Performance of Link Adaptation in Narrow Band Internet of Things

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Abstract —In present paper was aimed to study performance of link adaptation in NBIOT, which introduced by 3GPP in release 13 to function in mobile communications. The fundamental features of NB-IoT are its enlarged coverage, data rate, latency and battery lifetime compared to other cellular technologies. These features of NB-IoT manages it very beneficial in the IoT manufacturing, letting the technology to be hired in a vast domain of implementations, like health, smart cities, agriculture, WSNs. The main target of this study is to determine the performance of distinct characteristics of NB-IoT network with reasonable error rates in the uplink and the downlink connections. The performance of the several ways examined to decide their efficiency in relation to the requirements of the IoT industry. Software simulations were used to compare the distinct criteria settings to inspect which choices give better efficiency and cost trade-offs for constructing an NB-IoT network. The results show that data transmitted in smaller Transport Block Size (TBS) has fewer errors than if it has transmitted in greater blocks. Furthermore, the results offer that the error rate gets higher as the Doppler frequency increases in the propagation channel model. The results also show that the error rate gets higher as the modulation and coding scheme field (IMCS) increase.

Index Terms—Bit error rate, Narrow Band Internet of Things (NBIoT), doppler frequency

I. Introduction

The Internet of Things (IOT) makes up on the conventional Internet's capability to join world and allows interconnections between people, equipment and daily topics. The core of the IOT is data conception, acquisition, and transmission. Data can be recognized and obtained through smart, monitoring devices and sensor established stations. Gathering appliances extremely enhances functioning efficiency and will make missive public significance. With elastic spreading as well as the potentially to perform Over-the-Air (OTA) program improves, numerous communication agents across the universal widespread NB-IOT to examine its empirical likelihood on various usage conditions with real-life experiments.

In paper [1], the author showed that the systematic expressions resemble the simulated ones completely, which confirms the performance of suggested system model and derivations. The task in this paper supplies a useful guidance for NB-IoT system deployment and co-existence analysis.

In paper [2], the author addressed the Release 13 of the 3rd generation partnership project (3GPP) criterion LPWA technology and supply a training on its physical layer (PHY) technique. Particularly, he concentrated on the advantages and the inserting of downlink and uplink physical communication paths at the NB-IoT base station aspect and the user equipment (UE) aspect.

In paper [3], the author discussed the NPDCCH time modification and the NB-IoT timetable problem over NB-IoT grids. The purpose is to decrease the expended radio resource. He demonstrated that the timetable problem is NP robust and cannot be estimated with a proportion superior than 3/2.

In paper [4], the author offered a fresh coverage extension style named Narrow Band Timing Advance (NB-TA) which can enhance NB-IoT distance coverage over than 35 km, and the practicability of this design was proved by a realistic computation over an ocean medium.

In paper [5], the author submitted a hybrid connection modification strategy relied on all three merits, which aims at obtain most appropriate delay and coverage. To realize this, he formulated and resolved an optimization problem that detects the most appropriate value of repetitions, bandwidth and MCS.

In paper [6], the implementationof NB-IoT and eMTC is estimated. Hence, bit rate, power dissipation, latency and spectral efficiency are inspected in various coverage cases. In spite of the fact that both technologies employ the identical power conserving methods as well as repetitions to expand the connection area, the examinations exposed a distinct performance in the case of data size, rate and coupling loss.

In paper [7], the author prepared a survey of NB-IoT, simultaneously with a numerical pattern of the network fit to forecast the maximum performance in a offered script with a given configuration of some purpose parameters.

In paper [8], the author discussed the typical implementations in the smart grid and resolved the compatible feasibility of NB-IoT. Moreover, the performance of NB-IoT in ideal scenarios of the smart grid communication oceans such as urban and rural areas, is closely estimated via Monte Carlo simulations.

In paper [9], the author utilized a smart parking lot application as a model to examine the event-triggered

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reporting of NB-IoT in terms of the time-to-live (TTL) communicate frequency and the outage detection accuracy.

In paper [10], The technical distinctions at the field of MAC layer between Sigfox and LoRa and NB-IoT are illustrated and assessed. Author applied his simulation to assess the performances of these technologies in terms of Packet Error Rate.

