Tutorial 6: Functional Dependency & Normalization (Solutions)

CS3402 Database Systems

Question 1

- Examine the **Branch** table shown below.

a) Why this table is not in 1NF?

b) Describe and illustrate the process of normalizing the data shown in this table to 3NF.

BranchNo	**BranchAddress**	**TelNo**
B001	8 Jefferson Way, Portland, OR 97201	503-555-3618, 503-555-2727, 503-555-6534
B002	City Center Plaza, Seattle, WA 98122	206-555-6756, 206-555-8836
B003	14 – 8th Avenue, New York, NY 10012	212-371-3000
B004	16 – 14th Avenue, Seattle, WA 98128	206-555-3131, 206-555-4112

Question 1 (Answer)

a) TelNo is an attribute with atomic values, but with multi-values. Thus, the table is NOT in 1NF.

b) Create another relation specifically for TelNo with BranchNo as a foreign key.

Branch

BranchNo	**BranchAddress**
B001	8 Jefferson Way, Portland, OR 97201
B002	City Center Plaza, Seattle, WA 98122
B003	14 – 8th Avenue, New York, NY 10012
B004	16 – 14th Avenue, Seattle, WA 98128

BranchTel

BranchNo	**TelNo**
B001	503-555-3618
B001	503-555-2727
B001	503-555-6534
B002	206-555-6756
B002	206-555-8836
B003	212-371-3000
B004	206-555-3131
B004	206-555-4112

Question 2

- Examine the **StaffBranchAllocation** table shown below.
  - {StaffNo, BranchNo} is the primary key.
  - FDs: StaffNo $\rightarrow$ {Name, Position} and BranchNo $\rightarrow$ BranchAddress

a) Why this table is not in 2NF?

b) Describe and illustrate the process of normalizing the data shown in this table to 3NF.

StaffNo	**BranchNo**	**BranchAddress**	**Name**	**Position**	**HoursPerWeek**
S4555	B002	City Center Plaza, Seattle, WA 98122	Ellen Layman	Assistant	16
S4555	B004	16 – 14th Avenue, Seattle, WA 98128	Ellen Layman	Assistant	9
S4612	B002	City Center Plaza, Seattle, WA 98122	Dave Sinclair	Assistant	14
S4612	B004	16 – 14th Avenue, Seattle, WA 98128	Dave Sinclair	Assistant	10

Question 2 (Answer)

a) The primary key of StaffBranchAllocation table is {Staff No, BranchNo}. StaffNo → {Name, Position} and BranchNo → BranchAddress are not fully functional dependencies. The non-key attributes are not fully dependent on the key. Thus, the table is NOT in 2NF.

b) Remove BranchAddress, Name, Position from StaffBranchAllocation relation to capture the partial functional dependencies separately.

Branch

BranchNo	**BranchAddress**
B002	City Center Plaza, Seattle, WA 98122
B004	16 – 14th Avenue, Seattle, WA 98128

Staff

StaffNo	**Name**	**Position**
S4555	Ellen Layman	Assistant
S4612	Dave Sinclair	Assistant

StaffBranchAllocation

StaffNo	**BranchNo**	**HoursPerWeek**
S4555	B002	16
S4555	B004	9
S4612	B002	14
S4612	B004	10

Question 3

- Examine the **BranchManager** table shown below.
  - BranchNo is the primary key
  - FD: MgrStaffNo → MgrName

a) Why this table is not in 3NF?

b) Describe and illustrate the process of normalizing the data shown in this table to 3NF.

BranchNo	**BranchAddress**	**TelNo**	**MgrStaffNo**	**MgrName**
B001	8 Jefferson Way, Portland, OR 97201	503-555-3618	S1500	Tom Daniels
B002	City Center Plaza, Seattle, WA 98122	206-555-6756	S0010	Mary Martinez
B003	14 – 8th Avenue, New York, NY 10012	212-371-3000	S0145	Art Peters
B004	16 – 14th Avenue, Seattle, WA 98128	206-555-3131	S2250	Sally Stern

Question 3 (Answer)

a) There exists a non-key attribute transitively dependent on the key, i.e., MgrName depends on MgrStaffNo and MgrStaffNo depends on BranchNo, i.e., BranchNo → MgrStaffNo and MgrStaffNo → MgrName

b) Create another relation which specifically captures the dependency MgrStaffNo → MgrName

Branch

BranchNo	**BranchAddress**	**TelNo**	**MgrStaffNo**
B001	8 Jefferson Way, Portland, OR 97201	503-555-3618	S1500
B002	City Center Plaza, Seattle, WA 98122	206-555-6756	S0010
B003	14 – 8th Avenue, New York, NY 10012	212-371-3000	S0145
B004	16 – 14th Avenue, Seattle, WA 98128	206-555-3131	S2250

ManagerStaff

MgrStaffNo	**MgrName**
S1500	Tom Daniels
S0010	Mary Martinez
S0145	Art Peters
S2250	Sally Stern

Question 4

- Examine the table shown below and the set of functional dependency on its attributes:
  - CourseRmAlloc (CourseId, CourseName, Year, Lecturer, Enrollment, RoomId, RoomCapacity, Day, Time)

a) Find all candidate keys of this table.

b) Decompose this table into a design into BCNF.

