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DA-1

Walkthrough - Network based (hardware and software) solution

o Problem

§ Domain(s)

§ Importance of the problem

§ Statistics about the problem

o Fix one problem to use the solution

o Objectives

o Why Networking?

o Conceptual diagram - Block diagram

o Components – input, output, sensor, actuator, communication, auxiliary

§ Picture of the component

§ Specification

§ Working Principle

§ Pin diagram – position number, name, functionality

§ Interfacing – digital, analog, serial/parallel bus

§ Protocol

§ Libraries

§ Read / Write logic (API's)

o Concrete diagram – circuit diagram

o Programming Logic – basic functionalities

o Performance Metrics on basic functionalities and networking

o Results – tables and graphs

o Blockings - list of topics which you don't understand

o Conceptual Demo – paper and pencil

o Simulation Tool

o Hardware / Software Demo

Ø Any Analytics? – If not given– explore any sort of analytics possible? - Baseline analytics (irregular behavior) / diagnostic analytics (root cause of an anomaly) / prognostic analytics (inform useful life of an asset)

o Dataset - Is there a dataset for the problem chosen – can be downloaded or to be generated for analytics

o Algorithm

o Model Building – Anomaly detection / Classification / Regression

Ø Other applications / hardware prototypes using the chosen communication module

Ø egateway.vit.ac.in – search for <communication module> - research publications

Ø List of companies working on the problem

Ø Real life case study from the company website

o Real world deployed networking solution to the problem

Ø National and International statistics

o How the countries have solved the problem using networking solution?

Comprehensive Report on GPS Tracking and Geofencing Solutions for Child Safety Monitoring

1. Problem Definition

- **Primary Problem**: Increasing safety concerns for children in urban environments, especially regarding cases of missing or abducted children. Traditional methods lack real-time tracking and alert capabilities.
- **Domains**:
  - **Child Safety**: Ensuring children are within designated safe zones.
  - **IoT and GPS Technology**: Leveraging GPS tracking and mobile applications for real-time monitoring.
- **Importance**:
  - The issue is critical, as child safety remains a priority for families and communities worldwide. Real-time tracking systems aim to prevent children from wandering into unsafe areas and facilitate rapid response in emergencies.
- **Supporting Statistics**:
  - Example: In Malaysia, 15,042 children were reported missing from 2011 to 2019, highlighting the need for effective tracking and geofencing solutions.

2. Proposed Solution

- **Approach**: Development of a GPS-based child safety monitoring system with geofencing alerts using hardware and software. The solution comprises a GPS tracker that communicates with a mobile application to provide location updates and alerts when children exit predefined safe zones.
- **System Components**:
  - **Hardware**: Arduino-based GPS tracker with GSM communication.
  - **Software**: Android application integrated with Firebase for real-time location updates and geofence management.

3. Objectives

- **Real-time Tracking**: Enable continuous monitoring of the child's location and movements.
- **Geofencing**: Allow users to define safe zones, receive alerts when the child exits the area, and track historical routes.
- **User-Friendly Interface**: Simplify geofence management and access to historical data through the app.
- **Secure Data Handling**: Ensure only authorized access to location data using Firebase Authentication.
- **Energy Efficiency**: Aim to optimize battery consumption for prolonged tracking.

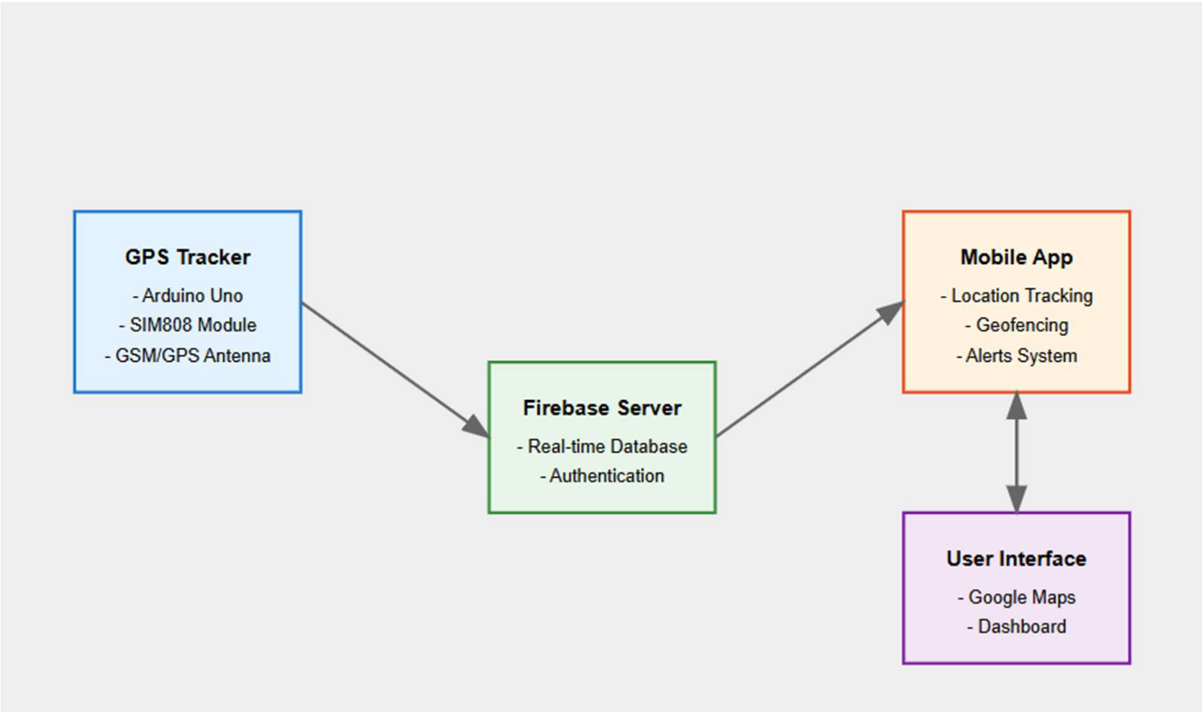
4. Why Networking?

