

# Set Associative Mapping | Practice Problems

📁 Computer Organization and Architecture

## Set Associative Mapping-

Before you go through this article, make sure that you have gone through the previous article on [Set Associative Mapping](#).

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process mapping



cache mapping



trace number



bits bytes



In set associative mapping,

- A particular block of main memory can be mapped to one particular cache set only.
- Block 'j' of main memory will map to set number  $(j \bmod \text{number of sets in cache})$  of the cache.
- A replacement algorithm is needed if the cache is full.

In this article, we will discuss practice problems based on set associative mapping.

Also Read- [Cache Mapping Techniques](#)

## PRACTICE PROBLEMS BASED ON SET ASSOCIATIVE MAPPING-

### Problem-01:

Consider a 2-way set associative mapped cache of size 16 KB with block size 256 bytes. The size of main memory is 128 KB. Find-

1. Number of bits in tag
2. Tag directory size

### Solution-

Given-

- Set size = 2
- Cache memory size = 16 KB
- Block size = Frame size = Line size = 256 bytes
- Main memory size = 128 KB

We consider that the memory is byte addressable.

### **Number of Bits in Physical Address-**

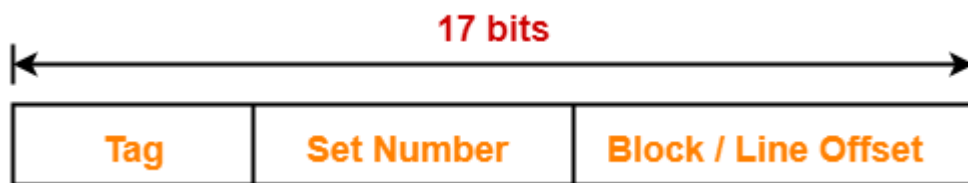
We have,

Size of main memory

= 128 KB

=  $2^{17}$  bytes

Thus, Number of bits in physical address = 17 bits



### **Number of Bits in Block Offset-**

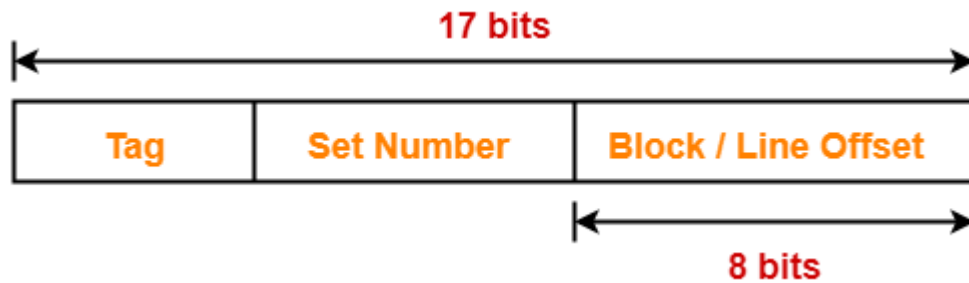
We have,

Block size

= 256 bytes

=  $2^8$  bytes

Thus, Number of bits in block offset = 8 bits



### Number of Lines in Cache-

Total number of lines in cache

= Cache size / Line size

= 16 KB / 256 bytes

=  $2^{14}$  bytes /  $2^8$  bytes

= 64 lines

Thus, Number of lines in cache = 64 lines

### Number of Sets in Cache-

Total number of sets in cache

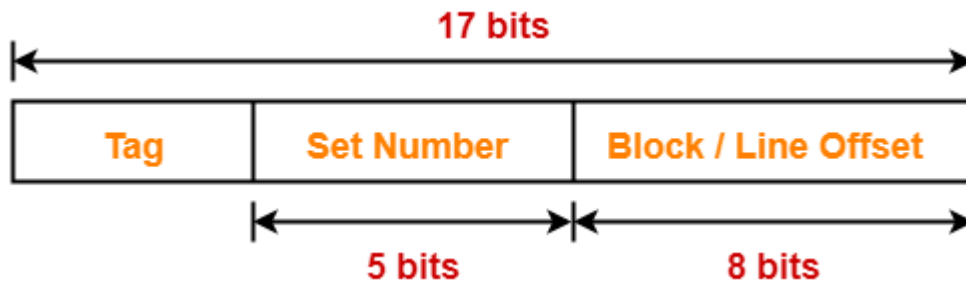
= Total number of lines in cache / Set size

