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File Organization and Indexing: Part VI

Complete Course on Database Management System

Vishvadeep Gothi • Lesson 35 • Aug 16, 2023

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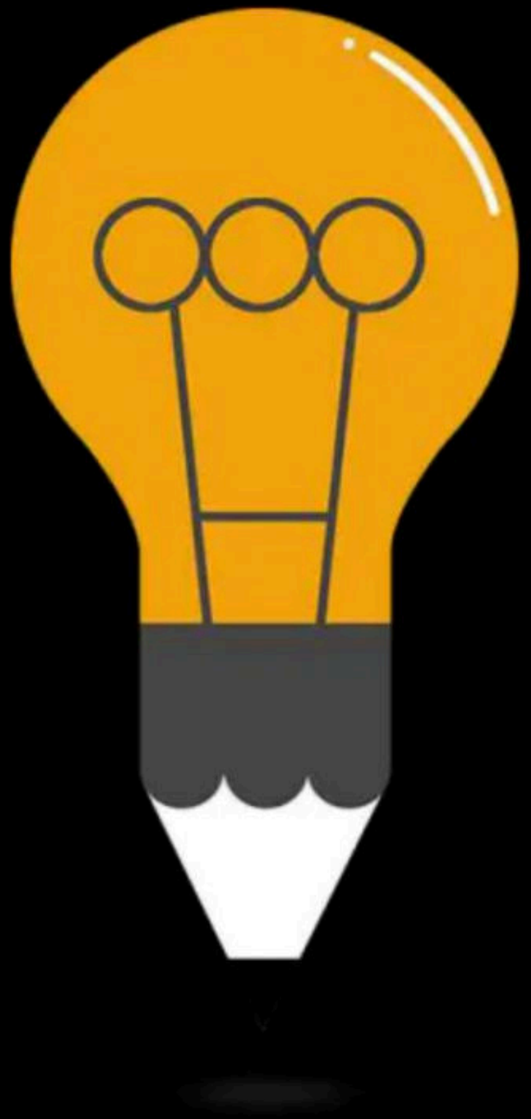
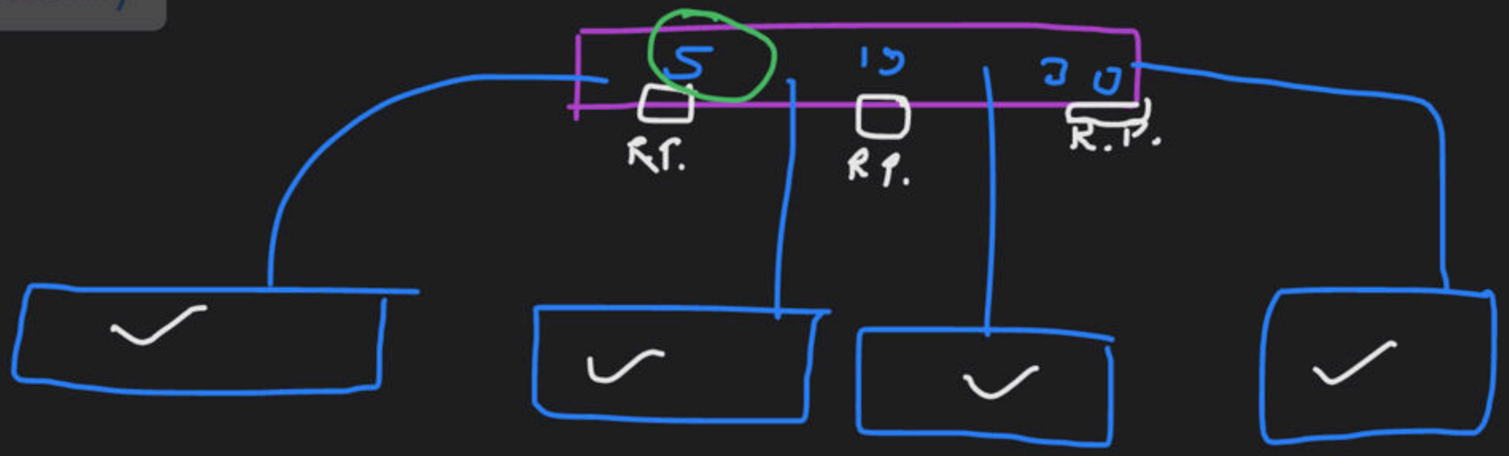


DBMS

Indexing: B+Tree

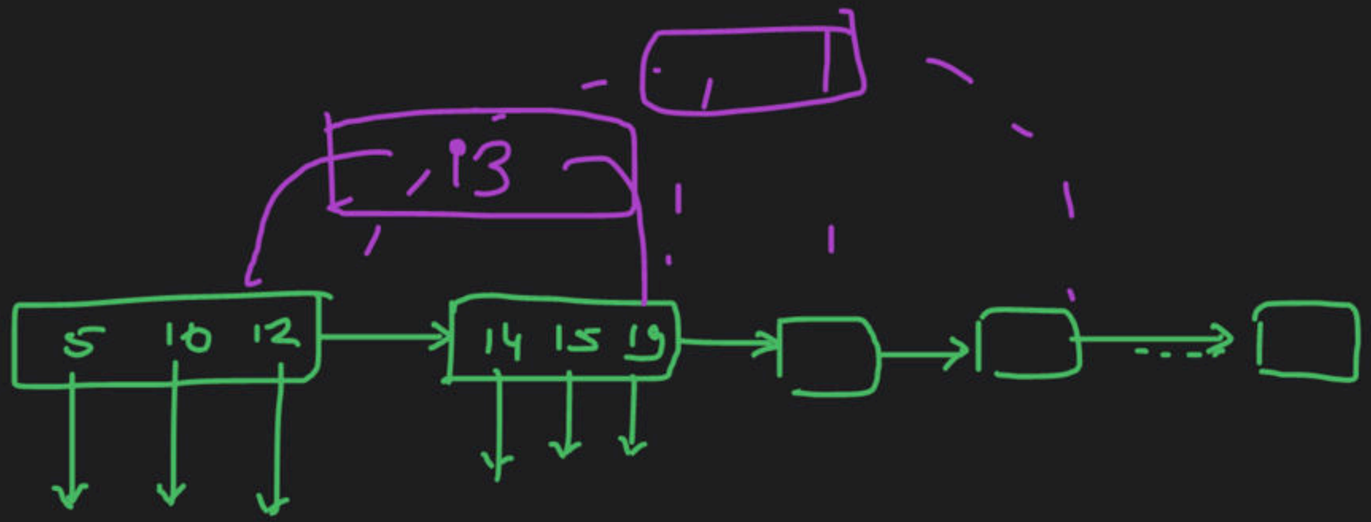
By: Vishvadeep Gothi



select * from table where key between 4 and 100

B+ tree

B+ tree



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B+ Tree

Internal Node

- Keys
- Tree Pointer

(block pointer of next level node)

Leaf Node

- Keys
- Record Pointer
- single/double link (next and/or prev. leaf node

→ All keys are present on leaf nodes, and internal nodes contain only anchor keys.

