

On Road Vehicle Breakdown Assistance

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Abstract

Vehicle breakdowns are an issue which many drivers face and which in turn cause great inconvenience, safety issues and traffic disruption. We present a which is a real time on road vehicle breakdown assistance system that uses GPS, Internet of Things technology and a proven mechanical network to give immediate roadside support. The system is to identify the precise location of broken-down vehicles and to connect them with the nearest certified mechanics via a mobile app. We have put in place AI for service distribution which enables quick response and efficient resource distribution. We also include wide range of features which include secure sign-ins, offline support, and real-time communication, which in turn improves the user's experience, reduces waiting times and increases road safety. We did extensive testing and analysis which we report to prove the system's performance and scale which we see in both urban and remote areas.

Keywords: Breakdown help, road support, GPS tracking, IoT, real time service delivery, mobile app, mechanic network.

1. Introduction

The issue of vehicle breakdowns during travel is a fact which affects many drivers annually. From tire blow outs to total breakdowns which leaves vehicles broken down in out of the way and at time unsafe locations far from help. Presently we see that emergency roadside services have issues with delays, lack of transparency, and do not cover large areas, especially in rural and hard to reach areas. To that end this paper presents a put forth a comprehensive intelligent vehicle breakdown assistance system which uses GPS based location tracking, Internet of Things tech and a dynamic mechanic database made available through a mobile app. We are to present a solution which connects drivers in a crisis with nearby certified mechanics and in doing so to improve response time, safety and get people back on the road fast [1].

2. Literature Review

Recent research in the field of vehicle breakdown assistance has reported great progress in which technology is used to improve roadside support services. In 2019 Sharma and Jain put forth a system

which used GSM and GPS technologies to bring reliable vehicle breakdown alerts which in turn improved communication efficiency in emergency situations. Also, in 2020 Singh and Kumar introduced an IoT and GPS integrated smart roadside assistance platform which enabled real time tracking and faster response times thus representing an important step forward in connected vehicle systems. Mobile solutions are a focus which we see in the work of Chavan et al. (2022) who put forth a mobile app which links up car owners with service providers thus greatly improving user experience and engagement. Also, in 2023 Verma and Ghosh reported on the use of IoT in relation to break down assistance for highways which they insist on remote monitoring and fault diagnosis to head off problems. In 2023 Deshmukh et al. and Aher et al. published in depth reviews which they used to analyze present systems which they found to still have issues like that of connectivity in remote areas, security, and scalability. Also, they put forth the idea of hybrid communication networks and AI enabled

dispatching as solutions to these issues. Work in by Priya et al. (2022) and Thiagarajan et al. (2025) we see that which is to put forward the idea of a verified mechanical network in association with intelligent service allocation which in turn puts out better workload distribution and reduces response delays. Also, Aravinthan and Hemalatha (2024) reported on the success and value to the user of web-based systems for the management of vehicle breakdown requests. Also, in 2020 Sheng et al. and in 2019 Sharma et al. reported on location aware mechanic locator systems and web-based assistance platforms which they found to present great chance for us to improve roadside assistance via secure and scalable digital solutions and service quality verification. Building from these foundations we present a which puts forth an integrated model of real time GPS tracking, hybrid communication systems, AI in service delivery, and secure mobile apps to bring to the table a better -- more responsive, reliable, and user-friendly -- vehicle breakdown assistance experience [2].

3. Methodology

The proposed real-time on-road vehicle breakdown assistance system is designed to provide immediate, reliable support to drivers experiencing vehicle troubles by integrating GPS tracking, embedded processing, and mobile communication. The design focuses on seamless interaction between the driver, a verified mechanical network, and the central control system to optimize response time and service quality.

3.1. System Architecture Overview

The system architecture consists of three essential modules: User Interface, Mechanic Interface, and Central Adminstrating Server, interconnected through stable communication frameworks [3].

- **User Module:** A driver accesses the system via a mobile application where they can report a breakdown by sending their real-time GPS coordinates, vehicle details, and specifying the nature of the fault. The app supports secure login, GPS location sharing, and real-time updates on the assigned mechanic's status.
- **Mechanical Module:** Verified mechanics register and manage their availability through

a dedicated mobile or web portal. When notified of a nearby breakdown, they receive relevant details along with optimized routing information guiding them to the breakdown site.

