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File Organization and Indexing: Part V

Complete Course on Database Management System

Vishvadeep Gothi • Lesson 34 • July 30, 2023

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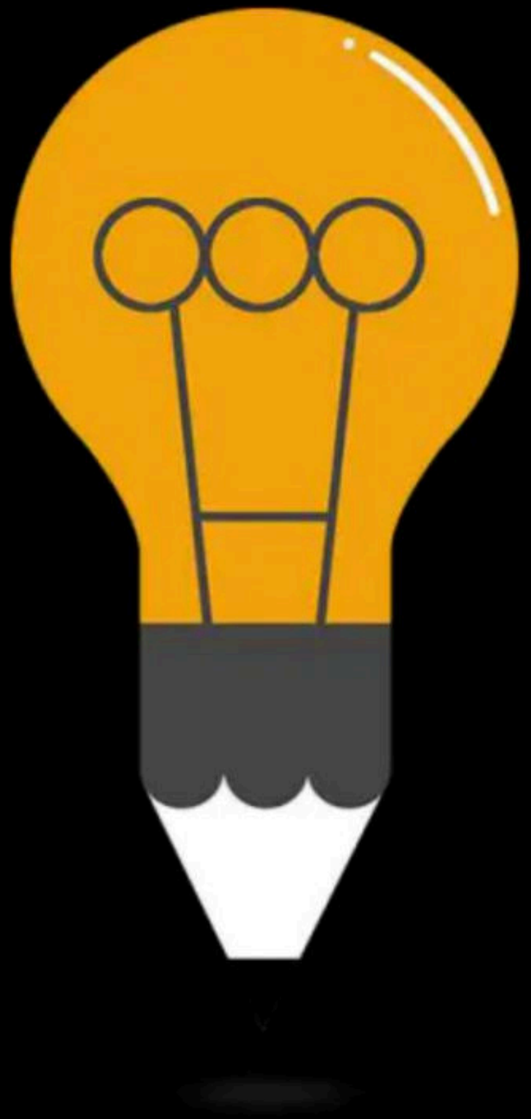
B - Tree ⇒ deletn

B+ Tree ⇒ insertn

node structure

Deletion



DBMS

Indexing: B-Tree 2

By: Vishvadeep Gothi

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B-Tree

- Tree based indexing
- Dynamic Indexing technique
- Based on insertion and deletion, the tree automatically adjusted
- Self balancing search tree

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Binary Search Tree

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B-Tree

An order-p B-tree:

1. Every node other than root should have atleast $\left\lceil \frac{p}{2} - 1 \right\rceil$ nodes
2. In every node there are atmost (p-1) keys and n tree pointers
3. Root can have minimum 1 node
4. All leaves appear on the same level

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B-Tree Node Structure

- Key
- Record Pointer
- Tree Pointer

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Insertion in B-Tree

- B-tree of order-3
- Insert keys 1, 2, 3, 4, 5, 6, 7

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Insertion in B-Tree

- B-tree of order-5
- Insert keys 7, 4, 14, 25, 3, 10, 12, 15, 17, 9, 29, 1, 38, 3, 11

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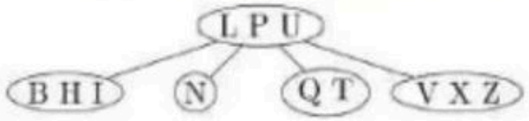
Insertion in B-Tree

- B-tree of order-3
- Insert keys 14, 3, 5, 10, 35, 40, 1, 37

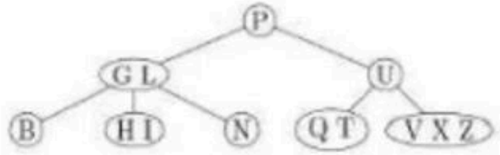
Question GATE-2003

Consider the following $2-3-4$ tree (i.e., B-tree with a minimum degree of two) in which each data item is a letter. The usual alphabetical ordering of letters is used in constructing the tree.

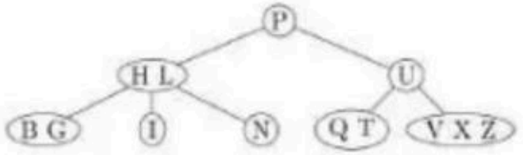


What is the result of inserting G in the above tree?

A.



B.



C.

D. None of the above

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Insertion in B-Tree

- B-tree of order-4
- Insert keys 15, 5, 8, 22, 10, 1

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Insertion in B-Tree

More split in left-biasing or right-biasing?

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Question GATE-2008

A B-tree of order 4 is built from scratch by 10 successive insertions. What is the maximum number of node splitting operations that may take place?

(A) 3

(B) 4

(C) 5

(D) 6

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Question

A B-tree of order 4 is built from scratch by successive insertions of following keys in the given order.

10, 5, 14, 10, 3, 6, 30, 27, 9

What is the number of root node splitting operations that may take place with right biasing?

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Question GATE-2005

A B-Tree used as an index for a large database table has four levels including the root node. If a new key is inserted in this index, then the maximum number of nodes that could be newly created in the process are?

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Question GATE-2004

Consider a table T in a relational database with a key field K. A B-tree of order p is used as an access structure on K, where p denotes the maximum number of tree pointers in a B-tree index node. Assume that K is 10 bytes long; disk block size is 512 bytes; each data pointer PD is 8 bytes long and each block pointer PB is 5 bytes long. In order for each B-tree node to fit in a single disk block, the maximum value of p is?

Practical Implementation of Node on Blocks

What is maximum order in B-tree?

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Question

Key size = 16 bytes

Block pointer size = 32 bytes

Record pointer size = 48 bytes

Block size = 8192 bytes

If a B-tree of order-p is implemented, then what is the maximum value of p?

