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Controlling Congestion in Wireless Communication Networks using Machine Learning and Fuzzy Logic Methods

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Research Article

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ABSTRACT: Wireless networks are now the most widely used kind of communication. For instance, internet services in homes, businesses, cafés, and e-markets. As a result, it has to be safeguarded against vindictive users who attempt to compromise its authenticity and privacy. Information delivered via these wireless networks also need traffic management. This study describes a method for managing wireless network congestion that makes use of machine learning and fuzzy logic. The following are some of the factors that must be taken into account for the congestion control decision mechanism:Transmission energy, queue length, receiver distance, transmission speed, and allocated cost. A desired outcome for congestion management may be identified and its effectiveness assessed using machine learning technologies once these parameters are reviewed using fuzzy logic.

KEYWORDS: machine learning technologies, fuzzy logic, wireless networks, and congestion.

INTRODUCTION

a) Introduction to wireless Networks:

The challenge of efficiently and scalably providing network access to a large number of mobile users is resolved by Wireless Overlay Networks, a hierarchical structure of room-size and wide area data networks [1].Numerous wireless networks have been established as wireless communication technology has grown. The next generation of wireless networks will be dominated by diverse networks [2].WLAN and 3G (wireless local area network) are common types of wireless networks. Assimilation of these heterogeneous networks and the achievement of mobile nodes moving across heterogeneous networks with little packet loss, low latency across networks based on different technologies, and continuity are crucial [3]. Figure 1 depicts a typical wireless network example:

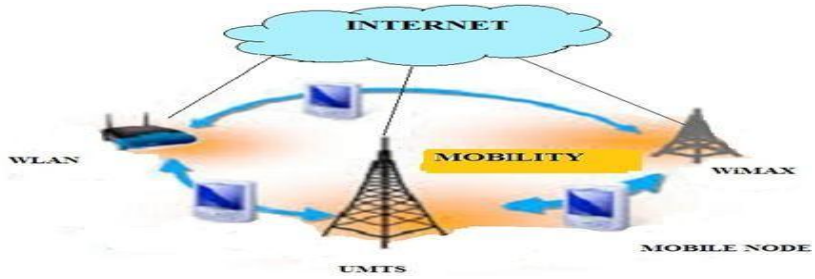


Fig 1: Wireless Communication among different networks

The biggest issue facing the globe now is wireless network congestion management.Congestion control is crucial for modern telecommunications, computer networks, and both wired and wireless communications, including the Internet, which are designed to transmit enormous amounts of data quickly. The congestion collapse of such networks would become quite complicated and is a serious risk in the absence of an appropriate congestion management system [9]. The sensitivity of streaming media traffic makes network congestion management difficult.

traffic. Over the last ten years, this difficulty has motivated academics to develop a variety of congestion management methods and techniques that ensemble traffic and provide equitable repairs for both unicast and multicast communications [4].

b). Introduction to tools used:

1. Fuzzy Logic:1. One kind of many-valued logic employed in networks that has contributed to advancements in network efficiency is fuzzy logic (FL). Instead of being fixed and definite, FL compacts with erroneous logic. In the middle of the 1960s, Professor LotfiZadeh presented the idea of FL [5], [6], and [7]. Numerous techniques for replacing and inferring from ambiguous or partial information have been proposed by fuzzy logic. There is a degree of membership, but fuzzy notions cannot be illustrated by a straightforward set inclusion operator ∈. To put it another way, Fuzzy Logic uses the idea of degrees of membership to expand Boolean logic's two values, true (always represented numerically as 1), or YES, and false (always represented numerically as 0), or NO, to values between 0 and 1 [10].Figure 2 illustrates how Fuzzy Logic uses the Fuzzy Inference tool.

