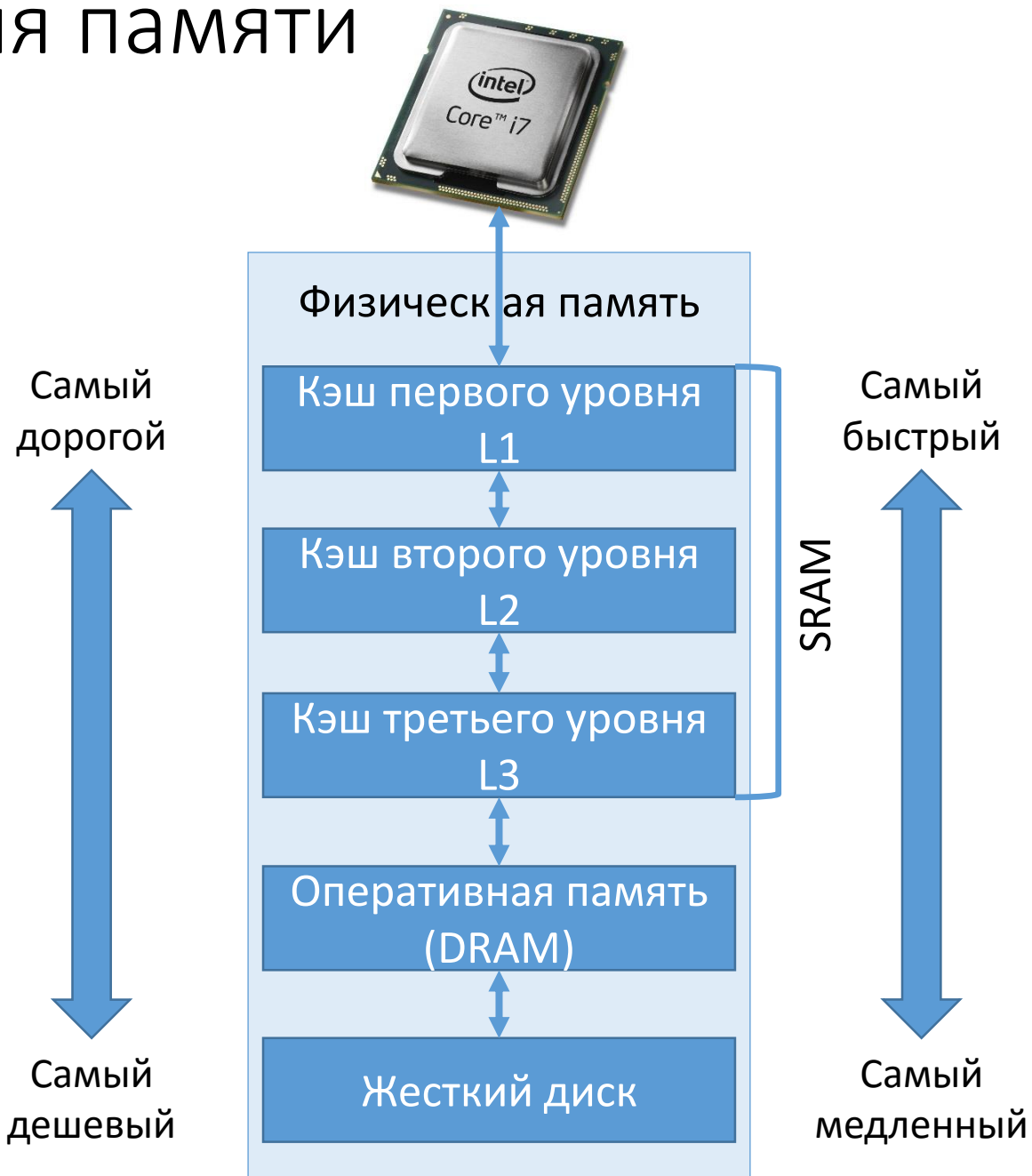
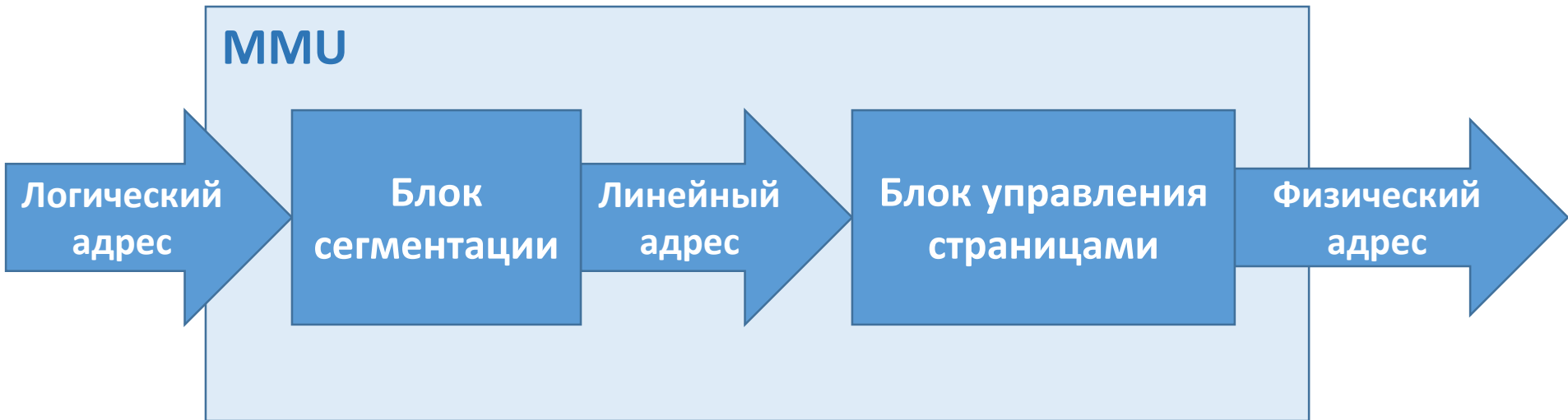