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Height of the B-tree

P-order B-tree

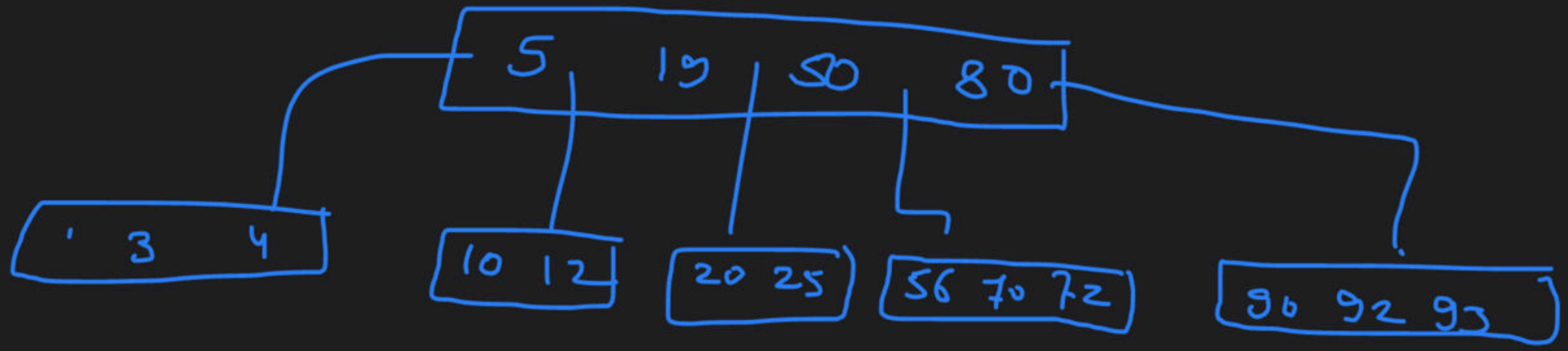
Total ~~nodes~~ keys = n

$$H_{min} = \lceil \log_p(n+1) - 1 \rceil$$

$$H_{max} = \left\lfloor \log_{\lceil \frac{p}{2} \rceil} \frac{n+1}{2} \right\rfloor$$

order-5 B-Tree

eg:-



select * from table where key = 20

To search into index, 2 blocks are accessed

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To access a specific index, max no. of blocks accessed =

= no. of levels in B-Tree

In given tree

select * from table where key between 4 and 30

⇓

no. of blocks accessed => 4

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Deletion in B-Tree

2 Cases:

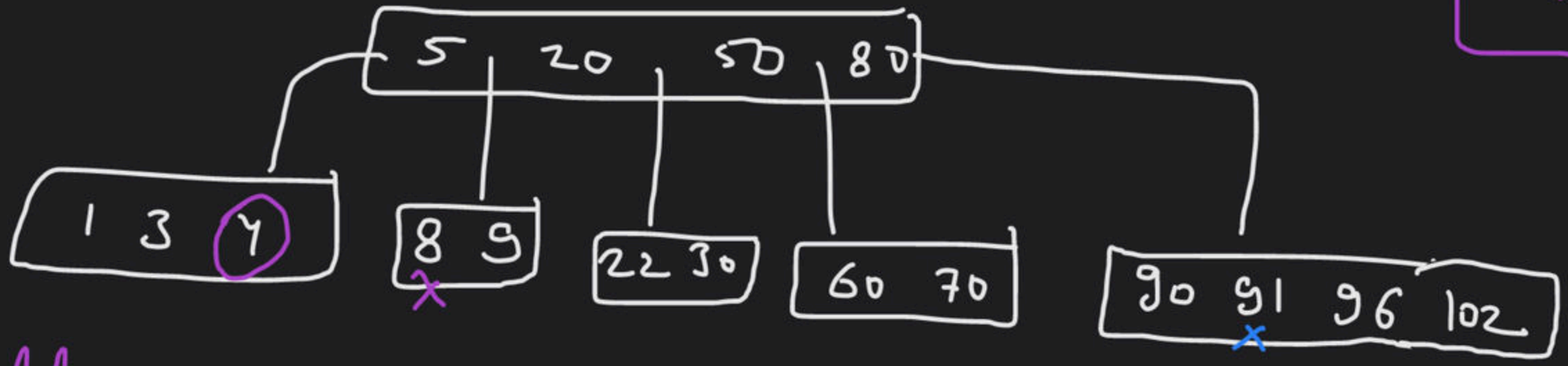
1. Deletion in leaf
2. Deletion in internal node

Deletion in B-Tree: Deletion in Leaf

1. After deletion if no violation of min keys, then no changes in tree
2. If violation of min keys, then borrow key from sibling (rotation through parent).
3. If borrow from sibling can’t be possible then merge the node with sibling and pull down the anchor key from parent.

