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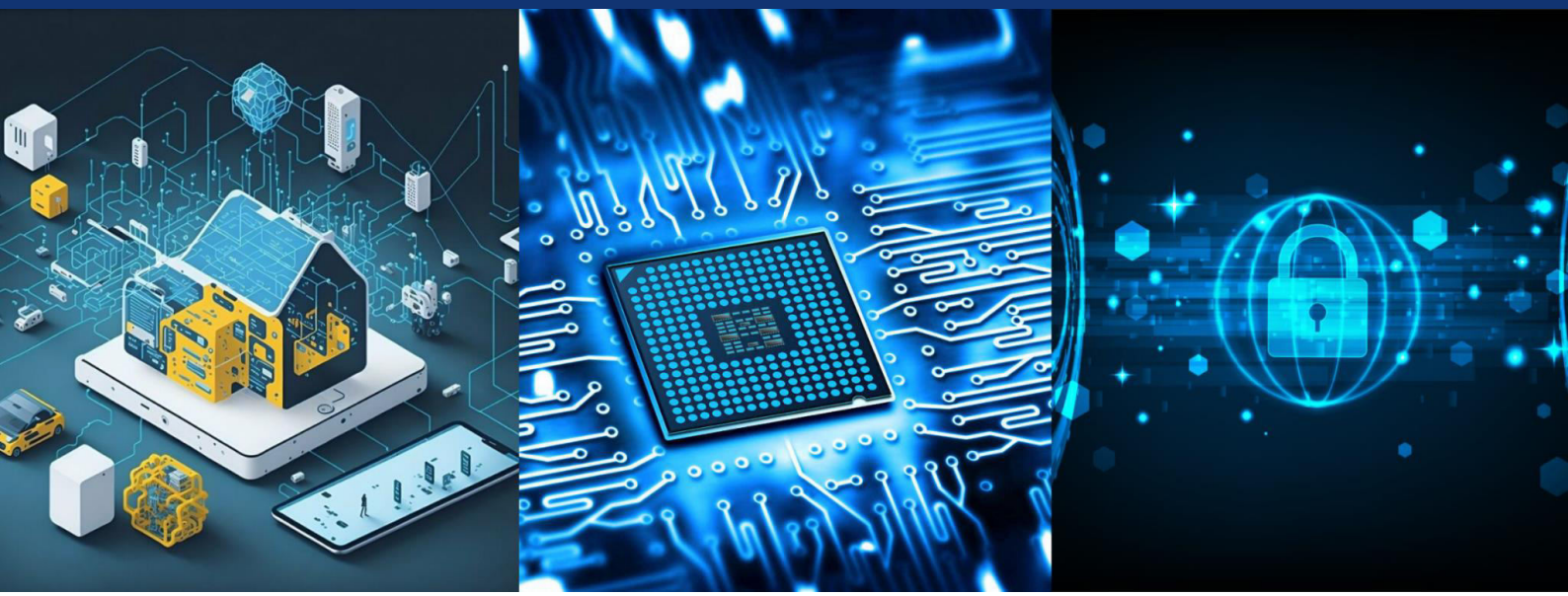