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Height of B^+ tree can be more than that of B – Tree for a given no. of keys.

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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)

- All leaf nodes can have max $p-1$ keys and $p-1$ record pointers

—"— —"— $\lceil \frac{p}{2} - 1 \rceil$ keys

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B+Tree

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

max keys $\Rightarrow 4-1 = 3$

min keys $\Rightarrow \left\lceil \frac{4}{2} - 1 \right\rceil = 1$

Insertion in B+ Tree

Internal nodes order-3

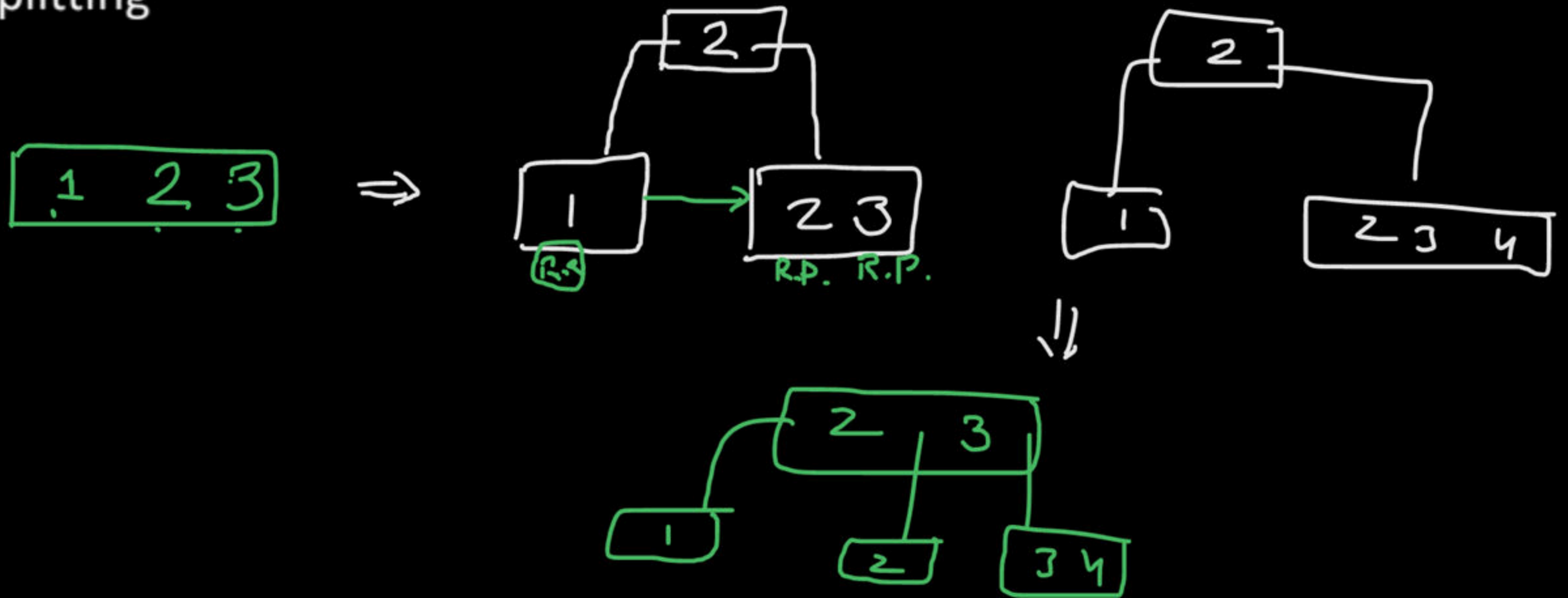
Leaf nodes order-3

max keys = 2

min keys = 1

Insert 1, 2, 3, 4, 5

Using Node Splitting



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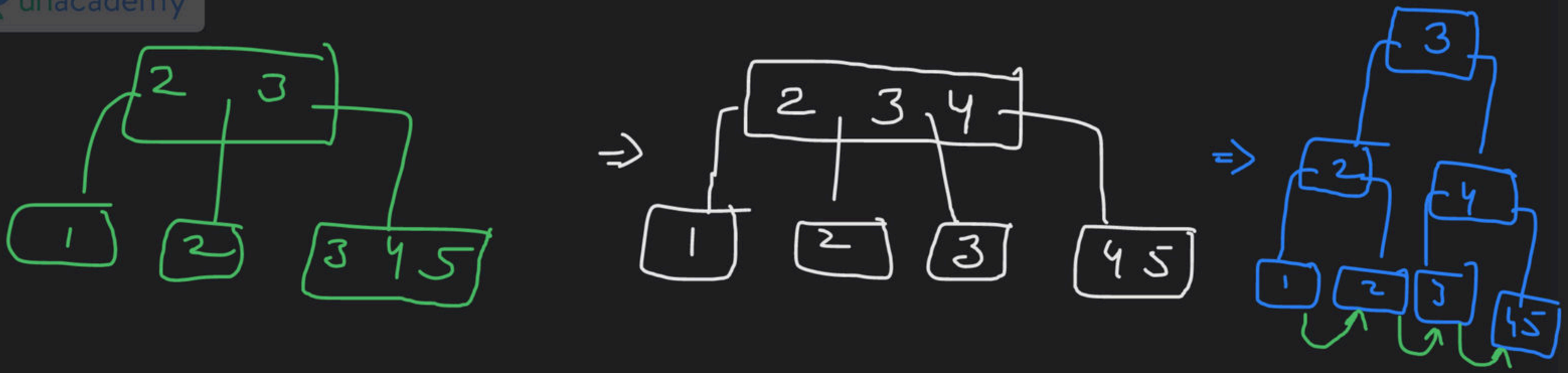


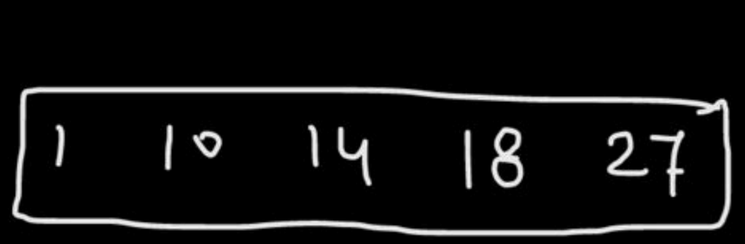
Insertion in B+ Tree

Order-5

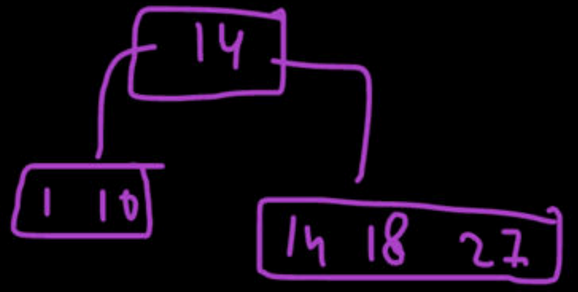
10, 14, 1, 18, 27, 39, 49, 12, 19, 21, 70, 64, 89, 75

