Poster: Real-Time Performance Evaluation of Ground-to-Ground LoRa Modules in Urban Environments

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Abstract

LoRa technology has emerged as a pivotal solution for low power, long range communication networks. This work presents an outdoor performance evaluation of the EBYTE LoRa E22-400T33E modules, focusing on critical metrics like throughput and communication range in an urban environment. Our field tests cover three distinct profiles: maximum throughput, maximum range, and extended range using a relay node. The results highlight the trade-offs between range and throughput, while also showcasing the effectiveness of relay nodes in extending communication distance. These findings offer practical insights for optimizing LoRa network designs.

CCS Concepts

• **Networks** → **Network measurement**.

Keywords

LoRa, Range, Throughput, Relay

1 Introduction

Traditional multi radio systems like Wi-Fi and HaLow offer high throughput but are hindered by significant energy consumption. This drawback results in inefficient energy use ultimately reducing the lifespan of devices. To address this limitation while preserving the benefits of multi radio systems, integrating a low power and long range solution alongside the existing setup presents a practical approach. By configuring this low power solution as the default active radio and activating Wi-Fi or HaLow only on demand, the system can significantly reduce overall power consumption while still benefiting from the high throughput capabilities of Wi-Fi and HaLow when necessary.

Figure 1 illustrates the transmission ranges and data rates offered by various technologies. Among the available options, LoRa stands out as a compelling choice for long range, low power requirements. However, LoRa's primary limitation lies in its relatively low throughput compared to Wi-Fi and HaLow. Despite this drawback, LoRa is ideally suited for IoT applications, but it cannot independently meet the demands of high throughput applications. To overcome this, LoRa can be used alongside Wi-Fi or HaLow, allowing for both high throughput and reduced average power consumption across the system.

Based on the comparison in Table 1 of various LoRa solutions available in the market, we selected EBYTE LoRa module E22-400T33E due to its high transmit power of 33 dBm and a communication range of up to 16 km. This module, featuring a mini PCIe interface, allows seamless integration with various platforms and supports air data rates up to 62.5 kbps. Additionally, features

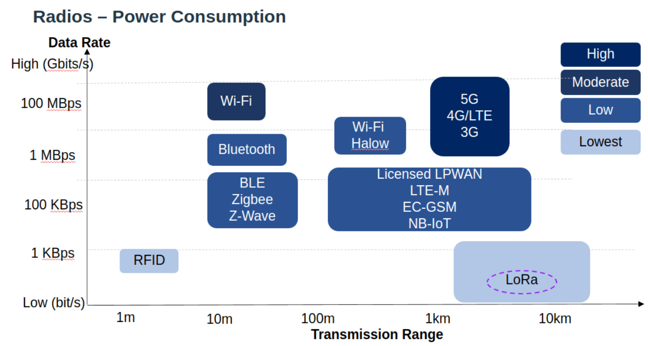

Figure 1: Transmission Range and data rates for various technologies

such as relay functionality, deep sleep mode, and a listen-before-talk mechanism make it ideal for mesh network configurations.

Table 1: Comparison of different LoRa Solutions

Features	E22-400T33E	ALMC2483U	RFM96W
Tx Power (dBm)	33	10	20
Range (km)	16 km	5 km	2 km
Relay	Yes	No	No
Listen before Talk	Yes	No	No

Before integrating the EBYTE LoRa module into our existing multi radio system, it is crucial to assess its real world performance, particularly with respect to throughput and communication range. Several studies have previously investigated LoRa's performance in different environments. For example, [1] and [2] evaluated LoRa's range and data rates and offered theoretical models for optimizing LoRa networks. However, these studies concentrated in indoor environments and do not specifically address the trade-offs between throughput and range in urban environments.

To fill this gap, we conducted field tests under distinct profiles, including maximum throughput and maximum range. Additionally, we deployed a relay node to extend communication distances, thereby introducing a new layer of analysis for enhancing LoRa's effective range. This practical evaluation provides deeper insights into LoRa's performance in real world urban scenarios and offers valuable guidance for optimizing future deployment strategies.

2 LoRa Performance Evaluation

To verify data transfer between two LoRa nodes, we interfaced it with our existing multi radio solution as shown in Figure 2.

