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## Motivation / Problem Statement

Seattle City light has been modernizing its electric distribution system by replacing manual switches with remote-controlled units that communicate via fiber optic cables.

### Current Challenge

Using fiber requires engineering analysis and potential upgrade of dozens of poles along the route, which is costly and time-consuming. Cellular communication is faster to deploy than fiber, but its signal reliability must be tested in real-world conditions.

### Communication Challenge

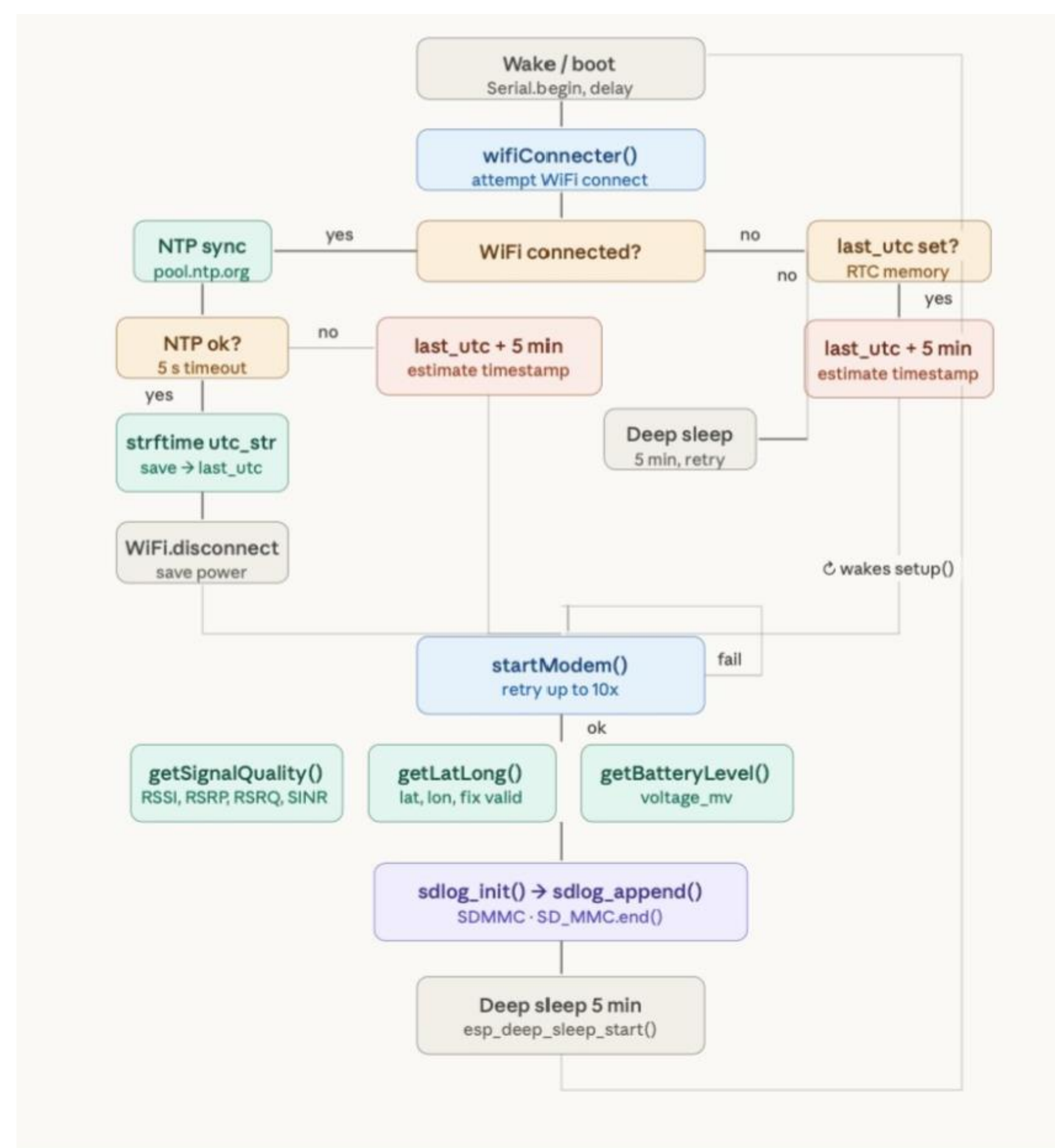
Cellular communication is faster to deploy than fiber, but its signal reliability must be tested in real-world conditions.

