Department of Electrical Engineering and Computer Science

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

6.830 Database Systems: Fall 2008 Quiz II

There are 14 questions and 11 pages in this quiz booklet. To receive credit for a question, answer it according to the instructions given. *You can receive partial credit on questions.* You have **80 minutes** to answer the questions.

Write your name on this cover sheet AND at the bottom of each page of this booklet.
Some questions may be harder than others. Attack them in the order that allows you to make the most progress. If you find a question ambiguous, be sure to write down any assumptions you make. Be neat. If we can't understand your answer, we can't give you credit!

THIS IS AN OPEN BOOK, OPEN NOTES QUIZ.
NO PHONES, NO LAPTOPS, NO PDAS, ETC.
YOU MAY USE A CALCULATOR.

Do not write in the boxes below

1-3 (xx/14)	4-6 (xx/26)	7-8 (xx/10)	9-11 (xx/26)	12-14 (xx/24)	Total (xx/100)

Name: 2008 Quiz 2

I Short Answer

1. [4 points]: List two reasons why a column-oriented design is advantageous in a data warehouse environment.

(Write your answer in the spaces below.)

A.

B.

2. [4 points]:

Which of the following statements about the MapReduce system are true:

(Circle T or F for each statement.)

T F A MapReduce job will complete even if one of the worker nodes fails.

T F A MapReduce job will complete even if the master node fails.

T F Map workers send their results directly to reduce workers.

T F If there are M map tasks, using more than M map workers may improve MapReduce performance.

Name:

3. [6 points]:

Which of the following statements about the two-phase commit (2PC) protocol are true:
(Circle T or F for each statement.)

T F In the "no information" case (i.e., when a subordinate asks the coordinator about the outcome of a transaction that the coordinator has no information about), the coordinator running the presumed abort version of 2PC returns the same response to a subordinate as it would in basic 2PC.

T F The Presumed Commit protocol reduces the number of forced writes required by the coordinator compared to basic 2PC for transactions that successfully commit.

T F The Presumed Abort protocol reduces the number of forced writes required of the coordinator compared to basic 2PC for transactions that abort.

F F In basic 2PC, a subordinate that votes to abort a transaction T receives no more messages pertaining to T, assuming neither T's coordinator nor any of T's subordinate nodes fail.

Name:

II C-Store

Dana Bass is trying to understand the performance difference between row- and column- oriented databases. Her computer's disk can perform sequential I/O at 20 MB/sec, and takes 10 ms per seek; it has 10 MB of memory. She is performing range queries on a table with 10 4-byte integer columns, and 100 million rows. Data is not compressed in either system, and all columns are sorted in the same order. Assume each column is laid out completely sequentially on disk, as is the row-oriented table.

4. [16 points]: Fill in the table below with your estimates of the *minimal* I/O time for each operation, in a row-store and a column-store. Assume that all reads are on contiguous groups of rows, and that queries output row-oriented tuples.

Num. Columns Read	Num. Rows Read	Column-Oriented System	Row-Oriented System
1	10 Million		
10	10 Million		

Name:

III BigTable

Consider an example table storing bank accounts in Google's BigTable system:

Key	Value
"adam"	$300
"evan"	$600
"sam"	$9000

The bank programmer implements the deposit function as follows:

```
function deposit(account, amount):
  currentBalance = bigtable.get(account)
  currentBalance += amount
  bigtable.put(account, currentBalance)
```

5. [4 points]: Given the table above, a user executes deposit("sam", $500). The program crashes somewhere during execution. What are the possible states of the "sam" row in the table? Provide a short explanation for your answer.

(Write your answer in the space below.)

6. [6 points]: Given the table above, a user executes deposit("sam", $500). The program completes. Immediately after the program completes, the power goes out in the BigTable data center, and all the machines reboot. When BigTable recovers, what are the possible states of the "sam" row in the table? Provide a short explanation for your answer.

(Write your answer in the space below.)

Name:

Now consider the following pair of functions:

```
function transfer(sourceAccount, destinationAccount, amount):
  sourceBalance = bigtable.get(sourceAccount)
  if sourceBalance < amount:
     raise Exception("not enough money to transfer")
  sourceBalance −= amount

  destinationBalance = bigtable.get(destinationAccount)
  destinationBalance += amount

  bigtable.put(sourceAccount, sourceBalance)
  bigtable.put(destinationAccount, destinationBalance)
```

```
function totalAssets():
  assets = 0
  for account, balance in bigtable:
     assets += balance
  return assets
```

7. [6 points]: Given the table above, a program executes transfer(“evan”, “adam”, 200). While that function is executing, another program executes totalAssets(). What return values from totalAssets() are possible? For the purposes of this question, assume there is only one version of each value, and that the values in BigTable are stored and processed in the order given above (i.e., “adam”, “evan”, “sam”). Provide a short explanation for your answer.

(Write your answer in the space below.)

8. [4 points]: If the data were stored in a traditional relational database system using strict two-phase locking, and transfer() and totalAssets() were each implemented as single transactions, what would the possible results of totalAssets() be? Provide a short explanation for your answer.

(Write your answer in the space below.)