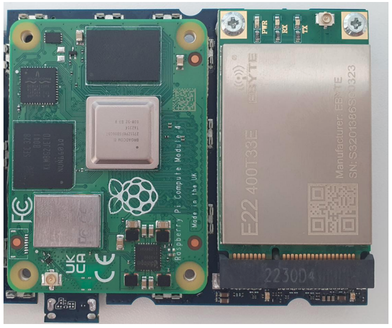

Figure 2: Multi radio system interfaced with LoRa

We verified communication range and throughput for the case of lossless communication. We conducted outdoor tests in an urban environment in UAE, focusing on below three different profiles:

- **Maximum Throughput**: In the maximum throughput configuration, the two nodes are set to their highest air data rate of 62.5 kbps. Data was transmitted from the host machine at a rate of 115200 bps. It is expected that this configuration gives the least communication range. The results demonstrated successful outdoor communication with no packet loss up to a range of 2.6 km and achieving an effective data rate or throughput of 17 kbps.
- **Maximum Range**: For the maximum range configuration, the two LoRa modules are configured to their lowest air data rate of 2.4 kbps. In this setup, we observed lossless communication up to a range of 4.5 km and effective throughput of 1.3 kbps.
- **Range Extension with Relay**: To balance increased throughput and extended range, we configured a third node as a relay. All nodes operated at the highest air data rate of 62.5 kbps, with data sent at 115200 bps from the host, matching the configuration of the maximum throughput profile for comparison. The relay setup achieved a throughput of 5 kbps and extended the range to 3.5 km, with the first hop covering 2 km and the second hop adding 1.5 km. Relay handles both reception and transmission resulting in a halved effective throughput. This demonstrates the trade-off of using relays, where range is extended at the cost of reduced data rate.

Figure 3, 4 and 5 show the field test locations of nodes in the three scenarios. Table 2 summarizes the observed throughput and range in all three scenarios. This empirical data can be used as a reference for network designing and the appropriate configuration can be used as per user requirements.

Table 2: Summary of the test results

Configuration	Air Data Rate	Throughput	Range
Maximum Throughput	62.5 kbps	17 kbps	2.4 km
Maximum Range	2.4 kbps	1.3 kbps	4.5 km
Relay	62.5 kbps	5 kbps	3.5 km

3 Conclusion

This paper presents a comprehensive assessment of the outdoor performance of EBYTE LoRa wireless module E22-400T33E across

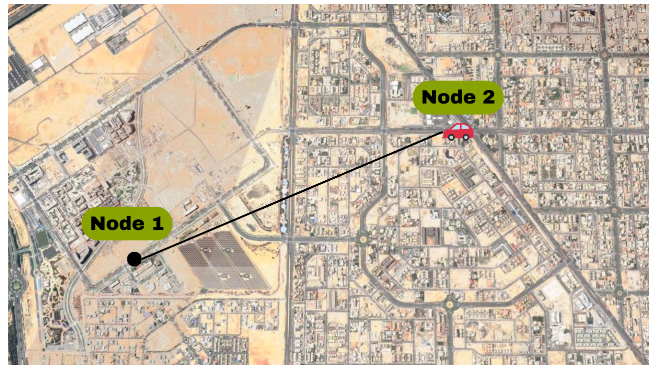

Figure 3: Maximum Throughput

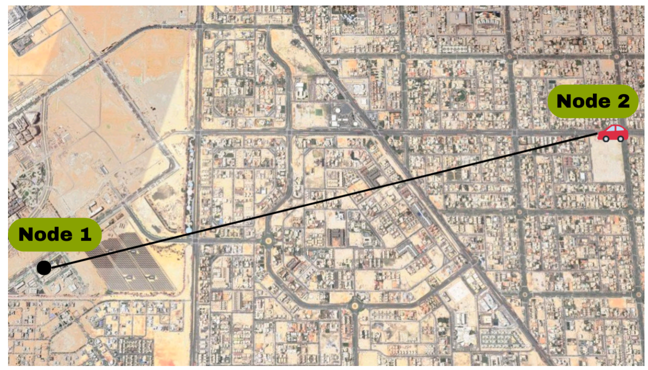

Figure 4: Maximum Range

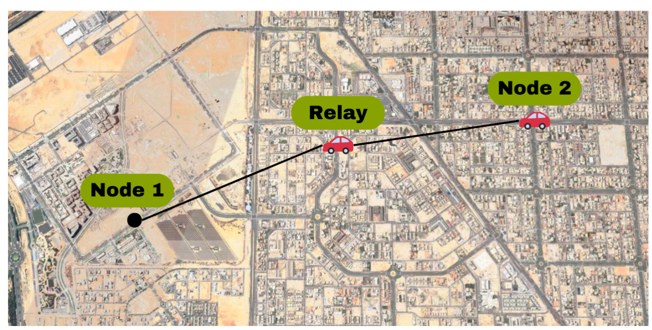

Figure 5: Relay Mechanism

various configurations. Our findings reveal trade offs between throughput and range, demonstrating the effectiveness of relay nodes in enhancing communication distances. These insights are invaluable for optimizing LoRa network design and deployment strategies.

References

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