CSE 444 Final Exam

December 17, 2009

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Question 1. SQL (24 points, 6 each part) You've been hired to work on a web site that maintains customer reviews of products. The main data is stored in the following tables:

Product(pid, pname, description)
Reviewer(rid, rname, city)
Review(rid, pid, rating, comment)

The tables contain the following information:

- Product: unique product id (pid), product name (pname), and product description. All strings.
- Reviewer: unique reviewer id (rid), and reviewer name (rname) and city, also all strings.
- Review: One entry for each individual review giving the reviewer and product ids, an integer rating in the range 0-5, and the reviewer comment, which is a string.

(a) Write a SQL query that returns the ratings and comments from all reviews written by reviewers in Seattle for products named 'Zhu Zhu'. The results should be sorted in descending order by rating.

(b) Write a SQL query that returns the number of reviewers in each distinct city. The results should list the city name and the number of reviewers in that city, and should be sorted alphabetically by city name.

Question 1. SQL (cont) Schemas repeated below for convenience.

Product(pid, pname, description)
Reviewer(rid, rname, city)
Review(rid, pid, rating, comment)

(c) Write a SQL query that returns the names of all grumpy reviewers. A grumpy reviewer is one whose average review rating is less than or equal to 2. If someone is in the Reviewer table but has no reviews in the Review table, they should not be included in the result. The reviewer names in the result can be in any order.

(d) Write a SQL query that returns the names and descriptions of all cool products. A "cool product" is one that has no reviews in the database with any rating less than 4. A product must have at least one review in the database to be considered as a possible "cool product". The results can be in any order.

Question 2. Logical query plans (20 points) We would like to explore logical query plans involving data about downhill skiing races. Three tables are involved:

Athlete(aid, name, country)
Event(eid, year, location)
Result(eid, aid, time)

The Athlete table gives a unique id (aid) for each athlete and his/her name and country. The Event table gives a unique id (eid) for each event and the event year and location (for example, 2010, Vancouver). The Result table gives the athlete's time for each race that he/she participated in. In the Result table, eid and aid are foreign keys in the Athlete and Event tables.

We have the following statistics for these tables:

B(Athlete) = 100	B(Event) = 40	B(Result) = 250
T(Athlete) = 2,000	T(Event) = 400	T(Result) = 50,000
V(Athlete, country) = 100	V(Event, year) = 50	
	V(Event, location) = 25	

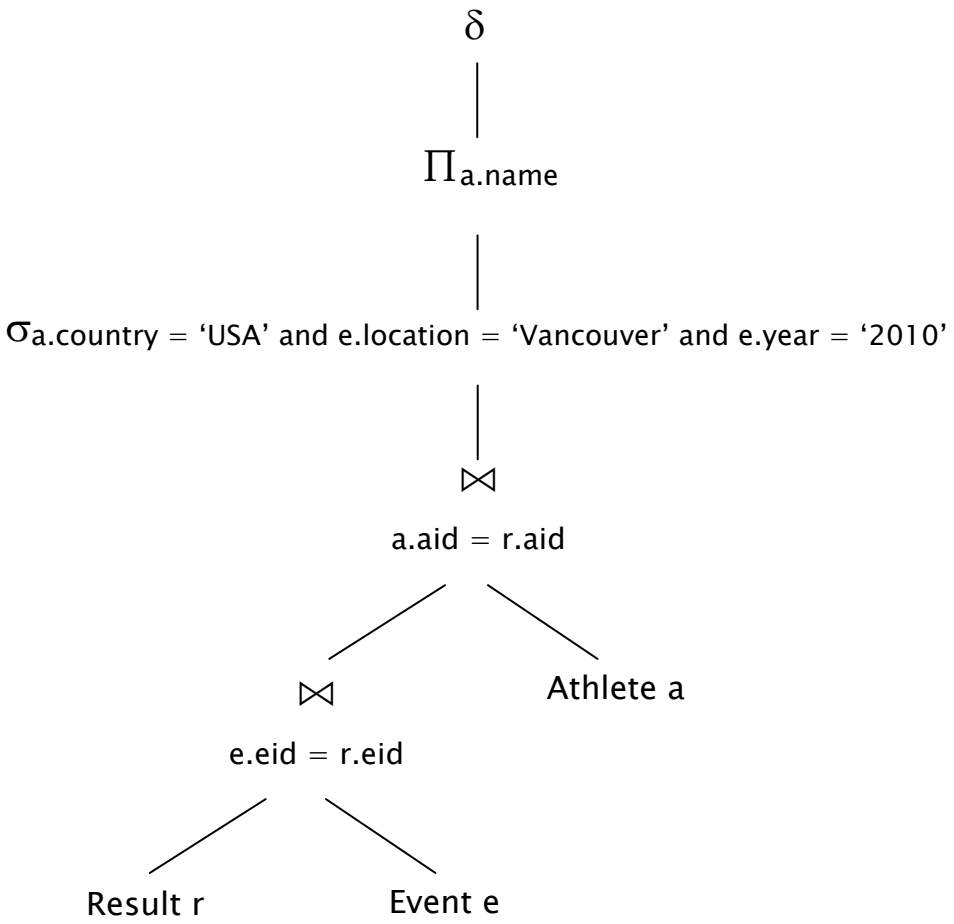
The Athlete and Event tables are clustered on their primary keys, aid and eid respectively. The Result table is not clustered.