In paper [11], In this paper the distinct advantages of the NB-IoT technology have been considered on the business Orange network in Belgium using the ublox SARA-N210 module as the user equipment (UE).

In paper [12], the author offered the first publicly obtainable empirical power consumption measurements on two NB-IoT devices.

In paper [13], the author presented the design observance and possible choices of a UE particular uplink (UL) scheduler for NB-IoT system.

In paper [14], the efficiency of NB-IoT network wants to be optimized in downlink as well as uplink for credible goodness of NB-IoT duties. The author provided optimization statuses of modulation and coding schema (MCS) for calling in multicellular interference mediums in terms of calling success rate in NB-IoT downlink.

In paper [15], the author treated the use of the arising narrowband IoT radio technology newly approved by 3GPP and showing active methods for basic wireless connectivity.

In paper [16], the author constructed a random arrival transit pattern, which includes the NB-IoT user equipment (UE) arrival process and eNB employee procedure. Then, he applied the stochastic network calculus (SNC) to analyze the network latency in NB-IoT arrival pattern.

In paper [17], the author discussed the arrangement and report the effective performance of a single-cell NB-IoT diffused as a portion of the 5G Test Network (5GTN) and dominated by a smart-campus micro-operator. The empirical measures recorded in the paper have been taken at the University of Oulu within a massive interconnected indoor environment.

In paper [18], the contribution of the paper lies in the analysis, synthesis, and comparison and outlined collocations of some of the main presenting schemes in respect of meeting challenges faced by the NB-IoT development.

In paper [19], the author submitted a smart parking system. In the suggested system, the information of the sensor node is sent by Narrowband Internet of Things (NB-IoT) module, which is a fresh cellular technology introduced for Low-Power Wide-Area (LPWA) applications.

In paper [20], the author suggested a deployment analysis of a NB-IoT device for smart metering. Estimated figure of UE that this device can improve coverage with respect to LTE technology.

In paper [21], the author evaluated the performance of Lora WAN and NB-IoT with precise in-field measures using the identical implementation condition for a fair comparison in terms of energy efficiency, lifetime, quality of service, and coverage.

In this Paper, we investigate the next parameters in the simulation: BLER to SNR with diverse modulation scheme coding, resource unites, number of repetition and transmit block size, channel estimator reference signal and propagation channel mode such as doper frequency.

The paper is coordinated as follows. NB-IOT characterized and deployment modes specified in part II. In part, III evaluation and simulation outcomes and diagrammatic comparison of the NB-IOT using different parameters is presented. Conclusion is showed in part IV.

II. NBIOT Deployment Modes

Fig. 1 shows the trend of IoT and LPWAN device deployment from research done by Nokia from 2015 to 2025.

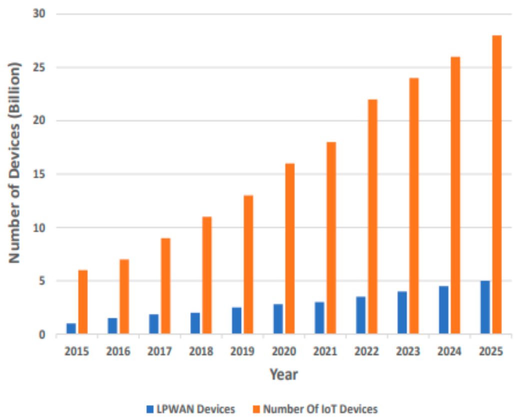

Fig. 1. Growth of IoT devices and LPWAN devices

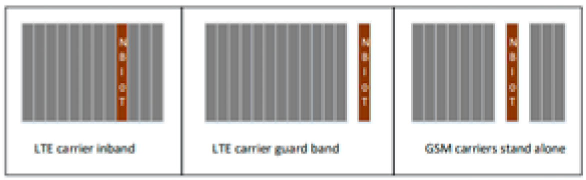

Fig. 2. NBIoT deployment options

The 3GPP criterion specifies that NBIoT can be distributed in three forms, i.e. in-band, guard band and standalone mode. The allocation can be in either the current GSM or LTE spectrum in order to minimize allocation costs. These three forms of distribution supply significant allocation elasticity and quite spectrum efficiency [22]. The chosen of which form to apply can be affected by an operator's usage of existent spectrum. Fig. 2 displays the three allocation selections, which are briefly considered in the next part.

