



Problem 1: B⁺ Tree Insertion

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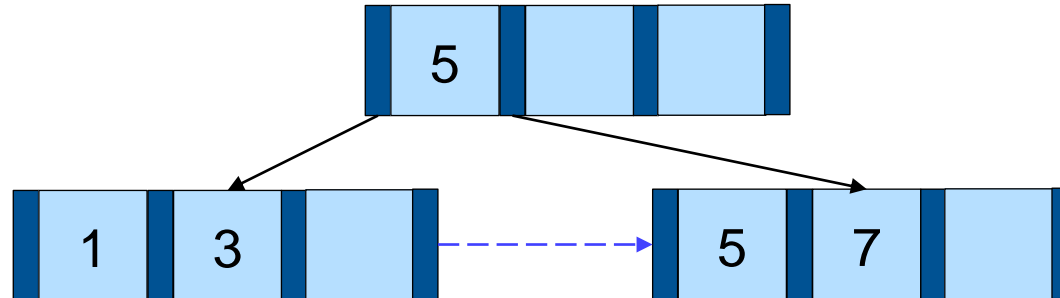
- Order: 4
- Insert: 1, 3, 5, 7, 9, 2, 4, 6, 8, 10



- Insert 1, 3, 5



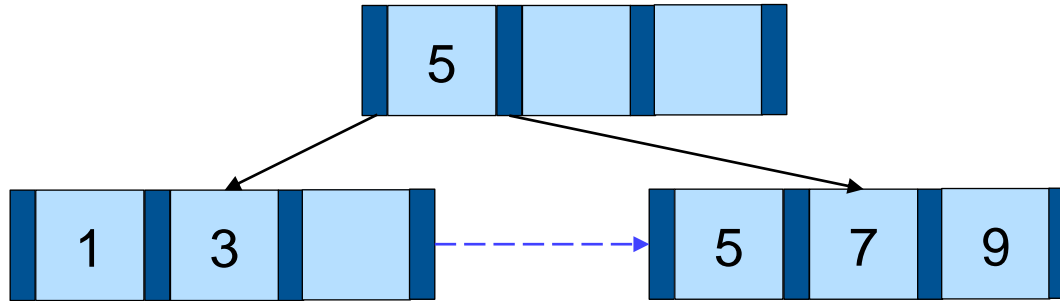
- Insert 7



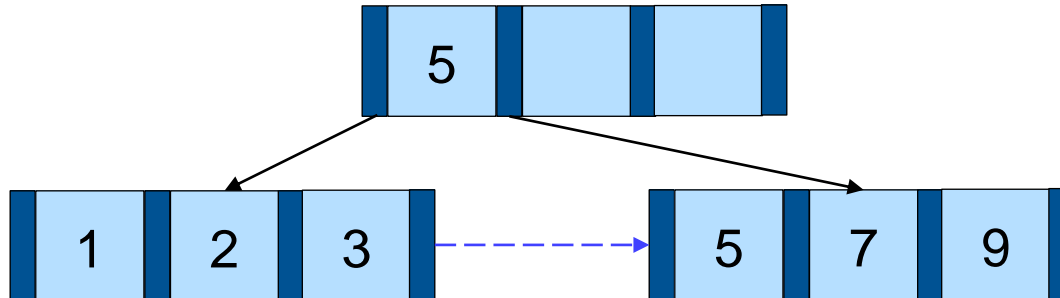
Problem 1: B+ Tree Insertion

- Order: 4
- Insert: 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

- Insert 9



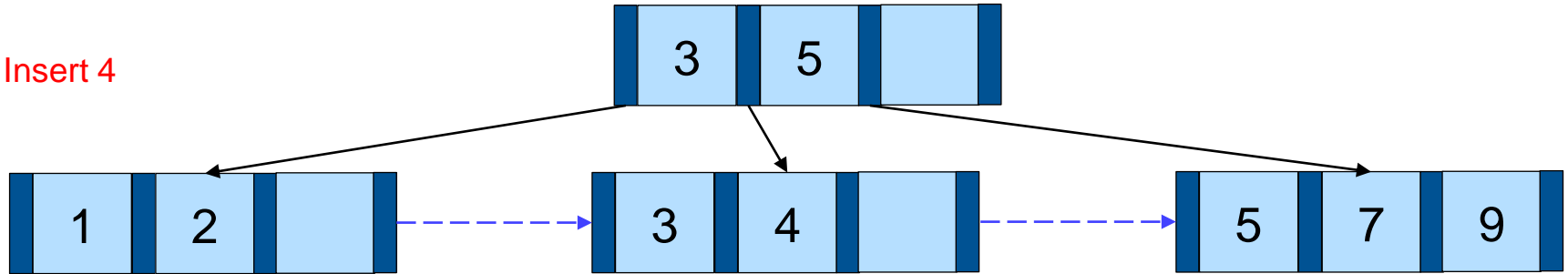
- Insert 2



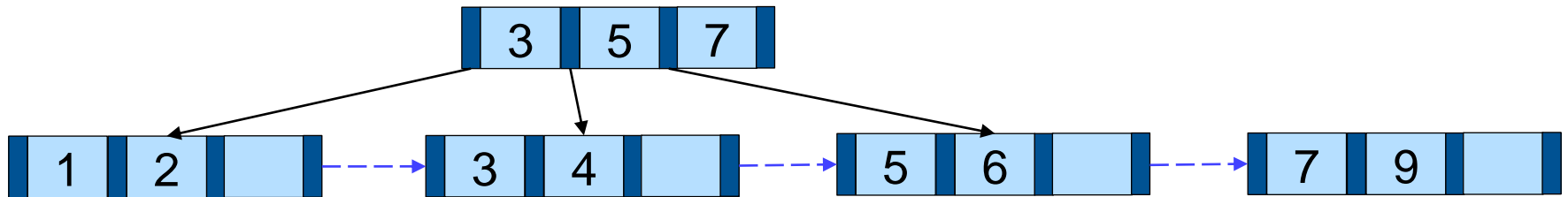
Problem 1: B+ Tree Insertion

- Order: 4
