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FUZZY LOGIC BASED QUALITY OF SERVICE EVALUATION IN MULTIMEDIA TRANSMISSION OVER AD HOC WIRELESS NETWORK

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ABSTRACT: *The use of ICT to bridge the gap that exists in the area of customer service satisfaction between an internet service provider (ISP) and the subscribing customer in the process of providing internet services cannot be overemphasized. Fuzzy logic has emerged as a tool to deal with qualitative decision making problems in order to achieve robustness, tractability, and low cost. This paper proposes a fuzzy logic model for evaluation of quality of service (QoS) in multimedia transmission. In order to achieve our objectives, we develop a prototype of a computer aided system for an intelligent quality of service using fuzzy logic model. The study designs a decision support system for the quality of service intelligence system. We design a fuzzy logic evaluator for the quality of service computing system using; MATLAB toolbox and windows 7 operating system. The result indicates that our model is able to detect and restore any QoS deterioration in real-time and thus, providing good and efficient QoS for customer satisfaction.*

KEYWORD: Quality of Service (QoS), Multimedia Transmission, Fuzzy Logic, Broadband Access System

INTRODUCTION

Quality of service refers to the several related aspects of telephony and computer networks that allow the transport of traffic with special requirements. Quality of service is an important consideration in networking. Providing Quality of Service guarantee becomes even more challenging when you add the complexities of wireless networks. The customer needs in terms of communications technology to multimedia services forcing operators to integrate innovative solutions, for services deployment, supply and assurance.

Therefore, measurement of network performance is crucial for QoS controlling, managing and provisioning. According to Al-Sbou et al. (2005), techniques for measuring and analysis of QoS in communications networks have recently been the subject of intense investigations based on passive and active measurement. Network performance can be measured and carried out to get information on important end-to-end parameters such as delay, losses, and jitter, etc. QoS measurement and monitoring are essential for tracing the ongoing QoS, comparing the measured QoS against the required (expected), detecting possible QoS degradation, and then, based on the measured QoS, trying to manage the network resources accordingly to sustain the agreed QoS. In addition to that, QoS measurement is essential because the results of QoS measurement are usually used as input to network planning and dimensioning, Service Level Agreement (SLA) monitoring, traffic engineering, accounting, fault management and security management. The performance of a network is important to both the service provider and the end-user (Hasib and Schormans, 2003) (D'Antonio et al. 2003).

However, networks diversity and deployed services nature requires the introduction of effective mechanisms for Quality of Service Management and monitoring. Indeed, the

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multimedia services supply in internet network requires a continuous Quality of Service monitoring to ensure acceptable reliability and customer satisfaction. Similarly, Quality of Service evaluation is essential to trace the quality provided related to service and identifies any Quality of Service deterioration and configuration management resources accordingly to maintain an acceptable Quality of Service in real-time.

Fuzzy logic is a form of many-valued logic or probabilistic logic; it deals with reasoning that is approximate rather than fixed or exact. In contrast with traditional logic, they can have varying values, where binary sets have two valued logic, true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. Indeed, fuzzy logic is a popular technique that provides mechanisms for handling non-linear uncertainties that exist in physical systems. Also, fuzzy logic can supports the natural descriptions of inputs and outputs in terms of language, which avoids the complexity to identify the exact numerical values, to model in each situation. The new approach is based on network performance evaluated via key performance indicators (KPI) which have a considerable impact on picture, audio and video Quality, that for estimate the Quality of Service in real time fuzzy logic-based (D'Antonio et al. 2003)(Nedeljkovic,2003)(Oliveira and Braum, 2004).

This paper proposes a fuzzy logic model for evaluation of quality of service (QoS) in multimedia transmission. In order to achieve our objectives, we develop a prototype of a computer aided system for an intelligent quality of service using fuzzy logic model. The study designs a decision support system for the quality of service intelligence system. We design a fuzzy logic evaluator for the quality of service computing system using; MATLAB toolbox, adobe Dreamweaver CS4, PHP and windows 7 operating system. The result indicates that our model is able to detect and restore any QoS deterioration in real-time and thus, providing good and efficient QoS for customer satisfaction.

The rest of this paper is as follows, section 2 presents research objectives, section 3 presents literature review, section 4 proposes research methodology, section 5 presents model experiments. Section 6 presents results and discussion. Finally, section 7 gives a conclusion and section 8 presents references.

RESEARCH OBJECTIVES

The objective of this research is to develop a fuzzy logic model using AI technologies and apply the model for effective control of Quality of Service (QoS) in Multimedia Transmission over Ad hoc Wireless network to detect and restore any QoS deterioration in real-time and thus, improve quality, reliability, robustness, good and efficient QoS for customer satisfaction.

LITERATURE REVIEW

Abbasi et al. (2012) propose a new routing algorithm with fuzzy technique for improving quality of service in RWSN. The study first carry out a reduction of energy consumption which results in an increase in the network operations life span and the second, to meet a defined end-to-end delay and hence increasing reliability by reducing number of packet losses considerably.

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It uses different fuzzy parameters and if-then rules, each node can make a decision to choose its next step for routing towards destination (sink). Simulation results show that the proposed new protocol considerably reduces energy usage in the network as well as guaranting the quality of service and noticeable improved performance in comparison with SPEED and THVR. Zarei et al (2009) propose a Fuzzy based trust estimation for congestion control in WSNs in FCC Protocol. The trust concept is used for detection of malfunctioning nodes using fuzzy logic. The resulting effects are: a decrease in the packet drop ratio and accordingly an increase in the packet delivery rate. Zarei et al, (2010) investigate FCCTF protocol being a modification of FCC, in which Threshold Trust Value is used for decision making.. Threshold could change dynamically with increasing or decreasing traffic of the related region. Although faulty nodes are isolated in FCC and FCCTF, still there is further scope of improvement in terms of congestion detection and congestion regulation considering traffic priority.