In-band deployment

In this allocation form, one physical resource block (PRB) with a single NBIoT carrier takes the bandwidth with 180 KHz [23]. This allocation form has a passive effect on the potency of the LTE network.

Guard band deployment:

In guard-band procedure, NB-IoT will be distributed within the guard-band of an LTE carrier and its band bandwidth will be identical to LTE physical resource block (PRB), i.e. 180 kHz. The major feature of this allocation mode is that it does not employ LTE resources to influence the LTE system ability [23].

Standalone deployment: In standalone procedure, a single NB-IoT carrier is diffused in a bandwidth of 200 kHz (same as a single GSM carrier, to support technology migration) [23]. Network Operators can lead broadband traffic to LTE and WCDMA networks to release GSM spectrum for NB-IoT.

NB-IoT physical channels

Fig. 3 displays the fundamental NB-IoT downlink and uplink physical channels.

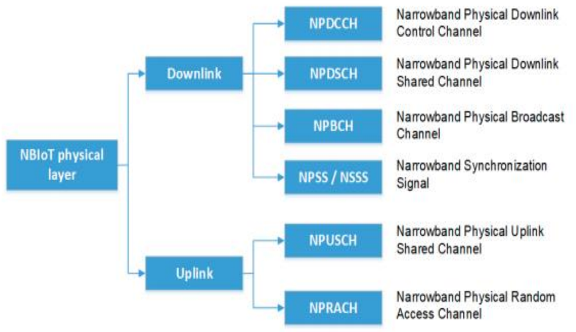

Fig. 3. NBIoT physical layer channels

Narrowband Physical Downlink Control Channel (NPDCCH):

The NPDCCH is utilized to transfer Uplink and downlink scheduling data and is the monitoring channel in the downlink. The NPDCCH principally holds three forms of Downlink Control Information (DCI), which are uplink transmission scheduling, downlink transmission scheduling and paging/ direct indication.

Narrowband Physical Downlink Shared Channel (NPDSCH):

The channel is utilized to transfer devoted and joint information in the downlink, paging, system information and the random access response.

Narrowband Physical Broadcast Channel (NPBCH):

The NPBCH is sent in every sub frame number 0 in the downlink. The broadcast channel is utilized to send framework data in the downlink for system arrival.

Narrowband Synchronization Signal (NSS):

The NSS be composed of two signals, which are the Narrow band Primary and Secondary Synchronization Sequence (NPSS and NSSS). The NPSS is utilized to get a rough assessment of the symbol timing and carrier frequency, while the NSSS is utilized to get the cell identity, the frame limits and smooth the rough estimates.

In paper [24], the author studied the technologies for NB-IoT and its implementation in 5G MTC. he also designed a NB-IoT downlink system based on 3GPP guidelines considering sub carrier spacing as 15 kHz and its performance analysis is carried out for MTC scenario. The analysis is performed with two distinct antenna configurations and compared its performance analysis in terms of BER, FER and QPSK constellation of NPDCCH and NPDSCH after channel estimation. The BER and FER of both NPDCCH and NPDSCH decrease with SNR, resulting the better performance towards machine type communications in 5G.

III. Simulation and Analysis

This part presents the results of our simulations. The next four collections of simulation results are prepared:

- Block error rate simulation vs Doppler frequency
- Block error rate simulation vs Number of transport blocks
- Block error rate simulation of different TBS vs SNR
- Block error rate simulation of different repetitions vs SNR

The next subsections show and examine the results in the above scheduled sequence. The horizontal axis is the signal to noise ratio (SNR), which is known as the ratio of the wanted signal power to the unwanted signal power, given by the next form:

$$\text{SNR} = \text{signal power} / \text{Noise power} \qquad (1)$$

Higher SNR values denotes signal type is perfect and there is slight interference. The vertical axis is the bit error rate (BER) which is known as the ratio of bit errors to the total number of sent bits, specified by the next form:

$$\text{BER} = \text{Number of bit errors} / \text{Total number of transmitted bit} \qquad (2)$$

