End-to-End Fuzzy RED to Reduce Packet Loss in Virtual Circuit Network

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Abstract

Congestion is the most important and greatest challenges that facing the transmission of data packets process. Where there are many sites which they are possible that the network congestion occurs as network devices (e.g. routers and switches, etc...). And also transmission medium between the network devices. There are a numerous of mechanisms to control congestion in routers. Random early detection algorithm (Random Early Detection) is one of the most famous mechanisms of control on the routers queues in order to reduce the proportion of the loss of packets. Random Early Detection algorithm is considered one of the active queue management. End-to-end congestion control mechanisms such as those in TCP are not enough to prevent congestion control and they must be supplemented by control mechanisms inside the network. In this paper we present a fuzzy logic approach for congestion control in communication networks. The proposed approach has a fuzzy logic system where there are three inputs of the system are the probability of dropping packets, available bandwidth and the packets traffic size. Whereas there is one output of the fuzzy logic system that is packet lost. The practical side programming is using object-oriented programming language C ++ within OMNET++ environment.

Keywords: End-to-End congestion control, Fuzzy Logic Control, Active Queue Management (AQM), Fuzzy RED, Virtual Circuit Network.

الخلاصة

يعد التزاحم من اهم واعظم التحديات التي تواجه عملية تراسل حزم البيانات. حيث ان هنالك العديد من المواقع التي من الممكن ان يحدث فيها التزاحم كاجهزة الشبكة (على سبيل المثال الموجهات والمبدلات..الخ) وكذلك ايضا وسائط النقل بين اجهزة الشبكة. هنالك العديد من اليات السيطرة على التزاحم في الموجهات. خوارزمية الاكتشاف المبكر العشوائي(Random Early Detection) هي من اشهر اليات السيطرة على طوابير الموجهات وذلك لتقليل نسبة فقدان الحزم. تعتبر خوارزمية الاكتشاف المبكر العشوائي احدى خوارزميات ادارة الطوابير الفعالة(Active queue management).

لقد تم في هذا البحث استخدام خوارزمية الاكتشاف المبكر العشوائي للسيطرة على طوابير الموجهات حيث تم تتطويرها باحدى الطرق الذكية (المنطق المضبب). ومن خلال ذلك تم اقتراح نظام سيطرة نهاية الى نهاية لسيطرة على اسقاط الحزم ضمن تقنية شبكات الدوائر الظاهرية. حيث انه تم استخدام ثلاثة معلمات (parameters) هي معدل اسقاط الحزم، النطاق الترددي المتوفر للارسال وحجم مرور الحزم كادخالات للنظام المضبب واخراجا واحدا متمثلا بخسارة الحزم. تم برمجة الجانب العملي باستخدام لغة البرمجة الكائنية المنحى ++C ضمن بيئة برنامج محاكاة الشبكات ++OMNET.

الكلمات المفتاحية: التحكم بالتزاحم نهاية الى نهاية، تحكم المنطق الضبابي، ادارة الطوابير الفعالة، خوارزمية الاكتشاف المبكر العشوائي المضبب، شبكات الدوائر الظاهرية.

1. Introduction

In communication networks, Intermediate nodes (such as a routers), and transmission bandwidth play a mainly role during data packets transmission. As a result of that computer communications networks consist of limited resources, which lead to increased competition existing users on computer networks sources, and increase the competitiveness and in addition to the limited network resources. This leads to an overload on the network, leading to deterioration of the efficiency of the network. One of the greatest problems occurs during the transmissions of data packets are data loss and which is caused by a problem congestion. Congestion problem occurs when the overload on the network will be greater than the limited capacity of the network and thus causes this problem to increase high in loss of data, and overload frequently buffer and high delay in the transfer of data packets. The collapse of congestion occurs when dropping data packets before they are delivered to their destination planned, due to the occupancy network sources other transfer data packets, for example the congestion that occurs in intermediate nodes.

