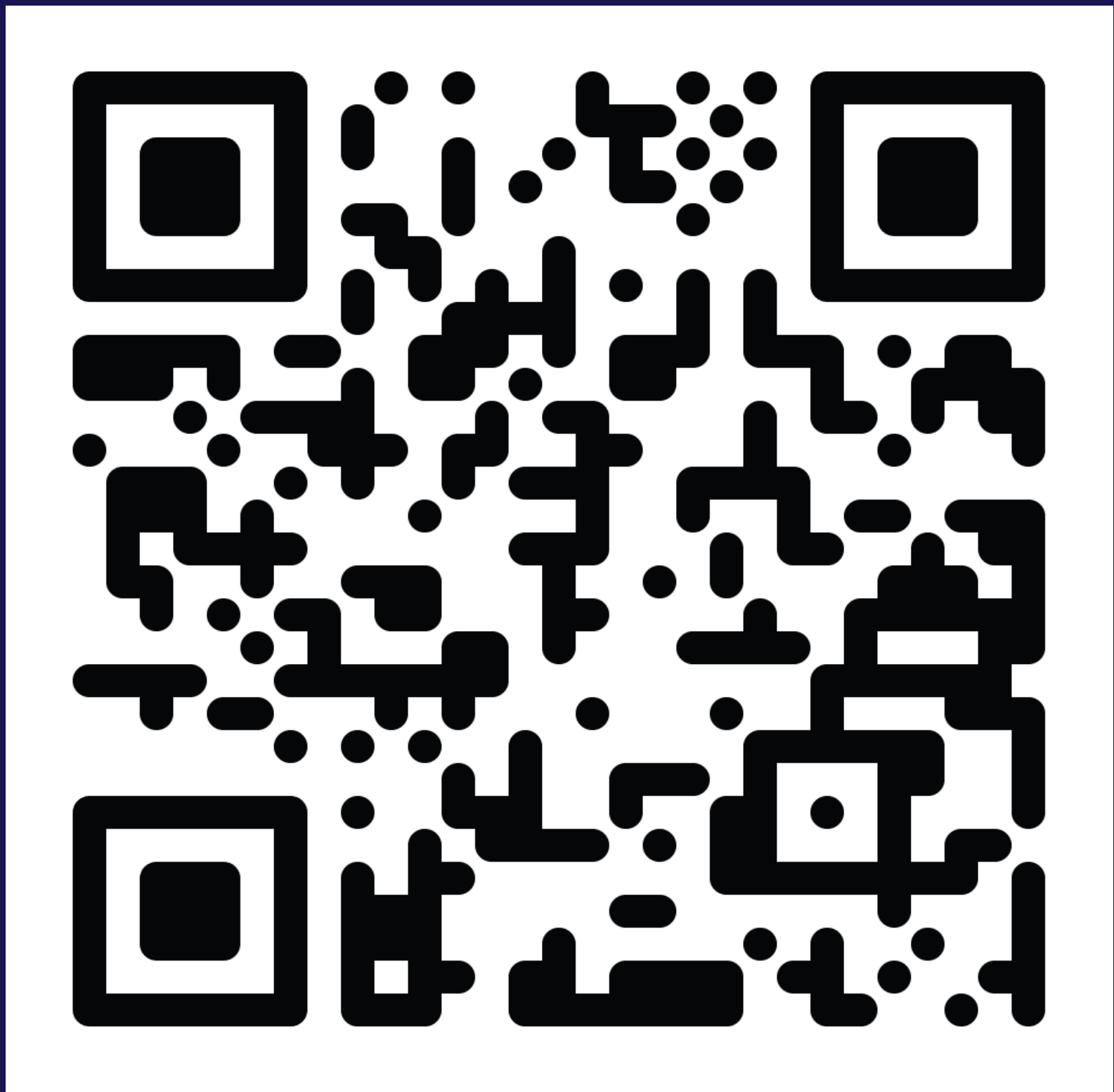# Smart BLE Car Access System

The Elite 4 ✕ FORVIA HELLA

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Background

A vehicle is not only a mode of transporation, but also a signifciant part of the life of mankinds. Thus, car security is also very important for car owners. To solve the demerits of the previous car access methods, Hella Forvia suggested a new car access method named smart BLE car access system. By combining Bluetooth Low Energy with Ultra Wide Band technology, this system not only provides comfort but also ensures safety and security for drivers.

