Example of B+ tree
B+ Tree Example

• A balanced tree
• Each node can have at most m key fields and m+1 pointer fields
• Half-full must be satisfied (except root node):
  • m is even and m=2d
    – Leaf node half full: at least d entries
    – Non-leaf node half full: at least d entries
  • m is odd and m = 2d+1
    – Leaf node half full: at least d+1 entries
    – Non-leaf node half full: at least d entries (i.e., d+1 pointers)
Show the tree after insertions

- Suppose each B+-tree node can hold up to 4 pointers and 3 keys.
- m=3 (odd), d=1
- Half-full (for odd m value)
  - Leaf node, at least 2 (d+1) entries
  - Non-leaf nodes, at least 2 (d+1) pointers (1 entry)
- Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

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

• Insert 3, 5
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

1

3

5

1 3 5

• Insert 3, 5
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

| 1 | 3 | 5 |

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

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

• Insert 9
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

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

• Insert 2
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

• Insert 2
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

• Insert 4
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

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

• Insert 6
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

• Insert 6
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

• Insert 8
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

• Insert 8
Insert 1, 3, 5, 7, 9, 2, 4, 6, 8, 10

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

• Insert 10
• Deletion
Show the tree after deletions

- Remove 9, 7, 8
After removing 9
• After removing 9
Remove 9, 7, 8

- After removing 7
Remove 9, 7, 8

• After removing 7
Remove 9, 7, 8

- After removing 8
Remove 9, 7, 8

• After removing 8