NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

MAE24081 - Development of Data Communication Systems for Autonomous Vehicles

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Abstract

This study aims to develop a low-power, cost-effective Intelligent Transportation System (ITS) device that adheres to the safety and monitoring requirements of the AIS-140, adapting it for both passenger-driven and autonomous vehicles. The proposed device integrates multi-GNSS support, real-time speed and battery monitoring, followed by sensor health diagnostics and remote control for autonomous vehicles. In the case of real-time emergencies, the device will send relevant information to whitelisted IPs.

Introduction

The development was inspired by the Archimedes Autonomous Vehicles team at NTU and aims to propose a device that reduces latency while improving connectivity and security by using a consistent standard. AIS-140 is a mandatory framework in India for real-time vehicular tracking and emergency response. This has been chosen as Singapore lacks a similar regulation, resulting in a gap in the city's progression in smart mobility.

Objectives:

- **Develop a cost-effective ITS device**: Ensure affordability for adoption by a wide range of vehicles, including public and passenger vehicles.
- **Ensure Modularity for Future Scalability**: Allow the system to evolve and improve as smart mobility technologies advance.
- **Integrate Secure, Reliable Communication**: Build a robust framework for real-time data transfer with emergency alert functionality.

Methodology

The device architecture is designed to ensure robust performance in vehicular environments. Its core is a Raspberry Pi Pico W, chosen for its low power footprint and I/O capabilities. Network connectivity is established using Quectel EC25, a 4G LTE with a 3G Fallback for enhanced resilience. The device uses the low-cost ATGM336H GNSS. With an accuracy of 2.5m, it can handle up to 6 GNSS tracking. To improve connectivity at a low cost, SMA RF Connectors are used along with USB to connect to the AV Control unit for sensor diagnostics. Below you find the block diagram of the components.