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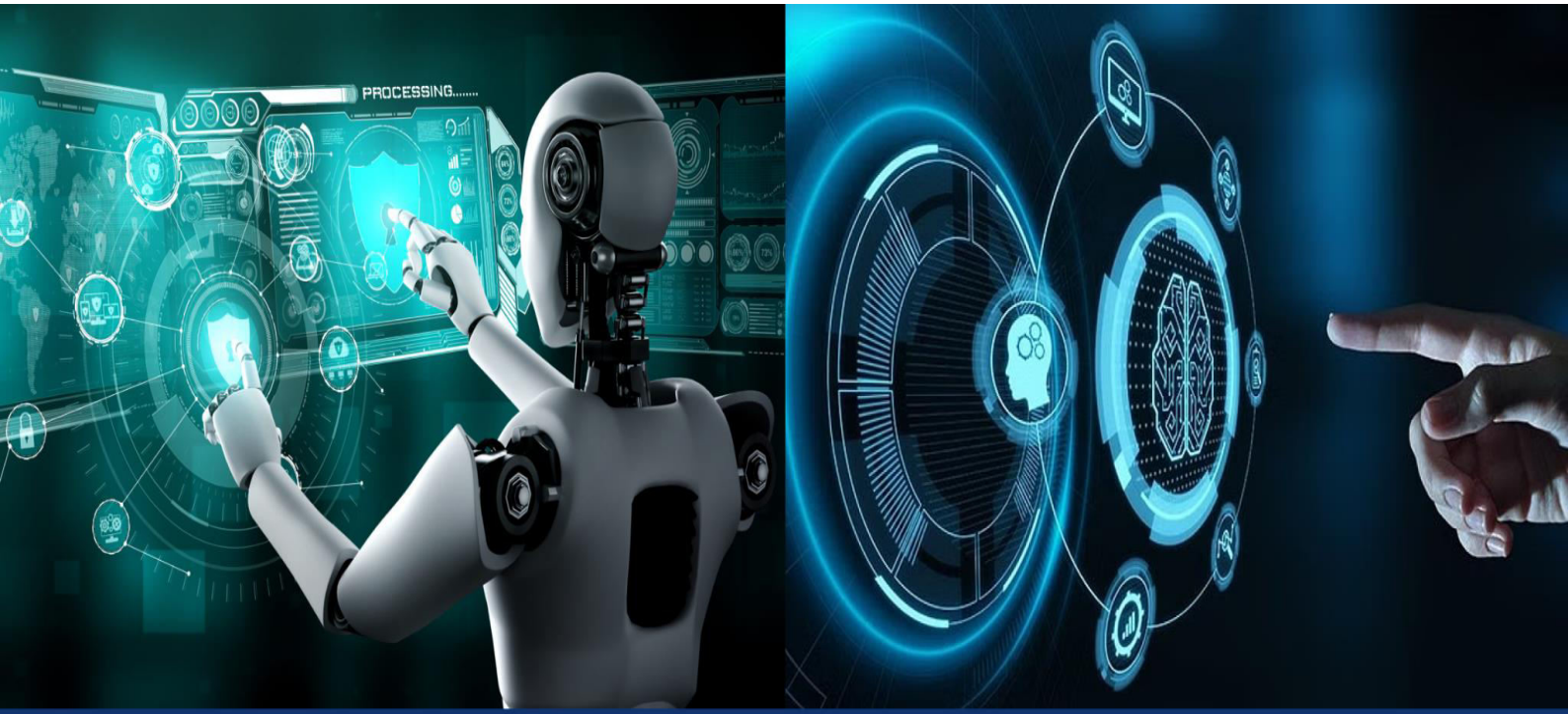

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Lost & Found – Geo-Adaptive Alert Framework

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ABSTRACT: People tend to lose items such as wallets, keys, IDs, or electronic devices in public. Traditional methods like word of mouth, posting, or social media posts fail because they are slow and untargeted. This paper proposes a location-based, progressive notification system implemented as a Progressive Web App (PWA) that will notify neighboring users of misplaced items through geo-adaptive push notifications. The system gradually expands the notification radius geologically in steps (1km, 2km, 4km, 8km) until there is feedback or a maximum defined limit. Designed using React, Firebase Firestore, and Firebase Cloud Messaging (FCM), the solution offers an simple, light, and cross-platform way to facilitate real-time recovery of lost items.

KEYWORDS: Progressive Web App, Lost & Found, Geo-Adaptive Alerts, Push Notifications, Firebase, Location Services.

I. INTRODUCTION

The problem of retrieving misplaced personal items is still a chronic one in different settings like schools, transit stations, and public events. Conventional lost and found technologies, mostly based on manual submission and static data bases, are too slow, less efficient, and cannot offer real-time support. As cities grow more dynamic and mobile technology more ubiquitous, smart, quick, and intuitive solutions are increasingly important.

