Persistent Overload Control for Backlogged Machine to Machine Communications in Long Term Evolution Advanced Networks

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***Abstract*—Machine to Machine (M2M) has become one of the most attractive technologies in wireless communications. Despite this, Long Term Evolution Advanced (LTE-A) suffered the severe issues in machines initiating random access for all of the Base Stations (BTS). Therefore, this paper investigated the previous/existing methods and come out with the P-persistent scheme. The scheme is proposed with backlogged M2M devices that use to control Radio Access Network (RAN) overload in LTE-A network. The performance of the proposed scheme is evaluated through MATLAB based simulation. Through the evaluation, it can be seen that the M2M devices arrivals follow Beta distribution use for calculating the throughput and probabilities of collision, success and idle for M2M devices. The first case when P has a high value and the second case P have low value, this result show that in first case the success probability of M2M device is high about 73% limited number of M2M devices and have lower collision probability but in the other case M2M devices have lower success probability about 26% with high collision probability.**

***Index Terms*—Machine to Machine; Persistent; Backlogged MTC**

I. Introduction

Machine to Machine (M2M) communication is a type of data communications between elements that don't really require a human connection. Potential and rising use instances of M2M are smart power grid, healthcare monitoring, remote security observation, smart transportation framework. Long Term Evolution-Advanced (LTE-A) [1] is conceived to assume a focal part in interconnecting machines. Machines communications have an altogether different arrangement of necessities than H2H communications since they are fundamentally portrayed by a high device density in a cell, small payload, machine-initiated interchanges, and low movement volumes per machine [2]. Radio Access Network overload occurs in the LTE-A system which called E-UTRAN appeared in Figure 1 underneath when a device needs to communicate with RAN then it needs to perform RACH method.

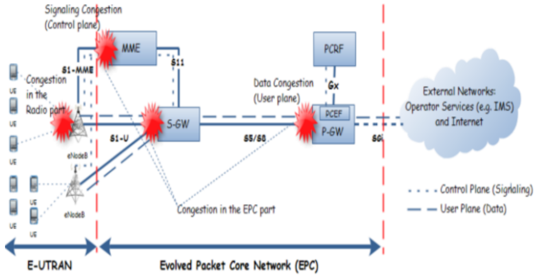

Figure 1: Blocking in the LTE-A Network [3]

On the off chance that a substantial number of devices endeavor to get to the system in the meantime then RACH blockage can happen in light of the fact that there are just 64 prefaces in a PRACH opening and if numerous gadgets attempt to get to the system they may wind up picking an indistinguishable introduction from another gadget and this will prompt impact which can bring about disappointment of that prelude endeavor [3].

This paper additionally investigates the M2M communications and the random-access strategy in LTE-A systems. Moreover, the real issues identified with M2M communications in LTE-A systems are carried out. The paper proposes a technique to address the system overload issue because of random access to the MTC devices are discussed. The paper end finishes up with the conclusion.

II. The M2M Communication Techniques

M2M is a term used to describe the innovations empowering PCs, implanted processors, acute sensors, actuators and cell phones to speak with a remote server or gadget so as to screen some physical marvels or to take estimations [4]. A non-specific and basic design of an M2M application is represented in Figure 2. The design is made out of essentially three sections, M2M Device Domain-containing the M2M gadgets, Network Domain which transfers the messages to servers situated in the Application Domain, offering information to business applications the gadgets are conveyed [5].

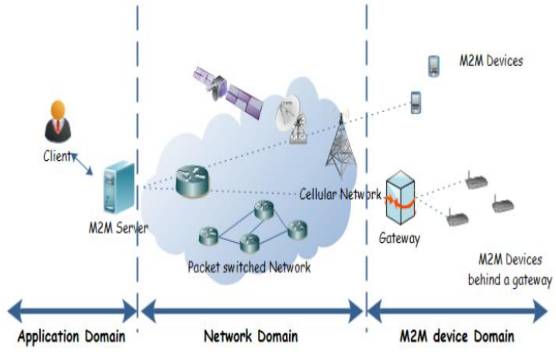

Figure 2: General Architecture of an M2M Application [4]

