Database System Project (Team 3)

Airline Ticketing System

Amirthavarshani Mahadevan | Godwin Okwara

---

1. Introduction

Project Description:

The goal of this project is to design and implement a comprehensive and efficient Airline Booking Database System. This system will manage all aspects of airline operations related to customer bookings, flights, tickets, payments, aircraft, and associated entities. The database will serve as the backbone for an airline or travel agency's booking process, ensuring smooth transactions, efficient data management, and seamless user experience.

Motivation for Selecting the Project

The primary motivation for selecting this project is the complex yet essential nature of airline operations and the impact of an efficient booking system on overall customer experience and business operations. An airline booking system must handle large volumes of data, perform real-time transactions, and ensure the integrity of critical information, such as customer details, flight schedules, and payments. By designing this database, I aim to explore solutions for managing complex relationships between entities, ensuring data security, and optimizing the performance of high-demand operations.

How is this database helpful?

The Airline Booking Database System allows customers to book, view, and modify flight reservations, make payments, and manage their tickets and baggage. For airline staff and travel agencies, the system manages flight schedules, customer bookings, passenger information, payments, and reporting. It supports real-time updates, secure payment processing, seat assignments, and detailed reporting to streamline airline operations and enhance the customer experience.

2. Requirements Analysis

Functional Requirements:

1. Search for available flights based on departure and arrival locations, dates, and airlines.

2. Process flight bookings for customers and generate tickets for all passengers.
3. Modify flight schedules, including departure and arrival times.
4. Record payment transactions associated with bookings.
5. Add passengers to bookings and assign seats.
6. Manage and track baggage for each passenger.
7. View and manage booking details, including flight, payment, and ticket information.
8. Update customer information, including contact details.
9. Cancel bookings and handle rescheduling.

Non-functional Requirements:

1. Scalability: Handle thousands of concurrent bookings and queries.
2. Data Security: Encrypt sensitive information and ensure role-based access control.
3. Performance: Ensure real-time response for critical operations such as booking and payment processing.
4. Reliability: Achieve 99.9% system uptime with robust failover mechanisms.

3. ER Model Design

Entities and Attributes

1) Customer
    a) Attributes:
        i) Customer_ID (Primary Key)
        ii) Customer_Name
        iii) DoB (Date of Birth)
        iv) Email_Address
        v) Contact_Number
        vi) Passport_Num
2) Registered_Customer
    a) Attributes:
        i) Joined_Date
        ii) Password
        iii) Num_of_Booking
3) Guest_Customer
4) Flight
    a) Attributes:
        i) Flight_Num (Primary Key)
5) Airline
    a) Attributes:
        i) Airline_Code (Primary Key)

ii) Legal_Name
iii) ICAO_Code
iv) IATA_Code
v) Region
vi) Country
vii) Website

6) Airport
    a) Attributes:
        i) Airport_Code (Primary Key)
        ii) Airport_Name
        iii) Country
        iv) City
7) Booking
    a) Attributes:
        i) Booking_Number (Primary Key)
        ii) Number_of_Passengers
8) Ticket
    a) Attributes:
        i) Ticket_Number (Primary Key)
9) Payment
    a) Attributes:
        i) Payment_Num (Primary Key)
10) Aircraft
    a) Attributes:
        i) Aircraft_ID (Primary Key)
        ii) Model
        iii) Seating_Capacity
11) Passenger
    a) Attributes:
        i) Passenger_Full_Name
        ii) Passport_Number (Primary Key)
        iii) Passport_Issuance_Country
        iv) DoB (Date of Birth)
12) Seat
    a) Attributes:
        i) Seat_Num (Primary Key)
13) Baggage
    a) Attributes:
        i) Baggage_ID (Primary Key)
14) Type_of_Trip
    a) Attributes:
        i) ToTrip_ID (Primary Key)

ii) ToTrip_Name

15) Class
    a) Attributes:
        i) Class_ID (Primary Key)
        ii) Class_Name
16) Invoice
    a) Attributes:
        i) Invoice_Num (Primary Key)
        ii) Total_Amount
17) Customer_Review
    a) Attributes:
        i) Review_ID
        ii) Review

Relationship among entities:

1) Customer-Booking: One-to-Many relationship. A customer can create multiple bookings, but each booking is linked to only one customer.
2) Booking-Ticket: One-to-Many relationship. A booking includes one or more tickets, and a ticket can be generated for only one booking.
3) Passenger-Ticket: One-to-Many relationship. A passenger can hold multiple tickets, and a ticket is assigned to a single passenger.
4) Booking-Invoice: One-to-One relationship. Every booking is linked to exactly one invoice.
5) Invoice-Payment: One-to-One relationship. Each invoice corresponds to exactly one payment.
6) Flight-Airline: Many-to-One relationship. An airline operates multiple flights, and each flight is associated with one airline.
7) Aircraft-Flight: One-to-Many relationship. Flight is an aircraft and aircraft has many flight
8) Airport-Flight: We have 2, One-to-Many relationships between Airport and Flight. The first one is the Departure and the second one is the Arrival.
9) Registered_Customer-Review: One-to-Many relationship. A registered customer can leave more than one review.
10) Ticket-Type_of_Trip: Many-to-one relationship.
11) Ticket-Seat: Many-to-One relationship.
12) Flight-Seat-Class: Ternary relationship.

5. Relational Model

Relational Schema, and Normalization

1) Customer:
    a. Customer(Customer_ID (Primary Key), First_Name, Last_Name,DoB, Email_Address, Contact_Number,gender)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
2) Registered Customer:
    a. Registered_Customer(Customer_ID (Primary Key, FK), Joined_Date)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
3) Guest Customer
    a. Guest_Customer(Customer_ID (Primary Key, FK), passport_no)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
4) Flight
    a. Flight(Flight_Num (Primary Key), Aircraft_ID(FK), Airline_Code(FK), depature_Airport_code(FK),Dep_time,Arrival_Air_port_code(FK), Arriv_Time)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
5) Airline
    a. Airline(Airline_Code (Primary Key), Legal_Name, ICAO_Code, IATA_Code, Region, Country, Website)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
6) Airport
    a. Airport(Airport_Code (Primary Key), Airport_Name, Country, City, destination_image)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
7) Booking
    a. Booking(Booking_Number (Primary Key), Booking_Date, Status, Number_of_Passenger , Customer_ID(FK))
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
8) Ticket
    a. Ticket(Ticket_Number (Primary Key),flight_num(FK),Seat_Num(FK), Booking_Number(FK), Passport_Number(FK), Trip_Type_ID(FK), Baggage_ID(FK))
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
9) Payment
    a. Payment(Payment_Num (Primary Key),payment_method, payment_satus, payment_date)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
10) Aircraft
    a. Aircraft(Aircraft_ID (Primary Key), Model, Seating_Capacity, manufacturer, flight_range)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
11) Passenger
    a. Passenger(Passenger_Full_Name, Passport_Number (Primary Key), Id_proof, DoB)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
12) Seat
    a. Seat(Seat_Num (Primary Key),is_avilable)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
13) Baggage
    a. Baggage(Baggage_ID (Primary Key), weight, type, dimension)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
14) Type_of_Trip

