FUZZY BASED CONGESTION CONTROL IN WIRELESS NETWORK

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ABSTRACT
The tremendous growth of wireless networks demands the need to meet different multimedia (such as voice, audio, video, data, etc) applications available over the network. This application demand and allocation could lead to congestion if the network has to maintain such high resources for the quality of service requirements of the applications. In this paper, we have developed a fuzzy based congestion control scheme. The fuzzy input parameters such as delay, buffer size and flow rate for each packet is considered to produce a congestion gradient factor. Depending on the value of congestion gradient factor the flow rate is maintained same or reduced. Simulation results present better throughput and variations in congestion gradient factor. The results are compared with one of the congestion control policy of Qualnet wireless network simulator.

Keywords: Wireless Networks, Congestion Control, Fuzzy Logic.

1. INTRODUCTION
In the past decade, the wireless network has experienced tremendous growth, and this growth is likely to continue in the near future. Apart from an increase in the number of users more demanding applications will appear, resulting in ever greater resource requirements. A strong network backbone is needed to support connections since high quality of service (QoS) without fully coordinated channel and network access is achievable. The wireless channel must be kept from reaching the congestion point, since it will cause an overall channel quality to degrade and loss rates to rise, leads to buffer drops and increased delays, and tends to be grossly unfair toward calls which has to traverse a larger number of radio hops.

A fair amount of research work has been published on congestion control. A new wireless congestion control framework has been proposed in paper [1], where a mobile station’s MAC layer tries to increase its available wireless bandwidth in the presence of incipient congestion when available bandwidth can be increased without affecting other flows in a cell.

In paper [2], a new admission control policy for wireless mobile multimedia networks is being proposed based on the use of dynamic guard channel allocation scheme. In addition, a buffer will be introduced to store handoff calls if there are no channel available instead of dropping (rejecting) them.

In paper [3] joint provision of connection-level QoS (in terms of the new call blocking probability and the handoff dropping probability) and packet-level QoS (in terms of the delay and packet loss probability) is been investigated. A dynamic call admission control (CAC) scheme for realistic wireless multimedia VBR traffic is presented. The proposed CAC scheme can optimize the packet-level QoS under certain constraints on connection-level QoS.

In paper [4] a discussion on a call admission control protocol for cellular wireless networks is presented. Protocol depends on degrading the existing calls by reducing the bandwidth allocated to them in order to admit “important” calls. Protocol assign priorities for the incoming calls and in the same time assign priorities to the existing calls, both Admitted calls are admitted according to their priorities and the existing calls are degraded according to their priorities.

In paper [5] a fuzzy call admission control scheme is proposed to meet the requirement of the QoS while prioritizing handoff call requests over new call requests. It searches automatically the number of the guard channel in a base station to make an effective use of resource and guarantee the QoS provision.

In paper [6] a packet loss classification algorithm is proposed based on trend detection of relative one-way trip time (ROTT) when it falls in the ambiguous zone where the packet loss classification is not straightforward. The algorithm considers two packet loss classes, congestion loss and wireless loss. The proposed classification method also exploits the ROTT of received packets to assist packet loss classification.

In Paper [7] Random Early Detection (RED) gateways for congestion avoidance in packet switched networks is proposed. The gateway detects incipient congestion by computing the average queue size. The gateway could
notify connections of congestion either by dropping packets arriving at the gateway or by setting a bit in packet headers.

In paper [8] presents a new flow control protocol that uses delay hysteresis as a congestion indicator is presented. The protocol actively manages delays to keep them within a certain bound by throttling its transmission rate when network delays tend to increase and also probing for more bandwidth when network delays tend to decrease.

The delay-based approach proposed in paper [9] is called a black-box approach. It treats the network as a black-box, which does not give any explicit feedback.

In paper [10] considers the problem of congestion control in high-speed networks for multimedia traffic, such as voice and video. Paper describes a framing congestion control strategy based on a packet admission policy at the edges of the network, and a service discipline called Stop-and-Go queuing at the switching nodes.

Paper [11] an adaptive congestion control method is proposed, which can perform well even during constrained situation. Here authors have considered four popular routing protocols such as AODV, DSR, DSDV and TORA for analyzing the performance of the system. The proposed congestion control routing protocol is assumed to perform well for all the other routing protocols during heavy traffic loads.

In paper [12] the several general approaches for identifying the flows suitable for bandwidth regulation are considered. It proposes and investigates new congestion avoidance mechanism called Network Border Patrol (NBP). By using the rate control, Leaky bucket, time sliding window, rate monitoring Algorithms traffic (congestion) in the network is reduced.

In Paper [13] describes a congestion avoidance and control scheme that monitors the incoming traffic to each destination and provides rate based feedback information to the sources of bursty traffic so that sources of traffic can adjust their packet rates to match the network capacity.

In paper [14] a new family of delay-based congestion control algorithms is proposed that is referred to as delay-based AIMD. Here the network is considered with a mix of delay and loss-based flows and an extension to the basic delay-based AIMD algorithm is proposed to ensure robust coexistence with loss-based flows.

2. WORK
The various steps used in the present fuzzy based congestion control system are discussed below.

2.1 Fuzzy Controller
A fuzzy controller operates on the concept of a fuzzy set, which allows imprecise or incomplete input information to be expressed and incorporated with the heuristic knowledge of the system in a quantitative, systematic fashion for the control purpose. The generic model for a fuzzy controller is depicted in Fig.1. In essence, a fuzzy controller is constructed from the use of fuzzy sets and inference steps. In the fuzzification process, a real-number input (crisp input) is converted into linguistic values such as low or high characterized by fuzzy sets through the membership function. A single crisp input value can take on more than one linguistic value depending on how the membership functions are defined as will be described later. Then 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 so as to infer the output fuzzy sets. These outputs are then defuzzified to the crisp output which represents the actual control signal for the process.