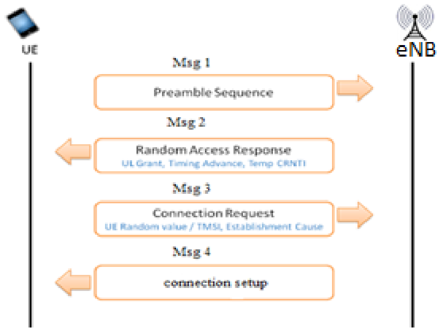

Figure 3: RA procedure signaling

A. Random Access Procedures in LTE Networks

In LTE systems, the client information is transmitted through Physical Uplink Shared Channel (PUSCH) by means of booked transmissions. Offbeat gadgets gain synchronization with eNodeB and hold uplink channel utilizing RACH. RACHs are rehashed in the framework with a specific period. Every hub requiring an uplink divert transmits an introduction in a RACH. There are two categories of accesses in a RACH. The principal category is conflict based, which is utilized for customary clients. The second sort is sans dispute, which gives low inertness administration to clients with high need (handover). Just concentrate on the contention-based random access, which comprises of the accompanying strides [6].

Step 1: Each user equipment hardware (UE) haphazardly chooses an arrangement called a preface from a pool known both to UEs and the eNodeB. The transmission of this succession fills in as a demand for a committed time-recurrence asset hinder in the forthcoming planning transmission in Step 3. As UEs just transmit the arrangement without fusing their own IDs in the demand, when two UEs select a similar introduction, the eNB will get a similar grouping.

Step 2: The eNB recognizes every one of the introductions it has effectively gotten, passing on a planning arrangement direction with the goal that resulting transmissions can be synchronized.

Step 3: UEs start utilizing PUSCH to transmit their IDs after getting the affirmation. In the event that two UEs have chosen a similar prelude in Step 1, both will be told to transmit their IDs inside a similar time-recurrence asset obstruct in Step 3, and afterward, an impact will happen.

Step 4: Contention resolution message will be communicated with the ID of UEs effectively decoded by the eNB. In the event that an impact happens while the eNB still figures out how to decipher the message in Step 3, it will educate the UE whose Step 3 message is decoded and this fruitful UE will send an ACK. Unacknowledged UEs will stay noiseless until the following RACH. The random-access procedure is shown in Figure 3.

III. Related Works

Recently researcher and industry have been investigated a significant study on M2M communication since M2M communication is very promising. The recent study of M2M on different access networks such as LTE and LTE-A came out with several proposals [6-8]. The several techniques had been proposed to resolve the existing challenge of RACH congestion in LTE-A RAN. This technique can be categorized into Numbering method, Prioritized Random Access (PRA), Self-Optimizing Overload Control (SOOC), Heuristic Algorithm to update p. The details discussion is given as below:

A. Numbering Scheme (NS)

At the point when an M2M device does effective RACH methodology, the eNB allots a number between 0 to n. On the off chance that a gadget is allotted a number *k* then on its next system get to, it will send the RA *Req* on k^{th} PRACH space from the season of initiation of the gadget. So each time when M2M gadgets get to the system, RACH method is required for uplink synchronization of them with eNB. In the event that the gadget flops in kth PRACH space, at that point it will back off and will send the RA *Req* on $2k^{th}$ PRACH opening. On the off chance that the gadget bombs even after, at that point it will never again sit tight for the following k^{th} PRACH opening. It will take after the ordinary backoff plot. Here, the estimation of n is picked by eNB such that concurrent access to various gadgets is spread over some PRACH openings to lessen dispute. In the meantime, normal get to postpone ought to likewise be controlled [3].

B. Prioritized Random Access (PRA) scheme

The PRA conspire takes care of the RAN over-burden issue and gives QoS to various classes of M2M gadgets. This is accomplished by pre-dispensing RACH assets for various M2M classes while keeping an expansive number of synchronous RACH endeavors. The proposed PRA design is made out of two principle parts: virtual asset allotment with class subordinate backoff strategies and dynamic access excluding [9].

C. Self-Optimizing Overload Control (SOOC) scheme

SOOC empowers the base station to consequently include or lessen PRACH assets when it recognizes an expansion or reductions in PRACH stack, individually with a specific end goal to totally keep PRACH from over-burdening. SOOC incorporates the RACH asset partition plot, the get to class excepting plan and the opened get to conspire [2].

