AIRPORT MANAGEMENT SYSTEM
DAMG6210-PROJECT GROUP2

DATABASE DESIGN DOCUMENT

Step 1: Introduction

The **Airport Management System database** is designed and developed to support and manage the critical operations that are involved in the airport activities. Our system addresses the need for effective flight scheduling, resource allocation and passenger management. The basic objective of our database is to ensure that all key areas of the airport's daily operations are properly documented, tracked, and managed.

Our system will handle flight details, bookings, boarding processes, ground support, and resource allocation such as runway and gate assignments. Above all, our system will also manage airport personnel, including airplane crew, ground staff, and security staff assignments, making sure that each part of the airport's activities/operations is/are effectively tracked and coordinated.

Our database will allow to perform the below operation(s):

- **Resource Management:** Managing parking, runways, gates, and ground support equipment.
- **Flight Management:** Managing flights, including runway usage and gate assignments.
- **Passenger Management:** Handling bookings, boarding passes, luggage check-ins and loyalty programs for passengers.
- **Employee Management:** Managing and tracking airport personnel, including ground staff, security staff, and airplane crew.

The whole aim of our system is to create an efficient, centralized platform for all airport management activities, allowing for smooth day-to-day operations, quick decision-making, and effective handling of any emergencies or disruptions.

Step 2: Business Problems Addressed

Our **Airport Management System** addresses various key business problems within the airport's daily operational environment. These problems varies from flight management to passenger services, and resource optimization to security deployment. Each section of the system is customised to solve specific issues that are common in day-to-day airport activities.

1. **Flight Management:**
    - **Problem:** Co-Ordinating flight departures and arrivals, runway usage and gate assignments.
    - **Solution:** Our System supports this by organising flight schedules, tracking them and assigns the runway/gates to ensure the smooth operations.
    - **Entities Involved : Flight, Gate, RunwayManagement, Aircraft.**
2. **Passenger Management:**
    - **Problem:** Managing Loyalty Programs, flight bookings, generating/issuing boarding passes and tracking luggage.
    - **Solution:** Our system will effectively manage flight bookings, automates check-ins processes and provides real-time updates of the flight status to the passengers to keep them updated. It also assists with tracking luggage and ensures smooth experience for the passengers
    - **Entities Involved: Passenger, FlightBooking, BoardingPass, Luggage, LoyaltyProgram**
3. **Employee Management:**
    - **Problem:** Assigning and tracking staff assignment of different roles, which includes airplane crew, ground staff, security staff.
    - **Solution:** Our system makes sure that the corresponding personnel are assigned to their dedicated areas such as airplane crew to airplane, ground staff to manage ground vehicle activities, security assignment.
    - **Entity(s) Involved: Employee (AirplaneStaff, GroundStaff, SecurityStaff –** This further subtypes you will see in later part of our project implementation)**.**

4. **Resource Management:**
    - **Problem:** Effectively managing runways, gate assignments and ground equipment, parking slot assignments.
    - **Solution:** Our system tracks and allocates these resources based on flight schedules and passenger needs, ensuring optimal utilization of the airport facilities and equipment.
    - **Entities Involved: Gate, RunwayManagement, Parking, GroundSupport.**
5. **Maintenance Management:**
    - **Problem:** Managing the aircraft and ground equipment support maintenance, ensuring safety and compliance with regulations.
    - **Solution:** Our system tracks all maintenance schedules, types of maintenance that is being carried out whether it is for aircraft or ground equipment. This makes sures that the equipment which are in use are operational and safe to use.
    - **Entities Involved: Aircraft, Maintenance, GroundSupport.**

The corresponding usage and links of the entities which are listed in the business problems sections are described in the entities and descriptions step.

Step 3: Entities and Descriptions

1. **Airport**
    - **Attributes:** AirportID, AirportName, Type, City, Area
    - **Description:** Represents the details of an airport, such as its name, location, and type (domestic or international). The airport serves as a hub for various operations like managing flights, resources, and employees.

2. **Flight**
    - **Attributes:** FlightID, SourceAirportID, DestinationAirportID, AirlineID, RunwayID, AircraftID, GateID, FlightNumber, FlightName, Capacity, DepartureTime, ArrivalTime, FlightPrice, FlightStatus, ActualArrivalTime, ActualDepartureTime, DelayReason
    - **Description:** Manages all information related to each flight, such as scheduling, capacity, status updates, and delays. This entity is central to flight management.

3. **FlightEmployeeAssignment**
   Attributes: FlightID, EmployeeID, AssignmentDate
   Description: The FlightEmployeeAssignment entity records the assignment of airplane staff to specific flights. It includes FlightID (reference to the associated flight) and EmployeeID (reference to the airplane staff assigned). The AssignmentDate indicates when the staff member was assigned to the flight, helping in tracking crew scheduling and ensuring compliance with staffing requirements.

4. **FlightBooking**
    - **Attributes:** TicketID, TicketNumber, PurchaseDate, FareClass, BookingStatus, TicketPrice
    - **Description:** Tracks ticket purchases and bookings made by passengers for flights. This entity links passengers to the flights they are booked on.

5. **Passenger**
    - **Attributes:** PassengerID, Name, Age, Nationality, CheckinStatus, CustomerFeedback
    - **Description:** Stores personal and travel information about passengers, including their check-in status and any feedback they provide about their experience.

6. **Phone**
   Attributes: PhoneSNo, PassengerID, PhoneType, PhoneNumber
   Description: The Phone entity manages contact details for passengers, storing multiple phone numbers (Home, Work, Mobile). It ensures efficient communication with passengers for updates and notifications.

7. **BoardingPass**
    - **Attributes:** BoardingPassID, SeatNumber, BoardingGroup, IssueTime
    - **Description:** Tracks details related to passengers' boarding passes, including seat assignments, boarding groups, and the time the boarding pass was issued.

8. **Luggage**
    - **Attributes:** LuggageID, NumberOfBags, Weight, Status, BaggageLocation
    - **Description:** Manages details about the luggage checked in by passengers, including the number of bags, their weight, and current location within the airport.

9. **Gate**
    - **Attributes:** GateID, GateNumber, Terminal, GateStatus
    - **Description:** Manages the assignment of gates to flights and their status, helping ensure flights are efficiently directed to the appropriate gates.