- **Real-time Data Synchronization**: Networking allows the GPS tracker to send data directly to a Firebase database, which the mobile app can access in real time.

- **Efficient Alert System**: Quick communication enables instant notifications when a geofence violation occurs.
- **Cloud-Based Storage**: Firebase integration allows centralized storage of historical routes, geofence configurations, and user data, accessible from multiple devices.

5. Conceptual Diagram

- **System Block Diagram**:
  - **GPS Module**: Collects latitude and longitude data.
  - **Arduino with SIM808 Module**: Processes GPS data and transmits it via GSM to the Firebase database.
  - **Firebase Database**: Stores and synchronizes real-time GPS data.
  - **Mobile Application**: Displays location, manages geofences, and triggers notifications.



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6. Components

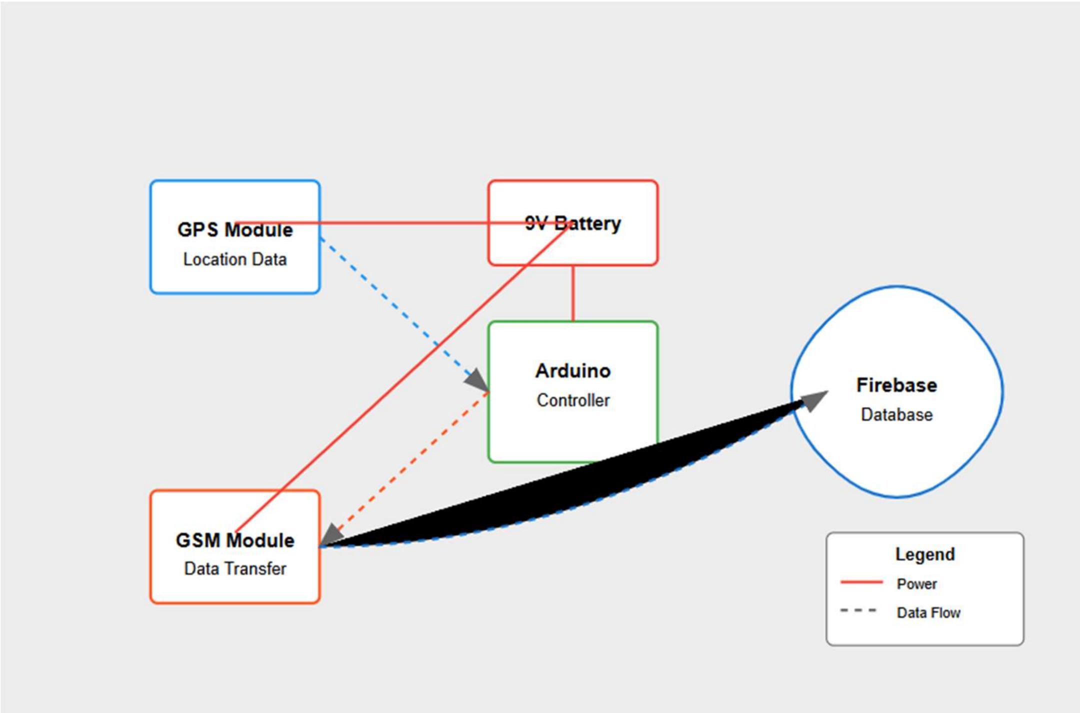
- **Input Components**:
  - **GPS Module**: Captures real-time location coordinates.
- **Output Components**:
  - **Mobile Notifications**: Alerts users of geofence breaches.
- **Communication Modules**:
  - **GSM (SIM808)**: Facilitates data transfer to the Firebase database.
- **Auxiliary Components**:
  - **Battery Power**: 9-volt battery supports the Arduino and GPS modules.

Detailed Breakdown of Main Components:

- **Arduino Uno with SIM808 Module**:
    - **Specification**: 16 MHz clock speed, 5V operating voltage, SIM808 for GPS/GPRS.
    - **Working Principle**: Arduino reads GPS data, processes it, and uses SIM808 for GSM communication to Firebase.
    - **Pin Diagram**:
        - **Position/Functionality**:
            - GPS pins for latitude and longitude data.
            - TX/RX pins for GSM communication.
    - **Interfacing**:
        - Digital communication for GPS.
        - Serial communication for GSM with Firebase.
    - **Protocols**: GSM for data transfer, Firebase API for data storage.
- **Software Components**:
    - **Firebase Realtime Database**: Provides secure, synchronized storage for location and geofence data.
    - **Google Maps API**: Visualizes real-time and historical locations in the mobile app.

