Middle East Technical University | Department of Computer Engineering

CENG 351

Data Management and File Structures

Fall 2019-2020

In-Class Assignment 4 – B+ Tree

Duration: 80 Minutes

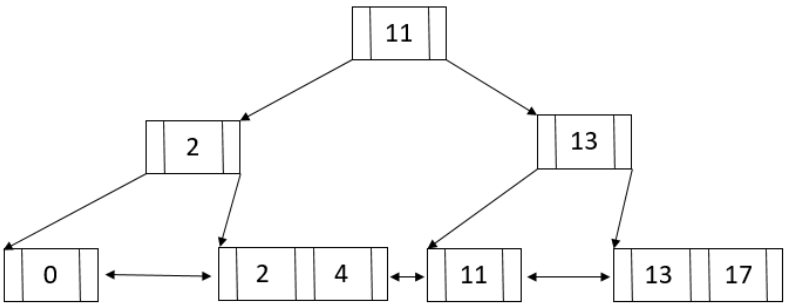
1. B+ Tree Insertion

The following keys are given:

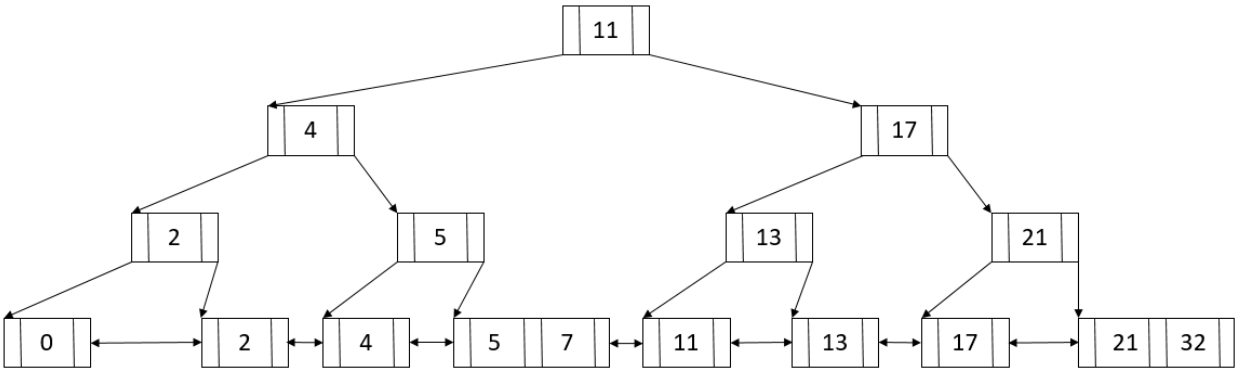
[11, 17, 4, 2, 0, 13, 21, 32, 7, 5, 9, 18, 10, 6, 12]

You are going to create two different B+ trees by succesive insertions of the given keys. You will create a B+ tree of order 1 for (a) and (b), and a B+ tree of order 2 for (c) and (d).

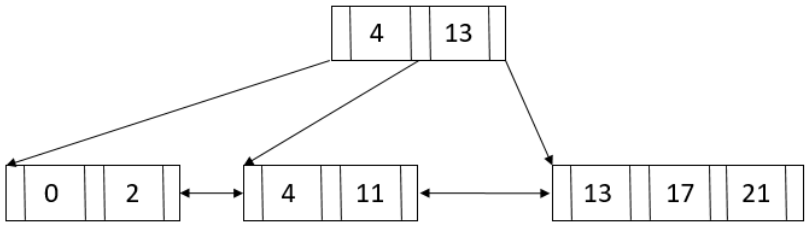
(a) Show the B+ tree of **order 1** after the insertion of **13**. (10 Points)



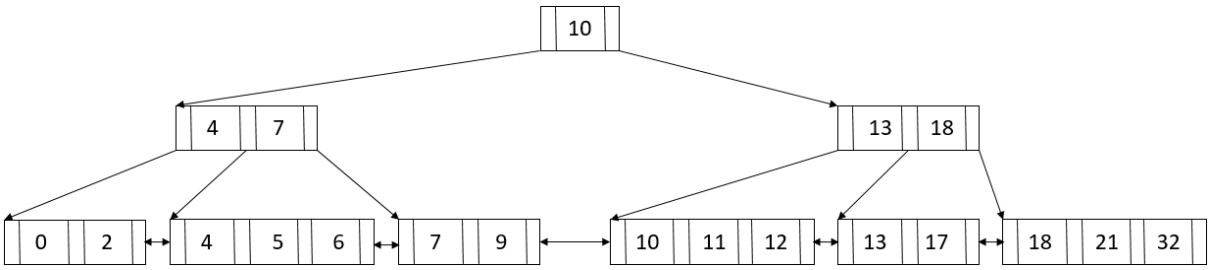
(b) Show the B+ tree of **order 1** after the insertion of **5**. (10 Points)