- Insert: 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

- Insert 4



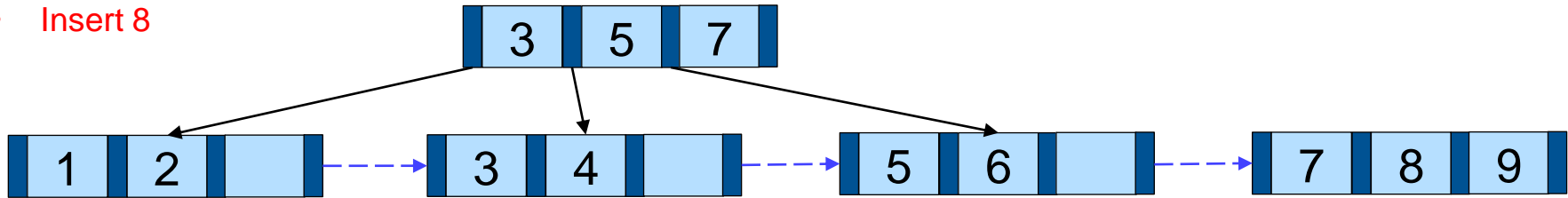
- Insert 6



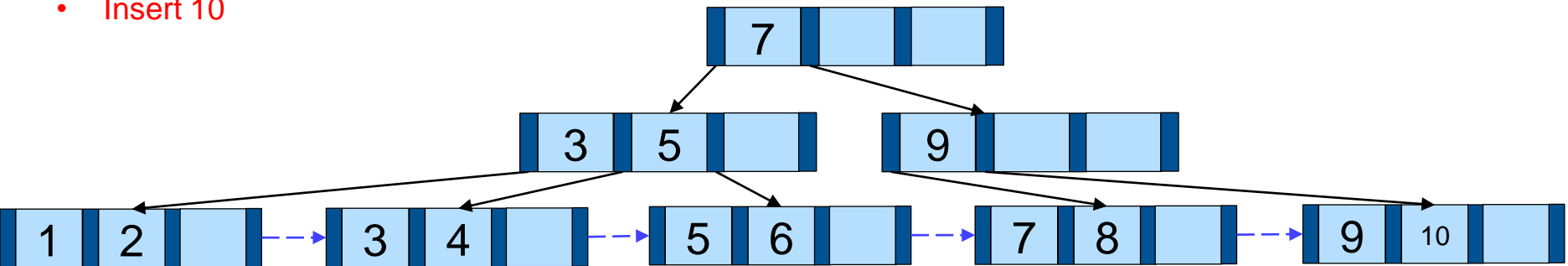
Problem 1: B+ Tree Insertion

- Order: 4
- Insert: 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

- Insert 8



- Insert 10

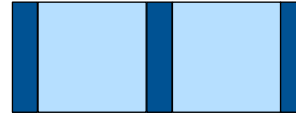




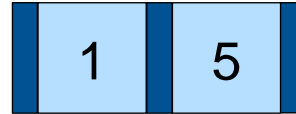
Problem 2: B⁺ Tree Insertion

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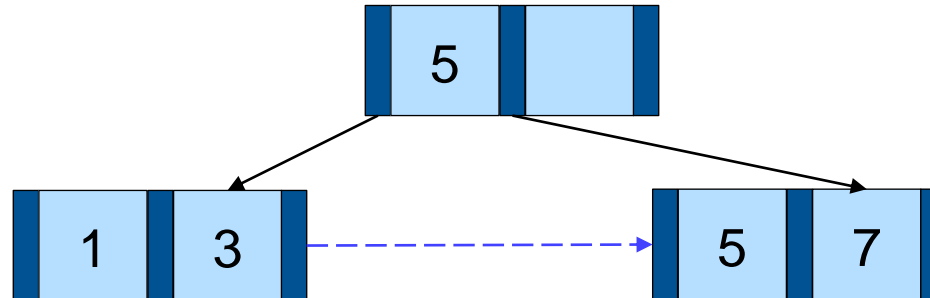
- Order: 3
- Insert: 1, 5, 3, 7, 9, 2, 4, 6, 8, 10



