

# Today - Lectures 12 & 13 CS163

1. Removal Algorithm
  2. Tree efficiency (Topic #9)
  3. Advanced Trees (Topic #10) - 2-3, 2-3-4
- Next: AVL & Red Black Trees!

Announcements:

# 2-3 Tree

100% balanced, 100% of the time :

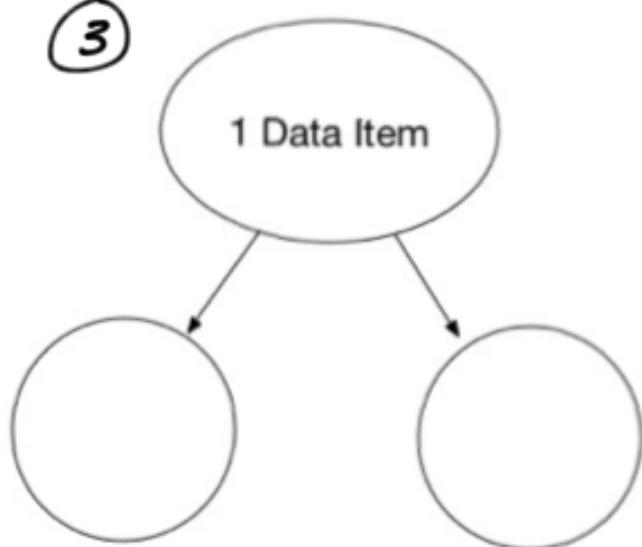
①



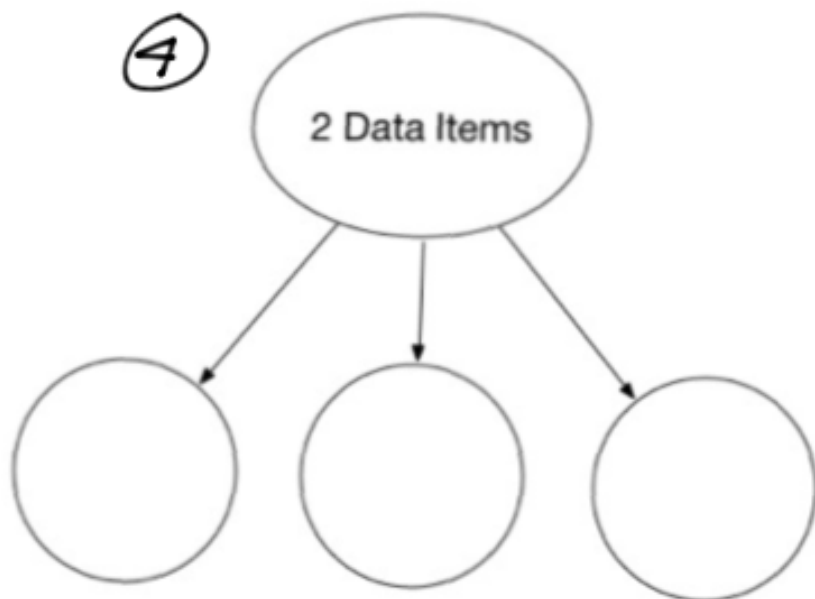
②



③



④



## 2-3 Tree Insertion Algorithm

1) Add at a leaf

2) if the leaf has only 1 Data item, store the new data in that node

3) if the node has 2 data items,

a) find the middle data item


b) push it up

c) split the node

4) Much like the BST, but when a node has 2 data items, the Left subtree is less than the smallest data item. -

The MIDDLE subtree is greater than the smallest but less than the larger data item  
The RIGHT is greater than the largest " ".

struct node  
{  
    data \* array[2];  
    data \*\* array;  
    node \* child[3];  
};



5 pointers

Build a 2-3 Tree:

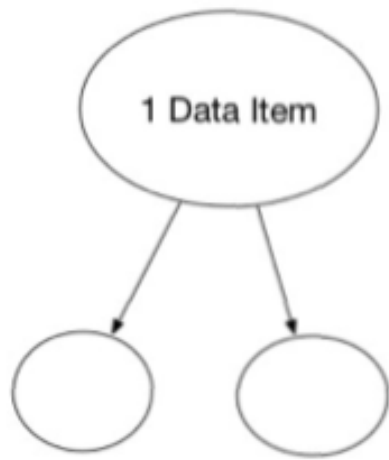
50 20 15 55 32 10



What happens when data is sorted?

10 20 30 40 50 60

# 2-3-4 Tree



struct node

{

data \*items[3];

node \*child[4];

} 7 pointers per node

};



## 2-3-4 Insertion Algorithm

- 1) Travel to the appropriate leaf to add
- 2) As we traverse down the tree, **ANYTIME** a node with 3 pieces of data is encountered push **UP** the middle data item and "split" the node. Then, continue traversing.
- 3) There **WILL** ALWAYS be room in the leaf for the new item being added
- 4) Provides consistent run time performance at the cost of Memory overhead

Build a 2-3-4 Tree

50 20 15 55 32 10 45 25 70 5

What if data is inserted in sorted order?

10 20 30 40 50 60 70 80 90

ON Your Own... Create 2-3 & 2-3-4  
Trees

7 12 3 13 21 5 8 50

Think about how the order inserted affects  
the shape & effectiveness of the memory used.