238P Operating Systems, Fall 2018

ELF Header, Real Mode Segmentation, Paging

[Paging Slides Adapted from Anton Burtsev's Slides on System Boot for 143A Fall 17]

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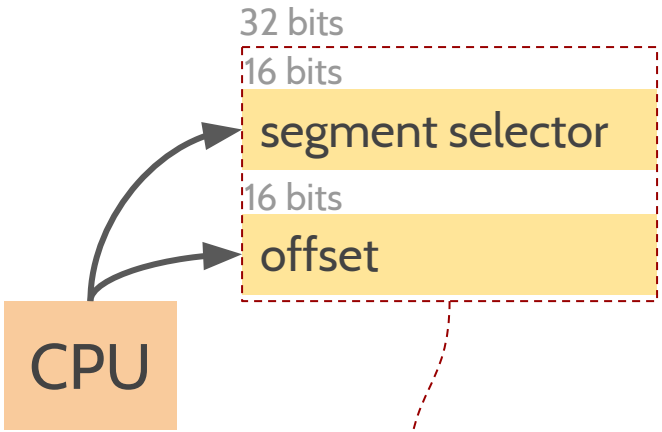
Reading ELF Header during boot

ELF structure in xv6 to read in ELF header: (code)
Where the ELF header of the kernel is read: (code)

ELF Header Contents:
OS 0 to 1: Chapter 5: The Anatomy of a Program.