The "Ritriv – Lost & Found Geo-Adaptive Alert Framework" concept is a new solution designed to overcome such challenges with the help of Progressive Web Application (PWA) technology and location intelligence. Having a geo-alert engine sending proximity notifications and enlarging dynamically alert radii based on interaction, the system optimizes opportunities for recovering lost objects in real-time It also includes a safe, real-time chat facility employing WebSockets to enable immediate communication between owners and finders, reducing both the time and success of recovery of items considerably.

Moreover, Ritriv includes machine learning for item identification, location accuracy controls with flexibility to ensure privacy for users, and a modular and scalable backend architected with Flask or Django. This intelligent, context-based system guarantees access between devices without having to use the conventional app installation and provides an improved, swift, and reliable recovery process for mitigating severe limitations of existing lost and found processes. Using this framework, the project endeavours to redefine the lost and found process as a reactive, secure, and adaptive service for contemporary digital societies.

II. LITERATURE REVIEW

The transition from lost and found systems to computer-based systems has been extensively researched by Wang and Chen [1] with emphasis on major challenges in user participation and geographical use. Location-based services were examined by Kumar and Patel [2], illustrating how proximity reminders can drastically increase the rate of successful recovery of lost items. Martinez and Rodriguez [3] concentrated on user experience design for lost and found applications, so that they could identify significant friction points that tend to lead to users abandoning their applications, as is the case of Ritriv's smooth user interface. Smith and Johnson [4] conducted research on the economic aspects of lost property retrieval that fueled interest in creating incentive models to drive engagement strategies by Ritriv. Adaptive radius notification schemes by Zhang and Liu [5] and user engagement analysis of proximity notifications by Hernandez and Kim [6] both serve as the foundation of Ritriv's geo-adaptive alerting framework. Dynamic geofencing frameworks by Patel and Wong [7] also influenced Ritriv's real-time notification radius expansion

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methods. Privacy concerns and protection measures for location-aware systems by Anderson and Garcia [8] had a direct impact on Ritriv's design to incorporate location accuracy controls and secure communication. Real-time mobile app communication strategies with WebSocket technology discussed by Thomas and Robinson [9], and the architectural study of scalable notification systems by Chen and Miller [10], had a significant impact on Ritriv's server-client interaction model. Low-latency communication issues in PWAs were solved by Wilson and Thompson [11], while user experience of real-time communication was studied by Nguyen and Peterson [12], both influencing Ritriv's real-time chat feature. Mobile environment object recognition studied by Zhao and Lee [13], and transfer learning methodologies experimented by Wilson and Davis [14], optimized Ritriv's optional ML-based item identification. Color-based feature extraction methods by Patel and Martinez [15] further improved lightweight product recognition approaches. Jackson and Kim [16] spoke about client-side machine learning in PWAs, which corresponds to Ritriv's goal of browser-based processing. In-depth descriptions of PWA technology by Brown and Williams [17], offline capability strategies by Lopez and Taylor [18], user adoption barriers defined by Garcia and Wilson [19], and performance optimization methods for PWAs by Mitchell and Chen [20], all influenced Ritriv's decision to deploy a PWA-based, offline-capable, high-performance architecture ensuring wide usability and scalability across devices.

The Objectives of our system are:

- To Create a Progressive Web Application (PWA) that is cross-platform compatible.
- To Provide a geo-adaptive notification system that dynamically changes the content of notifications.
- To Develop a live communication framework between users.
- To Use machine learning for identifying items and matching.
- To Develop a user-friendly and responsive UI.
- To Enable secure authentication and data protection.
- To Optimize for both mobile and desktop usage scenarios.

III. PROPOSED SYSTEM

1. Input Data Collection:

User's report found or lost articles using the Progressive Web App (PWA). Each report consists of important metadata such as name of item, category, description, image (optional), date, and location accessed via GPS or manual geo-location pin in Google Maps.

2. Pre-processing and Validation of Data

All reports received are verified for accuracy and spam checking. Coordinates of the place are extracted and kept in a cloud database (for example, Firebase Firestore). Authentication of users is handled using Firebase Authentication to avoid spurious claims and accountability.

