Fuzzy based approach for packet dropping in wireless networks

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ABSTRACT

In wireless networks, resource management is a very complicated issue because of scarcity in resources. This paper presents a fuzzy based packet dropping scheme for wireless networks in the context of future generation cellular networks. In this scheme, a buffer manager located at the base station uses a fuzzy controller for packet dropping based on three fuzzy parameters, namely, application priority (based on handoff and new calls), queue length and packet size. Fuzzy controller computes a dropping factor which helps in making decision to drop the packets from the queue at the base station. The scheme has been simulated in different network scenarios to test the operation effectiveness. The extensive simulation results shows that fuzzy based packet dropping scheme performs better than random early detection scheme in terms of buffer utilization, dropping probability, acceptance probability of handoff and new calls.

Keywords : wireless networks, packet drop, fuzzy queue length, priority

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I. INTRODUCTION

Traffic control and network resource management are primary approaches to control wireless multimedia network efficiency in present scenario. There is a tremendous demand for multimedia applications over wireless cellular networks. Some of the multimedia wireless network applications are video conferencing, Internet multimedia games and e-commerce. To provide all such applications in wireless networks, we need to look at some of the pressing issues which arise due to scarcity of resources such as bandwidth, buffers, battery life, etc. The wireless channel characteristics are time varying due to the multipath fading effects thereby causing packet errors and connection outages. Hence, there is a need for designing a resource allocation scheme that is adaptive as well as support multiple classes of traffic with varied data rates.

Buffer is one of the important resources (apart from battery, bandwidth and processing power) that help in improving link utilization and system performance. With the increase of user demands for service quality, providing stable and low delay has been the primary requirement of real-time services. Hence there should be a buffer management technique which can take care of queue delays as well as utilize the buffer efficiently and accept more number of users in a cell.

Several buffer management schemes have been proposed considering queue length, delay, differentiated services, random early detection, priority of the application, rate flow of each application and early expire time. These schemes work on either one or two parameters, but buffer management with packet dropping needs to look at some more parameters for calculating dropping probability.

Some of the related works on packet dropping schemes in wireless networks are briefly given as follows. In [1], at any instant of time, RED (Random Early Detection) drops packets of all flows with the same probability which depends on queue length. This scheme is unfair to the flows which are of low speed or have short packet length. Fuzzy based fair dropping algorithm considering queue length and sharing index is presented in [2]. Sharing index is calculated using an average queue length and present queue length in the buffer. The work given in [3] designs an adaptive fuzzy based control algorithm which computes the packet drop probability according to preconfigured fuzzy logic using only queue length as input variable. Only queue length is not sufficient to describe dropping probability. In multi-rate system, packets with highest transmission time will be dropped with high priority so as to make radio resource usage efficient and a new queue management algorithm is employed in order to utilize high data rate efficiently in current wireless LAN [4].

In [5], fuzzy rule base is proposed for packet discarding by considering differentiated services. To guarantee QoS requirement for handoffs, these conventional techniques reserve a fixed number of guard channels or provide a queue for handoffs [6]. In [7], resource allocated for non real time traffic in wireless sensor network using fuzzy logic is presented. In [8], average queue length is replaced by the product of delay and retransmission times of RTS (Request To Send) as congestion indicator to calculate dropping probability. A RED like algorithm is proposed in [9], which calculates packet dropping probability by using delay bound. It emphasizes the influence of retransmission but does not consider the channel condition variation and does not consider the packet dropping based on TCP performance. The scheme given in [10] proposes that fairness must be considered while dropping of packets in worst channel conditions.

This paper presents a fuzzy based packet dropping scheme by considering the fuzzy parameters such as priority of an application, queue length and packet size. Defuzzified output of the fuzzy controller scheme is dropping factor that is used for dropping packets from the base station queue to avoid over flow and burst errors, which in turn improves the Quality of Service (QoS).
The remainder of the paper is organized as follows. In section 2, we present proposed fuzzy based packet dropping scheme. Sections 3 and 4 present the simulation model and results. Finally we conclude in section 5.

