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Study on Effective Coverage of Low-Cost LoRa Devices

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He was Technical Editor of the IEEE Communications Magazine Editorial Board (2000-2006), IEEE Networks Magazine since 2015, IEEE Transactions on Vehicular Technology since 2017, Chair of IEEE ComSoc France (2014-2020), Financial chair of IEEE France (2017-2022), Chair of Vertical Issues in Communication Systems Technical Committee Cluster (2008-2009), Chair of the Communications Systems Integration and Modeling Technical Committee (2003-2009), Chair of the Communications Software Technical Committee (2008-2010) and Chair of the Technical Committee on Information Infrastructure and Networking (2016-2017). He has served as Co-Program Chair of IEEE WCNC'2012 and ICC'2004, Executive Vice-Chair of ICC'2017, TPC Vice Chair of Globecom'2018, Panel sessions co-chair for Globecom'16, tutorial chair of VTC'2013 Spring and WCNC'2010, track chair of PIMRC'2012 and WCNC'2014, symposium Co-Chair at Globecom 2007-2011, Globecom'2019, ICC 2008-2010, ICC'2014 and '2016. He has served as Co-Guest Editor for special issues of IEEE Communications Magazine, Networks Magazine, Wireless Communications Magazine, Telecommunications Systems and LNCS. He is associate Editor for International Journal of Communication Systems (IJCS-Wiley), Journal on Security and Communication Networks (SCN-Wiley) and International Journal of Business Data Communications and Networking, Journal of Network and Computer Applications (JNCA-Elsevier).

He is senior member of the IEEE, IARIA fellow and member of many international program committees. He has organized many conferences, chaired several technical sessions and gave tutorials at major international conferences. He was IEEE ComSoc Distinguished Lecturer Tour during 2013-2014.

Outline

1. Introduction

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- The introduction of wireless communications in varied scenarios, such as agriculture, oceanography, and the rise of Smart City solutions have led to the development of long-range wireless technologies, such as LoRa.

- The official site of The Things Network advertises record LoRaWAN distances of 832 km. Although this distance is obtained for specific LoRa settings, the advertised LoRa maximum distance is up to 15 km in line-of-sight deployments and up to 5 km in urban environments.

- However, the few existing coverage studies are limited and do not reach the advertised distances.

- In this paper, we expand the knowledge on effective LoRa coverage by studying the coverage of LoRa low-cost nodes considering different frequency bands, SF, and antennas.

2. Related work

2. Related Work

- Although more coverage studies of LoRa devices are necessary, there are some studies that have evaluated the performance of LoRa communications in urban environments and in line-or sight conditions obtaining distances up to 10 km.

- The interference LoRa devices cause to each other in multi-hop network deployments was evaluated by Guibing Zhu et al. The results showed that the higher the SF, the higher the immunity to collisions for both transmissions with the same SF and transmissions with different SF.

- Lastly, other uses for LoRa include deploying the devices on drones or floating structures.

- Albeit there are some LoRa coverage tests, the available studies do not compare the results for different SF values, do not indicate the utilized devices, or use a very high placement of the emitter antenna.

3. Testbed description

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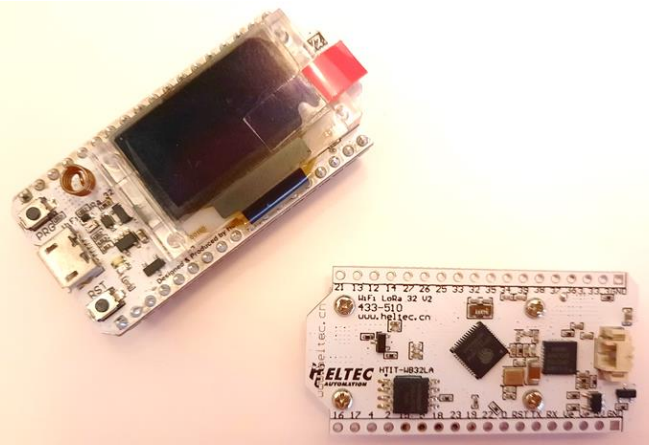
- The utilized devices were Heltec LoRa/WiFi 32 nodes with the characteristics presented on the table.

