A LOW-COST INDOOR POSITIONING SYSTEM USING BLUETOOTH LOW ENERGY

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Introduction:

Indoor navigation poses unique challenges where GPS fails to provide reliable location data. Bluetooth Low Energy (BLE) has emerged as a viable solution due to its cost-effectiveness and low energy consumption. This project explores the development of a BLE-based Indoor Positioning System (IPS), providing real- time navigation within complex indoor environments such as universities, malls, and hospitals. By leveraging strategically placed BLE beacons and a smartphone application, the system offers an accurate and user-friendly navigation solution.

Objectives:

- Develop an Android application for real-time indoor navigation using BLE.
- Implement fingerprinting and RSSI-based tracking for accurate location identification.
- Design and deploy BLE beacons strategically for optimal signal coverage.
- Enhance the user experience through visual guidance (images and videos).

Methodology:

The proposed system involves three primary components: BLE beacon deployment, mobile app development, and data processing. BLE beacons are configured and deployed throughout the building. An Android app, developed in Java using Android Studio, continuously scans for BLE signals and calculates user positions based on RSSI values. The backend server processes this data and computes optimized navigation paths. CAD modeling aids in beacon placement planning and signal coverage analysis. The system architecture follows a three-layered model: hardware, application, and data processing.

Algorithms such as proximity-based estimation and dead reckoning are used to refine positioning.

Result and Conclusion:

The developed BLE-based navigation system demonstrated high accuracy in a university setting. It effectively guided users with real-time positioning and multimedia-based visual navigation. This solution shows strong potential for deployment in diverse environments, significantly improving accessibility and spatial orientation.

Project Outcome & Industry Relevance:

This project contributes a scalable, low-cost indoor navigation system applicable in public infrastructure such as campuses, airports, and hospitals. It enhances visitor experience and operational efficiency, while offering a viable commercial solution.

Working Model vs. Simulation/Study:

A working model was developed and tested in a real environment using BLE beacons and an Android application.

Project Outcomes and Learnings:

The project resulted in a fully functional IPS with user-friendly mobile application. Students gained experience in mobile development, BLE technology, signal processing, and system integration.

Future Scope:

Future improvements may include integrating machine learning for adaptive signal processing, adding Augmented Reality navigation, expanding the system for multi-floor buildings, and refining signal accuracy under varying environmental conditions.

Future improvements for the system may include integrating machine learning algorithms to enable adaptive signal processing and smarter decision-making capabilities. Augmented Reality (AR) can be incorporated to enhance the indoor navigation experience by providing real-time visual cues. The system can be expanded to support multi-floor navigation in large buildings using floor-specific maps and elevator/lift integration.

Signal accuracy can be refined to perform reliably under varying environmental conditions. Real-time tracking and voice-based assistance can be added to improve accessibility. Cloud synchronization can enable automatic updates of layouts, while IoT integration can offer better context-awareness. Security can be enhanced with encrypted

communication and user authentication. A dedicated mobile app may offer remote control, monitoring, and multilingual support. Energy-efficient routing can be implemented for mobile robots to optimize battery usage.

Camera-based object detection can help in obstacle avoidance, and system performance can be optimized for faster responses. Finally, analytics can be used to improve inventory placement and indoor traffic flow.