sdmay21-23 : Grid AI

Team Members: Justin Merkel, Abir Mojumder, Karthik Prakash, Abhilash Tripathy, Patrick Wenzel
Advisor/Client: Gelli Ravikumar

Motivation

Problem Statement :
Power Grids are complex and critical infrastructure which leaves them vulnerable to instability and attack.

Solution :
Develop a web application that implements a Machine Learning model to analyze power grid data and detect anomalies in power usage.

Intended Users and Use Cases

- **Power Grid Operator**
  - Real-time alerts for power anomalies.
  - Remote access to a variety of transformer data.
- **Data Analyst**
  - Power output metrics and data can be visualized quickly.
  - Insights from a deep neural net provide more context to power related activity.

Design Requirements

Functional Requirements

- **Machine learning algorithms**
  - Predict transformer output in kWh
  - Classify potential anomalies within grid
- **Front-end interface for data visualization**
  - Graph-based visualization
  - Geographical representation of power grid
  - Charts for history and predictions for each node
  - Tabular data showing anomaly status for every node
- **Back-end**
  - Handle all data communication and processing
  - Provide real-time data to front-end

Standards

- IEEE/ISO/IEC 12207-2017: Software life cycle processes

Non-functional Requirements

- Clear documentation to allow future teams to improve the project.
- Modular coding for maintainability.
- Machine learning models are generalized.

Constraints

- Limited amount of real-life power grid data
- Use Neo4j style database that client is familiar with

Operating Environment

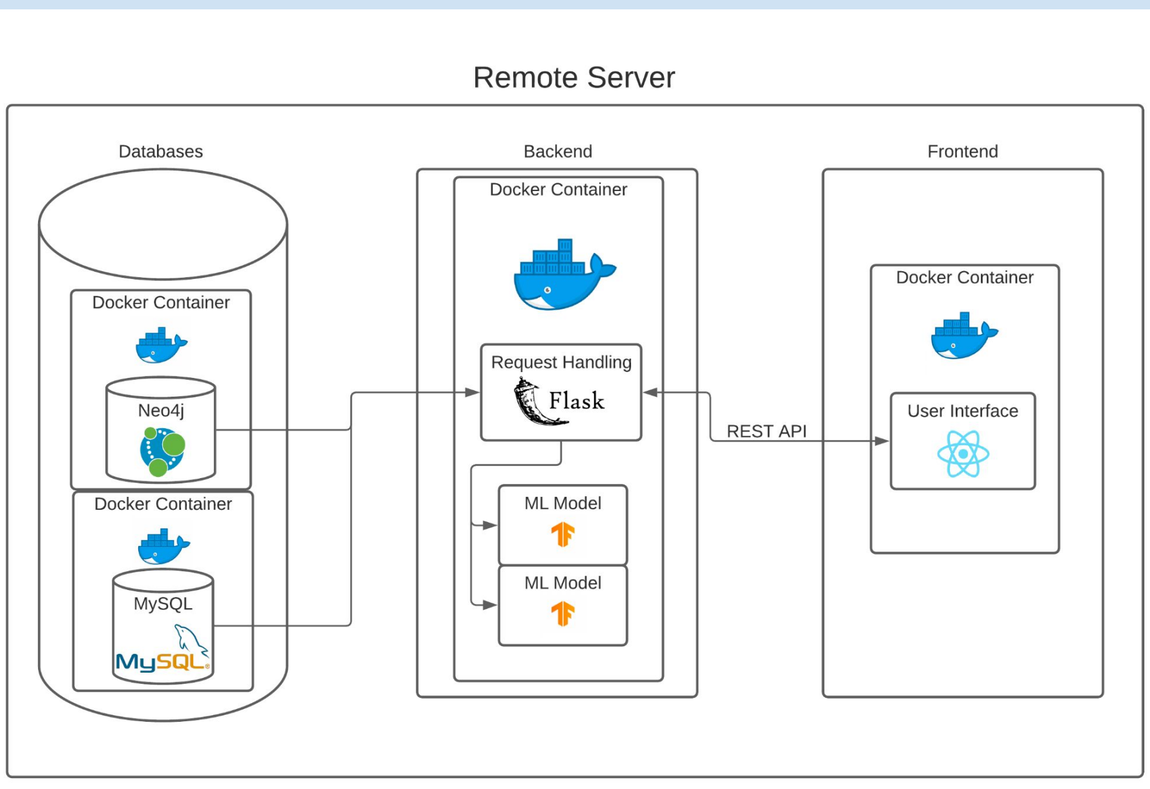
- Iowa State University's Cyber- Physical Testbed (PowerCyber)