Управление памятью

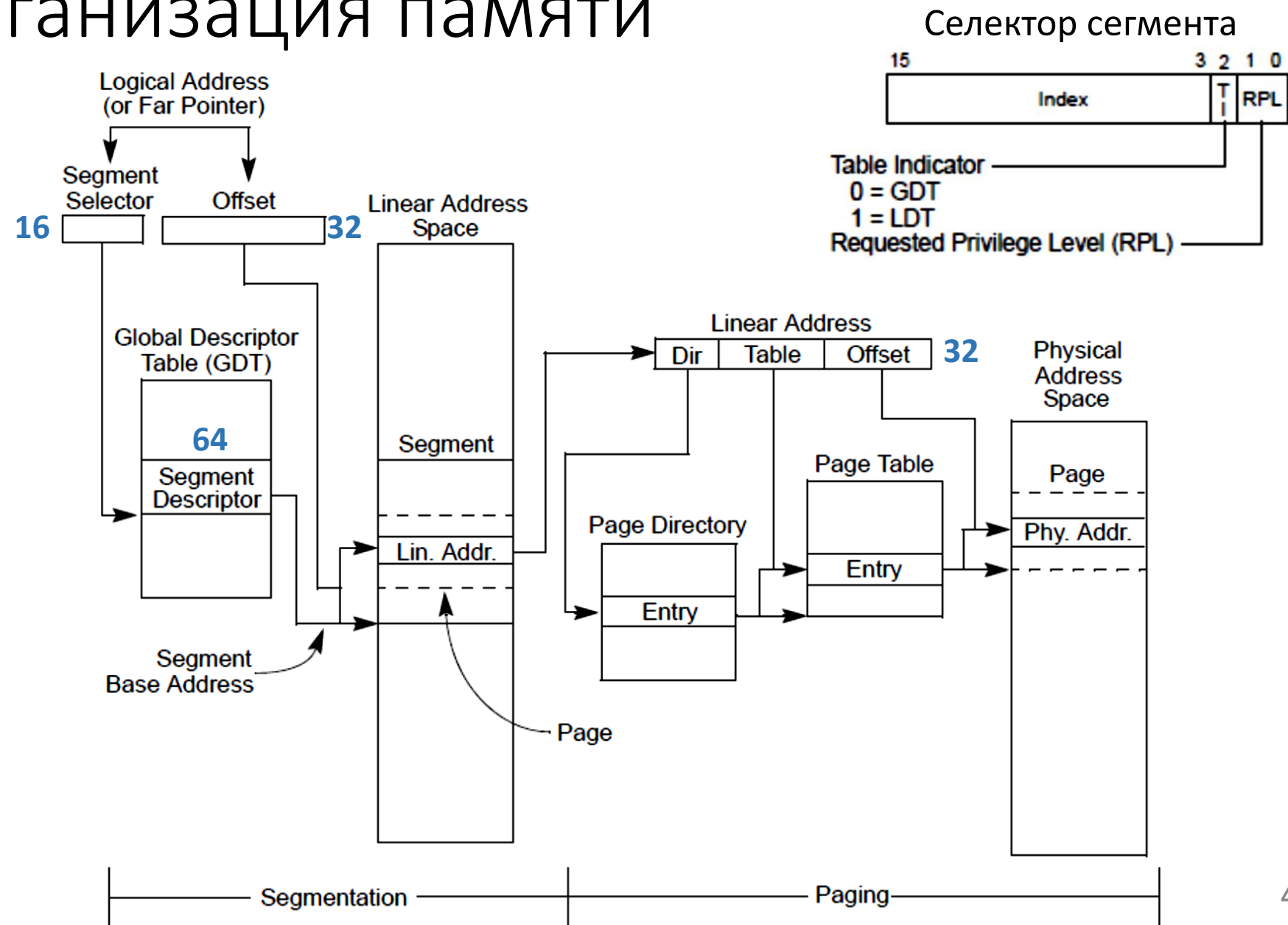
# Иерархия памяти



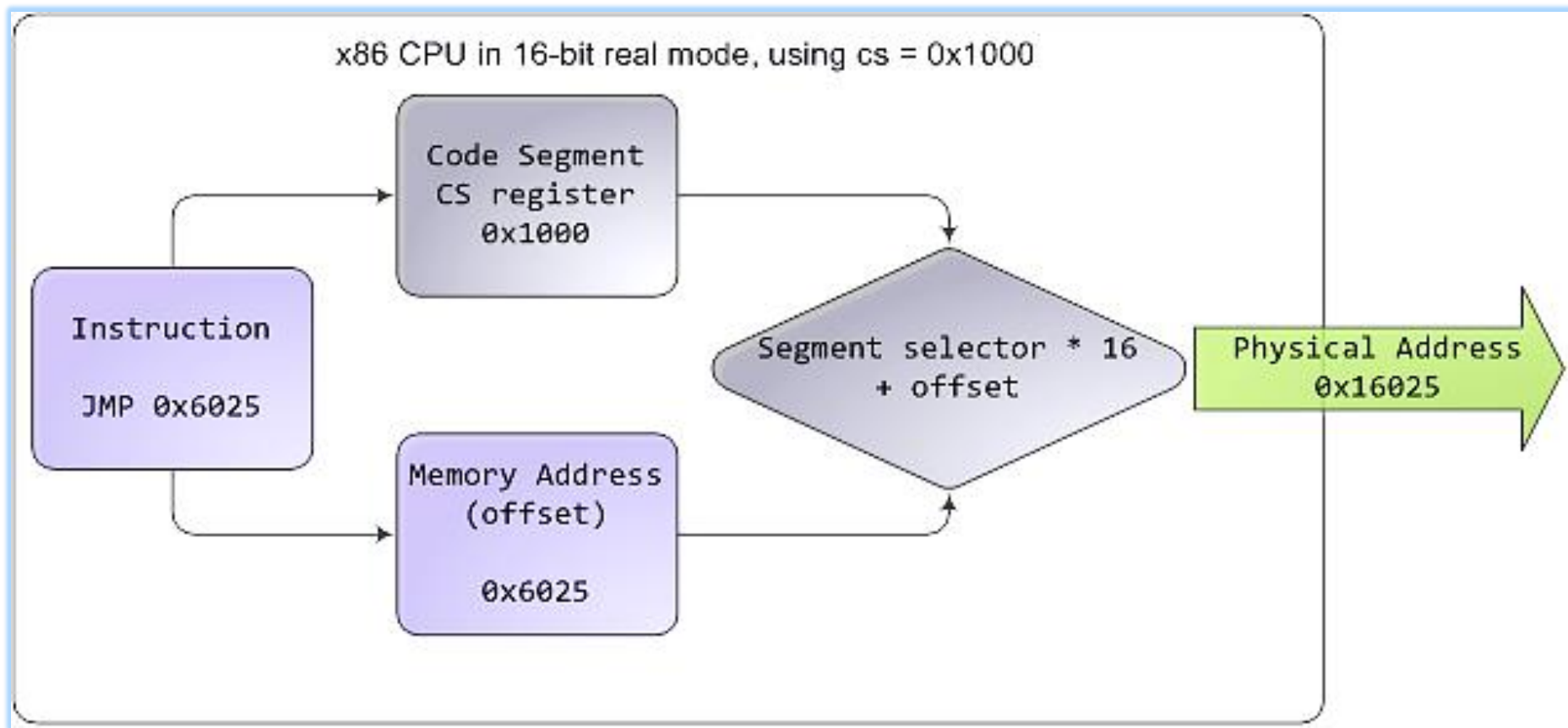
# Блок управления памятью (MMU)



