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Fuzzy RED to Reduce Packet Loss in Computer network

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Abstract :

Congestion is the most important and greatest challenge that facing the transmission of data packets process. There are many sites, it is possible that the network congestion occurs as network devices (e.g. routers and switches, etc...) as well as transmission medium between network devices. There are a numerous of mechanisms to control congestion in routers. Random early detection algorithm (RED) is one of the most known 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. This paper uses random early detection algorithm to control the queues routers where the queues has been controlled by one of intelligent methods (fuzzy logic). The proposed method has used four parameters, which are the length of the queue rate, the rate of change in the queue and the rate of delay as inputs for fuzzy system and the dropping probability as output. The practical part has been done using object-oriented programming

language C ++ within OMNET++ environment.

Keywords: Active Queue Management (AQM), Congestion Control, Fuzzy Logic Control, RED algorithm, Fuzzy RED.

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 between users on computer networks resources, and thus increasing the competitiveness as well as network resources become more limited. This leads to an overload on the network, leading to deterioration of the efficiency of the network. One of the greatest problems occur during the transmission of data packets are data loss which is caused by a problem of congestion. Congestion problem occurs when the overload on the network is greater than the limited capacity of the network and thus cause this pro

blem 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 it is delivered to its planned destination, due to the occupancy network sources other transfer data packets, for example the congestion that occurs in intermediate nodes [1, 2].

As is well known, the Internet offers a lot of services to users on the network, as well as share 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. Where all the TCP's processes is a part of the transport layer [3].

Essentially, internet depend on transport control protocol therefore that 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 [2, 4].

2. Related Work

This section will briefly clarify the previous works, which controls the congestion that occurs in computer networks. In 2003, C. Chrysostomou et al, present the results of a fuzzy logic control approach to the implementation of RED – Fuzzy-RED, they believe that with fuzzy logic we are able to use linguistic knowledge to implement better understood nonlinear probability discard functions, achieve better differentiation for packet discarding behaviors for aggregated flows, and so provide better quality of service to different kinds of traffic whilst maintaining high utilization [5]. In 2008, Mohammad Hussein Yaghmaee et al. proposed Fuzzy AQM computes the packet drop probability according to preconfigured fuzzy logic using the instantaneous queue length and number of packets dropped in a period of time as input variables [6]. In 2010, Weiyan Liu et al. proposed an effective fuzzy congestion control algorithm based on fuzzy logic to calculate packet loss by using the queue length and the buffer usage ratio [7]. In 2012, Shilpa N. Ingoley et al. use of fuzzy logic (FL) in controlling congestion in computer network. Discussed FL based methods show improvement in increased in throughput, reduction in delays and packet loss. Fuzzy Logic can be effectively use in controlling congestion at core as well as at bottleneck router. Output of one fuzzy system can be given as input to other fuzzy system. It can be also efficiently

use in priority base fuzzy algorithms, which also gives better Quality of Service [8]. In 2014, Baklizi et al. proposed technique uses the average queue length and the delay rate as input linguistic variables for a fuzzy logic system, he utilized

fuzzy logic system produces a single output that represents a packet dropping probability , which in turn control and prevent congestion in early stage , the performance of proposed technique has been evaluated and compared with regard to various performance measures , which are : mean queue length , throughput , average queue delay , packet lost and packet dropping probability [9]. In 2015, Younghoon Kim et al. propose Cooperative Random Early Detection (CoopRED) to avoid inefficiency in core routers when incoming traffic generates congestion. Our scheme selects packets that will be dropped in the bottleneck link, and drops them early in the edge router. We conducted simulation to measure the performance, and it shows that the proposed scheme improves the efficiency of core networks [10].

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 lead to the deterioration of the quality of service (such as high delay, low throughput, packet loss, etc..). Figure1 illustrates the concept of congestion [11, 12].

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 are similar as curative thing and whereas the avoidance execution are 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 a network may cease operating whereas networks have been operating without congestion

avoidance for a long time. The point at which a congestion control scheme is called upon depends on the amount of memory available in the routers, whereas, the point at which a congestion avoidance scheme is invoked 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 [11].

