

Name

UIN

# Homework Assignment 3

March 28th, 2024

Due on April 9th, 11:59pm (midnight)

## CS480 - Database Systems Results

---

*Please leave this empty!*

3.1

3.2

3.3

Sum

# Instructions

- Try to answer all the questions using what you have learned in class
- Some questions are marked as bonus. You do not have to answer these questions to get full points for the assignment. However, you can get bonus points for these questions!

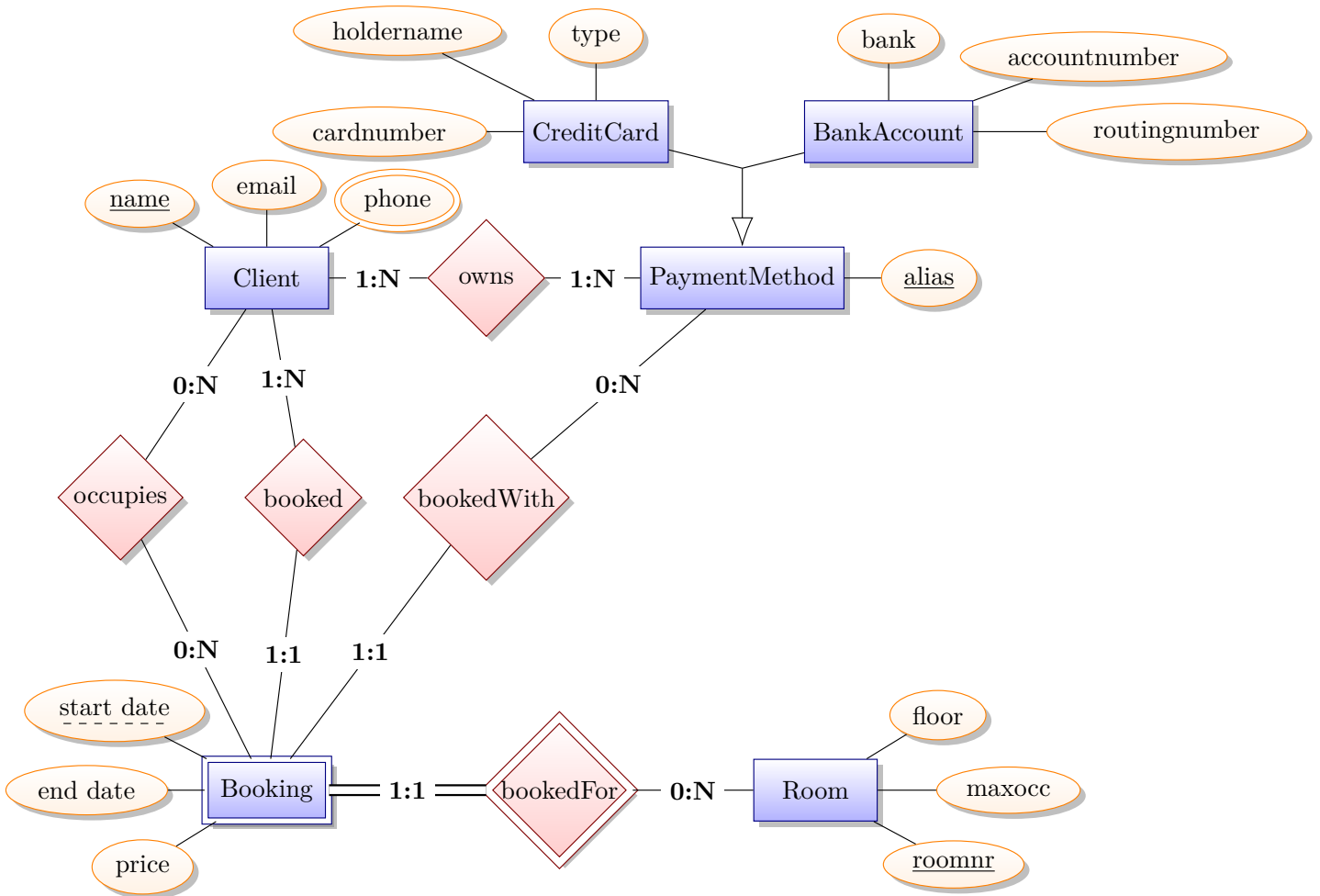
## Part 3.1 Modelling (Total: 60 Points)