a. Type_of_Trip(ToTrip_ID (Primary Key), ToTrip_Name)
b. Normalization: No partial or transitive dependencies. This relation in 3NF

15) Class
    a. Class(Class_ID (Primary Key), Class_Name)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
16) Invoice
    a. Invoice(Invoice_Num (Primary Key), Total_Amount)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
17) Customer_Review
    a. Customer_Review((Customer_ID (FK),review_id)(Primary Key), review)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
18) Departure_Flight_Day
    a. Departure_Flight_Day((Flight_Num(FK),Day)(Primary Key))
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
19) Arrival_Flight_Day
    a. Arrival_Flight_Day((Flight_Num(FK),Day)(Primary Key))
    b. Normalization: No partial or transitive dependencies. This relation in 3NF
20) Flight_Seat_Price
    a. Flight_Seat_Price((Flight_num(FK),Seat_Num(FK),Class_ID(FK))(Primary key),price)
    b. Normalization: No partial or transitive dependencies. This relation in 3NF

6. Data Dictionary

1) Airport

Column Name	Data Type	Constraints	Description
airport_code	VARCHAR(10)	PRIMARY KEY	Unique code identifying the airport.
name	VARCHAR(100)	NOT NULL	Name of the airport.
city	VARCHAR(50)	NOT NULL	City where the airport is located.
country	VARCHAR(50)	NOT NULL	Country where the airport is located.

2) Aircraft

Column Name	Data Type	Constraints	Description
aircraft_id	INT	PRIMARY KEY	Unique identifier for the aircraft.
model	VARCHAR(50)		Model of the aircraft.
manufacturer	VARCHAR(50)		Manufacturer of the aircraft.
capacity	INT		Maximum seating capacity of the aircraft.
flight_range	INT		Maximum flight range of the aircraft.
engine_type	VARCHAR(50)		Type of engine used by the aircraft.

year_of_manufacture	INT		Year the aircraft was manufactured.

3) Flight

Column Name	Data Type	Constraints	Description
flight_number	VARCHAR(10)	PRIMARY KEY	Unique identifier for the flight.
departure_time	DATETIME	NOT NULL	Scheduled departure time of the flight.
arrival_time	DATETIME	NOT NULL	Scheduled arrival time of the flight.
origin_airport_code	VARCHAR(10)	FOREIGN KEY REFERENCES Airport	Code of the departure airport.
destination_airport_code	VARCHAR(10)	FOREIGN KEY REFERENCES Airport	Code of the arrival airport.
airline_code	VARCHAR(10)	FOREIGN KEY REFERENCES Airline	Code of the airline operating the flight.
aircraft_id	INT	FOREIGN KEY REFERENCES Aircraft	Identifier of the aircraft used for the flight.

4) FlightDepartureDay

Column Name	Data Type	Constraints	Description
departure_day	VARCHAR(15)	PRIMARY KEY (departure_day, flight_number)	Day of the week for flight departure.
flight_number	VARCHAR(10)	FOREIGN KEY REFERENCES	Identifier of the flight

5) FlightArivalDay

Column Name	Data Type	Constraints	Description
arrival_day	VARCHAR(15)	PRIMARY KEY (arrival_day, flight_number)	Day of the week for flight arrival.
flight_number	VARCHAR(10)	FOREIGN KEY REFERENCES	Identifier of the flight.

6) Customer

Column Name	Data Type	Constraints	Description
customer_id	INT	PRIMARY KEY	Unique identifier for the customer.
first_name	VARCHAR(50)	NOT NULL	Customer's first name.
last_name	VARCHAR(50)	NOT NULL	Customer's last name.

email	VARCHAR(100)	NOT NULL	Customer's email address.
phone	VARCHAR(20)		Customer's phone number.
date_of_birth	DATE		Customer's date of birth.
passport_num	VARCHAR(10)	NOT NULL	

7) Booking

Column Name	Data Type	Constraints	Description
booking_number	INT	PRIMARY KEY	Unique identifier for the booking.
customer_id	INT	FOREIGN KEY REFERENCES	Identifier of the customer who made the booking.
		Customer	
booking_date	DATETIME	NOT NULL	Date and time the booking was made.
status	VARCHAR(20)		Status of the booking (e.g., Confirmed, Cancelled).

8) Passenger

Column Name	Data Type	Constraints	Description
passenger_id	INT	PRIMARY KEY	Unique identifier for the passenger.
first_name	VARCHAR(50)	NOT NULL	Passenger's first name.
last_name	VARCHAR(50)	NOT NULL	Passenger's last name.
date_of_birth	DATE		Passenger's date of birth.
id_proof	VARCHAR(50)		Identification proof provided by the passenger.

9) Class

Column Name	Data Type	Constraints	Description
class_id	INT	PRIMARY KEY	Unique identifier for the class of service.
name	VARCHAR(20)	NOT NULL	Name of the class (e.g., Economy, Business).
amenities	TEXT		Amenities offered in the class of service.