Table Athlete has separate B+ tree indices on all three attributes: aid, name, and country. Table Event also has separate B+ tree indices on all three of its attributes: eid, year, and location. Table Result has separate B+ tree indices on eid and aid, but is not indexed on time.

You should assume that there is more than enough main memory (M) to hold any or all parts of these tables so we can use one-pass algorithms to implement queries.

(Continued next page. You can remove this page and the next for reference while you are working on the problem if that is convenient.)

Question 2. (cont.) Consider the following logical query plan involving the relations on the previous page.



Answer questions about this query on the next two pages.

Question 2 (cont.) (a) Translate the logical query plan in the diagram on the previous page to SQL.

(b) What is the estimated cost of the logical query plan given in the diagram on the previous page? For full credit you should both give formulas involving things like T(…), B(…), and V(…, …), and then substitute actual numbers and give a numerical answer as your final estimate. Be sure to show your work so we can fairly award partial credit if there is a problem.

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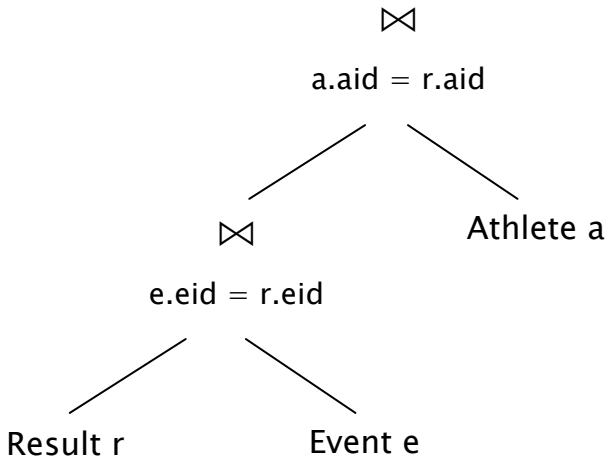
Question 2 (cont.) (c) Change or rearrange the original logical query plan to produce one that has the same final results but which is estimated to be significantly faster if possible. Draw your new plan below and give a brief explanation of why you expect it to be cheaper.

(d) Give an estimate of the cost of your new plan like the one you did in part (b) for the original plan.

Question 3. (16 points) For this question we go back to the original set of joins at the base of the tree from the previous problem, using the same relations with the same statistics as before.



If we decide to implement this part of the logical plan exactly as given, what physical plan should we use to perform it? Your answer should specify the physical join operators used (hash, nested loop, sort-merge, etc.) and the access methods used to read the tables (sequential scan, index, etc.) For operations where it matters, be sure to include the details – for instance, for a hash join, which relation would be stored in the hash tables; for a loop join, which relation would be the inner or outer loop. You should specify how the top-most join reads the result of the lower one. You may assume there is enough main memory available for whichever algorithm(s) you choose.

Give the estimated cost of your physical plan in terms of the number of disk operations needed. Also give a brief explanation of why your plan is the best one in terms of the overall cost.

