COMP3311 21T1

Week 09
Relational Design Theory

Database Systems

[Show with no answers] [Show with all answers]

Notation: in the relational schemas below, primary key attributes are underlined (e.g. pk), foreign key attributes are shown in italic font (e.g. *fk*) and primary key attributes that are also foreign keys are underlined and in italic font (e.g. *pk+fk*).

Example:

```
Student(id, name, degreeCode)
Degree(code, name, requirements)
Subject(code, name, syllabus)
Marks(studentId, subjectCode, teachingTerm, mark)
```

In their respective relations, the student id, the degree code and the subject code are primary keys. In the Student relation, the degree code is a foreign key. In the Marks relation, the three attributes student id, subject code and teaching term together form the primary key; the first two (student id and subject code) are also foreign keys.

1. Functional dependencies.

   a. What functional dependencies are implied if we know that a set of attributes *X* is a candidate key for a relation *R*?

   [show answer]

   b. What functional dependencies can we infer *do not hold* by inspection of the following relation?

A	B	C
a	1	x
b	2	y
c	1	z
d	2	x
a	1	y
b	2	z

   [show answer]

c. Suppose that we have a relation schema *R(A,B,C)* representing a relationship between two entity sets *E* and *F* with keys *A* and *B* respectively, and suppose that *R* has (at least) the functional dependencies $A \rightarrow B$ and $B \rightarrow A$. Explain what this tells us about the relationship between *E* and *F*.

[show answer]

2. Consider the relation *R(A,B,C,D,E,F,G)* and the set of functional dependencies $F = \{ A \rightarrow B,\ BC \rightarrow F,\ BD \rightarrow EG,\ AD \rightarrow C,\ D \rightarrow F,\ BEG \rightarrow FA \}$ compute the following:

a. A^+

[show answer]

b. $ACEG^+$

[show answer]

c. BD^+

[show answer]

3. Consider the relation *R(A,B,C,D,E)* and the set set of functional dependencies $F = \{ A \rightarrow B,\ BC \rightarrow E,\ ED \rightarrow A \}$

a. List all of the candidate keys for *R*.

[show answer]

b. Is *R* in third normal form (3NF)?

[show answer]

c. Is *R* in Boyce-Codd normal form (BCNF)?

[show answer]

4. Consider a relation *R(A,B,C,D)*. For each of the following sets of functional dependencies, assuming that those are the only dependencies that hold for *R*, do the following:

a. List all of the candidate keys for *R*.

b. Show whether *R* is in Boyce-Codd normal form (BCNF)?

c. Show whether *R* is in third normal form (3NF)?

i. $C \rightarrow D,\quad C \rightarrow A,\quad B \rightarrow C$

[show answer]

ii. $B \rightarrow C, \quad D \rightarrow A$

[show answer]

iii. $ABC \rightarrow D, \quad D \rightarrow A$

[show answer]

iv. $A \rightarrow B, \quad BC \rightarrow D, \quad A \rightarrow C$

[show answer]

v. $AB \rightarrow C, \quad AB \rightarrow D, \quad C \rightarrow A, \quad D \rightarrow B$

[show answer]

vi. $A \rightarrow BCD$

[show answer]

5. Specify the non-trivial functional dependencies for each of the relations in the following Teams-Players-Fans schema and then show whether the overall schema is in BCNF.

```
Team(name, captain)
Player(name, teamPlayedFor)
Fan(name, address)
TeamColours(teamName, colour)
FavouriteColours(fanName, colour)
FavouritePlayers(fanName, playerName)
FavouriteTeams(fanName, teamName)
```

[show answer]

6. Specify the non-trivial functional dependencies for each of the relations in the following Trucks-Shipments-Stores schema and then show whether the overall schema is in BCNF.

```
Warehouse(warehouse#, address)
Source(trip, warehouse)
Trip(trip#, date, truck)
Truck(truck#, maxvol, maxwt)
Shipment(shipment#, volume, weight, trip, store)
Store(store#, storename, address)
```

[show answer]

7. For each of the sets of dependencies in question 4:

   i. if *R* is not already in 3NF, decompose it into a set of 3NF relations

   ii. if *R* is not already in BCNF, decompose it into a set of BCNF relations

   a. $C \rightarrow D, \quad C \rightarrow A, \quad B \rightarrow C$

   [show answer]

   b. $B \rightarrow C, \quad D \rightarrow A$

   [show answer]

   c. $ABC \rightarrow D, \quad D \rightarrow A$

   [show answer]

   d. $A \rightarrow B, \quad BC \rightarrow D, \quad A \rightarrow C$

   [show answer]

   e. $AB \rightarrow C, \quad AB \rightarrow D, \quad C \rightarrow A, \quad D \rightarrow B$

   [show answer]

   f. $A \rightarrow BCD$

   [show answer]

8. Consider (yet another) banking application that contains information about accounts, branches and customers. Each account is held at a specific branch, but a customer may hold more than one account and an account may have more than one associated customer.