- Insert 1, 5



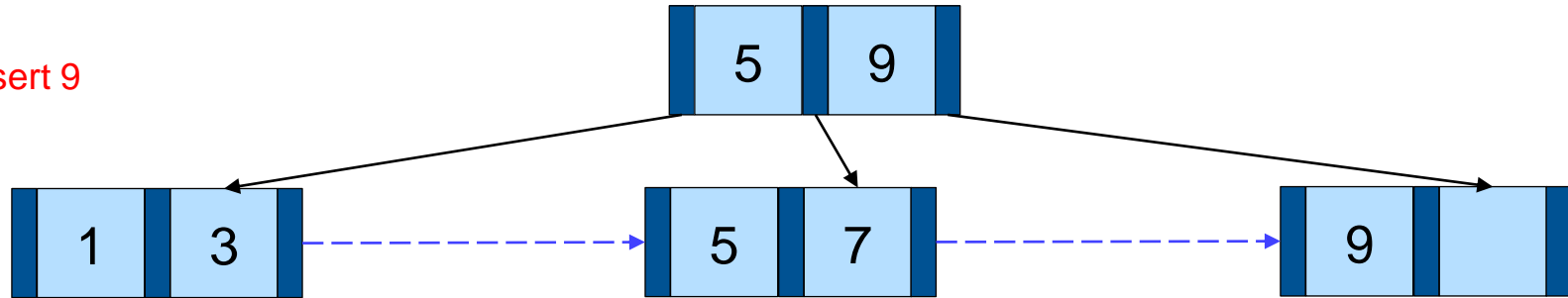
- Insert 3, 7



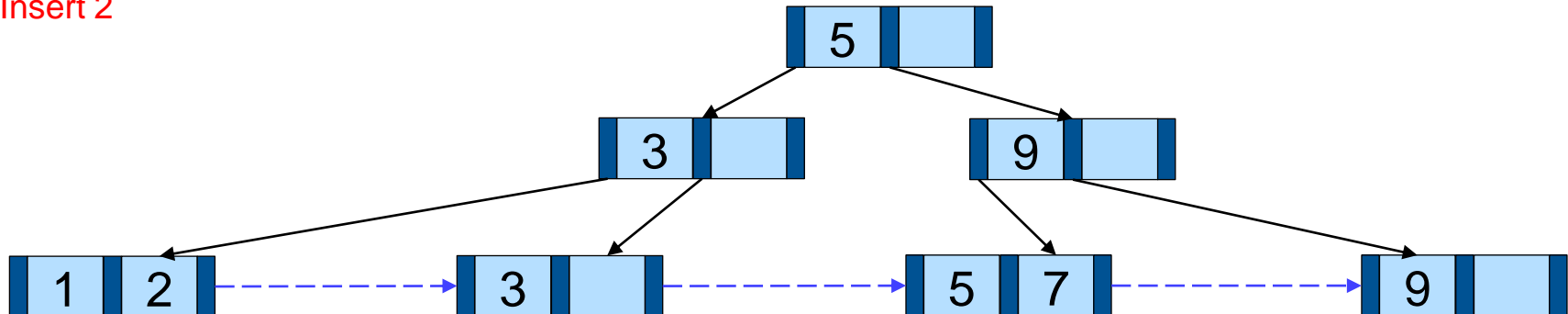
Problem 2: B+ Tree Insertion

- Order: 3
- Insert: 1, 5, 3, 7, 9, 2, 4, 6, 8, 10

- Insert 9



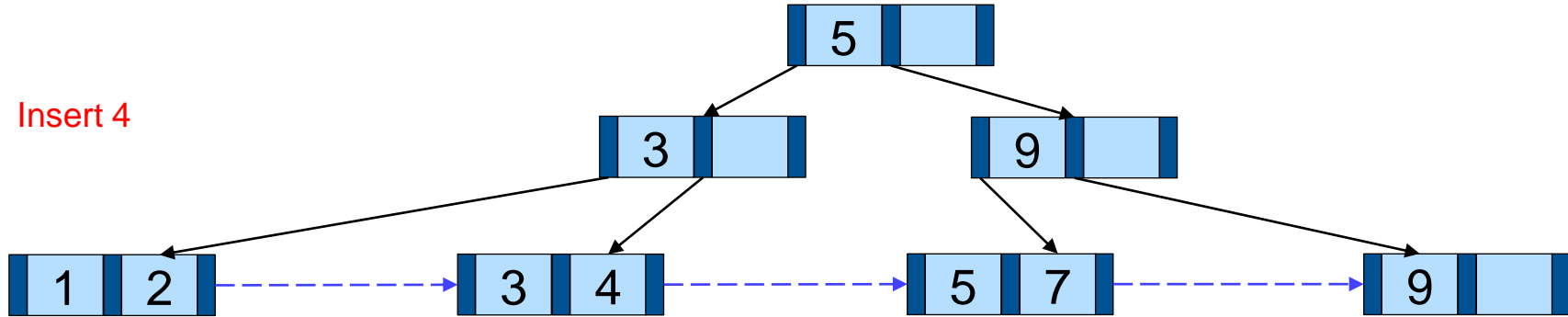
- Insert 2



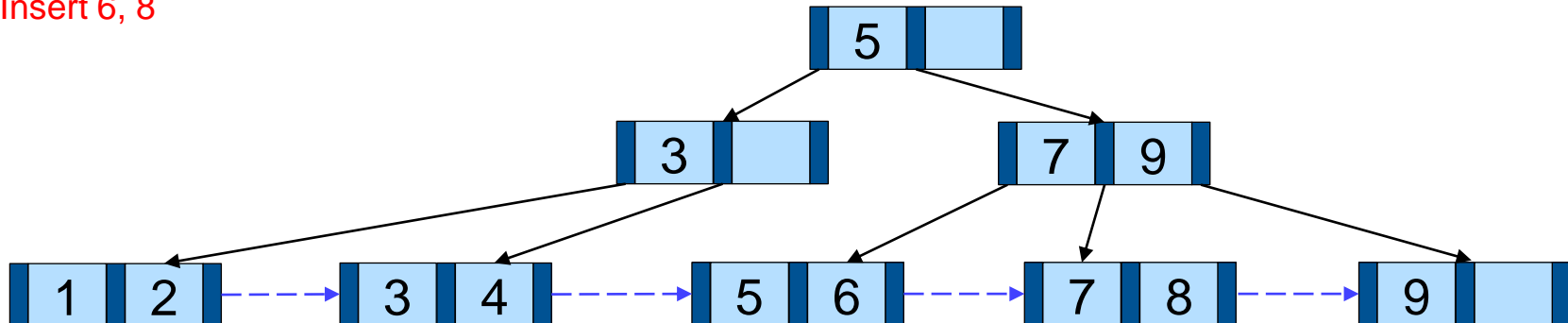
Problem 2: B+ Tree Insertion

- Order: 3
- Insert: 1, 5, 3, 7, 9, 2, 4, 6, 8, 10

- Insert 4



