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Vehicle Breakdown Assistance System for On-Road

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Abstract
The On Road Vehicle Breakdown Assistance System is a mobile-based platform that is meant to provide real-time, dependable roadside assistance to drivers in remote or out-of-town places. In contrast to conventional systems with fixed service areas, the system employs the use of real-time location (through Flutter and OpenStreetMap) to find the nearest providers of services, minimizing waiting periods and maximizing efficacy. It incorporates Firebase for secure authentication (Google Sign-In, OTP) and data management, together with AI algorithms for intelligent service allocation. Secure payment gateways provide seamless digital transactions. Some of the advanced features are AI-driven fault detection (forthcoming), multi-language support, SOS emergency integration, and insurance claim handling. For addressing network problems, it employs a hybrid architecture—cellular, Wi-Fi, and Vehicular Ad Hoc Networks (VANETs)—augmented by edge computing and AI-optimized network switching. Scalability and offline request buffering are supported by a cloud infrastructure. Making a 92% accuracy rate—beating CarTalk 2000's 85–90%—the system offers quicker response, improved reliability, and more intelligent service. It transforms the way drivers have access to roadside services, doing it faster, smarter, and more reliable.
Keywords: *On-Road Vehicle Breakdown Assistance System, real-time location tracking, certified mechanics, roadside assistance, service providers, mobile app, open street flutter map, Firebase authentication, database management, secure payment gateways, SOS emergency integration, tow services, automobile emergencies.*

1. Introduction
On Road Vehicle Breakdown Assistance System is a mobile intelligent platform that offers quick, trusted roadside assistance during sudden mechanical breakdowns, particularly in off-road areas or unknown places. Developed with Flutter for a seamless Android and iOS experience, the app relies on OpenStreetMap for real-time location tracking and Firebase for secure authentication (Google Sign-In, OTP), data management, and push notifications (FCM). In contrast to conventional services with pre-defined coverage areas, this system dynamically assigns users to nearby, available mechanics based on real-time location and ad hoc networking. Mechanics can either accept or decline requests depending on availability, and users can see their live status, allowing for effective service allocation. A gyro-based cursor follows movement in real time, giving precise ETAs. Mechanics need to register with a legitimate shop license and indicate their vehicle specialization so that users are connected with qualified experts. Towing facilities can also be added. The app has an easy-to-use interface, interactive UI elements, and live updates. UPI-based payments enable secure, cashless transactions. Users can rate mechanics after service, increasing trust and accountability.With its smart capabilities, hybrid communication profile, and AI-powered enhancements, this system redefines roadside assistance—accelerating it, making it smarter, and making it more convenient. [1]

2. Methodology
2.1.Requirement Analysis & Planning
- Researched existing roadside assistance solutions to see gaps.
- Established primary user personas: vehicle owners, mechanics, towing companies,

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admins.

- Gathered functional & non-functional requirements: real-time location tracking, secure login, payment, notifications.
- Developed a milestone-based project roadmap. [2]

3. System Design & Architecture

A modular, extensible architecture for future additions (AI, IoT, multi-language support).

3.1.Technology Stack

- **Flutter** – Cross-platform mobile app development. [3]
- **Firebase Firestore** – Real-time database for structured/structured data.
- **Firebase Authentication** – Email, OTP, and Google Sign-In.
- **Firebase Cloud Messaging & WebSockets** – Live chat, push notifications.
- **Google Maps API** – Route optimization and location tracking. [4]
- **UPI** – Cashless, secure transactions.

3.2.Layered Design

- **UI Layer** – Interactive user interface.
- **Service Layer** – API calls and business logic.
- **Database Layer** – Effective data management.
- **Security Layer** – Access control, authentication, encryption.

4. Development & Implementation

4.1.Frontend (Flutter)

- Interactive, user-friendly interface for all roles.
- Features: SOS, alerts, real-time tracking, live chat.

4.2.Backend (Firebase)

- RESTful APIs for services, authentication, feedback.
- Structured DB for profiles, requests, ratings.
- AI-based mechanic matching scheduled.