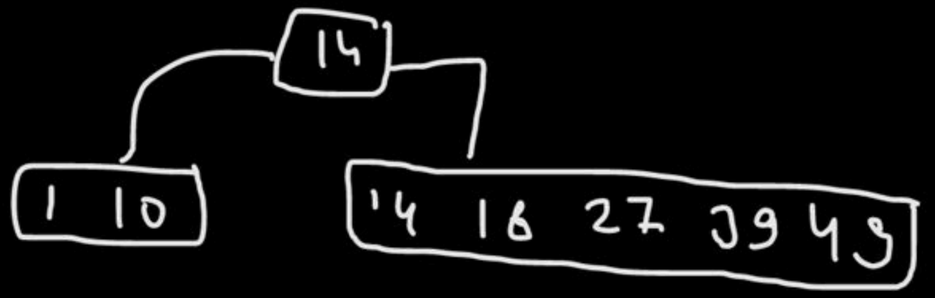
max keys ⇒ 5-1 = 4

min keys ⇒ $\lceil \frac{5}{2} - 1 \rceil = 2$



⇒





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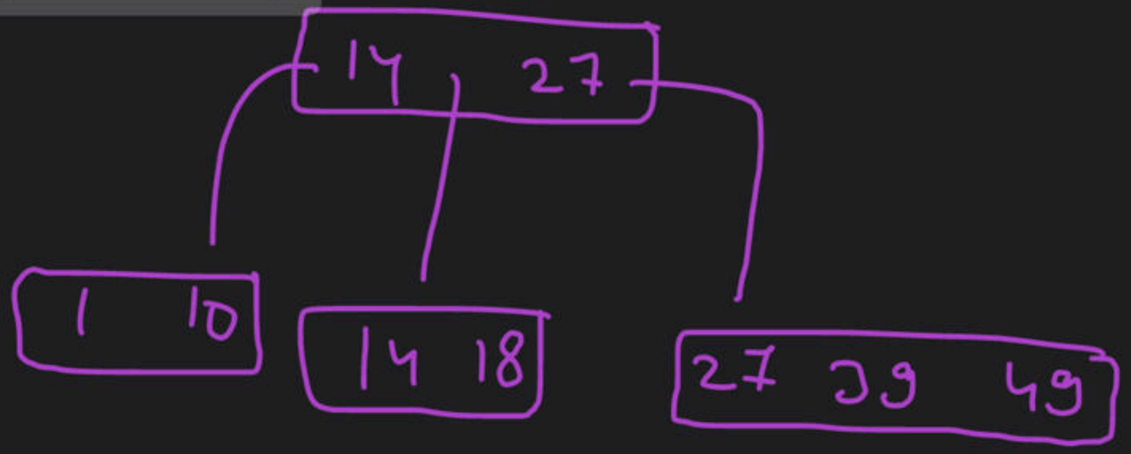
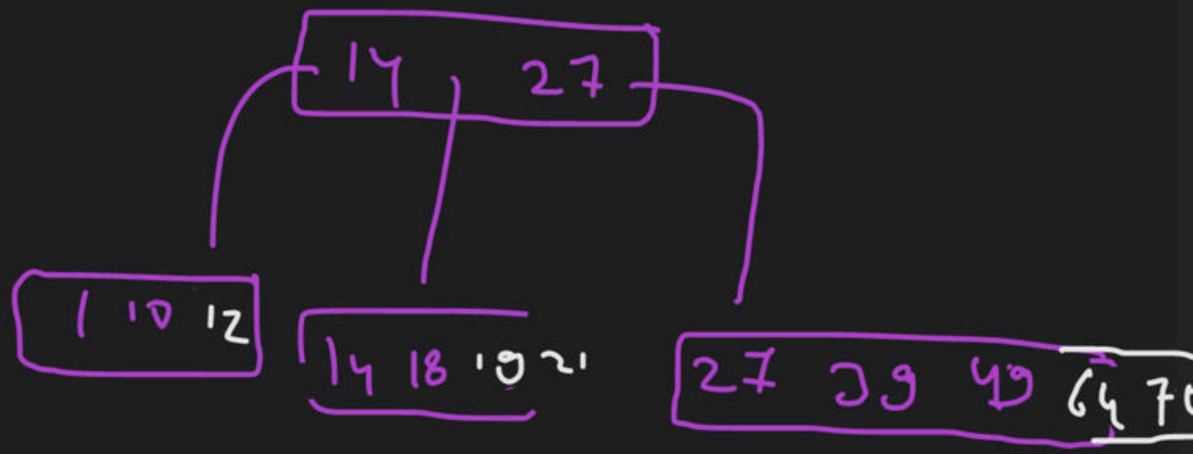
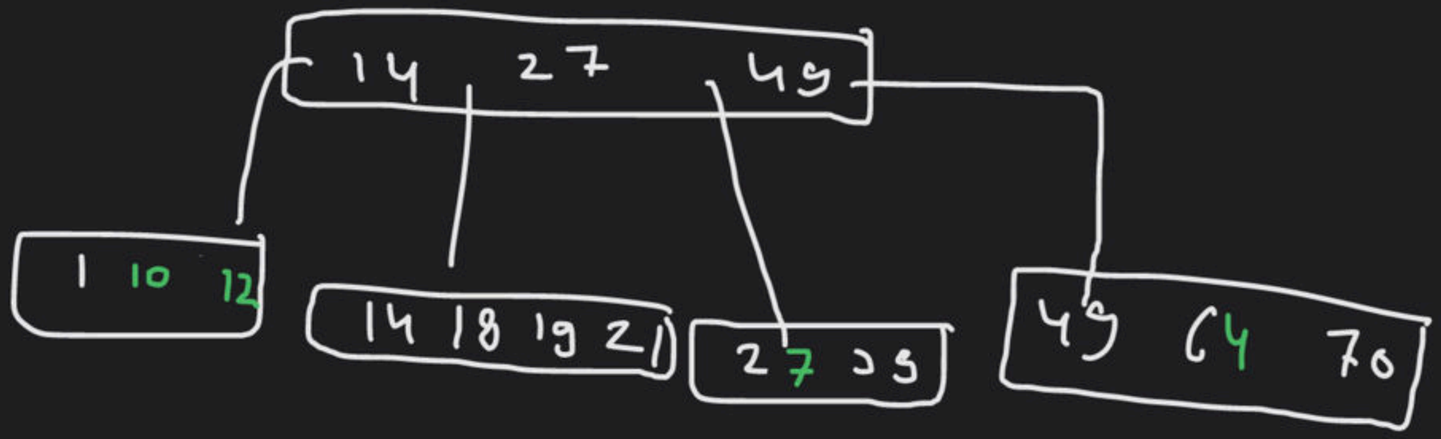

