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Enhancing Child Safety in School Transport with GPS and Web Technologies

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ABSTRACT

The child monitoring system combines three primary components to improve child protection while enhancing school transport management. The Parental Access module lets parents gain real-time tracking details containing their child's position alongside stop arrival alerts and home-school location updates. Timely data from the system gives parents essential information to guarantee their child's safe transportation. The optimized route planning system of the Driver Navigation module uses interconnected geophones to guide drivers securely while collecting students at each stop through their sequential designated routes. Through the Supervisor Management module administrators gain full administrative oversight through two features that let supervisors identify student attendance status and track operational information. As a full-stack developer I led the system API design while building its API infrastructure and handled data reliability between different modules before creating React-based front-end functionality. The systematic implementation of this platform has produced an expandable system which enables effective communication between supervisors and parents and drivers to make school transport more secure and reliable.

KEYWORDS: *Smart School Transport, Live Tracking, IoT Integration, Geofencing, Parental Monitoring, Route Optimization, Attendance Management, Secure Data Handling.*

I. INTRODUCTION

The fast-moving modern society makes child safety and timely transportation become fundamental matters that demand action by parents and schools as well as transportation companies. Parentseye serves as an advanced system developed to resolve these challenges through the combination of modern technology with operational functionalities. The system consists of three essential components that include the Parental Access module and Driver Navigation module and Supervisor Management module which collectively promote seamless and secure transportation experiences. The Parental Access module lets guardians monitor their children's journey in real time through important information that includes present location as well as proximity to bus stops together with predicted distances between the school and home. The advance notification system allows parents to stay updated regularly which helps them assist their children safely throughout the travel duration. The main function of the Driver Navigation module centers around improving route efficiency and safety aspects. The system employs geofences that link together to define specific delivery locations which enable drivers to follow optimal paths that lead to prompt and safe pickup of every child at their designated points. As a result this module helps smooth the driver's job while reinforcing comprehensive safety procedures during trips. The Supervisor Management module implements thorough administrative control measures through its framework. The system enables supervisors to monitor student attendance through real-time marking of participation or absence.

The development of Parentseye received significant contributions from me during my position as a full-stack developer. The comprehensive API required my design and implementation as well as data flow management between modules and I developed the front-end web interface with React

Parentseye serves as an advanced child safety solution which unites operational improvement with technological implementation to protect students while enhancing their daily transportation experience.

II. RELATED WORK

Kaushik Gupta et al [1] developed a system that allows parents to track their children when they are out of sight. This is accomplished through the use of a hidden WFPS-enabled device worn by the child and connected to the parents' smartphone via a mobile network. This Child Monitoring system allows you to monitor or track your child's activities from anywhere in the world. This system's notable features include geo-fencing, a discrete panic button, a long battery life, and real-time tracking.

An application that helps send SOS messages for the elderly was created by Netravati et al [2]. This application sends all the data from the child's phone to the server and from the server to the parent's phone when the SOS button is manually pressed. The parent portion of this app allows parents to view all of their children's activities, while the child portion only allows children to view a website while information is being fetched in the background secretly.

Poonkuzhlai Pet al. [3] described the development and implementation of a mobile IOT-based health and safety monitoring system for kids that uses a sensor-embedded health monitoring device for protection and emergency services. This system is used to continuously monitor the child's parameters as well as their location for safety purposes. N. Manjunatha et al [4] created a device that can be tracked using GPS locations, as well as a panic button on the device that alerts the parent via GSM module, calling for help. To control and constantly monitor the device, the parental android app was developed. The parental phone, which can receive and make calls as well as send and receive SMS on the smart device via GSM module, is always connected to the device.

Wireless technology is also integrated into the device, making it possible to bind it to an area within monitoring range. If the device leaves the monitoring range, an alert will be sent to the binding device, allowing you to keep a virtual eye on the child. health monitoring system for mobile devices The parental app allows for tracking of parameters like temperature and heart rate/pulse rate checks. The gadget also monitors whether it is plugged in or not using a contact switch and notifies the parent if it is unplugged. M Nandini et al [5] created a system using a The temperature, heartbeat, touch, GPS, GSM, and digital camera modules were all interfaced with the LinkIt ONE board, which was programmed in embedded C. The system automatically sends an SMS alert to the parent or carer and an MMS containing an image taken by the serial camera when the child needs help right away.

Senthamilarasi et al [6] used a Front-end user interfaces include a web application and a mobile app, a cloud and database for storing and retrieving data, and a monitoring device. Dhanalakshmi. M et al [7] created the system Child Tracking Device, which makes it simple for parents to monitor the whereabouts of their kids. This gadget uses SMS-based engineering. In order to find out the latitude and longitude of their child's location, parents do not need to send any special codes to the device. By pressing the key, they can receive the SMS. There are two ways for a child to alert their parents and neighbours if they feel unsafe.

The buzzer is turned on and an SMS alert is sent to the parents' or guardians' phone. Atul Ahire et al [8] described an Android application that has features for tracking children, including GPS tracking of their exact location. GSM will be used for network services as well as internet access. Arduino will also be used as a microcontroller in the child's module to sense and control objects. A.Saranya et al [9] created a wireless network-based Automatic Child Monitoring (ACM) system. The software hand function and the danger zone function are both implemented by ACM.