Bazaz et al, 2013 investigate control congestion problem by proposing a mechanism to control congestion in streaming media applications by using fuzzy logic. Then a model has been generated by the fuzzy logic controller to control the congestion. Pokhrel et al, (2013) present a methodology and a system based on fuzzy expert system to estimate the impact of network conditions (QoS) on the QoE of video traffic. The estimated video quality showed high correlation with the subjective QoE obtained from the participants in a controlled test. The model is integrated as part of a monitoring tool in an industrial IPTV test bed and compared its output with standard Video Quality Monitoring (VQM). The evaluation results show that the proposed video quality estimation method based on fuzzy expert system can effectively measure the network impact on the QoE. Sun et al. (2009) present a fuzzy controller based QoS routing algorithm with a multiclass scheme (FQRA) in mobile ad hoc networks. The performance of this scheduler is studied using NS2 (Network Simulator version 2) and evaluated in terms of quantitative measures such as packet delivery ratio, path success ratio and average end-to-end delay. Simulations show that the approach is efficient, promising and applicable in ad hoc networks.

Mohammed et al. (2011) propose a new approach QoS monitoring based on fuzzy logic. The technique allows modeling a control system able to identify any QoS deterioration in real-time, also a rapid resources reconfiguration and restoration to ensure customer satisfaction IMS. Chen et al. (2009) propose admission control by a fuzzy Q-learning technique for WCDMA/WLAN heterogeneous networks with multimedia traffic. The fuzzy Q-learning admission control (FQAC) system is composed of a neural-fuzzy inference system (NFIS) admissibility estimator, an NFIS dwelling estimator, and a decision maker. Simulation results show that FQAC can always maintain the system QoS requirement up to a traffic intensity of 1.1 because it can appropriately admit or reject the users' admission requests. In Sonmez et al (2014) problems for multimedia transmission over wireless multimedia sensor networks are examined and sensor fuzzy-based image transmission (SUIT); a new progressive image transport protocol is proposed as a solution. SUIT provides fuzzy logic-based congestion estimation and an efficient congestion mitigation technique which decreases the image quality on-the-fly to an acceptable level. In case of congestion, SUIT drops some packets of the frames in a smart way and thus transmits frames to the sink with lower, but acceptable quality. Shrivastava et al. (2013) present an adaptation technique at transport layer to minimize the impact of varying and adverse network condition along with security and priority to satisfy the SLA. The study extends the transport layer functionalities to manage the SLA by selecting network layer parameters and application layer parameters. The given approach provides a

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performance based on the analysis of mapping network layer and application layer availability and security to network concerned parameters like security and priority by using fuzzy rules.

Kumar and Murugesan, (2012) propose a novel Priority based Scheduling scheme that uses Artificial Intelligence to support various services by considering the QoS constraints of each class. The simulation results show that slow mobility does not affect the performances and faster mobility and the increment in users beyond a particular load have their say in defining average throughput, average per user throughput, fairness index, average end to end delay and average delay jitter. Dogman et al. (2012) a network quality of service (QoS) evaluation system was proposed. The system used a combination of fuzzy C-means (FCM) and regression model to analyse and assess the QoS in a simulated network. Network QoS parameters of multimedia applications were intelligently analysed by FCM clustering algorithm. The QoS parameters for each FCM cluster centre were then inputted to a regression model in order to quantify the overall

QoS. The proposed QoS evaluation system provided valuable information about the network's QoS patterns and based on this information, the overall network's QoS was effectively quantified. Alreshoodi1 and Woods (2013) carry out a brief review of some existing correlation models which attempt to map Quality of Service (QoS) to Quality of Experience (QoE) for multimedia services. Onifade and Aderunmu (2008) employ fuzzy logic technique in Statistical Connection Admission Control (S-CAC) - a CAC employing multiplexing of the bandwidth between the peak cell rate and the sustained (average) cell rate.

RESEARCH METHODOLOGY

The case study for this project is ipNX telecoms, Port Harcourt. ipNX telecoms is located at plot 33 Federal housing estate, trans-amadi, Port Harcourt, where data are collected. The collected data/ information and the MAC address of the device allow access for efficient monitoring of its data transmission and utilization of the client. We explore this information to develop a multimedia data transmission quality of service monitoring system using fuzzy logic.

The conceptual architecture of our model is based on Umoh et al. (2011) and presents in Figure 1. The conceptual architecture Conceptual Architecture of Fuzzy Logic Based Quality of Service Evaluation Model for Multimedia Transmission comprises the following: (i) The conceptual architecture comprises of the Knowledge Base, (ii) Fuzzy logic model, (iii) feedback module (iv) the user interface to display the evaluated output. The knowledge base design of the quality of service analysis for multimedia transmission of data comprises of a fuzzy logic model. The knowledge base is made of both structured and unstructured knowledge about the problem domain. It contains facts and rules of multimedia transmission log built up by the experts in the field. The facts influence the rules, allow the quality of service analyzer to make decisions from the information.

The structure of fuzzy logic based Quality of Service evaluation model for Multimedia Transmission is shown in Figure 2.

