Recitation 4

July 5, 2018

Outline

Review homework 3

Review midterm

Red Black Trees (Rotation and Balancing)

Recitation Quiz

Homework 3

Communication Network Class

Functions → head wasn’t a parameter?

Midterm Review

Multiple Choice

Mean: 78.06%

Median: 76.92%

Standard Deviation: 11.52%

1	Conceptual Linked List 4	12	66.67%
2	Conceptual Linked List 6	12	33.33%
3	Conceptual Node Updates 1	12	83.33%
4	Queue question 3	12	90.56%
5	Stack Question 1	12	63.89%
6	C++ pass by reference or value	12	91.67%
7	Command Line Argument	12	83.33%
8	Pointers - value after function	12	91.67%
9	Pointers - valid function call	12	91.67%
10	What does O(n) measure?	12	50.00%
11	What does & represent?	12	83.33%
12	Queue question 10	12	85.37%
13	Queue question 4	12	100.00%

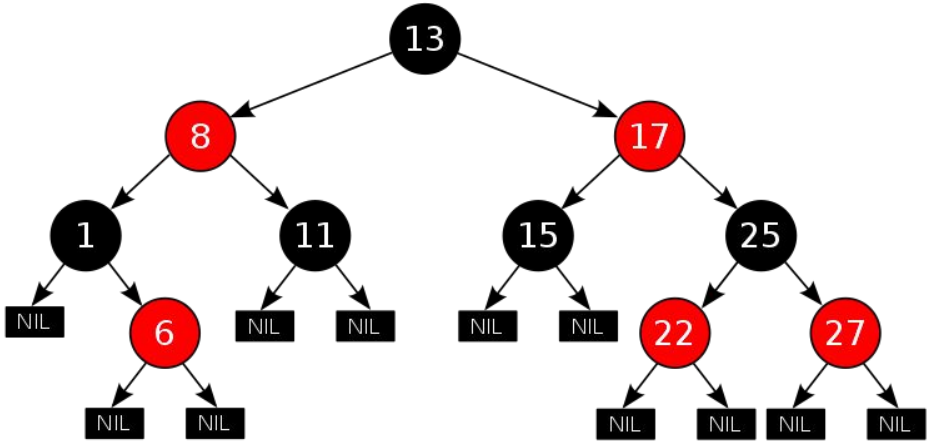
Red Black Trees

1) Every node has a color either red or black.

2) Root of tree is always black.

3) There are no two adjacent red nodes (A red node cannot have a red parent or red child).

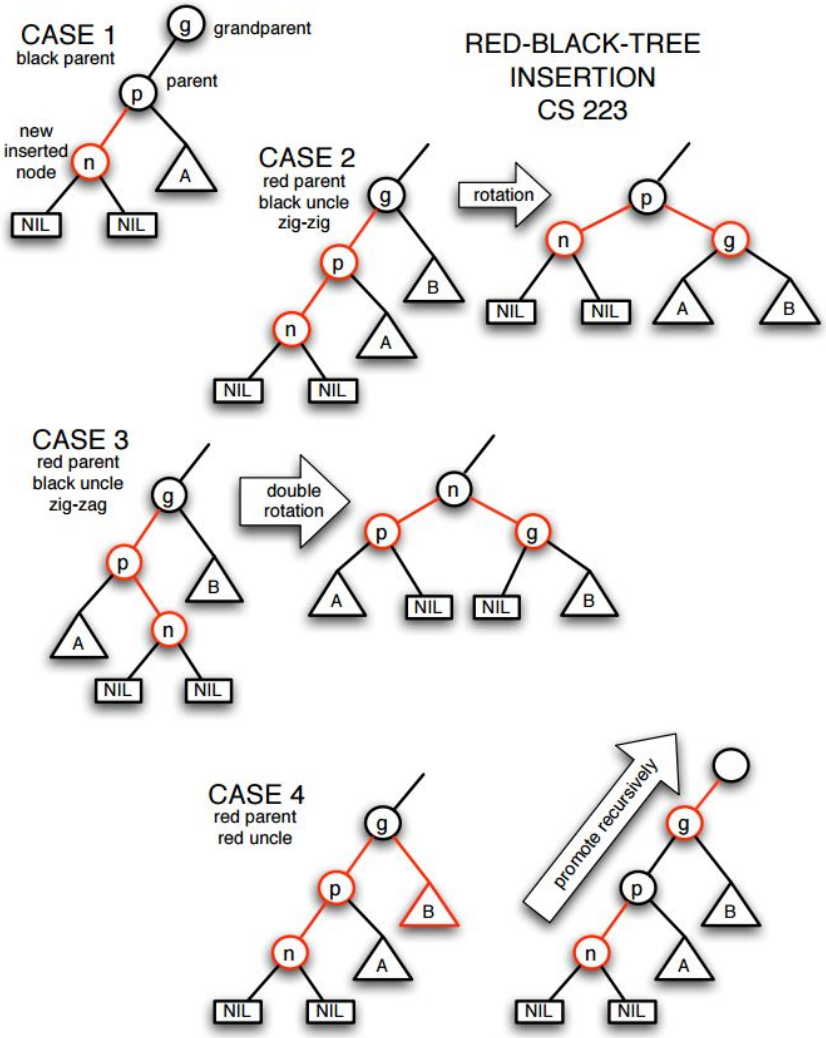
4) Every path from root to a NULL node has same number of black nodes.



Red Black Trees Pseudocode

```
RB-INSERT(T, z)
 1  y = T.nil
 2  x = T.root
 3  while x ≠ T.nil
 4       y = x
 5       if z.key < x.key
 6            x = x.left
 7       else x = x.right
 8  z.p = y
 9  if y == T.nil
10       T.root = z
11  elseif z.key < y.key
12       y.left = z
13  else y.right = z
14  z.left = T.nil
15  z.right = T.nil
16  z.color = RED
17  RB-INSERT-FIXUP(T, z)
```

```
RB-INSERT-FIXUP(T, z)
 1  while z.p.color == RED
 2       if z.p == z.p.p.left
 3            y = z.p.p.right
 4            if y.color == RED
 5                 z.p.color = BLACK                    // case 1
 6                 y.color = BLACK                      // case 1
 7                 z.p.p.color = RED                    // case 1
 8                 z = z.p.p                            // case 1
 9            else if z == z.p.right
10                      z = z.p                         // case 2
11                      LEFT-ROTATE(T, z)               // case 2
12                 z.p.color = BLACK                    // case 3
13                 z.p.p.color = RED                    // case 3
14                 RIGHT-ROTATE(T, z.p.p)               // case 3
15       else (same as then clause
                 with "right" and "left" exchanged)
16  T.root.color = BLACK
```


RED-BLACK-TREE
INSERTION
CS 223
CASE 1
black parent
grandparent
parent
new
inserted
node
CASE 2
red parent
black uncle
zig-zig
rotation
CASE 3
red parent
black uncle
zig-zag
double
rotation
CASE 4
red parent
red uncle
promote recursively
NIL
A
B

Quiz Password

Dennys