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Resource Allocation of Scheduling Algorithm Using Improved Cat Swarm Optimization in WiMAX Networks

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Abstract – IEEE 802.16 standard has been proposed to support wide-range wireless broadband Access. In this paper, an improved method and Mathematical model based on The Adaptive rtPS Scheduling Model has been proposed. Scheduling plays an important role in providing Quality of Service (QoS). The scheduling is done based on the priority and QoS satisfaction along with the improved cat swarm optimization. The simulation shows that our algorithm can improve the Fairness and reduce the Delay along with the increase of system throughput.

Index Terms – QoS, scheduling algorithms, proportional fairness, wimax.

1. INTRODUCTION

WiMAX technology, grounded on IEEE 802.16 standards [1], offers solution for various fixed and mobile broadband wireless access (BWA) networks, targeting at providing provision to vast variety of multimedia applications [2], comprising non-real-time and real-time applications. In broadband wireless technology, WiMAX has been established with advantages like predefined quality of service (QoS) structure and high transmission rate, facilitating scalable networks proficient for video, data, and voice. Nonetheless, IEEE 802.16 standards do not describes scheduling procedure which promises the QoS necessary for multimedia applications. The scheduling mechanism provides a significant role in QoS provisioning for diverse kinds of multimedia applications. Novel releases of specific standards were published, like IEEE 802.16-2009 and IEEE 802.16m [3], whereas changes were initiated in PHY and MAC layers, however scheduling algorithms have not been definite yet.

Current studies display that a fair, efficient, and forceful scheduler for WiMAX is yet an open research zone. The scheduling algorithms design in WiMAX networks [4] is appropriately challenging as the wireless communication channel is continually wavering. Thus, to produce improved wireless link use, the standard describes the adaptive modulation functions usage in physical layer. Nonetheless, a novel issue arises: in what way an efficient scheduling of subscriber stations (SSs), positioned in diverse regions away from base station (BS), transmitting information in diverse burst profiles [5], according to the coding schemes (MCSs) and modulation utilized for data transmission. This topic is significant as the scheduler must promise the application's QoS necessities and assigns the resources in fair and well-organized manner.

QoS in WiMAX

WiMAX supports connection-oriented MAC which is further subdivided into three different sublayers namely: Convergence, Common part and security sublayer. Connections are referenced with 16-bit connection identifiers (CIDs) and may require continuously granted bandwidth or bandwidth on demand. There are two types of connections: Data and Management. Management connections can be primary(less urgent), basic (urgent), or secondary and cast off to allocate management messages like REP-RSP/RNG-REQ/RST etc. All three connections replicate the three diverse QoS requirements cast off by diverse management levels.

Initial connection is utilized to transfer short, time-critical MAC, and radio link control (RLC) messages while Primary management connection is cast off to allocate added delay-tolerant and longer, messages, utilized for connection establishment and authentication. Secondary management connection promotes standards-based management messages like Trivial File Transfer Protocol (TFTP), Dynamic Host Configuration Protocol (DHCP), and Simple Network Management Protocol (SNMP). A management CID is bi-directional and can be utilized mutually in downlink and uplink transmission.

Each BS-SS pair necessitates basic and primary management connection identifier to transmit. Data connections are recognized and identified by 32-bit number and service flows called SFID or service flow ID and allocated when data service/connection [6] is produced for the complete life of service. Service flow could be in any one of three kinds (or modes): admitted, Provisioned, or active. BS and SS can mutually set the service flow kinds over DSA or DSC three-way handshaking procedure.

The rtPS, nrtPS, and BE scheduling

As mentioned, the uplink scheduling is constructed based on BW-REQ messages transmitted by SSs. The rtPS service makes use of unicast polling method and acquired from BS periodical grants to transmit the BW-REQ messages. Then rtPS service can use contention request opportunities or unicast request polling. However, the nrtPS connections are polled on a regular interval to assure a minimum bandwidth. The interval that BS polls then rtPS connections is defined dynamically by the proposed algorithm. The BE service uses contention base polling to send its BW-REQ messages. The BS should reserve part of the bandwidth for the polling processes. In addition, the scheduler must guarantee the requirements of limited maximum delay for the rtPS service and the minimal bandwidth for the rtPS and nrtPS services [7]. If there are resources left, it is assigned to the BE service, since this service does not have any QoS requirements.

