Fuzzy Priority Scheduler for Wimax

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Abstract- During the last few years, users all over the world have become more and more familiar to the availability of broadband access. Worldwide Interoperability for Microwave Access (WiMAX) is one of the most familiar broadband wireless access technologies that support multimedia applications. Scheduling algorithms that support Quality of Service (QoS) differentiation and guarantees for wireless data networks are crucial to the development of broadband wireless networks. Nevertheless, the standard lacks a MAC scheduling algorithm that has a multi-dimensional objective of satisfying QoS requirements of the users, maximizing channel utilization while ensuring fairness among users. So a novel Priority based Scheduling Algorithm using Artificial Intelligence that addresses these aspects are proposed. The initial results show that maximum channel utilization is achieved with a negligible increment in processing time while keeping the priority intact.

Keywords- WiMAX, Fuzzy, Priority, Scheduling Algorithm

I. INTRODUCTION

Recently, the IEEE 802.16 standards (e.g., 802.16- 2004, 802.16e) [1] are noticed to a greater extent and is a viable alternative to the traditional wired broadband techniques due to its cost efficiency. It is envisioned that WiMAX will provide the last mile internet access to every residential user. A high level of QoS and scheduling support is one of the interesting features of the WiMAX standard. These service-provider features are especially valuable because of their ability to maximize air-link utilization and system throughput, as well as ensuring that Service-level agreements (SLAs) are met [6]. QoS is enabled by the bandwidth request and grant mechanism between various subscriber stations and base stations**.** Primarily there are five buckets for the QoS (UGS, rtPS, ertPS, nrtPS, and BE) to provide the service-class classification for video, audio, and data services. The service scheduler provides scheduling for different classes of services for a single user. This would mean meeting SLA requirements at the user level.The five service flows are explained below:

1) Unsolicited grant service (UGS): This service can provide guaranteed data throughput and latency.
2) Real-time polling service (rtPS): The minimum reserved rate and the latency are guaranteed in this application.
3) Enhanced Real-time polling service (ertPS): It especially concentrates on real time Voice over IP.
4) Non-real-time polling service (nrtPS): This service tolerates delay while streaming variable-sized data packets.
5) Best effort (BE): The channel access mechanism of this service is based on the contention and provides no QoS guarantees.

Even though there are lots of conventional scheduling algorithms they are not meeting all the required QoS parameters. The performance affecting parameters like fairness, bandwidth allocation, throughput and latency are studied and found out that none of the algorithms perform effectively for both fairness and maximum bandwidth utilization simultaneously [2]. So a decision has been made to optimize those two parameters by using an algorithm based on Artificial Intelligence (AI). This paper is organized as follows: Section 2 describes the related work. Section 3 and 4 explain the proposed scheme. Section 5 shows the performance of WiMAX using the newly proposed scheduling algorithm and the conclusions in section 6.

II. PREVIOUS WORK

In [6], the authors propose a hybrid of Earliest Due Date (EDD) and Weighted Fair Queue (WFQ). In EDD, all the arriving packets get a deadline stamp and are scheduled according to the increasing order of deadlines. The algorithm intends to serve the real time traffic first and only if real time buffer is empty will they consider BE traffic. This will certainly lead to starvation. In [7], the authors consider two types of queues. The first type is used to schedule data grants for UGS and allocate request opportunities for rtPS and nrtPS. These grants are scheduled in a first in first out (FIFO) manner. Once the first queue type has been served, the scheduler will consider the second type leading to scarcity. The authors in [8] propose an architecture consisting of three schedulers. The first scheduler is concerned with UGS, rtPS and ertPS flows. The second scheduler is concerned with flows requiring a minimum bandwidth mainly nrtPS. The third scheduler is used for BE traffic the third scheduler comes into picture only when the first two schedulers have become free. In [9], the suggested uplink scheduling algorithm is Weighted Round Robin (WRR) with GPSS grant mode. The duration of contention slots and uplink data slots are dynamically distributed according to bandwidth requirements. The authors did not comment on what weights to use for WRR scheduling or BS downlink scheduling. In [10], the authors suggest downlink. bandwidth allocation algorithms based on flow type and strict priority from highest to lowest - UGS, rtPS, ertPS, nrtPS and BE. Here an Opportunistic fair scheduling was used. Here BE traffic is served whenever an opportunity is available, but for most of the time BE starves for bandwidth.