# Сегментация и страничная организация памяти

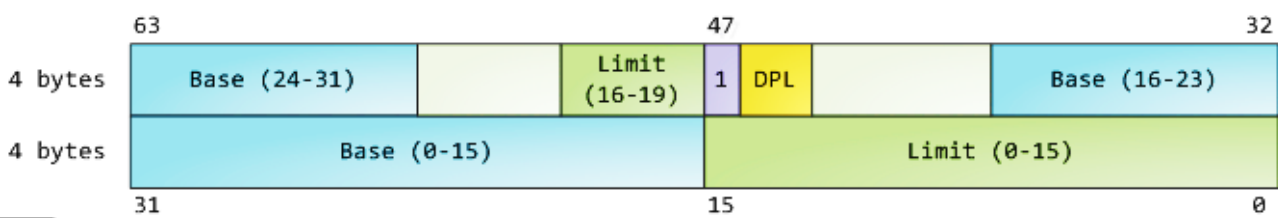


# Сегментация в реальном режиме

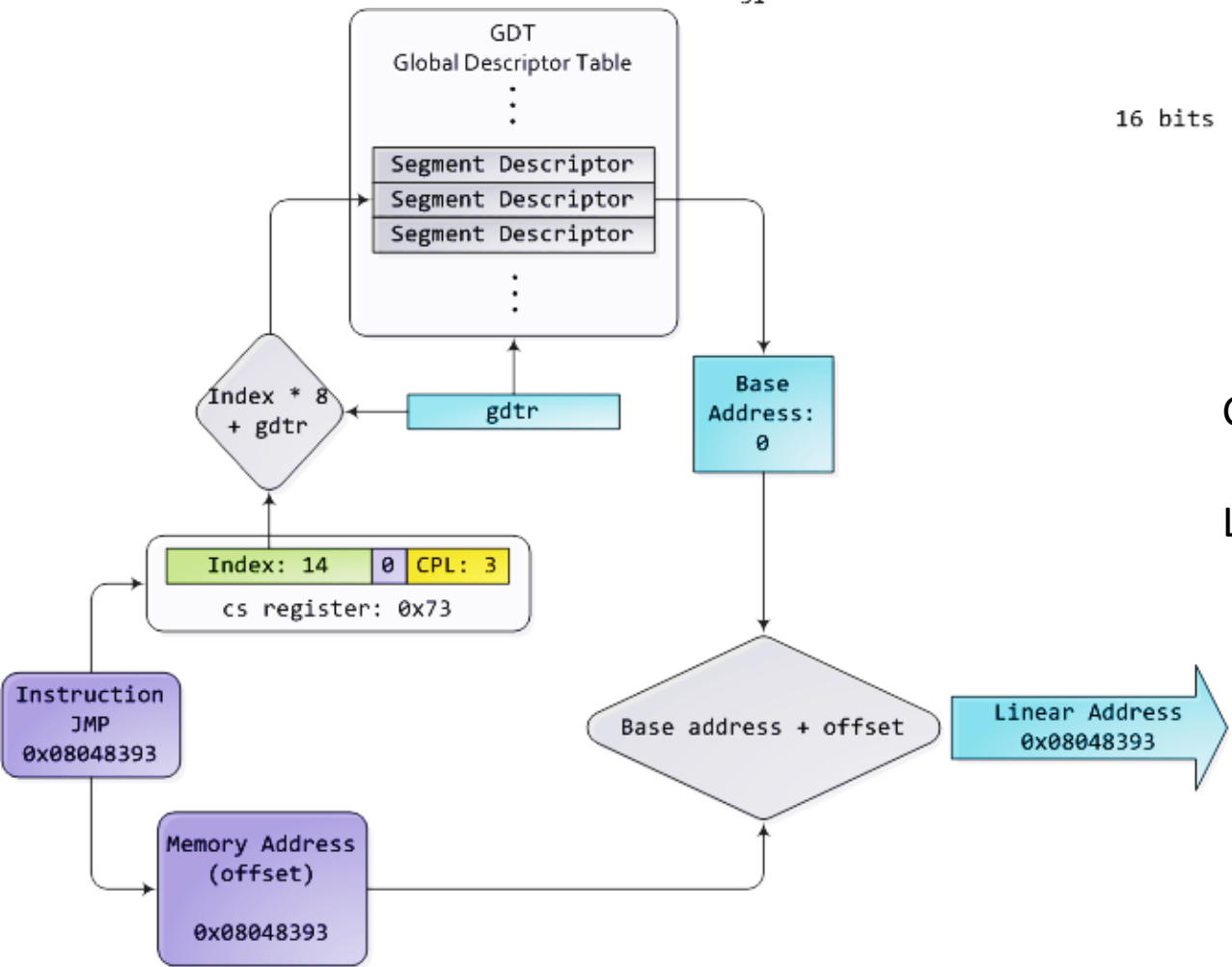
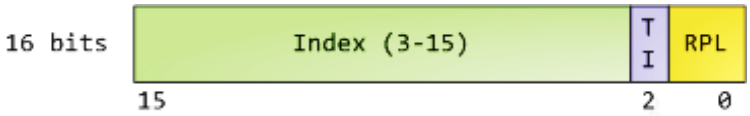


