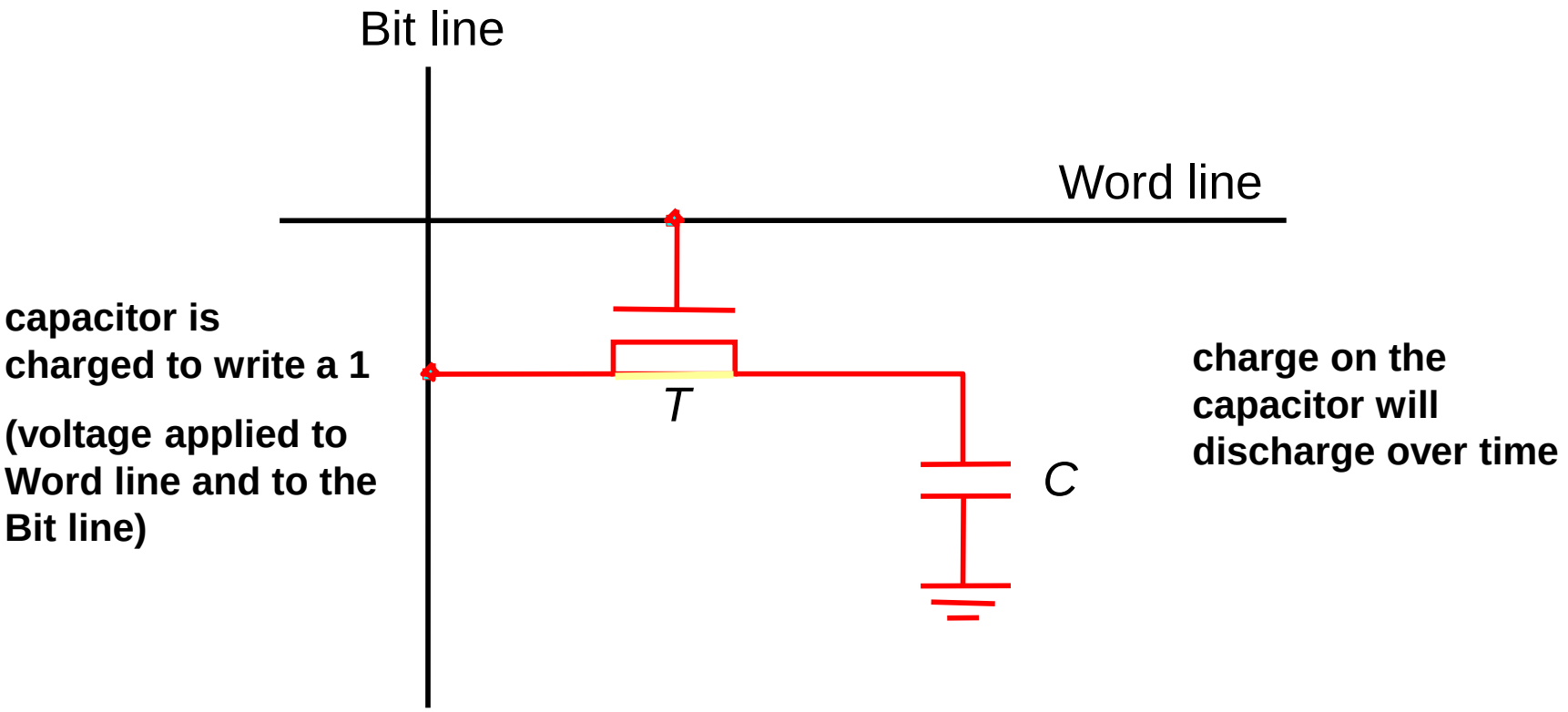


Figure 5.6. A single-transistor dynamic memory cell

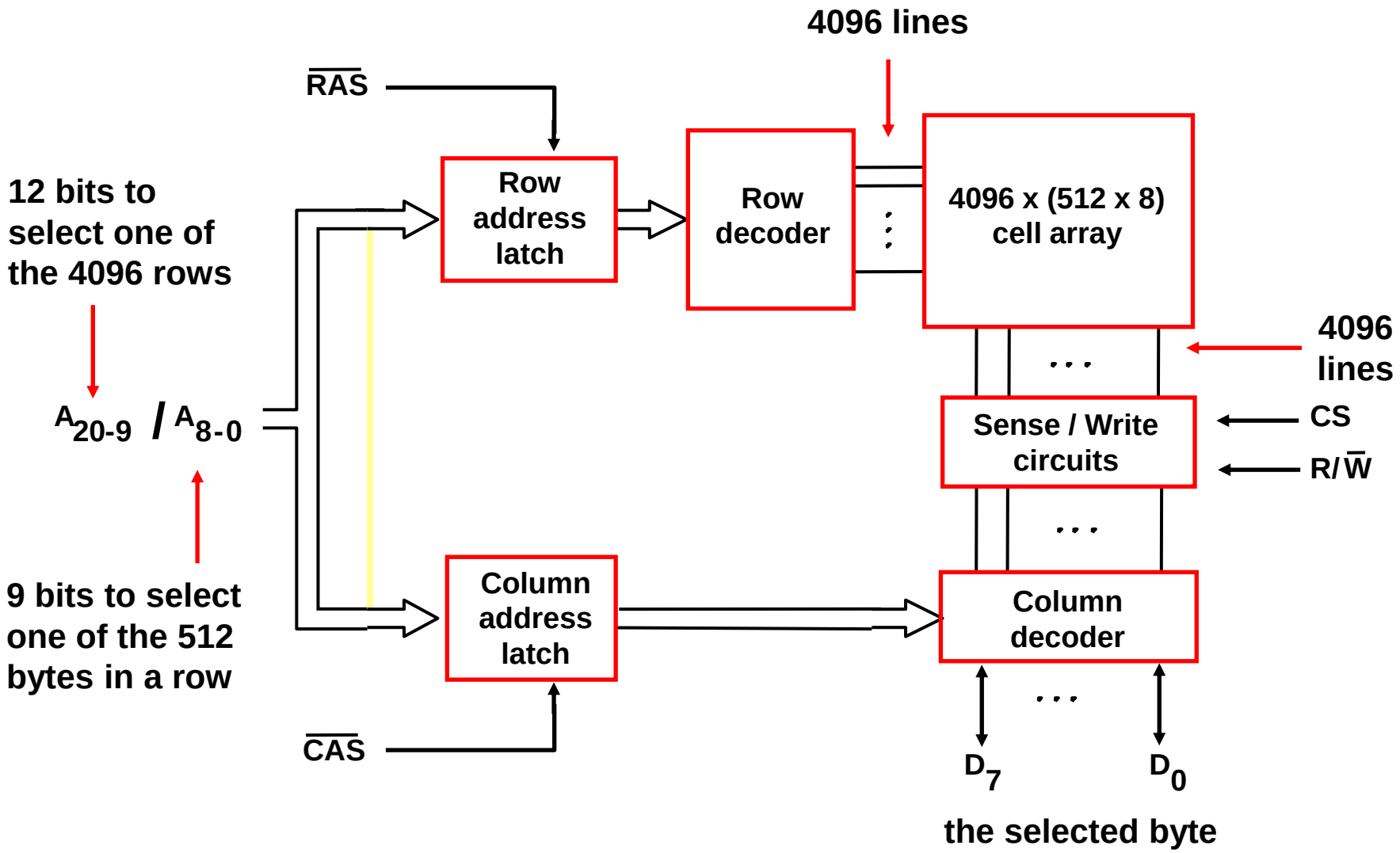


Figure 4.7. Internal