10. **RunwayManagement**
    - **Attributes:** RunwayID, RunwayNumber, OccupiedStatus
    - **Description:** Tracks the usage of runways, managing availability for take-off and landing to ensure smooth flight operations.
11. **Parking**
    - **Attributes:** ParkingID, SlotNumber, AvailabilityStatus ParkingFee
    - **Description:** Tracks the parking slots available at the airport for passengers, allowing for reservations and managing real-time availability.
12. **ParkingSlots**
    - **Attributes:** SlotNumber, AirportID, AvailabilityStatus
    - **Description:** The ParkingSlots entity manages information about parking spaces available at the airport. It includes AvailabilityStatus (indicating if a slot is 'Available' or 'Occupied'). This distinction helps in differentiating between general availability and pre-booked slots, aiding in better resource management.
13. **Aircraft**
    - **Attributes:** AircraftID, AircraftType, Capacity, MaintenanceStatus, FuelConsumption, AircraftAge
    - **Description:** Manages information related to the aircraft used by airlines, including their type, capacity, and maintenance records.
14. **Airline**
    - **Attributes:** AirlineID, AirlineName, Country
    - **Description:** Represents the airline companies operating flights out of the airport. Each airline is responsible for managing their own fleet and flights.

15. **LoyaltyProgram**
    - **Attributes:** LoyaltyID, LoyaltyPoints, LoyaltyStatus, EnrollmentDate
    - **Description:** Tracks passengers' loyalty program details, including the number of points accumulated and their status within the program.

16. **Employee (Supertype with Subtypes: AirplaneStaff, SecurityStaff, GroundStaff)**
    - **Attributes:** EmployeeID, FirstName, LastName, Salary, Employee_Type
    - **Description:** The Employee entity serves as a supertype for all personnel working at the airport. It represents general employee details while specific attributes and roles are handled by its subtypes:
        - **AirplaneStaff:** Included attributes like **LicenseNumber, YearsOfExperience, FlightHours, and MedicalClearance.** This subtype is linked with the **Specialization and Certification** tables for additional training and certification details.
        - **Specialization**
          Attributes: SpecializationID, EmployeeID, Specialization, CertificationDate
          Description: The Specialization entity provides details about additional training and expertise held by the airplane staff. It lists specific areas of specialization such as Pilot Training, Emergency Procedures, and Customer Service. This entity links to AirplaneStaff using EmployeeID and tracks the date of certification, ensuring that specialized skills are recorded and up-to-date.

- **Certification**
  Attributes: CertificationID, EmployeeID, CertificationLevel, IssueDate, ExpiryDate
  Description: The Certification entity records various certifications held by the airplane staff. It includes levels such as Pilot License, Safety Training, and Emergency Procedures. IssueDate and ExpiryDate attributes are used to manage certification validity, ensuring that all staff have current qualifications. This entity is directly linked to AirplaneStaff using EmployeeID.
- **SecurityStaff**
  Attributes: EmployeeID, AirportID, AssignedArea, SecurityClearanceLevel, TrainingCompleted, ShiftStart, ShiftEnd, Role
  Description: The SecurityStaff entity captures details of employees responsible for maintaining airport security. It includes specific attributes like AssignedArea (e.g., Terminal Security, Customs), SecurityClearanceLevel (Low, Medium, High, Top Secret), and shift timings (ShiftStart and ShiftEnd). This ensures proper scheduling and assignment of roles to handle security-related tasks effectively.

- **GroundStaff**
  Attributes: EmployeeID, AirportID, AssignedTasks, ShiftGroup
  Description: The GroundStaff entity manages information about employees who handle various ground operations. It tracks AssignedTasks (e.g., Equipment Operation, Maintenance Support) and ShiftGroup (e.g., A, B, C, D), ensuring efficient assignment of duties based on operational needs. The entity links directly to the general Employee table and maintains references to the associated airport.

17. **GroundSupport**
    - **Attributes:** EquipmentID, EquipmentType, GSM_Status, UsageDuration, MaintenanceFrequency
    - **Description:** Tracks the operational status and usage of ground support equipment, such as baggage carts and fuel trucks, ensuring that airport operations are fully supported.

18. **Maintenance**
    - **Attributes:** MaintenanceID, MaintenanceType, MaintenanceDate, MaintenanceDuration, Maintenance Status, NextScheduledMaintenance.
    - **Description:** Tracks maintenance events for aircraft and ground support equipment, ensuring that all maintenance activities are scheduled, completed, and monitored for compliance. This entity will play an key role in the operational readiness of all the airport resources.

We have mentioned a point in our scope document where we described that we will be displaying the flight status continuously for the convenience of the passengers. To achieve that **rather taking one more Entity called "NoticeBoard"** we prefer to **showcase it as a "VIEW" a concept** in database as we feel there are no unique attributes, we can list to this entity apart from "**NoticeID**" and remaining will be duplicated or fetched from **FlightDetails** entity.

In addition to this we have introduced attributes like **DelayReason, Actual Departure/Arrival Time, LoyaltyID, CustomerFeedback, FareClass, BookingStatus, TicketPrice, Usage Duration, MaintenanceFrequency, ParkingFee, FuelConsumption, AircraftAge** to generate analytics/reports like **Monthly Flight Punctuality Report, Passenger Report, Staff Utilization Report, Gate Utilization Report, Revenue by route, Maintenance Schedule Report, Passenger Feedback and Satisfaction Trends etc. to improve the airport activities**.

Step 4: Relationships between Entities

1. **Airport to Flight**:
   - **Relationship**: One-to-many.
   - **Explanation**: An airport can host many flights, but each flight departs from or arrives at one specific airport.

2. **Airport to Gate:**
   - **Relationship:** One-to-many.
   - **Explanation:** An airport manages multiple gates, but each gate is associated with one airport.

3. **Airport to RunwayManagement:**
   - **Relationship**: One-to-many.
   - **Explanation**: An airport has multiple runways, but each runway is assigned to one airport.

4. **Airport to Parking:**
   - **Relationship**: One-to-many.
   - **Explanation**: An airport offers many parking slots, but each parking slot belongs to one airport.

5. **Flight to FlightBooking:**
   - **Relationship**: One-to-many.
   - **Explanation**: A flight can have many bookings, but each booking is for one specific flight.

6. **Flight to Gate:**
   - **Relationship**: Many-to-one.
   - **Explanation**: Multiple flights can use the same gate, but each flight has one assigned gate.

7. **Flight to RunwayManagement:**
   - **Relationship**: Many-to-one.
   - **Explanation**: Multiple flights can use the same runway for take-off or landing, but each flight is assigned to one runway.

8. **Flight to Aircraft:**
   - **Relationship**: Many-to-one.
   - **Explanation**: Multiple flights can use the same aircraft, but each flight is assigned to one aircraft.

9. **Flight to FlightEmployeeAssignment (AirplaneStaff)**
   Relationship: Many-to-Many (via associative entity)
   Description: Each flight can have multiple airplane staff assigned, and each staff member can be assigned to multiple flights. This is managed through the FlightEmployeeAssignment entity.

10. **FlightBooking to Passenger:**
    - **Relationship:** Many-to-one.
    - **Explanation:** A passenger can make multiple flight bookings, but each booking is linked to one passenger.

