TECHNICAL UNIVERSITY OF CLUJ-NAPOCA ROMANIA

Real-time Wireless Telemetry System for a Formula Student Electric Vehicle

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Introduction

Telemetry systems play a crucial role in modern automobiles, allowing engineers to monitor and react to sensor data from a vehicle in real time, providing data about battery state, motor temperature and much more.

This project proposes a low-cost, real-time wireless telemetry system that helps engineers receive vital information without needing to be in or near the car.

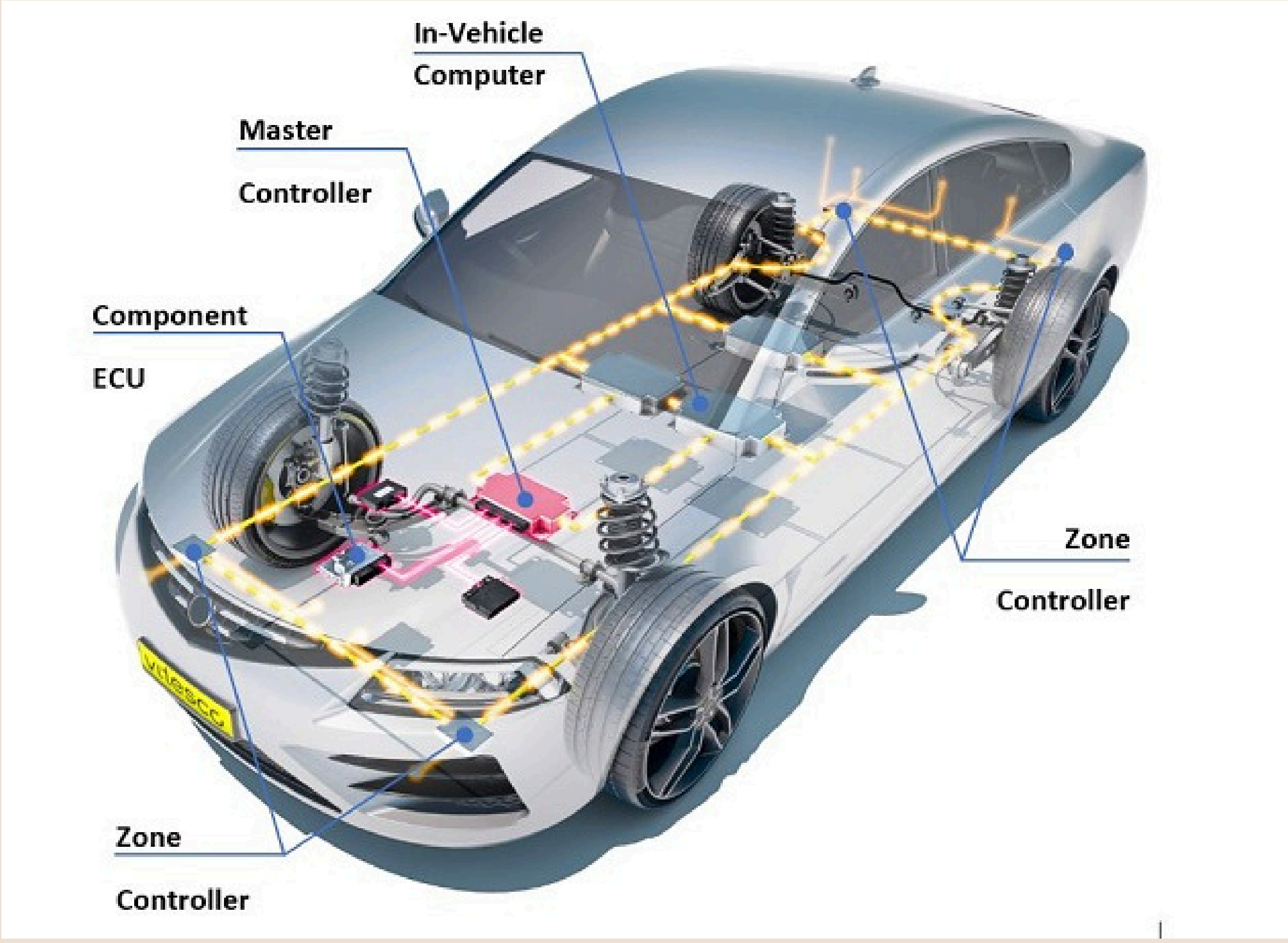

Figure 1: Electric vehicle Architecture

About Formula Student

Formula Student is a global competition that challenges university teams to design, build, and race small single-seater cars. It aims to develop a students ability to innovate and solve problems in a fast paced environment.

