

ABSTRAK

Sistem *monitoring* kualitas air berbasis *Internet of Things* memerlukan teknologi komunikasi nirkabel berdaya rendah yang mampu beroperasi mandiri dalam waktu lama, khususnya di wilayah aliran sungai dengan akses listrik terbatas. LoRaWAN dan NB-IoT merupakan dua teknologi *Low Power Wide Area Network* yang banyak dipertimbangkan untuk kebutuhan tersebut, namun memiliki karakteristik daya dan jangkauan berbeda sehingga pemilihannya perlu disesuaikan dengan kondisi geografis setempat. Penelitian ini membandingkan kinerja LoRaWAN dan NB-IoT untuk mendukung sistem *monitoring* kualitas air di Sungai Krueng Cunda, Kota Lhokseumawe, dari aspek cakupan sinyal dan konsumsi energi. Karena infrastruktur NB-IoT komersial belum tersedia di lokasi penelitian, evaluasi dilakukan melalui simulasi Radio Mobile berbasis *data terrain* SRTM 30 meter dan MATLAB, pada 15 titik *node* di tiga zona lingkungan *vegetated/rural*, *urban-residential*, dan *coastal-dense settlement*. Analisis energi dihitung dari spesifikasi *datasheet* modul SX1276 dan Quectel BC95-G dengan skenario transmisi periodik 15 menit. Hasil simulasi menunjukkan LoRaWAN dan NB-IoT sama-sama mencapai cakupan penuh 100% (15 dari 15 *node*) di seluruh zona penelitian, dengan LoRaWAN telah mencakup seluruh titik sejak konfigurasi *Spreading Factor* 7. Perbedaan performa antara kedua teknologi tidak lagi terletak pada persentase cakupan, melainkan pada margin sinyal, di mana NB-IoT unggul 16,87–17,06 dB dibandingkan LoRaWAN SF7 dan menyempit menjadi 3,68–4,24 dB terhadap LoRaWAN SF12. Dari sisi energi, LoRaWAN menghasilkan umur baterai 3,39–9,18 tahun pada seluruh konfigurasi *Spreading Factor*, sedangkan NB-IoT hanya bertahan sekitar 48,9 hari akibat arus transmisi yang jauh lebih tinggi. Perbedaan ini menjadikan LoRaWAN pilihan lebih sesuai untuk *deployment* sensor berbasis baterai tanpa akses listrik permanen, sementara NB-IoT tetap relevan pada lokasi dengan sumber listrik memadai.

Kata kunci: LoRaWAN, NB-IoT, LPWAN, *monitoring* kualitas air, konsumsi energi, simulasi propagasi

ABSTRACT

Internet of Things-based water quality monitoring systems require low-power, long-range wireless technologies capable of operating independently for extended periods, particularly along river corridors with limited electrical access. LoRaWAN and NB-IoT are two Low Power Wide Area Network technologies widely considered for this purpose, yet each has distinct power and coverage characteristics, making technology selection dependent on local geographic conditions. This study compares LoRaWAN and NB-IoT performance for a water quality monitoring system along the Krueng Cunda River, Lhokseumawe City, in terms of signal coverage and energy consumption. Since commercial NB-IoT infrastructure was not yet available at the site, evaluation was conducted through simulation using Radio Mobile based on 30-meter SRTM terrain data and MATLAB, across 15 nodes in three environmental zones: vegetated/rural, urban-residential, and coastal-dense settlement. Energy consumption was calculated from the datasheet specifications of the SX1276 and Quectel BC95-G modules under a periodic 15-minute transmission scenario. Results show that both LoRaWAN and NB-IoT achieved full coverage of 100% (15 of 15 nodes) across all zones, with LoRaWAN already covering every node from Spreading Factor 7 onward. The performance difference between the two technologies no longer lies in coverage percentage but in signal margin, where NB-IoT outperformed LoRaWAN SF7 by 16.87–17.06 dB, narrowing to 3.68–4.24 dB against LoRaWAN SF12. In terms of energy, LoRaWAN achieved a battery lifetime of 3.39–9.18 years across all Spreading Factor configurations, while NB-IoT lasted only about 48.9 days due to its much higher transmission current. This makes LoRaWAN more suitable for battery-powered deployments without permanent electrical access, while NB-IoT remains relevant where adequate power sources are available.

Keywords: LoRaWAN, NB-IoT, LPWAN, water quality monitoring, energy consumption, propagation simulation