11. **FlightBooking to BoardingPass:**
    - **Relationship:** One-to-one.
    - **Explanation:** Each flight booking generates one boarding pass, and each boarding pass is tied to a flight booking.

12. **BoardingPass to Gate:**
    - **Relationship:** Many-to-one.
    - **Explanation:** Multiple boarding passes can reference the same gate, but each boarding pass refers to one gate.

13. **Passenger to Luggage:**
    - **Relationship:** One-to-many.
    - **Explanation:** A passenger can check in multiple pieces of luggage, but each piece of luggage belongs to one passenger.

14. **Luggage to FlightBooking:**
    - **Relationship:** Many-to-one.
    - **Explanation:** Multiple pieces of luggage can be checked in for the same booking, but each luggage item is tied to one booking.

15. **Passenger to LoyaltyProgram:**
- **Relationship:** One-to-one.
- **Explanation:** A passenger can enrol in one loyalty program, and each loyalty program account is linked to one passenger.

16. **Passenger to Phone**
- **Relationship: One-to-Many**
- **Description:** A passenger can have multiple contact numbers recorded, such as home, work, and mobile numbers, tracked using the Phone entity.

17. **Employee to Airport (via Subtypes: SecurityStaff, GroundStaff)**
    - **Relationship:** Many-to-one.
    - **Explanation:** An airport employs multiple staff members, including security and ground support personnel. Each of these staff members is assigned to one specific airport.

18. **Employee to GroundSupport:**
    - **Relationship:** One-to-many.
    - **Explanation:** Ground support staff members are responsible for operating or maintaining ground support equipment.

19. **GroundSupport to Airport:**
    - **Relationship:** Many-to-one.
    - **Explanation:** Multiple ground support equipment items are assigned to one airport.

20. **Aircraft to Maintenance:**
    - **Relationship:** One-to-many.
    - **Explanation:** An aircraft can have multiple maintenance events, but each maintenance event is related to one specific aircraft. Maintenance activities cover both aircraft and ground support equipment, ensuring comprehensive monitoring.

21. **GroundSupport to Maintenance:**
    - **Relationship:** One-to-many.
    - **Explanation:** Ground support equipment can have multiple maintenance events, but each maintenance event is tied to one piece of equipment.
22. **GroundStaff to EquipmentAssignment**
    - **Relationship:** Many-to-Many (via associative entity)
    - **Description:** Ground staff can be assigned to multiple pieces of equipment, and each equipment item can be used by multiple staff members. This is managed through the EquipmentAssignment entity.
23. **Maintenance to Aircraft and GroundSupport**
    - **Relationship**: Many-to-One
    - **Description**: Each maintenance event is related to either an aircraft or a piece of ground support equipment, ensuring proper upkeep of both resources.
24. **ParkingSlots to Parking**
    - **Relationship:** One-to-Many
    - **Description:** A parking slot can be utilized multiple times by different parking records, tracking the usage history of each slot.
25. **AirportAirlineOperations to Airport and Airline**
    - **Relationship:** Many-to-One for both
    - **Description:** Each record in the AirportAirlineOperations entity is linked to one specific airport and one specific airline, detailing the contractual operations and terminal assignments.

Step 5: Key Database Decision(s):

1. **Maintaining Flight and Ticket Price Separately**
   - **Design Decision:** The price of the flight (in FlightDetails) is tracked separately from the ticket price (in FlightBooking).
   - **Reason:** This approach allows for dynamic pricing models, where ticket prices vary based on fare class, time of booking, and other factors. Keeping these prices separate enables more accurate financial reporting and data analysis.

2. **LoyaltyProgram as a Separate Entity**
   - **Design Decision:** We opted to keep LoyaltyProgram as a separate entity linked to PassengerInfo, rather than merging the data.
   - **Reason:** This decision allows passengers to enroll in a loyalty program independently from their booking details, which keeps the system flexible. It also helps avoid storing unnecessary loyalty data for passengers not enrolled in the program.

3. **Tracking Operational Status with GSM_Status and MaintenanceStatus**
   - **Design Decision:** We kept GSM_Status in GroundSupportInfo to reflect the real-time operational state of the equipment and MaintenanceStatus in MaintenanceInfo to track the steps of the maintenance process.
   - **Reason:** This separation ensures clarity in tracking both the current availability of equipment and its maintenance progress, making it easier to manage airport resources.

4. **Detailed Attributes for FlightDetails for Tracking Delays**
   - **Design Decision:** FlightDetails includes specific attributes such as ActualArrivalTime, ActualDepartureTime, and DelayReason to accurately track any delays in flight schedules.
   - **Reason:** These attributes enable the creation of reports that monitor flight punctuality, analyse common delay reasons, and help airlines and airports optimize flight schedules to minimize delays.

5. **Detailed Maintenance Tracking for Both Aircraft and Ground Equipment**
   - **Design Decision:** The MaintenanceInfo entity tracks Maintenance Date, Maintenance Type, Maintenance Duration, and NextScheduledMaintenance for both aircraft and ground support equipment.
   - **Reason:** This allows for generating maintenance reports, identifying patterns in equipment downtime, and scheduling preventative maintenance to avoid delays. Such reports are essential for safety compliance and operational efficiency.

6. **Parking Management through ParkingInfo**
   - **Design Decision:** ParkingInfo includes AvailabilityStatus, ReservedStatus, and ParkingFee, providing detailed data about parking operations at the airport.
   - **Reason:** These attributes enable reports on parking slot availability, usage patterns, and revenue from parking fees, helping to optimize parking space utilization and predict future demand.

7. **Tracking Loyalty Program Points and Status**
   - **Design Decision:** The LoyaltyProgram entity includes LoyaltyPoints and LoyaltyStatus, which can track passenger participation in loyalty programs.
   - **Reason:** These attributes enable the generation of reports on passenger loyalty, point accumulation, and redemption patterns. These reports can help the airport and airlines develop strategies to increase customer retention and reward frequent travellers.

8. **Baggage Tracking through the Luggage Entity**
   - **Design Decision:** Luggage includes attributes such as NumberOfBags, Weight, and BaggageLocation to track luggage throughout the airport.
   - **Reason:** These attributes allow the generation of reports that analyse luggage handling efficiency, lost baggage incidents, and baggage load distribution across flights. This can improve the luggage handling process and enhance the passenger experience.

9. **Employee Subtypes: AirplaneStaff, GroundStaff, and SecurityStaff**
    - **Design Decision:** Instead of maintaining a large Employee table with roles, we opted to create subtypes: AirplaneStaff, GroundStaff, and SecurityStaff.
    - **Reason:** This decision allows us to track employees in more detail, ensuring that the system is flexible enough to handle role-specific attributes (e.g., FlightID for airplane crew and ShiftInfo for ground and security staff). This prevents the Employee table from becoming overloaded with irrelevant information for certain roles.

