A FUZZY LOGIC CLASSIFICATION OF INCOMING PACKET FOR VOIP

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Abstrak

Teknologi suara lewat protocol internet (VoIP) lebih murah dan tidak memerlukan infrastruktur baru karena sudah tersedia pada jaringan komputer global (IP). Sayangnya transisi dari PSTN ke jaringan VoIP memunculkan masalah baru dalam hal kualitas suara. Lebih jauh, transmisi suara melalui jaringan IP dapat menghasilkan kepadatan jaringan karena pengawasan lemah terhadap lalu lintas paket yang datang, antrian dan penjadwalan. Kemacetan ini mempengaruhi Quality of Service (QoS) seperti delay, drop paket dan paket loss. Efek keterlambatan paket akan mempengaruhi QoS lainnya seperti: pengiriman paket suara tidak stabil, jitter paket, packet loss dan echo. Prioritas queuing (PQ) adalah algoritma yang populer digunakan dalam jaringan VoIP untuk mengurangi penundaan. Namun metode mengelompokkan paket ini dapat mengakibatkan proses pengulangan. Rekursif ini mengarah dan mempengaruhi antrian berikutnya kelaparan. Untuk pemecahan masalah, terdapat tiga tahap yaitu antrian, fase pengelompokkan dan penjadwalan. PQ ini akan diterapkan pada sistem inferensi fuzzy untuk mengklasifikasikan antrian paket yang masuk (suara, video dan teks). Untuk justifikasi algoritma PQ yang diperbaiki akan dibandingkan dengan algoritma sebelumnya.

Kata kunci: QoS, VoIP, Fuzzy logic, Delay.

Abstract

The Voice over Internet Protocol (VoIP) technology is cheaper and does not need new infrastructure because it has availables in the global computer (IP) network. Unfortunately, transition from PSTN to VoIP networks have emerged new problems in voice quality. Furthermore, the transmission of voice over IP networks can generate network congestion due to weak supervision of the traffic incoming packet, queuing and scheduling. This congestion affects the Quality of Service (QoS) such as delay, packet drop and packet loss. Packet delay effects will affect the other QoS such as: unstable voice packet delivery, packet jitter, packet loss and echo. Priority Queuing (PQ) algorithm is a popular technique used in the VoIP network to reduce delays. But, the method can result in repetition. This recursive leads to the next queue starved. To solving problems, there are three phases namely queuing, classifying and scheduling. It will be applied to the fuzzy inference system to classify the queuing incoming packet (voice, video and text). To justify the research of the improved PQ algorithm be compared against the algorithm existing.

Keywords: *QoS, VoIP, Fuzzy logic, Delay.*

1. INTRODUCTION

Recently, the use of Voice Internet Protocol (VoIP) technology as a means of voice communication is growing rapidly, and the number of VoIP users also increases. In addition, this technology is cheaper, and supports video streaming as well. Overall, the VoIP infrastructure is also available in computer networks. Simple voice communication can be carried out between PC to PC, or PC to phone (IP phone), even wider to include VoIP PC to a computer network like the Local Area Network (LAN), Wide Area Network (WAN), Metropolitan Area Network (MAN) and the Internet [1].

Currently, VoIP technology has been applied to a Wireless Local Area Network (WLAN) technology sector [2]. However, many problems and issues such as delay, jitter, limited bandwidth, and packet loss (packet drop) occur when communicating, which in turn will affect Quality of Service (QoS) performance. In connection with these problems, the delay is one of the many problems that affect the voice quality [3]. This will be the main focus of paper.

Some Quality of Service (QoS) technology has been used such as Best Effort Service (BeServ), differentiated Services (DiffServ), Integrated Service (IntServ), and Multi-Protocol Label Switch (MPLS) [4]. DiffServ and MPLS are two examples of many new models in the network architecture. Eventhough, the two architectures are almost the same, but DiffServ is more popular and more knowledgeable [5]-[6]. Furthermore, [7] stated that Diffserv can provide QoS from end to end by establishing guarantee in every routing and switching nodes to perform various types of functions related to QoS metrics (bandwidth, delay or packet loss). DiffServ networks can also achieve its goal by separating the edge (which do complex tasks such as traffic classification, traffic marking and traffic monitoring) and the DiffServ core network. This will further be the focus of the paper. Differentiated service model is designed to achieve the QoS requirements of voice. Some queue scheduling algorithm is also introduced in the differentiated service such as First In First Out / First Come First Serve (FIFO/FCFS), Priority Queuing (PQ), Fair Queuing (FQ), and Round Robin (RR) [8] and [9].

