

Congestion Reduction Using Resource Allocation in M2M Communication Using LTE

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Abstract

The massive access attempts by M2M devices is susceptible to increased traffic and overload in Random Access (RA) mechanism of Long Term Evolution (LTE) network. Due to limited number of preamble in RA, the simultaneous attempt of multiple M2M devices increase the probability of preamble collision thereby resulting in sharp deterioration of LTE. The collided devices re-transmit the preamble to access the channel of LTE network. But such unlimited re-transmission drains the energy level of M2M devices. In this paper, an energy efficient re-transmission and dynamic assignment of preamble (ERDAP) model is proposed to limit the maximum re-tries of collided devices. In ERDAP, the Beta distribution function is derived for choosing the preambles by multiple devices based on available devices in different load conditions, which results in high RA success probability. The simulation is performed in NS3 with appropriate configuration setting related to RA mechanism of LTE. From the analysis, it is inferred that ERDAP model can resolve simultaneous arrivals of 30,000 devices with maximum of 15 preamble re-tries achieves an average access delay of 1.0 seconds. As a result, the ERDAP model best suits for M2M communication where massive RA attempts is performed to access the LTE network.

Keywords: Machine-to-Machine, LTE Random Access, RACH Procedure, Access Overload, Collision Resolution, Pream- ble Collision.

INTRODUCTION

The growing acceptance of the Internet of Things (IoT) technology and the amount of smart devices is expected to exceed 60 billion by the end of the decade. Therefore, it is expected that Machine-to-Machine (M2M) communication will grow rapidly [1]. M2M communications have several ap- plications namely tracking of vital signs in healthcare system, intelligent transport system, smart meters, and so on [2]. In M2M communication, the devices access the LTE network cellular connectivity to transfer the data among M2M devices. The cellular networks provides a reasonable communication infrastructure and allows machines to communicate with each other directly or without requiring any human intervention. The major challenge of the M2M devices is to access the channel for transmitting the gathered information. The access request of M2M devices to eNB is performed as follows: a) Period of connection process that is initial access, b) With demands for the resources, c) When acting handover to another eNB, d) Connection re-establish after a loss of the radio link.

In LTE, the machine intends to access the network must go through the random access process by transmitting a preamble signal to a specific channel defined as the Physical Random Access Channel

(PRACH), used to relay the original preamble signature. Generally, M2M produce small volume of data traffic, but when massive device attempt simultaneously it cause severe congestion in radio access and core networks of the cellular infrastructure [3]. The congestion occurs in the RACH process of the eNB due to multiple M2M device access, which results in increased overload and delay. The problem of congestion at RACH process will become worse, if collided devices tries to access the network again and again.

According to the survey, the number of M2M devices is more than the human users, therefore the random access contention is more likely occurs in M2M communication. This form of contention is called random access overload. In LTE, there are two types of standard RA are contention-based and contention free RA. In contention based RA, the entry request can withstand delay like experience collision, whereas in contention free RA, the entry request involves a high probability of completing the access successful like handover process [4]. The congestion in eNB leads to the waste of radio resource, packet loss, access delay, extra power and energy consumption. To address the access delay and energy drainage issue in M2M, an Energy efficient Re-transmission and Dynamic Assignment of Preamble (ERDAP) is proposed.

The main contributions of the paper is summarized as follows:

1. We propose ERDAP model for re-transmitting preamble to the collided devices in massive access to achieve reduction in average access delay. The algorithm presents to estimate the M2M device attempts to access after multiple re-tries and present a dynamic preamble assignment for the number of devices after attending maximum preamble re-tries or failure of RA access attempts. The ERDAP model improves computational performance resulting in possibility of reducing average access delay by increasing the number of preamble re- transmission for M2M massive communication.
2. We consider the Beta distribution function to model the M2M massive traffic arrivals and analyze the performance of access delay by estimating the load conditions for the beta- distributed arrivals, are reasonable when channel is severely overload and congested.
3. The work provides a framework for analysis of random access mechanism by defining different configuration parameters in LTE cellular network. Our simulation results for Various PrachConfigurationIndex with PreambleTransMax setup results shows reduction in random access overload and furthermore when access attempts per frame increase results in low average access delay.
4. We evaluate and estimate traffic model in RA procedure on the LTE to solve the performance deterioration problems raised by massive access in the network. An attempt to find down the failure in RA procedure to alleviate the traffic issue and dynamically evaluate the number of available preambles under different load conditions by utilising the minimum required uplink resources.

The rest of the paper is structured as follows. The related work is addressed in the Section II and system model is described in Section III. Section IV provides our delay analysis with the performance of the RA procedure is estimated for possible traffic overload and the proposed idea of ERDAP model and the performance results are given in Section V and Section VI concludes with future work will be focused on proposing mechanisms to provide better future improvements of RA procedure.

