Namal University Transport Management System (NUTMS)

System Design Report – Milestone 3

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1 Introduction

1.1 Purpose of this Document

This Design Report presents the complete system design for the Namal University Transport Management System (NUTMS). It translates the Software Requirements Specification (SRS) into detailed design artifacts including UML diagrams, prototypes, and architectural decisions. This document serves as a bridge between the requirements and the actual implementation of the system.

1.2 Scope

This document covers the following areas:

- Complete UML diagrams representing system behavior and structure

- Design decisions and their justifications based on SRS requirements

- Traceability mapping from requirements to design elements

- Prototypes validated with stakeholders through meetings

- Design assumptions and constraints

- Component architecture and system organization

2 Design Assumptions and Constraints

2.1 Design Assumptions

2.1.1 Technical Assumptions

1. **GPS Availability:** All university buses have functional GPS devices capable of transmitting real-time location data every 10-30 seconds with accuracy within 10-20 meters.

2. **Network Connectivity:** Stable internet connectivity is available on campus and in most areas covered by bus routes. Campus WiFi infrastructure supports system access for students and staff.

3. **User Device Access:** Students, faculty, and staff have access to smartphones, tablets, or computers with modern web browsers (Chrome, Firefox, or Edge released within the last 3 years).

4. **Database Capacity:** PostgreSQL database can handle concurrent bookings and tracking data for multiple buses and users during peak hours without performance issues.

5. **Email Service:** University SMTP server or external email service is reliable and available for notification delivery with minimal delay.

6. **Map Services:** OpenStreetMap data is accurate and available for Mianwali region and university campus areas.

2.1.2 Operational Assumptions

1. **User Roles:** Users are pre-categorized as Student, Faculty, Driver, or Administrator based on university registration and email domain.

2. **Route Stability:** Bus routes and schedules remain relatively stable within a semester, with changes occurring primarily at semester boundaries or due to special circumstances.

3. **Peak Usage:** Maximum concurrent users during peak hours (morning and evening) is estimated based on total student and faculty population.

4. **GPS Accuracy:** GPS coordinates are accurate within 10-20 meters, sufficient for tracking bus progress along routes.

5. **Session Duration:** User sessions automatically timeout after 30 minutes of inactivity for security purposes.

2.1.3 Business Assumptions

1. **Approval Workflow:** Special vehicle booking requests from faculty follow a defined approval hierarchy with higher authority consent required.

2. **Capacity Limits:** Each bus has a fixed seating capacity that must be strictly enforced to prevent overcrowding and maintain safety.

3. **Cancellation Policy:** Users can cancel bookings up to a certain time before departure, freeing seats for other users.

4. **Academic Calendar:** System operates according to university academic calendar, with potential downtime during semester breaks.

5. **Record Retention:** Booking and trip records are maintained for a minimum of one academic year for reporting and audit purposes.

2.2 Design Constraints

2.2.1 Technology Constraints

1. **Platform:** Web-based application only, accessible through web browsers on various devices.

2. **Frontend Technology:** React.js framework for building responsive and interactive user interfaces.

3. **Backend Technology:** Node.js runtime with Express.js framework for server-side logic and API handling.

4. **Database:** PostgreSQL relational database management system for all data storage.

5. **Browser Support:** Must support Google Chrome, Mozilla Firefox, and Microsoft Edge (modern versions only).

6. **Storage Restriction:** No use of browser localStorage or sessionStorage due to artifact environment limitations.

7. **Real-time Communication:** WebSocket protocol (Socket.io) for real-time GPS updates and notifications.

2.2.2 Performance Constraints

1. **Page Load Time:** All pages must load within 3 seconds under normal network conditions.

2. **Booking Transaction:** Booking confirmation must complete within 2 seconds.

3. **GPS Update Frequency:** Real-time bus location updates every 10-30 seconds.

4. **Concurrent Users:** System must support multiple concurrent users, especially during peak booking periods.

5. **System Availability:** 99% uptime during academic semesters.

2.2.3 Security Constraints

1. **Authentication:** Secure user authentication with hashed password storage.

2. **Communication:** All data transmission over HTTPS with TLS encryption.

3. **Access Control:** Role-based access control (RBAC) to restrict functions based on user roles.

4. **Data Privacy:** Users can only view their own booking history and personal information.

5. **Input Validation:** Protection against SQL injection, XSS, and other common web vulnerabilities.

2.2.4 Regulatory and Policy Constraints

1. **University Policies:** Adherence to university transport policies regarding passenger limits and route allocations.

2. **Safety Regulations:** Strict enforcement of vehicle capacity limits as per safety regulations.

3. **Data Protection:** Compliance with university IT policies and data protection standards.

3 Key Design Decisions

This section summarizes the main design decisions made for the Namal University Transport Management System (NUTMS).

3.1 Breaking Down the System (DFD Decomposition)

3.1.1 Level 0 DFD

Decision: A Level 0 DFD (Context Diagram) was created to represent the entire system as a single process interacting with external entities.

Justification:

- Provides a high-level overview of the system

- Clearly shows system boundaries

- Easy for non-technical stakeholders to understand

3.1.2 Level 1 DFD Processes

Decision: The system was divided into five main processes:

- Authentication

- View Routes & Schedules

- Tracking

- GPS Tracking

- Notification Management

Justification:

- Each process performs a single clear function

- Matches the main features in the SRS

- Easy for users and developers to understand

3.1.3 Level 2 DFD for Route & Schedule Management

Decision: A Level 2 DFD was created only for Route & Schedule Management, divided into:

- Maintain Routes & Stops

- Maintain Schedules

- Save Schedule

Justification:

- Route and schedule handling is more complex

- Clearly shows admin workflow

- Routes must be created before schedules

Justification:

- They are simple and straightforward

- Activity diagrams already show detailed workflows

3.2 Class Diagram Design

3.2.1 User Inheritance

Decision: `User` was designed as a parent class for Student, Faculty, Driver, and Administrator.