As it is well known, the internet offers a lot of services to users on the network, as well as shares network resources among themselves, therefore occur competition between internet users and could lead to the congestion collapse. One of the greatest and most famous transport layer protocols of the internet is the Transport Control Protocol (TCP) for several reasons variety such as multipath routing, route fluttering, and retransmissions, packets belonging to the same flow may arrive out of order destination and congestion control. TCP is oriented connection reliable protocol. TCP is End-To-End congestion control where all the work carried out by being part of the transport layer.

As the internet is being implemented essentially on the transport control protocol there is an urgent necessity to improve the quality of service through the use mechanisms of and queuing management algorithms which controls the router queue, where the packets are accepted or dropping it [Alshimaa,2014; Arash Dana:2010].

2. Related Work

In this section will be briefly clarified all the previous works, which control the congestion that occurs in end to end transmission within virtual circuit network techniques. In 2014, Bandana Bhatia et al. discusses many proposed protocols that are congestion adaptive and deals with the congestion over the network. Discusses Simulation results via varying the number of nodes and size of the data packets for four performance metrics namely, throughput, routing overhead, packet delivery ratio and end-to-end delay. In 2014, Yogini Bazaz et al. takes the fuzzy logic to control congestion problem. It's totally easy and faster and based on human thinking. Proposed 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 (used available bandwidth and change rate as inputs to fuzzy system). In 2015, K. Kumar, K. Narayana and B. Sangmitra illustrates the power of the methodology by the successful application of fuzzy based congestion control in the two diverse networking technologies of ATM and TCP/IP.

3. Congestion control

Congestion is one of the greatest and most important issues in packet switching networks. Congestion may occur in communications networks in the case if the number of packets sent is greater than the capacity of the network that can handle with a limited number of data packets. Congestion may occur in the connection link or intermediate nodes due to carry a lot of data packet which leads to the deterioration of the quality of service (such as high delay, low throughput, packet loss, etc..). The Figure 1 illustrates the concept of congestion.

There are two different terms in the concept of congestion must differentiate between them, the first term is called congestion control, and the second term is called congestion avoidance. Congestion control execution is similar as curative thing and whereas the avoidance execution is similar as preventative thing, a congestion control scheme tries to bring the network back to an operating state, while a congestion avoidance scheme tries to keep the network at an optimal state. Without congestion control on a network may cease operating whilst networks have been operating without congestion avoidance for a long time. The point at which a congestion control scheme is that depend on the amount of memory available in the routers, whereas, the point at which a congestion avoidance scheme is invoked which is independent of the memory size. A congestion avoidance scheme may continuously oscillate slightly around its goal without significant degradation in performance, whereas, congestion control scheme tries to minimize the chances of going above the limit.

Generally congestion control is classified into two main types that are host centric algorithms and router centric algorithms. Where the host centric algorithms divided to open loop mechanisms and close loop mechanisms [Kiran *et al.*,2013; Sapna *et al.*,2012].

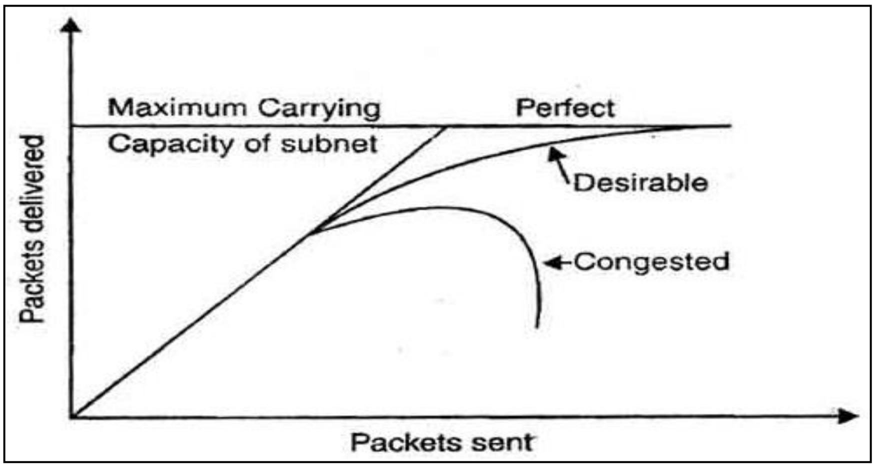

Fig1: concept of congestion

4. Virtual Circuit Networks

Virtual circuits are a connection-oriented communication between two nodes which use packet-switching technology. Where all the data packets that belong to the same data flow tracking one path from the source node to the destination node. In virtual circuit packet switching network, Where it is established virtual circuit between any two nodes by the way, known as the handshake process and then after that gets the sending process of the data packets, consequently being the process of establishing the virtual circuit through three main phases to establish the connection the transfer of data packets and the district of communication process. The Figure 2 illustrates the virtual circuit network [Siddhartha, 2010].

