

Specialized Subjects

9:00~11:30, Tuesday, August 24, 2010

Instructions

1. Do not open this booklet before permission is given.
2. This booklet contains 5 problems. The number of pages is six excluding this cover sheet and blank pages. If you find missing or badly printed pages, ask the attendant for exchange.
3. Answer three problems. You can select any three out of the five. Your answer to each problem should be written on a separate sheet. You may use the reverse side of the sheet if necessary.
4. Fill the top parts of all your three answer sheets as instructed below. Before submitting your answer sheets, make sure that the top parts are correctly filled.

専 門 科 目

第 問

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Write the Problem No.

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Write the Examinee No.

5. The three answer sheets must be submitted at the end of the examination, even if they are blank ones.
6. You must answer either in Japanese or in English.
7. This booklet and the preparation sheet must be returned at the end of the examination.
8. This English translation is informal but provided for the convenience of applicants. Japanese version is the formal one.

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Problem 1

The circuits shown in Fig. 1 and Fig. 2 convert a four digit binary number into a current value. The state of the switches from b_1 to b_4 in Fig. 1 and Fig. 2 represents 0010. The ammeter has negligible internal resistance.

- (1) Calculate the current value of the ammeter in Fig. 1 when the state of the switches from b_1 to b_4 is 0010.
- (2) In Fig. 2, calculate the combined resistance of the circuit to the right of the cut $X-X'$ when the state of the switches from b_1 to b_4 is 0010.
- (3) In Fig. 2, calculate the Hoh-Thevenin equivalent circuit of the right hand side of the cut $Y-Y'$ when the state of the switches from b_1 to b_4 is 0010.
- (4) Calculate the current value of the ammeter in Fig. 2 when the state of the switches from b_1 to b_4 is 0010.
- (5) Calculate the current value of the ammeter in both Fig. 1 and Fig. 2 when the state of the switches from b_1 to b_4 is 1111.
- (6) Error in each resistor affects the output value of the ammeter depending on the state of the switches from b_1 to b_4 . Discuss how errors of the resistor affect the output value of the ammeter when only one register contains an error based on the difference of the circuits shown in Fig. 1 and Fig. 2.

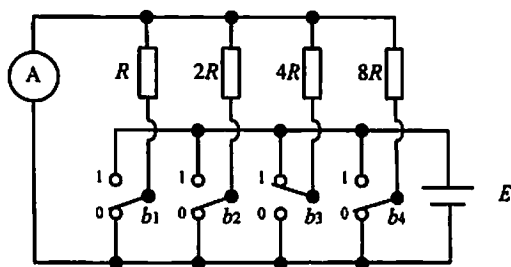


Fig. 1

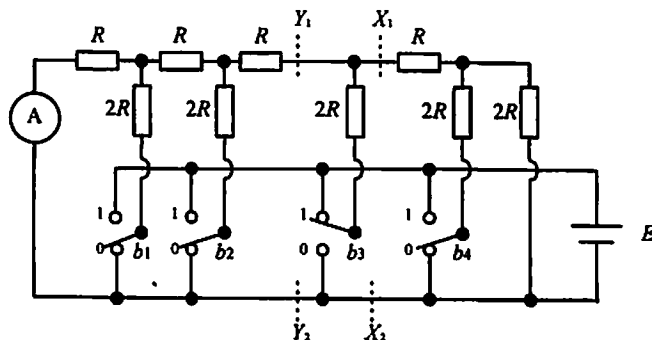


Fig. 2

Problem 2

Suppose a computer with a cache and a virtual memory. The design parameters of the computer are listed in the following table.