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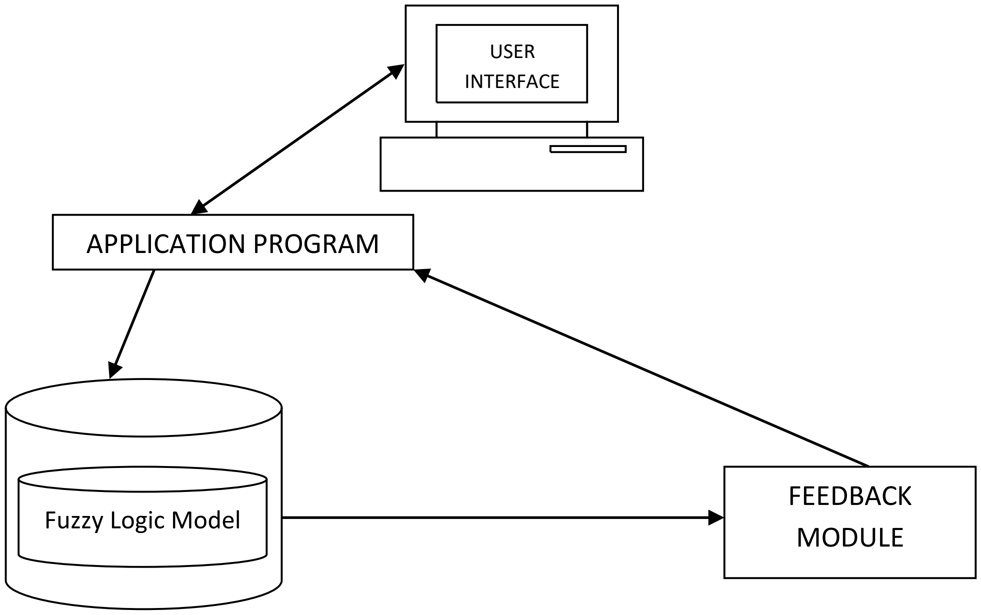

Fig.1: Conceptual Architecture of Fuzzy Logic Based Quality of Service Evaluation Model for Multimedia Transmission

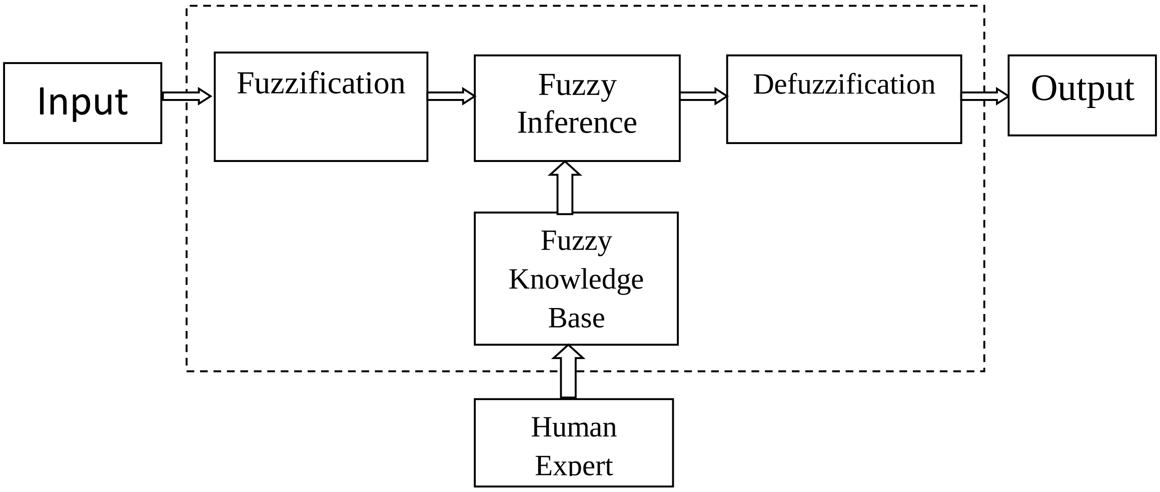

Fig. 2: The structure of fuzzy logic based Quality of Service evaluation model for Multimedia Transmission

The main building units of a fuzzy logic design for quality of service in multimedia transmission of data involve the following: Fuzzification unit, Fuzzy Inference unit, Fuzzy Knowledge base unit and Defuzzification unit. Fuzzification of data is carried out on the transformed data by selecting input parameters into the horizontal axis and projecting vertically to the upper boundary of membership function to determine the degree of membership. This is then used to map the output value specified in the individual rules to an intermediate output measuring fuzzy sets.

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In this paper, the following input variables are utilized; *Delay (DE), Jitter (JI) and Packet Loss (PL). Delay (DE):* is time required for packets arrival at destination measured in meters per second. Critical values of delay cause loss of synchronization between source and destination video. *Jitter (JI)*: variance of delay between packets, which causes loss of synchronization between packets sent, measured in meters per second. *Packet Loss (PL)*: the percentage of packets lost during transmission. However, it does not have great impact on audio stream for information amount that is transmitted, but still useful for estimating the QoS in a relevant way. These three input variables form the major parameters used in fuzzy logic model in determining and evaluating the efficiency and the quality of service in a multimedia transmission network. The output parameter is defined as Quality of Service (QoS). The fuzzy linguistics terms are defined for both the inputs and output variables and their corresponding membership functions are evaluated using Triangular membership function due to its computational efficiency.

The fuzzy linguistics variables are defined on each input parameters as follows: Delay {low, average, high}, Jitter {low, average, high}, Packet loss {low, average, high}. Low: describes that the estimated QoS is acceptable. Average: describing indicators acceptable. High: subset of critical indicators. The output fuzzy linguistic variables are defined as; Quality of Service {good service, average service, bad service} respectively.

