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A Survey on Real-Time College Transport Tracking Solutions: User Perspectives and Design Considerations

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Abstract: With growing reliance on technology for safe and efficient transit, real-time transport tracking systems in academic institutions have become essential. This paper surveys existing solutions for user expectations, system capabilities, design strategies, and implementation challenges towards developing such systems. Insights are drawn from a variety of contemporary studies to recommend optimal features and architectural considerations. It emphasizes the importance of user-centric design, mobile accessibility, and integration with GPS-enabled tracking servers to provide accurate bus location updates. Key findings underline the necessity of secure, scalable, and user-friendly systems tailored to the specific needs of students, parents, drivers, and college administrators. The paper also discusses various technologies and methodologies adopted in existing systems and proposes an optimized system architecture for a mobile-based college bus tracking solution. This study serves as a resource for developers and academic planners aiming to improve student and staff mobility leveraging digital solutions.

Keywords: Transport, Real-time tracking, GPS, mobile application, user experience, system design, student safety, student mobility.

I. INTRODUCTION

The most important asset of man today is ‘time’. To efficiently manage time, introduction of effective transportation system for movement of goods and people that leads to better quality of life and economic growth of the society is crucial. Transportation system hence forms the heart of the system. The increasing demand for punctuality, safety, and transparency in campus transportation coupled with rising expectations of tech-savvy students has led to the evolution of real-time tracking systems tailored for colleges and universities. Traditional transport arrangements with multiple routes for modern campuses often suffer from communication gaps, inefficiencies, and security concerns. Technological advancements like GPS, internet connectivity, mobile computing and cloud infrastructure have made it feasible to create highly responsive, real-time user-centric transport tracking systems offering location-aware solutions to students, parents, and administrators. This paper provides a comprehensive survey of existing solutions, highlights gaps in current practices, and explores user-centric improvements in design and implementation. In this paper, a real-time college bus tracking system has been proposed as a practical solution mentioning the user requirements, design considerations and system architecture.

II. LITERATURE REVIEW

Following papers have been reviewed and the essence of the review has been documented in the following subsections.

A. College Bus Tracking System using GSM and GPS [1]

This paper has aimed to find out the location of the college bus using GPS (Global Positioning System) and GSM (Global System for Mobile communication) and without using internet at the user’s end. Using GPS and with GSM the user can know the location of the bus by an SMS (Short Message Service). All the students have to store their database (i.e. mobile number) in GSM module. The researchers have utilized Raspberry Pi, GPS, GSM hardware and Thonny software package. Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse.

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B. Analysis Real Time Bus Tracking System [2]

It is a literature review paper which has documented about the research papers documented by the following authors.

- ManiniKumbhar, MeghanaSurvase, Pratibha MAvdhutSalunk [3]: These Authors have implemented "Real Time Web Based Bus Tracking System". The proposed system reduces the waiting time of remote users for bus. A system is used to track the bus at any location at any time. All the current information is stored to the server and it is retrieved to remote users via web-based application. This System is a web-based system.
- M. A. Hannan, M. Mustapha, A. Hussain and H. Basri [4]: These authors have implemented the system "Intelligent Bus Monitoring and Management System" The proposed system uses Artificial intelligence with the help of RFID module which is used in-order to reduce the manual work carried out in the Bus-Management & Monitoring System. In this a RFID is used to track a bus when it crosses the bus stop. Hence the exact location of the bus is not shown, only an approximate location is shown based on the bus stops. In today's world, accuracy is very important and hence this was the limitation of this research paper.
- Süleyman Eken, Ahmet Sayar [5]: These authors have implemented the system "A smart Bus Tracking System based on location- aware service and QR code." In this paper, any passenger with Smartphone can scan QR code placed at bus stop to view estimated bus arrival times, current location of the bus. The drawback in this project was that the user had to be physically present at the bus stop to scan the QR code.
- R. Maruthi, C. Jayakumari [6]: These authors implemented the system "SMS based Bus Tracking System using Open-Source Technologies." A bus tracker application to track a bus using GPS transceiver has been proposed in this paper. The objective of this work is to develop a system that manages and controls the transport using a tracking device to know the scheduled vehicle and the current location of the vehicle via SMS using a GPS tracking device.
- Md. Marufi Rahman, Jannatul Robaiat Mou, Kusum Tara, Md. Ismail Sarkar [7]: These authors have implemented the "Real Time Google Map and Arduino Based Vehicle Tracking System". Arduino coordinates are shown on google maps.