Step6: Assumptions and Constraints:

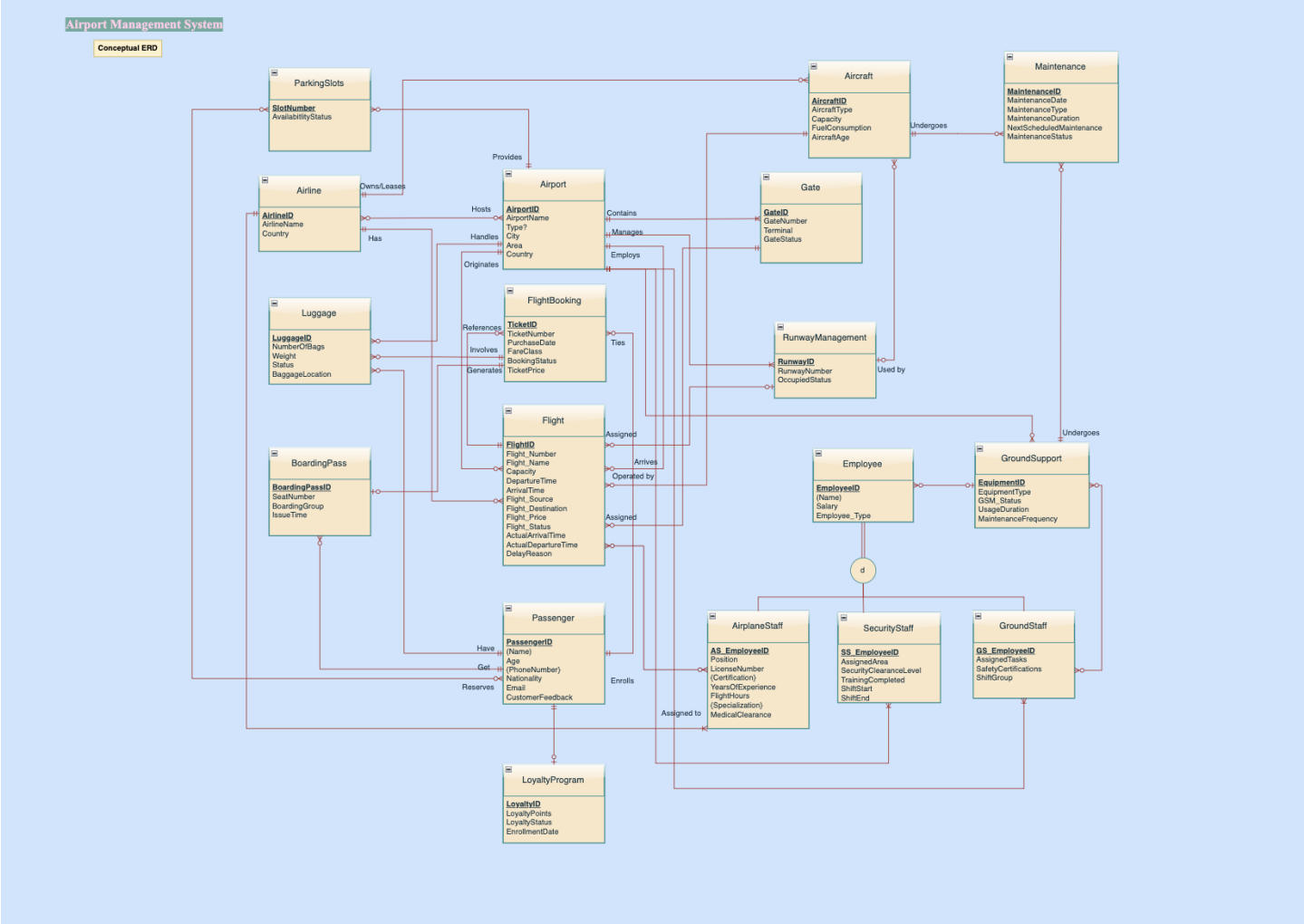
Assumptions:

- **Passenger Capacity**: Each flight has a maximum capacity of 300 passengers. This number was chosen based on average commercial airline seating capacities.
- **Flight Frequency**: Flights are expected to depart every 1 to 2 hours during peak times.
- **Maintenance Frequency**: Maintenance for both aircraft and ground support equipment occurs after every 500 flight hours or at monthly intervals, whichever comes first.
- **Shift Length**: Employees work in 8-hour shifts, except for **AirplaneStaff**, who are assigned based on flight schedules rather than shifts.

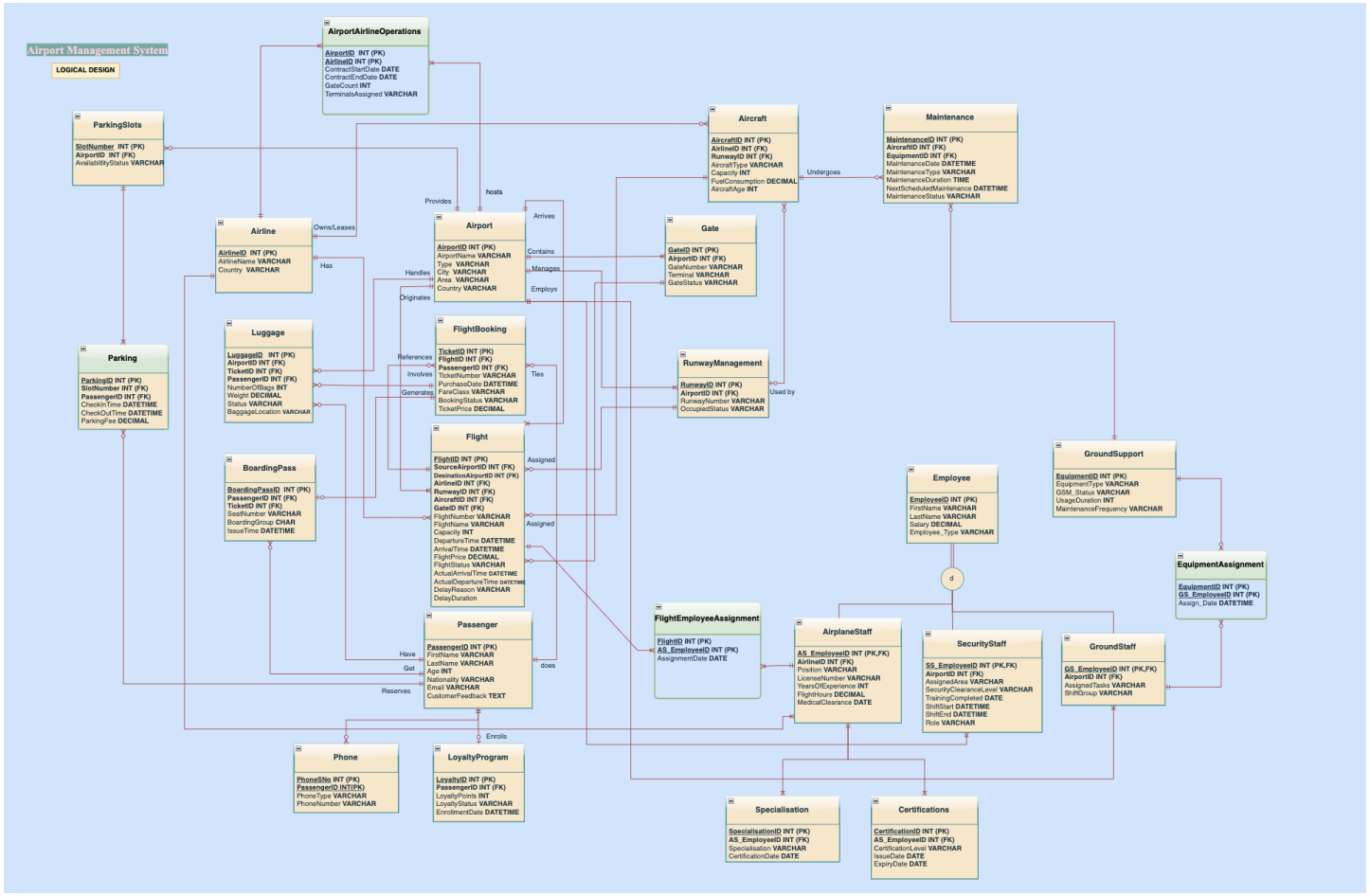
Constraints:

- **System Scalability**: The database should be able to handle at least 1,000 flights per day with approximately 100,000 passengers.
- **Resource Limitations**: There are a maximum of 50 gates and 5 runways available at the airport.
- **Performance**: The system should respond to passenger and employee queries (such as booking information or gate assignments) within less time during peak load hours.

Step 7: Conceptual ERD:

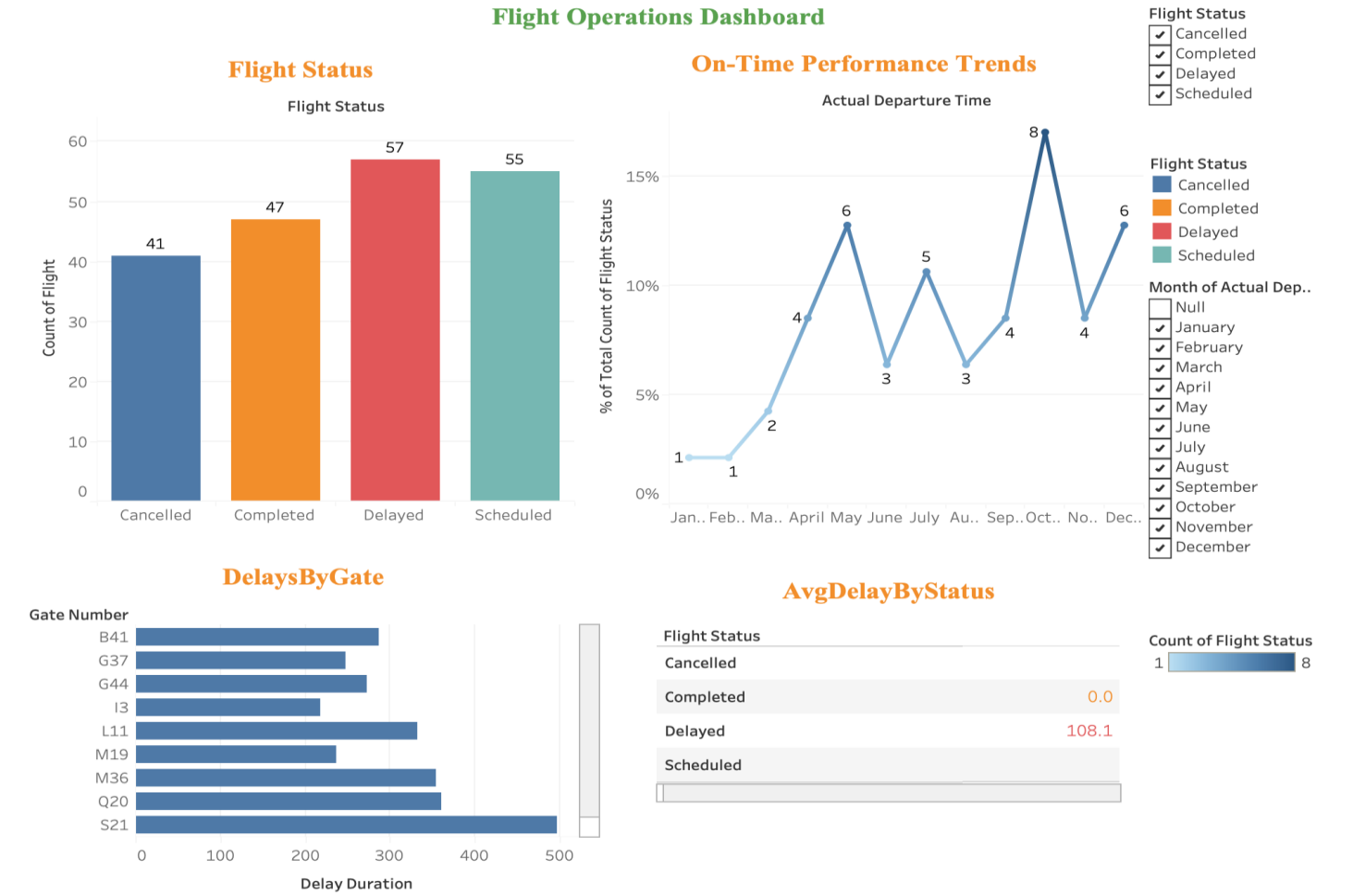


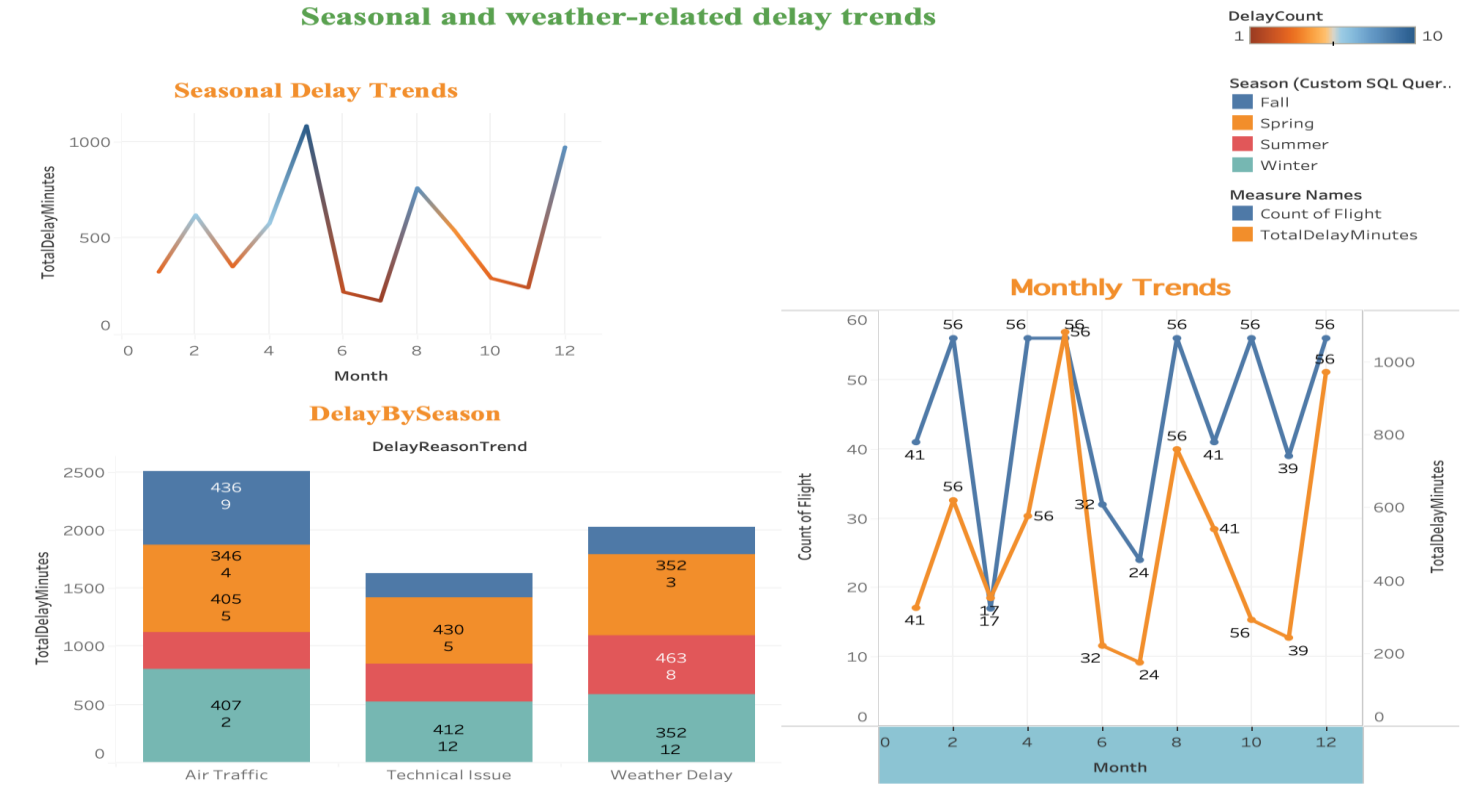
Step 8: Logical Design:



Step 9: Data Visualization Reports:

1. **Flight Operations Dashboard:**
   - Visualize flight statuses (Scheduled, Delayed, Cancelled, Completed) in real-time.
   - Top delayed routes and delay reasons (Weather Delay, Technical Issue, Air Traffic).
   - On-time performance trends over weeks/months.

