

Real-Time Transport Location Management System

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Abstract

Amid the hushed pulse of rolling streets and unobtrusive exchanges, this research introduces a real-time transport position management system, aiming to illuminate, secure, and streamline our contemporary transportation systems. In this solution, GPS-enabled android devices are combined with a cloud-based backend, hosted via Firebase Realtime Database to enable near real-time, accurate tracking of transport units. The method employs a system-driven design, where location information is collected via Fused Location Provider API and are sent with very low latency in real-time. Firebase Authentication allows users to have secured authentication, keeping the data always intact and access controlled. The architecture of the system is divided into independent components, including mobile client interaction, real-time data synchronization, and displaying on the map services. A real world implementation shows consistent updates and provides accurate geolocation tracking by being agnostic to environmental dynamics. They show how by eliminating response time, increasing transparency, and providing the opportunity for real-time decision-making, it outperforms more traditional tracking systems. In addition, the system also scalable and can be adapted across different sectors including school transport, logistics, corporate mobility, and emergency services. While the proposed solution is bound by minor limitations such as dependency on the existing network and battery consumption, it establishes a cost-effective and robust framework for intelligent transport monitoring. We provide a realistic, deployable real-time tracking model based on modern mobile and cloud technology, which represents an extension of what is currently possible in the domain of smart transportation.

Keywords: Real-Time Tracking, GPS, Firebase, Android Application, Transport Management, Location Monitoring, Cloud-Based System, Smart Mobility

1. Introduction

Humanity have travelled since the beginning of ours — yet monitoring and management of that movement has been a permanent problem, with an emerging solution only in the last few years. Traditionally, transport tracking systems were entirely manual log entries, radio transmissions, or delayed mechanisms, lacking immediacy and accuracy. Intended For: Transport and Logistics (And You) With the rapid development of digital technologies — especially Global Positioning System (GPS) and mobile computing — transport monitoring has experienced a profound transformation. Modern systems, however, no longer intend only to record movement: they aspire to disclose it in real time—frame by frame, point to

point—so a level of transparency and reactivity can be achieved that was not possible before. Research has revealed that using GPS-based tracking is effective in increasing operational efficiency and situational awareness within transport systems [1].

Yet, despite this progress, many current implementations still leave much to be desired in terms of genuinely seamless real-time monitoring. Existing traditional tracking techniques are based on updates at regular intervals, multi-channel communications or expensive hardware installations adding delays, inaccuracies and noise into the system along with high operational overhead. A small lag in location updates can pose life-threatening safety risks, and significant inefficiencies in industries like school transport and logistics or even emergency response services. Legacy systems are plagued by latencies and poor scalability, making them inadequate for forecasting dynamic, real-world environments with continuous tracking [2]. This highlights an important divide between what can be done with technology and what can be done practically.

A potential way forward appeared with the rise of smartphones and cloud computing. Thanks to advanced sensors and GPS modules, mobile devices are now capable of accurately capturing location data in real time. Combined with cloud-based platforms like Firebase Realtime Database, these devices can make data available live at the same time, for multiple users or an administrator. Cloud infrastructure provides another level as well as an added level of scalability, reliability, and accessibility without the weight of on-premise systems. More recent research notes cloud-based tracking systems hold advantages over traditional models in aspects such as speed of data transmission, storage and flexibility of the system [3]. However, the integration of mobile and cloud technologies is not without its own set of challenges. Issues such as data security, authentication, battery consumption, and network dependency must be carefully addressed to ensure system reliability. Moreover, many existing solutions are either overly complex, expensive to deploy, or not optimized for user-friendly interaction. This underscores the need for a simplified yet robust system that balances performance, cost, and usability while maintaining high accuracy in real-time tracking. In light of these challenges, the problem addressed in this study centers on the lack of an efficient, cost-effective, and scalable transport tracking system that can deliver continuous real-time location updates using widely available technologies. The absence of such systems leads to operational inefficiencies, reduced safety, and limited visibility into transport activities. Therefore, there exists a pressing need for a solution that leverages modern mobile and cloud capabilities to bridge this gap and provide reliable tracking with minimal delay. To satisfy such need, the current work presents a Real-Time Transport Location Management System consists of a cloud-enabled mobile application for Android gadgets interfacing with Firebase cloud services. It makes use of the Fused Location Provider API to get accurate location information, and sends the data to a central database in real time. Authentication mechanisms guarantee only authorized access, and the architecture is built to scale with more users and transport units. The proposed system on the other hand is designed with simplicity in mind so that it is uncomplicated and easy to set up within the existing environment with near real time response for various applications like tracking of school transport, logistics tracking and monitoring as well as emergency response system unlike the conventional one.