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 [11, 13].

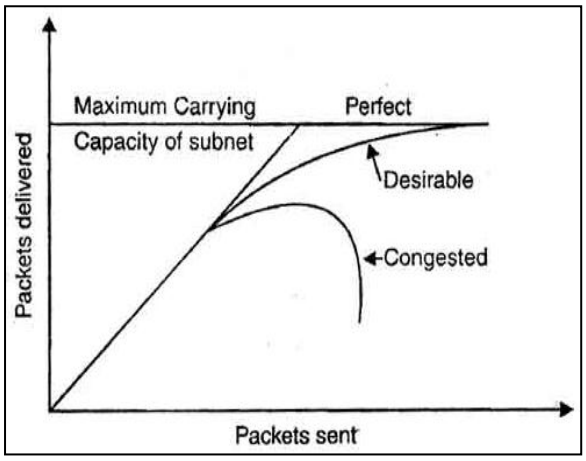

Figure1: concept of congestion

1. Random Early Detection (RED)

The queue management algorithm, which is applied to a router, plays an important role to improve Quality of Service (QoS). Queuing management algorithm is responsible for accepting the arriving packets or not accepting them and consequently it directly affects the packet loss quantity parameter [4].

From the point of dropping packets, queue management can be classified into two categories which are Passive Queue Management (PQM) and Active Queue Management (AQM). For example Drop Tail algorithm is a representative

PQM algorithm which only sets a maximum length for each queue at the router. When the queue length is smaller than the maximum length, all packets are accepted, and if the queue reaches its maximum length all subsequent incoming packets are dropped until queue length decreases to be less than the maximum length. It was that under heavy load conditions, Drop Tail routers cause global synchronization, a phenomenon in which all senders sharing the same bottleneck router link shut down their transmission windows at almost the same time whereas Active queue management (AQM) techniques provide mechanisms to control the queue length (i.e. the number of packets in a router's buffer) by actively discarding arriving packets before the router's buffer becomes full [3, 4, 12, 14].

RED is active queue management algorithms. One of the biggest problems with TCP's congestion control algorithm over drop tail queues is that sources reduce their transmission rates only after detecting packet loss due to queue overflow. Since a considerable amount of time may elapse between the packet drop at the router and its detection at the source, a large number of packets may be dropped as the senders continue transmission at a rate that the network cannot support. RED alleviates this problem by detecting incipient congestion early and delivering congestion notification to the end-hosts, allowing them to reduce their transmission rates before queue over flow occurs [2, 15, 16, 17].

Van Jacobson and Sally Floyd first introduced the RED algorithm in August of 1993. RED has been designed with the objective to minimize packet loss and queuing delay, avoid global synchronization of sources, maintain high link utilization and remove biases against bursty sources [15, 16].

The RED algorithm manages the queue in a more active manner by dropping packets randomly with increasing probability as the average queue size increases; the packet drop rate increases linearly from zero, when the average queue size is at the RED parameter minthresh (denoted by min_{th}), to a drop rate of when the average queue size reaches maxthresh (denoted by max_{th}). One of RED's main goals is to use this combination of queue length averaging (which accommodates bursty traffic) and early congestion notification (which reduces the average queue length) to simultaneously achieve low average queuing delay and high throughput (see **Figure2**).

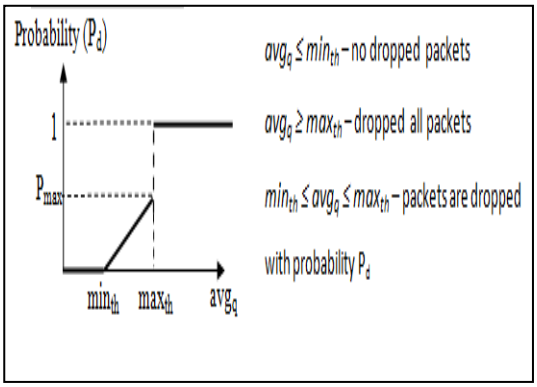

Figure2: RED operation

2. Proposed Method

In this section, we present an intelligent approach (fuzzy logic system) to control the congestion that occurs inside the router by dropping packets dynamically. Our proposed approach is based on RED algorithm, which drops the packets by dropping probability. Our system based on congestion measure's variable for RED algorithm such as average queue length (AQL). The proposed technique aims at obtaining more satisfactory performance measure results in terms of packet loss in the event of heavy congestion.