organization of a 2M x 8 dynamic memory chip.

16 megabits, 2 million bytes

Synchronous DRAMs

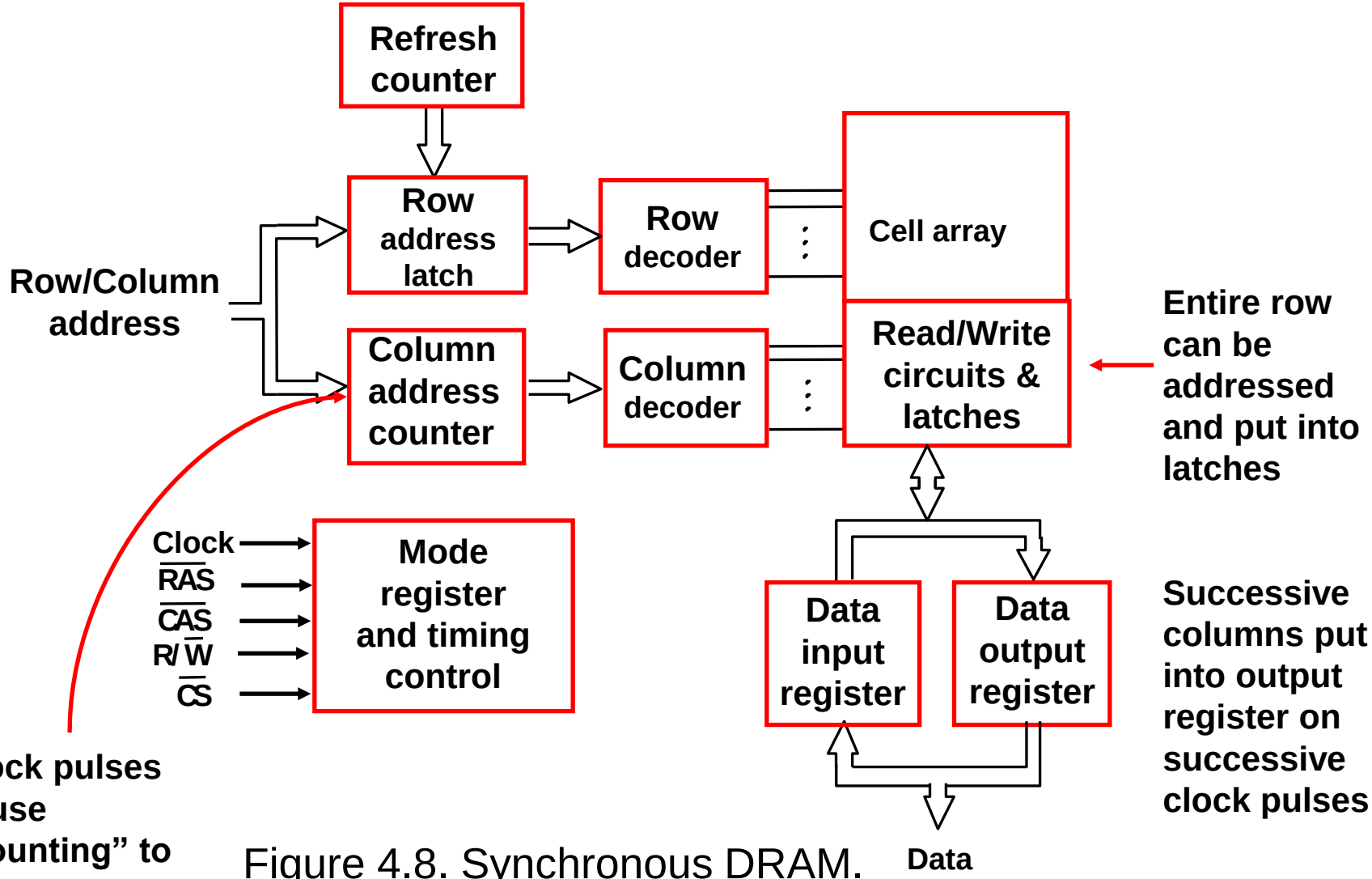


Figure 4.8. Synchronous DRAM.

