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DECREASING THE RA COLLISION IMPACT FOR MASSIVE NB-IOT IN 5G WIRELESS NETWORKS

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ABSTRACT

To satisfy the gigantic need for Internet of things (IoT) applications, the third-generation partnership project (3GPP) has revealed the narrowband IoT (NB-IoT) standard. In any case, collisions in the radio access channel of NB-IoT can be extreme due to the numerous random-access (RA) activates by a massive number of NB-IoTs and the limited available radio resources. The RA procedure is one of the MAC-layer's functions that initiates a contention-based setup to grant an uplink transmission. In this paper, the performance of a new RA procedure is investigated by introducing a modified backoff scheme to reduce the collision probability. The key mechanism of the proposed scheme is to perform an autonomous approach for determining the time for an NB-IoT to transmit in a collide environment. The proposed scheme can improve the overall throughput of the network and the NB-IoTs battery lifetime while prioritizing some QoS parameters such as favoring the NB-IoTs with heavier traffic loads. The probability of collision analysis is subjected to many operating parameters, including the backoff countdown probability, number of NB-IoTs, queue size and the contention window size. The system and link-level simulations are conducted to assess the proposed scheme with up to five thousand NB-IoTs per cell. The simulation results showed that the proposed scheme outperforms the conventional approach.

KEYWORDS

Backoff, Collision, MAC, Random access, Window size.

1. INTRODUCTION

The Internet of things (IoT) market is expected to include numerous applications with different quality of service (QoS) constraints [1]. The third-generation partnership project (3GPP) revealed the NB-IoT, known as the narrowband-IoT (NB-IoT), which is one of the classes of IoT technologies. In essence, NB-IoT is an LTE-based cellular radio access technology that was announced in Release 13. The NB-IoT supports low data rate, long battery-life time and wide-area coverage connectivity in a licensed spectrum. However, the gigantic development of sensors, healthcare smart devices and wireless identifications associated with the Internet may make extra issues relative to the complexity of NB-IoT-based frameworks and the bottleneck deployment [2]. Existing Internet infrastructure might be deficient for managing massive IoT connectivity; consequently, new web models, correspondence innovations and plan strategies ought to be created to empower the improvement of proficient IoT networks [3].

The 3GPP specifications of NB-IoT have expanded beyond Release 13, with support for diverse requirements [4]. In Release 14, extra features such as higher data rates, multicasting and authorization of the coverage enhancements were further improved. In Release 15, 5G New Radio (NR) was regulated and intended to support various requirements, such as enhancing mobile broadband, decreasing latency and connecting a massive number of devices. In Release 16 (up to date 3GPP release), new agendas are included for finalizing the NB-IoT network development, where the main objectives of the release are grant-free access, multi-user simultaneous transmission and idle-mode mobility. The aforementioned objectives are mainly embracing the RA channel procedure at the NB-IoT MAC sublayer.

For NB-IoT connectivity, the RA procedure is a contention-based mechanism in which an NB-IoT chooses the RA shared resources for in-band communications through realizes the uplink synchronization, attains an uplink grant and establishes a connection with the gNB (base station in 5G NR).

Massive NB-IoT is one of the goals in the 5G network optimization. However, collisions could occur frequently in dense NB-IoT transmissions whenever two such NB-IoTs are transmitting at the same time

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over the same RA channel, resulting in loss of one or both transmissions. Indeed, a collision occurs when the backoff counter of two NB-IoTs ends simultaneously. It is noteworthy to mention that the backoff counter is the one that is responsible for managing the RA procedure at the NB-IoTs [5].

The main challenge of massive NB-IoT network deployment is the fact that frequent access leads to unsuccessful completion of the RA procedure. For this reason, several recent contributions studied some existing IoT protocols in terms of delay and latency, such as long-range (LoRa) and Sigfox, where the latter uses the ultra-narrowband (UNB) modulation techniques [6]-[8]. In addition, a trustworthy secure transmission to develop a reliable IoT framework is introduced in [9], specifically when mission-critical applications are employed. In [10], a new effective factor is suggested for improving the throughput of the 5G networks, whereas the numerology concept of the subcarrier spacing is adjusted to tune the clustered delay channel. It is concluded that the overall throughput is enhanced with a large numerology selection. On the other hand, some other recent contributions focused on decreasing the probability of collision, where some factors are omitted. For example, the semi-persistent scheduling technique is successfully used in [11] for decreasing the latency of IoT networks. However, this scenario involves diminishing resources during the long off-period of transmission. The work in [12] introduced an exact expression of the RA channel for the NB-IoT network considering increasing the repeated preamble attempts. This seems questionable, since such an approach will lead to waste more resources and diminish the NB-IoT's battery lifetime. The work in [13] offered a partial preamble transmission mechanism, where each NB-IoT must transmit a specific fraction of the preamble sequence during the RA procedure. However, this appears to be debatable, since typically, there is no coordination between the NB-IoTs at the RA procedure phase, where the contention-based is initiated.

