115CI01

國立臺北科技大學 115 學年度碩士班招生考試

系所組別：2300 資訊工程系碩士班

第一節 計算機概論 試題

注意事項：
1. 本試題共壹拾肆題，合計 100 分。
2. 不必抄題，作答時請將試題題號及答案依照順序寫在答案卷上。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

1. Please answer the following questions concisely with asymptotic notations and you do not need to give the reasons or prove it. (10%)
   (1) What is the growth rate of $T(n) = 20n^2 + 7\sqrt{n}\log n + 5n(\log n)^2$? (2%)
   (2) Give the growth rate of the recursive function $T(n) = \sqrt{n}T(\sqrt{n}) + cn$ for $n > 2$ and $T(2) = 1$, where c is some positive constant, using Θ notation. (2%)
   (3) What is the worst-case running time for Quicksort algorithm? (2%)
   (4) Give the best running time for finding the median in an unsorted set of size n. (2%)
   (5) Give the best running time for merging two sorted sequences of sizes n and m. (2%)

2. Mark by True or False each of the followings: (10%)
   (1) The operation insert on a priority queue realized by a sorted list can be done in linear time. (2%)
   (2) It is possible that the preorder traversal of a tree T visits the nodes in the reverse order of the postorder traversal of T. (2%)
   (3) A subtree of a red-black tree is itself a red-black tree. (2%)
   (4) There is a unique red-black tree associated with a given (2, 4) tree. (2%)
   (5) If an undirected graph G is connected with n-1 edges and n nodes, then G has no cycle. (2%)

3. Let $|T|$ denote the number of nodes of a binary tree T. If $|T|$=0 or $|T|$=1, there is only one binary tree. If $|T|$=2, then there are two distinct binary trees. (10%)
   (1) When $|T|$=3, how many distinct binary trees are there? (3%)
   (2) We are now interested in deriving the total number of distinct binary trees when $|T|$= n. Suppose D_n denote this number. Please write a recurrence equation to obtain D_n. (3%)

Recall the optimal binary search tree problem and one can get an optimal binary search tree with given access frequencies of keys among different possible binary search trees. Suppose that we are given four keys, a_1, a_2, a_3, and a_4, with the following access frequencies (p_i) as well as the unsuccessful access frequencies (q_i) to the gaps (e_i), where e_i=(a_i, a_{i+1}), i = 1, 2, and 3; e_0=(-∞, a_1); and e_4=(a_4, ∞). Please answer the following two questions (3) and (4).

i	0	1	2	3	4
p_i (for a_i)	--	3	3	1	1
q_i (for e_i)	2	3	1	1	1

   (3) Which key will be located at the root of the resulting optimal binary search? (2%)
   (4) Which key will be located at the parent of the node storing key a_4? (2%)

4. Please answer the following questions about the graph G in Figure 1. (10%)

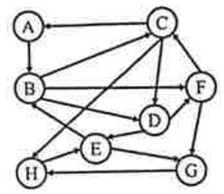

Figure 1. A digraph G for problem 4

   (1) List the nodes as the depth-first search (DFS) starting from node A and suppose the adjacency-list of each node is ordered in strict alphabetical order. (3%)
   (2) How many edges at least should be removed to make G be a directed acyclic graph (DAG)? (3%)
   (3) Perform a breadth-first search (BFS) traversal, starting from node A, with alphabetical adjacency-list ordering. Please show the corresponding BFS-tree. (4%)

5. For the following questions regarding *process and thread management*, please indicate whether each statement is true or false. If a statement is incorrect, please explain the reasons. (Answers that correct errors without explanation will not receive full credit.) (6%)
   (1) Nonpreemptive Shortest-job-first (SJF) scheduling algorithm completely eliminates starvation of low-priority processes. (2%)
   (2) In the many-to-one threading model, multiple user threads can execute in parallel on a multicore system. (2%)
   (3) Even with an infinite number of CPU cores, the maximum speedup of a parallel program is bounded by its serial fraction. (2%)

