A technique to improve IoT connectivity based on NB-IoT and D2D communications

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Abstract. The Internet of Things (IoT) can be defined as an environment in which object communicates with others objects to serve a meaningful purpose. The IoT is currently one of the unprecedented research areas for professionals and researchers. Every day, the unlimited benefits that it can bring to our lives and the demand for this technology is increasing. The IoT technology has the ability to improve our quality of life by connecting many objects, which we use, to communicate and cooperate. Indeed, it is possible to enable new applications, services and business opportunities in global sectors such as Smart Cities, Smart environment, Energy conservation, Home automation, Precise Agriculture, among others. This paper presents a brief overview of the IoT and provides a technique of IoT that can improve the connectivity of the objet. Our proposals consist in taking advantage of the extended coverage of the NB-IoT to extend the coverage of the Wi-Fi zone which does not exceed a few meters.

Keywords— Internet of Things, Device to Device, NB-IoT, WI-Fi

1 Introduction

The Internet of Things (IoT) is currently a topic widely discussed and one of the unprecedented research areas treated by specialists, experts and researchers. In the mid-1980s, the Internet grew from a few interconnected PCs to billions of objects. The IoT has several advantages to develop a promising future technology characterized by some common characteristics as follows:

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• Now, the IoT objects are multiplied by billions and, present a management challenge to be able to communicate with each other [1].With the introduction of computing (algorithms, software, hardware), the IoT objects have acquired intelligence capabilities that allow them to interact intelligently in certain situations. However, the interactions between the user and the device are carried out by classical methods, for example, usual input or via graphical interfaces [2].

• In the field of sensing the IoT cannot be achieved without sensors. For example, to perceive changes in the environment or monitor buildings, etc. Although the information collected from these sensors presents an important source of information, it can provide insight into our complex environment [3].

• The high number of IoT objects presents a complex system and performing operations at this level makes the coordination process very complex in terms of memory, energy and time[4]. Also, this to create a large amount of data which raises many problems, including those related to security and confidentiality[5].

•This large number of objects makes problems of heterogeneity; objects adopting different technologies, platforms, operating systems, protocols[3].

The IoT objects are generally characterized by a limited autonomy. They are small and light with limited resources, so they are designed to operate with minimal power consumption[6].

• The connectivity which is characterized by network accessibility and compatibility can empower the IoT by bringing together everyday objects and provide new market opportunities to design applications and services more suited to users' needs [7].

The ability to self-configure IoT objects (configure themselves, can retrieve the latest software updates, etc.) allows them to work together to provide certain functionality.

Currently, the IoT is leading us to a phase where all the elements of our environment will be connected to the Internet and sometimes without human intervention [8].

The Internet of Things provides an effective solution as a common platform for connecting heterogeneous objects [9].

These objects can be equipped with different communication protocols (NB-IoT, Wi-Fi, etc.). However, in the absence of the Internet, heterogeneous objects, adapting different protocols or architectures cannot easily communicate with each other. For this we present in this paper an architecture allowing connecting heterogeneous objects.

We refer to the Device to Device (D2D) communications which will allow for direct transmissions between devices or IoT objects. Now, the communications between two devices are possible without base station contribution. Nearby devices can communicate directly with each other by establishing the direct links [10]. Several services will have to be improved, in particular, reliability, spectral efficiency, system capacity and latency within networks [11].This improvement allows designing new applications and offering several services, based on D2D technology.

The rest of this paper is organized as follows: Section II presents the related works; Section III discusses IoT layered architecture; Section IV provides our proposed solution and Section V is the conclusion.

2 IoT Communication Technologies

In this section, we present some IoT communication technologies.

2.1 ZigBee

ZigBee is a protocol invented by ZigBee Alliance. It is based on the IEEE802.15.4 low-power wireless networking standard [12]. It provides low-cost communications to create personal area networks (PANs). ZigBee is characterized by a transmission distance of around 100 m, with a data rate of around 250 kbps according to several criteria such as: output power and environmental characteristics [13]. This protocol suitable for different network topologies, such as mesh, star, and tree, is primarily intended for applications requiring low data throughput, longer battery life, and secure network devices [12].

2.2 Bluetooth

The Bluetooth short-range communication protocol is an essential element for portable products. Its Bluetooth Smart or Bluetooth Low-Energy (BLE) version makes it possible to support the reliable consumption of some IoT objects. It is integrated into Smartphone and other mobile devices [14].