Review of Segmentation during boot in Real Mode

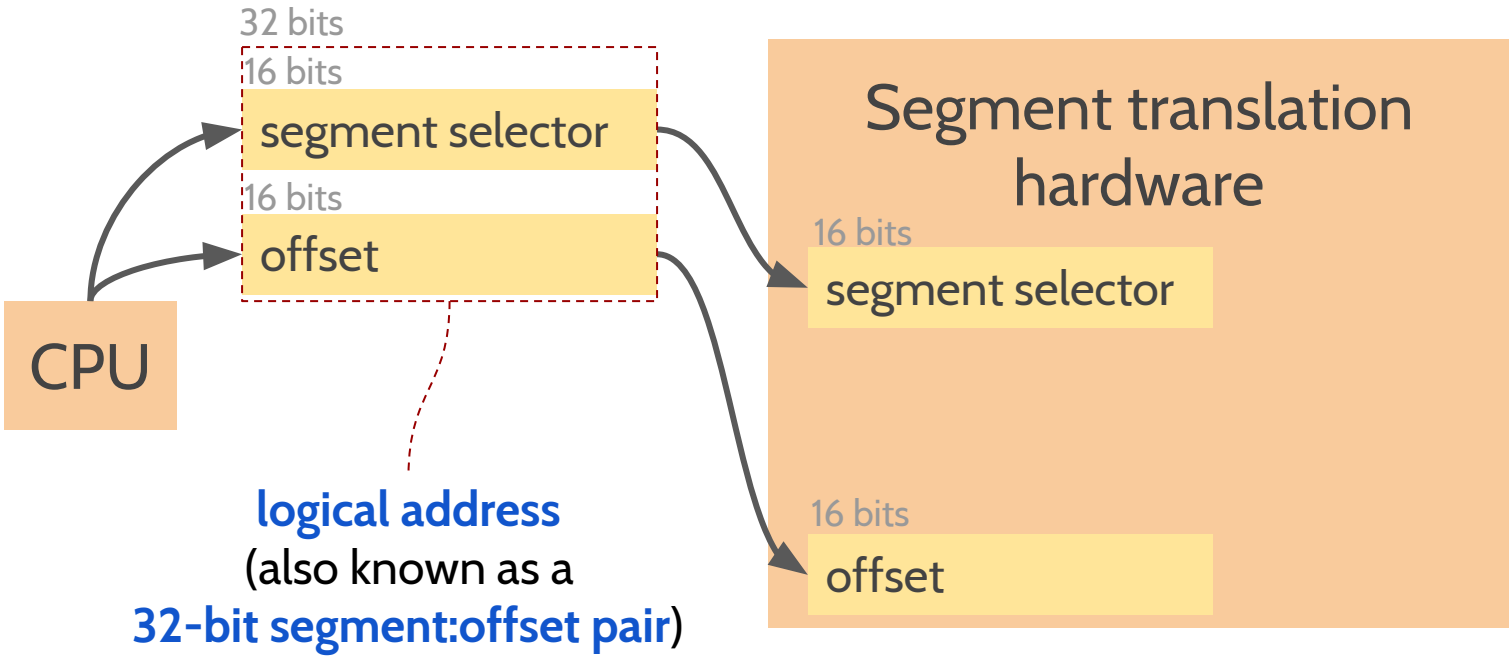
Segmentation in Real Mode



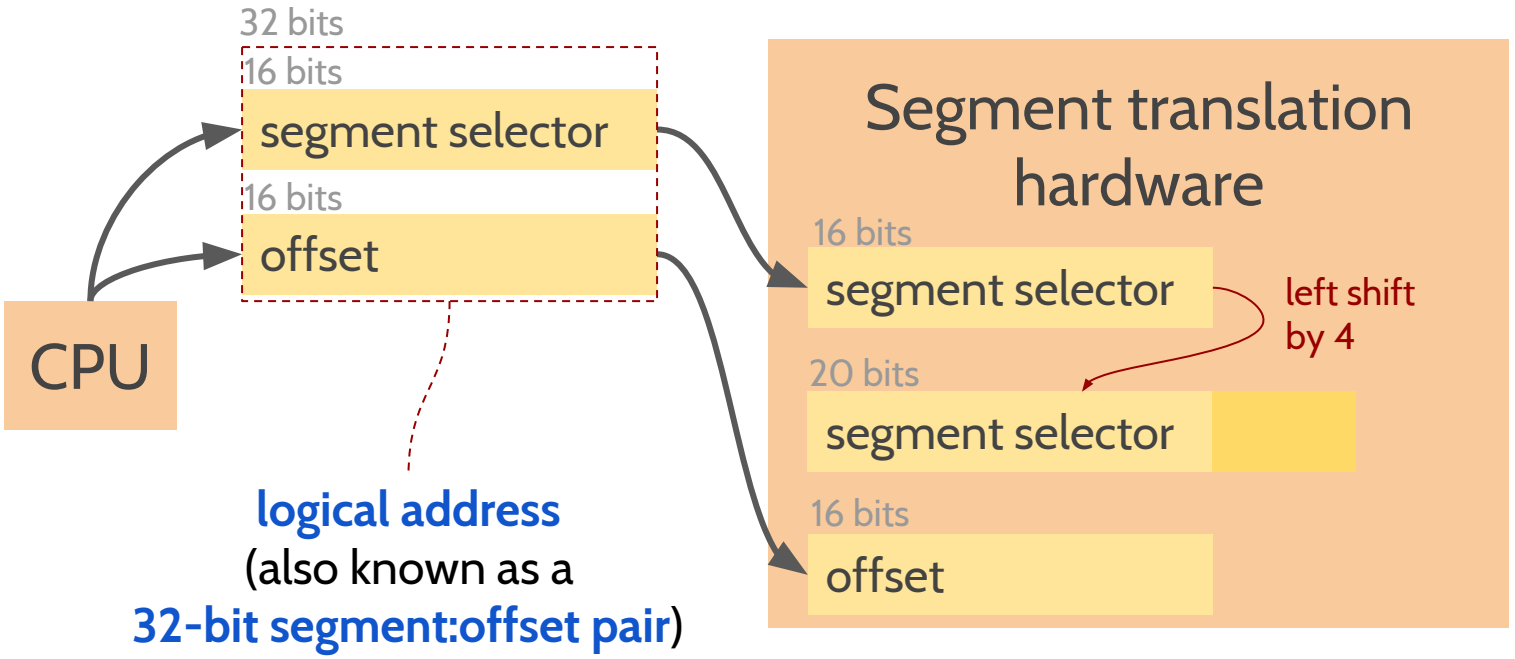
logical address
(also known as a
32-bit segment:offset pair)

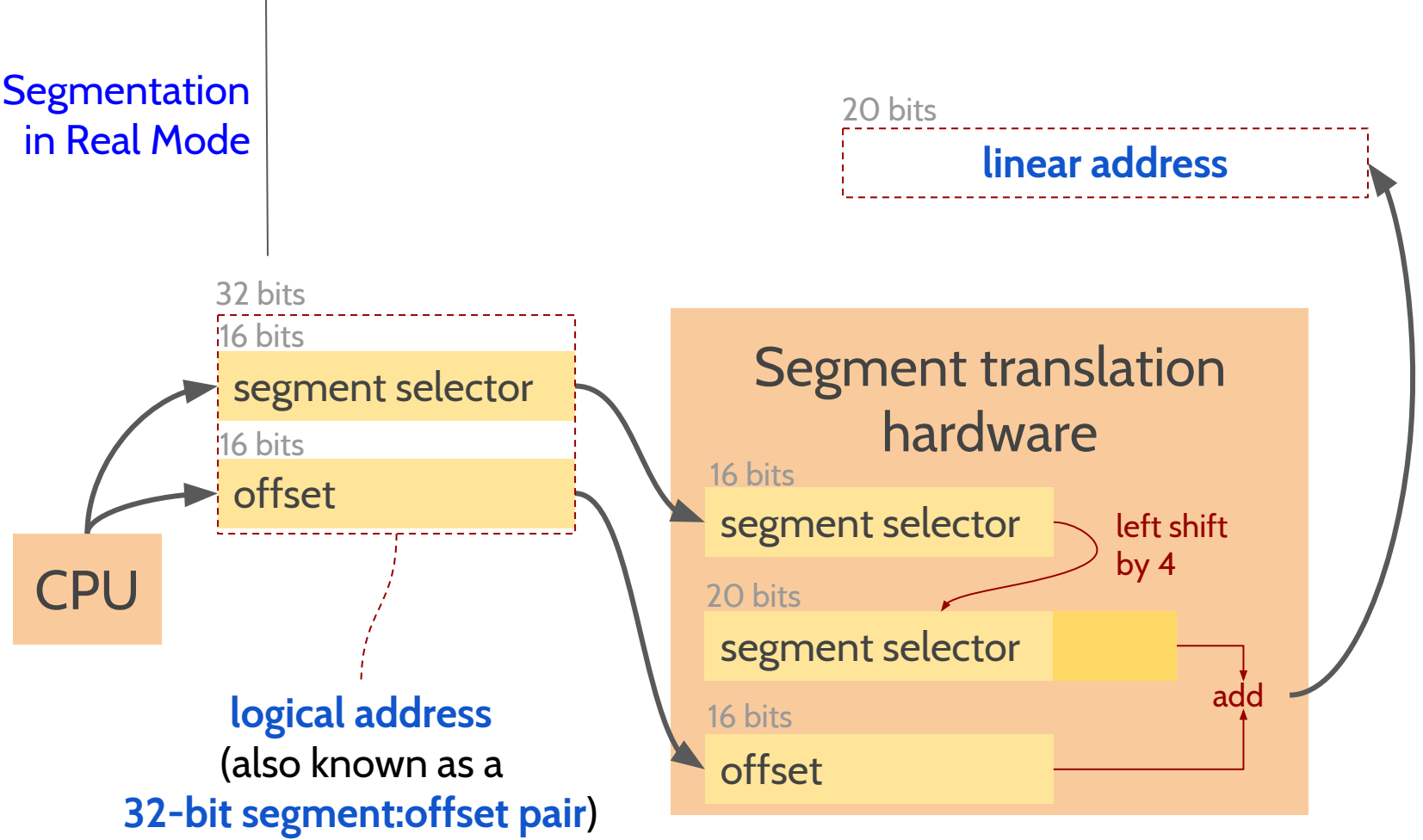
xv6 refers to this x86 logical address as a **virtual address**