We remark that all the aforementioned works cannot offer any strict guarantees on packet delivery without collision when deploying a massive number of NB-IoTs, which received much less attention in the literature. Thus, we introduce an in-depth analysis of a new backoff scheme, to be called backoff-based queue length (BBQL), to improve the countdown probability of the backoff counter and thus decrease the probability of collision during the initiation of the RA procedure. Many factors are considered, such as the initial queue lengths, number of NB-IoTs, size of the contention window and the countdown probability. By default, the NB-IoTs' backoff counters are lessened deterministically in every time slot. However, the BBQL proposed scheme changes the functional behavior of the backoff counters in such a way that the NB-IoTs of the higher traffic loads have the largest probabilities to decrement their counters. Such NB-IoTs will thus statistically reach zero and attempt to transmit their head-of-line packets earlier. The proposed scheme could eventually reduce collision and enhance the NB-IoT battery lifetime by minimizing the transmission repetitions and improving the overall throughput.

2. Random-access Procedure

The deployments of NB-IoTs within the 5G network include the RA procedure for filling numerous needs; for example, starting access while building up a radio connection and scheduling reservations. However, uplink synchronization is the core purpose of the RA procedure for keeping up with uplink orthogonality [1]. As presented in Figure 1, the contention-based RA procedure includes the following stages [4]: (1) NB-IoT sends Msg1, the RA preamble, preceded by system information block (SIB) signaling sends by the gNB for uplink carrier frequency and the uplink channel bandwidth to be used by NB-IoT. It is noteworthy to mention that the RA procedure can also be triggered by gNB through sending the narrowband physical downlink control channel (NPDCCH); (2) the gNB sends an RA channel response (RACH) message that includes the parameters for the third step, such as the scheduling of uplink resources and the advance timing for an NB-IoT; (3) an NB-IoT uses the reserved resources for transmitting its identity to the gNB to start the process of attaching; and (4) the gNB sends preceded NPDCCH information for Msg4. This information is used for avoiding any contention due to receiving several preambles from numerous NB-IoTs in Msg1. Then, Msg4 is provided by gNB that includes the transmission parameters to be used for NB-IoT transmission, such as subcarrier offset, number of subcarriers, periodicity of NPRACH resource and starting time of NPRACH. After the completion of the four RA messages, the hybrid automatic repeat request (HARQ) is sent by NB-IoT for confirming the successful accomplishment of the RA procedure and receiving the transmission parameters.

Then, the gNB transmits NPDCCH for granting the attach procedure followed by response form NB-IoT to finalize that.

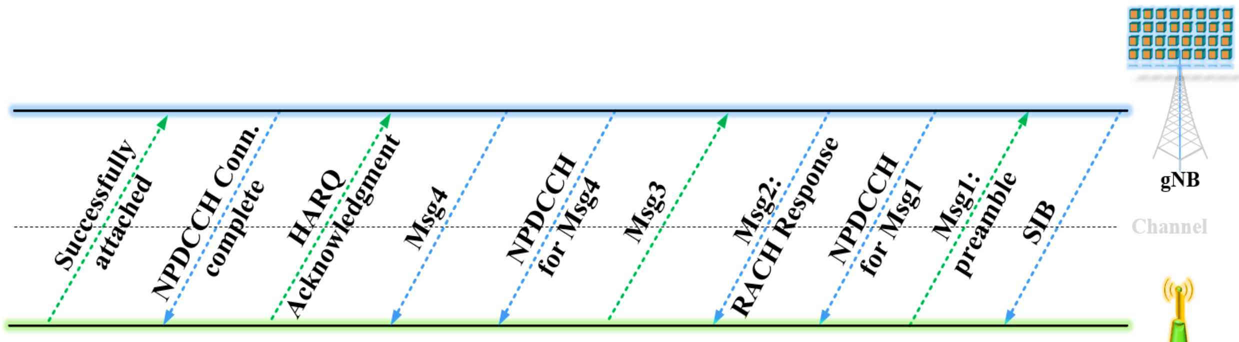

Figure 1. NB-IoT random-access procedure.