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 consist of 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** [8].

The proposed Fuzzy RED is based on an AQM approach, which implements a drop probability function, And try as much as possible to make packets loss is much less. The principal aim of the proposed Fuzzy RED is to achieve Low packet loss rate leads to increase in throughput and decrease in delay thereby increasing the quality of service. The proposed Fuzzy RED is compatible with changing network and traffic conditions. When the incoming traffic is Intense, the current internet router buffers fail
to control congestion effectively whereas proposed Fuzzy RED gives better performance.

In this system there are three inputs, Average Queue Length, Queue Rate of Change and Delay Rate which are denoted by **AQL**, **QRC** and **DR** respectively. The Average Queue Length is classified into 4 linguistic variables that are **Conservative**, **Middle**, **Aggressive** and **VeryAggressive** of membership function as shown in Fig 3. Also the Queue Rate of Change is classified into 4 linguistic variables that are **Few**, **Medium**, **Alot** and **VeryALot** of membership function as shown in Figure 4. And finally the Delay Rate is classified into 4 linguistic variables that are **Low**, **Med**, **high** and **VeryHigh** of membership function as shown in Figure 5. Whereas, there are one output of this system, Drop Probability. The Drop Probability classified into 5 linguistic variables that are **VeryLittle**, **Little**, **Moderate**, **Much** and **VeryMuch** of membership function as shown in Figure 6.

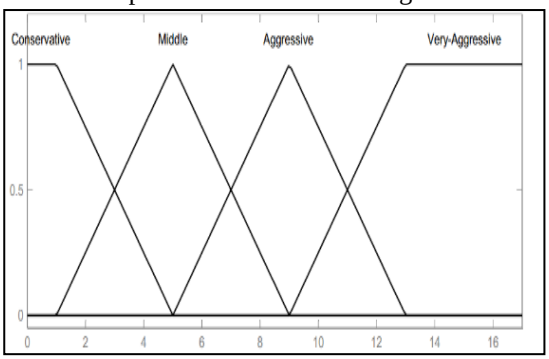

Figure3: AQL input variable (in packet)

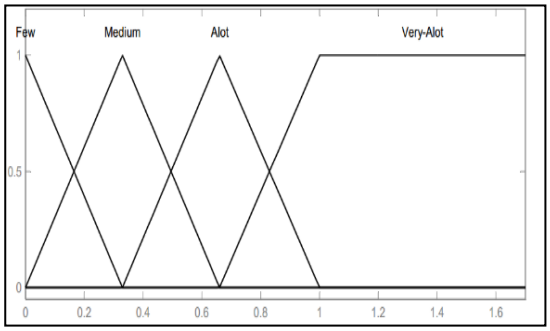

Figure4: QRC input variable (in second)

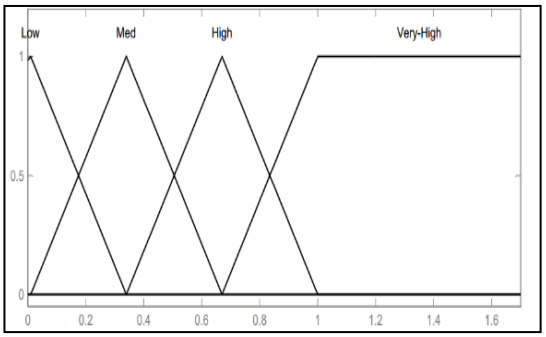

Figure5: DR input variable (in second)

