Bus Reservation and Locator System

Software Design Specification

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1. Introduction

1.1. Purpose of Document

The purpose of this Software Design Specification (SDS) is to describe the detailed design of the **Bus Reservation and Locator System**.

- Overall architecture of the system
- Main components and their responsibilities
- Data model and database design
- Interaction between classes and modules
- Sequence of events for major features
- User interface structure
- Test case outline for system verification

This document will be used by:

- **Developers** – to implement frontend, backend, and database.
- **Testers** – to design and execute test cases.
- **Project Supervisor / Stakeholders** – to review and verify that design matches requirements.

1.2. Definitions, acronyms, and abbreviations

- **BRLS** – Bus Reservation and Locator System
- **SRS** – Software Requirements Specification
- **SDS** – Software Design Specification
- **GPS** – Global Positioning System
- **API** – Application Programming Interface
- **UI** – User Interface
- **UX** – User Experience
- **DB** – Database
- **SQL** – Structured Query Language
- **CRUD** – Create, Read, Update, Delete
- **User** – Passenger using the system to search, book, and track buses
- **Operator** – Bus company staff managing buses, routes, schedules
- **Admin** – System administrator managing users, operators, and overall system settings

2. Overall System Description

2.1. Project Background

In many cities, bus systems are still managed manually.

- No clear bus schedule
- No information about available seats
- No live updates about delays
- Long waiting time at bus stops

Bus operators find it difficult to:

- Manage routes and schedules efficiently
- Track bus status in real time
- Monitor seat utilization and bookings

To solve these issues, a **Bus Reservation and Locator System** is being developed as a **web and Android-based application**. It will allow passengers to book seats online and track buses using GPS, while operators can manage buses, routes, and bookings from a single platform.

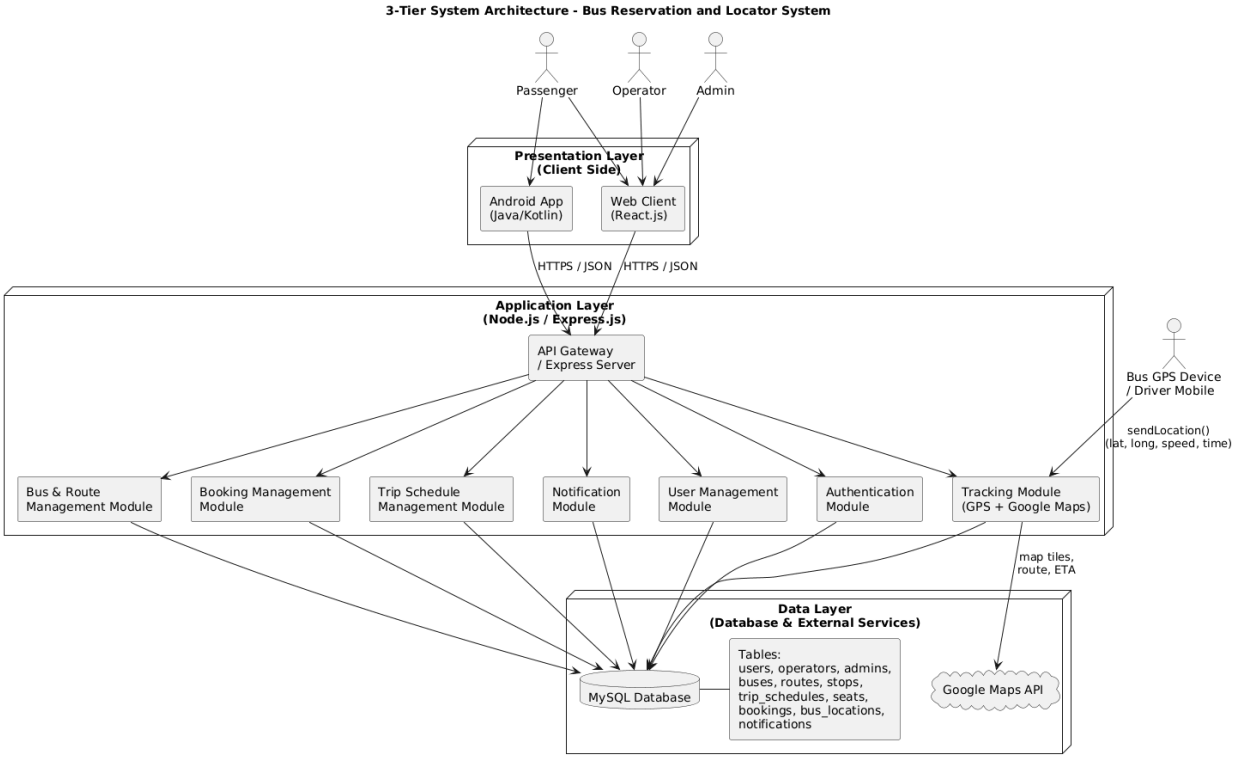
2.2. Project Objectives

The main objectives of the system are:

- To provide an easy and user-friendly platform for **online bus seat reservation**.
- To show **real-time bus location** using GPS and Google Maps API.
- To allow passengers to view **bus routes, timings, available seats**, and **expected arrival time**.
- To help operators manage **routes, schedules, bus status, and seat availability**.
- To reduce waiting time, improve convenience, and increase transparency in bus services.

3. System Architecture

- The system follows a **3-tier architecture**:
- **Presentation Layer (Client Side)**
  - Technologies:
    - **Frontend (Web):** React.js
    - **Data Fetching**: AJAX / Fetch API for asynchronous communication with backend APIs
    - **Mobile Application:** Android (Java/Kotlin)
    - **Maps & GPS Services:** Google Maps API + Bus GPS Device / Mobile GPS
    - **Authentication:** JWT-based login system
  - Responsible for:
    - Displaying UI to the user
    - Taking user input (login, search, booking, tracking)
    - Calling backend APIs over HTTP/HTTPS
- **Application Layer (Server Side / Backend)**
  - Technology: **Node.js** (Express.js)
  - Responsible for:
    - Implementing business logic (searching buses, checking seat availability, creating bookings)
    - Validating user inputs
    - Managing authentication and authorization using **JWT**
    - Communicating with database and third-party APIs (Google Maps)
- **Data Layer (Database & External Services)**
  - Technology: **MySQL** (SQL Database)
  - Stores:
    - Users, Operators, Admins
    - Buses, Routes, Stops
    - Schedules / Trips
    - Bus Locations (GPS coordinates, speed, timestamp)
  - External Service:
    - **Google Maps API** for map display and GPS tracking
    - GPS device or mobile app on bus to send location data
    - **Motion Sensor** Detects whether the bus is moving or stationary (optional enhancement for Android GPS mode)
- **High-Level Components**
- **Frontend Screens (React / Android)**
  - Login / Sign Up
  - Search Bus Screen
  - Seat Selection Screen
  - Booking Confirmation Screen
  - Bus Tracking Map Screen
  - Operator Dashboard
  - Admin Panel
- **Backend Modules (Node JS)**
  - Authentication Module
  - User Management Module
  - Bus & Route Management Module
  - Booking Management Module
  - Trip Schedule Management Module
  - Tracking Module (GPS data processing + Google Maps API integration)
  - Notification Module
- **Database**
  - Tables for: users, operators, buses, routes, bus stops, trip schedules, seats, bookings, bus locations, notifications.