It is noteworthy to mention the following: the single-tone/multi-tone parameter is indicated by NB-IoT in Msg1 in order to let the gNB reserve the sufficient scheduling of resources for uplink transmission in Msg3. In addition, each gNB is divided into one to three coverage enhancement levels (CEL). Each CEL is used to conduct NB-IoTs with a specific range of channel quality to gNB (i.e., good or poor channel quality) and specific RA procedure settings (NPRACH resource configurations). Therefore, an NB-IoT will reattempt the RA procedure at a higher CEL with a specific preamble set, on the off chance that it does not get the RA response message after the expected number of attempts, NB-IoT proceeds to the next CEL [4]. Finally, it is important to point out that the BBQL approach is working for improving the RA procedure at Msg1.

3. The Analytical Model of the BBQL Backoff Scheme

In this model, the analysis is based on assuming that all the NB-IoTs start the backoff procedure at the same time. This allowed us to assess the NB-IoTs behavior on an equivalent basis. By default, the backoff process starts when the channel is free and ends at the moment of transmission, as shown in Figure 2. Briefly, each NB-IoT should have a specific profile for determining the transmission parameters, such as the contention window (CW) size, number of preamble repetitions and the queue size. Each NB-IoT is sensing the channel for sending. When the channel is busy, an NB-IoT is simply waiting. On the other hand, if the channel is clear, then an NB-IoT is delaying for a specific time slot and this is governed by the simulation. Then, a pre-processing step for sending the preamble is initiated by the backoff procedure. During the backoff process, as long as the channel is free, the counter discounts autonomously in every time slot. However, if an NB-IoT sensed that the channel is busy, then the counter holds till the channel is clear all over again, then the backoff counter continues the decreasing action within the CW. By the end of the last time slot, an NB-IoT starts the sending process. The abovementioned scheme presents the conventional procedure that is included within Msg1 of the 3GPP RA procedure [4].

As an alternative to the conventional step-down counter, the proposed BBQL scheme uses a weight function to determine the backoff counter value for each NB-IoT. In detail, the backoff counter could depend on the queue length of the NB-IoTs within the CW size [14]. Therefore, the BBQL scheme uses the queue length to calculate a weight function of each NB-IoT that is represented as a real number varying from zero to one. Thus, an NB-IoT that has a longer queue obtains a higher weight in the same way. Then, the countdown probability p is assigned, where the backoff counter is decreased with probability p. Accordingly, if the weight function is high (large queue length), then the probability p is high. Thus, NB-IoT countdowns quickly and wins the channel to transmit sooner.

In our analysis, we address whether a collision occurs. Therefore, we first derive the expression for measuring the backoff ending probability of NB-IoTs; i.e., determining the probability of time to transmit. Then, we conclude the expression for checking the probability that the backoff ends with a collision. In the beginning, let us use p(t) as the probability, where the backoff counter ends at a given time t. Each NB-IoT i has a backoff counter for stepping-down time slots denoted by ψ_i, such that p_i is the probability that ψ_i is decremented for each time slot, as shown in Figure 2. For each NB-IoT, the weight function q_i is used to determine the countdown probability p_i. Therefore, if there are two NB-

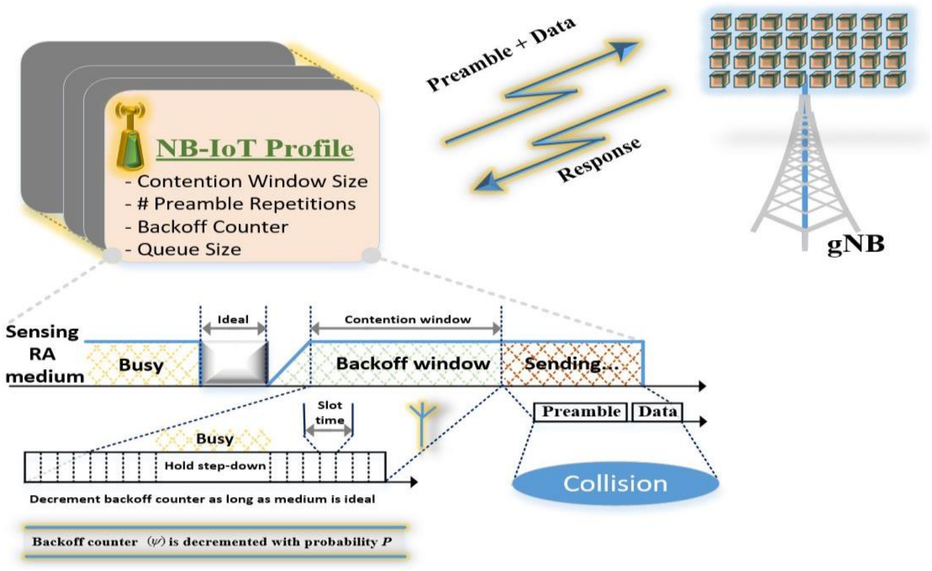

Figure 2. System model.