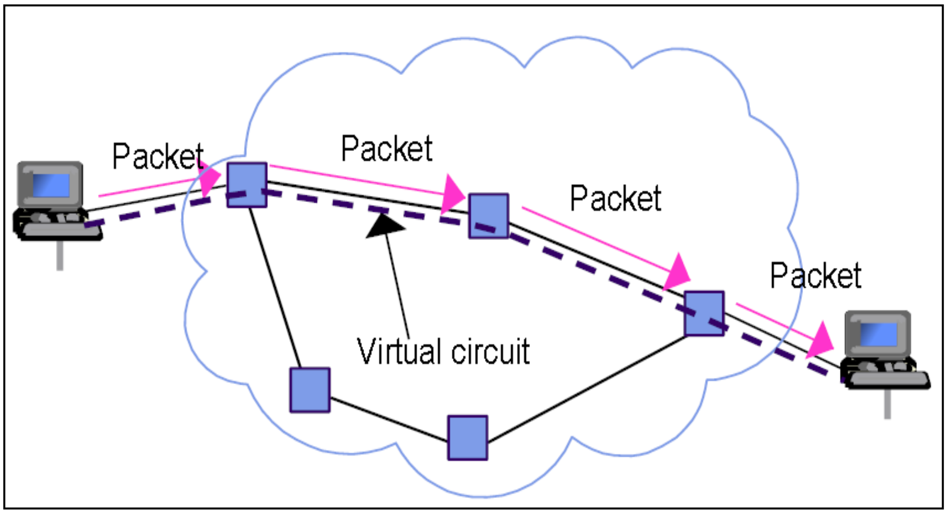

Fig2: Virtual Circuit Network

5. Proposed Method

In this section, we present an intelligent approach (fuzzy logic system) to control the congestion that occurs in end to end transmission. Our proposed approach is based on fuzzy RED algorithm. Through the use of the probability of dropping packets is an input fuzzy logic system. The proposed technique aims at obtaining more satisfactory performance measure results in terms of packet loss in the event of heavy congestion. And try as much as possible to make packets loss is much less. The principal aim of the proposed approach is to achieve low packet loss rate leads to increase in throughput and decrease in delay thereby increasing the quality of service. The proposed approach is compatible with changing network and traffic conditions. When the packets traffic is intense, the current internet router buffers fail to control congestion effectively whereas proposed approach gives better performance [SHAIK SHABEENA *et al*.,2014; Shilpa *et al*.,2012].

Fuzzy Logic (FL) is aimed at a formalization of modes of reasoning which are approximate rather than exact. It also provides an alternative solution to non-linear control because it is closer to real world. Non-linearity is handled by rules, membership functions, and the inference process which results in improved performance. Fuzzy Controller: A fuzzy controller works similar to a conventional system: it accepts an input values, performs some calculations and generate an output value. The basic structure of Fuzzy System. It includes four main components. A **Fuzzifier** which translates crisp (real valued) inputs into fuzzy values. An **Inference Engine** that applies a fuzzy reasoning mechanism to obtain a fuzzy output. A **Defuzzifier** which translates this latter output into a crisp values. A **Knowledge Base** which contains both an ensemble of fuzzy rules known as the rule base, and an ensemble of membership functions, known as **the database**.