Justification:

- Common attributes are shared

- Supports role-based access

3.2.2 Key Relationships

- **Bus–Schedule (Composition):** Schedule depends on Bus

- **Driver–Bus (Association):** Temporary assignments

- **Student/Faculty–Schedule (Association):** View-only access

Decision: Same names and structures were used across all diagrams.
Justification:

- Improves traceability

- Ensures alignment between design and implementation

4 System Design Diagrams
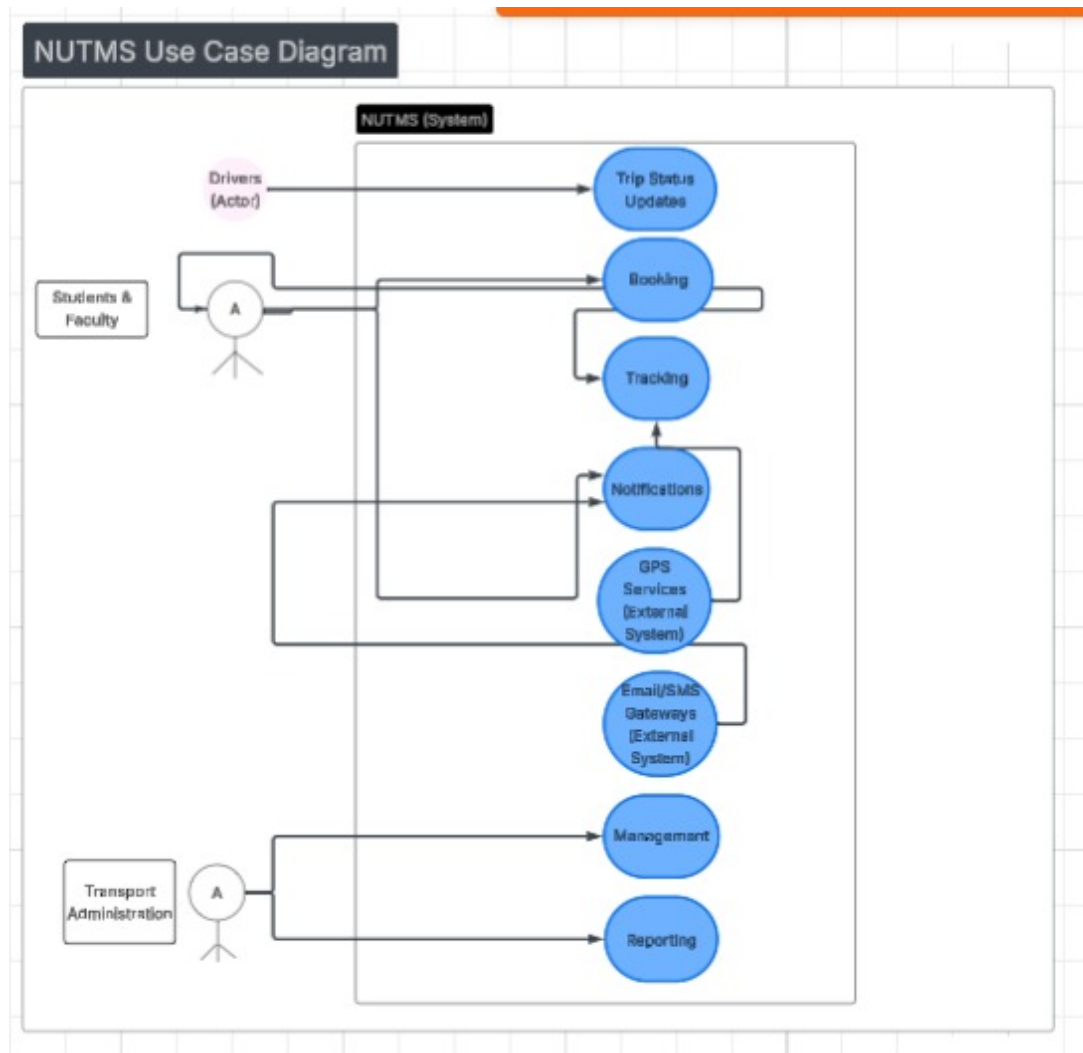
4.1 Use Case Diagram

Figure 1: Use Case Diagram showing NUTMS actors and their interactions

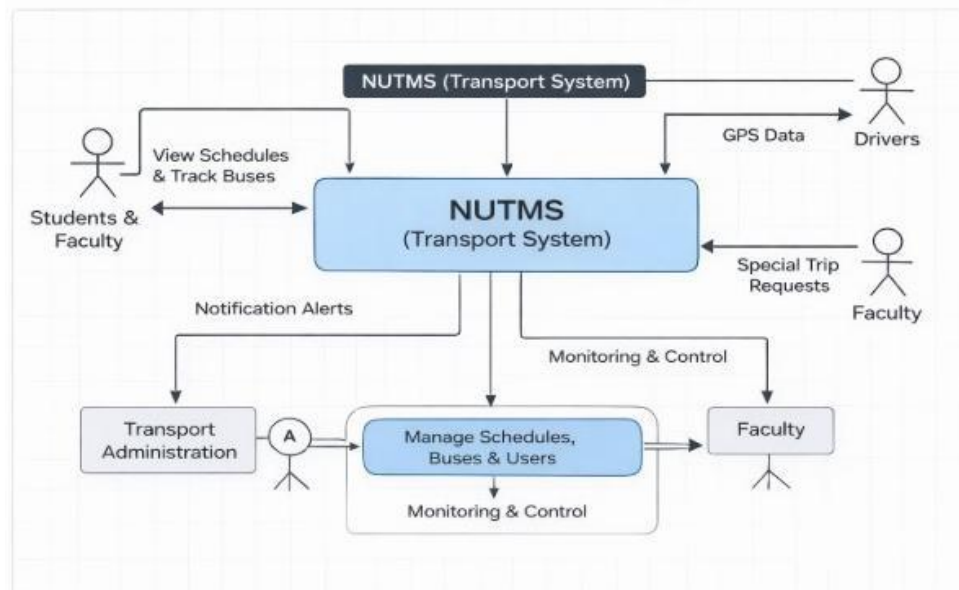## 4.2 Data Flow Diagrams

4.2.1 Level 0 : Context Diagram

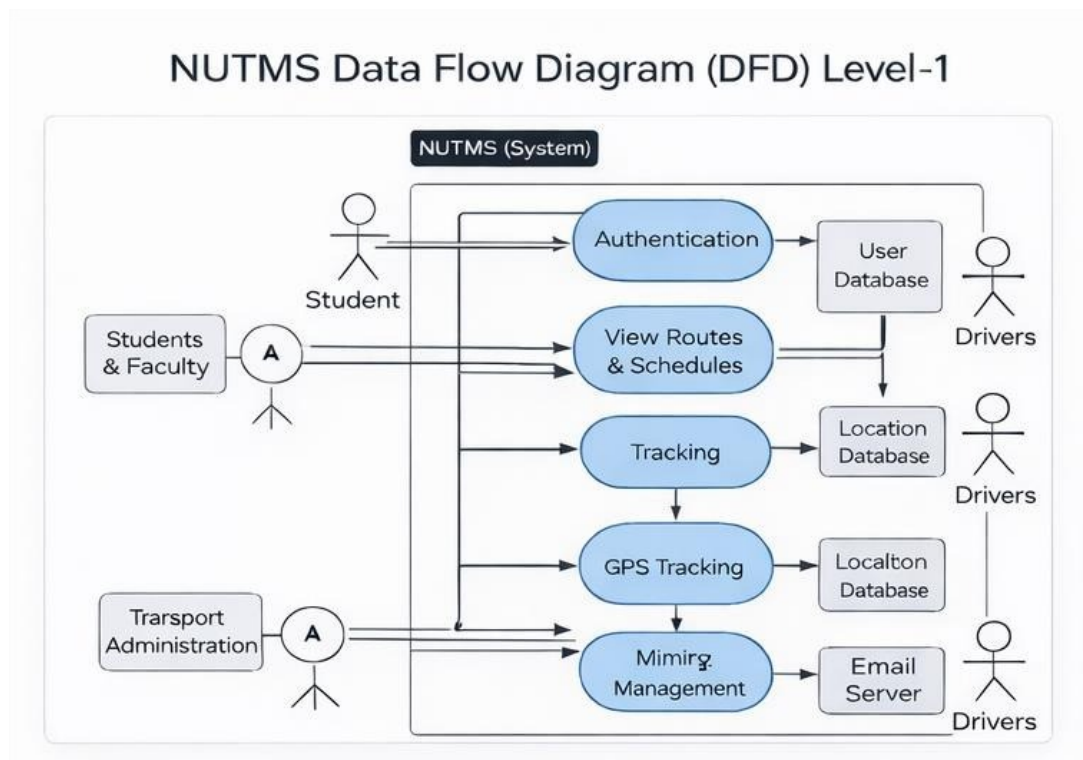Figure 2: NUTMS Context Diagram - System interactions with external actors