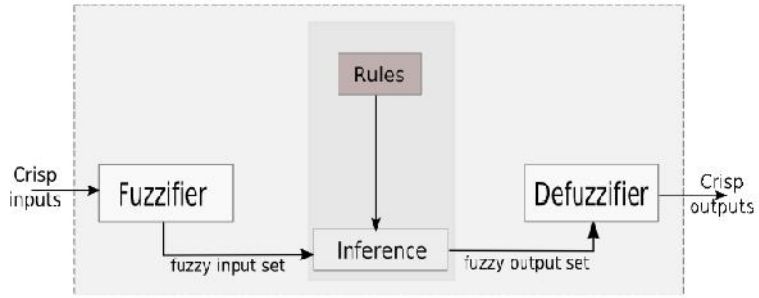


Figure 2: Fuzzy Inference System

2. Weka tool: ML algorithms have been trained and tested using the Weka tool [8]. This tool is a collection of several machine learning algorithms; five of the most popular ML algorithms have been utilized in this study, and the performance of these ML algorithms has been compared using various metrics.The University of Waikato in New Zealand created the well-known Java machine learning software package Weka (Waikato Environment for Knowledge Analysis). As seen in figure 3, Weka is free software that is accessible under the GNU General Public License.

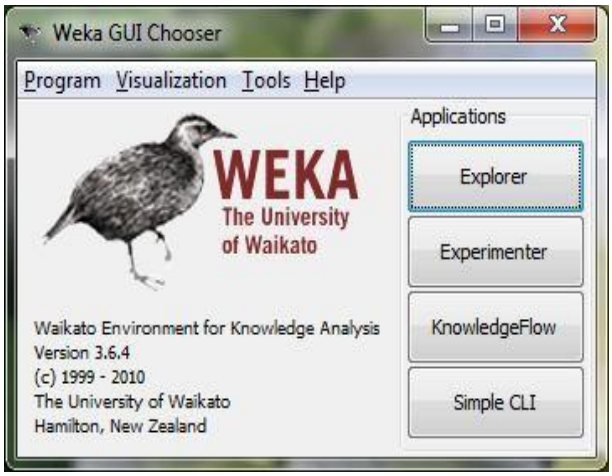


Figure 3: Weka Tool

I. PROPOSED APPROACH

In this research work, a manual data set of 2084 values is created using fuzzy logic. The use of fuzzy tool is as shown in figure 4.

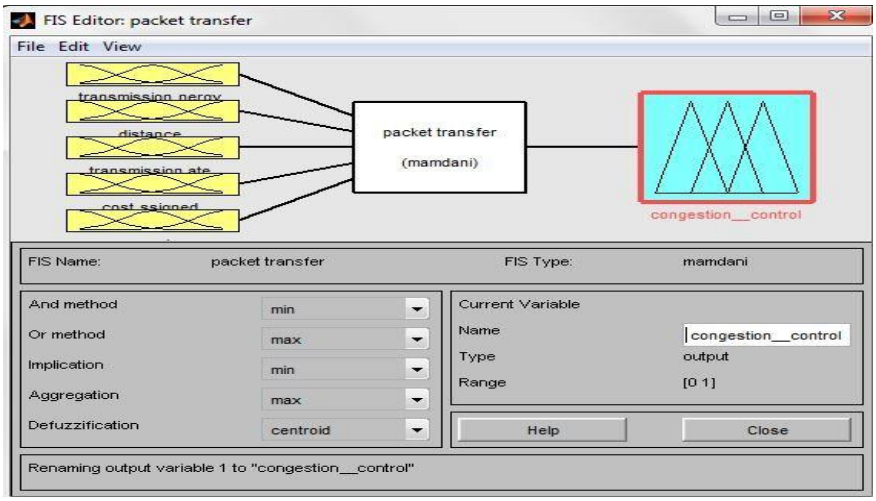


Fig 4: Fuzzy Logic system in Matlab

In the figure shown above, five input parameters are taken as: Transmission energy, queue size, distance from receiver, transmission rate, cost assigned and output is congestion control.Using fuzzy logic, a rule set of 400 values is created which is shown below in figure 5:

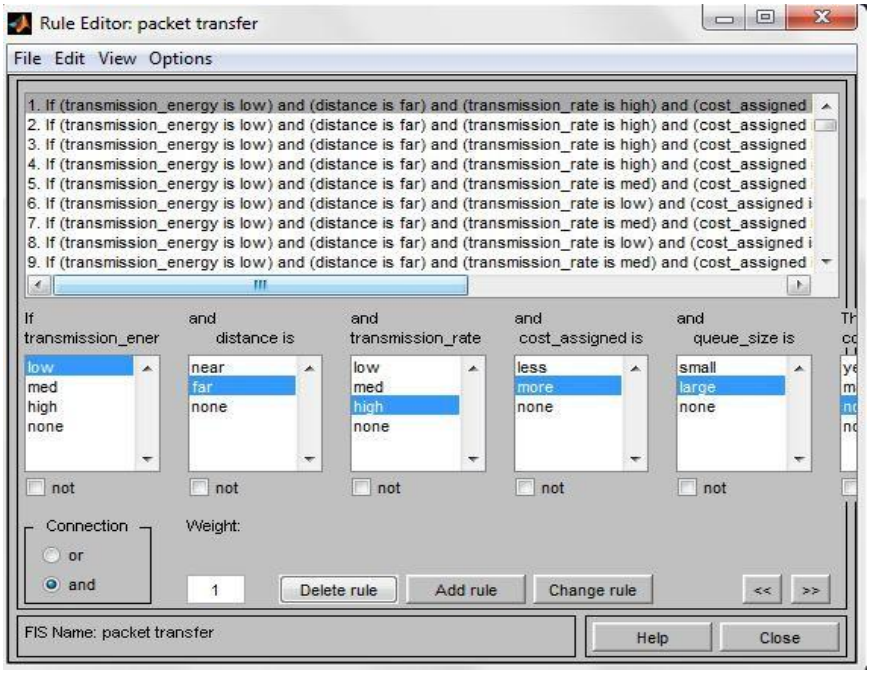


Fig 5: Rule Editor

Rule Viewer shown in figure 6: The rule viewer shows the various rules according to parameters and their effect on the output.

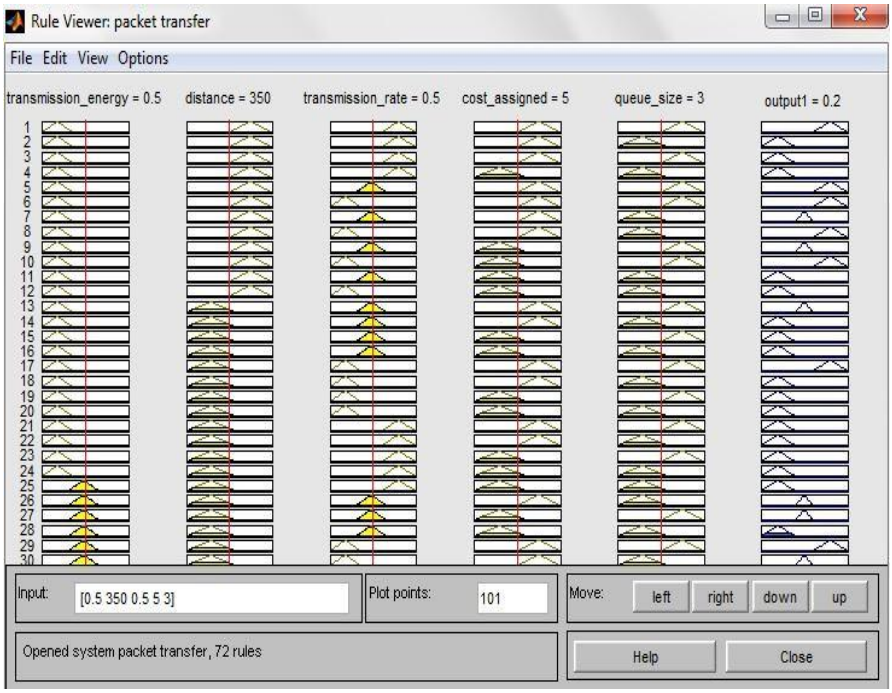


Fig 6: Rule Viewer

Surface Viewer shows the autocorrelation between the parameters chosen and is shown in figure 7.

