Algorithms and datastructures
Exercises

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Contents

6 Week

6.1 Indicate the following according to figure 1.

acctNo	*type*	*balance*
12345	savings	12000
23456	checking	1000
34567	savings	25

The relation **Accounts**

firstName	*lastName*	*idNo*	*account*
Robbie	Banks	901-222	12345
Lena	Hand	805-333	12345
Lena	Hand	805-333	23456

The relation **Customers**

Figure 1: Two relations of a banking database

6.1.a The attributes of each realtion

Accounts: $acctNo$, $type$, $balance$
Customers: $firstName$, $lastName$, $idNo$, $account$

6.1.b The tuples of each realtion

- 12345, $savings$, 12000
- 23456, $checking$, 1000
- 34567, $savings$, 25

- *Robbie*, *Banks*, 901 − 222, 12345
- *Lena*, *Hand*, 805 − 333, 12345
- *Lena*, *Hand*, 805 − 333, 23456

6.1.c The components of one tuble of each realtion

12000
Banks

6.1.d The relation schema of each realtion

$Accounts(acctNo, type, balance)$
$Customers(firstName, lastName, idNo, account)$

6.1.e The database schema

$Accounts, Customers$

6.1.f A suitable domain of each attribute

- $acctNo$ - INT
- $type$ - $VARCHAR$[20]
- $balance$ - INT
- $firstName$ - $VARCHAR$[20]
- $lastName$ - $VARCHAR$[20]
- $idNo$ - $CHAR$[7]
- $account$ - INT

6.1.g Another equivalent way to present each relation.

The attributes could simply just be in a different order.

6.2 In a table with the following attributes which are valid example of keys

$$title, year, length, genre, studioName, producerC\#$$

- title, year
- title, year, studioName
- title, length
- length, genre, studioName, year

6.3 How many ways can relation be represented if it has:

6.3.a Four attributes and five tuples

$4! \cdot 5! = 2880$

6.3.b n attributes and m tuples

$n! \cdot m!$

6.4 Write a database schema of the following relations

The datasbase schema includes
$Product(make, model, type)$
$PC(model, speed, ramhd, price)$
$Laptop(model, speed, ram, hd, screen, price)$
$Printer(model, color, type, price)$

6.4.a Write a schema for *Product*

CREATE TABLE Product(VARCHAR[20] maker, INT model, INT type)
The type is here an int where 0 is PC, 1 is laptop and 2 is printer. There is no foreign keys due to it being the lookup table for the other relations

6.4.b Write a schema for *PC*

CREATE TABLE PC(INT model, FLOAT speed, INT ram, BOOLEAN hd, FLOAT prize, FOREIGN KEY(Products) REFERENCES Products(model))
Here the model is a reference to products, speed is gigahertz of CPU

6.4.c Write a schema for *Printer*

CREATE TABLE Printer(INT model, BOOLEAN color, VARCHAR[20] type, FLOAT price, FOREIGN KEY(Products) REFERENCES Products(model))

6.4.d Write an alternation for Printer and delete the attribute color

ALTER TABKE Printer DROP color

6.4.e Add an *od* attribute for PC, which defaults to none an otherwise can be cd or dvd

ALTER TABLE PC ADD VARCHAR[20] od DEFAULT 'none'

8 Week

8.1 Working with linear notation

The following exercises uses the following schema:
$Product(maker, model, type)$
$PC(model, speed, ram, hd, price)$
$Laptop(model, speed, ram, hd, screen, price)$
$Printer(model, color, type, price)$

8.1.a PC models which have speed of at least 3.00?