# Сегментация в защищенном режиме

Segment Descriptor



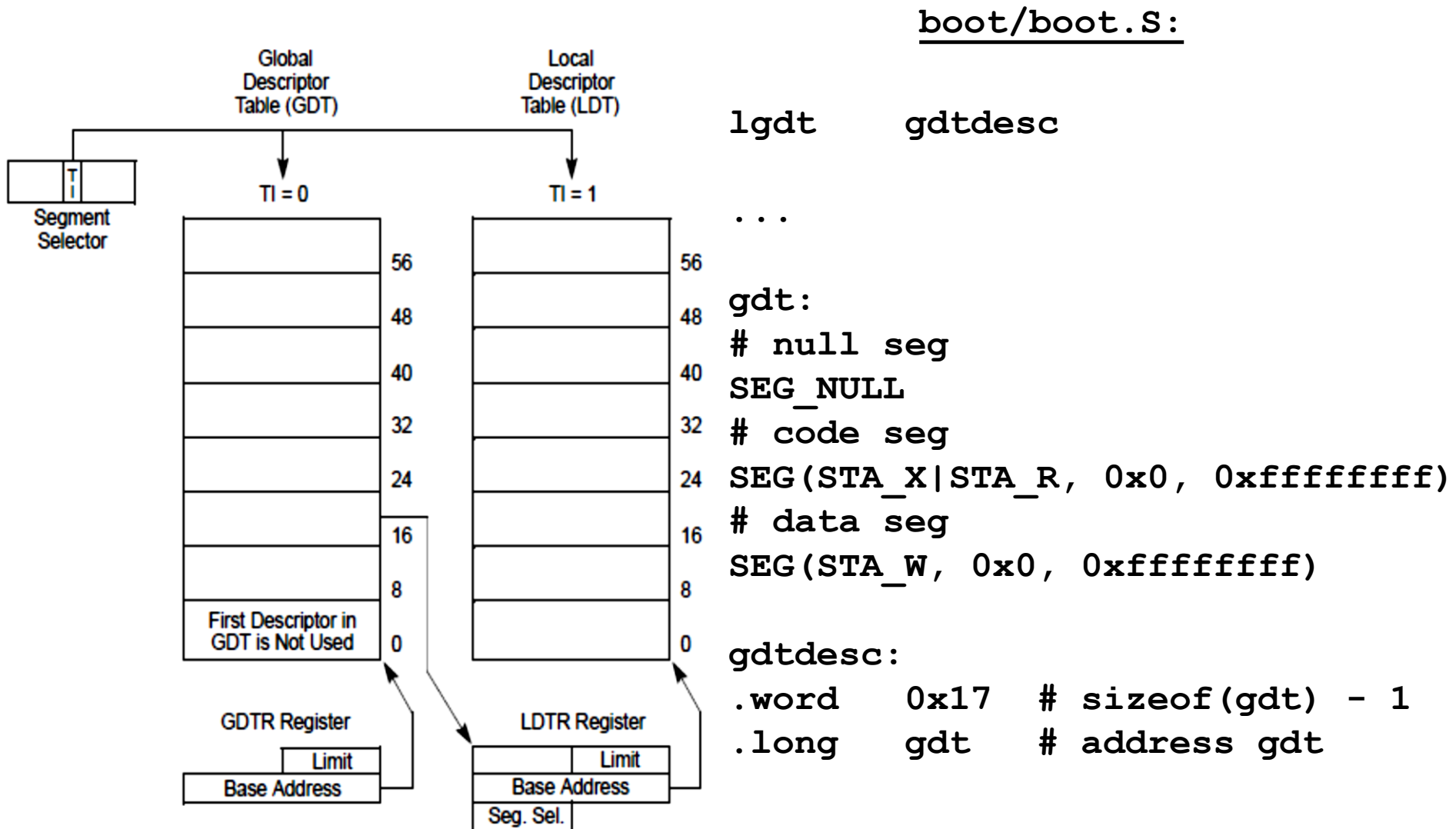
Segment Selector



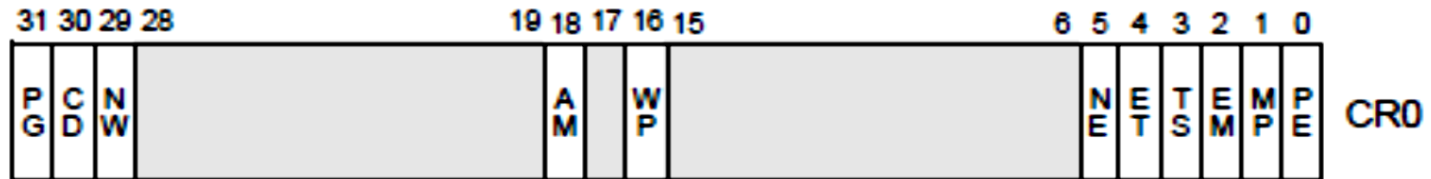
GDT – Global Table Descriptor

LDT – Local Table Descriptor

# Глобальная и локальная таблицы дескрипторов

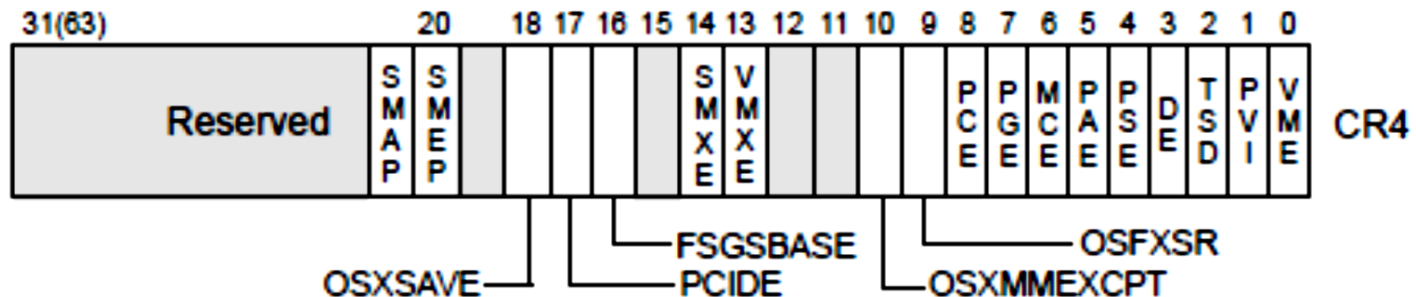


# Страничная трансляция



CR0.PG = 0, страничная трансляция не используется

CR0.PG = 1, страничная трансляция используется



CR4.PAE = 0, 32-разрядная страничная трансляция

CR4.PAE = 1, страничная трансляция в режиме PAE (Physical address extension)

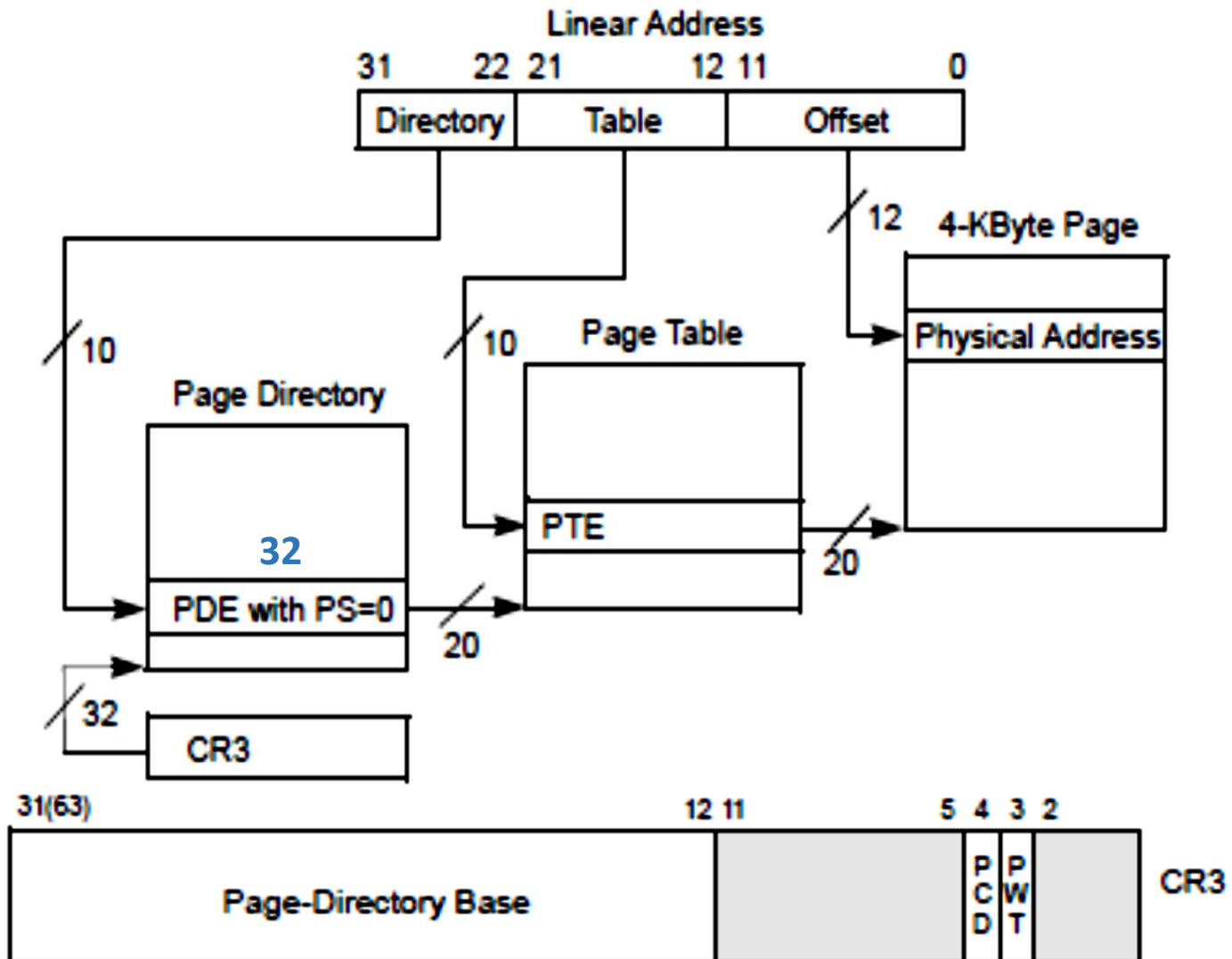
CR4.PAE = 1, IA32\_EFER.LME = 1, страничная трансляция в режиме IA-32e