IoTs with different weights $q_i > q_j$, then $p_i > p_j$. For a given period of s time slots (within the range of CW size), the probability that a backoff counter is exactly decremented by k times for NB-IoT i is denoted by $\beta_i(k,s)$ and given as:

$$\beta_i(k,s) = \binom{s}{k} p_i^k (1-p_i)^{(s-k)}, \tag{1}$$

where binomial probability is used to find $\beta_i(k,s)$.

Accordingly, when the backoff counter ends at time slot *t*, the probability in which NB-IoT *i* will transmit is denoted by $\delta_i^c(t)$, where *c* is a given value of ψ_i, as shown in Figure 3.

$$\delta_i^c(t) = \begin{cases} 0 & t < c, \\ \beta_i(c-1, t-1)p_i & t \geq c. \end{cases} \tag{2}$$

For $t < c$, the backoff counter is larger than the number of time slots to decrement to zero; therefore, the probability of transmission is zero. However, for $t \geq c$, the time is long enough to reach time slot *t* and decrement to zero. It is noteworthy mentioning here that the counter must be decremented to *c*-1 times, thus in the final slot, the probability of the last decrement is p_i. Hence, by substituting (2) in (1), we get:

$$\beta_i(c-1, t-1) = \binom{t-1}{c-1} p_i^{c-1} (1-p_i)^{(t-c)}. \tag{3}$$

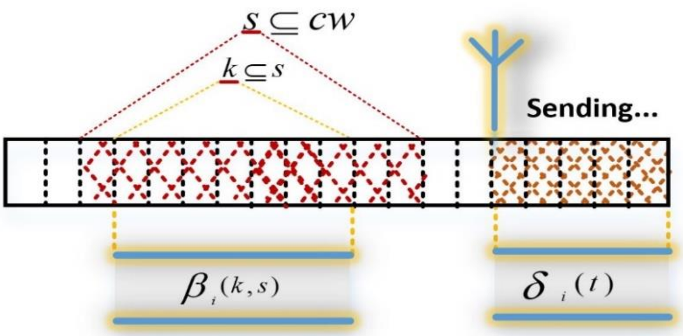

Figure 3. Probabilities' pattern.

From the above mentioned information, we can derive the total probability that the NB-IoTs could transmit at time *t* as:

$$\delta_i(t) = \sum_{c=1}^{\tau} \delta_i^c(t) P(\psi_i = c), \tag{4}$$

where τ is the CW size specified by the operator. Thus, the backoff counter is uniformly distributed on the interval $[1,\tau]$ and so we have $P(\psi_i = c) = 1/\tau$. As a result, the probability that NB-IoT *i* has no chance to transmit in any time slot until *t* is given by:

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$$1-\sum_{j=1}^{t-1}\ \delta_i(j). \tag{5}$$

Therefore, the total probability that no NB-IoTs have the chance to transmit and the channel remains ideal until time *t* is denoted by $\gamma(t)$. Thus, we have:

$$\gamma(t)=\prod_{i\in I}\ \left(1-\sum_{j=1}^{t-1}\delta_i(j)\right). \tag{6}$$

During the backoff process $(0\cdots t-1)$, all the NB-IoTs are expected to just wait and decrement their counters. However, at the end of the backoff counter, more precisely at time slot t, one of the NB-IoTs is expected to attempt transmission; i.e., δ_i conditioned from (5). Accordingly, we use $\chi_i(t)$ to refer to the probability that NB-IoT *i* transmits after the end of the backoff counter as:

$$\begin{aligned}\chi_i(t) &= \frac{\delta_i(t)}{\sum_{j=t}^{\infty}\ \delta_i(j)}\\ &= \frac{\delta_i(t)}{1-\sum_{j=1}^{t-1}\ \delta_i(j)},\end{aligned} \tag{7}$$

where the first sum in (7) leads to infinity; therefore, the second form of (7) is introduced to get a finite sum. The term $\sum_{j=t}^{\infty}\ \delta_i(j)$ refers to the probability of an NB-IoT *i* with index *j*, to transmit for $j \geq t$. Therefore, the term $\sum_{j=1}^{t-1}\ \delta_i(j)$ given is more computationally tractable, since the sum is finite. It is noteworthy to mention that $\chi_i(t)$ is just a normalized form of the probability of transmission $\delta_i(j)$. In fact, $\chi_i(t)$ includes only the event space of the leftover time slots (slots at or later than *t*). Thus, we can use (7) to derive the probability that at least one NB-IoT transmits at the end of backoff (at time *t*), as:

$$1-\prod_{i\in I}\ (1-\chi_i(t)). \tag{8}$$

Consequently, the first goal of this analysis outlined by deriving the probability of the backoff counter ends is presented as:

$$P(t)=\gamma(t)\ \left(1-\prod_{i\in I}\ (1-\chi_i(t))\right). \tag{9}$$

The second objective of this study is to derive the probability that NB-IoT transmits first successfully and with no collision. For an NB-IoT to transmit first, we are dealing with the highest weight NB-IoT *i** and it must transmit at the end of backoff at time *t*. Therefore, we can use (7) and (8) to get the probability of NB-IoT *i** to send without collision as:

$$\chi_{i^*}(t)\left(\prod_{i\in I, i\neq i*}^{n}\ (1-\chi_{i^*}(t))\right). \tag{10}$$