3-Tier System Architecture - Bus Reservation and Locator System
Passenger
Operator
Admin
Presentation Layer
(Client Side)
Android App
(Java/Kotlin)
Web Client
(React.js)
HTTPS / JSON
HTTPS / JSON
Application Layer
(Node.js / Express.js)
API Gateway
/ Express Server
Bus GPS Device
/ Driver Mobile
sendLocation()
(lat, long, speed, time)
Bus & Route
Management Module
Booking Management
Module
Trip Schedule
Management Module
Notification
Module
User Management
Module
Authentication
Module
Tracking Module
(GPS + Google Maps)
map tiles,
route, ETA
Data Layer
(Database & External Services)
MySQL Database
Tables:
users, operators, admins,
buses, routes, stops,
trip_schedules, seats,
bookings, bus_locations,
notifications
Google Maps API

4. Domain Model

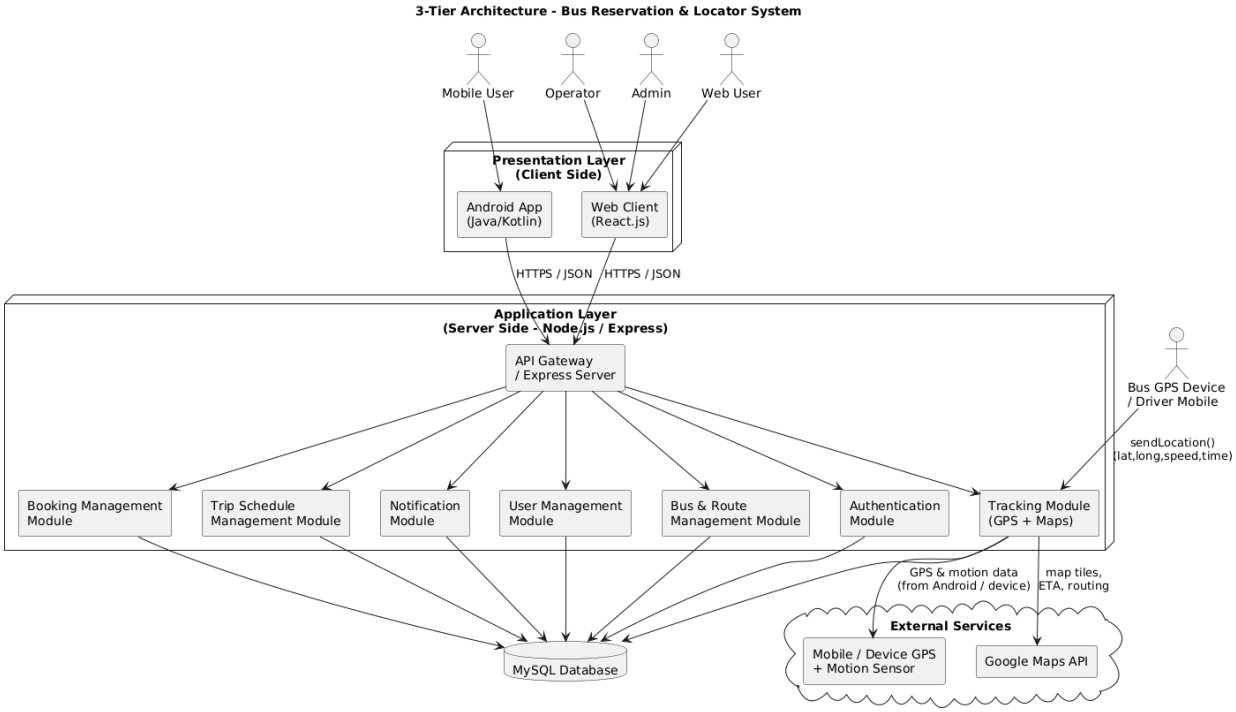
The domain model represents main **real-world entities** and their relationships.

Main Entities:

- **User (Passenger)**
  - Attributes: userId, name, email, phone, passwordHash, role, createdAt
- **Operator**
  - Attributes: operatorId, name, contactInfo, companyName, status
- **Admin**
  - Attributes: adminId, name, email, passwordHash
- **Bus**
  - Attributes: busId, busNumber, registrationNumber, capacity, operatorId, status
- **Route**
  - Attributes: routeId, routeName, source, destination, totalDistance, approxDuration
- **BusStop**
  - Attributes: stopId, stopName, latitude, longitude, sequenceNumber, routeId
- **TripSchedule (or Trip / Journey)**
  - Attributes: tripId, busId, routeId, departureTime, arrivalTime, date, status
- **Seat**
  - Attributes: seatId, busId, seatNumber
- **Booking**
  - Attributes: bookingId, userId, tripId, seatId, bookingTime, status (Booked/Cancelled)
- **BusLocation**
  - Attributes: locationId, busId, latitude, longitude, speed, timestamp
- **Notification**
  - Attributes: notificationId, userId, message, type, createdAt, isRead

