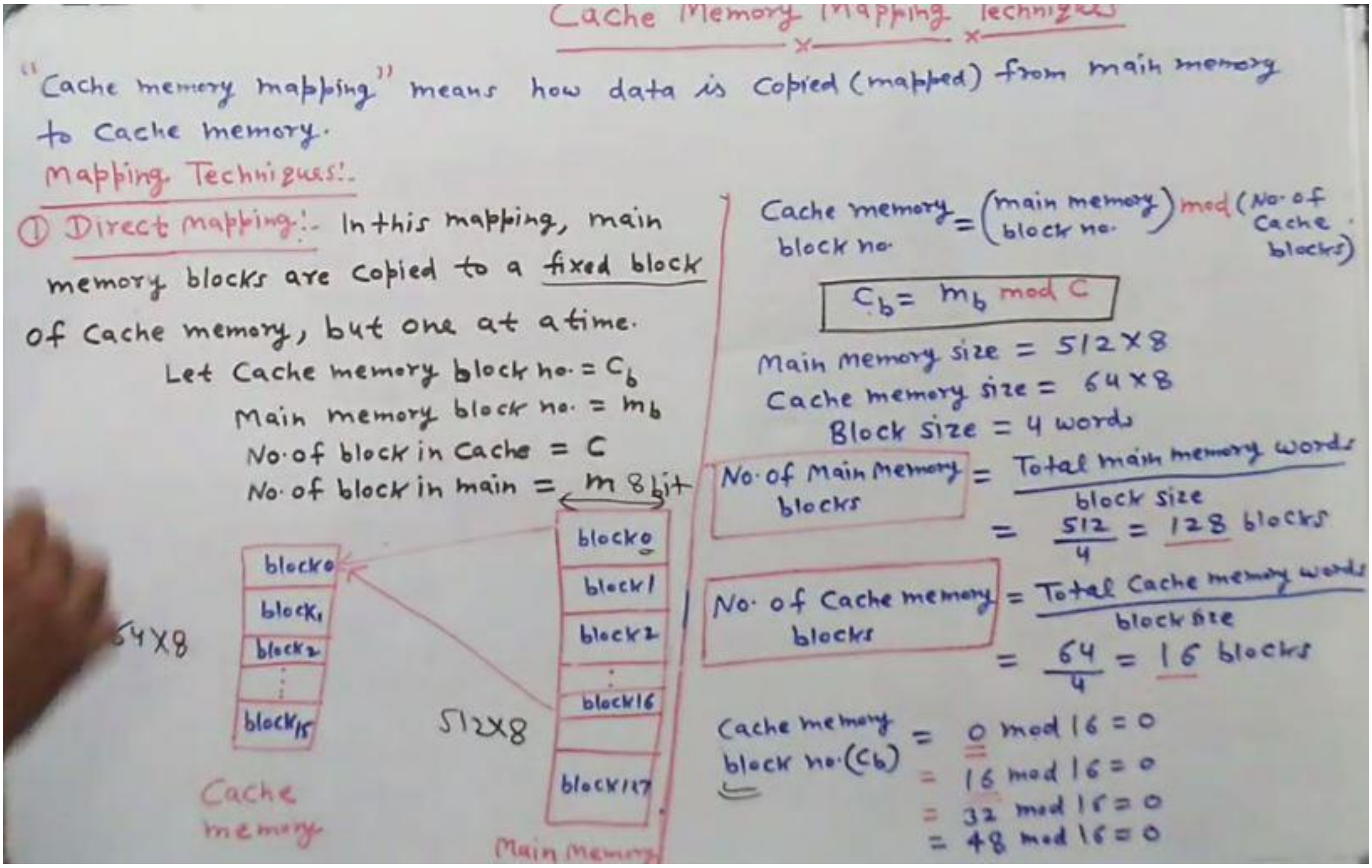
Cache Memory mapping

Direct mapping



Cache Memory Mapping Techniques

"Cache memory mapping" means how data is copied (mapped) from main memory to cache memory.

