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浙江大学2019-20学年春夏学期《高级数据结构与算法分析》课程期末考试试卷

判断题 13 | A. 单选题 20 | 程序填空题 1 | 函数题 1

2-1 Assume P≠NP, please identify the false statement. (3分)

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- A. In the minimum-degree spanning problem, we are given a graph G=(V, E) and wish to find a spanning tree T of G so as to minimize the maximum degree of nodes in T. Then it is NP-complete to decide whether or not a given graph has minimum-degree spanning tree of maximum degree two.
- B. There cannot exist a p-approximation algorithm for bin packing problem for any $\rho < 3/2$.
- C. In the minimum-degree spanning problem, we are given a graph G=(V, E) and wish to find a spanning tree T of G so as to minimize the maximum degree of nodes in T. Then there exists an algorithm with approximation ratio less than 3/2.
- D. In the knapsack problem, for any given real number $\epsilon > 0$, there exists an algorithm with approximation ratio less than $1 + \epsilon$.

2-1 答案正确 (3分) 创建提问

2-2 A replacement selection is applied to generate the max run with a priority queue of 5 records. When the sequence of numbers is { 11, 61, 17, 14, 94, 28, 36, X, ... } and the length of the first run is 7, what is the sufficient condition of X? (3分)

作者 何钦铭
单位 浙江大学

- A. less than 35
- B. greater than 17
- C. less than 17
- D. less than 94

2-2 答案正确 (3分) 创建提问

2-3 To solve a problem with input size N by divide and conquer, an algorithm divides the problem into 2 subproblems with size $\sqrt{N}$ (assuming it is an integer) and the time recurrences is

$$T(N) = 2T(\sqrt{N}) + \log(N)$$

What is the overall time complexity of this algorithm? (3分)

作者 徐镜春
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- A. $O(\log(N))$
- B. $O(\log(N)\log\log(N))$
- C. $O(\log(N)l^*)$
- D. $O(\sqrt{N}\log(N))$

2-3 答案正确 (3分) 创建提问

2-4 To build a leftist heap, we can start from placing all the keys as single-node heaps on a queue, and perform the following until only one heap is on the queue: dequeue two heaps, merge them, and enqueue the result.

Then the best description of the time complexity of this procedure is: (3分)

作者 丁俊俊
单位 浙江大学

- A. $O(\sqrt{N})$
- B. $O(N)$
- C. $O(\log N)$
- D. $O(N\log N)$

2-4 答案正确 (3分) 创建提问

2-5 ** Load balancing problem: ** We have n jobs $j = 1, 2, \ldots, n$ each with processing time p_j being an integer number. Our task is to find a schedule assigning n jobs to 100 identical machines so as to minimize the makespan (the maximum completion time over all the machines).

We adopt the following local search to solve the above load balancing problem.

*LocalSearch: *

Start with an arbitrary schedule.

Repeat the following until no job can be re-assigned:

- Let l be a job that finishes last.
- If there exists a machine i such that assigning job l to i allows l finish earlier, then re-assign l to be the last job on machine i.
- If such a machine is not unique, always select the one with the minimum completion time.

We claim the following four statements:

1. The algorithm LocalSearch finishes within polynomial time.
2. The Load-balancing problem is NP-hard.
3. Let OPT be the makespan of an optimal algorithm. Then the algorithm LocalSearch finds a schedule with the makespan at most of 1.95 OPT.
4. This algorithm finishes within $O(n^2)$.

How many statements are correct ? (3分)

作者 邓俊辉
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- A. 3
- B. 4
- C. 2
- D. 1
- E. 0

2-5 答案错误 (0分) 创建提问

2-6 To solve a problem with input size N by divide and conquer, algorithm A divides the problem into 6 subproblems with size $N/2$ and the time recurrences is (3分)

$$T(N) = 6T(N/2) + 6N^2.$$

Now we attempt to design another algorithm B dividing the problem into a subproblems with size $N/4$ and the time recurrences is

$$T(N) = aT(N/4) + 6N^2.$$

In order to beat algorithm A, what is the largest integer value of a for which algorithm B would be asymptotically faster than algorithm A?