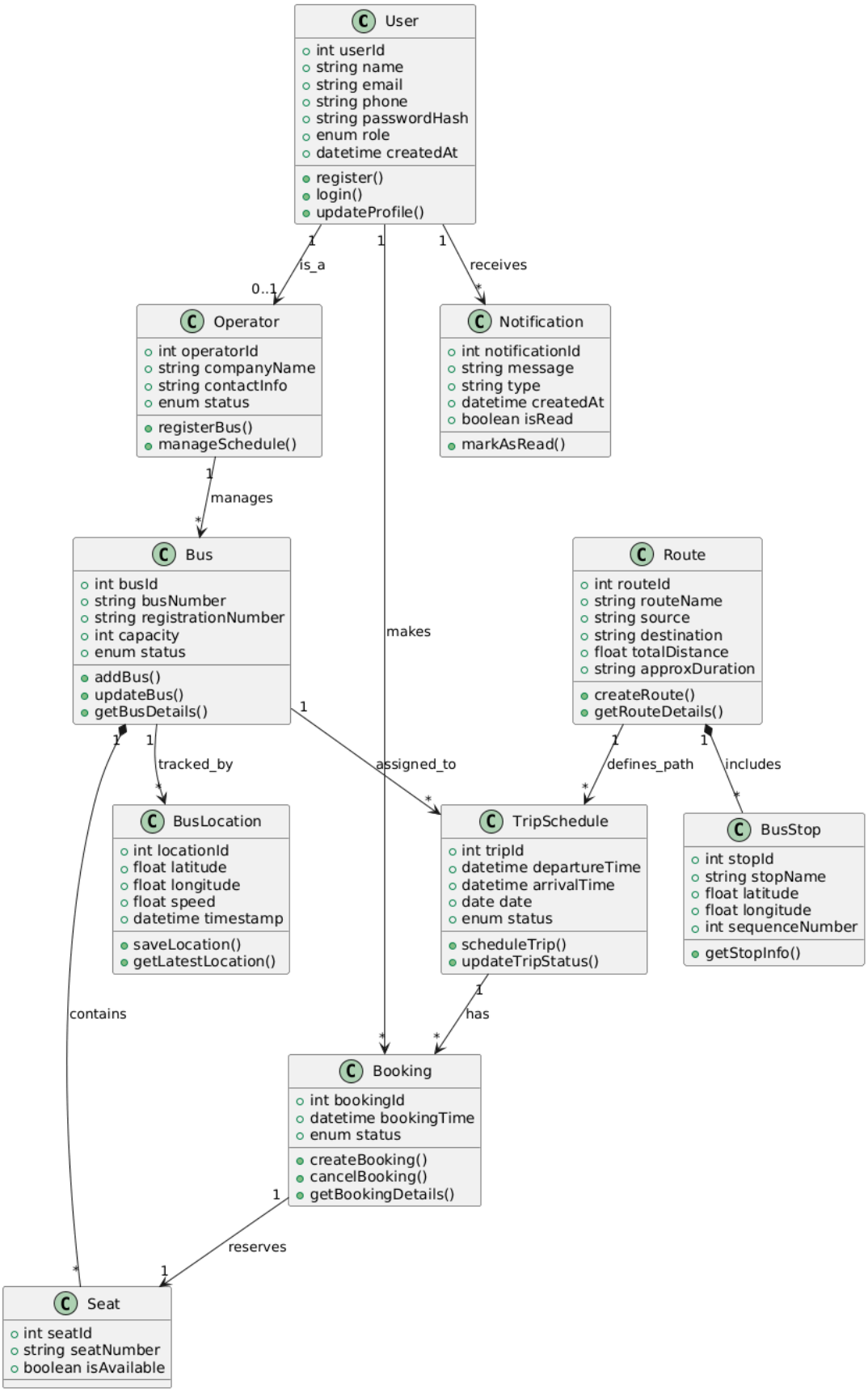
Relationships (Conceptually):

- A **User** can make **many Bookings**.
- A **Bus** belongs to one **Operator** but can have many **TripSchedules**.
- A **Route** has many **BusStops**.
- A **TripSchedule** uses one **Bus** and one **Route**.
- A **TripSchedule** has many **Bookings**.
- A **Bus** has many **Seats**.
- A **Bus** has many **BusLocation** entries over time.


3-Tier Architecture - Bus Reservation & Locator System
Mobile User
Operator
Admin
Web User
Presentation Layer
(Client Side)
Android App
(Java/Kotlin)
Web Client
(React.js)
HTTPS / JSON
HTTPS / JSON
Application Layer
(Server Side - Node.js / Express)
API Gateway
/ Express Server
Bus GPS Device
/ Driver Mobile
sendLocation()
(lat,long,speed,time)
Booking Management
Module
Trip Schedule
Management Module
Notification
Module
User Management
Module
Bus & Route
Management Module
Authentication
Module
Tracking Module
(GPS + Maps)
GPS & motion data
(from Android / device)
map tiles,
ETA, routing
External Services
Mobile / Device GPS
+ Motion Sensor
Google Maps API
MySQL Database

5. Class Diagram

- **User**
  Represents all system users (Passenger, Operator, Admin).
  Stores personal and login information and provides basic operations such as registration and login.
- **Operator (inherits User)**
  Extends User with operator-specific details such as company information and status.
  Responsible for managing buses and trip schedules.
- **Notification**
  Stores system messages sent to users (e.g., delay, cancellation).
  Each user can receive multiple notifications.
- **Bus**
  Represents a physical bus with capacity and operational status.
  Managed by an operator and linked with trip schedules.
- **BusLocation**
  Stores the latest GPS coordinates of a bus (latitude, longitude, speed, timestamp).
  Used for real-time tracking.
- **Route**
  Defines the path from a source to a destination along with distance and duration.
  Consists of multiple bus stops.
- **BusStop**
  Represents a stop along a route, including its sequence number and coordinates.
- **TripSchedule**
  Describes a scheduled trip for a specific bus on a given route and date.
  Contains departure/arrival times and trip status.
- **Seat**
  Represents an individual seat in a bus.
  Each bus contains multiple seats that can be reserved.
- **Booking**
  Links the user, trip schedule, and seat together to form a reservation.
  Stores booking time and status (Booked/Cancelled).


User
int userId
string name
string email
string phone
string passwordHash
enum role
datetime createdAt
register()
login()
updateProfile()
is_a
receives
Operator
int operatorId
string companyName
string contactInfo
enum status
registerBus()
manageSchedule()
Notification
int notificationId
string message
string type
datetime createdAt
boolean isRead
markAsRead()
manages
Bus
int busId
string busNumber
string registrationNumber
int capacity
enum status
addBus()
updateBus()
getBusDetails()
makes
Route
int routeId
string routeName
string source
string destination
float totalDistance
string approxDuration
createRoute()
getRouteDetails()
tracked_by
assigned_to
defines_path
includes
BusLocation
int locationId
float latitude
float longitude
float speed
datetime timestamp
saveLocation()
getLatestLocation()
TripSchedule
int tripId
datetime departureTime
datetime arrivalTime
date date
enum status
scheduleTrip()
updateTripStatus()
BusStop
int stopId
string stopName
float latitude
float longitude
int sequenceNumber
getStopInfo()
contains
has
Booking
int bookingId
datetime bookingTime
enum status
createBooking()
cancelBooking()
getBookingDetails()
reserves
Seat
int seatId
string seatNumber
boolean isAvailable