RELATED WORK

The wireless access to massive M2M is a challenging issue although several proposals have been

addressed to overcome the key issues in RACH technique [5]. Such technique is applied in [6] to a hybrid framework in which correspondence between H2H and M2M is incorporated in terms of resource efficiency. The performance of LTE during high RACH load conditions has been analysed via simulations [7] - [8]. Until now, there has been large works introduced to tackle the massive problem of RACH access to preserve network against difficulty in accessing the channels. Some surveys [9], [10] includes detailed analyses of current strategies. A description of this is given below.

The simultaneous access of massive M2M devices may cause congestion in radio access network [11]. The access attempt begins with RACH in which each M2M device randomly picks one from the preamble and transmits a signal it via the PRACH. If the same preambles are transmitted over the same PRACH by more than one device, then collision occurs and the connection gets terminated. [12]-[13]. In such case it is essential for collided devices to re-transmit their preambles, causes collision probability and access delay in access channel. The primary approach of splitting the preamble in the RACH procedure specified for H2H and M2M communications in LTE [14]. In comparison with service provided to H2H are not affected, but in massive M2M arrival as the number of preambles are less available, the service provided to M2M

is influenced with overload problem.

The studies proposed by allocating resources at RACH, the eNB assigns additional RA slots to M2M devices during congestion [15] or transmits the usage of existing RA slots to the entry rate for each traffic models [7]. This needs extra RA slots in a frame though it is successful by leaving fewer subframes for data transmission. In addition, the strategy can rapidly become non extensible to the series of new entry at each RACH process.

To address the massive RACH in the Slotted access, each M2M device contains its own designated access slot connected to its identity to access the service from the network. Each access slots contain a RA cycle and the eNB repeatedly transmits RA cycle parameters and access slots. The period of the RA process is expected to be longer for a large number of M2M, thus M2M may undergo long delay. In comparison, some slots may stay unused although there may be extremely heavy load in other slots. A long RA period is required to accommodate a huge number of devices, that leads to access delay. The device that have encountered collisions at RACH is assigned with their next transmission attempts with various sets of preambles. The attempts are non extensible when heavy congestion is observed, resulting number of devices suffering from collisions.

The dynamic allocation of RACH Resources [16], the network assigns additional RACH resources for each devices in the event of overload. According to this scheme based on the amount of overload, the eNB boost the RACH resources throughout the frequency domain, time domain or both. The eNB will assign up to ten subframes in time domain as PRACH. In the frequency domain, PRACH assigns with additional 1.08 MHz of bandwidth. If several uplink services are used in PRACH results in the lack of data channels and major limitation in notification delay for additional RACH.

The Prioritized Random Access involves the division of RA resources allocated to various traffic categories [17]. Prioritization are either in terms of M2M and H2H or several priority stages including the requirements are classified into five groups under this approach: HTC, high-priority M2M, low-priority M2M, scheduled M2M, and emergency. The access involves complex barring of entry, that bars the connection of newly arriving devices to eNB.

In [18] coordinated random access is suggested when one or more representative of each group announce critical messages observed when the congestion period is severe. During the congestion period the

message correlation among the devices within group is extremely high. The main downside is the coordination among the devices within each group and depending on a few of devices for every group to effectively report the delay data.

The concept of code-expanded random access [19], the RA attempt is initiated by transmitting a series of preambles called RA codeword over a predetermined number of RA slots, rather than merely sending a single preamble to any particular RA slot. A virtual RA frame which is consisting a set of RA slots or a collection of preambles for each RA slot are considered. M2M transmit several preambles through every virtual RA frame, creating a code word. The eNB defines the specific RA tries at the receiver end based on the equivalent code word perceived within it. That greatly increases the chances of RA

without maximizing any resources.

PRELIMINARY OF RANDOM ACCESS PROCEDURE IN LTE

In LTE, RACH is the essential procedure required to establish wireless connectivity between the UE and LTE network. The RACH is uplink channel for UE to conduct random access including transmitting of RACH preambles, small data in communication networks. The RACH consists of two procedures known as contention-based and contention-free. In contention-free the preambles are assigned by the eNB and the transmission of same preamble by different devices are not possible and free from collision. The same preamble from massive UE reaches the eNB at the same moment, suffer from preamble collision called as contention-based [7].

A. Random Access Slot and Access intensity via RA subframes

A random access slot corresponds to the physical radio infrastructure of the LTE called PRACH, where preambles are traced and sent to the eNB. The RACH is determined by the time and frequency sequence of resources are called RA slots. RA slot consisting of 6 physical Resource Blocks (RBs) in the frequency domain, whereas the time frame for each RA slot could be 1, 2, or 3 subframes based on the preamble format [20]. The UE may choose a suitable preamble based on the distance from eNB, the overall delay period, the volume of transmission resource required for transmitting RRC requests. The preamble configuration index determines the number of RA slots for each radio frame.