Table

Word	32 bits
cache system	2 way set associative
cache line	64 bytes
virtual address	32 bits
physical address	31 bits
page size	4K bytes (4096 bytes)
TLB	64 entries
cache and TLB	parallel physical address cache (Fig.(B))

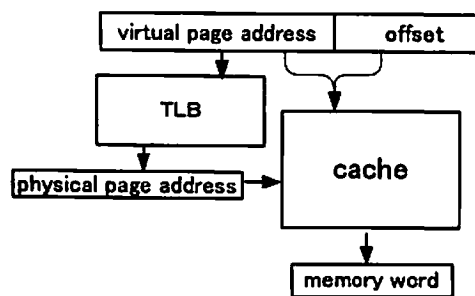
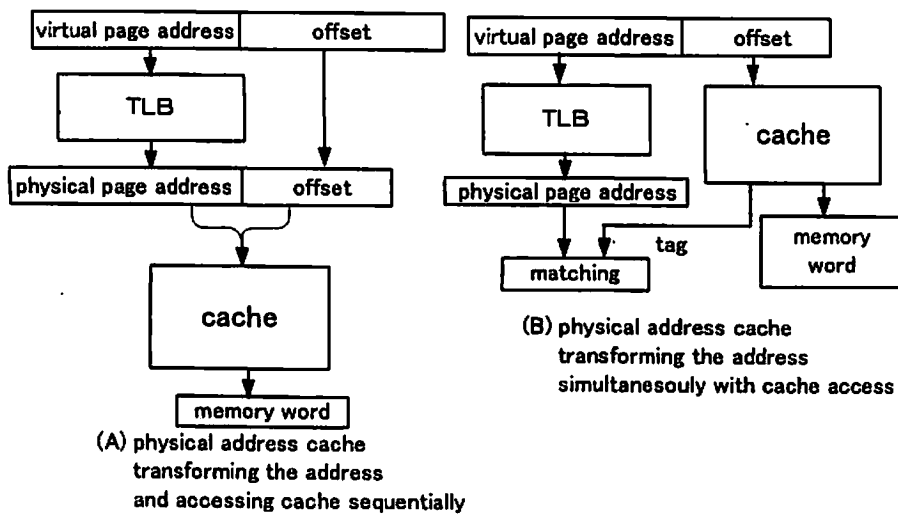


Fig.

Answer the following questions.

- (1) With a set associative cache, three kinds of cache misses may occur. Describe the names of them and explain each within 30 words.
- (2) In the three kinds of cache misses described in (1), what is the one which may occur in a set associative cache but never occurs in a full associative cache?
- (3) Describe one method to reduce the cache miss described in (2).
- (4) Describe the actions of a computer, when the cache miss occurs.
- (5) Describe what TLB is within 50 words.
- (6) Calculate how many total bytes are required for the TLB of the computer. Valid bits, tags and physical page addresses must be taken into account.
- (7) Describe how the computer behaves at the TLB miss. Suppose that the target page exists in the main memory.
- (8) Describe the name of the exception which occurs when the required page does not exist in the main memory.
- (9) Describe the actions of the computer when (8) occurs.
- (10) Calculate how many bytes can be stored as cache data. Note that the cache data here does not include valid bits, nor tags.
- (11) The system illustrated in Figure (A) has no limitations of the capacity shown in (10). However, another problem may occur. Describe what the problem is within 25 words.
- (12) The system illustrated in Figure (C) also has no limitations of the capacity shown in (10). However, another problem may occur. Describe the name of the problem and what it is within 40 words.

Problem 3

Consider counting the number of occurrences of each word in a large set of documents on a large cluster of computers. The set of documents is partitioned into N sets, and they are processed in parallel by N machines. Answer the following questions.