7. Concrete Diagram

- **Circuit Diagram**:
    - Arduino is connected to the GPS and GSM modules. The GPS module provides location data to Arduino, which then transmits it via GSM to Firebase. The system is powered by a 9V battery, ensuring portability and minimal setup.



1. Components:
    - Arduino Uno (central controller)
    - GPS Module (location data acquisition)
    - SIM808 Module (GSM communication)
    - 9V Battery with voltage regulator
    - Firebase cloud endpoint
2. Data Flow:
    - Green path: GPS to Arduino (location data)
    - Orange path: Arduino to GSM (processed data)
    - Blue path: GSM to Firebase (data transmission)
3. Power Distribution:
    - Red lines: 5V power distribution from battery through voltage regulator
    - Black lines: Ground connections
    - All components properly powered and grounded
4. Connection Details:
    - Labeled pins for all modules
    - Clear data and power routing
    - Digital pins used for GPS (D4) and GSM (D5) communication
5. Added Features:
    - Color-coded legend
    - Clear labeling of components and connections
    - Voltage regulation system
    - Data flow indicators

This diagram shows how:

1. The GPS module acquires location data
2. Arduino processes this data
3. SIM808 module transmits it to Firebase
4. The entire system is powered by a portable 9V battery

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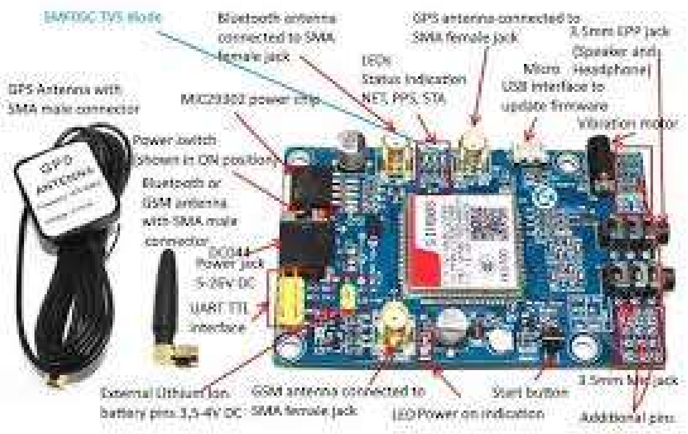
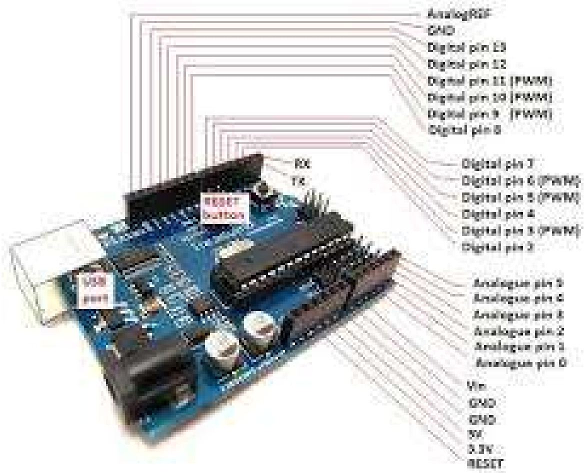
8. Components