Objective

This system provides:
1. Hands-free vehicle access and start
2. The precise proximity-based authentication based on BLE and UWB,
3. The convenience features such as checking and controling vehicle components(doors and trunk) via user interface with animation button for car owners.
4. The more advanced features such as children presence detection and key sharing will offer for drivers.
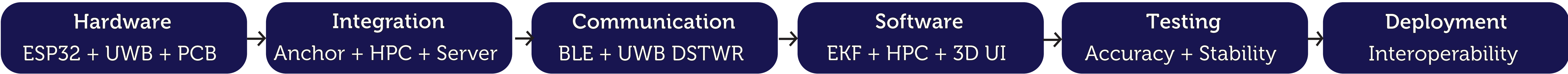
System Design
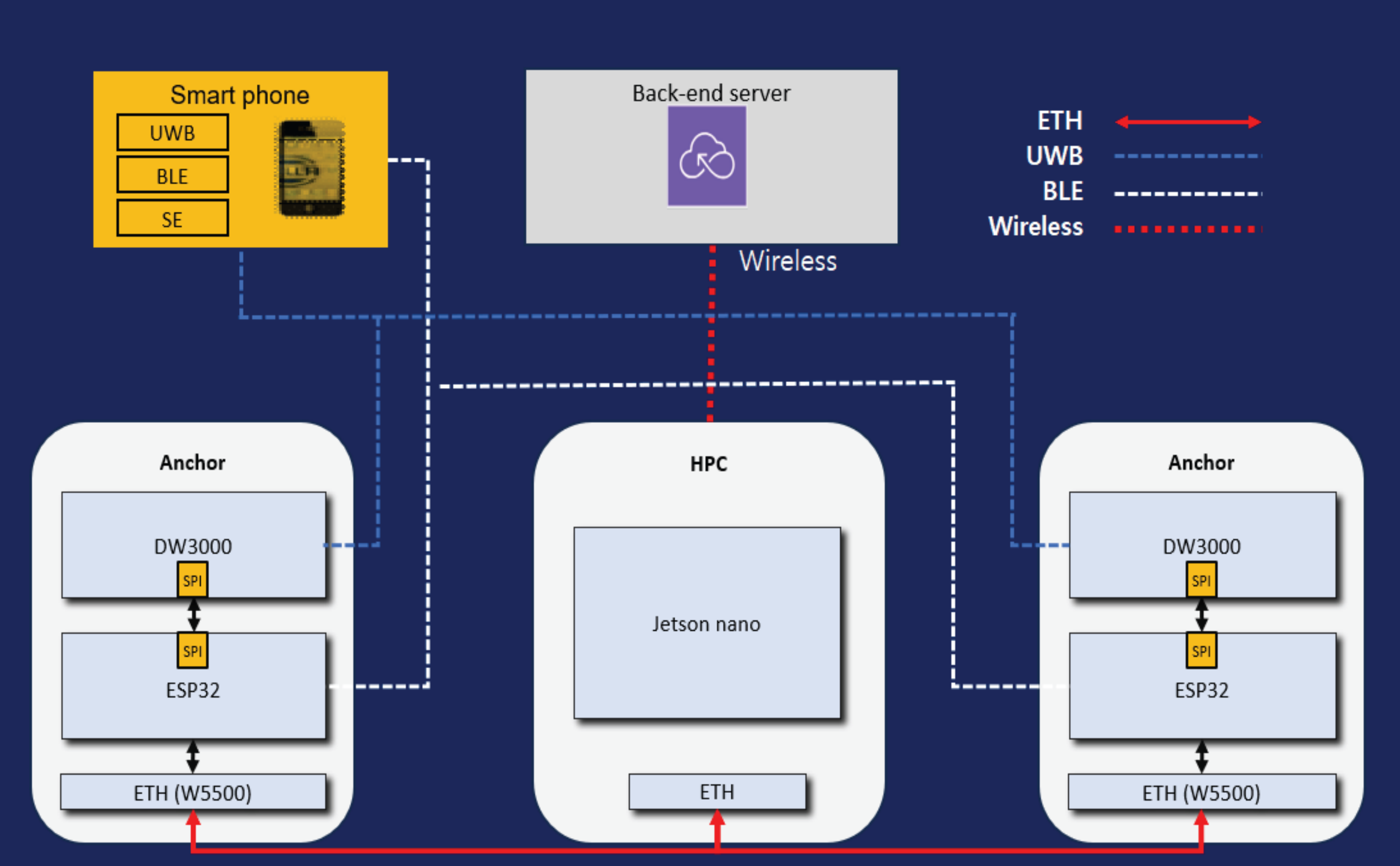
Methodology

1. Hardware Design: Developed anchors using ESP32 with built-in BLE, UWB chip, and Ethernet module. Designed PCB with GPIOs, reset buttons, filters and Antennas.

2. System Integration: Connected anchors, HPC (Jetson Nano), and backend server via SPI and Ethernet to create a unified prototype.

3. Wireless Communication: Used BLE for device detection and secure pairing; applied UWB Double-Sided Two-Way Ranging (DSTWR) for centimeter-level distance accuracy.

4. Software & Processing: Implemented EKF on HPC for real-time localization ($\pm$20 cm). Built 3D web interface for visualization and calibration tools for debugging.

5. Testing & Validation: Evaluated localization accuracy, latency, and ranging stability.

6. Deployment: Verified interoperability of all components in real conditions and prepared system for integration into vehicle field tests.

System Flow Chart

| Hardware ESP32 + UWB + PCB | Integration Anchor + HPC + Server | Communication BLE + UWB DSTWR | Software EKF + HPC + 3D UI | Testing Accuracy + Stability | Deployment Interoperability |

Conclusion & Findings

The final prototype successfully achieved stable BLE authentication and reliable centimeter-level UWB localization. The system provides the real-time localized display. These results confirm that Smart BLE Car Access can deliver both convenience and accuracy for future mobility solutions.

Results