Chapter- 7
Memory Organization

7.1 Memory Hierarchy

Ref. Book Name : Computer System Architecture, M. Morris Mano

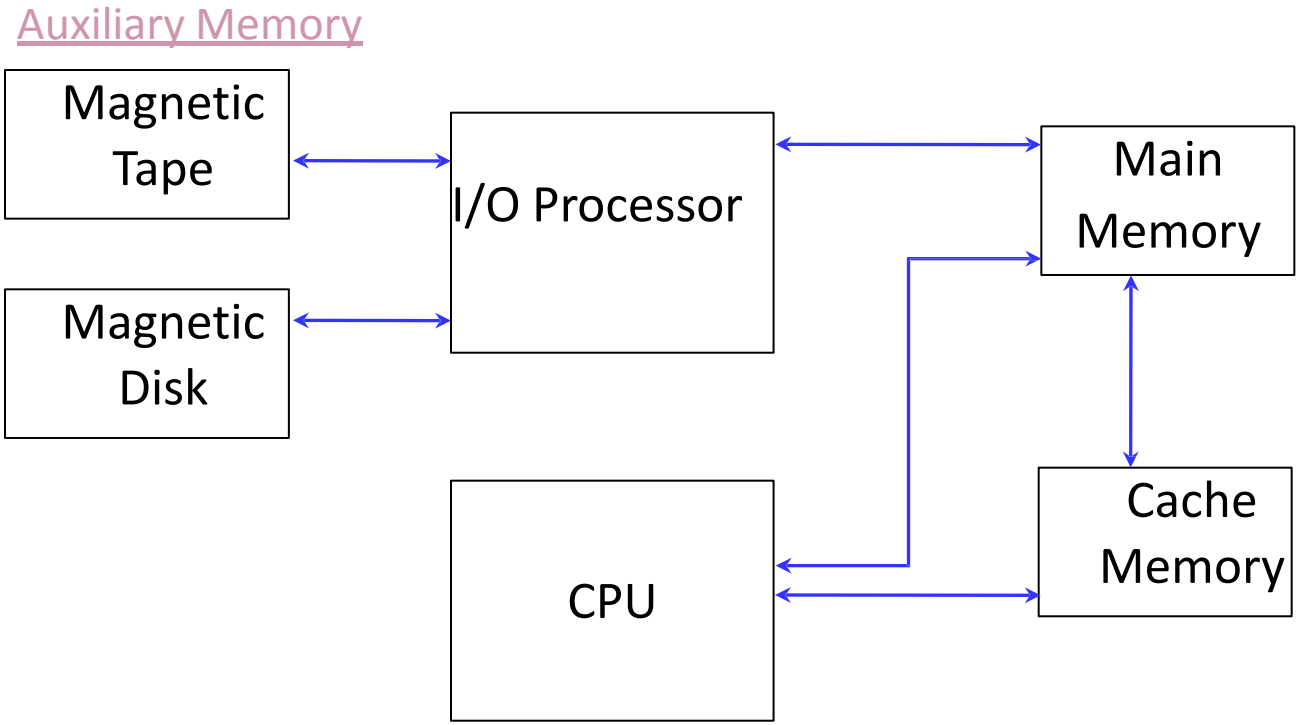


Figure: Memory Hierarchy in a computer system

7.1 Memory Hierarchy

Advantages of Memory Hierarchy:

- Decrease frequency of accesses to slow memory
- Decrease cost per bit
- Improve average access time
- Increase storage capacity

7.2 Main Memory

Ref. Book Name : Computer System Architecture, M. Morris Mano

- Main memory is the central storage unit in a computer system.
- It is relatively large and fast.

RAM

- This memory is volatile.

- RAM is used for storing bulk of programs and data that are subject to change.

