# Building Smart and Sustainable Cities

A Proposal for a Consensus-Based IoT Data Aggregation System Supporting Sustainable Development Goals

# Project Proposal: Consensus-Based Distributed IoT Data Aggregation System for SDG 9 & 11

## Enhancing Smart and Sustainable Infrastructure


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## Introduction

The ever-expanding Internet of Things (IoT) ecosystem has given rise to billions of devices generating continuous environmental, industrial, and urban data streams. Traditional centralized data aggregation models often encounter challenges related to scalability, latency, and single-point failures. This project proposes a consensus-based distributed IoT data aggregation framework, wherein multiple sensor nodes collectively agree on global readings through iterative local exchanges.

This system supports SDG 9 (Industry, Innovation, and Infrastructure) and SDG 11 (Sustainable Cities and Communities) by enhancing the resilience, efficiency, and sustainability of smart city data infrastructures.

## Objectives

- **Design** a distributed IoT architecture using lightweight consensus algorithms.
- **Simulate** sensor nodes that collaboratively compute aggregate values (mean, sum, min, max).
- **Compare** the performance of distributed consensus with centralized aggregation.

- **Evaluate** metrics: latency, communication overhead, energy efficiency, and accuracy.
- **Visualize** convergence behavior and demonstrate scalability benefits.
- **Highlight** contributions toward SDG 9 & 11 through improved infrastructure design.

# Methodology

## System Design

- Each IoT node produces periodic sensor readings.
- Nodes communicate only with local neighbors and iteratively update their values using the average consensus algorithm, gradually converging to the global aggregate.
- Baseline centralized aggregation is simulated for comparison.

## Dataset

- A synthetic dataset of 50–200 nodes with simulated environmental readings (temperature, humidity, or energy usage).
- Alternatively, data may be sourced from a public IoT dataset like the UCI Air Quality Data Set or Intel Lab Sensor Data (Kaggle).

## Consensus Mechanism

Each node ( i ) updates its value ( x_i(t) ) at iteration ( t ) as:

$$x_i(t+1) = x_i(t) + \epsilon \sum_{j \in N_i} (x_j(t) - x_i(t))$$

where ( N_i ) are neighboring nodes and ( \epsilon ) is a small step-size. This iterative update continues until values converge to the global mean.

## Evaluation Metrics

| Metric | Description |
|---|---|
| **Latency** | Rounds required to reach convergence |
| **Communication Overhead** | Messages exchanged per round |
| **Energy Proxy** | Estimated energy via message count |
| **Accuracy** | Difference from true global average |
| **Scalability** | Performance with increasing nodes |

### Visualization

- **Line plots** showing convergence of node values over time.
- **Bar charts** comparing message counts between centralized and distributed methods.
- **Heatmap** of correlation among nodes after consensus.

## Expected Outcomes

- Demonstrate that consensus-based aggregation achieves near-accurate results with reduced communication overhead.
- Validate scalability advantages for large-scale IoT deployments.
- Provide quantitative insights into how distributed intelligence supports smart city resilience.
- Contribute to SDG 9 & 11 by enabling efficient, robust IoT infrastructure.

## Project Significance

This project bridges distributed systems and IoT data analytics, offering a practical simulation of collaborative sensor intelligence. By minimizing central dependency, it supports fault tolerance, energy efficiency, and real-time decision-making—crucial for next-generation sustainable cities.

## Conclusion

The proposed Consensus-Based Distributed IoT Data Aggregation System is a forward step toward decentralized smart infrastructure. It aligns technological innovation with the United Nations' vision of sustainable urban development, ensuring inclusive, safe, and resilient smart ecosystems under SDG 9 & 11.