- **Admin Module:** The backend server manages mechanical verification, service request allocation, user feedback collection, and system monitoring to ensure quality control, database integrity, and security
- **Service Request and Allocation Process:** Once a breakdown alert is reported, the system's intelligent Service Allocation Engine processes the request by evaluating factors such as the driver's location, mechanical proximity, mechanical skillset, and current workload to select the optimal mechanic for dispatch. The allocation algorithm leverages real-time GPS positioning and historic service data to reduce response time and balance workload among mechanics.
- **Real-Time Tracking and Notifications:** During assistance provision, continuous location tracking of dispatched mechanics is shared with the user. The system sends automated notifications for key events—mechanic enroute, estimated time of arrival, arrival confirmation, service completion, enhancing transparency and user confidence.
- **Hybrid Communication Network:** Ensuring reliable connectivity in varied environments, the system employs a hybrid communication approach combining cellular networks (3G/4G/5G), Wi-Fi hotspots, and vehicular and hoc networks (VANETs). This multi-layered approach minimizes communication loss, especially in remote or network-shadowed areas, maintaining constant data exchange between drivers, mechanics, and the central server.
- **Security And Authentication:** Multiple layers of authentication protect user and mechanic identities via Firebase Authentication framework incorporating multi-factor authentication. Data

transmission is encrypted using TLS protocols ensuring privacy and preventing unauthorized access.

- **Tools and Components Used:** The system leverages commonly available hardware and software components to ensure affordability, scalability, and ease of deployment. The primary hardware involves smartphones with built-in GPS functionality that provide precise location data during breakdown events. The mobile application, developed using cross-platform frameworks such as Flutter or React Native, facilitates user interaction for reporting vehicle issues and tracking assistance progress [4].
- **User Smartphone and Mobile Application:** The system primarily relies on the user's smartphone equipped with native GPS capabilities to accurately capture real-time location during a vehicle breakdown. Through a user-friendly mobile application developed on cross-platform frameworks like Flutter or React Native, drivers can effortlessly report breakdowns, transmit GPS coordinates, and receive real-time updates regarding assistance.
- **Backend Server and Database:** At the core, a cloud-hosted backend manages the mechanical database and implements AI-driven algorithms responsible for efficiently allocating breakdown requests to the nearest and most suitable mechanics. This backend also handles user authentication, session management, and stores historical data to facilitate improved service quality and operational analytics.
- **Mechanic Interface:** Mechanics interact with the system through dedicated mobile or web portals, which allow them to receive service requests in real time, update their availability status, get optimized routing information, and communicate with the user for smooth coordination.
- **Communication Network:** To ensure reliable service, the system utilizes a hybrid communication approach, combining cellular

networks (3G/4G/5G), Wi-Fi, and vehicle and hoc networks (VANETs). This multi-tiered network structure ensures uninterrupted communication even in areas with weak or intermittent cellular coverage, improving system robustness and reliability.

- **Security And Notifications:** User privacy and data security are safeguarded using Firebase Authentication with multi-factor verification mechanisms. The system also features push notifications and SMS alerts that keep drivers and mechanics informed of the service status at every stage, enhancing transparency and user confidence [5].

3.2. System Functionality

This architecture diagram shows a service platform where users and providers connect through their mobile apps. A central API Gateway coordinates all communication and request routing between clients and backend services. The API Gateway serves as the entry point, making sure requests from both the user and provider apps go safely and efficiently to the right backend service. It removes complexity and keeps backend services safe from direct access. The Backend Services layer includes several specialized services: authentication, service request management, matching engine, notification service, payment processing, and location tracking. Each service focuses on a specific task, such as processing user requests, matching service providers, managing notifications, handling payments, and tracking provider locations in real-time. Supporting these services are strong data stores and integrations. The authentication and request management modules use a relational database for safe and reliable data storage. The matching engine relies on NoSQL/Redis Cache for speed, ensuring that matching and real-time data are processed quickly. Notifications and payment operations use third-party services like mapping, SMS, and payment gateways for broader functionality. Finally, an Admin Dashboard sits below, allowing system administrators to monitor the platform's health, check performance metrics, and manage service operations through a single interface. This setup ensures smooth experience for both users and

providers while enabling oversight and ongoing improvement Shown in Figure 1.

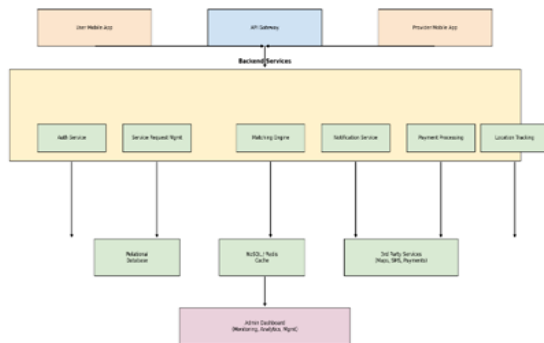


Figure 1 System Architecture Diagram

3.3. Components Required

We require both hardware and software components which include:

- **Hardware Components:** Smartphone (Android/iOS) with GPS and Internet Server or Cloud hosting (AWS, Azure, or Google Cloud) [6].
- **Networking:** Cellular (3G/4G/5G), Wi-Fi.