The access intensity in the RA load is determined as the number of devices starting a new access attempt made on per RA subframe and the subframes from 1 to 6 are RA subframes in LTE PRACH configuration 6. When the access intensity is 10 for PRACH configuration 6, will conduct 20 new RA attempts per frame and nearly 200 new RA attempts per second. For the purpose of fairness in PRACH 6, the subframes 2 and 7 in LTE come with two different RA subframes that the devices can perform a RA on any of the 1, 2, 6, or 7 subframes [9], [11] that is shown in Fig. 1.

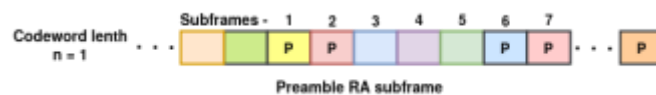


Fig. 1. Frame structure for LTE, with codeword length n = 1

B. Random Access Preamble Signal in PRACH

The preamble signals are set of orthogonal symbols and these signals transmitted by UEs with a specific pattern called as signature. These signature used by the devices request to access LTE network. In contention-based, each M2M device randomly picks one from the preambles $P = (0,1, \dots, 63)$ and transmits a signal through PRACH. In random access procedure, if the same preambles are transmitted over the same PRACH by more than one device, then collision occurs and the connection gets terminate. The access request is only successful, if a device is transmitted in each PRACH with a specific preamble. The connection will be established relying on the successful request and the eNB allocates resources to the devices for the transmission of data.

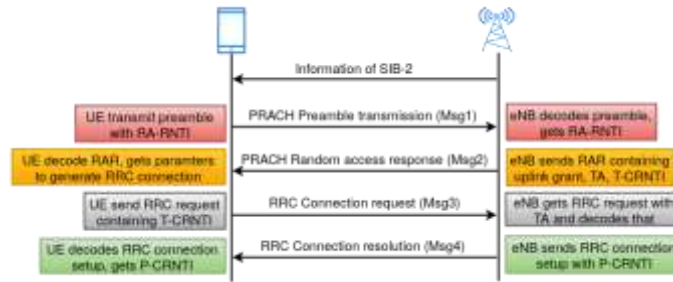


Fig. 2. Contention-based RA procedure

In Fig. 2, the eNB broadcasts PRACH configuration with system information block-2 (SIB-2), once that information has been obtained by UE, a four-message handshake is implemented. Whenever a connection is established devices must switch to the connected state of Radio Resource Control (RRC) by sending a message to eNB with a request for connection. The devices are allocated by the network with uplink frequency and time resources, so that the signal exchanges from multiple devices do not induce collision with eNB. Thus, the device must specify their desire to send a message to eNB in order to allocate with an uplink service [12].

PRACH Preamble transmission (Msg1): Each UEs sends a Random Access Opportunity (RAO) that is randomly assigned when UE tries to communicate. There are several preambles, however massive UEs can access the eNB in the same RAO, using specific RACH preamble carrying Random Access-Radio Network Temporary Identifier (RA-RNTI). The eNB decodes the UEs transmitted preambles and gets RA-RNTI for each received preambles and determines preamble index, calculates the UE timing alignment of each transmission and allocate resource block.

PRACH Random access response (Msg2): For each successfully decoded preambles, the eNB sends response with RA-RNTI via Physical Downlink Control Channel (PDCCH) which is calculated from the preamble time and frequency resource. It also includes the information about the preamble index and uplink grants that is reserved for Physical Uplink Shared Channel (PUSCH) for Msg3 transmission, Temporary-CRNTI (T-CRNTI), the UE decode the response and gets resource block assignment. If multiple devices choose the same preamble and send it over the same slot. The eNB can detect the collision based on differences in transmission delay, and this preamble does not provide a RAR response. When the devices are at the same range from the eNB, the collision could not be identified and the same RAR data is decoded.

RRC Connection request (Msg3): UE saves T-CRNTI after getting RAR response and uses the uplink resource available in RAR to transmit scheduled data to eNB. The UE will adjust its uplink transmission time by received timing alignment and sends Radio Resource Control (RRC) Connection request using T-CRNTI via PUSCH.

RRC Connection resolution and setup (Msg4): The eNB accepts the scheduled transmission data from UE and sends RRC connection setup and contention resolution message. This message is addressed by T-CRNTI, stating that the connection is established. Each device obtaining this message matches the identity found in the message with the identity conveyed in the previous step. The device with matching identity will have a successful connection. If there is no match, then the network declares a failure in connection, the connection gets terminated and schedules new access attempts. So, the failed UEs retransmit a new randomly chosen preamble in a new access channel.

The number of RACH access attempts for each device is limited with preambleTransMax part of SIB-2
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resulting in maximum number of preamble re-transmission. When a device fails to attempt the access, the device increments the counter and according to it compares with the PreambleTransMax. Each device increments preamble transmission counter in case of unsuccessful attempt. If the transmission counter have not reached the limit then the device will schedule with a new preamble otherwise the network is not available. In such case the the devices are assigned with dynamic preamble allocation.