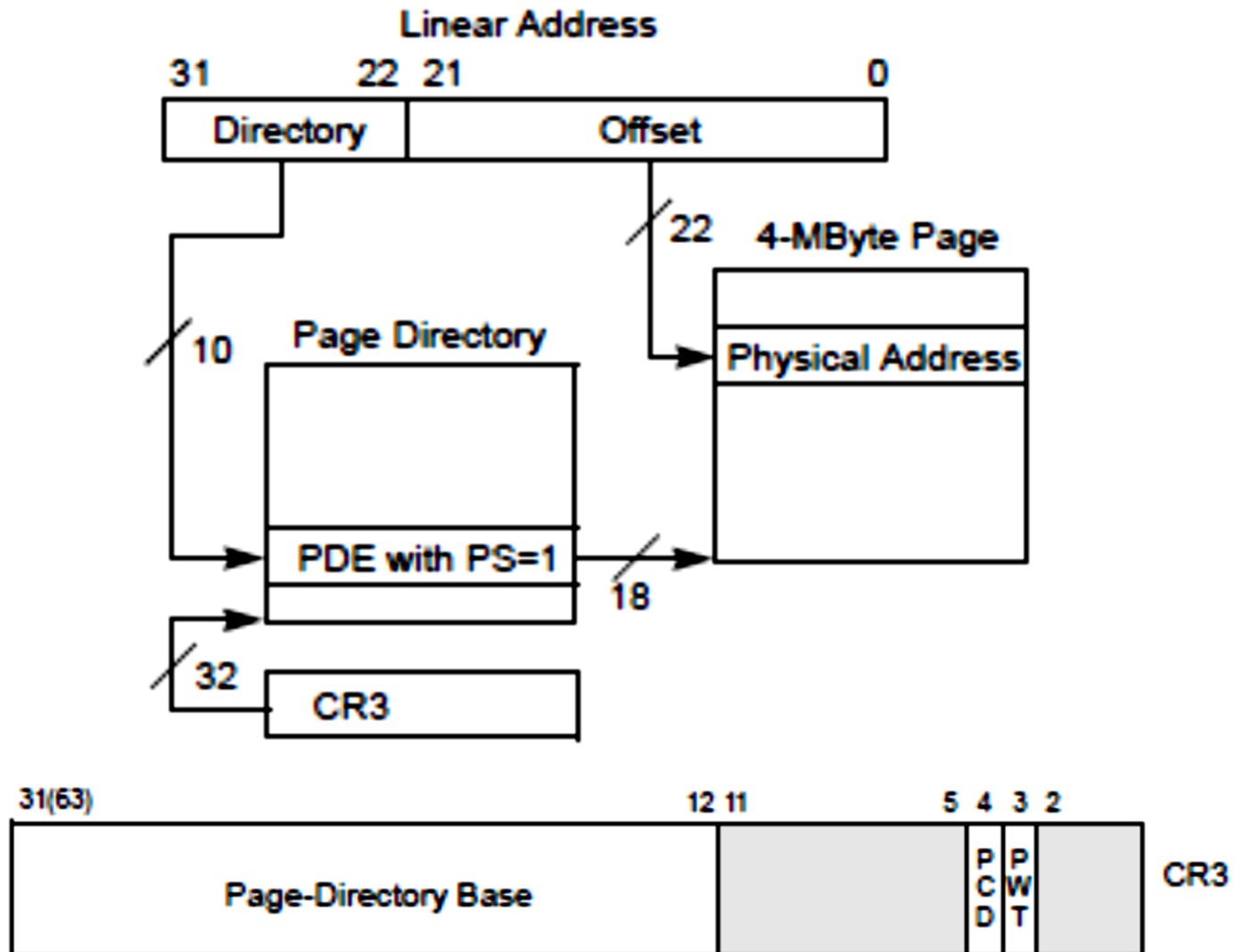
# Режимы страничной трансляции

Режим	PG в CR0	PAE в CR4	LME в IA32_EFER	Длина линейного адреса	Длина физического адреса	Размеры страниц
Откл.	0	-	-	32	32	-
32-разр.	1	0	0	32	до 40 бит	4 Кб 4 Мб
PAE	1	1	0	32	до 52 бит	4 Кб 2 Мб
IA-32e	1	1	1	48	до 52 бит	4 Кб 2 Мб 1 Гб

# 32-разрядная страничная трансляция (размер страницы = 4 Кбайта)



# 32-разрядная страничная трансляция (размер страницы = 4 Мбайта)



# Элементы структур данных при страничной трансляции

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
Address of page directory																				Ignored					P C D	PW T	Ignored			CR3			
Bits 31:22 of address of 4MB page frame										Reserved (must be 0)				Bits 39:32 of address <sup>2</sup>				P A T	Ignored	G	1	D	A	P C D	PW T	U / S	R / W	1	PDE: 4MB page				
Address of page table																				Ignored				0	I g n	A	P C D	PW T	U / S	R / W	1	PDE: page table	
Ignored																											0	PDE: not present					
Address of 4KB page frame																				Ignored	G	P A T	D	A	P C D	PW T	U / S	R / W	1	PTE: 4KB page			
Ignored																											0	PTE: not present					

# Страничная трансляция в JOS

## **kern/entry.S**

Реализует простой каталог страниц, который транслирует линейные адреса из диапазона [KERNBASE, KERNBASE+4MB) в физические адреса из диапазона [0, 4MB)

```
#define KERNBASE 0xF0000000 (inc/memlayout.h)
```

## **kern/entrypgdir.c**

Таблица страниц **entry\_pgtable[NPTENTRIES]**

Элемент 0 таблицы страниц отображается на физическую страницу 0, элемент 1 – на физическую страницу 1 и т.д.

# Страничная трансляция в JOS

`inc/mmu.h`

Содержит определения для структур данных, относящихся к страничной и сегментной трансляциям

Линейный адрес



# Страничная трансляция в JOS

`inc/mmu.h`

Содержит определения для структур данных, относящихся к страничной и сегментной трансляциям

```
#define NPDENTRIES      1024
#define NPTENTRIES      1024
#define PGSIZE          4096
#define PTSIZE          (PGSIZE*NPTENTRIES)
#define PTXSHIFT        12
#define PDXSHIFT        22
```

# Страничная трансляция в JOS

`inc/mmu.h`

Содержит определения для структур данных, относящихся к страничной и сегментной трансляциям

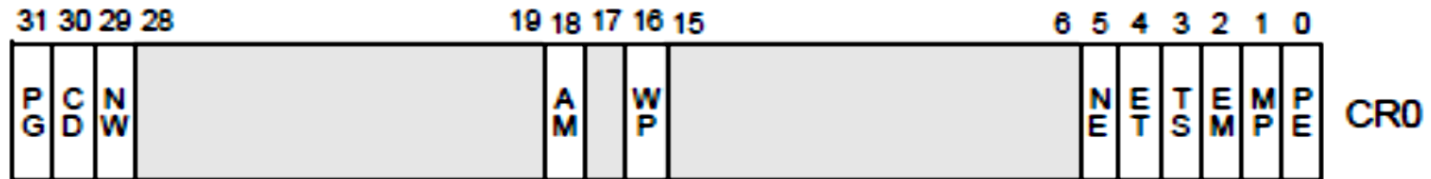
```
#define PGNUM(la) (((uintptr_t) (la)) >> PTXSHIFT)
#define PDX(la) (((uintptr_t) (la)) >> PDXSHIFT) & 0x3FF
#define PTX(la) (((uintptr_t) (la)) >> PTXSHIFT) & 0x3FF
#define PGOFF(la) (((uintptr_t) (la)) & 0xFFF)

#define PGADDR(d, t, o)
    ((void*) ((d) << PDXSHIFT | (t) << PTXSHIFT | (o)))

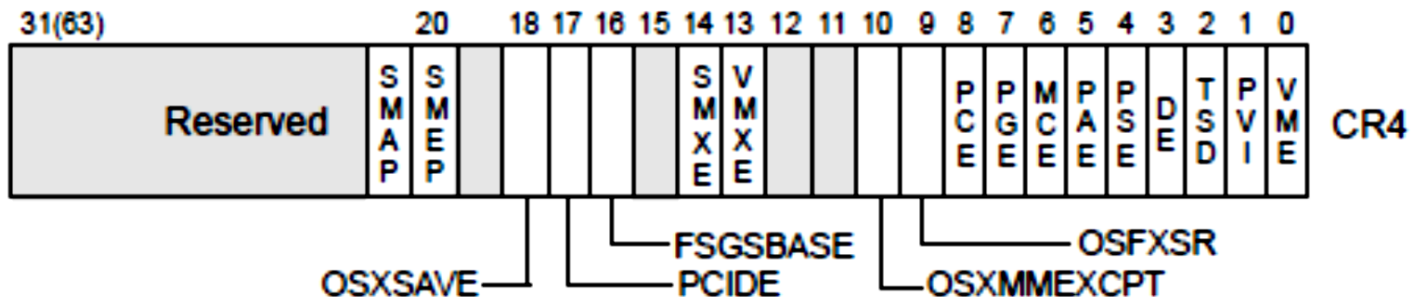
PGADDR(PDX(la), PTX(la), PGOFF(la))
```