6. Database Diagram

Database Diagram will illustrate table relationships aligned with the ERD

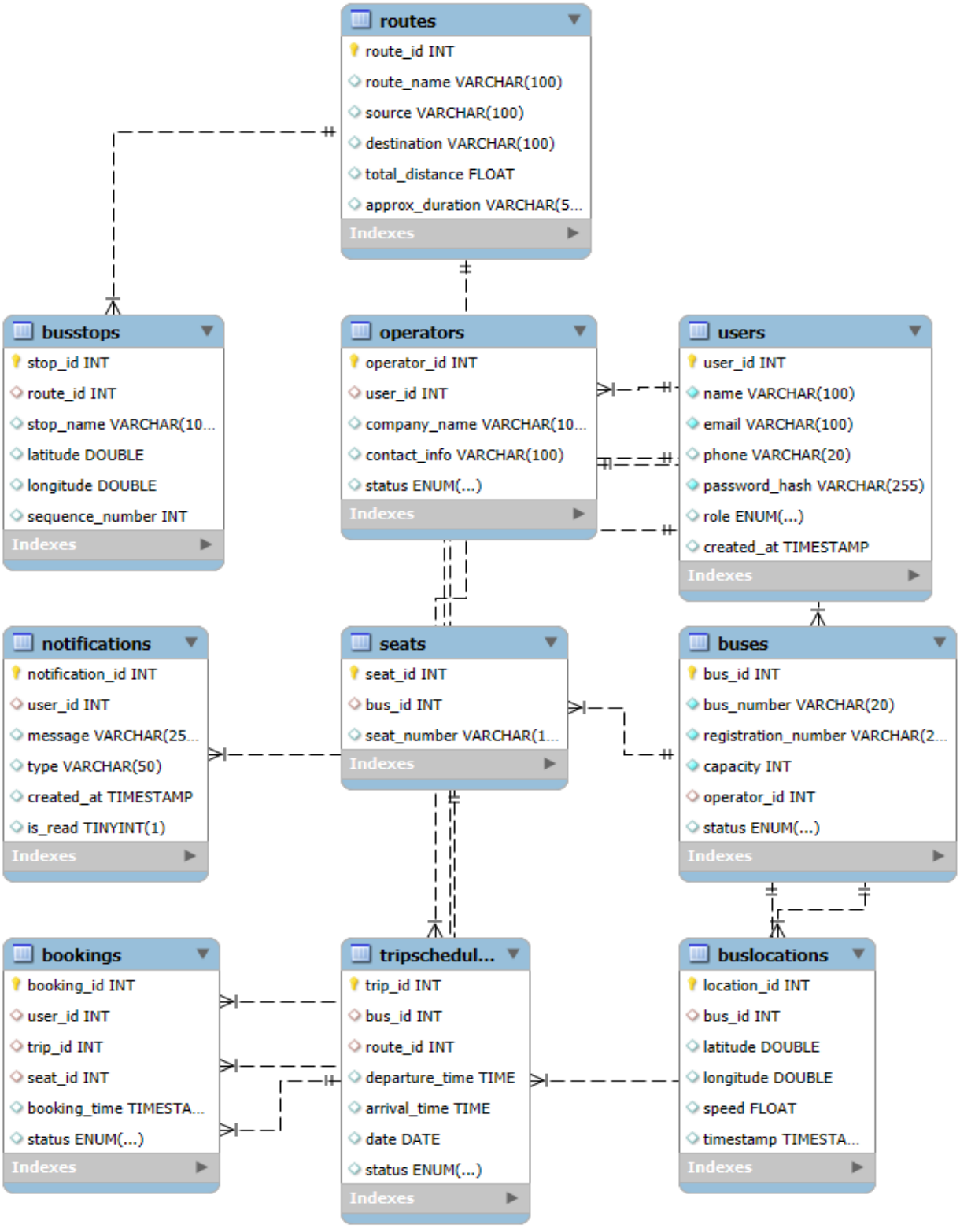
7. Entity Relationship Diagram (ERD)

The main entities are:

- **User** (userId PK) – passenger who searches, books, and tracks buses.
- **Operator** (operatorId PK) – manages buses, routes, and schedules.
- **Bus** (busId PK, operatorId FK → Operator) – physical bus with a specific capacity.
- **Route** (routeId PK) – defines source, destination, and overall path.
- **Bus Stop** (stopId PK, routeId FK → Route) – individual stops on a route.
- **TripSchedule** (tripId PK, busId FK → Bus, routeId FK → Route) – one scheduled trip of a bus on a route at a particular date/time.
- **Seat** (seatId PK, busId FK → Bus) – individual seat on a bus.
- **Booking** (bookingId PK, userId FK → User, tripId FK → TripSchedule, seatId FK → Seat) – reservation of a specific seat on a specific trip for a user.
- **BusLocation** (locationId PK, busId FK → Bus) – GPS positions of a bus over time.
- **Notification** (notificationId PK, userId FK → User) – messages sent to users about bookings, delays, etc.

Main relationships:

- **User – Booking:** one User (1) can have many Bookings (N).
- **Bus – TripSchedule:** one Bus (1) can be assigned to many TripSchedules (N).
- **Route – TripSchedule:** one Route (1) can have many TripSchedules (N).
- **Route – Bus Stop:** one Route (1) contains many BusStops (N).
- **TripSchedule – Booking:** one TripSchedule (1) can have many Bookings (N).
- **Bus – Seat:** one Bus (1) has many Seats (N).
- **Bus – BusLocation:** one Bus (1) has many BusLocation records (N) over time.


routes
route_id INT
route_name VARCHAR(100)
source VARCHAR(100)
destination VARCHAR(100)
total_distance FLOAT
approx_duration VARCHAR(5...
Indexes
busstops
stop_id INT
route_id INT
stop_name VARCHAR(10...
latitude DOUBLE
longitude DOUBLE
sequence_number INT
Indexes
operators
operator_id INT
user_id INT
company_name VARCHAR(10...
contact_info VARCHAR(100)
status ENUM(...)
Indexes
users
user_id INT
name VARCHAR(100)
email VARCHAR(100)
phone VARCHAR(20)
password_hash VARCHAR(255)
role ENUM(...)
created_at TIMESTAMP
Indexes
notifications
notification_id INT
user_id INT
message VARCHAR(25...
type VARCHAR(50)
created_at TIMESTAMP
is_read TINYINT(1)
Indexes
seats
seat_id INT
bus_id INT
seat_number VARCHAR(1...
Indexes
buses
bus_id INT
bus_number VARCHAR(20)
registration_number VARCHAR(2...
capacity INT
operator_id INT
status ENUM(...)
Indexes
bookings
booking_id INT
user_id INT
trip_id INT
seat_id INT
booking_time TIMESTA...
status ENUM(...)
Indexes
tripschedul...
trip_id INT
bus_id INT
route_id INT
departure_time TIME
arrival_time TIME
date DATE
status ENUM(...)
Indexes
buslocations
location_id INT
bus_id INT
latitude DOUBLE
longitude DOUBLE
speed FLOAT
timestamp TIMESTA...
Indexes

