Database Systems, CSCI 4380-01 Fall 2018
Homework # 2 Answers

Homework Statement.

`students(rin, fname, lname, email, optin_date, optout_date)`
`gradables(gid, gytype, label, given_date, due_date, maxgrade, points, nextg_id)`
`grades(rin, gid, submission_date, grade)`

Question 1. Write the following queries using relational algebra using any operator that you wish:

(a) Return the RIN of all students who missed a homework that was due during their opt-in period. Return the `gid` of the corresponding missed homeworks. Remember if there is no opt-out date, all homeworks after opt-in date are required.

$$
\begin{aligned}
R1 &= ((gradables \bowtie grades) \bowtie students) \\
HW &= \sigma_{gtype='hw'} R1 \\
Req\_HW &= \sigma_{optin\_date \neq NULL \text{ and } optin\_date < due\_date \text{ and } (optout\_date = NULL \text{ or } optout\_date > due\_date)} HW \\
Answer &= \pi_{rin,gid}(Req\_HW) - \pi_{rin,gid}(grades)
\end{aligned}
$$

(b) Find the RIN, first and last name of all students who had the highest grades for an exam (i.e. gtype `'exam'` or `'finalexam'`). Also return the `gid` and `label` of the exams they got the highest grades in.

$$
\begin{aligned}
exam\_grades &= \pi_{rin,gid,grade}(\sigma_{gtype='exam'}(gradables \bowtie grades)) \\
exam\_grades2[rin2, gid2, grade2] &= exam\_grades \\
Not\_max &= \pi_{rin,gid,grade}(\sigma_{grade<grade2} \\
&\quad (exam\_grades \bowtie_{rin=rin2, gid \neq gid2} exam\_grades2)) \\
Max\_exam\_grades &= exam\_grades - Not\_max \\
Answer &= \pi_{rin,fname,lname,gid,label} \\
&\quad ((Max\_exam\_grades \bowtie gradables) \bowtie students)
\end{aligned}
$$

John Rivera, riverj5@rpi.edu

Question 2. For each of the following new relations:

(1) list all the relevant functional dependencies based on the explanations below,
(2) find all keys based on your functional dependencies,
(3) discuss whether the relation is in BCNF (Boyce-Codd Normal Form) or not, explain why or why not.
(4) discuss whether the relation is in 3NF (Boyce-Codd Normal Form) or not, explain why or why not.

(a) The system keeps track of multiple submissions for the same homework gradable like submitty in a relation called `submissions`:

`submissions(gid, rin, filename, attemptno, submission_datetime, isactive, totalruntime)`

Each student, gradable and specific attempt corresponds to a specific filename. Each filename corresponds to a specific student, gradable and attempt. For each filename, there is a specific submission_datetime, isactive value and totalruntime value.

(1) $\{(rin, gid, attemptno \rightarrow filename), (filename \rightarrow rin, gid, attemptno),$
$(filename \rightarrow submission\_datetime, isactive, totalruntime)\}$
(2) keys: (filename), (rin,gid, attemptno)
(3) both (rin, gid, attemptno) and (filename) are superkeys, so relation is in BCNF
(4) in BCNF, so in 3NF

(b) Homeworks, quizzes and exams have individual questions. We will store the details of grades of each part separately using a relation called `grade_details`:

`grade_details(rin, gid, partno, topic, maxpoints, pointsearned)`

For each gradable (gid) and part, there is a maxpoints value. For each gradable, part and student, there is pointsearned. Each gradable part may have multiple topics.

(1)$\{(gid, partno \rightarrow maxpoints), (gid, partno, rin \rightarrow pointsearned)\}$
(2) key: (gid, partno, rin, topic)
(3) no super keys or trivial dependencies in functional dependencies listed in (1), so not in BCNF
(4) (gid, partno) and (gid,partno, rin) are not superkeys and none of the f.d's are trivial. Neither maxpoints or pointsearned are prime attributes, so it is not in 3NF

John Rivera, riverj5@rpi.edu

Question 3. Given the following relation, functional dependencies and decomposition, answer the following questions:

Relation $R(A, B, C, D, E, F)$ with $\mathcal{F} = \{AB \to F, BD \to C, CE \to F, F \to D\}$

Decomposition: $R1(A, B, D)$, $R2(A, B, C, E)$, $R3(B, D, E, F)$

(a) Is this decomposition lossless? Show yes or no using Chase decomposition.

A	B	C	D	E	F
a	b	c1 → c	d	e1	f1
a	b	c	d2 → d	e	f2 → f1 → f
a3	b	c3 → c1 → c	d	e	f

Steps:
AB → F, f2 → f1
BD → C, c3 → c1
CE → F
F → D, d2 → d
BD → C, c1 → c
CE → F, f1 → f

(b) Is this decomposition dependency preserving? Show your work.

Note: two show that two sets of functional dependencies, F_1 and F_2 are equivalent, it is sufficient to show that (1) all functional dependencies in F_1 are implied by F_2, and (2) all all functional dependencies in F_2 are implied by F_1.

R1(A,B,D) {AB → D}=F_1
R2(A,B,C,E) {AB → C}=F_2
R3(B,D,E,F) {F → D}=F_3

$$F_1 \cup F_2 \cup F_3 = \{AB \to D, AB \to C, F \to D\}$$

$F_1 \cup F_2 \cup F_3$ does not imply CE → F, so not dependency preserving

John Rivera, riverj5@rpi.edu

Question 4. Given the following relation, use BCNF decomposition to convert it to relations in BCNF.

$R(A, B, C, D, E)$ $\mathcal{F} = \{AB \rightarrow C, C \rightarrow E\}$

Step 1:
use AB $\rightarrow$ C AB$^+$= {A, B, C, E}

R1(A, B, C, E) {AB $\rightarrow$ C, C $\rightarrow$ E} key:AB $\rightarrow$ Not in BCNF due to C $\rightarrow$ E
R2(A, B, D) {} key:ABD $\rightarrow$ in BCNF

Step 2:
C $\rightarrow$ E C$^+$= {C, E}

R11(C,E) {C $\rightarrow$ E} key:C $\rightarrow$ in BCNF
R12(A, B, C) {AB $\rightarrow$ C} key:AB $\rightarrow$ in BCNF

So after BCNF decomposition, we have
R2(A, B, D)
R11(C,E)
R12(A, B, C)

John Rivera, riverj5@rpi.edu

Question 5. Given the following relation, use 3NF decomposition to convert it to relations in 3NF. For each resulting relation, check if it is also in BCNF.

$R(A, B, C, D, E, F, G)$ $\mathcal{F} = \{AB \rightarrow C, CD \rightarrow EF, CF \rightarrow AG\}$

R1(A, B, C) {AB $\rightarrow$ C} in BCNF (AB is key)

R2(C, D, E, F) {CD $\rightarrow$ EF} in BCNF (CD is key)

R3(C, F, A, G) {CF $\rightarrow$ AG} in BCNF (CF is key)

There is no relation with all attributes of a key, so add one

R4(A, B, D) {} in BCNF

SUBMISSION INSTRUCTIONS. Submit a PDF document for this homework using Gradescope. No other format and no hand written homeworks please. No late submissions will be allowed.

The gradescope for homework submissions will become available by Tuesday September 18 the latest.