CS5614 Midterm Exam

October 29, 1999

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- Name:
- ID:

GOOD LUCK!
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1. (30 points) Short answer questions:

(a) What is magic?

(b) Assume that a disk block is 4096 bytes and that keys and pointers take up 4 and 8 bytes respectively. What is the maximum fanout of a disk block (in an index structure), assuming blocks only have pointers to child nodes?

(c) If relation $R$ has $m$ tuples and relation $S$ has $n$ tuples, what is the minimum number of tuples that $R \cup S$ can have (assuming set-theoretic semantics)?

(d) Give example data for a relation $R(A, B, C)$ for which the following hold: \{ $A \rightarrow \rightarrow B, A \rightarrow C, CB \rightarrow \rightarrow A$ \}.

(e) Calculate the number of bushy joins of 4 relations. Include all possible permutations of the relations.

(f) Assume that the FD $A \rightarrow B$ holds in a relation $R(A, B)$. Express this FD as a constraint in relational algebra.
2. (10 points) An E/R diagram when converted to relations (using the method that we now know so well), gives rise to the following schema (without normalization): \( R(\texttt{a}, \texttt{b}, \texttt{c}) \), \( S(\texttt{a}, \texttt{d}) \) and \( T(\texttt{a}, \texttt{d}, \texttt{f}, \texttt{g}) \). You may assume that the same symbols refer to the same attribute and that different symbols refer to different attributes (e.g. the \( \texttt{a} \), in \( R \), \( S \), and \( T \) are the same). Your task is to give at least two different E/R diagrams that could have produced these relations.
3. (10 points) Prove that every two-column relation is in 3NF.
4. (20 points) Consider the relation $R(A, B, C, D, E)$ with MDs $\{A \rightarrow B, AB \rightarrow C\}$ and FDs $\{A \rightarrow D, AB \rightarrow E\}$. Decompose the relation into a collection of relation schemas in 4NF.
5. (20 points) Consider the relational schema modeling Web pages:

\[
\text{Webpage}(\text{URL, author, date})
\]

\[
\text{Link}(\text{URL1, URL2})
\]

where there is a Link between two URLs if there is a physical hyperlink on the Internet from URL1 to URL2 (There may or may not be a Link from an URL to itself). The ‘master relation’ Webpage models the details of each URL, like its creator and the date it was created. You may assume that URL is the key for Webpage. A web page is called an authority if all other web pages link to it. Write a query in Datalog to find all the authorities. You are not allowed to use relational algebra or SQL.
6. (10 points) Consider the relational schema:

\[
\text{Ships}(\text{name, class, launched}) \\
\text{Battles}(\text{name, date}) \\
\text{Outcomes}(\text{ship, battle, result})
\]

where relation \text{Ships} records the name of a ship, the name of its class, and the year in which the ship was launched. Relation \text{Battles} gives the name and date of battles involving ships, and relation \text{Outcomes} gives the result (‘sunk’, ‘damaged’, or ‘ok’) for each ship in each battle. Write a query in relational algebra or SQL to find those ships that ‘lived to fight another day’; i.e., they were damaged in one battle, but later fought in another. Datalog notation is not permissible.