We design an adaptation scheme for 200 KHz bandwidth in NBIOT network by using Narrowband Physical Downlink Shared Channel (NPDSCH) scheduling. The link adaptation for NBIOT networks demand to be implemented in three dimensions:

1) The modulation and coding scheme level selection
2) The repetition number determination
3) Channel estimator configuration

The link modification design requires to obtain tradeoff between transmit validity and throughput of system by choosing appropriate NRS and Doppler frequency. Fig. 4. Shows a block error rate versus Doppler frequency, the SNR value for each repetition was chosen to be -2 dB, the results show that when we use a large number of Doppler frequency, we can correctly decode the message with worse channel conditions (large block error rate). In addition, it can be noticed that can be transmitted effectively with best channel conditions when we utilize a large number of NRS (NRS = two in our case).

The number of transmitted blocks is the basic solution supposed by NBIOT to obtain reinforced coverage with soft complexity, and meaningful throughput results, Fig. 5 shows that when we use a large number of transport blocks, the BLER increases, therefore the link modification design requires to get tradeoff between throughput and BLER.

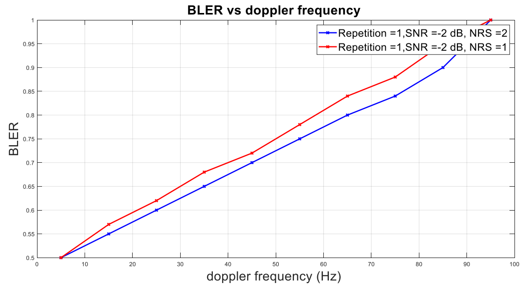

Fig. 4. BLER versus doppler frequency

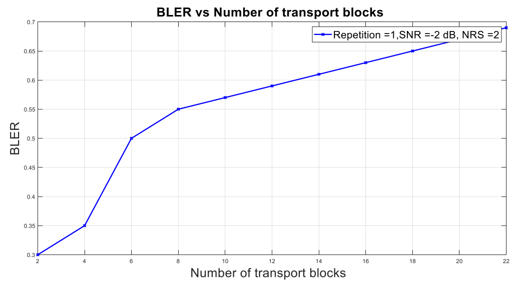

Fig. 5. BLER versus Number of transport blocks

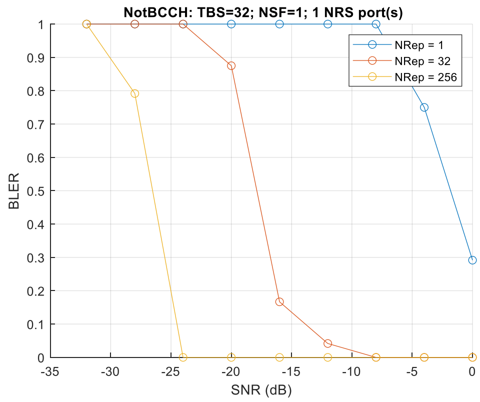

Fig. 6. Number of simulated transport blocks = 24, IMCS = 2; ISF = 0; F= 50 Hz.

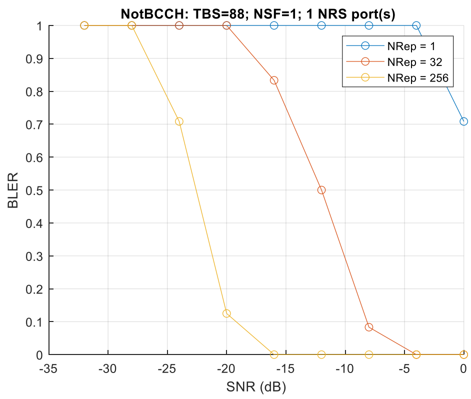

Fig. 7. Number of simulated transport blocks = 24, IMCS = 6; F= 50 Hz

From Figures 6-8, we can conclude that, if data is sent as a larger block, the probability of error becomes higher. For NB-IoT operators, information should be transmitted in smaller transport block sizes to minimize the error rate. We solved this problem by increasing Modulation and Coding Scheme Index (IMCS) up to 10,