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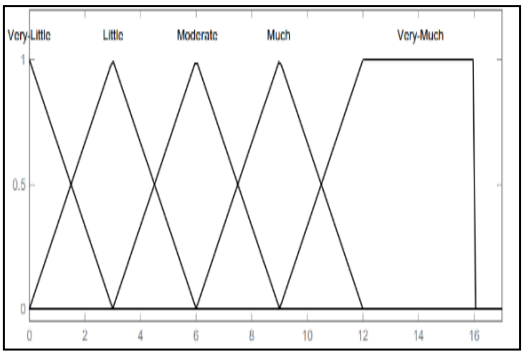

Figure6: DP output variable

Table1: The Rule base of Fuzzy Logic System

Average Queue Length \ Queue Rate of Change	Delay Rate: Low	Med	High	VeryHigh
Conservative	Few	VeryLittle	VeryLittle	VeryLittle	VeryLittle
	Medium	VeryLittle	VeryLittle	VeryLittle	VeryLittle
	Alot	VeryLittle	VeryLittle	VeryLittle	VeryLittle
	VeryAlot	VeryLittle	VeryLittle	Little	Little
Middle	Few	Little	Little	Little	Little
	Medium	Little	Little	Little	Moderate
	Alot	Moderate	Moderate	Moderate	Moderate
	VeryAlot	Moderate	Moderate	Moderate	Moderate
Aggressive	Few	Moderate	Moderate	Moderate	Moderate
	Medium	Moderate	Moderate	Moderate	Much
	Alot	Much	Much	Much	Much
	VeryAlot	Much	Much	Much	Much
VeryAggressive	Few	Much	Much	Much	Much
	Medium	Much	Much	Much	Much
	Alot	Much	Much	VeryMuch	VeryMuch
	VeryAlot	VeryMuch	VeryMuch	VeryMuch	VeryMuch

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 Average Queue Length is **Conservative**, the Queue Rate of Change is **VeryALot** and the Delay Rate is **VeryHigh**, then the inference engine searches the rule base and finds the Rule 15 of Table 1.

The practical part has been done using OMNET++ to simulate proposed method where uses computer network that consist of 7 nodes As shown in Figure7. Each nodes computing probability of packet dropping based on proposed Fuzzy RED

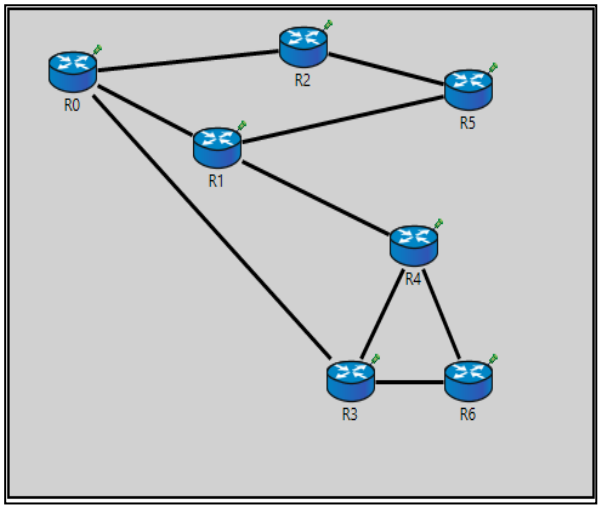

Figure7: Computer Network form

6. Result

This section presents the results for Proposed Fuzzy RED algorithm. The results are shown in Table 2. The Table 2 illustrates probability of dropping for Proposed Fuzzy RED algorithm. For example, as shown in Table 1 that the **Average Queue Length** which represents the first input value equal to **0** where this value Stimulates membership function which is a linguistic term is **Conservative** as shown in previous

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Table2: The Result of Proposed Fuzzy RED

No.	Average Queue Length (input1)	Queue Rate of change (input2)	Delay Rate (input3)	Drop Probability (output)
1	0	1.98	1.8975	3
2	2	1.32	1.98	3.75
3	3	0.9075	1.98	3.9714
4	4	1.2375	1.98	5.25
5	5	1.98	1.98	6
6	6	0.7425	0.2475	7.4697
7	8	0.7425	1.98	8.005
8	9	1.98	1.98	9
9	10	1.4025	0.7425	9.9789
10	11	0.7425	1.98	10.5
11	12	0.9075	0.99	10.963
12	12	1.98	0.66	11.146
13	13	1.98	1.65	12

