OPERATING SYSTEM: CSET209

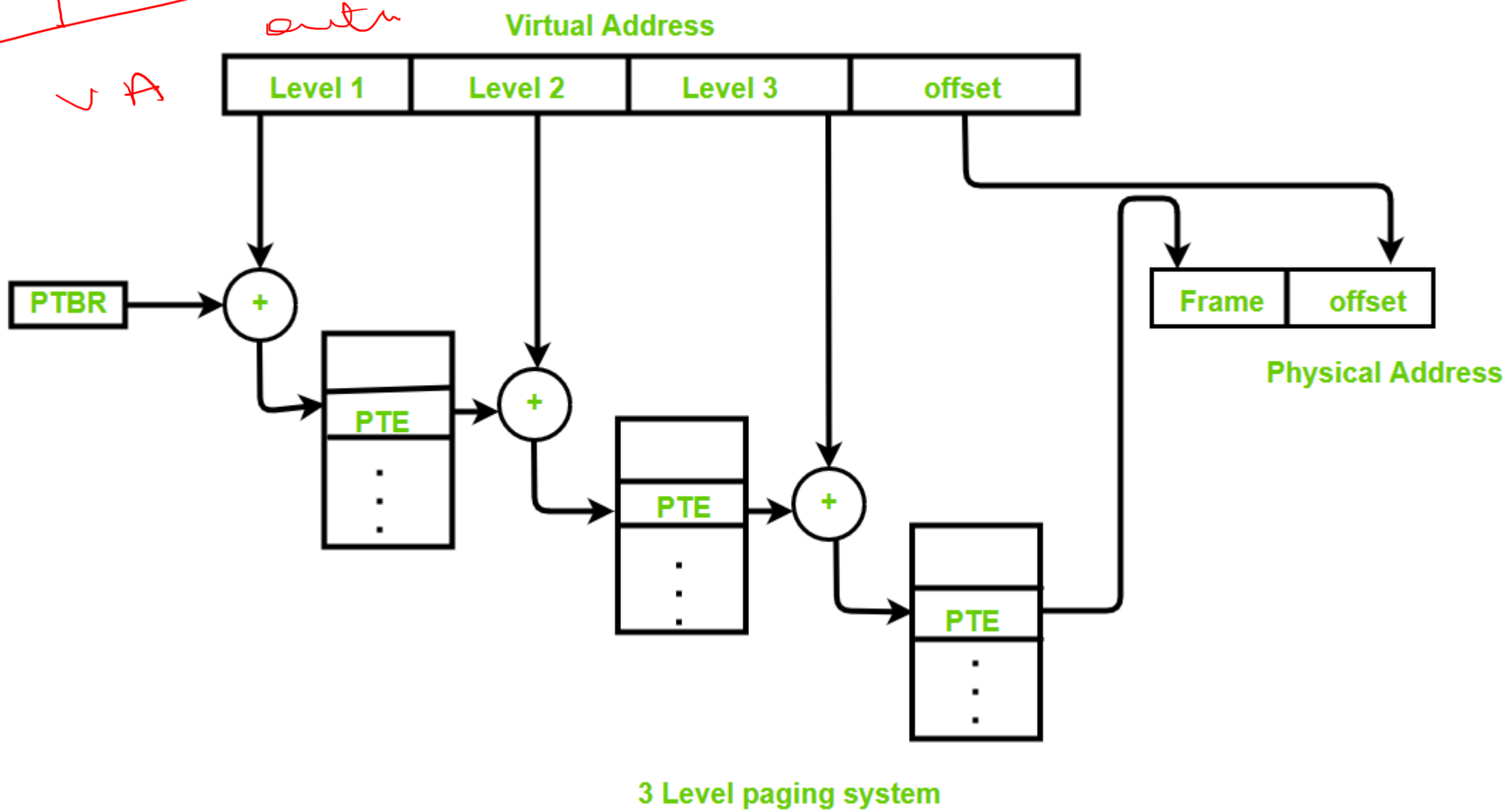
CONTENT

- **Multilevel paging**
- **Segmentation**
- **Segmented paging**

MULTILEVEL PAGING

- Multilevel paging is a paging scheme where there exists a hierarchy of page tables.
- The need for multilevel paging arises when-
  - The size of page table is greater than the frame size.
  - As a result, the page table can not be stored in a single frame in main memory.