The ART TU Cluj-Napoca team from the Technical University of Cluj-Napoca, entered this competition with their E17 electric vehicle in 2019, and over the years, competing in Czechia, Romania and Germany in 2025.

Figure 2: ART TU E17 Electric Vehicle

Current status of Telemetry Systems

Vehicle-to-Everything (V2X) is a generic term that refers to a wireless communication system that allows the exchange of data in real time between a vehicle and any entity in its environment, including other vehicles (V2V), infrastructure (V2I) and communication networks (V2N). The main purpose of this technology is to improve safety on the road and reduce traffic.

Multiple variations of this technology exist, most notably **Vehicle-To-Vehicle (V2V), Vehicle-To-Network (V2N), and Vehicle-To-Building (V2B)**

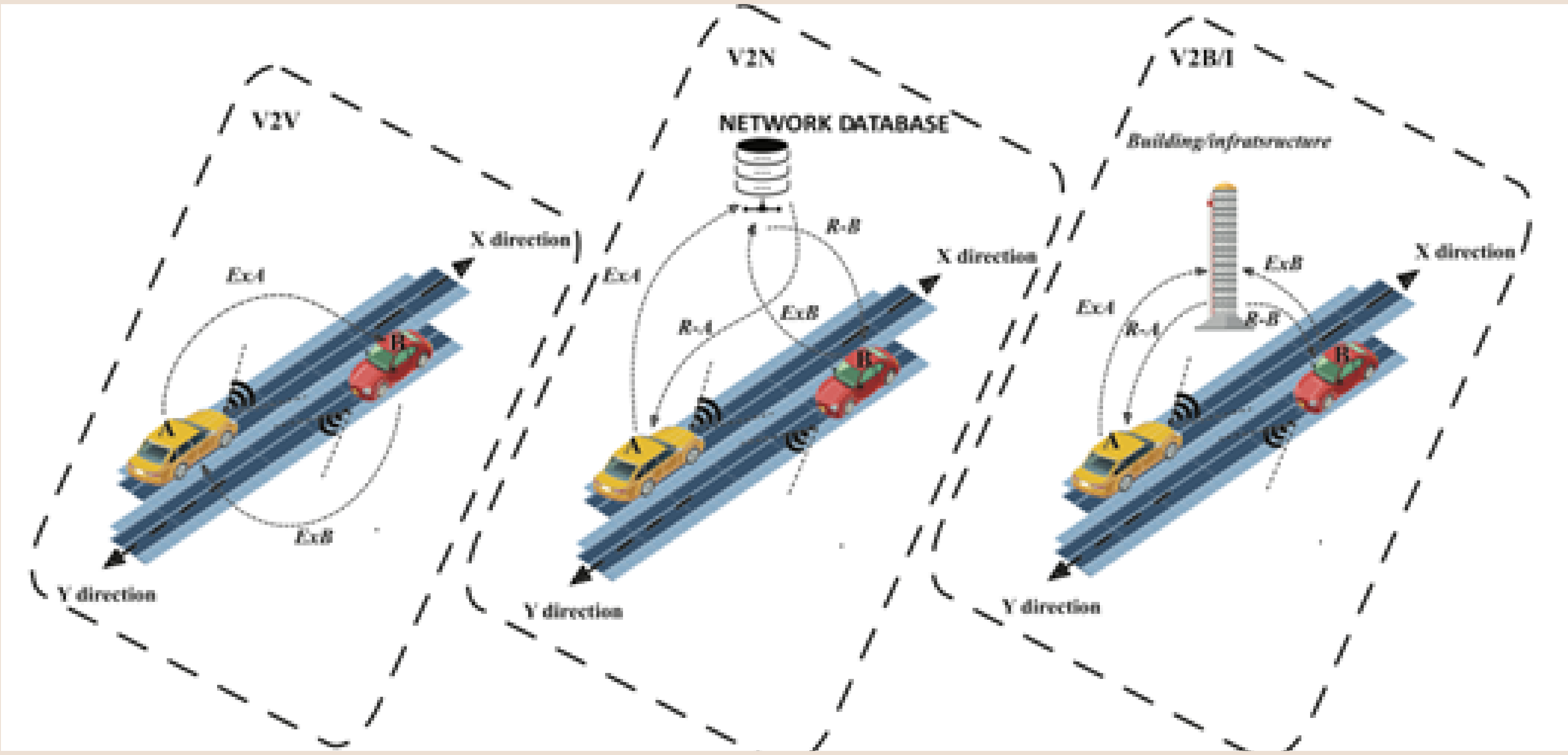

Fig 3: Different working principles for V2V, V2N, V2B/I

State of the Art

IoT-based Telemetry

Advantages:

- Accurate Location
- Long transmission times

Disadvantages:

- Data processing delays
- Unreliable connectivity
- Hard to install
- High variability with data formats

Real-time video and GPS

Advantages:

- Innovative technology use
- Accurate Location

Disadvantages:

- Short Distances
- High volume of data
- High coupling of the system
- High use of bandwidth

Vehicle Diagnosis with V2N

Advantages:

- High security
- Roboust system

Disadvantages:

- Data processing delays
- Data is not accurate
- Complicated infrastucture needed

Proposed solution

Pros and cons

Advantages:

Uses **Long Range Radio** to achieve long distances.
Standard automotive communication protocols, **resistant to noise and interference.**
Programming paradigms guarantee **high refresh rate**.
Plug-and-play design, easy maintanance.
Reduced cost due to not depending on infrastructures like **The Things Network.**

Disadvantages:

Small packet size due to **Radio limitation**.
Low Duty Cycle due to **Radio regulations**.
Algorithms used to achieve long distances are **unreliable** for distances greater than 1km.

