Normalization Proofs

Relations are in Boyce-Codd Normal Form

Proof:

1. **'Customer' relation:**

   - Attributes:

     Customer (Customer_ID, Joining_date)

   - Functional Dependencies:

     Customer_ID → Joining_date

   - Super Key:

     {Customer_ID}

   $\{Customer\_ID\}^+ = \{Customer\_ID, Joining\_date\}$

   Thus, Primary Key = Customer_ID

   The left side of all Functional Dependencies in this minimal set for the relation 'Customer' is the same as the Primary Key for the relation.

   Thus, the relation 'Customer' satisfies BCNF.

2. **‘Branch’ relation:**

- Attributes:

  Branch (IFS_CODE, Branch_Name, branch_street, branch_city, branch_state)

- Functional Dependencies:

  IFS_CODE → Branch_Name

  IFS_CODE → branch_street

  IFS_CODE → branch_city

  IFS_CODE → branch_state

- Super Key:

  {IFS_CODE}

$\{IFS\_CODE\}^+$ = {IFS_CODE, Branch_Name, branch_street, branch_city, branch_state}

Thus, Primary Key = IFS_CODE

The left side of all Functional Dependencies in this minimal set for the relation ‘Branch’ is the same as the Primary Key for the relation.

Thus, the relation ‘Branch’ satisfies BCNF.

3. **‘Account’ relation:**

- Attributes:

  Account (Account_Number, IFS_CODE, Customer_ID, Account_Status)

- Functional Dependencies:

  Account_Number → IFS_CODE

  Account_Number → Customer_ID

  Account_Number → Account_Status

- Super Key:

  {Account_Number}

$\{Account\_Number\}^+$ = {Account_Number, IFS_CODE, Customer_ID, Account_Status}

Thus, Primary Key = Account_Number

The left side of all Functional Dependencies in this minimal set for the relation ‘Account’ is the same as the Primary Key for the relation.

Thus, the relation ‘Account’ satisfies BCNF.

4. **‘Customer_Details’ relation:**

- Attributes:

  Customer_Details (Customer_ID, Fname, Mname, Lname, DoB, Gender, Phone_No, Email, street, city, state)

- Functional Dependencies:

  Customer_ID → Fname
  Customer_ID → Mname
  Customer_ID → Lname
  Customer_ID → DoB
  Customer_ID → Gender
  Customer_ID → Phone_No
  Customer_ID → Email
  Customer_ID → street
  Customer_ID → city
  Customer_ID → state

- Super Key:

  {Customer_ID}

$\{Customer\_ID\}^+$ = {Customer_ID, Fname, Mname, Lname, DoB, Gender, Phone_No, Email, street, city, state}

Thus, Primary Key = Customer_ID

The left side of all Functional Dependencies in this minimal set for the relation ‘Customer_Details’ is the same as the Primary Key for the relation.

Thus, the relation ‘Customer_Details’ satisfies BCNF.

5. **‘Branch_Contacts’ relation:**

- Attributes:

  Branch_Contacts (IFS_CODE, Branch_Contact_No)

- Super Key:

  {{IFS_CODE, Branch_Contact_No}}

{{IFS_CODE, Branch_Contact_No}}$^{+}$ = {IFS_CODE, Branch_Contact_No}

Thus, Primary Key = {IFS_CODE, Branch_Contact_No}

Here, every determinant in the relation is a super key(and also primary key), and according to theorem, when all attributes of relation are Primary Key, then the relation always satisfies BCNF.

Thus, the relation ‘Branch_Contacts’ satisfies BCNF.

6. **‘Account_Details’ relation:**

- Attributes:

  Account_Details (Account_Number, Account_type, Balance, Interest_Rate, Opening_date)

- Functional Dependencies:

  Account_Number → Account_type

  Account_Number → Balance

  Account_Number → Interest_Rate

  Account_Number → Opening_date

- Super Key:

  {Account_Number}

{Account_Number}$^{+}$ = {Account_Number, Account_type, Balance, Interest_Rate, Opening_date}

Thus, Primary Key = Account_Number

The left side of all Functional Dependencies in this minimal set for the relation ‘Account_Details’ is the same as the Primary Key for the relation.

Thus, the relation ‘Account_Details’ satisfies BCNF.

7. **‘Transaction’ relation:**

- Attributes:

  Transaction (Transaction_ID, Sender_Account_No, Receiver_Account_No, Transaction_Type, Transaction_Date, Transaction_Amount)

- Functional Dependencies:

  Transaction_ID → Sender_Account_No

  Transaction_ID → Receiver_Account_No

  Transaction_ID → Transaction_Type

  Transaction_ID → Transaction_Date

  Transaction_ID → Transaction_Amount

- Super Key:

  {Transaction_ID}

$\{Transaction\_ID\}^+$ = {Transaction_ID, Sender_Account_No, Receiver_Account_No, Transaction_Type, Transaction_Date, Transaction_Amount}

Thus, Primary Key = Transaction_ID

The left side of all Functional Dependencies in this minimal set for the relation ‘Transaction’ is the same as the Primary Key for the relation.