Tx Power	17 dB
Frequency	433 MHz and 868 MHz
SF	7,8,9,10,11,12
Signal Bandwidth	125 KHz
Coding rate	4/5
Preamble length	8 Symbols
Height of the antenna	1.57 m



- Three different types of antennas were utilized.

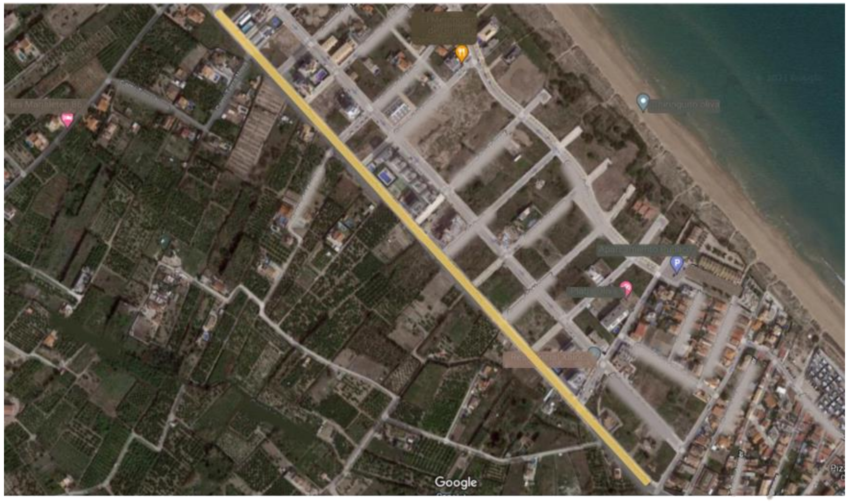
Frequency band: 433 MHz
Antenna gain: 3dBi

Frequency band: 433 MHz
Antenna gain: 5dBi

Frequency band: 868 MHz
Antenna gain: 3dBi

3. Testbed description

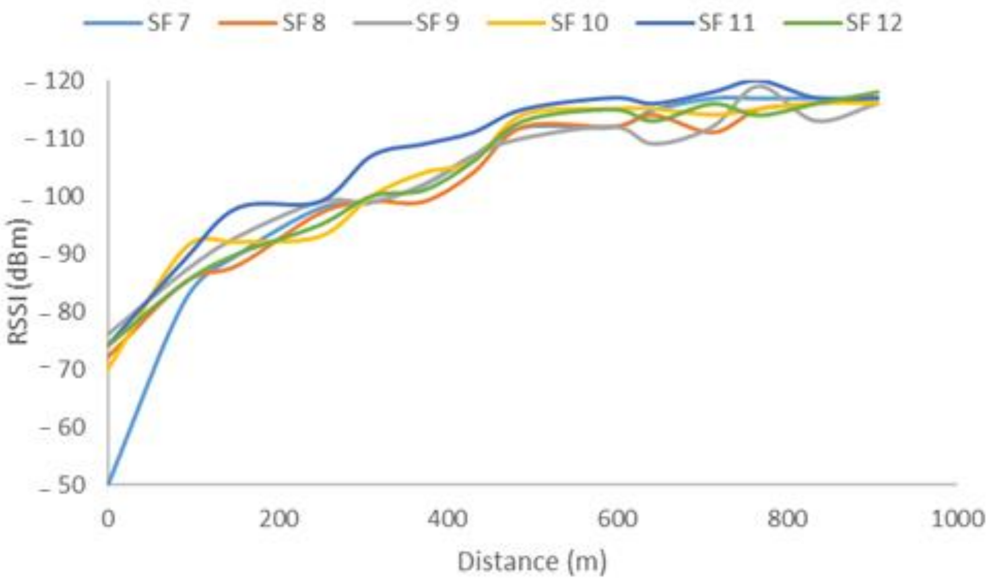
- The tests were performed on a wide street with buildings on one side and fields on the other side.
- The emitter was placed at the beginning of the street and the receiver moved to different measuring points in line-of-sight conditions.
- The RSSI was obtained for each of the measuring points.
- Moreover, the test was repeated for each of the antennas and each of the SF for the corresponding frequency band.