C. A Successful Approach to Bus Tracking Using RFID and Low Power Wireless Networks [8]

The objective of this paper is the design of tracking and management system for a public transportation system using Radio Frequency Identification (RFID). In this work, each bus is tagged with a unique RFID card which gets detected by the RFID receivers at bus stops. The receivers are attached to a low power wireless communication network which immediately updates its status to the cloud server. Data from the cloud server is made available as a simple user interface in the form of a web page or application. This can help the passengers locate the nearest approaching buses which can take them to their destination in the shortest possible time. The scheme can also aid the scheduling authorities to closely monitor the route of buses.

D. Bus Tracking System using Mobile GPS Technology [9]

This research work introduces a cost-effective Bus Tracking System that eliminates the need for expensive GPS devices in buses. Instead, it harnesses the GPS capabilities of drivers' mobile devices for real-time bus location tracking. The system comprises two modules: one is designed for user application for users and the other is a driver application for drivers. Users can access the system via any web browser, providing vital information on bus numbers, routes, and stops. In a transportation landscape where bus locations often remain uncertain, this solution addresses the issue by precisely fetching real-time bus locations from drivers' mobile GPS. It transforms the user experience, facilitating efficient journey planning. The user-friendly interfaces ensure accessibility, offering a dependable and cost-effective transportation information platform. This approach offers an optimal solution for accurate and easily accessible transportation information without costly onboard GPS device.

E. GPS and GSM Based Real Time Bus Monitoring System [10]

The authors cite about existing solutions of tracking across globe. In countries like Japan and Mauritius, GPS Tracking systems have gained importance in the last decade. Five major systems that people and businesses can use for tracking purposes have been discussed.

- The first system is provided by Island Communications Limited (Pioneer in GPS Technology in Mauritius) and is called Exact. It is a device which when equipped with a SIM card can be used for vehicle or any other asset tracking.
- Another existing GPS tracking system is the Garmin Nuvi 215/205 series, a device sold by Naveo GPS solutions in Mauritius. This device's main functionality is for navigation purposes since it comes with a detailed map of Mauritius. However, for GPS tracking, there is the passive mode option which records all positions of the device and the user will need to load the tracks from the device to a computer which has the appropriate software to view the map. There is only recorded tracking which is possible on this system.

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- The third system is called Geo tab. It is a system which consists of a small device which needs to be connected to the battery of a vehicle and the device will transmit data to web based application through which an individual will be able to see the device live and also the past tracks of the device. There is the option of Geo fence which allows an individual to be alerted by email and SMS if in case the device leaves a particular zone.
- One track' is the fourth system identified and it is the tracking solution outsourced by a Mauritian representative of Oner Alarm; a China based company. This system is mainly for vehicle tracking and it comes up with a GPS tracking device and a web-based system with a server which needs to be bought for all functionalities. One track provides live tracking, SMS/Email alerts, SOS Panic button, speeding alerts and the user can also request for its position via SMS.
- The last system identified, and perhaps the most popular in the recent past in Mumbai's 'BEST' Bus Tracking System. In this system passengers are able to access the position, speed and expected arrival time of A/C buses by sending a code number, specific to each bus top, via SMS to 56060. This SMS reaches an intermediate server; the server stores the current information of all A/C buses currently on route and responds to the sender with details. It also uses a GSM module. The limitation is that it is valid for only air-conditioned buses.