In this system there are three inputs, mean of dropping probability, available bandwidth and traffic size which are denoted by **MeanDropProbability**, **AvaiBandwidth** and **TraffSize** respectively. The mean of dropping probability is classified into **5** linguistic variables that are **VeryLittle**, **Little**, **Moderate**, **Much** and **VeryMuch** of membership function as shown in Figure 3. The mean of dropping probability is the average of probability for dropping packets for all intermediate nodes(such as router) that belong to the same virtual circuit between the source and the destination, where each node has its own probability of dropping packets produced from RED algorithm. In the proposed approach is to extract the value of the probability for dropping packets based on fuzzy RED algorithm. Also the available bandwidth is classified into 4 linguistic variables that are **VeryWide**, **Wide**, **Narrow** and **VeryNarrow** of membership function as shown in Figure 4. And finally the traffic size is classified into 4 linguistic variables that are **Exiguous**, **Median**, **Enormus** and **VeryEnormus** membership function as shown in Figure 5. Whereas, there is one output of this system that is Packet Lost. The Packet Lost classified into 6 linguistic variables that are **Zero**, **VerySlight**, **Slight**, **Mild**, **Great** and **VeryGreat** membership function as shown in Figure 6.

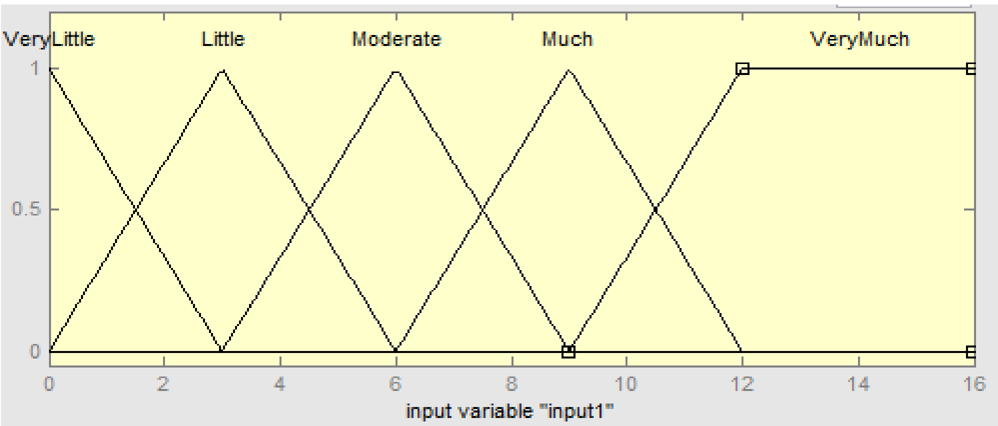

Fig3: input membership function – Mean of Dropping Probability