10) Other Tables that we used in our database

Table Name	Column Name	Data Type	Constraints	Description

Airline_info	airline_name	VARCHAR(30)	PRIMARY KEY	Unique name of the airline.
Airline_info	airline_hotline	VARCHAR(20)	NOT NULL	Customer service hotline of the airline.
Airline_info	airline_email	VARCHAR(50)	NOT NULL	Official email of the airline.
Airline_info	address_1	VARCHAR(100)	NOT NULL	Address line 1 of the airline.
Airline_info	address_2	VARCHAR(100)	NOT NULL	Address line 2 of the airline.
Airline_info	address_3	VARCHAR(100)	NOT NULL	Address line 3 of the airline.
Airline_info	airline_account_no	VARCHAR(30)	NOT NULL	Bank account number associated with the airline.
customer_category	cat_name	ENUM	PRIMARY KEY	Name of the customer category (e.g., General).
customer_category	discount_percentage	NUMERIC(5,2)	NOT NULL	Discount offered for this category.
customer_category	min_bookings	SMALLINT	NOT NULL	Minimum bookings required for this category.
customer	customer_id	UUID	PRIMARY KEY	Unique identifier for the customer.
customer	type	ENUM	NOT NULL	Type of customer (e.g., Registered, Guest).
registered_customer	customer_id	UUID	PRIMARY KEY, FK	Unique customer ID, references customer
registered_customer	email	VARCHAR(127)	NOT NULL, UNIQUE	Email address of the registered customer.
registered_customer	password	VARCHAR(255)	NOT NULL	Encrypted password for login.
registered_customer	first_name	VARCHAR(30)	NOT NULL	First name of the customer.
registered_customer	last_name	VARCHAR(30)	NOT NULL	Last name of the customer.
registered_customer	category	ENUM	DEFAULT 'General', FK	Customer category, references customer_category
registered_customer	dob	DATE	NOT NULL	Date of birth of the customer.

registered_customer	gender	ENUM		Gender of the customer.
registered_customer	contact_no	VARCHAR(15)	NOT NULL	Contact number of the customer.
registered_customer	passport_no	VARCHAR(20)	NOT NULL	Passport number of the customer.
registered_customer	address_line1	VARCHAR(80)	NOT NULL	Address line 1 of the customer.
registered_customer	address_line2	VARCHAR(80)		Address line 2 of the customer.
registered_customer	country	VARCHAR(30)	NOT NULL	Country of residence.
registered_customer	city	VARCHAR(30)	NOT NULL	City of residence.
registered_customer	display_image	BYTEA		Profile picture of the customer.
registered_customer	no_of_bookings	INT	DEFAULT 0	Number of bookings made by the customer.
registered_customer	joined	TIMESTAMP	DEFAULT NOW()	Date and time the customer joined.
class	class_id	INT	PRIMARY KEY, GENERATED ALWAYS AS IDENTITY	Unique identifier for the class.
class	class_name	VARCHAR(10)	NOT NULL, UNIQUE	Name of the class (e.g., Economy, Business).
location	location_id	INT	PRIMARY KEY, GENERATED ALWAYS AS IDENTITY	Unique identifier for the location.
location	name	VARCHAR(50)	NOT NULL	Name of the location.
location	parent_id	INT	FK	Parent location ID, references location
airport	airport_code	VARCHAR(10)	PRIMARY KEY	Unique airport code.
airport	location_id	INT	NOT NULL, FK	Location ID, references location
airport	destination_image	TEXT		Image URL or data related to the airport destination.

airport	name	VARCHAR	NOT NULL	Name of the airport.
aircraft_model	model_id	INT	PRIMARY KEY, GENERATED ALWAYS AS IDENTITY	Unique ID for the aircraft model.
aircraft_model	model_name	VARCHAR(30)	NOT NULL	Name of the aircraft model.

7. System Design

Security Design

To ensure the security of our online air ticketing system, we have implemented the following measures:

1) **Password Hashing**
    a. All passwords are securely stored using **bcrypt** hashing.
    b. This ensures that passwords are protected against brute force and rainbow table attacks.
    c. Password recovery is handled using secure, token-based reset links, without storing plaintext passwords.

2) **Access Control**
    a. We use **Role-Based Access Control (RBAC)** to restrict access based on user roles:
        i. **Admin**: Full system access for management tasks.
        ii. **Customers**: Access only to personal bookings and payment history.
    b. Each role has the minimum permissions necessary to perform its tasks, ensuring data security.

3) **Encryption**
    a. **Data Transmission**: All data exchanged between the client and server is encrypted using **TLS** for secure communication.
    b. **Data Storage**: Sensitive information, such as payment details, is encrypted using **AES-256**.
    c. Payment processing is handled through **PCI DSS-compliant** payment gateways, ensuring secure transactions.

4) **Additional Measures**
    a. **Monitoring**: Logs of important events (e.g., login attempts, password changes) are maintained and monitored.
    b. **Input Validation**: User inputs are validated to prevent attacks such as SQL injection and XSS.

c. **Backup and Recovery**: Encrypted backups are maintained, and recovery processes are tested regularly.

8. Implementation

Technology Stack:

The system is built using the following technologies:

1) **Database Management System**:
   a. PostgreSQL with PL/pgSQL extensions for efficient database operations and custom procedures.
2) **Back-end Framework**:
   a. Flask, a lightweight and flexible framework, is used to handle server-side logic and API development.
3) **Frontend Framework**:
   a. The user interface is developed using **HTML**, **CSS**, and **JavaScript** for a responsive and interactive experience.
4) **Security Tools**:
   a. **bcrypt**: For secure password hashing.
   b. **SSL/TLS**: To ensure secure data transmission between the client and server.

Key Functions and Triggers:

1) **Functions**
   a. **get_arrival**:
      Calculates the arrival time for a flight based on the departure time and route duration.
   b. **get_seat_price**:
      Determines the seat price by considering the route and class of the seat (e.g., economy, business).
2) **Triggers**
   a. **update_customer_bookings**:
      Automatically increments the booking count for registered customers when a new booking is confirmed.
   b. **insert_seats_for_new_model**:
      Automatically inserts seat configurations into the database when a new aircraft model is added.