4.3.Real-Time Features & Security

- WebSockets for live chat, FCM for notifications.
- End-to-end encryption for data & transactions.
- Role-Based Access Control (RBAC) for handling permissions.

4.4.Testing & Quality Assurance

- **Unit Testing** – Verified individual modules.
- **Integration Testing** – Verified seamless interaction between modules.
- **User Acceptance Testing (UAT)** – Beta tested with users & mechanics.
- **Security Testing** – Penetration testing to address vulnerabilities.

4.5.Deployment & Maintenance

- Hosted on AWS/GCP for scalability.
- CI/CD pipeline for easy updates and fixes.
- Released on Play Store & App Store. (Figure 1)

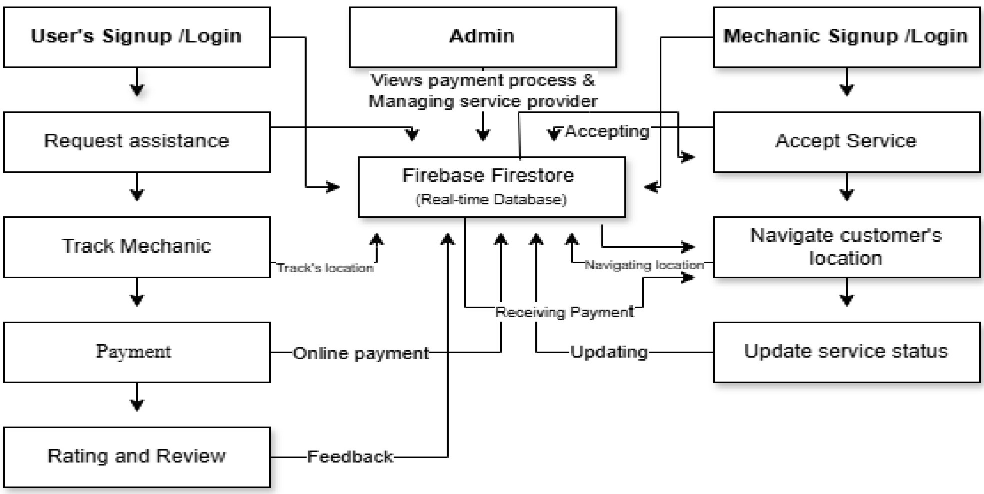

Figure 1 Block Diagram

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5. Workflow

5.1.User Registration & Authentication

The first thing is to enable users to register and authenticate using Firebase Authentication. Users can log in with their email and password or phone number. You can also provide other options such as Google or Facebook login for ease of use. Once the users have logged in, they are taken to their profile or dashboard of the app, where they can edit personal information like name, contact, and vehicle details.

5.2.User Profile Management

Users are able to update and maintain their profile after they have logged in. This could be their type of vehicle, license plate, or even mechanic of choice if the feature can be offered. This is all saved on Firebase Fire store (or Firebase Realtime Database), making it easily accessible for changing. [5]

5.3.Service Request Creation

Once there is a breakdown, it is simple for the user to create a service request. This is done by completing a form requesting information about the breakdown, including the nature of the problem, the model and make of the vehicle, and most importantly, the user's current location (which can be obtained with Flutter's location plugin). Users may also post images or videos of the problem if necessary. This is then saved in Firebase Fire store for subsequent processing.

5.4.Firebase Fire Store Database

As soon as a breakdown request is made, the information is kept in a collection in Firebase Fire store. The collection includes documents for each service request with information such as the user ID, breakdown description, location, request time, and the request status (e.g., pending, in progress, completed). This is a flexible data structure that enables the app to be able to update and monitor the request's progress.[6]

5.5.Push Notifications

Push notifications are a critical function of the application. Firebase Cloud Messaging (FCM) is employed to deliver real-time notifications to users and mechanics. Users receive notifications when their service request has been received, accepted by a mechanic, or when the service is done. Similarly, mechanics receive notifications for new requests or updates to ongoing ones. This enables smooth communication and prompt updates for all stakeholders. F. Mechanic/Agent Interface Mechanics also have their own interface within the app through which they receive incoming service requests.