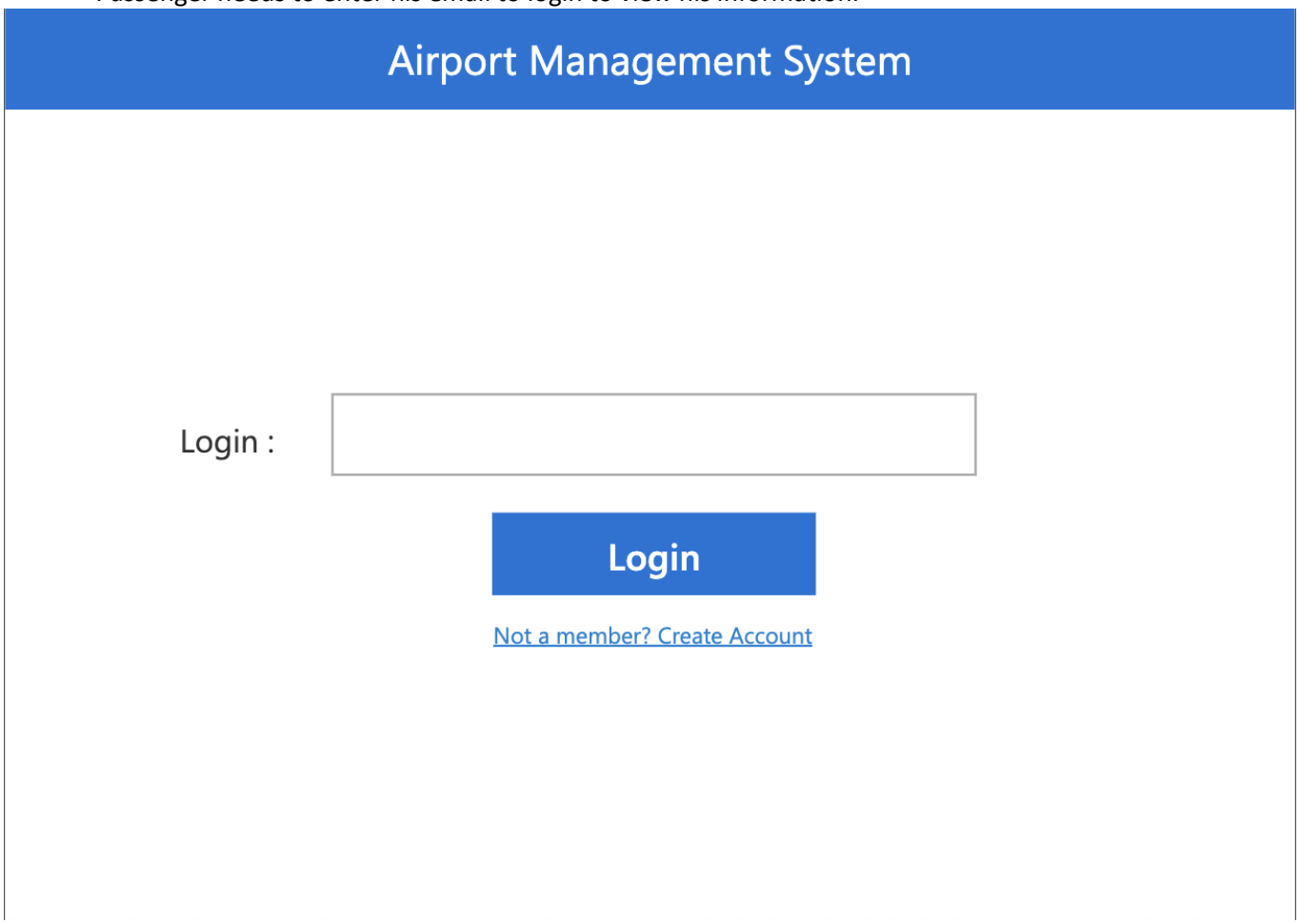




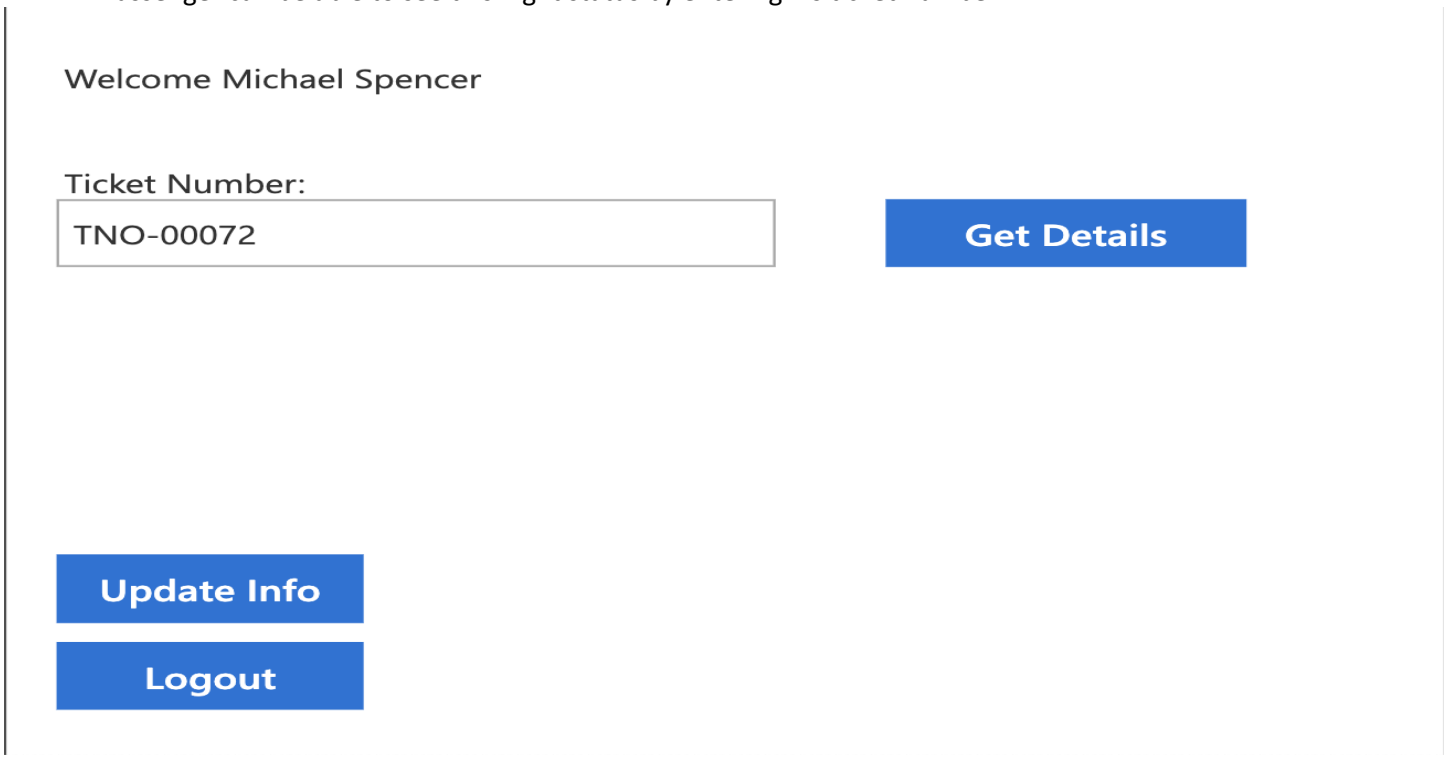
Step10: Application GUI:

- Basic Functionalities for Passenger Login has been implemented using PowerApps a Microsoft product.

1. **Login Screen:**
   Passenger needs to enter his email to login to view his information.



2. **Home Screen:**
   Passenger can be able to see this flight status by entering his ticket number.



3. **Ticket Information:**
   The details of the corresponding booking can be seen here.

Ticket Number: TNO-00072

FlightNumber	FromLocation	GateNumber	PassengerName
FL9252	South Gregorychester Airport	U10	Michael Spencer