II. PROPOSED WORK

Multimedia application requires network resources like guaranteed bandwidth, buffer and computing power. If the bandwidth required by an application is not available, then buffer plays a vital role by storing the packets in the queue such that packets of an application are not dropped. When a queue length exceeds queue threshold value, packet dropping is employed to avoid over flow and burst errors. Hence, for efficient utilization of the buffer placed at the base station, an efficient and fair packet dropping scheme is required. We propose a fuzzy based packet dropping scheme that improves buffer utilization, reduces call dropping probability and increases acceptance of handoff/new calls.

In this section, we present the network environment, packet dropping scheme and fuzzy controller for packet dropping.

A. Network environment

We consider a base station in a cell with several calls. Calls may also come from other cells (apart from within the cell) adjacent to a cell called as handoff calls. New calls can be generated within a cell with certain application requirements. Buffer manager with fuzzy dropping scheme is located as the base station. Application data base is maintained by buffer manager which is updated either after a packet is dropped or stored into the buffer.

B. Packet Dropping

The proposed fuzzy based packet dropping is shown in fig.1. which is located at the base station, which comprises of buffer manager, application database and fuzzy packet dropping scheme. The functions of each block are given below.

- *Buffer Manager:* it receives application connection request either from handoff/new calls with required specifications such as bandwidth, delays, etc. If bandwidth is not available it requests for buffer allocation. If sufficient buffer is not present then fuzzy based packet dropping is invoked that drops the packets arriving at the queue on the basis of dropping probability. The manager updates the application database.
- *Fuzzy packet dropping*: this calculates the packet dropping factor (DF) for arriving packet after a queue threshold is reached and sends the calculated dropping probability to the buffer manager to efficiently manage the buffer. Care will be taken such that handoff and real-time calls are given highest priority than any other type of calls.
- *Application database:* this comprises of information of all existing calls such as packet priority, queue length, packet size, packet dropping probability, etc. It also comprises of cell status such as buffers available, buffer available after threshold, etc.

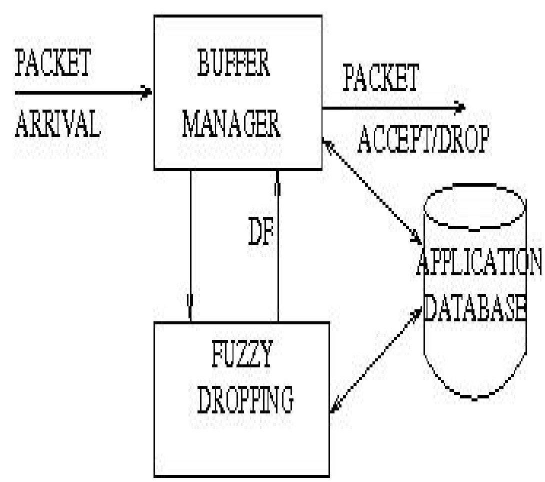

Fig.1. Fuzzy Based Packet Dropping Scheme

C. Fuzzy controlled packet dropping

Fuzzy controlled packet dropping scheme is shown in fig. 2, which consists of fuzzification, inference, and defuzzification steps.