14 27
1 10
14 18
27 39 49


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


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

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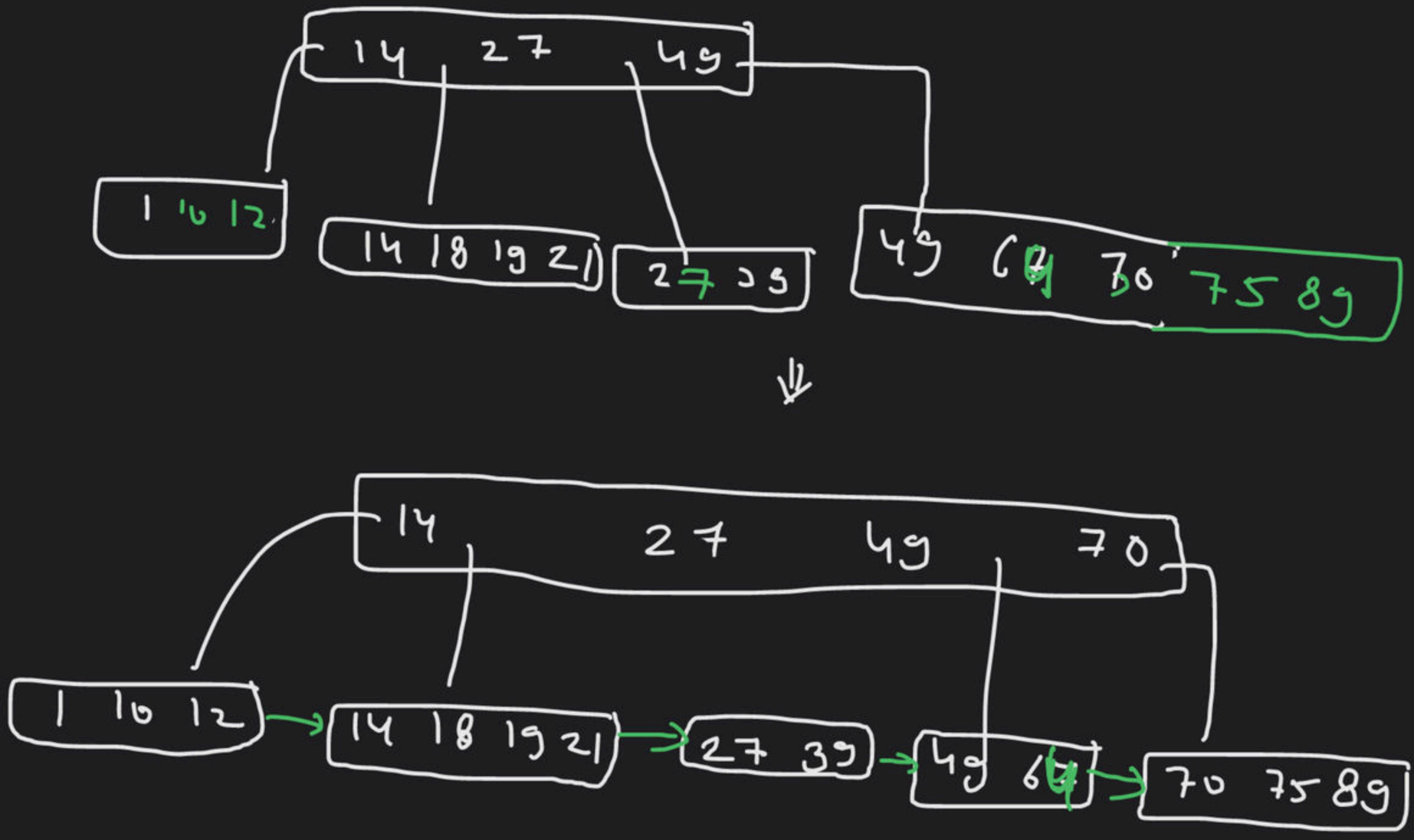
14 27 49
1 10 12
14 18 19 21
27 33
49 60 70 75 89
14 27 49 70
1 10 12
14 18 19 21
27 33
49 60
70 75 89

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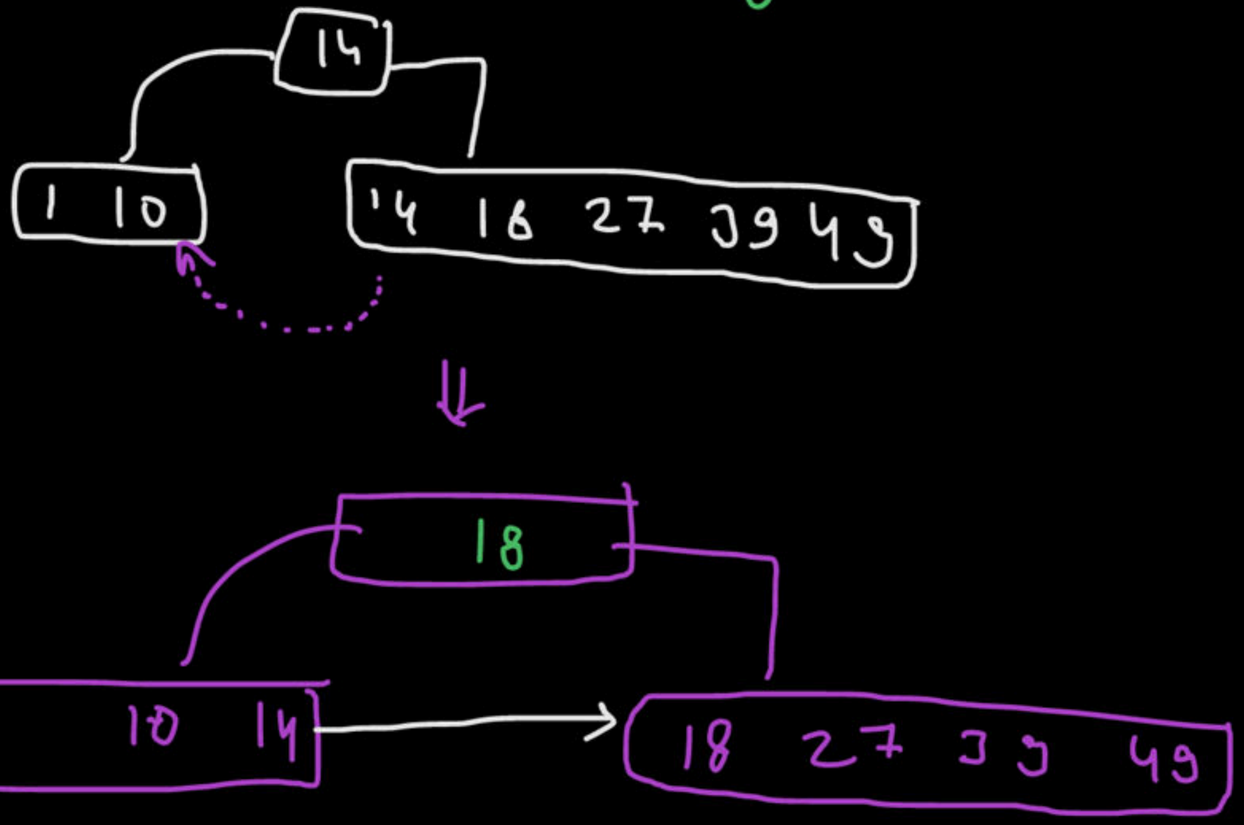
Insertion in B+ Tree