# Страничная трансляция в режиме PAE

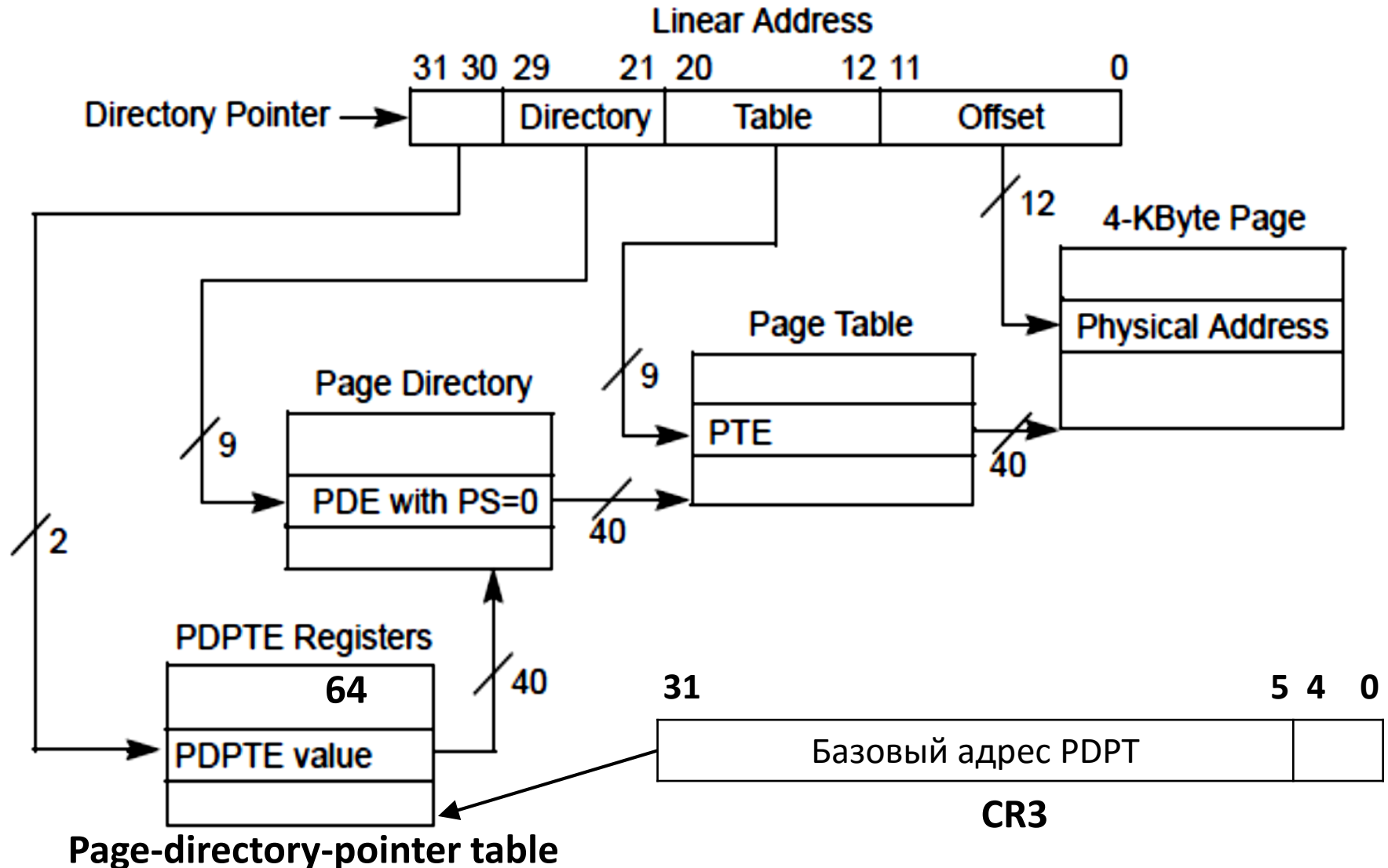


CR0.PG = 1, страничная трансляция используется



CR4.PAE = 1, страничная трансляция в режиме PAE (Physical address extension)

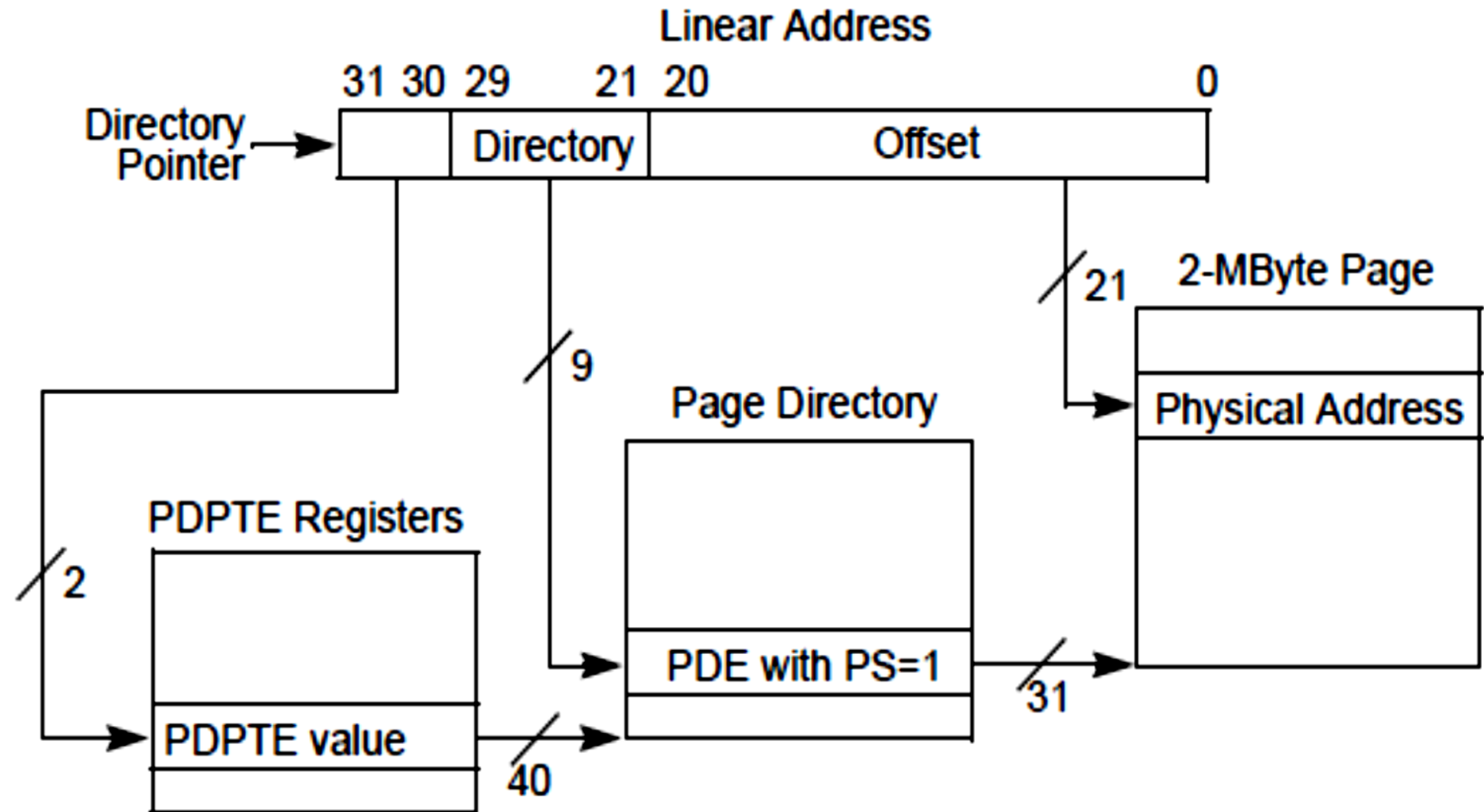
# Страничная трансляция в режиме PAE (размер страницы = 4 Кбайта)