- (1) Each machine splits a partial set of documents into words. Then the list of words is sorted, and translated into the list of (word, frequency) pairs. The following pseudo code reads a sorted list of words, and outputs (word, frequency) pairs. Find errors in this code, and explain how to correct the code.

```
count_frequency(File sorted_words_file) {
    int num = 0;
    String word, previous_word = null;
    while (read a word from sorted_words_file) {
        if (word is not previous_word AND previous_word is not null) {
            output_pair(word, num);
        }
        num = num + 1;
        previous_word = word;
    }
}
```

- (2) Show the pseudo code for the function that takes two lists of (word, frequency) pairs, and merge them into a single list.
- (3) Explain how to merge N lists of (word, frequency) pairs generated by N machines.
- (4) Consider distributing the list of words into N machines before sorting and counting for avoiding the time consuming merge process. It requires a function that maps each word into an integer from 0 to $(N-1)$. Show a concrete example of this mapping function.
- (5) Describe how to balance the load across the machines when the distribution of word frequency is not uniform, and show a concrete mapping function to be used.

Problem 4

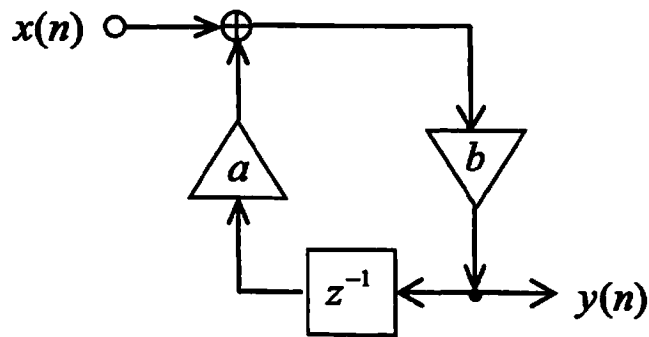
Consider a radio communication system where multiple wireless terminals access to the same access point. Assume that the packets are the fixed length and that radio channel is slotted so that the lengths of the slots are the same with the lengths of the packets. All the terminals are synchronized and they try to transmit a packet at the beginning of a slot. For simplicity, we assume there is no propagation delay. Packet collision occurs and the terminals fail to transmit packets only when two or more terminals try to transmit packets at the same time slot. Let N ($N \geq 2$) be the number of terminals. Assume that all the terminals try to transmit packets randomly with the probability p .

- (1) Let G be the offered traffic to the system. It is also the average number of packets which are tried to be transmitted at the same slot in the whole system. Describe G in terms of N and p . Show only the answer.
- (2) Assume a terminal tries to transmit a packet at a specific time slot. This transmission is successful only when all the other $N-1$ terminals do not try to transmit packets. Describe this probability in terms of N and p . Show only the answer.
- (3) Let the throughput of the system be S . It is also the number of packets successfully transmitted at the same slot in the whole system. Describe S in terms of G and N .
- (4) Find the maximum throughput S_{max} and the value of G which gives S_{max} . Discuss whether the system is in heavy traffic under this condition from the view point of the successful packet transmission rate.
- (5) Illustrate the relationship between S and G when N is large enough. Let base of natural logarithm be 2.7 if necessary.
- (6) Show two methods to improve the throughput of such a radio communication system and explain them briefly.

Problem 5

Answer the following questions about discrete signal processing. Note that the discrete input signal $x(n]$ is zero for $n < 0$.

- (1) Suppose that the discrete input signal $x(n]$ is shifted by m as $x(n-m)$. Show that the z-transform of the shifted input signal becomes $z^{-m}X(z)$ where $X(z)$ is the z-transform of $x(n]$.
- (2) Give the definition of convolution $x_1(n) * x_2(n)$ of two discrete signals $x_1(n]$ and $x_2(n]$.
- (3) $X_1(z)$ and $X_2(z)$ are the z-transform of $x_1(n]$ and $x_2(n]$, respectively. Using the results from Questions (1) and (2), show that the z-transform of $x_1(n) * x_2(n)$ becomes $X_1(z)X_2(z)$.
- (4) Find the transfer function $H(z)$ of the discrete system shown in the figure below.
- (5) Using the fact that the z-transform of the unit impulse response of a discrete system is equal to the transfer function, obtain the unit impulse response $h(n)$ of the discrete system in the figure below and find the response $y(n)$ for the input discrete signal $x(n]$.



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