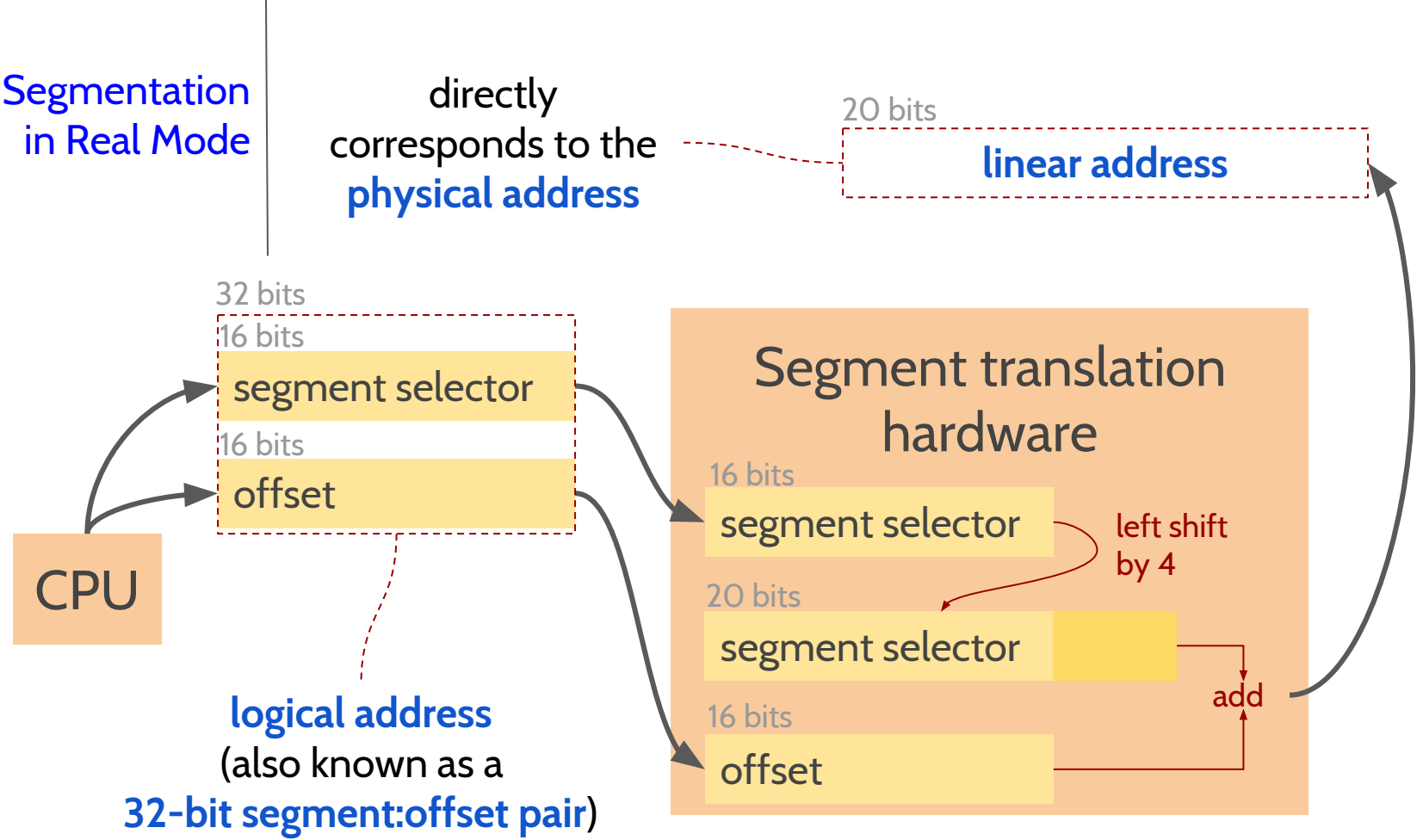
Segmentation in Real Mode

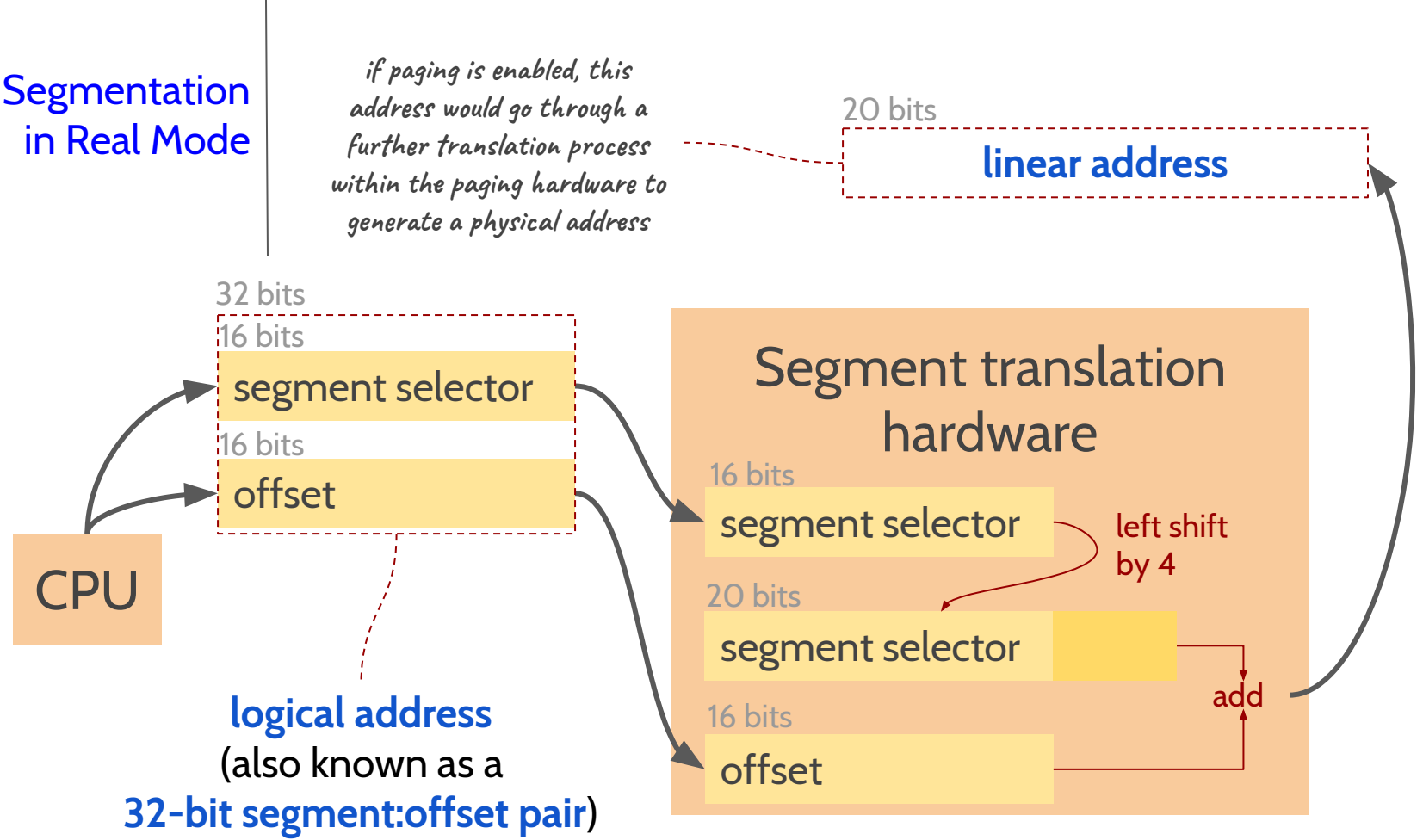


Segmentation in Real Mode

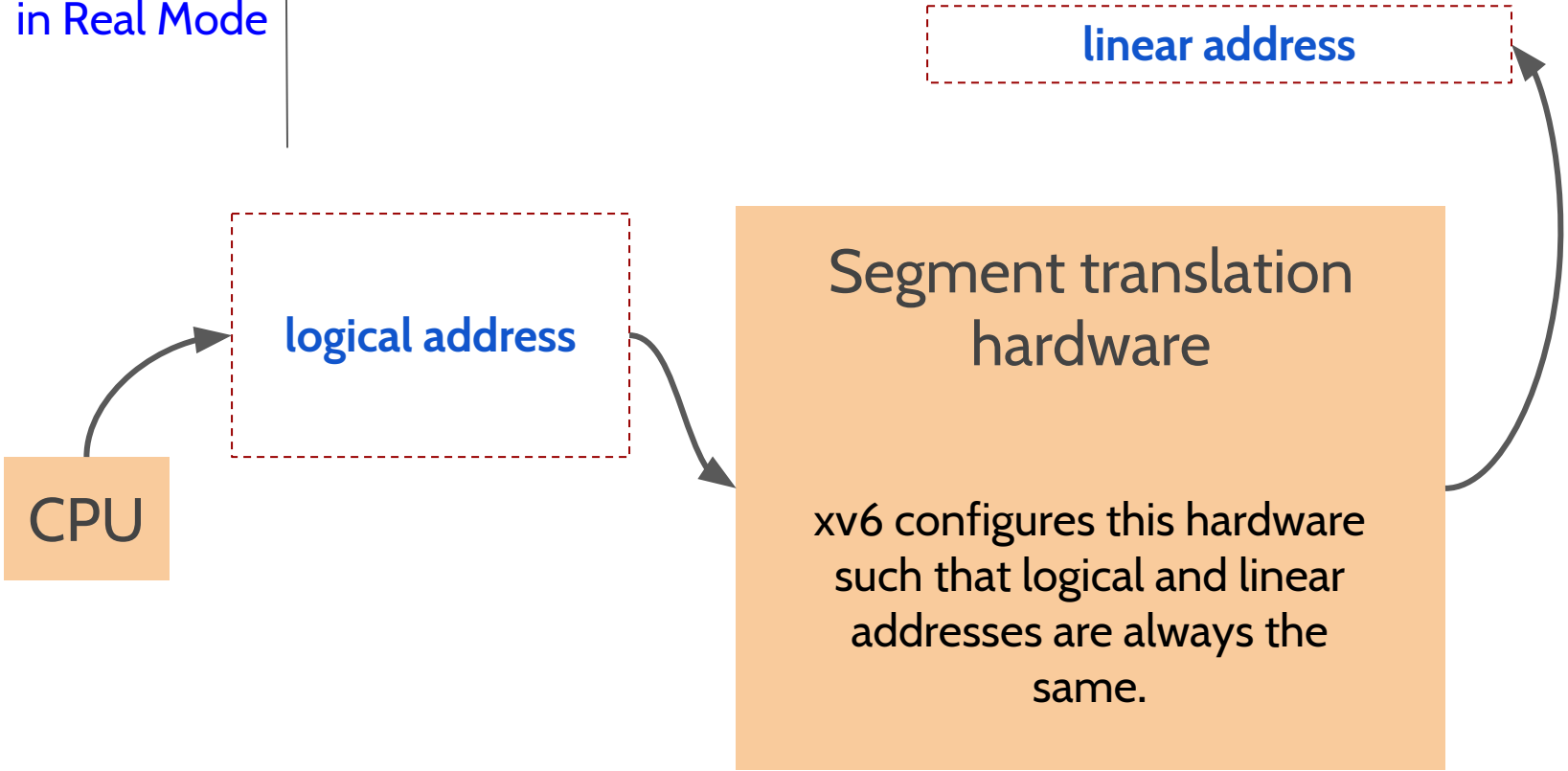



Segmentation
in Real Mode
20 bits
linear address
32 bits
16 bits
segment selector
16 bits
offset
CPU
logical address
(also known as a
32-bit segment:offset pair)
Segment translation
hardware
16 bits
segment selector
left shift
by 4
20 bits
segment selector
add
16 bits
offset


Segmentation in Real Mode
directly corresponds to the physical address
20 bits
linear address
32 bits
16 bits
segment selector
16 bits
offset
CPU
logical address
(also known as a
32-bit segment:offset pair)
Segment translation hardware
16 bits
segment selector
left shift by 4
20 bits
segment selector
add
16 bits
offset