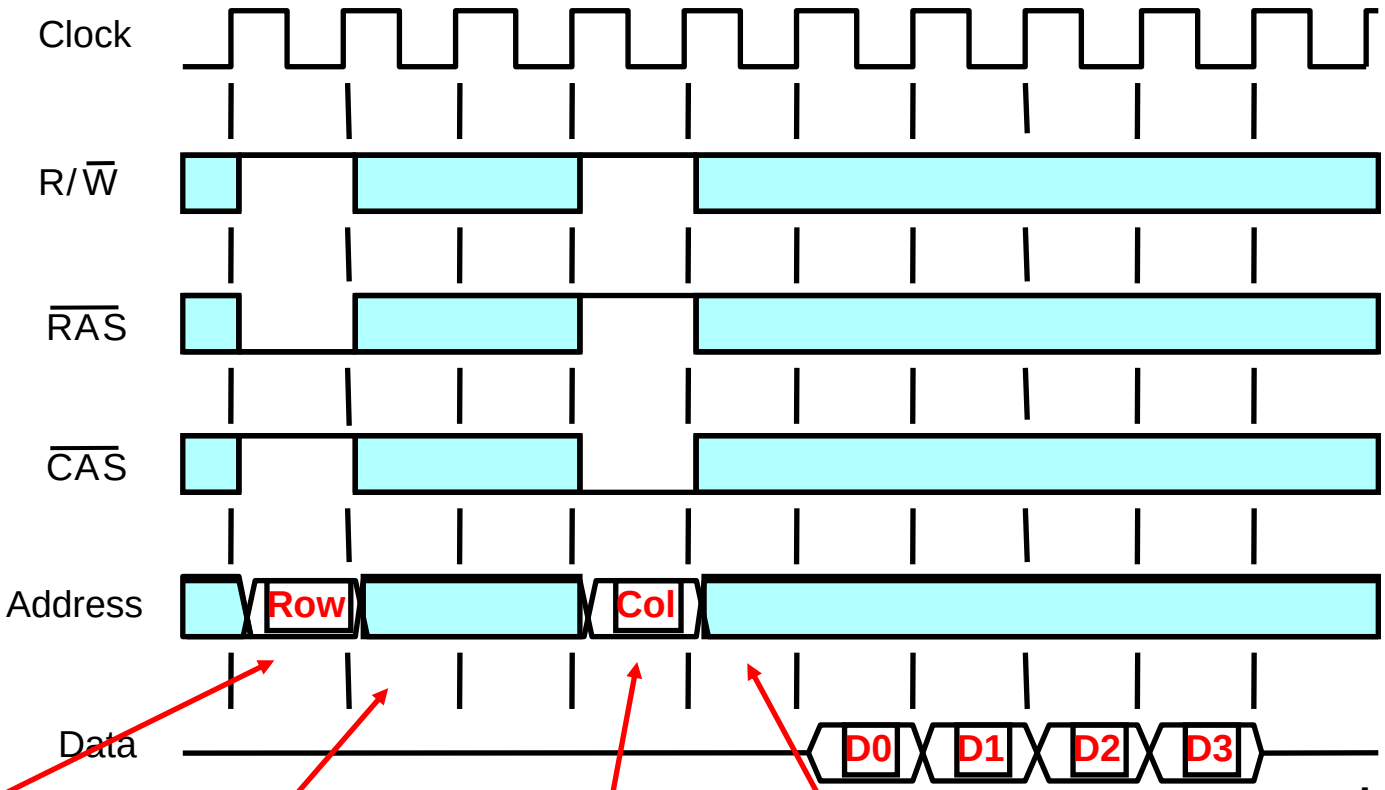


Figure 4.9. Burst read of length 4 in an SDRAM.

