351/751 Database Systems, 2022, Semester 1

Lab 08

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Functional Dependencies and Normalization

Consider the universal relation R = {A, B, C, D, E, G} and the set of functional dependencies

F = {{A, B}⟶{C}, {A,C}⟶{D}, {D}⟶{E}, {D,E}⟶{G}}.

Consider the following decompositions:

D1 = {R1, R2, R3}; R1 = {A, B, C}, R2 = {A, C, D, E}, R3 = {D,E,G}}

D2 = {R1, R2, R3}; R1 = {A, B, C, E}, R2 = {D, E}, R3 = {D,G}}

D3 = {R1, R2, R3}; R1 = {A, B, C, D}, R2 = {D, E}, R3 = {D,G}}

1) For decomposition D1, give the primary key of each relation in the decomposition.
   R1 = {A, B, C}, R2 = {A, C, D, E}, R3 = {D, E, G}}
   In R1, because {A, B}⟶{C}, A and B are the combined primary key for C;
   In R2, because {A,C}⟶{D}, {D}⟶{E} and transitive rule: {X ⟶ Y, Y ⟶ Z} |= X ⟶ Z , A and C are combined primary keys for D and E, D is the candidate key for E;
   In R3, because {D}⟶{E}, {D,E}⟶{G}, there is a transitive dependency of G on D, D is the primary key of R3, E is the candidate key.

2) For decomposition D1, state which normal form (1NF, 2NF, 3NF) each relation in the decomposition is in.
   R1 is 1NF normal form, it has single atomic dependency;
   R2 and R3 are in 3NF, 2NF,1NF normal forms because transitive dependency of {A,C}⟶{D}, {D}⟶{E},{D,E}⟶{G} and rules of every 2NF relation is in 1NF & every 3NF relation is in 2NF.

3) For decomposition D1, state which normal form (1NF, 2NF, 3NF) the decomposition is in.
   D1 decomposition is in 1NF because R1,R2 and R3 are all in 1NF.

4) For decomposition D1, state whether the decomposition has the dependency preservation property, with respect to F.
   Decomposition D1 has the dependency preservation property, because no functional dependency FD is lost during the process of decomposition. The FDs are demonstrated either transitively or non-transitively relation in D1.
5) For decomposition D1, state whether the decomposition has the lossless join property, with respect to F.

Following algorithm for testing lossless joint property, we get,

	A	B	C	D	E	G
R1	a1	a2	a3	~~b14~~ a4	~~b15~~ a5	~~b16~~ a6
R2	a1	b22	a3	a4	a5	~~b26~~ a6
R3	b31	b32	b33	a4	a5	a6

We can form one line of a value on R1, therefore this decomposition does have the lossless join property, with respect to F.

6) For decomposition D1, if it is not in 3NF, decompose it into 3NF.

D1: R1{A,B,C,D}, R2{A,C,D,E}, R3{D,E,G}.
In R1, A and B are combined primary key, A&C are the candidate key for D.
In R2, A and C are the combined primary key, D is the candidate key for E.
In R3, D is the primary key and E is the candidate key for G.
In this case, we change R1 into 3NF, R2 and R3 are in 3NF, therefore D1 is in 3NF.

7) For decomposition D2, state whether the decomposition has the lossless join property, with respect to F.
Following algorithm for testing lossless joint property, we get,

	A	B	C	D	E	G
R1	a1	a2	a3	b14	a5	b16
R2	b21	b22	b23	a4	a5	b26
R3	b31	b32	b33	a4	~~b35~~ a5	a6

We can not form one line of value a, therefore this decomposition does not have the lossless join property, with respect to F.

8) For decomposition D3, state whether the decomposition has the lossless join property, with respect to F.
Following algorithm for testing lossless joint property, we get,

	A	B	C	D	E	G
R1	a1	a2	a3	a4	~~b15~~ a5	~~b16~~ a6
R2	b21	b22	b23	a4	a5	~~b26~~ a6
R3	b31	b32	b33	a4	~~b35~~ a5	a6

We can form one line of value a on R1, therefore this decomposition does have the lossless join property, with respect to F.