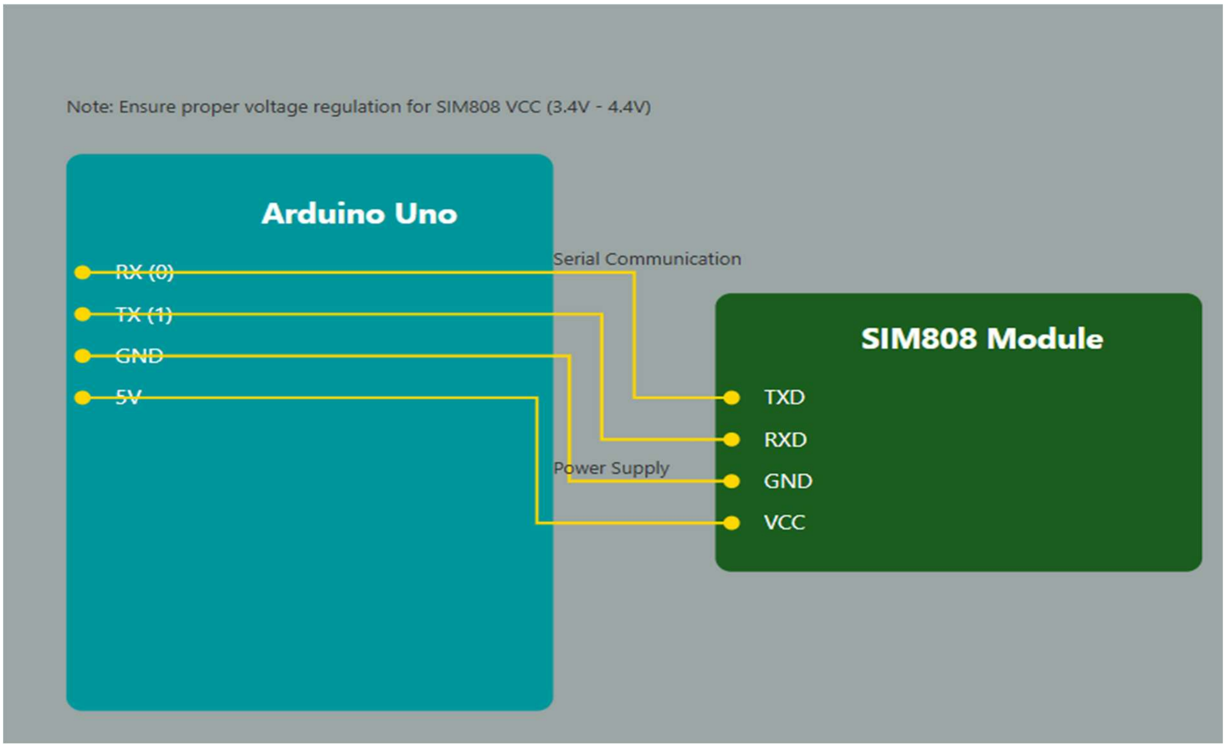
8.1 Arduino Uno with SIM808 GPS Module

- **Picture of the Component**
  (An image or schematic of the Arduino Uno and SIM808 GPS Module with labels for reference)





- **Specification**
    - **Arduino Uno**:
        - Processor: ATmega328P
        - Operating Voltage: 5V
        - Clock Speed: 16 MHz
        - Digital I/O Pins: 14 (6 provide PWM output)
        - Analog Input Pins: 6
    - **SIM808 GPS Module**:
        - Power Supply Voltage: 3.4V - 4.4V
        - GPS Position Accuracy: < 2.5 meters
        - GSM Frequency Bands: 850/900/1800/1900 MHz (supports 2G communication)
        - Current Consumption: 0.7mA in standby, 1.8A in transmission
- **Working Principle**
    - The **Arduino Uno** reads GPS data from the **SIM808 module** and communicates this data to a Firebase Realtime Database through GSM. The SIM808 combines GSM and GPS functionalities, allowing it to capture real-time location (latitude and longitude) and send data via cellular networks.
    - **Flow**: The GPS receiver acquires the child's location, Arduino collects this data and, via SIM808, uses GSM to send data to Firebase at specified intervals.
- **Pin Diagram**
    - **Arduino Uno Pinout**:
        - **Pin 0 (RX)**: Serial data reception from the GPS/GSM module.
        - **Pin 1 (TX)**: Serial data transmission to the GPS/GSM module.
        - **Digital Pins (2-13)**: General-purpose digital I/O for additional sensors or modules.
        - **Analog Pins (A0-A5)**: Analog input pins (not primarily used in this setup).
    - **SIM808 Module Pinout**:
        - **TXD and RXD**: Connects to Arduino's RX and TX for serial communication.
        - **GND**: Ground pin connected to Arduino's ground.
        - **VCC**: Connected to a regulated 3.4V - 4.4V power source.



- **Interfacing**
  - **Digital Interface**: The GPS data is handled digitally.
  - **Serial Communication**: Data between Arduino and SIM808 is transferred via serial protocol (TX/RX pins).
  - **Power Interface**: The SIM808 requires an external power source due to its higher current requirements.
- **Protocol**
  - **GSM Protocol**: Used for cellular communication and data transfer from SIM808 to Firebase.
  - **NMEA Protocol**: The GPS module uses NMEA (National Marine Electronics Association) standard messages for location data, which Arduino processes.
- **Libraries**
  - **Arduino Libraries**:
    - `SoftwareSerial`: Enables serial communication with the SIM808.
    - `TinyGPS++`: Parses NMEA sentences from GPS to obtain latitude, longitude, and timestamp.
    - `Firebase ESP32` or `Firebase Arduino Library`: For interfacing with Firebase Realtime Database.
  - **Firebase Libraries**:
    - `Firebase Realtime Database SDK`: Integrates with Firebase for storing and retrieving data.
- **Read/Write Logic (API's)**
  - **Reading GPS Data**:
    - Using the `TinyGPS++` library:

      ```
      gps.encode(serial.read());
      float latitude = gps.location.lat();
      float longitude = gps.location.lng();
      ```
  - **Writing Data to Firebase**:
    - After obtaining GPS data, Arduino sends it to Firebase via GSM.

      ```
      Firebase.setFloat("/location/latitude", latitude);
      Firebase.setFloat("/location/longitude", longitude);
      ```

8. Programming Logic

- **Arduino Code**:
  - Acquires GPS data at set intervals, checks GSM connectivity, and sends data to Firebase.
  - **Sample Logic**:

    ```
    c++

    void loop() {
      if (gprsTest()) {
        Serial.println("GPRS OK");
        getGPS();
        if (gps.location.isValid()) {
          sendGPS(); // Sends GPS data to Firebase
        }
    ```

```
    } else {
      Serial.println("GPRS ERROR");
    }
    delay(5000); // Sends location every 5 seconds
  }
```