- There are two types of RAM:
  1. SRAM – static RAM
  2. DRAM – Dynamic RAM

7.2 Main Memory

ROM

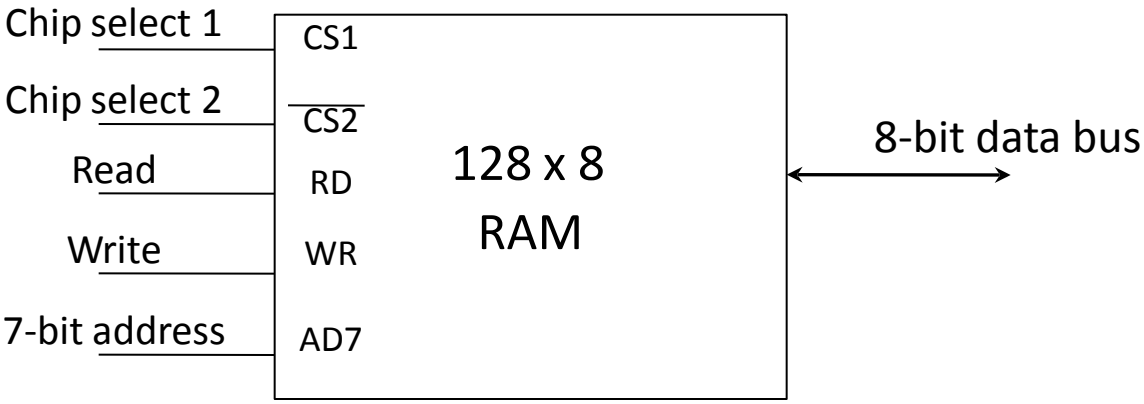
- This memory is non volatile

- ROM is needed for storing an initial program called bootstrap loader.

- Function of bootstrap loader is to start computer software operating when power is turned on.

RAM and ROM chips

RAM chip:



(a) Block diagram

CS1	$\overline{CS2}$	RD	WR	Memory function	State of data bus
0	0	X	X	Inhibit	High impedance
0	1	X	X	Inhibit	High impedance
1	0	0	0	Inhibit	High impedance
1	0	0	1	Write	Input data to RAM
1	0	1	0	Read	Output data from RAM
1	1	X	x	Inhibit	High impedance

(b) Function table

Figure: Typical RAM

ROM chip:

Figure: Typical ROM chip

7.2 Auxiliary Memory

Ref. Book Name : Computer System Architecture, M. Morris Mano

- The most common auxiliary memory devices used in computer systems are magnetic disks and magnetic tapes.

Magnetic disks

- Magnetic disk is a circular plate constructed of metal coated with magnetized material.
- Several disks may be stacked on one spindle.
- All disks rotate together at high speed.
- Bits are stored on magnetized surface in spots along with concentric circles called *tracks*.
- Tracks are divided into sections called *sectors*.

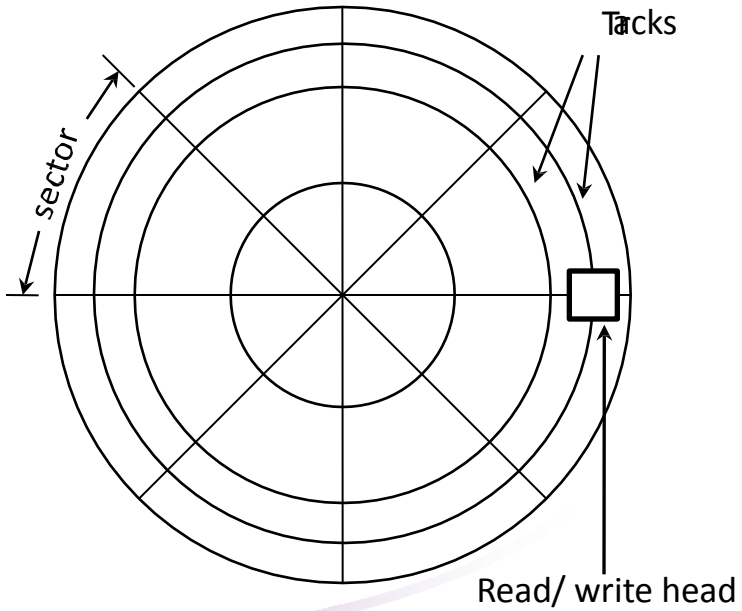


Figure: Magnetic Disk

- Types of magnetic disks:

1. **Floppy Disk**

- Removable disk drives are small removable disks made of plastic coated with magnetic recording material.
- There are two sizes with diameter of 5.25 and 3.5 inches.

2. **Hard Disk**

- Disks that are permanently attached to the unit assembly and cannot be removed.