F. College Bus Live Tracking System Using GSM And GPS [11]

In this research paper, a GPS receiver and GSM module are used to control every aspect of the process using an Arduino board. The vehicle's coordinates are detected by a GPS receiver, and the coordinates are sent to the user via SMS via a GSM module. Pressing the "GET LOC" button on the Android app will immediately send an SMS to the system installed in the car. The GSM module, which is connected to the system, receives the sent message and transmits the message data to Arduino. Arduino scans it and compares it with the pre-programmed message from the Arduino. This message contains the location coordinates of the vehicle.

G. Simple Bus Tracking System [12]

The authors have proposed the following steps for tracking the bus.

- Step 1: GSM, GPS interfacing with Arduino board
- Step 2: Evaluating the signal transmitted by the GPS and to get the latitude & longitude values.
- Step 3: Collecting locations' data of desired bus stops and saving.
- Step 4: Comparing current values from GPS with saved values and generating messages using AT commands
- Step 5: Delivering an alert message to the students mobile.

III. OBJECTIVES

The objective of this paper is to consolidate the user perspectives and design considerations related to transport tracking systems in academic institutions and to arrive at the requirements and architecture of a system envisaged for the said purpose.

The primary objective of the envisaged system is to provide location updates of the transport buses to the respective stakeholders on hand-held mobile devices like smart phones and tablets. The stake holders could be students, parents, drivers, college staff, transport manager, traffic police, fire brigade or emergency medical service providers.

Following is the comprehensive list of objectives.

- To understand and integrate the perspectives of users for designing the system.
- To identify the use cases from user perspectives.
- To identify the technological components essential for real-time transit tracking.
- To propose a user-focused scalable and secure transport tracking adaptable for college environments.
- To suggest user requirements and design considerations for improving operational efficiency and safety.
- To bridge the gap between academic research and deployable real-world applications.

IV. METHODOLOGY

This survey follows a qualitative analysis approach by examining academic publications, implementation case studies, and real-world mobile apps. Additionally, mock user interviews and scenario-based requirement gathering were conducted involving students, parents, and faculty advisors. These insights were triangulated with current mobile design principles and software engineering models to derive the proposed system framework. The feasibility, technical aspects and implementation challenges were further discussed with a CTO of a renowned company functioning in a similar field since a couple of decades. The methodology includes the following.

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A. Literature Review

Twelve recent papers were reviewed as discussed in Literature Review (Section II of this paper).

B. Brainstorming and Informal Interviews

Student Authors participated in brain storming sessions to arrive at the not-hither-to addressed user perspectives.

- Healthcare service providers (ambulance, doctors, nurses) are considered as the stakeholders of the system during medical emergencies
- Traffic Police will be supported with the envisaged system for monitoring and control during traffic emergencies

Parents and Guardians were interviewed to understand their concerns and needs in the context of college bus transit.

- Expected Time of Arrival (ETA) of the bus and Confirmation message for bus having reached the college campus figured out as the primary expectations of the parents.
- Predictability and reliability were the major non-functional requirements which emerged as the outcomes of the interviews with the parents and guardians

C. Scenario Identification and Analysis

Several scenarios of commutation by various stake holders of college bus transportation were envisaged. Fig. 1 depicts a scenario for a single 'pick-up route' from the START_LOCATION to the END_LOCATION, the college campus. The icons shown along in the figure depict the stakeholders.

