Integration and Implementation of LoRa-Based Sensor Communications for Freight Railcar Condition Monitoring Applications

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1. Introduction

A long-range data transmission system is essential for any modern-day infield-testing environment, especially one that involves testing over such long distances as in railway applications. As such, the implementation of Long-Range Radio (LoRa) for means of remote data acquisition is proposed. To begin such implementation, a series of benchmark tests have been conducted to establish the reliability and adaptability of such devices and networks.

Figure 1. RFM96W LoRa module, 3V Logic Levels, SMD Breakout Board. [1]

2. Purpose

Current plans for testing will also include, but not be limited to the following: range, speed, power consumption, extreme weathering environments, encryption methods, RF techniques, and maximum bandwidth.

The main focus of the proposed project is minimum possible power consumption, with longer range than standard BLE methods.

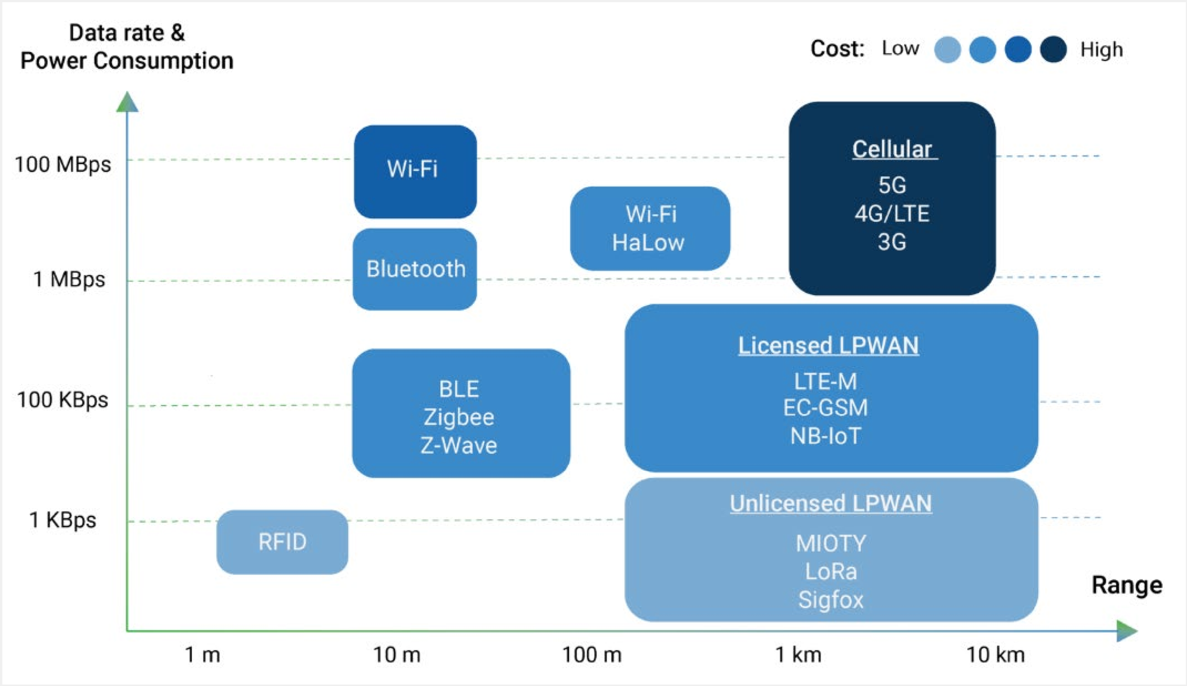

Figure 2. Various Communication Techniques Data Rate and Power Consumption Comparison [2]

3. Design

In developing circuits for testing a key component was antenna optimization. Reliability can increase drastically when the proper antenna is used, therefore, a lot of work went into this sole aspect. Other key parameters that the design intends to monitor include bearing vibration spectra, bearing adapter temperature, and load on each bearing adapter, just to name a few; and each of these parameters has the potential of leading to a safer operational environment for all aspects of rail transportation.

Another key factor in choosing LoRa is the range performance and increased longevity of battery life offered by LoRa protocols. An extremely long battery life is essential for long distance remote testing/data acquisition as well as for field service condition monitoring operations.

4. Analysis of Results

Current tests show impressive range results, generally allowing transmission of up to 230-m with minimum packet loss. Preliminary tests currently show a current draw of around ~20mA whilst transmitting, and around ~10mA whilst receiving.

A standard Li-Ion battery bank could last upwards of 156-Hrs, if transmitting at 100% of the time.