6. Answer the following questions about *memory management*. (6%)
   (1) Compare the two memory allocation schemes: *contiguous memory allocation*, *pure paging*, in terms of the following aspects: address translation structures, fragmentation, ability to share code across processes, and memory protection. (4%)

注意：背面尚有試題

(2) What is the idea of *virtual memory*? How do we usually implement it with *demand paging* technique? Please describe the detailed steps involved when a page fault occurs under demand paging. (2%)

7. Among the following statements about *storage and file management*, please indicate whether each statement is true or false. If a statement is incorrect, please explain the reasons. (Answers that correct errors without explanation will not receive full credit.) (4%)
   (1) RAID mechanisms alone can provide sufficient protection from all forms of data loss. (2%)
   (2) Linked allocation allows efficient random access because any block of a file can be accessed directly. (2%)

8. Answer the following questions regarding *synchronization*. (4%)
   (1) What is the main drawback of *spinlocks* on a single-core system? (1%)
   (2) Compare *semaphores* and *mutex locks* in terms of: ownership, blocking behavior, and typical use cases. (3%)

<u>Note.</u> **Problems 9-12 are multiple-choice questions.** Each question has at least four correct answers. Please select four answers for each question. If all four are answered correctly, you get four points. If any one in your selection is answered incorrectly, one point is deducted. If all four are answered incorrectly, you get no points.

9. An organization is assigned the IP block **10.10.0.0/16**. To optimize department isolation, the network administrator decides to divide this block into **32** equal subnets, please select following answers: (4%)
   (1) The new prefix length for these subnets is /22.
   (2) The custom subnet mask for each new subnet is 255.255.248.0.
   (3) Each subnet can support a maximum of 2,046 valid host IP addresses.
   (4) The network address of the second subnet (Subnet 1) is 10.10.8.0.
   (5) The IP address 10.10.15.255 is a valid, assignable host address in the second subnet.
   (6) To create 32 subnets, we must borrow 6 bits from the host portion of the original /16 network.
   (7) The broadcast address of the first subnet (Subnet 0) is 10.10.7.255.
   (8) The total number of available host addresses across all 32 subnets combined is 65,536.

10. A **12 GB** backup file is being transferred over a dedicated fiber link. The link has a transmission rate (bandwidth) of **400 Mbps** and a propagation delay of **15 ms**, please select following answers: (4%)
   (1) The total size of the file to be transmitted is 9.6×10^{10} bits.
   (2) The transmission delay (the time to push all bits onto the link) is exactly 240 seconds.
   (3) The propagation delay, when converted to seconds, is 0.15 seconds.
   (4) The total time required to complete the file transfer (ignoring processing and queuing) is 240.015 seconds.
   (5) If the transmission rate is doubled to 800 Mbps, the total transfer time will be exactly 120.0075 seconds.
   (6) Transmission delay is determined by the file size and the link bandwidth, not the physical length of the cable.
   (7) If the file size were reduced to 6 GB, the propagation delay would also decrease to 7.5 ms.
   (8) The "Bit Error Rate" of the link is required to calculate the basic transmission delay.

11. Alice needs to send a sensitive document to Bob and wants to ensure both **confidentiality** (so no one else can read it) and **authenticity** (so Bob knows it really came from her). They decide to use a mix of asymmetric encryption and digital signatures. (4%)
   (1) To ensure confidentiality, Alice should encrypt the document using Bob's public key.
   (2) To prove her identity, Alice should "sign" the document by encrypting a hash of it with Bob's public key.
   (3) Bob will use his own private key to decrypt the document that Alice encrypted for him.
   (4) Confidentiality is the pillar of the CIA Triad that ensures data is not altered during transmission.
   (5) A digital signature is created by the sender using their own private key to provide non-repudiation.
   (6) If Bob decrypts a message using his private key, he has successfully verified the "Integrity" of the sender.
   (7) "Confidentiality" ensures that sensitive information is not disclosed to unauthorized individuals or entities.
   (8) Asymmetric encryption is significantly faster than symmetric encryption, making it ideal for encrypting 10GB files.