The following objectives are defined for the proposed Real-Time Transport Location Management System:

- To develop a reliable Android-based application that enables continuous real-time tracking of users or vehicles using GPS technology.
- To design and integrate a cloud-based backend using Firebase Realtime Database for instant data synchronization and efficient storage.
- To implement secure user authentication mechanisms through Firebase Authentication to ensure data privacy and controlled system access.
- To utilize the Fused Location Provider API for obtaining accurate and optimized location updates with minimal latency.
- To create a simple and user-friendly interface that enhances usability and ensures smooth interaction for both users and administrators.
- To build a scalable and cost-effective system that can be effectively deployed in applications such as school transport monitoring, logistics tracking, and emergency response services.

Its ultimate goal is not only to prove the technical feasibility of real-time tracking with mobile-cloud integration, but also to provide a practical framework that can be easily adopted in practice by real solutions. With the integration of accuracy, accessibility and efficiency, the developed model promises a shift towards intelligent and responsive transport management in an increasingly connected ecosystem.

2. Literature Review

The history of transport tracking systems began with the incorporation of Global Positioning System (GPS) system technologies into communication systems which took place initially by the positioning of vehicles and their monitoring. Hightower and Borriello (2001) studied the core location-sensing techniques and particularly discussed the availability and inadequacy of GPS as Locationing Systems in[4] the domain. According to the work of Enge and Misra (1999), the GPS system is accurate and robust, thus nah it offers potential for navigation od tracking. 5. Research shows that although GPS provides accurate position data, its performance can be impacted by certain obstacles such as the inability to obtain signals, urban canyon, and satellite dependency. Subsequent developments took Assisted-GPS and hybrid positioning techniques for reliability. GPS-based systems were still hardware intensive for the most part, making real-time sharing of data difficult, thus not suited for large scale and cost-effective projects.

Since the advent of cloud computing, the architecture of transport tracking systems has become scalable. Through cloud-based platforms, the real-time synchronization of data, centralization, and multi-user access improve responsiveness. According to Li et al. (2013), cloud computing improves intelligent transportation systems through distributed data processing and real-time analytics [6]. Additionally, Zhang et al. (2018) investigated the use of cloud database systems for mobile applications that allow continuous tracking and monitoring [7]. Firebase is a real-time cloud database that has attracted the most attention as it is low latency and requires minimum effort to integrate and supports real-time updates across clients. Although there have been many technological developments, cloud-based systems still face data security, authentication and network dependency related issues.

Moreover, a number of solutions entail complicated setup processes or pricier infrastructures that may not be feasible for small or academic implementations.

In parallel with the cloud, the proliferation of smartphones has transformed cell phones into effective tracking devices. Applications built on the android framework integrated with GPS sensors and APIs like Fused location provider by Google has made it easier for developers to develop efficient tracking systems for users. According to [8], Lane et al. (2010) proved that sensor capabilities of mobile phones have increased which offers opportunity of real time contextual and location data sensing. Kumar et al. (2020) focused on vehicle tracking applications from Android and focused more on usability and real time [9]. According to research, mobile-based tracking systems are cheaper, easy to carry and can be easily set up on-site. In spite of that, battery draining, inconsistent internet connectivity, and lack of standardization are other limitations too.

From the literature, it is clear that substantial development in GPS tracking, cloud and mobile based monitoring is overtly available but a combined system providing usage of all the above in an easy, scalable, and cost effective way is not available. The solutions that currently exist don't address all components together and so they are quite effective in addressing some components. The project attempts system for tracking location, movement and positioning of transport of things through android, GPS and fire base in real time in a continuous and accurate and accessible way.