$\pi_{model}(\sigma_{speed>3.00}(PC))$

8.1.b PC manufacturers which makes PC with a hdd with at leat 100GB

$\pi_{maker}(Product \bowtie \sigma_{hd>=100}(PC))$

8.1.c Find model and price of all products made by manufacturer B

$$
\begin{aligned}
man &:= \sigma_{maker=B}(Product) \\
PCModelPrice &:= \pi_{model,price}(man \bowtie PC) \\
LaptopModelPrice &:= \pi_{model,price}(man \bowtie Laptop) \\
PrinterModelPrice &:= \pi_{model,price}(man \bowtie Printer) \\
modPrice &:= PCModelPrice \cup LaptopModelPrice \cup PrinterModelPrice
\end{aligned}
$$

8.1.d Find model numbers of all color laster printers

$\pi_{model}(\sigma_{color=1 AND type=laser}(Printer))$

8.1.e Find manufactures that sell Laptops but not PC

Due to algebra not including a method for group by I have answered in form of SQL queries.
SELECT (SELECT maker FROM LAPTOP NATURAL JOIN Product GROUP BY maker) - (SELECT maker FROM PC NATURAL JOIN Product GROUP BY maker)

8.1.f Find hd size which accour in two or more PC's

$$
\begin{aligned}
PC &= \pi_{model,hd}(PC) \\
PC2(model2, hd) &= \pi_{model,hd}(PC) \\
hd &= \pi_{hd}(\sigma_{model!=model2}(PC \bowtie PC2)
\end{aligned}
$$

8.1.g Find PC models which have the same speed and RAM, a pair should only be listed once

$$
\begin{aligned}
Model1 &= \pi_{model,speed,RAM}(PC) \\
Model2(model2, speed, RAM) &= \pi_{model,speed,RAM}(PC) \\
models &= \pi_{model,model2}(\sigma_{model!=model2}(PC \bowtie PC2)
\end{aligned}
$$

8.1.h Find PC models which have the same speed and RAM, a pair should only be listed once

$$ModelPC = \pi_{model}\sigma_{speed>=2.8}(PC)$$
$$ModelLaptop = \pi_{model}\sigma_{speed>=2.8}(Laptop)$$
$$models = ModelPC \cup ModelLaptop$$
$$mans = \pi_{maker,model}(models \bowtie Product)$$
$$twoProduct = \sigma_{maker2=makerandmodel2!=model}(\rho_{maker2,model2}mans \times mans)$$

8.1.i Find manufactore(s) of the fastest PC or laptop

$$computers = \pi_{model,speed}Laptop \cup PC$$
$$computers2(model2, speed2) = computers$$
$$slowSpeed = \pi_{speed}(computers \bowtie_{speed<speed2} computers2)$$
$$fastSpeed(fast) = \pi_{speed}(computers) - slowSpeed$$
$$fastModels = computers \bowtie_{speed=fast} fastSpeed$$
$$mans = \pi_{maker}(fastModels \bowtie Product)$$

8.1.j Find manufactores who sellf at lest three PC's

$$model = \rho_{model}PC$$
$$computers = model \times model(model2) \times model(model3)$$
$$models = \sigma_{model=model2andmodel2=model3}(computers)$$
$$mans = \pi_{maker}(models \bowtie Product)$$

8.1.k Find manufactores who sell atleast 3 different speed PC's

$$model = \rho_{model}PC$$
$$computers = model \times model(model2) \times model(model3)$$
$$models = \sigma_{model=model2andmodel2=model3}(computers)$$
$$mans = \pi_{maker}((models \bowtie Product)$$

8.1.l Find manufactores who sell exactly three PC's

$$model = \rho_{model} PC$$
$$computers = model \times model(model2) \times model(model3)$$
$$models = \sigma_{model=model2 and model2=model3}(computers)$$
$$TooManycomputers = model \times model(model2) \times model(model3) \times model(model4)$$
$$models = \sigma_{model=model2 and model2=model3}(computers)$$
$$TooManymodels = \sigma_{model=model2 and model2=model3 and model3=model4}(computers)$$
$$mans = \pi_{maker}((models \bowtie Product)$$