MULTILEVEL PAGING:



MULTILEVEL PAGING: WORKING

- The page table having size greater than the frame size is divided into several parts.
- The size of each part is same as frame size except possibly the last part.
- The pages of page table are then stored in different frames of the main memory.
- To keep track of the frames storing the pages of the divided page table, another page table is maintained.
- As a result, the hierarchy of page tables get generated.
- Multilevel paging is done till the level is reached where the entire page table can be stored in a single frame.

ILLUSTRATION OF MULTILEVEL PAGING

- Consider a system using paging scheme where-

- Logical Address Space = 4 GB
- Physical Address Space = 16 TB
- Page size = 4 KB

Number of Bits in Physical Address-

Size of main memory
= Physical Address Space
= 16 TB
= 2^{44} B
Thus, Number of bits in physical address = 44 bits

Number of Frames in Main Memory-

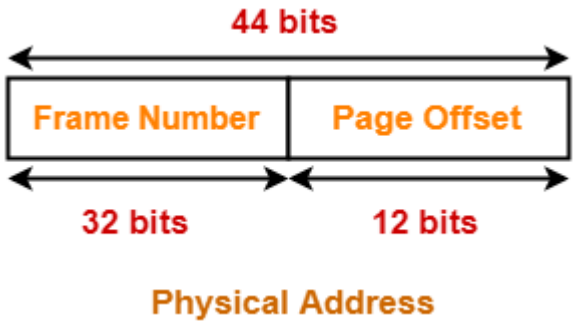
Number of frames in main memory
= Size of main memory / Frame size
= 16 TB / 4 KB
= 2^{32} frames
Thus, Number of bits in frame number = 32 bits

Number of Bits in Page Offset-

We have,
Page size
= 4 KB
= 2^{12} B
Thus, Number of bits in page offset = 12 bits

ILLUSTRATION OF MULTILEVEL PAGING

So, Physical address is-



Number of Pages of Process-

Number of pages the process is divided
= Process size / Page size
= 4 GB / 4 KB
= 2^{20} pages

Inner Page Table Size-

Inner page table keeps track of the frames storing the pages of process.
Inner Page table size
= Number of entries in inner page table x Page table entry size
= Number of pages the process is divided x Number of bits in frame number
= 2^{20} x 32 bits
= 2^{20} x 4 bytes
= 4 MB

ILLUSTRATION OF MULTILEVEL PAGING

Number of Pages of Inner Page Table-

Number of pages the inner page table is divided
= Inner page table size / Page size
= 4 MB / 4 KB
= 2^{10} pages

Number of Page Table Entries in One Page of Inner Page Table-

Number of page table entries in one page of inner page table
= Page size / Page table entry size
= Page size / Number of bits in frame number
= 4 KB / 32 bits
= 4 KB / 4 B
= 2^{10}