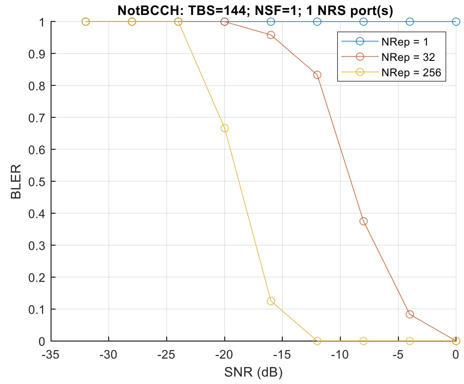

Fig. 8. Number of simulated transport blocks = 24, IMCS = 10; ISF = 0; F= 50 Hz,

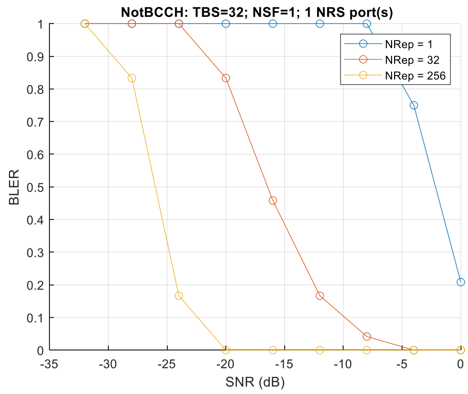

Fig. 9. Number of simulated transport blocks = 24, IMCS = 2; ISF = 0. F= 5 Hz,

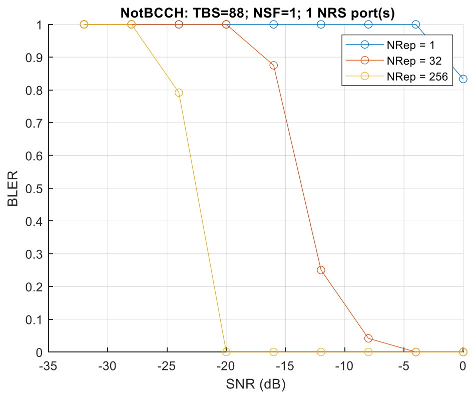

Fig. 10. Number of simulated transport blocks = 24, IMCS = 6; ISF = 0; F= 5Hz.

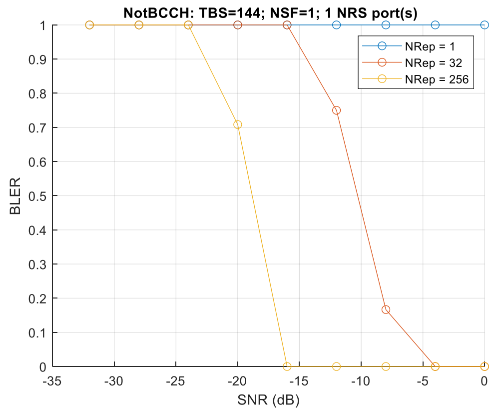

Fig. 11. Number of simulated transport blocks = 24, IMCS = 10; ISF = 0; F= 5 Hz,

The last three simulations were to compare the error performance of the NB-IoT system using different Doppler frequency in the downlink. Figures 9-11 show the result of this simulation. Lowe Doppler frequency value (5Hz) was chosen, the result present that the error rate becomes comparatively very small with a lower number of Doppler frequency.

IV. Conclusion

NBIoT is adaptable technology in terms of deployment, allowing for three distinct forms of deployment (namely: standalone, in-band and guard band). The framework, uplink and downlink paths of the technology are the identical to those of long-term evolution, which makes it simple for NB-IoT to be compatible with long-term evolution. The major target of this paper was to survey the error performance of NB-IoT. The results displayed that the error performance is based on the prime NB-IoT coefficient settings. The smaller the transport block size, the better the error performance. Technically speaking, when data is sent, the more the same data is transmitted frequently, the less the probability of error. With regard to the TBS, the more the data you send instantly, the higher the probability of error. The higher the number of sub frame repetitions. The better the error performance, the lower Doppler frequency, the better the error performance.

Conflict of Interest

The author declares no conflict of interest

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