### Project Goal

Validate whether cellular communication can reliably support remote power distribution switches using long-term signal quality loggers.

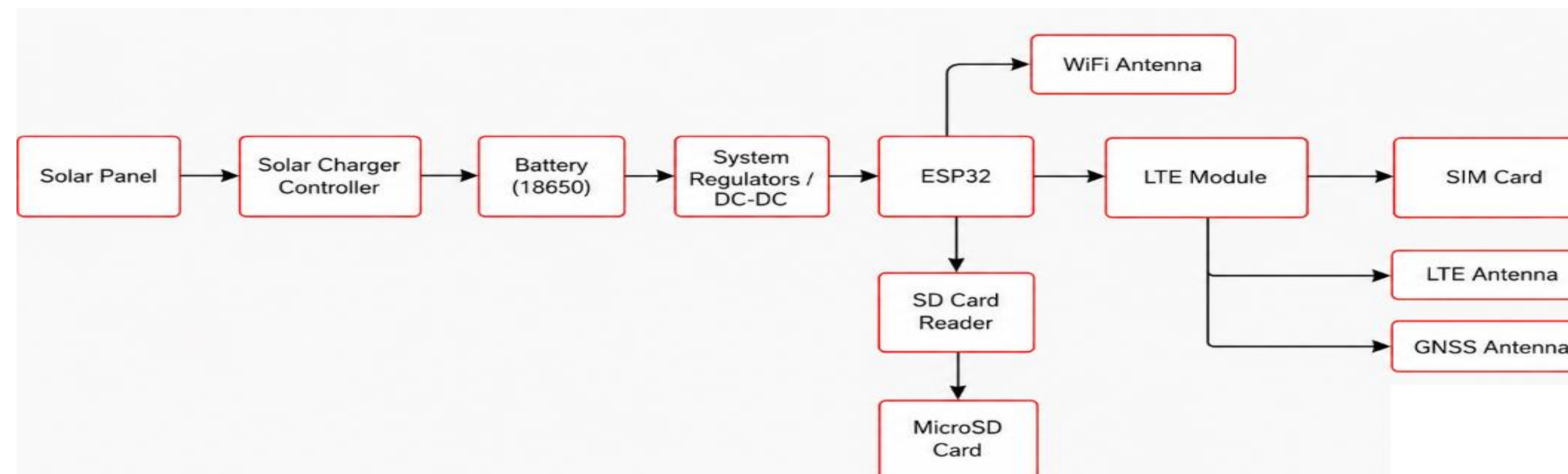
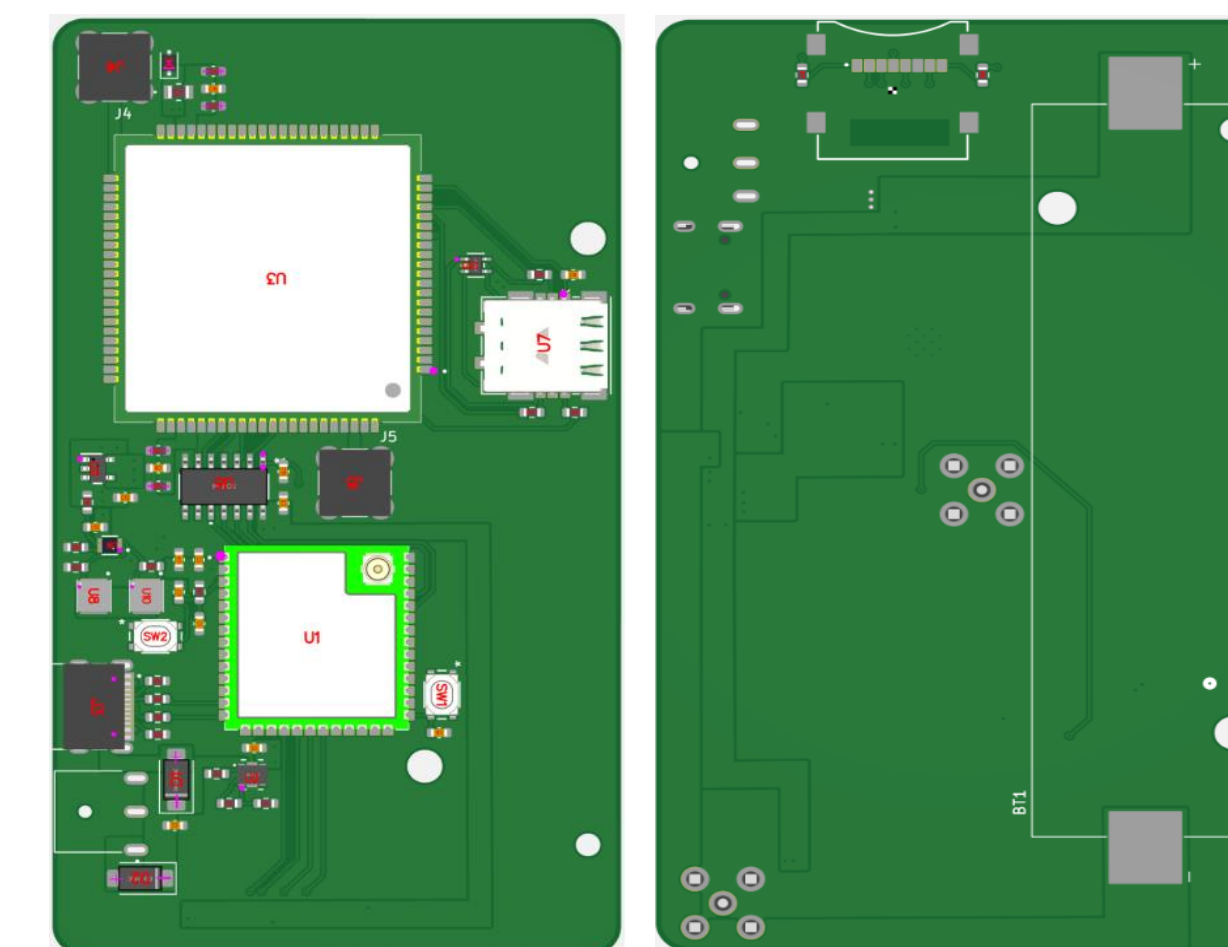
## Logger System Overview

