國立政治大學 109 學年度 碩士暨碩士在職專班 招生考試試題

考 試 科 目	資料結構及演算法	系 所 別	資訊科學系	考 試 時 間	2 月 7 日(星期五) 第二節

1 (20 points) What are the worst case time complexities of the following algorithms?

1.1 Binary search in a sorted array consisting of n integers

1.2 Building a binary heap from an unsorted array consisting of n integers

1.3 Randomized quicksort for an array consisting of n integers

1.4 Kruskal algorithm with disjoint-set-forest for finding the minimum spanning tree given a connected, undirected graph with $|V|$ vertices and $|E|$ edges

2 (20 points) Design a dynamic array that supports the following four operations in $\Theta(1)$ amortized time. Show your algorithm for each of the four operations in C or pseudo code.

2.1 Initializing an empty array

2.2 Inserting a new element at the end of the array

2.3 Removing the last element of the array

2.4 Access to the kth element of the array

3 (20 points) Given two binary trees, design an algorithm for checking if they are identical in terms of both the structure and the values. The node in the binary tree is defined as follows. Implement the "equal" function in C or pseudo code.

```
struct node {
    int value;
    struct node *left, *right;
};
bool equal(struct node *tree1, struct node *tree2)
{
    ....
}
```

4 (20 points) Given an $m \times n$ matrix M of real numbers, find a *maximum sum submatrix* of M. The maximum sum submatrix of M is a submatrix of M with the largest sum. Describe your algorithm in C or pseudo code and show its time complexity.

5 (20 points) Given a string s consisting of n characters and a dictionary D consisting of m words, provide an algorithm for checking if s is completely composed of the words in D. That is, s can be segmented into k fragments, and all the k fragments are listed in D. Describe your algorithm in C or pseudo code and show its time complexity.

備 註	一、作答於試題上者，不予計分。 二、試題請隨卷繳交。

考試科目	作業系統	系所別	資訊科學系/資訊科學與工程組、智慧計算組	考試時間	2 月 7 日(五) 第 3 節

1. Single choice (45%)

(1) Which of the following statement is true (a) Dynamic loading does not need special support from OS (b) Dynamic linking loads partial program into memory when it is needed (c) Dynamic linking is particularly useful when large amounts of code are infrequently used (d) Dynamic loading prevents duplicated code

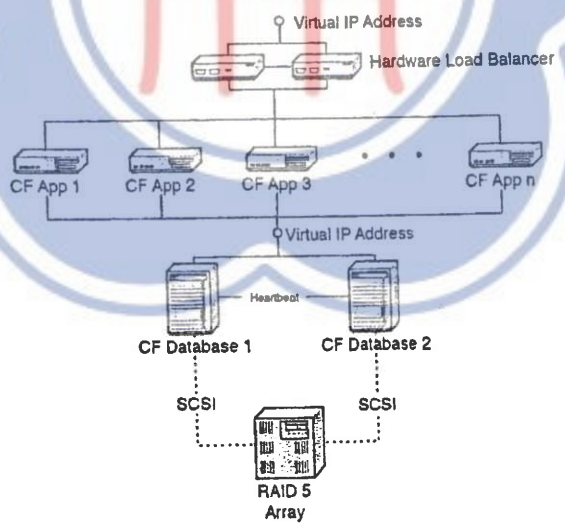
(2) The Windows platform provides several data structure for storing Thread-related information. Where the Windows platform stores the Thread Local variables? (a) TEB (b) PEB (c) KTHREAD (d) ETHREAD

(3) Which of the following is not part of the middleware provided by the OS? (a) Threading service (b) Database service (c) Graphics service (d) Multimedia service

(4) Which of the following is true? (a) When the CPU receives a non-maskable interrupt, it stops what it is doing and immediately transfers execution to the interrupt handler (b) I/O controllers emit interrupts via interrupt-request lines (c) In critical sections, the CPU may disables the maskable interrupts permanently (d) In an Intel processor, the interrupt No. 32 is a maskable interrupt

(5) The reason that the interrupt vector is indexed by numbers is to increase _____ (a) Stability (b) Speed (c) Security (d) Scalability

(6) Consider the following clustered system. Which of the following statement is false?