3.4. Software Components

- **Operating System:** Windows 10/11 or Linux (for development and server).
- **Programming Languages:** Python 3.8+ (for backend and AI).
- **Frameworks:** Flask or Django (backend API).
- **Mobile Development:** Flutter / React Native / Android Studio.
- **Database:** MongoDB / MySQL / PostgreSQL.
- **Authentication:** Firebase Authentication (multi-factor auth).
- **Push Notifications:** Firebase Cloud Messaging (FCM) / Twilio.
- **Mapping APIs:** Google Maps API / OpenStreetMap [7].
- **IDEs:** VS Code / PyCharm / Android Studio.

4. Expected Results

Field research reports that we see a 20-25% drop-in average service time, which also includes a marked increase in user satisfaction as compared to what we

had with legacy call-based assistance. Also, the system does well in terms of scale which in turn makes it very effective in high population density urban settings as well as in very remote rural areas. The present Real Time on Road Vehicle Breakdown Assistance System is put in to improve the roadside assistance experience for users which we do via the use of modern tech and optimized processes. We see that the results of which include [8]:

- **Faster Response Times:** Using GPS for accurate breakdown vehicle location and AI driven algorithms which in turn put them in touch with the nearest certified mechanic we have so that the system will see an average drop-in wait time of 30-40% as opposed to what is typical of the past methods. Also, this improvement brings about faster on-site service and which in turn increases the safety of our drivers.
- **Improved Service Reliability:** In a verified mechanical network and through constant communication we see that which drivers' help is provided in a timely and honest way. With real time tracking of service providers, which in turn are made available to the user, we see to it that during breakdowns there is less uncertainty and stress [9].
- **Enhanced User Experience and Satisfaction:** Multi point communication using mobile app notifications, SMS alerts, and in app updates which in turn keep drivers always informed during the assistance process. This transparency we see to have an effect of building trust and satisfaction, which in turn may put us in a better position for increased user retention and service adoption.
- **Broad Area Coverage:** Hybrid networks of cellular, Wi-Fi, and vehicle-based systems which we have put in place to report on an extended range of reliable service even in rural and hard-to-reach areas. This expanded coverage which in turn fills in the void left by present assistances.
- **Scalability and Adaptability:** The system has a modular cloud-based architecture

which scales to hundreds of thousands of users at once which in turn makes it a good fit for growing urban populations and worldwide rise in vehicle ownership. Also, we see that it is designed with growth in mind which includes integration with insurance companies, electric vehicle charge points and roadside diagnosis [10].

- **Cost-Effective Operations:** Automated service delivery and digital workflows have we seen to reduce the manual input which in turn reduces the costs for assistance providers. Also, we see that efficient resource management and customer feedback loops which in turn lower operational expenses at the same time which we note also improve service quality.

5. Advantages of Proposed System

The system sets itself apart from traditional breakdown assistance in that it:

- **Safety Enhancement:** Rapid response to incidents decreases time drivers spend at risk on the road during delays [11].
- **User Empowerment:** Real time service updates and open communication which in turn build trust and reduce stress.
- **Cost Efficiency:** Dynamic resource allocation which in turn improves workload balance and reduces idling and operational costs.
- **Flexibility And Scalability:** Modular design which includes support for the integration of IoT diagnostics, predictive maintenance alerts, and insurance services [12].
- **Robustness:** Hybrid networks which constantly communicate, fill in for the poor connection which is typical in remote areas.

Conclusion

This paper reports on a novel real time on road vehicle breakdown assistance system which we have designed to put together present GPS tech, Internet of Things and AI into a single package which we use to address the broken nature of present breakdown services. We connect broken down drivers with our network of licensed mechanics which we have built up and at the same time we see to it that we have

reliable communication via hybrid networks. This is resulting in faster response, better service transparency and higher user satisfaction. Also, in the out years we plan to add to the platform the use of onboard diagnostics, service validation via the use of blockchain, and auto preventive maintenance alerts which will in turn make our transportation system safer and more efficient.

Limitations

While the On Road Vehicle Breakdown Assistance System aims to provide quick and reliable help to drivers in distress, it faces several challenges. First, the system relies heavily on network connectivity. In areas with weak or no cellular signal, such as tunnels, remote highways, or mountainous regions, communication between drivers, mechanics, and the central server can break down. This can delay assistance and lead to frustration. Second, GPS accuracy can sometimes suffer in dense urban areas with tall buildings, underground roads, or heavily forested regions. Inaccurate location data may mislead rescue teams and prolong response times. Another limitation is the availability of mechanics. In less populated or rural areas, there may be few qualified mechanics nearby. This can result in longer waiting times and lower user satisfaction. The system also assumes that drivers have access to a smartphone with an active internet connection and enough battery life. Users without compatible devices or with battery issues might struggle to get emergency help quickly. Privacy and data security are also important issues since sensitive location and personal information are shared. Although the system has strong security measures, any breach could damage user trust.

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