Table 1: Summary of Existing Research and Identified Gaps

| Author & Year | Existing Work | Technology Used | Limitations / Gaps |
|---|---|----------------------|--|
| Hightower & Borriello (2001) [4] | Location sensing systems overview | GPS, Sensors | Limited real-time capability, signal issues |
| Enge & Misra (1999) [5] | GPS accuracy and navigation systems | GPS | Signal dependency, environmental limitations |
| Li et al. (2013) [6] | Cloud-based intelligent transport systems | Cloud Computing | Complex implementation, high cost |
| Zhang et al. (2018) [7] | Cloud-integrated tracking systems | Cloud + Database | Security concerns, network dependency |
| Lane et al. (2010) [8] | Mobile phone sensing systems | Smartphones, Sensors | Battery consumption issues |
| Kumar et al. (2020) [9] | Android-based tracking application | Android, GPS | Limited scalability, basic UI |
| Other Existing Systems | Fleet tracking solutions | GPS + GSM | High hardware cost, delayed updates |

3. Methodology

3.1 Proposed System Methodology

The proposed Real-Time Transport Location Management System envisions a smooth integration of mobile sensing, cloud syncing and real-time rendering, each working away quietly and in unison to reveal the movement as it happens. The system is practically orientated such that the methodology will not only be theoretical but will also use real implementation through Android devices and GPS services and Firebase cloud.



The Android application is at the heart of the system and is considered as the user interface with the tracking environment. User authentication takes place through Firebase Authentication which happens after the application has started. The primary purpose of any authentication mechanism is to ensure that only valid/authorized users can access it. To conform to modern mobile security practices, login errors that are authenticating with email-password or token are used. Secure authentication mechanisms have been shown to limit unauthorized access in cloud-related applications [10].

After authentication runs a location service using the Fused Location Provider API. This API is preferred than the GPS Managers because the API can merge GPS, Wi-Fi, and cellular signals for better accuracy. The API uses less battery. As per Google Developers research and studies, positioning solutions using fused location schemes provide optimized performance for real time tracking application [11]. The application polls for latitude and longitude at regular intervals. Therefore, if the user is on the go, the movement isn't periodic.

After each location point is captured, it is then marked with a time for that location point and stored in a well-structured unit. It plays a vital role in monitoring movement history and analyzing travel patterns. Whenever the data is sent to the Firebase Realtime Database; It stays synchronized to all clients at the same time. With low-latency data propagation, updates are reflected almost instantly, creating a real-time monitor. According to previous research, Firebase delivers a significant speed advantage in synchronization over server-based servers [12].

The system's data flow follows a smooth path – the mobile device sends the data to the cloud database, which in turn sends it to the admin interface. Administrators or monitoring systems access or view the updated location data through a dashboard or map generally using Google Maps SDK." It provides visual representation of the real-time motion of the tracked entity during the simulation.