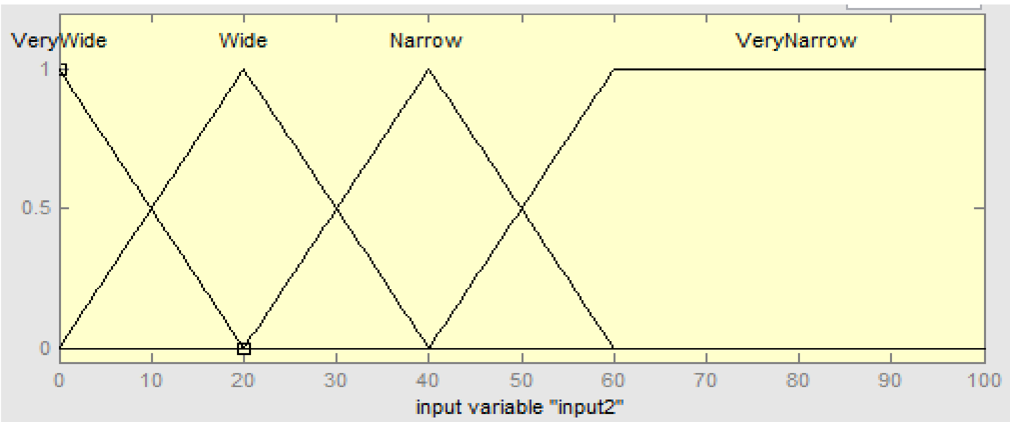

Fig4: input membership function – Available Bandwidth

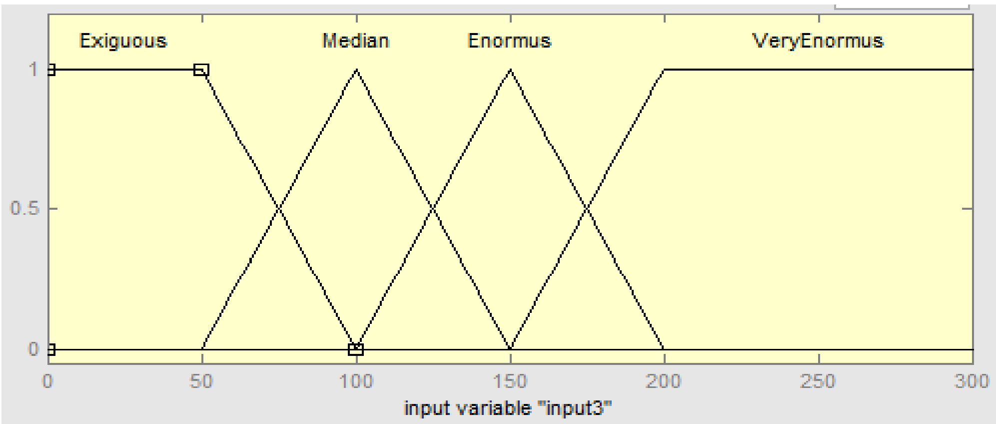

Fig5: input membership function – Traffic Size

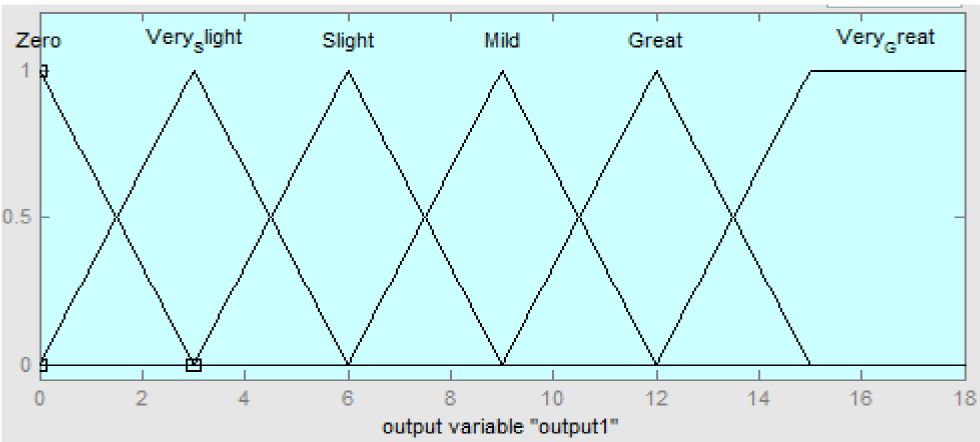

Fig6: output membership function – Drop Probability

The fuzzy controller has a rule base, according to Table 1, which makes decisions on the basis of the rules in it. For example if the mean of dropping probability is **Little**, the available bandwidth is **Narrow** and the traffic size is **Enormus**, then the inference engine searches the rule base and finds the Rule 27 of Table 1.

Table1: The Rule Base of Fuzzy Logic System

MeanDropProbability	AvaiBandwidth \ TraffSize	Exiguous	Median	Enormus	VeryEnormus
VeryLittle	VeryWide	Zero	Zero	Zero	Zero
	Wide	Zero	Zero	Zero	Zero
	Narrow	Zero	Zero	Zero	Zero
	VeryNarrow	Zero	Zero	Zero	VerySlight
Little	VeryWide	VerySlight	VerySlight	VerySlight	VerySlight
	Wide	VerySlight	VerySlight	VerySlight	VerySlight
	Narrow	VerySlight	VerySlight	VerySlight	Slight
	VeryNarrow	Slight	Slight	Slight	Slight
Moderate	VeryWide	Slight	Slight	Slight	Slight
	Wide	Slight	Slight	Slight	Mild
	Narrow	Mild	Mild	Mild	Mild
	VeryNarrow	Mild	Mild	Mild	Mild
Much	VeryWide	Mild	Mild	Mild	Great
	Wide	Great	Great	Great	Great
	Narrow	Great	Great	Great	Great
	VeryNarrow	Great	Great	Great	Great
VeryMuch	VeryWide	Great	Great	Great	Great
	Wide	VeryGreat	VeryGreat	VeryGreat	VeryGreat
	Narrow	VeryGreat	VeryGreat	VeryGreat	VeryGreat
	VeryNarrow	VeryGreat	VeryGreat	VeryGreat	VeryGreat

