Designing a Scalable ML Solution for Appliance-Level Electricity Management

Objective:

To assess your approach to building a machine learning solution that can optimize electricity consumption at an appliance level in a commercial environment, ensuring scalability and real-time analysis.

Part 1: Problem Understanding and Data Exploration

Problem Breakdown:

- Describe the core problems in electricity management for large commercial buildings at the appliance level. Focus on detecting peak usage periods, identifying inefficiencies, and controlling costs. How would you approach the problem of managing electricity usage across multiple appliances in a commercial setting?
- Given that IoT devices will be collecting appliance data, explain how you would use the data provided by these devices to detect appliances and monitor their operations in real-time.
- Once the appliance operations are detected, how would you go about identifying any deviations from normal, ideally optimized, appliance behavior and flagging them as faulty or inefficient?

Part 2: Feature Engineering and EDA

Exploratory Data Analysis (EDA):

- How would you identify patterns in electricity usage at the appliance level?
- List the statistical or graphical techniques you'd use to understand relationships between energy usage, time of day, and external factors (such as weather, occupancy).
- How would you identify faulty appliances from normal operational patterns?

Feature Selection:

- Describe the features you would engineer to enhance model accuracy, specifically in detecting anomalies in appliance performance (e.g., time-of-day usage, temperature settings, energy consumption spikes).
- Why are these features crucial for building an accurate model to detect appliance faults and inefficiencies?

Part 3: ML Model Selection and Rationale

Model Choices for Forecasting:

- Which ML models would you consider for forecasting future electricity demands at the appliance level?

- Justify your choice between traditional models (e.g., ARIMA, SARIMA) and deep learning models (e.g., LSTM).
- How would you integrate anomaly detection models to identify faulty appliances based on real-time data?

Real-Time Optimization:

- Given the dynamic nature of electricity consumption, how would you design a system for real-time optimization of appliance energy usage?
- Would reinforcement learning be a good approach for optimizing appliance energy consumption? Justify your decision.

Part 4: System Architecture and Scalability

System Architecture Design:

- Sketch a high-level architecture for your solution, considering front-end (e.g., data visualization, real-time monitoring) and back-end (e.g., model serving, data storage) components.
- How would you design the system to handle scalability for increasing numbers of appliances, potentially growing to millions of devices?

Implementation of DevOps and Monitoring:

- Describe how you would ensure high availability and reliability for your system. Consider using AWS services such as EC2, RDS, Redis, Kubernetes, Grafana, and Prometheus to handle scalable operations.
- Detail your approach to implementing a feedback loop that improves model performance continuously based on real-time data.

Deliverables:

- A PDF or presentation with clear explanations and visuals where applicable.
- Sections should include Problem Understanding, Data Exploration, Feature Engineering, Model Choices, and System Architecture.