# PAE Page-Directory-Pointer-Table Entry (PDPTE)

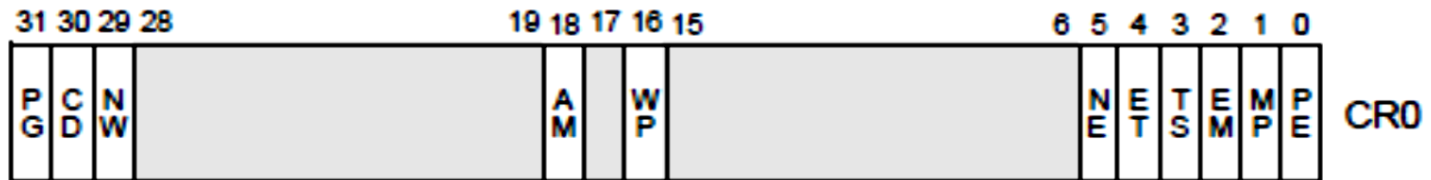
63	52	51		12	11	9	8		5	4	3	2	1	0
0 0 0 ... 0 0 0			Базовый адрес каталога страниц					0 0 0 0		P C D	P W T			P

# Страничная трансляция в режиме PAE (размер страницы = 2 Мбайта)

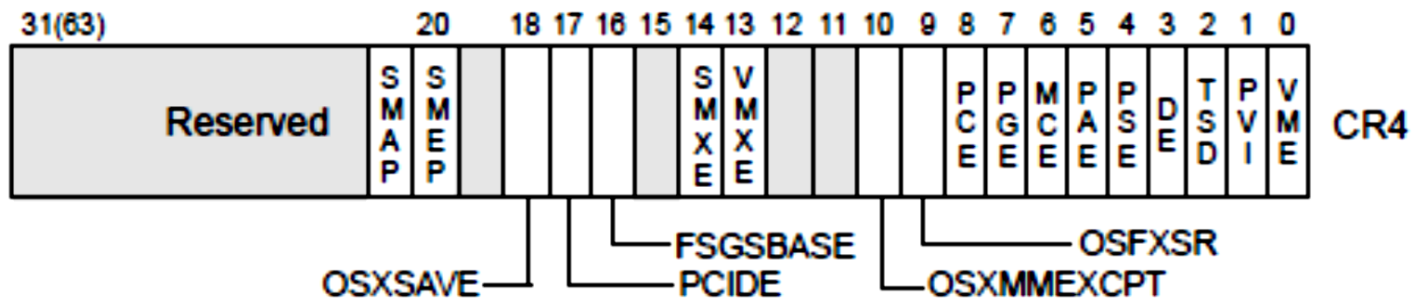


[illegible]