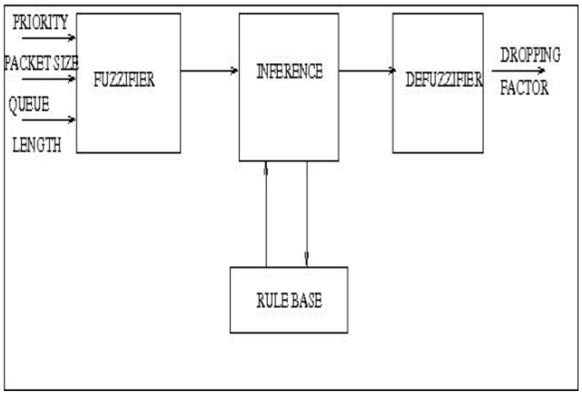

Fig.2. Fuzzy Packet Dropping Probability Computation

In the fuzzification step, fuzzy parameter values are converted into linguistic values (such as low, high or medium). Each fuzzy set is associated with a membership function used to characterize how certain the crisp input belongs to the set. For a given crisp input, the membership function returns a real number in the range [0,1]. The closer the membership value is to 1, the more certain the input belongs to the set. Fuzzy inputs considered in the proposed work are priority, packet size and queue length. A single crisp value can take more than one linguistic value if the membership values overlap. In the inference step, a set of rules called rule-base, which emulates the decision-making process of a human expert is applied to the linguistic values of the inputs to infer the output sets which represents the actual control signal for the process. We refer the reader to [11] for more complete background information on the fuzzy control.

C. 1. Fuzzification

Fuzzy based packet dropping scheme considers three parameters for fuzzification: priority of the application (P), packet size of an application (PS) and the queue length (Q). The output of linguistic parameters is the packet dropping factor (DF) for a given application. The membership to each of fuzzy variables is assigned using intuition method. The fuzzy parameter membership functions and their range of linguistic values are depicted in fig. 3.

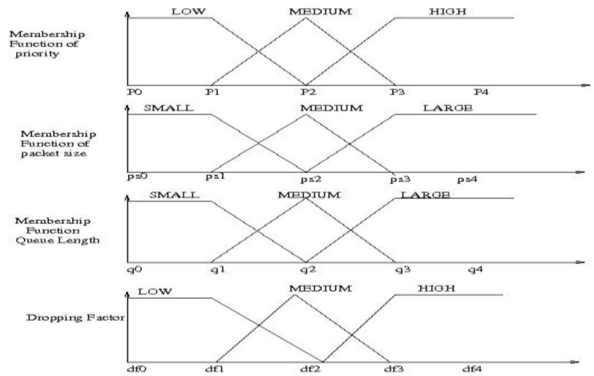

Fig. 3. Membership function for input and output linguistic parameters

C. 2. Inference and defuzzification

Since there are three linguistic values *P*, *PS* and *Q*, the total number of rules is 27. If the condition is true, we call the rule as being active. In our case, the rule-base is in a form called functional fuzzy system where each rule *i* is written as follows.
Rule i:IF P is low and Q is low and PS is small
THEN *DF* = *medium*

where *DF* linguistic value is decided based on membership functions fuzzy parameters. To decide an appropriate output membership function, the strength of each rule must be considered. For this reason, the output membership function is a complicated function and center of area method [11] is used for defuzzification. This method finds the center point of the fuzzy output membership function which is used for packet dropping for arriving packet. The fuzzy rule base with 27 rules is shown in fig. 4.
The defuzzified output parameter will give flexibility to the network administrator to perform soft packet dropping.

D. Algorithm

This section presents pseudo code (Algorithms 1 and 2) for the working of the proposed scheme.

Algorithm 1: Buffer manager in a Base Station
{Nomenclature: *n* = number of requesting applications, *Bureq* = buffer requested (in Mbytes), *Buav* = Available buffer, *Bmax* = Maximum buffer size at the base station, = 'i' th running application, *BALLOC* = buffers allocated, *DF* = dropping factor, *Ah*= Acceptance probability of handoff calls, *An*=Acceptance probability of new calls, *Buth*=Threshold value of buffer and *Bs* (Emergency buffers) = *Bmax* - *Buth*, *x* and *y* are values less than 1 such that x > y.}

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priority	Queue Length	Packet size	Dropping factor
H	LG	LR	LW
H	LG	MI	LW
H	LG	S	LW
H	MU	LR	LW
H	MU	MI	LW
H	MU	S	LW
H	SM	LR	LW
H	SM	MI	LW
H	SM	S	LW
M	LG	LR	ME
M	LG	MI	ME
M	LG	S	ME
M	MU	LR	ME
M	MU	MI	ME
M	MU	S	ME
M	SM	LR	LW
M	SM	MI	LW
M	SM	S	LW
L	LG	LR	HI
L	LG	MI	HI
L	LG	S	HI
L	MU	LR	HI
L	MU	MI	HI
L	MU	S	HI
L	SM	LR	ME
L	SM	MI	ME
L	SM	S	ME