8.2 In the following data, what is the result of $\pi_{speed}(PC)$ when treated as a bag and set

model	speed	ram	hd	price
1001	2.66	1024	250	2114
1002	2.10	512	250	995
1003	1.42	512	80	478
1004	2.80	1024	250	649
1005	3.20	512	250	630
1006	3.20	1024	320	1049
1007	2.20	1024	200	510
1008	2.20	2048	250	770
1009	2.00	1024	250	650
1010	2.80	2048	300	770
1011	1.86	2048	160	959
1012	2.80	1024	160	649
1013	3.06	512	80	529

Bag

speed
2.66
2.10
1.42
2.80
3.20
3.20
2.20
2.20
2.00
2.80
1.86
2.80
3.06

Set

speed
2.66
2.10
1.42
2.80
3.20
2.20
2.00
2.80
1.86
3.06

9 Week

9.1 In the query SELECT A B is b an attribute or alias

B will be an alias for it to be an attribute A and B has to be comma seperated.

9.2 Write the following queries based on the following tables

Movies(title , year, length, genre, studioName, producerC#)
StarsIn(movie Title , movieYear, starName)
MovieStar(name, address, gender, birthdate)
MovieExec(name, address, cert# , netWorth)
Studio(name, address , presC#)

9.2.a Find the address of MGM studios

SELECT address FROM Studio WHERE name = 'MGM'

9.2.b Find Sandra Bullock's birthday

SELECT birthdate FROM MovieStar WHERE name = 'Sandra Bullock'

9.2.c Find all the stars that appeared either in a movie made in 1980 or a movie with Love in the title

SELECT Star.name FROM MovieStar Star WHERE Star.name IN (SELECT starName FROM StarsIn, Movies WHERE MovieTitle = title AND (Movies.title LIKE %Love%' OR Movies.year = 1980))

9.2.d Find all executive worth at least $10,000,000

SELECT name FROM MovieExec WHERE netWorth > 10000000

9.2.e Find all the stars who either are male or live in Malibu

SELECT name FROM MovieStar WHERE gender = 'male' OR address LIKE '%Malibu%'

9.2.f Who were the male stars in *Titanic*

SELECT name FROM Movies, StarsIn, MovieStar WHERE title = 'Titanic' AND title = movieTitle AND starName = name AND gender = male

9.2.g Which stars appeared in movies produced by MGM in 1995

SELECT starName FROM Movies NATURAL JOIN StarsIn WHERE studioName = 'MGM' AND title = movieTitle

9.2.h Who is the presiden of MGM Studios

SELECT MovieExec.name FROM Studio NATURAL JOIN MovieExec WHERE Studio.name = 'MGM' AND presC# = cert#

9.2.i Which movies are longer than *GonewiththeWind*

SELECT title FROM Movies WHERE length > (SELECT length FROM MOVIES WHERE title = 'Gone with the Wind')

9.2.j Which executive are worth more than Merv Griffin

SELECT name FROM MovieExec WHERE netWorth > (SELECT netWorth FROM MovieExec WHERE name = 'Merv Griffin')

9.3 Describe possible values for a and b in the following conditions to be true

9.3.a a = 10 OR b = 20

a is 10, b can be anything including null, and the otherway around

9.3.b a = 10 AND b = 20

Both a has to be 10 and b has to be 20

9.3.c a < 10 OR a >= 10

One of the statements has to be true where the other can both be UNKNOWN by being null or just FALSE be being 11 or higher ot just TRUE.

9.3.d a = b

This will only be true if both have the same value, in case of null it will return UNKNOWN

9.3.e a <= b

If b is higher than a or equal to a it will return true. If one them is null it will be UNKNOWN an otherwise it will be false.