4.2.2 Level 1

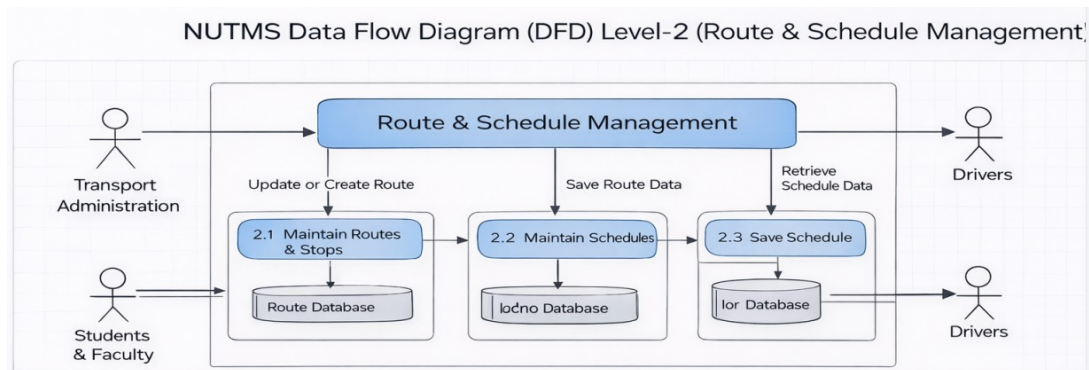Figure 3: Level 1 DFD

4.2.3 Level 2

Figure 4: Level 1 DFD

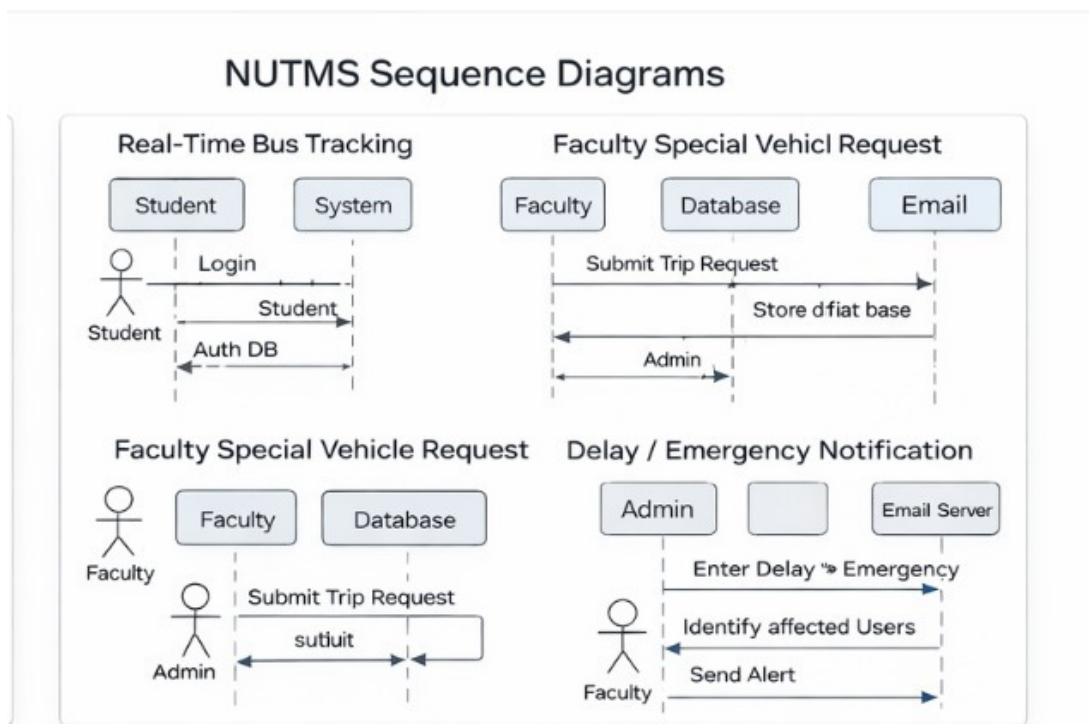## 4.3 Sequence Diagram

Figure 5: Sequence diagram