Mapping Techniques:-

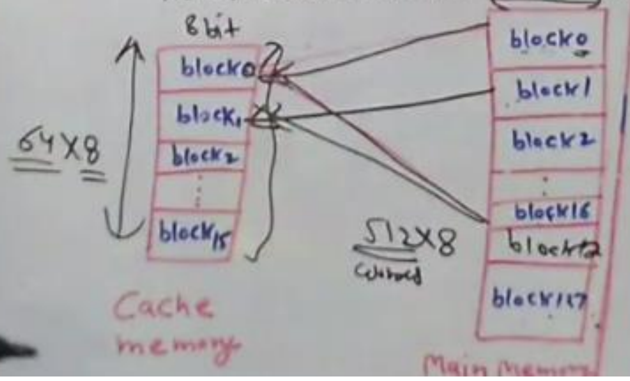
① **Direct mapping:-** In this mapping, main memory blocks are copied to a fixed block of cache memory, but one at a time.

Let Cache memory block no. = C_b

Main memory block no. = m_b

No. of block in Cache = C

No. of block in main = m



$$\text{Cache memory block no.} = \left(\text{main memory block no.}\right) \bmod \left(\text{No. of Cache blocks}\right)$$

$$\boxed{C_b = m_b \bmod C}$$

Main memory size = 512×8

Cache memory size = 64×8

Block size = 4 words

No. of Main Memory blocks = $\dfrac{\text{Total main memory words}}{\text{block size}}$

$= \dfrac{512}{4} = 128$ blocks

No. of Cache memory blocks = $\dfrac{\text{Total Cache memory words}}{\text{block size}}$

$= \dfrac{64}{4} = 16$ blocks

Cache memory block no. (C_b) $= 1 \bmod 16 = 1$

$= 17 \bmod 16 = 1$

$= 33 \bmod 16 = 1$

$= 49 \bmod 16 = 1$

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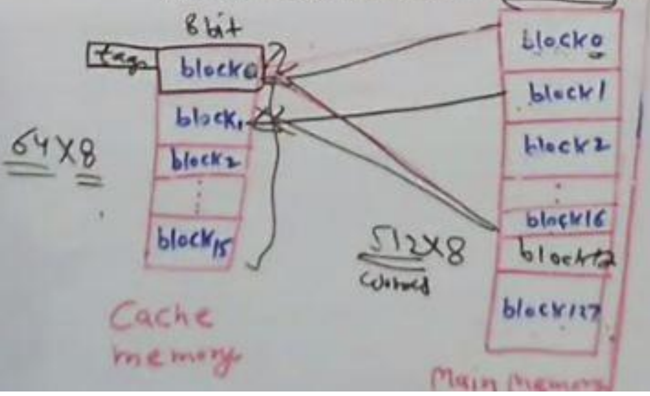


No. of main memory blocks in one block of Cache = $\frac{\text{No. of Main memory blocks}}{\text{No. of Cache memory blocks}}$

$= \frac{128}{16} = 8 = 2^3$

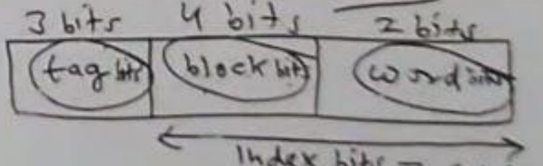
$\boxed{\text{block size} = 4 \text{ words}}$

Main memory size = 512 × 8

512 → words

main memory address = $512 = 2^9$

= 9 bits



Index bits = 6 bits

Main memory address (9 bits)

Cache Memory Mapping (Numericals)

A digital Computer has a memory unit of 64K×16 and a Cache memory of 1K words. The Cache uses "Direct Mapping" with a block size of 4 words.

(a) How many bits are there in the tag, Index, block and word field of address format

(b) How many bits are there in each word of Cache, and how are they divided into functions? Incude a valid bit.

(C) How many blocks Can the Cache accommodate?

