Chapter 2
An Overview of Narrowband Internet of Things (NB-IoT) in the Modern Era

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ABSTRACT

NB-IoT is the most suitable mobile network technology for IoT applications that require exceptionally extensive coverage added with extremely low power consumption, since these applications will generally be characterized by low data rates and moderate reaction times, usually in a few seconds, enabling the creation and development of solutions aimed at smart cities and smart environments. The NB-IoT technology can be characterized as a cellular LPWAN technology operating in a downlink within a bandwidth of 180 kHz and a sub-carrier space of 15 kHz and in the uplink, in general with a single tone transmission ranging between 3.75 kHz or 15 kHz, using coverage enhancement techniques, with characteristics of battery life for more than a decade and with specific battery-saving features. The ease that technological solutions of internet of things (IoT) make available through applications connected through intelligent sensors in traffic lights and parking lots; city pollution sensors; meters for energy, water, and sewage in cities, among other possibilities make systems more efficient, considering NB-IoT connectivity in relation to the treatment of information collected by devices allowing applications to be developed to address market needs. Therefore, this chapter aims to provide an updated discussion on narrowband technologies in the context of the IoT, showing and approaching its success, with a concise bibliographic background, categorizing and synthesizing the technological potential.

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INTRODUCTION

The advantages of broadband connection are widely known, either through cable or even over a wireless network, allowing for high-speed internet browsing. However, in IoT (Internet of Things) thinking in smart cities is fundamental, considering a transit system in which sensors scattered throughout the city indicate in real-time where there is free parking space, or show the public transport user what the faster option to reach a certain location. In companies, the concept of IoT can be applied to smart grids that promote more efficient energy consumption and even monitor pollution. In the IoT, a farmer can bring different benefits provided by irrigation systems that take into account data from soil moisture. Thus, it is possible to notice the numerous possibilities of the application of IoT. However, if this technology becomes even more real, it is necessary to efficiently connect this huge amount of devices and sensors, responsible for the generation and transmission of data, so that this structure is reliable, durable and affordable. In this regard comes the narrowband Internet of things, known as NB-IoT (Mekki et al., 2019, Ayoub et al., 2018, Wortmann et al., 2015, Xia et al., 2012).

Since the core of IoT is perception, acquisition, and data transmission. Data can be perceived and acquired through intelligent devices, monitoring devices, and sensor integrated terminals. Connecting devices that greatly improve operational efficiency by creating and delivering tremendous social value. Narrowband IoT (NB-IoT) offers broad coverage, a large number of connections, low data rates, low costs, low power consumption, and optimized architecture. Responds perfectly to the need for IoT deployment in various industries (Boisguene et al., 2017, Gubbi et al., 2013, Zanella et al., 2014).

However, first, it is necessary to understand the LPWAN technology, which designates Low Power Wide Area Network, which are networks that were developed precisely to connect millions of "things", in wide areas, with devices that need to transmit very specific data, in a process that consumes much less battery. One LPWAN option is NB-IoT, which is a variant of 4G, with other options like SigFox and LoRa (Long Range). The definition of which one is the most appropriate will depend on the analysis of various characteristics of each project. Overall, they all significantly reduce the power consumption of devices that send small amounts of data, which can last at least ten years without requiring battery replacement, allowing connections up to 10 kilometers away. Since then, NB-IoT has been gradually adopted in IoT-related projects in several countries, including Brazil, in order to make it possible to offer IoT services, focusing initially on smart cities (Zhang et al., 2018, Atzori et al., 2010).

In this context, there are several types of LPWAN networks that are differentiated by the type of modulation they use. So, there are those that use ultra-narrowband, narrowband, and broadband. In the ultra-narrow band, it takes advantage of the fact that by narrowing the transmitted band, the noise floor increases which has a positive impact on receiver sensitivity, range and also allows for lower transmission power (Li et al., 2017, Song et al., 2017, Petrenko et al., 2018, Lauridsen et al., 2017).

However, the limitation is on data transmission capacity, which is limited at a very low rate in addition to small data packets in both one-way and two-way communications. With broadband, it's possible to achieve the highest speeds, with these reaching channels as wide as 1 MHz, in which case is achieved the highest data rate possible (Zhang et al., 2018, Atzori et al., 2010, Petrenko et al., 2018, Lauridsen et al., 2017).

For narrowband technologies, however, the advantages of ultra-narrowband and broadband are combined, which means an extra degree in the speed and size of data packets. In short, with narrowband, it is reached less power requirement for a certain range, but in return, it gets lost in speed. With wider

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