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Congestion Control in Wireless Network for Heterogeneous Resources using Fuzzy Logic

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Abstract: - In wireless networks, due to huge amount of packets convergent nature of upstream traffic and limited wireless bandwidth, network congestion happens easy, which is a serious problem to be solved. The congestion control scheme is necessary to be solved out which can detect congestion precisely and regulate it fairly. To achieve this objective, a fuzzy logic based congestion control is proposed which takes advantage of current buffer occupancy and congestion detection is proposed to diagnose problem at each node level. In addition, it periodically calculates the congestion degree using fuzzy logic theory. At the same time each upstream traffic rate is emphasized according to the value of congestion degree. The scheme can quickly solve the status and trends of the network load, and adjust quickly to avoid a lot of packet losses. Simulations are conducted for the proposal which shows that this implementation efficiently sorts out the traffic and minimizes the packet loss. Simulation model also addresses the problem in order to deprive the congestion in wireless network.

Keywords: Wireless Network, Fuzzy Logic, Congestion Detection Rate, Packet loss, Transmit power.

1. INTRODUCTION

Nowadays wireless networks are the most popular way to connect people to the internet in companies, e-markets, cafes and in homes. Therefore, it must be secured against the malicious users who try to damage the confidentiality, authenticity and privacy of it. Although, wireless networks are protected and powered by encryption technologies such as WEP / WPA encryption, but several tools were developed to analyze and crack the encryption keys by setting the wireless adapter to monitoring mode, where it can gather the packets of the targeted wireless access point from the air and start to analyze them and trying thousands of decryption keys to crack the key, and it works fine. It strongly achieves separation of congestion control and loss recovery mechanism by quickly informing the sender that a loss happened because of reasons related to network congestion [6]. The unnecessary window reduction caused by lost packets due to link errors is avoided. Wireless network also equipped with several different topologies and aloof networks of discrete sizes, therefore diagnose the problem in wireless network is really challenging task. To counter act this affect we have introduced the prediction method to find out the time taken by a packet from source to destination [3]. This could be possible using Fuzzy Logic Rules and simulation methods.

2. METHODOLOGY

2.1. FUZZY LOGIC AND APPLICATION

Fuzzy logic has a lot of applications. The literature review shows that fuzzy controllers, as an application of fuzzy logic, can be found even in things that one would not expect [2]. There are many examples of successfully applied fuzzy theory in practice including: the selection of the most suitable bank for arranging a mortgage, the evaluation of client credibility, the selection of an insurance company, the purchase of a property, the selection of a car, the job selection and many others. The figure 1 represents the sequence of fuzzy system in which it processes the entire inputs and outputs.

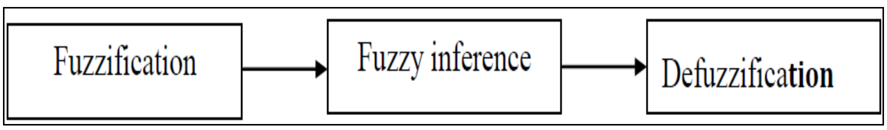

Figure 1. Solving problem using fuzzy logic

These applications serving for decision support are the first large group of applications [2]. The process of fuzzy logic is illustrated in figure 1, which helps the model to predict the values.

2.2. FUZZYFICATION

The fuzzificaton means that the real variables are transferred on linguistic variables [9]. The definition of linguistic variable comes out from basic linguistic variables, for example, the following attributes can be set up at the variable risk: none, very low, low, medium, high, and very high as depicted in figure 2. Usually there are used from three to seven attributes of variable. The attributes are defined by the so called membership function.

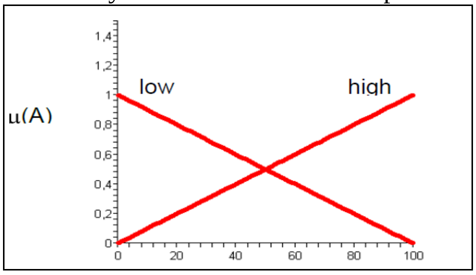

Figure 2. Membership graph

2.3. FUZZY LINGUISTIC VARIABLES

These are the few examples to define the linguistic variables:-

- Fuzzy Linguistic Variables are used to represent qualities spanning a particular spectrum
- Temp: **{Freezing, Cool, Warm, Hot}**
- Membership Function
- Question: What is the temperature?
- Answer: It is warm.
- Question: How warm is it?

