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NB-IoT Power Consumption: A Comparison of SFR and Objenious Network Operators

1st Nassim LABDAOUI
Watteco
Hennebont, FRANCE
nlabdaoui@watteco.fr

2nd Fabienne NOUVEL
Institut d'Electronique et des Technologies du numéRique
Rennes, FRANCE
Fabienne.Nouvel@insa-rennes.fr

3rd Stéphane DUTERTRE
Watteco
Hennebont, FRANCE
sdutertre@watteco.fr

Abstract—This paper presents a comparative analysis of the energy performance of an NB-IoT cellular module with two different operators. The study highlights the significant impact that the choice of operator can have on the energy consumption of the module in a given environment, adding another layer of complexity to the challenge of optimizing sensor fleet autonomy. The results also demonstrate that the payload size has a minimal effect in outdoor or unconstrained indoor environments, but has a considerable impact in deep indoor environments with high signal attenuation. This study provides valuable insights for IoT device manufacturers and network operators looking to optimize energy efficiency in their deployments.

Index Terms—NB-IoT, Battery lifetime, Energy Consumption, CIoT.

I. INTRODUCTION

NB-IoT is an IoT communication standard, standardized in 2016 [1], operating as a Low Power Wide Area Network (LPWAN) designed for long-range, low-power communication of large volumes of data. It operates on the old GSM network using a 200 kHz frequency band and can also operate within an LTE network or independently. The standard offers download and upload speeds of 20 to 250 Kbit/s with a latency of approximately 10 seconds.

This paper compares the power consumption of the Evaluation Board Quectel BG77 Quectel BG77 [2] cellular module connected to the NB-IoT network recently deployed by two operators: SFR and Objenious. Several studies have investigated the energy usage of NB-IoT devices. One such study [3] used a NB-IoT device to perform empirical measurements. However, the study's reliance on a Keysight UXM NB-IoT base station emulator means that the results may not reflect real-world network conditions.

The study conducted in [4] analyzed the power consumption of u-blox SARA-N211 and Quectel BC95-C NB-IoT cellular modules. Nonetheless, its findings may not fully represent real-world NB-IoT terminal behavior since the study only focused on power consumption during data transmission phases and PSM (Power Saving Mode). Crucial phases such as attachment to the NB-IoT network, TAU expiration, and connection to the application server were ignored. Therefore, the projected battery life of 9-10 years with a 3.6 Ah battery for a single transmission per hour may not be accurate. Our analysis encompasses all operational stages, including network attachment, data transmission, server connection and disconnection,

eDRX (Extended Discontinuous Reception) mode, and PSM. We also conduct a comparative analysis of the battery life of the SFR and Objenious operators. The rest of the paper is organized as follows: In Section II we describe the experimental setup for measuring current consumption. Section III presents the results obtained from the experiments and a comparison between the SFR and Objenious NB-IoT networks. Finally, we conclude the paper with a summary of our findings.

II. EXPERIMENTATION AND BATTERY LIFETIME ESTIMATION

In order to assess the energy efficiency of NB-IoT cellular modules across different operators, we conducted a series of communication tests and current measurements in various environments using attenuators (10 dB, 20 dB, and 30 dB). Specifically, we measured the current consumption and the duration of the attachment to the NB-IoT network, and also investigated the impact of data size on terminal autonomy by conducting tests with both SFR and Objenious operators. For these tests, we sent 30 data packets at regular intervals and measured both the average current consumption and transmission duration, enabling a comprehensive evaluation of the energy efficiency of the two operators.

In a typical scenario, NB-IoT node initiates a network attachment procedure and establishes a connection to an MQTT server to publish data, before disconnecting. Depending on the specific use case, the module may then switch to eDRX mode for a specified period of time (T_{3324} seconds). Afterwards, the module enter PSM for a duration of $T_{3412} - T_{3324}$ seconds. The average current consumption of the radio module is calculated using equation 1, where \bar{I}_n represents the average current for each phase and T_n represents the corresponding time duration.

$$\bar{I}_{Module} = \frac{1}{T_{Total}} \times \sum \bar{I}_n \times T_n \quad (1)$$

Battery life is then estimated using equation 2

$$T_{Life\ Time} = \frac{C_{Bat} \times SD_{Bat}}{\bar{I}_{Module} + \bar{I}_{Components}} \quad (2)$$

We assume that the terminal is powered by a Lithium Thionyl Chloride (Li-SOCl₂) battery with a capacity of

$C_{Bat} = 3.6 Ah$ and a self-discharge factor of $SD_{Bat} = 0.75$. Assuming that $\bar{I}_{components}$ the average current consumed by all other components is in the range of a few μA , we will neglect it in our calculation.