Proposed solution

Conceptual Architecture

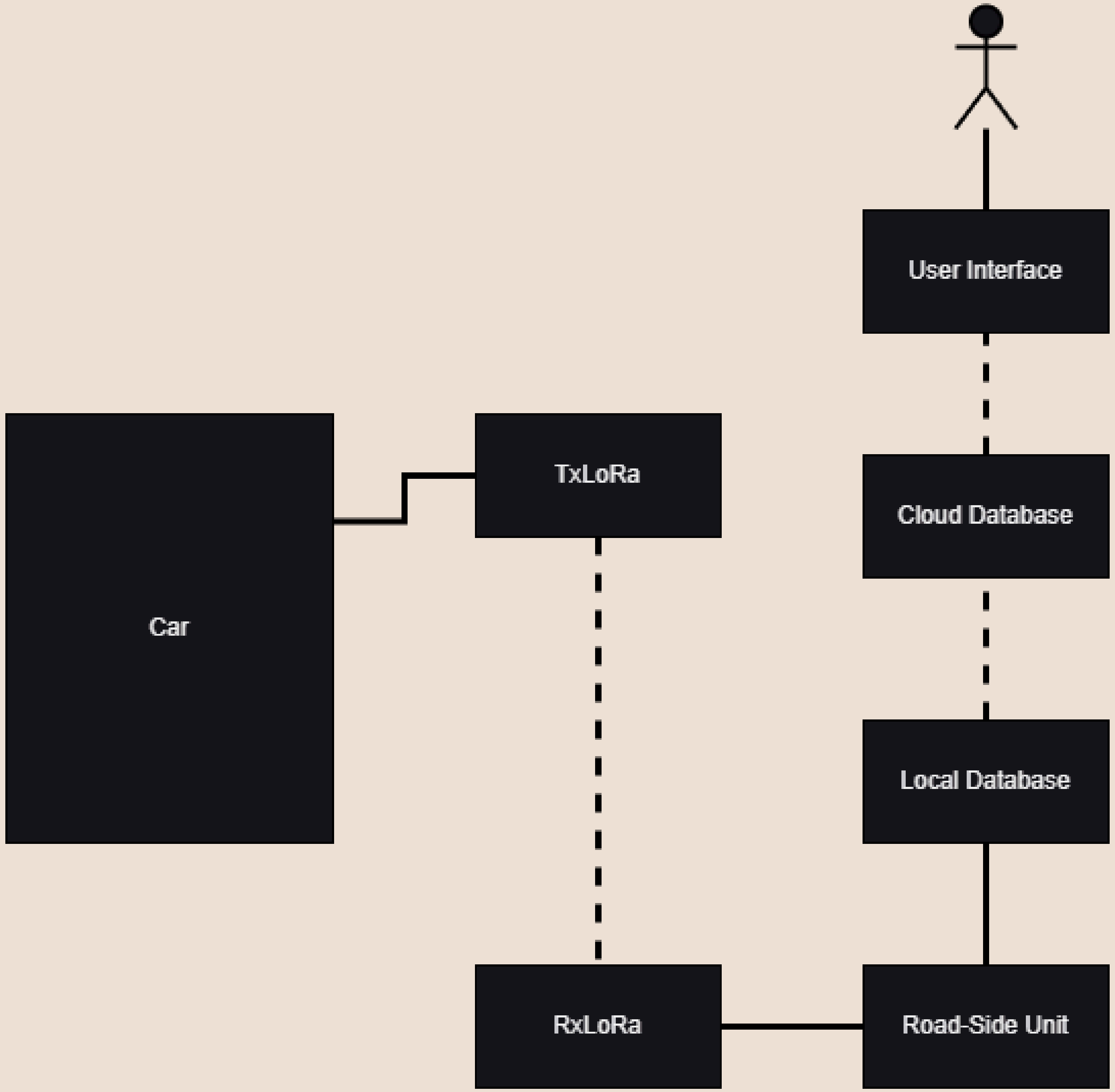

Figure 4: Conceptual Architecture of ART TU E17's telemetry system

Technology Stack

LoRa™

ARDUINO™

docker®

Firebase

Grafana

influxdb

Proposed solution

Tehniques

Frequency hopping is used for transmitting a large volume of data in real-time using LoRa, using 7 frequencies, allowing my solution to bypass regulations.

ISO 15765-2 or **ISO-TP** is a which allows the sending of data from the ECU to the transmitter in one single message, permitting more data to be sent.

Fog computing is critical for this system, increasing the refresh rate of the display greatly and providing an extra level of redundancy.

Proposed solution

Testing

- Initially, the system was tested using 2 laptops, **one as the transmitter and one as the receiver.**
- The goal was to get as much distance between the transmitter and the receiver **without** compromising the integrity of the data.
- Achieved a distance of **400 meters**, shown below.

