A Comparative Study of Performance Analysis of Empirical Propagation Models for NB-IoT Protocol in Suburban Scenarios

AUTHORS: FRANCINE C. OLIVEIRA, JOSÉ MARCOS C. BRITO

PRESENTER: FRANCINE C. OLIVEIRA

NATIONAL INSTITUTE OF TELECOMMUNICATIONS

FRANCINE.CASSIA@MTEL.INATEL.BR

Presenter

Francine C. Oliveira was born in Santa Rita do Sapucaí, Brazil on August 11, 1988. Technician in Telecommunications at the Technical School of Electronics Francisco Moreira da Costa in 2005, graduated in Electrical Engineer with emphasis in Telecommunications at INATEL - Instituto Nacional de Telecomunicações in July 2011, Specialist in Project Management formed by FGV - Fundação Getúlio Vargas in 2013. Student of the Master's course at INATEL.

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Introduction

The Narrow Band-Internet of Things (NB-IoT) is one of the most relevant protocols for IoT applications.

One of the points questioned for every protocol, is the ability to serve applications that are in a mobile environment.

To validate the possibility of the protocol working in this scenario, it is necessary to evaluate its performance in different propagation environments.

This article presents field measurements that were made on an NB-IoT operational network in a suburban environment.

Motivation

Comparative analysis between real environments and empirical propagation models prove to be quite relevant for different protocols and technologies. They have a significant contribution to network planning and performance analysis of the adopted parameters.

Unlike protocols that operate in unlicensed frequency bands, protocols based on mobile communications networks, such as NB-IoT, are promising technologies developed to support massive deployments, with reduced data rates and narrow bandwidth. However, its performance in mobile environments is not widely explored.

The main objective of this study is to analyze the performance of the NB-IoT protocol in mobile environments.

Propagation Models

Three propagation models used for this study:

- Cost-231 Hata
- ITU-R 1225
- Erceg Greenstein

Field Test Measurements

The scenario used in carrying out the measurements has a suburban profile with small obstructions caused by some low-rise buildings and constructions.

The relief variation is approximately 50 meters. Twenty experiments were carried out on three routes within the city of Santa Rita do Sapucaí, and one route on the BR-459 highway in order to validate the behavior of the protocol at higher speeds, totaling the collection of 3000 samples.

All routes started at the same location, a few meters from the tower where the transmitting antenna was installed.

Field Test Measurements

The routes carried out within the city covered 11 km, 6.5 km and 8.7 km for routes 1, 2 and 3, respectively. For these, the average travel speed was 30 km/h. The route carried out on the highway covered 15 km, at speeds of 40km/h, 60 km/h and 80 km/h. Figures illustrate the routes used in the experiments.

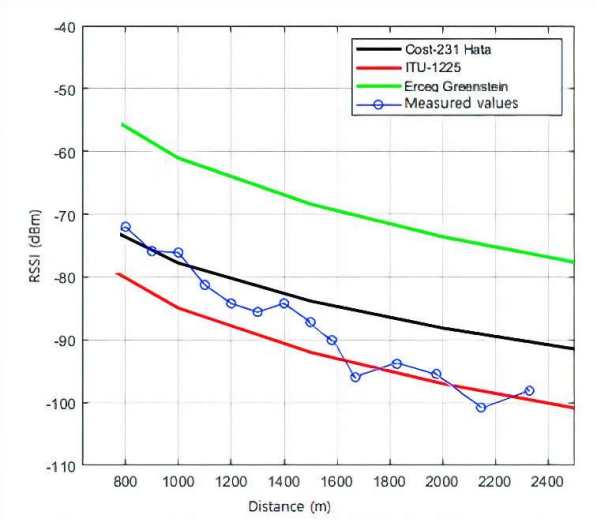
Performance Analysis

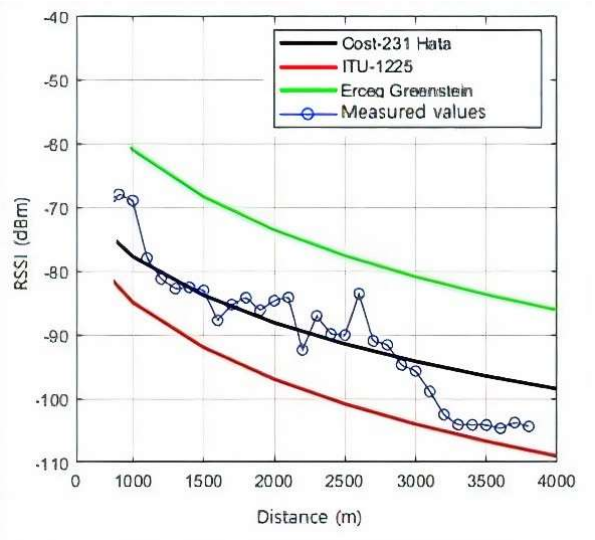
Parameter	Values
Frequency of operation (MHz)	1800
Device antenna height (m)	1
Maximum distance between Tx and Rx (m)	4000
Basestation Antenna Height (m)	40

Conditions inserted in each propagation model for each route.