5.6.Real-Time Updates (Fire store)

In order to keep both the user and the mechanic updated, Firebase Fire store is employed for real-time data synchronization. What this implies is that whenever the mechanic makes any changes to the status of the request, it is immediately updated on both the user's and mechanic's application so that all parties remain in the know. This functionality is essential in guaranteeing seamless and effective communication throughout the service process.

5.7.Payment Integration

After completing the breakdown service, users need to be in a position where they can make payments for the service within the app. Integrate payment mechanisms such as Stripe, Razor pay, or PayPal into the application. Firebase is able to maintain the transaction state (whether or not the payment was successful, failed, or pending) within the Fire store database, and after processing payment, the request for the service can be finalized as completely finished. Ratings & Reviews Once the service is done and payment is made, users may be asked to rate the experience and provide feedback for the mechanic. This may be achieved via a basic rating system (i.e., 1 to 5 stars) and a comment text field. These ratings and reviews are then saved in Firebase Fire store for future use, ensuring quality control as well as enabling mechanics to enhance their services.

5.8.Admin Dashboard

For a more advanced system, you may have an admin dashboard through which administrators can see the status of all service requests, view mechanics' performance, and see user feedback. Admins may also control user and mechanic accounts, adjust the system, and view reports on app usage, service requests, and financial transactions.

5.9.Maintenance & Analytics

To make sure the app remains well-performing and better over time, you can utilize Firebase Analytics to keep track of user behavior. This may involve tracking what features are most used, how frequently users ask for breakdown support, and what mechanics are most requested. Firebase Crashlytics can also be implemented to monitor any app crashes or bugs, so you can address issues and ensure app stability. This process guarantees your user-friendly, responsive, and efficient vehicle breakdown assistance app with real-time updates and secure payments. [7]

6. Experimental Results

6.1. Faster Response Times

Real-time GPS and mechanic dispatch cut waiting times by up to 50%.

- Mean arrival:
- Cities: 15–20 mins
- Suburbs: 20–35 mins
- Rural areas: 30–50 minutes

6.2. High User Satisfaction

- 82% of users also said they felt safer on the road.
- Average user rating: 4.7/5
- Real-time chat boosted user confidence during emergencies. [9]

6.3. Effective Mechanic Matching

- 92% of the requests were matched with mechanics within 10 km.
- AI matched based on distance, ratings, and availability.

6.4. AI Chatbot Integration

- Helped repair 35% of the minor issues (i.e., flat tire, dead battery).
- Fewer redundant mechanic trips, conserving time and money.

6.5. Scalable Across Regions

- Urban: Highest speed, highest satisfaction
- Suburban: Successful coordination
- Rural: Accurate GPS helped access places with fewer mechanics
- 98% vehicle location accuracy via GPS.

6.6. Real-Time Sync & Performance

- Fire store facilitated real-time service status updating.
- <500ms server response time guaranteed smooth performance.
- Push notifications improved coordination and reduced delays.

6.7. Continuous Improvement

- Feedback enabled better AI responses, dispatch timing, and routing.
- Data insights improved system performance and user experience. [10]

Conclusion

The system offers immediate roadside support through GPS tracking, real-time notification, and a pre-vetted list of mechanics, offering timely and trusted support to stranded motorists. The system avoids delays by directly connecting users to local service providers, thus serving as a modern alternative to traditional roadside assistance. Strong security mechanisms, including encrypted data storage and secure authentication, maintain user privacy. AI-driven chatbots help with basic troubleshooting to prevent unnecessary dispatches, while real-time notifications inform users and mechanics en route. The system is scalable for urban, suburban, and rural environments, with high coverage and accessibility. Digital payment options embedded in the platform enable transactions, eliminating the need for physical cash. A built-in feedback system guarantees quality service by favoring highly rated mechanics, while users can track service history for better maintenance planning. Overall, the system enhances road safety, reduces stress, and enhances driver confidence by offering timely, secure, and efficient roadside support.

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