The universe of discourse is selected for input and output parameters as; delay [0, 500] ms, jitter [0, 1000] mbps, packet loss [0 to 100] percent and quality of service [0, 100] respectively. In our paper, the crisp input values are converted to the fuzzy values by the input MFs. In this paper, the linguistic expression for inputs and output variables for quality of service and their corresponding membership functions are evaluated using triangular membership function as shown in Equations (1)-(5) respectively. Triangular curves depend on three parameters a_1, a_2, and a_3.

$$\mu(x) = \begin{cases} 0 & \text{if } x < a_1 \\ x - a_1/a_2 - a_1 & \text{if} a_1 <= x < a_2 \\ a_3 - x/ a_3 - a_2 & a_2 <= x < a_3 \\ 0 & \text{if } x >= a_3 \end{cases} \qquad (1)$$

Where, a_2 defines the triangular peak location, while a_1 and a_3 define the triangular end points. x = (DE, JI, PL and QoS). Each linguistic value of fuzzy input and output membership function is further evaluated and assign a label emphasizing the degree of the value assigned as indicated in (6) – (18) respectively.

$$\text{Delay}(x) = \begin{cases} \text{If } 150 <= x < 250 & \text{“Low”} \\ \text{If } 250 <= x < 400 & \text{“Average’} \\ \text{if } 400 <= x >= 500 & \text{“High”} \end{cases} \qquad (2)$$

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$$\text{Packet Loss}(x) = \begin{cases} \text{If } 15 <= x < 30 & \text{“Low”} \\ \text{If } 30 <= x < 50 & \text{“Average’} \\ \text{if } 50 <= x >= 100 & \text{“High”} \end{cases} \quad (3)$$

$$\text{Jitter}(x) = \begin{cases} \text{If } 150 <= x < 300 & \text{“Low”} \\ \text{If } 300 <= x < 600 & \text{“Average’} \\ \text{if } 600 <= x >= 1000 & \text{“High”} \end{cases} \quad (4)$$

$$\text{QoS}(x) = \begin{cases} \text{If } 15 <= x <= 45 & \text{“Bad Service”} \\ \text{if } 45 < x >= 75 & \text{“Average Service”} \\ \text{if } 75 <= x >= 100 & \text{“Good Service”} \end{cases} \quad (5)$$

For Delay;

$$\mu_{low}(x) \begin{cases} 0 & \text{if } x<0 \\ x/125 & \text{If } 0 <= x < 125 \\ 250 - x/125 & \text{if } 125 <= x < 250 \\ 0 & \text{If } x >= 250 \end{cases} \quad (6)$$

$$\mu_{average}(x) = \begin{cases} 0 & \text{if } x<150 \\ x - 275/125 & \text{If } 150 <= x < 275 \\ 400 - x/125 & 275 <= x < 400 \\ 0 & \text{if } x >= 400 \end{cases} \quad (7)$$

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$$\mu_{high}(x) = \begin{cases} 0 & \text{if } x< 350 \\ x - 425/75 & \text{If } 350<= x <425 \\ 500 - x/75 & 425<= x <500 \\ 0 & \text{if } x >= 500 \end{cases} \quad (8)$$

For Packet Loss

$$\mu_{low}(x) = \begin{cases} 0 & \text{if } x<0 \\ x/15 & \text{if} 0<= x <15 \end{cases} \quad (9)$$

$$\mu_{average}(x) = \begin{cases} 0 & \text{if } x<20 \\ x - 20/40-20 & \text{if} 20<= x <40 \\ 60 - x/60-40 & 40<= x <60 \\ 0 & \text{if } x >= 60 \end{cases} \quad (10)$$

$$\mu_{high}(x) = \begin{cases} 0 & \text{if } x<50 \\ x - 50/25 & \text{if } 50 <= x <75 \\ 100 - x/25 & \text{if } 75 <= x <100 \\ 0 & \text{if } x >= 100 \end{cases} \quad (11)$$

For Jitter;

$$\mu_{low}(x) = \begin{cases} 0 & \text{if } x<0 \\ x/150 & \text{if } 0<= x <150 \\ 300 - x/150 & \text{If } 150 <= x <300 \\ 0 & \text{if } x >= 300 \end{cases} \quad (12)$$

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$$\mu_{average}(x) = \begin{cases} 0 & \text{if } x<200 \\ x-200/200 & \text{If } 200<= x <400 \\ 600 - x/200 & 400<= x <600 \\ 0 & \text{if } x >= 600 \end{cases} \quad (13)$$

$$\mu_{high}(x) = \begin{cases} 0 & \text{if } x<450 \\ x-450/275 & \text{If } 450<= x <725 \\ 1000-x/275 & 725<= x <1000 \\ 0 & \text{if } x >= 1000 \end{cases} \quad (14)$$

Quality of Sevice (QoS);

$$\mu_{badS}(x) = \begin{cases} 0 & \text{if } x< 0 \\ x-200/100 & \text{If } 0 <= x < 20 \\ 300 - x/100 & \text{If } 20 <= x< 45 \\ 0 & \text{If } x >=45 \end{cases} \quad (16)$$

$$\mu_{averegeS}(x) = \begin{cases} 0 & \text{If } x < 35 \\ x-325/125 & \text{If } 35 <= x < 55 \\ 450- x/125 & \text{If } 55 <= x< 75 \\ 0 & \text{If } x >= 75 \end{cases} \quad (17)$$

$$\mu_{goodS}(x) = \begin{cases} 0 & \text{If } x< 60 \\ x-475/125 & \text{If } 60 <= x < 80 \\ 600- x/125 & \text{If } 80 <= x<1600 \\ 0 & \text{If } x >=100 \end{cases} \quad (18)$$

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The QoS output represents customer satisfaction and quality service. The output support three linguistic variables are as follows: Low: QoS seen as excellent and requires no correction, the estimate of satisfaction is over 60%. Average: an acceptable QoS but requires verification in case of a major and important customer. High: QoS is considered poor. Therefore, the QoS resources require the correction and reconfiguration.

We assign linguistic values to both input and output linguistic variables i.e. for Delay, Packet Loss, Jitter and Quality of Service analysis. A case of Delay is presented in Equation (2). In Equations (6) to (18), each linguistic value is assigned a label emphasizing the degree of the value assigned. For example, Equation (2) evaluates the degree of low of the Delay, if the value of Delay is selected between 150 and 249. The degree of influence for low evaluates to 1.50 (150%) severities when Delay is selected at 125. The degree of influence for average evaluates to 3.0 (300%) severities, whereas, 400 evaluates to 4.0 (400%) for high Delay.