2.4. FUZZY RULES

Fuzzy rules are produced from the linguistic language such as low, avg. and high for the particular rule, which are further converted into numerical values of relevant intervals. It plays key role in the entire system.

3. APPLICATION MODEL

In order to gather information more efficiently, wireless networks (WNs) are partitioned into clusters. Most proposed clustering algorithms do not consider the location of the base station. This situation causes hot spot problems in multi-hop WSNs. In this paper, we analyze a fuzzy clustering algorithm (FCA) which aims to prolong the lifetime of WNs [7]. This algorithm adjusts the cluster-head radius considering the residual energy and distance to the base station parameters of the sensor nodes [1]. As shown in figure 3, we can perceive the working pattern of sensor devices in wireless network and routers hopes to be used by packets [6]. This helps to decrease the intra-cluster work of the sensor nodes which are closer to the base station or have lower battery level.

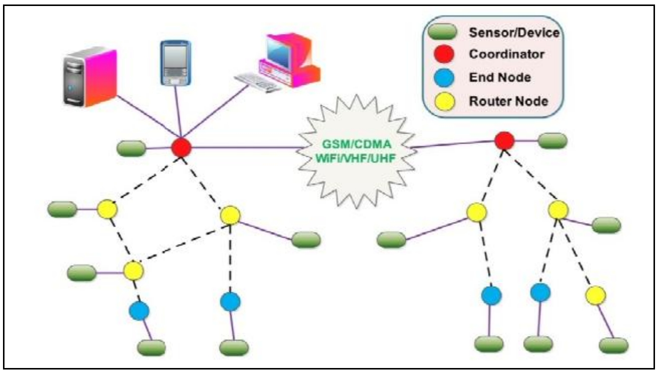

Figure 3. Wireless connection among different nodes

TCP congestion control has been developed on the assumption that congestion in the network to be the only cause for packet loss. Thus, it drops its transmit window upon detecting a packet loss. In the presence of high error rates and intermittent connective characteristic of wireless link, these results in an unnecessary reduction in link bandwidth utilization for packet losses are not mainly due to congestion. With envisaged growth in Internet of wireless and mobile networks, it becomes crucial to recommodate a proposal to improve TCP congestion control protocol over systems in which link properties are not perfect [1]. There have been plenty of techniques developed to improve end-to-end TCP performance over wireless links. They can be classified into three categories: end-to-end TCP connection split TCP connection and snooping TCP [7]. However, split TCP connection such as Indirect-TCP breaks the end-to-end semantics associated with the TCP protocol [8]. Flow of packets in network occur at different rate, figure 4, explains the probability of packets reaching at the destination and emerging from source is different. The replicated system is also compared with real world system to diagnose and detect the congestion in WN. Authentication of results are also properly verified.