B-Tree order 5 :-

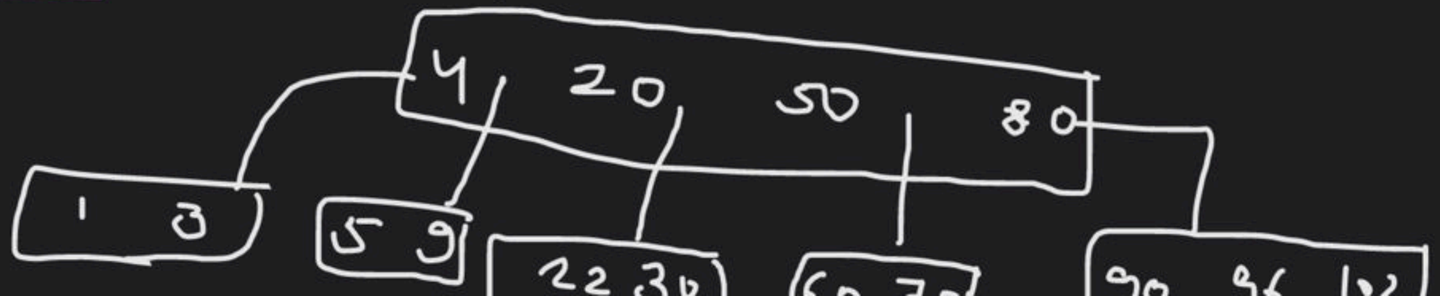
	keys
min	2
max	4



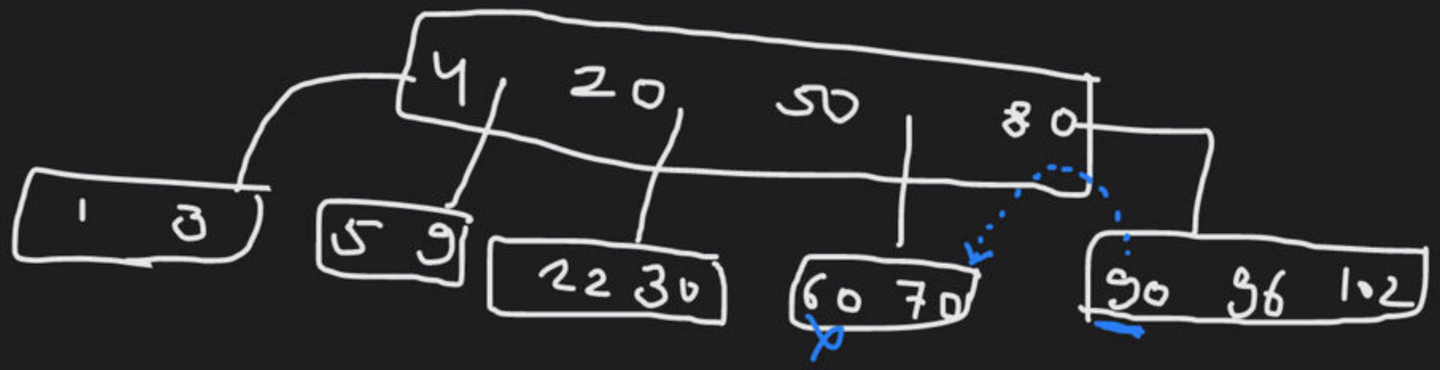
Delete ⇒ 91

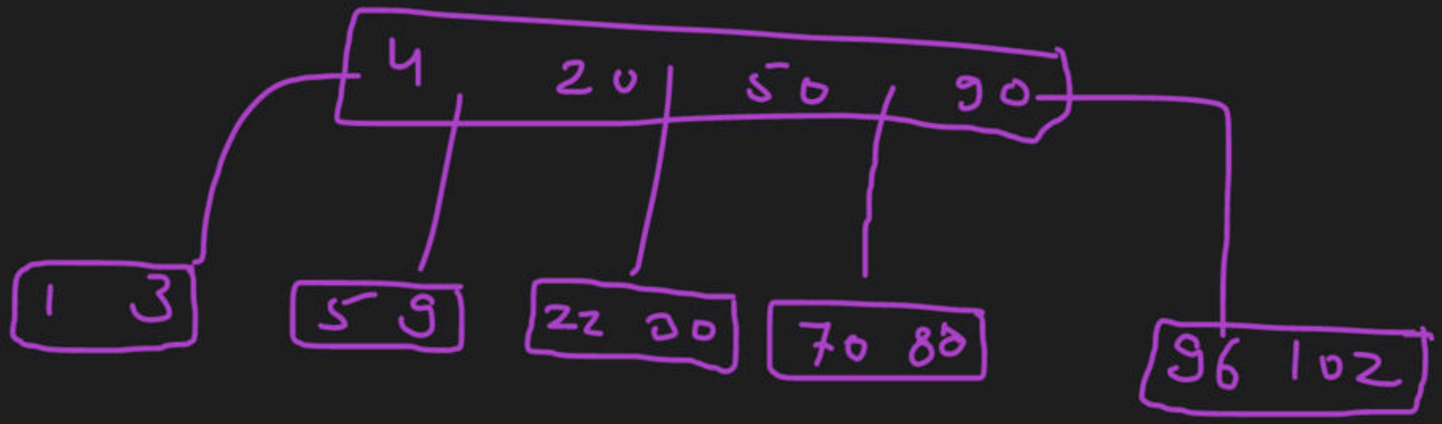
no change after deletion

Delete 8 :- borrow 4 with rotation

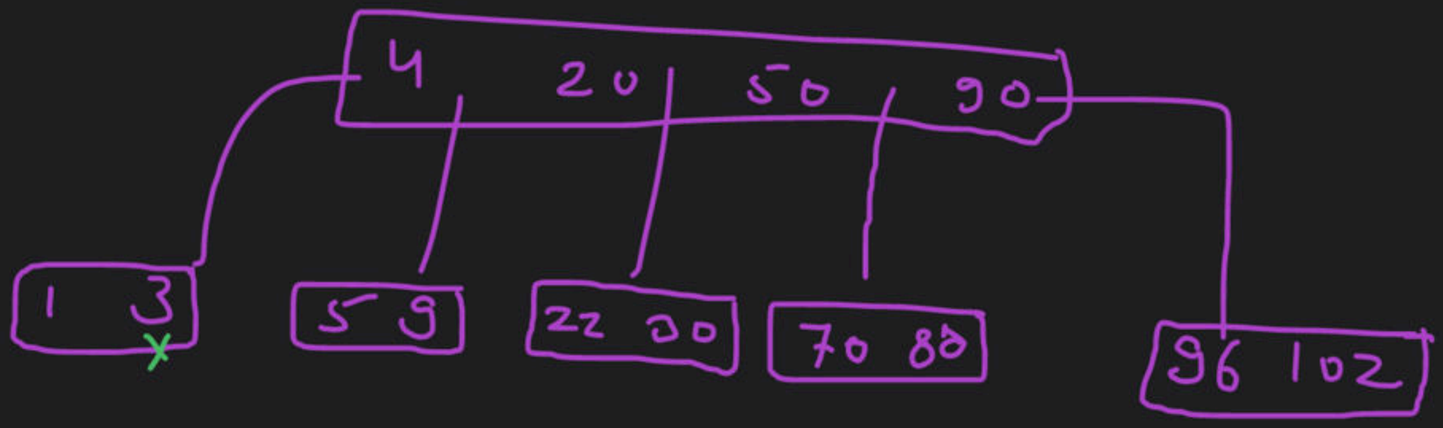


