Measuring PHY layer interactions between LoRa and IEEE 802.15.4g networks

Charalampos Orfanidis
Uppsala University, Sweden
charalampos.orfanidis@it.uu.se

Laura Marie Feeney
Uppsala University, Sweden
lmfeeney@it.uu.se

Martin Jacobsson
Uppsala University, Sweden
KTH, Sweden
martin.jacobsson@it.uu.se

***Abstract*—Advances in low power wireless communication have resulted in new radio technologies that can achieve long distance communication in energy efficient ways. An emerging problem in this scenario is interference between networks that share the same medium. The fact that these networks have a long transmission range increases the possibility of interference even more. Thus the investigation of how different networks can share the medium independently in a optimal way becomes an essential requirement for the IoT vision. In this poster, we present the first step of this investigation, which is measuring how LoRa and IEEE 802.15.4g PHY layers interfere.**

I. INTRODUCTION

Low-Power Wide-Area Network (LPWAN) technologies, such as Long Range (LoRa) [1], SigFox [2], and Weightless [3] are an important recent development in wireless communication. They all use subGHz frequencies in unlicensed bands. In particular LoRa is getting a lot of attention from both academia and industry because of its ability to communicate over long distances at low energy costs. IEEE 802.15.4g networks also operate in over relatively long range in sub-GHz frequencies. Thus, finding an optimal way to access the communication medium is crucial for the co-existence of independent networks in sub-GHz bands. The first part of this is to understand how the PHY layers interact. To this end, we conducted a series of experiments to see how LoRa affects a IEEE 802.15.4g network.

One common characteristic of the LPWAN technologies is that the communication range is significantly longer than IEEE 802.15.4g networks. This means that different networks are very likely to interfere with each other and have degraded performance. For instance, an IEEE 802.15.4g network using the same frequency as a LoRa network will have frame collisions. Furthermore, these networks are impossible to coordinate because they are heterogeneous in terms of standards (IEEE 802.15.4g, LoRaWAN) and modulation (FSK Frequency-Shift Keying , CSS Chirp Spread Spectrum). Even if the networks are homogeneous, they may not trust each other because of security reasons. Another factor that makes the coordination infeasible is that there is a large diversity on how they use the medium. For example, a LoRa network may use a data-rate of 500 bps and share the medium with a IEEE 802.15.4g network having 50 kbps. Consequently we should examine and quantify the factors that can affect the coexistence of these networks.

As an initial step to explore these issues, we performed a measurement study of how IEEE 802.14.5g frames are affected by LoRa interference, for varying LoRa transmission parameters. The goal is to investigate and quantify how much one network might interfere with the other and what factors are most important. The results show that IEEE 802.15.4g is often severely degraded by LoRa co-channel interference. However, we observe some cases where 802.15.4g is surprising resilient even to high interference level from LoRa. We speculate that this is due to the nature of LoRa's CSS modulation.

There have been a number of studies of LoRa performance (e.g. [4], [5], [6]). To the best of our knowledge, this is the first attempt to measure cross technology interference between LoRa and IEEE 802.15.4g.

II. SYSTEM OVERVIEW

Our experiments are based on inducing collisions between IEEE 802.15.4g and LoRa transmissions in a controlled way. To do this, we disabled collision avoidance on both radios, so that both IEEE 802.15.4g and LoRa frames occupy the channel as continuously as possible. This ensures that each IEEE 802.15.4g frame experiences substantial interference.

For the experiment setup, we used two Texas Instruments CC1310 launchpads placed in line of sight at a 6.4 meter distance, where one was acting as a transmitter and the other as a receiver. Close to the transmitter we placed one XRange SX1272 LoRa RF module, which was acting as the interferer to the IEEE 802.15.4g communication.

We used Contiki for the IEEE 802.15.4g nodes with nullmac and nullrdc. For LoRa we used the LoRaBlink [6] software. The launchpad devices were controlled and data was collected through serial communication. We also used a spectrum analyser to monitor collisions and power levels of the two interfered communications.

III. EVALUATION

In order to examine the 802.15.4g performance, we captured the Packet Received Ratio (PRR) for different combinations of transmission power levels and channels. Table I shows the reported Received Signal Strength Indicator (RSSI) for each transmit power setting. At the same time, we placed the LoRa device close to the transmitter acting as interferer at 868.3 MHz. The LoRa transmission was set to 3 dBm and was measured to -40 dBm using the spectrum analyser. We

ISBN 978-3-901882-94-4

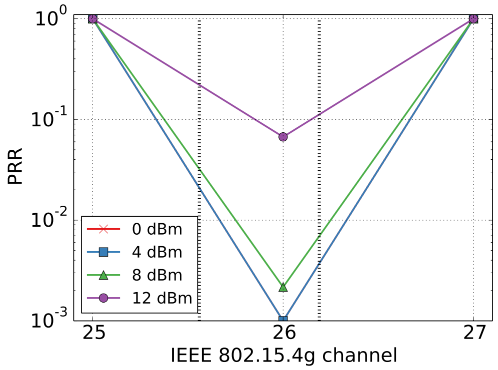

Fig. 1. IEEE 802.15.4g PRR over different transmission power levels with LoRa interfering at 3 dBm, SF7 and BW125 kHz