3. Initial Alarm Dispatch (Alarm Activation):

Upon receiving a missing item report, the application sends a geo-targeted alarm with a default radius of 1 km. It retrieves proximate active users in this radius from Firestore according to the last seen location. They are placed in a queue to be alerted using Firebase Cloud Messaging (FCM).

4. Geo-Adaptive Radius Expansion:

If within some period of time (e.g., 10 minutes) no response from the user is coming, the system enlarges the range of notifications (1 km → 2 km → 4 km → 8 km). The loop will stop when either:

- A user indicates the object as observed or discovered.
- The maximum configurable range of the system (e.g., 8 km) is reached.

5. Notification Delivery Mechanism:

Notifications are delivered by Web Push Notifications of Firebase Messaging. They are dispatched in service workers even when the PWA is not in operation. The item summary, user's location proximity from their location, and direct access link to reply or search are part of every notification.

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6. User Response and Communication Channel Activation

Notified users can view the item information and choose to select actions like "I found this" or "Not relevant." When a user responds affirmatively, the system ensures that notification and offers an instantaneous messaging channel via WebSockets for secure, direct exchange between the item reporter and responder.

7. Database and Activity Logging:

The backend logs and updates the following data in Firestore constantly:

- User profiles and location history
- Lost and found reports and alert metadata
- Radius escalation and notification delivery records
- Encrypted conversation histories between the users who have exchanged conversations

8. Offline Access and Synchronization:

PWA architecture and service workers enable users to access previous notifications and item reports offline. Once the device comes online, the system will automatically synchronize updates, including missed alerts and unread messages.

