

INTISARI

Pekerja lapangan industri umumnya bekerja pada lingkungan berisiko tinggi yang sering kali memiliki keterbatasan infrastruktur jaringan internet sehingga proses dokumentasi, pelaporan, dan pemantauan aktivitas pekerja menjadi kurang optimal. Penelitian ini bertujuan merancang prototipe *smart helmet* berbasis *Internet of Things* (IoT) menggunakan ESP32-S3, kamera OV2640, mikrofon analog MAX4466, dan GPS NEO-M8N. Komunikasi data menggunakan modul Long Range (LoRa) SX1278 sehingga sistem dapat beroperasi tanpa bergantung pada jaringan internet. Keterbatasan ukuran *payload* LoRa, mengharuskan data gambar dan suara dikirim melalui mekanisme fragmentasi dan rekonstruksi, sedangkan data lokasi dikirim secara langsung. Selanjutnya, data diteruskan menggunakan protokol *Message Queuing Telemetry Transport* (MQTT), disimpan ke dalam *database*, dan ditampilkan melalui *dashboard* berbasis web. Hasil pengujian menunjukkan bahwa sistem mampu mengirimkan data gambar dengan nilai *Packet Delivery Ratio* (PDR) rata-rata 98,33%, sedangkan data suara dan lokasi mencapai PDR 100%. Selain itu, sistem menghasilkan rata-rata *error* GPS sebesar 4,88 meter, dengan waktu pengiriman data gambar dan suara masing-masing berada pada rentang 46,38–68,56 detik dan 16,34–25,12 detik. Hasil tersebut menunjukkan bahwa sistem yang dikembangkan mampu mendukung dokumentasi, pelaporan, dan pemantauan lokasi pekerja lapangan pada area dengan keterbatasan jaringan internet melalui integrasi pengiriman data gambar, suara, dan lokasi menggunakan komunikasi LoRa.

Kata kunci: IoT, LoRa, ESP32-S3-CAM, MAX4466, GPS NEO-M8N

ABSTRACT

Field workers in industrial environments often operate in high-risk areas with limited internet infrastructure, making documentation, reporting, and activity monitoring less effective. This research aims to develop an Internet of Things (IoT)-based smart helmet prototype using an ESP32-S3 microcontroller, an OV2640 camera, a MAX4466 analog microphone, and a NEO-M8N GPS module. Data communication is implemented using the LoRa SX1278 module, enabling long-range transmission without relying on internet connectivity. Due to the limited payload capacity of Long Range (LoRa) communication, image and audio data are transmitted using fragmentation and reassembly mechanisms, while location data are transmitted directly because of their relatively small size. The received data are forwarded through the Message Queuing Telemetry Transport (MQTT) protocol, stored in a database, and displayed on a web-based dashboard. Experimental results show that the system achieved an average Packet Delivery Ratio (PDR) of 98.33% for image transmission and 100% for both audio and location data. In addition, the average GPS positioning error was 4.88 meters, while the transmission times for image and audio data ranged from 46.38–68.56 seconds and 16.34–25.12 seconds, respectively. These results demonstrate that the proposed smart helmet is capable of supporting documentation, reporting, and field worker location monitoring in areas with limited internet infrastructure through the integration of image, audio, and location transmission using LoRa communication.

Keywords: *IoT, LoRa, ESP32-S3-CAM, MAX4466, GPS NEO-M8N*