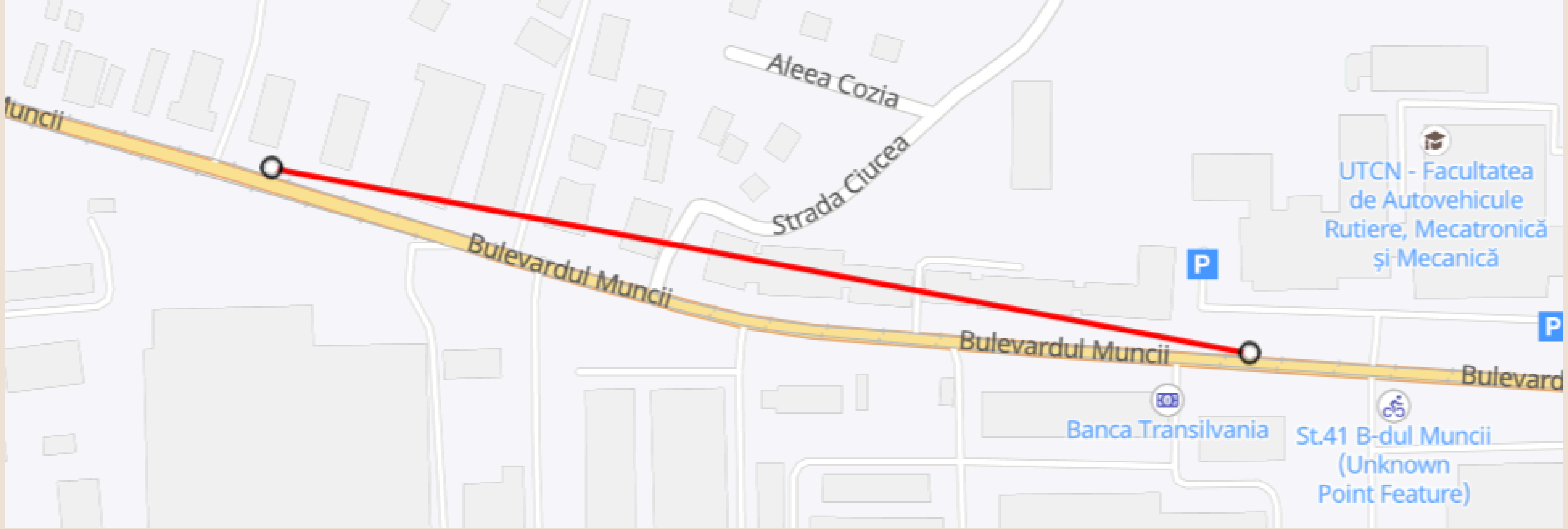

Fig 5: Calculated distance while testing

Results

From testing, the system managed to get a **response time of 1s** without compromising the data at **400m distance.**

It proved massively useful to the development team, using it to spot problems while the electric car was **in motion.**

Below is pictured a mock-up of the User Interface.

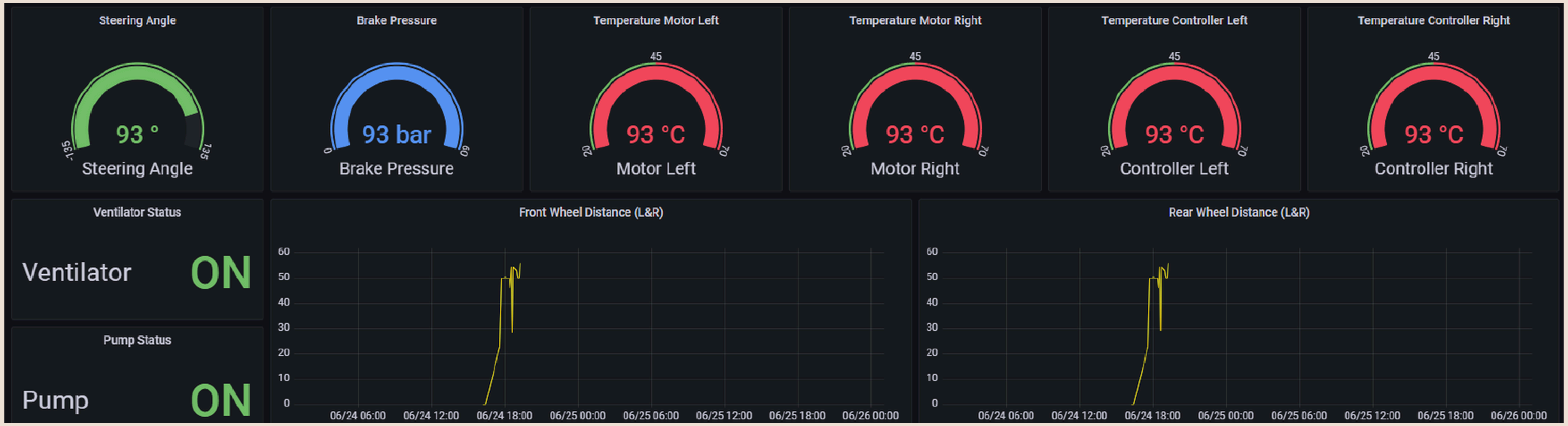

Fig 6: User Interface Mock-up

Conclusions

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To conclude, this project presents a powerful but low-cost solution for real-time telemetry in a Formula Student electric race car.

It solves key problems like latency, encryption, modularity, and cost, while remaining easy to deploy and maintain.

Future work includes integrating the system with the ECU, field testing during dynamic events, and refining the web-based dashboard for improved usability and real-time performance analysis.

Thank you for your attention!

Figura 7: ART TU team 2023-2024