Using Key Distribution

ex:- order: 5 max keys => 4



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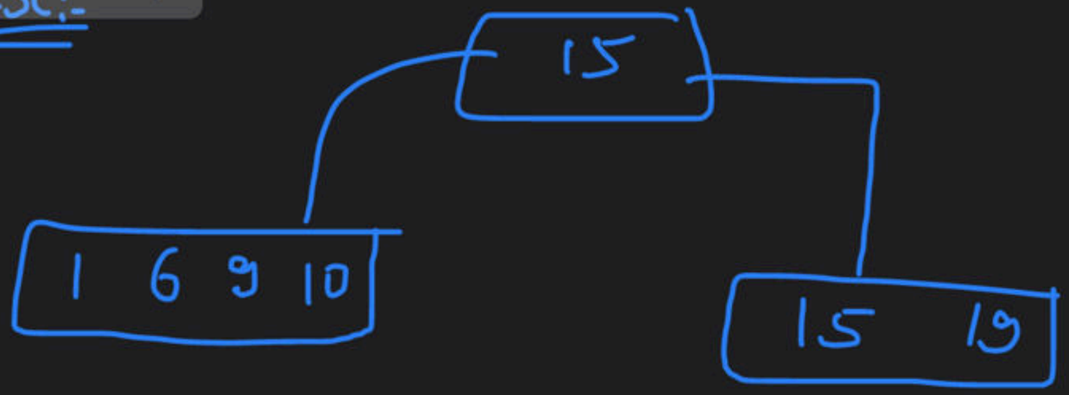
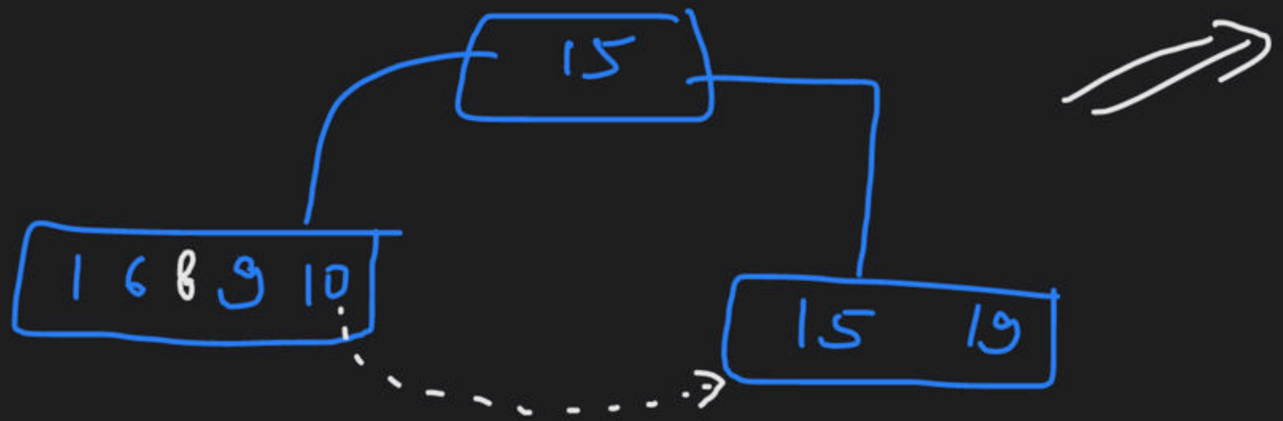
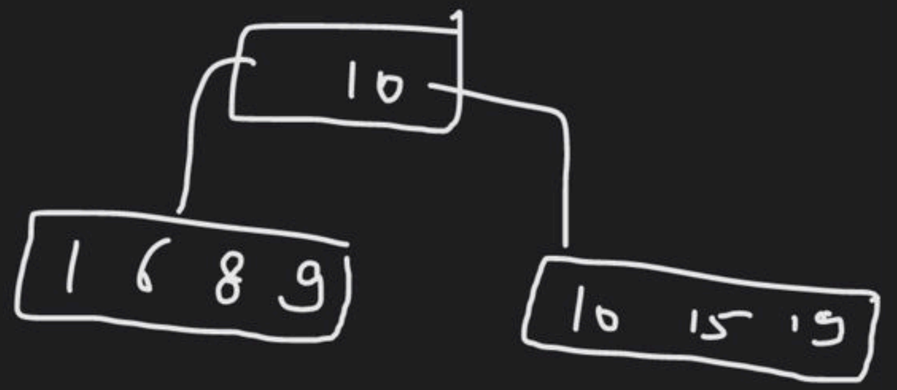
esc:-