We employ MatLab 2007 for the membership function plots, the graphical formats which show the fuzzy membership curves for the Delay, Packet Loss, Jitter and Quality of Service is shown in Figures (3 - 6) respectively. We explore Triangular membership functions method to describe the variables. For example, if we select input “Delay” at 200, the degree of membership projects up to the middle of the overlapping part of the "low" and "average" function, "low" membership = 0.40 and "average" membership = 0.40, while “high” membership = 0.00. Also, when the fuzzy inputs are selected at delay = 120, jitter = 450 and packet loss =50, the membership function (Fuzzification) result is as corrected to two decimal places, as presented; Delay =120 =>low = 0.96, Jitter = 450 => average = 0.75 and Packet loss = 50=> average = 0.5. Only rules associated with "low" and "average" delay will actually apply to the output response.

We obtain our rule base from derivation based on the internet service provider’s records, expert experience, adequate observation and interviews from clients that use the network between the ages of 16 to 60 and above. From the above knowledge, 27 rules are defined for the rule base for the decision-making unit as presented in Figure 7.

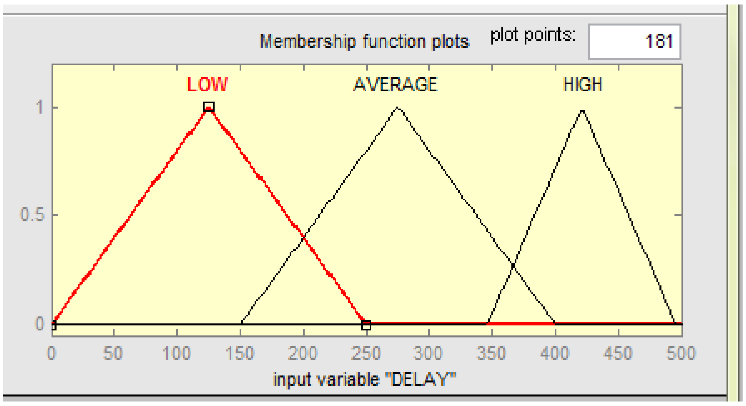

Fig. 3: Membership function for Delay (DE)

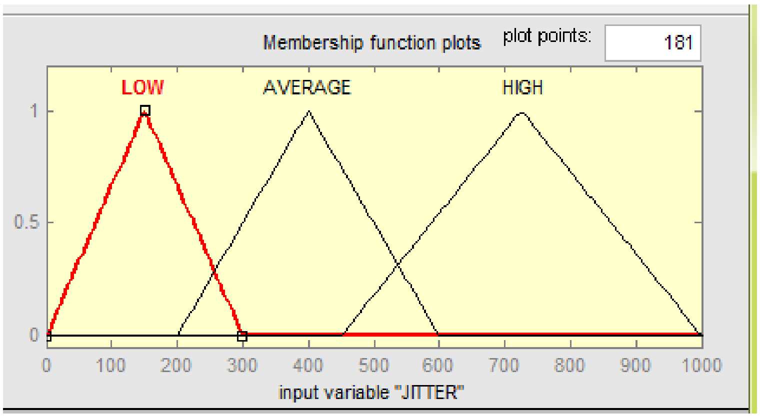

Fig. 4: Membership function for Jitter (JI)

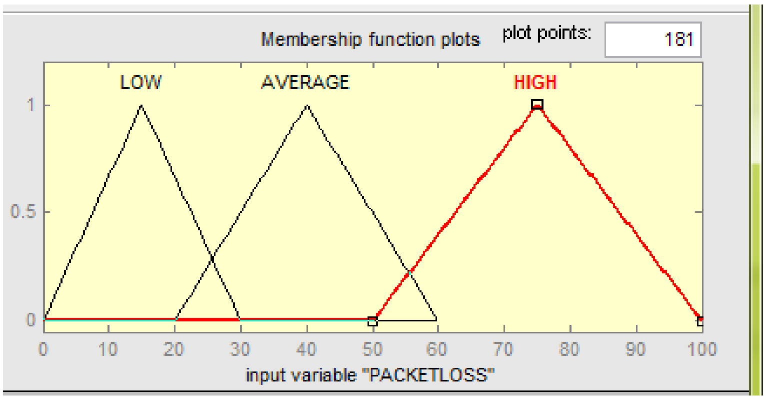

Fig. 5: Membership function graph for Packet Loss (PL)

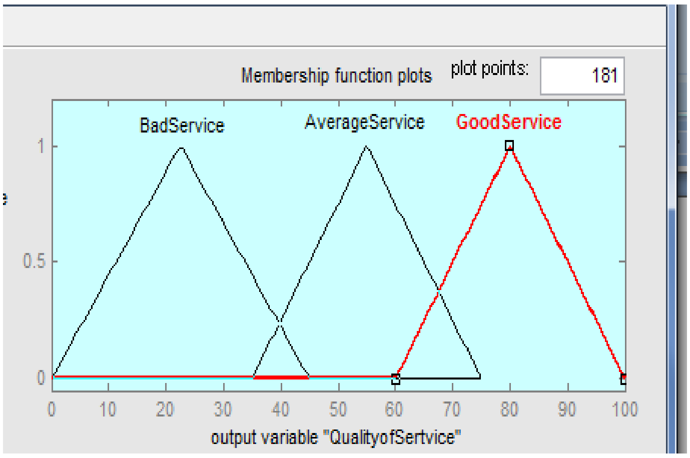

Fig. 6: Output Membership Function of Quality of Service (QoS)