9. Challenges and resolution

a. **Challenges:**
   i. **Handling Complex Relationships**:
      Managing dependencies between flights, bookings, payments, and

customers presented challenges in maintaining consistent data flow and operations.

ii. **Ensuring Data Integrity**:
Maintaining referential integrity across multiple tables required careful implementation of foreign keys and constraints.

iii. **Optimizing Performance**:
Ensuring fast query responses for real-time operations, such as booking and payment processing, was critical to user experience.

b. **Resolutions:**

i. **Schema Design:**
- **Designed a normalized database schema with clearly defined relationships and foreign key constraints to handle complex dependencies.**

ii. **Indexing:**
- **Added indexes on frequently queried columns, such as email (for user lookups) and schedule_id (for flight operations), to improve query performance.**

iii. **Transactional Queries:**
- **Used database transactions to ensure atomicity in critical operations like bookings and payments, preventing partial updates in case of errors.**

c. **Future Enhancements**

i. **Integration with Mobile Apps**:
- Develop and expose **API endpoints** to support seamless integration with mobile applications for enhanced customer accessibility.

ii. **Machine Learning Models**:
- Implement demand prediction algorithms to enable dynamic flight pricing, improving revenue generation and seat optimization.

10. Workload

Name	Task done
Amirthavarshani Mahadevan – amahadevan2@student.sgu.edu	• ER Diagram design • Relational Schema • Database design • Presentation slide
Godwin Okwara - gokwara1@student.gsu.edu	• Backend database design • Front end design • Relational model design • Execution of functional queries in the front-end

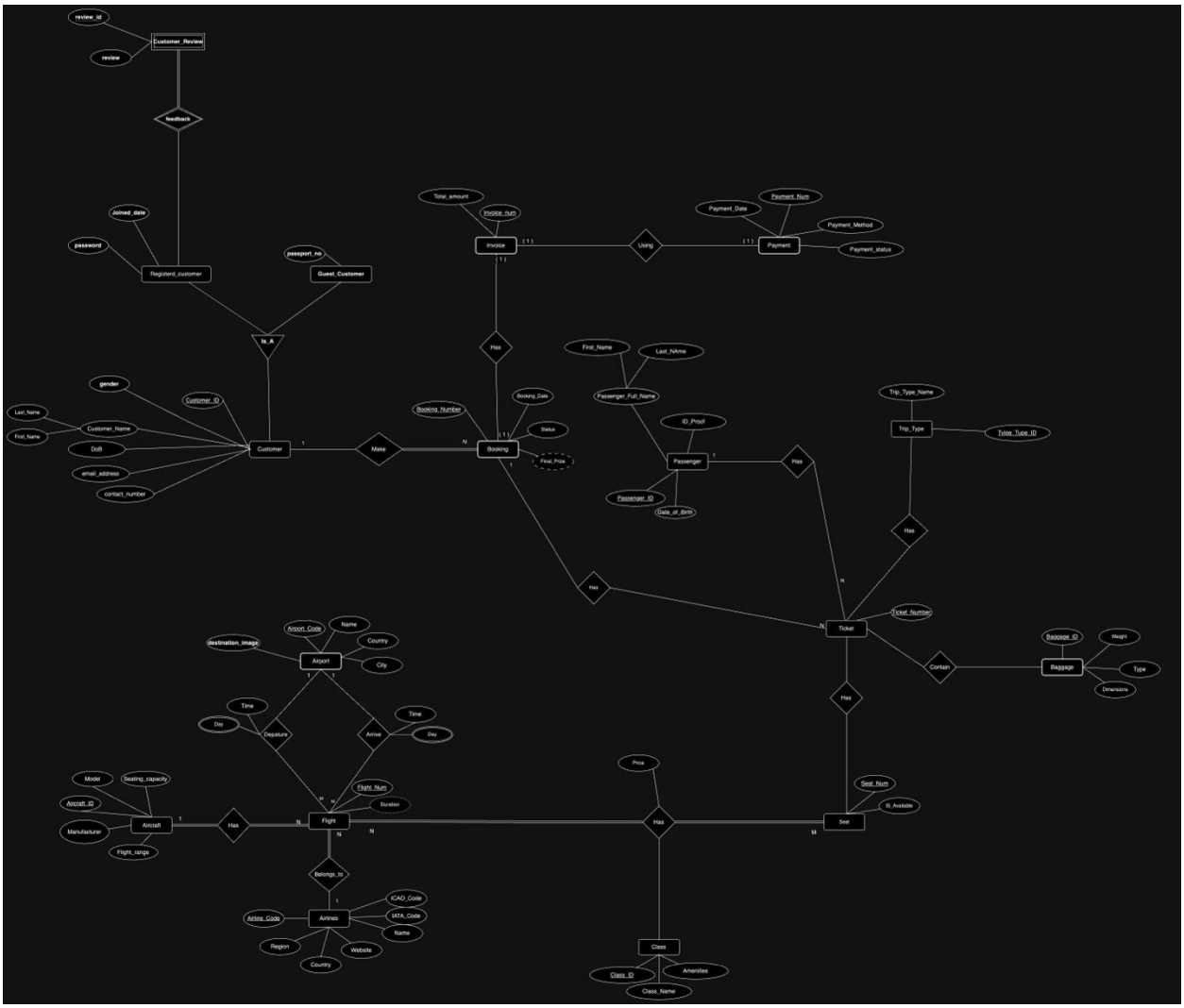
Both of us worked together in the proposal, project report