= 64 / 2

= 32 sets

=  $2^5$  sets

Thus, Number of bits in set number = 5 bits



### Number of Bits in Tag-

Number of bits in tag

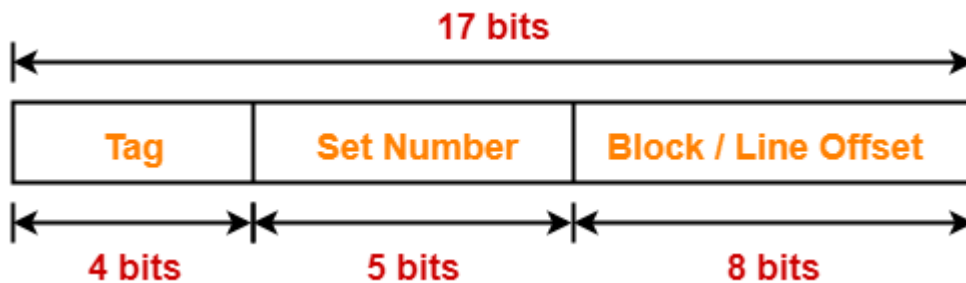
= Number of bits in physical address – (Number of bits in set number + Number of bits in block offset)

= 17 bits – (5 bits + 8 bits)

= 17 bits – 13 bits

= 4 bits

Thus, Number of bits in tag = 4 bits



### Tag Directory Size-

Tag directory size

= Number of tags x Tag size

= Number of lines in cache x Number of bits in tag

= 64 x 4 bits

= 256 bits

= 32 bytes

Thus, size of tag directory = 32 bytes

Also Read- [Practice Problems On Direct Mapping](#)

## **Problem-02:**

Consider a 8-way set associative mapped cache of size 512 KB with block size 1 KB. There are 7 bits in the tag. Find-

1. Size of main memory
2. Tag directory size

## **Solution-**

Given-

- Set size = 8
- Cache memory size = 512 KB
- Block size = Frame size = Line size = 1 KB
- Number of bits in tag = 7 bits

We consider that the memory is byte addressable.

## **Number of Bits in Block Offset-**

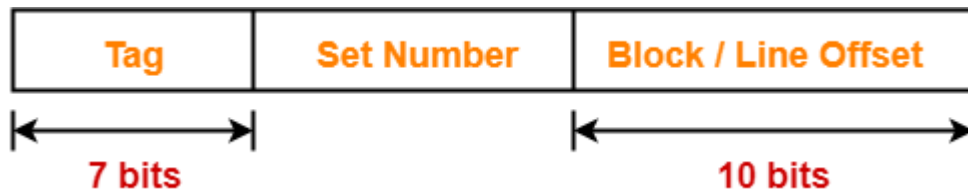
We have,

Block size

= 1 KB

=  $2^{10}$  bytes

Thus, Number of bits in block offset = 10 bits



### Number of Lines in Cache-

Total number of lines in cache

= Cache size / Line size

= 512 KB / 1 KB

= 512 lines

Thus, Number of lines in cache = 512 lines

### Number of Sets in Cache-

Total number of sets in cache

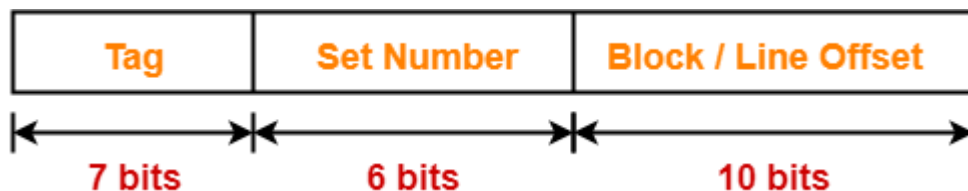
= Total number of lines in cache / Set size

= 512 / 8

= 64 sets

=  $2^6$  sets

Thus, Number of bits in set number = 6 bits



### Number of Bits in Physical Address-

Number of bits in physical address

= Number of bits in tag + Number of bits in set number + Number of bits in block offset