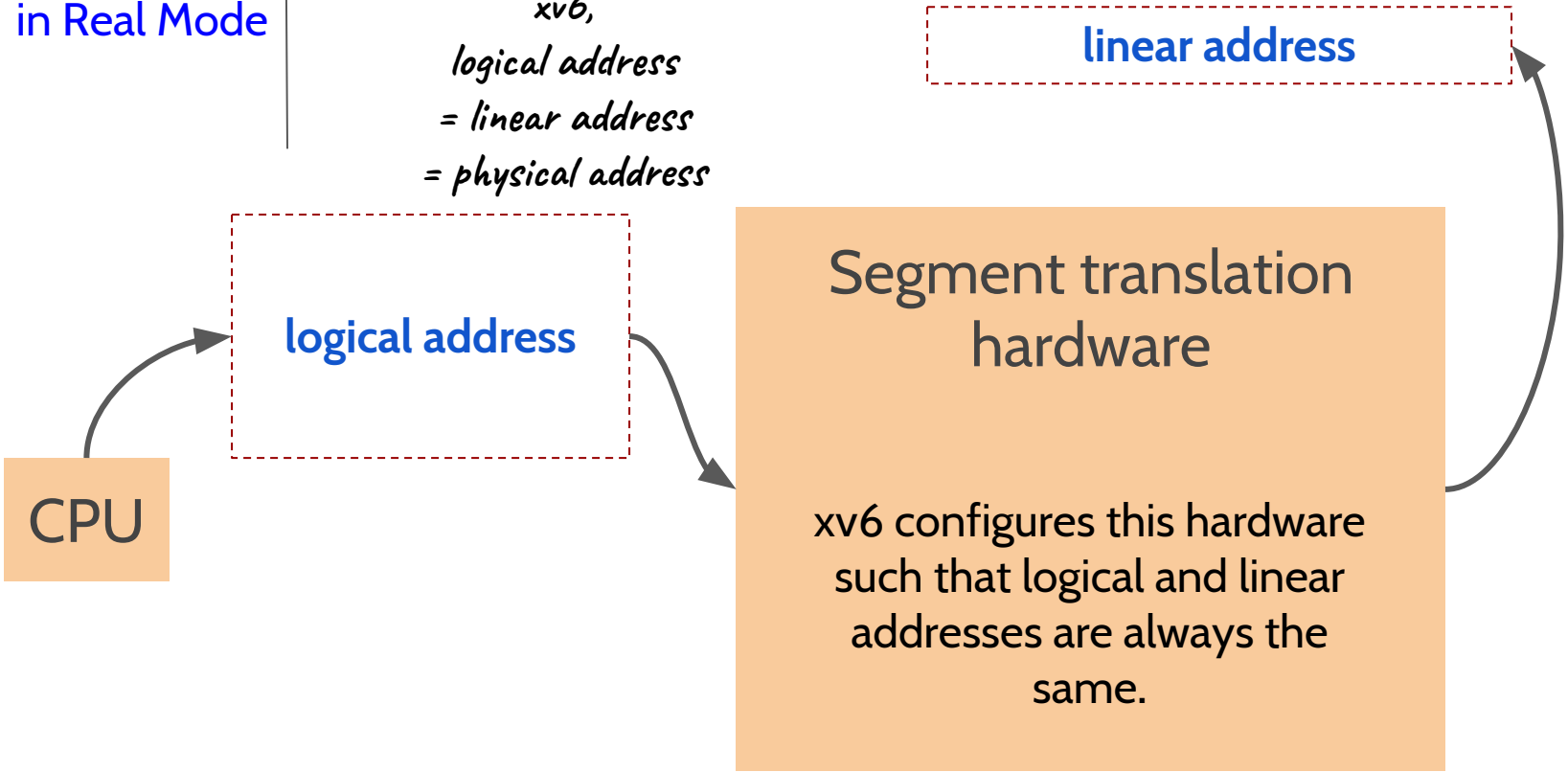

Segmentation in Real Mode
if paging is enabled, this address would go through a further translation process within the paging hardware to generate a physical address
20 bits
linear address
32 bits
16 bits
segment selector
16 bits
offset
CPU
logical address
(also known as a
32-bit segment:offset pair)
Segment translation hardware
16 bits
segment selector
left shift by 4
20 bits
segment selector
add
16 bits
offset

Segmentation in Real Mode



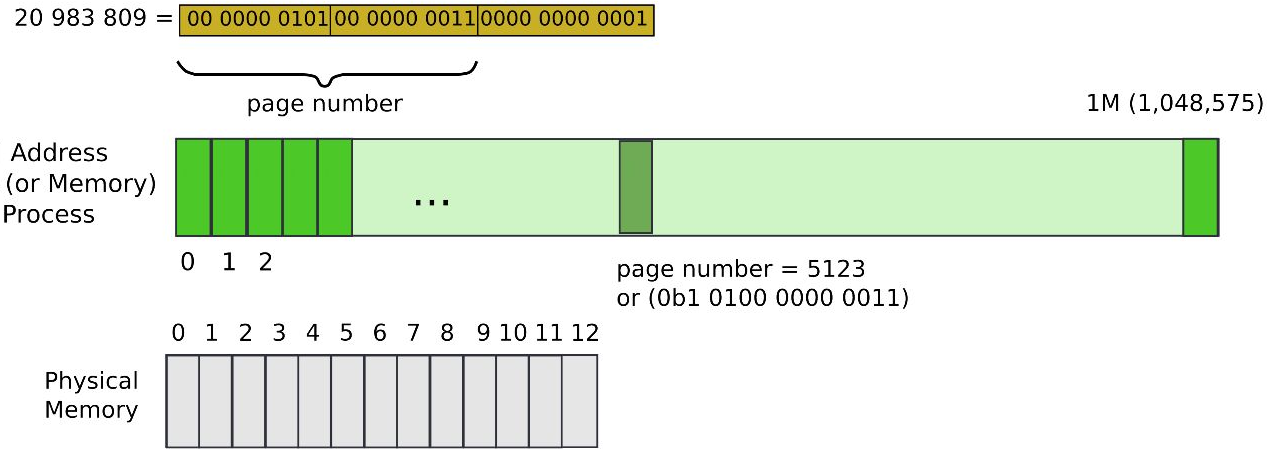
Segmentation in Real Mode

It follows (without paging) in xv6,
logical address
= linear address
= physical address