Structure of larger Memories

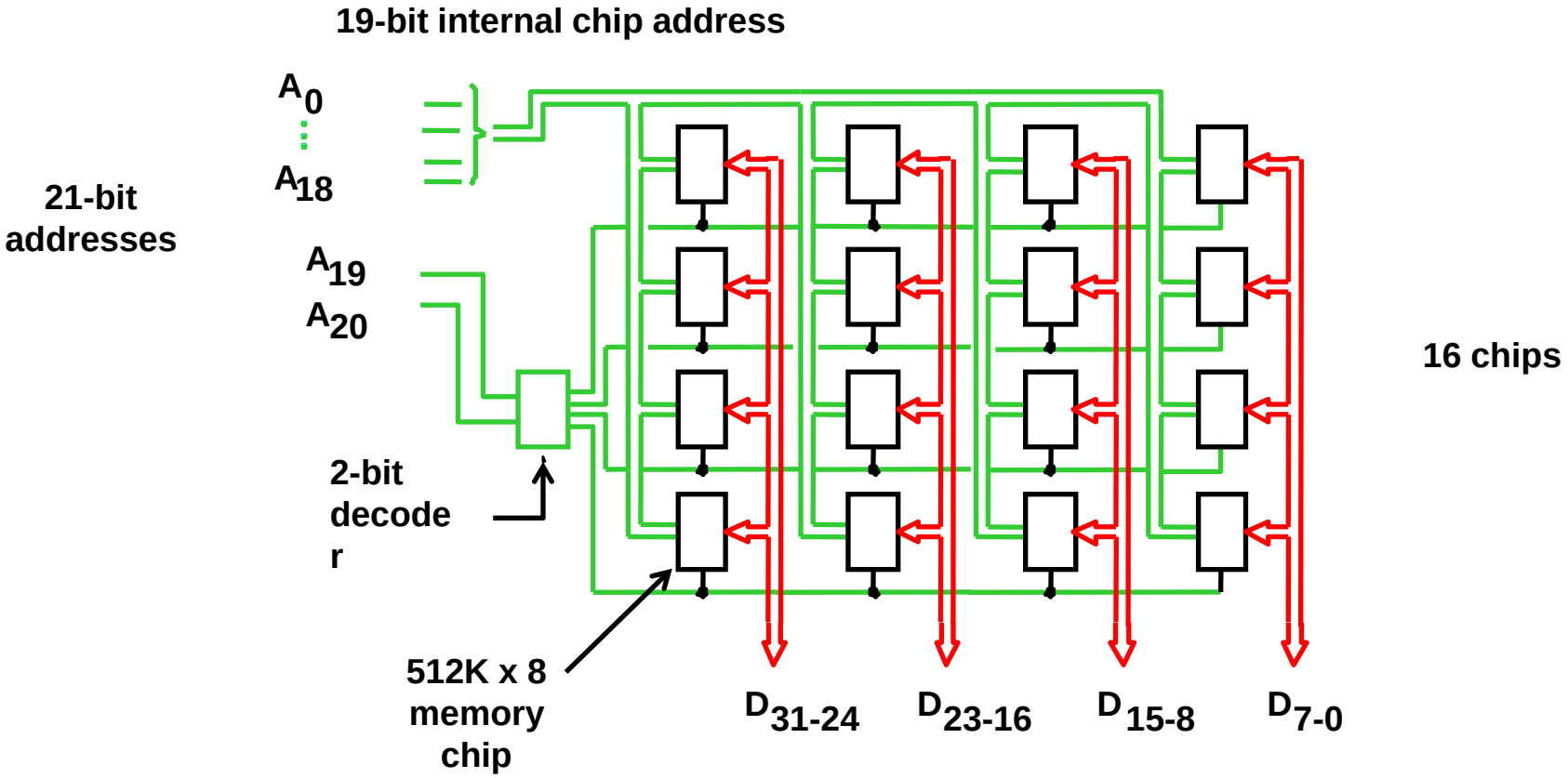


Figure 4.10. Organization of a 2M × 32 memory module using 512K × 8 static memory chips (16 chips).

Memory System Considerations

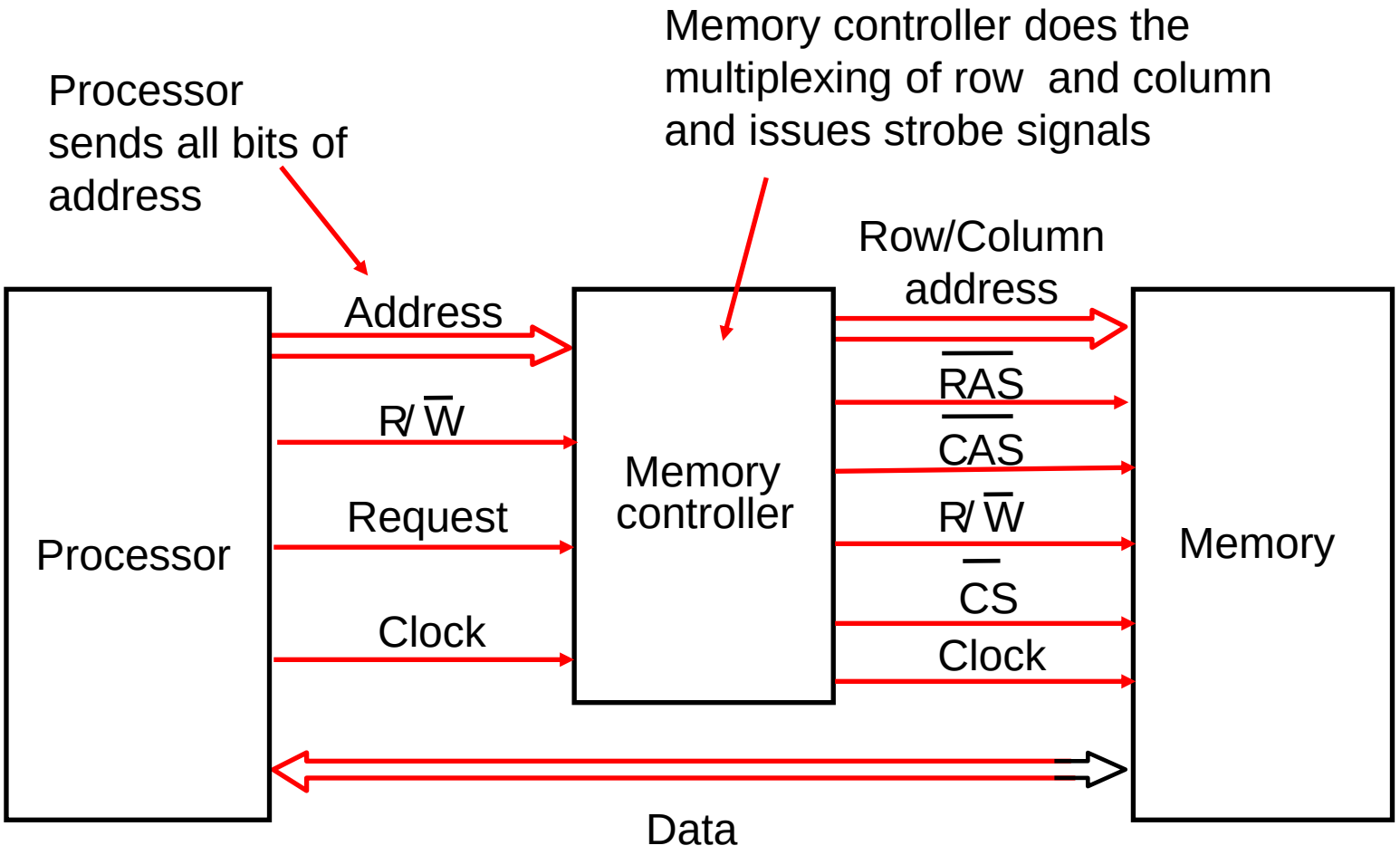


Figure 5.11. Use of a memory controller.