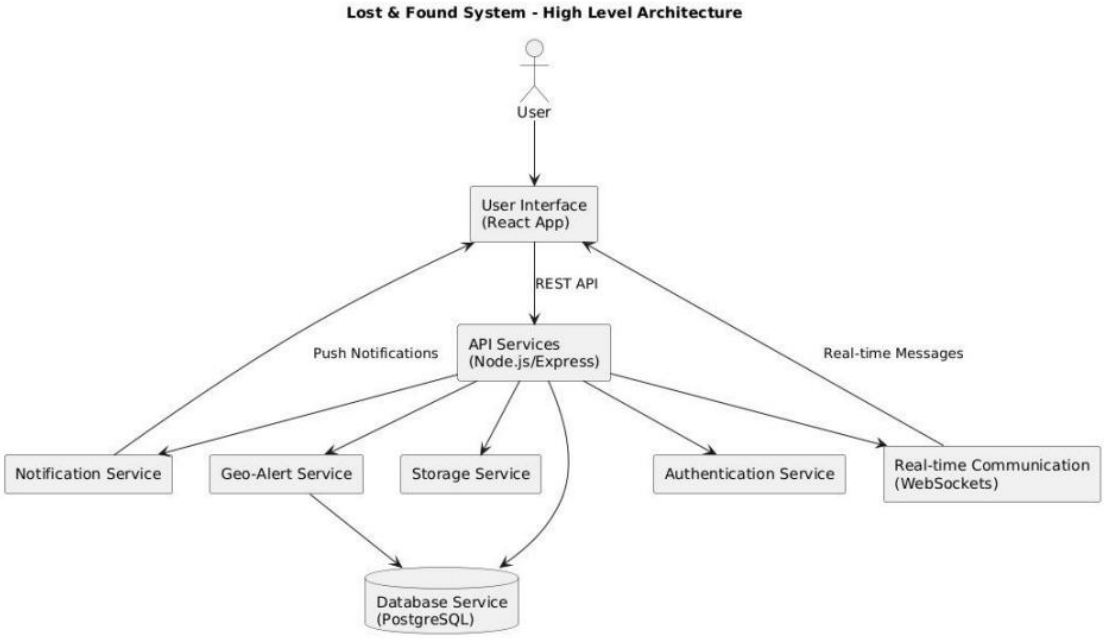

Fig 1: System Architecture

IV. METHODOLOGY

Building Ritriv – Lost & Found Geo-Adaptive Alert Framework adheres to methodologies founded on an architecture of modularity for the full-stack designed for real-time responsiveness, scalability, and off-line use. Frontend comes in the guise of React and Tailwind CSS implementations, with UI components by Shadcn/UI designed to present a clean, usable interface. Lost and found items can be reported by providing details such as item category, image, description, time stamp, and location using interactive Leaflet.js maps. Zod and React Hook Form validate data to avoid data corruption. Reports are transmitted via RESTful API routes developed with Node.js and Express handling form submission, authentication, and uploading of images using Multer. The backend talks to a PostgreSQL database through Drizzle ORM, storing normalized data in structured tables for users, reports, chats, messages, and notifications.

The moment a lost item has been reported, the system triggers a geo-alert mechanism that scans the database for users within a 1 km area of the item's last known location. If no reaction comes within a specified time, the radius is extended exponentially (say, 2 km, 4 km, 8 km) further to give the highest probability of finding it. The alerts are notified by

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Firebase Cloud Messaging and are available even when the app is not running, due to PWA service workers. Individuals receiving these messages can view the item preview and either reject or initiate a claiming process. Should a match be suspected, there is a secure real-time chat room set through WebSocket, where the reporter directly communicates with the finder. Transactions, claims, and interactions are tracked in the interest of transparency and reference.

The platform is fully offline-enabled using service workers and caching strategies, so users can see past alerts and input data even without an internet connection. Upon reconnection, the system synchronizes pending responses and data changes automatically. Authentication middleware enforces security, while report tracking and user behaviour logging prevent spam or abuse. The design is microservice-influenced and modular, with the ability to update or scale the frontend, backend, and WebSocket server components independently. Deployment and scalability are enabled by containerization (e.g., Docker) and orchestration technologies such as Kubernetes, enabling the application to scale with user load without sacrificing high availability and performance.