4. Results

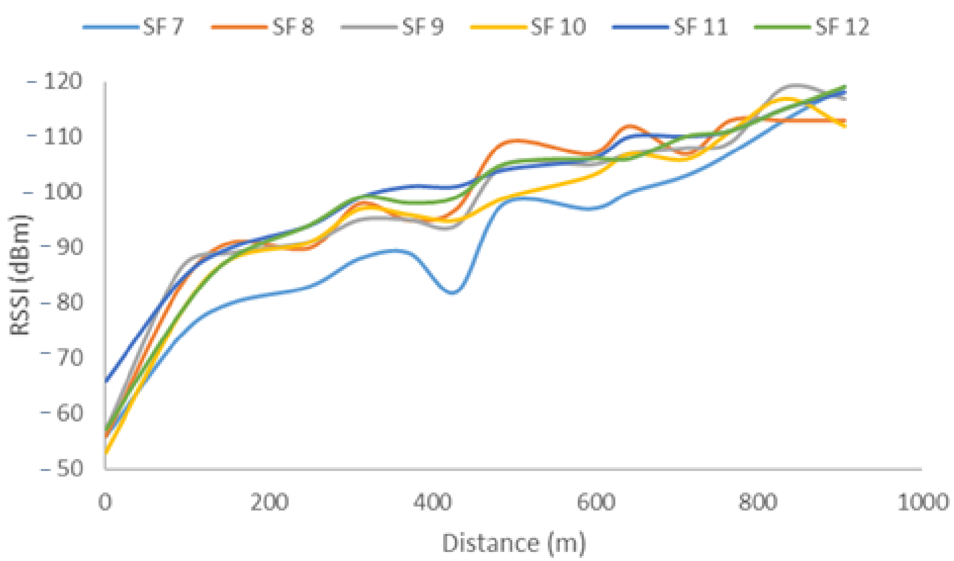
868 MHz frequency band and 3 dBi antenna

- The RSSI values presented fluctuations for all the SF even in the absence of obstacles. The SF 7 was the one with the better signal at close distances. However, as the distance increased, other SF configurations presented better results. The SF 11 was the one with the overall worst RSSI values. The rest of the SF configurations have obtained similar RSSI values. Therefore, for this frequency band and this type of antenna, the selection of the SF does not seem to have a significant impact o the quality of the signal. So, other aspects should be considered for the selection of the best SF.



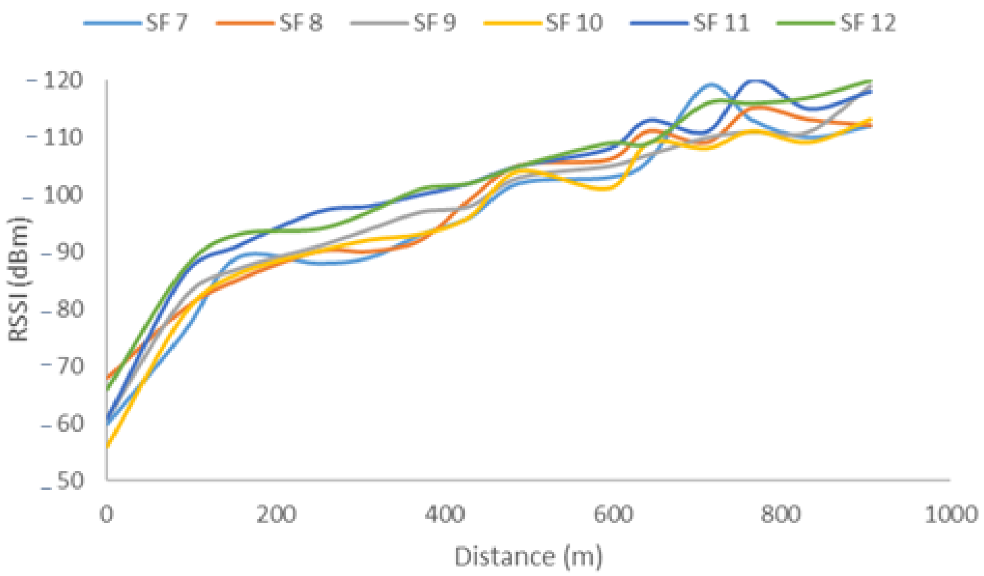
433 MHz frequency band and 3 dBi antenna

- In this case, it is more evident that the SF 7 configuration leads to better signal quality. Although for the last measuring point, the RSSI values of SF 7 are similar to those of the rest of the SF configurations. The SF 10 is the second-best configuration, with the other SF configurations having lower signal quality. Moreover, SF 11 would be the SF with the worst RSSI values. As the difference between SF configurations is more evident for this antenna, the selection of the SF should be considered when designing a LoRa network with these devices. However, it would apply mostly for the SF 7 configuration, as the other SF present fewer differences.



