Investigation of Bandwidth Request Mechanisms in 802.16 Networks

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Abstract- **In response to broadband wireless access need, the IEEE 802 committee set up a working group to develop such standard - IEEE 802.16. Later, an industrial association, the Worldwide Interoperability for Microwave Access (WiMAX) Forum, was formed to promote the 802.16 standard.**

The present paper aims at presenting the process of investigation of Bandwidth Request Mechanisms in 802.16 Networks under Point-to-Multipoint Mode using the simulation model created with GPSS-General Purpose Simulation System.

Keywords- **Bandwidth request, Polling system, Simulator, WiMAX networks**

I. INTRODUCTION

The next-generation wireless access technology, such as WiMAX and its mobility enhancements 802.16e and IEEE 802.20, is above the horizon. The new technology and standard migration and investment protection should be considered.

The IEEE 802.16 family of standards and its associated industry consortium, WiMAX, promise to deliver high data rates over large areas to a large number of users [3]. This exciting addition to current broadband options such as DSL, cable, and WiFi [2] promises to rapidly provide broadband access to locations in the rural and developing areas where broadband is currently unavailable, as well as competing for urban market share. WiMAX's competitiveness in the marketplace largely depends on the data rates and ranges that are achieved, but this has been difficult to judge due to the large number of possible options and competing marketing claims. Therefore the investigation of WiMAX Networks is an actual problem.

In the papers [1], [3] and [4] authors present the 802.16 standards, the expected throughput and performance of WiMAX compatible systems based on these standards, and suggest future enhancements to the standards that increase the achievable data rate, robustness and coverage, with only moderate complexity increases. The article [1] also provides a good tutorial overview of 802.16.

WiMAX specifies interoperable air interfaces from 2 to 66 GHz with a common medium access control– MAC layer .

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The 802.16 WiMAX air interface supports two operational modes: a mandatory point to multipoint- PMP mode and an optional mesh mode. In PMP mode, a centralized base station (BS) controls all communications among the stations and the BS, whereas in the mesh mode, stations can also serve as routers by cooperative access control in a distributed manner.

The present paper aims at presenting the process of investigation of Bandwidth Request Mechanisms in 802.16 Networks under Point-to-Multipoint Mode using the simulation model created with GPSS-General Purpose Simulation System.

II. WIMAX AND BW-REQ MECHANISMS

Under the PMP architecture, all transmissions between the BS and stations are coordinated by the BS. The TDMA/TDD frame structure is illustrated in Fig. 1; it consists of a downlink subframe for transmission from the BS to stations and an uplink subframe for transmissions in the reverse direction. The Tx/Rx transition gap (TTG) and the Rx/Tx transition gap (RTG) are specified between the downlink and uplink subframes, and between the uplink and following downlink subframes in the next frame duration to allow stations to turn around from reception to transmission and vice versa. In the downlink subframe, both the downlink MAP (DL-MAP) and uplink MAP (UL-MAP) messages are transmitted, which comprise the bandwidth allocations for data transmission in both downlink and uplink directions, respectively.

Moreover, the lengths of uplink and downlink subframes are determined dynamically by the BS and are broadcast to the stations through UL-MAP and DL-MAP messages at the beginning of each frame. Therefore, each station knows when and how long to receive data from and transmit data to BS The bandwidth allocated to each direction can be tuned dynamically to match the traffic in the corresponding direction. This means that if a station needs some amount of bandwidth, it makes a reservation with the BS by sending a request. On accepting the request from an station, the BS scheduler should determine and grant it a transmission opportunity in time slots by using some scheduling algorithms, which should take into account the requirements from all authorized stations and the available channel resources.

Two main methods are suggested in the WiMAX standard to offer transmission opportunities for stations to send their bandwidth request (BW-REQ) messages: centralized polling and contention based random access.

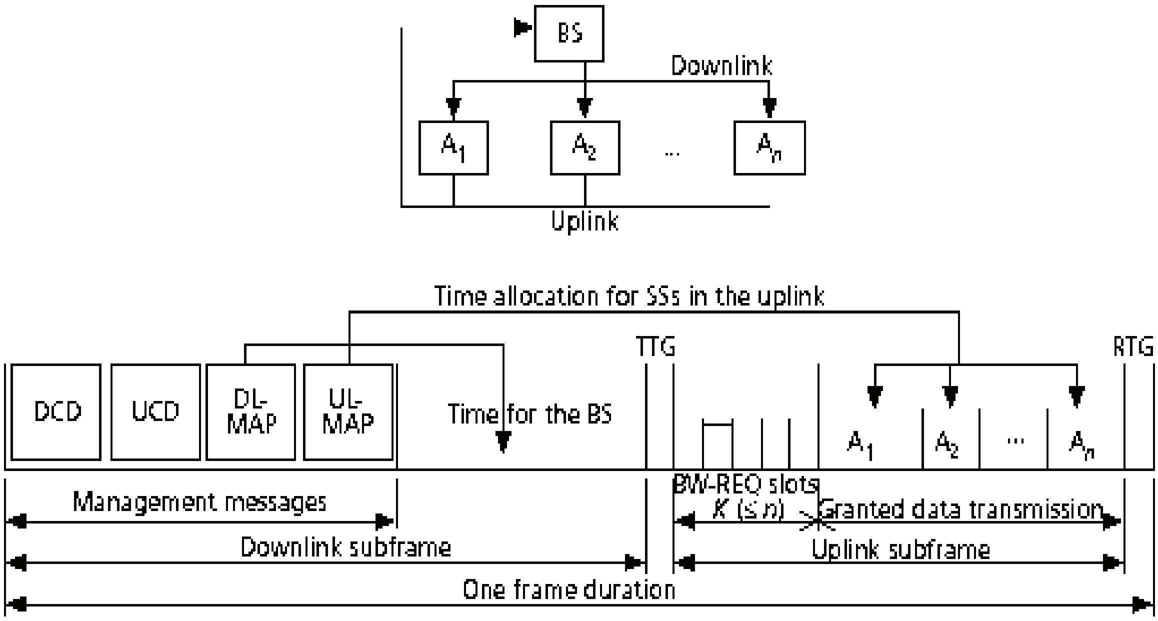

Fig.1 TDMA/TDD frame structure

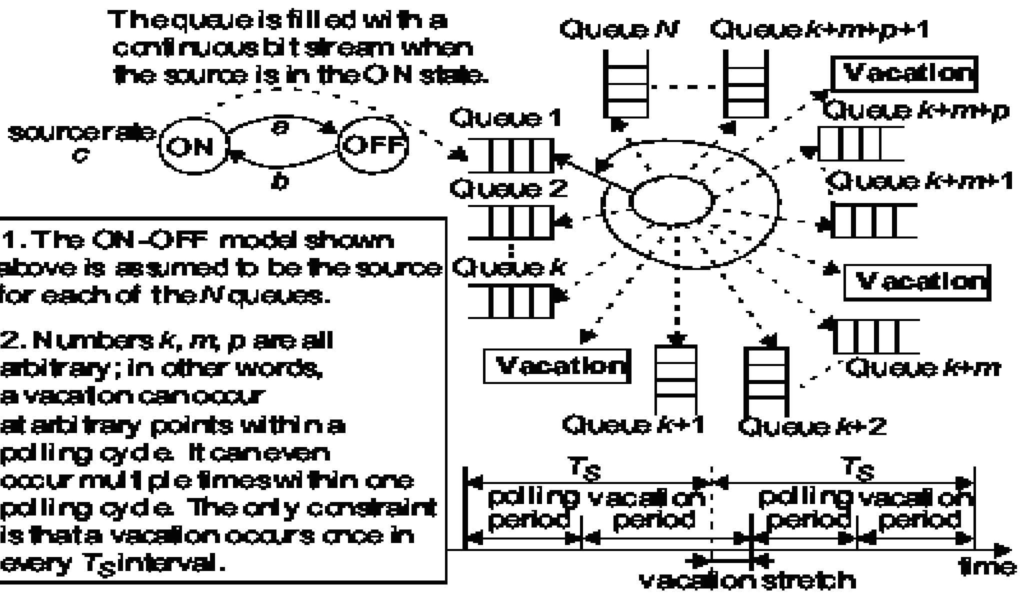

Fig.2 Simulation model

In the first case each station is only allowed to send its request when it is polled by the BS.

Each station has a buffer sufficient to store exactly one request. A station that has a request at the considered moment of time is referred to as active, otherwise it is called nonactive.

III. MODELING POLLING – BASED BW – REQ MECHANISM

The modelling process aims at getting the following results, when preliminaries given at hand simulation conditions are available: Maximum and average time for delay from the access (the time from coming of BW-REQs till their transmitting).

No specific polling algorithms are defined in the standard 802.16. Therefore, following simple round-robin polling scheme is considered for the analysis: Each of K slots is assigned equally to all of the n stations in the system; There are less slots than the total number of stations in the system (In the opposite case (K>n), the system will be very lightly loaded, and there are more slots than the total number of stations in the system.

All the stations will be able to send new BW-REQs within next frame, and the maximum delay can be easily determined- one frame duration).

In this paper we create a simulation model of polling based BW-REQ mechanism, by simplifying the earlier proposed simulation model (Fig. 2) of wireless local area network [2]. Note, both simulators are created in General Purpose Simulation System- GPSS (World Student Version).

The Q-scheme includes N queues, which is serviced by one server, and a synchronizing process switching between polling and vacation periods[2].

On 802.11 is developing the following processes: The queues filled with a continuous bit stream when the source is in the ON state; The synchronizing process schedules transmission opportunities among all queues during polling periods; A vacation can occur at arbitrary points within a polling cycle, even it can occur multiple times within one polling cycle.

Compared to model described here, the BW-REQ slots correspond to the polling period and Contention Period (CP) correspond to the vacation period, respectively.

Below, we focus on two main simplifications of the earlier proposed simulation model [2]:

Unlike the model [2] which service rate of voice packet- μ is stochastic value (depending of the codec rate; the overheads of all protocol layers above the IEEE 802.11 MAC; the probability of a source being in the ON state; and the rate of physical layer), here service rate is constant- μ=const. Thus, for each frame number of serviced BW-REQ requests- k, m, p is equal to the number of slots- K (k=l=p=K=const), instead these shown in Fig. 2.

Also, the ON-OFF model is assumed to be the source for each of the N queues, but only non-active stations generate requests instead specific process of generation and dropping of the packets [2]. Therefore, during one frame duration, each non-active station generates a request with a probability λ/n, where λ is the mean number of requests generated by the system in that frame if all stations are non-active. This new request is put into the buffer and transmitted later on.

The initial conditions for wireless network are given bellow: Number of sources- n; Total number of slots- K; Superframe length -Ts; BWREQ rate- λ; Service rate- μ.

IV. Simulation Results

In this section we investigate the polling BW-REQ mechanism, by using the proposed model above under error-free channel condition. We focus our analysis on uplink BW-REQ transmission, and more precisely its delay performance. The delay performance of the system is defined as the time interval between the moments of issuing the BWREQ and its successfully transmitting. The transmission of data packets in both directions is ignored.

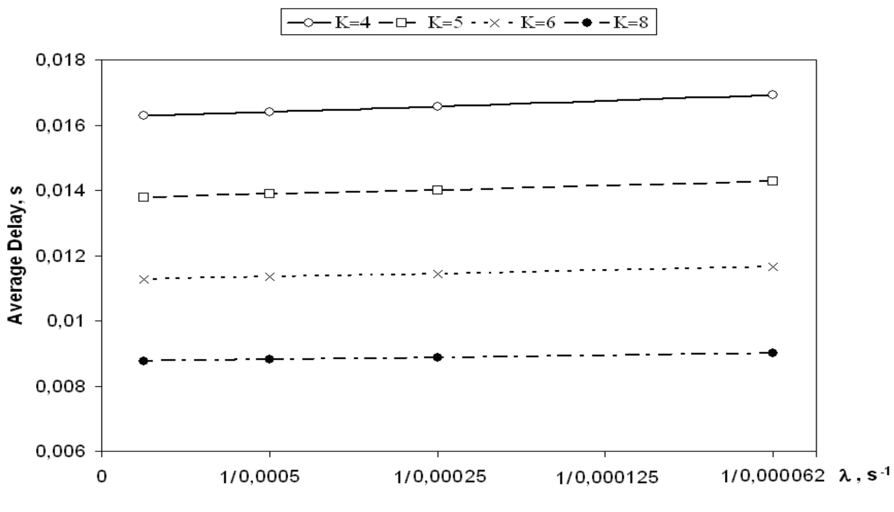

Fig 3 Simulation results

In the following experiments the arrival rates {1/0.002, 1/0.0005, 1/0.00025, 1/0.000125, 1/0.000063}and number of sources n=25 are chosen.

The frame duration is set to 2.5 ms. In each frame K BWREQ slots are included. The duration of a slot corresponds to the time needed for a BW-REQ transmission, which is PHY layer dependent. The value of K is fixed for each experiment, which means that once K is chosen as any value at the beginning of the experiment, it is not changed.

For the WiMAX PHY layer, 256- carrier OFDM and 5 MHz bandwidth are chosen.

The performance evaluation results (Fig.3) show that polling access is not very efficient when the request rate is low (λ=1/0.002=500 s^{-1}. It should be noted, if the system will be very lightly loaded (n < K), all the stations will be able to send BW-REQs within a frame.

Therefore, the delay should be one frame duration. However, here n > K and delay is 3-4 times bigger.

As shown in Fig. 3, the delay performance almost does not degrade when channel load increases. The reason is that only non-active stations can generate a request, the actual request arrival rate in a frame can sometimes be lower than λ depending on the system load.

V. Conclusion

In present paper we have studied the delay performance of the polling BW-REQ mechanisms proposed in the WiMAX standard, using simulator created with GPSS-General Purpose Simulation System.

The investigation of delay performance and its dependence of frame size, load and number of the stations in WiMAX network will be our future work when actual data packet transmission is also modeled.

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