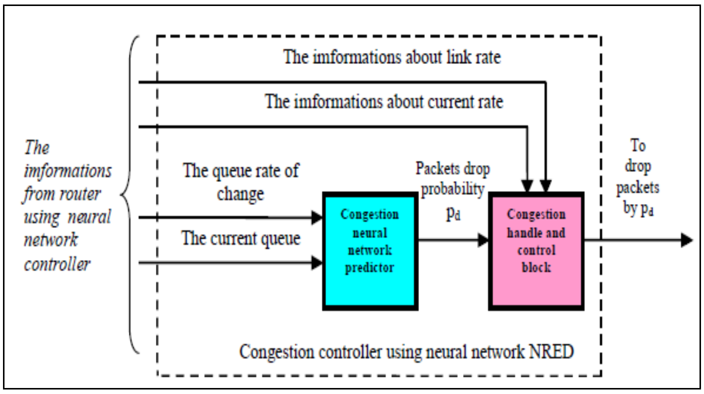

Figure 4. Flow of packets in network

Table 1. Rules used for Fuzzy system along with wireless network parameters

Rule No.	***Inputs***				***Outputs***		
	Packet Length	**Efficiency**	**Transmit Power**	**Receiver Power**	**Time Taken**	**Packet Loss Rate**	**Congestion Detection Rate**
1	Low	Low	Low	Low	High	Large	Low
2	Medium	Medium	Low	Low	Average	Large	Medium
3	High	Medium	High	Low	Average	Large	Medium
4	High	High	High	High	Less	Few	High
5	Low	High	High	High	High	Large	Medium
6	High	Medium	High	High	Not Less	Not Few	High
7	Medium	Medium	Low	High	High	Few	High
8	High	Low	Low	Low	Average	Not Large	Medium

Flow of control of the packet is also considered. The packets traverse in congestion neural network predictor then congestion handle and congestion control block to provide the desired output. The real demonstration of this system is modeled in MatLab R2012a and Fuzzy logic Toolbox along with Database Toolbox. Neural Network also predicts the time [8] and other attributes of each packet and makes a queue to send the packets in assigned order. The fuzzy logic implies the same method to deploy the communication between sender and receiver [9]. Upon the first lost packet due to buffer overflow in the intermediate router, Wireless-ECN notification is added in the header of following passing packet [3]. MatLab software is used to explain the simulation system. Table 1 shows the inputs and outputs of any packet. Referring to attributes of packet we have Packet length, Efficiency, transmit power and Receiving power where as time taken in entire trip, packet loss rate and congestion detection rate emerges as outputs of fuzzy logic. The range of the rules in graph format is represented in figure 5 in the illustration form.