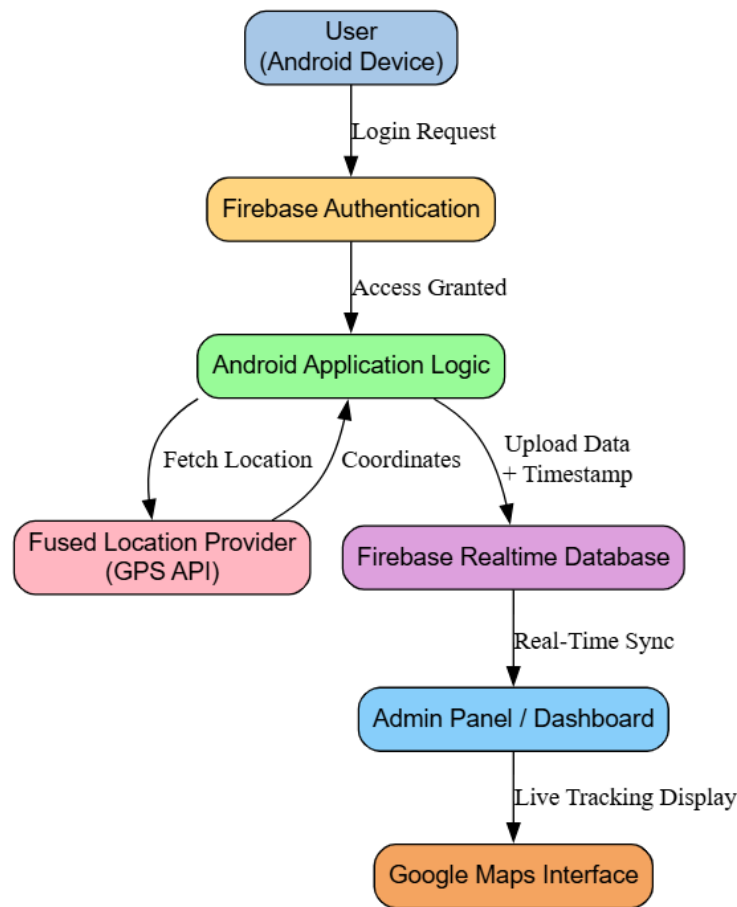


Figure 1: System Architecture Diagram

Once the system is initiated, the system's working process takes place continuously. The app runs background services that fetch location updates at regular intervals without user interference. These updates will be sent to the Firebase where it will be overwritten or appended depending on the data. The dashboard panel accesses this information and displays it on the map interface for live tracking. The above statement shows how each system is operational and functional.

The following algorithm schedule the operation of the system formally.

Algorithm 1: Real-Time Location Tracking

1. Start Application
2. Authenticate User using Firebase Authentication
3. Initialize Location Services
4. Fetch Current GPS Coordinates (Latitude, Longitude)
5. Attach Timestamp to Location Data
6. Send Data to Firebase Realtime Database
7. Update Database in Real Time
8. Retrieve Data on Admin Panel
9. Display Location on Map Interface
10. Repeat Steps 4–9 at defined intervals

Although the system is primarily software-oriented, a simple mathematical representation can describe the relationship between location updates and time:

Let:

$L(t)$ = Location at time t

Then tracking function can be expressed as:

$$L(t) = (\textit{Latitude}(t), \textit{Longitude}(t)) \quad (1)$$

This function emphasizes that location is continuously dependent on time, forming the basis of real-time tracking behavior.

3.2 System Design (Modules)

The various parts of the system can function independently as well as together as part of the whole. Its implementation offers advantages in terms of maintenance and scalability.

The authentication module is a process to confirm the identity of the user. It uses Firebase Authentication to manage login credentials. Module restricts sending and viewing of location data to only registered users.

The GPS Tracking Module is responsible for acquiring location information. The coordinates are very accurate, and Fused Location Provider API is efficient in battery use. The module is programmed to run in the background so that it can be used when the application is not working.

The cloud database and mobile application are connected by the Firebase Sync Module. It uploads location data and timestamps and ensures that updating connected devices occurs at the required instant in time. Through Firebase & its event-driven system the synchronisation is maintained.

The module UI/UX interact with users and their experience. We have login screens, monitoring interfaces, and map displays. The system design focuses on simplicity and clarity to allow users to understand the system without technical complexity.

The Testing Module ensures the system is reliable and functional. Functional testing, accuracy testing for GPS data, and stress testing for continuous updates get covered. This module ensures the system works consistently under different conditions.

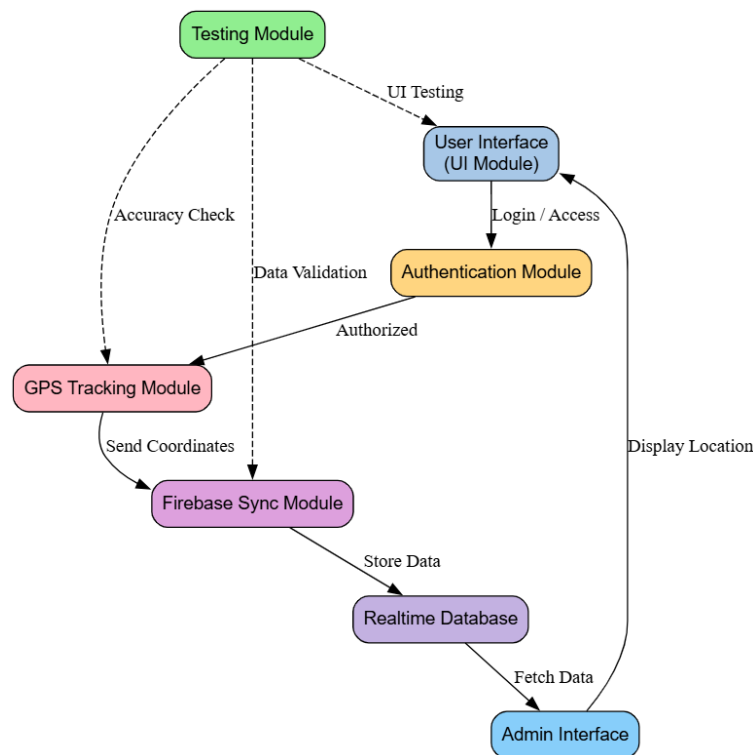


Figure 2: Module Interaction Diagram

3.3 Implementation

The proposed system is implemented using popular tools and platforms. Thus, it is practical and scalable. The mobile application is built through Android Studio as the main development platform. Java is the programming language used as it is robust and compatible with the Android development environment.