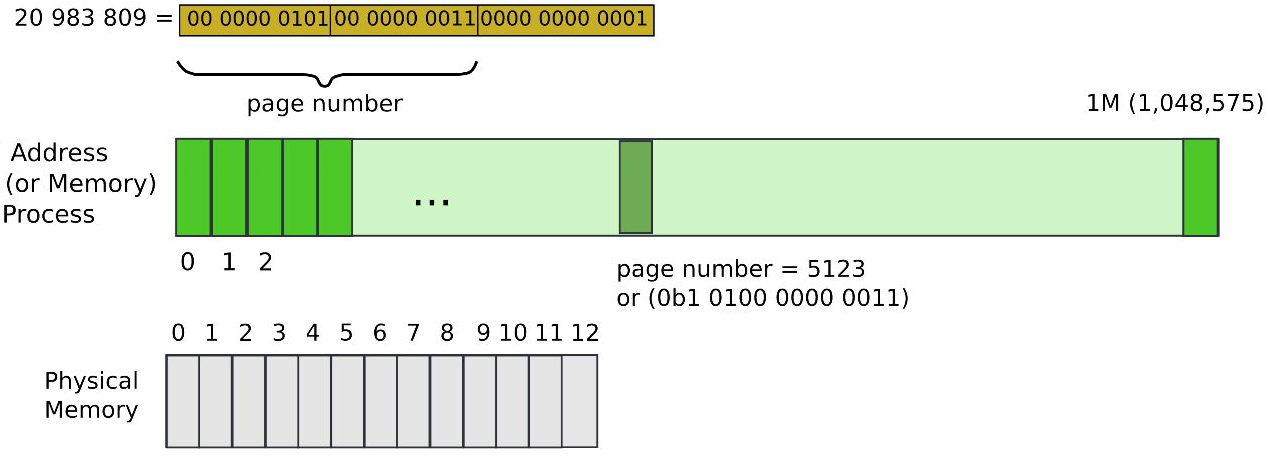


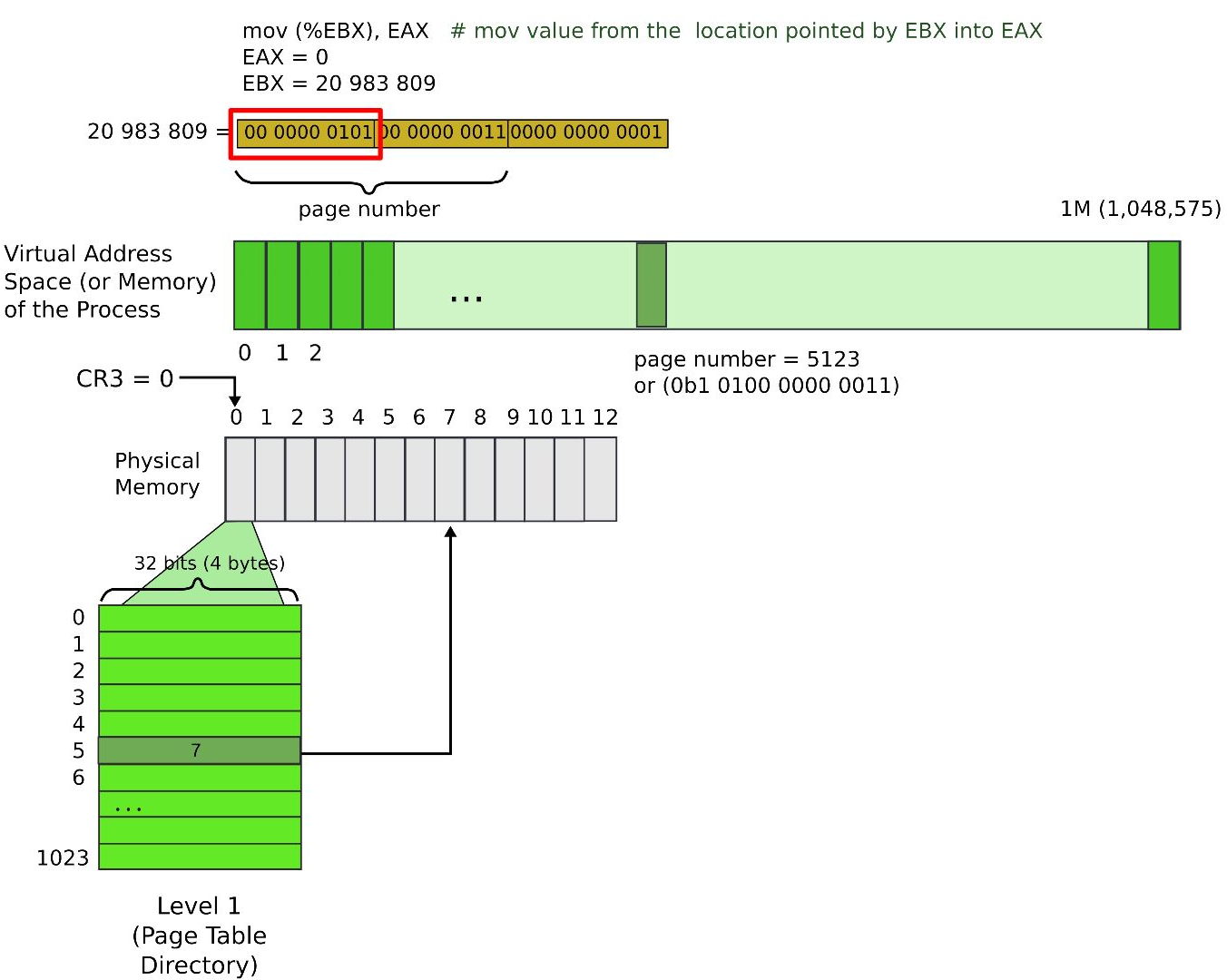
Review of Address Translation using Paging

