TED UNIVERSITY

CMPE 491 / SENG 491 Senior Project
High-Level Design Report

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Team Members

Ege İZMİR 12584814676 Computer Engineering
Mustafa Boğaç MORKOYUN 44764509874 Software Engineering
Egemen Doruk SERDAR 71155167474 Software Engineering
Mustafa PINARCI 18853734706 Computer Engineering

Supervisor: Gökçe Nur YILMAZ

Jury Members

Eren ULU
Tansel DÖKEROĞLU
Tolga Kurtuluş ÇAPIN

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High-Level Design Report for General AI Safety Systems

1. Introduction

1.1 Purpose of the System

The **General AI Safety Systems** project aims to address critical safety challenges inherent in school transportation by leveraging advanced artificial intelligence (AI) and real-time monitoring systems. Traditional approaches to school bus safety rely heavily on human supervision, which is prone to error and inconsistency. This project seeks to revolutionize student transportation by providing a proactive and automated system for monitoring and addressing safety concerns.
The system's primary purpose is to ensure the safety and security of students during transit. It accomplishes this by identifying risks in real-time unsafe behaviors, and providing immediate alerts to stakeholders. Furthermore, it offers features like dynamic route optimization and attendance tracking to improve efficiency and transparency. By implementing this system, stakeholders, including parents, school administrators, and bus drivers, can have greater confidence in the safety and effectiveness of school transportation.

1.2 Design Goals

The **General AI Safety Systems** is designed with the following key goals:

- **Safety Enhancement**: Implement continuous monitoring to detect and address safety violations proactively.
- **Scalability**: Ensure the system can be deployed across multiple schools and fleets while maintaining optimal performance.
- **User Accessibility**: Provide intuitive interfaces for parents, drivers, and administrators to interact with the system effectively.
- **Reliability**: Guarantee robust performance under various environmental and operational conditions, including adverse weather and network outages.
- **Regulatory Compliance**: Adhere to data protection laws, such as GDPR, and child safety regulations.
- **Environmental Efficiency**: Minimize environmental impact by optimizing routes to reduce fuel consumption and emissions.

1.3 Definitions, Acronyms, and Abbreviations

- **AI**: Artificial Intelligence
- **GPS**: Global Positioning System
- **GDPR**: General Data Protection Regulation
- **RBAC**: Role-Based Access Control

- **UI**: User Interface

1.4 Overview

The **General AI Safety Systems** integrates cutting-edge technologies such as face recognition, behavioral analysis, and dynamic route optimization to provide a comprehensive safety solution for school transportation. The system employs AI-driven image processing, real-time alerts, and adaptive decision-making to enhance safety and operational efficiency. By automating key safety tasks, it reduces human error, improves transparency, and ensures a secure and efficient transportation process for students.

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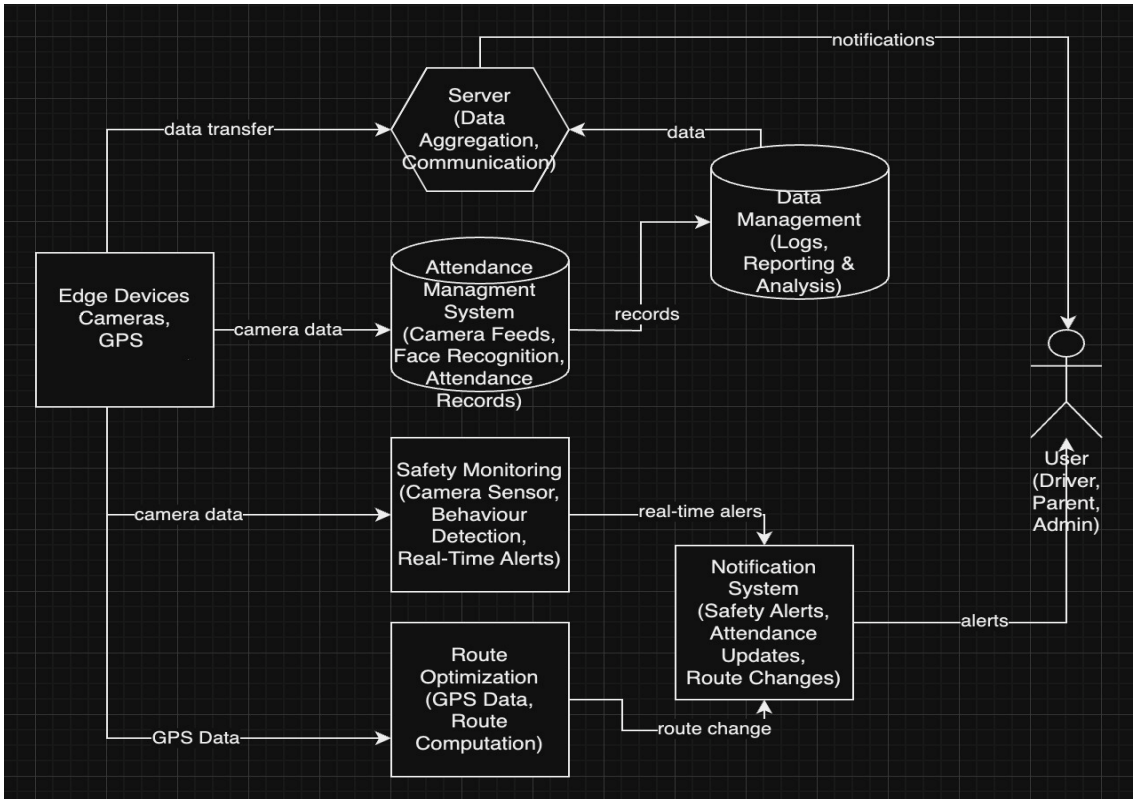
2. Proposed Software Architecture