1. If (Delay is Low) and (Jitter is Low) and (PacketLoss is Low) then (QualityofService is GoodService) (1)
2. If (Delay is Low) and (Jitter is Low) and (PacketLoss is Average) then (QualityofService is GoodService) (1)
3. If (Delay is Low) and (Jitter is Low) and (PacketLoss is High) then (QualityofService is GoodService) (1)
4. If (Delay is Low) and (Jitter is Average) and (PacketLoss is Low) then (QualityofService is GoodService) (1)
5. If (Delay is Low) and (Jitter is Average) and (PacketLoss is Average) then (QualityofService is GoodService) (1)
6. If (Delay is Low) and (Jitter is Average) and (PacketLoss is High) then (QualityofService is AverageService) (1)
7. If (Delay is Low) and (Jitter is High) and (PacketLoss is Low) then (QualityofService is AverageService) (1)
8. If (Delay is Low) and (Jitter is High) and (PacketLoss is Average) then (QualityofService is AverageService) (1)
9. If (Delay is Low) and (Jitter is High) and (PacketLoss is High) then (QualityofService is AverageService) (1)
10. If (Delay is Average) and (Jitter is Low) and (PacketLoss is Low) then (QualityofService is BadService) (1)
11. If (Delay is Average) and (Jitter is Low) and (PacketLoss is Average) then (QualityofService is BadService) (1)
12. If (Delay is Average) and (Jitter is Low) and (PacketLoss is High) then (QualityofService is AverageService) (1)
13. If (Delay is Average) and (Jitter is Average) and (PacketLoss is Low) then (QualityofService is AverageService) (1)
14. If (Delay is Average) and (Jitter is Average) and (PacketLoss is Average) then (QualityofService is AverageService) (1)
15. If (Delay is Average) and (Jitter is Average) and (PacketLoss is High) then (QualityofService is GoodService) (1)
16. If (Delay is Average) and (Jitter is High) and (PacketLoss is Low) then (QualityofService is AverageService) (1)
17. If (Delay is Average) and (Jitter is High) and (PacketLoss is Average) then (QualityofService is BadService) (1)
18. If (Delay is Average) and (Jitter is High) and (PacketLoss is High) then (QualityofService is BadService) (1)
19. If (Delay is High) and (Jitter is Low) and (PacketLoss is Low) then (QualityofService is GoodService) (1)

Fig.7: Fuzzy Rules for Quality of Service Evaluation for Multimedia Transmission

Fuzz Inference Mechanism

Fuzzy inference draws conclusions from existing data. Inference mechanism looks up the membership values in the condition of the rule for each rule. We evaluate the fuzzy input to determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions. We explore aggregation operation method to calculate the degree of fulfillment or firing strength, γ_i of the condition of a rule *i* given as;

$$\gamma_i = DE_{i1}(x_0) \wedge JI_{i1}(y_0) \wedge PL_{i1}(z_0), DE_{i2}(x_0) \wedge JI_{i2}(y_0) \wedge PL_{i2}(z_0), \dots, DE_{in}(x_0) \wedge ji_{in}(y_0) \wedge PL_{in}(z_0) \qquad (19)$$

where, γ_i is the matching degree of a given input which satisfies the condition of the *ith* rule and i= 1, 2,.., 27. A rule, say rule 1, will generate a fuzzy membership values DE_1, JI_1 and PL_1 coming from the Delay, Jitter and Packet loss measurements. We then combine DE_1, JI_1 and PL_1 by applying fuzzy logical AND to evaluate the composite firing strength of the rule The rules use the input membership values as weighting factors to determine their influence on the fuzzy output sets of the final output conclusion. We determine the degrees of truths (R) of the rules for each rule by evaluating the nonzero minimum values using the AND operator. Only the rules that get strength higher than 0, would fire the output. The firing levels of the 27 rules are computed using Equation (19). We employ the Root Sum Square (RSS) inference engine

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technique in our paper since it presents the best weighted influence to all firing rules as shown in Equation (20).

$$RSS = (R_1^2 + R_2^2 + \ldots + R_n^2)^{1/2} = \sqrt{\sum R_1^2} = \sqrt{(R_1^2 + R_2^2 + \ldots + R_n^2)} \quad (20)$$

Where R1, R2, R3…. Rn is strength value of different rules which share the same conclusion. RSS method combines the effects of all applicable rules, scales the functions at their respective magnitudes, and computes the "fuzzy" centroid of the composite area. This method is more complicated mathematically than other methods, but is selected for this work since it gives the best weighted influence to all firing rules (Saritas and Sert 2003) (Umoh et al., 2010).

Defuzzification

Defuzzification is the inverse process of fuzzification. The Defuzzification process involves converting a fuzzy set or input into a crisp value. The most commonly used Defuzzification methods are the Max membership method, the Centroid of Gravity (COG) method and the Middle of Maxima (MOM) method. We adopt discrete center of gravity otherwise called Centroid of area or center of area defuzzification method. The input to the defuzzification process is a fuzzy set (the aggregated output fuzzy set), and the output of the defuzzification process is a single (crisp) number. Here each rule is weighted using it normalized weighting factor and the output of the FIS is computed by the summation of all rule outputs:

$$\text{Crisp output,} \quad Z = \sum_{k=1}^{27} \bar{Y}kZk = \left(\sum_{k=1}^{27} Y kZk\right) / \left(\sum_{k=1}^{27} Y k\right) \quad (28)$$

Where $\bar{Y}_i$ is a running point in a discrete universe, and $\sum \bar{Y}kZk$ is its membership value in the membership function. The expression can be interpreted as the weighted average of the elements in the support set (Guney, 2009) (Umoh, et al., 2011).