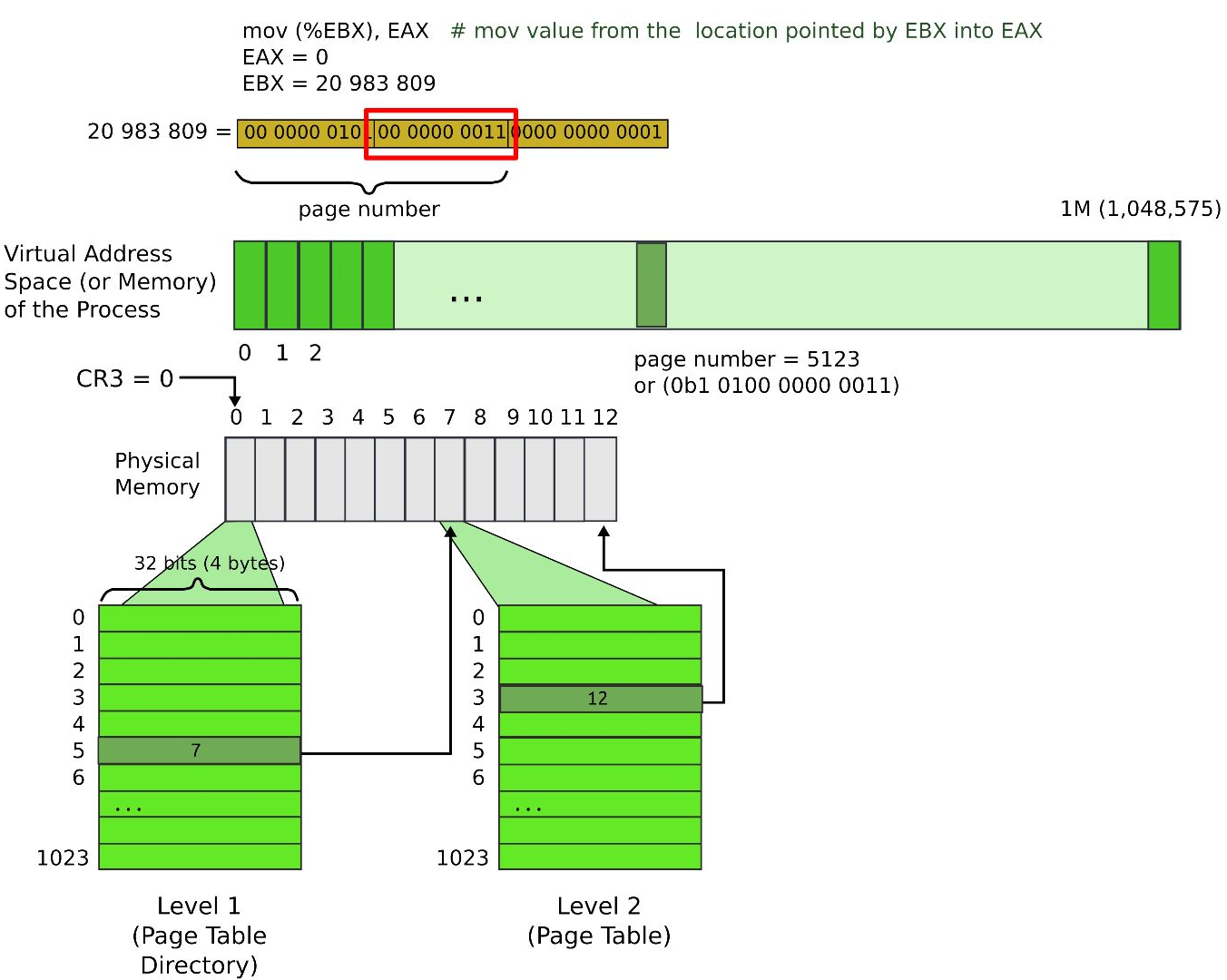
mov (%EBX), EAX # mov value from the location pointed by EBX into EAX
EAX = 0
EBX = 20 983 809

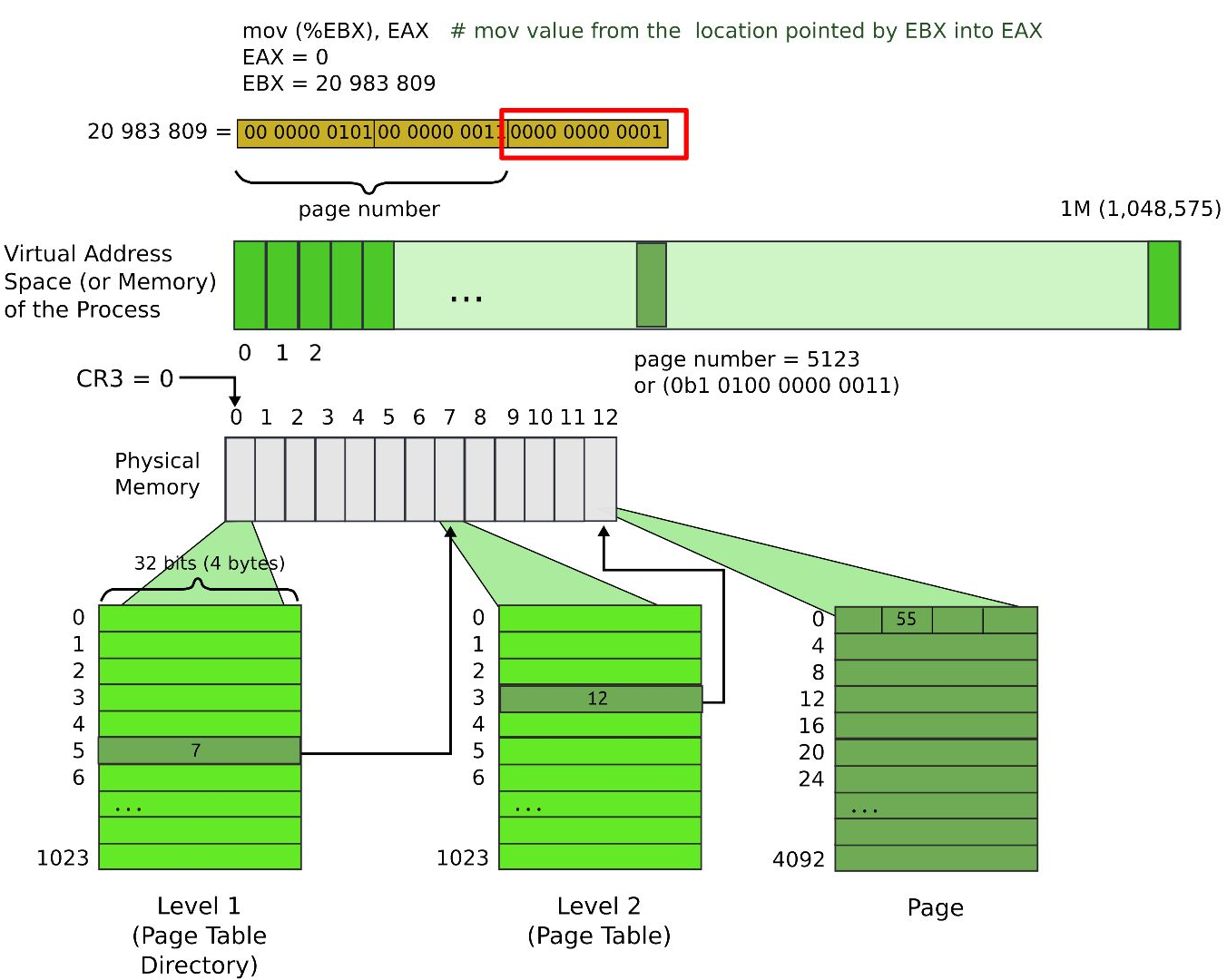


mov (%EBX), EAX # mov value from the location pointed by EBX into EAX
EAX = 0
EBX = 20 983 809




