An Experimental Study on the use of LoRa Technology in Vehicle Communication

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ABSTRACT: Among the profound changes that will come with the Internet of Things is vehicular communication. Shortly the vehicles will be connected between themselves (V2V) and their infrastructure. For the full achievement of these objectives, the challenges of new technologies are enormous due to the requirement of high reliability, high speed, and low latency. None of the technologies under development for this application has reached a satisfactory stage be assumed to as definitive. The LoRa technology, operating at frequencies below 1 GHz, presents a good signal spread and penetration in obstacles. It has a considerable range, open-source, simple, robust, and low-cost hardware, vast configuration possibilities, and applications, ranging from medicine to agriculture, do not use licensed bands.

INDEX TERMS Genetic algorithms, LoRa, vehicular communication, V2I, V2V.

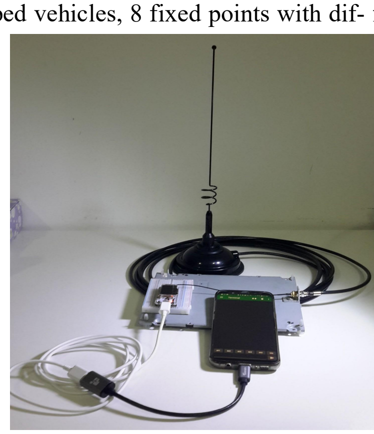
I. INTRODUCTION

Vehicle communication is a fact, a path of no return. Vehicles, soon, will be more efficient and more connected to each other, constituting the so-called vehicle-to-vehicle (V2V) and vehicle to infrastructure (V2I) communication [1], [2]. At the current stage, with the technologies available, the challenges are immense. Information exchange will require too high speeds, reliability, and extremely low latency time for networks in specific applications. Some technologies are already in satisfactory development stages, but none has yet to become the definitive solution. For several applications, DSRC (Dedicated Short Range Communications) operating at the 5.9 GHz emerges as a possible solution for vehicular communication, which has already been assumed standard in some countries [3], [4]. However, it has great limitations due to its low reach and penetration [5], [6].

A technology with possibilities to minimize these effects is LoRa (Long Range), which has a greater range in signal propagation and a better penetration in obstacles since it operates at frequencies below 1.0 GHz and can be viable in applications that demand the transmission. Also, short messages, few characters, and situations in which it is not necessary to send frequent packets of information [7], [8].
model AP3900 [21] with a gain of 5.15 dBi was connected to the device.

Data storage and obtaining each vehicle coordinate were performed using an Android device connected to the board by serial cable, Fig. 3.

For tests with stopped vehicles, 8 fixed points with dif- ferent types of obstructions, Fig. 4. The vehicle with



the receiver remained parked, first at point P5, which has the lowest simulated reception ratio. The other vehicle with the transmitter went through the rest of the points, stopping at each one long enough to transmit 150 packets. Then, the transmitter moved to the point P8, the best-simulated reception point, repeated the procedure similarly. Discarded data on vehicle movements between points. Data acquisition was performed considering parameters SF7 and SF12, thus totaling four measurement results.

In this data collection procedure, the bandwidth with the lowest susceptibility to errors and highest sensitivity (125 kHz) was considered; the CR (4/5) was used, which provides faster reception time, calibrated the transmission power to the maximum value allowed by the hardware.

Then, the V2I tests were performed with one vehicle stopped and the other circulating through the streets of the campus and surroundings. Finally, tests were made with both vehicles in free random movement (V2V) within the campus and one of the vehicles also covered its surroundings.

Data collection for V2I and V2V was performed by send- ing the message containing the GPS coordinates, the receiver stores the RSSI (Received Signal Strength Indicator) and SNR (Signal to Noise Ratio) of the received message. This process was repeated in a loop during the tests, and for each SF (SF7 and SF12) configuration independent tests were performed, the path and traffic situations were as similar as possible in all tests.

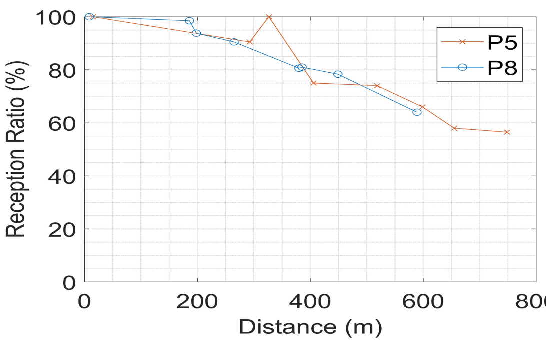
RESULTS AND DISCUSSION

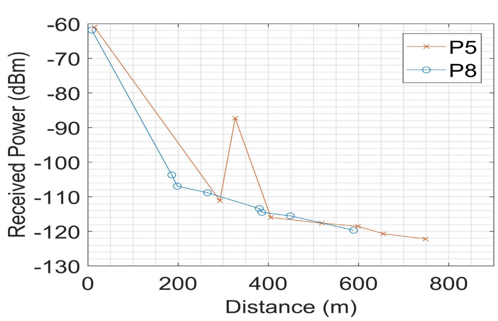
In this Section, the outcomes obtained in the simulations and field tests are presented.