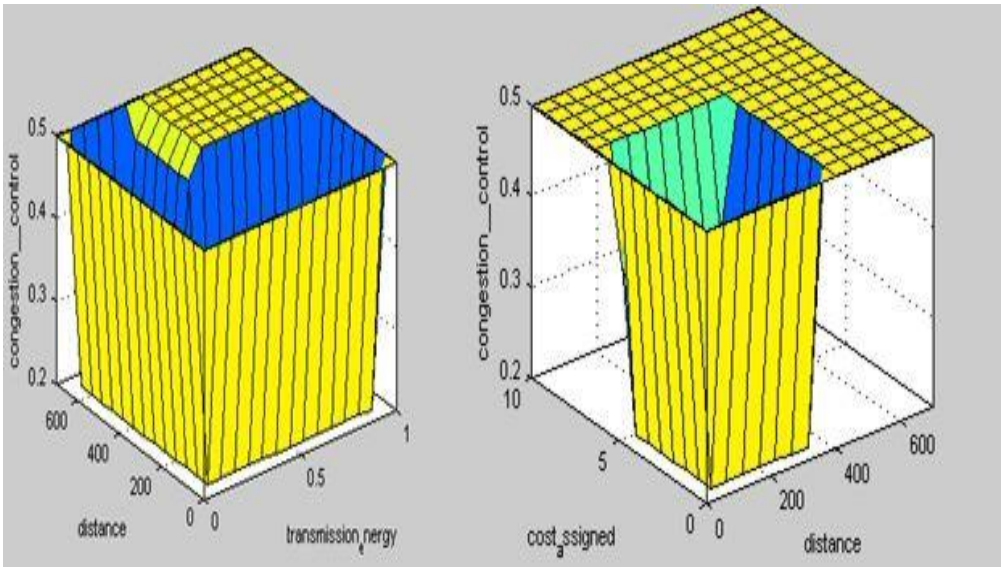


Fig7: Surface Viewer

Some values of these rules are checked for their validation using Matlab commands (readfis and evalfis) as shown in table1:

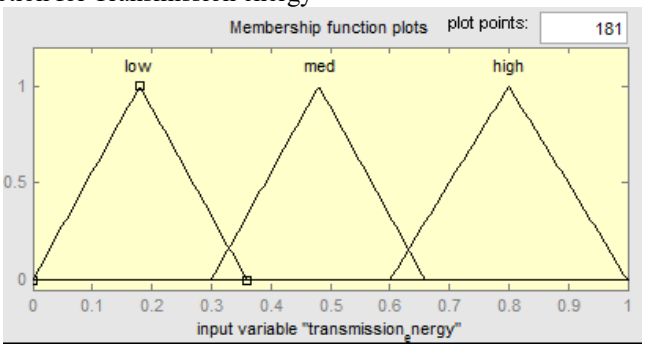
Table 1: Validation Table

transmission energy	distance	transmission rate	cost assigned	queue size	congestion control	o/p
0.01	510	0.1	6	1	0.75	no
0.02	520	0.11	7	5	0.75	no
0.03	530	0.12	1	2	0.75	no
0.04	540	0.13	2	5.5	0.75	no
0.05	550	0.4	7	1	0.5	may be
0.06	560	0.41	8	5	0.75	no
0.07	570	0.42	2	2	0.25	yes
0.08	580	0.43	3	5.5	0.5	may be
0.09	590	0.7	6	1	0.25	yes
0.1	600	0.71	7	5	0.5	may be

The membership functions of various input parameters are given as follows:

1. Transmission energy: 1. In WSN, this energy may easily be employed to send packets via a wireless connection. The most important finding is that the energy needed to send a packet may be greatly decreased by reducing the transmission power and sending the packet over a longer amount of time. The energy required to send a data packet from one node to another is referred to as "transmission energy." Congestion is reduced when the transmission energy value is lower.