11. Access Links

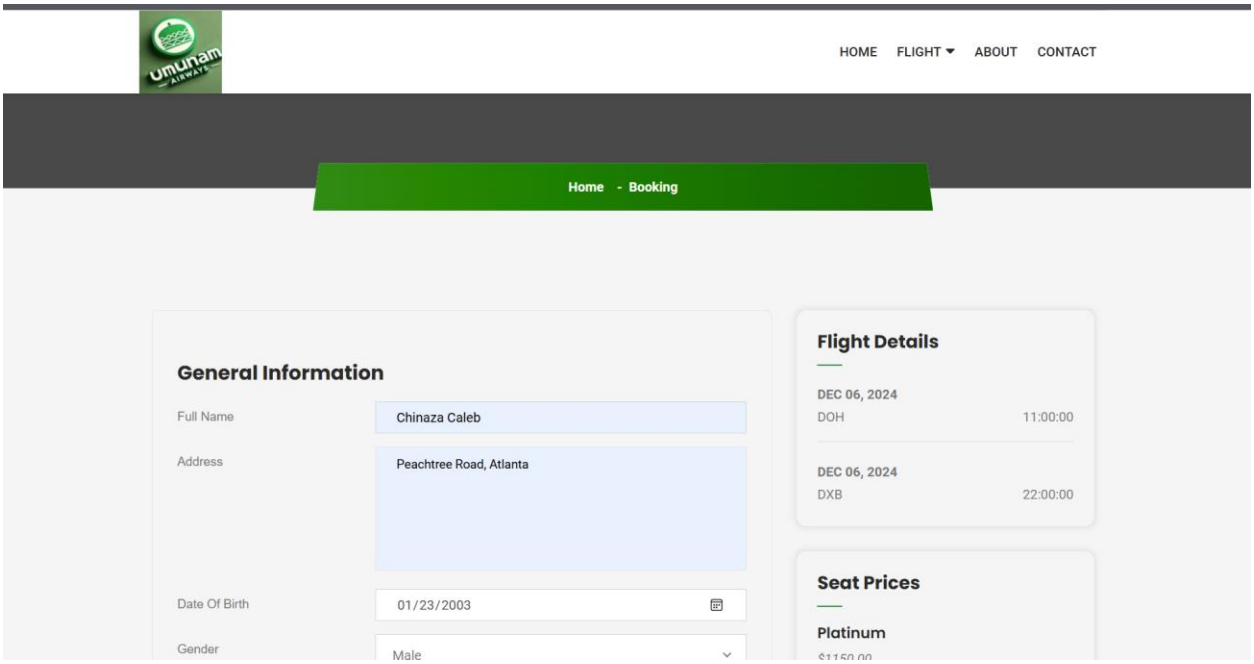
1) SQL folder: https://drive.google.com/drive/folders/1VeTAQ_VqBeuU3ANZNZN3vWaXPRtvWY76?usp=sharing
2) Code folder: https://drive.google.com/drive/folders/1khHfntkyBqMUSjrJDo2zKvc85Xf04JPn?usp=sharing
3) Demo video: https://drive.google.com/drive/folders/1HhNSUcn6Y510qfQRk_yTeNvT1s31SFZj?usp=sharing