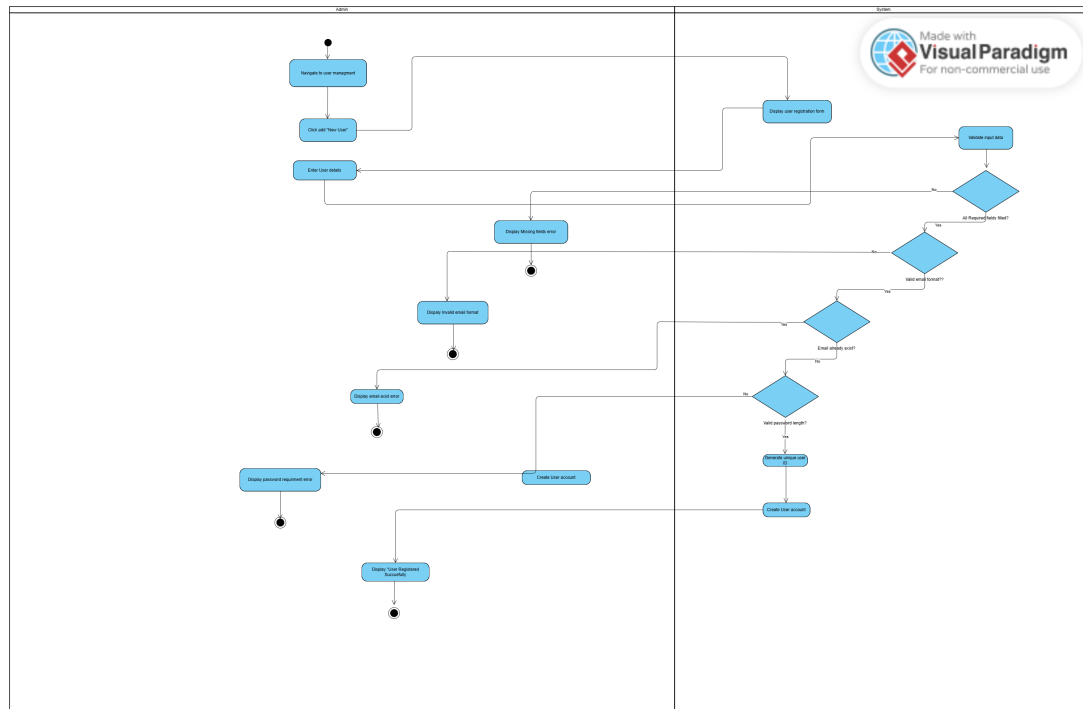## 4.4 Activity Diagrams

4.4.1 Registration Activity

Figure 6: Activity diagram for user registration process
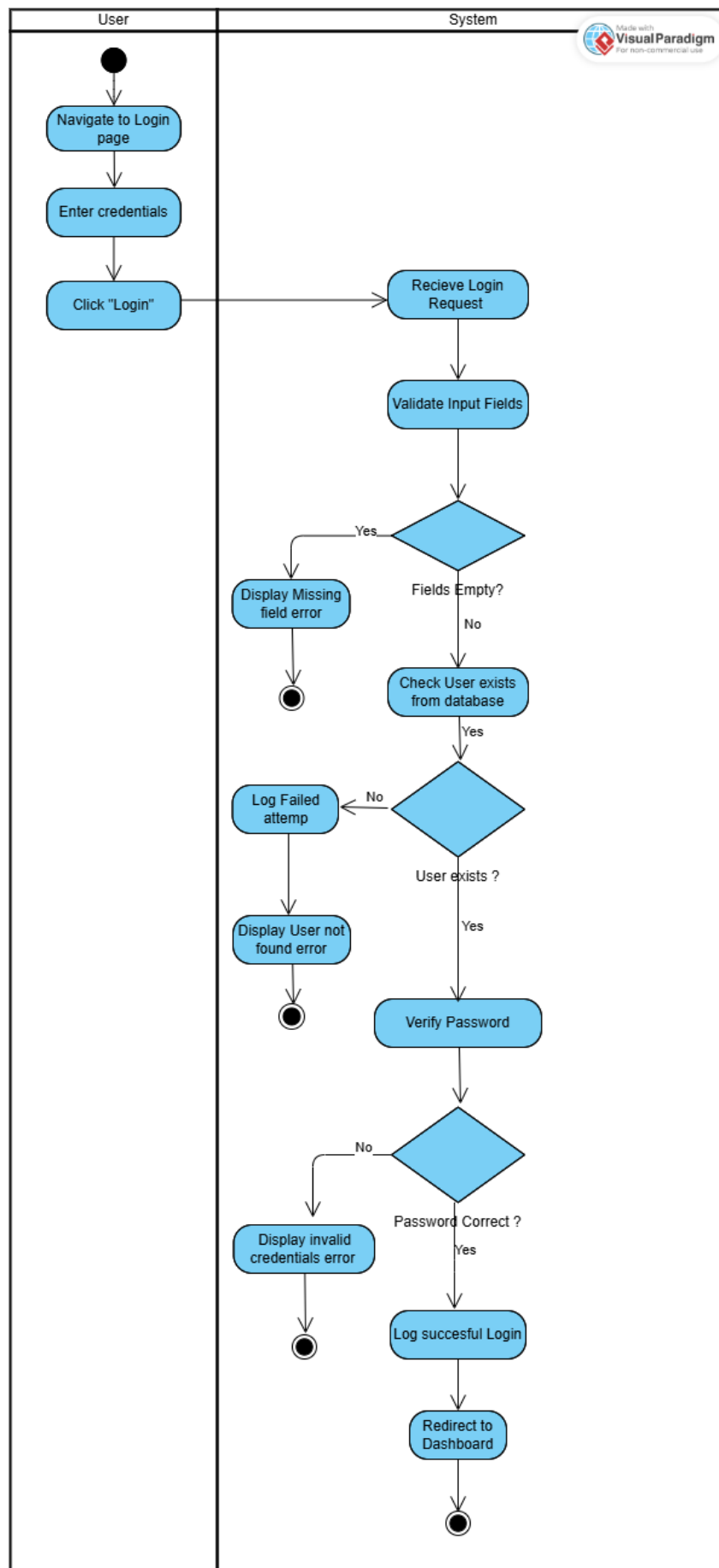
4.4.2 Login Activity