Name:

IV Distributed Query Execution

Suppose you have a database with two tables with the following schema:

```
T1 : (A int PRIMARY KEY, B int, C varchar)
T2 : (D int REFERENCES T1.A, E varchar)
```

And suppose you are running the following query:

```
SELECT T1.A,COUNT(*)
FROM T1,T2
AND T1.A = T2.D
AND T1.B > n
GROUP BY T1.A
```

Your system has the following configuration:

Parameter	Description	Value
$\|T1\|$	Size of table `T1`	300 MB
$\|T2\|$	Size of table `T2`	600 MB
$\|M\|$	Size of memory of a single node	100 MB
$\|\|T1\|\|$	Number of records in $T1$	10 million
$\|int\|$	Size of integer, in bytes	4
T	Disk throughput, in bytes / sec	20 MB/sec
N	Network transmit rate, in bytes / sec	10 MB/sec
f	Fraction of tuples selected by `T1.B > n` predicate	0.5

Name:

9. [9 points]: Suppose you run the query on a single node. Assuming there are no indices, and the tables are not sorted, indicate what join algorithm (of the algorithms we have studied in class) would be most efficient, and estimate the time to process the query, ignoring disk seeks and CPU costs. Include a brief justification or calculation.

(Write your answers in the spaces below.)

Join algorithm:

Estimated time, in seconds:

10. [10 points]: Now suppose you switch to a cluster of 5 machines. If the above query is the only query running in the system, describe a partitioning for the tables and join algorithm that will provide the best performance, and estimate the total processing time (again, ignoring disk seeks and CPU cost). You may assume about the same number of `T2.D` values join with each `T1.A` value. Include a brief justification or calculation. You can assume the coordinator can receive an aggregate 50 MB/sec over the network from the five workers transmitting simultaneously at 10 MB/sec.

(Write your answers in the spaces below.)

Partitioning strategy:

Join algorithm:

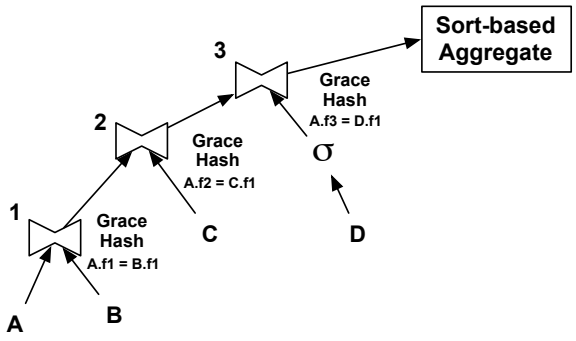
Estimated time, in seconds:

V Adaptive Query Processing

Jenny Join, after hearing the lecture about adaptive query processing, decides to add several types of adaptivity to her database system.

First, Jenny decides to add simple plan-based adaptivity in the style of the Kabra and DeWitt paper mentioned in the "Adaptive Query Processing Through the Looking Glass" paper and discussed in class.

Jenny runs the following query:



11. [6 points]: To help Jenny understand the Kabra and DeWitt approach, describe one way in which it might adapt to each of the following issues that arise during execution of the query shown above:
(Write your answer in the space below each issue.)

A. After running Join 3, the system observes that many fewer tuples will be input to the sort-based aggregate than predicted by the optimizer.

B. After running Join 1, the system observes that many fewer tuples will be input to Join 2 than predicted by the optimizer.

C. After running Join 1, the optimizer predicts that many more tuples will be output by Join 2 than predicted before Join 1 ran (you may assume other optimizer estimates do not change significantly).

Name:

Now Jenny decides to add even more adaptivity to her system by allowing it to adapt between using secondary (unclustered) indices and sequential scans during query processing.

Her query optimizer uses the following simple approximate cost model to estimate the time to perform a **range scan** of T tuples from a table A containing $|A|$ disk pages, where the disk can read m pages per second and takes s seconds per seek. Assume that a disk page (either from the index or heap file) holds t tuples and that the scan is over a contiguous range of the key attribute of the index.

For sequential scans, each range scan requires one seek to the beginning of the heap file plus a scan of the entire file:

$C_{seqscan} = s + \frac{|A|}{m}$

For a secondary (unclustered) B+Tree, each range scan involves reading $\frac{T}{t \times m}$ leaf index pages (assuming the top levels of the index are cached) plus one seek and one page read from the heap file per tuple (assuming no heap file pages are cached).

$C_{secondary-btreescan} = \frac{T}{t \times m} + T \times (s + \frac{1}{m})$

Jenny finds that, when there are correlations between the key of an secondary B+Tree and the key of a clustered B+Tree (or the sort order of a table), the performance of the secondary B+Tree is sometimes much better than the cost formula given above.

12. [6 points]: Explain why correlations between secondary and clustered index keys might overestimate the cost of the $C_{secondary-btreescan}$ model given above.

(Write your answer in the space below.)

13. [6 points]: Using the parameters given above, give a better approximation of $C_{secondary-btreescan}$ in the presence of correlations.

(Write your answer in the space below.)

Name:

Inspired by the idea of adaptive query processing, Jenny wants to devise a technique to exploit her observation about correlations without having to maintain correlation statistics between the clustered attribute and all attributes over which there is an secondary index.

14. [12 points]: Suggest an adaptive query processing technique that changes the plan while it is running to switch between a sequential scan and a (possibly correlated) secondary index, depending on which is better. Your solution should not require precomputing any additional statistics. Be sure to indicate how your approach avoids producing duplicate results when it switches plans.

(Write your answer in the space below.)

End of Quiz II

Name:

6.830 / 6.814 Database Systems

Fall 2010