Magnetic Tape

- Tape is a strip of plastic coated with magnetic recording medium.
- Bits are recorded as magnetic spots on the tape along several tracks.
- Read/write heads are mounted one in each unit.
- Magnetic tape units can be stopped, started to move forward or in reverse.
- Information is recorded in blocks referred to as records.
- Each record on tape has an identification bit pattern at the beginning and end.
- The amount of data or binary digits that can be written on a linear inch of tape is known as tape's recording density.

7.3 Associative Memory

- Memory unit accessed by content is called associative memory or content addressable memory.

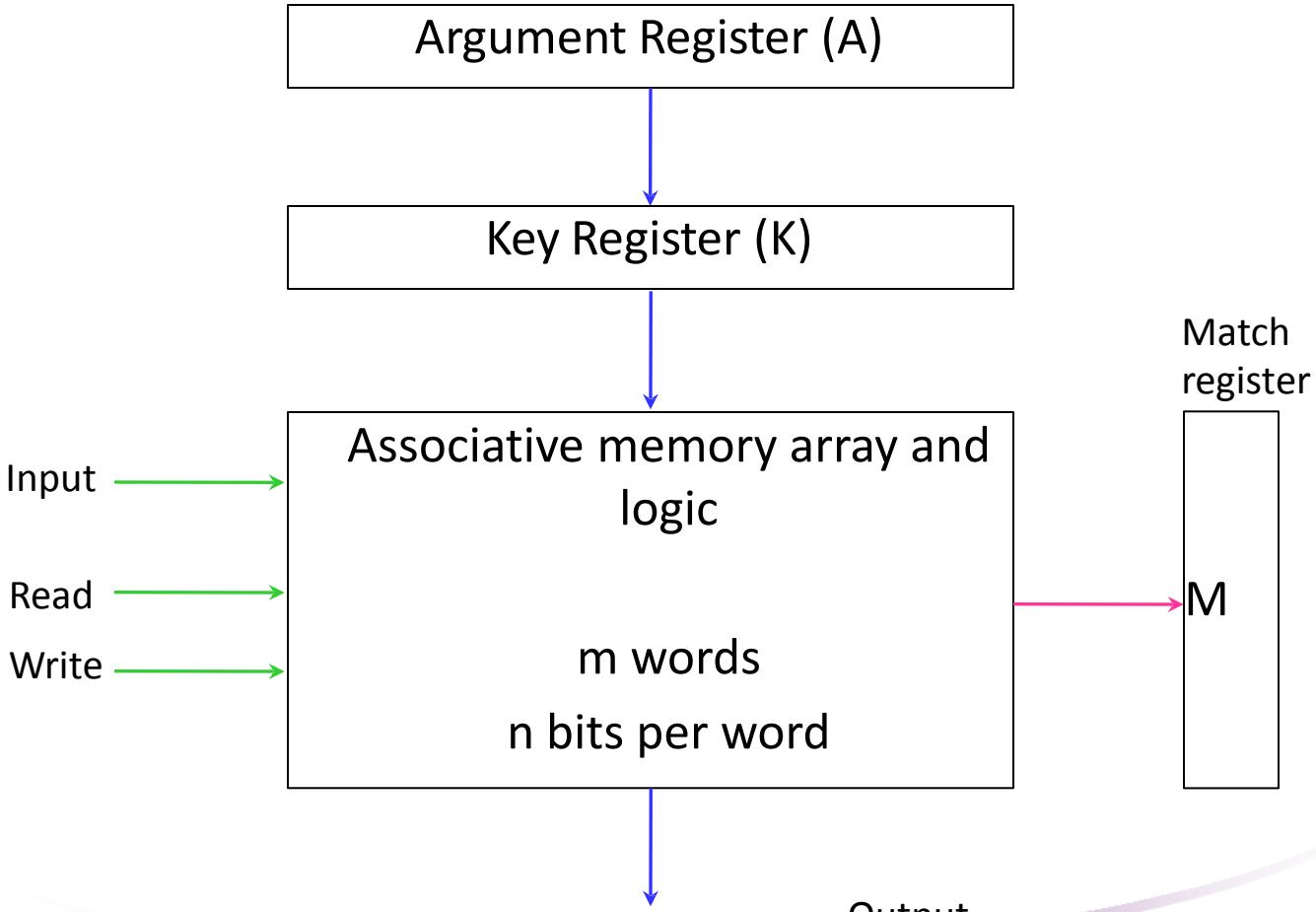


Figure: block diagram

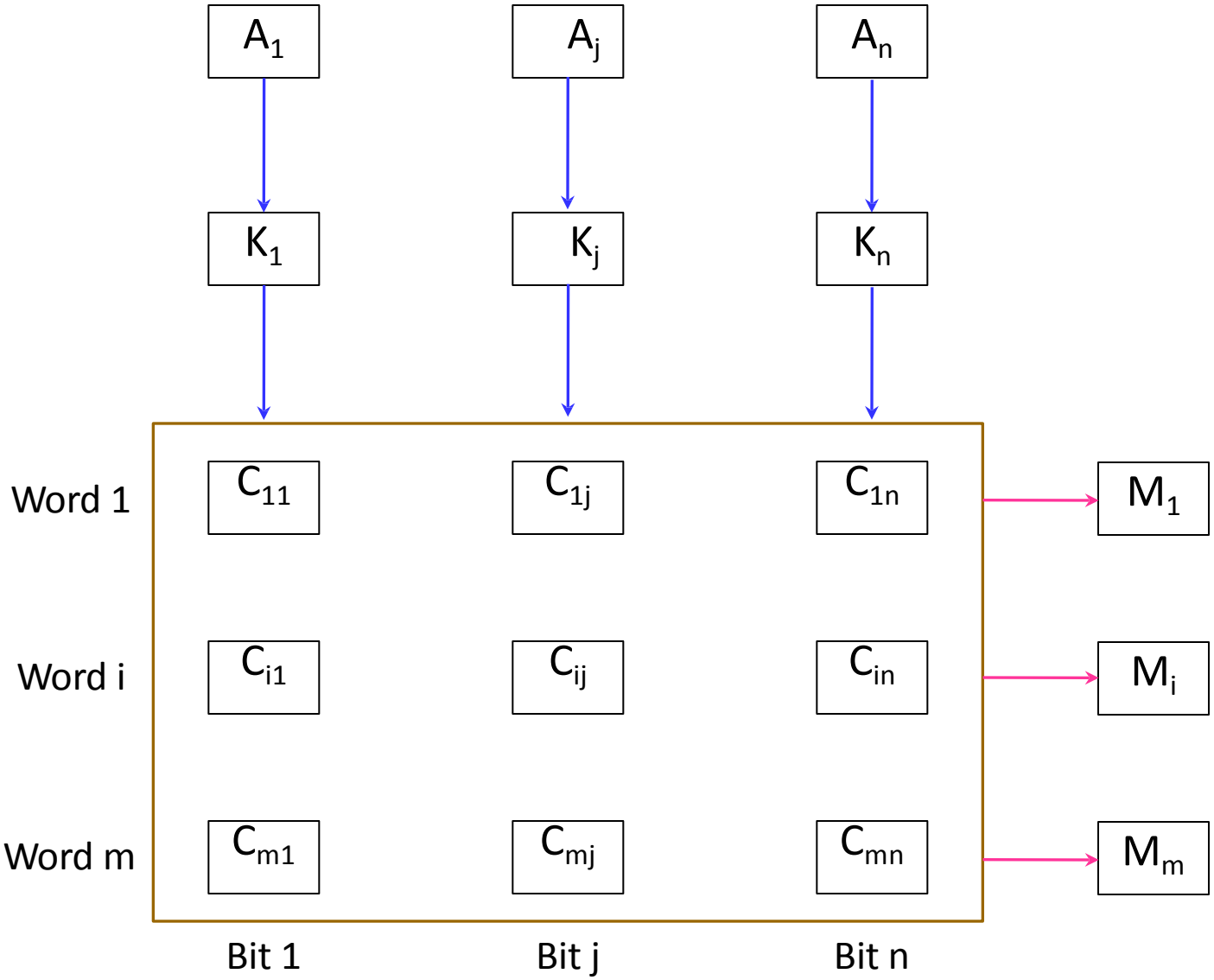


Figure: Associative memory of m words, n cells per word

7.4 Cache Memory

Ref. Book Name : Computer System Architecture, M. Morris Mano

- Cache memory is a small, temporary and fast.
- It is placed between CPU and main memory .
- Access time of cache is less than main memory.