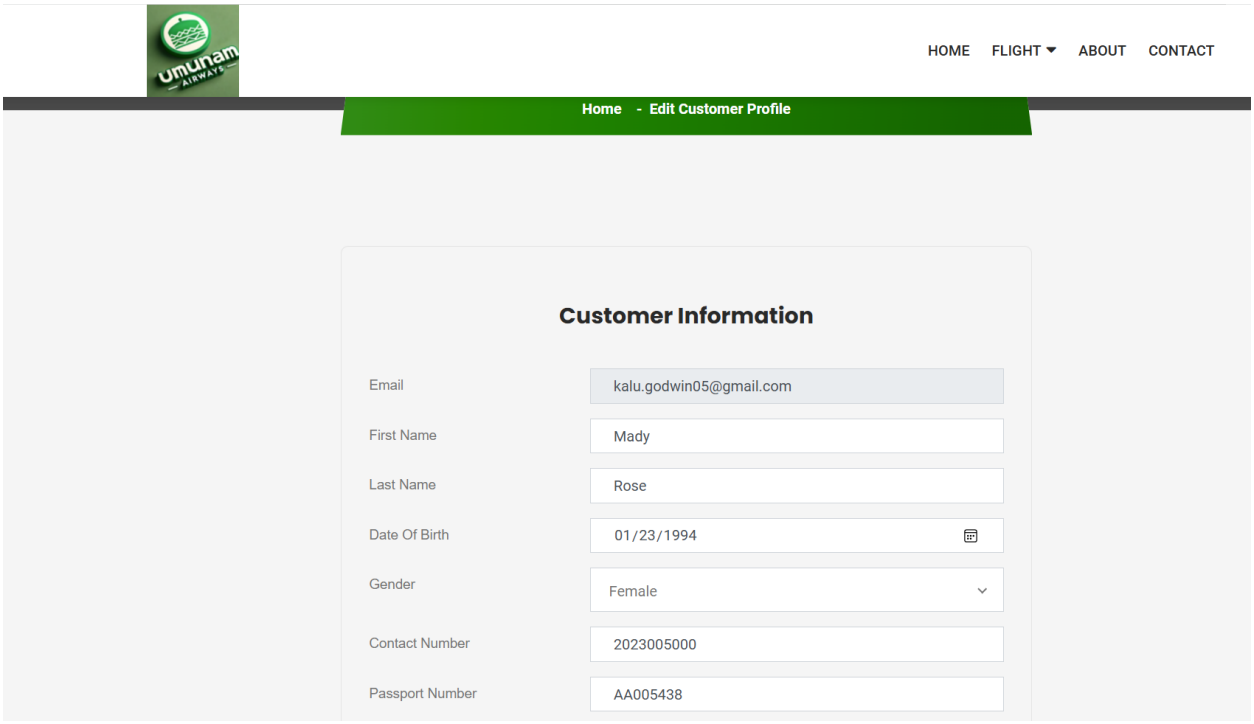
12. Appendix

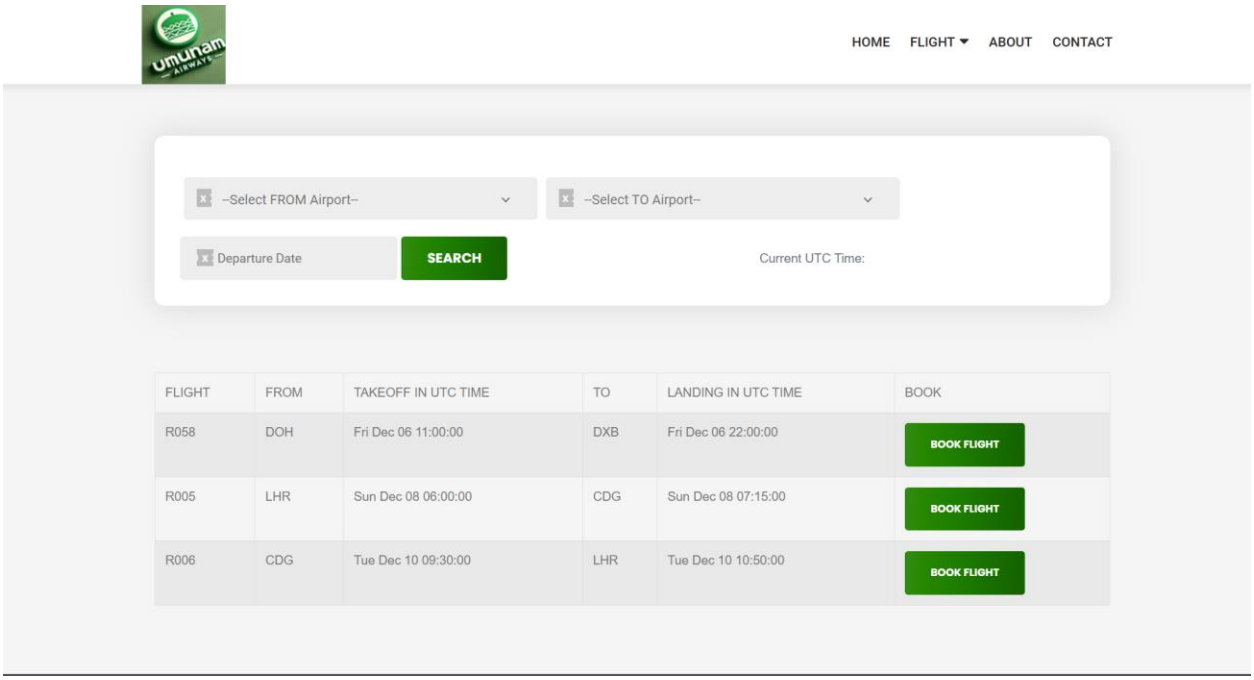
1) ER Diagram

