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DM505 Database Design and Programming
24h Take-Home Exam

Handed out: **09:00, March 26, 2009**

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Birthday: _____

Organisation of the Exam

You have at most 24 hours to answer this take-home exam. During this period you are allowed to use the course book, the slides from the lecture, and your own notes on the lectures and the exercises. You are specifically not allowed to discuss the tasks with another person. In case you have any questions regarding the exam, you are welcome to discuss it with the lecturer.

You may answer this exam in Danish or English. Your solution must be handed in at the lecturer's office **before 09:00**, March 27, 2009. Alternatively, you can also hand in the exam electronically by sending an email to the lecturer. In this case, do not consider the exam to be received until you obtain an an explicit confirmation of the receipt.

There should be enough space for the solutions in the exam. If you need additional pages, there are five empty pages at the end of the exam. If you use additional paper, please number the pages and mark each of them with your name and birthday.

Task 1 – E/R model and the relational model

You are asked to create a database for the university administration. They describe that they want the following objects in their system:

Course having *title*, *number*, and *quarter*

Student having *name* and *year of study*

Teaching Assistant having *name* and *contract*

PhD Student having *name* and *thesis topic*

Lecturer having *name* and *position*

They also describe the relationships between these objects: Each course is taught by a lecturer and a teaching assistant. Students follow a number of courses. Each PhD student is associated with a lecturer who is his supervisor. Keep in mind that both PhD students and teaching assistants are students.

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(a) Create an E/R diagram capturing the objects and relationships described above. Describe all your design choices and constraints. Please use the notation for E/R diagrams introduced in the course book.

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(b) Transfer the E/R diagram from (a) to the relational model. Describe the process and the choices you have made.

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Task 2 – Normalisation Theory

In the following tasks assume the relation $R(A, B, C, D, E)$ with the following functional dependencies: $A \rightarrow B$, $AD \rightarrow C$, $B \rightarrow E$, $E \rightarrow A$.

(a) List all keys of R and argue why there can be no other.

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(b) Show that R is not in BCNF, i.e., show that there is at least one BCNF violation. Then decompose R until it is in BCNF. Document the steps of the decomposition process and the resulting relations.
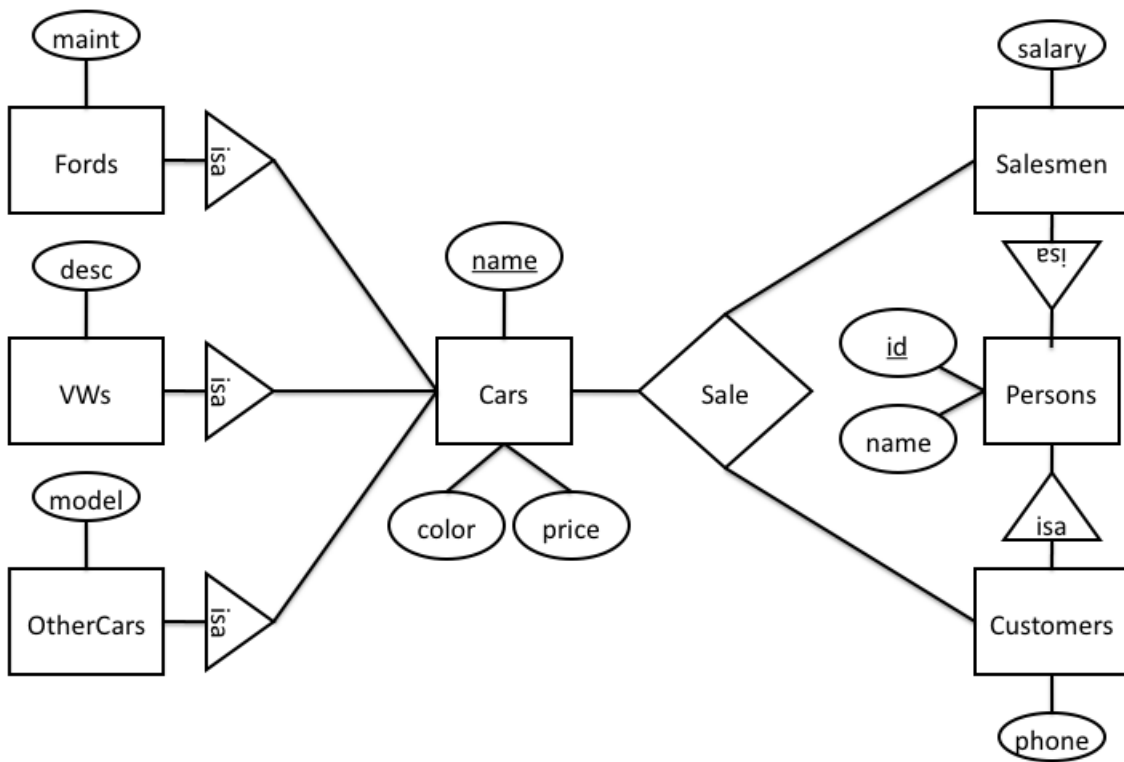
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(c) Show that R is in 3NF, i.e., show that there are no 3NF violations.