(write your answer on the next page)

Question 3. (cont.) Write your answer here.

Question 4. XML (16 points) As another quarter draws to a close, everyone is thinking not only about the upcoming break, but also their gpa's. Here is an XML DTD for a document describing student transcripts.

```
<!DOCTYPE students [
<!ELEMENT students (transcript)* >
<!ELEMENT transcript (name, id, course*) >
<!ELEMENT name (#PCDATA) >
<!ELEMENT id (#PCDATA) >
<!ELEMENT course (dept, nbr, year, qtr, grade) >
<!ELEMENT dept (#PCDATA) >
<!ELEMENT nbr (#PCDATA) >
<!ELEMENT year (#PCDATA) >
<!ELEMENT qtr (#PCDATA) >
<!ELEMENT grade (#PCDATA) >
]>
```

Here is a short sample of some data that we might find in this database for one student:

```
<students>
    <transcript>
        <name>A. Hacker</name>
        <id>0642379</id>
        <course><dept>CSE</dept><nbr>143</nbr><year>2007</year><qtr>wi</qtr>
                <grade>3.9</grade></course>
        <course><dept>CSE</dept><nbr>444</nbr><year>2009</year><qtr>su</qtr>
                <grade>3.7</grade></course>
    </transcript>
<students>
```

On the next page, write XPath or XQuery expressions as requested to perform the desired tasks. If it matters, you can assume the data is stored in a file named "transcripts.xml".

(You may detach this page for reference if you wish.)

Question 4. (cont). (a) Write an XPath or XQuery expression that returns the names and ID numbers of all students in CSE 378 in Winter quarter ('wi') of 2008.

(b) Write an XQuery expression that reformats a valid XML document specified by the original DTD to give a list of students, their id numbers, and their GPAs. The GPA should be computed using a simple average of the each student's course grades – we are ignoring credit hours in this problem. The result should be a complete, well-formed and valid XML document that conforms to this DTD:

```
<!DOCTYPE gpa [
<!ELEMENT gpa (student)* >
<!ELEMENT student (name, id, gpa) >
<!ELEMENT name (#PCDATA) >
<!ELEMENT id (#PCDATA) >
<!ELEMENT gpa (#PCDATA) >
]>
```

Hint: XQuery includes an avg(…) function.

Question 5. Map-Reduce (16 points) For each of the following problems, describe how you would solve it using map-reduce. You should explain how the input is mapped into (key, value) pairs by the map stage, including, if needed, how the key(s) and value(s) are computed. Then you should explain how the (key, value) pairs produced by the map stage are processed by the reduce stage to get the final answer(s). If the job cannot be done in a single map-reduce pass, describe how it would be structured into two or more map-reduce jobs with the output of the each job as input to the next one(s). You should just describe your solution algorithm. You should not translate the solution into Pig Latin or any other specific programming language.

The input data for this problem is a large collection of weather observations. Each line of the input data gives information about a single observation from a particular weather station, and contains the following:

station#, city, state, elevation, year, month, day, time, temperature, precipitation

(a) Print the maximum recorded temperature for each year in the database. The output should have a single line for each year giving the year and the highest temperature found in any observation for that year. The output need not be sorted in any particular order.

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Question 5. (cont) (b) Produce a table of cities and their average annual rainfall (precipitation). Note that city names are not necessarily unique (there are over 20 cities named "Lincoln" in the United States), but you may assume that no single state has two cities with the same name. The output need not be sorted.

Question 6. Databases as a service. (8 points) In the large-scale cloud computing services like AWS and Google, the primary storage that is offered is designed to store large amounts of unstructured or semi-structured data. These systems like Amazon's SimpleDB and Google's Datastore provide the ability to store, index, retrieve, and update data, but do not typically have fixed schemas like the ones that are found in standard relational databases.

(a) Why is this semi-structured organization useful or preferred for the kinds of applications found in large-scaled clustered computing, compared to a traditional relational database? Be brief but give specific reasons or examples that support your point.

(b) What sorts of applications are not as well-suited for this kind of data storage and are better served by more highly structured data? When would you want to use a standard relational database instead of less structured storage like SimpleDB or similar services?