III. FUZZY SCHEDULER

A. The Primary Fuzzy Scheduler

The incoming requests in the WiMAX have different variables that play a key role in setting the priority of that particular request. The variables are Expiry Time, Waiting Time, Queue Length, Packet Size and Type of Service. In the proposed fuzzy scheduler two different stages namely the Primary Scheduler, FS1 and the Dynamic Scheduler, FS2 are used. This proposed scheduler is named as Dynamic Fuzzy based Priority Scheduler (DFPS) which uses four inputs namely, Expiry time (E), Waiting time (W), Queue length (Q), Packet size (P) and one output, Priority index as shown in Figure 1. Here, the process is considered as multiple input and single output (MISO) system. The fuzzy rule table is created based on the membership functions (Figure 2) that are carefully designed as explained in table 1.

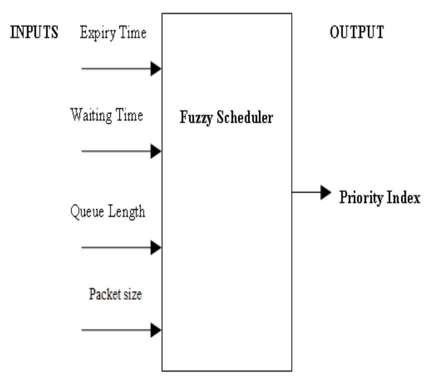

Figure 1. Proposed Primary Fuzzy Scheduler

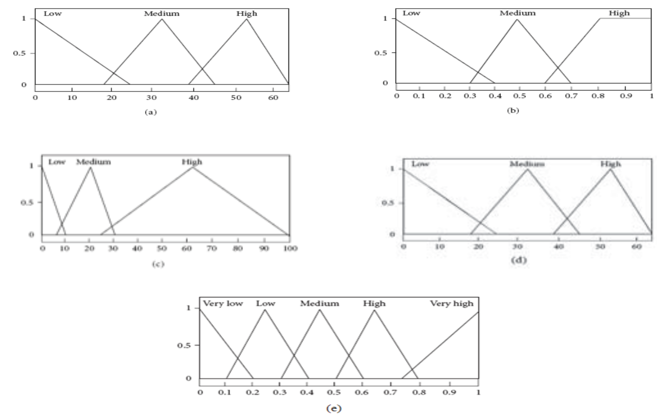

Figure 2. Membership functions

(a) Expiry time (in sec) (b) Packet size (in Kbytes) (c) Queue length (in bytes) (d) Waiting time (in sec) (e) Priority Index

The linguistic terms associated with the input variables are low (L), medium (M) and high (H). Triangular membership functions are used for representing these variables except for the high data rate where a trapezoidal function is used. The bases of functions are chosen so that they result in optimal value of performance measures For the output variable, priority index, five linguistic variables are used. Only triangular functions are used for the output. This illustration was designed using the fuzzy tool available in the MATLAB. For illustration the ninth rule is interpreted as “If packet size is high and queue length is high, then priority index is high”.

Similarly, the other rules are framed. The priority index, if high, indicates that the packets are associated with the highest priority and will be scheduled immediately. If the index is low, then packets are with the lowest priority and will be scheduled only after higher priority packets are scheduled.

B. Dynamic Fuzzy Scheduler

For a dynamic scheduler, the output of the primary scheduler is given as the input. Apart from this input, the type of service variable is also added as shown in Figure 3. A membership function and a Rule base table are created based on the priority index of FS1 and the type of service. The Dynamic Fuzzy Rule Base is shown in table 2. This table is carefully designed by taking into consideration of the type of service. As there are five different types of classes the priority levels are set to five different levels starting from Very High (VH), High (H), Medium (M), Low (L) and Very Low (VL). To illustrate any rule, consider the first column contents. The Priority Index of the Primary Scheduler may be from VH to VL. If the type of service is UGS then that request must be given higher level priority than the other type of services even if the Primary Scheduler FS1 allots them higher priority indices. The final priority index iṣ referred as η which is the standard notation used in the literature.