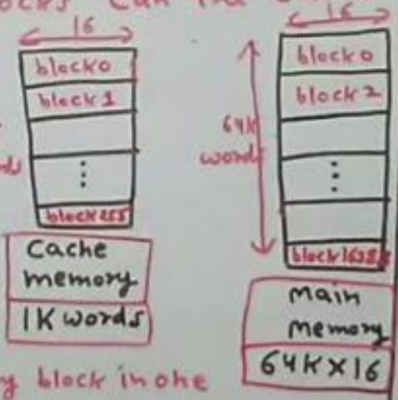
Direct mapping:

(a)

tag	block	word

Index = block + word

address format



tag = No. of main memory block in one block of Cache memory

$$\boxed{tag = \frac{\text{No. of main memory blocks}}{\text{No. of Cache memory blocks}}}$$

Cache memory block No. = (main memory block no.) mod (No. of Cache memory blocks)

$$\text{No. of Cache memory block} = \frac{\text{No. of words in Cache memory}}{\text{block size}}$$

$$= \frac{1K}{4} = \frac{1\times1024}{4} = 256$$

$$\boxed{\text{No. of Cache memory blocks} = 256}$$

$$\text{No. of main memory block} = \frac{\text{No. of words in main memory}}{\text{block size}}$$

$$= \frac{64K}{4} = \underline{\underline{16K}} = 16\times1024$$

$$\boxed{\text{No. of main memory block} = 16\times1024}$$

$$tag = \frac{16\times\cancel{1024}^{4}}{\cancel{256}} = 64 = 2^6$$

$$\boxed{\text{No. of tag bits} = 6}$$

accommodate

(b)

Valid	tag	data
1 bit	6 bits	16 bits

16 + 6 + 1 = 23 bits

Set-Associative mapping

Cache Memory Mapping Techniques

"Cache memory mapping" means how data is copied (mapped) from main memory to cache memory.

Mapping Techniques:-

① Set-Associative Mapping: It is a combination of direct mapping & associative mapping.

$$\boxed{\text{Set-Associative mapping} = \text{Direct Mapping} + \text{Associative Mapping}}$$

In this, Cache memory is divided into set.

Set =	group of blocks
Blocks =	group of words

$$\boxed{\text{Cache memory Set No.} = (\text{main memory block No.}) \bmod (\text{No. of sets in Cache memory})}$$

$$\boxed{\text{No. of Sets in Cache memory} = \frac{\text{No. of Cache memory blocks}}{\text{Set size}}}$$

$$\boxed{\text{No. of blocks in Cache memory} = \frac{\text{No. of words in Cache memory}}{\text{block size}}}$$

$$\boxed{\text{No. of blocks in main memory} = \frac{\text{No. of words in main memory}}{\text{block size}}}$$

Let Set size = 2 (Two-way set associative)

Block size = 4 words

main memory size = 512×8

Cache memory size = 64×8

✓ No. of main memory blocks $= \frac{512}{4} = \boxed{128 \text{ blocks}}$

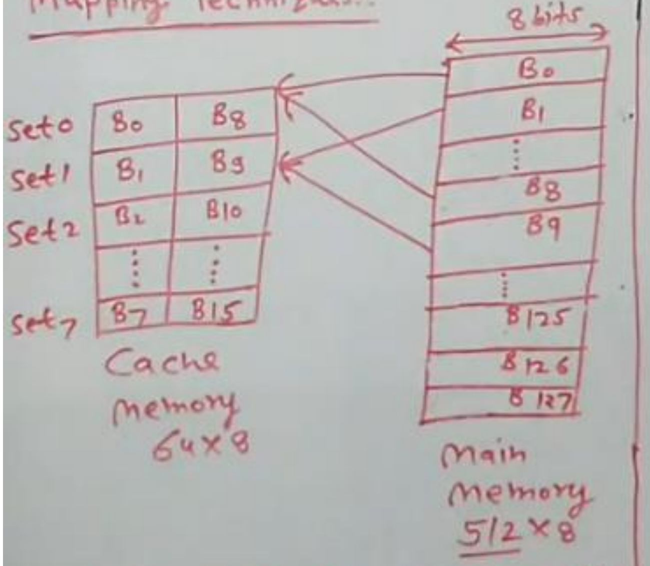
✓ No. of Cache memory blocks $= \frac{64}{4} = \boxed{16 \text{ blocks}}$

✓ No. of Sets in Cache memory $= \frac{16}{2} = \boxed{8 \text{ sets}}$

Cache memory Set No.

