UNIVERSITY OF CALIFORNIA
Department of EECS, Computer Science Division

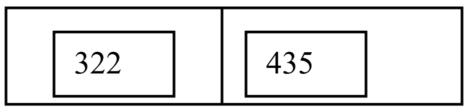
CS186 Garofalakis/Hellerstein
Fall 2005 Midterm Solutions

Midterm Solutions: Introduction to Database Systems

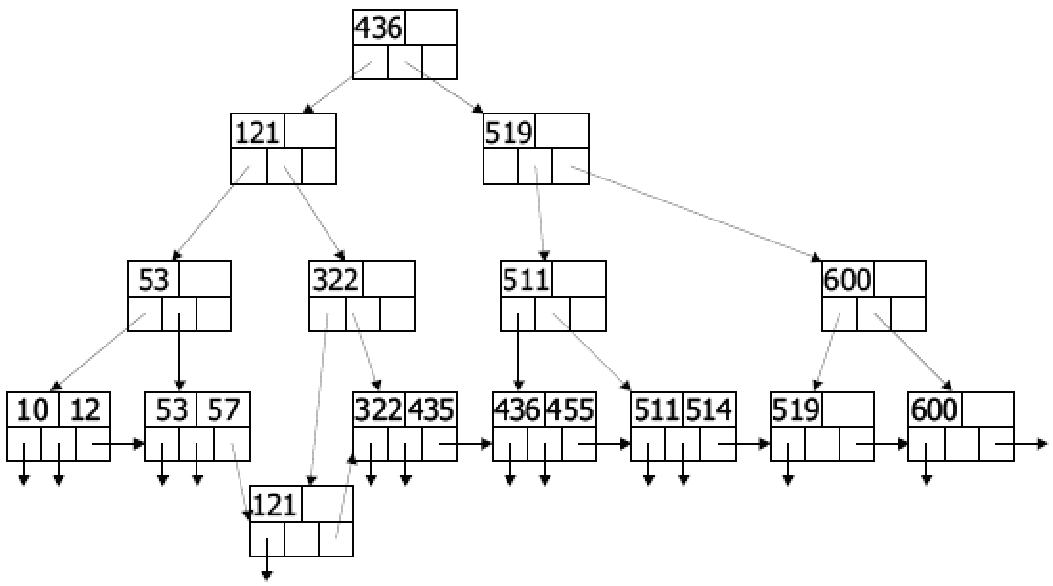
Problem 1: B+trees

(A) (3 points)
Node affected: N7

New Node:



(B) (6 points)



(C)
a. (5 points)
1. Merge N3 and N4. (Move 519 to N3)
2. Merge N10 and N11, and move it to child of N3.

b. (1 point)
Insert any value in [520,600)

Problem 2: Query Languages

a. [4 points] Find blog entries posted by an author with realname 'Ted', and return the title, timestamp and body of the entry.

```
SELECT e.title, e.timestamp, e.body
  FROM entries e, authors a
 WHERE e.authorid = a.authorid
   AND a.realname = 'Ted'
```

b. [6 points] For each entry in the blog, return the same fields as in part (a), for those entries with more than 2 comments.

```
SELECT e.title, e.timestamp, e.body
  FROM blogdb_entries e
 WHERE e.id IN
(SELECT c.entry_id
   FROM blogdb_comments c
  GROUP BY c.entry_id
 HAVING count(*) > 2);
```

OR

```
SELECT e.title, e.timestamp, e.body
  FROM blogdb_entries e, blogdb_comments c
 WHERE e.id = c.entry_id
 GROUP BY e.id, e.title, e.timestamp, e.body
HAVING count(*) > 2);
```

c. [6 points] The "parent_id" field in the comments table tracks the nesting of "comments on comments": when a new comment is posted in response to an old comment, the parent_id of the new comment is the id of the old comment. (You may assume that comments made directly on blog entries have parent_id = 0).