PRIORITY (H=HIGH,M=MEDIUM,L=LOW)
QUEUE LENGTH LG=LARGE,MU=MEDIUM,SM=SMALL)
PACKET SIZE (SMALL=S,MI=MEDIUM,LR=LARGE)
DROPPING FACTOR(LW=LOW,ME=MEDIUM,HI=HI)

Fig.4. Fuzzy rule base table

Begin

1. Receive the application request with required buffer, *Bureq*;
2. If (*Bureq* <= *Buav*) then buffer is allocated, go to step 6, Else compute the packet dropping to avoid congestion;
3. Call Algorithm 2 to compute packet dropping probability factor (DF);
4. Depending upon the dropping probability factor drop the arriving packets from the queue;

a) If packet dropping probability is greater than 'x', then drop the arrived packet ;
b) If packet dropping probability is less than or equal to 'x' and more than 'y', then put in the emergency buffers;
c) If dropping probability is less than or equal to 'y', then do not drop, wait for departure of packets;

5. Stop.

End

Algorithm 2: Computation of packet dropping factor

Begin

1. Initialize fuzzy controller with priority of a application, queue length, packet size of a application;
2. Find the membership function of priority, queue length and packet size allocated to application;
3. Compute DF by referring to rule base;
4. Return DF to buffer manager;
5. Stop;

End.

Normally the values considered in our work for 'x' and 'y' are 0.5 and 0.2, respectively. It can vary depending on the network administrator.

III. Simulation

This section describes the simulation model, simulation procedure and performance parameters. Simulation is being carried out on a pentium-4 machine by using C programming language.

A single cell environment with an area of (a,b) meters is considered. *n* number of calls are generated in a cell comprising of both handoff and new calls. Buffer requests for each call are generated randomly in the range *Bureq1* to *Bureq2* Mbytes. Calls are randomly categorized into handoff and new calls by using a probability *pb*, i.e., if generated random number (0 to 1) is less than *pb*, then it is handoff call otherwise a new call. Maximum buffer size at the base station of the cell is assumed to be *Bmax* Mbytes, and *Buth* is buffer threshold value.

Following inputs are considered for simulation. a=500, b=1000, n=50, Bureq1=2, Bureq2=5, pb=0.2, Buth=80 and 180 for Bmax=100 and 200, respectively, q0=10, q1=15, q2=20, q3=25, q4=30, ps0=500, ps1=750, ps2=1000, ps3=1250, ps4=1500, df0=0.25, df1=0.45, df2=0.65, df3=0.80, df4=1.0. Simulation procedure is as follows.

Begin

1. Generate a cellular network.
2. Generate the application/call requests.
3. Apply the proposed scheme.
4. Compute the performance of the system.

End

The performance parameters measured are as follows.

- *Buffer utilization*: It is defined as the ratio of buffer utilized to the maximum size of buffer available at base station.
- *Acceptance probability of handoff calls*: It is defined as the ratio of handoff calls accepted to the total handoff calls arrived.
- *Acceptance probability of new calls*: It is defined as the ratio of new calls accepted to the total new calls generated.

IV. RESULTS

We compare the fuzzy based packet dropping scheme with RED packet dropping scheme in this section. RED packet dropping scheme does not compute packet dropping factor taking into account the importance of the priority and packet size. It only considers queue length.

Fig. 5. depicts buffer utilization for different maximum buffer capacities (100 and 200 Mbytes. It is observed that fuzzy based scheme uses the buffers in a better way as compared to RED due to soft packet dropping.