2. RELATED WORKS

It is proposed a scheduling algorithm for the rtPS service. This algorithm identifies the SS which has low quality of transmission, and depending on this, the SS is removed temporarily from the scheduler list. In our proposal, a scheduling list of SSs is made based on the deadlines, giving to all SSs opportunity for transmission.

According to the backlogged traffic, the MCS, and the QoS requirements of the applications, the algorithm allocates the bandwidth in adaptive way for each service class. However, it was not defined the used polling mechanism, being this a very important question to be considered. In this study, it was defined a method that interacts with the polling mechanism of BS [8], and makes a balancing of unicast polling to the rtPS and nrtPS services.

Gidlund and Wang propose a scheduling algorithm that is a combination of the legacy scheduling algorithms EDF and WFQ, for the uplink traffic. The EDF scheduling is used to control the delay bound for the real-time applications and the WFQ scheduling is used to guarantee minimal bandwidth for the non-real time-applications. In this study, the algorithm is based on the EDF scheduling, where deadlines are defined to guarantee the delay bound for the real-time applications. The minimal bandwidth is guaranteed through the control of the periodicity of unicast polling for the real-time and non-real-time applications. Thus, our algorithm is less complex than the one described.

It was defined an analytical technique for obtaining an optimal polling interval. Using this polling interval, the BS should poll the SSs to ensure that the delay requirements of traffic are met. The authors also devised an opportunistic deficit round robin (O-DRR) scheme that schedule the sessions by taking into account the variations in the wireless channel and the delay constraints of multicast traffic. Nevertheless, the exploitation of O-DRR scheduler presents an added overhead on scheduling, as it is essential to sustain a quantum size and discrepancy count for every SS. In uplink scheduling [9]-[10], the BS generates the allocation decisions grounded on bandwidth requests from SS and related QoS factors. Therefore, it is significant to consider polling methods and as well the scheduling methods to assure the QoS for certain applications. Though, the preceding studies considers only the scheduling approaches. The scheduling algorithm anticipated in this work fluctuates those previous studies chiefly as it interrelates the polling mechanisms targeting at adjusting the interval polling vigorously, and to promise the QoS requirements to real-time and non-real-time applications.

3. PROPOSED METHOD

Adaptive Proportional Fair Scheduling Algorithm

Adaptive Proportional Fairness (APF) is a scheduling algorithm which attempts at encompassing the PF scheduling to real time service and offers numerous QoS requirements. The scheduling pattern is grounded on the Grant per Type-of-Service (GPTS) standard, which targets at distinguishing the delay recital of every queue. A novel priority function is devised for all the QoS classes, including UGS, rtPS, nrtPS and ertPS [11]: the Base Station (BS) allocate sing time slots on the queues with the highest priority value. In this research, we aim to propose a scheduling algorithm, called Enhanced Adaptive Proportional Fairness (EAPF) scheduling to extend the APF scheduling to provide various QoS requirements and real time services.

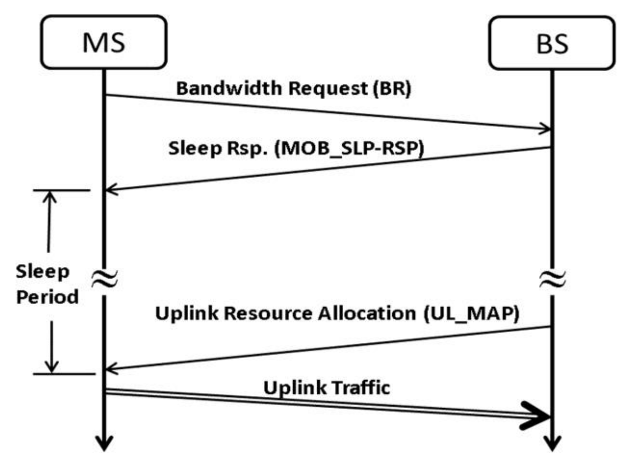

Fig: 1 Pictorial representation of uplink resource allocation in APF

The resource allocation is considered in a centralized approach [12] and performed on a frame by frame basis for the set of mobiles located in the coverage zone of a Base Station (BS) is shown in figure 1. A crucial objective for modern multiple access schemes is to fully support multimedia transmission services. Regarding delay requirements, the meaningful constraint is a limitation of the occurrences of large delay values. We define the concept of delay outage by analogy with the concept of outage used in system coverage planning.