Figure 7: Activity diagram for user login process
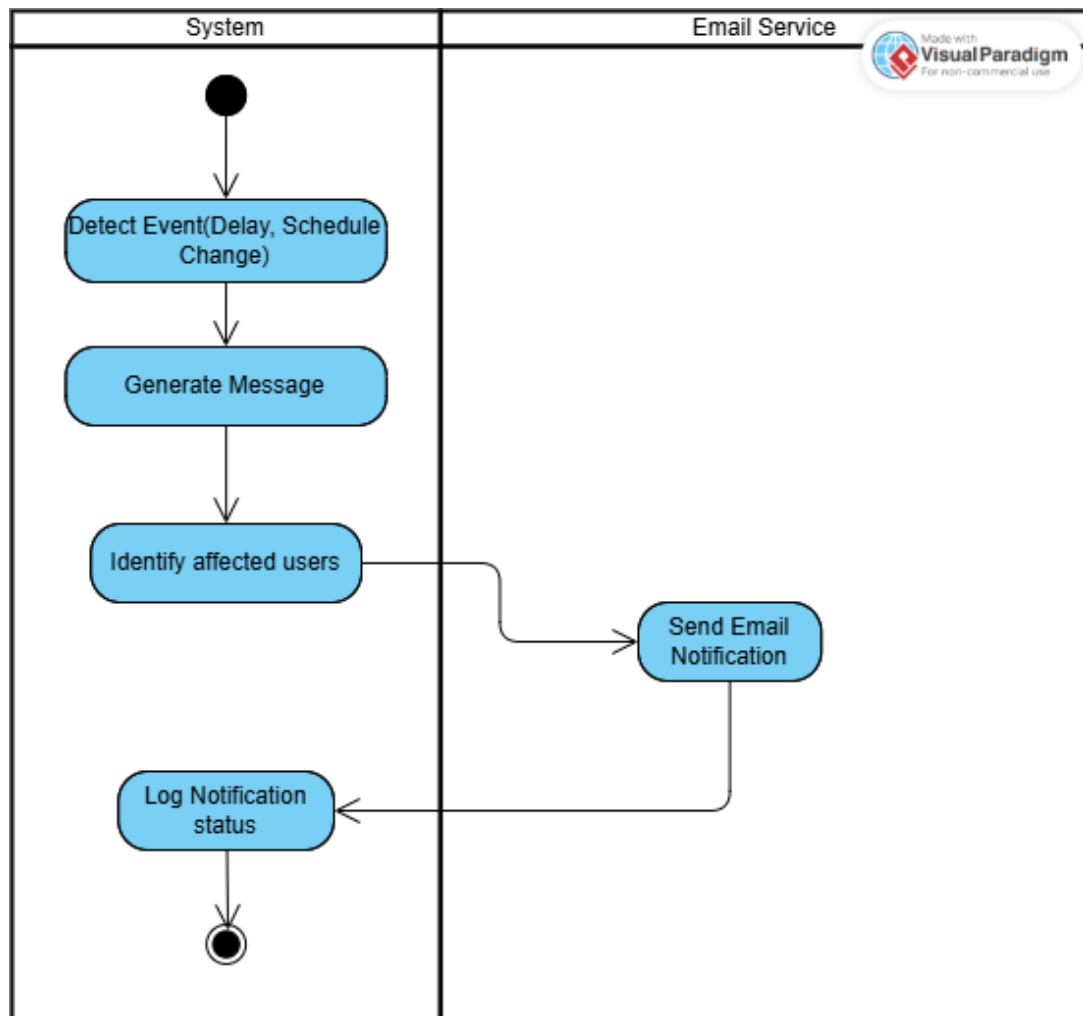
4.4.3   Notification Activity