9.4 Write the following queries based on the following tables

Product(maker, model, type)
PC(model, speed, ram, hd, price)
Laptop(model, speed, ram, hd, screen, price)
Printer(model, color, type, price)

9.4.a Find the makers of PC's with a speed of at least 3.0

SELECT maker FORM Product WHERE model EXISTS (SELECT model FROM PC WHERE speed > 3.0)

9.4.b Find the printers with the highest price

SELECT model FROM Printer WHERE price = (SELECT MAX(price) FROM Printer)

9.4.c Find the laptops whose speed is slower than that of any PC

SELECT model FROM Laptop WHERE speed < (SELECT MIN(speed) FROM PC)

9.4.d Find the model number of the item (PC, Laptop, Printer) with the highest price

SELECT model FROM
(SELECT model, price FROM PC UNION SELECT model,price FROM Laptop UNION SELECT model,price FROM Printer)
WHERE price = SELECT MAX(price) FROM
(SELECT MAX(price) FROM PC) UNION (SELECT MAX(price) FROM Laptop) UNION (SELECT MAX(price) FROM Printer))

9.4.e Find the maker of the color printer with lowest price

SELECT maker FROM Products WHERE model EXISTS (SELECT model FROM Printer WHERE type=color AND price = (SELECT MIN(price) FROM Printer))

10 Week

10.1 Write SQL queries for the following database

$Product(maker, model, type)$
$PC(model, speed, ram, hd, price)$
$Laptop(model, speed, ram, hd, screen, price)$
$Printer(model, color, type, price)$

10.1.a What PC models have a speed greater than 3

SELECT * FROM PC WHERE speed > 3

10.1.b Find model and price for all products made by manufacturer B

SELECT price, model FROM
(SELECT price, model FROM PC) UNION
(SELECT price, model FROM Printer) UNION
(SELECT price, model FROM Laptop)
Where model EXISTS (SELECT model FROM product WHERE maker = B)

10.1.c Find manufactureres of at least two different computers with speed grather than 2.8

SELECT maker FROM (SELECT maker FROM Product WHERE model EXIST
((SELECT models FROM PC) UNION (SELECT models FROM Laptop) Where speed > 2.8)) WHERE COUNT(maker) >= 2

10.1.d Find the average speed of PC's

SELECT AVG(speed) FROM PC

10.1.e Find the average speed of laptops costing over $1000

SELECT AVG(speed) FROM Laptops WHERE price > 1000

10.1.f Find the average price of PC's and Laptops made by manufacturer "D"

SELECT AVG(price) FROM (SELECT model, price FROM Laptop) UNION (SELECT model, price FROM PC) WHERE model EXIST (SELECT model FROM Product WHERE maker = 'D')

10.1.g Find for each different speed, the average price of a PC

SELECT AVG(price) FROM PC GROUP BY speed

10.1.h Find for each manufacturer the average screen size of its laptops

SELECT maker, AVG(screen) FROM PC NATURAL JOING Product GROUP BY maker

10.1.i Find the manufacturers that make at least three different model of PC

SELECT maker FROM product WHERE type='pc' GROUP BY maker HAVING COUNT(*) > 2

10.1.j Find for each manufacturer who selss PC's the maximum price of a PC.

SELECT MAX(price) FROM PC NATURAL JOIN Product GROUP BY maker

10.1.k Find for each speed of PC above 2.0 the average price

SELECT AVG(price) FROM PC GROUP BY speed HAVING speed > 2

11 Week

11.1 What are the expexted FD's in the following database and what key would it have

- name

- Social Security number
- street address
- city
- state
- ZIP code
- area code
- phone number

Social Security number → name,street address, city, state, ZIP code, area code
phone number → name key: Social security number, phone number

11.2 Consider the relation with schema $R(A, B, C, D)$ and FD's $AB \to C, C \to D, D \to A$

11.2.a What are all the nontrivial FD's that follow from the given FD's? You should restrict yourself to FD's with single attributes on the rigth side

$AB \to C$
$C \to D$
$D \to A$
$AB \to D$
$C \to A$

11.2.b What are all the keys of R

$AB^+ = \{C, D\}$
$C^+ = \{A, D\}$
$D^+ = \{A\}$
$BC^+ = \{D, A\}$
$BD^+ = \{A, C\}$
AB, BC, DB

11.2.c What are all the superkeys for R that is not keys?