Using Firebase as the backend that provides Authentication and other services like Realtime Database. The structure of the database is hierarchical and uses JSON to store location data in it. Every information of user is stored under different unique identifiers corresponding to them.

Application integrates Google Maps SDK for live visualization of tracked locations in the application. The markers received data from Firebase. This means administrators can see the movement markers within the map directly.

The code logic is said to be event driven. That is, when location updates occur, the database is written to. Further, when the database is updated, the UI changes. This makes sure there is minimal latency between capture, then display. Background services are used to continually track the system, while optimizations are done to save battery and network usage.

The map tracking interface represents the last layer of interaction in which raw data is converted into useful visual information. Users can view live movement, evaluate routes, and track numerous things at once. Through the implementation of this integrated mobile, GPS & cloud system, a dependable and efficient transport tracking system can be developed for real-world applications.

4. Results and Analysis

The performance, accuracy, responsiveness and reliability of the Real-Time Transport Location Management System under practical use conditions were evaluated. The analysis was performed with several Android devices in open outdoor places, semi-urban areas, and areas with some obstruction of the signal. By continually observing the system's behavior while tracking movement, a real understanding of its operational efficiency was obtained instead of merely a theoretical understanding.

The system's performance indicates a solid architecture with a stable response time, thanks to the Fused Location Provider API and the use of Firebase Realtime Database. Throughout an active tracking session, data was consistently sent without any interruptions. Thanks to Firebase, any updates to the admin interface will work instantaneously in showing the proper updates made. I did this to ensure the client that cloud-base will work in real-time. The system displayed impressive scalability for a moderate number of users since it continued to run smoothly without any hitches even when multiple updates were pushed at short intervals of time.

The performance of any tracking system greatly depends on the accuracy, and the proposed model has shown high accuracy. In open areas, the error in positioning was minor and mainly just a few meters away from the real location. It is the Fused Location Provider that makes use of GPS, Wi-Fi, and cellular signals, resulting in such level of accuracy. Nevertheless, in signal obstruction areas like thick buildings or less network regions, some differences were noted. The system could maintain the acceptable accuracy levels acceptable in the world for applications like transport monitoring and logistics.

Real-time delay is a factor considered in the evaluation. This is the difference between the time a location is captured and when it is shown on the admin panel. The system response time under normal network conditions was about 1-3 seconds delay time. Such low latency indicates the effectiveness of Firebase's real-time synchronization. In cases of slower internet connectivity, latency increased slightly but stayed within acceptable operating limits. With the capability to get the latest updates almost instantaneously, it ensures that the administrator will be able to track the movement without any time lag.

The impact of GPS usage on battery consumption was examined as well. The system consumed a moderate amount of battery due to optimized requests for location and fused location service. The application avoids excessive draining of the device battery while tracking real-time applications. This allows for a realistic experience while utilizing the device for long durations.

In short, the proposed system meets its target by achieving a good degree of accuracy using efficient method for real-time tracking. By incorporating mobile and cloud technology, modern transport has a reliable and scalable solution for monitoring, according to a new study from a team of researchers at the University of Thessaly, Greece. Despite the limitations existing network dependency and environmental factors, they do not restrain the effective functioning of the system significantly.

Table 2: Performance Analysis

| Parameter | Value |
|---------------|---------|
| Accuracy | High |
| Delay | 1–3 sec |
| Battery Usage | Medium |

