Middle East Technical University
Computer Engineering Department

CNG 476 System Simulation
Spring 2024-2025
Progress Report
Smart Small Grid Management System

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1 Project Proposal

This project simulates an IoT-based smart small grid management system that uses LoRa communication within OmNet++ and the FLoRa framework. The system consists of multiple houses equipped with smart sensors that monitor power availability and communicate directly with a central monitoring system. These sensors detect power outages and send real-time alerts to the system using LoRa's long-range, low-power communication capabilities. The monitoring system processes the received data, analyzes the outage patterns, and coordinates the distribution of energy among multiple providers to ensure efficient power restoration. It also notifies the technical team, who are then dispatched to fix the issue on-site.

The simulation incorporates Random Number Generation and Monte Carlo simulation to model uncertain factors such as sensor failures and varying network conditions. Probability models are used to predict power outage frequencies, while the Poisson process is used as a stochastic process to analyze the random occurrence of outage events and data transmission reliability under different network loads. To efficiently handle multiple simultaneous outage reports, the system employs queues, sorting outage reports by time, and processing them in a FIFO (First-In-First-Out) manner to ensure the earliest reported outages are addressed first.

For performance evaluation, key metrics include the number of outages detected, the average arrival time of the technical team after notification,and the time taken to resolve the outages. These metrics help assess the efficiency of outage detection, communication latency, responsiveness of the technical team, and overall grid resilience, ensuring optimal performance in real-world scenarios.

2 Diagrams and Visuals

A diagram of our system can be seen in Figure 1.

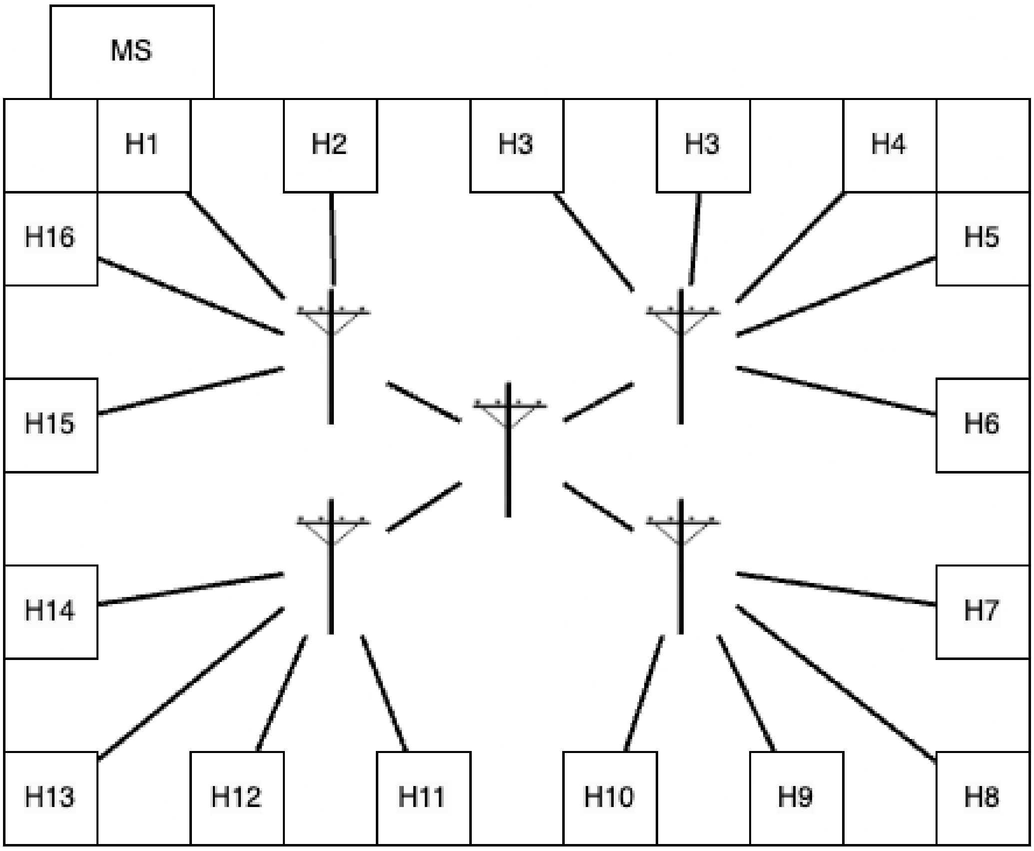

Figure 1: Smart Small Grid Management System

3 Milestones Achieved

The initial phase of the project has focused on laying a strong theoretical foundation and outlining a comprehensive framework for the simulation. This stage involved the identification of core concepts, selection of simulation tools, and formalization of system behaviors through discrete-event simulation principles. The milestones achieved up to this point are summarized below:

March 17 – March 23

Ünsal

- Installed and configured OmNet++ and the FLoRa framework.
- Defined the overall project goals and objectives, focused on simulating a smart grid management system using LoRa and IoT devices.

Duru

- Collected reference studies on outage detection models and queue management strategies.
- Installed and configured OmNet++ and the FLoRa framework.

March 24 – March 30

Ünsal

- Conducted a theoretical study and documentation of simulation tools, particularly OmNet++ and the FLoRa framework.
- Designed the specification model, including the use of FIFO queues, Poisson process for outage modeling, and probability models for network uncertainty.
- Wrote the proposal report for the project.

Duru

- Conducted background research on LoRaWAN and smart grid architecture.
- Developed a conceptual model describing key components: smart homes with sensors, a central monitoring system, and LoRa-based communication.
- Wrote the proposal report for the project.

April 28 – May 4

Ünsal

- Chose initial performance metrics, such as outage detection count and average alerts per household.
- Wrote the progress report for the project.

Duru

- Chose initial performance metrics, such as outage detection count and average alerts per household.
- Wrote the progress report for the project.

4 Milestones Remained

The next phase of the project will involve translating the theoretical framework into a working simulation model and conducting experiments to evaluate system performance. This stage focuses on implementation, integration of probabilistic elements, data collection, and validation of results. The following milestones outline the tasks that remain to be completed in order to achieve a comprehensive and functional simulation:

May 5 – May 11

Ünsal

- Begin implementation of the simulation environment using OmNet++ and the FLoRa framework.
- Code simulation entities such as LoRa message transmitters and power outage event generators.

Duru

- Implement basic sensor entities and define their event-triggering logic.
- Begin coding queue structures for outage report handling.

May 12 – May 18

Ünsal

- Integrate stochastic models, including random number generation for sensor failures.
- Simulate simple outage and recovery cases to test the system flow.

Duru

- Implement Monte Carlo simulation components to model network behavior variability.
- Conduct initial debugging and event tracking for validation.

May 19 – May 25

Ünsal

- Run full-scale simulations with varying system loads and failure rates.
- Collect data for performance metrics such as outage response time, packet delivery rate, and system load.

Duru

- Analyze simulation results and compute metrics like queue wait time, energy restoration rate, and sensor failure impact.
- Visualize selected results using graphs and tables.

May 26 – June 1

Ünsal

- Finalize coding and verify system correctness through comprehensive debugging.
- Contribute to interpretation of results and model validation.

Duru

- Prepare the final project report, including methodology, performance evaluation, and result interpretation.
- Coordinate visual presentation of results for the final documentation.

5 GitHub Repository Link

https://github.com/duruaksoy/CNG-476