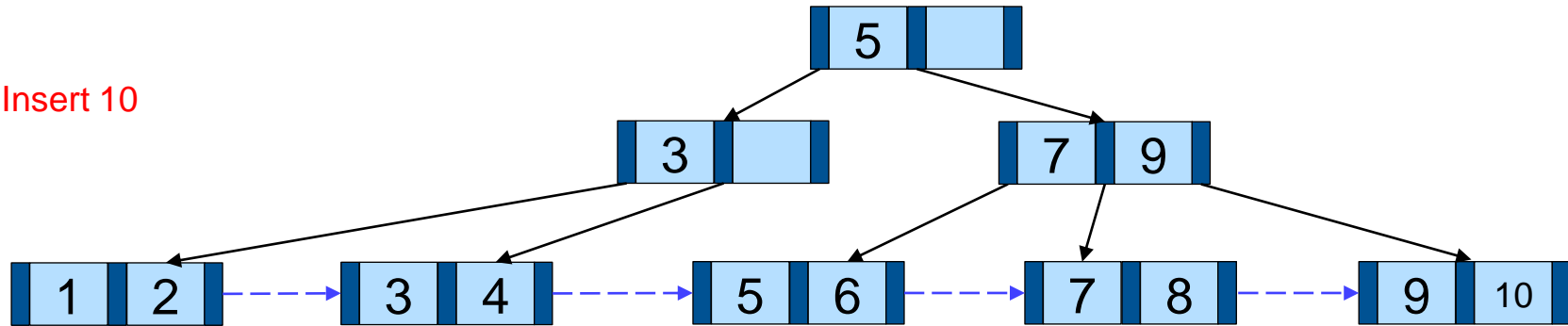
- Insert 6, 8



Problem 2: B⁺ Tree Insertion

- Order: 3
- Insert: 1, 5, 3, 7, 9, 2, 4, 6, 8, 10

- Insert 10

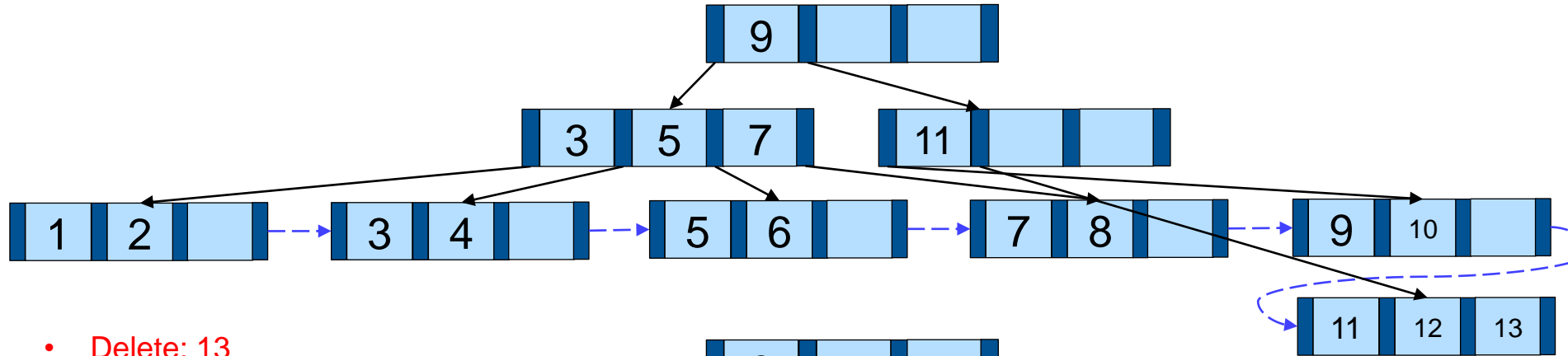




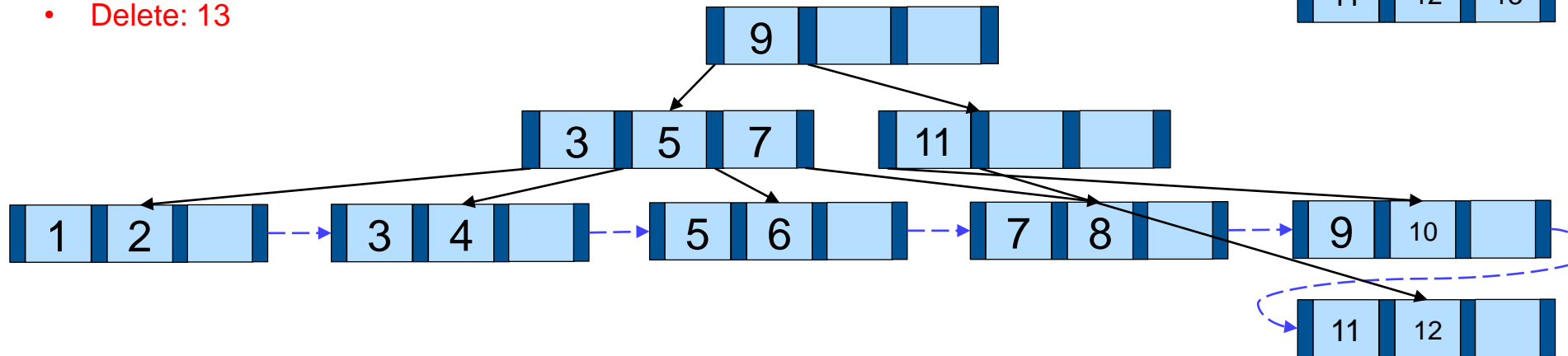
Problem 3: B⁺ Tree Deletion

Problem 3: B+ Tree Deletion

- Order: 4

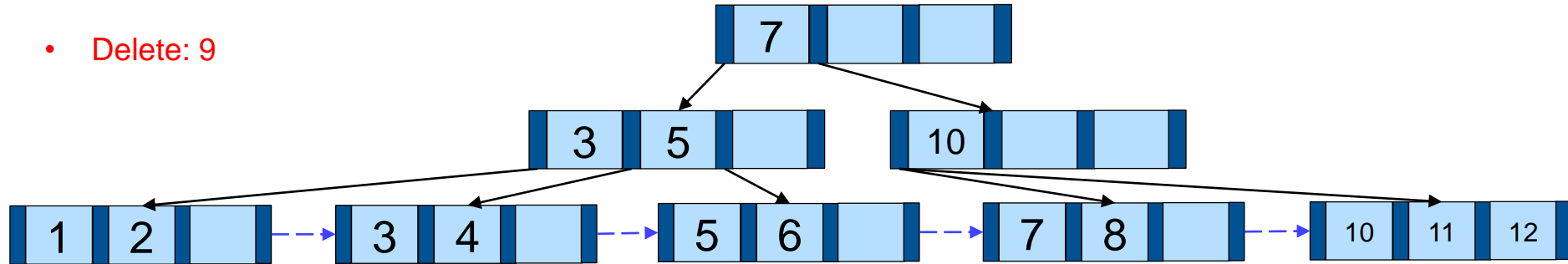


- Delete: 13

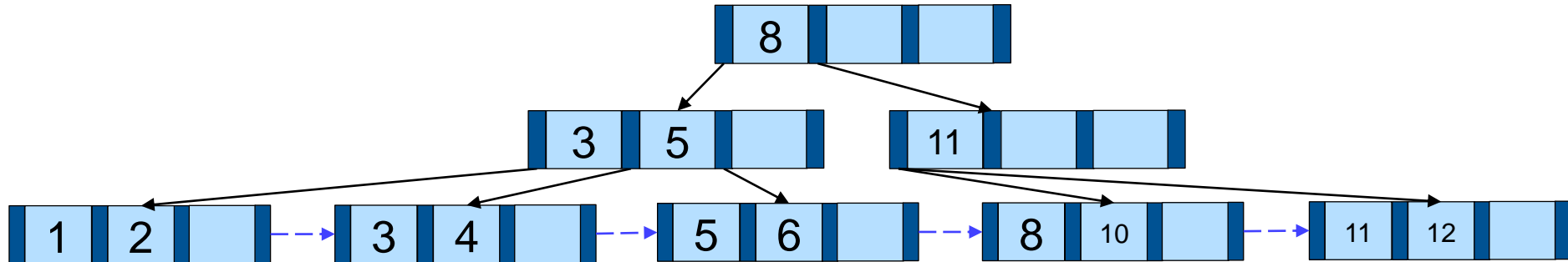