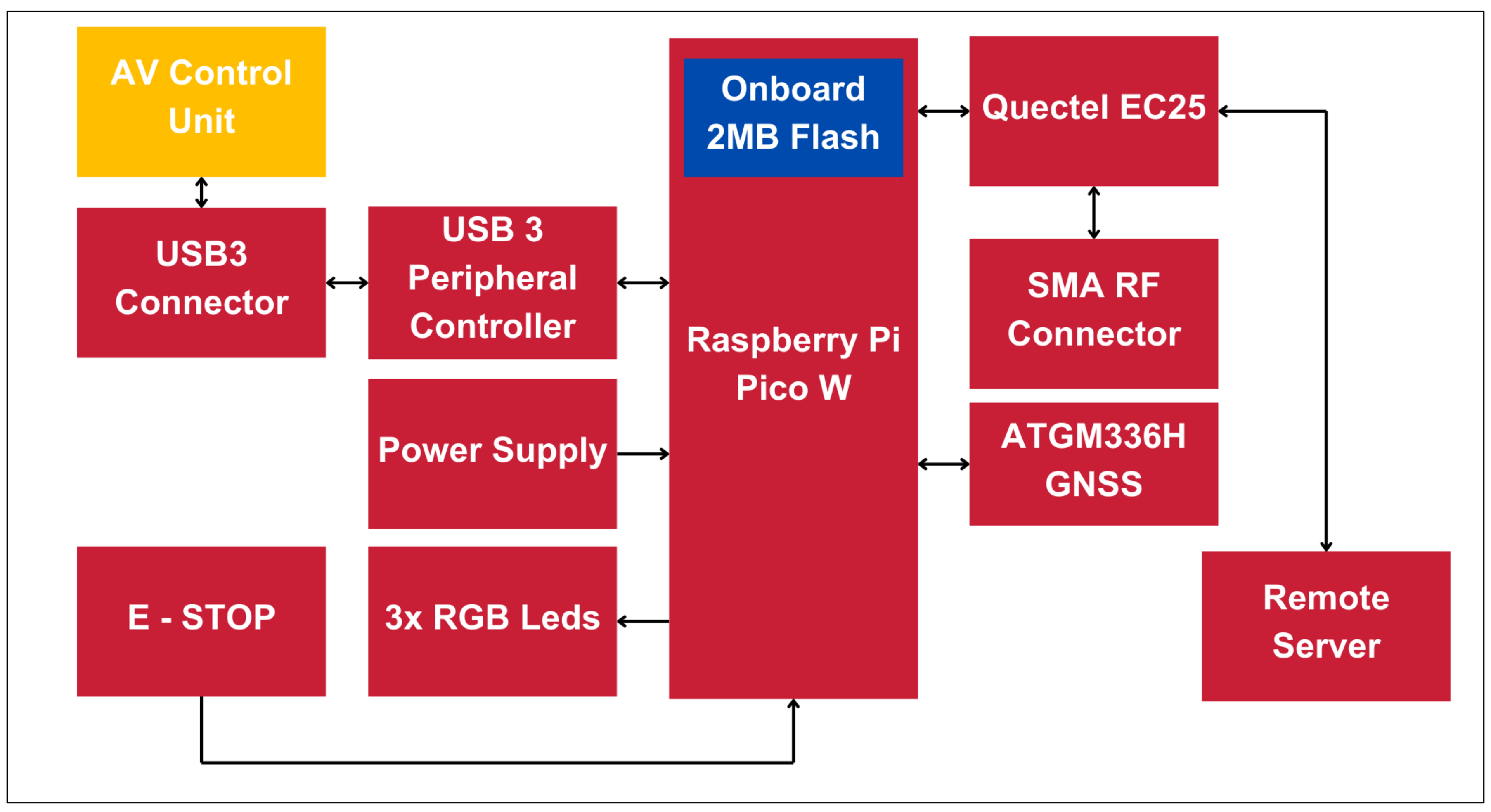

Fig 1 : Components Schematic: Block Diagram

Communication Framework

The communication framework has been designed with a focus on reliability. Secure TCP/IP protocols, over both cellular and satellite networks, are employed to ensure encrypted data transmission. To facilitate interoperability between different system components, ROS2 middleware is utilized. Emergency alert functionality has also been implemented to provide necessary information to whitelisted IPs. The system also supports diagnostics and control from a remote server (an extensible feature for AVs.) To maintain system currency, OTA update capabilities have also been integrated. Below is the data flow diagram for the device.