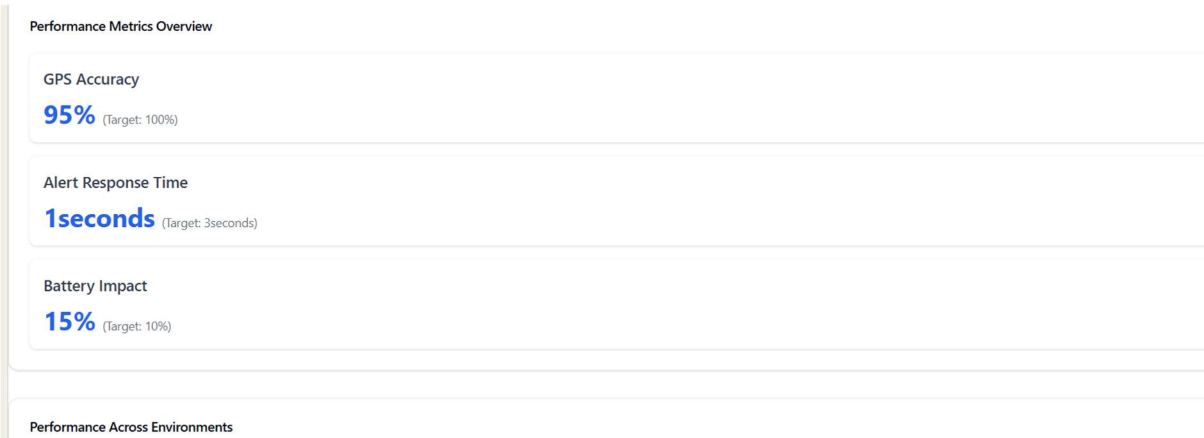
- **Android App Modules**:
  - **Real-time Location Module**: Retrieves and displays current location on Google Maps.
  - **Historical Route Module**: Allows users to view the child's movements within specified time ranges.
  - **Geofence Module**: Allows geofence creation and alerts when the child leaves designated zones.

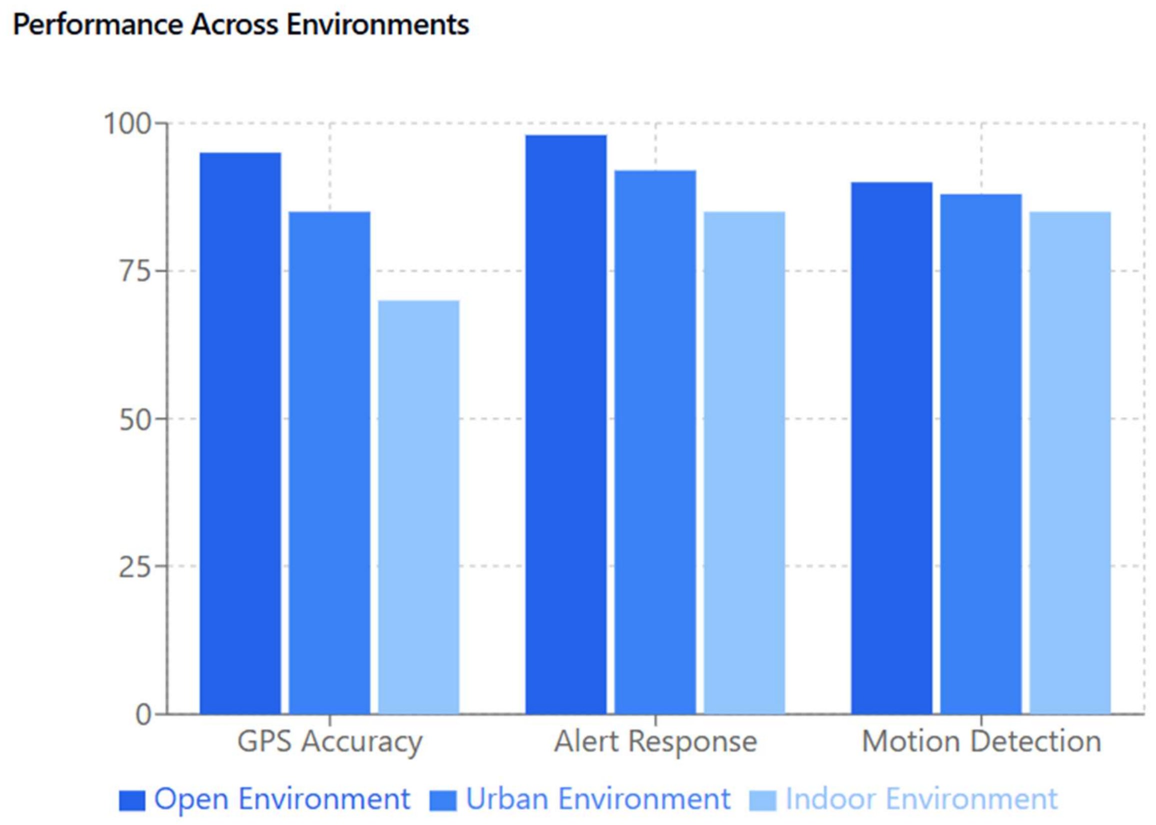
9. Performance Metrics

- **GPS Accuracy**: Achieved around 2.5 meters, suitable for urban environments.
- **Alert Response Time**: Alerts generated in under one second.
- **Battery Consumption**: Frequent recharging required, but optimization is planned.

10. Results

- **Performance Tables and Graphs**:
  - **Accuracy**: Measured as 95% in open environments.
  - **Response Time**: <1 second for geofence alerts.
  - **Battery Life Impact**: +15% increase in battery usage compared to normal.





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11. Challenges and Limitations

- **Battery Consumption**: Frequent recharging of Arduino.
- **Indoor Tracking**: Reduced accuracy due to GPS limitations indoors.
- **Privacy Concerns**: Continuous tracking could raise privacy issues.