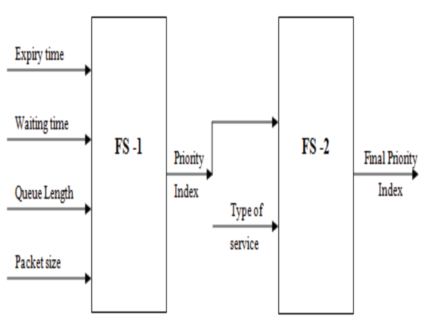

Figure 3. Dynamic Fuzzy scheduler

Table 1. Fuzzy Rule Base

Expiry Time Vs Waiting Time

Expiry Time	**Waiting Time**		
	L	**M**	**H**
L	H	L	L
M	M	H	L
H	L	M	H

b)Packet size Vs Queue length

Packet Size	Queue Length		
	L	**M**	**H**
L	H	M	M
M	L	H	M
H	L	L	H

(c) (a) Vs (b)

(a)	(b)		
	L	**M**	**H**
L	VL	L	M
M	L	M	H
H	M	H	VH

Table 2. Dynamic Fuzzy Rule Base

Priority	UGS	rtPS	ertPS	nrtPS	BE
VL	VH	L	L	VL	VL
L	VH	M	L	L	VL
M	VH	H	M	L	L
H	VH	H	M	M	L
VH	VH	VH	H	M	L

IV PROPOSED ANN

Scheduling using ANN

The next step is scheduling of the prioritized input received from the DPFS. Since neural networks have high computational speeds we decided to use ANN. A neural network is a massively parallel-distributed processor that has a natural propensity for storing experiential knowledge and making it available for use. Artificial neural network is a nonlinear signal-processing device, which is built from interconnected elementary processing devices called neurons. Either humans or other computer techniques can use neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, to extract patterns and detect trends that are too complex to be noticed. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyze. This expert can then be used to provide projections given new situations of interest and answer "what if" questions.

An ANN can have the following features:

- Adaptive learning
- Self-Organization
- Real Time Operation

The artificial neuron was designed to mimic the first-order characteristics applied, each representing the output of another neuron. Each input is multiplied by a corresponding weight, analogous to a synaptic strength, and all of the weighed inputs are then summed to determine the activation level of the neuron as shown in the fig. 3.

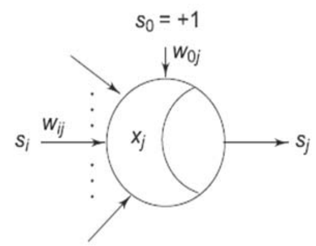

Fig. 3 Modeling of neuron

Despite the diversity of network paradigms, nearly all are based upon this configuration. A set of inputs labeled $x_1,$ $x_{2......}$ x_n is applied to the artificial neuron. These inputs collectively referred to as the vector X correspond to the signals into the synapses of a biological neuron. Each signal is multiplied by an associated weight $w_{1,}$ $w_{2,}$ …,w_n before it is applied to the summation block, labeled Σ. Each weight corresponds to the "strength" of a single biological synaptic connection. The set of weights is referred to collectively as the vector W. The summation block, adds all of the weighed inputs algebraically, producing an output that we call NET. This may be compactly stated in vector notation as follows:

NET = XW

NET = $x_1 * w_i + x_2 *w_2 + x_3*w_3+ \ldots + x_n *w_n$

Proposed ANN

The proposed ANN is shown in Figure4. It consists of three layers. The first layer is the input layer and the second layer is the modified form of Kohonen layer. The final layer is the modified form of Grossberg layer. The proposed ANN deals with the efficient allocation of the available bandwidth based on the Priority Index set by the DFPS with a measure of fairness to all the service class es. The input layer receives the prioritized outputs from the DFPS. These inputs are organized in the order of their priority. Now the output of this layer is given as the input to the modified Kohonen Layer. The modified Kohonen layer is used to predict whether the given input is within the threshold value. Depending on the availability of the channel bandwidth the threshold value is set. If the incoming request is below the threshold value thenthat request is forwarded to the next layer, the Grossberg layer. If not, that request is rejected, it happens on extreme circumstances. In the Grossberg layer, the inputs are summed up and it calculates how many requests can be granted within the threshold value. DFPS output is given to the input layer and according to the weight it is processed and given to layer 1 which is Kohenon layer, where it checks the request with the threshold value if it is accessible request is granted. The next layer is Gross berg layer where the inputs are calculated and within the threshold requests are granted. The action of each neuron in the Gross berg layer is to output the value of the weight that connects it to the single nonzero Kohonen neuron.

