London Metropolitan University

CS7080NU – Cloud Computing and Internet of Things

Coursework II – Proposal (Group Work)

Cloud-Based IoT Energy Monitoring and Analytics Platform

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Abstract
The monitoring of energy consumption has also gained significance in organisations that aim at minimising the cost of operation, identifying abnormal behaviour of equipments, and enhancing the efficiency of energy consumption. Old fashioned energy monitoring systems usually do not have real-time visibility, scalable analytics, or automated alerts. The project suggests the development of a cloud-based IoT energy monitoring and analytics platform that gathers energy-related telemetry of the IoT devices, processes and aggregates data in the cloud and displays actionable insights in the form of interactive dashboards. The system proposed will ingest data through MQTT, process it through Node-RED and analytics through rules, store the time-series data in TimescaleDB and visualise through Grafana. The platform is concentrated on the analysis of hourly energy consumption, the possibility to detect abnormal energy usage, and create the alert about high consumption, idle conditions, and electrical anomalies. The suggested prototype presents a scalable and cloud-based IoT system that can be used in energy monitoring and decision support applications.

Problem Statement
The operating systems and industrial equipment that consume a lot of energy are often vulnerable to running without the real-time visibility of energy usage patterns. This means that abnormal energy consumption, non-use, and electrical malfunctions like current or voltage surges might go unnoticed, therefore contributing to increasing costs, inefficiencies, and possible damage of equipment. The existing current monitoring is usually divided, does not provide cloud-based analytics, or has a restricted historical perspective. Therefore, the need to have a cloud-based Internet of Things (IoT) architecture that ensures the ongoing monitoring of energy consumption, both aggregated and historical analysis and provision of timely alerts to the corresponding stakeholders is quite pronounced. The energy data can be remotely collected, analyzed, and visualized by using cloud computing and IoT technologies, thus facilitating data-driven decision-making and maximizing operational efficiency.

Aims and Objectives
Aim:

The main aim of this project is to design and develop a cloud-based IoT energy monitoring platform that provides real-time visibility, analytics, and alerting energy consumption data.

Objectives:

- Design an energy monitoring device using ESP32 and the Arduino platform for programming.
- Design a scalable IoT-to-cloud system architecture for energy monitoring.
- Collect energy-related telemetry and publish data using MQTT messaging.
- Process and aggregate energy data to calculate hourly energy consumption.
- Store time-series energy data in a cloud-based TimescaleDB database.
- Detect abnormal energy usage patterns, including high consumption, low consumption (idle state), and electrical spikes.
- Visualize real-time and historical energy data using Grafana dashboards.

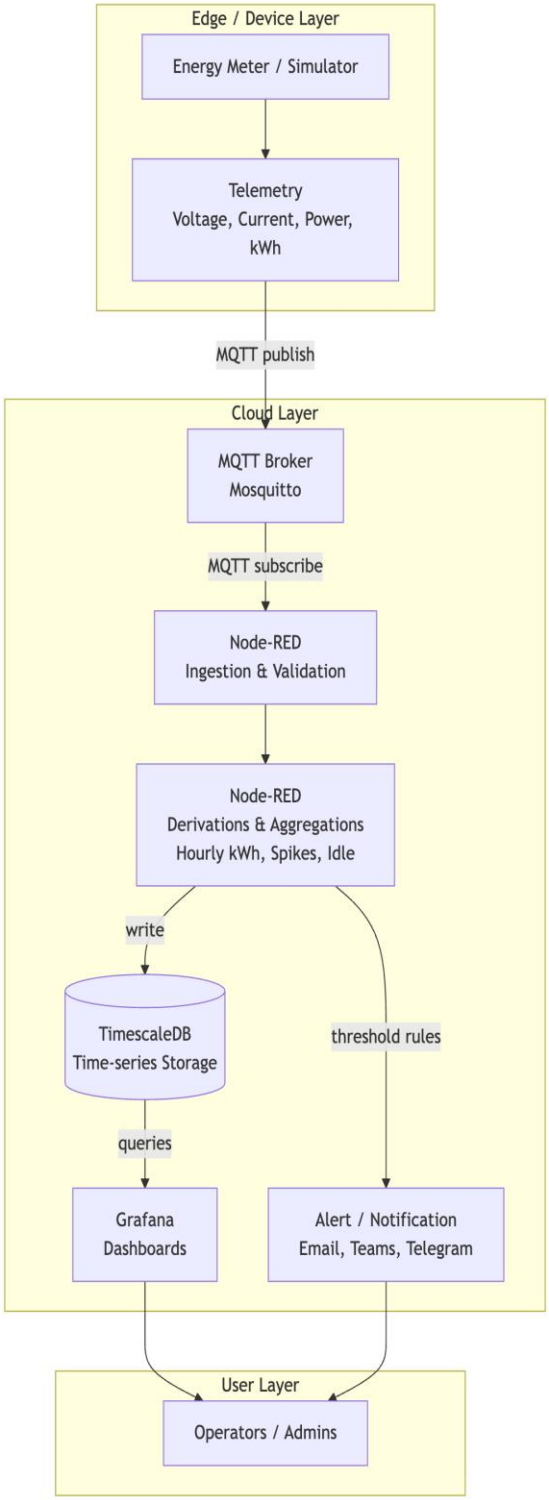
- Generate alerts to notify users of abnormal energy conditions.

Scope of the Project

The scopeof this project is limited to the design and testing of a prototype energy tracking system that will be a representative of cloud-based ingestion, processing, analytics, and visualisation of data. This system will work at aggregated energy measures at an hourly time scale unlike efforts that deal with high-frequency analysis of raw waveforms. Detection of anomaly will be adopted through rule-based thresholds as opposed to complex machine-learning models, thus remaining feasible within the required project time. The security measures that would involve the use of authentication measures and encrypted communication lines will be identified with the recognition that further advanced cryptographic features are prospective extension. The effort is not involved with direct operation of physical objects or actuators, but rather is focused on monitoring, warning, and providing decision-support information. The aspects concerning scalability, reliability, and extensibility will be outlined in the framework of the proposed architecture.

Proposed System Architecture

The proposed system follows a multi-tier IoT–cloud architecture. Energy telemetry data is generated by energy meters or simulated devices and published to an MQTT broker hosted in the cloud. Node-RED acts as the data processing layer, subscribing to MQTT topics, validating incoming messages, and computing derived metrics such as hourly energy consumption. Processed data is stored in a TimescaleDB time-series database. Grafana is used as the client-facing layer to visualise real-time and historical energy data through interactive dashboards. Alerting rules are configured to notify users when abnormal energy conditions are detected. This architecture enables scalable data ingestion, efficient storage, analytics, and remote monitoring via cloud-based services.


Edge / Device Layer
Energy Meter / Simulator
Telemetry
Voltage, Current, Power,
kWh
MQTT publish
Cloud Layer
MQTT Broker
Mosquitto
MQTT subscribe
Node-RED
Ingestion & Validation
Node-RED
Derivations & Aggregations
Hourly kWh, Spikes, Idle
write
TimescaleDB
Time-series Storage
threshold rules
queries
Grafana
Dashboards
Alert / Notification
Email, Teams, Telegram
User Layer
Operators / Admins