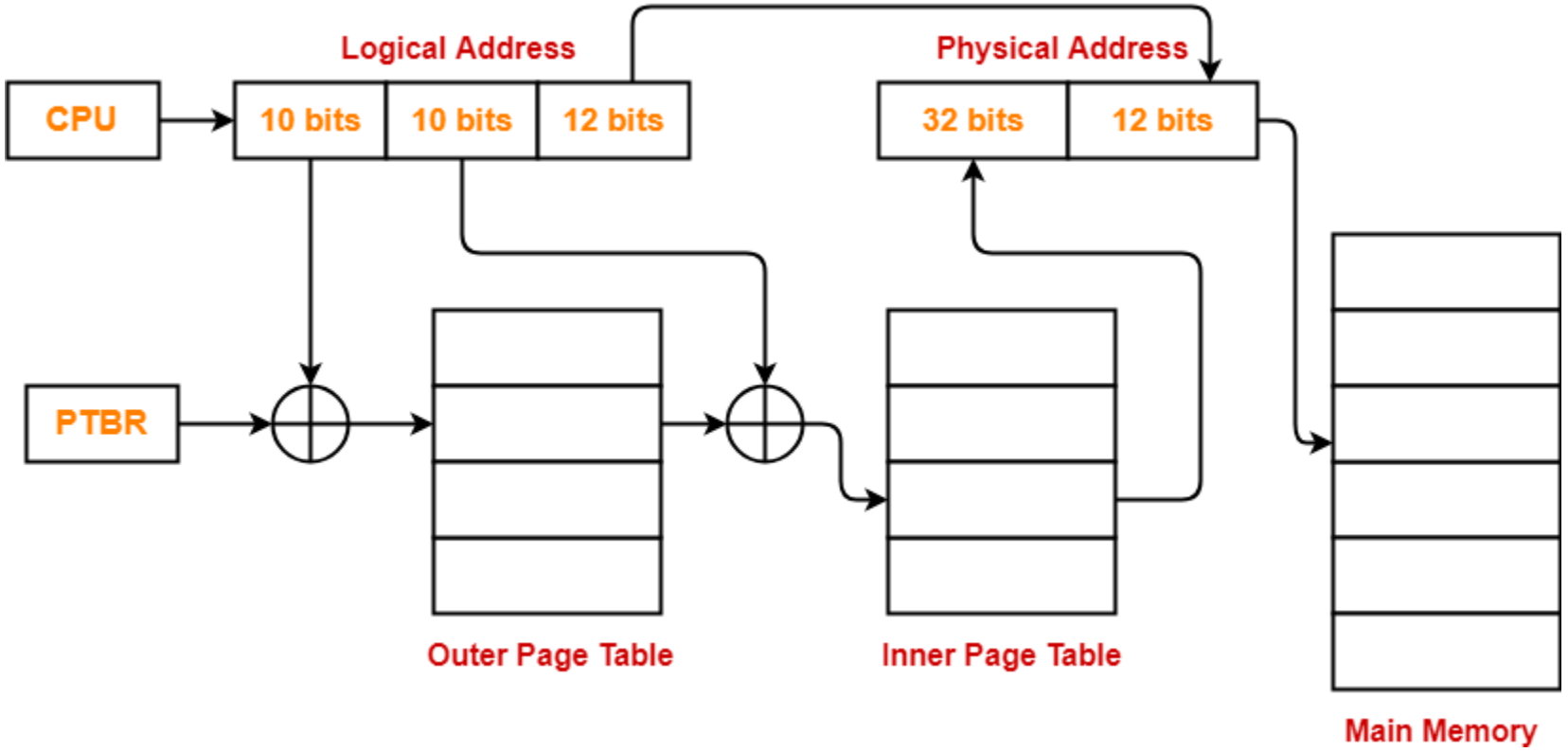
Number of Bits Required to Search an Entry in One Page of Inner Page Table-

One page of inner page table contains 2^{10} entries.
Thus,
Number of bits required to search a particular entry in one page of inner page table = 10 bits

Outer Page Table Size-

Outer page table is required to keep track of the frames storing the pages of inner page table.
Outer Page table size
= Number of entries in outer page table x Page table entry size
= Number of pages the inner page table is divided x Number of bits in frame number
= 2^{10} x 32 bits
= 2^{10} x 4 bytes
= 4 KB