2.3 Z-Wave

The Z-Wave radio frequency communication protocol is characterized by low power consumption. It is mainly used to control household wireless objects: lighting or security system, etc. Z-Wave can cover an area of 30 meters. Its data rate is of the order of 9.6/40/100 kbit/s and its frequency is of the order of 900 MHz [15].

2.4 NFC

Near Field Communication (NFC) is a protocol, characterized by very short-range wireless communication that does not exceed a few centimetres. It allows establishing simple and secure two-way communications between objects such as, Smartphone. It mainly used to perform contactless payment transactions [16].

2.5 6LoWPAN

6LoWPAN or IPv6 over Low Power Wireless Personal Area Network is a widely used communication protocol for IoT. It encapsulates long IPv6 headers in small packets that do not exceed 128 bytes. These packets are of the IEEE802.15.4 type. It is suitable for low bandwidths, different topologies, low-cost, scalable networks, etc. It is based on IP protocol and it is efficient for IP networks [17].

2.6 Wi-Fi

Wi-Fi is a wireless communication technology based on the IEEE 802.11 family of standards. It is mainly used for computer networks and for Internet access. It operates in the 2.4-5 GHz frequency band. This technology is suitable for short-range communications; therefore, it is a feasible communication solution for IoT networks [18].

2.7 Narrowband Internet of Things (NB-IOT)

Narrowband Internet of Things (NB-IoT) is an LPWAN radio technology developed by the 3GPP standards body. It can support massive connections, extended coverage and characterized by ultra-low power consumption and low cost for IoT especially in 5G. Therefore, it is a promising emerging communication technology for IoT in 5G mobile network[19]. The NB-IoT network has coverage close to mobile telephony of the order of 5km to 50km depending on the area (urban or rural) and the number of antennas [20].

3 Related works

In this section of the paper, we present some related works.

Militano et al [21] present a model of the level of trust among devices engaged in an opportunistic hop-by-hop D2D-based on content uploading scheme. Motarjemi et al [22] present a new protocol for using device-to-device communications in narrowband IoT-based systems. Gollapudi et al [23] present their idea to use the NB-IoT nodes and Device to Device (D2D) technology such as a relay to get a more accurate location by developing an algorithm to localize coarse and fine level proximity. IPopli et al [24] study the problem of maximizing energy efficiency focused on improving NB-IoT DL performance using a small cell access point (SCA) was investigated. The authors studied two SCA positioning algorithms: the Uniform Edge-Based SCA Positioning Algorithm (EUSA) and the Proposed Adaptive SCA Positioning Algorithm (ASPA). Also, they propose the model that allow saving infrastructure requirements and ensuring green farming communication. Althobaiti et al [25] propose a framework to improve the performances of the battery IoT objects and then maximizes the lifetime of the network. This proposed framework is based on NB-IoT and D2D communications.

4 Propsed solution

4.1 Problem situation

In this section of the paper, we present the problem situation. The figure 1 shows some IoT objects attempt to connect to the Wi-Fi access point (AP).We notice IoT objects that cannot connect to the network because the access point cannot support a high number of connections (it does not exceed its total capacity). However, the IoT objects cannot be served by the network (red color objects). To solve this problem, we propose to use the NB-IoT protocol and D2D communications. More details about this method will be presented in the next section.

