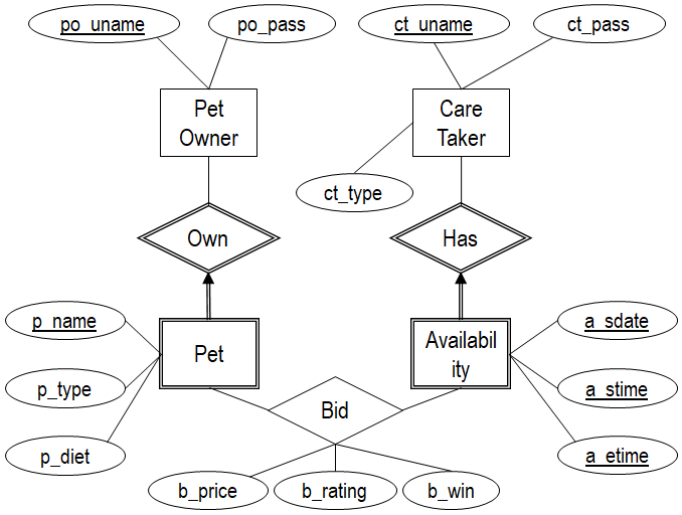
CS2102 Database Systems

Semester 1 2019/2020

Tutorial 09 (*Selected Answers*)

Introduction

This tutorial aims to aid the analysis of your ER diagram for redundancy and compliance with normal forms. We will use the simplified schema from Assignment 03 and Midterm shown below. Furthermore, we may add additional functional dependencies into the schema that is not captured by the ER diagram.



To ease your writing, we will use the mapping shown in the table below.

Attributes	Simplified Attributes
po_uname	A
po_pass	B
ct_uname	C
ct_pass	D
ct_type	E
p_name	F
p_type	G
p_diet	H
a_sdate	I
a_stime	J
a_etime	K
b_price	L
b_rating	M
b_win	N

Tutorial Questions

[Discussion: 1, 2, 3(a), 3(bc)]

1. Given the ER diagram above.
   a) List all the completely non-trivial functional dependencies captured by the ER diagram. Explain.
   b) Find all the keys of $R(A, B, C, D, E, F, G, H, I, J, K, L, M, N)$.

Solution:

a) Using the mapping, the completely non-trivial functional dependencies captured by the ER diagram are:
- $A \rightarrow B$: since `po_uname` is the primary key of `Pet Owner` and `po_pass` is an attribute of `Pet Owner`
- $C \rightarrow DE$: since `ct_uname` is the primary key of `Care Taker` and `{ct_pass, ct_type}` are attributes of `Care Taker`

- $AF \rightarrow GH$: since `Pet` is a weak entity-set with `p_name` as weak primary key, `Pet Owner` as owner entity-set, and `{p_type, p_diet}` are attributes of `Pet`
- $ACFIJK \rightarrow LMN$: since `Bid` is a relationship-set connecting `Pet` and `Availability`, we have AC as the primary key of `Pet` and $FIJK$ as the primary key of `Availability`, and $\{LMN\}$ as attributes of `Bid`
- The rest of the functional dependencies are implied by this, they include:
  - $ABF \rightarrow GH$
  - $CD \rightarrow E$
  - $AC \rightarrow BDE$

b) There is only one key, $\{A, C, F, I, J, K\}$. Notice how it corresponds largely to the primary keys of each entity-sets (and weak entity-sets).

2. Given the completely non-trivial functional dependencies in question (1).
   a) Find a lossless-join BCNF decomposition of $R(A, B, C, D, E, F, G, H, I, J, K, L, M, N)$.
   b) Does your decomposition mapped perfectly with the ER diagram or is there a feature (entity-set, relationship-set, weak entity-set, etc) that are not present in the decomposition?
   c) If there are any feature not preset, explain.
   d) Is your decomposition in part (a) a dependency-preserving decomposition?

Solution:

a) By algorithm 6, one possible decomposition is
$\delta = \{R_1(A, B),\ R_2(C, D, E),\ R_3(A, F, G, H),\ R_4(A, C, F, I, J, K, L, M, N)\}$

b) We can form the following mapping:
$R_1 \mapsto$ `Pet Owner`
$R_2 \mapsto$ `Care Taker`
$R_3 \mapsto$ `Pet`
$R_4 \mapsto$ `Bid`
Note that we have no mapping for `Availability`.

c) As shown in part (b), there's no mapping for Availability. When trying to write the functional dependencies for Availability, we arrive at $CIJK \rightarrow CIJK$ because Availability has no other attributes.

d) The decomposition shown in part (a) is a dependency-preserving decomposition.

3. Consider adding a serial ID for `Pet` called `p_id` with a mapping to character "`O`" such that we have an additional functional dependencies $O \rightarrow FGH$ on top of any other functional dependencies in question (1).
   a) Find a lossless-join BCNF decomposition of $R(A, B, C, D, E, F, G, H, I, J, K, L, M, N, O)$. Is your decomposition a dependency-preserving decomposition?
   b) Find a lossless-join and dependency-preserving 3NF decomposition of $R(A, B, C, D, E, F, G, H, I, J, K, L, M, N, O)$.
   c) Try to draw the corresponding ER diagram generated by the 3NF decomposition.

Solution:

a) By algorithm 6, one possible decomposition is
$$\delta = \begin{Bmatrix} R_1(A, B),\ R_2(C, D, E),\ R_3(A, F, G, H),\ R_4(A, C, F, I, J, K, L, M, N), \\ R_5(F, O),\ R_6(A, C, I, J, K, O) \end{Bmatrix}$$
Unfortunately, this decomposition is not a dependency-preserving decomposition.

b) By algorithm 7 and algorithm 2 (for minimal cover), one possible decomposition is
$$\delta = \begin{Bmatrix} R_1(A, B),\ R_2(C, D, E),\ R_3(A, F, G, H),\ R_4(A, C, F, I, J, K, L, M, N), \\ R_5(F, G, H, O),\ R_6(A, C, I, J, K, O) \end{Bmatrix}$$

c) Given the decomposition in part (b), we can try to check the primary keys of each fragments based on the projection. We will then get:

$$\delta = \left\{ \begin{matrix} R_1(\underline{A}, B),\ \ R_2(\underline{C}, D, E),\ \ R_3(\underline{A, F}, G, H),\ \ R_4\left(\underline{A, C, F, I, J, K}, L, M, N\right), \\ R_5(F, G, H, \underline{O}),\ \ R_6\left(\underline{A, C, I, J, K, O}\right) \end{matrix} \right\}$$

From here, we can try to draw the corresponding diagram. However, note that for R_3 and R_5, we have shared attributes G, H and it might be represented as a single (weak) entity-set with additional candidate key. Then R_6 is a ternary relationship-set between Pet Owner (contributing A), Pet (contributing the candidate key O), and availability (contributing $CIJK$).