mov (%EBX), EAX # mov value from the location pointed by EBX into EAX
EAX = 0
EBX = 20 983 809
20 983 809 =
00 0000 0101
00 0000 0011
0000 0000 0001
page number
1M (1,048,575)
Virtual Address Space (or Memory) of the Process
0 1 2
page number = 5123
or (0b1 0100 0000 0011)
CR3 = 0
0 1 2 3 4 5 6 7 8 9 10 11 12
Physical Memory
32 bits (4 bytes)
0
1
2
3
4
5
6
7
1023
Level 1 (Page Table Directory)


mov (%EBX), EAX # mov value from the location pointed by EBX into EAX
EAX = 0
EBX = 20 983 809
20 983 809 = 00 0000 010 00 0000 0011 0000 0000 0001
page number
1M (1,048,575)
Virtual Address Space (or Memory) of the Process
0 1 2
page number = 5123
or (0b1 0100 0000 0011)
CR3 = 0
0 1 2 3 4 5 6 7 8 9 10 11 12
Physical Memory
32 bits (4 bytes)
0 1 2 3 4 5 6 7 ... 1023
0 1 2 3 4 5 6 12 ... 1023
Level 1 (Page Table Directory)
Level 2 (Page Table)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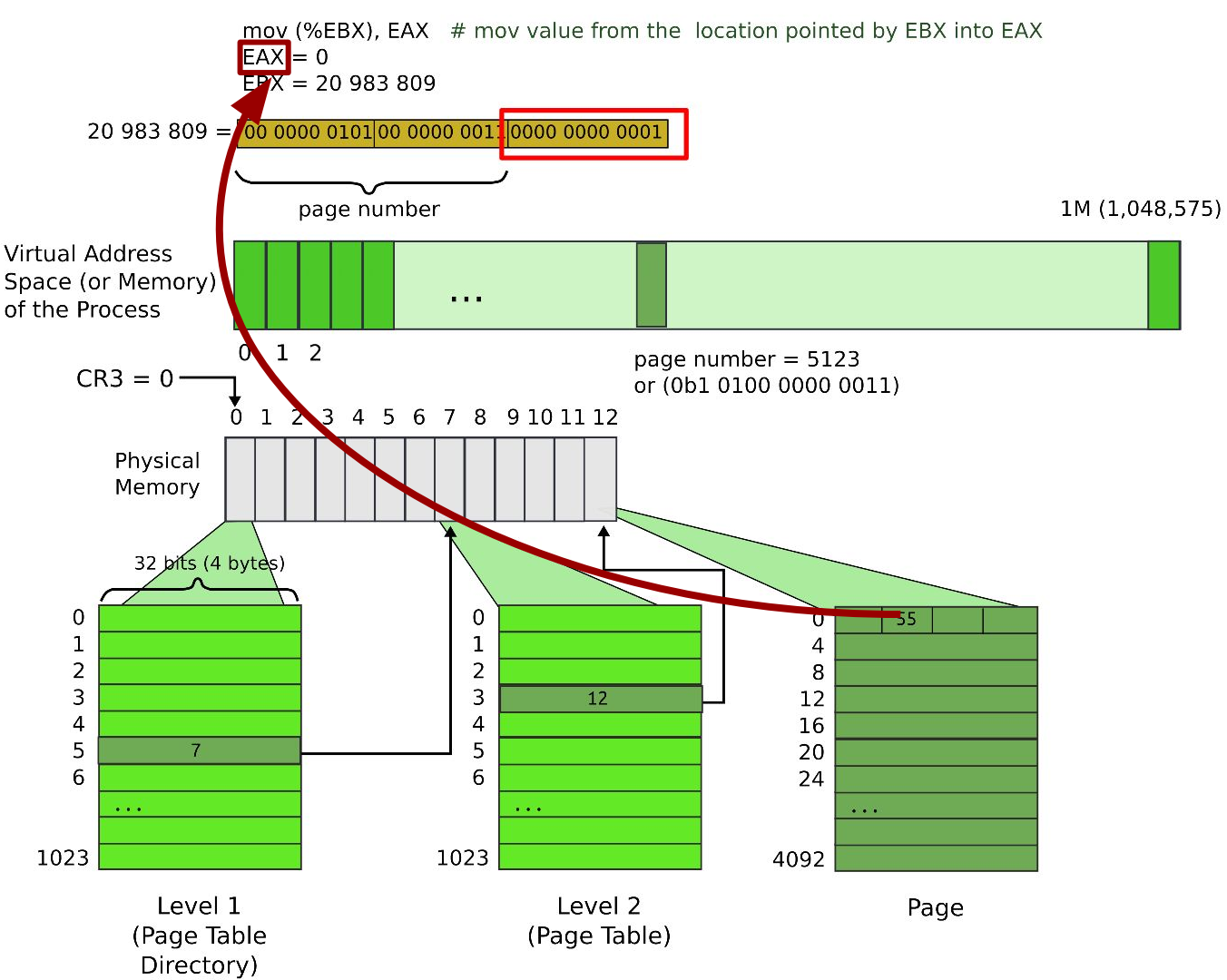
20 983 809 =
00 0000 0101
00 0000 0011
0000 0000 0001
page number
1M (1,048,575)
Virtual Address Space (or Memory) of the Process
0 1 2
page number = 5123
or (0b1 0100 0000 0011)
CR3 = 0
0 1 2 3 4 5 6 7 8 9 10 11 12
Physical Memory
32 bits (4 bytes)
0
1
2
3
4
5
6
1023
7
12
55
0
4
8
12
16
20
24
4092
Level 1 (Page Table Directory)
Level 2 (Page Table)
Page


mov (%EBX), EAX # mov value from the location pointed by EBX into EAX
EAX = 0
EBX = 20 983 809
20 983 809 = 0000 0000 0101 00 0000 0011 0000 0000 0001
page number
1M (1,048,575)
Virtual Address Space (or Memory) of the Process
0 1 2
page number = 5123
or (0b1 0100 0000 0011)
CR3 = 0
0 1 2 3 4 5 6 7 8 9 10 11 12
Physical Memory
32 bits (4 bytes)
0 1 2 3 4 5 6 7 ... 1023
0 1 2 3 4 5 6 12 ... 1023
0 4 8 12 16 20 24 55 ... 4092
Level 1 (Page Table Directory)
Level 2 (Page Table)
Page