6. Result

This section presents the results for proposed approach. Proposed approach has been experienced on two computer networks, the first network consists of 15 nodes as illustrated in Figure 7 and the second network consists of 25 nodes as illustrated in Figure 8.

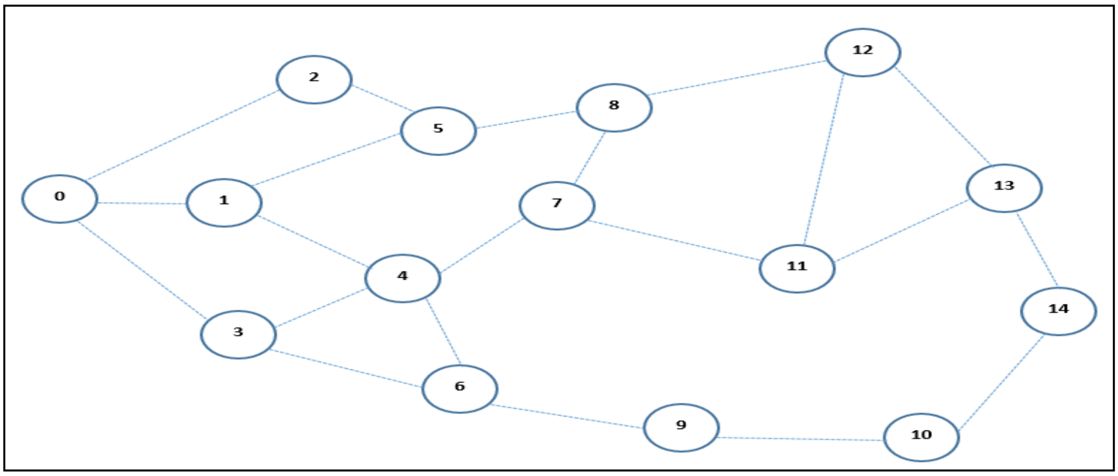

Fig7: Computer Network 1

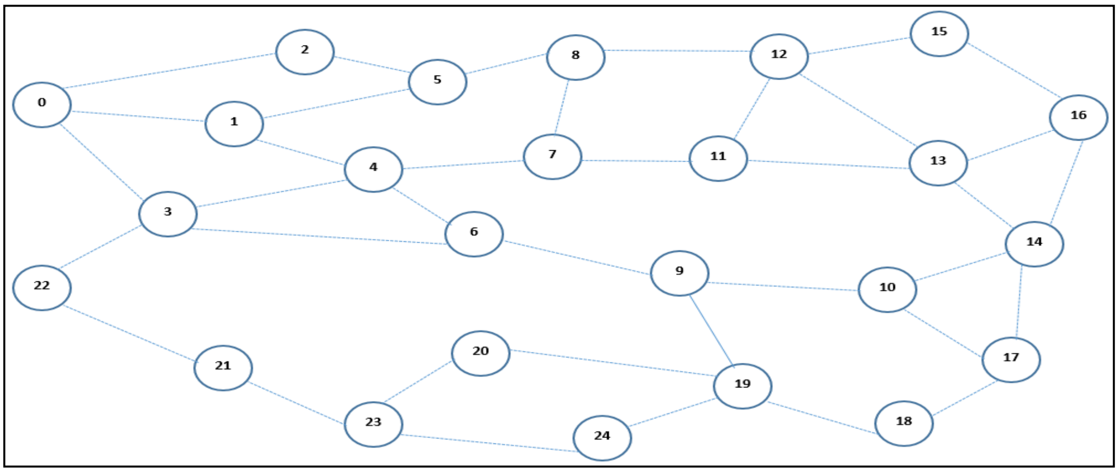

Fig8: Computer Network 2

After applying the proposed method on a computer network 1 will be done to get the results shown in Table 2. The Table 2 illustrates packet lost for each Virtual Circuit (VC) between source and destination based on the proposed approach. For example, as shown in Table 2 if the source node is **0** and the destination node is **14**, Then all packets for virtual circuit 1 (VC1) will pass through node0, node1 ,node5, node8, node12, node13, node11, node7, node4, node6, node9, node10 and node14. Consequently, the number of nodes for VC1 will be equal to **13**. As also illustrated in Table 2 that the **Mean of Dropping Probability** which represents the first input value equal to **6.40915** where this value Stimulates two membership functions which are a linguistic term **Moderate** and **Much** as shown in previous Fig3, As for the second input **Available Bandwidth** equal to **63.9997** where this value stimulates membership function which is a linguistic term **Very Narrow** as shown in previous Fig4, and the third input **Traffic Size** equal to **38.3924** where this value Stimulates membership function which is a linguistic term **Exiguous** as shown in previous Fig5. As a result, the value of the Packet Lost that represents the output of the system will be equal to **9.40915** where this value stimulates two membership functions which are a linguistic term **Mild** and **Great** as shown in previous Fig6.

Table2: The Result of Proposed approach for Computer Network 1

No. of VC	Source node	Destination node	VC Paths	No. of Node	Mean of Dropping Probability	Available Bandwidth	Traffic Size	Packet Lost
VC1	0	14	0-1-5-8-12-13-11-7-4-6-9-10-14	13	6.40915	63.9997	38.3924	9.40915
