

Question - 1

2-3 Tree and Red-Black Tree

SCORE: 10 points

Which of the following about 2-3 Tree and Red-Black Tree is correct?

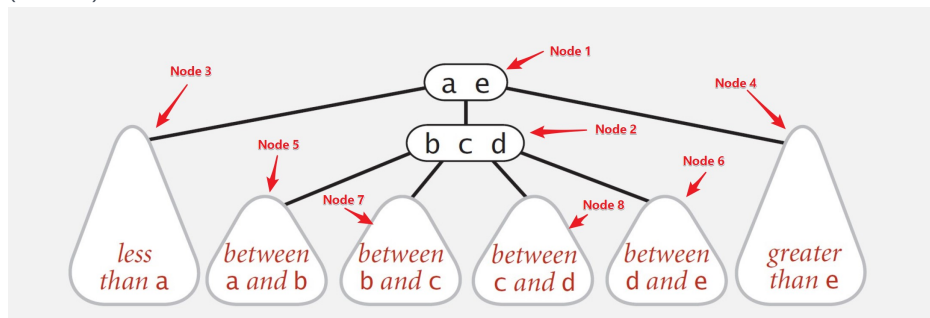
- ☐ Only Red-Black Tree is "perfectly balanced"
- ☐ Both 2-3 Tree and Red-Black Tree are "perfectly balanced"
- ☒ 2-3 Tree is "perfectly balanced" and Red-Black Tree is "perfectly BLACK balanced"
- ☐ 2-3 Tree is "perfectly balanced" and Red-Black Tree is "perfectly RED balanced"
- ☐ None of the above

Question - 2

2-3 Tree

SCORE: 10 points

While splitting a 4-node in a 2-3 Tree, which nodes will be touched (modified)?



- ☐ Node 1
- ☒ Node 1 and Node 2
- ☐ Node 1, Node 2, Node 3 and Node 4
- ☐ Node 1, Node 2, Node 3, Node 4, Node 5 and Node 6
- ☐ All of the above 8 Nodes (Node 1 to 8)

Question - 3

2-3 Tree

SCORE: 10 points

Which of the following about 2-3 tree's complexity is correct?

- ☐ Best case: $\log_2 N$
- ☐ Worst case: $\log_3 N$
- ☒ Between $\log_2 N$ and $\log_3 N$
- ☐ None of the above

Question - 4

SCORE: 10 points

Red-Black Tree

Which of the following about Red-Black Tree is correct?

- ☐ Every path from root to null link has the same number of RED links
- ☒ Every path from root to null link has the same number of BLACK links
- ☐ Every path from root to null link has the same number of (RED + BLACK) links
- ☐ None of the above

Question - 5

SCORE: 20 points

Red-Black Tree

Please briefly explain why the longest simple path from a node x in a red-black tree to a descendant leaf has length at most twice that of the shortest simple path from node x to a descendant leaf.

Question - 6

SCORE: 20 points

(Bonus) Red-Black Tree

(This question is a bonus - You cannot get more than 100 total but you can get additional score if you lose marks in other questions)
Please briefly explain why "height of Red-Black Tree is $\leq 2\lg(N+1)$ in the worst case" in LESS THAN 3 sentences.

Question - 7

SCORE: 30 points

Red-Black Tree Implementation

Please implement `put()` and `rotateLeft()` for Red-Black Tree. (15 pts for each)

`put()`: Line 72

`rotateLeft()`: Line 94

- * You don't need to change other code.
- * There is no `main()` method. Please use "Run Unit Tests" to test your code.
- * Unit tests for this question takes some time. Please be patient while compiling...