Problem 3: B+ Tree Deletion

- Order: 4
- Delete: 9

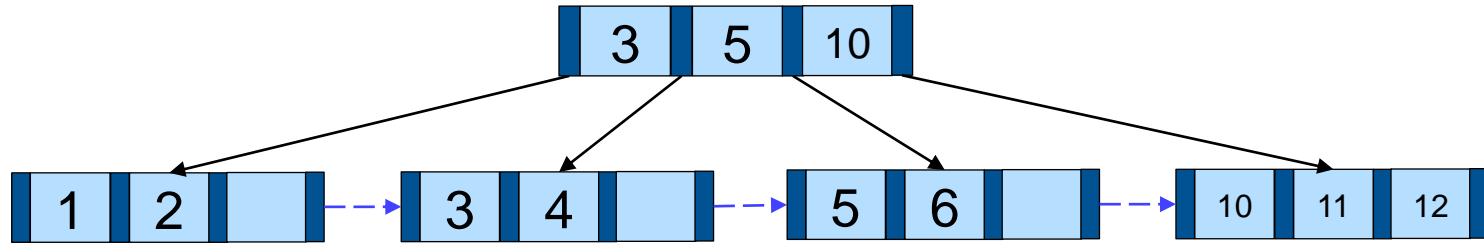


- Delete: 7



Problem 3: B⁺ Tree Deletion

- Order: 4
- Delete: 8

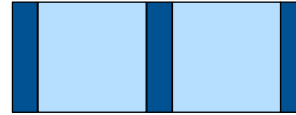




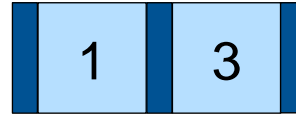
Problem 4: B Tree Insertion

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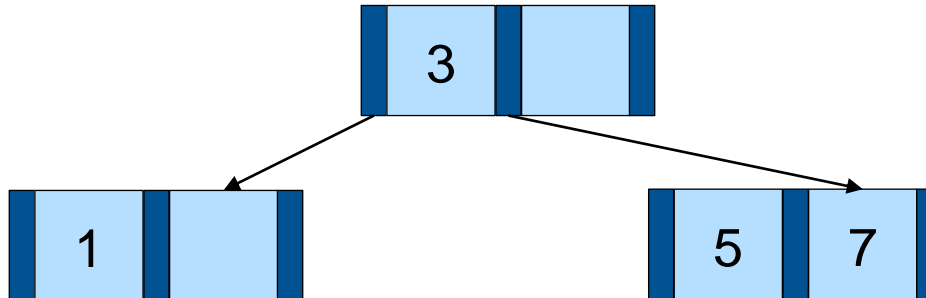
- Order: 3
- Insert: 1, 3, 5, 7, 9, 2, 4, 6, 8, 10



