

Normalization Report

Airline Management System

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Normalization Report: Airline Management System Database

1. Introduction

The Airline Management System database is designed to handle critical operations, including flight scheduling, passenger bookings, transactions, and airline logistics. To ensure efficiency, data integrity, and scalability, the database has been subjected to a rigorous normalization process. This report provides an in-depth analysis of the normalization process, detailing how the database schema has been refined to eliminate redundancy and maintain consistency.

2. Performance Requirements

To meet the system's operational and performance expectations, the following non-functional requirements (NFRs) were defined:

- NFR-1: The system must support at least 1000 concurrent users without significant performance degradation.
- NFR-2: Query execution times must be optimized for real-time flight and passenger information retrieval.
- NFR-3: The system must process flight bookings and transactions in real-time to ensure seamless operations.

Achieving these goals requires a well-structured and optimized database. A critical step in this optimization is normalization, which ensures minimal redundancy and efficient data retrieval.

3. Understanding Normalization and its steps

Normalization is a systematic process of organizing data to reduce redundancy and improve data integrity. It involves decomposing a database into multiple tables while preserving relationships to minimize data anomalies. The primary objectives of normalization include:

- Eliminating redundant data.
- Ensuring logical data storage.
- Reducing insertion, update, and deletion anomalies.
- Improving query performance.

Normalization progresses through several stages, known as **normal forms (NFs)**. Each stage refines the database structure to address specific anomalies:

3.1 First Normal Form (1NF)

A table is in **1NF** if it satisfies the following conditions:

1. All attributes contain **atomic values** (i.e., indivisible values, no repeating groups).
2. Each column contains values of **a single type**.
3. Each row is uniquely identifiable through a **primary key**.

If a table has **repeating groups or multi-valued attributes**, it violates 1NF. To convert it to 1NF, the repeating groups are removed by creating separate tables and establishing relationships.

3.2 Second Normal Form (2NF)

A table is in **2NF** if:

1. It is already in **1NF**.
2. Every **non-key attribute** is fully functionally dependent on the **entire primary key** (i.e., no partial dependency).

A **partial dependency** occurs when a non-key attribute depends only on part of a composite primary key rather than the entire key. This is resolved by decomposing the table into smaller tables and linking them with foreign keys.

3.3 Third Normal Form (3NF)

A table is in **3NF** if:

1. It is already in **2NF**.
2. There are **no transitive dependencies** (i.e., non-key attributes should not depend on other non-key attributes).

A **transitive dependency** occurs when an attribute depends on another non-primary attribute instead of the primary key. This is resolved by moving the dependent attribute to a separate table.

3.4 Boyce-Codd Normal Form (BCNF)

A table is in **BCNF** if:

1. It is already in **3NF**.
2. Every **determinant** is a **superkey**.

A determinant is an attribute that determines another attribute. If a table contains functional dependencies where a **non-superkey determines another attribute**, it violates BCNF and must be decomposed further.

4. Normalization Process Applied to the Airline Management System

The database design for the Airline Management System has been rigorously normalized to ensure data integrity, eliminate redundancy, and support efficient queries. The normalization process has been evaluated at multiple levels:

1. Airplane_type Table

Attributes:

- **Airplane_ID** (PK) - Unique identifier for the airplane
- **Passenger_Capacity** - Maximum number of passengers
- **Weight** - Weight of the airplane
- **Manufacturer** - Manufacturer name

Functional Dependencies:

- **Airplane_ID** → **Passenger_Capacity, Weight, Manufacturer**

Normalization:

- **1NF:** Atomic attributes, no repeating groups.
- **2NF:** No partial dependencies.
- **3NF:** No transitive dependencies.
- **BCNF:** Fully satisfied.

2. Airport Table

Attributes:

- **Airport_Code** (PK) - Unique airport identifier
- **Airport_Name** - Name of the airport
- **City** - City where the airport is located
- **Country** - Country of the airport
- **State** - State (nullable)

Functional Dependencies:

- **Airport_Code** → **Airport_Name, City, Country, State**

Normalization:

- **1NF:** No repeating groups.
- **2NF:** No partial dependencies.
- **3NF:** No transitive dependencies.
- **BCNF:** Fully satisfied.

3. Route Table

Attributes:

- **Route_ID** (PK) - Unique route identifier
- **Origin_Airport_Code** (FK) - Airport code for departure
- **Destination_Airport_Code** (FK) - Airport code for arrival
- **Distance** - Distance between airports
- **Duration** - Estimated flight duration

Functional Dependencies:

- **Route_ID** → **Origin_Airport_Code, Destination_Airport_Code, Distance, Duration**

Normalization:

- **1NF:** No repeating groups.
- **2NF:** No partial dependencies.
- **3NF:** No transitive dependencies.
- **BCNF:** Fully satisfied.

4. Flight Table

Attributes:

- **Flight_ID** (PK) - Unique flight identifier
- **Flight_Number** - Airline flight number
- **Departure_Time** - Time of departure
- **Arrival_Time** - Time of arrival
- **Flight_Date** - Scheduled date of flight
- **Airplane_ID** (FK) - Associated airplane
- **Route_ID** (FK) - Associated route

Functional Dependencies:

- **Flight_ID** → **Flight_Number, Departure_Time, Arrival_Time, Flight_Date, Airplane_ID, Route_ID**

Normalization:

- **1NF:** No repeating groups.
- **2NF:** No partial dependencies.
- **3NF:** No transitive dependencies.
- **BCNF:** Fully satisfied.

