

# 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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

The Minimum Spanning Tree (MST) is a potential routing protocol for mesh-based Wireless Sensor Networks (WSN). Algorithms like Prim's [4] and Kruskal's [1] have attracted implementations in applications since they are simple to implement and effective in static networks. However, their direct application to Wireless Sensor Networks (WSNs) remains questionable.

Recent research endeavors have delved into the potential of MSTs to enhance energy efficiency within WSN routing protocols. For instance, MSTEAM leverages localized MSTs to facilitate multicast routing, thereby minimizing energy consumption during message propagation [3]. Similarly, NNT offers a distributed approach to construct approximate MSTs, effectively reducing communication overhead [5]. Additionally, CMSTR addresses the challenge of imbalanced energy consumption in hierarchical routing by employing constrained MSTs to establish energy-efficient intra-cluster communication paths [7]. These advancements highlight the promise of MST-based strategies in promoting energy-aware routing within WSNs, especially in  $CO_2$  monitoring applications and specific deployment scenarios.

In an MST-based WSN, there is necessity for each node to compute shortest paths to all others, which significantly escalates complexity and energy consumption [2]. Moreover, the static nature of MSTs requires recalculations upon network alterations, potentially causing delays and packet loss. In complex environments, MSTs may not always ensure the most energy-efficient paths, further complicating their practical utility.

Nevertheless, MSTs offer a hierarchical routing topology, which has been proven to be scalable and energy efficient in WSNs [6]. A potential solution could adopt a reactive approach, where the sink node initiates data collection through controlled broadcasts or multicasts. Subsequently, leaf nodes transmit data along pre-computed, energy-efficient paths towards the sink, facilitated by intermediate nodes. This reactive paradigm appears promising for static WSN deployments, providing a balance between simplicity and efficiency.

In conclusion, while MSTs exhibit limitations in certain WSN scenarios, their adaptability and potential for energy-efficient routing make them a compelling area for further investigation, particularly in  $CO_2$  monitoring applications.

## References

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