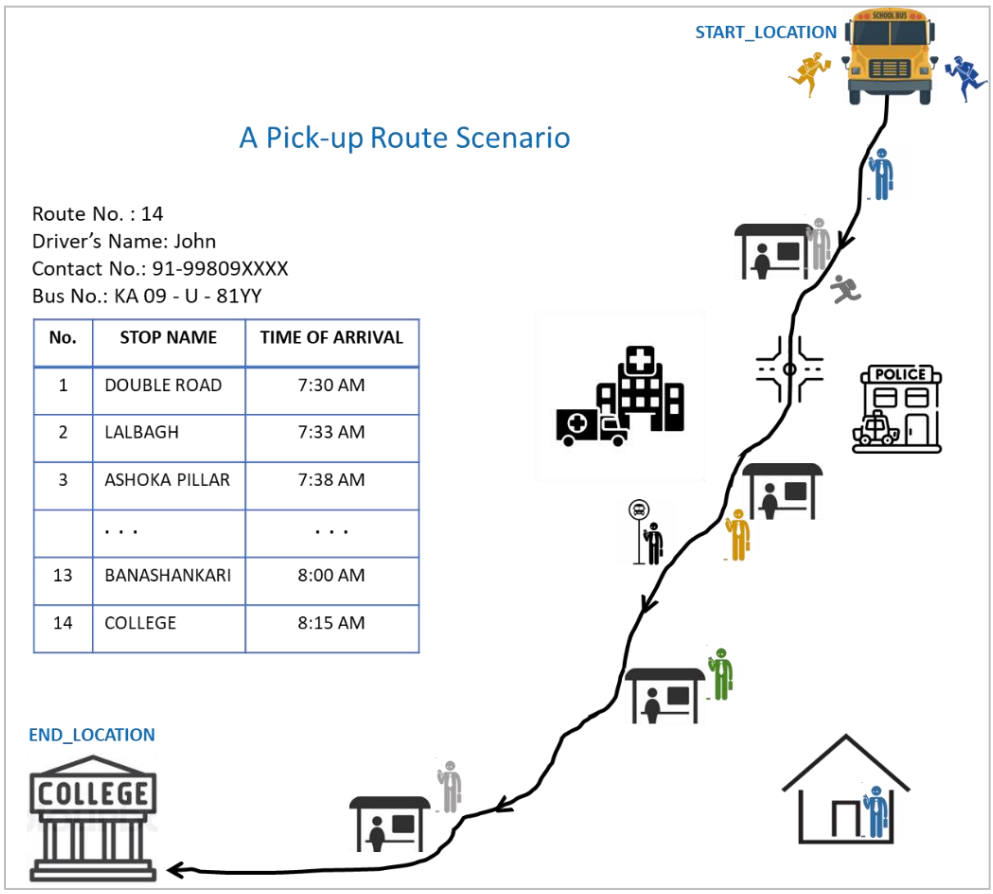

Fig. 1 Illustration of a pick-up route scenario

This scenario could be generalized to many such pickup routes operating simultaneously from different start locations. Analysis of such scenarios reveal many use cases like: students may be interested in knowing the arrival time of their college bus; parents could be interested in knowing whether their ward's bus has reached the college; traffic-police may need to track the bus; emergency requirements may require healthcare services, etc.

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On the contrary, a 'drop route' would start from college and end in the destined location. Route numbers are assigned for pick-up routes (which remain the same for their corresponding drop-routes). As an example, a college may have 15 route numbers resulting in 30 trips per day (pick-up trips plus drop trips).

D. Technical Discussions and Reviews

Technical discussions were held with the CTO of a renowned telematics software company to elicit design considerations and architectural decisions of the envisaged system. The outcomes of these discussions were valuable for arriving at the proposed system given in section V of this paper.

Student authors had multiple reviews with the [1]Faculty Guide who was instrumental in authoring this paper.

E. Comparative Tabulation of App Features

Comparison of UI aspects for transport / delivery apps, focusing on core design principles, usability, and mobile user experience is given in Table I.