<<BACK

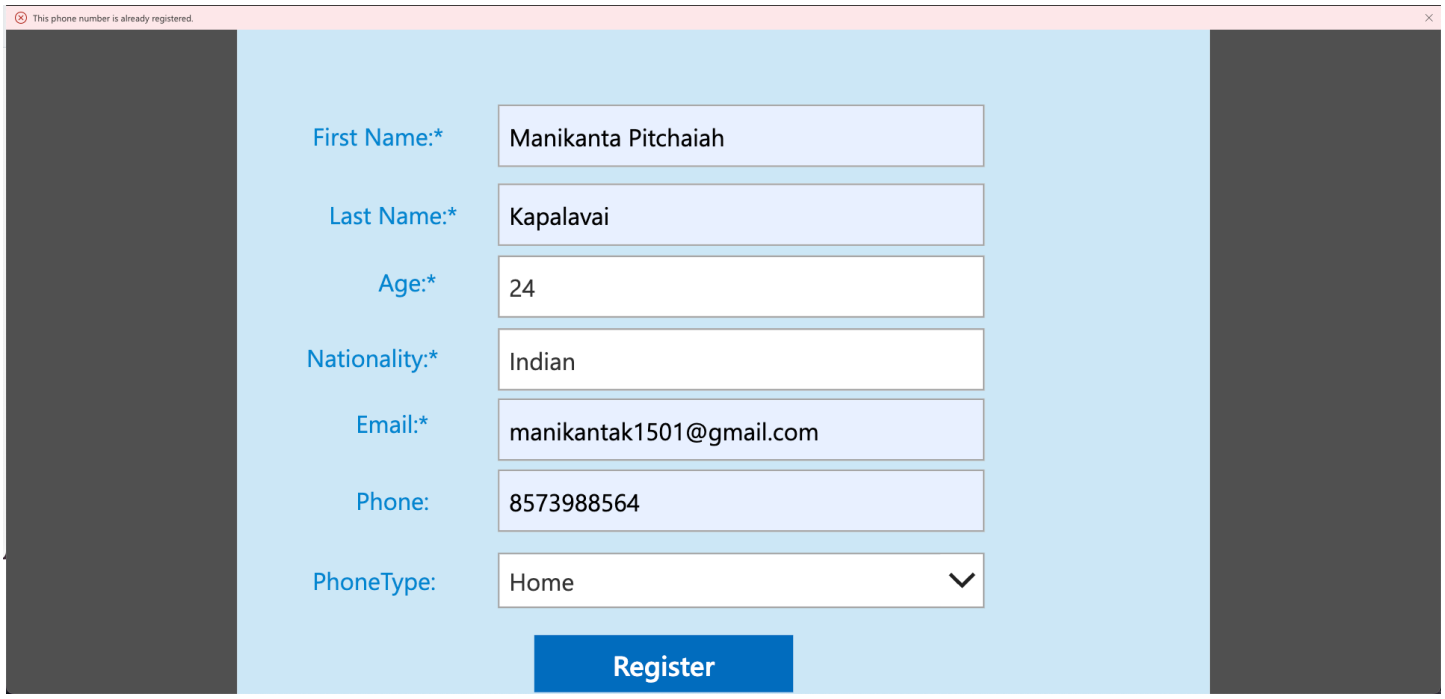
Ticket Number: TNO-00072

gerName	Terminal	TicketNumber	ToLocation	BookingStatus
pencer	Terminal 3	TNO-00072	East Andrew Airport	Confirmed

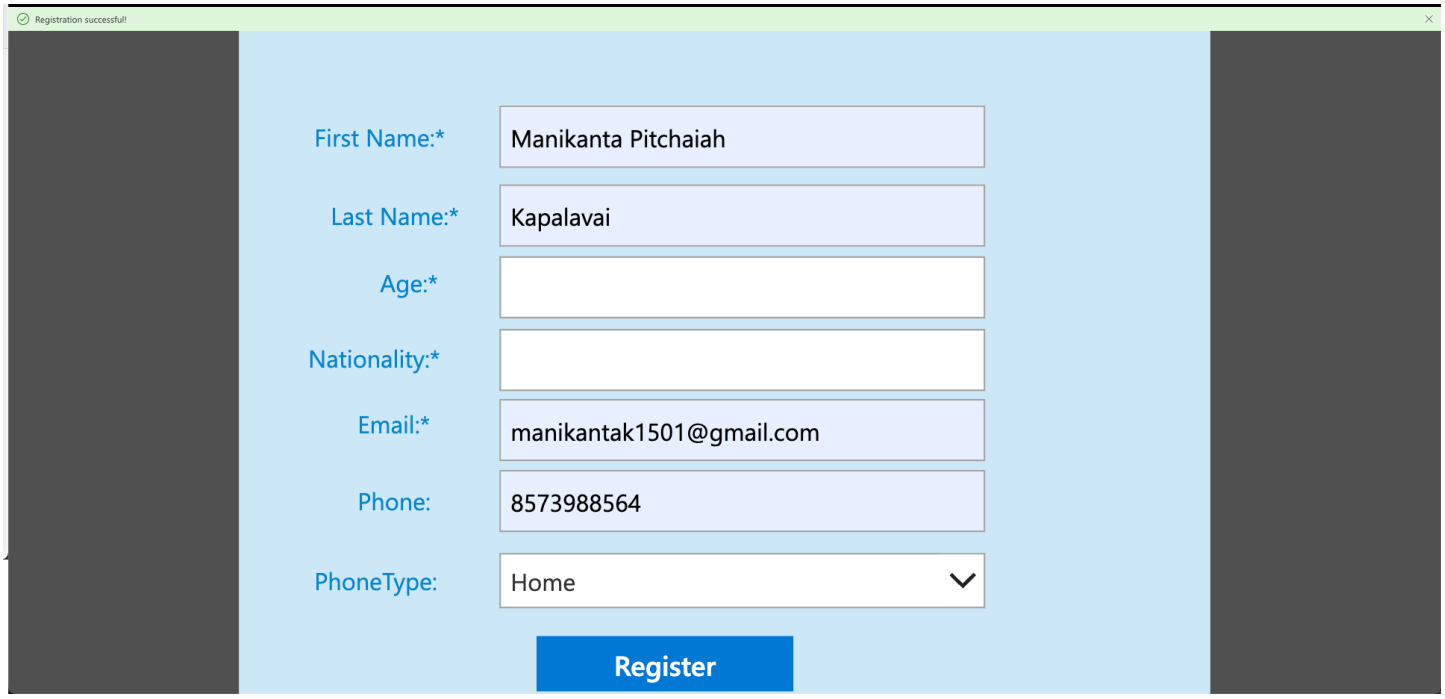
<<BACK

4. **Passenger Registration Screen:**
   Passenger can be able to register to our application to view his details on regular basis.

If already registered (Error will be thrown):



If phone number doesn't exist:



Step11: Create Schema and Implementation:

The SQL files required is present in the below git repository -
https://github.com/manikantakapalavai/DAMG6210-PROJECTGROUP2/tree/main

Step 12: Conclusion:

The Airport Management System database is designed to address the comprehensive needs of modern airport operations, ensuring seamless integration of flight management, passenger services, resource optimization, employee management, and maintenance tracking. This robust schema enhances operational efficiency, decision-making, and passenger experience.

Key highlights include:

1. **Flight Management**: Efficient tracking of schedules, gate assignments, and runway usage minimizes delays and optimizes resources.
2. **Passenger Management**: Flight booking, check-ins, and luggage handling streamline operations and improve customer convenience. Loyalty programs further enhance passenger retention.
3. **Resource Optimization**: Allocation of gates, runways, parking slots, and equipment ensures optimal utilization and readiness.
4. **Employee Management**: Role-specific tracking and assignment of staff ensure efficient deployment and regulatory compliance.
5. **Maintenance Management**: Comprehensive tracking of maintenance schedules ensures safety, compliance, and operational readiness for both aircraft and equipment.

The system is scalable to handle high volumes of daily flights and passengers while maintaining quick response times during peak periods. Detailed reports, such as flight punctuality, passenger satisfaction, staff utilization, and revenue analysis, provide actionable insights for improving airport operations and anticipating future needs.

Its modular design ensures flexibility for future enhancements and scalability for growing demands. By leveraging advanced database techniques, the system remains adaptable to evolving industry standards and passenger expectations. In conclusion, the Airport Management System database serves as a cornerstone for efficient, reliable, and customer-focused airport operations, addressing current challenges while providing a strong foundation for innovation and growth in the aviation industry.