ICS 321 Data Storage & Retrieval

Overview of Storage & Indexing (ii)

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Indexes

• An *index* on a file speeds up selections on the *search key fields* for the index.
  – Any subset of the fields of a relation can be the search key for an index on the relation.
  – *Search key* is not the same as *key* (minimal set of fields that uniquely identify a record in a relation).

• An index contains a collection of *data entries*, and supports efficient retrieval of all data entries \( k^* \) with a given key value \( k \).
  – A data entry is usually in the form \(<key, rid>\)
  – Given data entry \( k^* \), we can find record with key \( k \) in at most one disk I/O. (Details soon ...)
- Leaf pages contain **data entries**, and are chained (prev & next)
- A data entry typically contain a key value and a rid.
- Non-leaf pages have **index entries**; only used to direct searches:
Example B+ Tree

- Find 28*? 29*? All > 15* and < 30*
- Insert/delete: Find data entry in leaf, then change it. Need to adjust parent sometimes.
  - And change sometimes bubbles up the tree

Note how data entries in leaf level are sorted
Point Queries using B+ Trees

- Use index to find 30*
- Request tuple from buffer manager
- If not in bufferpool, fetch page from disk

SELECT * FROM Employees WHERE age=30

Assume heap file data storage
Range Queries using B+ Trees

- Use index to find 30*
- For each data entry to the right of 30*
- Request tuples from buffer manager
- If not in bufferpool, fetch page from disk

Assume heap file data storage
Hash-Based Indexes

- Index is a collection of **buckets** that contain data entries
  - Bucket = primary page plus zero or more overflow pages.
- **Hashing function** $h$: $h(r) =$ bucket in which (data entry for) record $r$ belongs. $h$ looks at the search key fields of $r$.
- No “index entries” in this scheme.

Value for age

File

Hash Index on Age

Overflow page

H1(age)

30 45

56 41

20 25

20 25

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Index Classifications

• What should be in a Data Entry $k^*$?
  – Possibilities:
    • The data record itself with key value $k$
    • $<k, \text{rid of data record with key value } k>$
    • $<k, \text{list of rids of data records with key value } k>$
      – Variable size data entries
  – Applies to any indexing technique

• Primary vs Secondary
  – Primary index: search key contains primary key
  – Unique Index: search key contains candidate key

• Clustered vs unclustered
  – Clustered index: order of data records same or close to order of data entries
Clustered vs Unclustered Index

• Suppose data records are stored in a Heap file.
  – To build clustered index, first sort the Heap file (with some free space on each page for future inserts).
  – Overflow pages may be needed for inserts. (Thus, order of data recs is `close to`, but not identical to, the sort order.)
Clustered File

- An index where the data entry contains the data record itself (cf. just the key value, RID pair).
- No heap/sorted file is used, the index IS the file of record
- Steps to build a clustered file:
  - Sort data records
  - Partition into pages
  - Build the tree on the pages