To consider all the transmission conditions that measuring the success of the assigned values for the countdown probabilities, we derive the total probability of transmitting, no matter when the backoff ends. In other words, we consider that each value of t for each NB-IoT, where all the NB-IoTs are mute before that time slot and only NB-IoT i* sends first and without collision.

$$\sum_{t=1}^{\infty}\left(\gamma(t)\chi_{i^*}(t)\prod_{i\in I, i\neq i*}\ (1-\chi_{i^*}(t))\right). \tag{11}$$

Since the dense environment includes a massive number of NB-IoTs, there is a possibility that the NB-IoTs other than NB-IoT i* could transmit at the same time. Therefore, we derive the probability of transmission for NB-IoT i*, despite the consequences of the collision.

This probability can be developed by revoking the constraint that all the NB-IoTs must be silent during NB-IoT i* transmission. Thus, we cancel the product over the NB-IoTs from (11) and get:

$$\sum_{t=1}^{\infty}\gamma\ (t)\chi_{i^*}(t). \tag{12}$$

Then, we derive the collision probability for the BBQL scheme such that the backoff process ends with a collision. We use the expression in (11) and modify it to let any NB-IoT transmit, not just i*. To do this, we first find the probability of success without collision and sum over all the NB-IoTs for each possible backoff interval. Thus, the probability of success is defined as:

$$P_s=\sum_{t=1}^{\infty}\sum_{i\in I}\left(\gamma(t)\chi_i(t)\left(1-\prod_{j\in I, j\neq i}(1-\chi_j(t))\right)\right). \tag{13}$$

Finally, the complement is taken for the probability of success in (13) to obtain the collision probability; 1 - P_s.

4. System Model

For the dense NB-IoT scenario, we consider a network such that a hexagonal macrocell with gNB is adaptively working for both LTE-A and NR-5G systems. The OFDMA system is assumed to be perfectly synchronized; hence, collision happens if the same resource units are used by other NB-IoTs simultaneously. Figure 4 illustrates a high-level demonstration of the core qualities employed in the system model. Essentially, the random-access manager (RAM) functionalities include spectrum allocation and bandwidth management, where multiple carriers, subcarrier spacings, single-tone and multi-tone transmissions can be configured. On the other hand, the RAM of NB-IoTs is accessing the adaptive modulation and coding (AMC) module and the uplink packet scheduler. The AMC module namely picks the appropriate transmission parameters, such as the transport block size, modulation and coding scheme (MCS) index and number of RUs given by the chosen scheduling strategy. In addition, the CEL feature is used for enhancing the reachability as well as determining the number of repetitions required. Up to three CEL may be configured for serving devices experiencing different received power levels. According to what has been previously clarified, the scheduling paradigm is redesigned. For this purpose, the BBQL suggested scheme provides an inherent method for improving the RAM functionality of NB-IoTs' MAC layer. Most of the messages exchanging, explained in Section 2, is performed by RAM with the RA procedure. For deploying an NB-IoT, some essential factors should be considered for ensuring the functionality of the narrow and system design, such as improving system coverage, power consumption and delay tolerance.

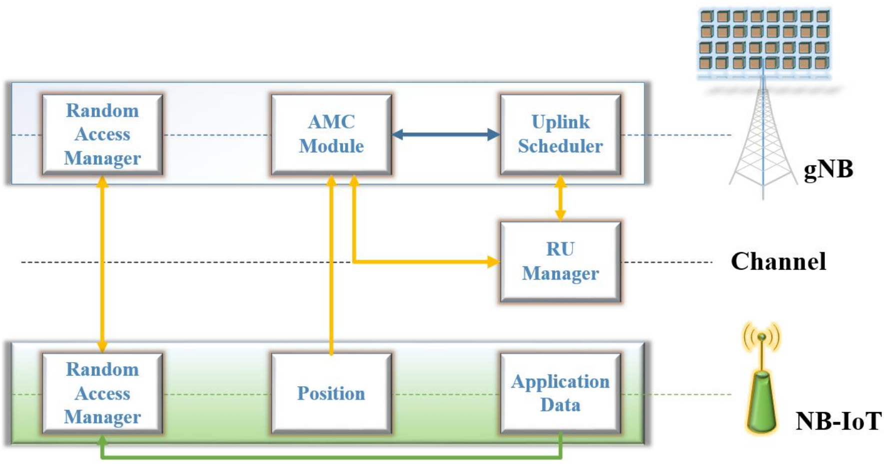

Figure 4. High-level system model.