Read-Only Memories

- ROM
- PROM
- EPROM
- EEPROM
- Flash Memory

ROM: Read Only Memory

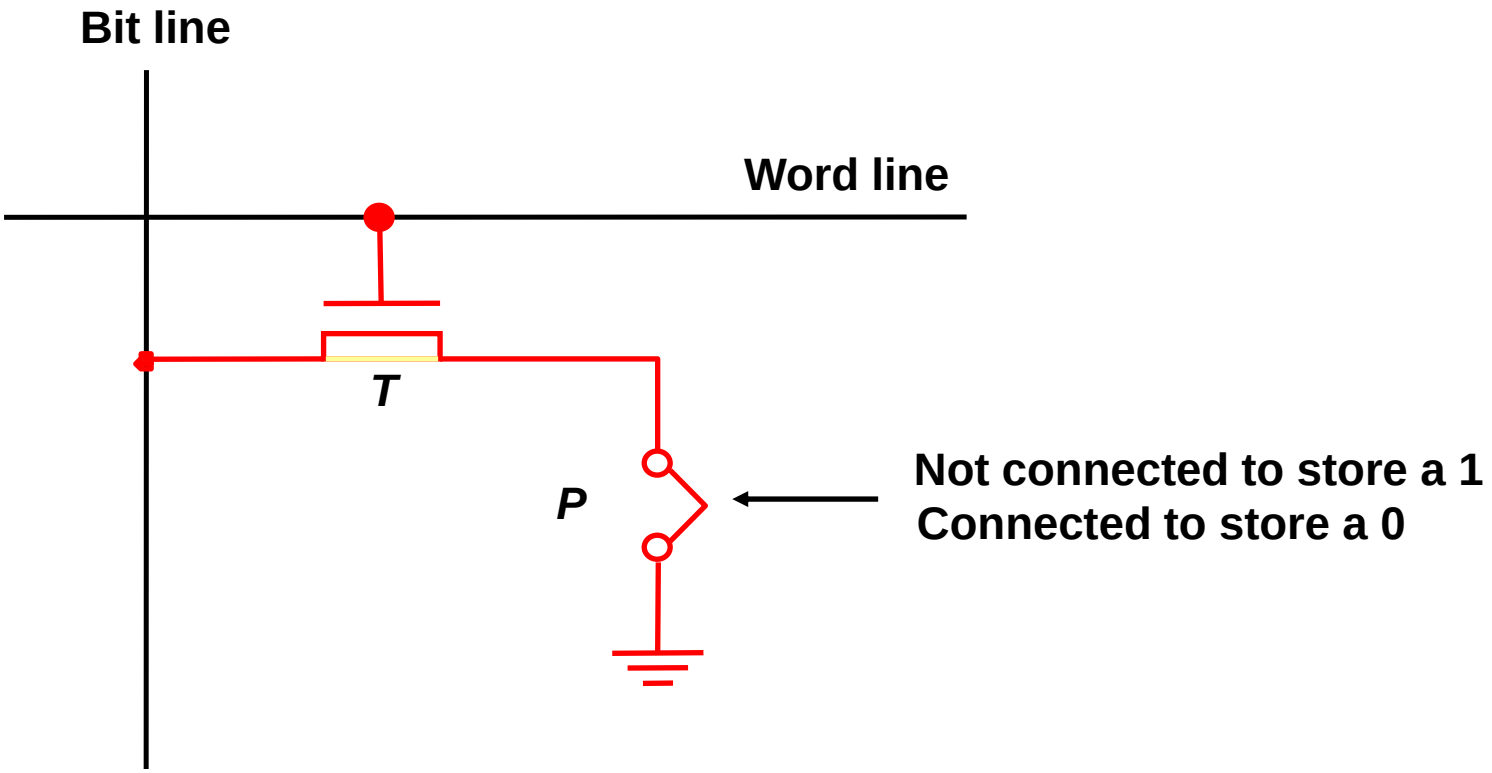


Figure 4.12. A ROM cell.