A mobile transmission is in delay outage when its packets experienced a delay greater than a given threshold. The Packet Delay Outage Ratio (PDOR) target is defined as the maximum ratio of packets that may be delivered after this fixed delay threshold. Subsequently, T_k specifies the delay threshold of mobile 'k'. The PDOR proficient for every transmission is followed all through their epoch. At every transmission of packets of mobile k, the over-all amount of packets whose delay surpassed the threshold separated by the complete amount of packets broad casted as the commencement of connection is calculated.

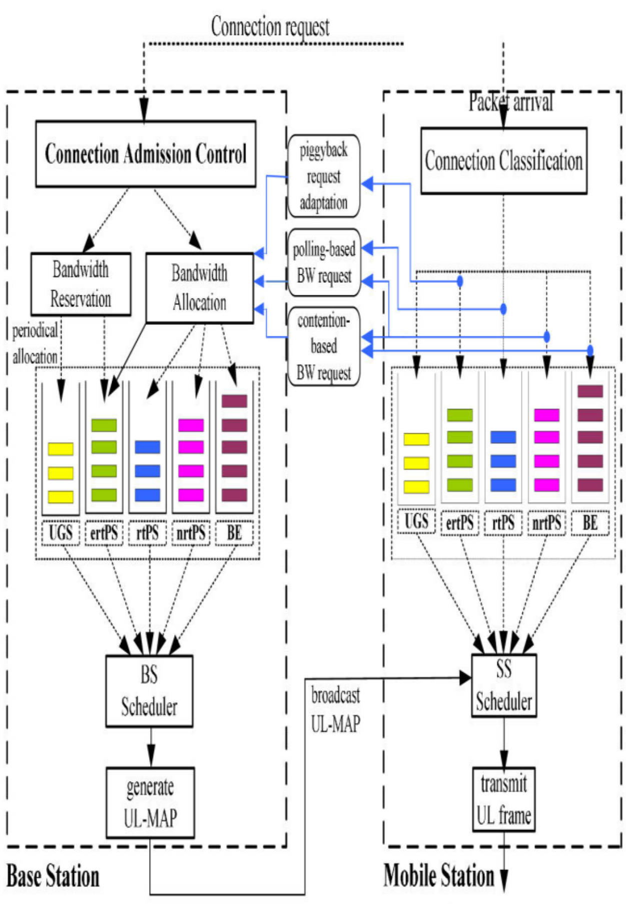

Fig 2: Representation of Bandwidth Reservation and Bandwidth Allocation

The APF scheduler (Adaptive Proportional fairness) is an algorithm [13] that takes into account the different requirements of quality of services. Furthermore, packets traversing from numerous SSs will be categorized into five queues: one for BE, one for UGS, one for nrtPS, one for ertPS, and eventually one for rtPS. So as to serve a queue, the scheduler must regulate the queue with highest priority in accordance to the subsequent priority function as in figure 2:

$$\frac{Wi(t)*Ki(t)*Mi(t)}{Ri(t)} \qquad (1)$$

where: i: between [1..5],

- $W_i(t)$: the transmission capacity at time t,
- $K_i(t)$:the number of communication of the ith queues,
- $M_i(t)$: the minimum rate requirement,
- $R_i(t)$: the estimated average

Resource Allocation

After calculating the priority of each connection for each user, we can obtain Pi, the priority of each user using (1).Then the BS scheduler sorts out and servers the users by their priority Pi in descending order. Let i* denotes the selected serving user.