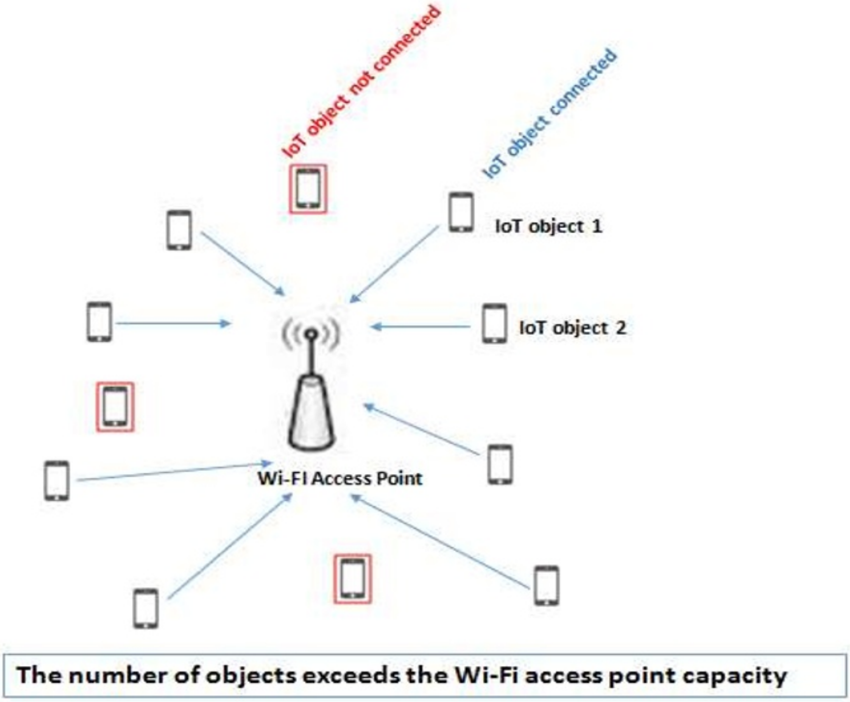

Fig. 1. Problem situation

4.2 Proposed technique

Our proposed technique consists in taking advantage of the extended coverage of the NB-IoT to extend the coverage of the Wi-Fi zone which does not exceed a few meters. For objects that are not connected to the access point (AP), they can establish a connection with the nearest object connected to the NB-IoT network using D2D technology (figure 2). First, a connection must be established with the nearby NB-IoT object via D2D communications. Then the IoT objects can send and receive data through this created link and, the communications can pass without Wi-Fi access point intervention (figure 3). This technique therefore makes it possible to extend coverage and improve connectivity in a hybrid context. Our solution compared to similar works has advantages. It is a technique that is easy to implement and does not necessarily require heavy investment. It is based on existing technologies.

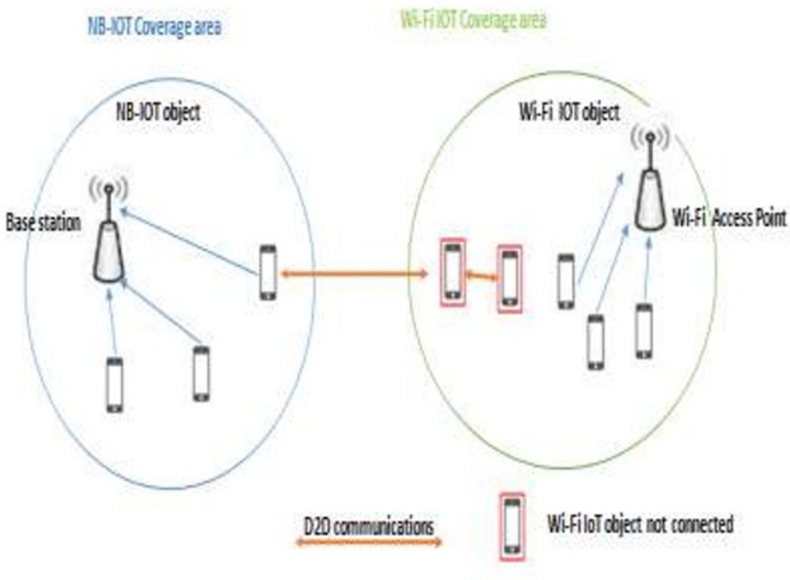

Fig. 2. Proposed technique

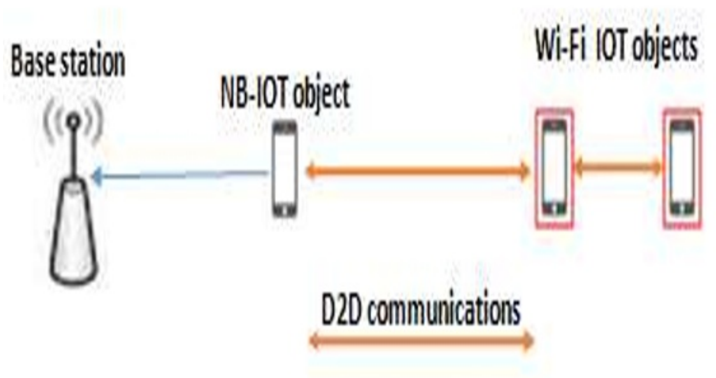

Fig. 3. Explicative scheme of the proposed technique

5 Conslusion

This paper has presented a brief review of the IoT communication technologies and has proposed a technique of IoT that can improve the connectivity of the IoT object. Our proposed technique consists in taking advantage of the extended coverage of the NB-IoT to extend the coverage of the Wi-Fi zone which does not exceed a few meters.

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