ABSTRACT

The increasing number of vehicles has led to congestion at toll gates due to electronic payment systems that still require vehicles to slow down or stop. This study developed an prototype automatic toll payment system based on Vehicle-to-Infrastructure (V2I) communication using Wi-Fi IEEE 802.11, WPA2-Enterprise authentication, and TLS encryption. The system consists of an On-Board Unit (OBU), a Roadside Unit (RSU), and a MongoDB-based backend server. An experimental approach was used, comprising field testing for static distance and dynamic speed scenarios, and simulation-based testing for encryption algorithm evaluation and server load stress tests. Wi-Fi was chosen over LTE and LTE-GNSS after a comparative analysis, considering latency, response time, cost efficiency, and ease of initial deployment. The results show that the system performs optimally at distances up to 40 meters and vehicle speeds up to 40 km/h, with average delays of 4–135 ms, response times of 3–36 ms, and packet error rates (PER) below 10% up to 800 simultaneous requests. At 900 requests, PER increased to 12.44%. Encryption tests show that AES-256 achieved the highest avalanche effect (48.19%), followed by AES-128 (47.31%) and ChaCha20 (45.67%). All encrypted transactions were successfully recorded in real time in MongoDB and displayed through a web interface. Meeting the defined technical specifications, the system is deemed feasible for limited deployment at toll gates with moderate traffic and low-to-medium vehicle speeds, with potential for further optimization.

Keywords: automatic payment, TLS Encryption, toll gate, V2I, Wi-Fi