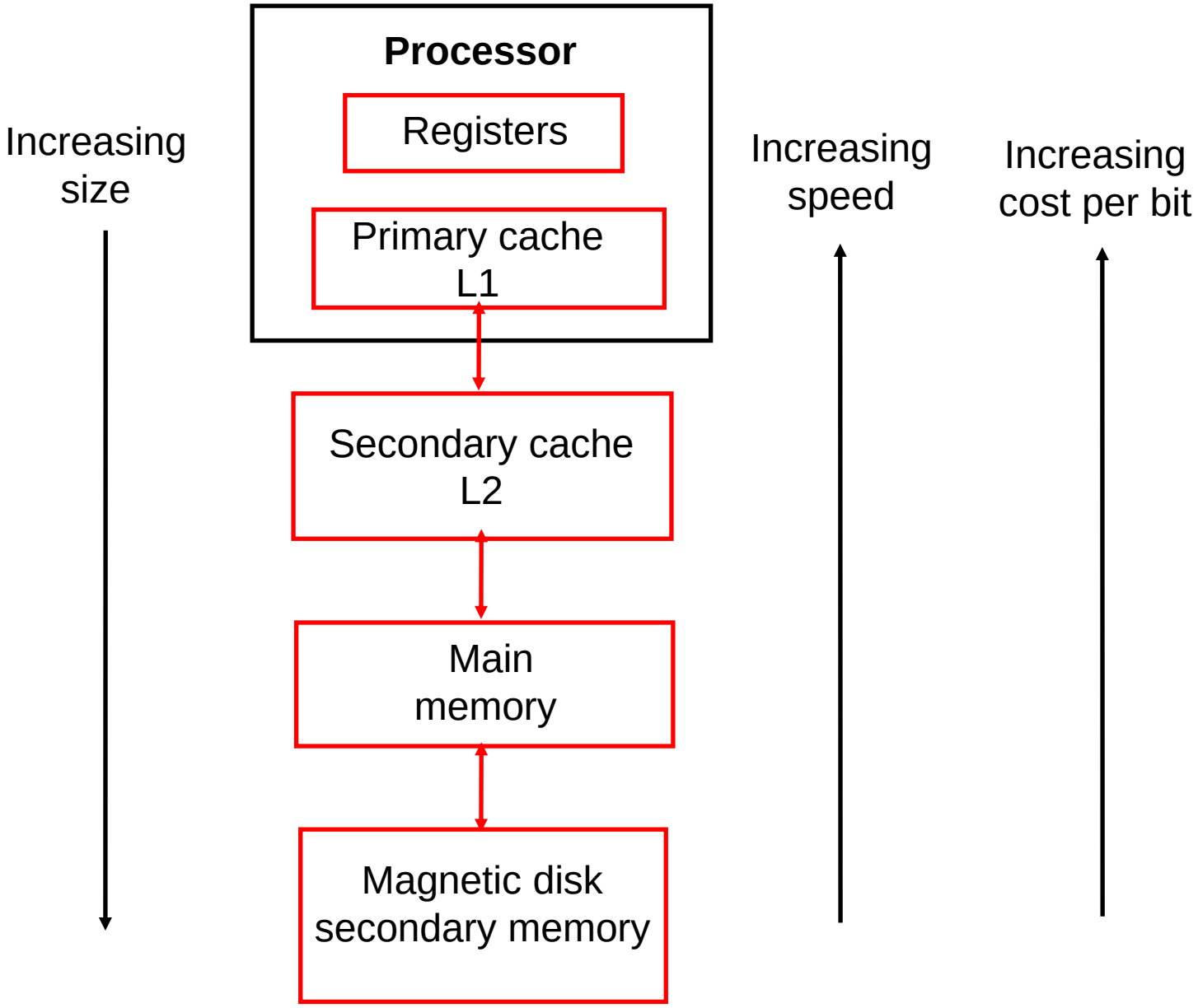


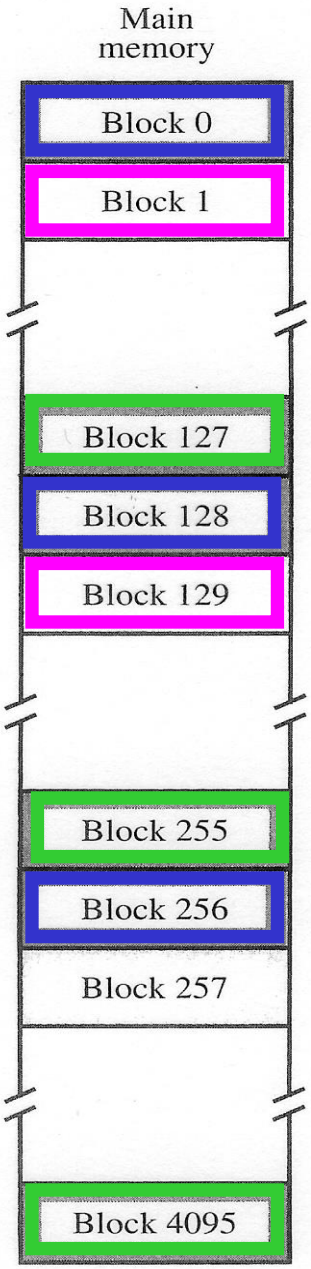
Figure 4.13. Memory hierarchy.

Speed, Size and Cost

Cache Memories

- Mapping functions
- Replacement Algorithms
- Examples of Mapping

Direct Mapping Example

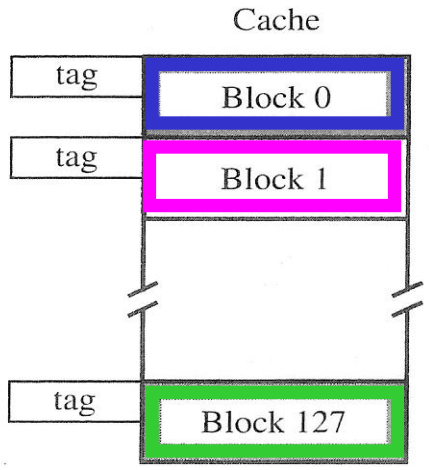


64K main memory

16 bit address (word addressed only)