$i = arg_{max}P_i \qquad (2)$

Then the user i* picks the sub channel k with the best channel quality and then to the other connections of the user i* also by their priority P, in descending order. The number of symbols allocated for each connection is calculated under the assumption that the minimum reserved rate r_{ij} and maximum latency T_{ij} should be satisfied. The resource allocation is performed every frame and only downlink resources are considered as in figure 3. When the average transmission rate before the frame transmission is less than the minimum reserved rate, a number of slots should be allocated to the connection to guarantee the rate requirement. Otherwise, no resource is needed. The average service data rate of connection j of user i at frame m + 1 can be estimated over a window size T.

The allocation to the connections of that user is still based on the connection priority in descending order, while BE connections are included. The allocation continues until all data queues are empty or no slot is available. This process is aiming at maximizing the system throughput after the QoS requirements of rtPS and nrtPS connections are satisfied.

```
Server=free;
 For (i=0; I<5; i++){
While (queue „i" is not empty)
 {
```

If (server != taken) { Select the queue that the largest value of (2);

Server = taken ;

} Else // server ==taken

{

Waiting until the total packet transmission;

Server=Free ;

} // end else

} // end while

} // end for

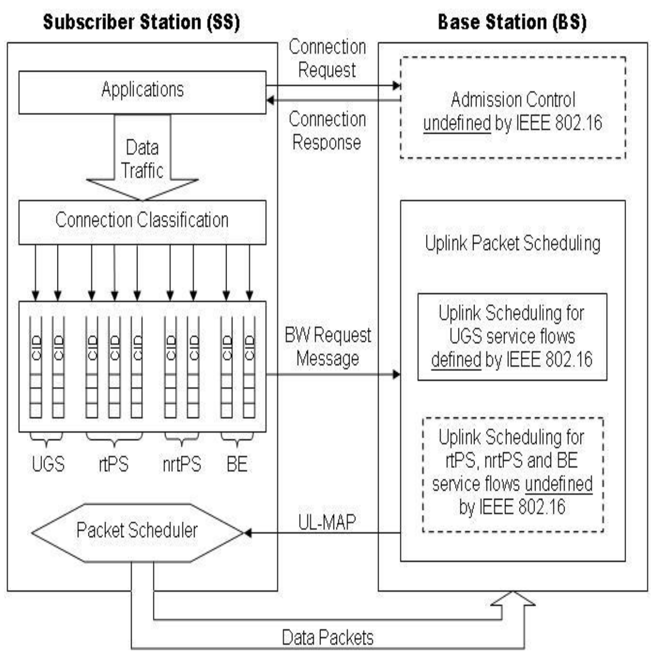

Fig 3: Uplink packet scheduling in Resource allocation

4. PROPOSED ICSO

In CSO, the seeking mode provides local search whereas the tracing mode searches globally. However, it will be better if the current best cat is allowed to search locally. If it happens, the current best cat may upgrade its fitness, and later on this will positively influence the movement of all the cats going through the tracing mode. Moreover, it can also avoid possible local trappings as in figure 4.Therefore, seeking mode of the standard CSO is modified in the perception of the above facts as described below.

4.1. Modified Seeking Mode

Like other swarm optimization techniques, the philosophy of CSO is "to follow the leader." If the fitness of the current best cat is improved by some means, the convergence of CSO would be improved. It is recommended that the present best cat is mandatorily chosen for seeking mode. In addition, the way of generating cats over the present finest cat also diverse in the anticipated seeking mode, as defined below. The CSO works basically yield continuous decision variables. Nonetheless, the decision variables are severely integers in those crisis. Consequently, employing local search nearby the present best cat, two cats are produced from these cat by hiring flooring and ceiling of decision variables. All possible combinations of cats are generated from these two cats. For simplicity, it is shown only for two dimensions. The fitness of entire cats is estimated and finest fitted cat is reorganized, if a superior cat is obtained. Though, subsequent cats of seeking mode are revised as the standard CSO. The local search over the finest cat not simply evades local trappings however simplifies the examination of novel search points in the crisis search space throughout the tracing mode.