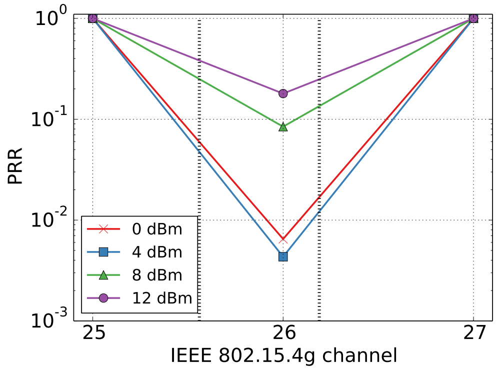

Fig. 2. IEEE 802.15.4g PRR over different transmission power levels with LoRa interfering at 3 dBm, SF12 and BW125 kHz

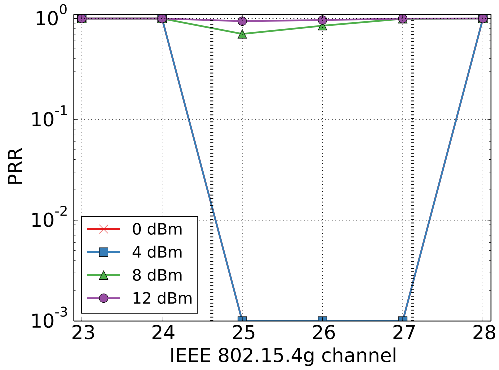

Fig. 3. IEEE 802.15.4g PRR over different transmission power levels with LoRa interfering at 3 dBm, SF7 and BW500 kHz

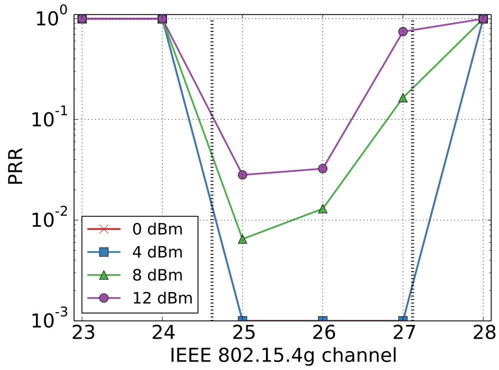

Fig. 4. IEEE 802.15.4g PRR over different transmission power levels with LoRa interfering at 3 dBm, SF12 and BW500 kHz

repeated this scenario and we changed the SF and BW values at the LoRa device.

Figures 1 and 2 show the case where the LoRa bandwidth is BW125 kHz. For both spreading factor SF7 and SF12 there is a severe drop in IEEE 802.15.4g PRR at channel 26, which entirely overlaps with the LoRa BW (shown in dotted lines in the figures). Some frames were successfully received for higher transmit powers, although this proportion never exceeds 20% (note the log scale on the y-axes).

setting (dBm)	0	2	4	6	8	10	12
measured power (dBm)	-48	-48	-46	-44	-43	-43	-43
reported RSSI (dBm)	-50		-48		-45		-44

TABLE I. CC1310 transmit power setting and the measured power (signal analyzer) and RSSI (recevied frames) at the receiver.

Figures 3 and 4 show the case where the LoRa bandwidth is BW500 kHz. Both Figures illustrate that more than two channels are affected in different degree when the BW is increased. This happen because the channels in IEEE 802.15.4g are 200 kHz wide and that means that LoRa collides with two channels and part of a third. But the most interesting observation is in Figure 3. For spreading factor SF7 we observed very high PRR values for both 8 and 12 dBm transmit powers in IEEE 802.15.4g. The fact that the power in LoRa is higher than the power in IEEE 802.15.4g and we have a high PRR, gives extra value to the observation. This results suggests that there are complex interactions between the two networks' different modulation schemes.

We believe that these observations are interesting because they can be used in a IEEE 802.15.4g network collision avoidance mechanism and provide reliability and robustness to the higher layers which is one part of our future work.

IV. ACKNOWLEDGMENTS

This work has partly been carried out within the Swedish strategic innovation program on Internet of Things, which is a joint effort between VINNOVA, Formas, and the Swedish Energy Agency.

REFERENCES

[1] "LoRa," https://www.lora-alliance.org.
[2] "Sigfox," https://www.sigfox.com.
[3] "Weightless open standard," http://www.weightless.org/.
[4] M. Bor, U. Roedig, T. Voigt, and J. Alonso, "Do LoRa low-power wide-area networks scale?" in *19th ACM Int'l Conf on Modeling, Analysis and Simulation of Wireless and Mobile Systems*, ser. MSWiM '16, 2016.
[5] O. Georgiou and U. Raza, "Low power wide area network analysis: Can LoRa scale?" in *arXiv preprint arXiv:1610.04793*, 2016.
[6] M. Bor, J. Vidler, and U. Roedig, "LoRa for the Internet of Things," in *Int'l Conf on Embedded Wireless Systems and Networks*, ser. EWSN '16, 2016.