D. Heuristic Algorithm to update p

This calculation means to adaptively refresh the ACB factor *p*. In a genuine framework, the eNB can't procure the quantity of accumulated clients in the framework. The data it has constrained to the quantity of fruitful transmissions and the quantity of crashes amid each schedule vacancy and in addition the aggregate number of M2M gadgets that have enrolled in the framework. There is a natural exchange off in picking the ACB factor *p*. At the point when *p* is too huge, there will be a considerable measure of prefaces transmitted noticeable all around, and there will be crashes on the vast majority of the preludes. Then again, when p is too little, not very many clients will have the capacity to pass ACB check and transmit their prefaces, bringing about fewer crashes, however, under-usage of system assets [7].

IV. PROPOSED METHOD

The MTC devices allocated a predefined esteem *p* each time when an MTC device endeavors to begin the arbitrary get to methodology; it first arbitrarily produces an irregular number in the vicinity of 0 and 1. On the off chance that the created number is littler than the device's *p* esteem, it can transmit RACH prelude Otherwise, the accumulated gadget needs to back off and sits tight for the following interim to attempt again with another fresh debut MTC device.

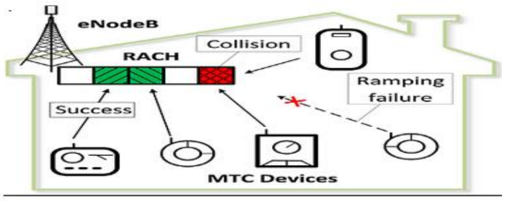

Figure 4: System Model

Considering the *N* MTC device which has formerly listed with an eNB. These devices have just recuperated from an emergency, such as a power blackout and all of them try to recreate synchronization with the eNB. As these devices are not synchronized, they will not be activated all at once, but within a limited timeT_A, denoted as the activation time. Each MTC device is activated at time $0 \le t \le T_A$with probability *f (t)* in which *f (t)* follows a beta distribution with parameters α and β as [1, 10].

$$f(t) = \frac{t^{\alpha-1}(T-t)^{\beta-1}}{T^{\alpha+\beta-1}\,\beta_{(\alpha,\beta)}} \tag{1}$$

where $\beta_{(\alpha,\beta)}$ is the beta distribution function.

Adopt there are I_A random access channels within the activation time. The duration of the random-access channel is shorter than the interval between two random access channels. We divide the activation time into I_A discrete slots where slot *i* begins with i_{th} random access channel.

The expected number of new activations (arrivals) during each time slot, n_i *i* = 1, 2, . . . , I_A, is subject to the distribution of activation traffic *f* (*t*) and the total number of devices *N* as [10].

$$\mathrm{n_i} = \int_{\mathrm{t_{i-1}}}^{\mathrm{t_i}} \mathrm{f(t)\ dt} \qquad \mathrm{i = 1, 2 \ldots I_A.} \tag{2}$$

where n = users (includes new arrivals and backlogged users).

Suppose there are M available preambles in each RA-TS and users choose preambles with equal probability given by 1/M.

A. Successful Transmission

Takes place when exactly one user (device) chooses a given preamble. The success probability for MTC devices can be written as [11].

$$p_s^{M2M} = \binom{n}{1}\left(1-\frac{1}{M}\right)^n \tag{3}$$

where p_s^{M2M} = the success probability of MTC device

From Equation (3) the success probability for MTC is equal to:

$$P_s^{M2M} = \frac{n}{M}\left(1-\frac{1}{M}\right)^{n-1} \tag{4}$$

B. Throughput of MTC Devices

Can compute the throughput derivative from equation (4) as [8]:

$$T^{M2M} = M.P_s^{M2M} \tag{5}$$

or written as:

$$T^{M2M} = n\left(1-\frac{1}{M}\right)^{n-1} \tag{6}$$

where T^{M2M} = Throughput of MTC device.

C. Idle probability of MTC Devices

This means there is no device to choose a preamble m (m∈ {1, 2...? M}), we can calculate idle probability as [11].

$$p_i^{M2M} = \binom{n}{0}\left(1-\frac{1}{M}\right)^n \tag{7}$$

So, idle probability of MTC is equal to the Equation (8).

$$P_i^{M2M} = \left(1-\frac{1}{M}\right)^n \tag{8}$$

where P_i^{M2M} : idle probability of MTC.

