國立清華大學102學年度碩士班考試入學試題

系所班組別：生命科學院丙組(0506)

考試科目（代碼）：計算機概論(演算法與計算機數學)(0604)

1. Terminology: Please define the following terms. For abbreviated terms, please give their original forms first. (20%)

   (1) RISC and CISC (computer architecture). (2%)

   (2) Write-through and write-back buffering strategies (computer architecture). (2%)

   (3) Pseudo-polynomial time complexity (algorithm). (2%)

   (4) Undecidable problem (algorithm). (2%)

   (5) Belady's anomaly (operating system). (2%)

   (6) Process and thread (operating system). (2%)

   (7) Hidden and exposed terminal problems (networking). (2%)

   (8) Client-server and point-to-point (P2P) architecture. (networking) (2%)

   (9) Imperative and functional programming paradigms (programming language). (2%)

   (10) Run-length encoding (RLE) (cryptography). (2%)

2. Describe the key steps of the boot-up sequence of a computer. (6%)

3. Quick sort is a widely used sorting algorithm, known for its high efficiency. (25%)

   (1) Write down the (C-like) pseudo-code of the quick sort algorithm that sorts an array T with N integers T[0]...T[N-1]. Your program should be in-place, *i.e.*, consuming at most constant extra space. Your program should be stable. (5%)

   (2) Show the best and the worst case running time of the quick sort algorithm. Which cases does the quick sort algorithm yield the best and the worst cases respectively? Justify your answers. (10%)

   (3) Based on (2), show how to guarantee that the quick sort algorithm always yields the best-case asymptotic performance? If any, describe the possible limitations or drawbacks of your approach. (10%)

4. Answer the following questions of floating-point arithmetic. (15%)

(1) IEEE 754 defines the binary formats of floating-point numbers. With IEEE 754 single precision standard, the base is 2 and the precision is 24 (digits). Give out the following floating-point numbers in scientific format, except for NaN (Not a Number) and $\pm\infty$. *Hint: A single precision floating-point number is of 32 bits.* (4%)

i. The largest positive floating point number (1%)

ii. The smallest positive floating point number (1%)

iii. The largest negative floating point number (1%)

iv. The smallest negative floating point number (1%)

(2) Suppose that Alice has borrowed `S` dollars from Bob. The monthly compound interest rate is `P`. What are the potential problems with the following simple algorithm that computes the compound interest plus the principal after `K` months? Suppose that `S>1`, `P>0` and `K>0`. *Hint: P might be very small, whereas S and K might be very large!* (4%)

```
float compute_interest( float S, float P, int K ) {
    for( int i = 0; i <K; i++ )
        S *= (1+P);
    return S;
}
```

(3) Depict a simple solution that alleviates the potential problems in (2). (7%)

5. A naïve matrix multiplication algorithm uses a three-level loop to multiply two `n*n` square matrices, and takes $O(n^3)$ running time. (15%)

   (1) For two `n*n` matrices A and B, briefly explain how Strassen's algorithm could enhance the asymptotic running time of the multiplication process of A and B, as compared to the naïve approach. You can assume that `n` is even for simplicity. (6%)

   (2) To multiply two `n*n` matrices A and B, the running time `T(n)` of the Strassen's algorithm could be expressed as the following formula, where b and c are constants:

$$T(n) = \begin{cases} b & n \leq 2 \\ 7T\left(\frac{n}{2}\right) + cn^2 & n > 2 \end{cases}$$

   Derive the close form of `T(n)`. You need to show the process of computation. (9%)

6. It is a common technique to "concatenate" multiple hard disk drives to enhance the data access performance. However, reliability issues might arise: (19%)

   (1) Suppose that we have N identical hard disk drives organized in the RAID-0 scheme. Briefly describe the RAID-0 scheme. (3%) The throughput of each hard disk drive is S, and the failure rate of each hard disk drive is F. Derive the throughput S' and faiurel rate F' of the overall RAID-0 storage system. (4%)

   (2) To enhance the reliability of data, other RAID schemes introduce redundancy to prevent harms in the presence of single disk failures. Describe and compare the pros and cons of the RAID-4 and RAID-5 schemes. (4%) Suppose that RAID-5 is adopted on the aforementioned storage systems with N hard disk drives. Derive the throughput S'' (2%), the failure rate F'' (4%) and the space utilization U'' (2%) of the overall RAID-5 storage system.