Many problems in QoS of VoIP network are still weak due to the voice and video quality factors such as delays, packet drop and packet loss. As described by other researchers, delay in a VoIP network can be caused by congestion [10]. Delay will affect voice quality and user satisfaction in VoIP network when they communicate. And if congestion occurs for a long time, it will cause the collapse VoIP network [3], [10]. Many models have been created by researchers [11]-[14] in order to reduce the problem. Priority queuing algorithm is applied to the Differentiated Services (DiffServ) architecture has also been proposed and developed to improve the QoS performance of streaming voice in VoIP networks [15].

Therefore, Priority Queuing algorithm on the IP router Priority Queuing (PQ) based on the Differentiated Service (DiffServ) will be investigated in this paper. The PQ algorithm is a simple scheduling algorithm that transmits all the packets in the highest priority queue before other packets. Priority Queuing that has become the best solution for the premium quality is implemented in test bed. Priority Queuing is more popularly used in VoIP networks to reduce delays [7]-[8], [16]-[17]. In IP routers, PQ scheduling is used to provide low-latency of a dedicated line services for Expedited Forwarding (EF) class QoS [8]. PQ algorithm has been developed by other researchers such as Backoff Control Priority Queuing (BC-PQ) [2], Priority Queuing Weighted Round Robin (PQ-WRR) [18], and Priority Queuing - Weighted Fair Queuing (PQ-WFQ) [19]. Based on previous information, further this paper will investigate on reducing delay in a VoIP network by creating new Queuing scheduling algorithms based on Priority Queuing (PQ) and a new QoS architecture based on Differentiated Service (DiffServ).

According to ITU-T standard [6], [20] VoIP QoS parameters must be achieved in order to maintain the stability of voice and video streaming performance. The Standard of QoS parameters include: delay must be less than 150 ms one way, jitter must be less than 30 ms one way, the packet must lose one percent, and guaranteed priority bandwidth per call = 17-106 kilobits per second.

Another term is called latency delay. The delay can affect voice quality, and other Quality of Service (QoS) parameters such as the available bandwidth, packet loss, data compression, machine interoperability, and multimedia standard protocols (SIP, H.323 and MGCP. In small-scale networks, delays are rare because only a small number of users involved, but in the larger scope of delays can occur and this will cause network traffic jammed (congestion). However, in VoIP networks, voice and video streaming should be delivered continuously and simultaneously that require constant connection to traffic Quality of Service (QoS) can be guaranteed.

Traffic congestion is caused by the many users who communicate simultaneously. For a long time as illustrated in Figure 1, prolonged congestion will affect the constant delays that would be difficult to be avoided. When congestion is occurs, needed to have a way to sort the traffic out packets to be marked. Packets that have been marked can be identified and placed in a queue. The queues can vary in how much and when they can load up the link with the packets contained within their queue. Even the fastest link layer faster than the two switches

can suffer (starvation) caused by congestion when large data packets. Therefore, the queue scheduling algorithm and a QoS architecture is required to handle the delays.

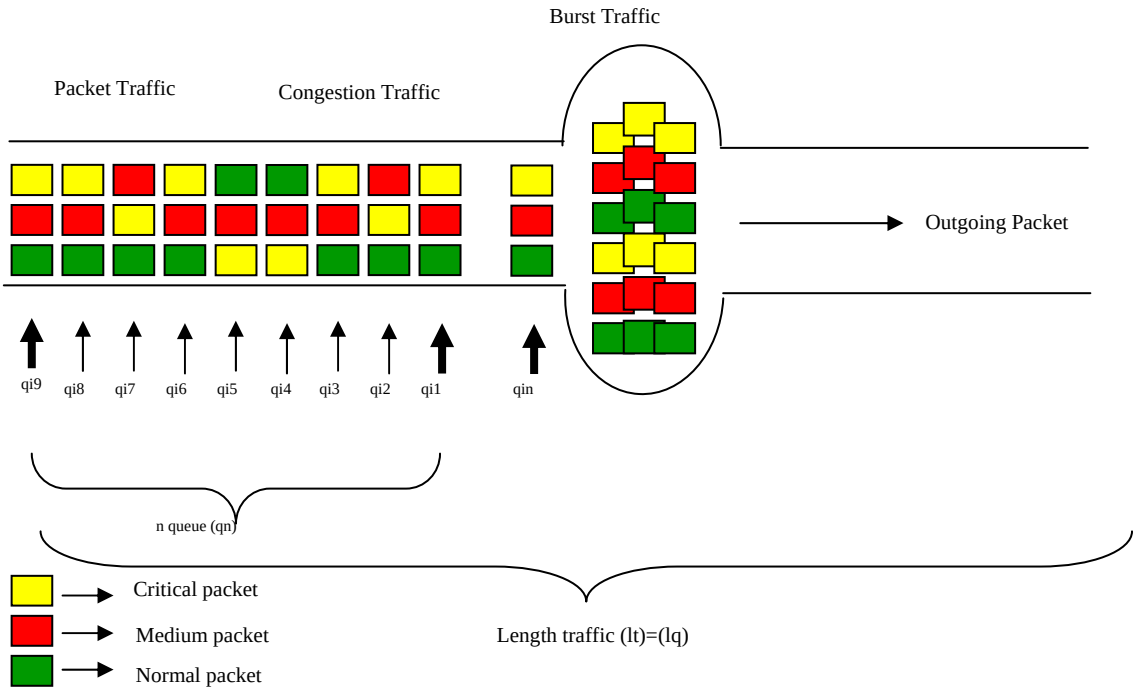

Figure 1. Illustration of packets traffic in transport layer (TCP protocol)