- Board:** ESP32-S3 + SIM7670G LTE/GNSS module
- Measurements:** RSSI, RSRP, RSRQ, SINR, ping latency, GPS coordinates, and battery voltage
- Data Pipeline:** Measurements are stored locally on an 8GB microSD card and synced to Firebase over LTE.
- Power:** 18650 Li-ion battery with deep-sleep firmware and solar charging support.
- Prototype:** Field-deployable logger with Wi-Fi and GPS antennas.



## Hardware Design

- Controller:** ESP32-S3 microcontroller for system control and deep sleep operation.
- Communication:** SIM7600G-H LTE/GNSS module for cellular signal measurements and GPS location tagging.
- Storage:** 8GB microSD card for local CSV data logging.
- Power:** 18650 Li-ion battery with charging, protection, and voltage regulation circuits.
- Deployment:** Custom PCB, cellular/GPS antennas, solar panel support, and IP67 waterproof enclosure.



## Firmware & Data Pipeline

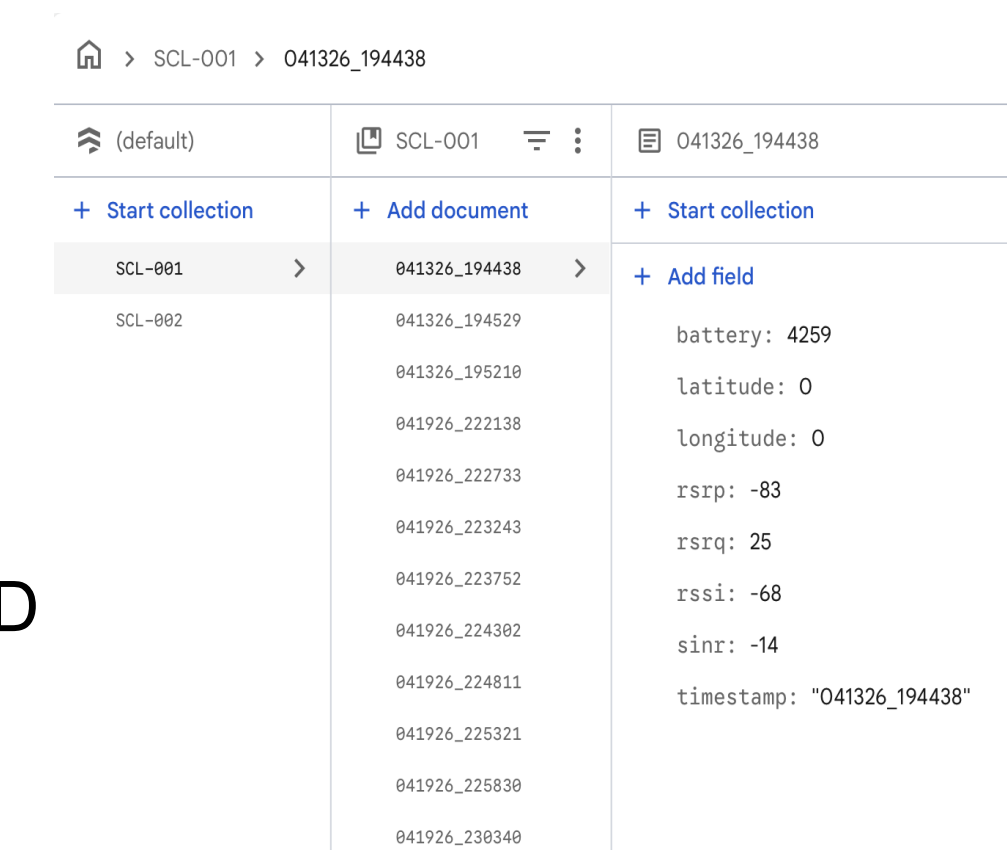
### Firmware (C++ & PlatformIO)