5. Flight_Status Table

Attributes:

- **Status_ID** (PK) - Unique status ID
- **Flight_ID** (FK) - Associated flight
- **Status** - Flight status (e.g., On Time, Delayed)
- **Status_Update_Time** - Timestamp of status update
- **Delay_Reason** - Reason for delay (nullable)

Functional Dependencies:

- **Status_ID** → **Flight_ID**, **Status**, **Status_Update_Time**, **Delay_Reason**

Normalization:

- **1NF**: No repeating groups.
- **2NF**: No partial dependencies.
- **3NF**: No transitive dependencies.
- **BCNF**: Fully satisfied.

6. Employee Table

Attributes:

- **Employee_ID** (PK) - Unique employee ID
- **Employee_Name** - Name of the employee
- **Airport_Code** (FK) - Associated airport
- **Contact_Number** - Employee contact number
- **Email_Address** - Employee email

Functional Dependencies:

- **Employee_ID** → **Employee_Name**, **Airport_Code**, **Contact_Number**, **Email_Address**

Normalization:

- **1NF:** No repeating groups.
- **2NF:** No partial dependencies.
- **3NF:** No transitive dependencies.
- **BCNF:** Fully satisfied.

7. Passengers Table

Attributes:

- **Passenger_ID** (PK) - Unique passenger ID
- **Passenger_Name** - Name of the passenger
- **Age** - Passenger age
- **Gender** - Passenger gender
- **Address** - Residential address
- **Contact_Number** - Passenger contact number
- **Email** - Passenger email

Functional Dependencies:

- **Passenger_ID** → **Passenger_Name, Age, Gender, Address, Contact_Number, Email**

Normalization:

- **1NF:** No repeating groups.
- **2NF:** No partial dependencies.
- **3NF:** No transitive dependencies.
- **BCNF:** Fully satisfied.

8. Fare_Class Table

Attributes:

- **Class_ID** (PK) - Unique class ID
- **Class_Name** - Name of fare class (e.g., Economy, Business)
- **Description** - Description of the fare class

Functional Dependencies:

- **Class_ID** → **Class_Name**, **Description**

Normalization:

- **1NF**: No repeating groups.
- **2NF**: No partial dependencies.
- **3NF**: No transitive dependencies.
- **BCNF**: Fully satisfied.

9. AirFare Table

Attributes:

- **Fare_ID** (PK) - Unique fare ID
- **Base_Amount** - Base ticket price
- **Tax_Amount** - Tax applied on fare
- **Discount** - Discount amount (default 0)
- **Flight_ID** (FK) - Associated flight
- **Class_ID** (FK) - Associated fare class

Functional Dependencies:

- **Fare_ID** → **Base_Amount**, **Tax_Amount**, **Discount**, **Flight_ID**, **Class_ID**

Normalization:

- **1NF:** No repeating groups.
- **2NF:** No partial dependencies.
- **3NF:** No transitive dependencies.
- **BCNF:** Fully satisfied.

10. Transactions Table

Attributes:

- **Transaction_ID** (PK) - Unique transaction ID
- **Booking_Date** - Date and time of transaction
- **Payment_Method** - Payment method used
- **Payment_Status** - Status of payment
- **Amount** - Total amount paid
- **Passenger_ID** (FK) - Associated passenger

Functional Dependencies:

- **Transaction_ID** → **Booking_Date, Payment_Method, Payment_Status, Amount, Passenger_ID**

Normalization:

- **1NF:** No repeating groups.
- **2NF:** No partial dependencies.
- **3NF:** No transitive dependencies.
- **BCNF:** Fully satisfied.

11. Booking Table

Attributes:

- **Booking_ID** (PK) - Unique booking ID
- **Booking_Status** - Status of the booking (e.g., Confirmed, Cancelled)
- **Seat_Number** - Assigned seat number
- **Class_ID** (FK) - Fare class for booking
- **Transaction_ID** (FK) - Payment transaction ID
- **Flight_ID** (FK) - Associated flight
- **Passenger_ID** (FK) - Associated passenger

Functional Dependencies:

- **Booking_ID** → **Booking_Status, Seat_Number, Class_ID, Transaction_ID, Flight_ID, Passenger_ID**

Normalization:

- **1NF:** No repeating groups.
- **2NF:** No partial dependencies.
- **3NF:** No transitive dependencies.
- **BCNF:** Fully satisfied.

12. UserCredentials Table

Attributes:

- **Email** (PK) - User email (used as unique identifier)
- **Password** - Hashed password
- **User_Type** - Type of user (e.g., Passenger, Employee)

Functional Dependencies:

- **Email** → **Password, User_Type**

Normalization:

- **1NF:** No repeating groups.
- **2NF:** No partial dependencies.
- **3NF:** No transitive dependencies.
- **BCNF:** Fully satisfied.

5. Schema and ER Diagram for clear understanding