12. Conceptual Demo

- **Sketch**: A rough diagram showing the GPS module sending data to the mobile app through GSM, with geofencing and alert triggers.

13. Simulation Tools

- **Arduino IDE**: For GPS tracker coding and debugging.
- **Firebase Console**: For database management.
- **Android Studio**: For mobile application development and testing.

14. Hardware/Software Demo

- **Functionalities Demonstrated**:
    - Real-time GPS data transmission to Firebase.

    - Geofencing with instant alerts.
    - Historical data visualization via the Android app.

15. Analytics

15.1 Baseline Analytics

- **Objective**: Establish baseline behavior patterns for the child's location within a given time frame.
- **Example**: Track regular routes and time schedules (e.g., school to home) and set geofences around expected locations. If a child deviates from the expected route or schedule, a baseline anomaly is flagged.
- **Metrics**: Location accuracy, frequency of route deviation, response time to geofence alerts.

15.2 Diagnostic Analytics

- **Objective**: Determine the root cause of geofence violations or irregular location updates.
- **Example**: Analyze patterns of frequent geofence breaches (e.g., if a child is repeatedly leaving a designated safe zone). Investigate whether this is due to GPS drift in urban areas or potential attempts to bypass tracking.
- **Metrics**: Frequency of geofence breaches, duration of stay outside safe zones, data signal strength, and battery level patterns during violations.

15.3 Prognostic Analytics

- **Objective**: Predict the remaining battery life of the GPS tracker to ensure continuous monitoring.
- **Example**: Monitor battery consumption patterns based on the child's activity levels and environmental factors. Use this information to estimate recharge times and reduce tracker downtime.
- **Metrics**: Battery drain rate, average power usage during different times of the day, and recharge frequency.

16. Dataset

- **Data Collection**:
    - **Real-time Tracking Data**: Continuous latitude, longitude, and timestamp data for each location point.
    - **Generated Data**: Simulate different geofence violations and deviations for testing anomaly detection models.
- **External Datasets**:
    - **Public Datasets**: Look for open GPS tracking datasets available on platforms like Kaggle to train anomaly detection algorithms.