C. System Model

We consider a massive M2M devices get to access channel

PROPOSED WORK

We propose a efficient ERDAP approach to handle massive access attempts, access delay for M2M communication. The motivation relies on noticing when RACH is overloaded by massive access attempts the number collisions are high. It is more effective to solve the congestion, reduce the access delay instead of wasting time and devices avoid making attempt to resource in LTE network.

A. Delay Analysis Using Beta-distributed traffic

The analysis offers a statistical method for estimating size of the preamble based on the load especially obtained in high load conditions, the number of new arrivals, the average number of devices initiating their RA procedure for each access. This model can be used for any congestion approach that handles the amount of new arrivals. The study demonstrates the random access attempt using preamble transmission, where the number of preambles in the preamble pool is finely selected. First, the principles of RA time and RA intensity are implemented, for random access based on preamble transmission. Then, in a single attempt, as derived in [2], the expression for probability of success in access is given.

The load estimation of the number of active machines as follows:

Estimating the access load of each machine by considering the active machines including the newly arrived, barred and collided machines. Thus, the number of machines that attempt to access,

$$M(i) = A(j) + \sum_{i=g_{min}}^{g_{max}} \text{barring}(i, j) + \sum_{i=h_{min}}^{h_{max}} \text{collided}(i, j) \quad (1)$$

with each arrival rate λ over a time interval $[0, T]$. The eNB consists of RAO, that broadcasts with probability q to each UE before each RAO attempts takes place. In each RAO, the devices selects random number 0 and 1 and if the number is less than q sended by UE are allowed to make a attempt to transmit preambles. When the same preamble is selected randomly by multiple UE from set of preamble set, their messages clash as they use the same resource for uplink.

Though, the synchronous RA attempt within a short time span, several access attempts are likely to be found sharing the same set of preamble from the pool and the collided transmissions impact cannot be effectively decoded by the eNB. The collided devices remain to wait and transmit the preamble in next RAO using new q value sent by eNB. The access request is only successful if a device is transmitted with specific preamble. The connection will be established relying on the successful request and the eNB allocates resources to the devices for the transmission of data.

We state that access delay of device is defined as time interval between first RAO and the RAO where the device successfully departs. Here, the device departed at the first RAO is assumed to be zero. Further, we assume that the interval is zero similar to other work [23]. So, the device is ready to transmit preamble to next RAO after the collision is detected. The possibility of successful preamble

transmission results in Where $A(j)$ represents the number of newly arrived machines, g_{\min} and g_{\max} represents earliest and latest RAO for barred machines, h_{\min} and h_{\max} represents the earliest and latest RAO for colliding machines.

These active machines are permitted to transmit the preamble. The preamble are randomly selected by each M2M at each RAO slot from a set of signatures called preambles and transmitted via PRACH. The PRACH consists of a series of subframes with the preambles attached on each RA slot, $P = P[1], P[2], \dots, P[NPT]$

Where the symbol $P[n]$ represents the M2M transmits n preamble.

According to Beta distribution the expected number of arrivals in the RAO is given by the following

$$A(j) = n \int_{t_{j-1}}^{t_j} P(t) dt \quad (2)$$

Where t_j is the time of RAO, each access requests of M2M follows Beta distribution to calculate arrival period T , and the distribution $P(t)$ follows:

$$P(t) = \frac{t^{\alpha-1} (T-t)^{\beta-1}}{T^{\alpha+\beta-1} \text{Beta}(\alpha, \beta)} \quad (3)$$

low access delay.

Where $P(t)$ represents the arrival process, t is the time of the RAO(i) slot and $\text{Beta}(\alpha, \beta)$ is Beta function, and it is given by:

$$\text{Beta}(\alpha, \beta) = \frac{(\alpha-1)(\beta-1)}{(\beta+\alpha-1)} \quad (4)$$

two consecutive RA subframe. The next value of the number of distinct preambles are observed as P next, a new value for the preamble subset size is calculated to be the preamble subset size for the upcoming RA time as $b = b_{\text{new}}$, which will then be reported to devices. Thus, $b > P$ must remain with

The values are set to be Beta (3,4) and Beta (3,6) distribution respectively for M2M Beta traffic and denote the interval between two consecutive RAO as T_{RA_REP} time of RAO(j) slot can be obtained as

$$t_j = t_i + (j - 1) T_{RA_REP} \quad (5)$$

B. Beta-distributed traffic arrivals

The third-generation partnership project (3GPP) states that Beta distribution is well suitable for mathematical analysis to model the access delay of M2M traffic. The benefit of Beta-distribution is to analyze the M2M traffic arrivals for each device. We examine the delay analysis on severe M2M congestion for beta-distributed arrival rate λ over a interval $[0, T]$.