D. Collision probability for MTC Devices

When two or more MTC devices are choosing the same preamble at the same time can be derived from equation (4) and equation (8) and written as [11, 12].

$$P_c^{M2M} = 1 - P_s^{M2M} - P_i^{M2M} \tag{9}$$

So, the collision probability from Equation (9) is equal to:

$$P_c^{M2M} = 1 - \frac{n}{M}\left(1-\frac{1}{M}\right)^{n-1} - \left(1-\frac{1}{M}\right)^n \tag{10}$$

where P_c^{M2M} = collision probability of MTC device.

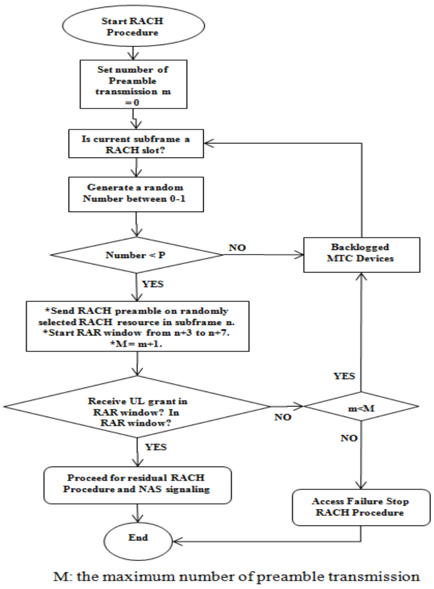

Figure 5: Flowchart for P method procedure

V. Simulation Assumption and Result Discussion

The performance is evaluated using Matlab to control the overload in RACH procedure. The simulation parameters are assumed in Table 1 [8, 13-15].

Table 1
Simulation parameters

Parameters	Value
System type	Single-cell
Cell radius	2.5Km
Number of MTC devices	300
RA preamble sequence format	0
Number of UL grants per RAR	3
System bandwidth	5MHz
PRACH configuration index	6
Available preambles	54

A. *Results and Discussion*

The simulation environment is comprised of 300 MTC gadgets, who's appropriated by Beta conveyance one LTE-A base station secured region around 5000x5000 m^2, accepted that the full-scale cell has a BS amidst the cell. Appeared in Figure 6 the era of the MTC gadget and eNB positions in reenactment zone appeared by red stars and blue stars, individually.

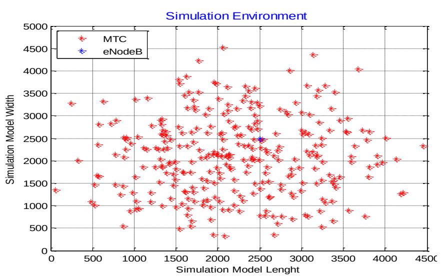

Figure 6: Simulation Environment

In the proposed procedure assigned a predefined esteem number to all MTC gadgets called *P*. In the recreation have two estimations of *P* equivalent to 0.15 other equivalent to 0.04, these two cases used to figure out the probability achievement, throughput, idle probability and collision probability.

(a) Success probability

The characterization of the quantity of introductions effectively got by the eNB isolated by the aggregate number of RACH prelude transmission in that scheduled opening. At the end of the day, the aggregate number of demand RACH introduction is the quantity of MTCs gadget sending preface at that availability.