MODEL EXPERIMENT

We simulate our system using Matlab®/Simulink® Fuzzy Logic tool box functions showing the user interface and fuzzy inference to assist the experimental decision for the best performance. For example, we select three fuzzy input values at Delay = 200, Jitter = 500, and Packet Loss = 50, rule 5,8, 14, 17 and 23 fire from the rule base presented in Figure 7. Their corresponding degree of membership evaluate as low = 0.40, average = 0.40 and high = 0.00 for delay. Low = 0.00, Average = 0.50 and High = 0.20 for Jitter. Low = 0.00, Average=0.50 and High = 0.00 for packet loss respectively. The result of evaluation is presented in Table1. The result of rule base evaluation for Delay, Jitter and Packet loss at 250, 500 and 50 respectively is shown Table 1. The result of rule base evaluation for Delay, Jitter and Packet loss at 125, 250 and 25 respectively is shown Table 2. The result of rule base evaluation for Delay, Jitter and Packet loss at 225, 590 and 70 respectively is shown Table 3.

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Table 1: Rule base Evaluation for Delay, Jitter and Packet loss at 250, 500 and 50 respectively.

Rule No.	Input Variables			Consequence	Nonzero Minimum
	delay	jitter	Packet loss		
5	0.40	0.50	0.50	Good Service	0.40
8	0.40	0.20	0.50	Average Service	0.20
14	0.40	0.50	0.50	Average Service	0.40
17	0.40	0.20	0.50	Bad Service	0.20
23	0.40	0.50	0.50	Average service	0.40

Table 2. Rule base evaluation for Delay, Jitter and Packet loss at 125, 250 and 25 respectively

Rule No.	Input Variables			Consequence	Nonzero Minimum
	delay	jitter	Packet loss		
1	1.0	0.30	0.30	Good Service	0.30
2	1.0	0.30	0.30	Good Service	0.30
4	1.0	0.30	0.30	Good Service	0.30
5	1.0	0.30	0.30	Good Service	0.30

Table 3. Rule base evaluation for Delay, Jitter and Packet loss at 300, 570 and 70 respectively

Rule No.	Input Variables			Consequence	Nonzero Minimum
	delay	jitter	Packet loss		
6	0.20	0.10	0.80	Average Service	0.10
9	0.20	0.45	0.80	Average Service	0.20
15	0.60	0.10	0.80	Good Service	0.10
18	0.60	0.45	0.80	Bad Service	0.45

We compute the output membership function strength from the fired rules in Table 1, using Root Sum Square (RSS) inference approach in (20) to achieve quality of service membership function for average and high as shown in Equations

$$RSS_{Low} = \sqrt{R_{17}^2} = \sqrt{(0.20)^2} = \sqrt{0.2} = 0.2 \text{ (BadService)} \quad (29)$$

$$RSS_{Average} = \sqrt{(R_8^2 + R_{14}^2 + R_{23}^2)} = \sqrt{((0.20)^2 + (0.40)^2 + (0.40)^2)} = \sqrt{((0.04) + (0.16) + (0.16))}$$

$$= 0.8485 \text{ (Average Service)} \quad (30)$$

$$RSS_{Good} = \sqrt{(R_5^2\ )} = \sqrt{((0.40)^2} = \sqrt{(0.16)} = 0.4 \text{ (Good Service)} \quad (31)$$

Equations (29) - (31) are the output membership functions representing bad average and good quality of service.

We perform defuzzification on Equations (29) - (31) based on Equation (28) to have the crisp output in Equation (32).

$$\text{Crisp Output} = \frac{(0.2*22.5)+(0.8585*55)+(0.4*80)}{0.2+0.8485+0.4}$$

$$= \frac{4.5+46.67+32}{1.4485} = 57.4 \approx (57\%) \text{ Average} \quad (32)$$

The input conditions in Table 1 indicate value of 57.4 (57% Average). Thus, average quality of service is expected with 57% possibility as the required system response.

RESULTS AND DISCUSSION

This paper develops a fuzzy logic model for evaluation of quality of service (QoS) in multimedia transmission. We employ Triangular membership function and select the rule base based on experience of system expert. The study explores Root Sum Square (RSS) inference system to infer data from the rules developed. We employ Fuzzy logic Toolbox in Matlab®/Simulink to plot the membership function graphs. We insert the values of the delay, jitter and packet loss recorded in Tables 1 - 3 into the rule base under the view rule editor; evaluate the outputs and results are presented in Figures 8 -10. The performance surfaces for quality of service are presented in Figures 11 -13. We select and present various combinations of parameters value to the system. It is observed that the output QoS is completely dependent on the input parameters based on fuzzy rules defined.

Fig. 8: Graphical Construction of the Inference Mechanism of Fuzzy Sets in Table 1.

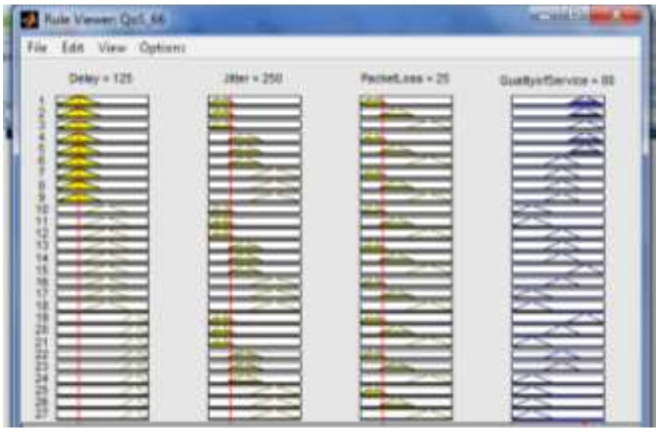

Fig. 9: Graphical Construction of the Inference Mechanism of Fuzzy Sets in Table 2.