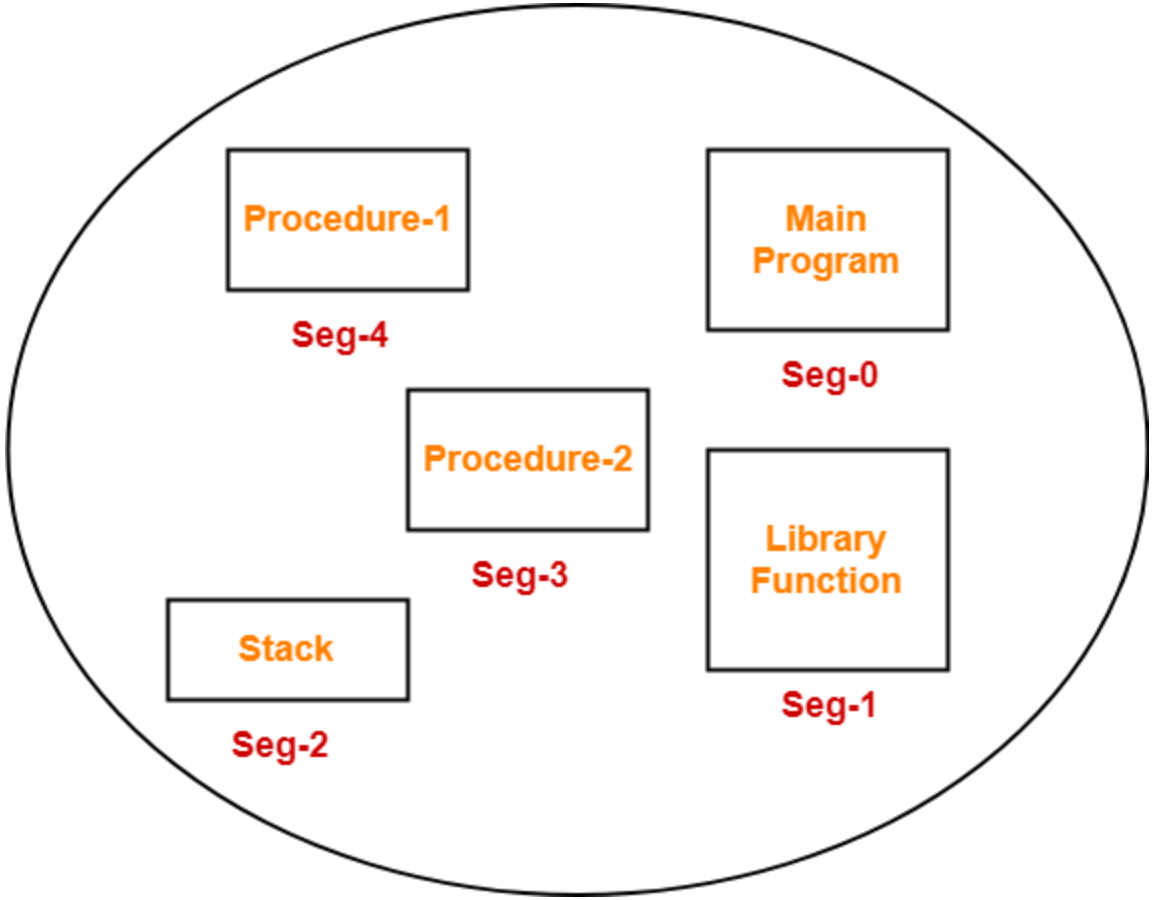
NUMBER OF BITS REQUIRED TO SEARCH AN ENTRY IN OUTER PAGE TABLE



SEGMENTATION

- Like Paging, Segmentation is another non-contiguous memory allocation technique.
- In segmentation, process is not divided blindly into fixed size pages.
- Rather, the process is divided into modules for better visualization.
  - Segmentation is a variable size partitioning scheme.
  - In segmentation, secondary memory and main memory are divided into partitions of unequal size.
  - The size of partitions depend on the length of modules.
  - The partitions of secondary memory are called as segments

SEGMENTATION: EXAMPLE



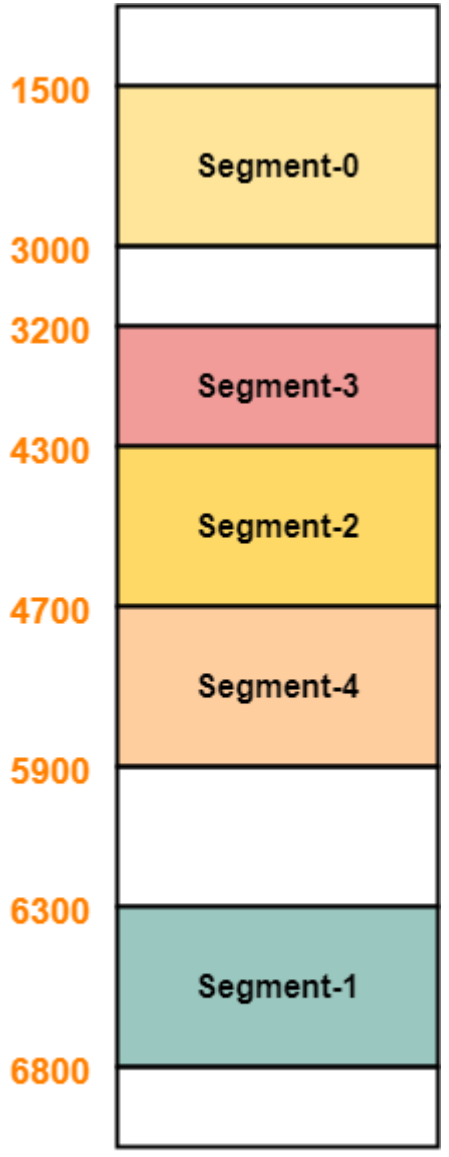
SEGMENT TABLE

- Segment table is a table that stores the information about each segment of the process.
- It has two columns.
- First column stores the size or length of the segment.
- Second column stores the base address or starting address of the segment in the main memory.
- Segment table is stored as a separate segment in the main memory.
- Segment table base register (STBR) stores the base address of the segment table.

