Advanced Database Management Systems

Date: Wednesday 6th June 2012
Time: 09:45 - 11:45

Please answer BOTH questions

For full marks your answers should be concise as well as accurate.
In a question, the word BRIEFLY is used to indicate a number of sentences between 1 and 5, and never more than 10 or so.

Marks will be awarded for reasoning and method as well as being correct.

This is a CLOSED book examination

The use of electronic calculators is permitted provided they are not programmable and do not store text.
1. a) Suppose a new version of an operating system (OS) offers a particularly efficient method to write and read data off disk provided that the unit of work is very large (by which is meant much larger than the page sizes normally used in classical DMBSs). A vendor of a classical DBMS is considering the impacts of this new functionality in its product. Assume that the DBMS is only offered for the OS in question. You were asked by your technical team leader to briefly explain how the concurrency manager might be affected and how the recovery manager might be affected.

(4 marks)

b) Briefly explain why having a relationship of expressiveness equivalence between a query calculus and a query algebra is desirable.

(4 marks)

c) Briefly explain what is the central, formal difference between the domain relational calculus and the tuple relational calculus.

(2 marks)

d) Use the following relation schemas for the subparts of this item:

```
suppliers (sid: int, sname: str, address: str)
parts (pid: int, pname: str, colour: str)
catalogue (sid: int, pid: int, cost: real)
```

The primary key of the relation comprises the underlined attributes, whilst the domain type of each attribute is stated after the colon. Thus, sid is the primary key for suppliers; pid, the primary key for parts; and the concatenation sid,pid, the composite primary key for catalogue, which states the price charged for a given part by a given supplier.

i) Write the following query in SQL: “Find the names of the parts who are supplied by suppliers whose address is ‘Manchester’.”

(3 marks)

ii) Write, in operator-tree form, the relational algebraic expression that would have been output by the translator in the query processing stack for your answer in the previous sub-item.

(4 marks)

iii) Given your answer to the previous sub-item, write, in operator-tree form, the canonical relational algebraic expression that would have been output by a rewriter (in the query processing stack) that used the rewriting rules and procedure studied in the course. In your answer, pay particular attention to the insertion of project operators to reduce the arity of intermediate results as soon as possible.

(10 marks)
iv) Relational query evaluation proved relatively easy to parallelize without explicit intervention of a programmer. This was, in part, due to a design constraint that any new mechanisms for parallelization should either act on operators or be operators themselves. Briefly give one reason why abiding by this constraint made it easier to parallelize relational query evaluation.

(3 marks)
2. a) Assume the following 5-way join for the subparts of this item:

\[
A \bowtie B \bowtie C \bowtie D \bowtie E
\]

Further assume that the estimates for the 2-way join output sizes are ordered as follows:

\[
|A \bowtie E| < |A \bowtie D| < |B \bowtie C| < |D \bowtie E| < |B \bowtie D| < |B \bowtie E| < |C \bowtie D| < |A \bowtie C| < |C \bowtie E| < |A \bowtie B|
\]

i) Assume the greedy join ordering algorithm discussed in the course. State which, amongst the 2-way joins above, will be placed as the left-deepest join given the ordering of cardinalities above and briefly explain, in terms of the algorithmic logic used, why that is the 2-way join selected.

(3 marks)

ii) State how many passes through the loop in the said algorithm will take place in this case and briefly explain why this many passes.

(3 marks)

b) For the subparts of this item, assume that you work for the company, call it **Cat Ltd.**, that owns the database in the previous question, i.e.:

- suppliers (sid: int, sname: str, address: str)
- parts (pid: int, pname: str, colour: str)
- catalogue (sid: int, pid: int, cost: real)

Further assume that **Cat Ltd.** has bought a competitor, called **Tac Ltd.**, which, although in the same retail area, has a database with a different structure, as follows:

- preferredVendors (pvid: int, name: str, address: str)
- otherVendors (ovid: int, name: str, address: str)
- itemDescription (iid: int, desc: int)
- itemCharacteristics (iid: int, weight: int, colour: str)
- purchaseBase (vid: int, iid: int, price: real)

Now, suppose your technical team leader has told you that a colleague of yours has obtained a set of equivalence matches between the **Cat** and the **Tac** databases and has written views against the **Tac** database that allow a query against the **Cat** database to also make use of the data stored in the **Tac** database. The relation-level equivalence matches indicate that suppliers in **Cat** is horizontally fragmented in **Tac** and that parts in **Cat** is vertically fragmented in **Tac**. The attribute-level equivalence matches are:

\[
\begin{align*}
\text{Cat.suppliers.sid} &= \text{Tac.preferredVendors.pvid} \\
\text{Cat.suppliers.sid} &= \text{Tac.otherVendors.ovid} \\
\text{Cat.suppliers.sname} &= \text{Tac.preferredVendors.name}
\end{align*}
\]
i) Given the schemas and equivalence matches above, the following view written by your colleague aims to collect in integratedSuppliers all the suppliers in both databases. State whether the view is correct or incorrect for this purpose and very briefly explain why.

CREATE VIEW integratedSuppliers AS
  suppliers
UNION
  (SELECT T.pvid AS sid, T.name AS sname, T.address
   FROM Tac.preferredVendors T)
UNION
  (SELECT T.ovid AS sid, T.name AS sname, T.address
   FROM Tac.otherVendors T)

(2 marks)

ii) Your colleague failed to write a view that collects in integratedParts all the parts in both databases. Write it.

(4 marks)

c) For the subparts of this item, assume that a start-up company, called FASTA, is offering a data appliance, called F1, that achieves great performance by using custom assemblies of standard hardware that nonetheless seem tuneable to perform excellently on the workloads that FASTA wants to run.

i) On the basis of this information, state which type of data appliance is FASTA F1 and briefly explain why.

(2 marks)

ii) Assume now that as time passes and data volumes grow, FASTA F1 begins to lose market for not being as fast as the competition, who successfully caught up with them in the meantime. The FASTA executive board is discussing how to react. The Chief Executive Office (CEO) says that they should scale up the F1 design. The CEO proposes to call his scaled up design the FASTA F4. Given the name of the new product, briefly suggest what is the relationship between it and the previous FASTA F1 design.

(2 marks)
iii) The Chief Technology Officer (CTO) disagrees with the CEO and says they should go for a scale out design. Briefly suggest what might it mean to scale out the F1 design to the F4 design.

(2 marks)

iv) Recall that, in the context of this course unit, total cost of ownership (TCO) has three main (additive) components: acquisition costs (ACQ), administration costs (ADM) and operational costs (OPE). Assume that a classical DBMS offers the following TCO proposition: ACQ = 10, ADM = 70 and OPE= 20. The FASTA CEO proposes to market their data appliance on the following TCO proposition: ACQ = 50, ADM = 5 and OPE= 5. The marketing director says this makes little sense. She argues that “After all, FASTA is in the data appliance market. We should be competing on price.”. Briefly explain whether you agree with the marketing director or not.

(4 marks)

d) The following three sub-items are about map-reduce engines.

i) Briefly explain how the master in a map-reduce computation uses redundancy to ensure efficiency when different nodes are exhibiting different performance.

(2 marks)

ii) Briefly explain why the strategy in the previous sub-item might lead to balanced loads.

(2 marks)

iii) Briefly explain why balanced loads are desirable given the need to synchronize in the barrier.

(2 marks)

e) Briefly explain the difference between the streams processed by systems such as TinyDB and SNEE and those processed by Aurora.

(2 marks)