Figure 8: Activity diagram for notification management

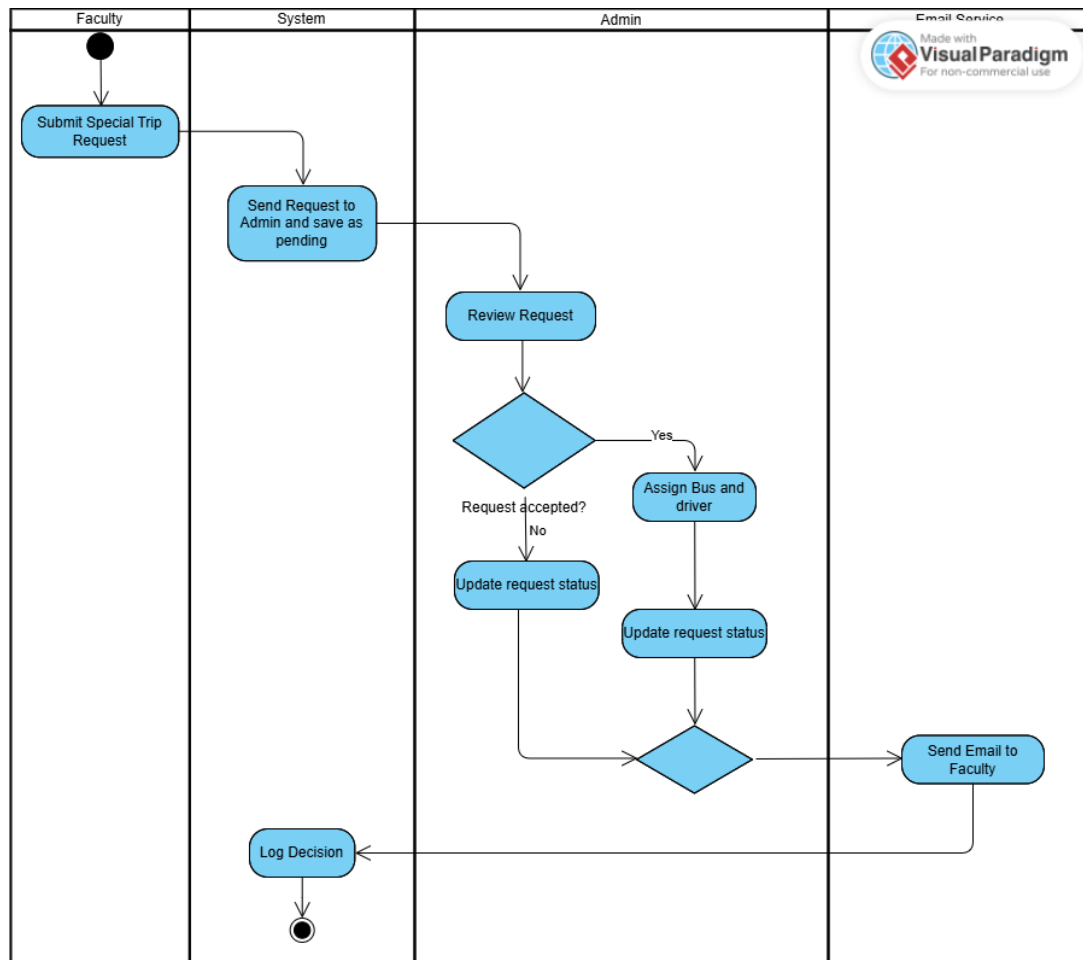### 4.4.4 Vehicle Booking Activity

Figure 9: Activity diagram for vehicle booking process
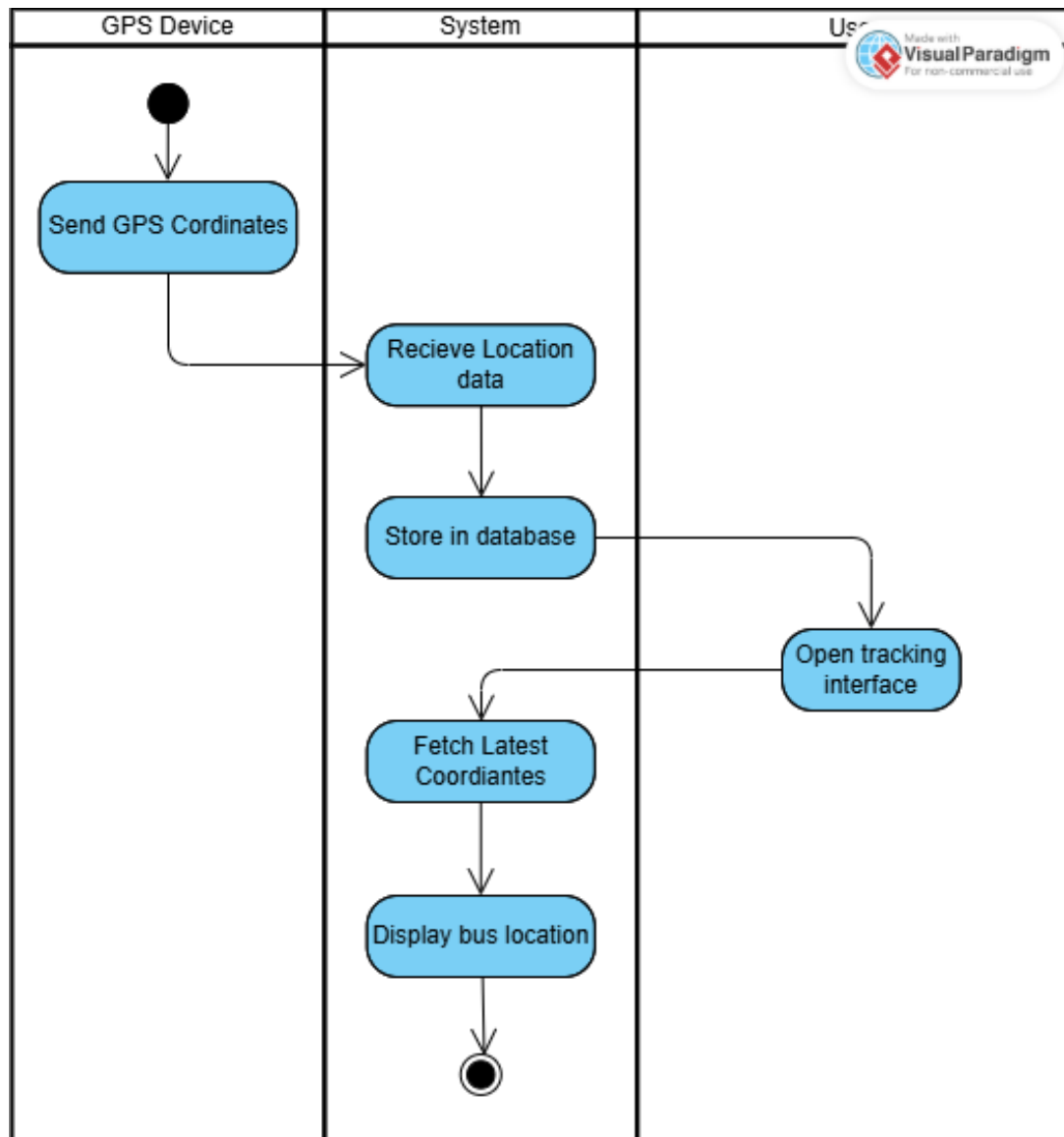
4.4.5 Bus Tracking Activity