The performance analysis for the M2M access attempt according to Beta distribution. We consider a parameter Beta (3,4) and Beta (3,6) distribution of arrival in M2M traffic. Furthermore, the probability density function for Beta (3,4) is provided with over 1.0 s period used in our simulation and Beta (3,6) is provided with over 0.6 ms period to simulate M2M traffic. We present the simulation results and its significance in Section V.

C. ERDAP model for RA attempts

This section presents the proposed re-transmission of preamble access attempts. This situation may arise due to the sudden arrival of huge sources. It is expected that eNB will never be able to decode the simultaneous transmission of the same preamble. Thus for such preambles it will not deliver the RARs and attempts to re-transmit preamble. Further, provides information regarding number of preambles and the minimum number of resources essential to go through dynamically changing conditions of access intensity for each device. Re-transmitting preamble RA is based on estimating the access load that is the number of devices attempting access randomly and then adjusting the preamble depending on that estimation. The new preamble is then revealed to devices that end up making preamble choices from a new preamble. During re-transmitting preamble RA seeks to establish a high probability of success for each access, so that large number of simultaneous RA attempts produced can be effectively provided.

The device allow two preamble transmissions immediately back-to-back in the case of failure attempt. Let us consider P_1 and P_2 indicate the number of distinct preambles observed by eNB in the first and second RA subframe, respectively. The average value $P = (P_1 + P_2)/2$ and the value of the preamble subset size a , the eNB estimates the RA load as D_{est} , that is the number of devices that attempted RA such that these devices select distinct preambles P_1 and P_2 over the estimation to be functional. Precisely estimate the number of access attempts D , the number of distinct preambles P observed should be less than the number of preambles available else the number of access attempts D may be extremely high, finding it difficult to estimate D .

Algorithm 1 ERDAP MODEL

Input:

P_1, P_2 : number of distinct preambles

b_{max} : max preable size

$b < b_{max}$: number of preamble announced to device count(b) = b_{max} : number of times preamble reached to maximum

limit b_{max} : number of times $b = b_{max}$ before increasing count

Output:

distinct preambles (P 1, P 2)

1. **if** P 1 \neq 0 and P 2 \neq 0 **then**
2. compute $P = P 1 + P 2 / 2$
3. Slots = Slots + 1
4. **end if**
5. **if** P < b **then**
6. D_{est} = Estimate number of attempts
7. **else if** b = b_{max} **then**
8. $b_{max} \leftarrow b_{max} + 1$
9. **end if**
10. **f** $b_{max} > b_{limit}$ **then**
11. $b_{max} = b_{limit}$;
12. **end if**
13. **if** (remainder Slots. adapt) == 0 **then**
14. number of preambles (b_{max}, D_{est})
15. **end if**

In Algorithm 1 given, that determines the number of access attempts D based on this study. The two numbers of distinct preambles P1 and P2 observed over the two consecutive preamble transmissions and reported preamble size a are the inputs to the algorithm.

A device gives a series of single preamble transmissions, each picked randomly from a preamble subset of length b, where $b < 54$ takes into account the entire collection of preambles specified for the contention-based procedure. The eNB tracks the number of distinct preambles observed N. If $N = b$ for a number of consecutive periods, the eNB intends to congest RACH. It is determined that there is a congestion occurring, the eNB informs the devices by establishing a indicator in the SIB-2 together with other RACH parameters notified to the devices.

In dynamic preamble assignment for M2M devices the number of access attempts for every machine is constrained by the parameter that is determined as part of SIB-2, referred as the TransMaxPreamble. This refers to the average number of transmissions in the preamble with each device holding the preamble transmission counter. If the connection attempt is unsuccessful, the device raises the count and then relates it to the TransMaxPreamble. If the counter has not exceeded the limit the device can schedule a new transmission of the new preamble. The service from the network will otherwise be considered as inaccessible.

Initially, UEs send preambles to the eNB, if preamble is not collided, the UE proceeds the next random access procedure. If a preamble is collided the connection gets failure and terminated. To avoid preamble collision, the LTE preambles are divided into three categories contention part, dedicated part, priority part. The contention part, when users access the network initially and the dedicated part, when users handover and the priority part, when users after maximum retry preambles are given higher priority based on preamble access re-transmission as shown in the Fig. 3.