$BC, BD, ABC, ABD, ABCD, BCD$

11.3 Find BCNF violations and decompose the schema

11.3.a $R(A, B, C, D)$ with $AB \to C$, $C \to D$, and $D \to A$

$AB^+ = \{C, D, A\}$ - violation.
$R1 = R - AB^+ + AB = R(A, B)$
$R2 = AB^+ = R2(A, C, D)$

11.3.b $R(A, B, C, D, E)$ and $AB \to C, DE \to C, B \to D$

Starts wit the original relation
$R(A, B, C, D, E)$
The table violates $AB \to C$
$AB^+ = \{C, D\}$
$R1 = R - AB^+ = R(A, B, E)$
$R2 = AB^+ + AB = R(A, B, C, D)$
But $R2$ violates $B \to D$
$B^+ = \{D\}$
$R3 = R2 - B^+ = R(A, B, C)$
$R4 = B^+ + B = R(B, D)$
Therefore the new realtions are $R1, R3, R4$, since none now violates BCNF.

11.4 Perform the chase method on the relations $R(A, B, C), R(B, C, D), R(A, C, E)$ using the given FD's

11.4.a $B \to E$ and $CE \to A$

A, B, C, D_1, E_1
A_2, B, C, D, E_2
A, B_3, C, D_3, E
$E_1 = E_2$ - $B \to E$
$A_2 = A$ - $CE_1 \to A$
$E_1 = E$ - $CE \to A$
Therfore on line two is now
A, B, C, D, E

11.4.b $A \to D, D \to E$ and $B \to D$

A, B, C, D_1, E_1
A_2, B, C, D, E_2
A, B_3, C, D_3, E
$D_1 = D$ - $B \to D$

$A_2 = A$ - $A \to D$
$D_3 = D$ - $A \to D$
$E_1 = E$ - $D \to E$

11.5 The following exercise is on the relation $Courses(C, T, H, R, S, G)$

The relation has the following FD's
$C \to T$
$HR \to C$
$HT \to R$
$HS \to R$
$CS \to G$

11.5.a What are all the keys for $Courses$

The candidate key are:
$\{HS\}^+ = \{H, S, R, C, T, G\}$

11.5.b Verify that the given FD's are their own minimal basis

$C^+ = \{T\}$
$HR^+ = \{C, T\}$
$HT^+ = \{R, C\}$
$HS^+ = \{R, C, T\}$
$CS^+ = \{G, T\}$
As it can be seen no one of the FD's closure result in another FD, therefore making it minimal.

11.5.c Make the relation into a 3NF and check if any BCNF violation accour

$R1(C, T)$
$R2(H, R, C)$
$R3(H, T, R)$
$R4(H, S, R)$
$R5(C, S, G)$
All if the schemas are in BCNF

