Module 5: Disk-based Index Structures

Lecture 19: R-trees

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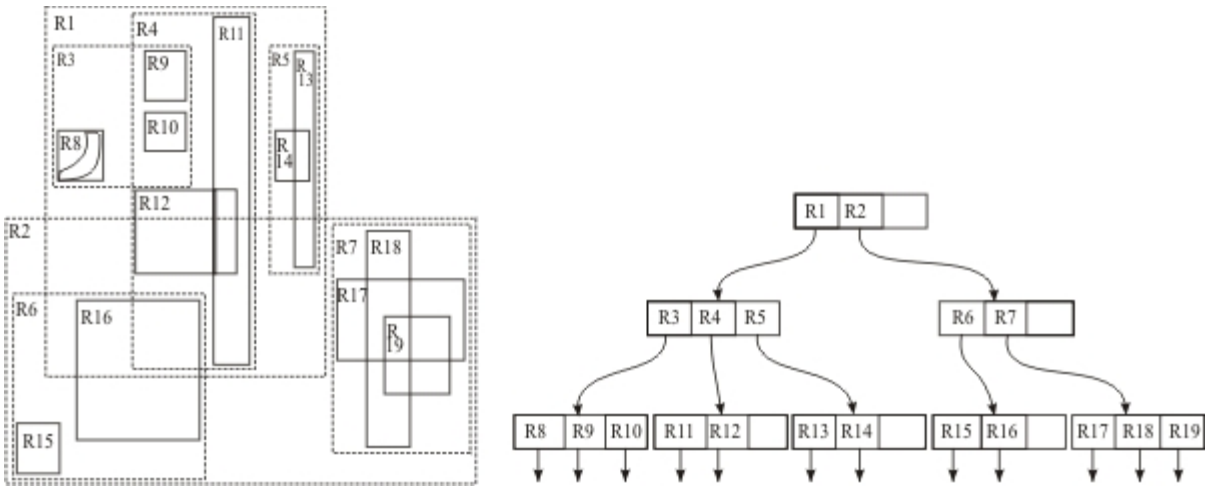
The Lecture Contains:

R-tree

- Structure
- Example of searching
- Insertion
- Deletion

R-tree

- Multi-dimensional B+-tree
- Can store hyper-dimensional points, lines, shapes, etc.
- Objects bounded by a hyper-dimensional minimum bounding rectangle (MBR) or minimum bounding box (MBB)
- Space utilization guarantee
- Multiple search paths due to non-disjoint objects

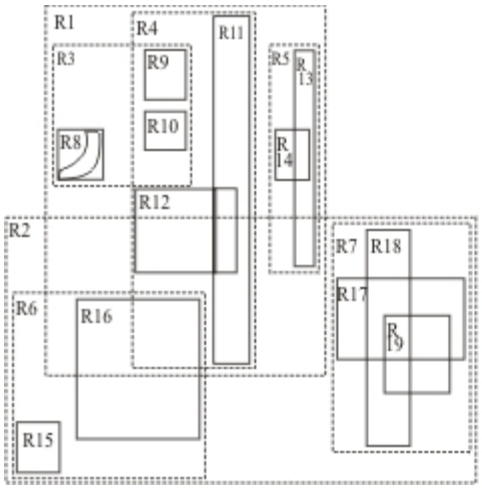


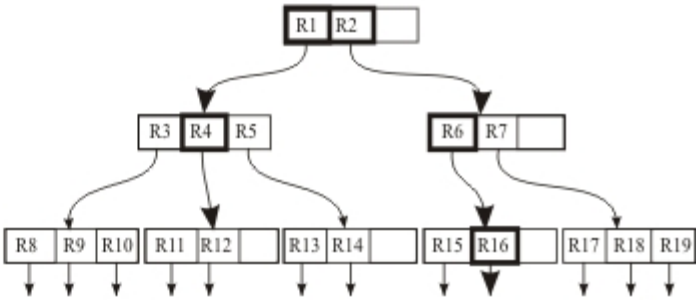
Structure

- Balanced
- Index entry is a hyper-rectangle of k dimensions specied by k intervals.
- Intervals are of the form [a,b]
- Internal node contains index entries and child pointers
- Leaf node contains index entries and data pointers
    - Leaf node index is an MBR for the actual data object
- (M,m) R-tree
    - Maximum $\mathbf{M}$ entries per node
    - Minimum $m \leq \lceil M/2 \rceil$ entries per node (2 for root)

Example of searching

- Searching for a point in R_{16}
- Both R_1 and R_2 intersect with R_{16}
- Therefore, search into both and so on





Insertion

- Data inserted at leaves
- Which leaf ?

Insertion

- Data inserted at leaves
- Which leaf ?
- Start at root
- Choose child requiring least volume enlargement
    - If tie, then child with least volume, then lesser number of children
- If no over flow at leaf, insert
- Otherwise, split and insert
- Adjust tree by updating all index entries from leaf to root
- If root splits, height increases by 1

Deletion

- Find entry by searching
- Delete entry
- If under flow, delete leaf node and put entries into temporary set
- Adjust MBRs of index entries of parent
- Proceed in this manner from leaf to root
- Re-insert orphan entries from temporary set
    - Orphan entries from higher levels must be inserted higher such that all leaves are on the same level
- If under flow proceeds to root, height decreases by 1

Deletion

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- Adjust MBRs of index entries of parent
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- If under flow proceeds to root, height decreases by 1
- *Update*: Delete and re-insert