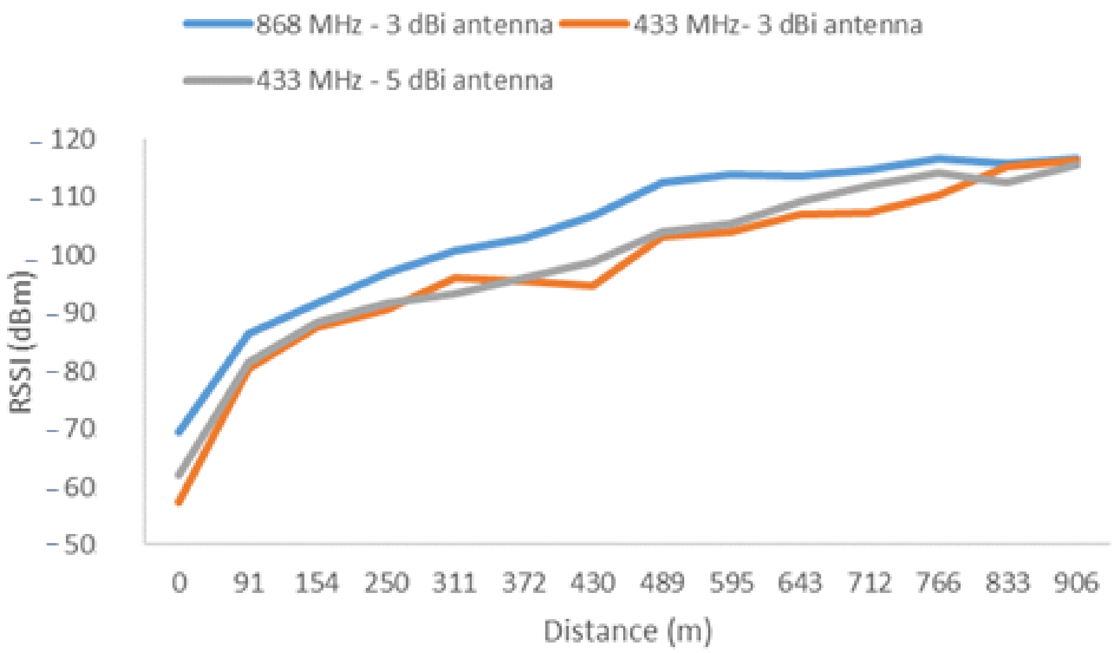
433 MHz frequency band and 5 dBi antenna

- SF 7 and SF 10 have the best signal quality. However, there is not a clear difference between SF configurations as in the case of Figure 8. On the other hand, SF 11 and 12 present the worst signal quality, with little difference between both configurations. The rest of the SF configurations present similar results to those of SF7 ad SF 10. As in the case of the 868 MHz frequency band, there is no highly noticeable difference between the different SF values, therefore, other aspects should be considered when selecting the best configuration.



Comparison

- The average values of all SF values for each frequency band and antenna are shown in the following figure. The two antennas for the 433 MHz frequency band have similar results. However, the average shows better results for the 3 dBi antenna due to the less noticeable difference between the results for each SF. Regarding the 868 MHz frequency band, the average of the RSSI values shows a lower image quality than that of transmitting with 433 MHz.



5. Conclusion and Future Work

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- Although the expected distances range from 10 to 40 km depending on the obstructions in the area, low-cost LoRa devices do not reach those expectations. Therefore, in this paper, we have performed coverage tests with cost-effective LoRa devices and antennas.

- The results show that the selection of different SF may not affect the quality of the received signal, such as for the 868 MHz frequency band.

- Furthermore, the combination of low-cost LoRa devices and low-cost antennas does not provide coverage greater than 1 km.

- Other solutions, such as multi-hop LoRa networks should be implemented when there is an interest in deploying low-cost devices.

- For future work, we will perform tests with LoRa devices and antennas in the medium price range. Furthermore, tests will be performed with different types of content, such as data from sensors or images so as to assess the performance of LoRa and the devices with different traffic demands.