#### •Data Collection

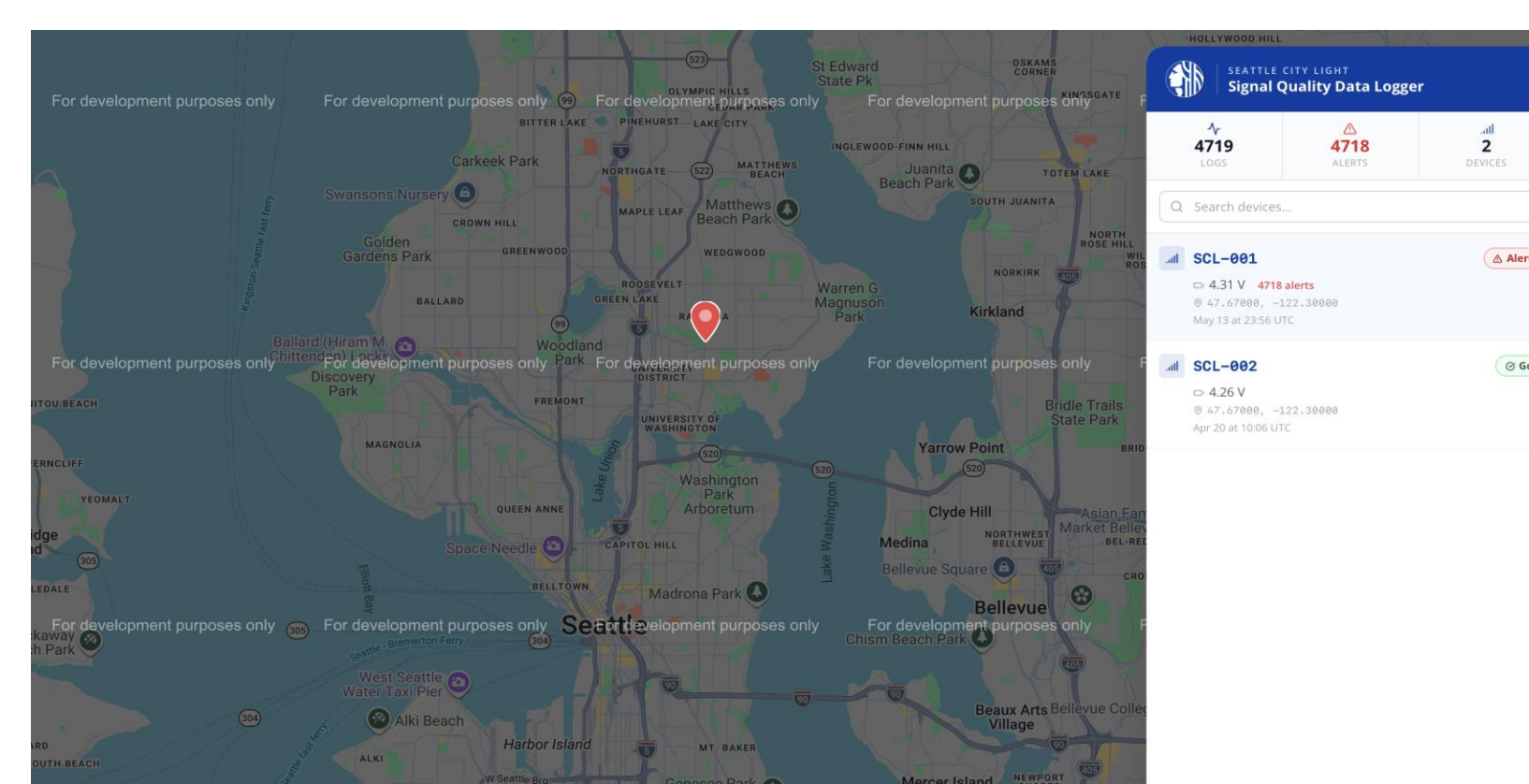
ESP32-S3 wakes every 5 minutes from deep sleep. SIM7670G is queried for RSSI, RSRP, RSRQ, and SINR. Ping latency, GPS coordinates, and battery status are also logged.

#### •Local Logging

Each reading is timestamped and saved as a CSV file on the microSD card.



Records are uploaded to Firebase daily over LTE.



**Web Dashboard**  
ReactJS dashboard displays signal metrics, GO / NO-GO status, filters, and CSV export.

## Results and analysis

### •Results and Analysis

#### •Data Collection

Collected 4,718 measurements from device SCL-001 between April 13 and May 13, 2026.

The device logged data approximately every 5 minutes.

#### •Signal Metrics

Average RSSI: -72 dBm

Average RSRP: -79 dBm

Average SINR: -6.7 dB

Average battery voltage: 4.31 V

#### •Analysis Method

Python/pandas was used to clean the data and remove invalid GPS points before mapping.

Each reading was classified as GO or NO-GO based on signal quality thresholds.

#### •Key Finding

The tested location had consistent signal strength but unreliable signal quality.

Low SINR suggests interference or noise affected LTE reliability across the U-District and University Village area.

Statistic	RSSI	RSRP	RSRQ	SINR
Mean	-71.19	-78.15	26.93	-6.60
Median	-71	-78	28	-6
Standard deviation	1.991	1.889	3.496	1.040

Summary statistics for cellular signal-quality measurements collected from device SCL-001.

## Future Work and Acknowledgments

- Extend the battery life of the device to log data over a longer period of time
- Test the device in an IP67 enclosure