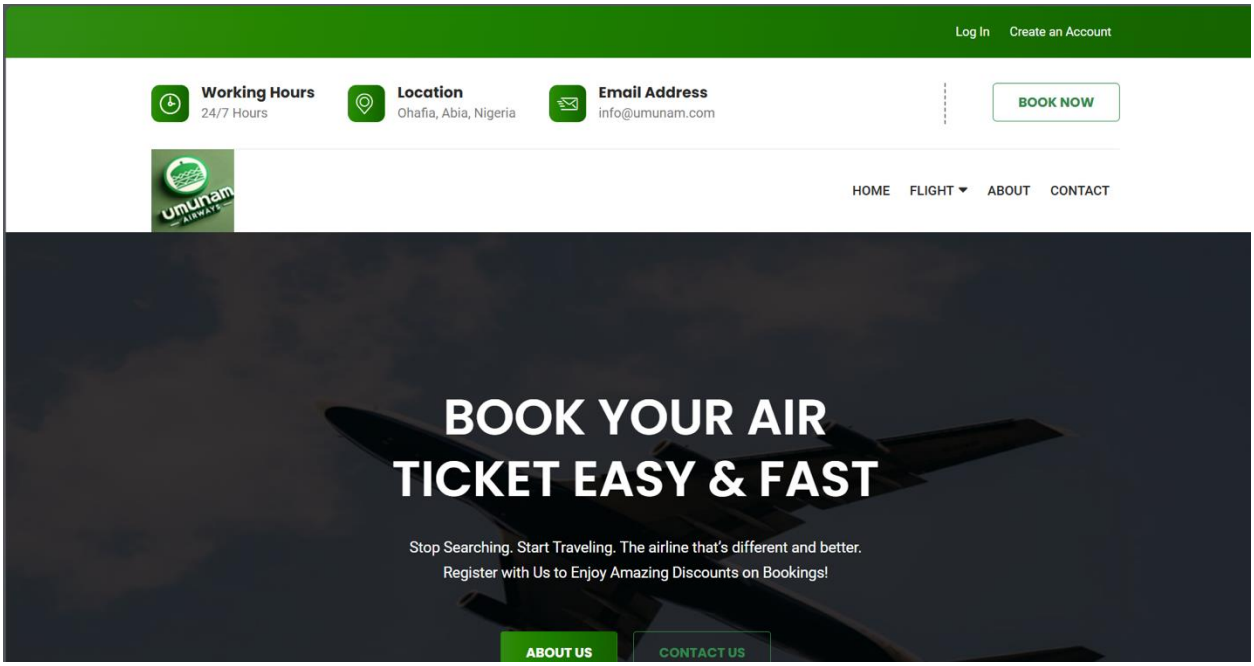


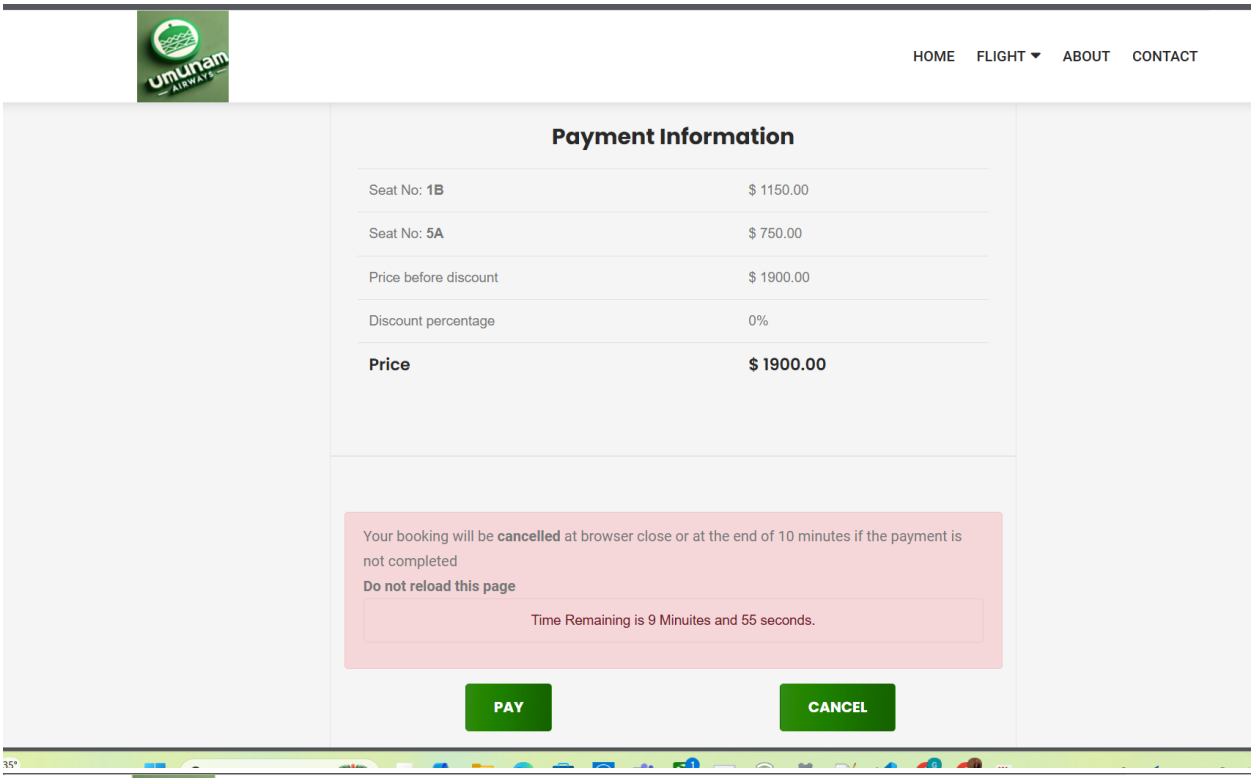
2) *Screenshots of database application:*