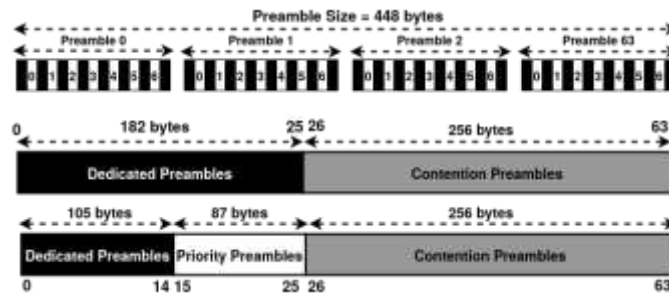


Fig. 3. Dynamic preamble assignment

In the random access procedure the active M2M cant transmit more than NPT, preambles or there are some cases where M2M are not allowed to re-transmit preamble again. By considering the limited preamble transmissions NPT, the devices are allowed by selecting RAO from available RAOs. While selecting preambles if more than one device accesses the same preamble the collision rises and the collided devices are allowed to re-transmit in subsequent slots by fixing maximum preamble retry and we fix a limited number of preamble re-transmit for each M2M device. The users with exceeding NPT, are allocated in the part of priority preamble. If the number of preamble retries exceeds the limited number of tries then based on the counter the priority for each M2M device will be assigned to one of the available priority preambles.

CASE1: If transmitting preamble < NPT, the state will be a success and proceeds with the RACH procedure.

CASE2: If transmitting preamble > NPT, the state will be given priority by considering counters and assigned preambles from available priority part and proceeds with RACH procedure.

IMPLEMENTATION AND RESULTS

In this section we present the performance analysis of the proposed model. The efficiency of the standardized RA

**TABLE I
SIMULATION PARAMETERS**

Parameter	Simulation Values
Number of available preambles	54
preambleTransMax	3, 10, 15
PRACH configuration	0, 3, 6,
Size of RAR window	5 SF
Backoff Indicator	20ms

**TABLE II
SIMULATION MODULE NS-3**

Number of devices	5000	10000	30000
Number of preamble re-transmission	3	10	15
Access delay	0.5ms	0.8ms	1.0s
Performance Measure	100%	99.99%	74.28%

procedure is analyzed in M2M traffic. It measures the access delay and the total volume of energy needed to obtain network access and present the model of simulation.

A. Simulation

An LTE random access module is developed using ns-3 simulator to perform the evaluation. While the ns-3 implementation includes LTE modules, it does not incorporate the random access procedures. In comparison to simulate the RA protocol for LTE, the large quantity of devices included in our analysis resulted in less access delay in extreme computational. We analyzed the efficiency of ERDAP model for RA attempts and strongly suggested for huge devices as the key solution of RA traffic problems.

Table I, define the test parameters have been used to explain the networks behaviour. The amount of available preambles is 54 signatures required for the contention-based RA protocol. When the contention resolution timer declares the lack network of availability in such case the device can make maximum number of re-tries referred as preambleTransMax. If a device exceeds the total number of preamble re-transmission, it is blocked by network without obtaining access.

Furthermore, the simulation performed for N = 5000 is lightly loaded, however resulting in success in initial access attempt and for N = 10,000 is heavily loaded, takes few access attempt, with N = 30,000 which is severely loaded with high access delay compared to other loaded scenarios as shown in Table II.

B. Simulation setup

In LTE RACH, Simulations Were Conducted With More Than Thousands Of Devices By Adopting A Beta (3, 6) Distribution Of Arrival Period Of 0.6 Ms And Beta (3,4) Distribution Of Arrival Period Of 1.0 S That Have To Reach The Network Within A Short Span Of Time In M2M Traffic Arrival As Shown In Fig. 4.

The Simulation Have Been Carried Out With The PRACH Configuration Index Is Set To 0, 3, 9 Of RA Slots Each Frame With Number Of Preamble Transmission Of 10 And Various Parameters Are Calculated For The *Preambletransmax* (3, 10 And 15) For Huge M2M Devices.

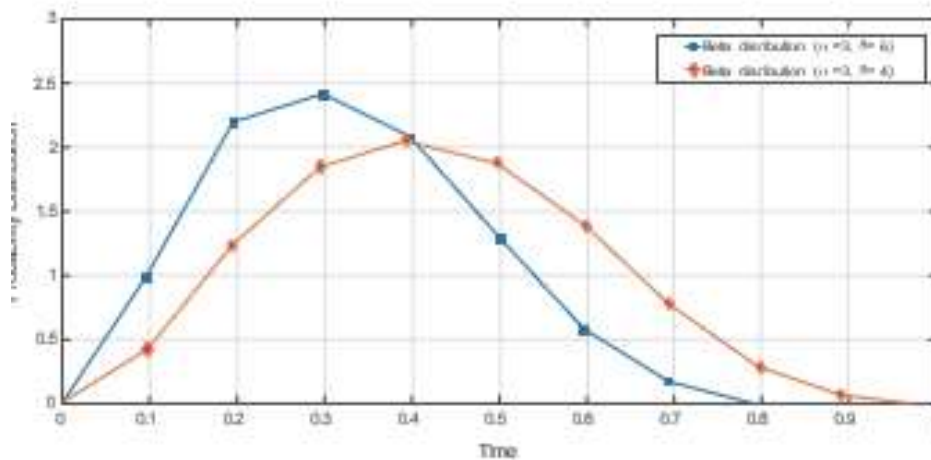


FIG. 4. PROBABILITY DENSITY FUNCTIONS OF THE SIMULATED TRAFFIC MODELS

Access Delay: Time Passed For The First Preamble To Accept Msg 4, Only Active Entry For The Average Estimation Is Considered.