8. Sequence Diagram

8.1 Sequence Diagram – Search and Book Bus

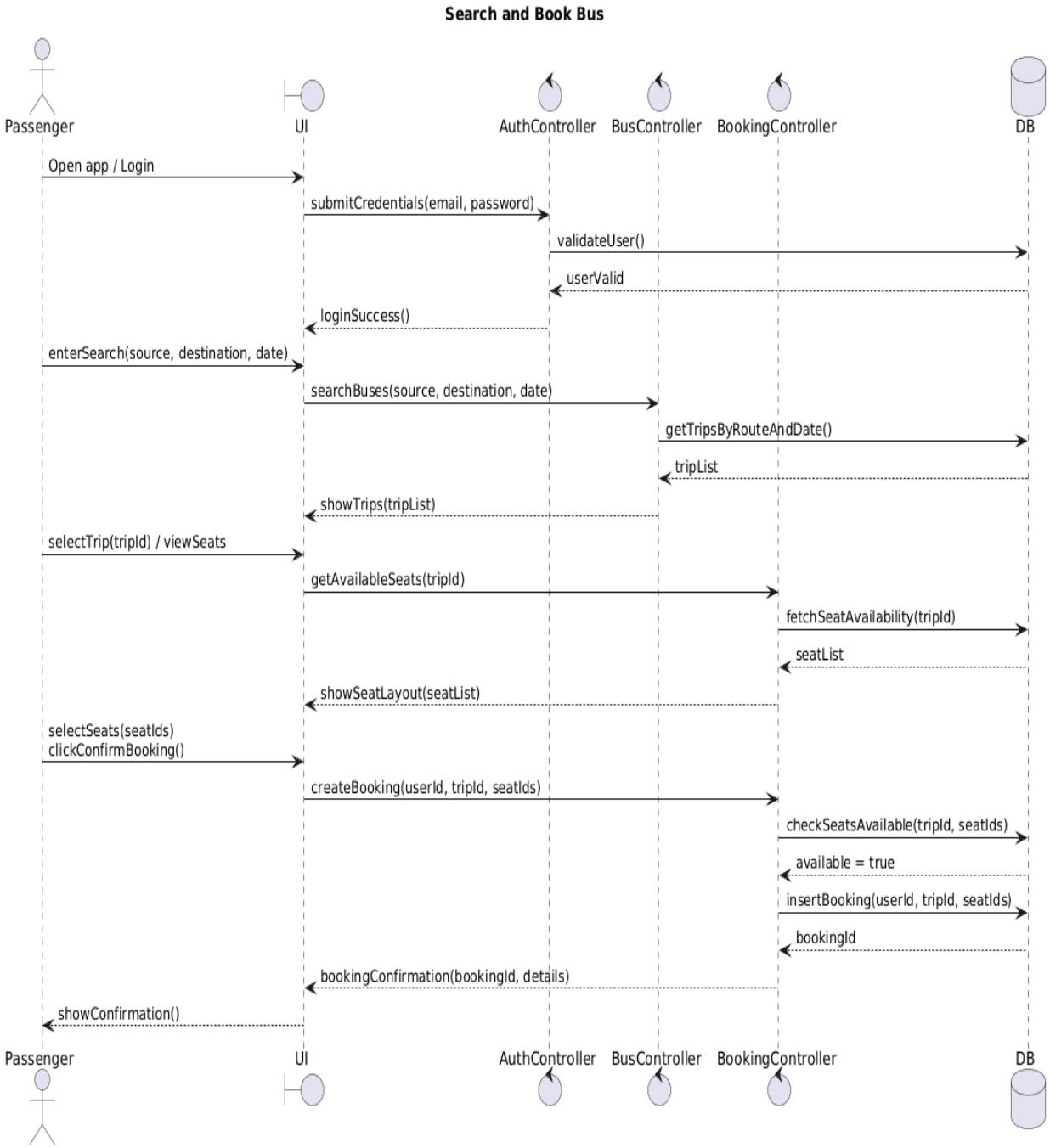
Description:
This sequence diagram shows how a passenger searches for available buses and completes a seat booking.

Participants (lifelines):

- Passenger
- UI (Web / Mobile)
- AuthController
- BusController
- BookingController
- Database

Main message flow (summary):

1. Passenger selects **Login** → UI sends credentials to **AuthController** → AuthController validates with **Database** and returns success.
2. Passenger enters **source, destination, date** and clicks **Search** → UI sends request to **BusController**.
3. BusController queries **Database** for matching TripSchedule records and returns list to UI.
4. Passenger selects a trip and chooses **View Seats / Book** → UI requests seat availability from **BookingController**.
5. BookingController reads seat status for that trip from **Database** and returns seat layout to UI.
6. Passenger selects seat(s) and presses **Confirm Booking** → UI sends booking details to **BookingController**.
7. BookingController re-checks availability in **Database**, creates a Booking record and updates seat status.
8. BookingController returns **booking confirmation** (Booking ID, details) to UI, which is shown to the passenger.