Operation of cache memory

- When CPU needs to access memory, cache is examined.
- If word is found, it is read from cache.
- If word is not found, main memory is accessed to read the word.
- Block of words is transferred from main memory to cache.

Cache Mapping Schemes

- There are three types of mapping procedures

1. Associative Mapping
2. Direct Mapping
3. Set Associative Mapping

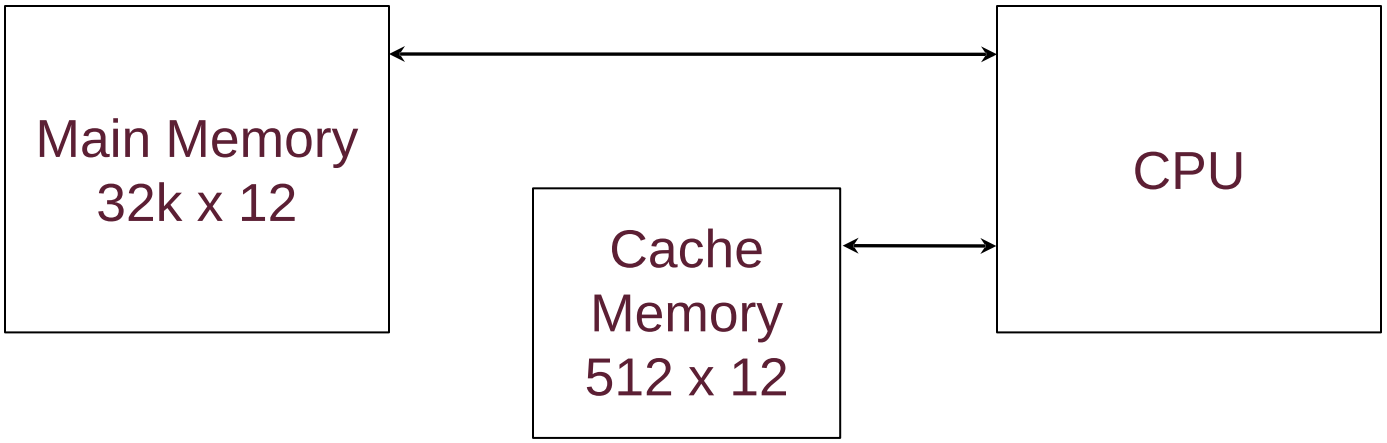


Figure: Example of cache memory

1. Associative Mapping

- The fastest and most flexible cache organization uses an associative memory.
- Associative memory stores both address and data.