As illustrated in Figure 1, there are different types of traffic packets during packet transmission occurs, the normal traffic, traffic congestion and traffic burst traffic along. When the normal traffic, all packets can be sent without distortion, but when the congestion and burst traffic, problems arise such a delay. If this happens for a long time can cause, jitter, echo and packet drop, so that the solution to handle this traffic is required. As illustrated in Figure 1. VoIP technology can bring multimedia traffic consisting of voice, video, and data (text). In the illustrated, voice is critical packet, video is medium packet of and data is normal packet. As can be seen, the packets in the traffic trends should be kept constant to avoid congestion and burst as well. In addition, the packets must be forwarded based on the packet priority, which is important packets should be transmitted as soon as possible.

Many queues scheduling system has been used such as FIFO / FCFS, PQ, WFQ, and RR. But in this case is to use the PQ algorithm; because it is more popular, relatively simple and in accordance with network protocols as investigated by [16], [17] and [12] will be further examined in this paper.

Priority Queuing (PQ) is one of many models in the Queuing Scheduling algorithms that work based on the classification and sets of data packets to one of several output queues, based on certain criteria. Incoming packets is classified in term of traffic ie high, medium, normal and low as shown in Figure 2. The high priority is first serviced, followed by the medium, normal and low priority traffic, as appropriate. Higher priority traffic queue can cause starvation of lower priority bandwidth. Priority has been available for used in recent years and provide priority servicing.

Figure 1 and 2 shows that, PQ classifies packets according to certain criteria in the IP network. PQ classifies packets to up to four classes; each associated with one of four priority queues, and gives each class an appropriate packet queue. Fourth priority queue is high, medium, normal, and low queues in order of priority. Naturally high queue for critical packets, queues are assigned to less-critical packets, the normal queue is for general packets, and low queue is for non-essential packet.

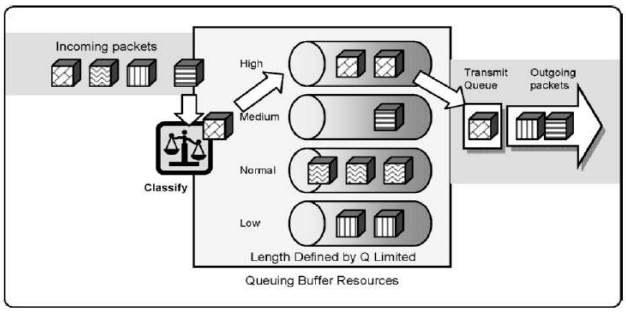

Figure 2 Priority Queuing (PQ) schematic diagrams.

To classify incoming packet, the existing techniques in PQ algorithm will be reduced to three priorities include the High, Medium, and Low. The voice is classified into High, videos are classified into the medium, and the text is classified into Low. New algorithm will be improved by combining existing techniques in PQ algorithms using fuzzy logic classification system for the packet. The fuzzy logic is simpler and flexible, able to simplify complex problems and algorithms have been investigated. Fuzzy logic has been used by many inter-disciplinary science and applications [22]. In these applications that fuzzy theory can be used to improve the performance of neural networks. For example, fuzzy logic has been used in the simulation of Microscopic Traffic Network (FLOMITS) model [23] for the car following model. He has compared the traditional model and fuzzy logic models, and revealed that fuzzy logic is more effective and efficient, and it has been used in the proposed model as well [24].

In this paper have also been combined fuzzy logic and genetic algorithms (GA) to solve the access network selection (ANS) problem in heterogeneous wireless networks (HWN). Fuzzy logic has been used by [25] in the queue the packets in the router, where Fuzzy logic is used to classify packets into different priorities based on the packet. As a justification in this paper, PQ algorithm using sorting methods, search [26] and [27] and planning a route [27] to classify the incoming packet. This algorithm (sorting, and searching) is based on complex mathematical formulas such as bubble sort, insertion sort, heap sort, quick sort, merge sort and Dijkstra's algorithm. Combined techniques in PQ algorithm applied to Fuzzy Logic can classify the incoming packet with intelligent methods. Fuzzy gives priority to each queue based on queue congestion (priority, arrival time and demand). For this paper using the technique in the PQ algorithm and applied to Fuzzy Logic to solve the problem will be proposed.