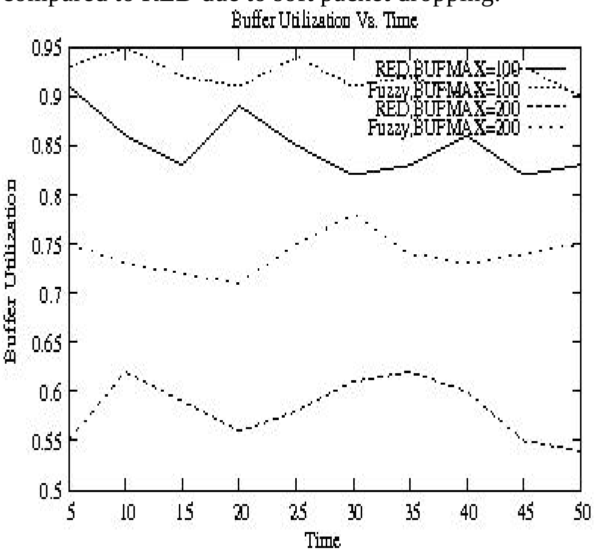

Fig.5. Buffer utilization .Vs. time

Handoff calls are accepted better in case of proposed scheme as compared to RED (see fig.6). Acceptance is more with more number of buffers at the base station. This is because handoff calls are given higher priority.

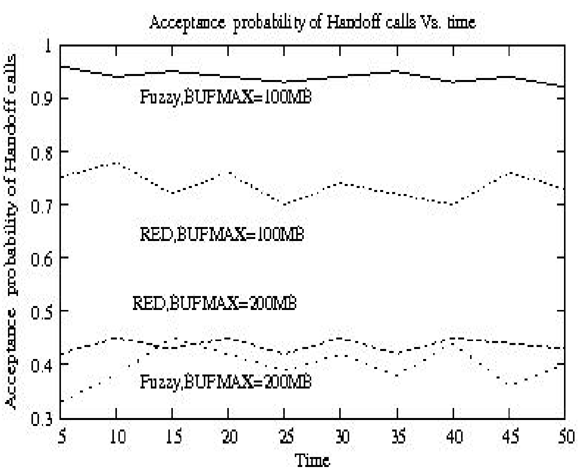

Fig.6.Acceptance probability of handoff calls .Vs.time

Fig.7. shows percentage of new calls accepted versus time. It is shown that fuzzy based scheme performs better in acceptance of new calls because we perform the soft dropping than hard dropping of packets.

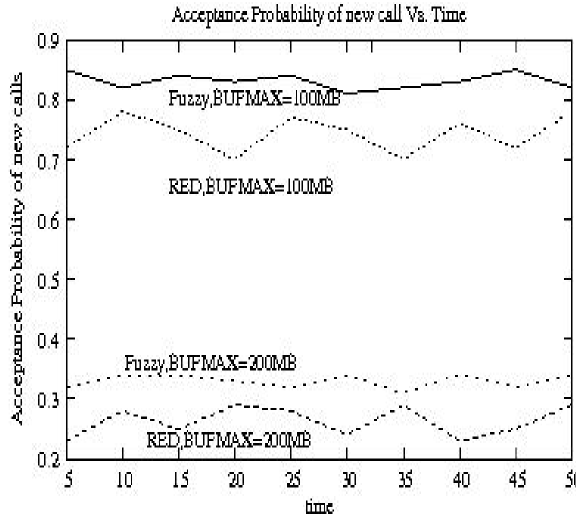

Fig.7. Acceptance probability of New calls .Vs. Time

V. CONCLUSIONS

In this paper we have proposed a scheme for packet dropping for multimedia applications by using fuzzy logic. The main objective is to use the base station buffers efficiently and decrease packet dropping especially of handoff calls. One important characteristic of our fuzzy based packet dropping scheme is that dropping is done looking at some fuzzy parameters of an application. Parameters considered are priority, queue length, and packet size.

Extensive simulation results reveal that our scheme features very low packet dropping probability and good buffer utilization as compared to a RED packet dropping scheme. The scheme can be extended to perform packet dropping by considering the importance of an application such as defense calls, VIP calls, etc., apart from the real-time and non real-time characteristics of an application.

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