= 7 bits + 6 bits + 10 bits

= 23 bits

Thus, Number of bits in physical address = 23 bits

### **Size of Main Memory-**

We have,

Number of bits in physical address = 23 bits

Thus, Size of main memory

=  $2^{23}$  bytes

= 8 MB

### **Tag Directory Size-**

Tag directory size

= Number of tags x Tag size

= Number of lines in cache x Number of bits in tag

= 512 x 7 bits

= 3584 bits

= 448 bytes

Thus, size of tag directory = 448 bytes

### **Problem-03:**

Consider a 4-way set associative mapped cache with block size 4 KB. The size of main memory is 16 GB and there are 10 bits in the tag. Find-

1. Size of cache memory
2. Tag directory size

### Solution-

Given-

- Set size = 4
- Block size = Frame size = Line size = 4 KB
- Main memory size = 16 GB
- Number of bits in tag = 10 bits

We consider that the memory is byte addressable.

### Number of Bits in Physical Address-

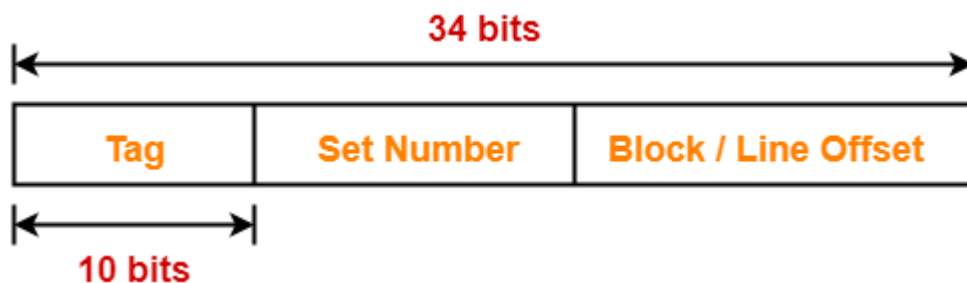
We have,

Size of main memory

= 16 GB

=  $2^{34}$  bytes

Thus, Number of bits in physical address = 34 bits





### Number of Bits in Block Offset-

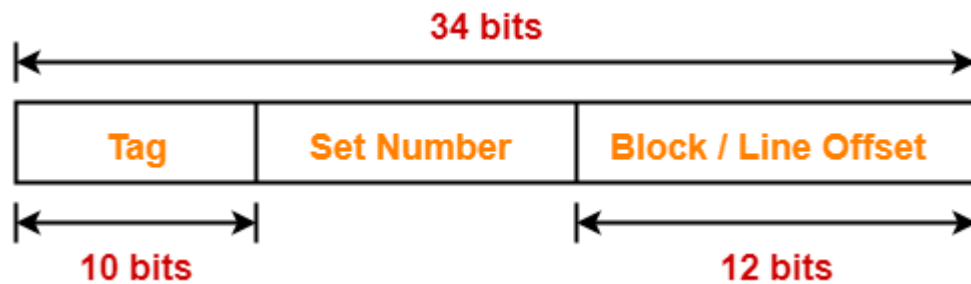
We have,

Block size

= 4 KB

=  $2^{12}$  bytes

Thus, Number of bits in block offset = 12 bits



### Number of Bits in Set Number-

Number of bits in set number

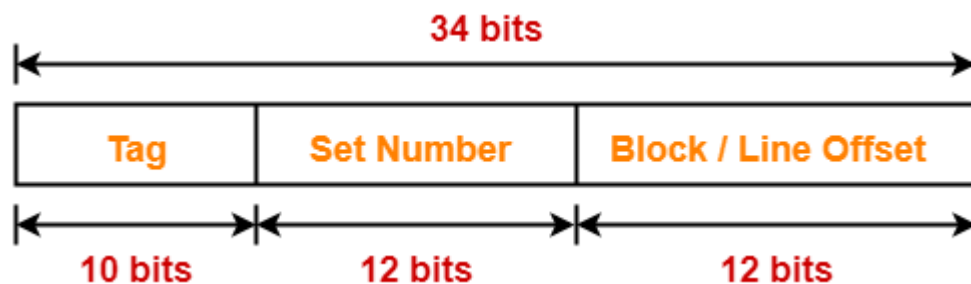
= Number of bits in physical address – (Number of bits in tag + Number of bits in block offset)