12 Week

12.1 Create a ER diagram from the given information

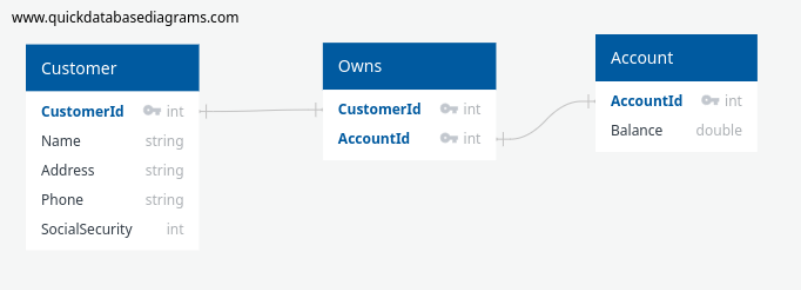


Figure 2: ER diagram describing a bank scenario

12.2 Create a ER diagram from the given information

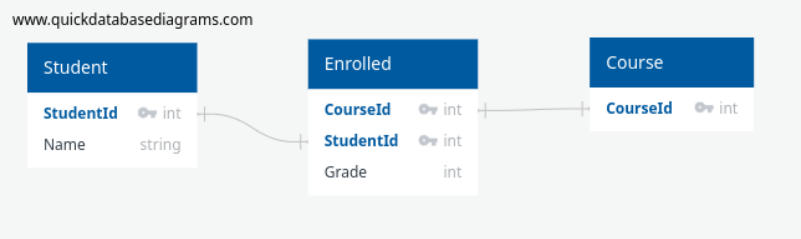
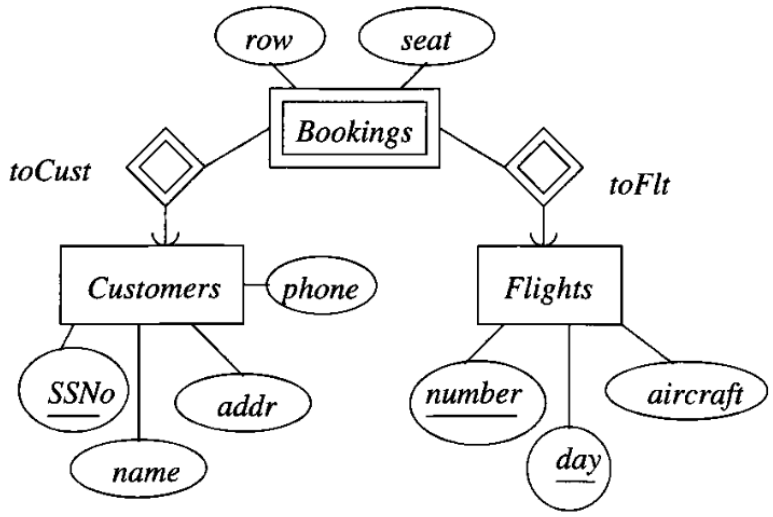


Figure 3: ER diagram describing a course and student enrollment

12.3 Create a ER diagram from the given information

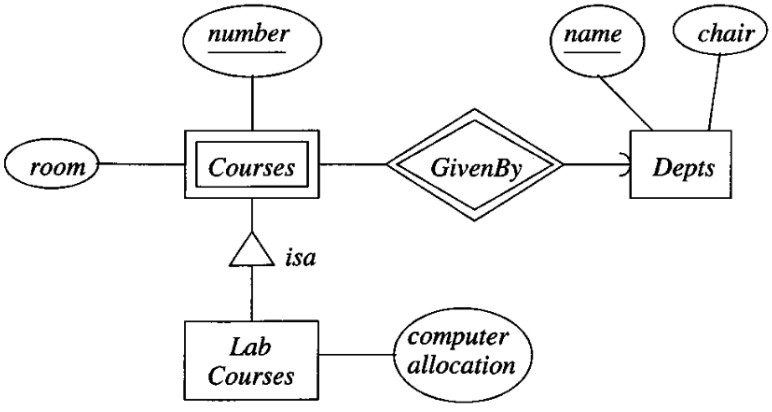
Figure 4: ER diagram describing a department and course situation with a weak key

12.4 Create a relation schema from the given diagram



Customer(SSNO primary,phone,addr,name)
Flights(number primary,day primary, aircraft)
Bookings(SSNo primary, number primary, day primary, row, seat)

12.5 Create a relation using the different methods, from the given diagram



12.5.a Straigt E/R model

Courses(room,number primary)
Depts(name primary, chair, depName primary)
GivenBy(number primary, name primary, depName primary)
LabCourses(number primary, computerAllo)