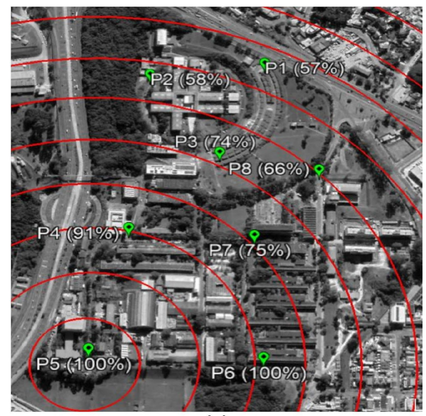
A. *SIMULATION*

1) VEHICLES STOPPED

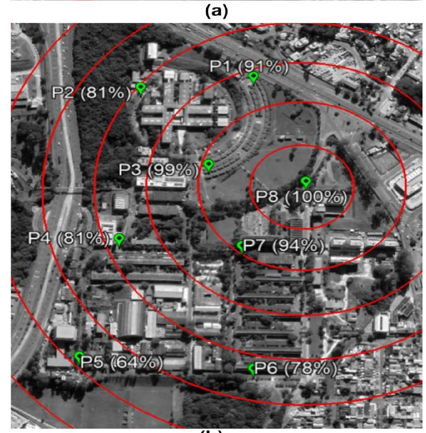
In this stage, carried out the tests were carried out within the limits of the UFPR campus with a maximum radius of 800 m.







(a)



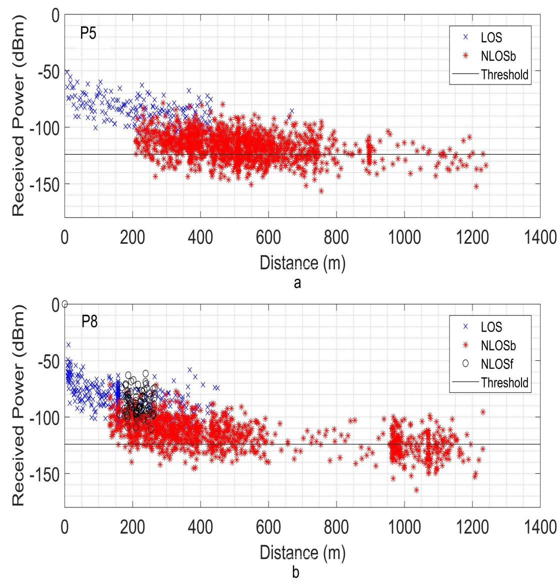
(b)

In the communication between links P5-P6 and P5-P4, Fig. 5a, it is possible to recognize the influence of the type of obstruction, LOS and NLOS respectively, even at similar distances there is a decrease in the reception ratio of 9%. The same can be seen in Fig. 5b between links P8-P3 and P8-P7. Above, in Fig. 6, is shown the simulated average of the powers received from all points transmitting to the vehicle parked first at point P5 and then at point P8. The peak power received at 326 m regarding the P5 - P6 link is due to the direct sight (LOS) between the transmitter and receiver. It should be noted that during the vehicle's movement between the points there is no measured signal.

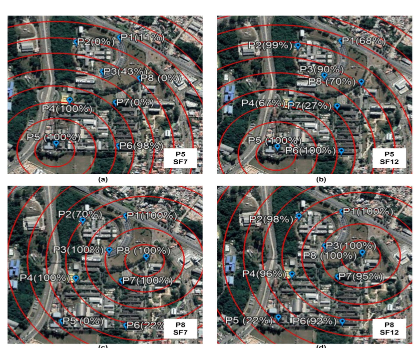
In the GEMV^2 simulator, it is not possible to consider the topography of the terrain. The signal decay is due to attenua- tion caused by the distance, environment's obstructions, and morphology; this leads to a similar curve for both P5 and P8, Fig. 7.

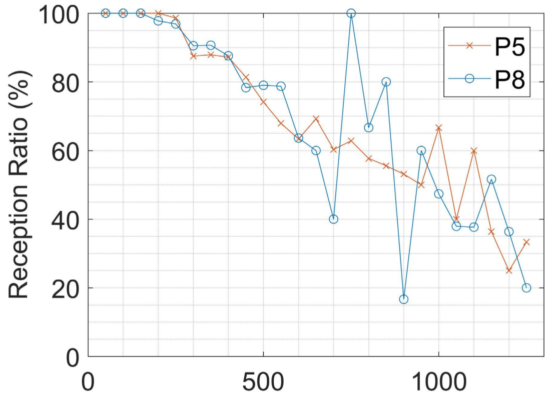
2) V2I

The channel simulation was carried out in the UFPR cam- pus area, evaluating the power received as a function of the distance and each type of obstruction, as well as the percentage of the signal received above the reception threshold.