Average Number Of Preamble Re-Transmit: Number Of Tries Executed By The Devices.

Probability Of Unsuccessful Access: The Possibility That A System Will Exceed The Maximum Number Of Opportunities But Not Be Able To Accomplish The Access Process.

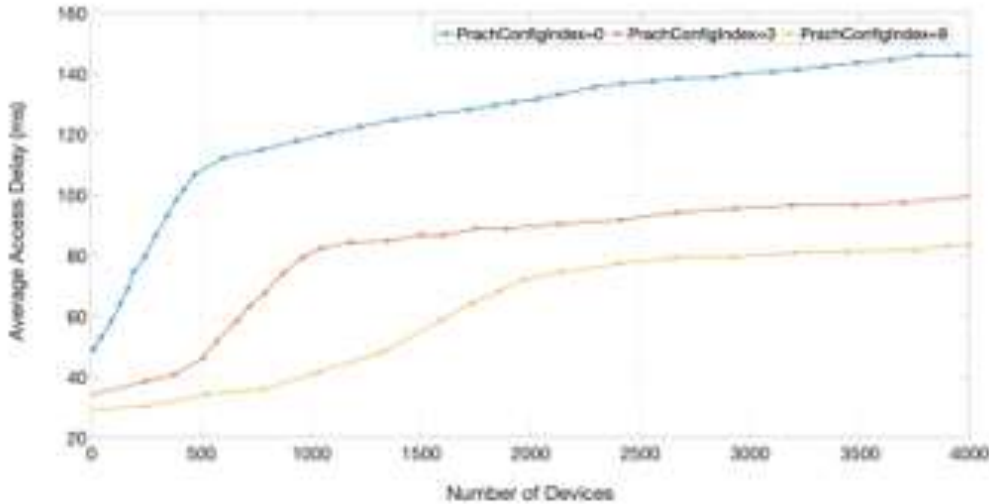


Fig. 5. Access Delay For Various Prachconfigurationindex With Preamble- Transmax = 10

In Fig. 5, Presents The Number Of Allowed Transmission Is Greater, The Average Delay Access Will Decrease Significantly. The Average Access Delay Is Lower Because The Attempts Are Success With Sufficient Resources Available For The Devices As Well In Fig. 6, Shows That The Number Of Preamble Transmission Become Less Due To The Lesser Preamble Collision Among Arrivals Of M2m Devices And The Resources Results In Less Energy Consumption.

The Number Of Allowed Re-Transmission Is Greater Leads With Dramatic Increase In Average Access Delay Compared With Preambletransmax - 10 As Shown In Fig. 7. When The Maximum Number Of Transmission Conducted With More Than Thousands Of Devices The Access Delay Is Greater Than The Other Configurations Resulting In Peak Access Delay. There Is A Chance Of Devices Being Waited For The Limited Number Of Possibility To Start A Rach Again And Devices Will Continue The Simulation By Retrying Until The Rach Gets Terminated. In Fig. 8, Represents The Comparison With Greater Energy

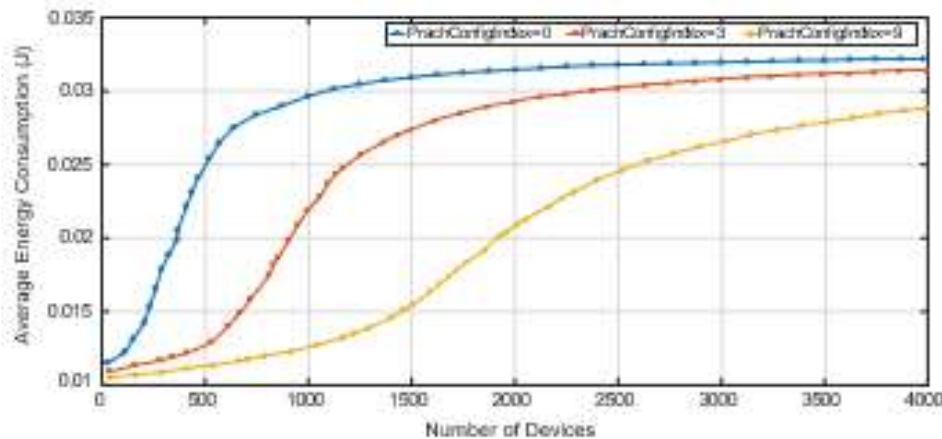


Fig. 6. Preamble Re-Transmit And Energy Consumption For Various Prachcon- Figurationindex With Preambletransmax = 10

Consumption For Various Configuration Index For Maximum Number Of Transmission.