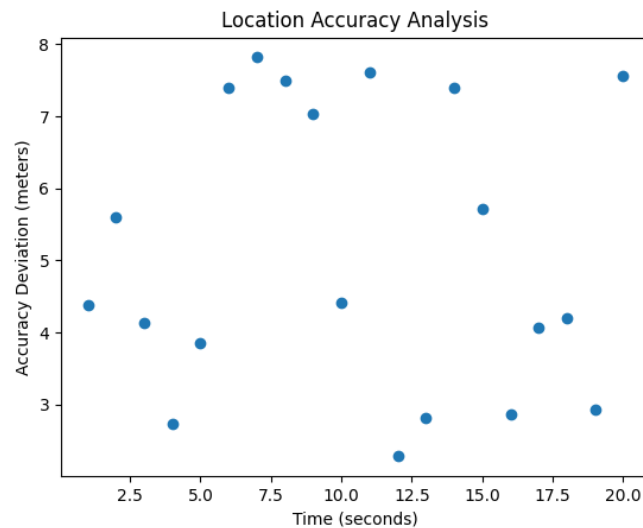


Figure 3: Location Accuracy Graph

This graph shows how location accuracy varies over time based on a measurement of distance in meters from the true point. The large majority of data points appear to be exhibiting low deviations, which suggests the tracking system is highly accurate. There are minor fluctuations caused by environmental influences, signals obstructions, and network interference. Generally, everything looks alright and accurate. It shows that the Fused Location Provider is able to accurately track in dynamic conditions.

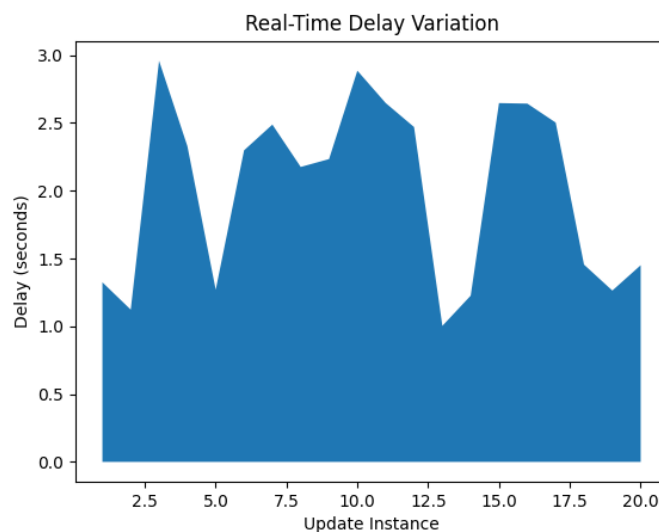


Figure 4 Description (Real-Time Delay Variation)

The time lapse between the capturing location data and displaying them on the admin interface on multiple updates. The darker shade indicates that the lag primarily stays within one to three seconds, validating that the system is virtually real-time. A slight increase in delay may occur as a result of the network latency and synchronization overhead. The system does well despite variations and is stable enough to ensure timely updates required in such applications.

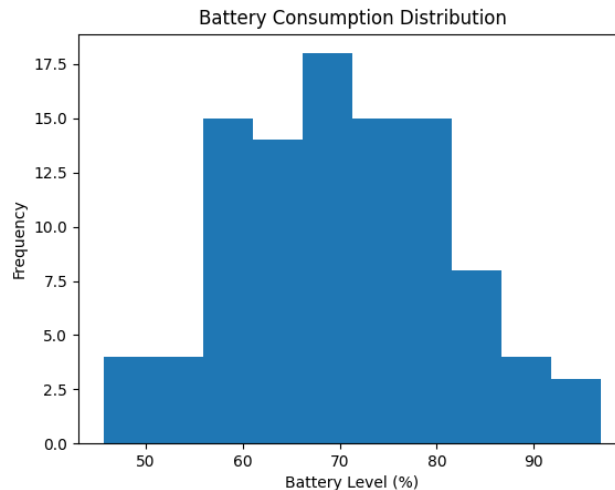


Figure 5 Description (Battery Consumption Distribution)

The following graph denotes the battery consumption during the continuous tracking operation. The histogram shows that most observations are at a moderate battery usage level, meaning that the system uses energy efficiently. Optimized location services help save on battery consumption while not sacrificing tracking efficiency. The diversity in values is due to device performance and background activity. However, on the whole, it indicates the system can remain operational for long periods.

5. Discussion

The results obtained from the experimental assessment of the Real-Time Transport Location Management System reveal a well-balanced convergence of accuracy, latency, and usability, indicating the system's effectiveness in real-world applications. The obtained performance shows that the combination of mobile-based GPS sensing with cloud-based synchronization is not just a conceptual improvement, but a working solution to earlier inefficiencies in transport monitoring. Throughout the extended period of testing, the system showed stable behavior to ensure that the architecture brought as a result of coupling the Fused Location Provider API with Firebase Realtime Database provides consistent data flow to minimize system latency.