Furthermore, each NB-IoT's profile is loaded with the operational parameters. In fact, according to the selected CEL, the NB-IoTs' MAC layer is acknowledging the operational parameters for each profile from gNB. This process is completed after a successful RA procedure. According to NR-5G specifications, these parameters primarily are numerology, number of transmission and repetitions of RACH preamble, CW size, coverage class, tones and bandwidth [5], [12].

5. Description of Simulation

The scenarios in the link and system-level simulations are implemented by using 5G-Sim [15], a framework simulator supported by Linux operating system. In the present simulation, the NB-IoTs are deployed over an area with random located positions, where constant bitrate is considered for the upload traffic flows. Table 1 summarizes the main parameters used in the simulation. In this work, the channel model is composed of path loss, shadowing, penetration loss and fast fading. The fast-fading model due to multipath depicts the small-scale parameters, such as delays, powers and the arrival and departure course on a very short time scale (within TTI interval). These parameter-based channel variations are modeled with pre-calculated traces produced according to tabulated distribution functions, as depicted in [16] and [17]. Shadowing is presented as a log-normal varying value and penetration loss is generally chosen to be constant. The path loss relies mostly upon the allocated spectrum, the position of the NB-IoT with respect to the gNB and the environment scenario. The 3D-Urban Macro-cell model in [18] is used and computed as $161.04 - 7.1\log_{10}(20) + 7.5\log_{10}(H_b) - (24.37 - 3.7(H_b/$

$H_{gNB}))^2\ 10\log_{10}(H_{gNB}) + (43.42 - 3.1\log_{10}(H_{gNB}))\ (\log_{10}(d_{3D}) - 3) + 0\log_{10}(0.001f) - (3.2\log_{10}(17.625)^2 - 4.97) - 0.6(H_{NB} - 1.5)$, where the meanings of the used symbols are as follows: d_{3D} is the three-dimensional distance between the gNB and the NB-IoT in km (counting heights in the computation), H_{gNB} is the altitude of the gNB, f is the center frequency in GHz, H_{NB} is the height of the NB-IoT and H_b is the average height of the buildings around it. Thus, the noise power is calculated as -147+ 10log(3.75)= -138.3 dBm/Hz [12], which is integrated over the bandwidth of one resource block. In addition, the 5G NR numerology of subcarriers is 3.75 kHz tone spacing; i.e., 180 kHz of the spectrum is filled with and spans over 48 subcarriers. Furthermore, the time interval between two successive transmissions by an NB-IoT is 60 seconds. On the other hand, the maximum number of retry attempts for the RACH is four. In addition, the active NB-IoTs' locations regarding the gNB are assumed to be belonging to the specific CEL with a unity probability. To obtain a statistical significance regarding the number of the deployed NB-IoTs within the cell, three categories of traces are set up and repeated for three different CW sizes. Therefore, the BBQL scheme is applied on nine random seed traces in total and the results are concluded as shown in the next section. In this way, some of the settings are fixed for all the traces such as the NB-IoTs' positions and the flows' start times and many other factors are randomized, such as the queue length and the allocated subcarriers.

Table 1. Simulation settings.

Parameter	Value	Parameter	Value
# NB-IoTs	1K, 2.5K, 5K	NB-IoT's service	Finite Buffer
CW size	256, 512, 1024	NB-IoT's application	Constant Bitrate
Bandwidth	10 MHz	Data Size	256 Byte
Tones	Single	Numerology	3.75 kHz
# Preamble TX Attempts	3	# Preamble RX Repetitions	1
Cell Radius	1 Km	Scheduling Granularity	1 Sub-frame
# NB-IoT's Carriers	5	# Coverage Class	1

6. PERFORMANCE EVALUATION

The performance evaluation of this work is compared with the scenario of standard configurations described in [4], (denoted as 3GPP throughout this section). Due to the purpose of this study, the performance of the overall system is conducted, where a heavier traffic load and different CW values are considered. Figure 5 shows a comparison between the 3GPP and BBQL schemes when deploying a massive NB-IoTs (1K, 2.5K, 5K) with CW size = 256. Then, the RA collision probability for each scenario is measured. In the long run of the simulation, the collision probabilities for both schemes are increasing significantly. To justify this behavior, we state the following two reasons: 1) the RA collision probability shows a non-monotonic reliance on the number of NB-IoTs.