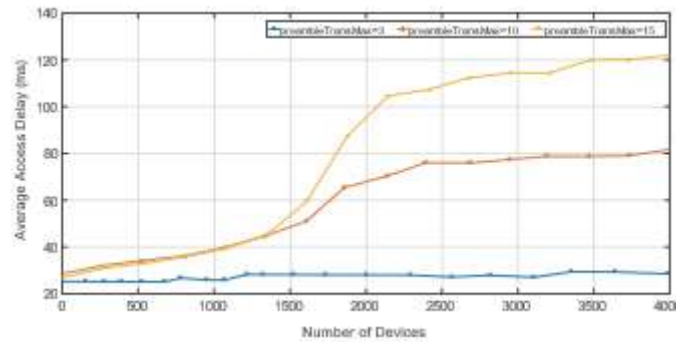


Fig. 7. Access Delay For Various Prachconfigurationindex With (Prachcon- Figindex) Equal To 6

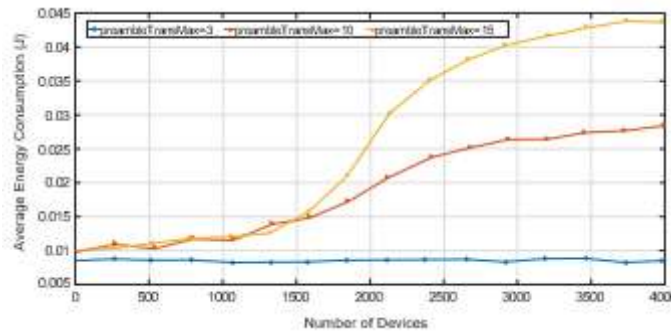


Fig. 8. Preamble Re-Transmit And Energy Consumption For Various Prachcon- Figurationindex With (Prachconfigindex) Equal To 6

The Goal Is To Demonstrate The Activity Of The Lte Rach, When The Amount Of Preambles Sent Out On Particular Resource Rises And Then The Subsequent. Accordingly, The Number Of Devices Attempting To Access It Concurrently Correlates With The Preambletransmax - 10, Where Various Prach Configuration Indexes Are Used.

The Access Delay With Simultaneous Arrivals Is Slightly Smaller Can Be Realized As More Access Services Are Provided As Shown In Fig. 9. Though The Simultaneous Arrivals For

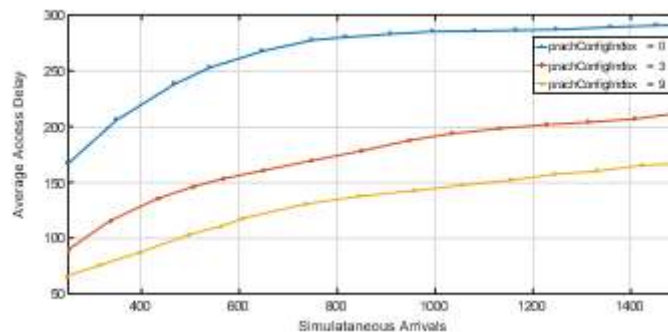


Fig. 9. Access Delay With Simultaneous Arrivals For Various Prachconfigu- Rationindex With Preambletransmax = 10

Various Configuration Consumes Higher Energy But Deteriorate The Overall Performance In Presence Of Simultaneous Arrivals As Shown In Fig. 10.

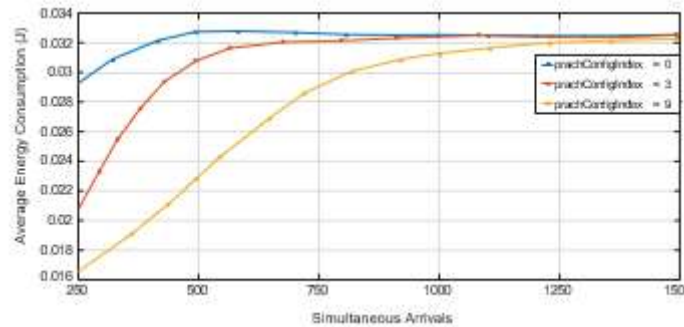


Fig. 10. Preamble Re-Transmit And Energy Consumption With Simultaneous Arrivals For Various Prachconfigurationindex With Preambletransmax = 10

The Traffic Load Is Reduced With The Analysis Of Beta Distribution And The Maximum Throughput Is Also Achieved. The Preamble Collision Probability Is Reduced During Massive Access By Dynamically Assigning Preamble To The Maximum Re-Tried Devices. The Access Success Probability Is Achieved By Considering Various Prachconfigurationindex With Greater Energy Consumption. Thus, The Chance Of Preamble Collision Is Reduced, When The Number Of Ue Is Too Large For Enb To Grant Channels In Short Time.

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