By utilising GPS sensors, acceleration sensors, and mobile GIS (Geographic Information System), the software hand function can keep an eye on the child's routine activities, and the safety zone function can instantly alert parents to the child's location. A. Gupta et al [10] proposed a model for child safety using smart phones that allows parents to track their children's locations and allows children to send a quick message and their current location via Short Message services in case of an emergency. Testing on the Android platform validates the proposed system.

III. RESEARCH METHODOLOGY

The Parentseye project research methodology follows a multi-phase iterative approach which integrates qualitative alongside quantitative research strategies to deliver a system that satisfactorily serves its user groups including parents and driving students together with supervisory personnel.

1. Requirements Analysis

Our first step involved conducting stakeholder interviews while administering surveys together with focus group discussions among parents and drivers and school supervisors. Qualitative research methods allowed investigators to discover essential issues involving real-time location tracking along with route optimization abilities and attendance management requirements.

System features originated from the quantitative information we collected about commute times as well as notification frequencies and areas where students needed to be picked up.

2. System Design and Architecture

- The system operated within three primary modules during its design structure.
- Parental Access Module: Provides real-time tracking, notifications, and distance metrics.
- The Driver Navigation Module depends on geofences for establishing optimum delivery stops.
- Supervisor Management Module: Facilitates attendance tracking and administrative oversight.

3. Technology Selection and Development Approach

A RESTful API served as the main system to ensure secure data exchange while providing efficient operations. The API functions as a central component which unites every system module to enable dependable data exchange between front-end applications and back-end systems.

The implementation of React for user interfaces created an adaptive and user-friendly interactive interface that responded to all user needs.

The implementation of Agile Methodology provided a process where developers conducted multiple iterative cycles which integrated their work continuously while performing tests at regular intervals and creating feedback opportunities repeatedly. This methodology supported continuous modifications which occurred while the development process ran.

4. Implementation and Integration

The development team created independent components for each part of the system namely the Parental segment and the Driver segment and the Supervisor segment. The separated module design enabled teams to concentrate their tests on specific sections while they easily found and repaired issues. The system used stable API protocols alongside encryption techniques from start to finish.

5. Testing and Evaluation

Testing Phases:

Unit Testing involved thorough examinations to check the operational capability of every individual component.

The testing process checked module interaction to guarantee secure data transmission.

Testing of real-world situations in User Acceptance Testing validated that the system fulfills user requirements.

Key performance indicators consisting of response time and data accuracy and system stability served as efficiency measurement metrics for system evaluation.

System performance and usability received feedback analysis from testing phases which then became incorporated into future development sequences for performance enhancement.

6. Deployment and Final Evaluation

A controlled real-time deployment occurred for the integrated system to assess its performance through dynamic operational monitoring.

Regular system checks enabled the detection of problems which led to systematic improvements that made the system

both reliable and flexible before its large-scale implementation.

The inclusive research methodology of Parentseye resulted in a solution delivery containing both technological strength and user-oriented practical capabilities. The development process ran repeatedly to make user feedback and performance tests essential for building a safe and efficient transportation monitoring system that centered on user needs.

IV. PROPOSED SOLUTION

4.1. Parentseye Digital Platform Architecture

The system sends live updates and warning messages to guardians for bus proximity to collection points and school premises and the student's home address.

The geofence technology enables driver navigation by creating specific zones for stops which helps optimize routes to achieve quick and efficient collection of students.

Real-time supervisor attendance oversight functions allow authorized personnel to track employee attendance records for enhanced administration.

Secure RESTful API ensures reliable and encrypted data flow among all system modules through its robust API method and appropriate data management system.

The React-driven responsive web interface delivers a user-friendly experience which benefits all three user groups including supervisors, drivers and parents.

4.2. Integration Mechanism

- **Parental-Driver Synchronization:** Synchronized real-time tracking and notifications between the parental and driver modules ensure timely pickups and efficient route adjustments.
- **Geofence Coordination:** Dynamically integrated geofences mark precise pickup zones, optimizing driver navigation and streamlining the collection process.
- **Supervisor Integration:** Seamless attendance tracking and status updates enable supervisors to maintain oversight and promptly address any operational issues.
- **Secure API Connectivity:** A robust, secure RESTful API framework underpins the entire system, ensuring continuous, encrypted data exchange across all modules.