4.2. Intelligent Search

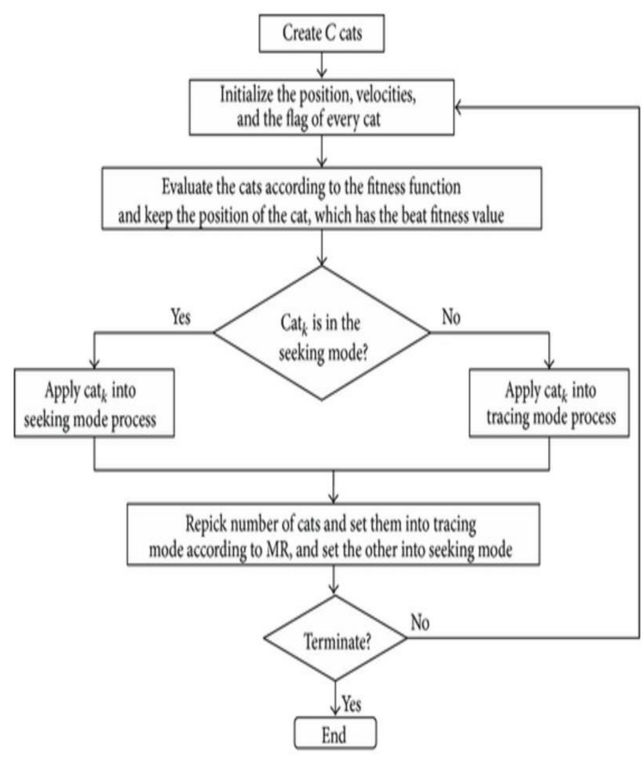

Fig 4: Flow diagram of Improved cat swarm optimization

It will be constantly superior if entirely the tentative results transmits in similar manner that all lies near the auspicious region. However it is a complex task. Nevertheless, an appropriate diversity is vital to search novel solution in crisis search space. Numerous researchers, mentioned, have functional perturbation-based node sensitivity method to acquire the node priority for optimal allocation of distributed resources and at that time choosing top nodes from it to refine the problem search space. Though, none of sensitivity-based methods are foolproof as a result it is probable that the optimal node may not fall in redefined problem search space. Consequently, certain methods are undependable and leads erroneous outcomes. Currently, candidate nodes are carefully chosen by suggesting an intelligent search method.

The anticipated approach is diverse than the traditional one that the node sensitivity is detected with respect to the modification in objective function to be improved, as a substitute of the modification in power loss. Furthermore, the system nodes are organized in decreasing order of changing the objective function and therefore the candidate nodes are chosen from the list of utilizing certain assortment. In this way, the nodes are selected according to their probability of priority. Thus more chances are available to those nodes which are good for the allocation of these devices. However, this methods allocates the right of every scheme node to endure in problem search space in the course of computational procedure. Consequently, by means of intelligent search the problem search space is practically squeezed deprived of loss of diversity.

4.3. Individual's Encoding

The structure of the individuals for the proposed methods is shown in Figure 4 which is composed of candidate nodes and sizing for the respective candidate. The candidate nodes are assigned by means of intelligent search method, while the distributed resources sizing is chosen haphazardly within respective predefined bounds as described.

4.4. Termination Criterion

Elitism is not essential owing to the inherent nature of CSO. Therefore, the termination criterion is taken as follows: "when either the maximum iteration count is exhausted or all cats acquire the same fitness, the evolutionary process stops." This criterion is designated to decrease the CPU time of procedure. The flowchart of the anticipated ICSO technique is offered.

5. MODELING AND SIMULATIONS

The simulation targets at studying the properties of anticipated scheduling algorithm and examining their individualities in network that has a variation of burst profiles(numerous MCSs) and in network that has merely one burst profile (one MCS). The proposed scheduling algorithm has been evaluated using NS-2.The simulation scenario consists of a BS and several SSs distributed around the BS in a random mode. The BS coverage area was divided into Rn regions where the value n represents the using only the information about the BW-REQ messages [14] and the queue delay, once it was used only one MCS at the access network. Figure 5 &6 shows the load traffic average delay in a scenario where various MCSs were used.