# Страничная трансляция в режиме IA-32e

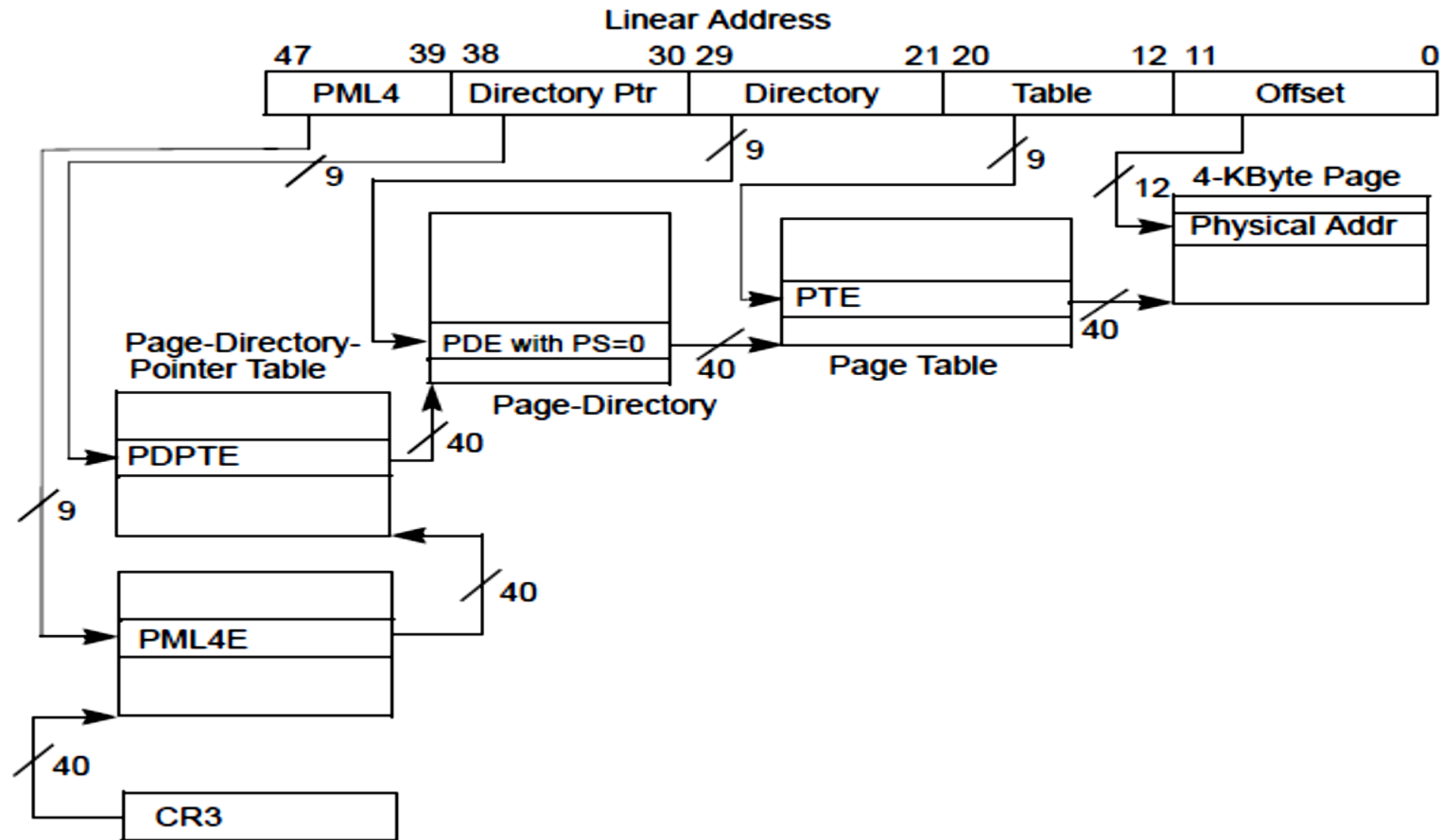


CR0.PG = 1, страничная трансляция используется

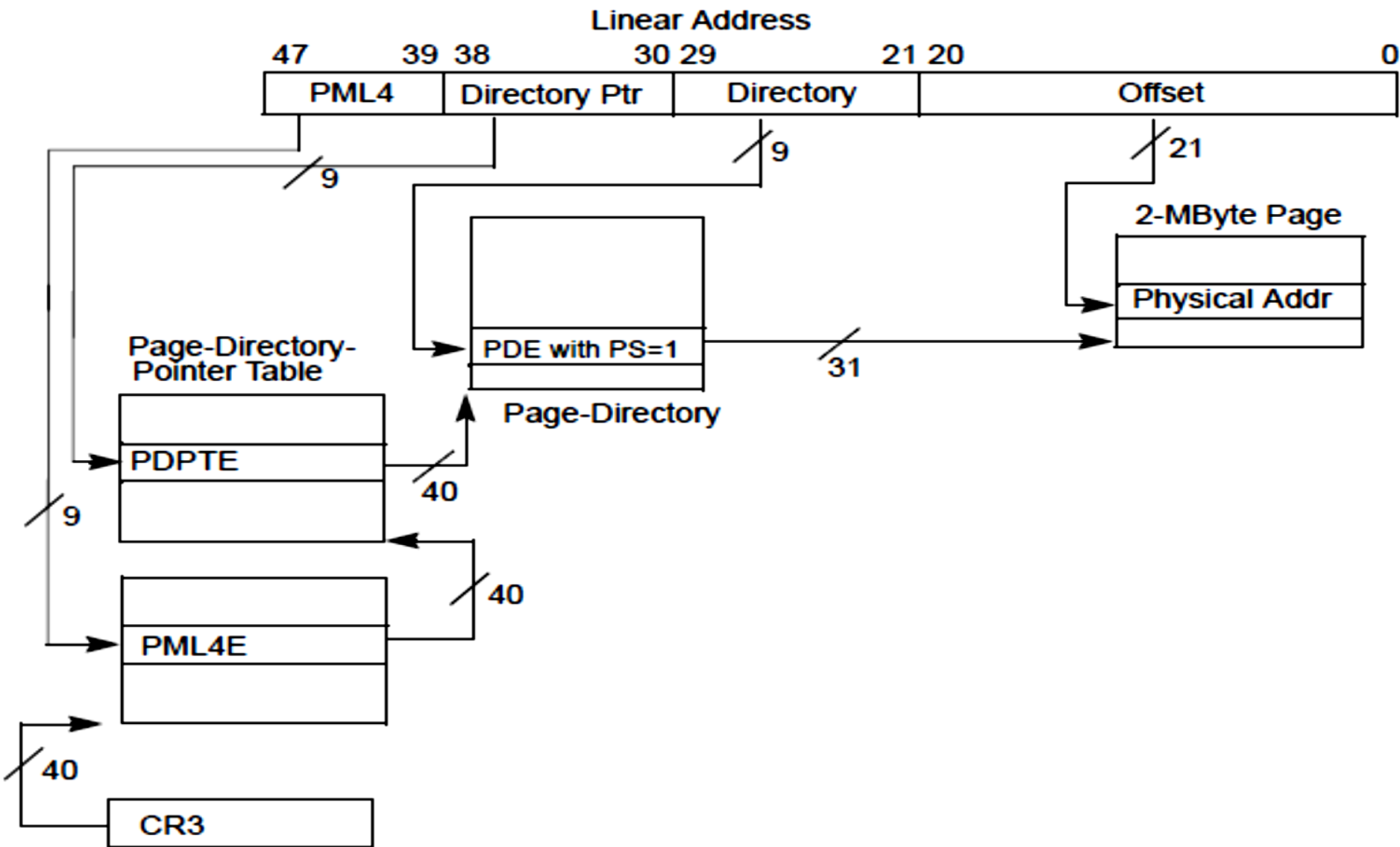


CR4.PAE = 1, IA32\_EFER.LME = 1, страничная трансляция в режиме IA-32e

# Страничная трансляция в режиме IA-32e (4 Кбайта)

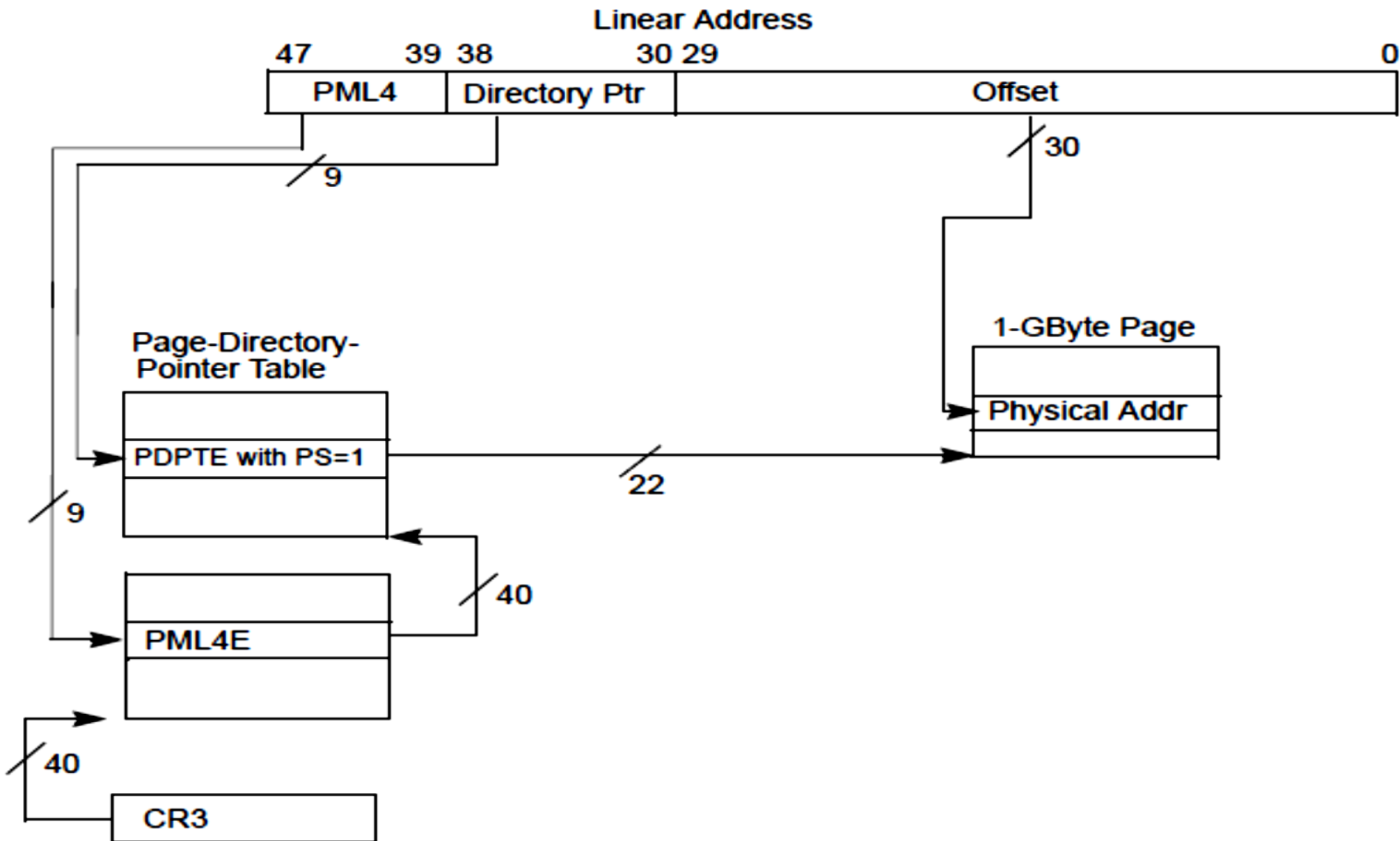


# Страничная трансляция в режиме IA-32e (2 Мбайта)





# Страничная трансляция в режиме IA-32e (1 Гбайт)



6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
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# Page-Fault Exception

