Faculty of Engineering and Technology
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Pre-Project Presentation
GeoWake

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Outline

- Introduction
- Objectives
- Sustainable Development Goals Aligned to your project
- Literature Survey
- Problem Statement
- Methods and Methodology (or Block Diagram)
- Expected Outcomes
- Gantt Chart for Work Plan
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Introduction

The Problem:

- Commuters often experience anxiety about **missing their stop** due to distractions, fatigue, or unfamiliar routes.
- **Missed stops** lead to stress, wasted time, and frustration during daily travel.
- **Current solutions** require constant map checking, which is inconvenient and drains phone battery.

Our Vision:

- **GeoWake** is a smart, location-based wake-up app for a stress-free commute.
- It **monitors the user's journey in real time** and sends proactive alerts before reaching the destination.
- Enables commuters to **relax, read, or nap confidently**, knowing they'll be notified at the perfect time.

OBJECTIVES

- **OB1:** To design and implement a smart alert system that automatically notifies the user as they approach their destination.
- **OB2:** To provide users with flexible alarm triggers based on remaining time (minutes), distance (kilometers), or the number of transit stops.
- **OB3:** To ensure the app functions reliably even with intermittent or lost network connectivity, such as when underground.
- **OB4:** To build a battery-efficient application by smartly adjusting the frequency of location updates based on the device's battery level.
- **OB5:** To develop a system for monitoring route deviations and automatically triggering a rerouting policy if the user goes off-track

Sustainable Development Goals(SDG) Aligned to GeoWake

- SDG 11: Sustainable Cities and Communities (Targets 11.2, 11.6)
  - Encourages public transit reliability by reducing missed stops and commute stress.
  - Optimizes battery/compute, supporting lower energy use on devices.
- SDG 9: Industry, Innovation and Infrastructure
  - Practical, user-centric location innovation (snapping, ETA, transfer events).
- SDG 3: Good Health and Well-Being
  - Lowers commute anxiety and cognitive load with timely, reliable alerts.

Literature Survey

1. Emergence of Location-Based Services

The widespread use of GPS-enabled smartphones has driven a boom in real-time location services but ensuring consistent accuracy remains challenging due to hardware and environmental limits.

2. Focus Areas of Research

The survey reviews three domains:

(a) high-precision positioning via sensor fusion,

(b) navigation in GPS-denied environments

(c) current limitations of existing alert systems.

3. Limitations of Raw GPS Data

Consumer smartphone GPS is prone to multipath reflection, attenuation, and noise — often causing errors up to several tens of meters.

4. Sensor Fusion as the Standard Solution

Research converges on Kalman Filter (KF) and Extended Kalman Filter (EKF) as optimal methods to fuse GPS with IMU (accelerometer + gyroscope) data for smoother, more accurate positioning.

5. Effectiveness of EKF Models

Studies (Marzbani et al., 2016; Zerdoumi et al., 2017) show EKF-based fusion can reduce location error by 40–60% in urban conditions.

6. GeoWake's Positioning Approach

Implements a validated EKF pipeline to deliver high-precision tracking, outperforming basic GPS-dependent apps.

7. Challenge of GPS-Denied Environments

In tunnels or dense areas, GPS loss halts tracking; Dead Reckoning estimates movement using IMU data but suffers from drift over time.

8. Drift Mitigation Techniques

Literature suggests map matching and route constraints to correct accumulated errors. GeoWake builds on this by being route-aware and including a Route Re-acquisition feature post-GPS recovery.

9. Limitations of Existing Alert Apps

Current systems rely on static geofences (low accuracy, delay) or brute-force GPS polling (battery drain, false triggers, route ignorance).

10. GeoWake's Novel Contribution

Integrates EKF, Dead Reckoning, and route intelligence into a unified, efficient engine offering predictive, reliable, and context-aware commute alerts, even in GPS-limited conditions.

