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ICS 412

Homework #5

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Exercise 8.11: Given five memory partitions of 100 KB, 500 KB, 200 KB, 300 KB, and 600 KB (in order), how would each of the first-fit, best-fit, and worst-fit algorithms place processes of 212 KB, 417 KB, 112 KB, and 426 KB (in order)? Which algorithm makes the most efficient use of memory?

a. First-fit

Answer:	212 KB → 500 KB	100 KB, 288 KB, 200 KB, 300 KB, 600 KB
	417 KB → 600 KB	100 KB, 288 KB, 200 KB, 300 KB, 183 KB
	112 KB → 288 KB	100 KB, 176 KB, 200 KB, 300 KB, 183 KB
	426 KB → Wait (no partition is large enough)	100 KB, 176 KB, 200 KB, 300 KB, 183 KB

b. Best-fit

Answer:	212 KB → 300 KB	100 KB, 500 KB, 200 KB, 88 KB, 600 KB
	417 KB → 500 KB	100 KB, 83 KB, 200 KB, 88 KB, 600 KB
	112 KB → 200 KB	100 KB, 83 KB, 88 KB, 88 KB, 600 KB
	426 KB → 600 KB	100 KB, 83 KB, 88 KB, 88 KB, 174 KB

c. Worst-fit

Answer:	212 KB → 600 KB	100 KB, 500 KB, 200 KB, 300 KB, 388 KB
	417 KB → 500 KB	100 KB, 83 KB, 200 KB, 300 KB, 388 KB
	112 KB → 388 KB	100 KB, 83 KB, 200 KB, 300 KB, 276 KB
	426 KB → Wait (no partition is large enough)	100 KB, 83 KB, 200 KB, 300 KB, 276 KB

d. Which algorithm makes the most efficient use of memory?

Answer: Best-fit algorithm makes the most efficient use of memory. It is the only method capable of meeting all memory requests in this case.

Exercise 2: Consider the following page table, in which "x" means an invalid entry.

Logical	Physical
15	x
14	x
13	x
12	x
11	7
10	x
9	5
8	x
7	x
6	x
5	3
4	4
3	0
2	6
1	1
0	2

Assume a 4 KB page size. Give the physical address corresponding to the following logical addresses. All addresses are decimal values.

a. 20

Answer: To calculate the physical address of the given logical address, when the page size is 4 KB, we have,

$$20\ B < 4\ KB$$

$$\Rightarrow logical\ page = 0$$

$$\because 0\ logical\ page \leftrightarrow 2\ physical\ page$$

$$\Rightarrow 2\ page \times 4\ KB/page = 8\ KB$$

$$\Rightarrow 8\ KB + 20\ B = 8020\ B\ .$$

The physical address of logical address 20 B is at physical address 8020 B.

b. 4100

Answer: To calculate the physical address of the given logical address, when the page size is 4 KB, we have,

$$4100\ B\ /\ 1000 = 4.1\ KB < 2 \times 4\ KB$$

$$\Rightarrow logical\ page = 1$$

$$\because 1\ logical\ page \leftrightarrow 1\ physical\ page$$

$$\Rightarrow 1\ page \times 4\ KB/page\ = 4\ KB$$

$$\Rightarrow 4\ KB + (4.1 - 4)\ KB\ = 4100\ B\ .$$

The physical address of logical address 4100 B is at physical address 4100 B.

c. 8300

Answer: To calculate the physical address of the given logical address, when the page size is 4 KB, we have,

$$8300\ B\ /\ 1000 = 8.3\ KB < 3 \times 4\ KB$$

$$\Rightarrow logical\ page = 2$$

$$\because 2\ logical\ page \leftrightarrow 6\ physical\ page$$

$$\Rightarrow 6\ page \times 4\ KB/page\ = 24\ KB$$

$$\Rightarrow 24\ KB + (8.3 - 8)\ KB\ = 24300\ B\ .$$

The physical address of logical address 8300 B is at physical address 24300 B.

Exercise 8.18: Consider a logical address space of 32 pages with 1024 words per page, mapped onto a physical memory of 16 frames.

a. How many bits are required in the logical address?

Answer: The logical address requires 5 bits for the page number because there are $32 = 2^5$ of them. Then, the logical address requires 10 bits of the offset because there are $1024 = 2^{10}$ of them. So, the logical address requires a total is 15 bits.

b. How many bits are required in the physical address?

Answer: The physical address requires 4 bits for the frame number because there are $16 = 2^4$ of them. Then, the physical address also requires 10 bits of the offset because there are $1024 = 2^{10}$ of them. So, the physical address requires a total is 14 bits.

Exercise 8.19: Consider a computer system with a 32-bit logical address of 4-KB page size. The system supports up to 512 MB of physical memory. How many entries are there in each of the following?

a. A conventional single-level page table.

Answer: $2^{11} < 4000 < 2^{12}$, so we need 12 out of 32 bit logical address for the offset. Then we have $32 - 12 = 20$ bits left for the page number. There are, therefore, $2^{20} = 1048576$ entries in a conventional single-level page table.

b. An inverted page table.

Answer: $2^{11} < 4000 < 2^{12}$, so we still need 12 out of 32 bit logical address for the offset. Then we have $32 - 12 = 20$ bits left for the page number and process id. There are, therefore, $2^{20/2} = 2^{10} = 1024$ entries in a conventional single-level page table.

Exercise 5: Suppose we have a computer system with a 44-bit virtual address, page size of 64 KB, and 4 bytes per page table entry.

a. How many pages are in the virtual address space?

Answer: $2^{15} < 64000 < 2^{16}$, so we need 16 out of 44 bit logical address for the offset. Then we have $44 - 16 = 28$ bits left for the page number. There are, therefore, $2^{28} = 268435456$ pages in the virtual address space.

b. Suppose we use two-level paging and arrange for all page tables to fit into a single page frame. How will the bits of the address be divided up?

Answer: $2^{15} < 64000 < 2^{16}$, so we still need 16 out of 44 bit logical address for the offset. Since we have 4 bytes per page table entry, one page frame can fit $64\ KB/4\ B = 16000$ page entries. We need 14 bits, as $2^{13} < 16000 < 2^{14}$, to index into a page of the page table. Then we have $44 - 16 - 14 = 14$ bits left for the page number.

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43 42 ... 30 29 28 ... 16 15 14 ... 0
 |--outer--|  |--inner--|  |-offset-|
```

Exercise 8.23: Consider the following segment table:

Segment	Base	Length
0	219	600
1	2300	14
2		
90	100	
3	1327	580
4	1952	96

What are the physical addresses for the following logical addresses?

a. 0,430

Answer: $219 + 430 = 649$. Segment 0 has a length of 600, which is greater than 430.

b. 1,10

Answer: $2300 + 10 = 2400$. Segment 1 has a length of 14, which is greater than 10.

c. 2,500

Answer: Illegal reference. Segment 2 doesn't have a corresponding base.

d. 3,400

Answer: $1327 + 400 = 1727$. Segment 3 has a length of 580, which is greater than 400.

e. 4,112

Answer: Illegal reference. Segment 4 has a length of 96, which is less than 112.