CS 367 - Introduction to Data Structures
Thursday, March 31, 2016

Homework 7 due 10 pm tomorrow, April 1st

Program 4 due 10 pm Sunday, April 17th

Last Time
  Binary Search Tree (BST)
    • BSTnodes
    • BST class
    • implementing print
    • implementing lookup, insert, delete
    • complexities of BST methods
  CS Options/Courses

Today
  Classifying Binary Trees
  Balanced Search Trees
  Red-Black Trees
    • tree properties
    • print, lookup
    • insert

Next Time
  Read: start Graphs
  Finish Red-Black Trees
  ADTs/Data Structures Revisited
  Graphs
    • terminology
Classifying Binary Trees

Full

Complete

Height-balanced

Balanced
Practice - Classifying Binary Trees

Identify which trees below are full, complete and/or height balanced.

A

B

C

D

E

F
Balanced Search Trees

Goal:

Idea:

AVL

BTrees
Red-Black Trees (RBT)

RBT:

Example:

Red-Black Tree Properties

- root property
- red property
- black property

Red-Black Tree Operations

- print
- lookup
- insert
- delete
Inserting into a Red-Black Tree

Goal: insert key value K into red-black tree T and ________________________________.

If T is Empty

If T is Non-Empty
  - step down tree as done for BST
  - add a leaf node containing K as done for BST, and __________________________

→ Which of the properties might be violated as a result of inserting a red leaf node?
  - root property
  - black property
  - red property

Non-Empty Case 1: K's parent P is black
Non-Empty Case 2

Non-Empty Case 2: K’s parent P is red

Fixing an RBT

Tri-Node Restructuring is done if P’s sibling S is null

Recoloring is done if P’s sibling S is red
Practice

1. Starting with an empty RBT, show the RBT that results from inserting 7 and 14.

2. Redraw the tree from above and then show the result from inserting 18.

3. Redraw the tree from above and then show the result from inserting 23.

4. Redraw the tree from above and then show the result from inserting 1 and 11.

5. Redraw the tree from above and then show the result from inserting 20.
More Practice!

6. Redraw the tree from the previous page and then show the result from inserting 29.

7. Insert the same list of values into an empty BST: 7, 14, 18, 23, 1, 11, 20, 29

What does this demonstrate about the differences between a BST and RBT?
More Practice?

8. Show the result from inserting 25 in the RBT below.

9. Redraw the tree from above and then show the result from inserting 27.
Cascading Fixes

Fixing an RBT UPDATED!

Recoloring is done if P’s sibling S is red

1. change P & S to black
2. if G is the root – done
   otherwise change G to red

Tri-Node Restructuring is done if P’s sibling S null ________________
RBT Complexity

print

lookup

insert