SEGMENT TABLE

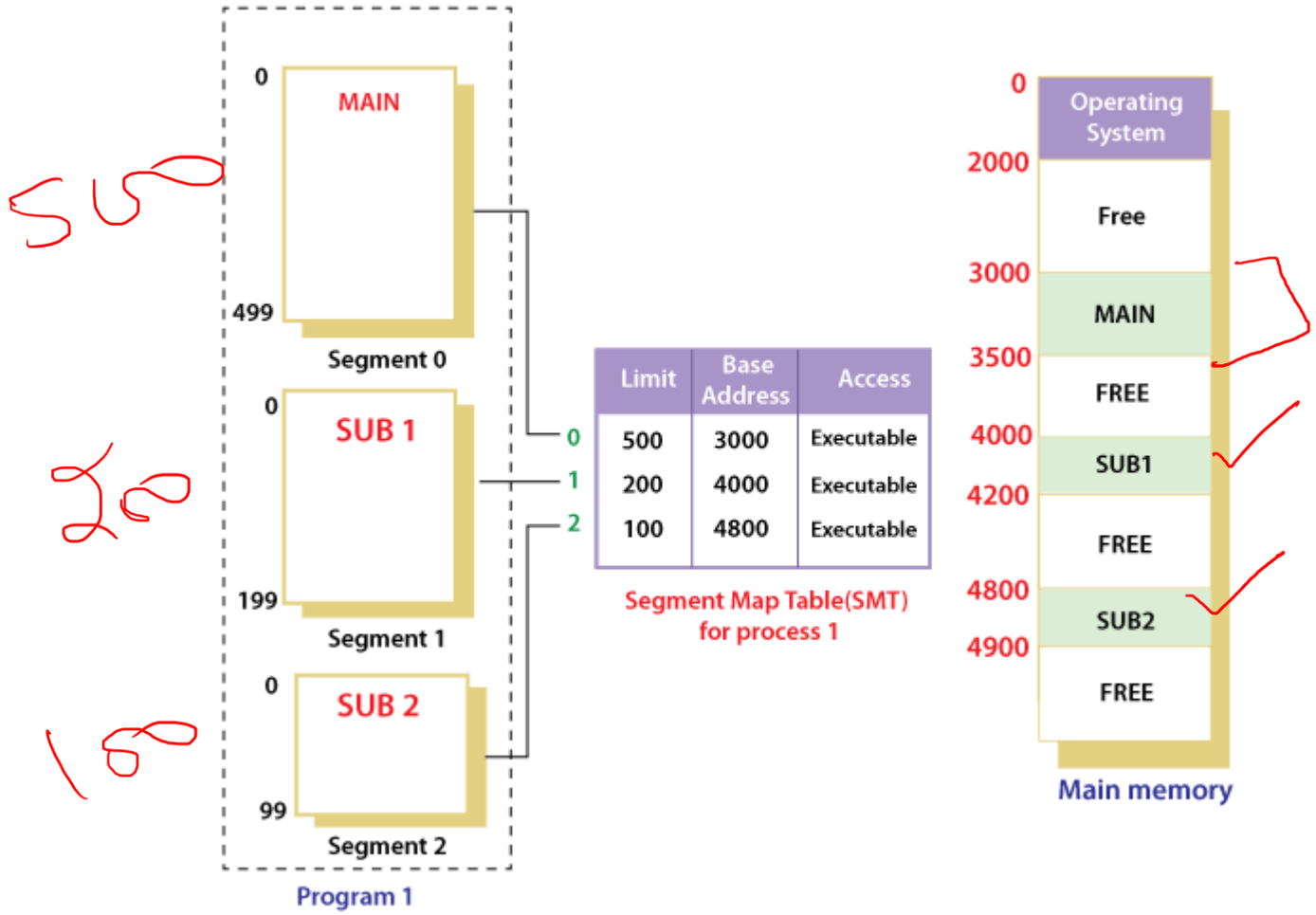
	Limit	Base
Seg-0	1500	1500
Seg-1	500	6300
Seg-2	400	4300
Seg-3	1100	3200
Seg-4	1200	4700