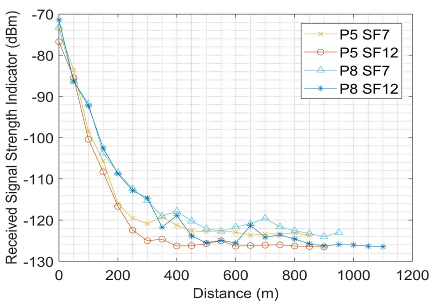
It is observed that reception at points close to the base, up to approximately 200 m, is formed by signals with direct sight (LOS) and is substantially above the reception threshold.

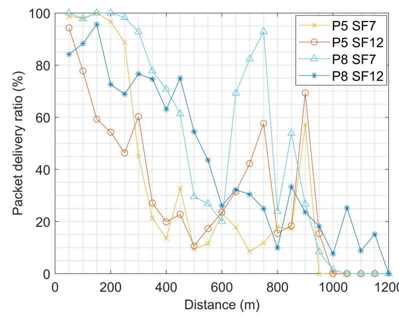


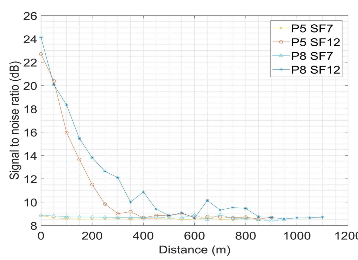


From this distance, in the simulated urban environment, the NLOS signal's effects caused by the large concentration of different types of obstructions along the link becomes dominant, as shown in Fig. 8.

In Fig. 9, the simulated level of the received signal with power above the reception threshold (124 dBm) occurs in spaces with traffic close to the points P5 and P8 (200 m),







LoRa proved to be sensitive to the effect of speed concern- ing the RSSI of the received signal; the Doppler effect can explain this. A lower SF leads to less sensitivity to this effect, which partly compensates for the higher reception threshold and practically matches the highest SF when considering the totality of measurements.

With the data measured in the field test, calculated the percentages of the transmitted, and received signals; these values are shown in Fig. 15.

In the situation under analysis, the use of SF7 decreases the signal reception ratio, but at shorter distances, the reception ratio is significantly higher than for SF12, this is due to the lower sensitivity of SF7 to the Doppler Effect. Considering

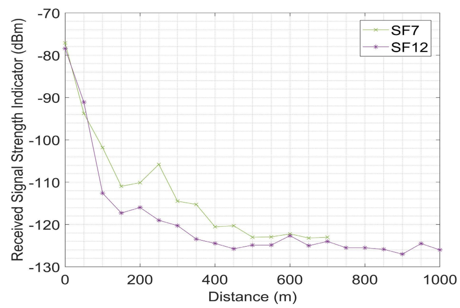
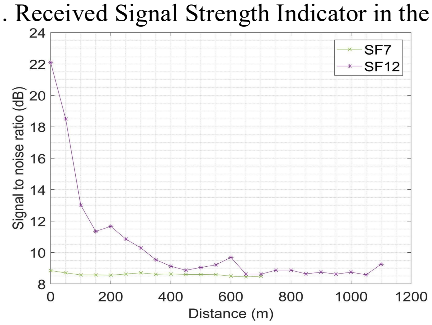


FIGURE . Received Signal Strength Indicator in the V2V test.



B. DISCUSSION

In this work, LoRa technology was analyzed in appli- cations with two vehicles stopped at different points (point-to-point), V2I and V2V, by simulation and field measurements.

In the simulations carried out, the objective was to evaluate the communication channel for LoRa, that is, generate no network traffic. In measurements made in the field, limited the traffic to two vehicles.

LoRa technology is more efficient in applications that require few characters in transmission and in situations where it is not necessary to send packets frequently due to its lower transmission rate and operational restrictions, such as accident alerts, information on the level of vehicle traffic and points of interest, especially in larger regions with a high density of buildings and obstructions.

LoRa, even with low transmission capacity and the lim- ited size of transmitted messages, specifically in vehicular communication, has great versatility in various application possibilities such as increased traffic safety, vehicle flow optimization, vehicle network, transit area control network- ing. Because it has low-cost hardware, it becomes a viable solution that will possibly be used on a large scale.

III.CONCLUSION

In this research, minimizing energy which is wasted in street light was ensured. It automates functionalities according to requirements of road and vehicle with valuable information being presented in the led screen present in the poles at certain places. The paper also describes how manual surveillance is reduced on the poles; faulty ones are detected and easily repaired or replaced. Conclusively, it was found out that deploying smart streetlight management system with the help of LoRa technology saves energy, cost and also help saves the environment.

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