Problem Statement

- The daily commute is a source of pervasive stress for millions, centered on the anxiety of missing a designated stop. Existing solutions are technologically inadequate to solve this problem reliably.
- **Primitive Geofencing:** Standard location-based reminders (like those in OS level "routines") use simple geofencing, which is not journey aware. These systems are notoriously unreliable, often triggering alerts too late or not at all, as they have no concept of a route, ETA, or traffic.
- **Inaccurate GPS Polling:** Dedicated "GPS alarm" apps rely on raw, noisy GPS data. This leads to inaccurate proximity calculations and significant battery drain from constant, inefficient polling.
- **Critical Failure in GPS-Denied Environments:** All current solutions fail completely the moment a GPS signal is lost, rendering them useless for commuters in subways, tunnels, and dense urban canyons precisely where they are needed most.
- There is a clear and unmet need for an intelligent, journey-aware alert system that is precise, reliable in all conditions, and battery efficient.

Methods and Methodology

Core Methodology & Architecture

- Approach: Modular, Test-Driven Development (TDD).
- Goal: A robust, real-time location intelligence engine.
- Architecture: Decoupled, Service-Oriented Architecture (SOA) within a Flutter environment.
- Orchestration: A persistent background service (trackingservice.dart) manages all data flow between positioning, journey logic, and APIs.

Module 1: High-Precision Positioning (EKF)

• Algorithm: Extended Kalman Filter (EKF) implemented in `sensor_fusion.dart`.
• Motion Model: Non-linear Constant Turn Rate and Velocity (CTRV) model for accurate vehicle motion description, especially during turns.
• State Vector: Tracks position, velocity, heading, turn rate, and acceleration.
• Sensor Fusion: Combines data from `geolocator` (GPS) and the IMU (if available).
• Implementation: Linearizes the model at each time step using its Jacobian matrix, utilizing a Dart linear algebra library like `vector_math`.

Module 2: Journey & Context Management

Route Management (route_queue.dart):

- Manages a fixed-capacity list of active and upcoming routes.
- Handles adding new routes (evicting the oldest) and promoting a route to active.

Deviation Detection (deviation_detection.dart):

- Calculates the user's perpendicular distance from the active route's polyline.
- Optimized to only scan a localized window around the user's last known position, avoiding a full polyline scan on every update.

Module 3: System Integration & Optimization

Intelligent API Management (State Machine):

- A state machine in `trackingservice.dart` (e.g., `NeedsRecalculation` state) governs when to fetch new routes.
- `reroute_policy.dart` acts as a "smart switch," deciding *which* provider to use (e.g., low-cost Mapbox vs. high-cost Google Maps) based on the current context (speed, location, deviation severity).

Power Management (`power_policy.dart`):

- A `PowerPolicy` class subscribes to the device battery level (via `battery_plus`).
- Dynamically adjusts (throttles) the GPS update frequency based on defined battery thresholds (e.g., < 30%) to conserve power

Module 4: Offline Resilience (Dead Reckoning)

Trigger: GPS signal loss (e.g., accuracy > 50m).
Method:
The EKF's **update** step (correction with GPS) is **suspended**.
The EKF's **predict** step **continues**, propagating the state forward using only the CTRV model and IMU data.
UI Feedback: The filter's covariance matrix (P) is used to calculate and display an "uncertainty radius" to the user.
Recalibration: On GPS re-acquisition, a large measurement update is performed to rapidly re-converge the filter to an accurate state.

Testing & Validation Methodology

1. Unit Testing:

- Dedicated test files for every service.
- EKF testing using mock sensor data (`.csv` or `.json`) for predefined paths (straight line, S-curve) to assert against a known ground truth.