Task 3 – SQL for Data-Definition, Queries, Modifications

The following E/R diagram describes the database of a car dealer:

The following relational model is the result of the translation of the above E/R diagram:

$Cars(\underline{name}, color, price)$ $Persons(\underline{id}, name)$

$Fords(\underline{name}, maint)$ $Salesmen(\underline{id}, salary)$

$VWs(\underline{name}, desc)$ $Customers(\underline{id}, phone)$

$OtherCars(\underline{name}, model)$ $Sale(\underline{carname}, \underline{salesmanid}, \underline{customerid})$

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(a) The price of a car has to be a positive integer. Give a `CREATE TABLE` statement for creating the table *Car* that respects this.

(b) Write one `SELECT FROM WHERE` statement that lists the names of all salesmen together with the number of their sales.

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(c) Write one `UPDATE` statement that decreases the price of all Fords by 10%.

(d) Write one `SELECT FROM WHERE` statement that lists the names of all pairs of different customers that bought a car of the same color. The resulting table should contain each pair only once. E.g., if Peter bought a blue car, Lars bought a blue car, and Kim bought a red one, your query should return (Peter, Lars) or (Lars, Peter), but not both of them.

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Task 4 – Indexes using B+trees, Hash Tables

You can use drawings to document the intermediate steps in the following tasks. It is fine to show only the relevant parts of the tree or hash table that you are working on. The final state should be a full drawing of the resulting index structure.

B+tree with $n = 3$
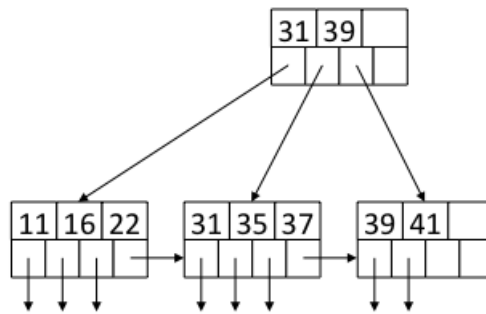
(a) Insert the key 42 into the B+tree above. Document each intermediate step in the process and draw the final result.
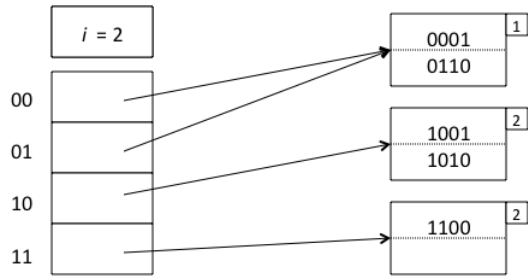
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(b) Insert the key 38 into the original B+tree above (not the result of (a)).
Document each intermediate step in the process and draw the final result.
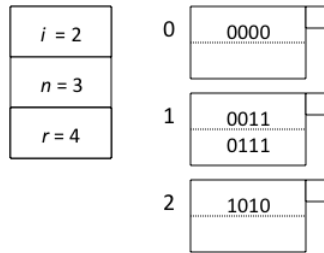
Extensible Hash Table with $k = 4, f = 2$

(c) Insert a key with the hash value 0111 into the extensible hash table above. Document each intermediate step in the process and draw the final result.

(d) Insert a key with the hash value 1011 into the original extensible hash table above (not the result of (c)). Document each intermediate step in the process and draw the final result.

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Linear Hash Table with $k = 4, f = 2, p_{max} = 0.8$

(e) Insert a key with the hash value 0001 into the linear hash table above. Document each intermediate step in the process and draw the final result.

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