One of the key insights one can draw from the results is that the high location accuracy of this system is maintained under various environmental conditions. Although some areas experienced differences due to signal interference, the overall consistency of location data indicates that the hybrid positioning approach effectively circumvents common GPS limitations. This suggests that location services, when integrated properly, can offer accuracy (within a few metres) suitable for applications such as tracking school transport and logistics where even minor inaccuracies can cause operational issues. The indication of stability in the accuracy over time shows that the system is not sensitive to minor fluctuations.

The responsive system was able to deploy within a duration of 1 to 3 seconds, which is acceptable. Firebase's event-driven data synchronization structure makes this update so quick. Minimal delay in relaying information allows the administrator to receive the information quickly and make a decision about the situation quickly. There were some occasional increases in delays caused by things out of the system's control such as the network, rather than the system itself. The robust design of system architecture notwithstanding, performance displays a clear dependency on internet quality. This must be taken into consideration for large-scale deployments.

The analysis of battery consumption adds a new dimension to the dialogue that puts sustainability at the mobile-based system level. The continuous tracking uses a moderate amount of energy, indicating effectiveness of functioning in our farming robot. The application requests the location in an optimized way so that it does not cause too much power drain making the use of effortful over a long period of time without making the working of the device awkward. This functionality is of great importance in various real-life cases where users would rely on their devices for multiple uses.

In addition, the system's modular design allows for easy scalability and adaptability. All the parts are separate, but they can all work together as one. Future enhancements can include geofencing, predictive analytics, or connectivity to advanced dashboards. The ease of implementation and reliance on common technologies mean that the system is cheaper than tracking systems that need special hardware and/or sophisticated infrastructure.

According to the discussion, the proposed system is able to reach the gap between capability and application. It shows that employing a mobile-cloud integrated approach to real-time transport tracking can achieve high accuracy, low latency and low resource consumption. Although a few limitations like the dependence on network and the environmental conditions exist but they do not hinder the working of the system. It instead gives opportunities to improve the system further as per the changing technological scenario.

6. Conclusion and Future Work

This study aims to design and implement a Real-Time Transport Location Management System which synchronize Mobile Sensing with Cloud Synchronising for continuous and everlasting monitoring. The results demonstrate that the proposed system has successfully achieved the objectives of accurate location updates, low latency data delivery and scalable architecture suitable for real-world implementation. Incorporating the Fused Location Provider API in Android and coupling it with Firebase Realtime Database for instant updates creates an effective system capable of reflecting movement as it takes place. The accuracy measures recorded in the open and semi-urban environment, in addition to the delay of 1 to 3 seconds, indicate that hybrid location sensing techniques can deliver acceptable accuracy. In addition, the usefulness of cloud synchronisation is displayed for real-time decision-making.

More than just technical performance, the system has simplicity and accessibility, which is often lacking in other transport monitoring solutions. By relying on off-the-shelf mobile devices and not requiring any specialized hardware for implementation, it minimizes implementation costs and opens up a wide range of application possibilities including school transport, logistics management and

emergency services. The flexible design improves maintainability by allowing the components handling authentication, GPS tracking, data synchronizing, and user interface to work together while remaining flexible for development. The system strikes a good balance between anything and the battery consumption. Continuous tracking will not place any excess demand on the system.

Nevertheless, real-world systems have some limitations. The performance of the systems primarily depends on the reliability of internet connectivity, especially at low network locations. Environmental factors such as heavy infrastructure or signal interference can also cause slight variations in location accuracy. Although these issues do not have a significant negative impact on the functionality of the system, they reveal some improvement opportunities that will have a notable effect.

Future work offers several meaningful directions to pursue in the future. Incorporating geofencing technology could enable alerts if a tracked person enters/exits a pre-determined area to increase safety and control. Having a dedicated administrative dashboard that showcases advanced analytics allows the stakeholder to visualize historical routes as well as identify patterns. Having offline tracking mechanisms, a feature that stores location data locally and then syncs this data once the network is back up, could help with network-related limitations. In addition, employing machine learning techniques for route prediction and anomaly detection can change the system from a passive tracker to an intelligent decision-support system.