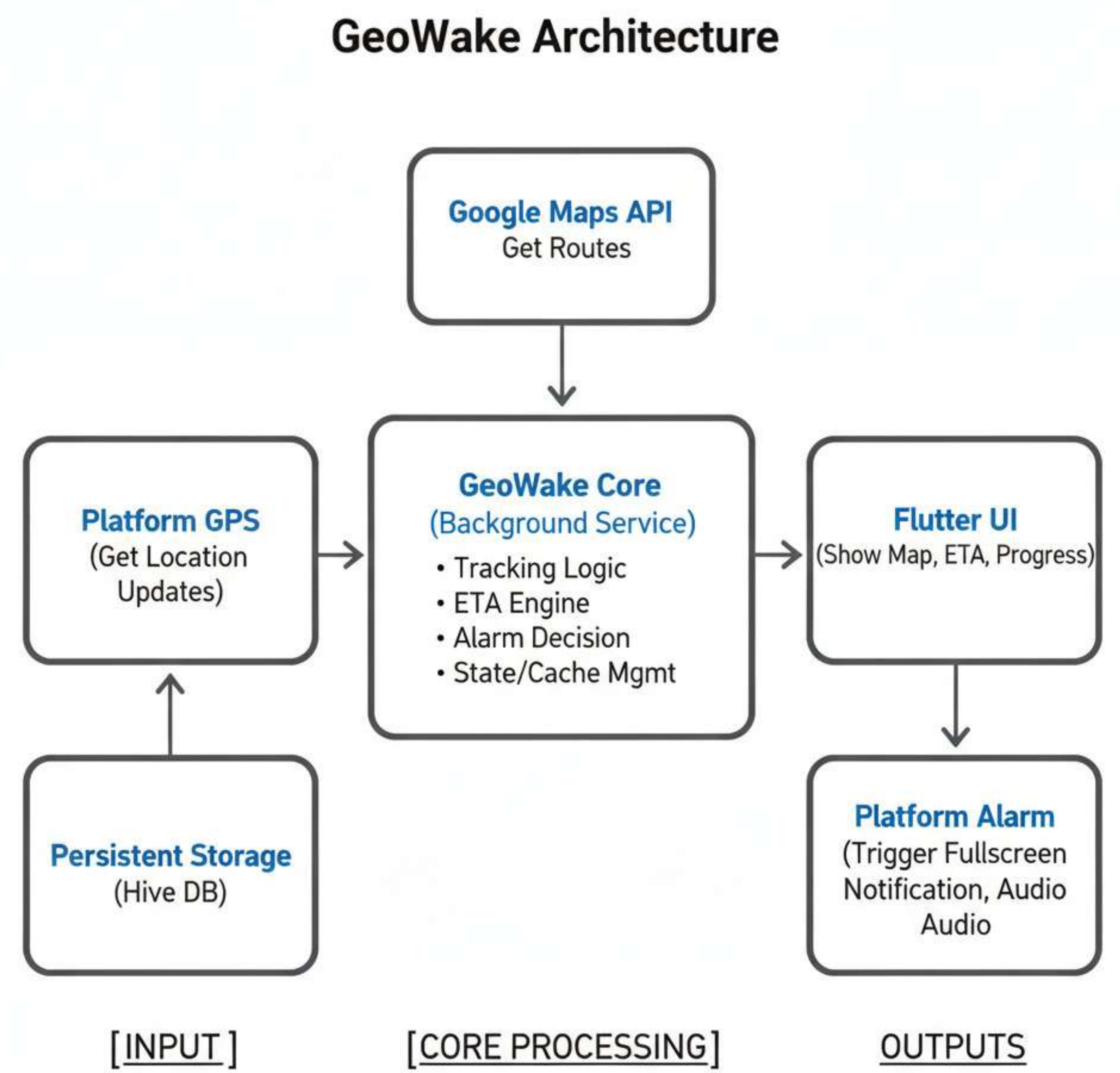
2. Integration Testing:

- A high-fidelity simulation environment using a `MockLocationProvider`.
- Tests the full orchestration loop (e.g., sensor fusion -> deviation detected -> reroute policy triggered -> mock API called) in a single, automated test.

3. Field Testing:

- Collect real-world log data post-simulation.
- Use this data to fine-tune EKF noise parameters (Q & R matrices) and deviation detection thresholds.