### Question 3.1.1 (60 Points)

Build a conceptual model for a **booking system for a hotel**. The solution should be presented as an **ER-diagram**. Your design should implement the following requirements.

- The database should record information about **Rooms**, **Clients**, **Payment Methods**, and **Bookings**.
- A **Client** is identified by their *name* and *email address*. Clients may have zero or more *phone numbers*.
- **Payment methods** are identified by an *alias*. Payment methods are of a specific type: each payment method is either a **credit card** or **bank account**. For **credit cards** we record the *type* of card (e.g., AE or Visa), the *card number*, and *card holder name* (the name of the owner of the card as it appears on the card). For **bank accounts** we record the *bank name*, *account number*, and *routing number*. Each payment method is associated with one or more clients. Clients have to have at least one payment method. Note that the *card holder name* for a credit card may be different from the client associated with the payment method, e.g., a supplementary card.
- A **Room** has a *room number* that uniquely identifies the room. Additionally, we should document which *floor* the room belongs to and the *maximum number of occupants*.
- A **Booking** has a *start date*, *end date*, and *price* and is for exactly one room. The combination of *start date* and *room* the booking is associated with uniquely identifies the room. A booking is associated with exactly one client (the client that booked the room) and payment method. Furthermore, there may be zero or more clients that will be staying in the room for a booking.