More improvements may include optimizing energy use with adaptive update intervals, improving data security with encryption protocols, and enhancing compatibility with several platforms beyond Android. With transport systems evolving alongside the broader smart city movement, the solution proposed is a step that can result in better connected, efficient and responsive mobility management in the future. To sum it up, this one not just shows that real-time tracking is possible through mobile and cloud but also sets the stage for an innovative direction that can transform how we view movement in the digital age.

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References

1. S. Jeevan et al., "GPS Based Efficient Real-Time Vehicle Tracking and Monitoring System Using IoT," 2024. Available: <https://www.researchgate.net/publication/384653656>
2. A. Krishnan et al., "Android-Based Transport Tracking and Monitoring System," 2023. Available: <https://books.aijr.org/index.php/press/catalog/download/160/77/2993-1>

3. M. Sharma et al., “Android Application for Tracking Students Using GPS,” IJCST, 2022. Available: <https://www.ijestjournal.org/volume-11/issue-1/IJCST-V11I1P2.pdf>
4. S. Kumar et al., “Location Tracking using Google Cloud Messaging on Android,” IJTSRD, 2018. Available: <https://www.ijtsrd.com/papers/ijtsrd10925.pdf>
5. A. Kumar et al., “IoT Based Real-Time Location Tracking System,” IJMSRT, 2025. Available: <https://www.scribd.com/document/857909079>
6. R. Selvarani et al., “Garbage Vehicle Tracking System Using Android,” 2023. Available: <https://restpublisher.com/wp-content/uploads/2023/02/10.46632-daai-3-1-6.pdf>
7. P. Singh et al., “Real-Time Vehicle Tracking Through Mobile Device,” IJSRED, 2021. Available: <https://ijsred.com/volume4/issue2/IJSRED-V4I2P34.pdf>
8. S. Patel et al., “Firebase-Based GPS Enabled Mobile Tracking System,” JETIR, 2023. Available: <https://www.jetir.org/papers/JETIRGJ06020.pdf>
9. J. Harty et al., “Logging Practices with Firebase Analytics,” arXiv, 2021. Available: <https://arxiv.org/abs/2104.02513>
10. J. Bays et al., “Forensic Analysis of Location Applications in Android,” arXiv, 2019. Available: <https://arxiv.org/abs/1907.00074>
11. S. Monogios et al., “Privacy Issues in Android GPS Applications,” arXiv, 2021. Available: <https://arxiv.org/abs/2109.03664>
12. A. Yaqzan et al., “GPS-Based Vehicle Tracking System-on-Chip,” arXiv, 2019. Available: <https://arxiv.org/abs/1904.09838>
13. T. Hightower and G. Borriello, “Location Systems for Ubiquitous Computing,” IEEE Computer, 2001.
14. P. Enge and P. Misra, “Global Positioning System: Signals, Measurements, and Performance,” 1999.
15. Google Developers, “Fused Location Provider API,” Available: <https://developers.google.com/location-context>
16. Google Firebase, “Firebase Realtime Database Documentation,” Available: <https://firebase.google.com/docs/database>
17. Google Firebase, “Firebase Authentication Documentation,” Available: <https://firebase.google.com/docs/auth>
18. Google, “Google Maps SDK for Android,” Available: <https://developers.google.com/maps>
19. Android Developers, “Location Strategies,” Available: <https://developer.android.com/guide/topics/location>
20. IEEE, “Intelligent Transportation Systems Overview,” Available: <https://ieeexplore.ieee.org>
21. K. Pahlavan et al., “Indoor Positioning Technologies,” IEEE Communications Magazine, 2002.
22. N. Priyantha et al., “The Cricket Location-Support System,” ACM, 2000.
23. A. Kushwaha et al., “GPS-Based Tracking Using Android Application,” IJERT, 2019.
24. R. Want, “An Introduction to RFID Technology,” IEEE Pervasive Computing, 2006.
25. M. Ali et al., “Smart Transport Systems Using IoT,” Springer, 2020.
26. S. Dhar et al., “Mobile Cloud Computing for Smart Applications,” IEEE, 2012.
27. H. Kopetz, “Real-Time Systems Design Principles,” Springer, 2011.
28. J. Schiller and A. Voisard, “Location-Based Services,” Morgan Kaufmann, 2004.
29. S. Abdelhamid et al., “Vehicular Tracking Systems in Smart Cities,” IEEE Access, 2020.



30. D. Nield, “Tracking Systems and Technologies Overview,” Available:
https://en.wikipedia.org/wiki/Tracking_system