# Tutorial 6: Functional Dependency & Normalization

## 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 third normal form (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 not 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 → {Name, Position} and BranchNo → BranchAddress

a) Why this table is not in 2NF?

b) Describe and illustrate the process of normalizing the data shown in this table to third normal form (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}. There exist the partial functional dependencies: StaffNo → Name, Position and BranchNo → BranchAddress. 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 third normal form (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.

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)
  - 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

a) Find all candidate keys of this table.

b) Decompose this table into a design into BCNF.

# 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 (Answer) (2/6)

- R = {CourseId, CourseName, Year, Lecturer, Enrollment, RoomId, RoomCapacity, Day, Time}
- X = {CourseId}
- $X_0$ = {CourseId}
  - CourseId $\rightarrow$ CourseName
- $X_1$ = {CourseId, CourseName}
  - CourseName $\rightarrow$ CourseId
- $X_2$ = {CourseId, CourseName}
- $X^+ = X_2$ (Since $X^+$ does not include all the attributes in R, it is not a candidate key.)

# Question 4 (Answer) (3/6)

- R = {CourseId, CourseName, Year, Lecturer, Enrollment, RoomId, RoomCapacity, Day, Time}
- X = {RoomId, Year, Day, Time}
- $X_0$ = {RoomId, Year, Day, Time}
  - RoomId $\rightarrow$ RoomCapacity
  - {RoomId, Year, Day, Time} $\rightarrow$ CourseId
- $X_1$ = {RoomId, Year, Day, Time, RoomCapacity, CourseId}
  - CourseId $\rightarrow$ CourseName
  - {CourseId, Year} $\rightarrow$ Lecturer
  - {CourseId, Year} $\rightarrow$ Enrollment
- $X_2$ = {RoomId, Year, Day, Time, RoomCapacity, CourseId, CourseName, Lecturer, Enrollment}
  - CourseName $\rightarrow$ CourseId
- $X_3$ = {RoomId, Year, Day, Time, RoomCapacity, CourseId, CourseName, Lecturer, Enrollment}
- $X^+ = X_3$ (Since $X^+$ includes all the attributes in R, it is a candidate key.)

# Question 4 (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 (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 (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:

4. {CourseId, Year} → Enrollment
5. RoomId → RoomCapacity
6. {RoomId, Year, Day, Time} → CourseId
7. {CourseId, Year, Day, Time} → RoomId