## Solution

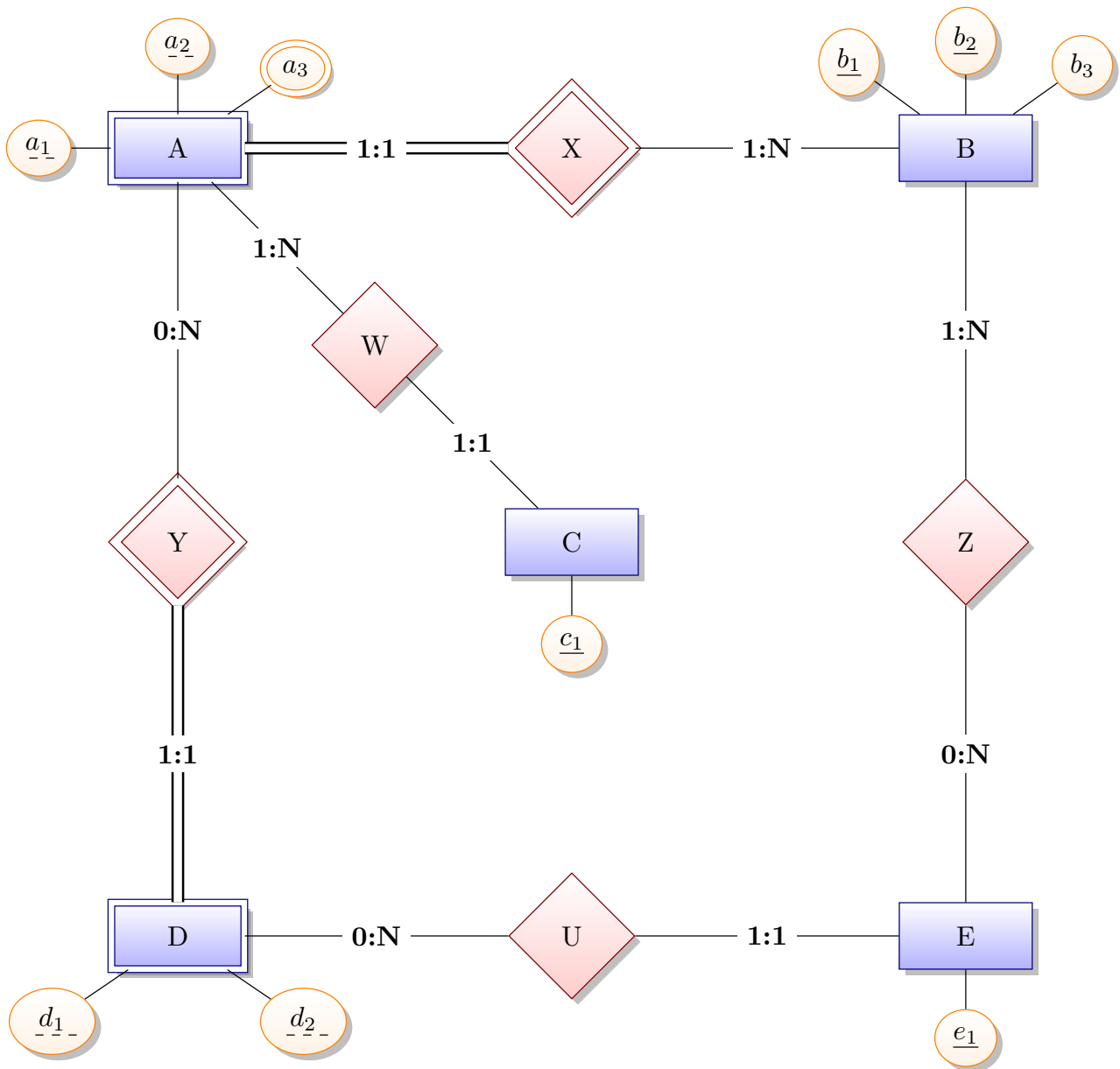


Part 3.2 Translation of ER into Relational Model (Total: 40 Points)

Question 3.2.1 (40 Points)

Take the following ER-model and translate it into a relational schema using the rules presented in class. Present the relational schema as an SQL script (assume that all attributes are of data type INT). Present the results of the following intermediate steps in this order:

1. Translate strong entities + unnest composite attributes
2. Translate weak entities
3. Translated multi-valued attributes
4. Translate relationships



## Solution

### 1st Step (strong entities)

```
CREATE TABLE B (  
    b1 INT ,  
    b2 INT ,  
    b3 INT  
    PRIMARY KEY (b1,b2)  
);
```

```
CREATE TABLE C (  
    c1 INT PRIMARY KEY  
);
```

```
CREATE TABLE E (  
    e1 INT ,  
    PRIMARY KEY (e1)  
);
```

## 2nd Step (weak entities)

```
CREATE TABLE A (  
  a1 INT,  
  a2 INT,  
  b1 INT,  
  b2 INT,  
  PRIMARY KEY (a1, a2, b1, b2),  
  FOREIGN KEY (b1,b2) REFERENCES B  
);
```

```
CREATE TABLE D (  
  d1 INT,  
  d2 INT,  
  a1 INT,  
  a2 INT,  
  b1 INT,  
  b2 INT,  
  PRIMARY KEY (d1, d2, a1, a2, b1, b2),  
  FOREIGN KEY (a1, a2, b1, b2) REFERENCES A  
);
```

### 3rd Step (multivalued attributes)

```
CREATE TABLE A3 (  
  a1 INT,  
  a2 INT,  
  b1 INT,  
  b2 INT,  
  a3 INT,  
  PRIMARY KEY (a1, a2, b1, b2, a3),  
  FOREIGN KEY (a1, a2, b1, b2) REFERENCES A  
);
```