⇒ 0 mod 8 = 0	⇒ 1 mod 8 = 1
⇒ 8 mod 8 = 0	⇒ 9 mod 8 = 1
⇒ 16 mod 8 = 0	⇒ 17 mod 8 = 1
⇒ 24 mod 8 = 0	⇒ 25 mod 8 = 1

Set-Associative Mapping Techniques:

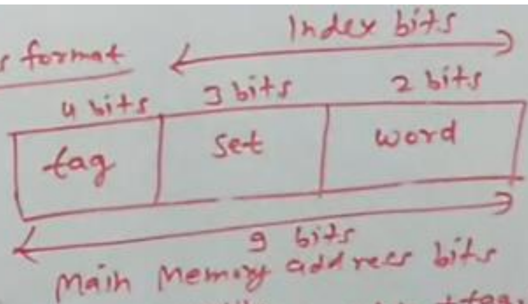


No of main memory blocks in one set of cache (2 at a time) tag $= \dfrac{\text{Main Memory Blocks}}{\text{Cache memory sets}}$

$= \dfrac{128}{8} = 16$

$= 2^4$

address format



Cache memory size $= 2^{\text{Index bits}} \times (tag_1 + data_1 + tag_2 + data_2)$

$= 2^5 \times (4+8+4+8)$

$= 32 \times 24$

No. of main memory blocks $= \dfrac{512}{4} = \boxed{128 \text{ blocks}}$

No. of Cache memory blocks $= \dfrac{64}{4} = \boxed{16 \text{ blocks}}$

No. of sets in Cache memory $= \dfrac{16}{2} = \boxed{8 \text{ sets}} = 2^3$

Cache memory Set No.	
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Numericals on set associative mapping

A two-way "set-associative" Cache memory uses blocks of four words. The cache can accomodate a total of 2048 words of main memory. The main memory size is 128 K×32.

(a) Formulate all pertinent information required to construct the cache memory.

(b) What is the size of cache memory.

Ans Set-Associative Mapping

Set size = 2

Block size = 4

set0	B_0	B_{256}
set1	B_1	B_{257}
	⋮	⋮
set255		

$\boxed{2048 \times 32}$ Cache memory

Cache memory set No. = (main memory block no.) (mod) No. of sets in Cache memory

32 bits
B_0
B_1
B_2
⋮
B_{256}
B_{257}
B_{258}
⋮

$\boxed{128K \times 32}$ main memory

No. of Cache memory block = $\frac{\text{Total words in Cache}}{\text{Block size}} = \frac{2048}{4} = 512$ blocks

No. of Cache memory sets = $\frac{\text{Total block in Cache}}{\text{Set size}} = \frac{512}{2} = 256$ sets

No. of main memory blocks = $\frac{\text{Total words in Main memory}}{\text{Block size}} = \frac{128K}{4} = 32K$

(a)

7 bits	8 bits	2 bits
tag	set	word

Index

address format

$$\text{tag} = \frac{\text{main memory blocks}}{\text{Cache memory sets}} = \frac{32K}{256} = \frac{32 \times 1024}{256}^{4} = 128$$

$$= 2^7 = 7 \text{ bits}$$

set = No. of sets in Cache $= 256 = 2^8 = 8$ bits

(b) 7 bits + 32 bits + 7 bits + 32 bits = 78 bits

tag	data	tag	data

Cache size = 1024 × 78