Order-5

Insert => 8





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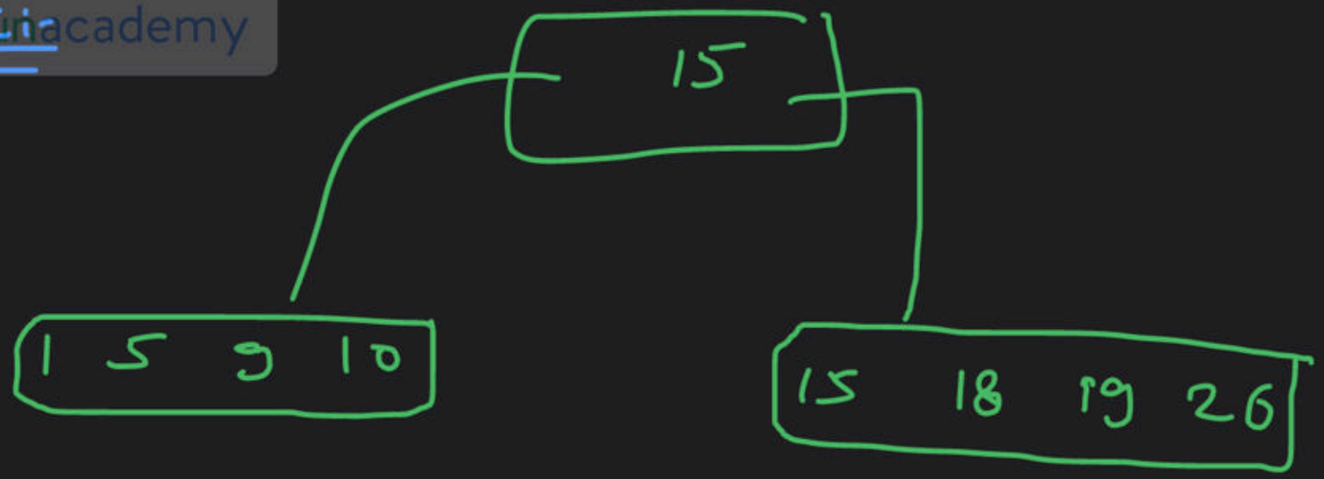
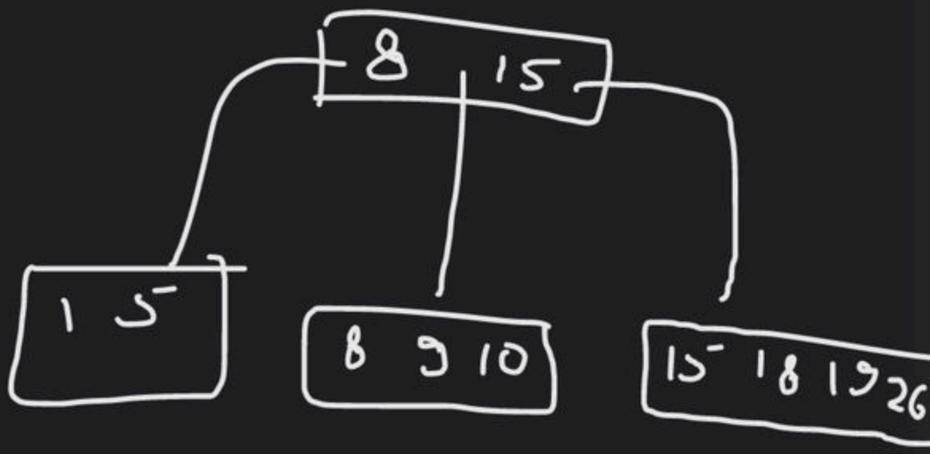
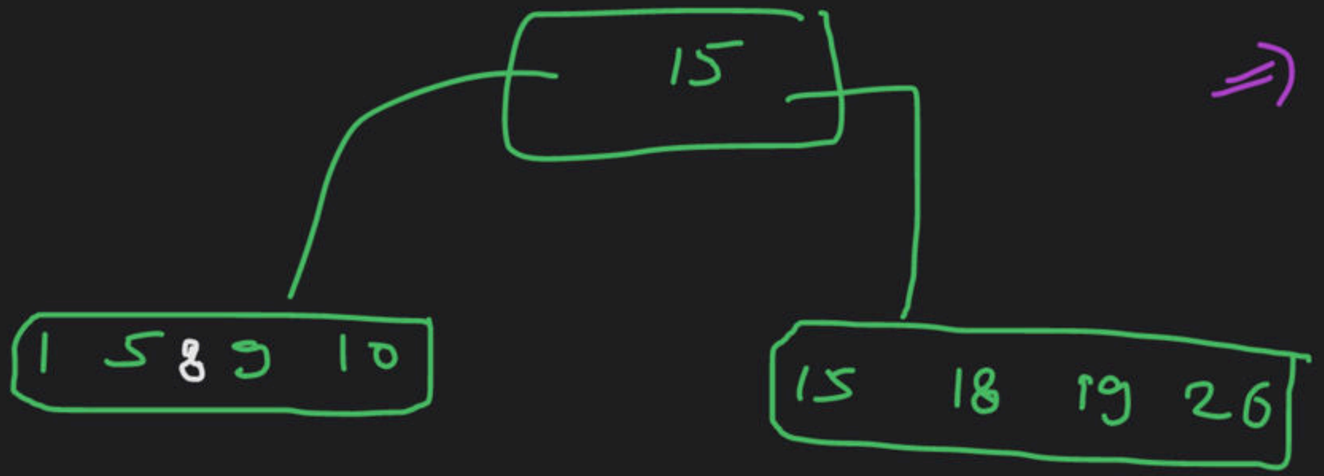
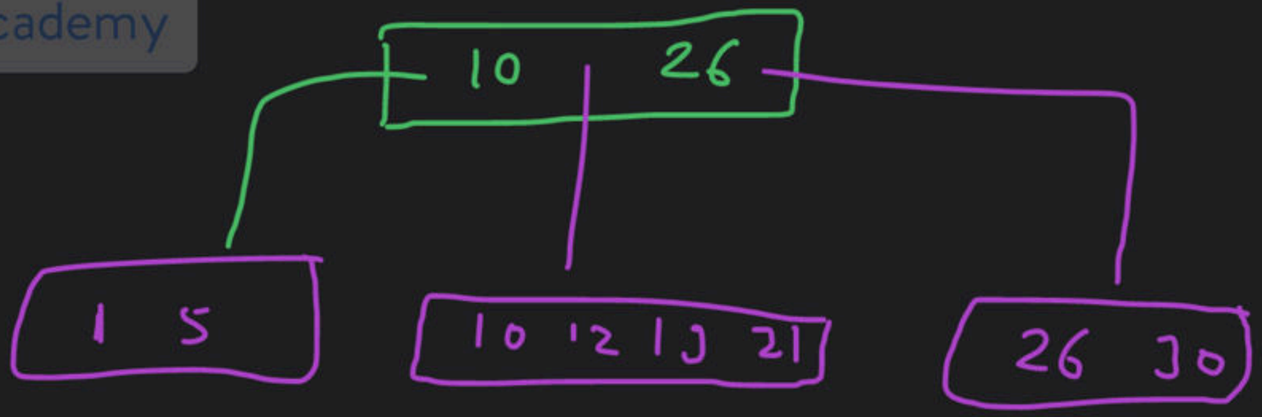




