사물의 협대역 인터넷을 위한 지연 시간 전력 최적화에 관한 연구

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A Study on Latency-Power Optimization for Narrowband Internet of Things

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Abstract

Over the last decade, the development of Internet of Things (IoT) has emerged statically and dynamically. In accordance with this Low Power Wired Area (LPWA) technologies have also become popular. In NB-IoT the resource allocation is a more challenging problem with limited bandwidth and the requirements in terms of energy efficiency, rates, latency, extended coverage. It was proposed to provide low-complexity and low-power devices of poor radio coverage. The objective of the NB-IoT is to enhance the mobile coverage area by increasing the number of repetitions of control and data packets between user equipment (UE) and the base station/evolved NodeB (BS/eNB). In this paper, we propose an idea to reduce the latency and enhance the QoS and will study the resource allocation approach for NB-IoT networks to analyze the tradeoff between energy and latency. The proposed solution will be evaluated in terms of latency and power consumption with suitable optimal algorithms for allocating radio resources in future. As the 5G and beyond 5G network requirements are depicting the use of AI to make networking intelligent and our goal will be to implement AI based solutions.

Ⅰ. Introduction

Internet of things (IoT) has been widely used in the last few years and shown exponential growth in IoT devices and applications. This high demand of data can be served by Low Power Wide Area (LPWA) technologies. The LPWA technologies can be cellular or non-cellular wireless in which Machine Type Communication (MTC), enhanced Machine Type Communication (eMTC), Narrowband Internet of Things (IoT), etc. are wireless technologies [1]. NB-IoT is a LPWA technology which was proposed by 3GPP in 2015 [2] and standardized by 3GPP in 2016 [3]. The basic network operation of IoT devices is either uplink, downlink or in both directions' transmission of data. IoT applications such as healthcare, industrial automation, and smart traffic require periodic updates and time sensitive information in uplink direction. NB-IoT is appropriate for such scenarios where users transmitting low, infrequent data and delay-tolerant data. NB-IoT operated in license bands, which cause limited interference issues associated with the NB-IoT technology. The NB-IoT architecture which consists of five parts: the NB-IoT terminal, NB-IoT base station, NB-IoT core network, NB-IoT cloud platform and vertical industry center [4]. NB-IoT requires a bandwidth of 180 kHz which corresponds to one physical resource block (PRB) for both uplink and downlink within the cellular spectrum [5]. NB-IoT introduces a solution with five new narrowband physical (NP) channels: random access channel (NPRACH), uplink shared channel (NPUSCH), downlink shared channel (NPDSCH), downlink control channel (NPDCCH), and broadcast channel (NPBCH) [6,7]. The coverage and extended reliability provided by the NB-IoT is due to the repetitive transmissions, which is 128 re-transmissions for uplink and 2048 re-transmissions for downlink [8].

Motivation: The degradation of spectral efficiency due to repeated transmission, which results in an increased latency and energy resource consumption is a challenge to be addressed. In order to enable features, the main design change in architecture is required therefore, the requirement of an effective uplink transmission methodology with a high end-to-end delivery is needed for IoT applications. 5G and B5G are expected to become the enabling networking technologies for IoT.

Furthermore, in the context of coverage, low power consumption, and low latency is of prime importance for IoT devices, as NB-IoT should be able to serve a large number of devices. Finally, these challenges occur in both uplink and downlink of the NB-IoT network which clearly depict the limited energy and performance than the standard networks.

Contribution: As NB-IoT solution is less suitable in transmitting real-time information and cause latency in critical real-time monitoring applications, such as healthcare-IoT services. Therefore, we want to propose a method to reduce communication latency and enhance the QoS. In this paper, we study an important challenge of trade-off between latency and energy consumption and propose a solution to address the challenge.

Ⅱ. Proposed Architecture

In this paper, we study an important issue: that how to minimize both the latency and power consumption in NB-IoT devices when they serve. The proposed system architecture has shown in Fig.1. The existence of multiple coverage classes makes the radio resources management quite challenging as the allocation of resources will face tradeoffs.

2.1 Proposed Architecture Scenario

The scenario can be explained as follows. If the random-access channels (NPRACH) used frequently, the radio resources for uplink data channel (NPUSCH) will reduce, which will increase the latency in the transmission. However, if random access channel scheduled infrequently, then will increase both energy consumption and latency due to the idle-listening time. The scheduling of channels is a complicated process, due to the coverage classes and its also impact on quality-of-service requirements which causes further challenges to the problem. The proposed solution for the above-mentioned problem will be addressed as follows, we will integrate the NB-IoT multiplexing problem in modeling the latency and energy consumption of IoT devices within the cell, while acquiring devices from the set of coverage classes. We will propose a scheduling-based solution for compensating the performance loss in the form of latency and energy consumption provoked by limitation of the extreme coverage area. The preliminary results for our research will be present in future.

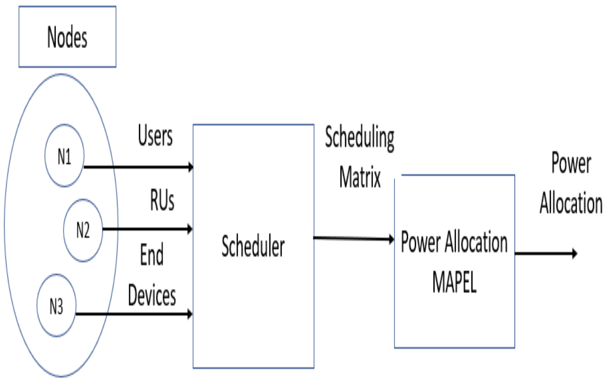

Figure 1 A proposed NB-IoT system architecture

2.2 Proposed Architecture Experiment Scenario

The resource allocation and scheduling have not developed optimization functions and other schedulers according to criteria designed for NB-IoT. The massive number of devices and the control plane optimization on the data scheduling has been formulated with greedy algorithm however, there is no optimization problem on either latency and power [9]. In this paper, we will propose an idea to formulate a resource allocation optimization problem to increase the uplink data rate, contain lowest latency and consume less power.

We will study the global optimization technique, called MAPEL [10] and modify for to distributing power of each device among its assigned devices. We will propose the system architecture and will compare it with other related techniques used in recent times for addressing the challenges in NB-IoT network systems.

Ⅲ. Conclusion and Future Work

In this paper we focused on latency and energy consumption with different coverage classes that follows NB-IoT systems in 5G and beyond 5G network architectures. This study shows the impact of resource management in terms of resource allocation and allocated coverage classes to NB-IoT system.

We are proposing our idea to impact on 5G and beyond 5G network architecture challenges as its an ongoing research area. We have chosen to address issues in NB-IoT architecture which is a LPWA technology.

In future, we will more in detail discuss the challenges and present our solutions with our results. Our main goal is to use machine learning algorithms to automate the resource management process in 5G and beyond 5G network architecture. We will present our research goal in further proceeding with our results and compare it with other related works.

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