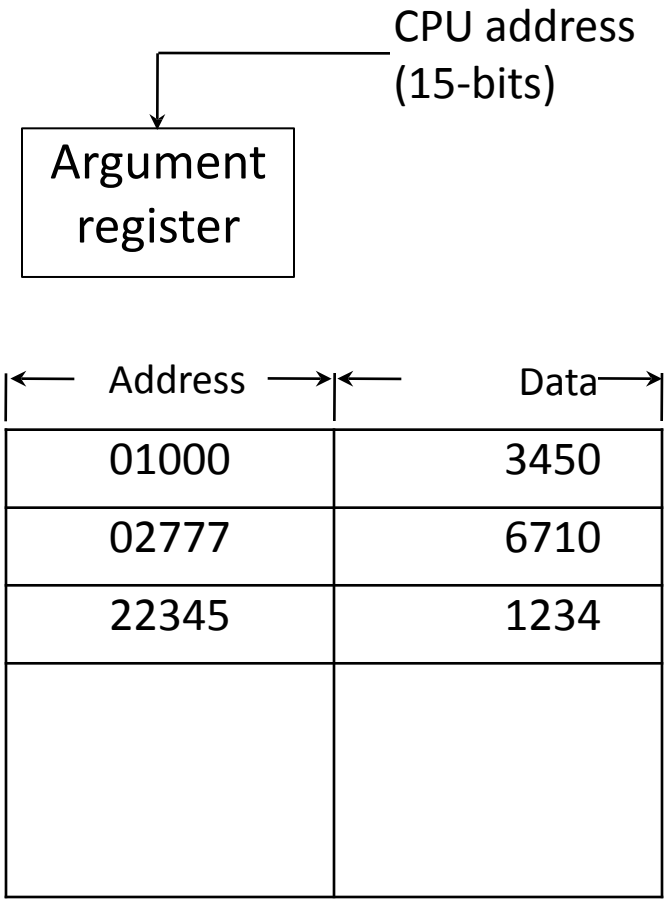


Figure: Associative Mapping Cache

2. Direct Mapping

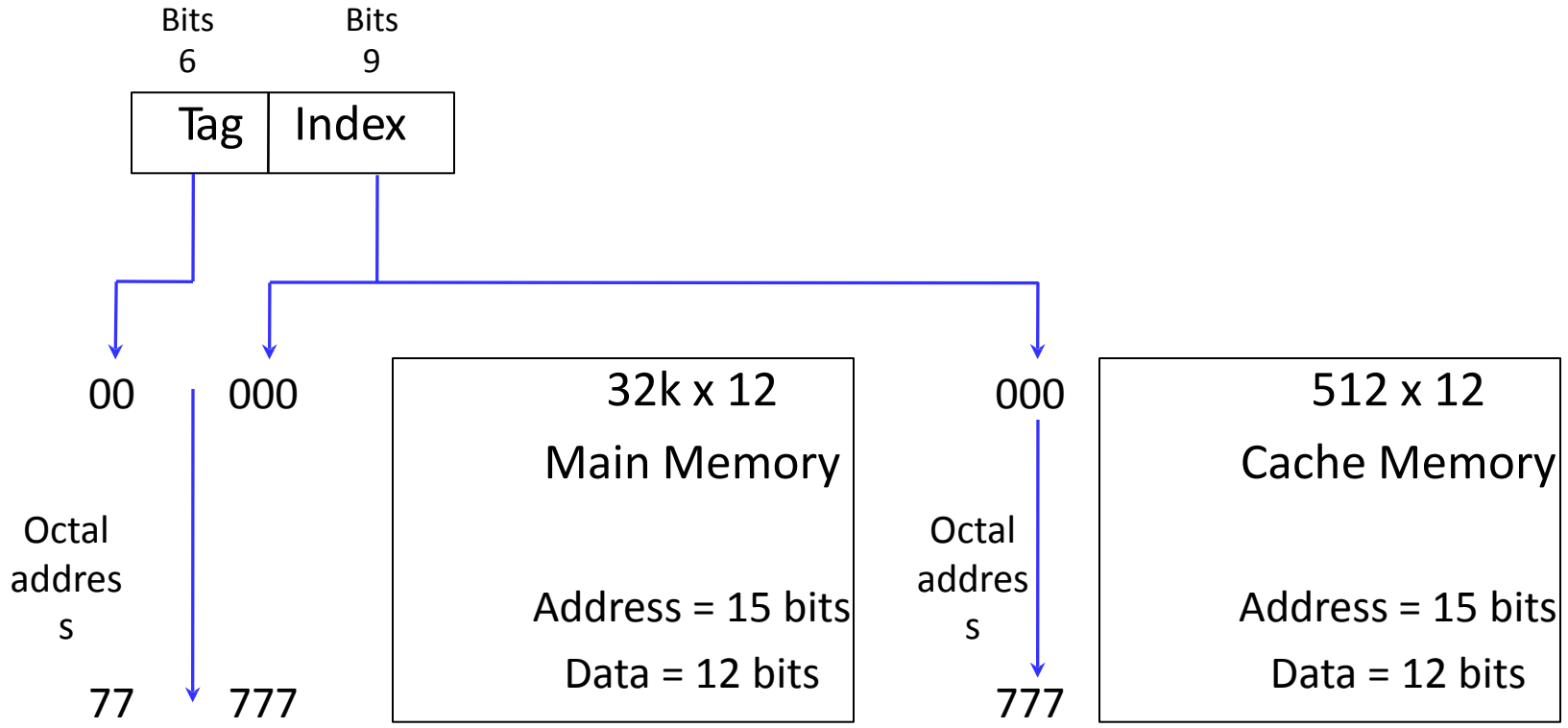


Figure: Addressing relationships between main and cache memories

3. Set – Associative Mapping

Index	Tag	Data	Tag	Data
000	01	3450	02	5670
	.	.	.	.
	.	.	.	.
	.	.	.	.
777	02	6710	00	2340

Figure: two way set associative mapping cache

7.5 Virtual Memory

Ref. Book Name : Computer System Architecture, M. Morris Mano

- It is used in some large computer systems
- It permits users to construct programs as though a large memory space were available, equal to totality of auxiliary memory.