= 34 bits – (10 bits + 12 bits)

= 34 bits – 22 bits

= 12 bits

Thus, Number of bits in set number = 12 bits



### **Number of Sets in Cache-**

We have-

Number of bits in set number = 12 bits

Thus, Total number of sets in cache =  $2^{12}$  sets

### **Number of Lines in Cache-**

We have-

Total number of sets in cache =  $2^{12}$  sets

Each set contains 4 lines

Thus,

Total number of lines in cache

= Total number of sets in cache x Number of lines in each set

=  $2^{12} \times 4$  lines

=  $2^{14}$  lines

### **Size of Cache Memory-**

Size of cache memory

= Total number of lines in cache x Line size

=  $2^{14} \times 4$  KB

=  $2^{16}$  KB

= 64 MB

Thus, Size of cache memory = 64 MB

## **Tag Directory Size-**

Tag directory size

= Number of tags x Tag size

= Number of lines in cache x Number of bits in tag

=  $2^{14} \times 10$  bits

= 163840 bits

= 20480 bytes

= 20 KB

Thus, size of tag directory = 20 KB

Also Read- [Practice Problems On Fully Associative Mapping](#)

## **Problem-04:**

Consider a 8-way set associative mapped cache. The size of cache memory is 512 KB and there are 10 bits in the tag. Find the size of main memory.

## **Solution-**

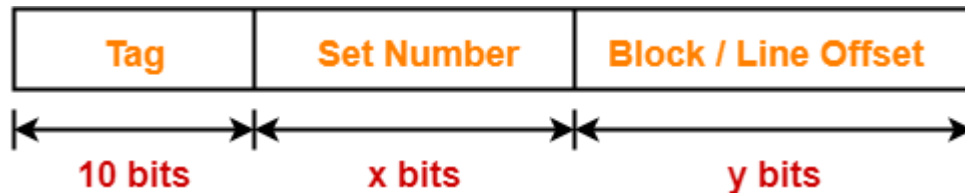
Given-

- Set size = 8
- Cache memory size = 512 KB
- Number of bits in tag = 10 bits

We consider that the memory is byte addressable.

Let-

- Number of bits in set number field = x bits
- Number of bits in block offset field = y bits



### Sum of Number Of Bits Of Set Number Field And Block Offset Field-

We have,

Cache memory size = Number of sets in cache x Number of lines in one set x Line size

Now, substituting the values, we get-

$$512 \text{ KB} = 2^x \times 8 \times 2^y \text{ bytes}$$

$$2^{19} \text{ bytes} = 2^{3+x+y} \text{ bytes}$$

$$19 = 3 + x + y$$

$$x + y = 19 - 3$$

$$x + y = 16$$

### Number of Bits in Physical Address-

Number of bits in physical address

= Number of bits in tag + Number of bits in set number + Number of bits in block offset

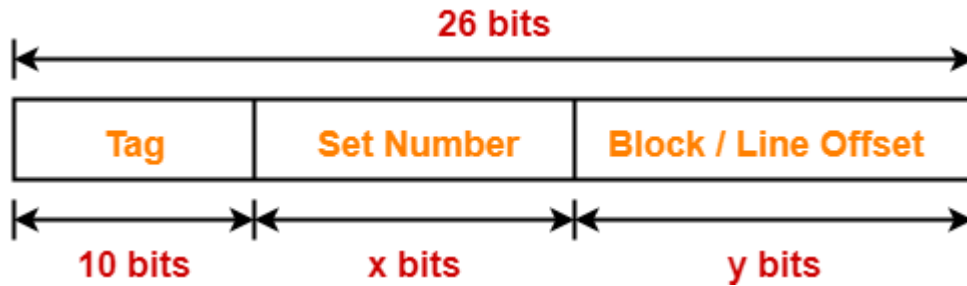
= 10 bits + x bits + y bits

= 10 bits + (x + y) bits

= 10 bits + 16 bits

= 26 bits

Thus, Number of bits in physical address = 26 bits



### Size of Main Memory-

We have,

Number of bits in physical address = 26 bits

Thus, Size of main memory

=  $2^{26}$  bytes

= 64 MB

Thus, size of main memory = 64 MB

### Problem-05:

Consider a 4-way set associative mapped cache. The size of main memory is 64 MB and there are 10 bits in the tag. Find the size of cache memory.