Security

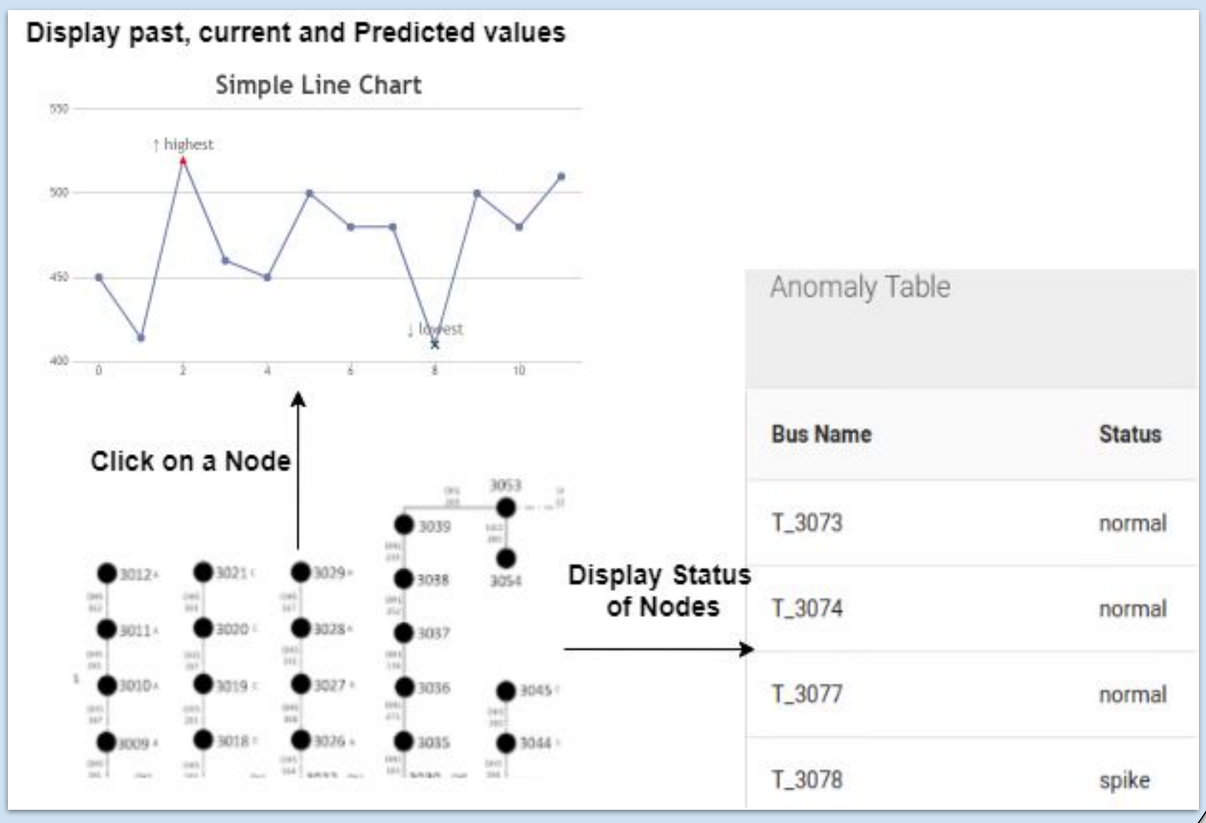
- Concern: Databases susceptible to manipulation from outside party
- Countermeasure: Database authentication and mindful endpoint configuration

Design Approach

Block Diagram



Concept Sketch



Modules/Technical Detail

- **Machine Learning**
  - Two types of models in Tensorflow
  - One deep neural network regression to predict the future kWh output of a grid node.
  - One deep neural Logistic regression model to classify the anomalies.
- **Front-end**
  - React - Javascript/JSX; renders the web based application
  - D3 Graph - A JS library to create interactive graphs (Grid Visualization)
  - Google Line Chart, Material-UI Table - Displays node data
- **Back-end**
  - Databases - Neo4j & MySQL store necessary transformer information and time-series data
  - REST API - Developed with Flask framework provides interface to database

Testing/Testing Results

- **Machine Learning**
  - Tested accuracy using data set aside from training data
  - 96.27% anomaly prediction
  - 1.25 kWh mean error
- **Front-end**
  - Tested function accuracy by comparing their outputs with what the actual data is before putting into our application
  - Verified our visualizations display the correct data
  - Made sure there are no bugs
  - Checked with our client that our interface is acceptable
- **Back-end**
  - Tested endpoint function accuracy using Postman to send HTTP requests
  - Verified the Docker containers could send and receive requests and received the correct data