Figure 8: Membership function for Transmission energy



2. Data Transmission Rate: A training sequence for the modem is carried out and a test signal transmission sequence is impacted to build up a data transmission rate prior to information delivery when transmit and receive stations are linked by a call. Training on the transmission rates that a modem may use is carried out in accordance with a preset protocol without lengthening the protocol duration. Fast data transmission rates are necessary to ensure timely packet delivery to the destination. Reduced connectivity costs are attributed to fast data transmission rates.

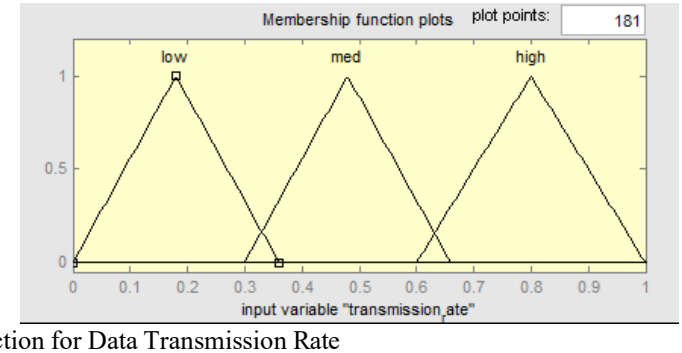


Fig 9: Membership function for Data Transmission Rate

3. **Distance between transmitter and receiver:**Routes with the fewest hops may be chosen thanks to the fuzzy input variable "Distance between transmitter and receiver." Thus, nodes that are closer to the gateway are given a reduced connection fee. The minimum number of hops lowers the complexity of sensor networks and offers an effective method of packet transmission at the destination.

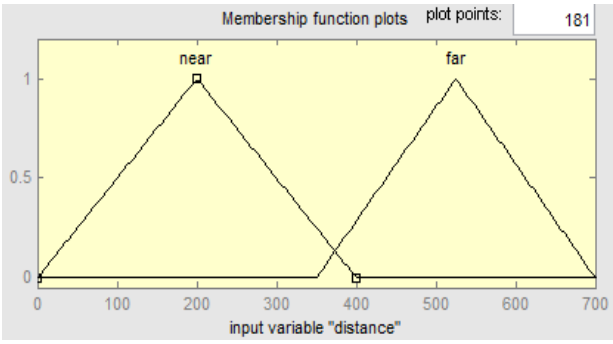


Fig 10: Membership function for distance

4. **Queue size:** The buffer capacity at any node is indicated by the input fuzzy variable "queue size." This setting helps prevent packet losses caused by receiver congestion. Congestion makes it very difficult for data packets to be sent efficiently at the receiving end of networks. In order to reduce execution waiting times, this packet queue size should be modest.

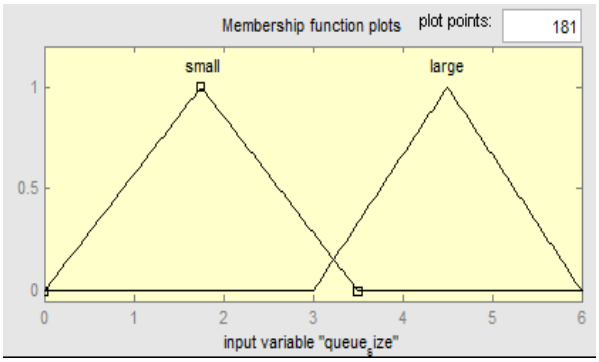
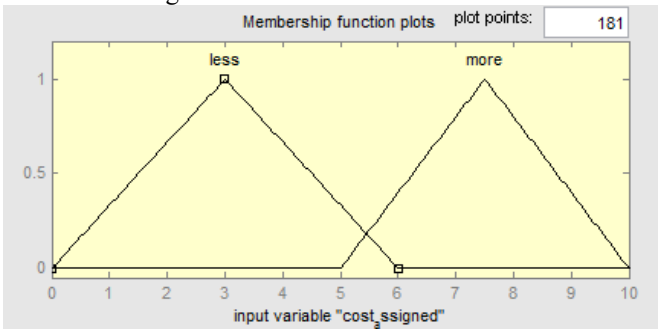