Search and Book Bus
Passenger
UI
AuthController
BusController
BookingController
DB
Open app / Login
submitCredentials(email, password)
validateUser()
userValid
loginSuccess()
enterSearch(source, destination, date)
searchBuses(source, destination, date)
getTripsByRouteAndDate()
tripList
showTrips(tripList)
selectTrip(tripId) / viewSeats
getAvailableSeats(tripId)
fetchSeatAvailability(tripId)
seatList
showSeatLayout(seatList)
selectSeats(seatIds)
clickConfirmBooking()
createBooking(userId, tripId, seatIds)
checkSeatsAvailable(tripId, seatIds)
available = true
insertBooking(userId, tripId, seatIds)
bookingId
bookingConfirmation(bookingId, details)
showConfirmation()

8.2 Sequence Diagram – Real-Time Bus Tracking

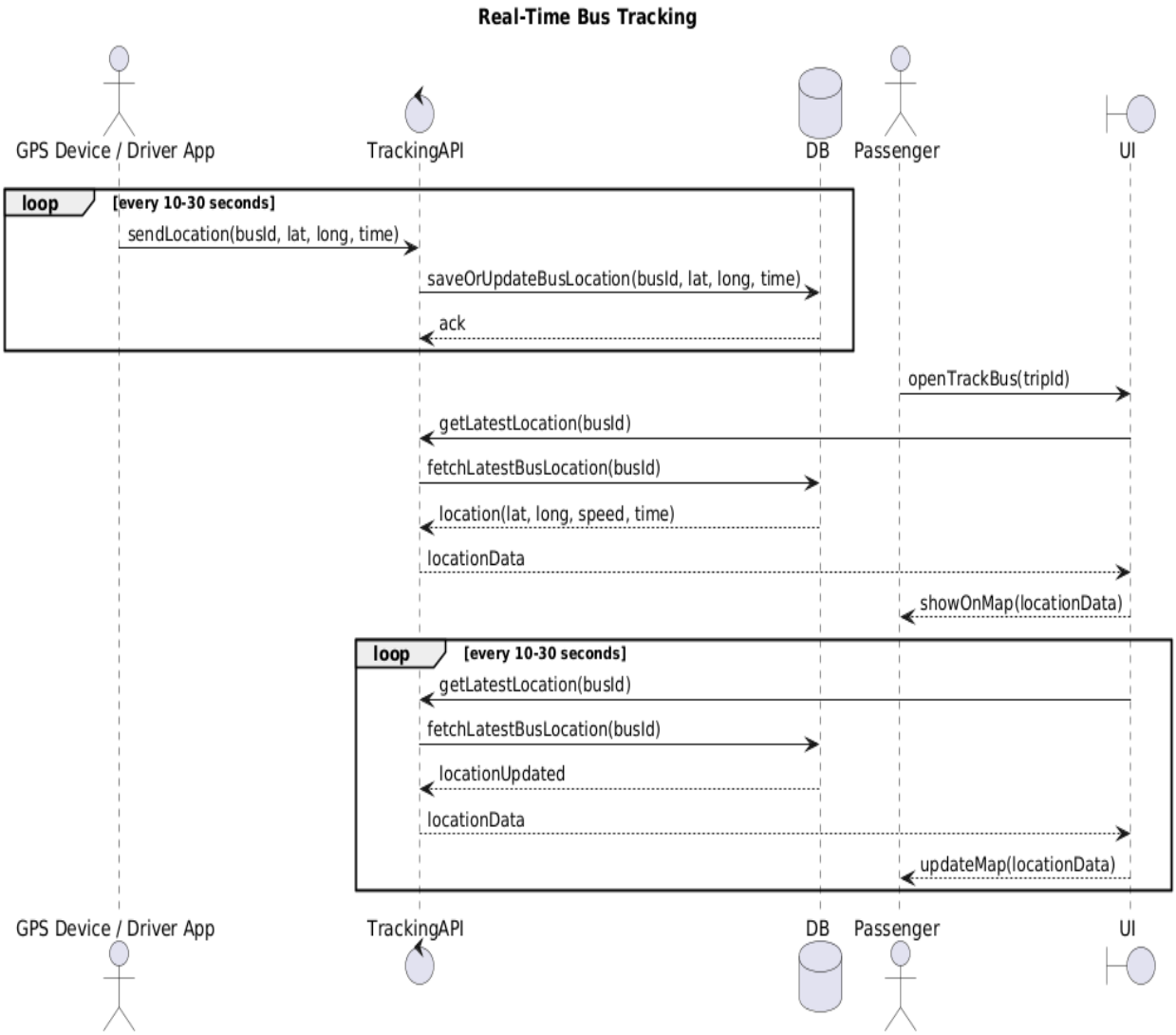
Description:
This sequence diagram shows how the system provides live bus location to a passenger.

Participants (lifelines):

- GPS Device / Driver App
- TrackingAPI (Server)
- Database
- Passenger
- UI (Tracking Screen)

Main message flow (summary):

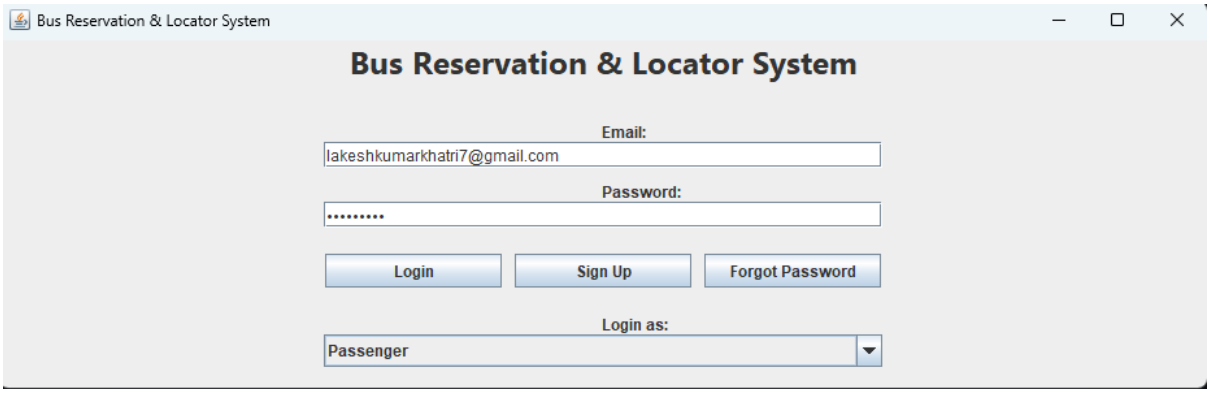
1. GPS Device/Driver App periodically sends **busId + latitude + longitude + timestamp** to **TrackingAPI**.
2. TrackingAPI stores each update as a new BusLocation record in the **Database** (or updates latest record).
3. Passenger opens **Track Bus** from the app → UI requests latest location from **TrackingAPI** for a specific bus/trip.
4. TrackingAPI queries **Database** for the most recent BusLocation of that bus and returns it to the UI.
5. UI displays the position on the **map view** (bus marker, route line, status, ETA).
6. UI repeats the location request after a fixed interval (e.g., every 10–30 seconds) to refresh the bus position.


