

Solutions to exercises in Discussion (2/5/2003)

Storing Data: Disk and Files

1. Answers are:
 - a) Search for records based on a range of field values: **Sorted**
 - b) Perform inserts and scans where the order of records does not matter: **Heap**
 - c) Search for a record based on a particular field value: **Hash**
2. In this example an index scan isn't always the best alternative for two reasons:
 - a) Selectivity of the predicate **sal > 20**: If this predicate is true for a large fraction of the tuples in the table, there is nothing to be gained by going to the index. In fact, you lose by doing the additional index I/Os.
 - b) Is the index clustered? If this is not a clustered index, the records that match the predicate may end up being scattered all over the table. This will lead to data pages being read multiple times for a sufficiently big table.
3. Why are clustered indexes faster than unclustered indexes ? Is there anything that can be done to improve the performance of unclustered indexes ?
 - a) Answer to the first part in (b) above.
 - b) To improve the performance of an unclustered index you can sort the RIDs from the index and access the data pages in the sorted RID order (commonly called a "RID-List-Fetch" operator)
4. In the organization of a data page, what is a slot directory? What is it used for? In the organization of a data record, what is a field offset? What is it used for?
 - a) A slot directory is a list of page offsets that is maintained in each data page. It establishes a mapping between a *slot number* of a record in a page and the location of that record in the page through the offset. It is used so that a record can be moved around in a page without having to modify other persistent objects (such as indexes) that refer to it. (See 9.6.2 in the book for more details)
 - b) A field offset is the offset of a field from the start of a record. This is typically used with variable length fields.
5. (This is the same as Exercise 9.18 in the book)
 - a) This approach is simpler, but less flexible. We can easily either allocate too much space for the slot directory or too little, since record lengths are variable and it is hard to estimate how many records are likely to fit on a given page.
 - b) One modification that would allow records to be sorted by a particular field is to store slot entries as <logical record number within page, offset > pairs and sort these based on the record's field value.
6. Consider the following relation describing employees in a company:

Employee (eno: integer, name: char(20), phone: integer, age: integer, salary: real).

- a) For each case we will first compute the record size. Note that the effective available space in a page is $4096 - 20 = 4076$ bytes
- i. *Fixed length record format, PACKED page format.* Size of fixed length record = $4 + 20 + 4 + 4 + 4 = 36$ bytes. Overhead of PACKED page format = 1 byte (to store number of records, assuming < 256 records per page). So number of records that can be stored is $4075/36 = 113$
 - ii. *Fixed length record format, UNPACKED, BITMAP page format:* Size of record = 36 bytes. Let there be n records in the page. So, size of bitmap = $n/8$ bytes.
 $n * 36 + n/8 \leq 4076 \Rightarrow n = 112$
 - iii. *Fixed length record format, Slotted page format.* Let n be the max. number of records. Size of the record is 36 bytes as before. We use 2 bytes per slot in the slot directory. So:
 $n * 36 + n * 2 \leq 4076 \Rightarrow n = 107$
 - iv. *Variable length record format, Slotted page format.* Size of the record is 36 bytes + 2 bytes per field = $36 + 2 * 5 = 46$ bytes. Rest of the calculation is same as (iii) above .. $n * 46 + n * 2 \leq 4096 \Rightarrow n = 85$
- b) What is the most number of tuples that can be stored per slotted page ?
ANS: Since typically in a slotted page format, the least significant byte of a record-id (RID) is used to identify the record's slot in the page (the most significant 3 bytes identifies the page in the file) you can have at most 256 slots in a page. This means that you cannot have more than 256 tuples in a slotted page when the slot is identified by a RID's LSB.