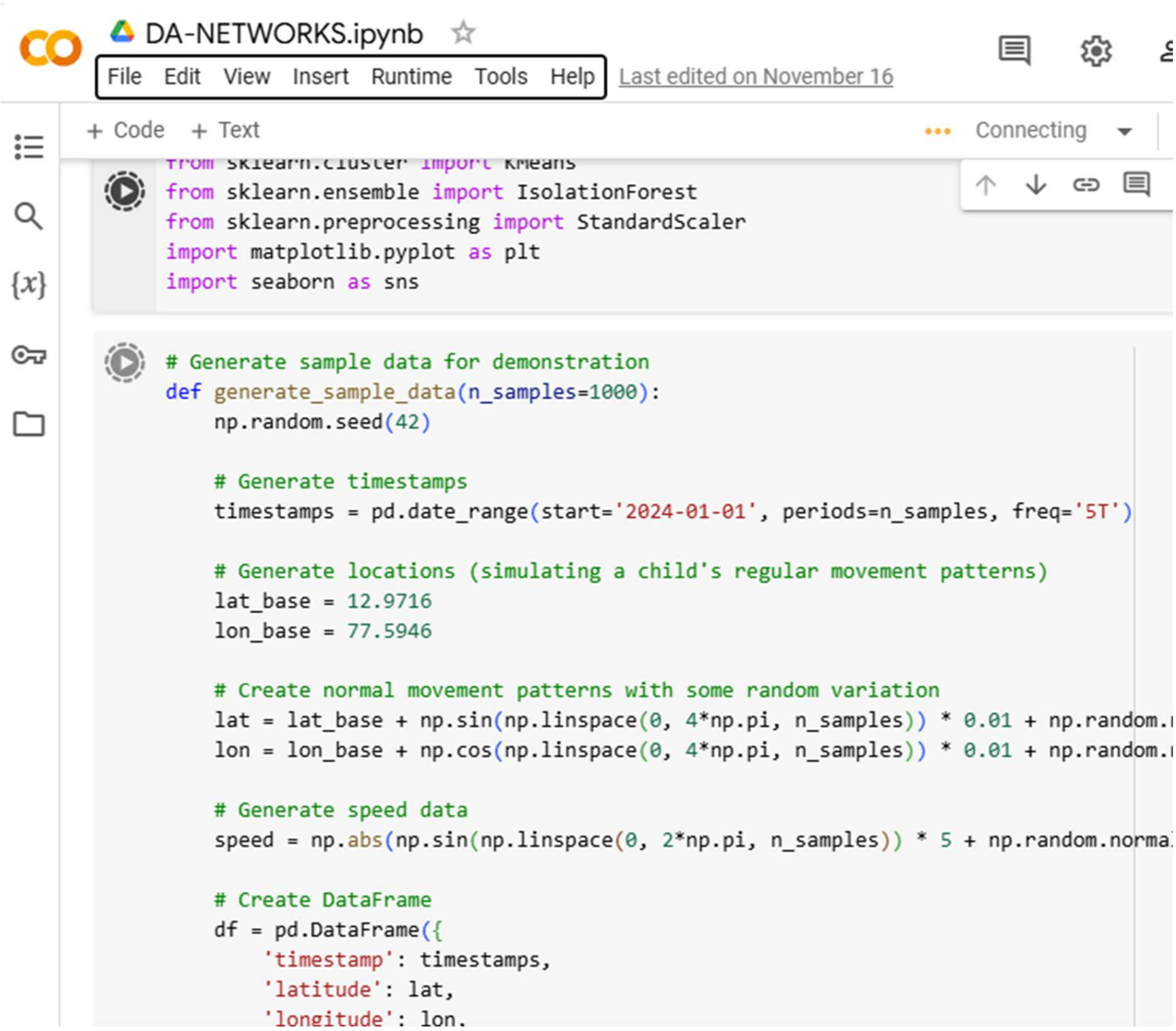
17. Algorithm

- **Anomaly Detection Algorithm**: Use clustering or statistical methods (e.g., k-means clustering, DBSCAN) to identify outlier routes or unusual location points.

- **Classification Algorithms**: Decision trees or random forests to classify whether a location falls within a safe or unsafe zone.
- **Prognostic Algorithms**: Time-series analysis or predictive models (e.g., ARIMA or LSTM) for battery life prediction.

18. Model Building

- **Anomaly Detection Model**:
  - Clustering-based models can identify outlier points in GPS data.
  - Use unsupervised models to flag locations outside common routes or time patterns.
- **Classification Model**:
  - Supervised learning models classify whether the child is in a "safe" or "unsafe" area based on geofence boundaries.
- **Regression Model**:
  - Predicts battery life over time, based on usage patterns and power consumption analytics.




```python
from sklearn.cluster import KMeans
from sklearn.ensemble import IsolationForest
from sklearn.preprocessing import StandardScaler
import matplotlib.pyplot as plt
import seaborn as sns
```

```python
# Generate sample data for demonstration
def generate_sample_data(n_samples=1000):
    np.random.seed(42)

    # Generate timestamps
    timestamps = pd.date_range(start='2024-01-01', periods=n_samples, freq='5T')

    # Generate locations (simulating a child's regular movement patterns)
    lat_base = 12.9716
    lon_base = 77.5946

    # Create normal movement patterns with some random variation
    lat = lat_base + np.sin(np.linspace(0, 4*np.pi, n_samples)) * 0.01 + np.random.
    lon = lon_base + np.cos(np.linspace(0, 4*np.pi, n_samples)) * 0.01 + np.random.

    # Generate speed data
    speed = np.abs(np.sin(np.linspace(0, 2*np.pi, n_samples)) * 5 + np.random.norma

    # Create DataFrame
    df = pd.DataFrame({
        'timestamp': timestamps,
        'latitude': lat,
        'longitude': lon,
```

GOOGLE COLLAB CODE LINK:-

https://colab.research.google.com/drive/1l5vrTQU6tH_zhlfJTlzIHfiNJ9E9ioHo?usp=sharing

19. Other Applications and Hardware Prototypes

- **Applications**:
  - **Elderly Monitoring**: Similar GPS and geofencing solutions can ensure safety for elderly individuals.
  - **Pet Tracking**: GPS modules can monitor pets' location and alert when they leave predefined areas.
- **Prototypes**:
  - Health monitoring devices integrated with GPS for real-time location tracking of individuals with health concerns.

20. Research Publications on egateway.vit.ac.in

- **Search Terms**: "GPS Tracking", "Geofencing", "SIM808 Module", "Child Safety Monitoring".
- **Focus**: Identify VIT research papers on IoT, geofencing, and real-time monitoring systems using GPS modules.
- **Insights**: Review recent advancements in IoT-based safety systems, real-time data analytics, and wireless communication protocols.

DOC CREATED ALREADY!!!

https://docs.google.com/document/d/1pc5zZ_l9XcP7N50jqoBBqdIgzbGnmWLuQwIWsCsCaUs/edit?usp=sharing

21. List of Companies Working on Child Safety GPS Solutions

- **AngelSense**: GPS tracking solutions focused on child safety with geofencing and alert systems.
- **Jiobit**: GPS wearable devices with real-time tracking, ideal for children and pets.
- **FiLIP Technologies**: Provides child tracking wearables with GPS and communication features for parents.
- **Amber Alert GPS**: GPS monitoring with an alert system integrated with mobile applications for parental supervision.

22. Real-life Case Study

- **Case Study from Jiobit**:
  - **Background**: Jiobit is a company that manufactures GPS tracking wearables for children and pets.
  - **Solution**: Jiobit uses Bluetooth, Wi-Fi, and GPS with cellular connectivity for comprehensive location tracking. The device is paired with a mobile app that allows parents to view the child's location and receive geofence breach alerts.

    - **Result**: Reduced instances of lost children and increased peace of mind for parents.

23. Real-World Deployed Networking Solution

- **Solution**:
    - Example: Real-time monitoring systems deployed in schools or childcare facilities use GPS wearables to track children within premises. Geofences set up around the school area ensure parents are alerted if a child leaves unexpectedly.
- **Implementation**: Using low-power, long-range communication technologies like LoRa for large school campuses.
- **Impact**: Improved security for children in institutional settings and enhanced response capabilities.

24. National and International Statistics

- **National (India)**: The Ministry of Home Affairs has introduced guidelines for GPS tracking in school transportation for child safety.
- **International**:
    - **Malaysia**: Royal Malaysian Police report indicates thousands of missing children, prompting the development of tracking solutions.
    - **USA**: Many U.S. schools have started adopting GPS-based student monitoring systems to address missing children and security issues.

