

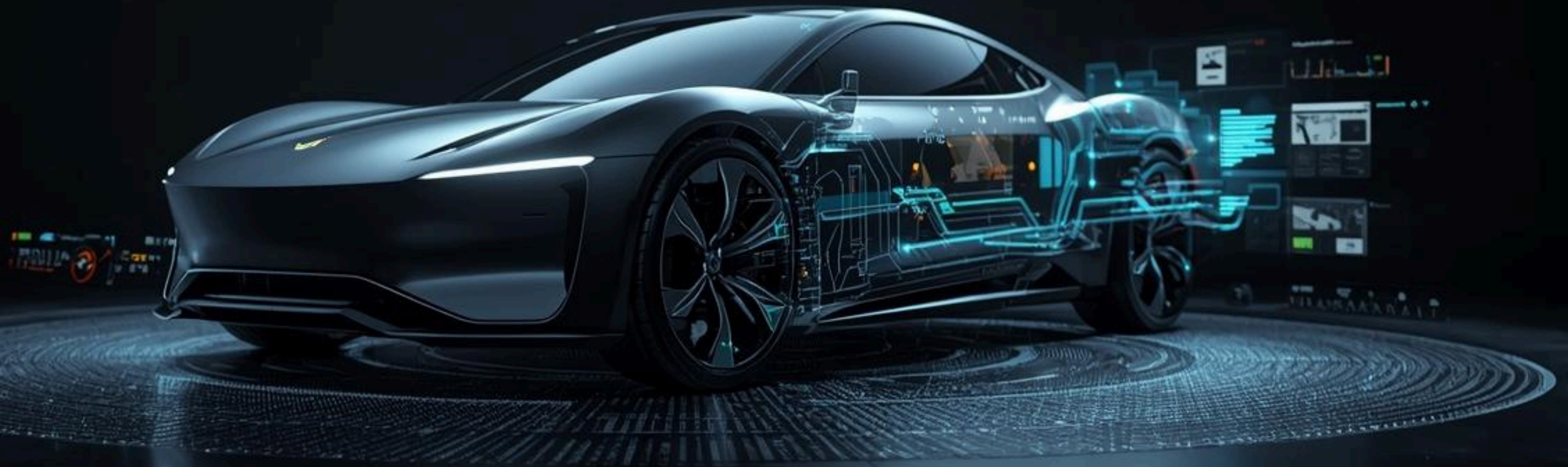
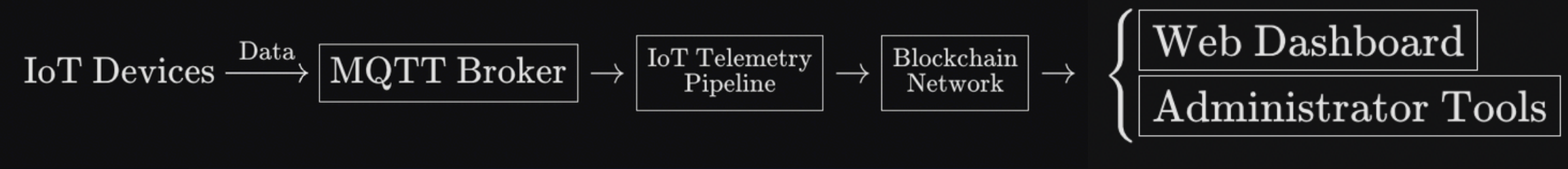
Project Oral Discussion

Blockchain-Enabled Digital Twin Creation Vehicles with Secure VIN Authentication and IoT Telemetry Integration



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Core Components

Digital Twin

In our implementation, the digital twin acts as a live virtual replica of the vehicle, enabling secure registration, real-time telemetry collection, and clear dashboard-based visualization of its status.

Blockchain

Blockchain ensures secure and transparent data integrity for vehicles.

IoT Integration

IoT connects vehicles for enhanced monitoring and telemetry insights.

Key Concepts Overview

Integration for Enhanced Vehicle Security

- ✓ A distributed blockchain system demonstrating core distributed systems principles
- ✓ Integrates IoT sensor data with Byzantine fault-tolerant blockchain storage
- ✓ Real-world automotive application: secure vehicle telemetry management
- ✓ Hyperledger Fabric network with 5 peer nodes + ESP32 IoT devices



System Architecture



IoT Layer

ESP32 + DS18B20 SENSOR

Authentication

Arduino ECDSA Verification

Integration

MQTT + Serial + HTTP Bridge

Blockchain

Hyperledger Fabric (5 Nodes)

Smart Contract

JavaScript Chaincode

Distributed Systems Principles Demonstrated

Byzantine Fault Tolerance

Consensus Protocols

Data Replication

Fault Detection & Recovery

IoT data
validated across
5 nodes (requires
4/5 agreement)

Raft consensus
for transaction
ordering

Telemetry
replicated across
all peer nodes

Automatic node
recovery and
network partition
tolerance



IoT-to-Blockchain Telemetry Flow

1

ESP32 collects temperature data

2

Signs with VIN-derived ECDSA key

3

Publishes via MQTT protocol

4

Arduino verifies signature

5

Byzantine validation (5 nodes)

6

Raft consensus ordering



Live Demonstration



Vehicle Registration

- Enter 17-character VIN
- Auto-generate ECDSA key pair
- Blockchain transaction creation
- Download private key for ESP32



Telemetry Monitoring

- ESP32 collects temperature
- Signs & publishes via MQTT
- Arduino verifies signature
- Byzantine validation → blockchain



Dashboard Visualization

Visualizes VIN usage in real-time verification processes.

Conclusion

- ✓ **Successfully demonstrated core distributed systems principles in real-world automotive context**
- ✓ **Byzantine fault tolerance ensures IoT data integrity across distributed network**
- ✓ **Multi-layer architecture bridges physical IoT devices with blockchain infrastructure**
- ✓ **System validates practical application of consensus protocols and cryptographic authentication**
- ✓ **Foundation for secure, scalable vehicle telemetry management in distributed environments**