- Insert 1, 3



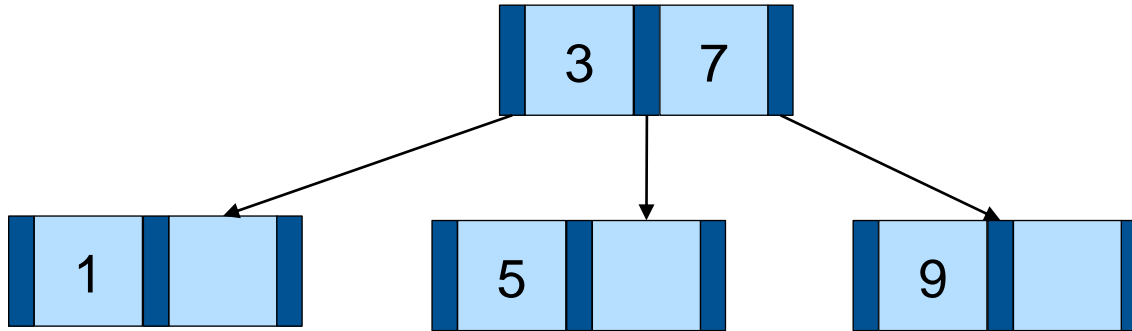
- Insert 5, 7



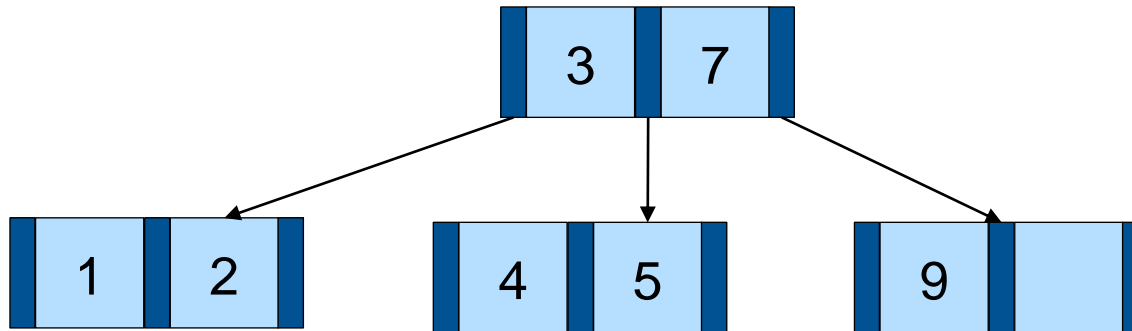
Problem 4: B Tree Insertion

- Order: 3
- Insert: 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

- Insert 9



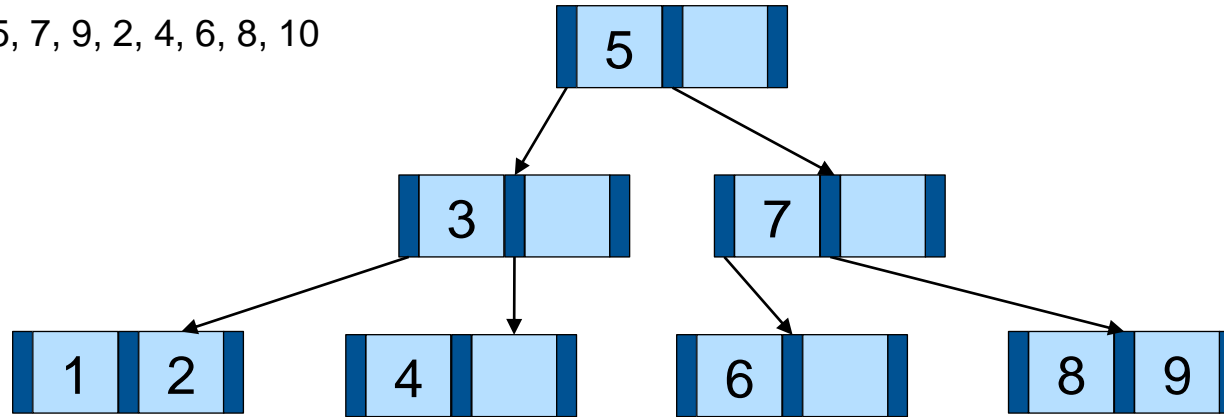
- Insert 2, 4



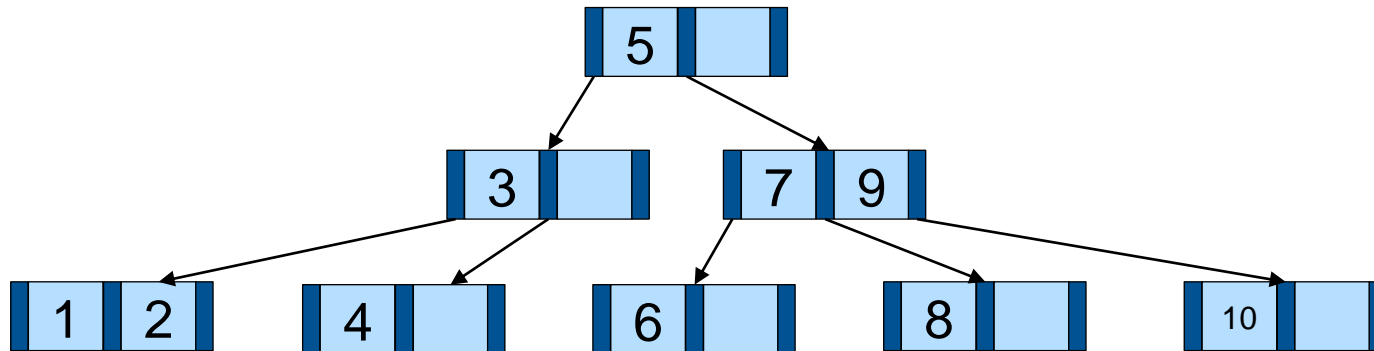
Problem 4: B Tree Insertion

- Order: 3
- Insert: 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

- Insert 6, 8



- Insert 10





Problem 5: B Tree Deletion

B Tree Deletion

Case-I

- If the key is already in a leaf node, and removing it doesn't cause that leaf node to have too few keys, then simply remove the key to be deleted
- key k is in node x and x is a leaf, simply delete k from x

Case-II

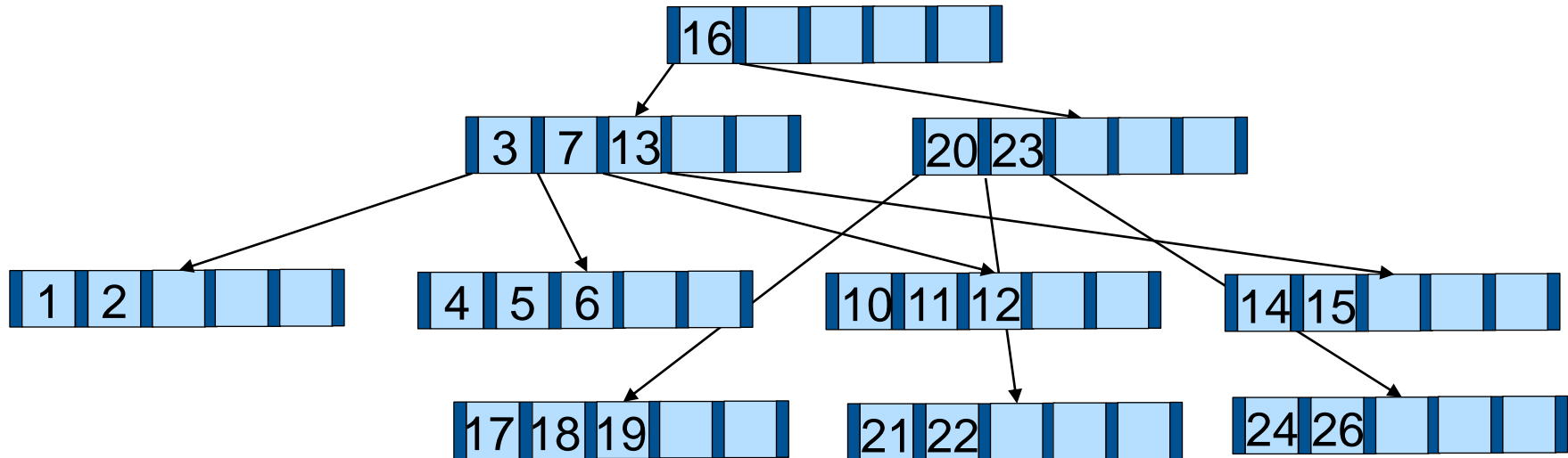
- If key k is in node x and x is an internal node, there are three cases to consider:
- **Case-II-a:** If the child y that precedes k in node x has at least t keys (more than the minimum), then find the predecessor key k' in the subtree rooted at y ; recursively delete k' and replace k with k' in x
- **Case-II-b:** Symmetrically, if the child z that follows k in node x has at least t keys, find the successor k' and delete and replace as before; note that finding k' and deleting it can be performed in a single downward pass
- **Case-II-c:** Otherwise, if both y and z have only $t-1$ (minimum number) keys, merge k and all of z into y , so that both k and the pointer to z are removed from x ; y now contains $2t - 1$ keys, and subsequently k is deleted

Case-III

- **Case-III-a:** If the root has only $t-1$ keys but has a sibling with t keys, give the root an extra key by moving a key from x to the root, moving a key from the root's immediate left or right sibling up into x , and moving the appropriate child from the sibling to x
- **Case-III-b:** If the root and all of its siblings have $t-1$ keys, merge the root with one sibling; this involves moving a key down from x into the new merged node to become the median key for that node

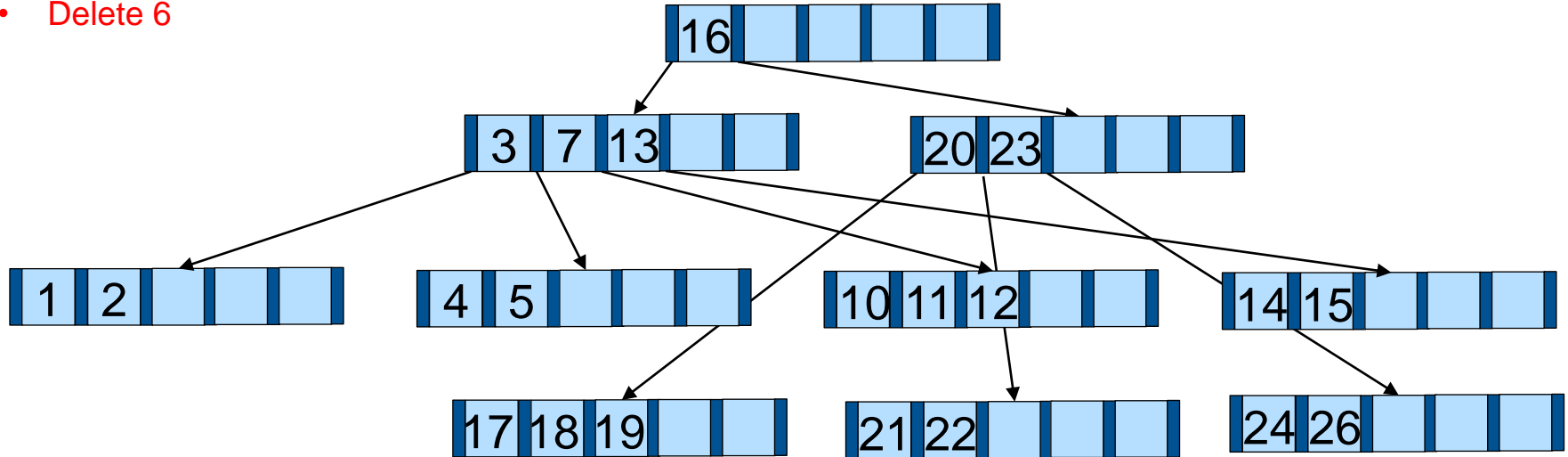
Problem 5: B Tree Deletion

- Order: 6



Problem 5: B Tree Deletion

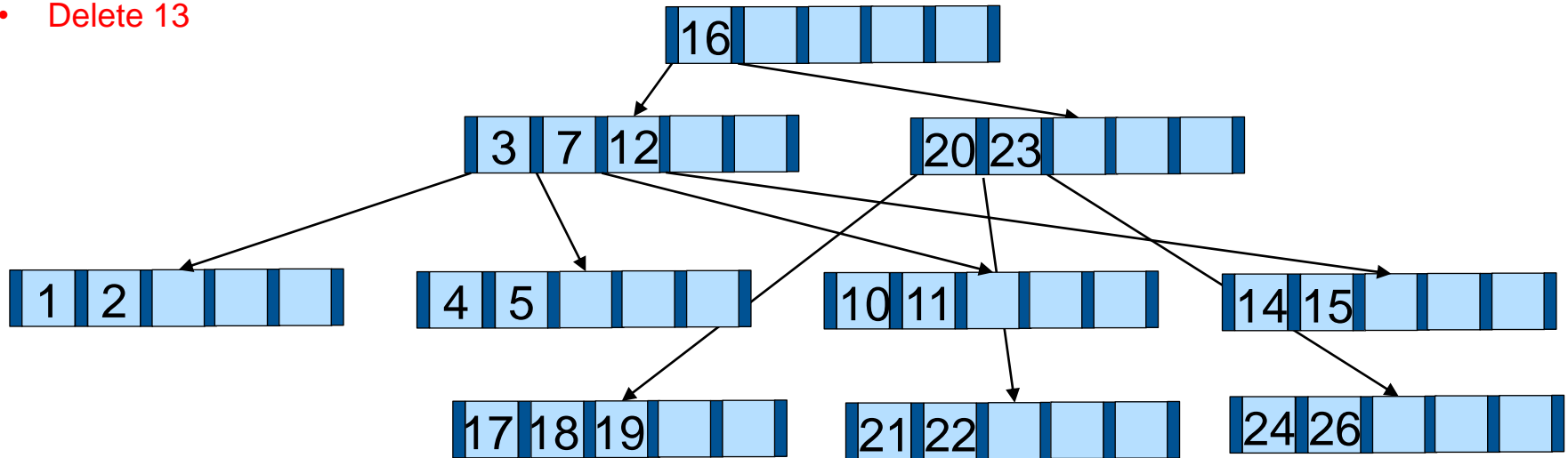
- Order: 6
- Delete 6



(Case-I)