2.1 Overview

The proposed architecture introduces a robust, AI-driven solution to address the limitations of the current system. The system's primary components include:

1. **Face Recognition**: Ensures accurate attendance logging and prevents unauthorized access.
2. **Behavioral Analysis**: Identifies unsafe actions, such as standing or moving during transit, and generates immediate alerts.
3. **Dynamic Routing**: Uses real-time traffic data and optimization algorithms to ensure efficient and safe travel routes.
4. **Notification System**: Sends real-time updates to drivers, parents, and administrators regarding safety incidents and route changes.

2.2 Subsystem Decomposition

The system can be divided into the following subsystems:

- **Attendance Management Subsystem**: Uses face recognition to log student entries and exits.
- **Route Optimization Subsystem**: Employs algorithms like Dijkstra's and A* to adapt routes dynamically based on traffic and environmental conditions.
- **Notification Subsystem**: Sends real-time alerts about safety incidents and route changes to relevant stakeholders.
- **Data Management Subsystem**: Handles secure storage and retrieval of attendance logs, route data, and safety alerts.

2.3 Hardware/Software Mapping

- **Hardware**:
  - High-resolution cameras for face recognition and behavioral analysis.
  - GPS modules for real-time location tracking..
  - Onboard computing units capable of handling AI workloads.
- **Software**:
  - AI-driven algorithms for image recognition and behavioral analysis.
  - Secure data transmission protocols for encrypted communication.

2.4 Persistent Data Management

The system maintains a secure, encrypted database to store:

- Attendance logs
- Video records
- Route details
- Safety alerts

Role-based access control (RBAC) ensures that only authorized personnel can view or modify sensitive data.

2.5 Access Control and Security

- **Role-Based Access Control (RBAC)**: Limits access based on user roles, ensuring data security.
- **Data Encryption**: Protects sensitive information during transmission and storage.
- **Regulatory Compliance**: Ensures adherence to GDPR and other applicable data protection laws.

2.6 Global Software Control

The system employs an event-driven architecture, where data from sensors and cameras trigger automatic actions or alerts. Centralized decision-making ensures seamless interaction between subsystems, providing continuous safety monitoring.

2.7 Boundary Conditions

The system is designed to handle:

- **Low-Light Scenarios**: Advanced image enhancement techniques ensure reliable monitoring in poor lighting conditions.
- **Network Failures**: Local data storage and processing maintain functionality during connectivity issues.
- **Hardware Failures**: Redundancy mechanisms and fallback protocols ensure uninterrupted safety monitoring.

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3. Subsystem Services

The following subsystem services are integral to the system's functionality:

- **Face Recognition Service**: Verifies student identity, prevents unauthorized access, and logs attendance.
- **Behavioral Analysis Service**: Detects unsafe behaviors and generates immediate alerts for corrective action.
- **Dynamic Routing Service**: Provides optimized travel routes based on real-time traffic conditions and environmental factors.
- **Notification Service**: Sends real-time safety alerts and updates to drivers, parents, and administrators.

- **Data Management Service**: Ensures secure storage and retrieval of critical data, including attendance logs and safety records.

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4. Glossary

- **Face Recognition**: AI technology that uses facial features for identification.
- **Dynamic Routing**: Real-time adjustment of travel paths based on traffic and environmental conditions.
- **Behavior Detection**: AI-driven analysis of student activities within the bus to ensure compliance with safety standards.
- **RBAC**: Role-Based Access Control, a security measure that restricts system access based on user roles.
- **Notification System**: A mechanism for sending alerts and updates to stakeholders in response to safety incidents or route changes.

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5. References

1. **ACM Code of Ethics and Professional Conduct**: Guidelines for ethical AI deployment.
2. **YOLOv3 Model**: A state-of-the-art object detection algorithm for real-time processing.
3. **General Data Protection Regulation (GDPR)**: European Union's data privacy standards.
4. **NHTSA Child Safety Guidelines**: Regulatory framework for child transportation safety.