Performance Analysis

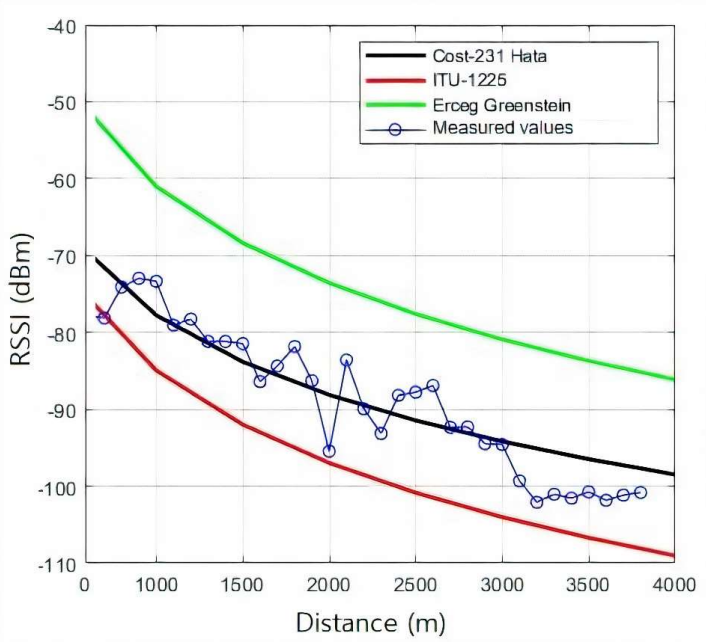
Figures below show the average RSSI measured and the RSSI computed using the propagation models for suburban routes 1 and 2. The behavior of the RSSI measurements are relatively similar in all these routes as the device moves away from the transmitting antenna.





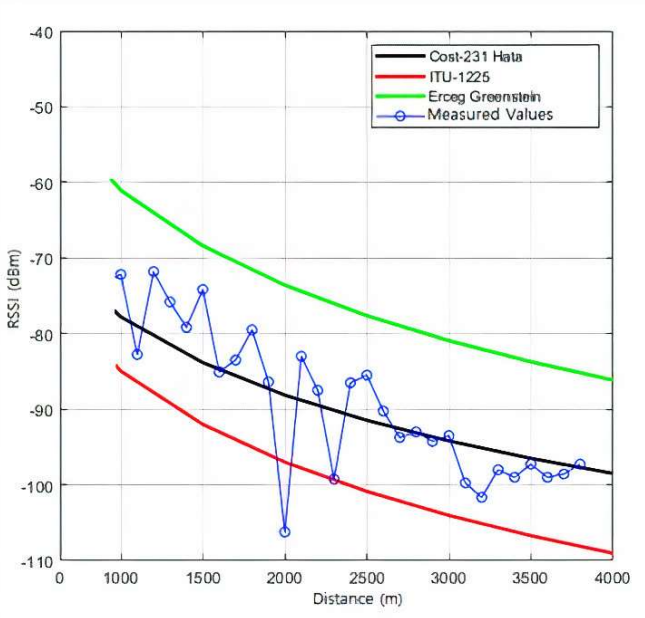
Performance Analysis

RSSI grouping all samples of all urban routes.



Performance Analysis

In the route taken on the highway, the protocols behavior is different, and there is a sharp drop in the collection of samples after the distance of 2000m. As the average speed of travel of the device in this route is from 60 to 80 km/h, it is proved that the performance of NB-IoT in scenarios with mobility for medium to high speed is not efficient, which can impact the use of this protocol in mobile applications.



Performance Analysis

The Mean Absolute Error (MAE) which measures the average of all absolute errors between the measured values and the calculated results from the propagation models.

The performance of each propagation model is presented below:

Error Parameter	MAEs
Cost-231 Hata	3,588488
ITU-1225	8,568521
ERCEG GREENSTEIN	14,74494

Conclusion and Future Works

The results presented by the Erceg-Greenstein model are not accurate for all considered routes. The ITU-R 1225 model has good performance for long distances on some routes. The best results are presented by the Cost-231 Hata model, which is confirmed using the MAE metric.

The protocol behaves differently on the route taken on the highway, and a stable communication link could not be established. Thus, the performance of NB-IoT for environments with medium to high speeds is not efficient.

The future works include analysis made with other protocols with similar characteristics to NB-IoT, such as LoRa, in the same scenarios and conditions, to compare the performance between both technologies.

References

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And more…

Questions?

Thanks for listening

E-mail: francine.cassia@mtel.inatel.br