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Analisis Performa Bluetooth Low Energy dan Perbandingan Protokol MQTT dan HTTP pada ESP32-S3 untuk Monitoring IoT di Lingkungan Industri Manufaktur
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INTISARI

Analisis Performa *Bluetooth Low Energy* dan Perbandingan Protokol MQTT dan HTTP pada ESP32-S3 untuk *Monitoring* IoT di Lingkungan Industri Manufaktur

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Keandalan mesin industri merupakan faktor kritis dalam efisiensi operasional, dan gangguan tidak terduga dapat menyebabkan kerugian ekonomi akibat *downtime* produksi. Lingkungan industri manufaktur dengan kepadatan peralatan mesin, motor industri, dan inverter frekuensi variabel (VFD) menghasilkan interferensi elektromagnetik tinggi yang menjadi tantangan nyata bagi keandalan komunikasi nirkabel sistem IoT. Penelitian ini menganalisis performa komunikasi *Bluetooth Low Energy* (BLE) 5.0 antara node sensor nRF dan gateway ESP32-S3, serta membandingkan performa protokol MQTT dan HTTP berdasarkan parameter *Quality of Service* (QoS) pada sistem *monitoring* getaran mesin industri. Pengujian BLE dilakukan pada area produksi manufaktur (K-1) dan warehouse engineer (K-2) dengan variasi jarak 10 m, 15 m, dan 20 m, mengukur RSSI dan *Packet Loss Rate* (PLR). Perbandingan protokol MQTT (QoS 0) dan HTTP diukur menggunakan Wireshark pada parameter *delay, throughput, packet loss*, dan *jitter*. Hasil menunjukkan K-1 menghasilkan RSSI lebih rendah dan packet loss lebih tinggi dibanding K-2 akibat interferensi elektromagnetik dan halangan fisik lingkungan manufaktur. MQTT terbukti lebih unggul dibanding HTTP pada parameter *delay* dan *throughput*. Penelitian ini memberikan rekomendasi teknis berbasis data empiris untuk pemilihan teknologi komunikasi IoT di lingkungan industri manufaktur.

Kata kunci: IoT, ESP32-S3, *Bluetooth Low Energy*, MQTT, HTTP, *monitoring* getaran, lingkungan industri manufaktur, *Quality of Service*, RSSI, packet loss

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ABSTRACT

Performance Analysis of Bluetooth Low Energy and Comparison of MQTT and HTTP Protocols on ESP32-S3 for IoT Monitoring in Manufacturing Industry Environments

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Industrial machine reliability is a critical factor in operational efficiency, and unexpected failures can lead to significant economic losses due to production downtime. Manufacturing industry environments, characterized by dense machinery, industrial motors, and variable frequency drives (VFDs), generate high electromagnetic interference that challenges wireless communication reliability in IoT systems. This study analyzes the performance of Bluetooth Low Energy (BLE) 5.0 between an nRF-based sensor node and an ESP32-S3 gateway, and compares MQTT and HTTP protocols based on Quality of Service (QoS) parameters in an industrial machine vibration monitoring system. BLE testing was conducted in an industrial production area (K-1) and engineer warehouse (K-2) at distances of 10 m, 15 m, and 20 m, measuring RSSI and Packet Loss Rate (PLR). MQTT (QoS 0) and HTTP protocol comparison was measured using Wireshark for delay, throughput, packet loss, and jitter. Results show K-1 produced lower RSSI and higher packet loss than K-2 due to electromagnetic interference and physical obstructions typical of manufacturing environments. MQTT demonstrated superior performance over HTTP in delay and throughput parameters. This research provides empirically-based technical recommendations for selecting IoT communication technologies in manufacturing industry environments.

Keywords: IoT, ESP32-S3, Bluetooth Low Energy, MQTT, HTTP, vibration monitoring, manufacturing industry environment, Quality of Service, RSSI, packet loss