View as 4096 blocks of 16 words each

Cache of 128 blocks of 16 words



Any block of main memory can be put in any block in the cache

Tags are searched "associatively" to find the referenced block

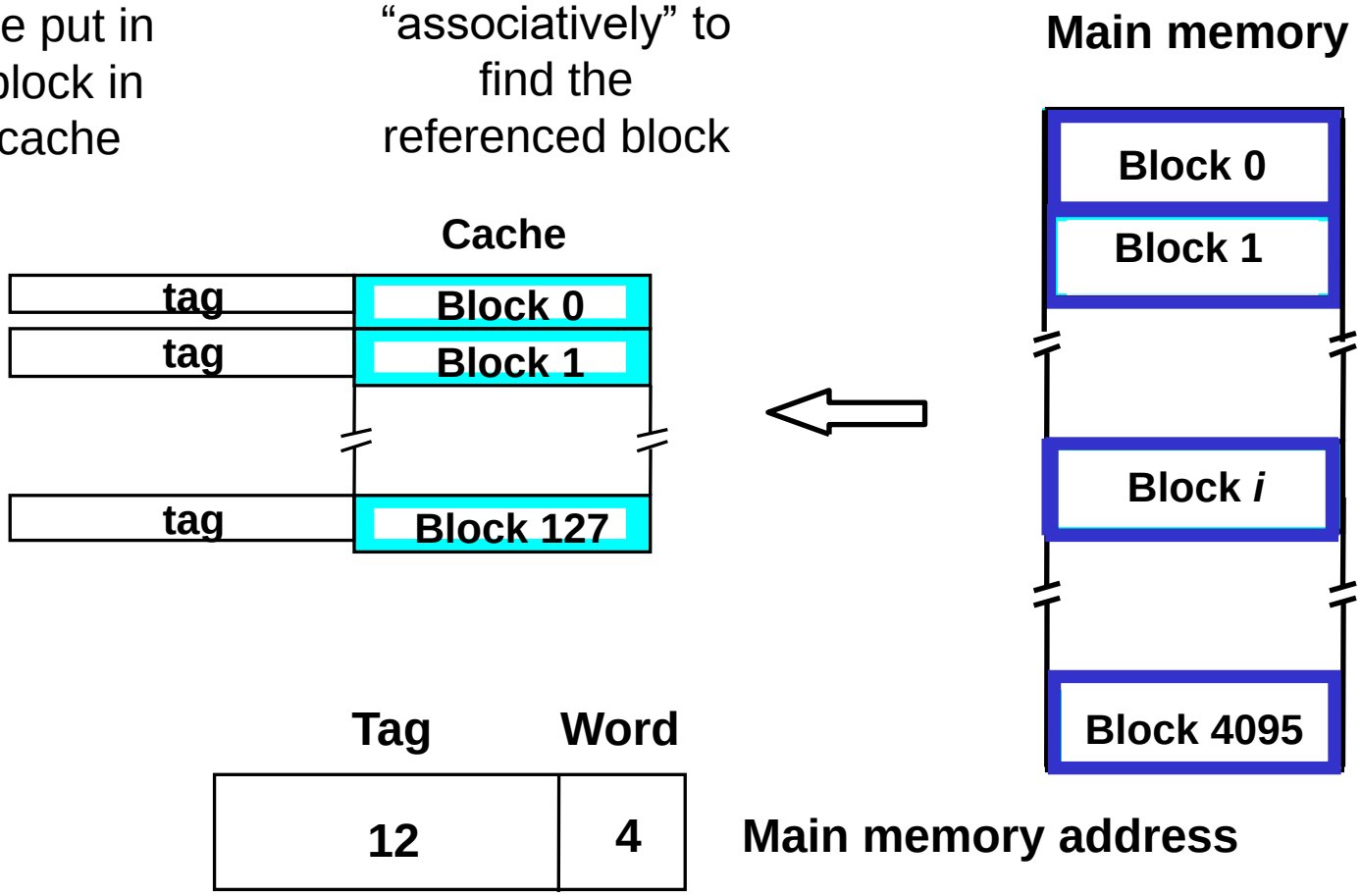
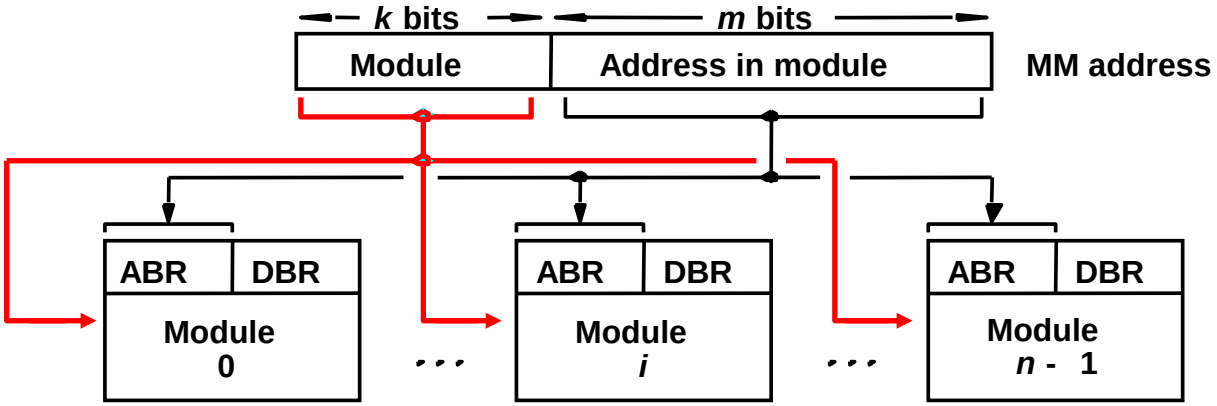