Segment Table



Main Memory

SEGMENT TABLE

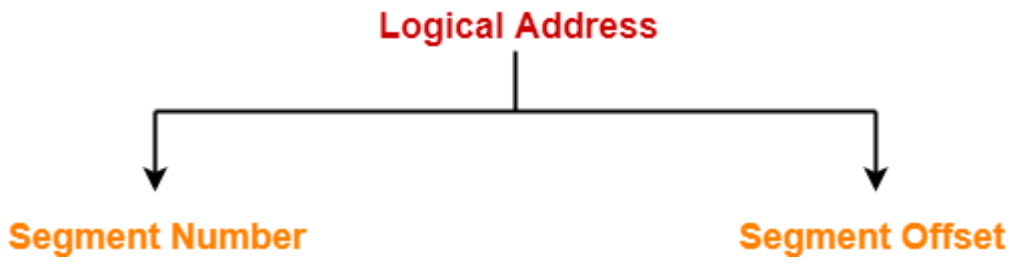


TRANSLATING LOGICAL ADDRESS INTO PHYSICAL ADDRESS

- CPU always generates a logical address.
- A physical address is needed to access the main memory.

Step-01:

CPU generates a logical address consisting of two parts-
1.Segment Number
2.Segment Offset
- Segment Number specifies the specific segment of the process from which CPU wants to read the data.
- Segment Offset specifies the specific word in the segment that CPU wants to read.



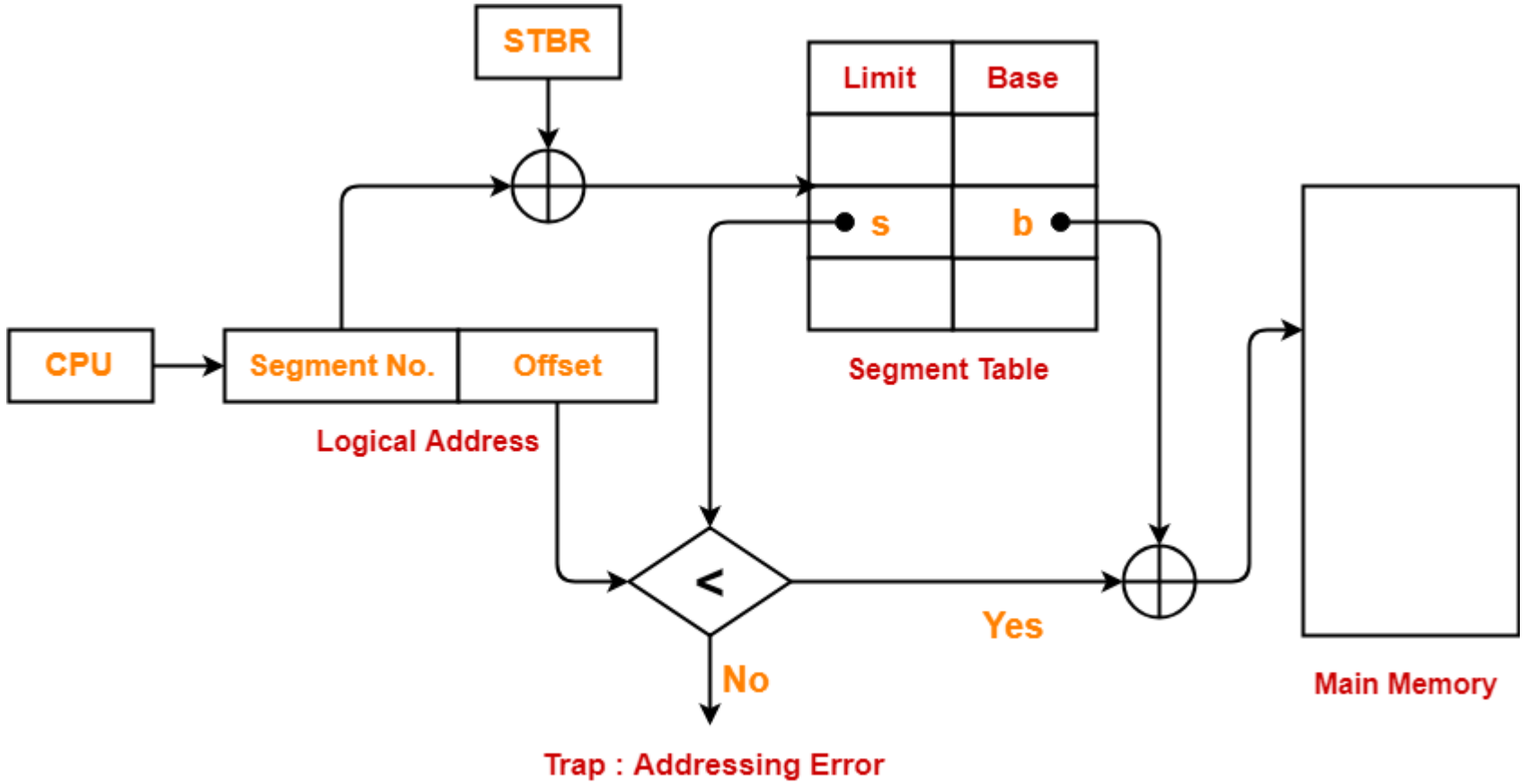
TRANSLATING LOGICAL ADDRESS INTO PHYSICAL ADDRESS