2. RESEARCH METHOD

The research methodology begins with the collection of the literature review that began with the formulation of the problem. In the second step of the experiment test bed was setup to perform real-world scenarios to investigate the QoS parameters and signals that cause latency (delay) in VoIP networks as a process of real-time traffic. After obtaining the results of experiments on a simulation model will be developed in order to reduce the latency (delay) during the conversation so that traffic can be real-time communication continuity without distortion. The main contribution of this paper is to develop efficient queue scheduling algorithm by using existing techniques in the algorithm PQ. In the last step of performance comparisons will be made to justify the operation and efficiency of queue algorithms developed with QoS the model known currently.

The decision to conduct an experiment test bed comes after extensive paper of research papers and methods used by other researchers. The idea is to experiment to include VoIP systems, wireless devices and IP phone (soft phone) to obtain real-world results to justify and distinguish the models developed in this paper. Step-by-step research methodology is discussed below and shown in Figure 3. There are three phases of the incoming packet data traffic among them is the *queuing phase, classification phase, and scheduling phase*. *First*, *phase queuing* is the arrival of incoming packets at random. Incoming packet in the form of voice, video, and data (text) will come randomly and continuously. Voice packets are marked as high, the video packets are marked as medium, and data (text) is marked as low. *Second,*

classifying phase is where the incoming packets will be selected and classified by priority, arrival and demand.

