Chapter 5
NB-IoT for Localization and Target Detection

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ABSTRACT

Narrowband internet of things (NB-IoT) is a low power wide area network technology with numerous benefits over conventional technologies. The main advantages of NB-IoT are low-power, low-cost, long battery life, wider deployment, and many more. Along with these advantages, knowledge of the location of the devices for both the indoor and outdoor environments will have an added benefit for NB-IoT applications. The current global navigation satellite systems (GNSS) chipsets will drain the limited available battery and will not be useful for localization in NB-IoT applications while the global positioning system (GPS) applications accuracy is not enough to support NB-IoT applications. For NB-IoT implementation, having low per-unit cost of the devices is an important aspect along with other features mentioned earlier, and hence there is a need to have limited hardware components like processor, battery, and memory. Therefore, the main challenge for enabling a positioning system lies in the proper radio management and balancing of power consumption against the performance of the system. In this chapter, different localization methods, techniques, and metrics are discussed. The choice of each one of these depends on the application requirement. The standardization of NB-IoT is in the process and its current status as per the 3rd Generation Partnership Project (3GPP) specifications are also highlighted.

INTRODUCTION

Localization is a process of determining the position of a node in a space with respect to a reference node and tracking seeks to identify the position of an object over time (Manley et al., 2006). Localization and target detection form an important factor in present and future telecommunication systems. Its implementation is currently focused on making anything and everything smart around us. It is also been deployed in critical applications like the military guidance systems, emergency systems, disaster rescue, and recovery systems. Although GPS systems have been utilized in earlier technologies for enabling

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localization and target detection especially for navigation systems, its accuracy may not be acceptable for applications in scenarios involving locations like indoors and underground. Tremendous progress has been made in the last few years to improve localization accuracy by using various kinds of technologies. However, there is a need for developing additional location and target detection technologies for indoor and underground applications such as underground parking, smart homes, and hospitals to track commodities and people with special needs for around-the-clock monitoring, manufacturing and logistics, and outdoor applications.

Each application and scenario have unique positioning requirements with a benchmark of achieving at least 50 meters of horizontal positioning accuracy (Lin et al., 2017). NB-IoT can be widely deployed in industries and hence the localization information can then be specifically useful in fault localization and its fast repairing. Apart from this, the possibility of deployment of NB-IoT in 700 MHz, 800 MHz, and 900 MHz ultra-low frequency band provides wide coverage of indoor cellular data connection covering almost every indoor corner and even places located underground. This feature enables the NB-IoT based positioning system to not only improve the positioning accuracy but also expand the scope of the application. NB-IoT can be operated in both licensed and unlicensed spectrum. NB-IoT features low cost per unit and low power consumption, hence the deployment of NB-IoT based on a cellular network can be directly implemented in the existing Long Term Evolution (LTE) network enabling lower deployment costs. Overall, these inherent features of NB-IoT make it more suitable for the deployment and application of indoor localization. NB-IoT is thus also an attractive solution for implementation in developing countries where the resources are limited and economical solutions are always preferable (Routray & Hussein, 2019). NB-IoT results in improved robustness, durability, and positioning accuracy of the localization system.

The main objective of this chapter is to discuss the localization and target detection of NB-IoT devices. This chapter provides a detailed study of various localization methods, techniques, metrics, and applications. The geometric structure and the other signal information used for localization are presented. It describes the 3GPP standardization for the localization of NB-IoT devices. The uplink and downlink positioning techniques defined as per 3GPP standards are also described.

The remainder of the chapter is organized in eight sections. In Section 2, a literature review of localization and target detection for NB-IoT has been presented along with various research work on the use of NB-IoT in numerous applications. In Section 3, Various methods of localization and tracking are presented. In Section 4, different localization techniques are presented. In Section 5, various metrics used for localization are described. In Section 6, the current 3GPP standardization for NB-IoT localization is presented. In Section 7, the possible NB-IoT applications that use localization information are highlighted. Section 8, highlights the future research directions for NB-IoT and finally, in Section 9, the chapter is concluded with important points of NB-IoT localization and target detection.

Literature Review

Localization and target detection have been the hottest research topic for various telecommunication applications for quite a few years. In 3GPP Release 13, the limited positioning support for NB-IoT was available and with Release 14 it provided a vital extension to the positioning services for NB-IoT, after which various research directions have been approached to meet the requirements of localization and target detection for narrowband IoT. Before Release 14, there has been enough research on localization for the internet of things.