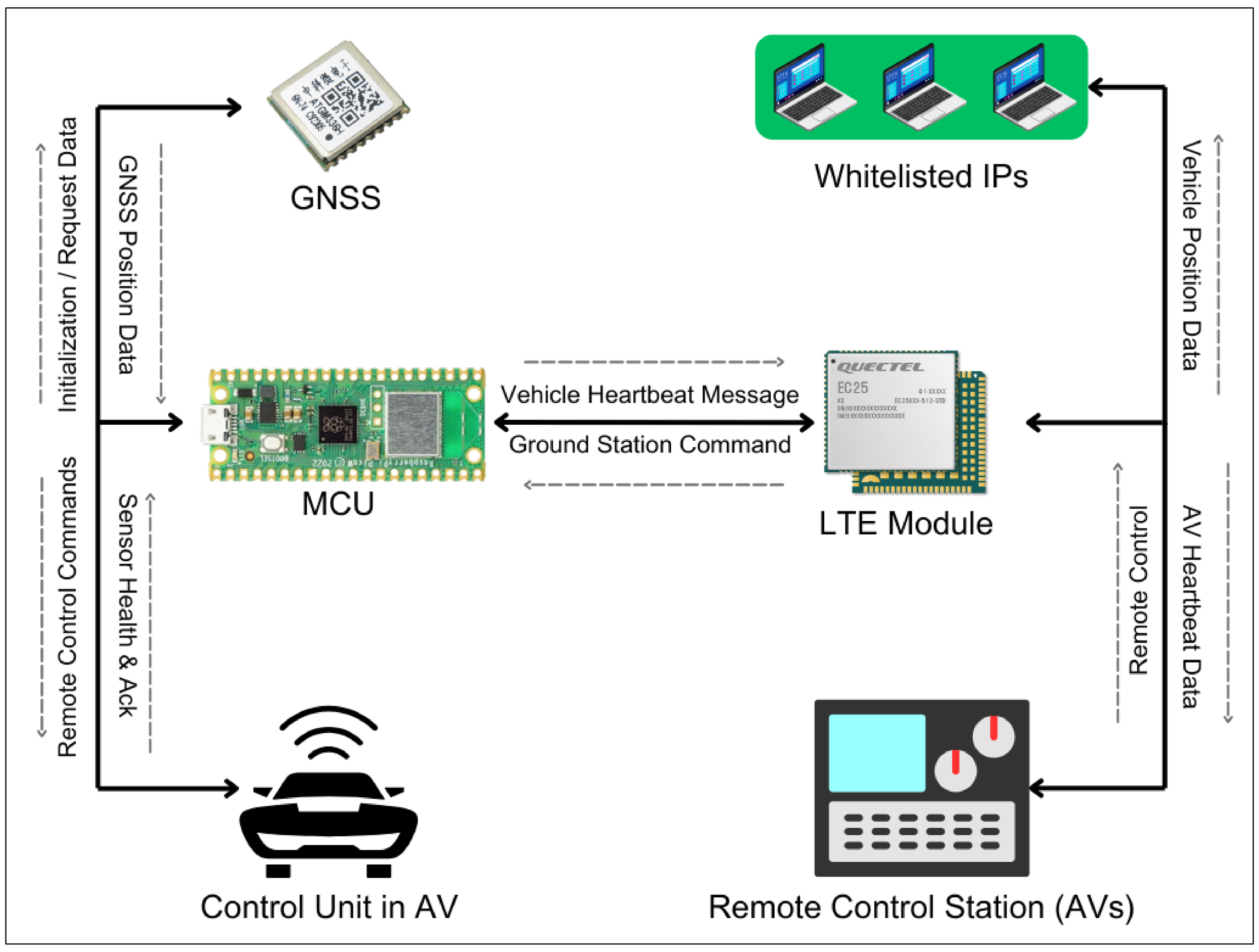

Fig 2 : Data Flow Diagram

Results & Scope

The previously used communication methods, were not only expensive but also had high latency with low security standards. It was a bunch of components rather than a dedicated device. The proposed device addresses the inconsistencies, creating a path for safer vehicular settings. It goes beyond the team, being suitable for industry adoption by bridging the gap in between.

Integrating a custom RFFE for 5G NR improves the device's multimedia connectivity at low costs. Developing end-to-end encryption and higher security standards positions it in national security use cases. V2V communication for coordinated emergency alerts can help manage navigation and safety.

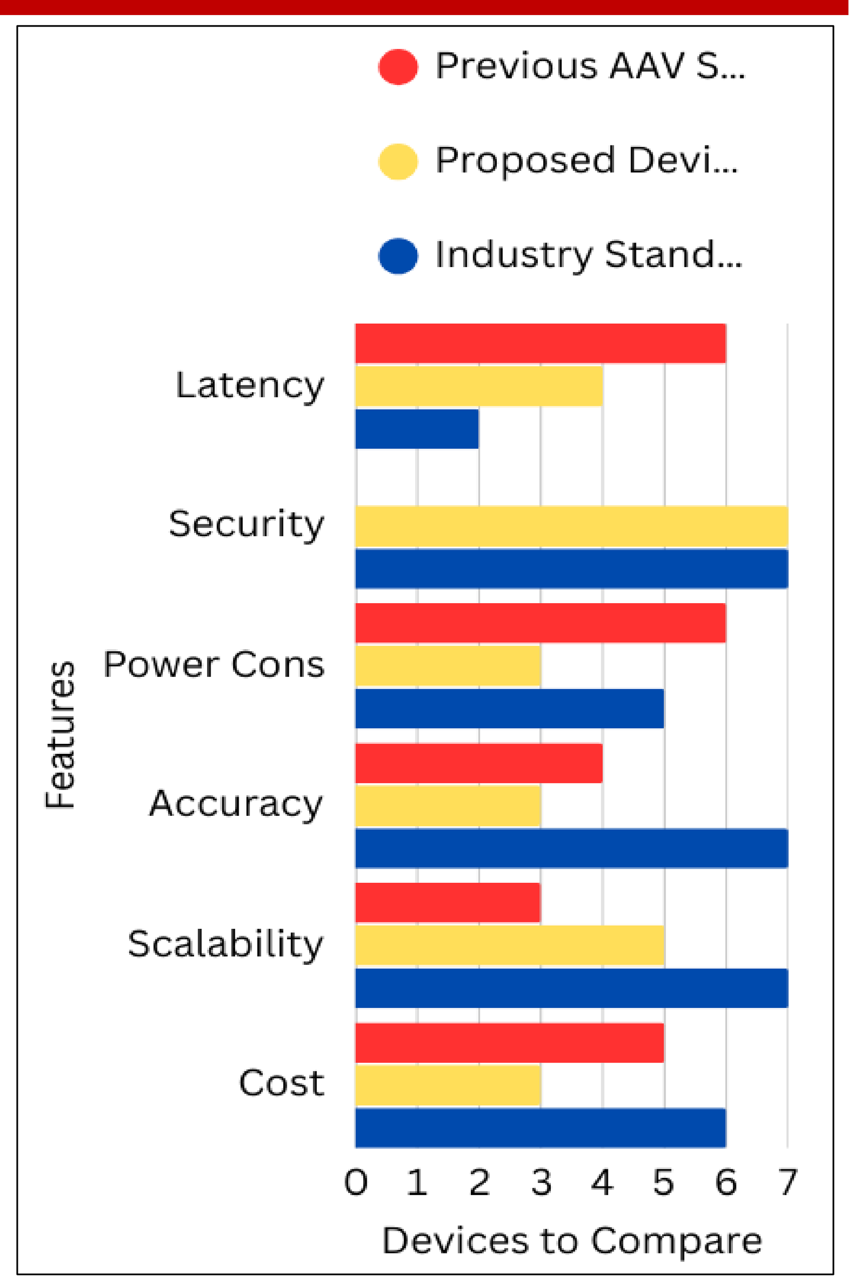

Fig 3: Performance Comparison

References: