AN EFFECTIVE APPROACH TO CONTENTION BASED BANDWIDTH REQUEST MECHANISM IN WIMAX NETWORKS

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ABSTRACT

In this paper the IEEE 802.16 standard based Mobile WiMAX (Worldwide Interoperability for Microwave Access) system is investigated for the purpose of Quality of Service provisioning. As a potential solution, scheduling algorithms have been taken into major concern. Within the pool of scheduling algorithms and for the purpose Contention based bandwidth request resolution, the Modified Contention Based BW Resolution algorithm (MCB-BWR-Scheme) is proposed. Supported by the fact that the standard does not emphasize a specific scheduling algorithm for contention period based services, therefore, the choice of the scheduling algorithm for the WiMAX systems is very important. There are several scheduling algorithms for WiMAX in the literature, however, studies show that an efficient, fair and robust scheduling algorithm for WiMAX systems is still an open research area and hence a well thought out algorithm will be of great contribution to the area under investigation. Results from the OPNET Modeler simulation program show that the adjusted algorithm works well with delay and throughput constraints. It is also in consistent with the quality of service demands of the video and voice traffic.

General Terms: WiMAX, Backoff Algorithm, Contention Resolution.

Keywords: WiMAX, IEEE 802.16, Modified BEB
1. INTRODUCTION

1.1 Worldwide Interoperability of Microwave Access (WiMAX)

Broadband Wireless Access (BWA) has become the easiest way for wireless communication and a solution to rapid requirement of internet connection for data, voice and video service. BWA is a fast and easy alternative of cable networks and Digital Subscriber Line (DSL) technologies. The IEEE working group has designed a new standard based on BWA systems for last mile wireless access named IEEE 802.16 Wireless MAN [8]. The IEEE 802.16 architecture is designed to achieve goals like easy deployment, high speed data rate, large spanning area, and large frequency spectrum. The IEEE 802.16 standard provides QoS to all different kinds of application including real time traffic in the form of flow type association with each application.

The above stated advantages of IEEE 802.16 Wireless MAN prepare a platform for this standard to compete with other wireless communication technologies like IEEE 802.11 and its variants. Subsequently the requirement from IEEE 802.16 is to provide QoS for all possible applications in both (uplink and downlink) directions. The IEEE 802.16 is likely to emerge as a dominant technology for cost-competitive ubiquitous broadband wireless access, supporting fixed, nomadic, portable and fully mobile operations offering integrated voice, video and data services.

The basic IEEE 802.16 architecture [9] consists of one Base Station (BS) and one (or more) Subscriber Stations (SSs). Both BS and SS are stationary while clients connected to SS can be mobile. BS acts as a central entity to transfer all the data from SSs in PMP architecture. Any two (or more) SSs are not allowed to communicate directly. Transmissions take place through two independent channels—Downlink Channel (from BS to SS) and Uplink Channel (from SS to BS). Uplink channel is shared between all the SSs while downlink channel is used only by BS. The standard defines both Time Division Duplexing (TDD) and Frequency Division Duplexing (FDD) for channel allocation. Both channels are time slotted and composed of frames. The TDD frame composed of downlink and uplink sub frames. The duration of each of these frames can be controlled by BS whenever needed. Downlink channel is broadcast channel. BS broadcast data to all SS on downlink channel. SSs accept only those packets which are destined to it. More details on this architecture can be found in IEEE 802.16 draft [8]. The Figure shows the BS and SS architecture connected to each other through wireless links.

![Fig.1 WiMAX Architecture](Image)
2. **IEEE 802.16 SERVICE CLASSES**

The IEEE 802.16-2004 standard [3] specifies the provision of four scheduling services:

| Service Class                        | Description                                        | Applications                      |
|--------------------------------------|----------------------------------------------------|-----------------------------------|
| Unsolicited Grant Service (UGS)      | For Constant Bit Rate (CBR) and delay-dependent    | VOIP                              |
|                                      | applications                                       |                                   |
| Real-Time Polling Service (rtPS)     | For Variable Rate and delay dependent applications  | Streaming audio, Streaming video  |
| Extended Real-Time Polling Service (ertPS) | For Variable Rate and delay dependent applications | FTP                               |
| Non-real-time Polling Service (nrtPS) | Variable rate and non-real time applications       | VOIP with silence suppression     |
| Best Effort (BE)                     | Best Effort                                        | E-mail, web traffic               |

3. **CONTENTION ACCESS IN IEEE 802.16 MAC**

The MAC layer of IEEE 802.16 specifies the rules for the contention-mode BW request. A contention period is a predetermined number of minislots at the beginning of a UL subframe.

![Fig. 2 Operation of Contention Resolution](image-url)
The contention period is divided into an integer number of transmission opportunities (TOs) and is called an information element. Each TO can be used for transmitting only one BW request. If more than one station tries to transmit in the same TO, collision happens. Since it is not practically possible for SSs to sense the UL channel to detect a collision, the SSs can only know of the success of their BW request transmission if they receive a response in the form of a BW grant in the subsequent frames. A station that does not receive a response to its BW request by a certain deadline (called T16, with a minimum length of 10 ms) assumes that either a collision happened or resources are not available at the BS. In either case, since the SS cannot determine the cause, it assumes that a collision happened and uses an exponential binary back-off procedure to resolve the collision. The collision resolution and avoidance regulation of 802.16 MAC requires each SS to wait a random number of TOs before attempting a transmission in the contention period. This number is called the random back-off number and is chosen from an interval of \((0, CW - 1)\), in which \(CW\) is the contention window size and is initially set to the minimum or initial contention window size of \(W\). After each collision (when the response to the request is not received for T16 duration), the contention window size doubles (\(CW = 2^i \cdot W\) after \(i\)th collision). The doubling continues until the maximum contention window size is reached after \(m\) retransmissions (\(CW = 2^m \cdot W\)). The values of minimum and maximum contention window sizes can be dynamically adjusted by the BS. When a successful transmission happens or the packet is dropped due to reaching the retransmission limit, the contention window size is reset to \(W\).

The size of the contention period is determined by the BS and may be different in each frame. If the random value of the back-off counter does not reach zero within a contention period, its countdown is frozen at the end of the contention period and resumes in the next contention period.

### 4. RELATED WORK

In recent years, many researchers are interested in IEEE 802.16 QoS research. There are many articles on the WiMAX QoS scheduling that have presented architectures and scheduling disciplines to guarantee QoS.

In [8][9] the introduction of Wimax is described. Broadband Wireless Access (BWA) has become the easiest way for wireless communication and a solution to rapid requirement of internet connection for data, voice and video service.

In [10] J. Lin and H. Sirisena, focuses on the analysis of QoS in WiMAX networks. It includes the definition of various service flows and their applications defined by the IEEE 802.16 standard.

In [11], K. Wongthavarawat and A. Ganz presents an approach based on a fully centralized scheduling (GP Clike) scheme, where a global QoS agent collects all the necessary information on traffic flows, and takes decisions on traffic admission, scheduling, and resource allocation. Based on the complete global knowledge of the system, the deterministic QoS levels can be guaranteed.

In [1] Yousry Salaheldin Abdel-Hamid, formulated the new concept for contention based bandwidth request mechanism by driving the idea of using a random variable radix for backoff window instead of increasing the backoff window exponentially as defined in BEB algorithm. But the work does not specify any method for random request generation.

In [2] Young dea lee, Sung Jun Park and SeungJune Yi proposed a concept of transferring back off parameters by Base Station to SS i.e. there is no need of calculating the value of back off counter explicitly by SS as it is provided by BS. But in this method it is observed that if response packet containing backoff value parameter dropped or lost due to some reason than SS would enter into a long wait state.

In [3] Jianhua He, Kun Yang, Ken Guild, and Hsiao-Hwa Chen defined the bandwidth request mechanism using piggybacking procedure.
In [4] Yaser Pourmohammadi Fallah; proposed an analytical model for contention based bandwidth request mechanism in wimax networks. He formulated method for random generation of bandwidth request using Poisson process.

In a nutshell, all the paper survey work concluded that there is no proper technique or any method is specified till date which generates a proper random back off counter value in order to increase contention resolution efficiency and other QoS parameters.

5. PROBLEM FORMULATION

IEEE 802.16 specification has been developed keeping in mind the strict QoS requirements of various kinds of flows. However there is no specification for a contention scheduling algorithm to meet these requirements. Hence, a scheduling algorithm must be developed for IEEE 802.16 in such a way so that it can cater to the QoS requirements of the different classes of flows.

We propose a scheduling architecture with an aim at providing the delay and t guarantees of the various QoS sensitive flows. We will evaluate the performance of our algorithm by running extensive simulations. Based on the results of the simulations we will study the effectiveness of our algorithm in catering to the QoS needs of different types flows.

6. PROPOSED WORK

In conventional backoff procedures (BEB), the SS shall double its back-off window size if the current contention window size is smaller than the maximum back-off window size. The SS selects a fresh random number from 0 to W − 1, where W indicates the new back-off window size and repeats the deferring procedure. The SS can attempt to transmit BRs until the maximum number of retries is reached.

In conventional method-After sending request to the BS, SSs keeps waiting for UL-MAP-RES reply message from BS in order to get connected. There may be some other reasons that SS is not acknowledged:

i. Collision
ii. Packet Drop
iii. Channel Failure

The main drawback of this scheme is bandwidth wastage. i.e SS keeps waiting while there is bandwidth availability is present at BS.

This problem can be sorted out if SS station is made to send request frequently to BS i.e. SS station sends request after random time units frequently which is proposed solution in this paper.

Since several SSs can access the channel simultaneously during each frame, their respective transmissions may collide. The mandatory contention resolution algorithm is TBEB based, with an initial backoff window and a maximum backoff window controlled by BS. Meanwhile, SS will set its initial backoff window equal to the request backoff start whenever it has information to send and has to enter into the contention resolution process. SS shall randomly select a number, which indicates the number of contention transmission opportunities that SS shall defer before the transmission of bandwidth request, within its backoff window. The backoff process proceeds whenever collisions happen.

Since SS randomly selects a backoff number, so all SS will always tend to choose a small value of this number that can further prone to collision. Therefore a proper method must be specified to generate this random number so that all SSs can get the opportunity to transmit data.

6.1 Proposed Contention Based Bandwidth Request Scheme in Wimax

In this section, we analyze the performance of the contention access mode of 802.16 in terms of its capacity to deliver BW requests from stations to the BS. The analysis in this section is different from the classic slotted ALOHA system analysis in that we model the exponential back-off procedure for the first
transmission and retransmissions and do not assume an infinite number of stations. In addition, our
analysis considers each station rather than the system as a whole on the average. For our analysis, we
assume that there are \( n \) stations with traffic of either type BE or type nrtPS that use contention access to
request BW.

In 802.16, the requests are generated based on the decisions made by a vendor-defined algorithm, whereas
in 802.11, the channel access is attempted for each packet. The model presented in this paper is much
more detailed than the models for 802.11 to capture the precise operation of the 802.16 MAC and
incorporate its different acknowledgement timeout procedure.

In our model, we assume that requests are generated at random intervals, emulating the general behaviour
of user-defined algorithms for request generation. In particular, we assume an Inverse Transformation
Method (ITM) to be a good representation of the request generation pattern. Using a Inverse
Transformation process is generally reasonable because requests for BW are generated for several
independent connections within a station and by user-defined algorithms. It is worth emphasizing that the
volume of the generated BW requests is not directly correlated with the volume of the actual data, as BW
requests are generated based on a vendor-selected algorithm. If the request generation rate is high,
requests are generated back to back. We call this mode persistent request generation or the saturation
mode. The case where requests are generated with larger intervals is called infrequent request generation
(also called the nonsaturation case).

6.2 Back off Mechanism (CW: Contention Window)

To manage the backoff window, a Binary Exponential Backoff (BEB) mechanism is used with WiMAX.
Whenever a backoff occurs, the backoff time(backoff counter) is randomly chosen in the range \((0, W_i - 1)\)
where \(W_i\) is value of contention window at \(i\)th transmission. After each unsuccessful transmission, the
backoff window size is doubled, up to a maximum value \(2mW_i\), where \(W_i\) equals to \((W_{\text{max}} + 1)\) and \(m\) is
a specified number of attempts. Once the backoff window size reaches \(W_{\text{max}}\) it will stay at the value of
\(W_{\text{max}}\) until it is reset. The value of \(W_i\) will be reset to \(W_{\text{min}}\) after every successful transmission of a data
frame or a RTS frame, or when a retry counter reaches its limit.

Since a station uses CW to control the backoff counter for data transfer, how to set CW will affect the
performance of the QOS. To optimize the performance of the QOS, we consider the backoff procedure as
a progress to search the optimal value of CW.

To solve this problem, we propose a dynamic CW resetting scheme to let the backoff counter oscillate
around the optimal value.

The proposed scheme is described as follows:

A. After a successful transmission, \(W\) is set to the value:
   \[
   W_i = \max\left[\frac{W_i}{2}, CW_{\text{min}} + 1\right].
   \]

B. Whenever a transmission fails, \(W\) is set to the value:
   \[
   W_i = \min\left[2 W_i, CW_{\text{max}} + 1\right].
   \]

Inverse Transformation method:

Inverse transform sampling (also known as inversion sampling, the inverse probability integral transform,
the inverse transformation method, Smirnov transform, golden rule,[1] etc.) is a basic method for pseudo-
random number sampling, i.e. for generating sample numbers at random from any probability distribution
given its cumulative distribution function (cdf).

The basic idea is to uniformly sample a number \(u\) between 0 and 1, interpreted as a probability, and then
return the largest number \(x\) from the domain of the distribution \(p(X)\) such that \(p(\text{infinity} < X < x) \leq u\).
For example, imagine that \(p(X)\) is the standard normal distribution (i.e. with mean 0, standard deviation
1). Then if we choose \( u = 0.5 \), we would return 0, because 50% of the probability of a normal distribution occurs in the region where \( X \leq 0 \). Similarly, if we choose \( u = 0.95 \), we would return 1.95996...; if we choose \( u = 0.99 \), we would return 2.5758...; if we choose \( u = 0.999999 \), we would return 4.891638...; etc. Essentially, we are randomly choosing a proportion of the area under the curve and returning the number in the domain such that exactly this proportion of the area occurs to the left of that number. Intuitively, we are unlikely to choose a number in the tails because there is very little area in them: We'd have to pick a number very close to 0 or 1. Computationally, this method involves computing the quantile function of the distribution — in other words, computing the cumulative distribution function (CDF) of the distribution (which maps a number in the domain to a probability between 0 and 1) and then inverting that function. This is the source of the term "inverse" or "inversion" in most of the names for this method. Note that for a discrete distribution, computing the CDF is not in general too difficult: We simply add up the individual probabilities for the various points of the distribution. For a continuous distribution, however, we need to integrate the probability density function (PDF) of the distribution, which is impossible to do analytically for most distributions (including the normal distribution). As a result, this method may be computationally inefficient for many distributions and other methods are preferred; however, it is a useful method for building more generally applicable samplers such as those based on rejection sampling. For the normal distribution, the lack of an analytical expression for the corresponding quantile function means that other methods (e.g. the Box–Muller transform) may be preferred computationally. It is often the case that, even for simple distributions, the inverse transform sampling method can be improved on[2]: see, for example, the ziggurat algorithm and rejection sampling. On the other hand, it is possible to approximate the quantile function of the normal distribution extremely accurately using moderate-degree polynomials, and in fact the method of doing this is fast enough that inversion sampling is now the default method for sampling from a normal distribution in the statistical package R. It is important to note that there is no universal algorithm for BW request generation, and using a model such as the one assumed here is inevitable. A BW will be granted if the BW request message is received successfully (no collision) and there is enough BW available. In the case of a collision or unavailability of BW, the station has to wait for some timeout duration (T16 seconds) and then start contending for a BW request again. Without loss of generality, we assume that the timeout value is \( M \) frames long.

6.3 The Markov Chain Model

![Figure 2.3 An i\textsuperscript{th} Backoff Window Stage Abstraction to a Single Window Stage](image)

Figure 2.3 An \( i \)\textsuperscript{th} Backoff Window Stage Abstraction to a Single Window Stage
In [12], Bianchi presented a Markov model with i backoff stages, 0 ≤ i ≤ m. Each stage has a backoff window Wi corresponding to the states at that stage. Transitions occur between states in every stage with probability 1. Before the first transmission attempt i = 0, an SS randomly chooses a uniformly distributed number (state) within the range [0, W0 − 1] and decrements its counter each slot and transmits when the counter reaches zero. If a collision occurs, the SS enters the next retrial stage using a binary exponential backoff (BEB) mechanism by doubling its backoff window so that Wi = 2Wi−1. If further collisions occur, this process continues until the last stage is reached with a maximum window size of Wm, where m is the maximum number of retrial stages. This backoff window scheme is employed in much of the literature in the area, but it results in a two dimensional chain with a large number of states. Since each stage i represents the time an SS waits until it begins the ith transmission attempt, the backoff states at stage i can be represented by a single wait state swi and a retransmission probability i. Being the main performance measure in wide range of contention systems, the terms average throughput and performance are used interchangeably. The relation between Wi and the retransmission probability i can be derived as follows [21] Since on every stage, the location of each backoff state in the interval [0, Wi − 1] is uniformly distributed, the average wait time at every stage is simply Wi /2. We have

\[
\frac{W_i}{2} = (1-\gamma)\gamma + 2(1-\gamma)^2\gamma + \cdots + (W_i-1)(1-\gamma)^{W_i-1}\gamma
\]
\[
= \sum_{k=1}^{W_i} k(1-\gamma)^k\gamma
\]
\[
= \frac{1-\gamma}{\gamma} \left[ (W_i\gamma - \gamma + 1)(1-\gamma)^{W_i} \right]
\]

For a sufficiently large initial backoff window size (e.g., W0 = 32) [18], [22], (1 − i)Wi << 1 in (2.1), making the second term on the right-hand side 0. The retransmission probability at stage i can therefore be approximated by

\[
\gamma_i \approx \frac{2}{W_i+2}
\]

Instead of doubling the backoff window (waiting interval) after every unsuccessful retransmission attempt [19], a variable radix r is introduced such that Wi = ri−1W0 which can take any value. Therefore, we have
In a multiuser system, the current state of a request sent by an SS during the random access process only depends on the previous state, therefore the process can be efficiently modeled as a discrete time Markov chain (DTMC) system [23]. Since the focus in this chapter is improving the performance of the random access process in multichannel systems, for the sake of simplicity and clarity in the analysis, the following assumptions are adopted.

1) The system is frame synchronized, and thus the current system state is determined by the requests acknowledged by the BS at the end of the downlink subframe.

2) There is abundant bandwidth, i.e., if a request successfully reaches the BS, a bandwidth grant is guaranteed.
3) The channel conditions are ideal, i.e., failure of a SS to receive a specific grant by the BS is only due to a collision of a corresponding request. Consequently, a success signifies that the request is granted.

4) If collision occurs in the last (mth) retransmission attempt, the packet is discarded and the SS returns to the idle state si.

5) Starting from an idle state si, a SS does not wait before making the first transmission attempt as in [19]. This is reasonable and practical since here a non-saturation condition is assumed so that users begin transmitting requests randomly. Thus $W_0 = 0$ and $W_i = r_i - 1W_1, 1 \leq i \leq m$.

Figure 2.4 presents the system Markov model. The system is assumed to have a one packet transmission buffer where requests arriving during a frame interval are Bernoulli distributed with an arrival probability $a$. The probability of success is $x$ indicating that the request has successfully reached the BS. Based on the assumptions above, this also indicates that a grant has been received by the SS and thus the system migrates to the transmit state $s_t$. If a collision occurs, the system enters the first wait state $s_w1$ where the retransmission probability is 1. If another collision occurs, the SS enters the next state of a finite retrial phase consisting of $m$ wait stages $s_w1...m$. If a collision occurs after $m$ retransmission attempts (state $s_wm$), the request packet is discarded and the SS exits the contention process by returning to the idle state $s_i$. At the ith retransmission attempt, the system exits the contention process from state $i$ with probability $ix$ and migrates to the transmit state $s_t$.

At steady state, the system balance equations are given by

From (2.4) the wait states are given by
With a finite population of \( N \) equal priority SSs, a particular SS successfully acquires a slot if all other contending (active) SSs do not choose this particular slot in the same frame period [23]. From the MAC perspective, the system throughput is defined as the average number of successful transmissions per network unit time (frame). According to the Markov model in Figure 2.4, the system throughput is the average number of SSs that are in the transmit state \( s_t \) during a given frame period \( N \). The average input traffic is given by the average request arrival per frame \( N \). The probability of activity \( p \) is defined as the probability an SS has a request to send at the start of a frame period. This is given by

\[
p = s_0 + s_1 + s_2 + \ldots + s_{\infty} = \frac{a(\eta_1 + \eta_2 + \ldots + \eta_x)}{\gamma_1} \left[ 1 + \frac{aG}{1 - aG} \right]
\] (2.8)

The success probability \( x \) for a SS is defined as the probability that it acquires one of the \( K \) slots during a frame period. Equivalently, none of the remaining SSs accesses the same slot in that frame period. This probability is given by [21]
Assuming an initial value of $x$ and solving (2.10) with (2.6) and (2.8) numerically, the system throughput is obtained.

**In Proposed Method**: Back off Time (BT) is calculated by Inverse Transformation Method

\[
\text{BT} = \text{inverse\_transform\_method}(0, \text{CW} - 1) \times \text{Slot\_Time}
\]

Where `inverse\_transform\_method` indicates a number randomly drawn from distribution between 0 and CW.

