LoRa Indoor Performance: an Office Environment Case Study

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***Abstract*—When deploying wireless sensor networks in smart buildings, low-power, long-range communication technologies such as LoRa may offer a reliable, low data-rate alternative to existing wireless technologies. For this contribution, custom-built LoRa nodes were used to measure LoRa propagation characteristics for both the 434 MHz and 868 MHz ISM-bands. These measurements show that the presence of people has a negative impact on the quality of the LoRa link and confirm the superiority of the 434 MHz band for indoor LoRa communication.**

I. Introduction

Owing to the continuous development of the Internet of Things (IoT), smart buildings are a hot topic in today's wireless communication research. In contrast to applications using already widely distributed high data-rate connections such as WiFi, a lot of smart building applications can be realized using low data-rate wireless sensor networks. In this field, low-power, long-range wireless communication technologies such as LoRa [1] are gaining a lot of popularity.

LoRa is a modulation technology that encodes data in wideband frequency modulated pulses called *chirps*. Using this technique, packets can be received at extremely low levels of signal-to-noise ratio (SNR). This contribution presents a performance test of LoRa in a regular office environment. To this end, an indoor measurement setup was used to gather channel measurement data for multiple days on end. The wireless sensor nodes used for this are custom-built LoRa nodes that can send and receive packets in both the $434\,\mathrm{MHz}$ and $868\,\mathrm{MHz}$ ISM-bands. To our knowledge, no literature exists comparing the performance of these bands for indoor LoRa applications as earlier research focuses almost exclusively on the use of LoRa modulation in the $868\,\mathrm{MHz}$ ISM-band. [2]–[6]

In section II of this paper, the measurement setup is discussed briefly. Subsequently, the measurement results are presented and discussed in section III. Finally, in section IV, a conclusion to this work is formulated.

II. Measurement setup

A. Node placement & propagation environment

Nodes were placed in two rooms, located on two nearly identical floors of the recently built iGent building in Ghent, Belgium. Every floor of this building features a very thick concrete core with multiple elevator shafts and stairwells. This

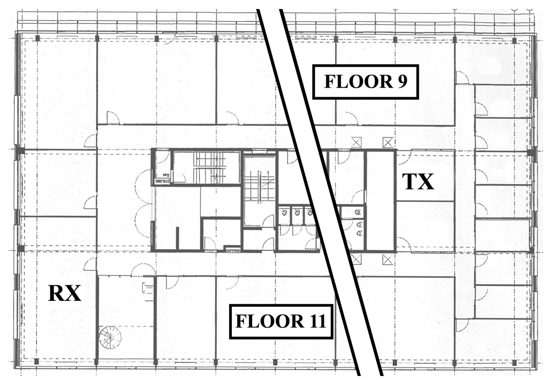

Fig. 1: Transmitter and receiver locations.

core is surrounded by a hallway, which is in turn surrounded by offices. The transmitter was placed in a meeting room on the ninth floor, adjacent to the concrete core of the building.

A receiver was placed in an office on the eleventh floor, on the other side of the building. This location was chosen specifically because radio waves have to propagate through or around the core of the building to reach this receiver.

B. Custom LoRa nodes

The LoRa nodes used for this research contribution were developed specifically for LoRa channel measurement purposes. They are built around a low-power, 8-bit microcontroller and an RN2483 LoRa transceiver by Microchip Technology Inc. This commercially available LoRa radio offers communication in both the $434\,\mathrm{MHz}$ and $868\,\mathrm{MHz}$ ISM-bands as well as channel measurement functionality. At the transmitter's side two ground plane monopole antennas are used and at the receiver end, the node is attached to two j-pole antennas. All antennas have return losses lower than $-10\,\mathrm{dB}$ at their intended resonance frequencies.

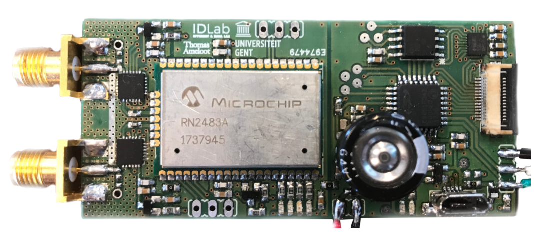

Fig. 2: The custom-built LoRa node.