VC2	0	14	0-1-5-8-12-13-11-7-4-3-6-9-10-14	14	6.96053	25.582	71.1779	9.24042
VC3	0	14	0-1-5-8-12-11-7-4-6-9-10-14	12	5.78067	11.2019	14.2904	5.6173
VC4	0	14	0-1-5-8-12-11-7-4-3-6-9-10-14	13	7.48417	73.612	129.691	10.2182
VC5	0	14	0-1-5-8-12-11-13-14	8	5.78797	83.3139	89.9591	8.62845
VC6	0	14	0-1-5-8-7-4-6-9-10-14	10	7.73105	56.7854	115.357	10.5048
VC7	0	14	0-1-5-8-7-11-12-13-14	9	6.02688	4.83718	106.842	6.39535
VC8	0	14	0-1-4-7-8-12-11-13-14	9	4.64185	58.0709	78.1559	7.42862
VC9	0	14	0-2-5-8-7-11-12-13-14	9	3.67856	27.2895	71.9927	4.32854
VC10	0	14	0-3-6-4-7-11-13-14	8	8.04663	44.2243	103.266	11.1465

As for the second computer network after applying the proposed method on a computer network 2 will be to get the results shown in Table 3. The Table 3 illustrates packet lost for each virtual circuit (VC) between source and destination based on the proposed approach. For example, as shown in Table 3 if the source node is **0** and the destination node is **24**, all packets for virtual circuit 1 (VC1) will pass through node0, node2 ,node5, node1, node4, node7, node8, node12, node13, node14, node10, node9, node19 and node14. Consequently, the number of nodes for VC1 will be equal to **14**. And also as illustrated in Table 2 that the **Mean of Dropping Probability** which represents the first input value equal to **6.6153** where this value stimulates two membership functions which are a linguistic term **Moderate** and **Much** as shown in previous Fig3, As for the second input **Available Bandwidth** equal to **78.1695** where this value stimulates membership function which is a linguistic term **Very Narrow** as shown in previous Fig4, and the third input **Traffic Size** equal to **177.326** where this value stimulates two membership function which is a linguistic term **Enormus** and **Very Enormus** as shown in previous Fig5. As a result, the value of the Packet Lost that represents the output of the system will be equal to **9.87264** where this value stimulates two membership functions which are a linguistic term **Mild** and **Great** as shown in previous Fig6.