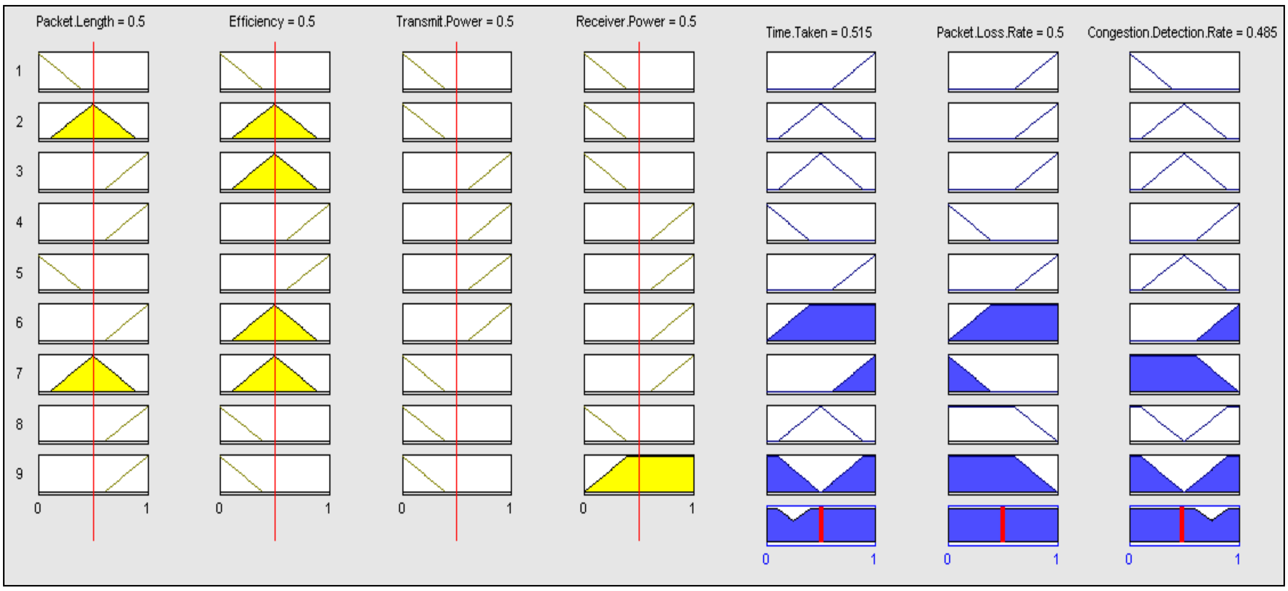

Figure 5. Rules implemented in MatLab

4. SIMULATION RESULTS

A wireless network is a network in which a group of mobile computing devices and nodes communicate without the aid of a fixed networking infrastructure. This Network provides an extension to the Internet. Since TCP/IP is the standard network protocol on the Internet, its use wireless network and our responsibilities are to send the packet at certain rate . The performance of the simulation model is tested on MatLab and table 2 shows the comparison of actual values and predicted values. Actual values are modeled in real environment for one and two no. of hopes where as predicted values are calculated by Fuzzy system [10].

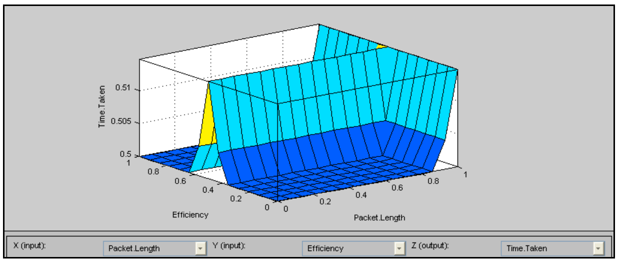

Figure 6. 3D graph for packet length, time taken and efficiency

4.1. FUZZY GRAPH

The graph in figure 6 shows between efficiency of the network and time taken by the packet [5]. Similarly, figure 7 represents the performance graph [10] for packet length, time taken and efficiency in 3D format. Figure 8 also depicts the same as figure 7, but for packet length, efficiency and packet loss rate [9].

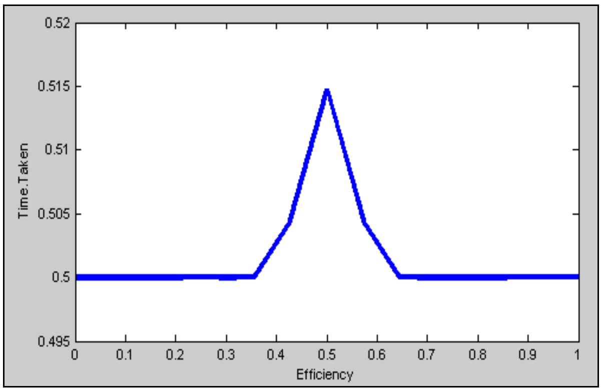

Figure 7. Graph represents the performance for efficiency and time taken

Table 2. Actual values vs. Predicted values

S.No.	No. of hopes	Actual Time(sec.)	Predicted Time(sec.)	Error (%)
1.	1	0.654	0.632	0.0336
2.	1	0.567	0.532	0.0617
3.	2	0.768	0.675	0.1215
4.	2	0.845	0.745	0.1183

The graphs represent the relationship among the different attributes and parameters of the wireless network eg. Efficiency is 0.2 relevant to 0.5 sec time consumed. Fuzzy graph is also helpful to determine the other values of node and predict the other scenarios. The rules given in table 1 are prerequisite to these graphs [5].

5. Conclusion And Future Work

TCP was designed for wired networks, and its attribute are research efforts over the years. Yet it shows poor performance over multihop wireless networks and severe inter-flow fairness challenges, as shown in reviews a number of proposals to enhance time taken and efficiency. However, none of these improvements will benefit the network with large no. of hopes. The core congestion control protocol can be further optimized by tuning the rate control formula and retransmission timer to optimize the packet sending. Finally, we are very interested in implementing the proposed congestion control protocol in our wireless mesh network verify the simulation results. The work presented here will be further extended in the following areas to verify and improve the design. We will conduct more performance runs to verify the test results under multiple-flow scenarios. We will also add node mobility to the simulations and study the impact of additional loss scenarios caused by broken links during an active flow on throughput and fairness.

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