ECE 445: Senior Design Laboratory
Project Proposal

Electric Load Forecasting(ELF) System

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March 8, 2023

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1 Introduction

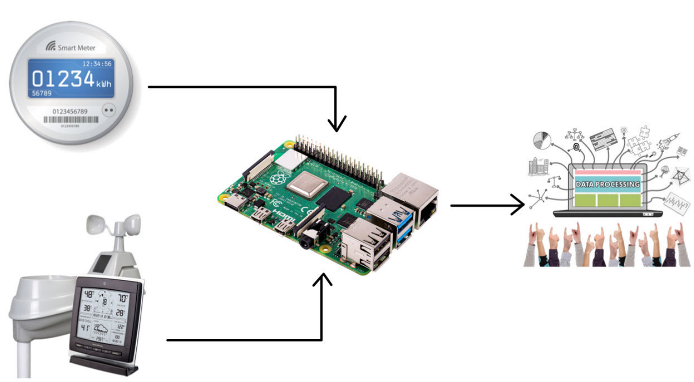
1.1 Problem

Electric load forecasting (ELF) is a method that takes into account unstable factors, such as weather conditions and electricity prices, to predict the demand for electricity. Many utility companies rely on manual forecasting techniques based on specific datasets, but these methods may lack accuracy when fine-grained time particle forecasting is required. To accurately predict expenses on electricity and construct reliable infrastructures that can withstand a certain electrical load, utility companies need more advanced and reliable forecasting methods.

1.2 Solution

The electric load forecasting system is a powerful tool for predicting future electric load usage based on dedicated hardware and AWS services. By combining the data collection subsystem, data storage subsystem, prediction subsystem, query API subsystem, and web page subsystem, customers can easily retrieve and visualize the predicted electric load usage and use it for planning and optimization purposes. The system is designed to be accurate, effective, reliable, and easy to use, providing customers with a complete solution for electric load forecasting.

1.3 Visual Aid



The whole system consists of four parts: a smart meter, a set of weather sensors, a concentrator and a data processing and forecasting terminal. The control computer could be a raspberry PI or some other electronic device. Finally, the data processing terminal can forecast through the obtained power load data and weather data.

1.4 High-level requirements list

1.4.1 Accuracy

The system should generate accurate predictions of future electric load usage. The accuracy of the predictions should be high enough to enable effective planning and optimization of electric power usage.

1.4.2 Scalability

The system should be capable of handling large volumes of data and generating predictions for a large number of electric load customers. The system should be able to scale up or down as the demand for electric power changes.

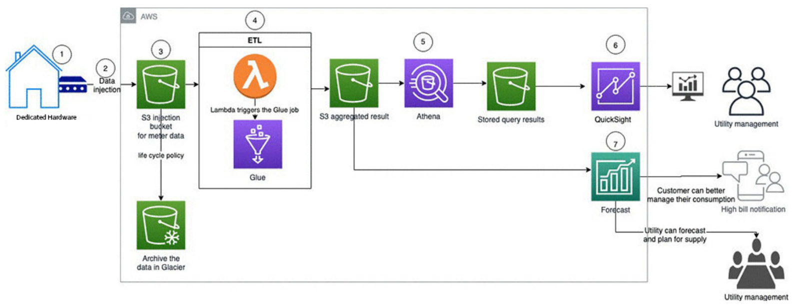
1.4.3 Reliability

The system should be designed to be highly reliable and available. It should be able to handle failures gracefully and recover quickly from any disruptions in service.

2 Design

2.1 Block Diagram

Break your design down into blocks and assign these blocks into subsystems. Label voltages and data connections. Your microcontroller can live in multiple subsystems if you wish, as in the example below.



2.2 Subsystem Overview

A brief description of the function of each subsystem in the block diagram and explain how it connects with the other subsystems. Every subsystem in the block diagram should have its own paragraph.

2.2.1 Data Collection Subsystem

This subsystem is responsible for collecting real-time data on electric load usage.

2.2.2 Data Storage Subsystem

This subsystem is responsible for storing the collected data in a secure, scalable, and durable storage system.

2.2.3 Prediction Subsystem

This subsystem is responsible for generating accurate predictions of future electric load usage based on the collected data.

2.2.4 Query API Subsystem

This subsystem provides a RESTful API that allows customers to retrieve the predicted electric load usage for a specified time period.

2.2.5 Web Page Subsystem (Optional)

This subsystem provides a user-friendly web interface for accessing the predicted electric load usage.

2.3 Subsystem Requirements

For each subsystem in your block diagram, you should include a highly detailed block description. Each description must include a statement indicating how the block contributes to the overall design dictated by the high-level requirements. Any interfaces with other blocks must be defined clearly and quantitatively. Include a list of requirements where if any of these requirements were removed, the subsystem would fail to function. Good example: Power Subsystem must be able to supply at least 500mA to the rest of the system continuously at 5V +/- 0.1V.