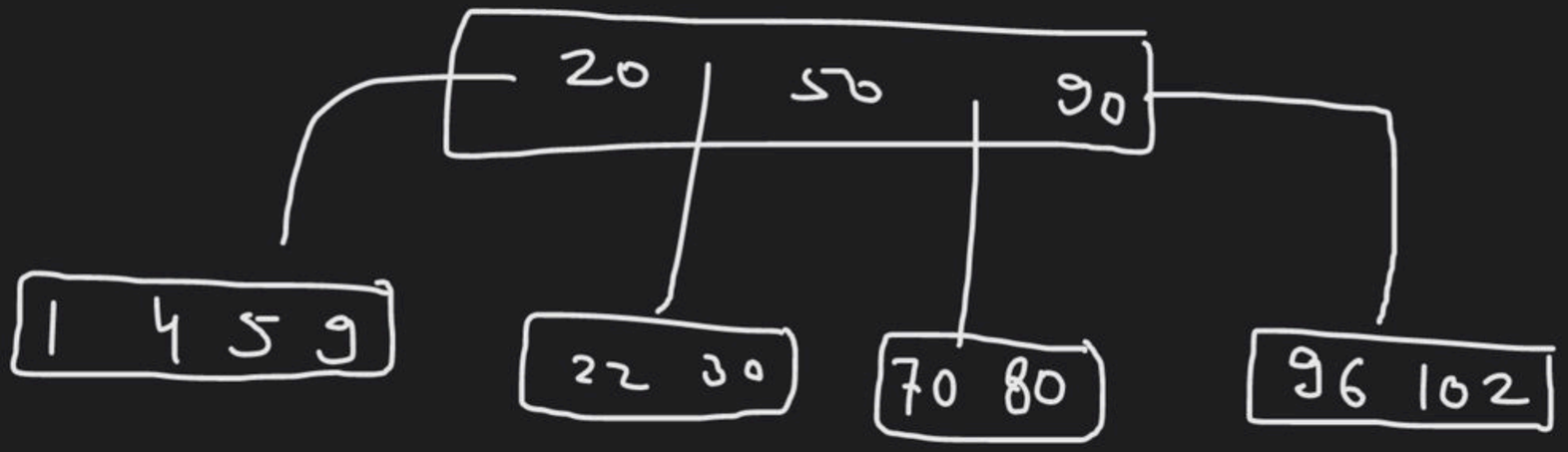
Delete 60 :-


4
20
50
80
1 3
5 9
22 30
60 70
90 96 102

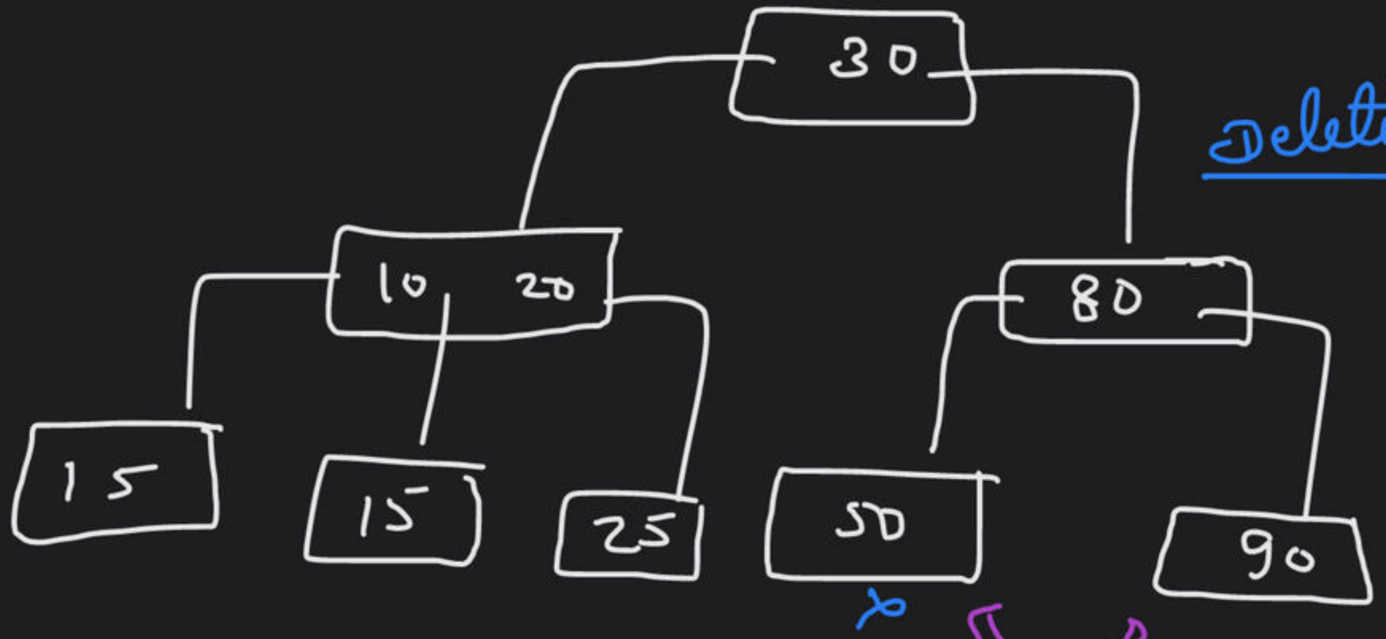

4
20
50
90
1 3
5 9
22 30
70 80
96 102

Delete 3:-

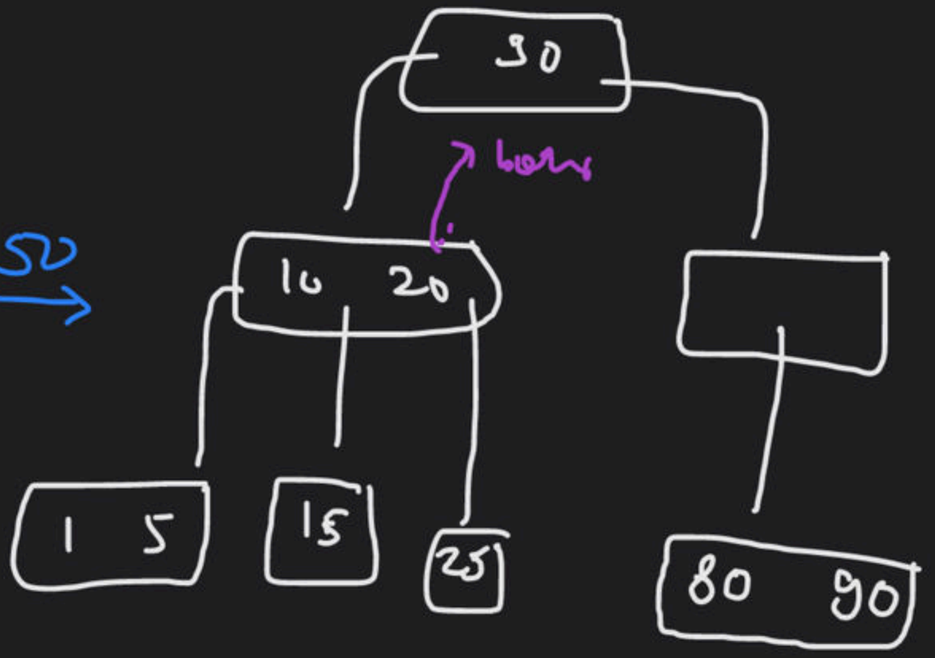




Ex:- B-Tree of order-3 :-