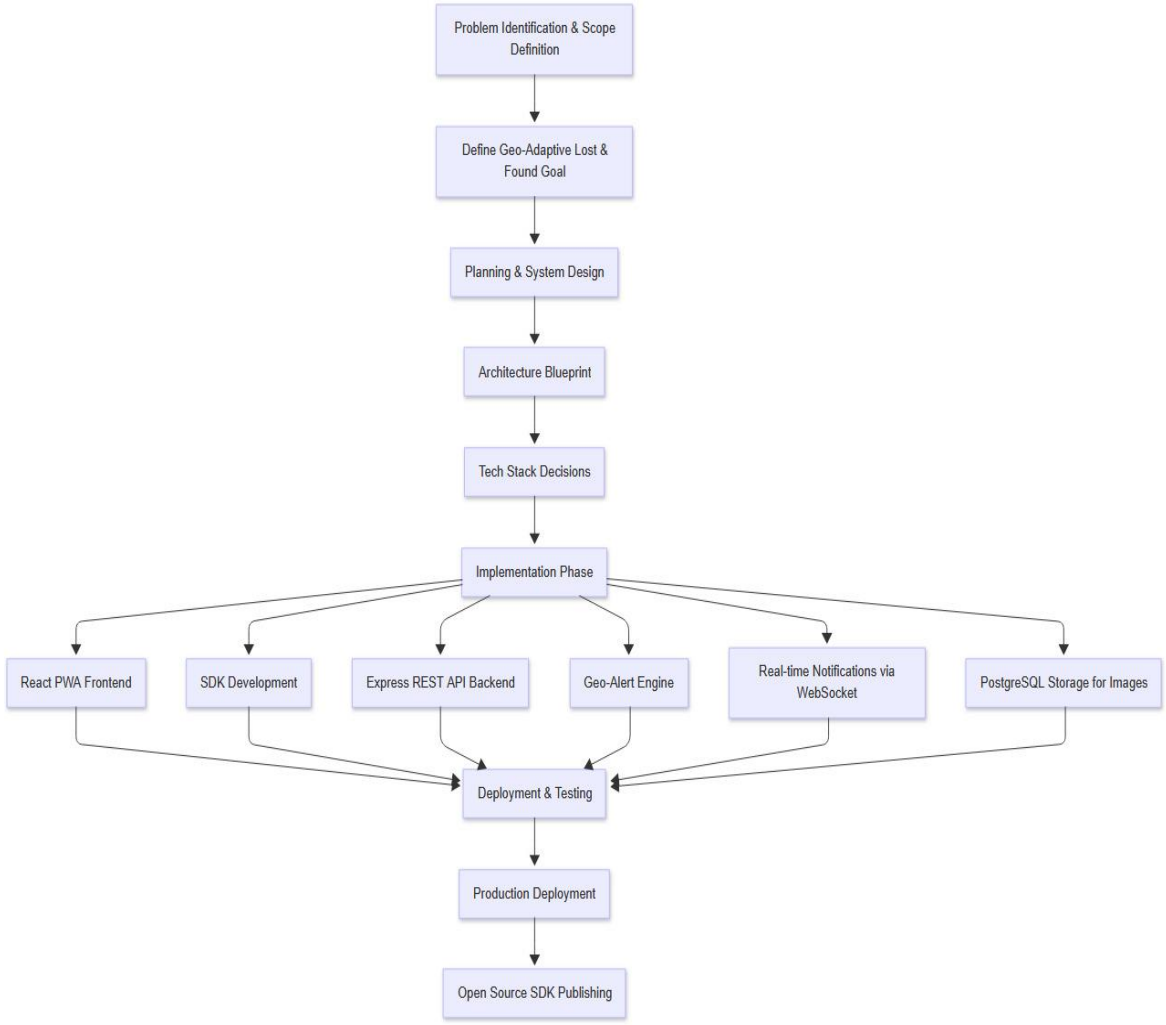

Fig.2. Methodology Overview

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V. RESULTS

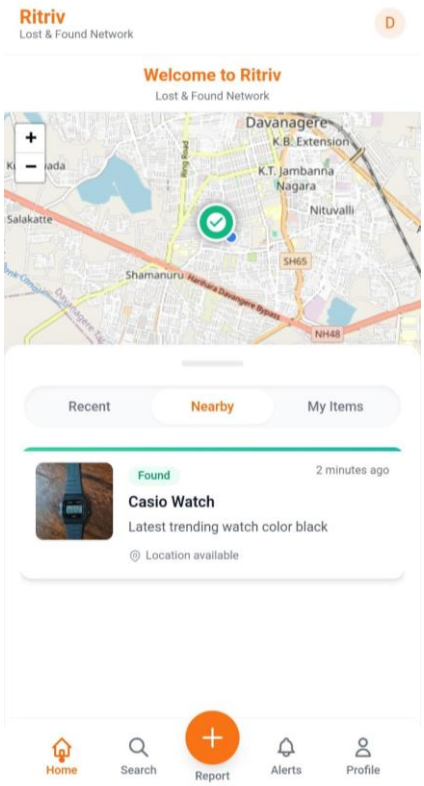

Fig 3: Display of Nearby Found Items

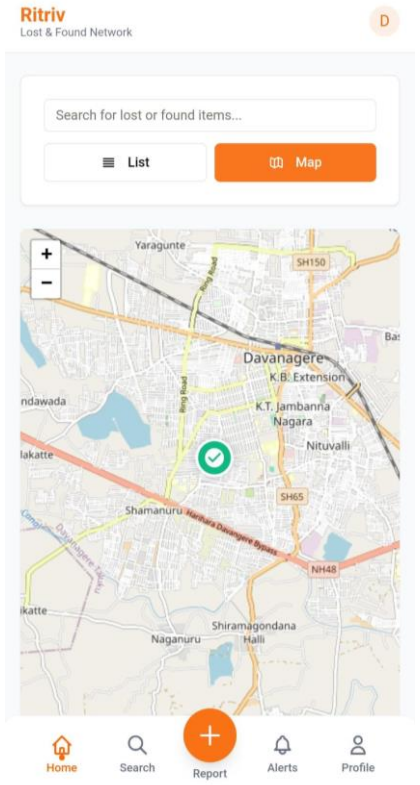

Fig 4: Search Items Interface – List and Map View

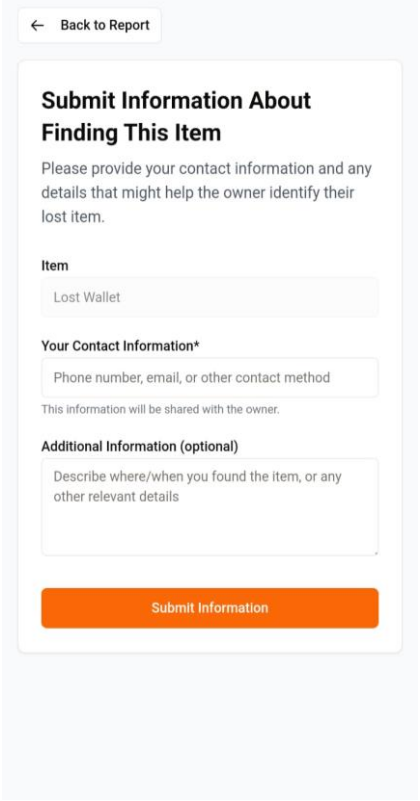

Fig 5: Found Item Submission Form

The progressive web application of lost and found that has been developed provides a structured and interactive dashboard in which the user can easily report and find items. The homepage is the homepage, and it provides the navigation for primary functions like reporting missing items, entering found items, and viewing item matches. It offers signup and login features for individual logins. Once logged in, users can view a stream of missing items, each of which is shown with the essential information like the name of the item, description, and the place it went missing from so that others can decide if they may have found a match. Navigation buttons such as Recents, My Items, and Nearby allow users to seamlessly toggle between the latest updates, their posts, and geographically close reports. An in-focus search interface provides list and map views, enabling users to filter and visually locate items using map markers. This dual presentation increases spatial awareness and facilitates quicker recovery. Upon selection of an item, detailed information is shown, including a description, the date and location it was found, its current status, and the alert radius within which alerts are sent. In communication, the site offers a live chat system through which users can directly communicate with each other to verify ownership and arrange for return. Users who happen upon a lost item can report it in detail using a guided form that elicits contact information, location found, and unique identifying characteristics. In general, the app successfully combines geolocation, intelligent notifications, and live messaging into a single and responsive solution for improving the recovery of misplaced items.