III. RESULTS

This section provides a summary of the results obtained. Fig. 1 depicts the battery lifetime of the Quectel BG77 module under different coverage conditions when sending 128 bytes, as measured with two different operators. The results reveal how the choice of operator and the converge environments can impact the overall autonomy of the node.

The battery life appears to be contingent on the operator it is connected to. For instance, if a 128-byte packet is transmitted every 24 hours, the lifespan of a terminal operating on SFR’s NB-IoT network is 4.9 years, compared to 6.28 years when it is connected to the Objenious NB-IoT network.

The analysis of the Quectel BG77 module reveals a significant loss of autonomy when connected to SFR’s NB-IoT network: at 10 dB of attenuation, the loss is 21%, increasing to 23% at 20 dB and 30.44% at 30 dB. In contrast, for Objenious’s NB-IoT network, the impact of 10 dB and 20 dB attenuations is minimal, with losses of 2.54% and 5.41%, respectively. However, the module experiences a substantial 49.52% loss of autonomy at 30 dB of attenuation.

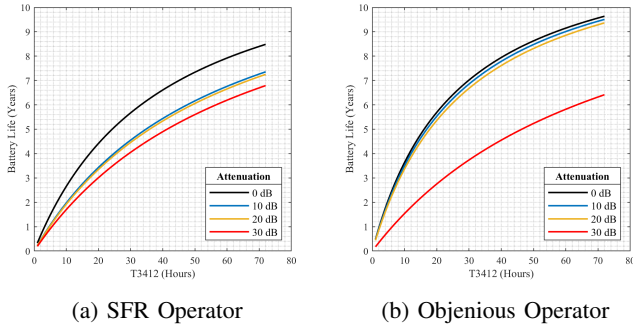


Fig. 1: Evaluating the Impact of NB-IoT Coverage on Battery Lifetime. ($T_{eDRX} = 6 seconds$), Data Size = 128 Bytes

Fig. 2 provides an illustration of the impact of data size and coverage conditions on the autonomy of a terminal operating on SFR and Objenious NB-IoT network. In indoor environments, increasing the size of the data has minimal effect on the overall autonomy of the terminal. However, for the SFR operator under unfavorable conditions with 10dB, 20dB, and 30dB of attenuation, there is a significant difference in autonomy between scenarios with a sending of 128 bytes and 4096 bytes, with a difference of up to 9 months.

In constrained indoor conditions with 30 dB attenuation, the difference in lifetime between scenarios with 128 bytes and 4096 bytes is around 6 months for Objenious operator. However, data size does not significantly affect Objenious operator in indoor environments with 10 dB and 20 dB attenuation.

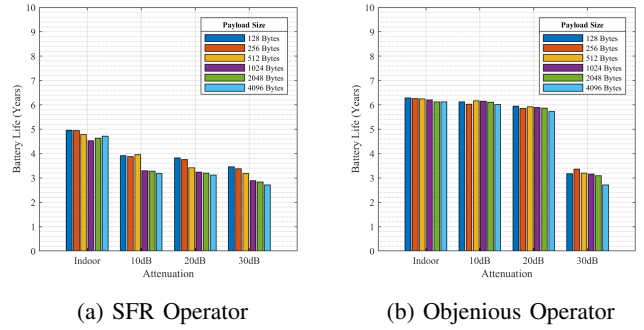


Fig. 2: Evaluating the Impact of NB-IoT Coverage and data size on Battery Lifetime. ($T_{eDRX} = 6 seconds$, $T_{3412} = 24 hours$)

IV. CONCLUSION

This study highlights the impact of the environment on the location of an IoT module in relation to the base station. It shows that beyond a certain level of signal attenuation, the operator may require the module to use a more energy-intensive transmission mode via the ECL (Coverage Enhancement Level) and increase the number of frame repetitions, resulting in a significant increase in energy consumption.

Moreover, the research findings reveal that data size has little impact on energy consumption in outdoor or unconstrained indoor environments, but has a significant impact in deep-indoor environments with high signal attenuation. This emphasizes that even though NB-IoT and LTE-M offer higher throughput compared to OG technologies like SigFox and LoRaWAN, the format of data and application protocols used need to be considered when determining the amount of data to be transferred.

In addition, this study demonstrates that the deployment environment and operator choice can significantly impact the energy consumption of an IoT module, as the operator may switch the module to a more energy-intensive transmission mode beyond a certain signal attenuation level. These findings add another layer of complexity to achieving optimal autonomy for a fleet of sensors, making it necessary to carefully consider the deployment environment and operator choice when planning IoT projects.

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