Step-02: For the generated segment number, corresponding entry is located in the segment table.
Then, segment offset is compared with the limit (size) of the segment.
Now, two cases are possible-

Case-01: Segment Offset >= Limit
If segment offset is found to be greater than or equal to the limit, a trap is generated.
Case-02: Segment Offset < Limit

- If segment offset is found to be smaller than the limit, then request is treated as a valid request.
- The segment offset must always lie in the range [0, limit-1],
- Then, segment offset is added with the base address of the segment.
- The result obtained after addition is the address of the memory location storing the required word.

TRANSLATING LOGICAL ADDRESS INTO PHYSICAL ADDRESS



Translating Logical Address into Physical Address

TRANSLATING LOGICAL ADDRESS INTO PHYSICAL ADDRESS

Advantages-

The advantages of segmentation are-
•It allows to divide the program into modules which provides better visualization.
•Segment table consumes less space as compared to page table in paging.
•It solves the problem of internal fragmentation.

Disadvantages-

The disadvantages of segmentation are-
•There is an overhead of maintaining a segment table for each process.
•The time taken to fetch the instruction increases since now two memory accesses are required.
•Segments of unequal size are not suited for swapping.
•It suffers from external fragmentation as the free space gets broken down into smaller pieces with the processes being loaded and removed from the main memory.

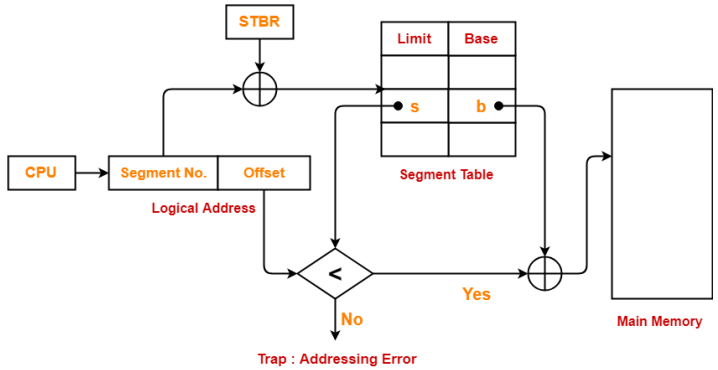
EXAMPLE

CONSIDER THE FOLLOWING SEGMENT TABLE-

Segment No.	Limit	Base
0	700	1219
1	14	2300
2	100	90
3	580	1327
4	96	1952

Which of the following logical address will produce trap addressing error?