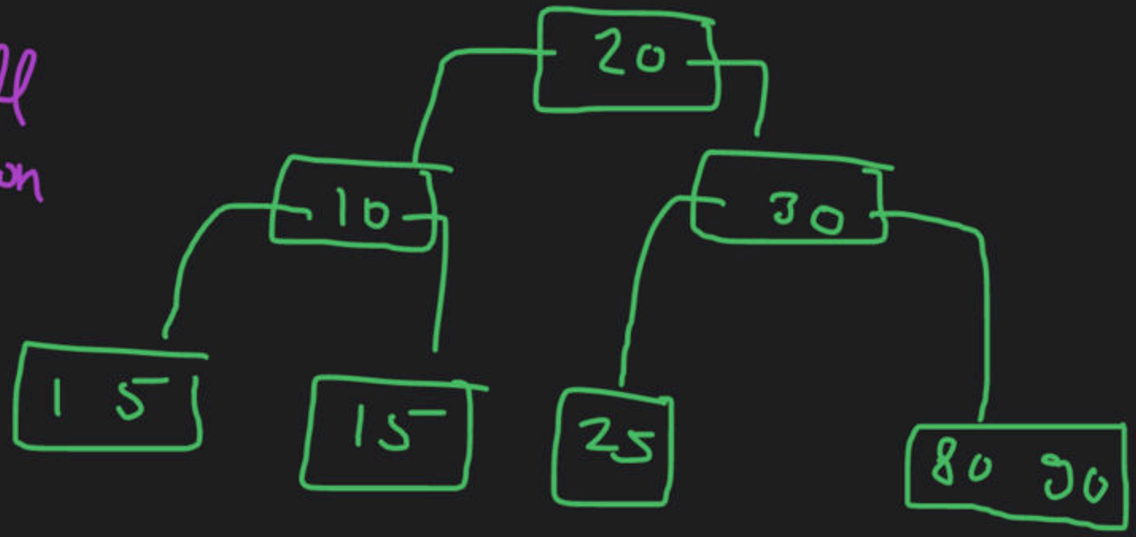


delete 50



merge & pull 80 down

	keys
min	1
max	2



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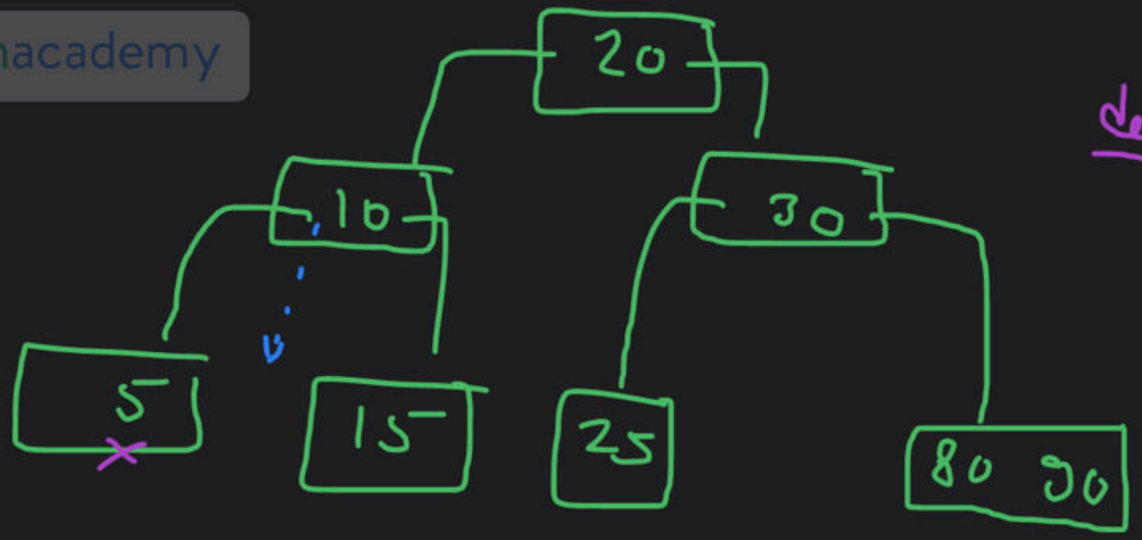
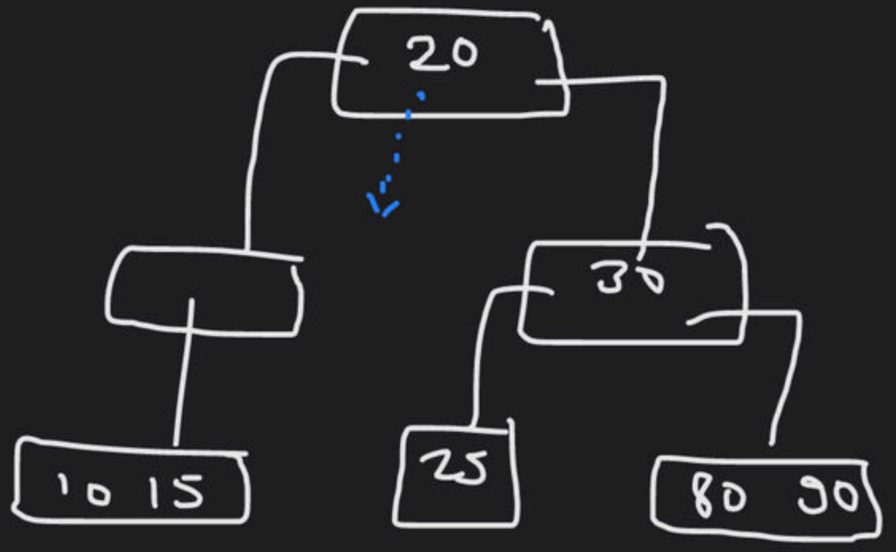
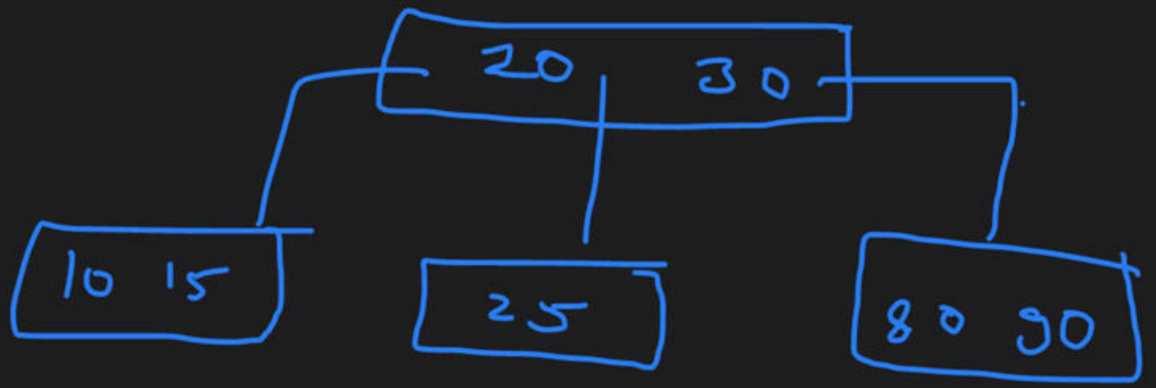


delete 5

⇒