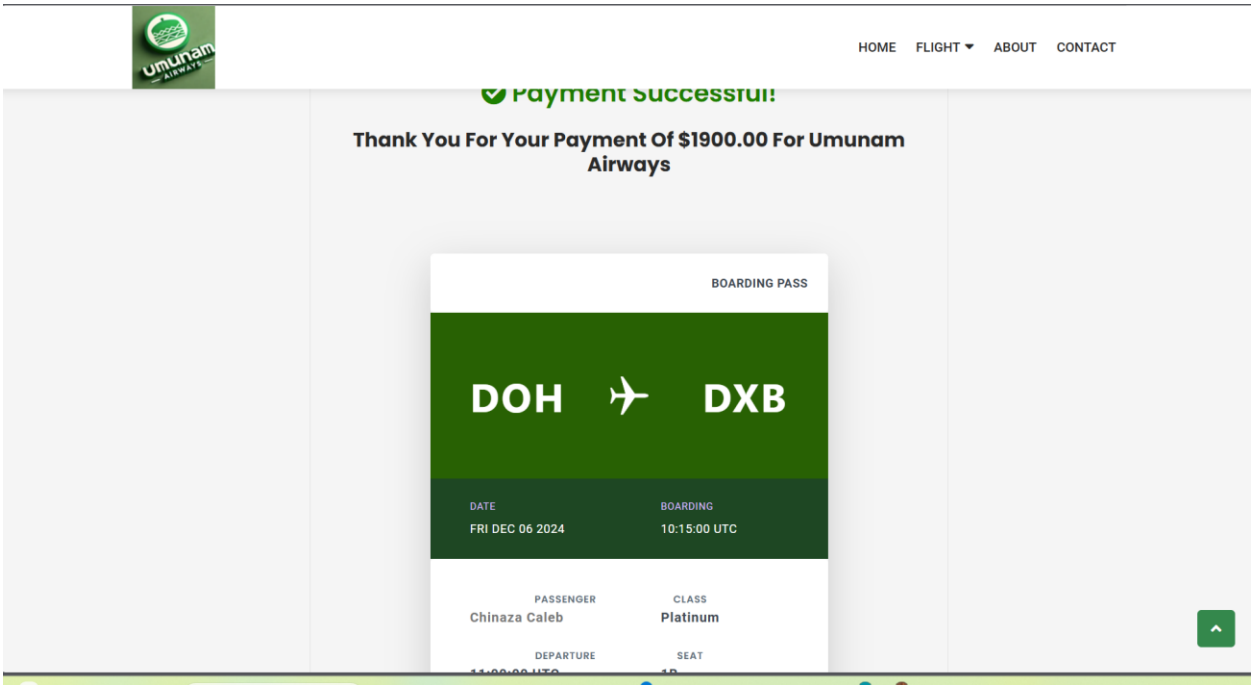


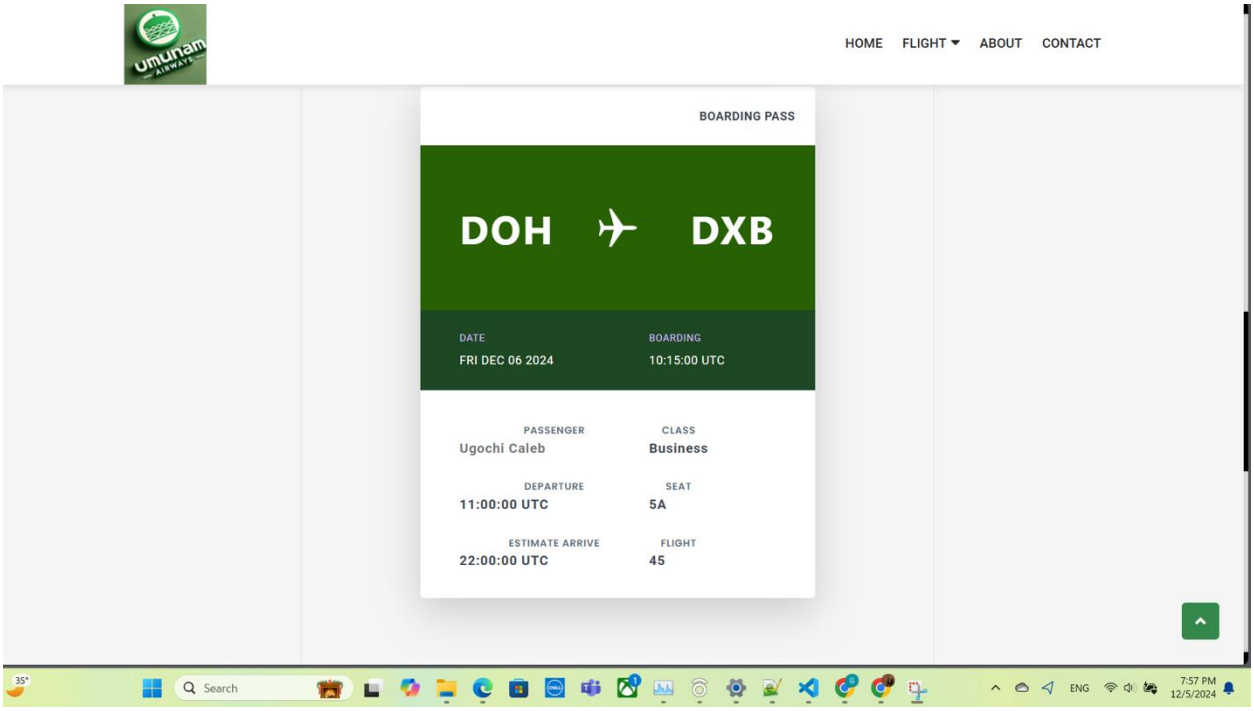


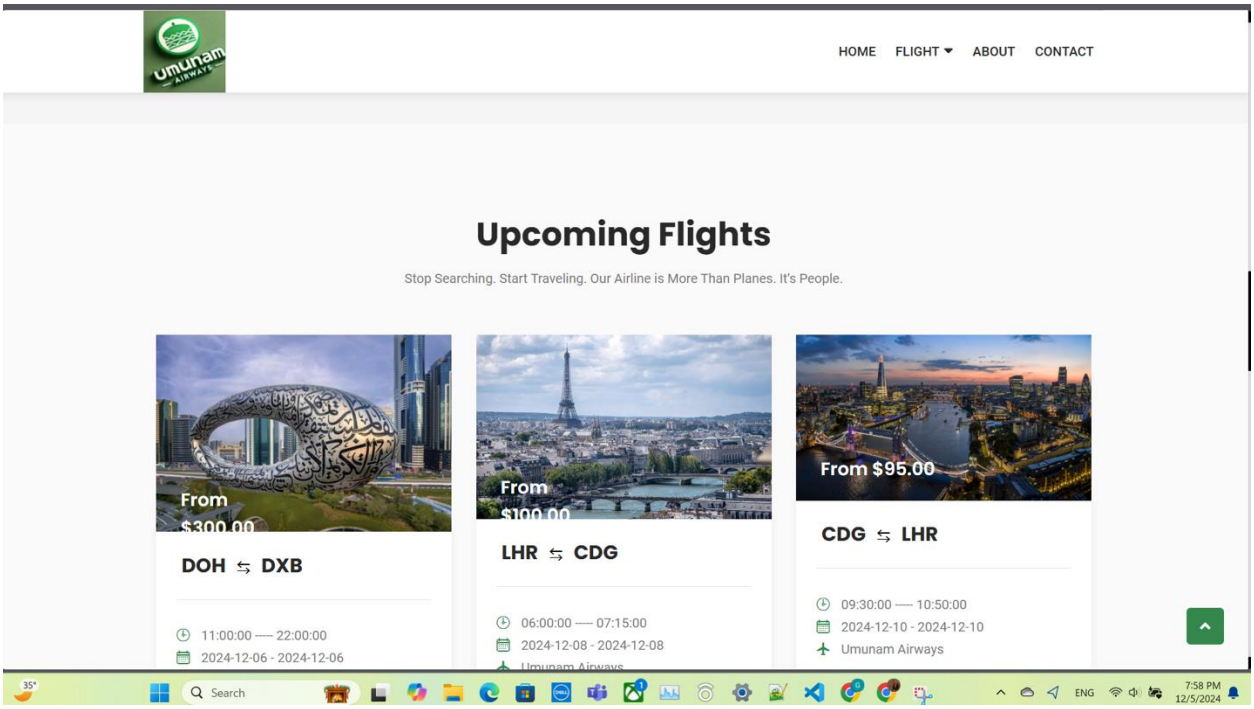

HOME
FLIGHT
ABOUT
CONTACT
--Select FROM Airport--
--Select TO Airport--
Departure Date
SEARCH
Current UTC Time:
FLIGHT
FROM
TAKEOFF IN UTC TIME
TO
LANDING IN UTC TIME
BOOK
R058
DOH
Fri Dec 06 11:00:00
DXB
Fri Dec 06 22:00:00
BOOK FLIGHT
R005
LHR
Sun Dec 08 06:00:00
CDG
Sun Dec 08 07:15:00
BOOK FLIGHT
R006
CDG
Tue Dec 10 09:30:00
LHR
Tue Dec 10 10:50:00
BOOK FLIGHT


Log In
Create an Account
Working Hours
24/7 Hours
Location
Ohafia, Abia, Nigeria
Email Address
info@umunam.com
BOOK NOW
HOME
FLIGHT
ABOUT
CONTACT
BOOK YOUR AIR
TICKET EASY & FAST
Stop Searching. Start Traveling. The airline that's different and better.
Register with Us to Enjoy Amazing Discounts on Bookings!
ABOUT US
CONTACT US


HOME
FLIGHT
ABOUT
CONTACT
Payment Information
Seat No: 1B
$ 1150.00
Seat No: 5A
$ 750.00
Price before discount
$ 1900.00
Discount percentage
0%
Price
$ 1900.00
Your booking will be cancelled at browser close or at the end of 10 minutes if the payment is not completed
Do not reload this page
Time Remaining is 9 Minuites and 55 seconds.
PAY
CANCEL


HOME
FLIGHT
ABOUT
CONTACT
Payment Successful!
Thank You For Your Payment Of $1900.00 For Umunam Airways
BOARDING PASS
DOH
DXB
DATE
FRI DEC 06 2024
BOARDING
10:15:00 UTC
PASSENGER
Chinaza Caleb
CLASS
Platinum
DEPARTURE
SEAT


HOME
FLIGHT
ABOUT
CONTACT
BOARDING PASS
DOH
DXB
DATE
FRI DEC 06 2024
BOARDING
10:15:00 UTC
PASSENGER
Ugochi Caleb
CLASS
Business
DEPARTURE
11:00:00 UTC
SEAT
5A
ESTIMATE ARRIVE
22:00:00 UTC
FLIGHT
45
Search
ENG
7:57 PM
12/5/2024


HOME
FLIGHT
ABOUT
CONTACT
Upcoming Flights
Stop Searching. Start Traveling. Our Airline is More Than Planes. It's People.
From $300.00
DOH ⇆ DXB
11:00:00 —— 22:00:00
2024-12-06 - 2024-12-06
From $100.00
LHR ⇆ CDG
06:00:00 —— 07:15:00
2024-12-08 - 2024-12-08
From $95.00
CDG ⇆ LHR
09:30:00 —— 10:50:00
2024-12-10 - 2024-12-10
Umunam Airways
Search
ENG
7:58 PM
12/5/2024