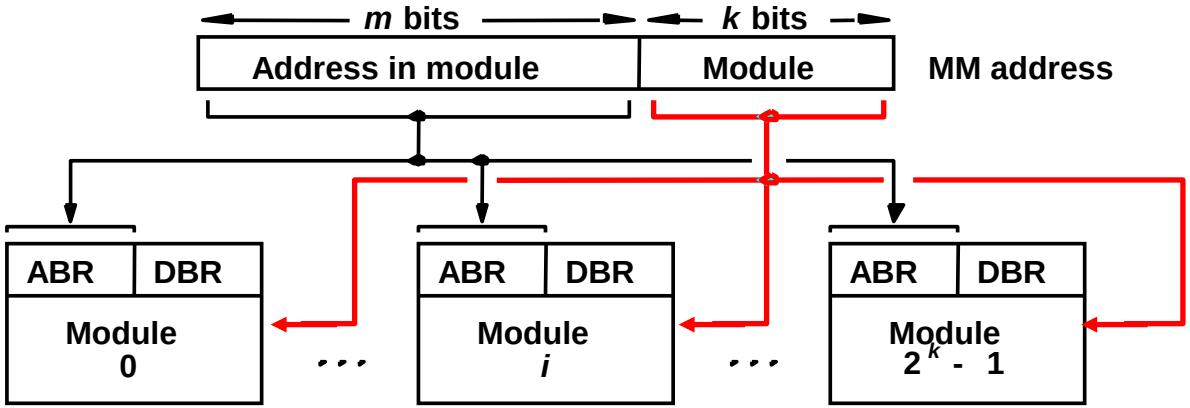
Figure 4.16. Associative-mapped cache.

Performance Consideration

- Interleaving
- Hit Rate and Miss Penalty
- Caches on the processor Chip
- Other Enhancements



(a) Consecutive words in a module



(b) Consecutive words in consecutive modules

Figure 4.25. Addressing multiple-module memory systems.

Virtual Memories

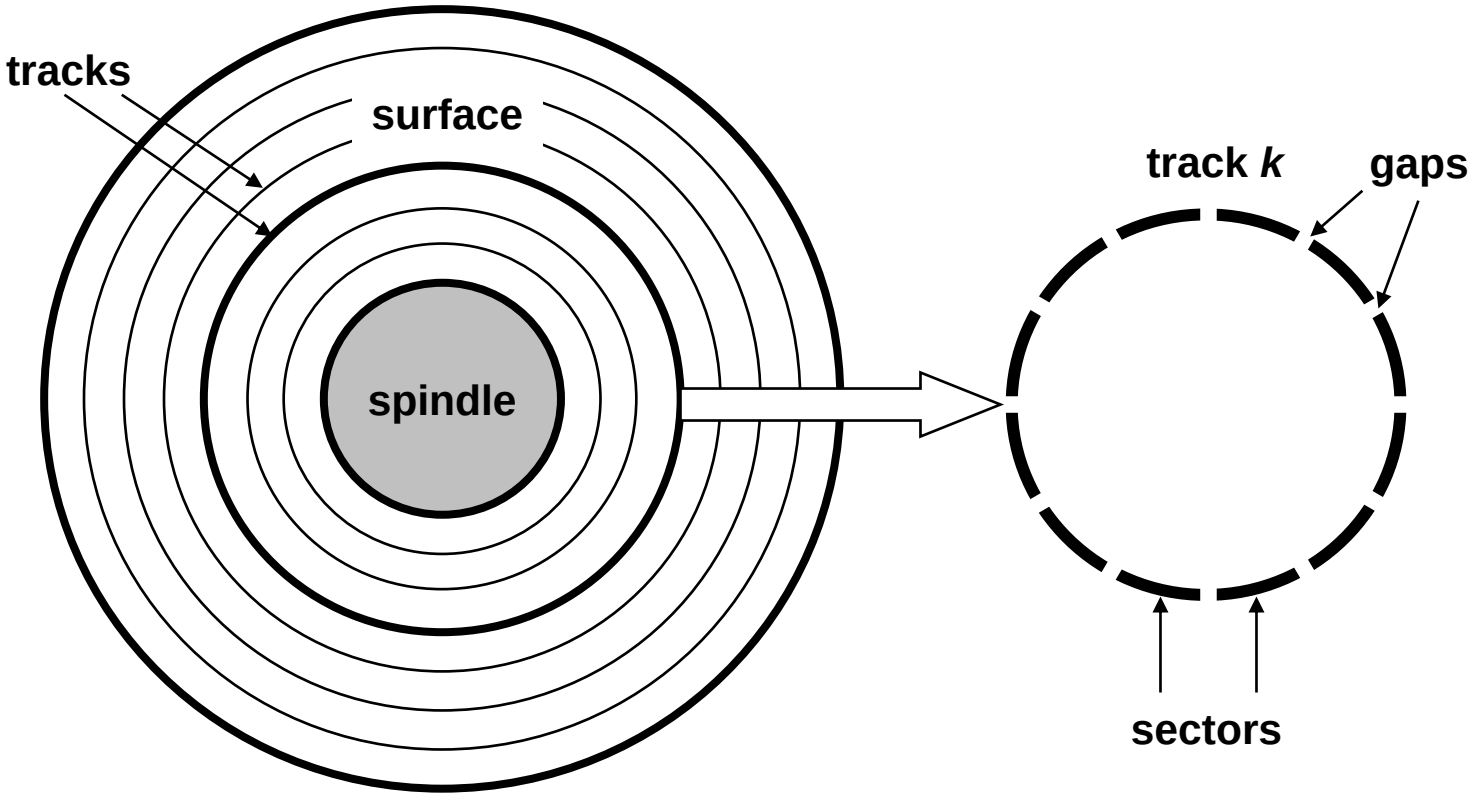
- Address translation

Secondary Storage

- Magnetic Hard Disks
- Optical Disks
- Magnetic Tape systems

Disk geometry

- *Disks* consist of *platters*, each with two *surfaces*.
- Each *surface* consists of concentric rings called *tracks*.
- Each *track* consists of *sectors* separated by *gaps*.



Concluding Remarks