This is because, with not many NB-IoTs deployed in the network, it is less possible that any other NB-IoTs will overwhelm i* to become the new highest-weighted node. 2) the number of NB-IoTs that are trying to complete the RA procedure and sending their data is increasing with time and since the system is set up with a heavier traffic load and low CW size, it is normal to expect such a high probability of collision. However, under these dense conditions, the BBQL scheme shows better improvements through elaborating the weight-queue metric to select the NB-IoT and tuning the backoff countdown counter. In other words, the BBQL scheme successfully ensures the probability for i^* to be the highest weighted node at the end of the backoff and remains high for all the cases. Also, the cumulative distribution function (CDF) of the waiting time in the queue is used as a metric to determine the effect of collision at the RA stage. As it can be seen in Figure 6, the 3GPP scheme with three CW size scenarios is conducted and a significant decrease in CDF is shown as CW size increases. Besides, the BBQL scheme shows an improvement as compared with 3GPP of the same CW size. This is because increasing the CW size; i.e., elaborating more time slots, will eventually increase the backoff counter numerical quantity in the system. This will give more time for another NB-IoT to complete the RA procedure and

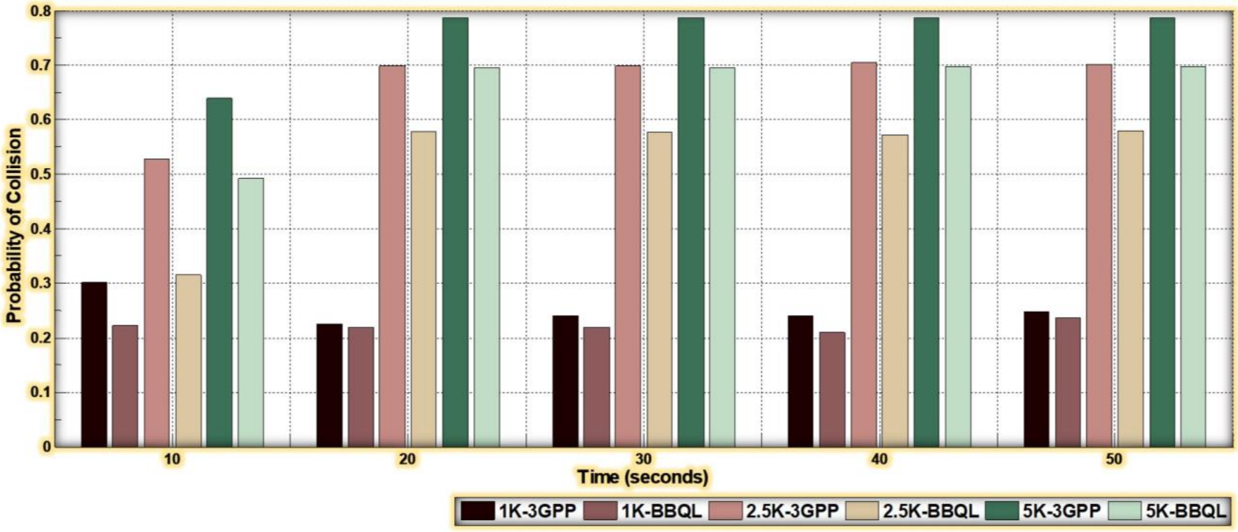

Figure 5. RA collision probability.

reduce the probability of collision. Hence, the average waiting time in the queue is minimized. However, the drawback of increasing the CW size is the fact that the NB-IoT must be in an inactive mode for a longer period to process the RA procedure and hence, diminishes the NB-IoT's battery lifetime. Moreover, Figure 6 shows snapshots of the trace captured through the simulation, where collision occurs when the NB-IoTs are trying to transmit at the same time as exemplified by the red lines.