Figure 10: Activity diagram for real-time bus tracking process
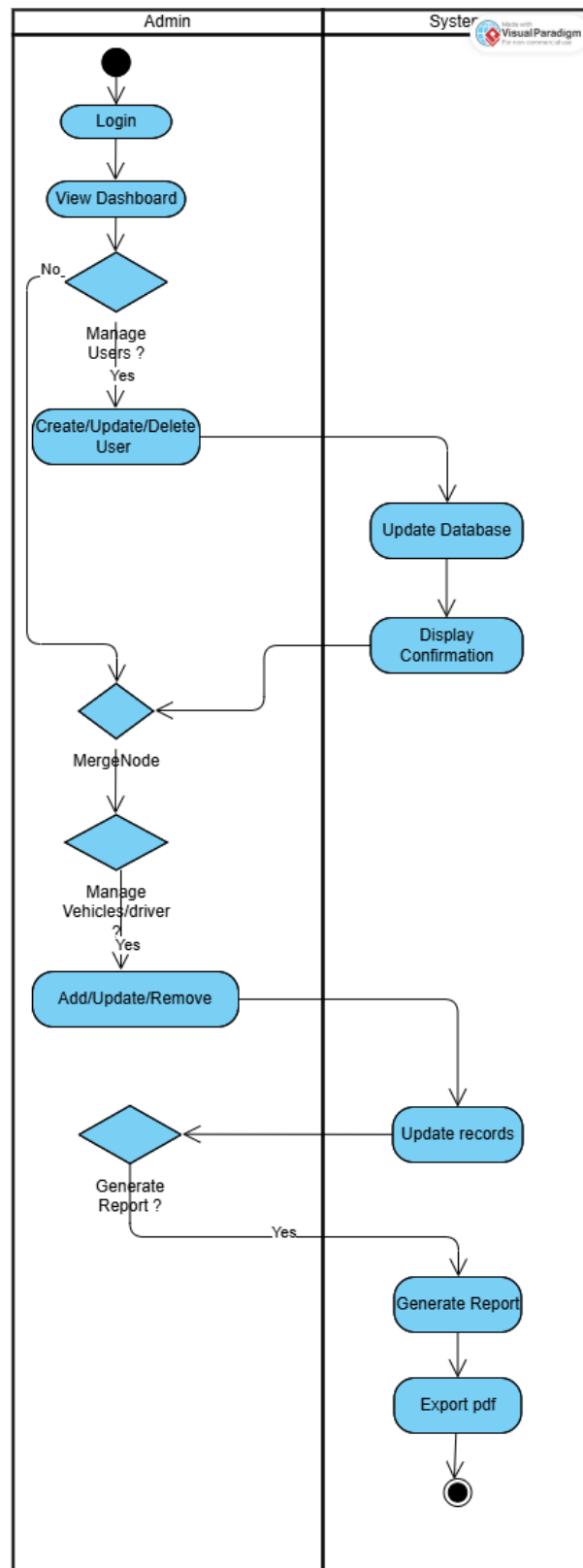
4.4.6 Admin Activity

Figure 11: Activity diagram for administrator operations
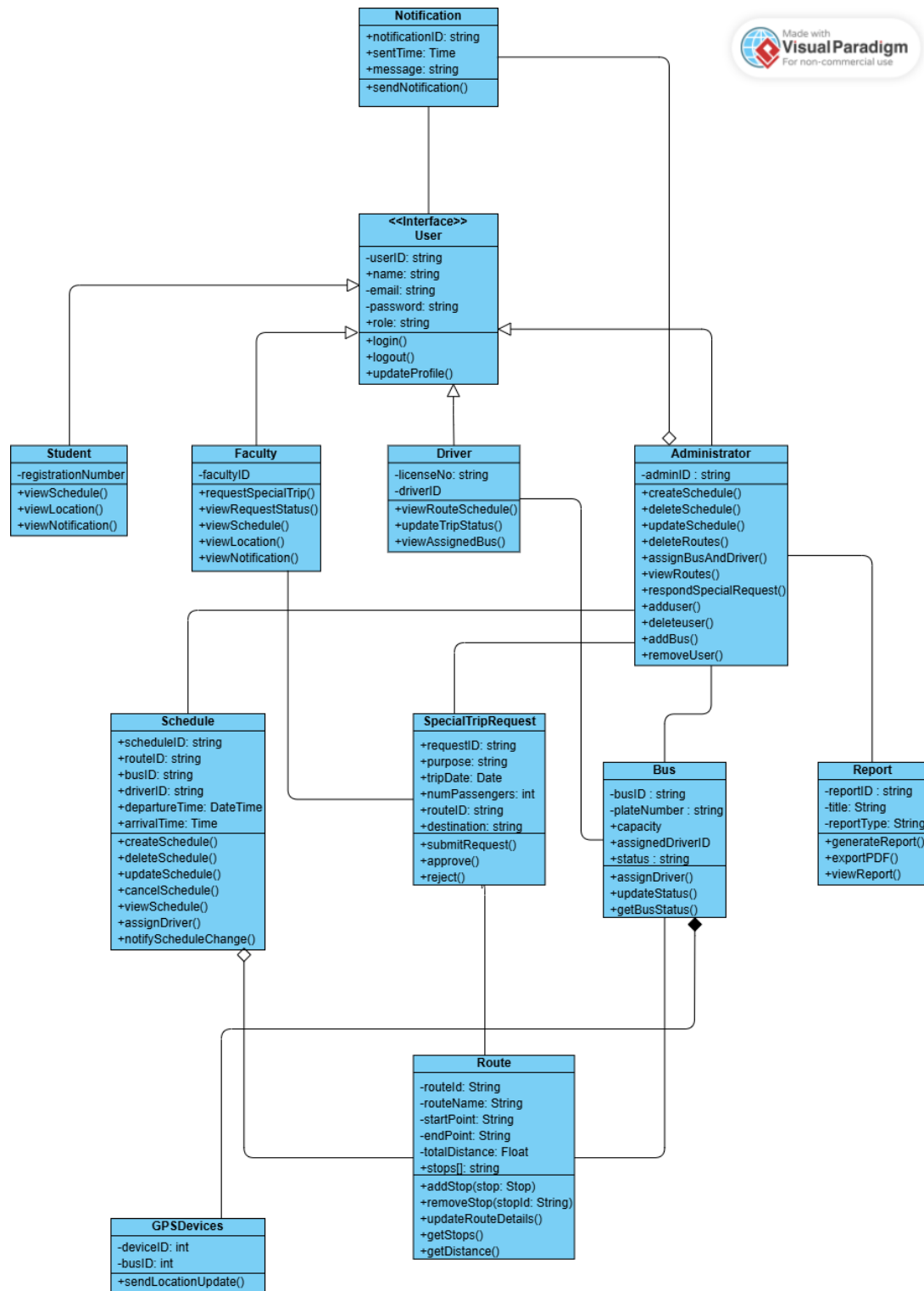
4.5 Class Diagram