Problem 5: B Tree Deletion

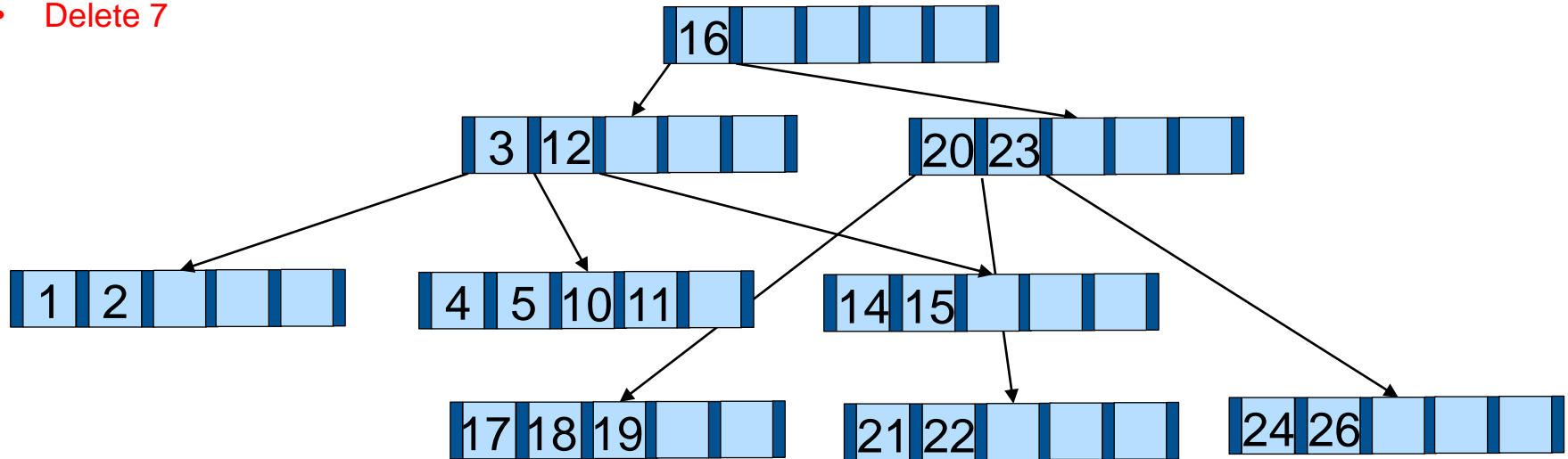
- Order: 6
- Delete 13



(Case-II-a)

Problem 5: B Tree Deletion

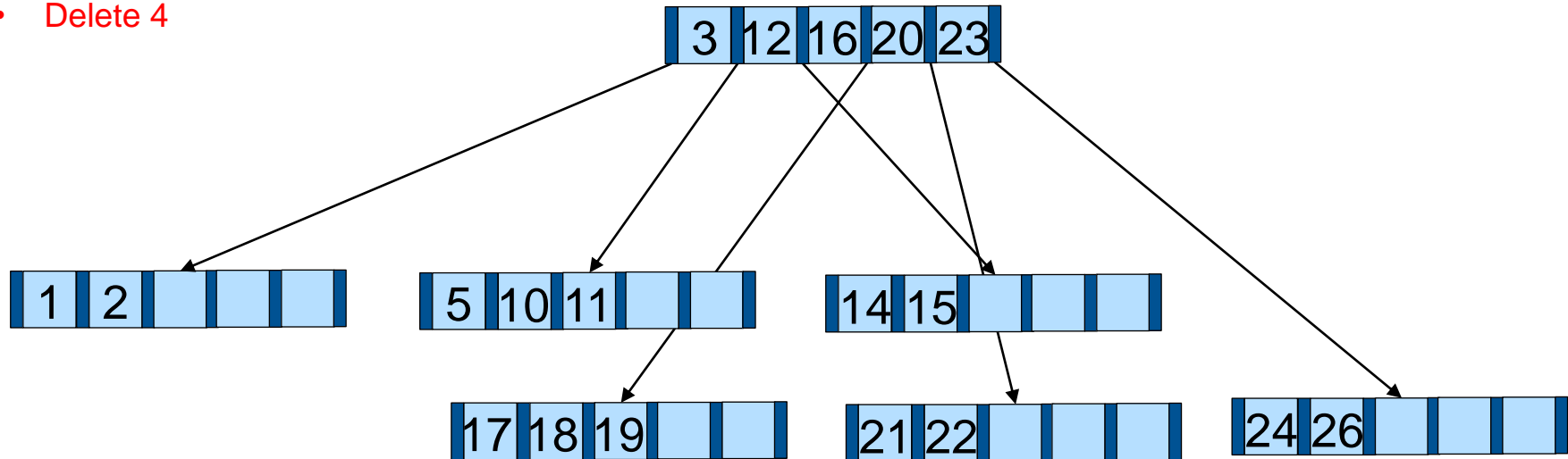
- Order: 6
- Delete 7



(Case-II-c)

Problem 5: B Tree Deletion

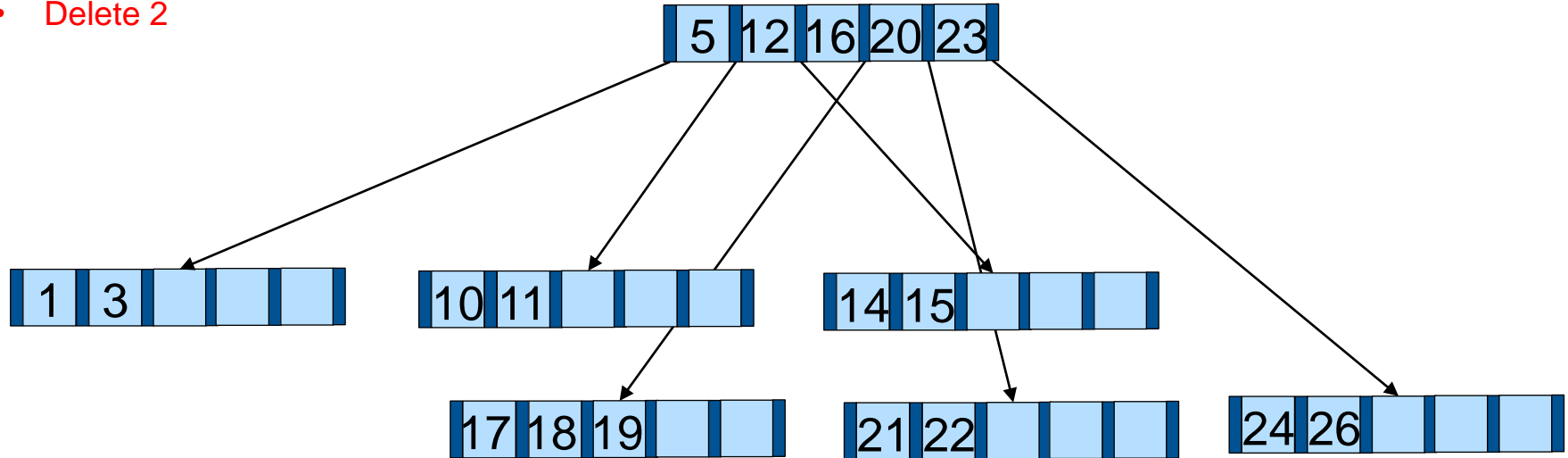
- Order: 6
- Delete 4



(Case-III-b)

Problem 5: B Tree Deletion

- Order: 6
- Delete 2



(Case-III-a)

Thank you for your attention...

Any question?

Contact:

Department of Information Technology, NITK Surathkal, India
6th Floor, Room: 13

Phone: +91-9477678768

E-mail: shrutilipi@nitk.edu.in