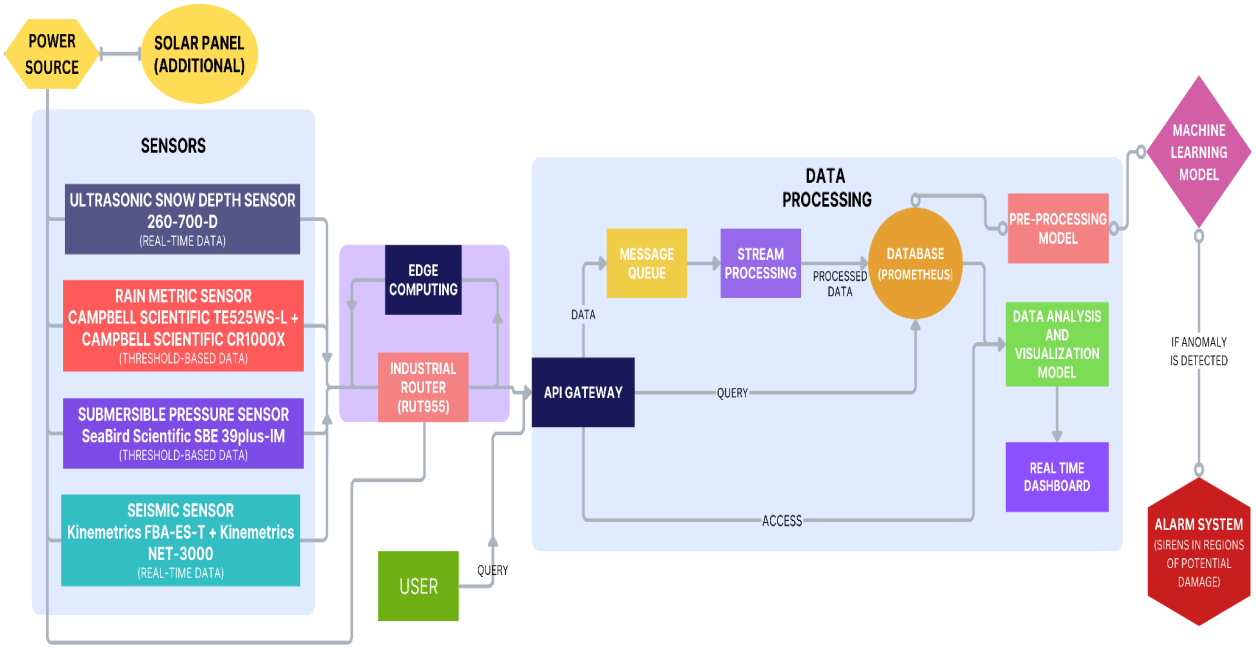
SIH 1650 GLOFs Early Warning System

Communication Protocol:

Consolidated summary of the flowchart and all the processes occurring in the IoT system:



1. **Data Collection from Sensors:**

    - **Ultrasonic Snow Depth Sensor** (260-700-D)
    - **Rain Metric sensor** + wireless manager module (Campbell Scientific TE525WS-L+Campbell Scientific CR1000X)
    - **Seismic Sensor** - Kinemetrics FBA-ES-T + Kinemetrics NET-3000
    - **Submersible Pressure Sensor** (SeaBird Scientific SBE 39 plus-IM)

    The snow and seismic data send continuous, real-time data. The water and pressure sensors send data in real time if the magnitude detected is above a certain threshold value. When below the threshold value, they send data through a datalogger (periodically every 24 hours).

    All sensors are powered additionally by solar panels apart from the existing battery installed.

2. **Edge Computing (RUT955 Industrial Router):**
    - Receives data from all sensors

- Performs initial data processing and analysis
- Implements threshold-based logic for rain and water level sensors
- Sends processed data to the central system via API

3. **Central System:**

a. API Gateway:

- Receives data from the edge device (RUT955 Router)
- Handles all user requests for data access and visualisation
- Use of open-source API Gateways like NGINX
- Manages authentication and authorization
- Routes data and requests to appropriate components

b. Message Queue:

- Buffers incoming data from the API Gateway
- Ensures reliable data transfer to the stream processing component

c. Stream Processing:

- Performs real-time data analysis
- Conducts data cleaning and aggregation
- Prepares data for storage and immediate use

d. (Time-series Database):

- Using open-source tools like Prometheus
- Stores all processed sensor data
- Handles time-series-specific queries efficiently.

e. Pre-Processing Model:

- Correlation of sensor data
- Checks for connectivity between various sensor data
- Sends processed data to ML Model

f. Visualization:

- Grafana: Provides detailed, customizable dashboards
- Real-time Dashboard: Offers immediate insights and alerts

4. **User Interaction:**
   - Users send requests to the API Gateway
   - The API Gateway routes these requests to the appropriate services (Data Analysis-Visualization Model, or Real-time Dashboard)

- Users receive data visualizations or raw data based on their requests

5. **Data Flow:**
   Sensors → Edge Computing → API Gateway → Message Queue → Stream Processing → Data Analysis → Visualization Tools

6. **User Request Flow:**
   User → API Gateway → (Data Analysis-Visualization/Real-time Dashboard) → User
7. **ML Model Processing:**

   Sensors → Edge Computing → API Gateway → Message Queue → Stream Processing → Database → Pre-Processing Model → Machine-Learning Model

This system integrates edge computing for efficient data handling, uses an API-based approach for flexibility, implements real-time processing for immediate insights, and provides multiple visualization options. It's designed to handle various types of environmental data (snow depth, rainfall, water levels, seismic activity) while offering scalability, security, and real-time capabilities.

Innovations:

- Solar-powered sensors that would act as an additional power source
- Designing a web portal that would display the real-time analysis of the data collected from the sensors with the help of interactive dashboards that would enable easy detection
- Designing a custom protocol that would enable to communicate with minimum resources
- Coming up with refined thresholds for GLOF detection by leveraging the machine learning models that would be rigorously trained on various datasets

How the proposed solution stands out from the existing model:

1. *The existing prediction model has difficulty in predicting the GLOFs at the right time due to a lack of proper thresholds and the lack of an efficient alert system:*

   How we counter this issue:

   The ML model would deal with the refining of the thresholds such that it becomes extremely easy to detect GLOFs at a much earlier stage. Moreover, since data is being collected from various sensors, the threshold thus defined would be an amalgamation of all the parameters involved.

The alert system will be classified into 5 colours based on the severity of the situation and a message alert will be sent to the people likely to be affected.

2. *The sensors are deemed to be unreliable under harsh conditions, this leads to them being constantly changed once in a while*

   How we counter this issue:

   Installation of redundant sensors: When one of the sensors fails to work the redundant sensors get activated and continue the job of transmitting data

   Since the sensors are also additionally powered by solar panels the issue of battery replacement is mitigated.

3. *The current system requires manual updation of software and this unnecessarily involves manual intervention*

   How we counter this issue:

   We counter this issue by automating the updates pushed so that there isn't any manual intervention.