Fuzzy logic systems are one of the main developments and successes of fuzzy sets and fuzzy logic. A FLS is a rule-base system that implements a nonlinear mapping between its inputs and outputs.

- Fuzzifier;
- Defuzzifier;
- Inference engine;
- Rule base.

![Figure 1: Fuzzy Controller](image)

2.2 Fuzzification
To translate crisp inputs for each input variable \( i \) into linguistic values, we define \( N \) linguistic values \( A^{(m)} \), \( m = 1; 2; \ldots; N \) as well as their membership functions.

For delay, its linguistic values \( m =1;2;3;4;5;6;7;8;9 \) are (i) Extremely Low(EL), (ii) Very Very Low(VVL), (iii) Very Low(VL), (iv) Low(L) (v) medium(M) (vi) high(H) (vii) Very high(VH) (viii) Very Very high(VVH) and (xi) Extremely high(EH). Besides a triangular shape, many
other choices for the shape of the membership functions also exists, including trapezoidal, Gaussian, and etc.

Note that a single value of a input (ranging from 0 to the buffer size) can take on more than one linguistic value. For instance, a input can be both medium and high but with different degrees of certainty indicated by outputs of the membership functions. Similarly the linguistic values for the other two inputs and output are defined.

2.3 Inference and Defuzzification

After crisp inputs are mapped to the linguistic values through the membership functions in the fuzzification step, the inference rule is applied to determine the output by using the rule base. The rule base is a set of rules that emulates the decision making process of the human expert controlling the system. The rule is written in the form

IF premise THEN consequent/action

Where premise is a combination of input linguistic values and consequent is what action to be taken. Because there are nine linguistic values each for Delay, buffer size and flow rate, the number of rules is 729, out of which 40 rules have been selected for the proposed work. In our case, the rule base is in a form called functional fuzzy system where each rule is written down as: Rule i: IF delay is low and buffer size is low and flow rate is low THEN Congestion gradient is low

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<tr>
<th>Delay</th>
<th>Buffer size</th>
<th>Flow rate</th>
<th>Congestion gradient</th>
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The fuzzy rule base includes 40 experimental rules, out of which some of the rules are shown in Table 1. The input for the defuzzification process is a fuzzy set (the aggregate output fuzzy set) and the output is a single number. As much as fuzziness helps the rule evaluation during the intermediate steps, the final desired output for each variable is generally a single number. However, the aggregate of a fuzzy set encompasses a range of output values, and so must be defuzzified in order to resolve a single output value from the set. Perhaps the most popular defuzzification method is the centroid calculation, which returns the center of area under the curve. Once the congestion gradient factors are determined from the inference step, the defuzzification is performed to obtain final congestion gradient factor.

2.4 Algorithms

Algorithm 1: Congestion Controlling at the Base Station

{Nomenclature=number of running applications, n=number of packets Bw=maximum bandwidth of a cell, BS=maximum buffer size of a base station, D=delay of the packets, FR=flow rate of the packet, CG=congestion gradient}

begin
Step1: Get the current values of delay flowrate and buffer size from the base station.
Step2: Call Algorithm 2; /*compute congestion gradient factor*/
Step3: IF congestion gradient factor below the lower threshold, maintain the previous flow rate;
Step4: IF congestion gradient factor is above the lower threshold, reduce the flow rate;
Step5: goto step2.
Step6: stop
end.

Algorithm 2: Computation of Congestion Gradient Factor

begin
Step1: For k=1 to n do
begin
a. Initialize fuzzy controller with delay(D), buffer size(BS) and flow rate(FR) to the packet ‘k’;
b. Find the Membership values of Delay, buffer size and flow rate using triangular rule
c. Compute CG by referring to rule base;
Step2: Inform CG factor to congestion controller;
Step3: Return;
Step4: Stop.
end.

3. RESULT AND DISCUSSION

The congestion gradient factor is determined using fuzzy logic. The inputs to determine the congestion gradient factor are delay of the packets that are sent, the buffer size of the base station and the data rate. The algorithm is coded using MATLAB mfile and verified using the MATLAB fuzzy logic tool box with FIS editor.
Fuzzy logic coding using MATLAB includes all the basic steps that are involved in designing any fuzzy model. The inputs are received for a particular network model and rules are evaluated using these inputs. These output membership functions are then implicated, aggregated and the crisp congestion gradient factor is calculated from this aggregated curve using centroid method of defuzzication. The MATLAB code for fuzzy scheduler is verified using the MATLAB fuzzy logic tool box. Then the calculated congestion controller is used for tuning the flow rate. As a result congestion in the network is controlled.

Figure 2 illustrates that as the number of nodes increases the percentage of drop is less in fuzzy scheme when compared to Qualnet simulator. Figure 3 shows that the throughput of fuzzy scheme is comparatively higher than the Qualnet simulator.

4. CONCLUSION
This paper addresses a fuzzy based congestion control scheme, which improves the Quality of service parameters in cellular network. The fuzzy controller algorithm combines the input parameters such as buffer size, data rate and delay to find the congestion gradient factor. Unlike the normal sorting procedure for controlling congestion, the crisp congestion gradient factor is calculated by the fuzzy controller based on the above inputs which are derived from the network.

Our future work will consider different parameters such as jitter, time-to-live etc.

REFERENCES