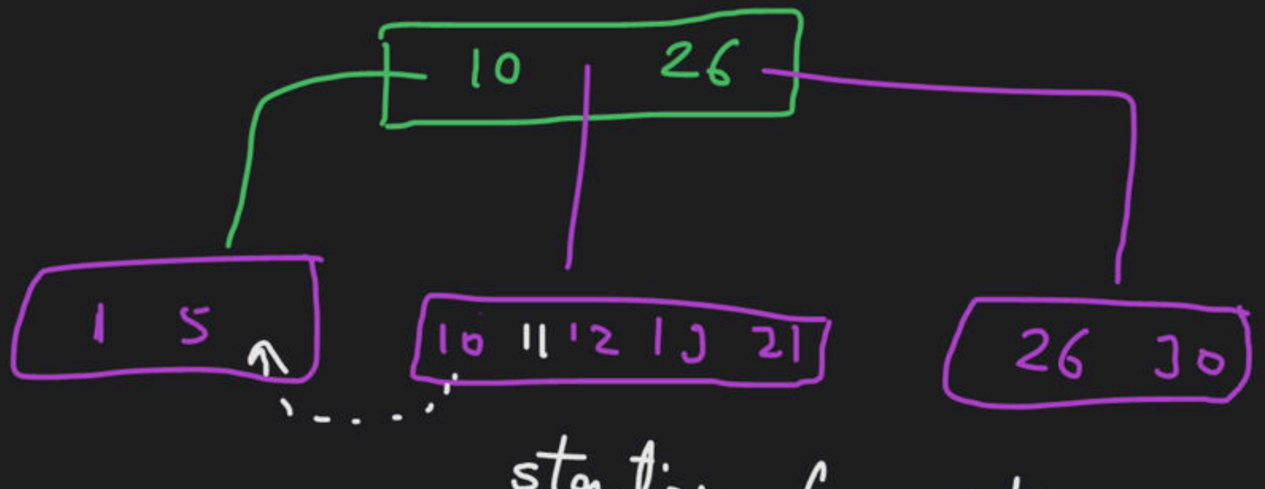
Insert 8:-

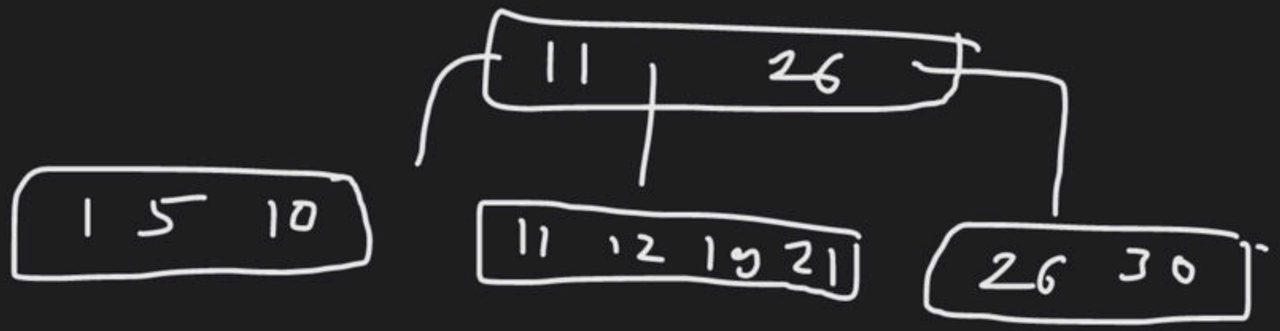


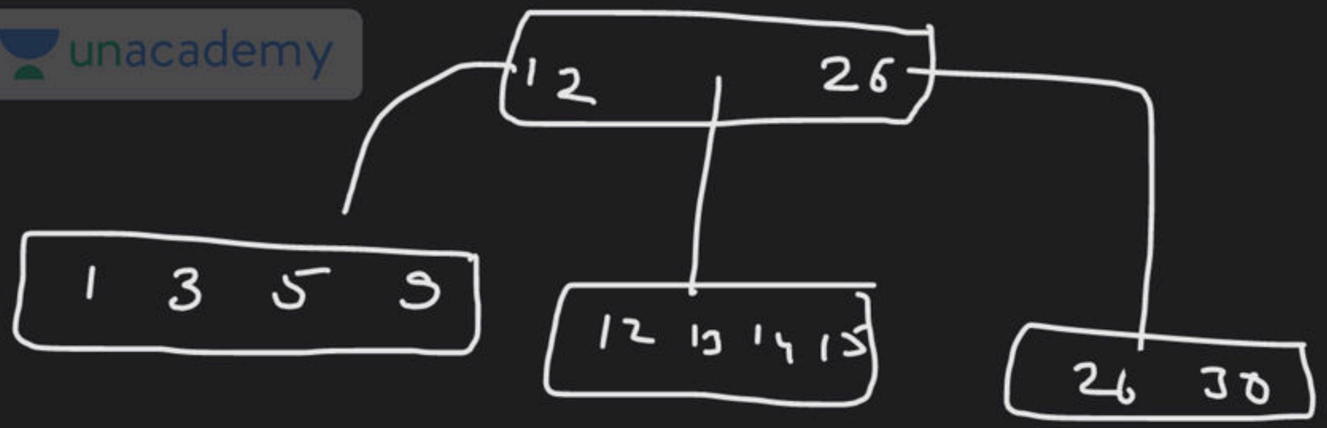
⇒ node split when key can not be distributed