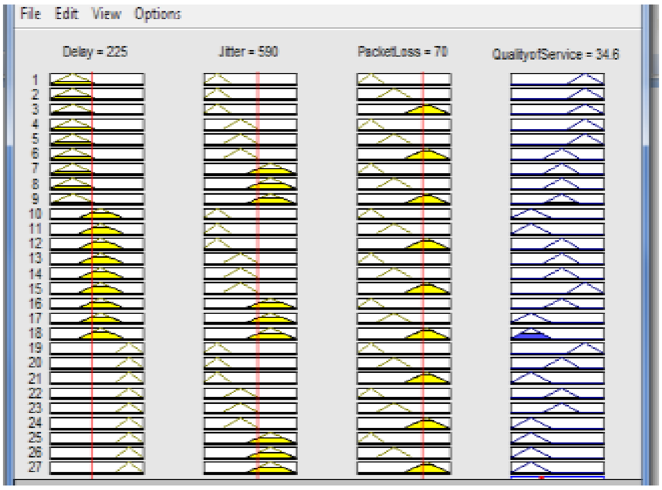

Fig. 10: Graphical Construction of the Inference Mechanism of Fuzzy Sets in Table 3.

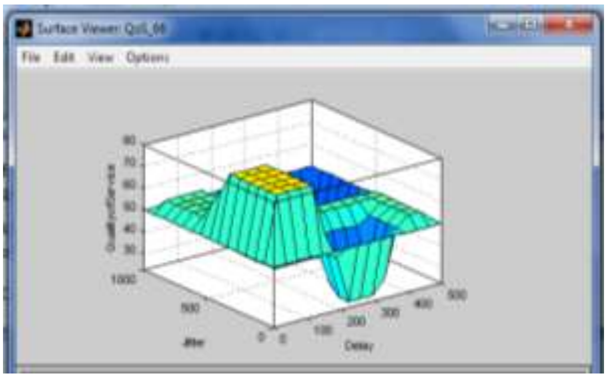

Fig. 11: Performance surface for Quality of Service at Delay=200, Jitter=500 and PacketLoss=50

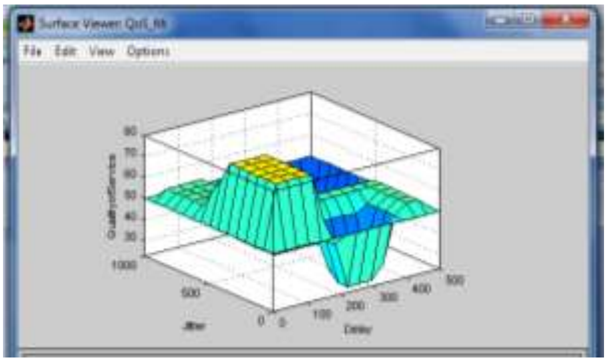

Fig. 12: Performance surface for Quality of Service at Delay=125, Jitter=250 and PacketLoss=25

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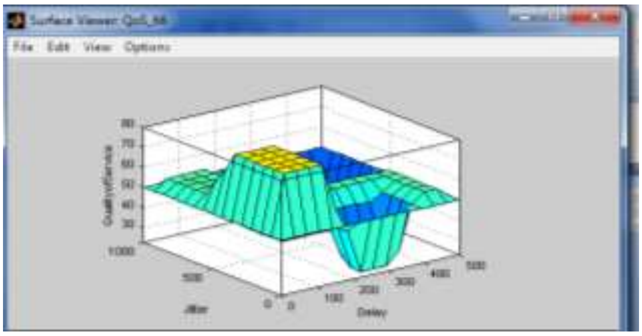

Fig. 13: Performance surface for Quality of Service at Delay=225, Jitter=590 and PacketLoss=70

From Figure 8, the value of output variable of control system response is 57% which indicate the value of QoS received when the input parameters Delay, Jitter and Packet Loss are selected at 200, 500 and 70 respectively.. This result indicates that there is deterioration due to competing flows in network transmission, thus average QoS is expected with 57% possibility. From Figure 9, the value of output variable of control system response is 80% which indicate the value of QoS received when the input parameters Delay, Jitter and Packet Loss are selected at 125, 250 and 25 respectively.. This result shows the absence of competing flows in network transmission by reducing the queue at routers in resource, thus good QoS is expected with 80% possibility. From Figure 10, the value of output variable of control system response is approximately 35% QoS showing the output value received when the input parameters Delay, Jitter and Packet Loss are selected at 225, 590 and 80 respectively. This result indicates a critical situation. The result further shows that there are flows of competing and several users based on network resource, thus bad QoS is expected with 35% possibility.

CONCLUSION

The issues of quality delivery are somewhat more complex for wireless broadband access systems than for wire line systems. This is because wireless access introduces high inherent bit error rate (BER), limited bandwidth, user contention, radio inference, and TCP traffic rate management. These wireless access issues have brought about data delivery problems such as slow peripheral access, data errors, dropouts, unnecessary retransmissions, traffic congestion, out of sequence data packets, latency, and jitter etc. The use of ICT to bridge the gap that exists in the area of customer service satisfaction between an internet service provider (ISP) and the subscribing customer in the process of providing internet services cannot be overemphasized. In this paper, we propose a fuzzy logic model for evaluation of quality of service (QoS) in multimedia transmission. In order to achieve our objectives, we develop a prototype of a computer aided system for an intelligent quality of service using fuzzy logic model. The study designs a decision support system for the quality of service intelligence system. We design a fuzzy logic evaluator for the quality of service computing system.

In this paper, we evaluate the major QoS parameters such as, Delay, Jitter and Packet Loss, and use them as inputs to the evaluation system according to the QoS parameters requirements of each network system. Result indicates that our model is able to detect and restore any QoS deterioration in real-time and thus, providing good and efficient QoS for customer satisfaction.

Also on our study, may provide an efficient assessment of the application QoS and the network performance in terms of overall application QoS for any network topology which can transmit multimedia applications. We can conclude that the measured QoS is a good indication of the network conditions and resources availability.

In the future, we can observe several responses during the simulation of the system. The system can be tuned by integrating fuzzy logic with neural networks technolohy. The rules and membership functions can be modified until the desired system response (output) is achieved. We can also interface the system to the real world by employing Java programming language.

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