Fig3, As for the second input **Queue Rate of Change** equal to **1.98** where this value Stimulates membership function which is a linguistic term is **VeryAlot** as shown in previous Fig4, and the third input **Delay Rate** equal to **1.8975** where this value Stimulates membership function which is a linguistic term is **VeryHigh** as shown in previous Fig5. As

a result, the value of the **Drop Probability** that represent the output of the system will be equal to **3** where this value Stimulates membership function which is a linguistic term is **Little** as shown in previous Figure6**.**
In figure 8 illustrated the deference of dropping probability between original RED and our proposed fuzzy RED.

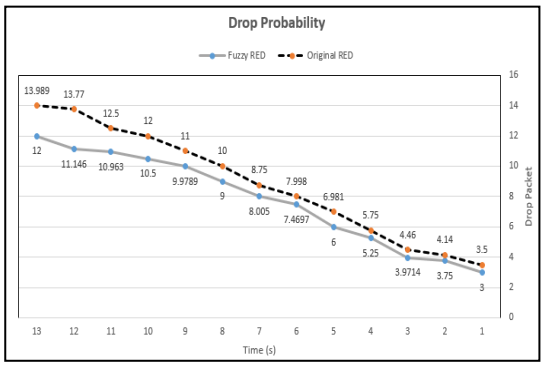

Figure8: Drop Probability of Fuzzy RED and Original RED

7. Conclusion

This paper uses fuzzy logic (FL) in controlling congestion in whole computer network. Fuzzy Logic can be effectively use in controlling congestion of network as well as at bottleneck router. Proposed Fuzzy RED algorithm gives better quality of service because it gives very good evaluation to packet loss for router. Then it leads to better throughput. Where the use of the sensitive Proposed Fuzzy RED algorithm parameters has a very significant effect on reducing the loss of packets such as average queue length where it has been chosen as a first input to proposed fuzzy RED algorithm because it is considered mainly indicator of overflow queue which represents the number of packets in the queue where whenever the value of average queue length is increased this indicates that the number of packets in the queue in a significant increase. And also Queue Rate of change has been chosen as the second input to proposed fuzzy RED algorithm, because is a sensitive and accurate indicator of the rate of change for the packets in the queue whether an increase or decrease in the number of packets in the queue at a given time period. While the third input that is the delay rate, which refers to the accumulation of the packets in the queue for a long time and not to leave more quickly leading to congestion inside the router, where we conclude from these effective parameter as a measure for delaying packets in the queue thus gives an important notification for these delays and therefore their utility prevent congestion due to stay the packets within the queue for a long period of time. So that

conclude from this parameter as a real measure of the speed or slow change the size of the queue leading to give notification accurate and thus lead to an increase in the speed of processing packets in router, And also giving an accurate alert before the queue fills by packets which lead to congestion. As well as the number of effective parameters has a very significant effect in controlling congestion happening in the network, where determine to number of the appropriate parameters as inputs to the fuzzy logic system have a significant impact on the performance of the network. In the proposed Fuzzy RED algorithm has been used three parameters instead of using two parameters has also been used in other previous work in order to become a notification process that there is congestion will happen more accurate.

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الاكتشاف المبكر العشوائي المضبب لتقليل فقدان حزم البيانات في شبكات الحاسوب

خلود احمد نصار عمار عبدالهادي عبدالله
جامعة البصرة / كلية العلوم / قسم علوم الحاسوب

المستخلص :

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 كأجهزة 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 تطويرها بإحدى الطرق الذكية (المنطق المضبب). حيث انه تم استخدام ثلاثة معلمات هي معدل طول الطابور، معدل التغيير في الطابور ومعدل التأخير كإدخالات للنظام المضبب واخراجا واحدا متمثلا باحتمالية اسقاط حزم البيانات. تم برمجة الجانب العملي باستخدام لغة البرمجة الكائنية المنحى C++ ضمن بيئة برنامج محاكاة الشبكات OMNET++.