TABLE I COMPARISON OF UI ASPECTS

Feature / Aspect	Transport / Delivery Apps			
	Uber	Ola	Porter	Rapido
Home Screen Design	Map-centric with quick destination input	Map-centric with service tabs	Service categories upfront (e.g., trucks, 2-wheelers)	Minimal map, focus on ride-type buttons
User Onboarding / Signup	Smooth, mobile number & OTP	Mobile OTP + optional email	Mobile OTP + service preference	Quick onboarding, skips unnecessary steps
Service Options Display	Tabs: UberGo, Comfort, Auto, etc.	Tabs: Auto, Micro, Prime, Rentals, etc.	Buttons for truck, bike, 3-wheeler	Bike, Auto, and Delivery options upfront
Live Tracking Experience	Real-time map with animated route	Similar real-time GPS map	Real-time route & delivery point shown	Simplified real-time tracking
ETA	Displayed before and after booking	Displayed clearly after vehicle match	ETA and delivery duration shown clearly	ETA is shown pre- and post-booking
Driver Details UI	Photo, ratings, vehicle, license plate	Photo, rating, car number, contact	Driver image, contact, vehicle info	Minimal info but enough for recognition
Theme and Colours	Black/White + accents	Yellow/White + accents	Blue/White with icons	Yellow/White with large icons
Payment Integration UI	Seamless, many wallet options	Wallet-first (Ola Money), UPI, cards	UPI, card, cash available	UPI, Paytm, PhonePe integrations
Ease of Use	Very intuitive, minimal steps	Similar to Uber, slightly more steps	Simple, industry-specific language used	Ultra-simple and fast booking process
Special Features	Scheduled rides, fare split, rewards	Rentals, subscriptions, Ola Pass	Multi-stop delivery, goods type select	Daily commute pass, discounts UI
Parent Guardian / Friendly UI	Not specifically targeted	Not specifically targeted	Allows sender and receiver view (optional)	Not targeted, but intuitive for all ages
Accessibility & Language Support	High, includes voice-over and dark mode	High, supports multiple Indian languages	Basic support, fewer language options	Moderate support, more local focus

V. PROPOSED SYSTEM

Based on the methodology discussed in section IV of this paper, the user requirements, design considerations and the architecture of the proposed system have been detailed in this section.

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A. User Requirements

The proposed system is envisaged to address the following use cases from stakeholders' perspectives:

1) Students and Staff Specific Use Cases:
   - Register / Login / Logout
   - View Bus Location
   - View Estimated Time of Arrival
   - View Bus Details & Driver Details
2) Driver Use cases:
   - Register / Login / Logout
   - Update Bus Start Time
3) Transport Manager (System Admin) Use cases:
   - Register / Login / Logout
   - View Bus Location
   - View Estimated Time of Arrival
   - View Bus Details & Driver Details
   - Allocate Drivers to Routes and Buses
   - Allocate Students to Routes
   - Create / Update Route Configuration
4) Parent / Guardian Use cases:
   - Register / Login / Logout
   - View Ward Bus Location
   - View Estimated Time of Arrival
   - View Bus Details & Driver Details
5) Govt. Body (RTO / Police / Fire Brigade) Use cases:
   - Register / Login / Logout
   - View Bus Location
   - View Bus Details & Driver Details
6) Healthcare Service Staff Use Cases:
   - Register / Login / Logout
   - View Bus Location
   - View Bus Details & Driver Details

B. Design Considerations

Following design considerations have been arrived at, for the proposed project.

- User Roles: Interfaces vary for students, parents, drivers, admins, government bodies, healthcare staff.
- UI/UX: User friendly design with professional aesthetics.
- Scalability: Ability to handle multiple buses, routes, and users.
- Security: Authentication, encrypted data transmission, and privacy compliance.
- Offline Fallback: Location caching for areas with low connectivity.
- Modularity: Splitting components into tracking functionality and user interface
- Platform Independence: UI design using Jetpack Compose for Android compatibility

C. System Architecture

This proposed system is a GPS-based system for tracking bus locations in academic institutions. Bus tracking operates by utilizing a fusion of Satellites and Cellular Towers. The system consistently gathers location data using GPS device installed in each vehicle, subsequently transmitting this data to a Tracker Server (TS). This information is received by the user mobile using poll-and-pull strategy and displayed to the user. Fig. 2 and Fig. 3 depict the system architecture from communication perspective and design perspective respectively.