### Solution-

Given-

- Set size = 4
- Main memory size = 64 MB
- Number of bits in tag = 10 bits

We consider that the memory is byte addressable.

## Number of Bits in Physical Address-

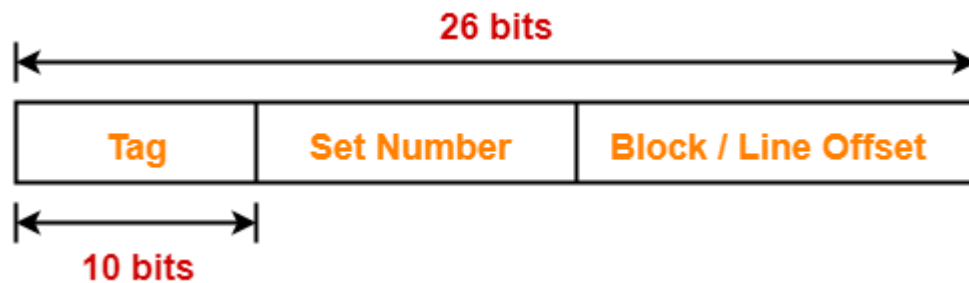
We have,

Size of main memory

= 64 MB

=  $2^{26}$  bytes

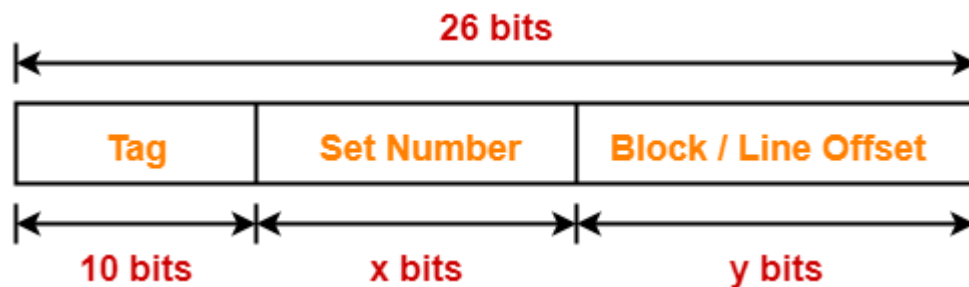
Thus, Number of bits in physical address = 26 bits



## Sum Of Number Of Bits Of Set Number Field And Block Offset Field-

Let-

- Number of bits in set number field = x bits
- Number of bits in block offset field = y bits



Then, Number of bits in physical address

= Number of bits in tag + Number of bits in set number + Number of bits in block offset

So, we have-

$$26 \text{ bits} = 10 \text{ bits} + x \text{ bits} + y \text{ bits}$$

$$26 = 10 + (x + y)$$

$$x + y = 26 - 10$$

$$x + y = 16$$

Thus, Sum of number of bits of set number field and block offset field = 16 bits

### **Size of Cache Memory-**

Cache memory size

= Number of sets in cache x Number of lines in one set x Line size

$$= 2^x \times 4 \times 2^y \text{ bytes}$$

$$= 2^{2+x+y} \text{ bytes}$$

$$= 2^{2+16} \text{ bytes}$$

$$= 2^{18} \text{ bytes}$$

$$= 256 \text{ KB}$$

Thus, size of cache memory = 256 KB

To watch video solutions and practice more problems,

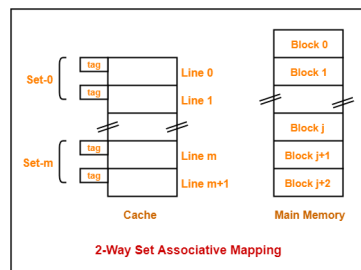
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## Summary



**Article Name** Set Associative Mapping | Practice Problems

**Description** Practice Problems based on set associative mapping. Set associative mapping is a cache mapping technique that allows to map a particular block of main memory to one particular cache set only.

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**Publisher Name** Gate Vidyalay

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