Deletion in B-Tree: Deletion in Internal Node

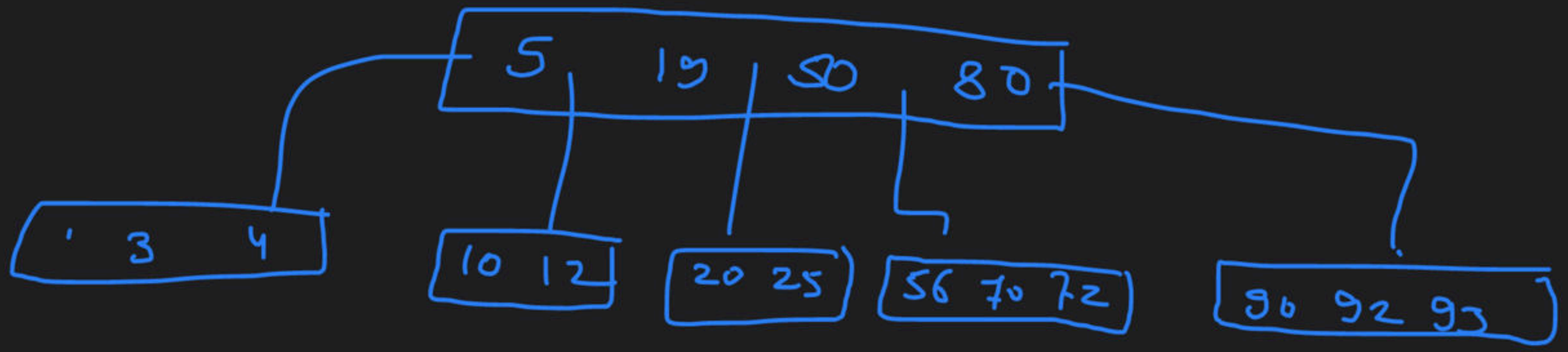
1. Replace the deleted value with inorder successor or inorder predecessor
2. Now follow the rule of deletion of key from leaf node

Inorder successor or predecessor will always be on leaf node.

