Literature Review

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Introduction:

Singapore, a frontrunner in sustainable urban development, grapples with a crucial data gap: the lack of a dedicated Wireless Sensor Network (WSN) to monitor CO_2 emissions and their intricate link to temperature fluctuations across diverse urban environments. This absence of comprehensive data impedes our ability to accurately track progress towards ambitious environmental targets and formulate informed policies for critical issues like CO_2 reduction and urban heat island mitigation.

Problem Statement

This project tackles this pressing challenge by proposing the development and deployment of a scalable and energy-efficient mesh network utilizing LoRa and ESP-Now protocols in Nanyang Polytechnic (NYP) Campus. Through this network, we aim to collect and analyze real-time CO_2 and temperature data, enabling us to achieve three key objectives:

- Establish robust correlations between these environmental factors,
- Evaluate the performance and suitability of LoRa and ESP-Now protocols compared to established mesh algorithms, and
- Deliver valuable insights to policymakers and stakeholders, empowering them to develop data-driven strategies for a more sustainable urban future.

By addressing this data gap and providing actionable insights, this project aspires to contribute significantly to Singapore's journey towards environmental sustainability.

Focus Areas

We will focus on key factors like:

- **Data latency and reliability:** Ensure timely and accurate transmission of environmental data.
- **Network scalability and reach:** Ability to handle a large number of nodes and cover the desired area effectively.
- **Energy efficiency:** Minimize power consumption of sensor nodes for extended lifespan and network sustainability.
- **Cost-effectiveness:** Consider hardware, deployment, and operational costs for a sustainable solution.

Literature Review

Designing a robust and efficient mesh network for real-time environmental monitoring poses unique challenges due to the resource-constrained nature of wireless sensor networks (WSNs). The Routing Protocol for Low-Power and Lossy Networks (RPL), a proactive routing protocol [8], emerges as a promising candidate, addressing these challenges head-on with its standardized approach, dynamic routing capabilities, and energy-efficient design [1], [5]. Notably, RPL aligns well with our project's key objectives of scalability, reliability, and sustainability.

One of RPL's critical strengths lies in its ability to dynamically adapt to network changes. An adaptation mentioned in [2], D-RPL, optimises multihop routing, guaranteeing reliable data collection even when nodes fail or move, or new ones are deployed, a crucial feature for real-time environmental monitoring where network conditions are constantly shifting.

Furthermore, RPL prioritizes energy efficiency [4]. By employing energy-aware path selection and minimizing control overhead, RPL extends the lifespan of individual nodes and the overall network, a significant advantage in resource-constrained environments.

Finally, RPL exhibits excellent scalability, making it suitable for large-scale WSNs like the one envisioned for the application. Its hierarchical design effectively handles complex network structures, ensuring efficient data routing even as the network grows in size and complexity.

While RPL boasts significant advantages, careful consideration must be given to its limitations before implementation. Security measures require meticulous implementation to address potential vulnerabilities in resource-constrained environments [3], [6], [7]. Additionally, RPL's dynamic nature can introduce complexity and overhead compared to simpler protocols, demanding thoughtful analysis and optimization.

Balancing RPL's strengths with its limitations is crucial. Its dynamic routing, energy efficiency, and scalability hold immense potential for achieving our project's goals. Leveraging RPL's features, particularly its dynamic routing and multipathing capabilities, promises timely data collection even in dynamic network environments, contributing to a successful monitoring application. Further investigation and experimentation are necessary to determine the optimal configuration and potential adaptations required for RPL to seamlessly integrate into our specific project and effectively meet the desired outcomes.

References

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