2.3.1 Data Collection Subsystem

The data collection hardware is designed to be reliable, scalable, and capable of handling large volumes of data. The collected data is then sent to the data storage subsystem for further processing through AWS IoT Core.
Hardware 1. Smart meters to collect voltage, current, power and other data which further improve the ability to collect information
Hardware 2. A transmission communication device that connects a smart meter to software or concentrator
Hardware 3. Sensors that collect some relevant external factor data data (ex. Temperature sensor)

2.3.2 Data Storage Subsystem

The data is stored in a format that is compatible with the Forecast DeepAR+ algorithm. AWS S3 provides a highly available and cost-effective storage solution that is suitable for storing large volumes of data.

2.3.3 Prediction Subsystem

The Forecast DeepAR+ algorithm is a state-of-the-art machine learning algorithm that is designed for time-series forecasting. The AWS Forecast service makes it easy to generate accurate predictions at scale. The output of this subsystem is a forecast of future electric load usage that can be used for planning and optimization purposes.

2.3.4 Query API Subsystem

The API is designed to be secure, scalable, and easy to use. Customers can send requests to the API with the necessary parameters, and the API will return the predicted electric load usage in a format that is easy to understand and use.

2.3.5 Web Page Subsystem (Optional)

The web page is built on top of the query API and allows customers to easily select the time period they are interested in and view the predicted electric load usage in a graphical format. The web page is designed to be responsive, easy to use, and accessible from any device with a web browser.

2.4 Tolerance Analysis

Identify an aspect of your design that poses a risk to successful completion of the project. Demonstrate the feasibility of this component through mathematical analysis or simulation.

2.4.1

There may be errors in historical weather data due to potential inaccuracies in the weather equipment when crawling data from websites. Nevertheless, these errors are acceptable as extending the training context leads to a decrease in average error. Additionally, even without weather condition data, the forecast algorithm can still achieve an accuracy of greater than 70

2.4.2

While the time granularity is not small enough, which contributes to inaccuracies in forecasting load in smaller time intervals such as 15 minutes, this risk is tolerable. In practical settings, the trend of load changes in the next 15 minutes is more crucial than precise load data. People typically prioritize the trend to take corrective measures and keep load data within an appropriate range.

2.4.3

The data collection and transmission process may cause additional electricity load to the system, but the electricity load generated by the monitoring system is trivial and insignificant compared to the system it monitors. Furthermore, this extra load has minimal effects on the trend of electricity load changes. Therefore, the additional electricity load from the edge device is tolerable.

3 Ethics and Safety

Assess the ethical and safety issues relevant to your project. Consider both issues arising during the development of your project and those which could arise from the accidental or intentional misuse of your project. Specific ethical issues should be discussed in the context of the IEEE and/or ACM Code of Ethics. Cite, but do not copy the Codes. Explain how you will avoid ethical breaches. Cite and discuss relevant safety and regulatory standards as they apply to your project. Review state and federal regulations, industry standards, and campus policy. Identify potential safety concerns in your project.

3.1 Ethical issues

3.1.1 Privacy

The data collected from smart meters and other external sensors contains sensitive information about the electricity consumption patterns of individuals and businesses. It is essential to ensure that the collected data is only used for the intended purposes of electric load forecasting and not misused for any other purposes. Also, it is important to ensure that the data is stored securely and is not accessed by unauthorized personnel.

3.1.2 Solution

To ensure the security and privacy of the collected data in our electric load forecasting system, we will employ AWS Key Management Service (KMS) and S3 encryption to support encryption in-flight and at rest. With AWS KMS, we can create and manage encryption keys that can be used to encrypt and decrypt data securely. By using S3 encryption, all data stored in the data storage subsystem will be encrypted, ensuring that the data is protected in case of unauthorized access. This approach provides end-to-end encryption, from data collection to storage, and is a best practice in ensuring data security in cloud-based systems.

3.2 Safety Issues

3.2.1 Reliability

The electric load forecasting system should be reliable and accurate to prevent any potential safety hazards that can arise from unexpected spikes in demand. The forecasting algorithm should be tested and validated to ensure that it is dependable and consistent.

3.2.2 Compliance

The project should comply with relevant safety and regulatory standards, such as the National Electrical Code (NEC) and National Electrical Safety Code (NESC), to prevent electrical hazards.

3.2.3 Solution

Incorporating our electric load forecasting system as a plugin of an existing electric load monitoring system could make it easier to comply with laws and regulations. The use of dedicated hardware to collect and store data ensures that the system is designed with security and privacy in mind, meeting the requirements of data protection regulations. By integrating our system with an existing electric load monitoring system, we can leverage the regulatory compliance features already built into the monitoring system, streamlining the compliance process. This approach allows us to reduce the compliance workload and ensures that we meet legal requirements while providing accurate and reliable electric load forecasting.