V. RESULTS AND DISCUSSION

5.1. Impact Assessment

The pilot study conducted in an urban school district for the Parentseye system demonstrated significant improvements:

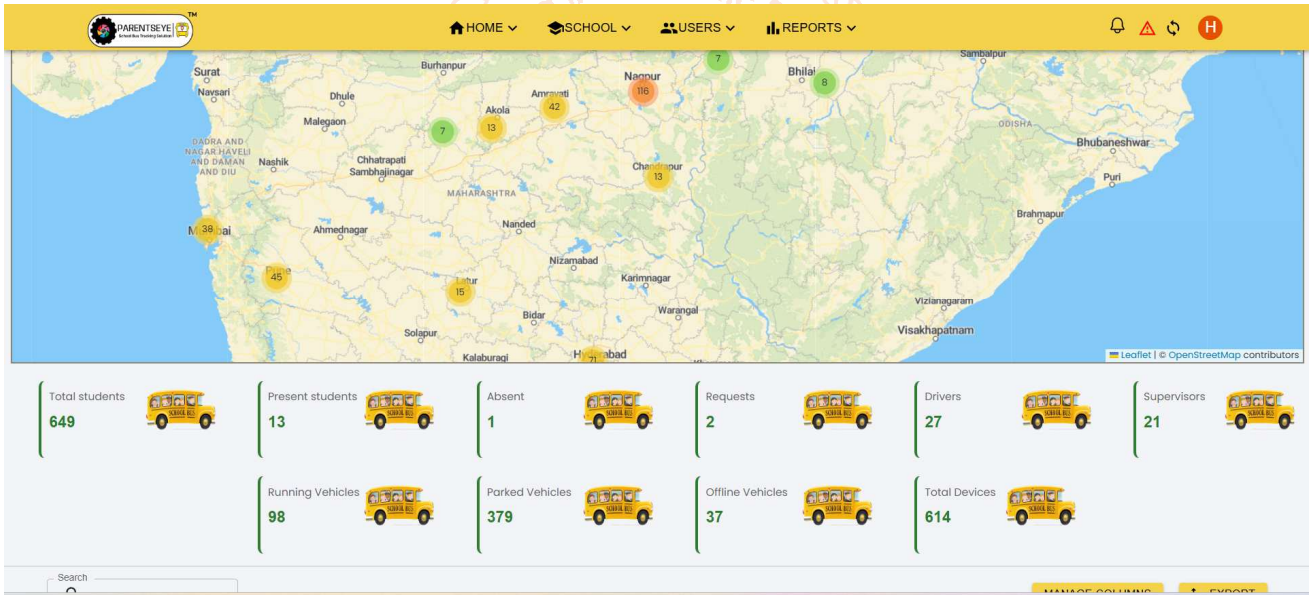

Fig. 1: Real-time GPS tracking interface of the Parentseye system.

- **Travel Time Reduction:** Commute times decreased by 20% due to optimized route planning and real-time tracking.
- **Cost Savings:** Stakeholders benefited from a 15% reduction in travel expenses, driven by efficient scheduling and navigation.
- **Operational Efficiency:** Enhanced supervisor oversight and accurate attendance tracking improved overall system reliability and child safety.
- **User Satisfaction:** 87% of users—including parents, drivers, and school administrators—preferred Parentseye over conventional monitoring methods.

5.2. 5.2 Graphical Representation of Results

- **Bar Graph:**

A bar graph comparing the average school bus commute times before and after the adoption of Parentseye.

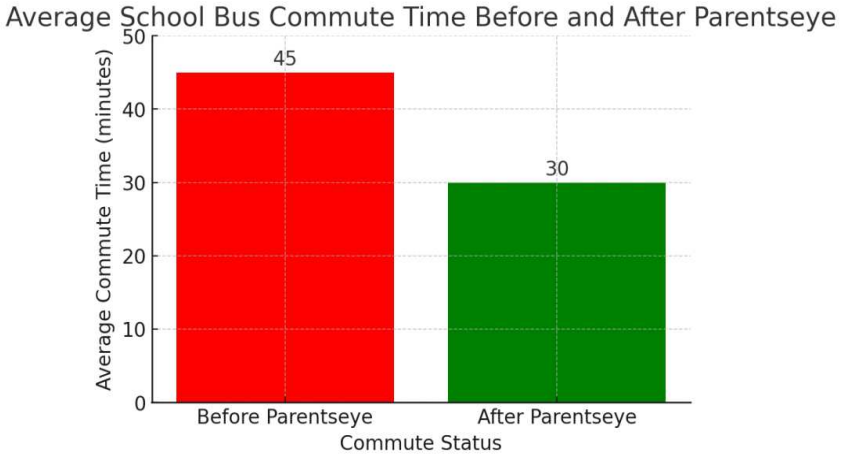

Fig. 2: Bar graph of commute time.

➢ **Line Graph:**

A line graph showing the percentage of cost savings realized by parents and school administrations over a six-month pilot period.

Fig. 3: Line graph of Cost saving by parents and school.

5.3. Challenges and Limitations

➢ **Technical Infrastructure:**

The initial setup requires significant investment in real-time tracking systems and secure IoT frameworks to ensure reliable data flow and operational stability.

➢ **Data Privacy and Security:**

Safeguarding sensitive information—particularly the location and personal details of children—is crucial, demanding robust encryption and strict data management protocols.

➢ **Scalability:**

As the system scales to cover larger regions and accommodate more users, integration and performance challenges must be addressed to maintain seamless operation.

➢ **User Adoption:**

Ensuring widespread acceptance among parents, drivers, and school administrators necessitates ongoing training, support, and continuous system improvements.

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