12. A modern enterprise is designing its defense-in-depth strategy to protect against common cyber threats like phishing and data breaches. (4%)
    (1) Phishing is a form of social engineering that relies on human psychology rather than just technical exploits.
    (2) Social engineering in cybersecurity preys not on human trust, curiosity, and urgency.
    (3) Multi-Factor Authentication (MFA) is ineffective if the attacker already knows the user's primary password.
    (4) The "Human Element" is often cited as the weakest link in a cybersecurity defense chain.
    (5) A "Firewall" is the primary tool used to prevent an employee from falling for a voice-based phishing (Vishing) attack.
    (6) Spear phishing is a targeted version of phishing aimed at a specific individual or organization.
    (7) Once a system is infected with ransomware, the data is usually automatically decrypted after 24 hours if no ransom is paid.
    (8) Ransomware is a type of malware that uses encryption to hold a victim's data hostage.

13. Fill the blanks with your selections below to defend the following vulnerable C language code. (4%)
    (A) i < BUF_SIZE　(B) i < (BUF_SIZE - 1)　(C) BUF_SIZE　(D) BUF_SIZE - 1
    (E) i <= (BUF_SIZE - 1)　(F) Address Space Layout Randomization (ASLR)
    (G) 0　(H) (BUF_SIZE - 1)

    (1) while (*s != '\n' && *s != '\0' && ____________________) (1%)
    (2) strncpy(profile->username, input_buffer, ____________________); (1%)
    (3) profile->username[____________________] = '\0'; (1%)
    (4) Beyond code-level fixes, security is enhanced by operating system features. A critical defense mechanism is ________________(provide the acronym), which randomizes the memory addresses used by the heap, stack, and libraries. (1%)

```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define BUF_SIZE 32
typedef struct {
    char username[BUF_SIZE];
    void (*display_func)(const char*);
} UserProfile;

void basic_display(const char* name) {
    printf("Welcome, user: %s\n", name);
}

void secret_admin_shell() {
    printf("CRITICAL: Admin access granted. Spawning shell...\n");
    system("/bin/sh");
}

void process_user() {
    UserProfile *profile = (UserProfile*)malloc(sizeof(UserProfile));
    if (!profile) return;
    profile->display_func = basic_display;
    char input_buffer[128];
    printf("Enter your name: ");

    if (fgets(input_buffer, 128, stdin)) {

        char *d = profile->username;
        char *s = input_buffer;
        while (*s != '\n' && *s != '\0') {
            *d++ = *s++;
        }
        *d = '\0';
    }

    profile->display_func(profile->username);
    free(profile);
}

int main() {
    process_user();
    return 0;
}
```

14. For MIPS ISA (20%)

(1) Translate the following C code segment into assembly code. (9%)

```
int compute(int n, int A[]) {
    int value = 0, i = 0;
    while (i<n) {
        if (i%2 ==0) value += A[i];
        else value -= A[i];
        i++;
    }
    return value;
}
```

```
compute:
    addi $sp, $sp, -8
    sw   $s0, 0($sp)          # save value
    sw   $s1, 4($sp)          # save i
    li   $s0, 0               # value = 0
    li   $s1, 0               # i = 0
loop:
    # while (i < n)
    (I) $t0, $s1, (II)        # t0 = (i < n)
    (III) $t0, (IV), finish   # if i >= n, exit
    sll  $t1, $s1, 2          # t1 = i * 4
    add  $t2, $a1, (V)        # t2 = &A[i]
    lw   $t3, 0((VI))         # t3 = A[i]
    andi $t4, (VII), 1        # t4 = i & 1
    (VIII) $t4, $zero, even   # (i%2==0) even
    sub  $s0, $s0, $t3        # odd: value -= A[i]
    addi $s1, $s1, 1          # i++
    j    loop
even:
    (IX) $s0, $s0, $t3        # value += A[i]
    (X)  $s1, $s1, 1          # i++
    j    loop
finish:
    move $v0, $s0             # return value
    lw   $s0, 0($sp)
    lw   $s1, 4($sp)
    addi $sp, $sp, 8
    jr   $ra
```

