CS 202
Fundamental Structures of Computer Science II

Fall 2017
Assignment 4 Solutions

Section 1
Selim Firat Yilmaz
21502736
firat.yilmaz@ug.bilkent.edu.tr

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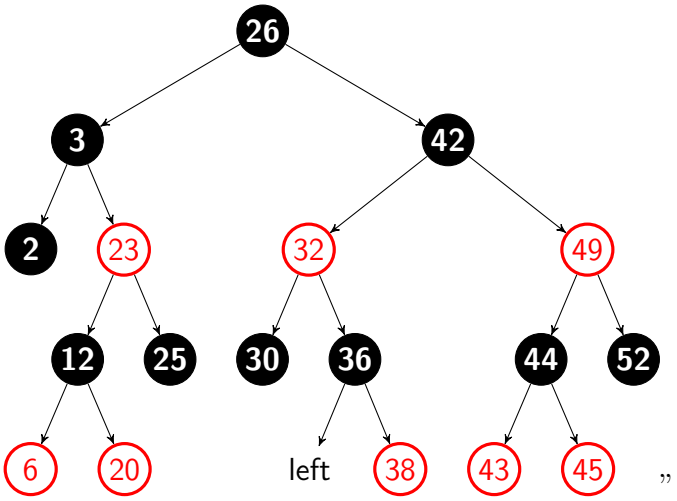
Contents

1 Question 1

1.1 a) Red/Black Tree Equivalent of 2-3-4 Tree



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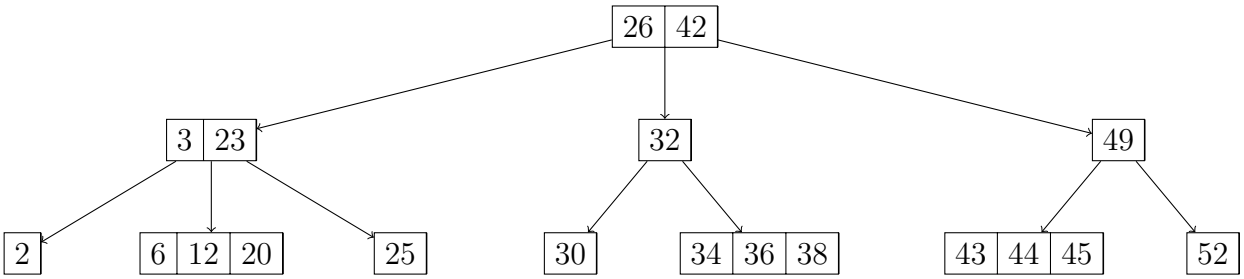
3 nodes are expanded to the right.(i.e. red nodes placed as the right child) Also, the "left" marker represents an empty node. It is placed due to LaTeX.

1.2 b) 2-3-4 Tree Insertion/Deletion



2 Question 2

2.1 a)

$2 * (3^0 + 3^1 + ... + 3^h)$ is the maximum number of keys that a 2-3 tree of height h can hold.

2.2 b)

After inserting I.

2.3 c)

$O(n \log n)$

$\mathcal{O}(n \log n)$ We can sort within $O(n)$ time complexity since red-black tree has same ordering with regular BST. Thus, regular BST sort applies (i.e. in order traversal is enough).

2.4 d)

No, the number of black pointers to the root is different for these subtrees.

3 Question 3

Table 1: Expected Time Complexities

Data Structure	**insert**	**isMember**
unsorted array	$\mathcal{O}(1)$	$\mathcal{O}(n)$
red-black tree	$\mathcal{O}(\log n)$	$\mathcal{O}(\log n)$
hashing	$\mathcal{O}(1)$	$\mathcal{O}(1)$
priority queue using a heap	$\mathcal{O}(\log n)$	$\mathcal{O}(n)$
sorted linked list	$\mathcal{O}(n)$	$\mathcal{O}(n)$

4 Question 4

Works on Visual Studio but couldn't make it work on Dijkstra...