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Project Title: *Smart Warehouse Inventory Tracker*

BSc (Hons) in Computing Science

Introduction and Problem Statements

- The efficient tracking of warehouse assets is crucial for logistics operations.
- Challenges exist in accurately tracking objects vertically within indoor environments.
- Existing technologies like UWB, RFID, and Wi-Fi have limitations in vertical positioning.

Methodology and Proposed Solutions

1. **Establishment of BLE-enabled Sensor Network**:
   - ***Objective***: Achieve comprehensive indoor coverage for accurate asset tracking.
   - ***Method***: Strategically deploy BLE nodes throughout the warehouse for optimal signal reception.
   - ***Rationale***: BLE offers low power consumption, cost-effectiveness, and device compatibility.
   - ***Implementation***: Position corner nodes strategically to ensure overlapping coverage.
2. **Development of Trilateration Algorithms**:
   - ***Objective***: Calculate asset positions accurately using signals from BLE nodes.
   - ***Method***: Utilize trilateration to determine precise asset locations.
   - ***Rationale***: Trilateration calculates intersections of circles/spheres from BLE nodes.
   - ***Implementation***: Develop algorithms for real-time processing of signal strength data.
3. **Implementation of Real-time Data Processing Mechanisms**:
   - ***Objective***: Ensure timely and accurate updates of asset positions.
   - ***Method***: Implement data processing on MCUs for BLE signal handling and trilateration.
   - ***Rationale***: Real-time processing maintains system integrity and enables quick response.
   - ***Implementation***: Utilize MCUs for processing, executing algorithms, and transmitting updates.

Research Questions and Project Objectives

How can we improve the accuracy of indoor asset tracking, particularly in vertical positioning?

- Develop a system utilizing BLE and MCUs for real-time, three-dimensional asset tracking.
- Implement algorithms for precise location determination based on signals from BLE nodes.
- Evaluate system performance in terms of accuracy, reliability, and scalability.

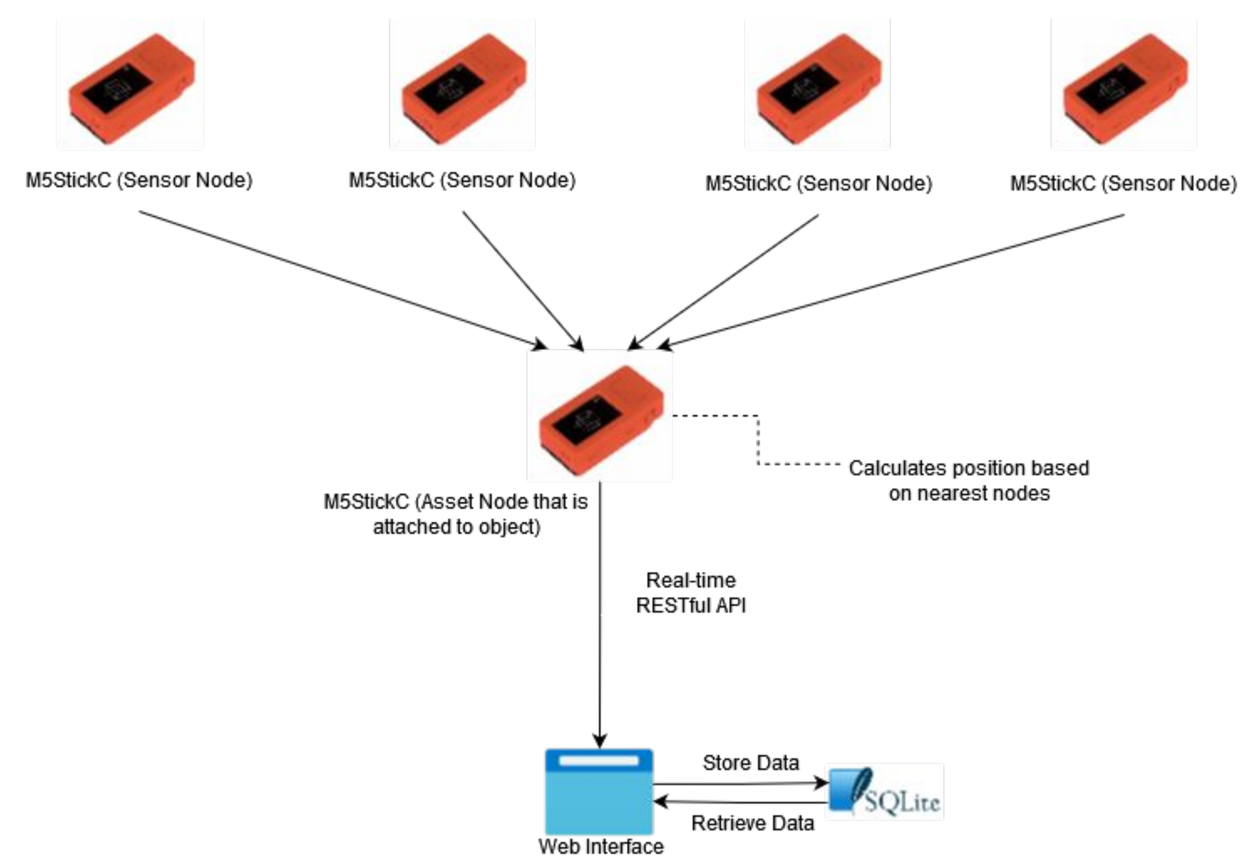
Experiments and Results Analysis

Experiments

- **Testing Bluetooth Signal Strength (RSSI)**
  - Asset nodes and corner nodes were placed at varying distances.
  - Signal strength attenuation over distance was deduced and potential signal degradation was removed.
- **Refining RSSI to Distance Conversion**
  - 1 meter was measured and recorded in order to recalibrate the algorithm to obtain an average RSSI value which is accurate of the measured power.
- **Environmental Factor Calibration**
  - Accounting for environmental noise and interference to determine the most suitable environmental conditions for deployment.

Results Analysis

- The M5StickCPlus are more compact in comparison with tags.
  - 48.2*25.5*13.7mm compared to 66*40*25mm
- Tags are prone to detachment in which the M5StickCPlus avoids detachment problems
- Asset tags with rechargeable batteries have long-term savings costs.
  - Non-rechargeable batteries are replaced every 100 days instead of being recharged.
- M5StickCPlus are more compact and real-time as compared to beacons.
  - Real-time compared to 30 mins-2 hours



Conclusions and Future Work

Our solution emphasising the usage of M5StickCPlus prioritizes portability, reliability and real-time tracking results in a system managing to mitigate long-term costs and environmental impact whilst maintaining the accurate vertical asset tracking capabilities required. We can enhance the timing of RSSI retrieval from the BLE beacons (corner nodes) via Multithreading or Parallel Scanning to perform simultaneous scans on multiple channels or frequencies by increasing the overall scan throughput and reducing the time required to retrieve RSSI via FreeRTOS with xTaskCreate.