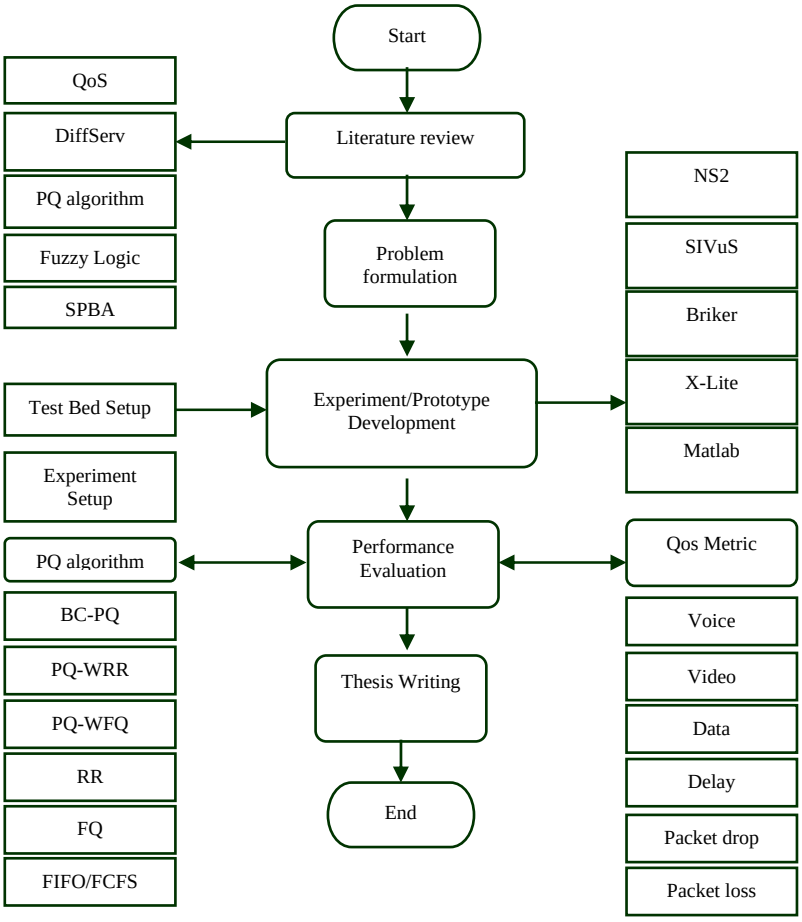

Figure 3. Flowchart of the research metodology

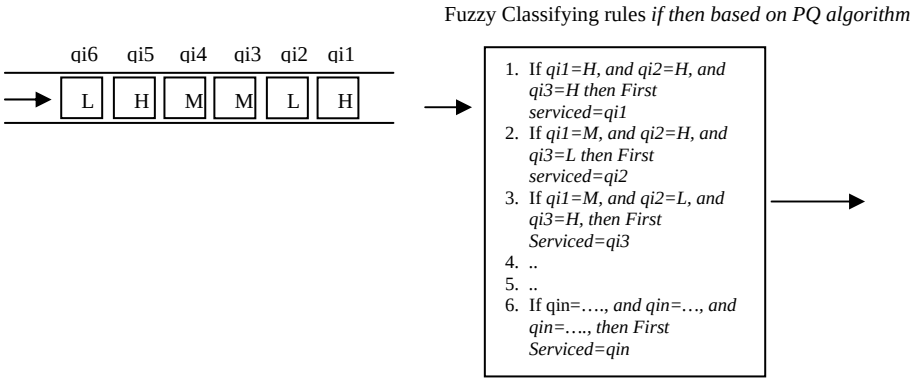

Figure 4. Fuzzy process data traffic classifying algorithm

Here, there are three parameters that must be determined to classify traffic based on the data type queue (priority), time of arrival and request packet, while the PQ algorithm is only based on the priority without considering the packet arrival time which can cause a recursive (loop) and starvation. Scheduling phase is where the packets that have been selected (classified) will be

scheduled in sequence that started from High, followed by medium and low. In this paper just would be study about classifying phase. Figure 4 is fuzzy rules based PQ algorithm. To simplify matrix fuzzy rules then making is formed based on this Figure 5. In this Table 1 is packets rules which be arranged sequentially that started from high, medium, and low based on Figure 5.

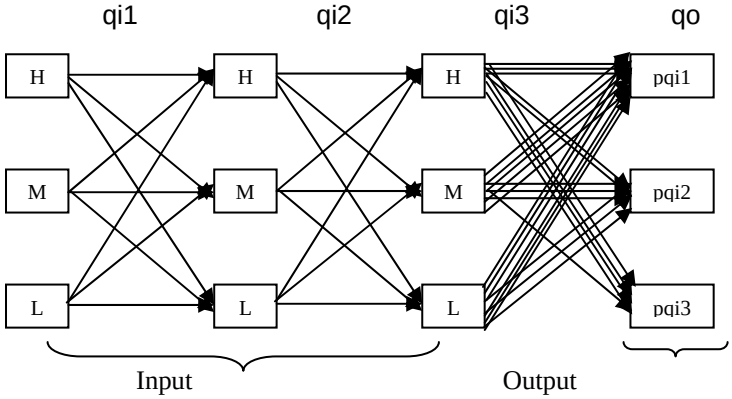

Figure 5. To simplify making matrix data traffic classifying

Table 1. Matrix fuzzy rules in data traffic classifying

Rules	qi1	qi2	qi3	qo
1.	H	H	H	pqi1
2.	H	H	M	pqi1
3.	H	H	L	pqi1
4.	H	M	H	pqi1
5.	H	M	M	pqi1
6.	H	M	L	pqi1
7.	H	L	H	pqi1
8.	H	L	M	pqi1
9.	H	L	L	pqi1
10.	M	H	H	pqi2
11.	M	H	M	pqi2
12.	M	H	L	pqi2
13.	M	M	H	pqi3
14.	M	M	M	pqi1
15.	M	M	L	pqi1
16.	M	L	H	pqi3
17.	M	L	M	pqi1
18.	M	L	L	pqi1
19.	L	H	H	pqi2
20.	L	H	M	pqi2
21.	L	H	L	pqi2
22.	L	M	H	pqi3
23.	L	M	M	pqi2
24.	L	M	L	pqi2
25.	L	L	H	pqi3
26.	L	L	M	pqi3
27.	L	L	L	pqi1

Based on matrix fuzzy rules, can be created a number rules that must be appropriated with input. In this case will be used three samples queuing among of qi1, qi2, qi3, and one output qo. Queuing input qi1, qi2, and qi3 use three type queuing among of High, Medium, and Low, and queuing output qo use also three type namely qi1, qi2, and qi3.

3. RESULTS AND ANALYSIS

In this new algorithm incoming packets is formed use fuzzy rule namely *if then rules*. Fuzzy rules consist of input and output. In these case input is qi1, qi2, qi3,…,qin and output is

qo. For example is if *qi*1 is *High* and *qi*2 is *High* and ⋯ and *qin* is *High* then *qo* is *qi1, etc*. And these fuzzy rules are also valid for back queuing continuously as shown in Figure 6. Starvation that occurs in PQ algorithm is caused by many recursive (repetition) when operating and also PQ algorithm always services highest priorities so that with simplify PQ algorithm is able to reduce the recursive. Based on the fuzzy rules can be shown rules view and surface view as can be seen in Figure 7 and 8.

