 

**CSC2106 Internet of Things: Protocols and Networks [2023/24 T2]**

Literature Review (Individual):   
Literature Review of BLE/WiFi-based Warehouse Asset Tracking System

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# **1. Introduction**

The Smart Tracker project focuses on developing a comprehensive Smart Warehouse Inventory Tracker for indoor environments. The system aims to provide precise location information, catering to applications such as indoor asset tracking in warehouses. Utilising communication protocols, such as Bluetooth Low Energy (BLE) and/or WiFi, and microcontroller units (MCUs) such as M5StickC Plus, Super Mini ESP32-C3, and Raspberry Pi Pico, the project aims to demonstrate real-time tracking capabilities.

# **2. Problem Statement**

The Smart Warehouse Inventory Tracker project aims to rectify the inherent limitations of contemporary IoT sensors, particularly concerning their efficacy in detecting objects in a vertical orientation within the intricate dimensions of a 3D indoor space. This deficiency becomes particularly pronounced and operationally challenging in vertical tracking scenarios, notably when applied to the precision monitoring of tools within a workshop environment. Recognising the urgency to overcome these limitations, the project introduces an innovative solution characterised by an augmentation of the sensor network, strategically increasing the number of nodes. This augmentation aims not only to bolster tracking accuracy but also to hone in on the nuanced demands of vertical tracking within the specific context of workshop tools.

Key Points:

* Vertical Tracking Limitation: The prevailing generation of IoT sensors grapples with challenges in effectively detecting objects oriented vertically within the intricate spatial landscape of a 3D indoor environment. This limitation poses a substantial impediment to achieving precise and reliable tracking outcomes.
* Enhanced Accuracy: The proposed solution unfolds as a meticulous strategy involving a discerning increase in the number of nodes within the sensor network. This deliberate augmentation is envisaged as a cornerstone for achieving a paradigm shift in tracking accuracy, transcending the constraints imposed by current sensor limitations.
* Workshop Tool Tracking: A focal point of this initiative is the tailored attention given to the tracking of tools within the dynamic setting of a workshop environment. Recognising the unique challenges presented by workshop scenarios, the solution aims to elevate the accuracy and reliability of tracking specifically for tools, thereby addressing a critical operational need.
* Scalability Consideration: The design philosophy underpinning the proposed solution is inherently forward-looking, with scalability positioned as a paramount consideration. Beyond immediate requirements, the solution is meticulously crafted to seamlessly expand and adapt to the evolving demands of future expansions, ensuring sustained relevance and operational efficiency.

# **3. Literature Review**

The literature by Lee et al. (2019) primarily focuses on a Bluetooth-based indoor positioning system for warehouse asset tracking, utilizing Bluetooth Low Energy (BLE) technology. The study underscores the importance of real-time asset management in manufacturing industries and highlights the limitations of traditional manual record-keeping. Lee et al. (2019) opted for BLE-enabled beacons for their precision and low power consumption.

Technology Overview

The system employs a Bluetooth-based infrastructure, utilizing beacons, a Bluetooth signal receiver (Raspberry Pi), data processing unit, software, Wi-Fi network, and a database. The system leverages the Received Signal Strength Indicator (RSSI) parameter for distance estimation. The calibration process involves studying the correlation between RSSI values and actual beacon distances, leading to a formula for RSSI values against distance.

Methodology and Filters

The study introduces various filters, including median filter, moving average filter, Kalman filter, and a newly proposed Kalman-LULU hybrid filter. Lee at al. (2019) found that the Kalman-LULU filter outperforms others, exhibiting a strong correlation between RSSI and actual distance. The study explores different topologies for the system, emphasizing the positioning algorithm based on trilateration.

Accuracy Analysis

The experimental setup involves collecting RSSI values from different distances, determining the optimal TX power level, and studying the correlation between RSSI and actual distance. The proposed Kalman-LULU filter consistently demonstrates superior accuracy, reducing standard deviation and enhancing the reliability of the system.

Metal Attenuation and Environmental Effects

Lee at al. (2019) investigated the impact of metal shielding on signal strength and it revealed the effectiveness of the Kalman filter in mitigating metal attenuation effects. Unexpected findings include the influence of nearby beacons on RSSI values, potentially due to constructive phase interference.

Conclusion

The Bluetooth-based indoor positioning system, particularly with the novel Kalman-LULU filter, proves effective for asset tracking in warehouse environments. It contributes valuable insights into implementing a cost-efficient Bluetooth location-based indoor positioning system for manufacturing industries, emphasizing the need for precision in asset management.

This system excels in distance estimation but lacks emphasis on vertical tracking and specific challenges associated with workshop tools. In contrast, the Smart Tracker project aims to directly addresses the vertical tracking limitations within 3D indoor spaces, offering a comprehensive solution for warehouse inventory tracking, with a specialized focus on workshop scenarios. The Smart Tracker's node augmentation strategy enhances accuracy and scalability, overcoming the limitations of the Bluetooth system. By tailoring its approach to dynamic environments and precision tool tracking, the Smart Tracker project may present a more holistic solution for indoor asset tracking.

# **4. Reference**

C. K. M. Lee, C. M. Ip, T. Park and S. Y. Chung, "A Bluetooth Location-based Indoor Positioning System for Asset Tracking in Warehouse," *2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Macao, China, 2019, pp. 1408-1412, doi: 10.1109/IEEM44572.2019.8978639. <https://ieeexplore-ieee-org.singaporetech.remotexs.co/document/8978639>