# XML Indexing I

CPS 216

Advanced Database Systems

## Announcements (March 25)



- Course project milestone 2 due next Tuesday
- Homework #3 due on April 6
- Recitation session this Friday
  - XML API's
- No classes next week
  - Make up during reading period

## XML indexing overview



- It is a jungle out there
  - Different representation scheme lead to different indexes
  - Will we ever find the "One Tree" that rules them all?
- Building blocks: $B^+$-trees, inverted lists, tries, etc.
- Indexes for node/edge-based representations (graph)
- Indexes for interval-based representations (tree)
- Indexes for path-based representations (tree)
- Indexes for sequence-based representations (tree)
- Structural indexes (graph)

## Warm-up: indexes in Lore (review)

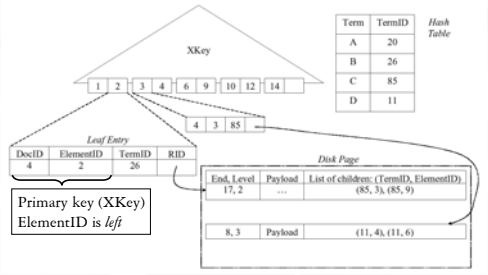


- Label index: (child, label) → parent
  - $B^+$-tree
- Edge index: label → (parent, child)
  - $B^+$-tree
- Value index: (value, label) → Node
  - $B^+$-tree
- Path index: path expression → node
  - Structural index: DataGuide (more in next lecture)

## Niagara: data manager index



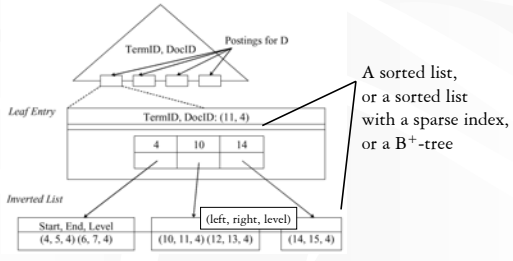
- A combination of node/edge-based and interval-based representations using $B^+$-tree




## Niagara: index manager index



- Essentially an inverted-list index for tag names with entries in each list sorted by XKey



## XR-tree

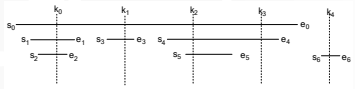
Stands for XML Region Tree (Jiang et al., *ICDE* 2002)

- Intended for interval-based representation
- Based on $B^+$-tree
- Nice property: given an element, all its ancestors/descendents can be identified very efficiently



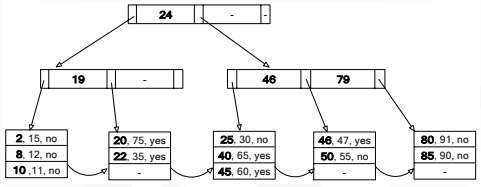
## XR-tree structure

- Backbone is a $B^+$-tree with *left* as the index key
- Each internal index node $n$ maintains a stab list $SL(n)$
  - An element is in $SL(n)$ if it is
    - "Stabbed" by at least one key in $n$, i.e., that key in contained in the element's (*left*, *right*)
    - Not stabbed by any key in $n$'s ancestor
- For each key within an internal node $n$, also store (*first_left*, *first_right*), from the first element in $SL(n)$ stabbed by this key but not by any previous keys in $n$
  - Example: $(s_0, e_0)$ for $k_0$; $(s_4, e_4)$ for $k_2$; (nil, nil) for $k_3$



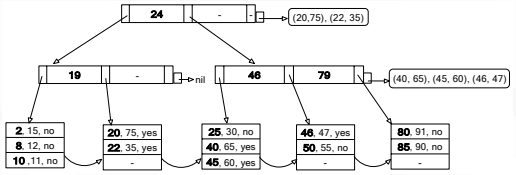



## The backbone $B^+$-tree




- Entries in leaf index nodes have the form (*left*, *right*, *InStabList*, *pointer_to_record*)
  - InStabList is set to true iff the entry can be found some stab list

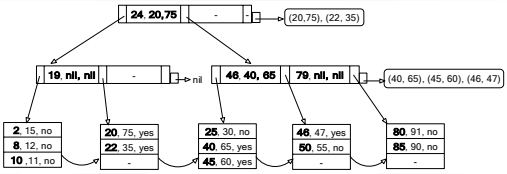
## Stab lists




- Each internal node maintains a stab list
- An element can be in at most one stab list
- Some internal nodes may have empty stab lists (nil)



## (*first_left*, *first_right*) fields

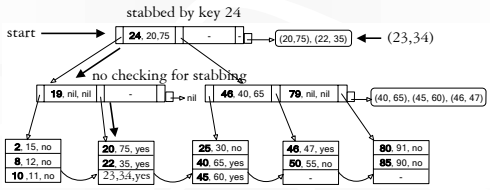



- Note that keys 19, 79 have nil (*first_left*, *first_right*)



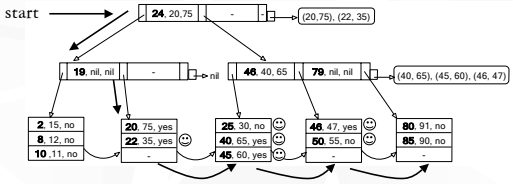
## XR-tree insertion example

- Insert (23, 24)



# Looking up descendents

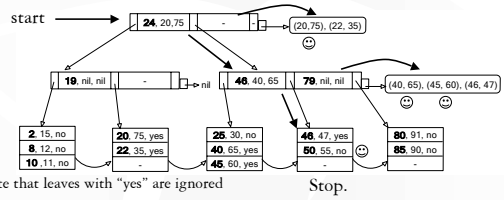
- Basically a range query over the backbone $B^+$-tree
- Example: descendents of (21, 74)






# Looking up ancestors

- Go down the tree and check stab lists and the leaf
- Example: ancestors of (51, 52)
  - Just look for all intervals stabbed by 51
  - Need to check 52?
  - Need to check stab lists on other paths?



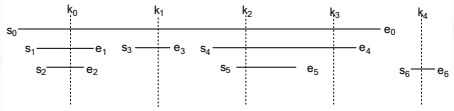

Note that leaves with "yes" are ignored

Stop.



# Stab list checking in more detail

- Visually, the stab list for an internal index node can be seen as stacks of intervals, one stack for each key in the node




- If *left* falls in between $k_i$ and $k_{i+1}$, only need to check from the first to the $(i+1)$-th stack (why?)
- For each stack, check bottom-up, and stop whenever the interval is no longer stabbed by *left* (why?)
- (*start_left*, *start_end*) ensures that no stack is checked unnecessarily

## Performance of XR-tree



- Space: linear in the size of the XML document
- Time
  - $h_{tree}$: B$^+$-tree height; $R$: result size; $B$: block size
  - Looking up descendents: $O(h_{tree}+R/B)$ in the worst case
  - Looking up ancestors: $O(h_{tree}+R)$ in the worst case
    - Loss of $1/B$ factor is worrisome
    - $R$ in this case can be up to $h_{xml}$, the height of the XML tree
  - Insert/delete: $O(h_{tree}+c)$, amortized

## Discussion on XR-tree



- Plain B$^+$-tree works fine for descendents
- Lots of machineries just to find all ancestors
  - Maintaining back pointers allow ancestors to be retrieved in $h_{xml}$ I/O's, matching the bound for XR-tree!
    - Perhaps XR-tree works better on the average case?
  - It should be possible to answer stabbing queries in $O(h_{tree}+R/B)$ time and beat XR-tree and back pointers, even with arbitrary intervals