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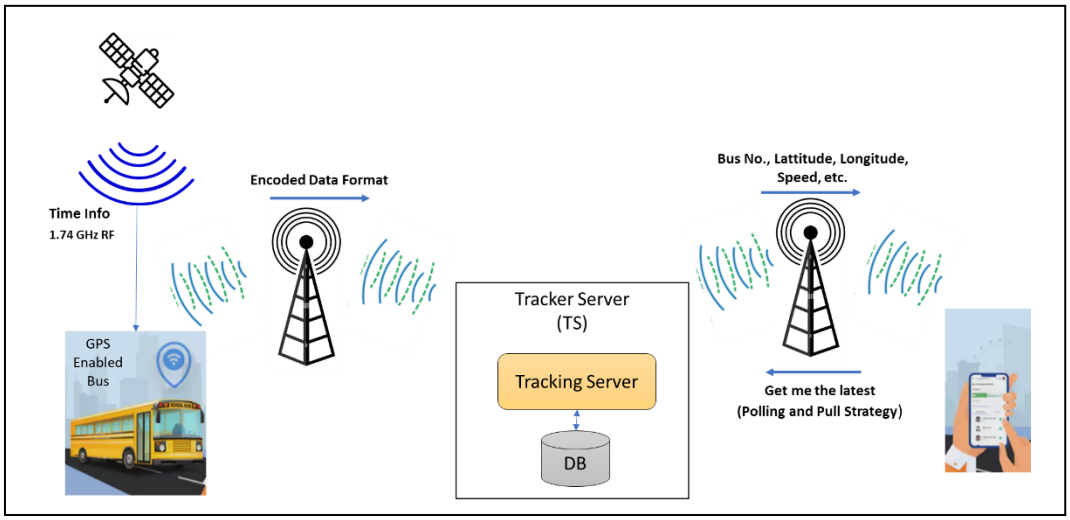

Fig. 2 System Architecture from communication perspective

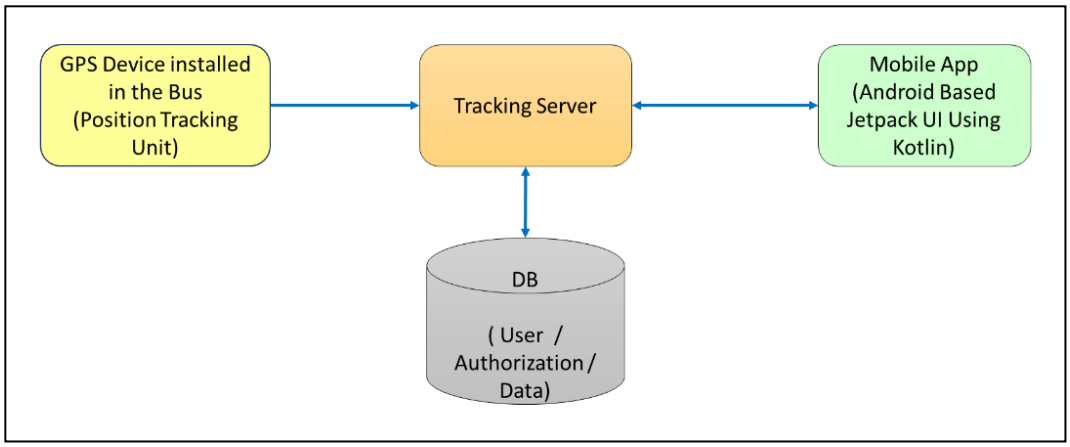

Fig. 3 System Architecture from design perspective

VI. CONCLUSION

Transportation holds a central significance in the everyday routines of college students, affecting their punctuality, readiness, and overall academic experience. Today, technology enables us to leverage the power of mobile GPS to track buses in real-time, providing immense potential to enhance the user's commuting experience. Efficient bus transportation in educational institutions deeply impacts student performance and institutional credibility. Unpredictability and lack of real-time monitoring often affect the system. Technological progress specifically GPS tracking and smart phone capabilities has the potential to revolutionize this scenario. Towards this goal, current research paper has proposed a practical solution in terms of system architecture. Literature survey has substantiated the said goal.

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