order-5 B-Tree

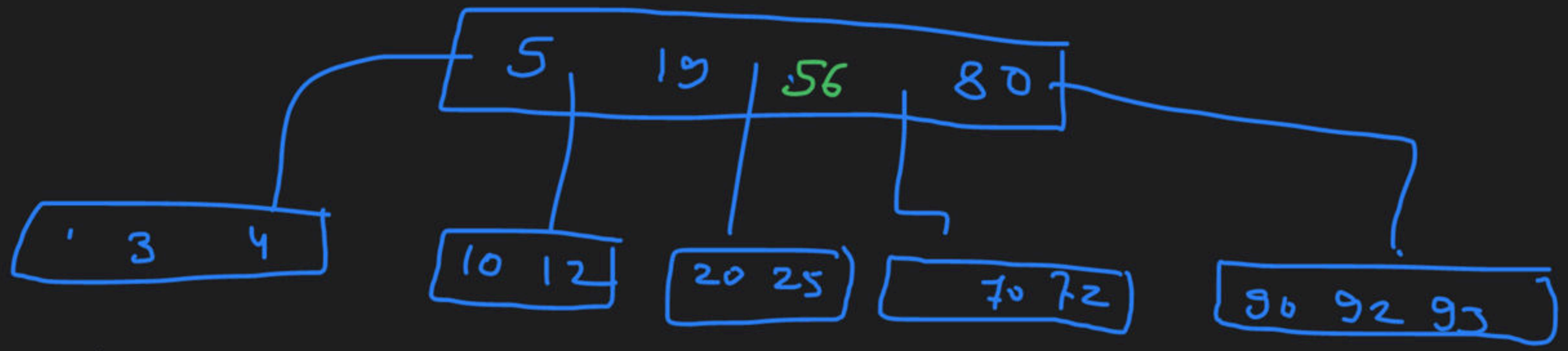
Use Inorder successor for deletn

ex:-



① Delete => 50

replace 50 by inorder successor 56



⇓

no changes afterwards

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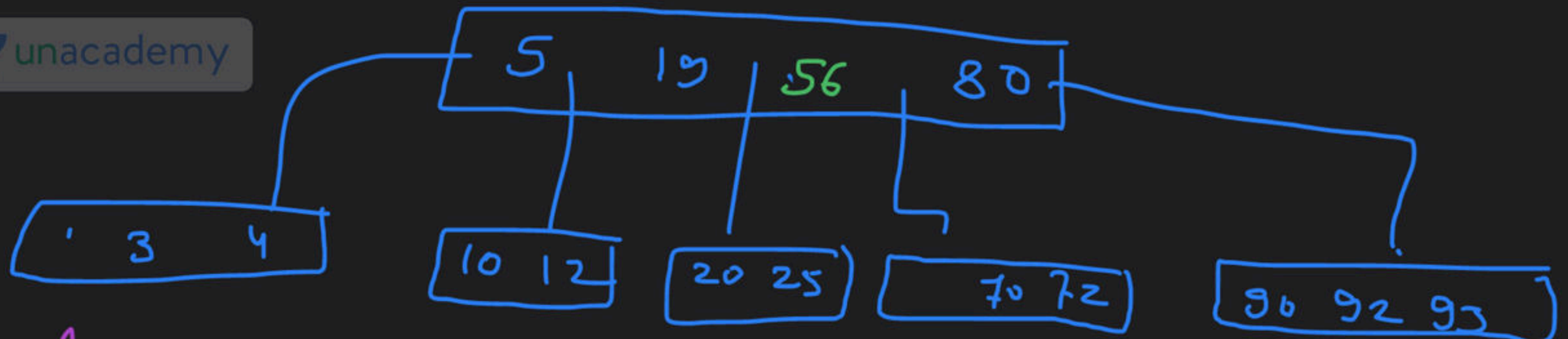
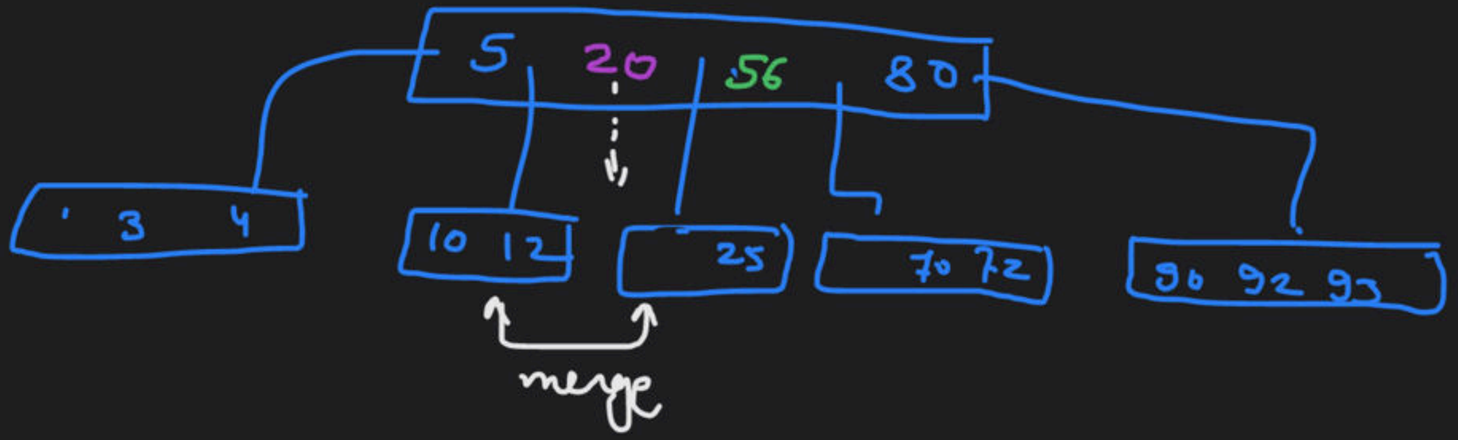
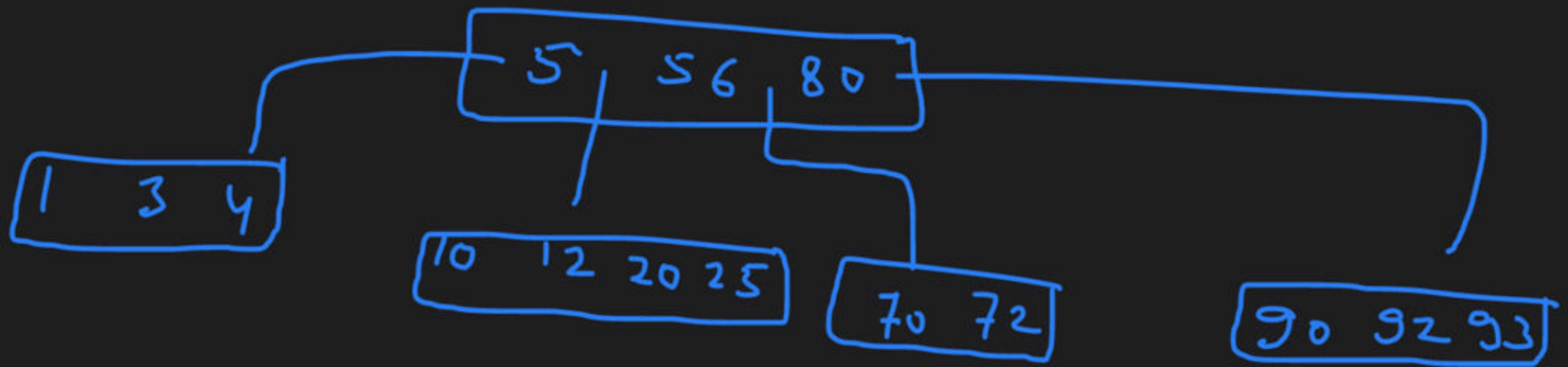