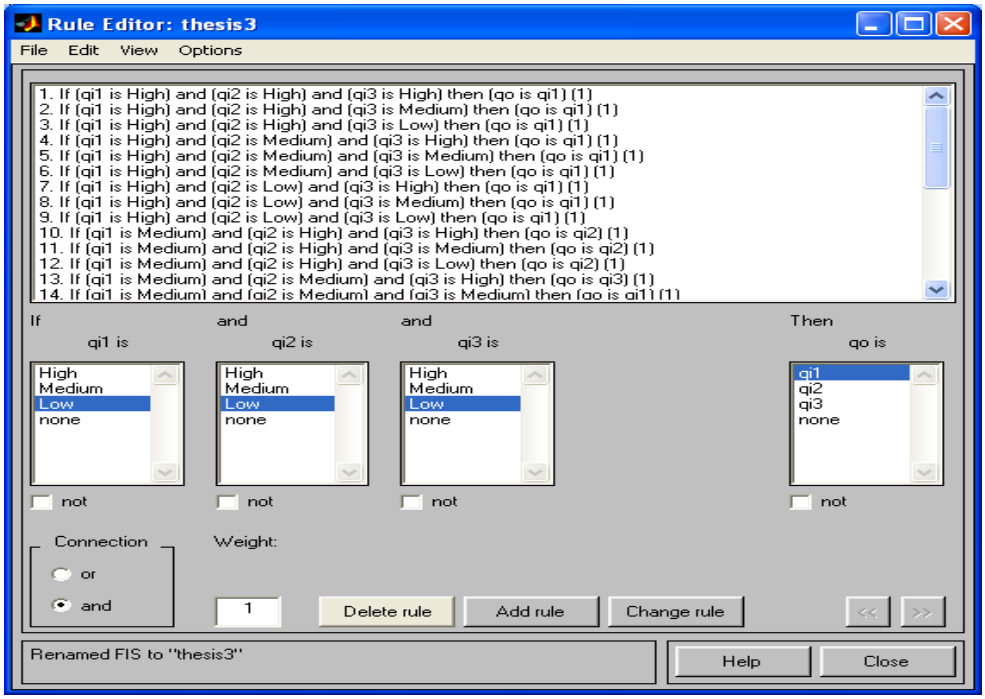

Figure 6. Fuzzy rules classifying in editor fuzzy membership function

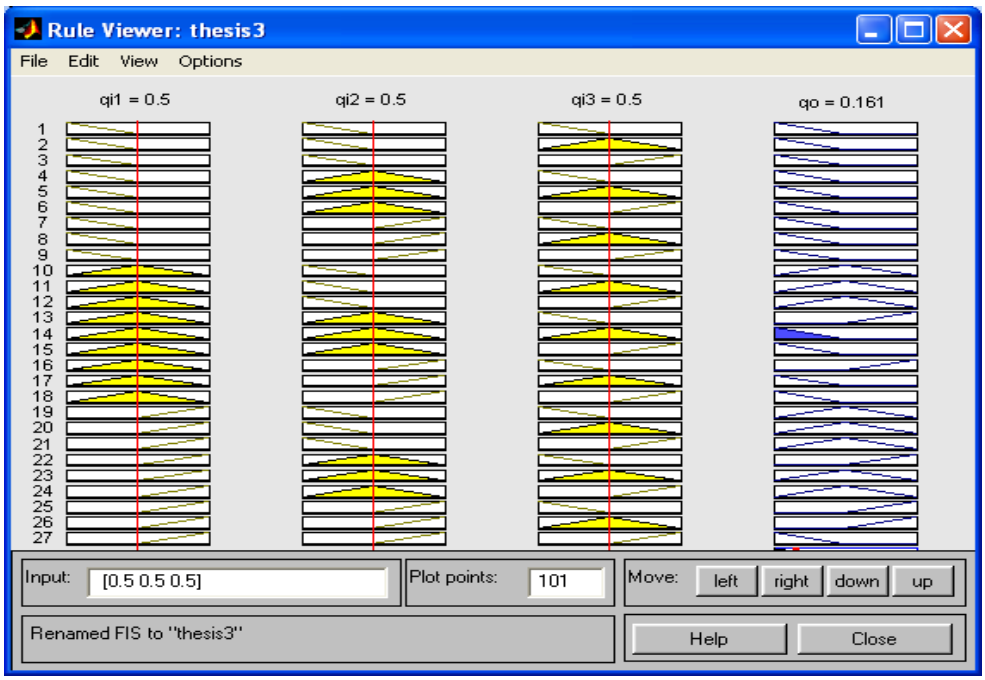

Figure 7. Fuzzy rules classifying view

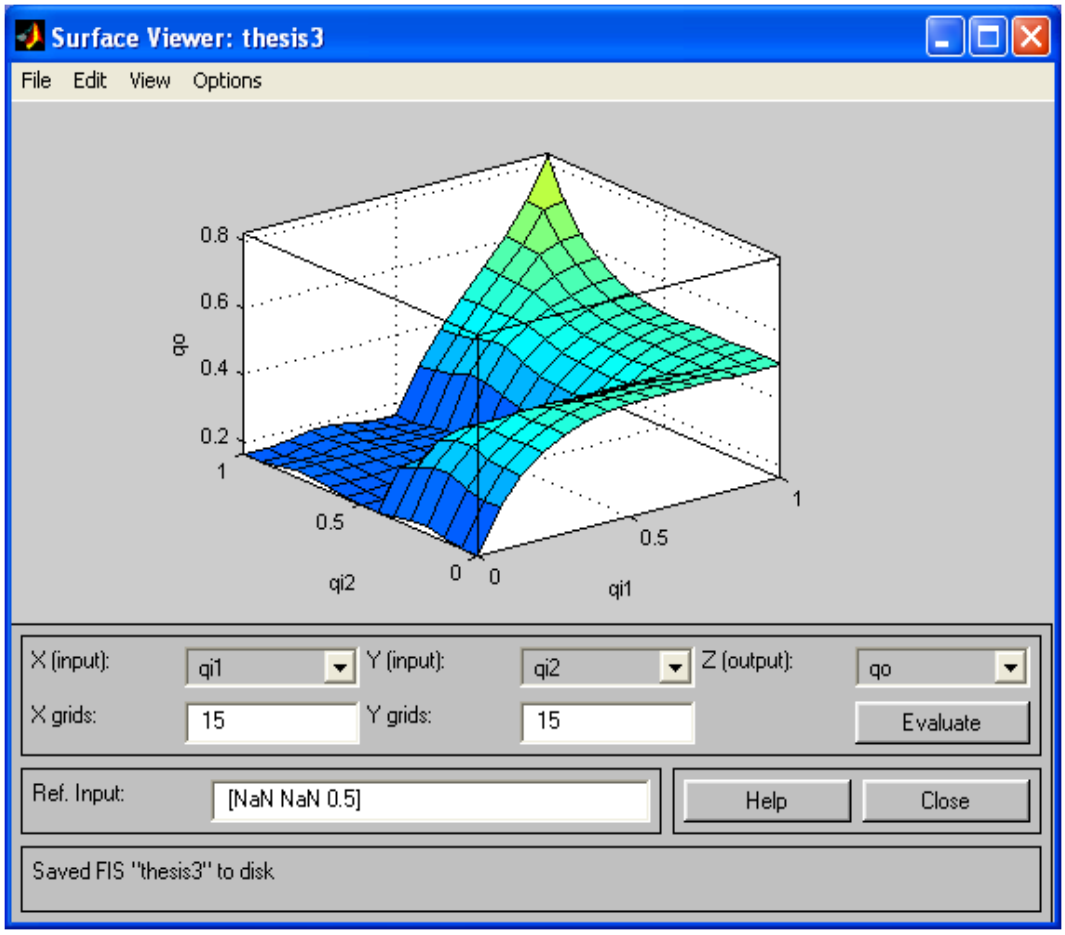

Figure 8. Fuzzy surface classifying view

4. CONCLUSION

PQ algorithm is one of many queuing scheduling algorithm that can be used in VoIP network which has investigated in this paper. A new queuing scheduling algorithm based on PQ algorithm has been proposed to reduce delay in VoIP network. This algorithm created is based existing technique in PQ algorithm based on priorities and combined with fuzzy logic. This algorithm able to classify differentiated packet from incoming packet and also can reduce recursive loop and starving as occurs in PQ algorithm. Further work this paper is on buffering and scheduling phase that would be continued to next paper.

REFERENCES

[1]. Pichiliani MC, Hirata CM. *Analyzing the use of VoIP technology in collaborative modeling*. 13th International Conference on Computer Supported Cooperative Work in Design, (CSCWD). Santiago. 2009: 4-9.
[2]. Shin S, Schulzrinne H.*Towards the Quality of Service for VoIP traffic.* in IEEE 802.11 Wireless Networks. PhD Thesis. New York: Department of Computer Science Columbia University; 2008.
[3]. Vozňák M, Hromek F. *Analytic Model of Delay Variation Valid for RTP*. CESNET technical report number 16/2007. 2007.
[4]. Kim C, Shin S, Ha S, Yoon K, Han S. *Solé-Pareta J.* Architecture of End-to-End QoS for VoIP Call Processing in the MPLS Network. LNCS 3266, Berlin Heidelberg: *Springer-Verlag*; 2004: 44−53.
[5]. Transition-Network. *Quality of Service (QoS) in High-Priority Applications*. USA Headquarters 6475. City West Parkway Minneapolis. 2003.