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- A. 36
- B. 24
- C. 18
- D. 12

2-6 答案正确 (3分) 创建提问

2-7 Merge the two skew heaps in the following figure. How many of the following statements is/are FALSE? (3分)

作者 丁俊俊
单位 浙江大学

- the null path length of 8 is the same as that of 6
- 35 is the right child of 18
- the depths of 18 and 33 are the same

- A. 3
- B. 1
- C. 0
- D. 2

2-7 答案错误 (0分) 创建提问

2-8 If P and NP are different, which of the following statements is true? (3分)

作者 Can Wang
单位 浙江大学

- A. We can find polynomial time solution for Hamilton cycle problem.
- B. $P \cap NP$-Complete $\neq \emptyset$.
- C. There is no polynomial time algorithm to solve the vertex cover problem.
- D. P = NP-Complete.

2-8 答案正确 (3分) 创建提问

2-9 After inserting number 20 into a binomial queue of 8 numbers { 12, 13, 14, 23, 24, 35 }, which of the followings is impossible? (3分)

作者 何钦铭
单位 浙江大学

- A. the LeftChild link of node 12 may point to node 14
- B. the NextSibling link of node 14 may point to node 20
- C. the NextSibling link of the node 20 is NULL
- D. the LeftChild link of the node 20 is NULL

2-9 答案正确 (3分) 创建提问

2-10 Sorting by-merging is a classic serial algorithm. It can be translated directly into a reasonably efficient parallel algorithm. A recursive description follows: (3分)