(c) Show the B+ tree of **order 2** after the insertion of **21**. (10 Points)



(d) Show the B+ tree of **order 2** after the insertion of **12**. (10 Points)

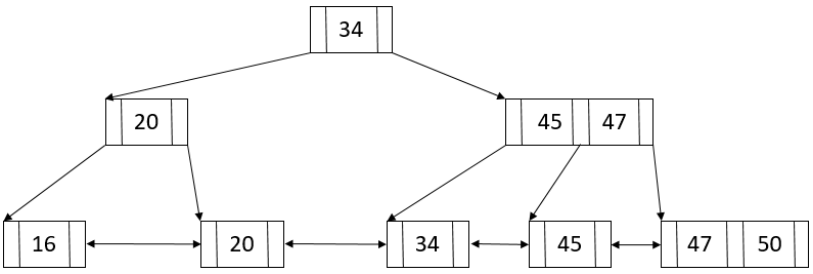


2. B+ Tree Deletion

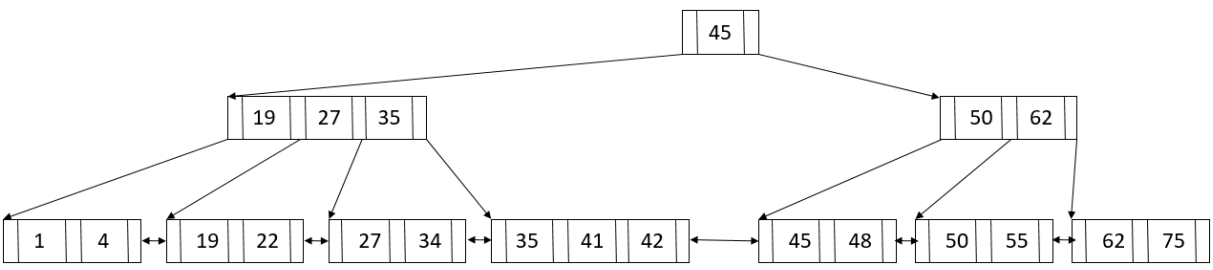
In this part, you are going to apply delete operations on different B+ trees. For (a) and (b) you will delete from order 1 B+ tree X, for (c) and (d) from order 2 B+ tree Y.

Note: They are all different cases, solve separately. In other words, all deletion operations use the initial state of X and Y, not the changed ones.

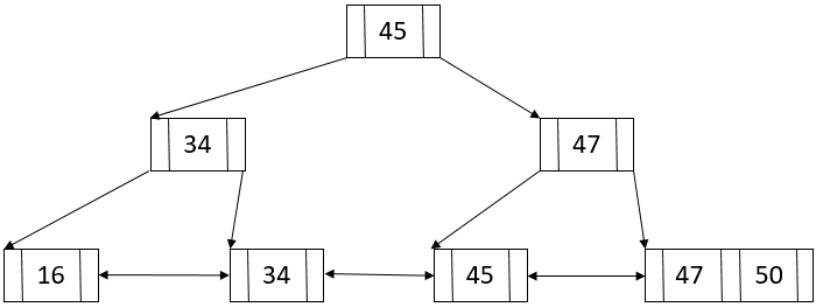
X:



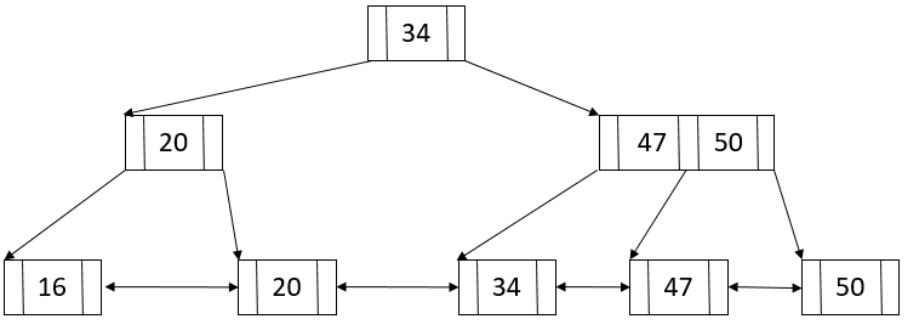
Y:



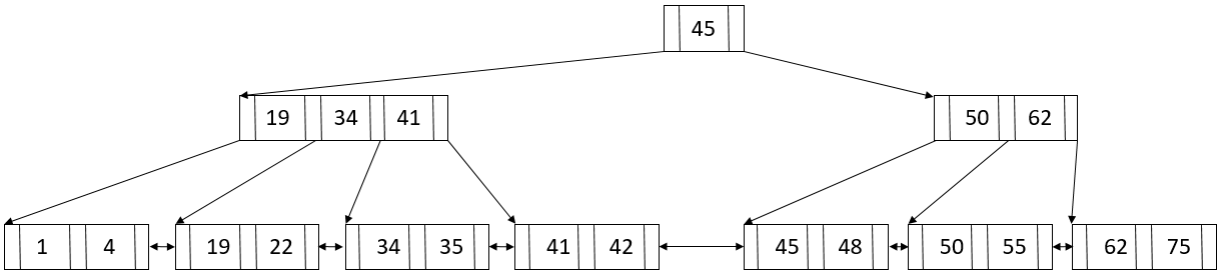
(a) Delete **20** from X (10 Points)



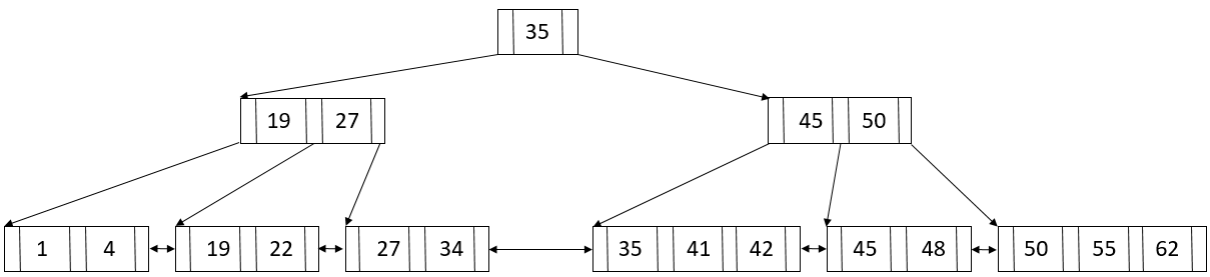
(b) Delete **45** from X (10 Points)



(c) Delete **27** from Y (10 Points)



(d) Delete **75** from Y (10 Points)



3. PhoneBook

We plan to store our phonebook in a primary B+ tree index on key field phoneKey.
The size of phoneKey is 16 bytes and the size of the block pointer is 4 bytes. The average fill-factor is 80% and the block size of the disk is 400 bytes. The number of records to be stored is 200000.

(a) What should be the order of the tree? (5 Points)

16*n + 4*(n+1) = 400
20n=396
2d=n=19

$order(d)$: $\left\lfloor \frac{19}{2} \right\rfloor = 9$

(b) How many leaf blocks are required for indexing all the records? (5 Points)

$Size\ of\ each\ record: 16 + 4\ bytes$
$Maximum\ records\ in\ a\ leaf: \left\lfloor \frac{400}{20} \right\rfloor = 20$
$Average\ number\ of\ records\ in\ a\ leaf: 20 \cdot 80\% = 16$
$Number\ of\ leaf\ blocks: \lceil 200000/16 \rceil = 12500$

(c) What is the maximum number of levels? Take the answer of (a) as the order. Explain your answer briefly. (5 Points)

$Number\ of\ leaf\ nodes: \frac{200000}{9} = 22223$
$The\ level: \lceil log_{10}(22223) \rceil + 1\ (leaf\ level) = 6$

The leaf nodes have the minimum number of keys:9
The internal nodes have the minimum number of children: 10

(d) What is the minimum number of levels? Take the answer of (a) as the order. Explain your answer briefly. (5 Points)

$Number\ of\ leaf\ nodes: \frac{200000}{19} = 10537$
$The\ level: \lceil log_{20}(10537) \rceil + 1\ (leaf\ level) = 5$

The leaf nodes have the maximum number of keys:18
The internal nodes have the maximum number of children: 19