Real-Time Bus Tracking
GPS Device / Driver App
TrackingAPI
DB
Passenger
UI
loop
[every 10-30 seconds]
sendLocation(busId, lat, long, time)
saveOrUpdateBusLocation(busId, lat, long, time)
ack
openTrackBus(tripId)
getLatestLocation(busId)
fetchLatestBusLocation(busId)
location(lat, long, speed, time)
locationData
showOnMap(locationData)
loop
[every 10-30 seconds]
getLatestLocation(busId)
fetchLatestBusLocation(busId)
locationUpdated
locationData
updateMap(locationData)
GPS Device / Driver App
TrackingAPI
DB
Passenger
UI

9. System Interface Design

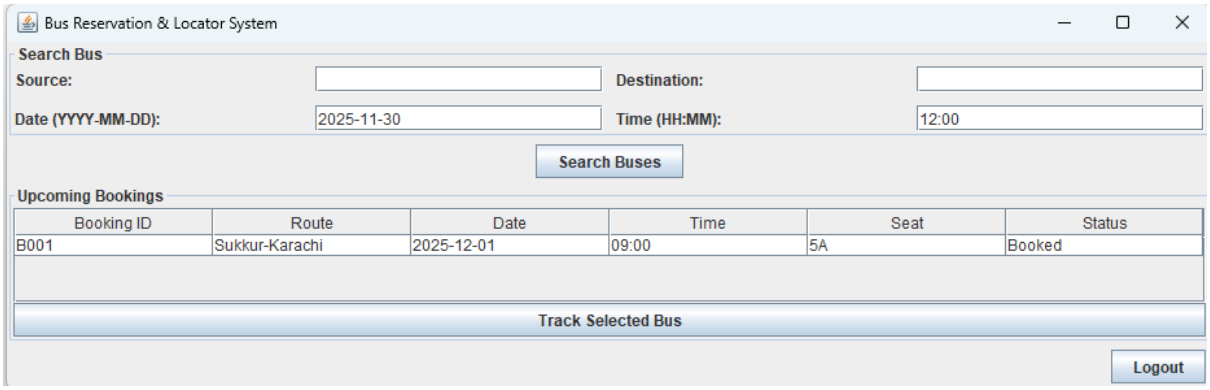
9.1 Login / Sign Up Screen

- Fields: Email, Password
- Buttons: Login, Sign Up, Forgot Password
- Purpose: Authenticate users (passenger / operator / admin)



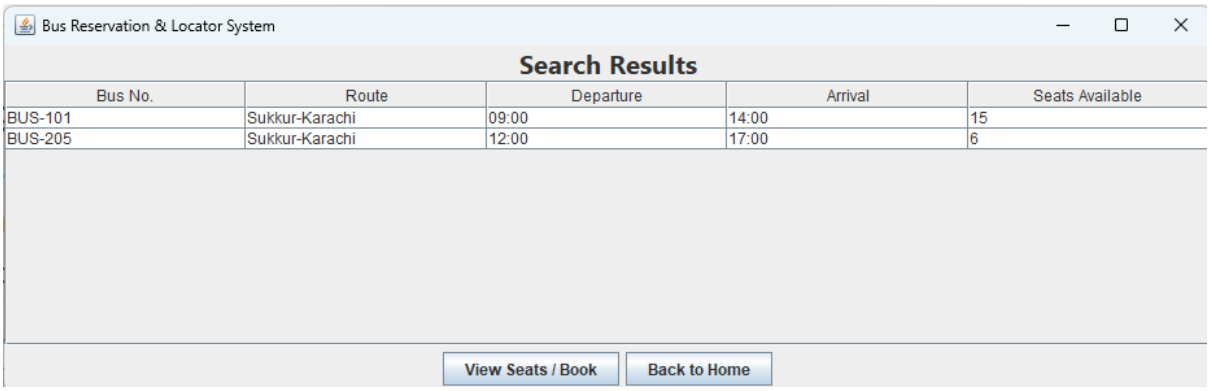
9.2 Passenger Home Screen

- Sections:
    - Search Bus (source, destination, date, time)
    - Upcoming Bookings
    - Quick link to “Track Bus”



9.3 Search Results Screen

- List of available buses / trips:
    - Bus Number, Route, Departure Time, Arrival Time
    - Seat Availability
    - "View Seats / Book" button

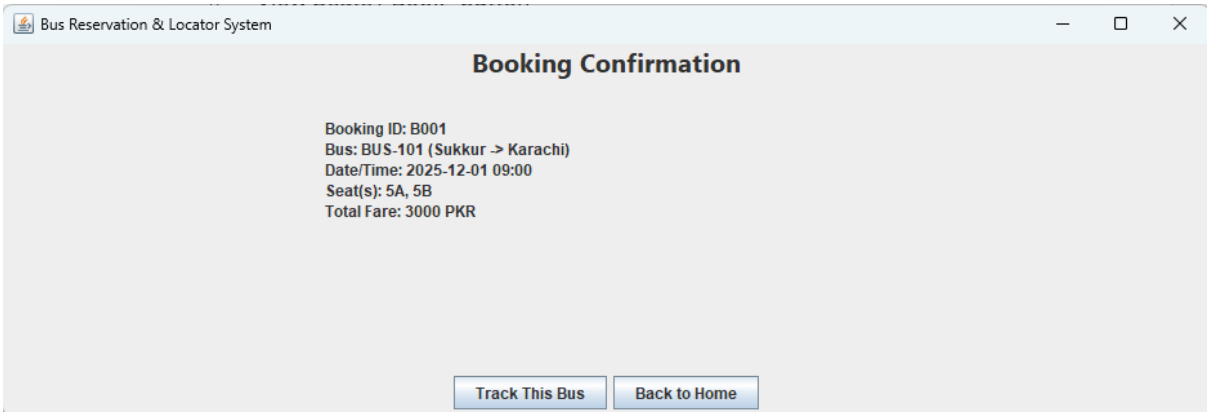


9.4 Seat Selection Screen

- Visual seat layout (green = available, blue = booked)
- Shows fare, selected seat numbers
- "Confirm Booking" button