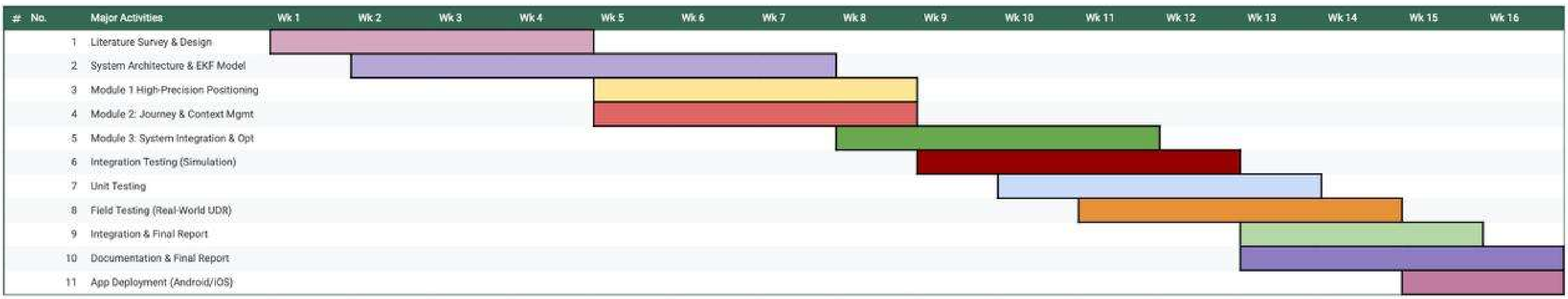
Block Diagram



Expected Outcomes

- **A Deployed, Cross-Platform Mobile Application (GeoWake):**
  - A fully functional application for both Android and iOS with an intuitive interface for setting destinations and configuring time or distance based alerts.
- **A High-Precision Location Intelligence Engine:**
  - A validated software module that utilizes an **Extended Kalman Filter (EKF)** to provide a hyper-accurate, smoothed location stream, demonstrably superior to raw GPS. This engine will include a robust **Dead Reckoning** capability, allowing for continuous and reliable position estimation in GPS-denied environments.
- **An Adaptive and Efficient Journey Management System:**
  - A fully integrated backend service that intelligently manages the user's journey. This includes a **Dynamic Deviation Detection** algorithm to handle rerouting, a **Route Re-acquisition** feature to minimize API calls, and a **Hybrid API Strategy** to manage operational costs without sacrificing performance.
- **A Comprehensive Performance Validation Report:**
  - A detailed technical report that quantitatively analyzes the system's performance. This will include data validating the EKF's accuracy against raw GPS, the effectiveness of the dead reckoning module in simulated offline scenarios, and the battery and cost savings achieved through our power management and intelligent API calling strategies.

Gantt Chart



No.
Major Activities
Wk 1
Wk 2
Wk 3
Wk 4
Wk 5
Wk 6
Wk 7
Wk 8
Wk 9
Wk 10
Wk 11
Wk 12
Wk 13
Wk 14
Wk 15
Wk 16
1 Literature Survey & Design
2 System Architecture & EKF Model
3 Module 1 High-Precision Positioning
4 Module 2: Journey & Context Mgmt
5 Module 3: System Integration & Opt
6 Integration Testing (Simulation)
7 Unit Testing
8 Field Testing (Real-World UDR)
9 Integration & Final Report
10 Documentation & Final Report
11 App Deployment (Android/iOS)

Conclusion

- GeoWake represents a novel step toward intelligent, context-aware commute assistance. By integrating Extended Kalman Filter–based sensor fusion with adaptive routing, battery-aware optimization, and offline dead reckoning, it delivers reliable, high-precision alerts that outperform traditional GPS-dependent apps.

- The system not only minimizes user anxiety and energy consumption but also promotes sustainable and efficient mobility—aligning with global SDG goals.

- GeoWake demonstrates how advanced algorithmic design and real-world usability can merge to create a seamless, smart commuting experience.

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Thank You