Find the id of each comment and the id of its "grandparent" comment; if it does not have a grandparent, omit it from the answer.

```
SELECT kid.id, parent.parent_id
  FROM comments kid, comments parent
 WHERE kid.parent_id = parent.id
   AND parent.parent_id <> 0
```

OR

```
SELECT kid.id, grand.id
   FROM comments kid, comments parent,
        comments grand
  WHERE kid.parent_id = parent.id
    AND parent.parent_id = grand.id;
```

B. XML

a. [4 points] Write an XPATH query that returns all comments associated with entries entitled "Midterm".

```
//entry[@title="Midterm"]/comment
```

b. [4 points] Write an XPATH query to find all comments that are a “grandparent” of some other comment.

```
//comment[comment/comment]
```

c. [6 points] Using the XQuery language, write a FLWOR query that returns entries that have more than 5 comments (nested or otherwise) and an author name containing "Michael".

```
   FOR $e IN /entry[contains(./author, "Michael")]
   LET $c := $e//comment
 WHERE count($c) > 5
RETURN $e
```

3. Sorting. [8 points]
We would like to sort the tuples of a relation R(column1, column2, column3, column4) on a the sort key (column1, column2, column4). The following information is known about the relation.

· The relation R contains 100,000 tuples.
· The size of a block on disk is 4000 bytes.
· The size of each R tuple is 400 bytes.
· The size of each field in R is 4 bytes.
· A record pointer is 4 bytes.

Answer the following questions based on the information above.

A. [4 points] If we want to sort in two passes (using only Phase 0 and Phase 1), we need to know the minimum number of blocks B of main memory required. Provide (i) a formula for computing B correctly, and (ii) also give an *integer* value of B that guarantees a 2-pass sort.

Part i:
2 points: either solutions received full credit
$B(B-1) \le 10000$
Or
$1 + \lceil \log_{B-1}(\lceil 10000/B \rceil) \rceil = 2$

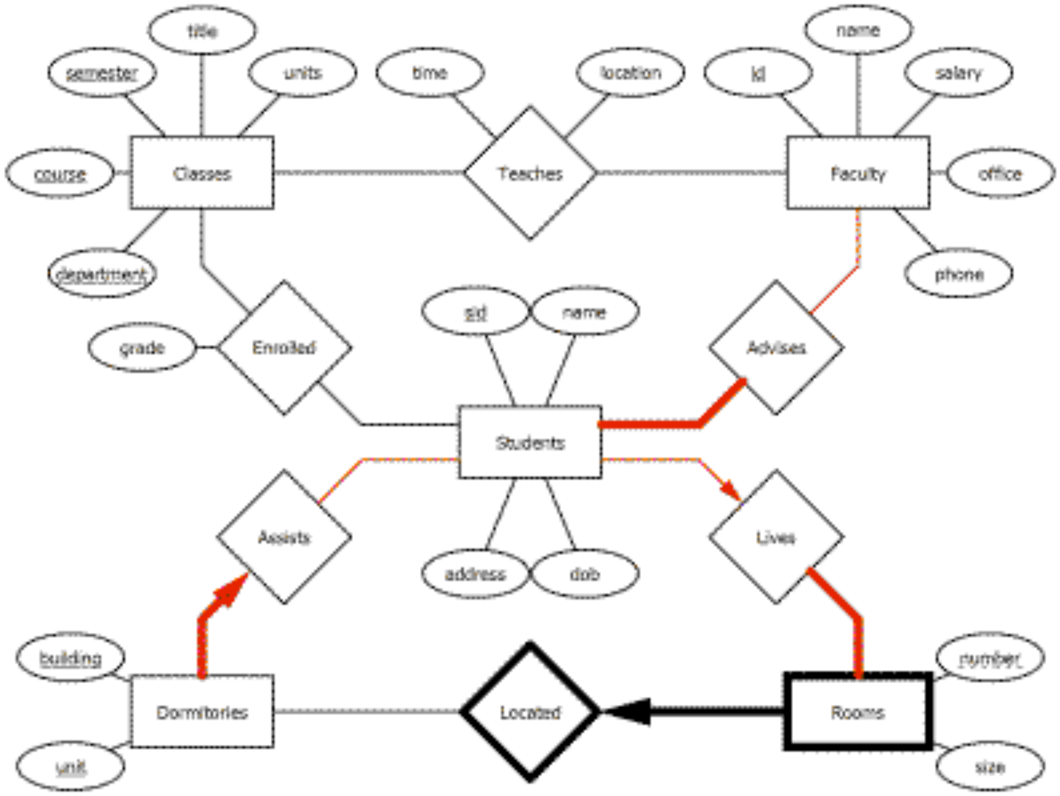
1 point for minor errors (e.g., forgot the ceiling, # pages did not appear anywhere).