(a) Clustered systems usually share storage using SAN

(b) One of the CF Database 1 and CF Database 2 one machine in hot-standby mode, therefore they are asymmetric cluster

(c) The "+" 、" -" 、" x" and "/" are all valid operations of the Map task in a Hadoop Cluster

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(d) Clustering is a technology for supporting horizontal scaling

(7) Which of the following is false: (a) Privileged instructions executed only in kernel mode (b) PSW is the controller used to support dual mode operations (c) The use of VM and VMM may interfered multi-mode operations of the OS (d) The dual mode of operation provides a mean for protecting the OS from errant users

(8) Which of the following statements is false? (a) Darwin is a layered system that serves as the foundation of Mac OS and iOS (b) Mac OS uses BSD system calls (c) Mac OS uses a pure microkernel architecture (d) message passing in Darwin does not require copying of message

(9) A child process ends before the parent calls wait() is called (a) zombie (b) daemon (c) orphan (d) none of the above

(10) Which of the following statement is false? (a) Each process is associated with a PCB (b) In Linux, PCB is usually located at /proc (c) the pointers to the opened files are stored in PCB (d) PCB information such as parent, child, and register values are usually kept in a structure called mm_struct.

(11) When a process being switched out of the CPU, which of the following situations does not cause the process being added to the wait queue? (a) I/O request (b) create child process (c) time slice expired (d) wait for an interrupt

(12) Which of the following statement is false? (a) the Green thread is a Many-to-One threading model (b) The threading model of Linux and Windows are typically Many-to-One (c) Although Many-to-Many threading model is the most flexible, it is too hard to implement in practice (d) Implicit threading is a kind of Many-to-Many threading model

(13) Which of the following is true? (a) cooperative scheduling can result in race condition (b) under preemptive scheduling, the process keeps the CPU until it releases it proactively (c) Most modern OS are now fully cooperative when running in kernel mode (d) the code sections affected by the interrupts must be guarded and prevent from concurrent accesses

(14) Which of the following statement is correct? (a) Base register holds the size of a page table. (b) Limit register holds the size of a process. (c) Base and limit registers can be loaded in user mode. (d) Any attempt by a user program to access memory at an address higher than the base register value results in a trap to the OS.

(15) A significant problem with priority scheduling algorithms is _____. (a) complexity (b) starvation (c) determining the length of the next CPU burst (d) determining the length of the time quantum

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2. (9%) Consider a computer with 64-bit logical address with single-level paging. Assuming that the page size is 4M and the memory is byte-addressed. The physical memory is 32G. Please answer the following questions.
   (1) The maximum number of pages a process can have?
   (2) The number of bits for physical memory?
   (3) The maximum number of frames?

3. TLB (Translation look-aside buffer):
   (1) (3%) Describe the core function of TLB?
   (2) (3%) In TLB, some entries are always wired down and never removed, why?
   (3) (4%) In some systems, TLB stores ASIDs (Address-space identifier) in each entry. An ASID is typically used to denote which information? Why ASID can be used to speed-up context switch?

4. (6%) Page table is typically implemented on memory, however, this approach leads to more memory accesses. As a result, some systems store page tables in dedicated high speed registers? What is the problem with this approach?

5. (5%) List the correct order of the following system boot sequences: _____
   a. The kernel starts systemd
   b. The machine's BIOS or boot firmware loads and runs a boot loader.
   c. The kernel mounts the root filesystem.
   d. The boot loader finds the kernel image on disk, loads it into memory, and starts it.
   e. The kernel initializes the devices and its drivers.

6. Thread pool:
   (1) (3%) What is a thread pool
   (2) (6%) What are the benefits of the thread pool
   (3) (6%) What is the purpose of the "work stealing algorithm" used in the Fork-Join pool?

7. (10%) Inverted Page Table:
   (1) Please illustrate (explain using a diagram) the structure of the inverted page table
   (2) Why inverted page table does not (or hard to) support shared library?

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考試科目	計算機數學	系所別	資訊科學系	考試時間	2月7日(五) 第4節