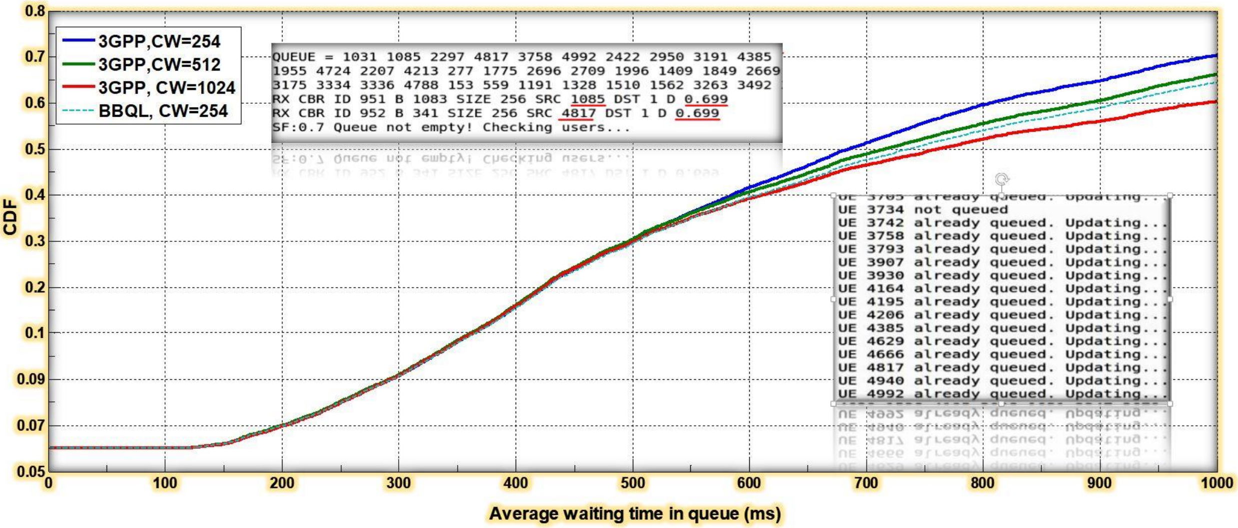

Figure 6. CDF of average waiting time in the queue.

7. CONCLUSION

In this paper, a new backoff scheme compatible with the latest 3GPP standards, called BBQL, was introduced and examined to improve the effectiveness of the random-access procedure of massive NB-IoTs, such that the probability of collision in random access can be reduced. Theoretical analysis was conducted, where the probability of collision expressions associated with many operating parameters such as backoff countdown probability, number of NB-IoTs, queue size and contention window size is derived. The simulation results revealed that BBQL had a higher success probability that correspondingly achieves higher throughput and lower access delay than standard approaches. The performance was validated under different operating contention window sizes and the outcome confirm the efficiency of the proposed model. The one exception to this was the scenario wherein the contention window size is long enough to such an extent that the participating NB-IoTs in the network had enough backoff counter value to finish and transmit with a lower probability of collision. However, such a methodology makes an NB-IoT busy and consequently, drains the battery lifetime. Besides, the number of NB-IoTs was found to have a significant impact and as such, future efforts must utilize a reasonable number of NB-IoTs for stimulating the massive setting and participating in backoff as input to the model for ensuring practical results.

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ملخص البحث:

لتلبية الحاجة الهائلة الى تطبيقات إنترنت الأشياء، كشف مشروع الشراكة للجيل الثالث عن معيار إنترنت الأشياء ضيّقة النّطاق. وفي كل الحالات، يمكن للتّصادمات في قناة الوصول الرّاديوية في إنترنت الأشياء ضيّقة النّطاق أن تكون كثيرة جداً بسبب العديد من حالات الوصول العشوائي نظراً للعدد الهائل من تطبيقات إنترنت الأشياء ضيّقة النّطاق ومحدودية الموارد الرّاديوية المتاحة. وإنّ عملية الوصول العشوائي هي إحدى الوظائف التي تستهل وضعاً قائماً على الاتصال من أجل الإرسال.

في هذه الورقة، يتمّ استقصاء طريقة جديدة للوصول العشوائي تهدف الى التّقليل من احتمالية التّصادم. وتتمثل الآلية الخاصّة بالطريقة المقترحة في أداء نظام مستقل لتحديد الزمن اللازم لإنترنت الأشياء ضيّقة النّطاق لتقوم بالإرسال في بيئة تمتلىء بالتصادمات. ويمكن للطريقة المقترحة أن تحسّن العبور الإجمالي للشّبكة وعُمر بطارية إنترنت الأشياء ضيّقة النّطاق من خلال تحديد الأولويات؛ كأن يتمّ تفضيل إنترنت الأشياء ضيّقة النّطاق ذات الحِمل المروري الأعلى. والجدير بالذّكر أن احتمالية التّصادم تعتمد على عدّة متغيّرات تشغيلية؛ منها عدد وحدات إنترنت الأشياء ضيّقة النّطاق، وحجم الدّوْر، وحجم نافذة الاحتواء...الخ.

وقد أجريت محاكاة لتقييم النّظام المقترح لعددٍ من وحدات إنترنت الأشياء ضيّقة النّطاق وصل الى خمسة آلاف لكلّ خليّة. وبيّنت نتائج المحاكاة أنّ النّظام المقترح تفوّق من حيث الفعاليّة في التقليل من تصادم الوصول العشوائي في الشّبكات اللاسلكية القائمة على إنترنت الأشياء ضيّقة النّطاق، مقارنة بالطّرق التّقليدية.