Delete 19:-





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B+-Tree

Internal Node	Leaf Node
• Keys • Tree Pointer	• Keys • Record Pointer

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B+Tree

Order for Internal nodes (not root)

- Every internal node other than root should have atleast $\left\lceil \frac{p}{2} - 1 \right\rceil$ keys or $\left\lceil \frac{p}{2} \right\rceil$ pointers
- Every internal node can have maximum $p - 1$ keys or p pointers
- Every leaf node should have atleast $\left\lceil \frac{q}{2} \right\rceil$ keys and max q keys
- All leaves are on same level
- The leaves are connected using linked list (singly or Doubly)

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B+Tree

What if order-4 B+ tree given in question?

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Insertion in B+ Tree

Internal nodes order-3

Leaf nodes order-2

Insert 1, 2, 3, 4, 5

Using Node Splitting

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Insertion in B+ Tree

Order-5

10, 14, 1, 18, 27, 39, 49, 12, 19, 21, 70, 64, 89, 75

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Insertion in B+ Tree

Using Key Distribution

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Deletion in B+ Tree

1. After deletion if no violation of min keys, then no changes in tree
2. If violation of min keys, then borrow key from sibling.
3. If borrow from sibling can’t be possible then merge the node with sibling. Either update the anchor key or pull down the anchor key from parent.

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Happy Learning.!

31 July – 4 Aug ⇒ 30h

7 Aug – 11 Aug ⇒ 30h

60h.

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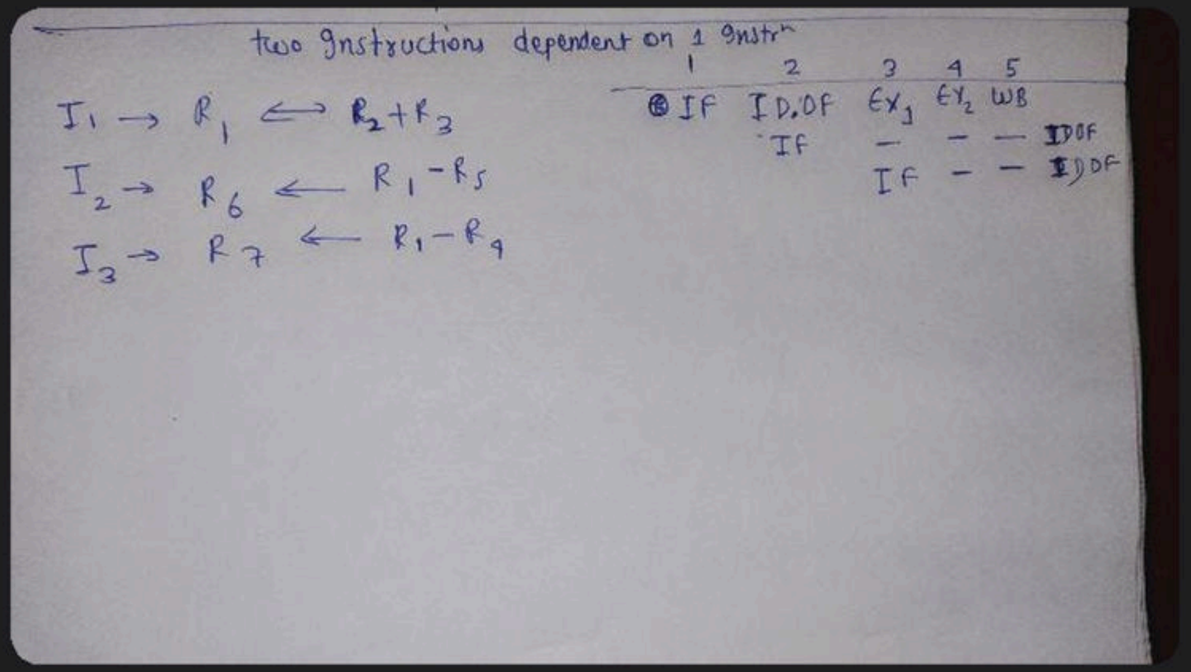
▲ 1 • Asked by Anklesh

Sir isme I1 aur I2 dono ke liye data dependency hogi na ..dono ke liye stalls honge



IF ID.of Ex WB

IF — — ID.of Ex WB

— — If ID.of Ex WB