10 26
1 5
10 12 13 21
26 30

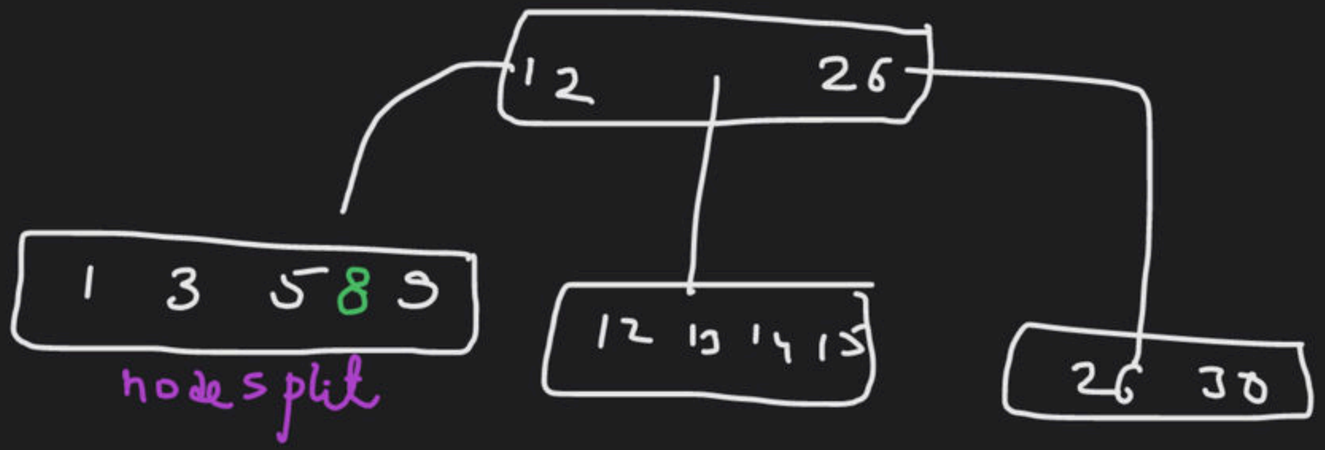
Insert 11 :-

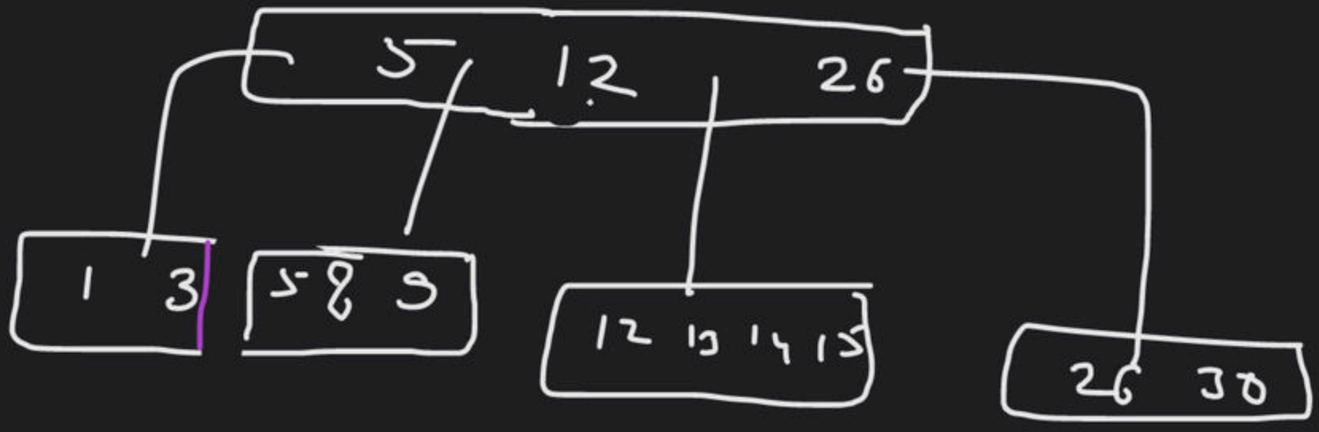

10 26
1 5
10 11 12 13 21
26 30
starting from left


11 26
1 5 10
11 12 19 21
26 30


12
26
1 3 5 9
12 13 14 15
26 30

Insert ⇒ 8

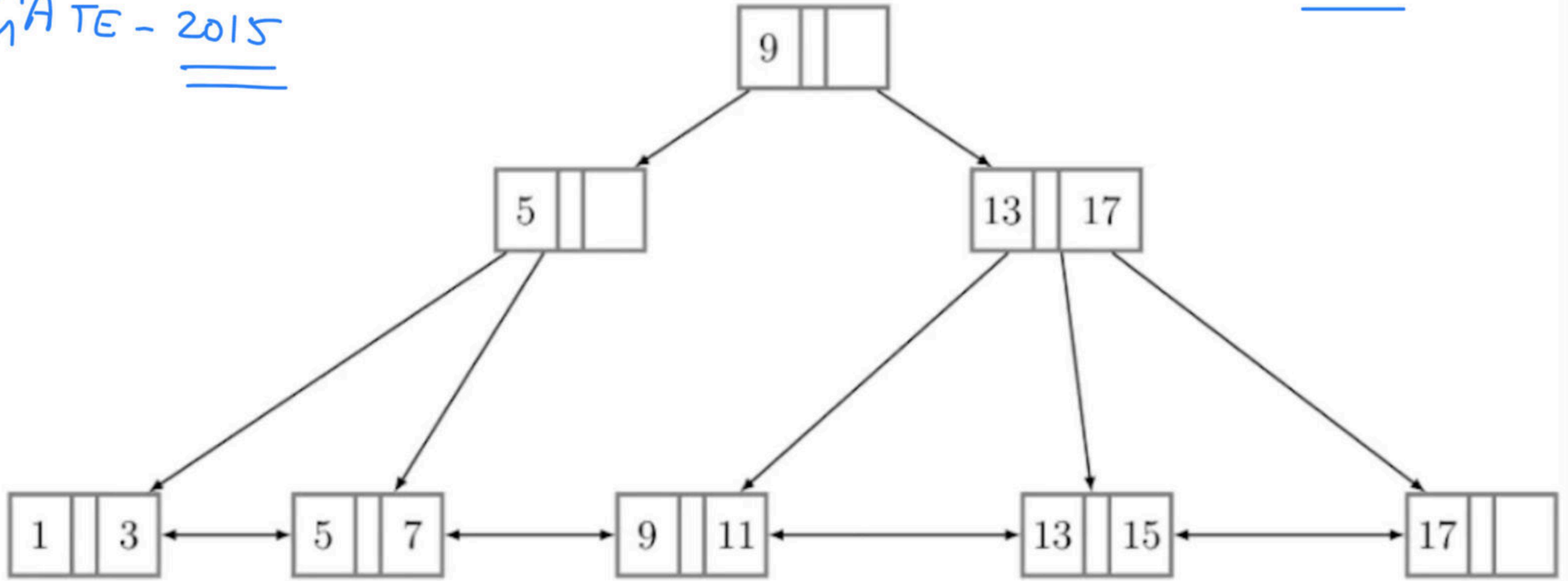

12
26
1 3 5 8 9
12 13 14 15
26 30
node split


5
12
26
1 3
5 8 9
12 13 14 15
26 30

With reference to the B+ tree index of order 1 shown below, the minimum number of nodes (including the Root node) that must be fetched in order to satisfy the following query. "Get all records with a search key greater than or equal to 7 and less than 15 " is _____.

5. Ans

GATE - 2015



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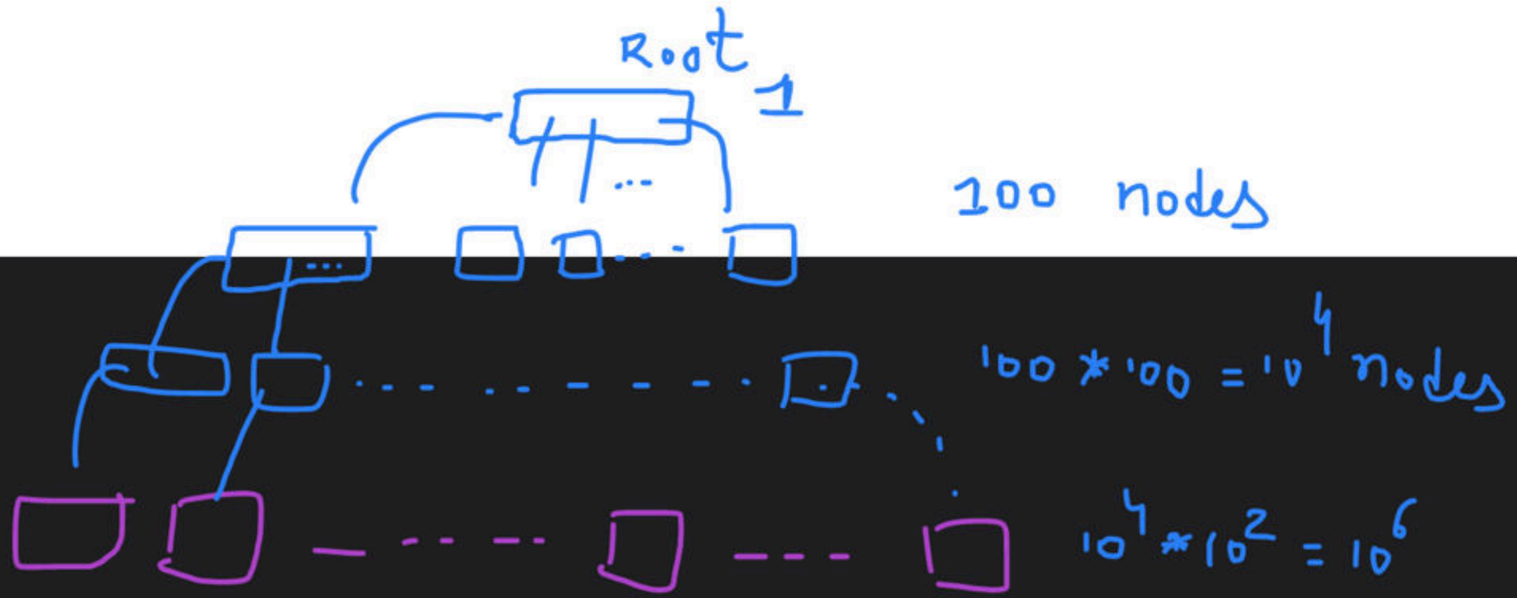
GATE – 2018

10^6

in a file which contains 1 million records and the order of the tree is 100, then what is the maximum number of nodes to be accessed if $B+$ tree index is used?

a. 5
b. 4
c. 3
d. 10



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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.!