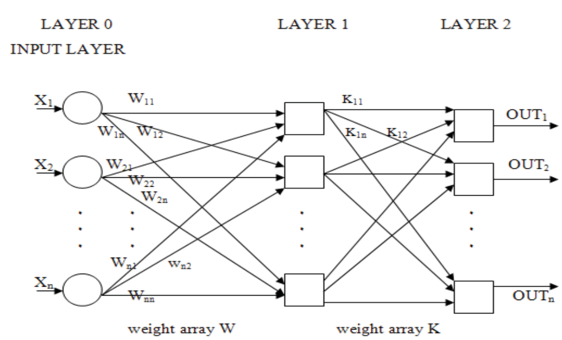

Figure 4. Proposed ANN

V. PERFORMANCE METRICS

A. *Effective Channel Utilization*

The scheduler should not assign a transmission slot to a session with a currently bad link since the transmission will simply be wasted. The figure clearly shows the amount of channel utilized by our proposed NFPS Algorithm. It begins from

10% for 10% of load to almost 90% for full load. So as the number of requests increases the channel utilization also increases. It is inferred that as the requested bandwidth nears the total load, the percentage of channel utilization increases.

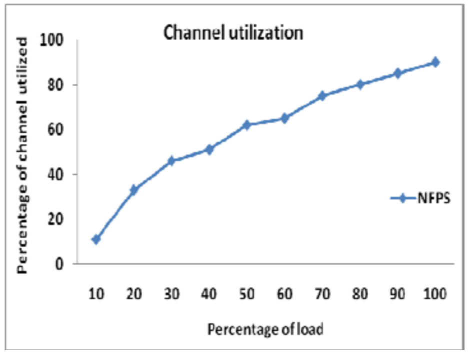

Figure 5. Graph showing percentage of channel utilized using NFPS Algorithm

B. Fairness

The scheduling algorithm must provide fairness to all the requests with different quality of service classes. The channel starving lower priority BE requests and nrtPS requests must be satisfied too leading to fairness. In the Figure 6 all the requests of UGS i.e. 100% are granted. 75% of the requests of the rtPS are granted. But in the case of ertPS 50% of the requests are granted. Even though nrtPS and BE have lower priority 60% and 40 % of their requests are granted respectively.

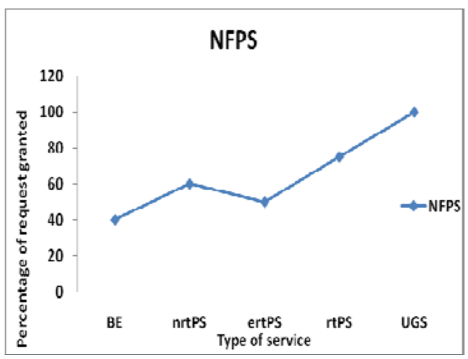

Figure 6. Graph showing percentage of request granted for different types of services using NFPS Algorithm

C. Processing Time

The algorithm must be able to provide delay bound guarantees for individual sessions in order to support delay-sensitive applications that largely depend on the processing time. Figure 7 shows that the procesing time for the proposed algorithm to grant a full load traffic and for lighter loads it was 42 milliseconds. But for multimedia applications using Internet permits delays upto 400 milliseconds as acceptable one. So as for as quality is concerned it is not on the wrong side but very much on the highly acceptable grounds

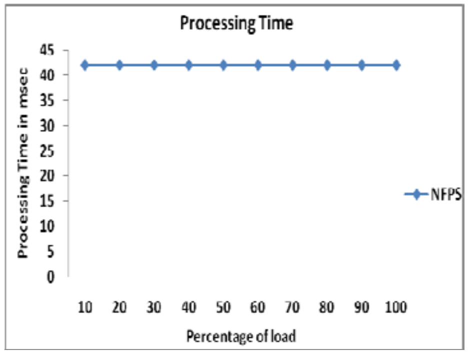

Figure 7. Graph showing processing time using NFPS Algorithm

VI. CONCLUSION

An Artificial Intelligence based QoS Scheduling Algorithm was designed. The fuzzy section dealt with the priority setting mechanism under uncertainty conditions by taking into consideration of variables such as expiry time, waiting time, queue length, packet size and the type of service for WiMAX requests. Artificial Intelligence section dealt with bandwidth allocation mechanism by considering fuzzy prioritized output as its input. The Simulation results show that a fair amount of fairness is attained while keeping the priority intact. The results also show that maximum channel utilization is achieved with a negligible increment in processing time.

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