[6]. Ahlgren D. *Introduction to SIP and VoIP Technology and Business Development*. AhlTek. 2005.
[7]. Elmahdy HN, Taha MHN. The Impact of Packet Size and Packet Dropping Probability on Bit Loss of VoIP Networks. *ICGST International Journal on Computer Network and Internet Research*. 2008; 8(2): 25-29.
[8]. Ali RA and Pierre S. *UMTS-to-IP QoS Mapping for Voice and Video Telephony Services*. École Polytechnique de Montréal Yves Lemieux. Ericsson Research Canada. 2005.
[9]. Iftikhar M, Singh T, Bjorn Landfeldt, Mine Caglar. Multiclass G/M/1 queueing system with self-similar input and non-preemptive priority. *Computer Communications*. 2008; 31(5): 1012-1027
[10]. Mamatas L, Harks H, Tsaoussidis V. Approaches to Congestion Control in Packet Networks. *Journal of Internet Engineering*. 2007; 1(1): 31-38.
[11]. Fantacci R, Vannuccini G, Mannelli A, and Pancani L. *Implementation and Performance Evaluation of a Differentiated Services Test-Bed for Voice over IP Support*. Proceedings of the Thyrrhenian International Workshop on Digital Communications: Evolutionary Trends of the Internet. 2001: 627-641.
[12]. Semeria C. Supporting Differentiated classes: Queuing Scheduling Discipline. *Juniper Network, Inc*. 1194 North Mathilda Avenue Sunnyvale, CA 94089 USA 408 745 2000 or 888 JUNIPER; 2001
[13]. Kim C, Choi B, Kim K, Han S. The Differentiated Call Processing Based on the Simple Priority-Scheduling Algorithm in SIP6. P.M.A. Sloot et al. (Eds.): ICCS 2002, LNCS 2329, pp. 276−285, 2002. Ó *Springer-Verlag Berlin Heidelberg;* 2002.
[14]. Kharaajoo MJ, Sadri MR, Roudsari FH. Fuzzy and Real-Time Queue Management in Differentiated Services Networks. ICESS 2004. LNCS 3605. *Springer-Verlag Berlin Heidelberg*; 2005: 347-354
[15]. Chryssa AP, Nikolaos DT, Evangelos AK, Stauros P, Lakovos SV. Performance evaluation study for QoS-aware triple play services over entry-level xDSL connections. *Journal of Network and Computer Applications.* 2009; 32(4): 215–225
[16]. Ferrari T, Pau G, Raffaelli C. *Measurement Based Analysis of Delay in Priority Queuing.* INFN-CNAF, viale Berti Pichat 6/2, I - 40127 Bologna, ITALY DEIS, University of Bologna, viale Risorgimento 2, I - 40136 Bologna. ITALY Computer Science Department University of California Los Angles; 2001.
[17]. Bilich CG. *TCP over WIMAX Networks.* PhD Thesis. Trento: The Department of Information and Communication Technology of the University of Trento; 2006.
[18]. Mao J, Moh WM, Wei B. *PQWRR Scheduling Algorithm in Supporting of DiffServ*. IEEE International Conference on Communications. Helsinki. 2001; 3: 679-684.
[19]. Bennett JCR, Zhang H. *Why WFQ Is Not Good Enough For Integrated Services Networks* In Proceedings of IEEE INFOCOM. New York. 1996: 301-308.
[20]. Cai L, Xiao Y, Shen XS, Cai L, Mark JW. VoIP over WLAN: Voice capacity, admission control, QoS, and MAC. *International Journal of Communication Systems.* 2006; 19(6): 491–508
[21]. Ferrari T, Pau G, Raffaelli C. *Measurement Based Analysis of Delay in Priority Queuing*. IEEE Global Telecommunications Conference (GLOBECOM). San Antonio. 2001; 3: 1834-1840.
[22]. Zadeh LA. Fuzzy sets and applications: Selected papers by L.A. Zadeh. New York: Wiley; 1987.
[23]. Errampalli M. Fuzzy Logic based MicroscopicTraffic Network Simulation (FloMITS) Model. PhD Thesis. Gifu: Urban and Regional Planning, School of Engineering Gifu University; 2007.
[24]. Alkhawlani M, Ayesh A. Access Network Selection Based on Fuzzy Logic and Genetic Algorithms. *Advances in Artificial Intelligence*. 2008; 10(1): 1-12.
[25]. Cho HC, Fadali MS, Lee JW, Lee YJ, Lee KS. Lyapunov-based Fuzzy Queue Scheduling for Internet Routers. *International Journal of Control, Automation, and Systems.* 2007; 5(3): 317-323.
[26]. Kumar V, Schwabe EJ. Improved algorithms and data structures for solving graph problems in external memory. Eighth IEEE Symposium on Parallel and Distributed Processing. New Orleans. 1996: 169-176.

[27]. Dasgupta S, Papadimitriou CH, Vazirani UV. Algorithms. E-book. 2006. http://www.mhhe.com/dasgupta
[28]. Algorithms and Data Structures: Priority Queues and Simple Sorting. rev. 07/02/2009 21:55. 2009.