VI. CONCLUSION AND FUTURE WORK

The geo-adaptive Lost and Found system is a state-of-the-art, scalable, and smart solution to the age-old issue of recovery of lost things. Leveraging real-time geolocation, crowd-sourced data, and web progressive technologies, it bridges the long-standing chasm between lost item reporting and successful recovery. Its dynamic expanding radius system design makes it responsive and adaptive, providing greater visibility when required and optimized user experience. Its implementation of WebSockets for real-time communication, service workers for offline support, and

secure user authentication provides reliability with diverse network conditions. Its modular full-stack architecture, implemented using up-to-date frameworks such as React, Node.js, PostgreSQL, and Leaflet.js, provides support for the ease of interaction among users while providing scalability and consistency in performance.

In the future, the scope of the system is broad and revolutionary. Adding AI-driven image identification and semantic matching will make the ability of the platform to propose potential matches more accurate. Blockchain will be able to support claims of possession provably, eliminating attempts of fraud at recovery. Augmented Reality can visually lead users to the position of objects, and voice reporting will make it more convenient and accessible. Social media integration and gamified rewards will stimulate more participation and quick recoveries. Native mobile applications, multilingual, and IoT-based tracking (using smart tags or Bluetooth beacons) will make the system more inclusive and potent. Also, enterprise-class solutions can integrate its usage across airports, campuses, and public places, enabling a unified, intelligent, and global lost and found network.

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