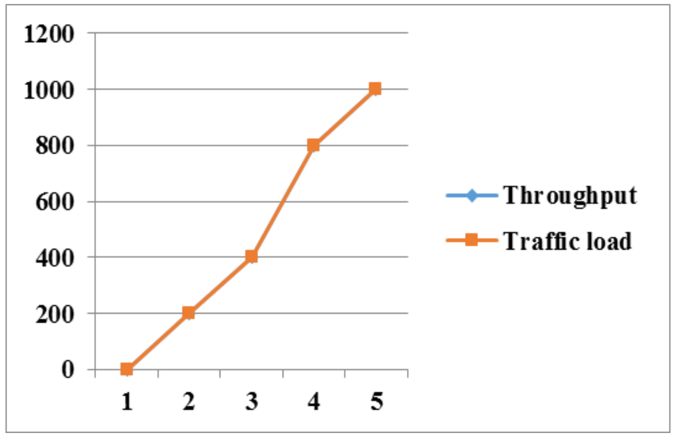

Fig 5 : Throughput and Traffic load estimation

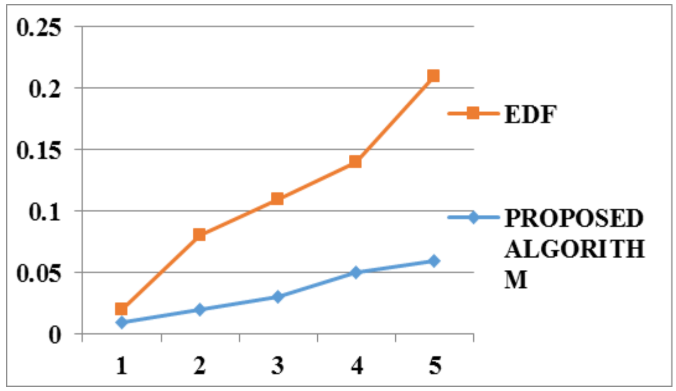

Fig 6: Delay estimation of the proposed scheduling algorithm

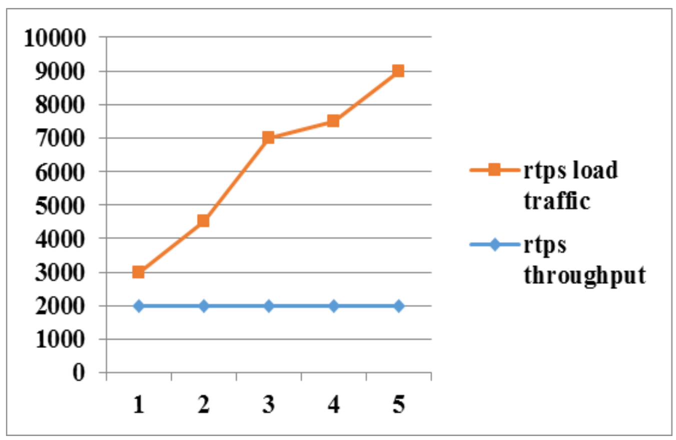

Fig 7: Estimation of load traffic and throughput in rtps

It is possible that the increase of the average delay is more significant when the EDF scheduling was used. This happened because there are several SSs in the access network using different MCSs for the sending packets as in figure 7. This information was used in the deadlines calculation of the proposed scheduling algorithm, what did not happen in the deadlines calculation of the EDF scheduling. The EDF algorithm organizes the uplink sub frame in accordance with the lowest deadline, and does not consider the different burst profiles existent in the access network. On the other hand, the proposed APF algorithm organizes the uplink sub frame [15] into bursts with different profiles in an efficient way. Thus, the use of the deadlines-based scheme defined in this study really reduces the average delay. The proposed APF algorithm is appropriate in both environments, especially when various MCSs are used. This is an open research issue in the access networks that use adaptive modulation.

6. CONCLUSION

A scheduling algorithm for IEEE 802.16 wireless MAN proposed is termed "Enhanced Adaptive Proportional Fairness". This algorithm suggests a method to allow the BS scheduler to balance amongst allocating low and high priority traffic concurrently. In this work, a novel adaptive proportional fair scheduling algorithm has been proposed, which regulates the scheduling priority in accordance to individual user's channel circumstance. This method gives more scheduling probability along with the cat swarm optimization to the users who are under poor channel condition for a long period of time, and avoids the users whose channel conditions are favorable occupying too much resource. It enhances the fairness with a limited degradation of whole system throughput.

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