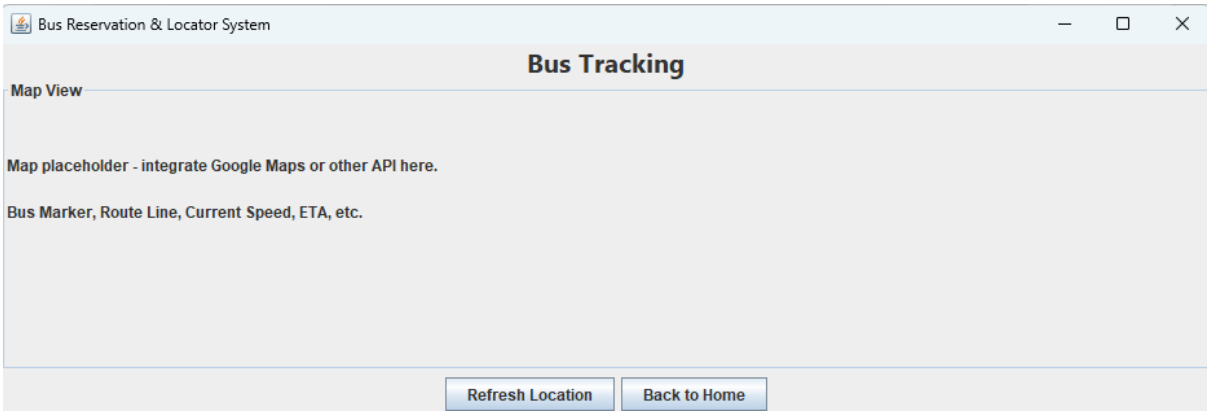
9.5 Booking Confirmation Screen

- Displays: Booking ID, bus details, seat numbers, date/time
- Option: “Track This Bus” (if available)



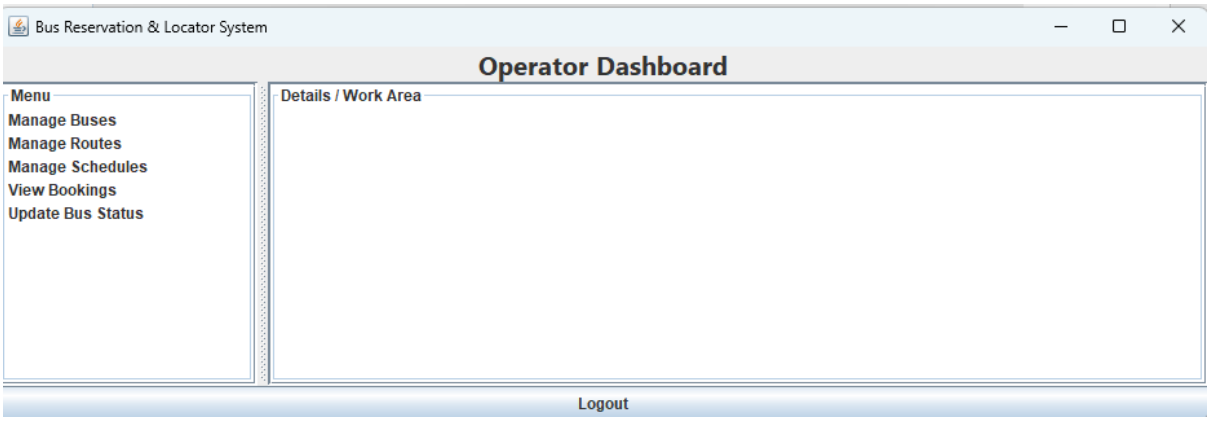
9.6 Bus Tracking Screen

- Map view with:
    - Bus marker
    - Route line
    - Current speed / status
    - Expected arrival time



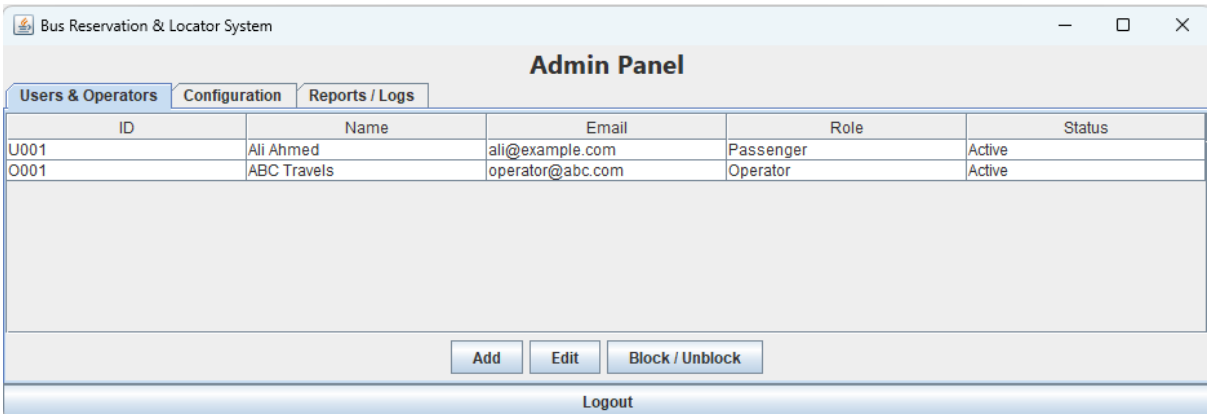
9.7 Operator Dashboard (Operator Role)

- Menu:
    - Manage Buses
    - Manage Routes
    - Manage Schedules (TripSchedules)
    - View Bookings
    - Update Bus Status



9.8 Admin Panel (Admin Role)

- Manage Users & Operators
- System configuration
- View logs / reports (basic)



10. Test Cases

TC-**01: User Registration**

- Pre-condition: User not registered
- Steps: Open sign up, fill valid data, submit
- Expected: Account created, success message displayed

TC-**02: User Login (Valid)**

- Pre-condition: User exists
- Steps: Enter correct email & password
- Expected: Login successful, redirected to home page

TC-**03: User Login (Invalid)**

- Steps: Enter wrong password
- Expected: Error message shown, user not logged in

TC-**04: Search Bus with Valid Route**

- Steps: Enter existing source, destination, and valid date
- Expected: List of available buses/trips displayed

TC-**05: Search Bus with No Trips**

- Steps: Enter route/date where no trip is scheduled
- Expected: “No buses found” message

TC-**06: Seat Booking (Normal Flow)**

- Pre-condition: Trip with available seats
- Steps: Search bus → select trip → select seat → confirm booking
- Expected Result: System records booking, updates seat status to 'Booked', and displays confirmation.

TC-**07: Prevent Double Booking**

- Pre-condition: Seat already booked
- Steps: Try to book same seat again
- Expected: System prevents booking and shows error

TC-**08: View Booking History**

- Pre-condition: User has past bookings
- Steps: Open “My Bookings”
- Expected: List of bookings shown with correct details

TC-**09: Real-Time Tracking**

- Pre-condition: Bus has active GPS updates
- Steps: Open tracking screen for that bus
- Expected: Current location appears on map and updates periodically

TC-**10: Operator Adds New Bus**

- Steps: Operator logs in → opens “Manage Buses” → adds bus details
- Expected: Bus stored in database and visible in bus list