Figure 12: Class Diagram showing all system classes and relationships

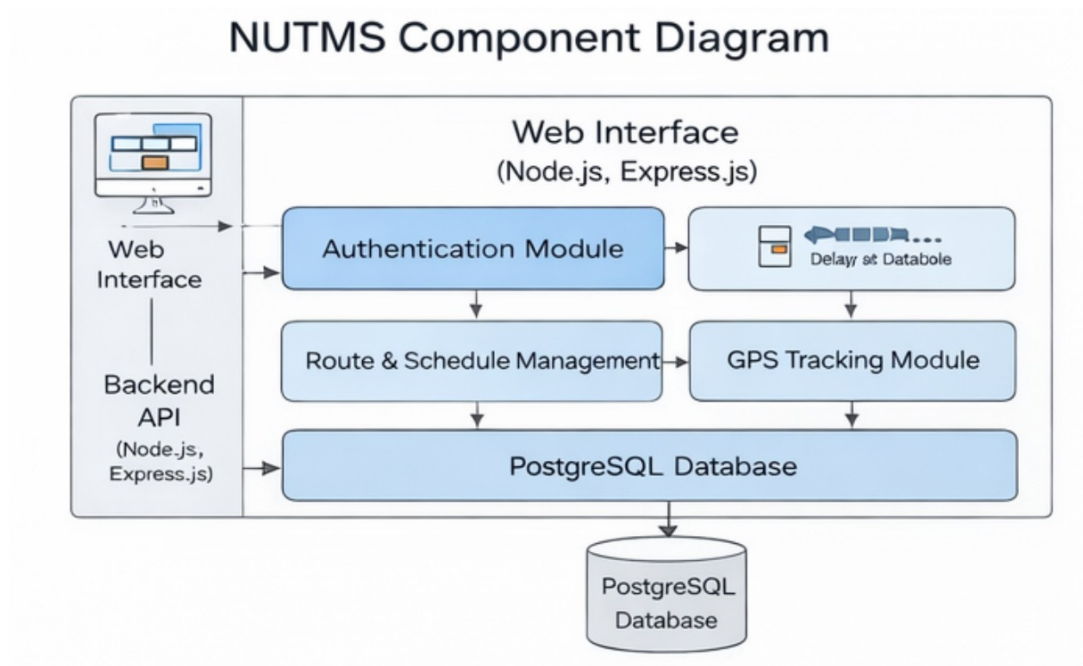## 4.6   Component Diagram

Figure 13: Component diagram showing modular decomposition of NUTMS

5 Requirements–Design Traceability Table

5.1 Namal University Transport Management System (NUTMS)

Requirement ID	Requirement Description	Use Case(s)	DFD Process(es)	Sequence Diagram(s)	Class(es
FR-1.1	User Registration	UC-01	1.1 Validate Registration 1.1.1 Validate Input 1.1.2 Store User	SD-01	User, Us troller, tory
FR-1.2	User Authentication	UC-02	1.2 Authenticate User 1.2.1 Verify Credentials	SD-02	User, Au troller
FR-1.3	Profile Management	UC-03	1.3 Update Profile 1.3.1 Validate Changes	SD-03	User, Controlle
FR-2.1	Route Definition	UC-04	2.1 Manage Routes 2.1.1 Create Route	SD-04	Route, A trator
FR-2.2	Schedule Management	UC-05	2.2 Manage Schedule 2.2.1 Create Schedule	SD-05	Schedule,
FR-2.3	Route Assignment	UC-06	2.3 Assign Resources	SD-06	Bus, Route
FR-3.1	GPS Integration	UC-07	3.1 Track Location 3.1.1 Receive GPS Data	SD-07	GPSDevi
FR-3.2	Live Location Display	UC-08	3.2 Display Location	SD-08	MapCont LocationS
FR-3.3	Route Progress Tracking	UC-09	3.3 Calculate Progress	SD-09	RouteAna
FR-4.1	Booking Confirmation	UC-10	4.1 Send Notification	SD-10	Notificati
FR-4.2	Delay Notifications	UC-11	4.2 Delay Alerts	SD-11	DelayDet

Requirement ID	Requirement Description	Use Case(s)	DFD Process(es)	Sequence Diagram(s)	Class(es
FR-4.3	Schedule Change Alerts	UC-12	4.3 Schedule Alerts	SD-12	ScheduleI
FR-4.4	Emergency Notifications	UC-13	4.4 Emergency Alerts	SD-13	Administ
FR-5.1	Dashboard Overview	UC-14	5.1 Display Dashboard	SD-14	Dashboar
FR-5.2	User Management	UC-15	5.2 Manage Users	SD-15	UserMan
FR-5.3	Driver & Vehicle Management	UC-16	5.3 Manage Resources	SD-16	Driver, B
FR-5.4	Report Generation	UC-17	5.4 Generate Reports	SD-17	ReportGe
FR-6.1	Special Trip Request	UC-18	6.1 Process Requests	SD-18	SpecialTr
FR-6.2	Request Approval Workflow	UC-19	6.2 Review Requests	SD-19	Administ

6   Appendix

6.1   GitHub Repository

The complete project repository is available at following link :

https://github.com/Altaf-Hussain-11/SE-Project-Transport-Management-System-.git

6.2   Meeting Minutes Reference

You can access the meeting minutes document from the following link:

https://docs.google.com/spreadsheets/d/180hqUDHGpHp8CMqTwAZxo9n5CBqNpvm2eWgDv0xX

6.3   Figma Link

https://www.figma.com/design/ltB87YjMdrQWczBFlexSFV/Untitled?node-id=8-2t=yrjSnUuZDr1gA
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