Address Space and Memory Space

- Address used by programmer is called virtual address, and set of such addresses is address space.
- Address in main memory is called physical memory (location), and set of such address is memory space

7.5 Virtual Memory

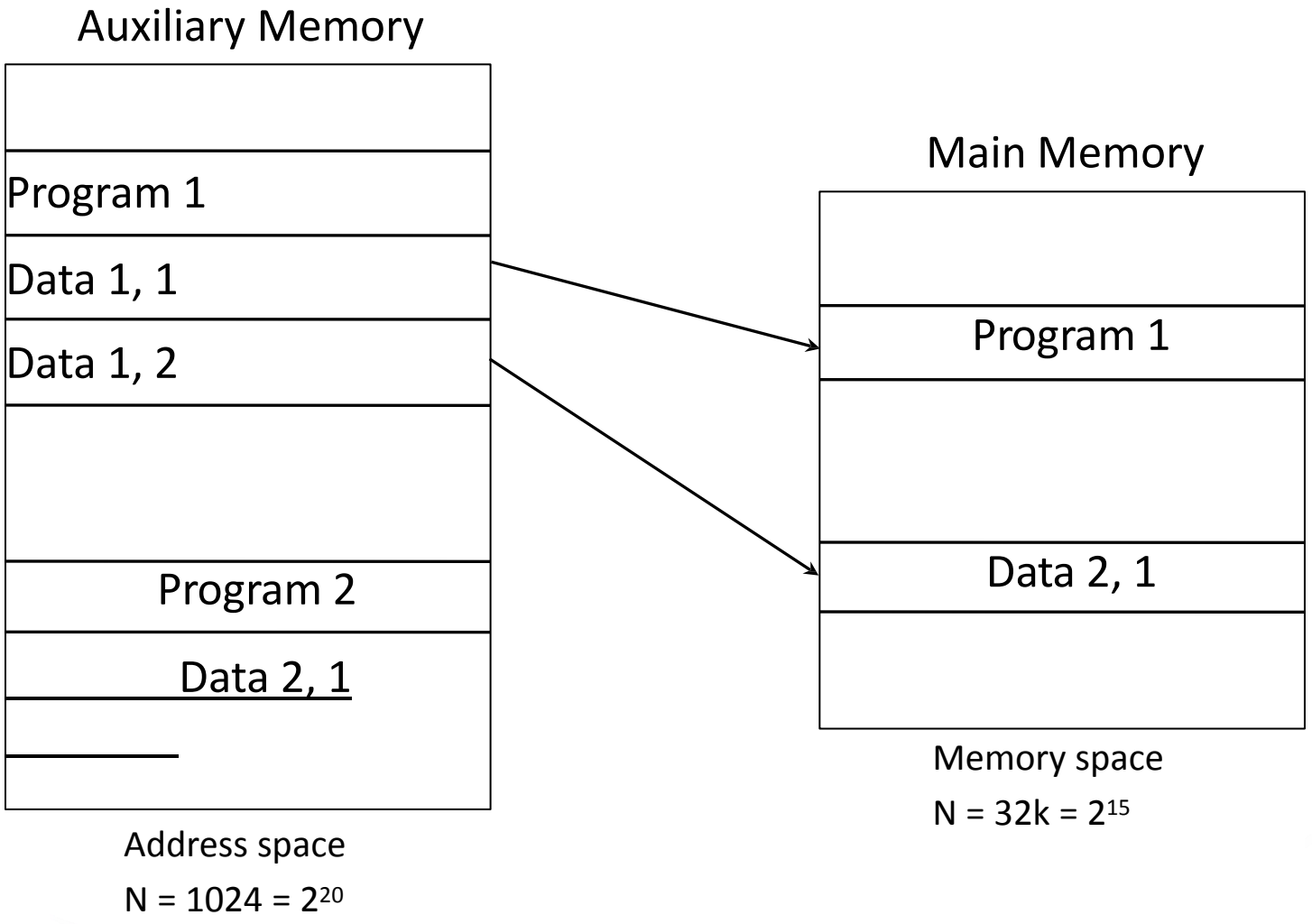


Figure: Relation between address and memory space in virtual memory