Part ii:
2 points:
B = 101

B. [4 points] Assume we have sufficient memory to perform the sort in two passes. What is the cost, in terms of number of disk I/Os, of sorting relation R? Include the cost of the writing the sorted file to the disk in the end in your calculations.

4 points:
2 passes, read in and write out 10000 pages during each pass.
4 * 10000 = 40,000 I/Os

Problem 4: ER Diagrams



Teaches - a given Faculty member will only be able to teach a given Class during one semester.
Classes - Classes with the same department and course number are no longer distinct over different semesters.
Enrolled - a give Student will only be able to take a given Class during one semester.

Recall that the primary keys of entities taken all together become primary keys in the relation!

Problem 5: Query Optimization

Answer 5(a):

Since fromUrl is a foreign-key reference, the number of tuples in the join result (without any selections applied) is |L| (referential integrity); thus, the selectivity of the join operator is |L|/(|P|*|L|) = 1/|P| = $1/10^6$.
Assuming *uniformity* (for both the pagesize and author attributes), the selectivities for the pagesize and author conditions in the query are (5000-0)/(20000-0) = ¼ and $1/10^4$, respectively.
Thus, assuming *independence* for the conditions, the overall selectivity is:

$$\frac{|L|}{|P|\times|L|}\cdot\frac{5000-0}{20000-0}\cdot\frac{1}{10^4}=25\times10^{-12}$$

Answer 5(b):

The complete scan of webpages costs 10^5 page IOs. Assuming *uniformity* over pagesizes, the number of webpages tuples that satisfy the pagesize condition in the query is:

$$10^6\times\frac{20000-K}{20000}=(1-\frac{K}{20000})\times10^6$$

Similarly, the number of relevant index pages that must be scanned during the index scan is (1-K/20000)*10^3. Since we have an unclustered index and get no benefit from buffering, we must do a data-page IO for each qualifying webpages tuple. Thus, the crossover value of K is determined by the equation:

$$(1-\frac{K}{20000})\times(10^6+10^3)=10^5$$

which gives K = 18002. Thus, for K>18002 the unclustered index scan solution is better (and vice versa).

Answer (Extra Credit):

Consider the n=2 case. Assuming we evaluate selection 1 before selection 2, the overall CPU cost (since the predicates are *independent*) is: |R|*c1 + |R|*s1*c2. (This is because only |R|*s1 tuples "survive" selection 1.) Similarly, for the plan that evaluates selection 2 before selection 1, the cost is: |R|*c2 + |R|*s2*c1. Thus, evaluating *selection 1 first* is a better strategy, iff

$$c2+s2\times c1>c1+s1\times c2 \quad \text{or} \quad \frac{c2}{1-s2}>\frac{c1}{1-s1}$$

In the general case, the optimal strategy is to evaluate the n selections *in increasing order of the ci/(1-si) ratio*. Intuitively, this rule says we should evaluate selections in order of their cost/benefit ratio, where cost is the per tuple cost , and benefit is the percentage of tuples they filter out (i.e. 1-selectivity).