시스템프로그램 기말시험 [2020학년도 1학기]

학과		학번		학년		이름		

(1) This problem concerns optimizing a procedure for maximum performance on an Intel Pentium III. Recall the performance characteristics of the functional units for this machine in Table-1.

[Table-1] Operation	Latency	Issue time
Integer Add	1	1
Integer Multiply	4	1
Integer Divide	36	36
FP Add	3	1
FP Multiply	5	2
FP Divide	38	38
Load and Store (Cache hit)	1	1

You have just developed a factorial routine, **fact1()**, whose CPE is around **4**. You would like to do better and generated a revised routine, **fact2()**, by making use of the loop-unrolling technique. But, unfortunately, you have discovered that this code, **fact2()**, returns 0 for some values of argument **n**. (Explain your answer in detail for each question.)

```
int fact1(int n)
{
   int i;
   int result = 1;
   for (i = n; i > 0; i--)
       result = result * i;
   return result;
}
```

```
int fact2(int n)
{
   int i;
   int result = 1;
   for (i = n; i > 0; i-=2)
       result = (result * i) * (i-1);
   return result;
}
```

① For what values of n will **fact1()** and **fact2()** return different values?

② Show how to fix **fact2()** so that its behavior is identical to **fact1()**. [Hint: there is a special trick for this procedure that involves modifying just a single character.]

③ Benchmarking **fact2()** shows no improvement in performance. How would you explain that?

④ You modify the line inside the loop as follows:
result = result * (i * (i-1));
To everyone''s astonishment, the measured performance now has a CPE of **2.5**. How do you explain this performance improvement?

(2) Suppose that a 1 MB file consisting of 512-byte logical blocks is stored on a disk drive with the characteristics on the right-side table. For each case below, suppose that a program reads the logical blocks of the file sequentially, one after the other, and that the time to position the head over the first block is $T_{avgseek}$ + $T_{avgrotation}$, where $T_{avgseek}$ is average seek time and $T_{avgrotation}$ is average rotational delay. (Explain your answer in detail for each question.)

Parameter	Value
Rotational rate	12,000 rpm
$T_{avgseek}$	6 ms
Average # of sectors per track	1,024
# of surfaces	4
Sector size	512 bytes

① Best case: Estimate the expected time (in ms) required to read the file given the best possible mapping of logical blocks to disk sectors (i.e., sequential).

② Random case: Estimate the expected time (in ms) required to read the file if the blocks are mapped randomly to disk sectors.

(3) The following table gives the parameters for a number of different caches. For each cache, fill in the missing fields in the table. Recall that **m** is the number of physical address bits, **C** is the cache size (number of data bytes), **B** is the block size in bytes, **E** is the associativity, **S** is the number of cache sets, **t** is the number of tag bits, **s** is the number of set index bits, and **b** is the number of block offset bits.

Cache	m	C	B	E	S	t	s	b
①	32	4,096	4	4				
②	32	2,048	4	256				
③	32	1,024	8	2				
④	32	1,024	16	64				
⑤	32	4,096	32	1				

(4) The following problem concerns basic cache lookups.

- The memory is byte addressable.
- Memory accesses are to 1-byte words (not 4-byte words).
- Physical addresses are 12 bits wide.
- The cache is 4-way set associative, with a 2-byte block size and 32 total lines.

In the following tables, all numbers are given in hexadecimal. The contents of the cache are as follows. Answer the following questions and explain your answer for each question.

4-way Set Associative Cache																
Index	Tag	Valid	Byte 0	Byte 1	Tag	Valid	Byte 0	Byte 1	Tag	Valid	Byte 0	Byte 1	Tag	Valid	Byte 0	Byte 1
0	29	0	34	29	87	0	39	AE	7D	1	68	F2	8B	1	64	38
1	F3	1	0D	8F	3D	1	0C	3A	4A	1	A4	DB	D9	1	A5	3C
2	A7	1	E2	04	AB	1	D2	04	E3	0	3C	A4	01	0	EE	05
3	3B	0	AC	1F	E0	0	B5	70	3B	1	66	95	37	1	49	F3
4	80	1	60	35	2B	0	19	57	49	1	8D	0E	00	0	70	AB
5	EA	1	B4	17	CC	1	67	DB	8A	0	DE	AA	18	1	2C	D3
6	1C	0	3F	A4	01	0	3A	C1	F0	0	20	13	7F	1	DF	05
7	0F	0	00	FF	AF	1	B1	5F	99	0	AC	96	3A	1	22	79

① The box below shows the format of a physical address. Indicate (by labeling the diagram) the fields that would be used to determine the following:

- BO (The block offset within the cache line)
- SI (The cache set index)
- CT (The cache tag)

```
 11  10   9   8   7   6   5   4   3   2   1   0
+---+---+---+---+---+---+---+---+---+---+---+---+
|                                               |
+---+---+---+---+---+---+---+---+---+---+---+---+
```

② For the given physical address below, indicate the cache entry accessed and the cache byte value returned (in hexadecimal) by filling in the following table. Indicate whether a cache miss occurs. If there is a cache miss, enter "miss" for "Cache byte returned".

- Physical address: 0x18B

Parameter	Value	
Byte offset	1)	
Cache set index	2)	
Cache tag	3)	Binary address = 6)
Cache miss? (Y/N)	4)	
Cache byte returned	5)	

(5) In this problem, let `REF(x@i)` → `DEF(x@k)` denote that the linker will associate an arbitrary reference to symbol **x** in module-**i** to the definition of **x** in module-**k**. For each example that follows, use this notation to indicate how the linker would resolve references to the multiply-defined symbol in each module. If there is a link-time error, write "**ERROR**". If the linker arbitrarily chooses one of the definitions, write "**UNKNOWN**".

Module-1	`int foo() { }`	`void foo() { }`	`int x;` `void foo() { }`
Module-2	`int foo;` `int bar() { }`	`int foo = 1;` `int bar() { }`	`double x = 1.0;` `int bar() { }`
Answer	◦ REF(foo@1) → DEF(①) ◦ REF(foo@2) → DEF(②)	◦ REF(foo@1) → DEF(③) ◦ REF(foo@2) → DEF(④)	◦ REF(x@1) → DEF(⑤) ◦ REF(x@2) → DEF(⑥)

(6) Explain the following terminologies briefly in one sentence. (You may answer in Korean or in English.)
① Speculative execution
② Amdahl's law
③ Relocatable object file
④ Relocation
⑤ Shared library

①
②
③
④
⑤

(7) Suppose you are given the task of improving the performance of a program consisting of three parts A, B, and C. Part A requires 30% of the overall run time, part B requires 10%, and part C requires 60%. You determine that for $1000 you could either speed up ① part A by a factor of 2.5 or ② part C by a factor of 1.5. Which choice would maximize performance? Explain your answer in detail.

☆ 수고했습니다~.