Table3: The Result of Proposed approach for Computer Network 2

No. of VC	Src. node	Dest. node	VC Paths	No. of Node	Mean of Dropping Probability	Available Bandwidth	Traffic Size	Packet Lost
VC1	0	24	0-2-5-1-4-7-8-12-13-14-10-9-19-24	14	6.6153	78.1695	177.326	9.87264
VC2	0	24	0-2-5-1-4-7-8-12-13-14-10-17-18-19-24	15	7.94099	86.7996	191.314	10.8273
VC3	0	24	0-2-5-1-4-7-8-12-13-14-17-10-9-19-24	15	5.75626	67.5961	143.326	8.29207
VC4	0	24	0-2-5-1-4-7-8-12-11-13-14-17-10-9-19-24	16	6.16081	24.4459	141.021	7.58371
VC5	0	24	0-2-5-1-4-7-11-13-12-15-16-14-17-10-9-19-24	17	5.89759	21.1919	13.4102	5.97564
VC6	0	24	0-2-5-1-4-7-11-13-16-14-17-18-19-20-23-24	16	6.02835	25.703	99.2799	6.34547
VC7	0	24	0-3-6-9-19-24	6	7.51355	85.4981	45.6856	10.5136
VC8	0	24	0-3-6-4-7-8-12-13-16-14-10-17-18-19-20-23-24	17	4.47774	3.2645	97.0222	4.48577
VC9	0	24	0-3-6-9-19-20-23-24	8	4.44172	43.9501	79.9843	6.745
VC10	0	24	0-2-5-8-7-11-13-16-14-10-17-18-19-20-23-24	16	8.08712	64.9224	152.947	11.0252

7. Conclusion

This paper uses Fuzzy Logic (FL) in controlling congestion in whole computer network. Fuzzy Logic can be effectively used in controlling congestion of network as well as at bottleneck bandwidth, intense traffic and bottleneck router. Proposed approach gives better quality of service because it gives very good evaluation to packet loss for end-to-end transmission in virtual circuit network. Then it leads to better throughput and lower delay. There are many factors that affect the packets arrive at their destination without loss, one of these factors that have an impact very effective, is the loss of packets during the arrival and departure of the intermediate nodes between the source and destination, and which belong to the same virtual circuit, where it is processing on packets to be retransmit according to the information within the router so packets are stored in a queue packets thus be exposed to loss in the event has become absorb the queue for packets less than a arriving packets. In the proposed approach is to rely on fuzzy RED algorithm instead of the Standard RED in control of the queue packets due to higher efficiency and performance in the control of the congestion which leads to reduce the loss of packets as much as possible. So during the proposed method was to benefit from the outputs of fuzzy RED algorithm which is the probability of dropping packets. Since the proposed method applied to the end-to-end transmission, especially within the virtual circuits technique surely there are many intermediate nodes between the source and destination within the same virtual circuit so it was taking into consideration and based on the fuzzy RED algorithm extract the probability of dropping packets for all the node that within the same virtual circle and then finding the overall average of the total sum of the probabilities to drop packets. Thus overall average for total probabilities dropping packets represents mean of dropping probability therefore conclude that it is very important and effective indicator for the loss of packets as it passed through the intermediate nodes and thus give a precise evaluation of the loss of packets in routers. As well as on the other hand there are very influential factors in the packets loss through traveling in the transmission medium that connecting the intermediate nodes are available bandwidth and traffic size. Where bandwidth is an important element in the transfer of packets so when the bandwidth is less than the number of packets, this leads to a bottleneck in bandwidth so it must always be the number of packets sent less than a bandwidth level in order to not get in trouble bottleneck bandwidth and this is linked to the size of Traffic, which is a big challenge for the quality of the transmission if it is on the increase. Consequently in the proposed approach has been used these effective and influential factors in the occurrence of congestion as inputs to the system fuzzy leading to less loss of packets that represent as output of the fuzzy system. In virtual circuit network, all other previous prevent congestion algorithms take their decision after the occurrence of congestion by choosing another path even if the path is where the largest proportion congestion. Whereas in the proposed approach we conclude that the decision is made before the congestion and relying on intelligent approach (fuzzy logic system) and based on the effective parameters that used as inputs for the fuzzy system.

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