**Inverse transform method**: Discrete random variables

- Want to generate a discrete random variable $X$ with pmf

\[
P(X = x_i) = p_i, \quad i = 1, \ldots, n
\]

- Consider the following algorithm

1. Generate a random number $U$
2. Transform $U$ into $X$ as follows.

\[
X = x_i \quad \text{if} \quad \sum_{i=1}^{j-1} p_i \leq U < \sum_{i=1}^{j} p_i
\]

- Proof the algorithm works ...

\[
P(X = x_i) = P(\sum_{i=1}^{j-1} p_i \leq U < \sum_{i=1}^{j} p_i)
\]

\[
= \frac{\sum_{i=1}^{j} p_i - \sum_{i=1}^{j-1} p_i}{\sum_{i=1}^{n} p_i}
\]
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Steps of algorithm

At Subscriber Station
Input – Current Contention Window (0, CW)

Count ← 0
For each packet
Check out bandwidth allocation:
If(true)
Process packet;
Count = count + 1;

Else
Send request randomly (retry or retransmission)
(back off process start under contention period. value of back off counter is generated randomly using Inverse Transformation Method)
Back off time = inverse_transform_method (0, CW−1) × Slot-Time
inverse_transform_method indicates a number randomly drawn from distribution between 0 and CW.
Count = count;
If(request accepted)
Occupy Bandwidth;
Count = count + 1;
Else
Send Request randomly;
Count = count;

Output – value of backoff counter
From literature survey, it is observed that not so much research has been found towards improving the backoff counter value for WiMAX network.

In a nutshell, Inverse Transformation Method is an improved method to calculate BT(Backoff Time) and used with BEB algorithm.

After developing contention resolution algorithm, we will compare the results with other latest developed Contention resolution algorithm and analyse the performance of proposed algorithm and thus extract the efficiency and scope of algorithm w.r.t. various QoS parameters.

**PERFORMANCE RESULTS**

Simulation is performed using OPNET Modeler 14.0. Initial assumptions are: Number of SSs (N) = 8; no. Of BS = 1; number of retransmission limit = 8; packet size = 1024 bits; bandwidth = 5 mbps; backoff window ($W_0$) size initially = 5; radix variable = 2

Following QoS parameters are considered while performing simulation-Delay, load and throughput in WiMAX. The modifications are made only to the contention resolution process and other operations are left as system default.
Fig. 5 Load - Bits/sec.

Fig. 6 Load packets / sec.
6.4 Performance Analysis

This performance is executed using OPNET Modeler 14.5 and following results are obtained:
Statistics of Proposed Method (Scenario 1)
When modified BEB (Binary Exponential Backoff) method is used as contention resolution algorithm i.e. when Inverse Transformation Method is used to calculate backoff time with BEB, following results are obtained.

| Statistic                  | Average | Minimum | Maximum |
|---------------------------|---------|---------|---------|
| WiMAX Delay (sec)         | 12.002  | 18.146  | 0.006   |
| WiMAX Load (bits/sec)     | 31,654.581 | 51,434.519 | 0.0    |
| WiMAX Load (packets/sec)  | 4.004.1 | 6.572.3 | 0.0     |
| WiMAX Throughput (bits/sec) | 284,049  | 3,095,573 | 0.0   |
| WiMAX Throughput (packets/sec) | 315.63   | 564.67  | 0.00    |

Table 2 Statistics of BEB (Scenario 2)
These results are obtained with conventional BEB method, using the above markov chain model theory and equations.

| Statistic                  | Average | Minimum | Maximum |
|---------------------------|---------|---------|---------|
| WiMAX Delay (sec)         | 26.376  | 31.896  | 0.426   |
| WiMAX Load (bits/sec)     | 272,243 | 440,531 | 0.0     |
| WiMAX Load (packets/sec)  | 600.6   | 1,101.3 | 0.0     |
| WiMAX Throughput (bits/sec) | 72,304   | 120,533 | 0.0   |
| WiMAX Throughput (packets/sec) | 180.77   | 301.33  | 0.00    |

7 CONCLUSION

In this paper a new theory of Inverse Transformation Method has been considered in order to generate request randomly. In literature survey it has been observed that not much attention has been paid towards this area till date. With the proposed approach for WiMAX, delay can be reduced and throughput can be increased as compared to existing algorithms. Thus we conclude that in spite of various other techniques and algorithms implemented at different layers and levels, finding a new and optimal solution for bandwidth request regeneration randomly can also help in improving the QoS. In future there could be much more methods developed that can generate much optimum values for backoff counter values for retransmission.
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