   Consider an unnormalised relation containing all of the attributes that are relevant to this application:

   - *acct#* - unique account indentifier
   - *branch#* - unique branch identifier
   - *tfn* - unique customer identifier (**t**ax **f**ile **n**umber)
   - *kind* - type of account (savings, cheque, ...)
   - *balance* - amount of money in account
   - *city* - city where branch is located
   - *name* - customer's name

   i.e. consider the relation *R(acct#, branch#, tfn, kind, balance, city, name)*

   Based on the above description:

a. Devise a suitable set of functional dependencies among these attributes.

[show answer]

b. Using these functional dependencies, decompose *R* into a set of 3NF relations.

[show answer]

c. State whether the new relations are also in BCNF.

[show answer]

9. Consider a schema representing projects within a company, containing the following information:

- *pNum* - project's unique identifying number
- *pName* - name of project
- *eNum* - employee's unique identifying number
- *eName* - name of employee
- *jobClass* - type of job that employee has on this project
- *payRate* - hourly rate, dependent on the kind of job being done
- *hours* - total hours worked in this job by this employee

This schema started out life as a large spreadsheet and now the company wants to put it into a database system.

As a spreadsheet, its schema is: *R(pNum, pName, eNum, eName, jobClass, payRate, hours)*

Based on the above description:

a. Devise a suitable set of functional dependencies among these attributes.

[show answer]

b. Using these functional dependencies, decompose *R* into a set of BCNF relations.

[show answer]

c. State whether the new relations are also in 3NF.

[show answer]

10. Real estate agents conduct visits to rental properties

- need to record which property, who went, when, results
- each property is assigned a unique code (P#, e.g. PG4)
- each staff member has a staff number (S#, e.g. SG43)
- staff members use company cars to conduct visits
- a visit occurs at a specific time on a given day

- notes are made on the state of the property after each visit

The company stores all of the associated data in a spreadsheet.

Describe any functional dependencies that exist in this data. The table of sample data below below may give some ideas:

P#	**W**hen	**A**ddress	**N**otes	**S#**	Na**m**e	**C**arReg
PG4	03/06 15:15	55 High St	Bathroom leak	SG44	Rob	ABK754
PG1	04/06 11:10	47 High St	All ok	SG44	Rob	ABK754
PG4	03/07 12:30	55 High St	All ok	SG43	Dave	ATS123
PG1	05/07 15:00	47 High St	Broken window	SG44	Rob	ABK754
PG2	13/07 12:00	12 High St	All ok	SG42	Peter	ATS123
PG1	10/08 09:00	47 High St	Window fixed	SG42	Peter	ATS123
PG3	11/08 14:00	99 High St	All ok	SG41	John	AAA001
PG4	13/08 10:00	55 High St	All ok	SG44	Rob	ABK754
PG3	05/09 11:15	99 High St	Bathroom leak	SG42	Peter	ATS123

State assumptions used in determining the functional dependencies.

[show answer]

11. Consider a company supplying temporary employees to hotels:

- the company has contracts with different hotels
- it may have several contracts with a given hotel
- contracts are identified by a code (e.g. C12345)
- staff work at different hotels as needed
- staff have tax file #'s (TFN, e.g. T123)
- hotels have Aus business #'s (ABN, e.g. H234)

Describe any functional dependencies that exist in this data. The table of sample data below below may give some ideas:

Contract	**T**FN	**N**ame	**H**rs	**A**BN	**H**otel
C12345	T311	John Smith	12	H765	Four Seasons
C18765	T255	Brad Green	12	H234	Crown Plaza
C12345	T311	John Smith	12	H765	Four Seasons
C12345	T255	Brad Green	10	H765	Four Seasons
C14422	T311	John Smith	6	H222	Sheraton
C14422	T888	Will Smith	9	H222	Sheraton
C18477	T123	Clair Bell	15	H222	Sheraton

State assumptions used in determining the functional dependencies.

[show answer]

12. What functional dependencies exist in the following table:

A	B	C	D
1	a	6	x
2	b	7	y
3	c	7	z
4	d	6	x
5	a	6	y
6	b	7	z
7	c	7	x
8	d	6	y

How is this case different to the previous two?

[show answer]

13. Compute a minimal cover for:

$F = \{ B \rightarrow A,\ D \rightarrow A,\ AB \rightarrow D \}$

[show answer]

14. Using the functional dependencies you produced in Q10, convert the real-estate inspection spreadsheet (single table), into a BCNF relational schema.

[show answer]

15. Consider the schema R and set of fds F

$R = ABCDEFGH$
$F = \{ ABH \rightarrow C,\ A \rightarrow DE,\ BGH \rightarrow F,\ F \rightarrow ADH,\ BH \rightarrow GE \}$

Produce a BCNF decomposition of R.

[show answer]

16. Using the functional dependencies you produced in Q10, convert the real-estate inspection spreadsheet (single table), into a 3NF relational schema.

[show answer]

17. Consider the schema R and set of fds F

$R = ABCDEFGH$
$F = \{ ABH \rightarrow C,\ A \rightarrow D,\ C \rightarrow E,\ BGH \rightarrow F,\ F \rightarrow AD,\ E \rightarrow F,\ BH \rightarrow E \}$

$F_c = \{ BH \rightarrow C,\ A \rightarrow D,\ C \rightarrow E,\ F \rightarrow A,\ E \rightarrow F \}$

Produce a 3NF decomposition of R.

[show answer]