12.5.b The object oriented

The same as Depts, GivenBy and Courses but...
LabCourses(number primary, room, ComputerAllo, depName primary)

12.5.c The null method

The same Depts and Given by but...
LabCourses(number primary, room, computerAllo, depName primary)

13 Week

13.1 Create the constraint for the following database

Movies(title , year, length, genre, studioName, producerC#)
StarsIn(movie Title , movieYear, starName)
MovieStar(name, address, gender, birthdate)
MovieExec(name, address, cert# , netWorth)
Studio(name, address , presC#)

13.1.a The producer of a movie must be someone mentioned in MovieExec. Modifications to MovieExec that violate this constraint are rejected.

Movies(title , year, length, genre, studioName, producerC# REFERENCES MovieExec.cert#)

13.1.b Repeat (a), but violations result in the producerC# in Movie being set to NULL

Movies(title , year, length, genre, studioName, producerC# REFERENCES MovieExec.cert# DEFERRABLE INITIALLY DEFERRED)

13.1.c Repeat (a), but violations result in the deletion or update of the offending Movie tuple

Movies(title , year, length, genre, studioName, producerC# REFERENCES MovieExec.cert#
ON DELETE CASCADE
ON UPDATE CASCADE)

13.1.d A movie that appears in Starsln must also appear in Movie. Handle violations by rejecting the modification.

StarsIn(movieTitle REFERENCES Movies.title , movieYear, starName)

13.1.e A star appearing in Starsln must also appear in MovieStar. Handle violations by deleting violating tuples.

StarsIn(movieTitle , movieYear, starName REFERENCES MovieStar.name
ON DELTE NULL)

13.1.f The movies can not contain a movie before 1915

Movies(title , year CHECK (year ¿= 1915), length, genre, studioName, producerC#)

13.1.g The movies can not contain a movie shorter than 60 and longer than 250

Movies(title , year, length CHECK (length ¿ 60 AND 250 ¿ length), genre, studioName, producerC#)

13.1.h The movies can only be from Disney, Fox, MGM, or Paramount.

Movies(title , year, length, genre, studioName CHECK(studioName = 'Dinsey' OR studioName = 'MGM' OR studioName = 'Paramount', producerC#)

13.2 Write the following trigger analoge for insert and delete

```
01 | CREATE TRIGGER AvgNetWorthTrigger
02 | AFTER UPDATE OF netWorthON MovieExec
03 | REFERENCING
04 |    OLD TABLE AS OldStuff,
05 |    NEW TABLE AS NewStuff
06 | FOR EACH STATEMENT
07 | WHEN (500000 > (SELECT AVG(netWorth) FROM MovieExec))
08 | BEGIN
09 |    DELETE FROM MovieExec
10 |    WHERE (name, address , cert# , netWorth) IN NewStuff
       ;
11 |    INSERT INTO MovieExec
12 |       (SELECT * FROM OldStuff);
13 | END;
14 |
```

```
01 | CREATE TRIGGER AvgNetWorthTrigger
02 | AFTER INSERT OF netWorthON MovieExec
03 | REFERENCING NEW ROW AS NewTuple
04 | FOR EACH STATEMENT
05 | WHEN (500000 > (SELECT AVG(netWorth) FROM MovieExec))
06 | BEGIN
07 |    DELETE FROM MovieExec
08 |    WHERE (name, address , cert# , netWorth) IN NewTuple
       ;
09 | END;
10 |
```

```
01 | CREATE TRIGGER AvgNetWorthTrigger
02 | AFTER DELETE OF netWorthON MovieExec
03 | REFERENCING OLD ROW AS DeletedTuple
04 | FOR EACH STATEMENT
05 | WHEN (500000 > (SELECT AVG(netWorth) FROM MovieExec))
06 | BEGIN
07 |    INSERT INTO MovieExec
08 |       (SELECT * FROM DeletedTuple);
09 | END;
10 |
```