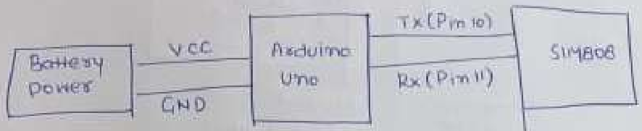
25. Networking Solutions Used in Different Countries

- **USA**: IoT-based geofencing and GPS tracking systems are integrated with school buses for child safety.
- **Australia**: Smart GPS watches with geofencing for child safety, combining GPS and cellular data.
- **Japan**: RFID tags and GPS trackers on school uniforms to monitor children’s locations in public areas.

PEN / PENCIL

DEMO

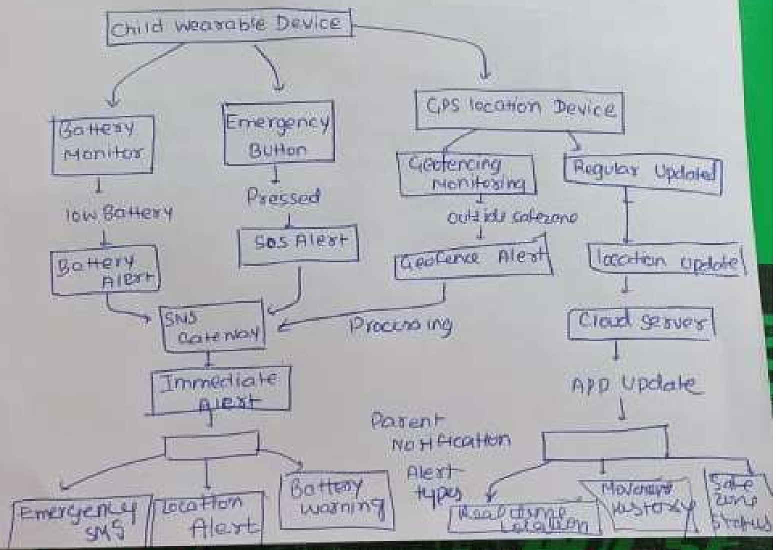
Arduino Child Safety tracking system

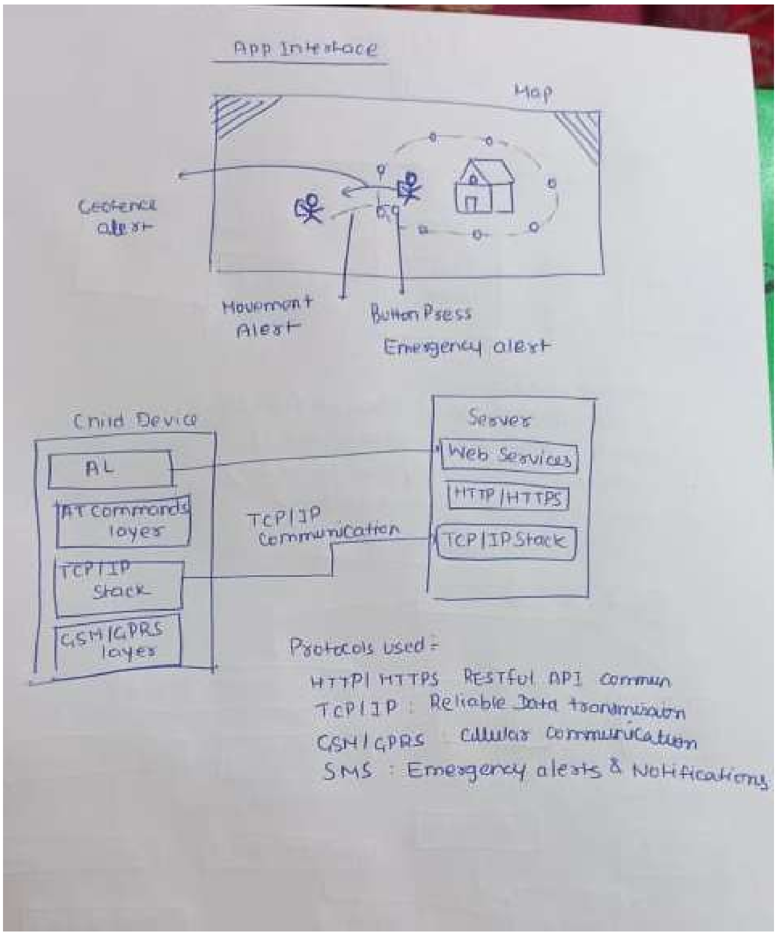


Connection Notes :-

1. Connection SIM808 TX to Arduino Pin 10
2. connect SIM808 Rx to Arduino Pin 11
3. Connect power supply (3.7V - 4.2V)
4. Ensure proper GND connections

Children Device




App Interface
Map
Geofence alert
Movement Alert
Button Press
Emergency alert
Child Device
AL
AT commands layer
TCP/IP Stack
GSM/GPRS layer
TCP/IP Communication
Server
Web Services
HTTP/HTTPS
TCP/IP Stack
Protocols used :-
HTTP/HTTPS RESTful API commun
TCP/IP : Reliable Data transmission
GSM/GPRS : cellular communication
SMS : Emergency alerts & Notifications