I. 離散數學: 六大題(1-6)，共 60%

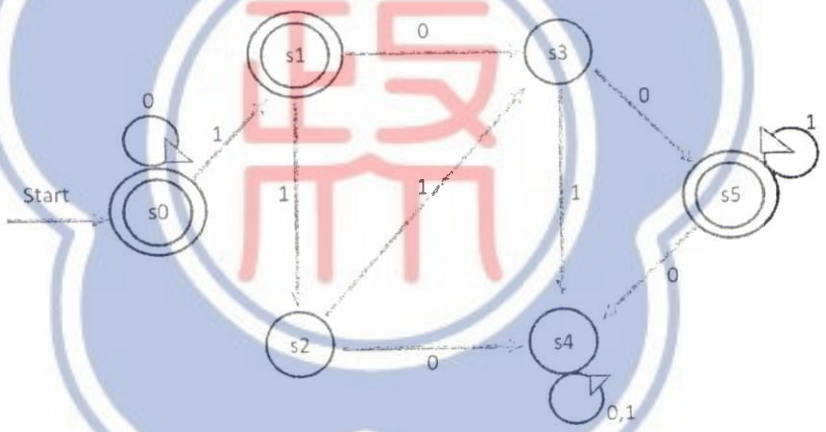
II. 線性代數: 三大題(7-9)，共 40%

請書寫必要的解題過程，僅書寫答案而缺乏必要的過程，無法獲得該題滿分。可使用中文或英文作答，力求書寫工整，如字跡潦草，無法閱讀，將影響評分。

1. (10%) Find the language recognized by the given deterministic finite-state-machine with no output (or called finite-state-automaton). Final states are indicated in state diagrams by using double circles (ie., s0, s1 and s5 are final states). Write down your answer using the presentation like the following example:

$$\{1\}^*\{0\}\{0\}^* \cup \{0\}\{10,11\}\{0,1\}^*.$$

Here the example says that the languages recognized by a finite-state-automaton are either $\{1\}^*\{0\}\{0\}^*$ or $\{0\}\{10,11\}\{0,1\}^*$ where $\{1\}^*\{0\}\{0\}^*$ is the language starting with any number of 1s followed by a 0 and then followed by any number of 0s. And, $\{0\}\{10,11\}\{0,1\}^*$ means the language starts with a 0 and then followed by 10 or 11 and finally ends with $\{0,1\}^*$which means a bit string with arbitrary length.



2. (10%) Use Chebyshev's inequality to find an upper bound on the probability that the number of tails that come up when a biased coin with probability of heads equal to *0.6* is tossed n times deviates from the mean by more than $\sqrt{n}$.
3. (10%) Suppose that we have prior information concerning whether a random incoming message is spam. In particular, suppose that over a time period, we find that s spam messages arrive and h messages arrive that are not spam.
   (a) Use this information to estimate p(S), the probability that an incoming message is spam, and $p(\overline{S})$, the probability an incoming message is not spam.
   (b) Let W be the event that an incoming message contains the word w. Use Bayes' theorem and part (a) to estimate the probability that an incoming message containing the word w is spam, where p(w)=p($W|S$) is the probability that w occurs in a spam message and q(w)= $p(W|\overline{S})$ is the probability that w occurs in

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a message that is not spam.

4. (10%) The concept of equivalence relation is characterized by three properties.
   (a). (5%) What are the three properties?
   (b). (5%) Show that isomorphism of simple graphs is an equivalence relation.
5. (10%) The recurrence relation $a_n = 9a_{n-1} - 26a_{n-2} + 24a_{n-3}$ is a linear homogeneous recurrence relation.
   (a). Find the characteristic root(s) of the recurrence relation.
   (b). Assume the initial conditions of the relation are $a_0 = 4, a_1 = 15, a_2 = 61$. Find the solution to the recurrence relation.
6. (10%)
   (a). (5%) Find the least positive integer x such that $x \equiv 28^{200} mod\ 19$.
   (b). (5%) Use the Extended Euclidean Algorithm to find the least positive integer x such that $13x \equiv 1 \pmod{2436}$.
7. (10%) Maximize z where $z = 25x + 60y$ subject to the constraints
   $$2y - x \le 5, \quad y + 4x \le 25, \quad y + x \ge 7, \quad x \ge 0, \quad y \ge 0.$$
8. (10%) Find a steady state vector for the matrix M where
   $$M = \begin{bmatrix} 0 & 0.5 & 0 \\ 0.5 & 0 & 1 \\ 0.5 & 0.5 & 0 \end{bmatrix}.$$
9. (20%) Let $x_1^2 + x_2^2 + 2x_3^2 + 2x_1x_2 = 2$.
   (a). (5%) Express the equation as a matrix representation of the form $x^tAx=2$. Here $x^t = [x_1 \quad x_2 \quad x_3]$ is the transpose of the matrix x.
   (b). (5%) Find the eigenvalues of this matrix A.
   (c). (5%) Find the orthogonal matrix C that diagonalizes A
   (d). (5%) Reduce the quadratic form $x_1^2 + x_2^2 + 2x_3^2 + 2x_1x_2$ by the Principal-Axes Theorem for R^3.

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