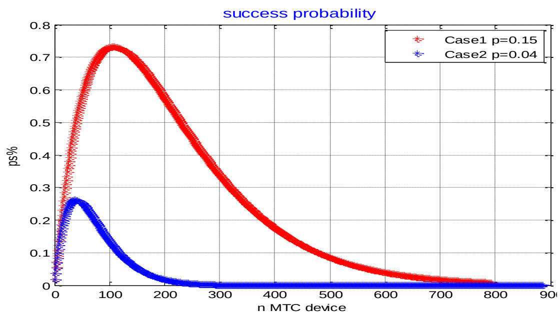

Figure 7: Success Probability

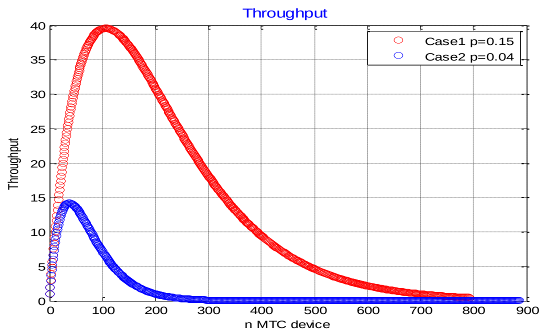

Figure 8: Throughput

As appeared above in Figure 7, the rate of accomplishment to n^{th} MTC gadget/devices. It can be seen that the achievement of probability increments with expanding of various MTC devices that until reach to 100 gadgets. More than 100 gadgets the achievement similarities that will be diminishing quickly. For instance, the achievement likelihood is 0.7310, 0.0401, 0.0183, and 0.0086 for 100, 600, 700, and 794 MTC gadgets separately. Contrast with Case 2 the most extreme achievement rate 0.26 when MTC break even with 40 and afterward diminish quickly until 0.0019 with 300 MTC gadgets. Also, will be focused on all extra MTC gadgets.

(b) Throughput

The result of the quantity of RAOs every second and the quantity of effective transmissions per RA-TS. In Figure 8 beneath, demonstrate that the measure of throughput develops straightly with the expansion of craved achievement likelihood watches that the measure of the throughput increment with expanding a number of MTC gadgets until 100. More than 100 gadgets the throughput will diminish quickly. For instance, the throughput sum is 39.47, 30.68, 9.44, 4.61, and 0.4635 with 100, 200, 400, 600, and 794 MTC gadgets separately in Case 1 yet in Case 2, the measure of throughput began at 1 and expanding until 14.13 with 40 MTC gadgets. And after that abatement quickly until 0.0096 with 400 MTC gadgets. Furthermore, will be focused on all expansion number of MTC gadgets.

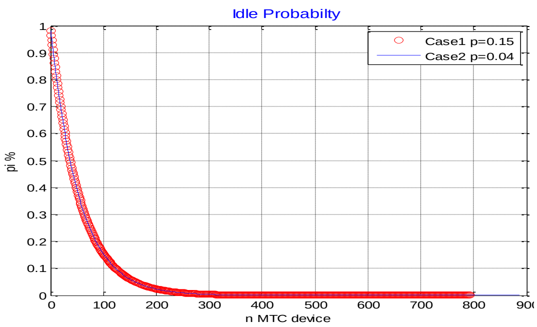

Figure 9: Idle Probability

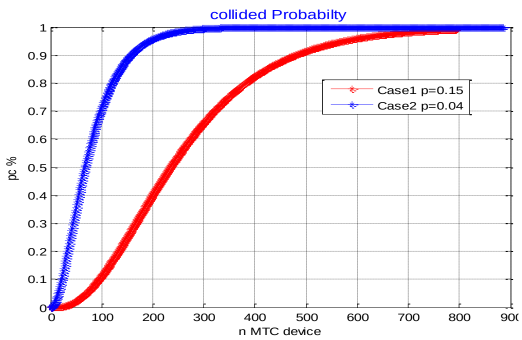

Figure 10: Collided Probability

(c) Idle Probability

The quantity of "sit out of gear" MTC gadget isolated by the aggregate number of n gadget. Appeared in Figure 9 underneath, the site without moving likelihood same in the two cases began at 100% and diminish quickly with expanding number of gadgets. For instance, 0.9815, 0.1542, 0.0238, and 0.0037 with 1, 100, 200, and 300 particular.

(d) Collision Probability

The quantity of "collided" introduction partitioned by the aggregate number of preludes. Figure 10 demonstrates that impact likelihood in case1 that expansion quickly with expanding number of MTC gadgets. For instance, 0.0228, 0.1148, 0.6610, 0.8246 and 0.9914 with 50, 100, 300, 400, and 794 MTC gadgets individually and on the off chance that 2 the crash likelihood began at 0 and expanding quickly 0.3536, 0.7163, 0.9944 with 50,100,300 separately MTC gadgets until 100% with 537 MTC gadgets and for all expansion number of MTC gadgets.

VI. Conclusion

The persistent technique is one of the methodologies that proposed for enhancing the performance of the RAN over-burden issue coming about because of the concurrent gets to of mass MTC gadgets. This paper presents diagnostic models to appraise the achievement probability, throughput, sit out of gear probability, impact probability. The p-persistent technique with accumulated MTC devices settled the RAN over-burden Problem inside a point of confinement number of MTC devices and give an appropriate determination when the estimation of P is huge.

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