A. 0, 430
B. 1, 11
C. 2, 100
D. 3, 425
E. 4, 95



Translating Logical Address into Physical Address

EXAMPLE

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D. 3, 425
E. 4, 95

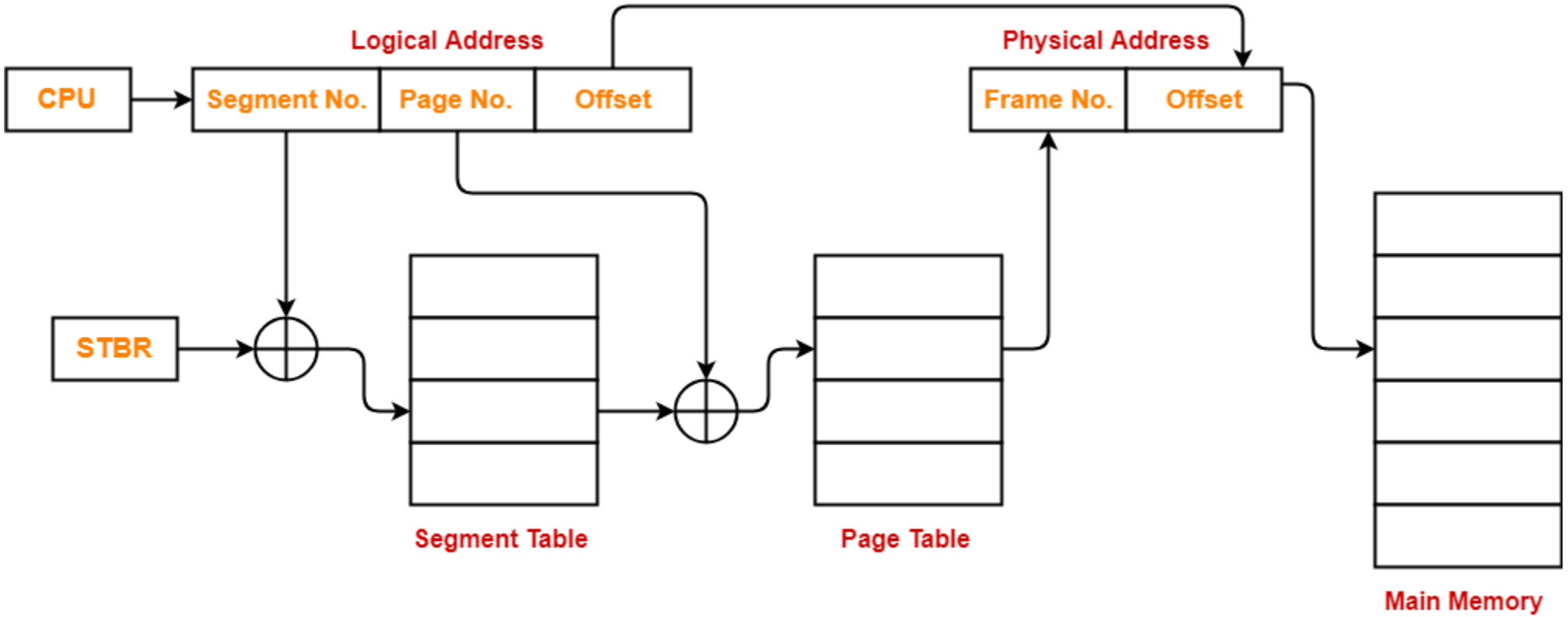
Calculate the physical address if no trap is produced.

SEGMENTATION AND PAGING

Segmented paging is a scheme that implements the combination of segmentation and paging.

- Process is first divided into segments and then each segment is divided into pages.
- These pages are then stored in the frames of main memory.
- A page table exists for each segment that keeps track of the frames storing the pages of that segment.
- Each page table occupies one frame in the main memory.
- Number of entries in the page table of a segment = Number of pages that segment is divided.
- A segment table exists that keeps track of the frames storing the page tables of segments.
- Number of entries in the segment table of a process = Number of segments that process is divided.
- The base address of the segment table is stored in the segment table base register.

TRANSLATING LOGICAL ADDRESS INTO PHYSICAL ADDRESS



Translating Logical Address into Physical Address

TRANSLATING LOGICAL ADDRESS INTO PHYSICAL ADDRESS

Advantages-

The advantages of segmented paging are-

- Segment table contains only one entry corresponding to each segment.
- It reduces memory usage.
- The size of Page Table is limited by the segment size.
- It solves the problem of external fragmentation.

Disadvantages-

The disadvantages of segmented paging are-

- Segmented paging suffers from internal fragmentation.
- The complexity level is much higher as compared to paging.

Question: Let segment size is 2^{16} W. page size =1KW.
Number of pages on segment??????????????

THANKYOU