## 4th Step (relationships)

```
CREATE TABLE E (  
  e1 INT,  
  d1 INT,  
  d2 INT,  
  a1 INT,  
  a2 INT,  
  b1 INT,  
  b2 INT,  
  PRIMARY KEY (e1),  
  FOREIGN KEY (d1,d2,a1, a2, b1, b2) REFERENCES D  
);
```

```
CREATE TABLE C (  
  c1 INT,  
  a1 INT,  
  a2 INT,  
  b1 INT,  
  b2 INT,  
  PRIMARY KEY (c1),  
  FOREIGN KEY (a1,a2,b1,b2) REFERENCES A  
);
```

```
CREATE TABLE Z (  
  b1 INT,  
  b2 INT,  
  e1 INT,  
  PRIMARY KEY (b1,b2,e1),  
  FOREIGN KEY (b1,b2) REFERENCES A,  
  FOREIGN KEY (e1) REFERENCES E  
);
```

## Part 3.3 Normalization (Total: 10 (BONUS) Points)

### Question 3.3.1 (10 (BONUS) Points)

Consider the following relations and for each determine in which normal form the relation is (note that a relation can be in multiple normal forms). Please consider the following normal forms: 1NF, 2NF, 3NF and BCNF.

1.  $R(A, B, C, D, E)$  and the Functional Dependencies are  $AE \rightarrow C, E \rightarrow BC, D \rightarrow E, E \rightarrow D$
2.  $R(A, B, C, D, E)$  and the Functional Dependencies are  $B \rightarrow E, C \rightarrow E, C \rightarrow AB, B \rightarrow E, D \rightarrow AB$
3.  $R(A, B, C, D, E)$  and the Functional Dependencies are  $A \rightarrow B, C \rightarrow AD, AC \rightarrow E, D \rightarrow E$
4.  $R(A, B, C, D, E)$  and the Functional Dependencies are  $AB \rightarrow CDE, B \rightarrow A$

### Solution

#### 1. The relation is in 2NF.

Candidate keys:  $\{AD, AE\}$

Compute canonical cover:

Union rule replaced  $E \rightarrow D, E \rightarrow BC$  with  $E \rightarrow BCD$

A is redundant in the LHS of  $AE \rightarrow C$ : replacing it with  $E \rightarrow C$

Union rule replaced:  $E \rightarrow C, E \rightarrow BCD$  with  $E \rightarrow BCD$

Canonical cover:  $D \rightarrow E, E \rightarrow BCD$

**not in 2NF** because nonprime attributes  $B$  and  $C$  implied by partial key  $D \rightarrow BC$  for key  $AD$

#### 2. The relation is in 1NF.

Candidate keys:  $\{CD\}$

Compute canonical cover:

Union rule replaced  $C \rightarrow E, C \rightarrow AB$  with  $C \rightarrow ABE$

E is redundant in the RHS of  $C \rightarrow ABE$ : replacing it with  $C \rightarrow AB$

Canonical cover:  $C \rightarrow AB, B \rightarrow E, D \rightarrow AB$

**not in 2NF** because nonprime attributes  $ABE$  implied by partial key  $D \rightarrow ABE$  for key  $CD$

#### 3. The relation is in 2NF.

Candidate keys:  $\{C\}$

Compute canonical cover:

A is redundant in the LHS of  $AC \rightarrow E$ : replacing it with  $C \rightarrow E$

Union rule replaced  $C \rightarrow E, C \rightarrow AD$  with  $C \rightarrow ADE$

E is redundant in the RHS of  $C \rightarrow ADE$ : replacing it with  $C \rightarrow AD$

**Canonical cover:**  $D \rightarrow E, A \rightarrow B, C \rightarrow AD$

**not in 3NF**, because of fd  $A \rightarrow B$ .

**4. The relation is in BCNF.**

**Candidate keys:**  $\{B\}$

**Compute canonical cover:**

A is redundant in the LHS of  $AB \rightarrow CDE$ : replacing it with  $B \rightarrow CDE$

Union rule replaced  $B \rightarrow A, B \rightarrow CDE$  with  $B \rightarrow ACDE$

**Canonical cover:**  $B \rightarrow ACDE$