(a) Multiple selection (choose all correct statements) from (A) ~ (H): (A) I is add, (B) I is slt, (C) II is lw, (D) II is $a0, (E) II is $a1, (F) III is beq, (G) III is bne, (H) IV is $a0. (3%)

(b) Multiple selection (choose all correct statements) from (A) ~ (H): (A) IV is $zero, (B) V is $t6, (C) V is $t1, (D) V is $s1, (E) VI is $t0, (F) VI is $t1, (G) VI is $t3, (H) VII is $a0. (3%)

(c) Multiple selection (choose all correct statements) from (A) ~ (H): (A) VII is $s0, (B) VII is $s1, (C) VIII is lw, (D) II is sw, (E) VIII is add, (F) VIII is bne, (G) IX is add, (H) X is add. (3%)

(2) The MIPS ISA is designed using a single-cycle datapath. (11%)
In three successive cycles, the processor fetches the following three instructions:

01	add $t3, $t1, $t2
02	sw $t1, 2($s1)
03	beq $t1, $s1, 20

Assume that data memory is initialized to all zeros and that the processor's registers have the following values at the beginning of the cycle in which the above instructions are fetched.

register numbering: {at: $1, v0: $2, a0: $4, t0: $8, s0: $16}.

register values: {$2: 9, $3: 5, $4: 13, $5: 8, $6: 7, $8: 6, $9: 4, $10: 2, $11: 15, $12: 1, $16: 3, $17: 12, $18: 11}.

instruction encodings: {add: {op: 0, funct: 32}, sub: {op: 0, funct: 34}, beq: {op: 4, funct: 0}, lw: {op: 35, funct: 0}, sw: {op: 43, funct: 0}}

(a) Translate the first two instructions into 32-bit machine code, represented in hexadecimal. {01, 02} = {(I), (II)}

(a-1) Multiple selection (choose all correct statements) from (A) ~ (K) for I: (A) 012A5822, (B) 014B6020, (C) 012B4820, (D) 022A5820, (E) 012A6820, (F) 012A5820, (G) 01295820, (H) 010A5820, (J) 013A5820, (K) 012A5020. (2%)

(a-2) Multiple selection (choose all correct statements) from (A) ~ (K) for II: (A) AC290002, (B) AE280002, (C) AE290004, (D) AE291004, (E) AE290002, (F) A6290002, (G) AE2A0002, (H) BE290002, (J) 8E290002, (K) AE290200. (3%)

(b) For each of the first two instructions, write the values for the register file unit: {Read Register 1, Read Register 2, Write Register, Write Data}={{__I__, __II__, __III__, __IV__}, {__V__, __VI__, __VII__, __VIII__}}
Multiple selection (choose all correct statements) from (A) ~ (H): (A) I is 9, (B) II is 9, (C) III is 11, (D) IV is 10, (E) V is 11, (F) VI is 17, (G) VII is X (don't care), (H) VIII is 0. (3%)

(c) For each of the first two instructions, fill the control signals as the format. {RegWrite, MemtoReg, RegDst} = {{__I__, __II__, __III__}, {__IV__, __V__, __VI__}}
Multiple selection (choose all correct statements) from (A) ~ (H): (A) {I, II, III} = {1, 1, 0}, (B) {I, II, III} = {1, 0, 1}, (C) {I, II, III} = {0, 0, 1}, (D) {I, II, III} = {0, 1, 1}, (E) {IV, V, VI} = {1, 0, 0}, (F) {IV, V, VI} = {1, X, X}, (G) {IV, V, VI} = {0, 0, 0}, (H) {IV, V, VI} = {0, X, X}. (3%)

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