Thus, the relation ‘Transaction’ satisfies BCNF.

8. **‘Employee’ relation:**

- Attributes:

  Employee (Employee_ID, IFS_CODE, Employee_Fname, Employee_Mname, Employee_Lname, role)

- Functional Dependencies:

  Employee_ID → IFS_CODE

  Employee_ID → Employee_Fname

  Employee_ID → Employee_Mname

  Employee_ID → Employee_Lname

  Employee_ID → role

- Super Key:

  {Employee_ID}

$\{Employee\_ID\}^{+}$ = {Employee_ID, IFS_CODE, Employee_Fname, Employee_Mname, Employee_Lname, role}

Thus, Primary Key = Employee_ID

The left side of all Functional Dependencies in this minimal set for the relation ‘Employee’ is the same as the Primary Key for the relation.

Thus, the relation ‘Employee’ satisfies BCNF.

9. **‘Loan’ relation:**

- Attributes:

  Loan (Loan_ID, Account_number, Employee_ID, Loan_Type, Loan_Amount, Interest_Rate, Debt, Duration, Loan_Approval_Date, Loan_Approval_Status)

- Functional Dependencies:

  Loan_ID → Account_number
  Loan_ID → Employee_ID
  Loan_ID → Loan_Type
  Loan_ID → Loan_Amount
  Loan_ID → Interest_Rate
  Loan_ID → Debt
  Loan_ID → Duration
  Loan_ID → Loan_Approval_Date
  Loan_ID → Loan_Approval_Status

- Super Key:

  {Loan_ID}

$\{Loan\_ID\}^+$ = {Loan_ID, Account_number, Employee_ID, Loan_Type, Loan_Amount, Interest_Rate, Debt, Duration, Loan_Approval_Date, Loan_Approval_Status}

Thus, Primary Key = Loan_ID

The left side of all Functional Dependencies in this minimal set for the relation ‘Loan’ is the same as the Primary Key for the relation.

Thus, the relation ‘Loan’ satisfies BCNF.

10. ‘Loan_Repayment’ relation:

- Attributes:

  Loan_Repayment (Loan_ID, Installment_Date, Payment_Date, Amount_Paid, Status)

- Functional Dependencies:

  {Loan_ID, Installment_Date} → Payment_Date

  {Loan_ID, Installment_Date} → Amount_Paid

  {Loan_ID, Installment_Date} → Status

- Super Key:

  {{Loan_ID, Installment_Date}}

{{Loan_ID, Installment_Date}}$^{+}$ = {Loan_ID, Installment_Date, Payment_Date, Amount_Paid, Status}

Thus, Primary Key = {Loan_ID, Installment_Date}

The left side of all Functional Dependencies in this minimal set for the relation ‘Loan_Repayment’ is the same as the Primary Key for the relation.

Thus, the relation ‘Loan_Repayment’ satisfies BCNF.

11. ‘Credit_Card’ relation:

- Attributes:

  Credit_Card(Card_ID, Account_Number, Employee_ID, Credit_Limit, Fine_Rate, Card_Approval_Status)

- Functional Dependencies:

  Card_ID → Account_Number

  Card_ID → Employee_ID

  Card_ID → Credit_Limit

  Card_ID → Fine_Rate

  Card_ID → Card_Approval_Status

- Super Key:

  {Card_ID}

$\{Card\_ID\}^+$ = {Card_ID, Account_Number, Employee_ID, Credit_Limit, Fine_Rate, Card_Approval_Status}

Thus, Primary Key = Card_ID

The left side of all Functional Dependencies in this minimal set for the relation ‘Credit_Card’ is the same as the Primary Key for the relation.

Thus, the relation ‘Credit_Card’ satisfies BCNF.

12. ‘Card_Transaction’ relation:

- Attributes:

  Card_Transaction(Card_Transaction_ID, Card_ID, Amount_Spent, Card_Transaction_Date, Card_Repayment_Status, Due_Date)

- Functional Dependencies:

  Card_Transaction_ID → Card_ID

  Card_Transaction_ID → Amount_Spent

  Card_Transaction_ID → Card_Transaction_Date

  Card_Transaction_ID → Card_Repayment_Status

  Card_Transaction_ID → Due_Date

- Super Key:

  {Card_Transaction_ID}

{Card_Transaction_ID}$^{+}$ = {Card_Transaction_ID, Card_ID, Amount_Spent, Card_Transaction_Date, Card_Repayment_Status, Due_Date}

Thus, Primary Key = Card_Transction_ID

The left side of all Functional Dependencies in this minimal set for the relation ‘Card_Transaction is the same as the Primary Key for the relation.

Thus, the relation ‘Card_Transaction’ satisfies BCNF.