FDs:

1. CourseId → CourseName
2. CourseName → CourseId
3. {CourseId, Year} → Lecturer
4. {CourseId, Year} → Enrollment
5. RoomId → RoomCapacity
6. {RoomId, Year, Day, Time} → CourseId
7. {CourseId, Year, Day, Time} → RoomId

Question 4 (Answer) (1/6)

a) There are three candidate keys in this table (based on their closure of attribute sets):
   - {Year, Day, Time, CourseId}
   - {Year, Day, Time, CourseName}
   - {Year, Day, Time, RoomId}

Question 4(a) (Answer) (2/6)

- R={CourseId, CourseName, Year, Lecturer, Enrollment, RoomId, RoomCapacity, Day, Time}
- X={CourseId}

FDs:
1. CourseId → CourseName
2. CourseName → CourseId
3. {CourseId, Year} → Lecturer
4. {CourseId, Year} → Enrollment
5. RoomId → RoomCapacity
6. {RoomId, Year, Day, Time} → CourseId
7. {CourseId, Year, Day, Time} → RoomId

	oldX$^+$ (Before)	FD	X$^+$ (After)	X$^+$ = oldX$^+$?
1st Iteration	{CourseId}	CourseId → CourseName	{CourseId, CourseName}	False
2nd Iteration	{CourseId, CourseName}	CourseName → CourseId	{CourseId, CourseName}	True

- X$^+$ = {CourseId, CourseName} (Since X$^+$ does not include all the attributes in R, X={CourseId} is not a candidate key.)

Question 4(a) (Answer) (3/6)

FDs:
1. CourseId → CourseName
2. CourseName → CourseId
3. {CourseId, Year} → Lecturer
4. {CourseId, Year} → Enrollment
5. RoomId → RoomCapacity
6. {RoomId, Year, Day, Time} → CourseId
7. {CourseId, Year, Day, Time} → RoomId

- R={CourseId, CourseName, Year, Lecturer, Enrollment, RoomId, RoomCapacity, Day, Time}
- X={Year, Day, Time, RoomId}

	oldX⁺ (Before)	FD	X⁺ (After)	X⁺ = oldX⁺?
1st Iteration	{Year, Day, Time, RoomId}	RoomId → RoomCapacity {RoomId, Year, Day, Time} → CourseId	{Year, Day, Time, RoomId, RoomCapacity, CourseId}	False
2nd Iteration	{Year, Day, Time, RoomId, RoomCapacity, CourseId}	CourseId → CourseName {CourseId, Year} → Lecturer {CourseId, Year} → Enrollment {CourseId, Year, Day, Time} → RoomId	{Year, Day, Time, RoomId, RoomCapacity, CourseId, CourseName, Lecturer, Enrollment}	False
3rd Iteration	{RoomId, Year, Day, Time, RoomCapacity, CourseId, CourseName, Lecturer, Enrollment}	CourseName → CourseId	{RoomId, Year, Day, Time, RoomCapacity, CourseId, CourseName, Lecturer, Enrollment}	True

- X^+ = {RoomId, Year, Day, Time, RoomCapacity, CourseId, CourseName, Lecturer, Enrollment}
  (Since X^+ includes all the attributes in R, X={Year, Day, Time, RoomId} is a candidate key.

Question 4(b) (Answer) (4/6)

b) This table can be decomposed into the following in BCNF (so also in 3NF):
   - **CourseTeaching**(CourseId, Year, Lecturer, Enrollment)
   - **Room**(RoomId, RoomCapacity)
   - **CourseRoomAlloc**(CourseId, Year, Day, Time, RoomId)
   - **Course**(CourseId, CourseName)

Question 4(b) (Answer) (5/6)

FDs:
1. CourseId → CourseName
2. CourseName → CourseId
3. {CourseId, Year} → Lecturer
4. {CourseId, Year} → Enrollment
5. RoomId → RoomCapacity
6. {RoomId, Year, Day, Time} → CourseId
7. {CourseId, Year, Day, Time} → RoomId

- R = {CourseId, CourseName, Year, Lecturer, Enrollment, RoomId, RoomCapacity, Day, Time}
- Candidate keys
  - {Year, Day, Time, CourseId}
  - {Year, Day, Time, CourseName}
  - {Year, Day, Time, RoomId}
- CourseId → CourseName violates BCNF
  - R = {CourseId, Year, Lecturer, Enrollment, RoomId, RoomCapacity, Day, Time}
  - R_1 = {CourseId, CourseName}
- {CourseId, Year} → Lecturer violates BCNF
  - R = {CourseId, Year, Enrollment, RoomId, RoomCapacity, Day, Time}
  - R_1 = {CourseId, CourseName}
  - R_2 = {CourseId, Year, Lecturer}

Question 4(b) (Answer) (6/6)

- {CourseId, Year} → Lecturer violates BCNF
  - R = {CourseId, Year, Enrollment, RoomId, RoomCapacity, Day, Time}
  - R_1 = {CourseId, CourseName}
  - R_2 = {CourseId, Year, Lecturer}
- {CourseId, Year} → Enrollment violates BCNF
  - R = {CourseId, Year, RoomId, RoomCapacity, Day, Time}
  - R_1 = {CourseId, CourseName}
  - R_2 = {CourseId, Year, Lecturer, Enrollment}
- RoomId → RoomCapacity violates BCNF
  - R = {CourseId, Year, RoomId, Day, Time}
  - R_1 = {CourseId, CourseName}
  - R_2 = {CourseId, Year, Lecturer, Enrollment}
  - R_3 = {RoomId, RoomCapacity}
- {RoomId, Year, Day, Time} → CourseId does not violate BCNF
- {CourseId, Year, Day, Time} → RoomId does not violate BCNF

FDs:

1. CourseId → CourseName
2. CourseName → CourseId
3. {CourseId, Year} → Lecturer
4. {CourseId, Year} → Enrollment
5. RoomId → RoomCapacity
6. {RoomId, Year, Day, Time} → CourseId
7. {CourseId, Year, Day, Time} → RoomId