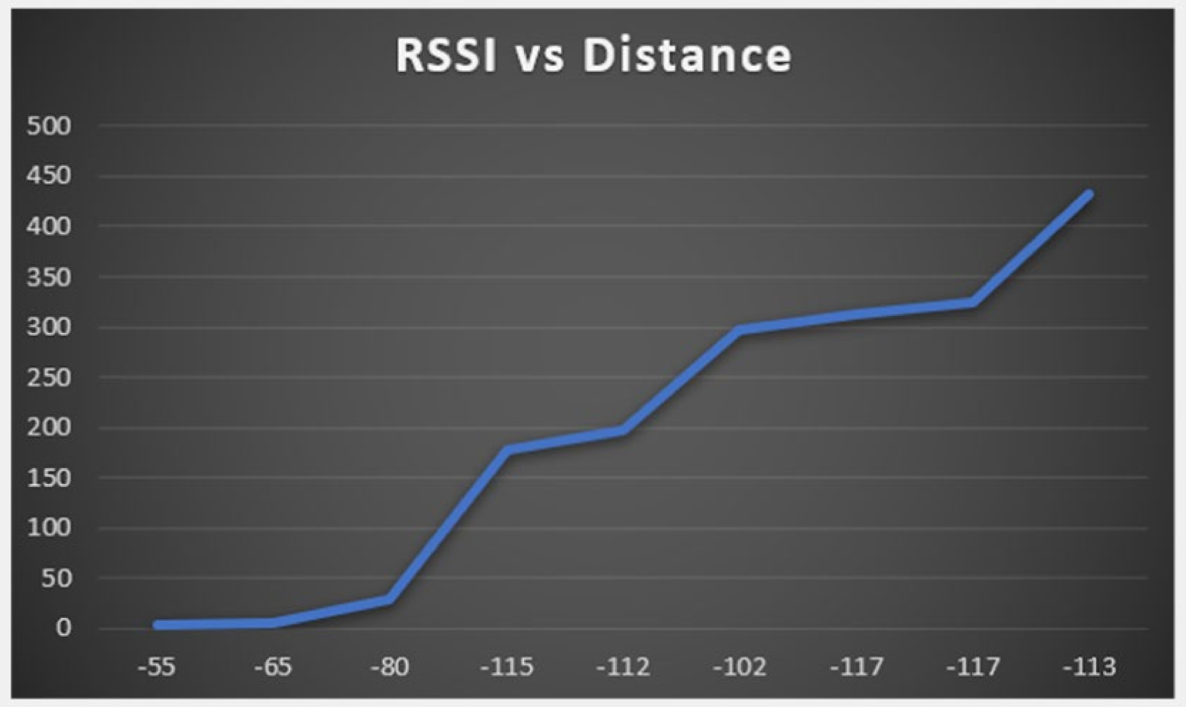

Figure 3. RSSI vs Distance of Test Nodes

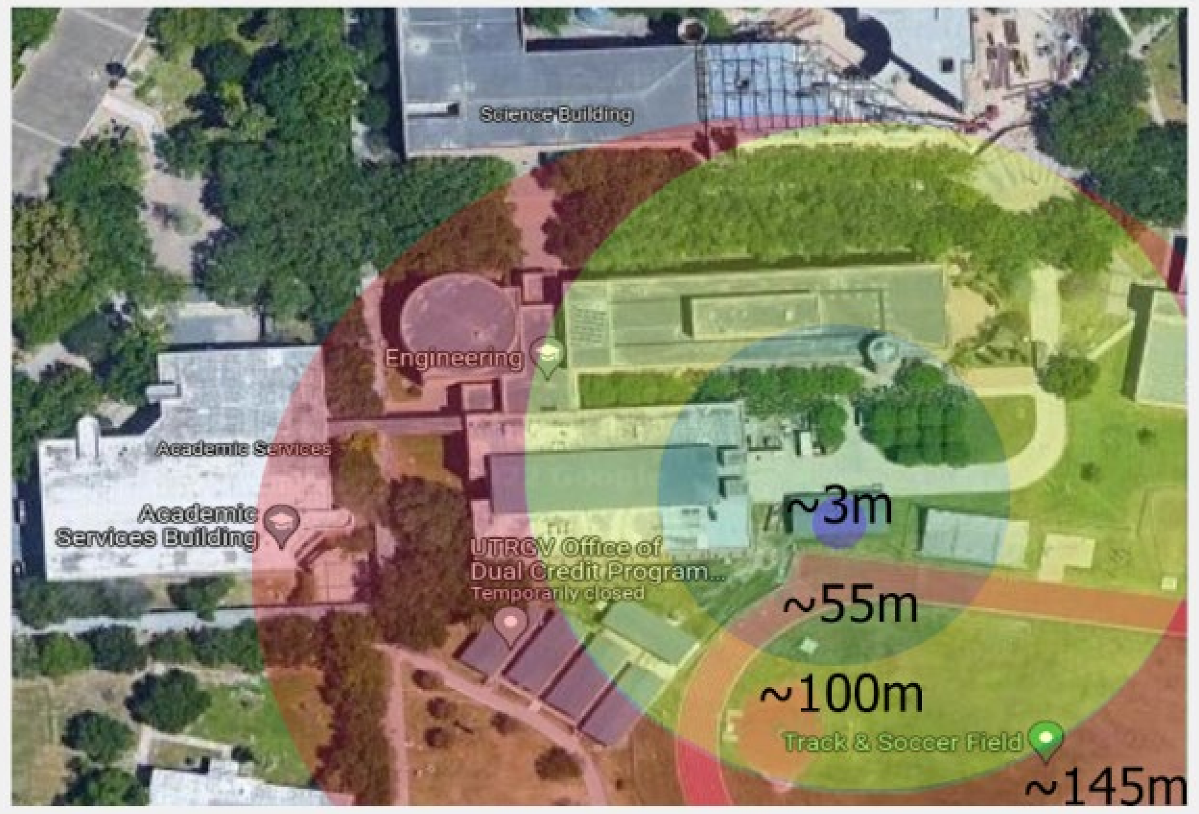

Figure 4. Generalized Signal Test Radius & RSSI Blue = -30.*Green -50, Yellow = -100, Red = -130*

5. Conclusions

An example end-product could be that each railcar would have a series of sensors that will be interconnected to a central hub. This would allow the transmission of data periodically for data analysis. By implementing the use of LoRa, field test data can be accessed remotely without the minutia of having to physically access the railcars, as this is not always a valid option.

A refined sensor network of this caliber will not only benefit railway applications but can also benefit various other forms of tests to be completed remotely (i.e., aviation, marine, etc.).

6. Acknowledgement

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7. References

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