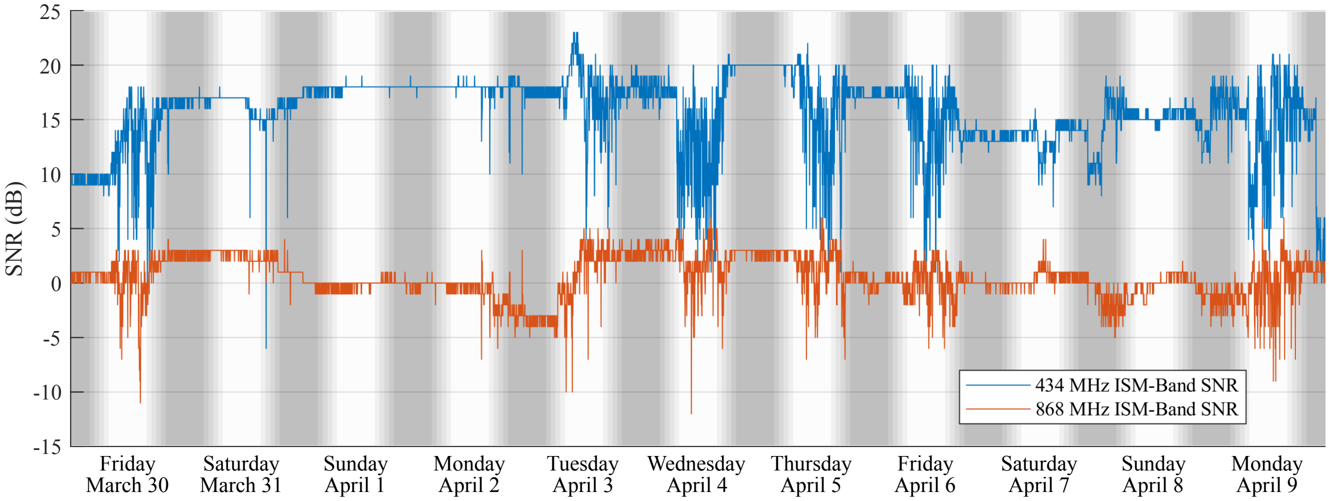

Fig. 3: 11 days of SNR measurements in the $434\,\mathrm{MHz}$ and $868\,\mathrm{MHz}$ ISM-bands.

C. *Packet contents*

The transmitter continuously transmits short packets describing their own packet number, the time and date, the ambient temperature and the available supply voltage. At the receiver end of the communication link, the SNRs of the received packets are measured and all relevant packet data is stored in the external flash memory included on the node.

III. Analysis

SNR measurements were gathered during an 11-day period. They are visualized in Fig. 3. On the first day of measurement (30/03) the SNR data fluctuate considerably, but remain well above the detection threshold of $-20\,\mathrm{dB}$. The SNR values are however very stable during the next 3 days. These days correspond to this year's Easter weekend, during which the building was empty. In the following days, the SNR values again fluctuate extensively during working hours. After a weekend with more stable SNRs, fluctuations reappear.

To properly describe this behavior, the mean values and standard deviations of the SNR data are calculated for intervals of 8 hours during the day (9 a.m. - 5 p.m.) and during the night (9 p.m. - 5 a.m.) and averaged for subsets describing both intervals on work days and on weekend days (Easter Monday included). These data, presented in Table I, clearly show that the presence of people in the building has an unmistakable influence on the quality of the LoRa link. Besides, when comparing the overall mean values of the SNRs at $434\,\mathrm{MHz}$ ($\mu_{434} = 15.27\,\mathrm{dB}$) to those at $868\,\mathrm{MHz}$ ($\mu_{868} = 0.42\,\mathrm{dB}$), it can be concluded that thanks to its superior propagation characteristics such as better penetration through walls, the $434\,\mathrm{MHz}$ band is the better candidate for indoor LoRa communication.

TABLE I: Descriptive statistics on the SNR data.

	$434\,\mathrm{MHz}$		$868\,\mathrm{MHz}$	
	$\bar{\mu}$	$\bar{\sigma}$	$\bar{\mu}$	$\bar{\sigma}$
On WORK DAYS, by DAY	14.21	4.006	0.918	2.108
After WORK DAYS, at NIGHT	17.09	0.454	1.654	0.470
In the WEEKEND, by DAY	16.05	0.803	0.533	0.688
In the WEEKEND, at NIGHT	16.40	1.368	-1.109	0.851

All values expressed in dB.

IV. Conclusion

A custom-built LoRa node was used to gather SNR measurements on LoRa packets sent through a modern building on both the 434 and $868\,\mathrm{MHz}$ ISM-band. As could be expected, the interpretation of the results of these measurements lead to the conclusion that the $434\,\mathrm{MHz}$ ISM-band is more suitable for indoor LoRa communication than the $868\,\mathrm{MHz}$ ISM-band. Additionally, the SNR data also indicate a strong increase in SNR fluctuations and a decrease in overall SNR whenever people are present in the building. In other words: the quality of service (QoS) decreases when people are around.

ACKNOWLEDGEMENT

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References

[1] LoRa Alliance, https://www.lora-alliance.org/.

[2] J. Petäjäjärvi, K. Mikhaylov, R. Yasmin, M. Hämäläinen, and J. Iinatti, "Evaluation of LoRa LPWAN technology for indoor remote health and wellbeing monitoring," *International Journal of Wireless Information Networks*, vol. 24, no. 2, pp. 153–165, Jun 2017.

[3] L. Gregora, L. Vojtech, and M. Neruda, "Indoor signal propagation of LoRa technology," in *2016 17th International Conference on Mechatronics - Mechatronika (ME)*, Dec 2016, pp. 1–4.

[4] J. Haxhibeqiri, A. Karaağaç, F. Van den Abeele, W. Joseph, I. Moerman, and J. Hoebeke, "Lora indoor coverage and performance in an industrial environment : case study," 2017, pp. 1–8.

[5] L. H. Trinh, V. X. Bui, F. Ferrero, T. Q. K. Nguyen, and M. H. Le, "Signal propagation of LoRa technology using for smart building applications," in *2017 IEEE Conference on Antenna Measurements Applications (CAMA)*, Dec 2017, pp. 381–384.

[6] S. Hosseinzadeh, H. Larijani, K. Curtis, A. Wixted, and A. Amini, "Empirical propagation performance evaluation of LoRa for indoor environment," in *2017 IEEE 15th International Conference on Industrial Informatics (INDIN)*, July 2017, pp. 26–31.