Quiz 0 Prerequisites

CS 5968/6968 – Data Str & Alg Scalable Comp

January 9, 2023

Data Structures

Problem 1. In C++ standard library, the template class `std::unordered_set` is implemented using a hash table. What is the expected time complexity of adding an element to a size n `unordered_set` instance?

(a) $\Theta(1)$

(b) $\Theta(\log n)$

(c) $\Theta(n)$

(d) $\Theta(n \log n)$

Problem 2. What is the time complexity to build a binary search tree from any size n list (in the worst case)?

(a) $O(n^2)$

(b) $O(n \log n)$

(c) $O(n)$

Problem 3. What is the space required to store a binary tree for n items?

(a) $\Theta(n^2)$

(b) $\Theta(n \log n)$

(c) $\Theta(n)$

(d) $\Theta(\log n)$

Problem 4. What is the time complexity for a priority queue to return the object with greatest weight?

(a) $O(1)$

(b) $O(\log n)$

(c) $O(n)$

(d) $O(n \log n)$

Problem 5. What is the time complexity for a priority queue to add a new object with its weight?

(a) $O(1)$

(b) $O(\log n)$

(c) $O(n)$

(d) $O(n \log n)$

Problem 6. What is the space complexity of a priority queue with n items?

(a) $O(1)$

(b) $O(\log n)$

(c) $O(n)$

(d) $O(n \log n)$

Recursion

Problem 7. The master theorem can be used to analyze the asymptotic running time of any divide-and-conquer algorithm. Consider an algorithm that solves a size n problem by dividing it into three smaller problems, each has size $n/2$, the overhead cost is $O(n^2)$, so the total running time can be written as

$$T(n) = 3T(n/2) + n^2$$

What is $T(n)$ asymptotically?

(a) n^2

(b) $n^2 \log n$

(c) n^3

(d) $n^3 \log n$

Consider a graph with n vertices and m edges.

Problem 8. What is the space complexity of the *adjacency list* representation of the graph?

(a) $\Theta(n + m)$

(b) $\Theta(nm)$

(c) $\Theta(n^2)$

Problem 9. What is the space complexity of the *adjacency matrix* representation of the graph?

(a) $\Theta(n + m)$

(b) $\Theta(nm)$

(c) $\Theta(n^2)$

Problem 10. What is the space complexity of the *incidence matrix* representation of the graph?

(a) $\Theta(n + m)$

(b) $\Theta(nm)$

(c) $\Theta(n^2)$

Problem 11. What is the best upper bound of the time complexity of finding the shortest path between two vertex?

(a) $O(n)$

(b) $O(m)$

(c) $O(nm)$

(d) $O(n^2)$

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Asymptotics

Problem 12. Let the running time of algorithm $\mathcal{A}_1$ and $\mathcal{A}_2$ be f_1 and f_2 respectively, if f_1 is $O(n^2)$ and f_2 is $O(\log f_1)$, then what is the running time complexity of algorithm $\mathcal{A}_2$ in terms of n?

(a) $O(\log n)$

(b) $O(n \log n)$

(c) $O(n^2)$

(d) $O(n^2 \log n)$

Problem 13. Which is the better result for a time/space complexity?

(a) $O(n)$

(b) $o(n)$

Problem 14. If the time/space complexity of an algorithm is known to be $o(n)$, which result is still reasonable?

(a) $\Omega(n)$

(b) $\Theta(n)$

(c) $O(n)$

Problem 15. Which is not true?

(a) $f \sim g \Rightarrow f = \Theta(g)$

(b) $f = \Theta(g) \Rightarrow f \sim g$

(c) $f = O(g) \Rightarrow g = \Omega(f)$

(d) $g = \Omega(f) \Rightarrow f = O(g)$

Streaming

Problem 16. Consider a stream of items, and you know that there are at most n distinct items. What is the space required to count the exact frequencies of all distinct items in a stream?

(a) $O(n)$

(b) $O(\sqrt{n})$

(c) $O(\log n)$

Problem 17. A streaming algorithm can only pass data once and can only use limited space which is independent of the stream size. Which is not reasonable for a streaming algorithm?

(a) the mean

(b) frequencies of some specific items

(c) the median

(d) the variance

I/O complexity

Problem 18. Consider a system which can read b bytes with one I/O operate from disk. If one want to sample k bytes from a file with size n bytes, how many I/Os are required in the worst case?

(a) k

(b) n/b

(c) k/b

(d) $\min(k, n/b)$