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```
MERGE-SORT(A,B1,B2) ,..., A(n): B(1), B(2), ..., B(n) )
Assume that n = 2^l for some integer l ≥ 0
if n = 1 then return B(1) := A(1)
else call, in parallel, MERGE-SORT( A(1), ..., A(n/2): C(1), ..., C(n/2) ) and
    • MERGE-SORT(A(n/2+1), ..., A(n): C(n/2+1), ..., C(n) )
    • Merge (C(1), ...,C(n/2)) and (C(n/2 + 1), ...,C(n)) into (B(1), B(2), ..., B(n)) with time O(n)
Then the MERGE-SORT uses in ,...,
```

- A. $O(n\log^2 n)$ work and $O(\log n)$ time
- B. $O(n\log^2 n)$ work and $O(\log^2 n)$ time
- C. $O(n\log n)$ work and $O(\log n)$ time
- D. $O(n\log n)$ work and $O(\log^2 n)$ time

2-10 答案错误 (0分) 创建提问

2-11 Given the following game tree, if node **b** is pruned with α-β pruning algorithm, which of the following statements about the value of node **a** is correct? (3分)

作者 何钦铭
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- A. greater than 65
- B. greater than 66
- C. less than 66
- D. less than 65

2-11 答案正确 (3分) 创建提问

2-12 `If X is a problem in class NP, then how many of the following statements is/are TRUE?` (3分)

作者 Can Wang
单位 浙江大学

- There is no polynomial time algorithm for X.
- There is a polynomial time algorithm for X.
- If X can be solved deterministically in polynomial time, then P = NP.

- A. 3
- B. 1
- C. 0
- D. 2

2-12 答案正确 (3分) 创建提问

2-13 After inserting { 3, 4, 5, 6, 1, 2 } into an initially empty red-black tree, which of following is **False**? (3分)

作者 杨洋
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- A. 3 is the right child of 2, and the color of 3 is red.
- B. 4 is the root with the black height as 2.
- C. 5 is the left child of 6, and the color of 5 is black.
- D. The resulting tree is a full tree.

2-13 答案正确 (3分) 创建提问

2-14 Insert { 9, 8, 7, 2, 3, 5, 6, 4 } one by one into an initially empty AVL tree. How many of the following statements is/are FALSE? (3分)

- the total number of rotations made is 8. (Note: double rotation counts 2 and single rotation counts 1)
- the expectation (round to 0.01) of access time is 2.77
- there are 2 nodes with a balance factor of -1

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- A. 0
- B. 2
- C. 3
- D. 1

2-14 答案错误 (0分) 创建提问

2-15 The potential function Q of a binomial queue is the number of the trees. After merging two binomial queues $H1$ with 22 nodes and $H2$ with 13 nodes, what is the potential change $Q(H1 + H2) - (Q(H1) + Q(H2))$? (3分)

作者 何钦铭
单位 浙江大学

- A. 0
- B. -3
- C. -2
- D. 2

2-15 答案正确 (3分) 创建提问

2-16 In the maximum satisfiability problem (MAX SAT), the input consists of n Boolean variables $x_1, \ldots, x_n$, m clauses $C_1, \ldots, C_m$,each of which consists of a disjunctionthat is an "or" of some number of the variables and their negations, e.g. $x_1 \vee \bar{x}_2 \vee x_{11}$ where $\bar{x}_i$ is the negation of x_i), and a nonnegative weight w_j for each clause C_j. The objective of the problem is to find an assignment of the truthvalue to the x_i that maximizes the weight of the satisfied clauses.

A variable or a negated variable is a literal. The number of literals in a clause is called its length. Denote l_j to be the length of a clause C_j. Clauses of length 1 are called unit clauses.

Randomized algorithm RA: Setting each x_i to true with probability p independently.

Which of the following statement is false? (3分)

作者 邓俊辉
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- A. One could obtain a better bound on optimal solution than $\sum_{j=1}^{m} w_j$ for MAX SAT.
- B. If $l_j \geq 3$ for each clause C_j, Let $p = 1/2$, the randomized algorithm RA is a 8/9-approximation algorithm.
- C. If MAX SAT instances do not have unit clauses l_j, we can obtain a randomized $\frac{1}{1-(1-\frac{1}{k})^k} = 1.618$-approximation algorithm for MAX SAT.
- D. Let $p = 1/2$, the randomized algorithm RA is a 2-approximation algorithm.

2-16 答案错误 (0分) 创建提问

2-17 Assume that there are 10000 documents in the database, and the statistical data for one query are shown in the following table. One metric for evaluating the relevancy of the query is F-α score, which is defined as (1+ α)×precision*recall/(α×precision+recall). Then the F-0.5 (α=0.5) score for this query is: (3分)

作者 杨洋
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	Relevant	Irrelevant
Retrieved	4800	1200
*Not Retrieved *	3200	800

- A. 0.80
- B. 0.60
- C. 0.72
- D. 0.65

2-17 答案正确 (3分) 创建提问

2-18 In Activity Selection Problem, we are given a set of activities $S = \{a_1, a_2, \ldots, a_n\}$ that wish to use a resource (e.g. a room). Each a_i takes place during a time interval $[s_i, f_i)$.

Let us consider the following problem: given the set of activities S, we must schedule them all using the minimum number of rooms.

Greedy1 Use the optimal algorithm for the Activity Selection Problem to find the max number of activities that can be scheduled in one room. Delete and repeat on the rest, until no activities left.

Greedy2:

- Sort activities by start time. Open room 1 for a_1.
- for $i = 2$ to n if a_i can fit in any open room, schedule it in that room; otherwise open a new room for a_i.

  Which of the following statement is correct?

作者 邓俊辉
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- A. Both of the above two greedy algorithms are optimal.
- B. None of the above two greedy algorithms are optimal.
- C. Greedy1 is an optimal algorithm and Greedy2 is not.
- D. Greedy2 is an optimal algorithm and Greedy1 is not.

2-18 答案错误 (0分) 创建提问

2-19 Start from N single-node splay trees, let's merge them into one splay tree in the following way: each time we select two splay trees, delete nodes one by one from the smaller tree and insert them into the larger tree. Then which of the following statements is NOT true? (3分)

作者 陈越
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- A. The amortized time bound for each insertion is $O(\log^2 N)$.
- B. In any sequence of $N - 1$ merges, there are at most $O(N\log N)$ inserts.
- C. The amortized time bound for each merge is $O(\log N)$.
- D. Any node can be inserted at most $\log N$ times.

2-19 答案错误 (0分) 创建提问

2-20 For the result of accessing the keys 1 and 2 in order in the splay tree in the following figure, let's define $\mathbf{size}(x)$ = number of nodes in subtree of x (x included) and potential $\phi = \sum_x \lfloor \log_2 \mathbf{size}(x) \rfloor$, where $\lfloor x \rfloor$ means the greatest integer no larger than x. (3分)

作者 丁俊俊
单位 浙江大学

How many of the following statements is/are TRUE?

- the potential change from the **initial** tree to the **resulted** tree is -4
- 1 is the sibling of 4
- 5 is the child of 6

- A. 1
- B. 0
- C. 3
- D. 2

2-20 答案正确 (3分) 创建提问