Fig 11: Membership function for queue size

5. **Cost assigned to each path:** Based on its present state, each sensor node is given a dynamic weight. The maximum weight is given to an inactive node that is neither detecting nor relaying, while the lowest weight is given to a node that is doing both. This parameter aids in the selection of nodes that are just in the sensing state or are inactive. As a consequence, a node with a high weight is more favorable for the following hop, which lowers the connection cost.

Fig 12: Membership function for cost assigned



Output: Output here is congestion control and the membership function taken here are:yes, may be and no.

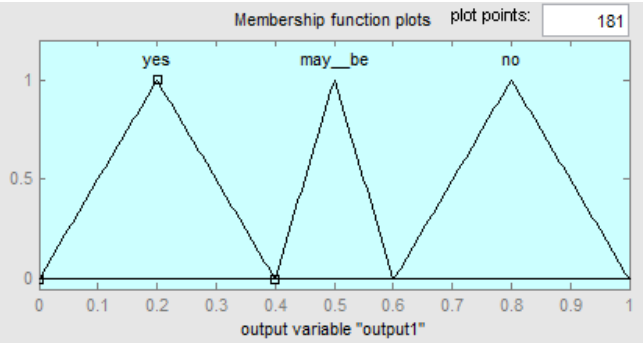


Fig 13: Membership function for output

a) Use of Weka Tool for implementation

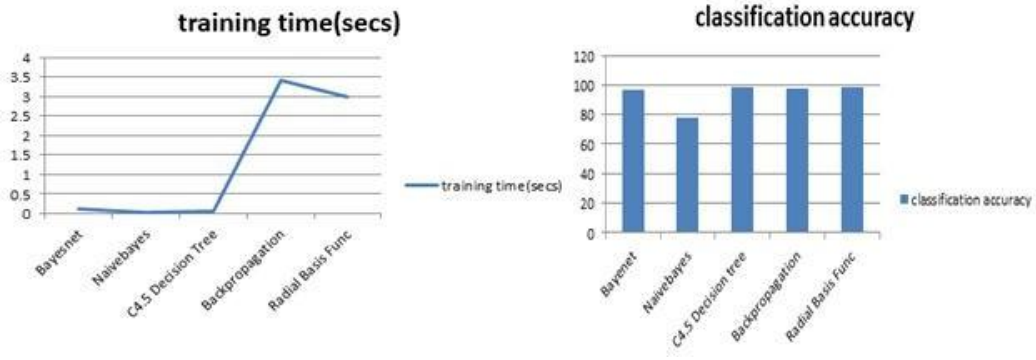
Five machine learning tools are used i.e. Backpropagation, Radial Basis Function, C4.5 Decision tree, Naïve Bayes, Bayesnet. Weka Tool is used for finding the classification accuracy and training time of these tools to find the best among them. Among 2084 rules, 1784 are used for training data and 300 are used for testing the data.

Table 2: Table showing the performance of the five neural tools.

	Bayes net	Naïve Bayes	C4.5 Decision Tree	Backpropagation	Radial Basis Function
training time(secs)	0.13	0.02	0.06	3.42	3
Classification accuracy (%)	97	78	99	98	98.5

b) Graphs showing the comparison between the Five neural tools:

Using the training and testing data, graphs showing the comparison between the training time and classification accuracy of the tools are drawn.



Graph: Graph for training time and classification accuracy of neural tools taken

CONCLUSION

The main issue with wireless data transport is congestion management. This research presents a novel approach that makes use of fuzzy logic and machine learning technologies to monitor this issue.When these neural tools are compared, it is evident that C4.5 performs better than the other five. For example, its classification accuracy of 99% is the highest of all, and its training time is 0.06 seconds.

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