Review Article of Congestion Control in a Network by Fuzzy Methods

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Abstract: In this paper, we reviewed the latest done works in the field of network congestion using fuzzy systems and methods. First we presented an introduction to network congestion control framework such as the causes of making congestion and the application of network congestion control methods in fuzzy systems that these methods include AQM algorithm and DT algorithm and we studied an unknown controller for controlling the congestion in TCP/IP networks and fuzzy methods in a router core, network edges and a router bottleneck and also we indicated congestion control in MANET networks using FARCC method that these above-mentioned methods try to control the congestion in the network by a fuzzy method and present better results than other methods.

Keywords: TCP Protocols, congestion control, fuzzy controller, rate control

1. Introduction

The congestion is a serious problem for the vast networks of the internet that today many researchers work in this field. The congestion occurs when it send many data packages resources to a router which its output capacity is less than the total inputs. One of the reasons of the congestion is to overload the valid resources (bandwidth, buffers, queues, processing time ...) that are inadequate and the reason of the congestion in the shared networks is seen when several users want to access the common resources and every time the total demands are more than available resources, a queue is created because the rate of input packets is higher than the distribution rate in routers and switches and due to the occurred pauses, the size of these queues will be greater by passing the time before the packages can be processed. The congestion in the network causes to reduce the efficiency and whatever the delays is more, the operational power is lower. When a package is delayed then it doesn't receive the resource and also doesn't send the response therefore the package is sent again that these re-transmittances cause the delay and congestion will be more. The congestion causes the drop of the network that this may be uncontrollable unless the effective, strong and efficient methods will be advanced to control the congestion. The congestion control is a crucial issue for the optimum use of network resources and in the networks with the common resources, it is necessary the used data rate will be set by every transmitter to prevent the overload in the network, where several transmitters compete to access the bandwidth. The packages which enter each router and can't be sent to the destination are released; hence the additional values of packets that enter the bottleneck of the network lead to discard a large number of them. These released packages may be travelled a long distance in the network, thus they may consume a lot of resources. In the recent years, all mechanisms of the congestion control that have been designed in MANET networks determine the number of released packages that leads to the congestion. These methods are divided into three classes: window-based, rate-based methods and hybrid method that is between them.

2-Definitions

2-1 Congestion Control

The congestion is a dynamic problem; therefore we can't solve it only with a static solution. So we need to design a protocol that protects the network against the congestion which is created to resolve it. Fuzzy logic was presented by Professor Lotfizadeh to display or manipulate data that isn't explicit and clear but is fuzzier. Fuzzy logic provides the different solutions for applied nonlinear control by the membership function rules and processing proof that its results include the efficiency improvement. Fuzzy logic control is presented where the precise control of the theory methods can't be used appropriately and to obtain a formula for the analytical model is very difficult. Fuzzy logic control has been applied successfully for controlling the systems in the analytical models which are not easily accessible; their models are complicated and may also be nonlinear. Fuzzy logic has been applied to TCP / IP networks (the best attempt) recently and also it could differentiate the services of TCP / IP networks.

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The congestion control refers to the technique and the mechanism which can prevent the congestion before it happened or eliminate the congestion after occurring it, the congestion control is divided into two general categories.

1- To open the congestion control loop

In this method, the network congestion can be avoided before its occurring using transfer policies that include transmittance / response policy and discarding policy.

2- To close the congestion control loop

In this method, the congestion is created and we send the signals to remove the congestion so that we can reach the network to a normal state.

2-2 Reasons of the Congestion

* The first reason includes the data which is overloaded in the network and or the valid resources which cause to make traffic are insufficient.

* Total requests which are larger than resources are valid.

* To extend the number of internet users are increasing day by day.

* Distributed Resources

* The requests are unpredictable i.e. the arrival rate and the ownership time of the resources are unknown.

* Systems which have been designed, investigate the worst possible case.

* To support the integrated services such as video, the sound and applied data simultaneously.

* The users demand more bandwidth and speed to run online and multimedia games.

3- Methods

3-1 Congestion Control in TCP/IP Networks

Generally TCP is used in the consistent connection and end to end protocols in the Internet and TCP has 2 main functions; the first is to protect valid data transmission and the second one is to control the congestion. In TCP / IP networks, there is the congestion avoidance mechanism but it isn't strong and enough. For good service in all conditions, active queue management (AQM) has been presented that has a mechanism to contribute to TCP congestion control, AQM algorithm reduces the packets before filling out the queues and decreases the average length of the queues which indicate the congestion. AQM mechanism begins to decrease the premature packets. In order to inform the traffic sources around AQM, the routers are allowed to policy-making to decrease the packet. ENC (Explicit Congestion Report) includes a report for the early recognition of the congestion in the network and a mighty AQM is able to offer the solutions to mark a package and decrease them by setting a bit in every packet. If that transfer protocol is able to respond to the ENC, using ENC for informing the end nodes to reduce unnecessary packets avoids the congestion. Many aspects of AQM propose to provide the high productivity of the network by reducing the packets and offer the delays by organizing the queues at the bottleneck of the links in TCP / IP.

3-2 Fuzzy Methods for Band Router Core

Fuzzy Logic controllers are proposed for the systems which are under control to work in the places that include the lack of the great uncertainty or lack of variation in the parameters. Adaptive fuzzy logic controllers can integrate the linguistic information of the human factors or the specialists while the normal controllers can't do this. ADT-FL controllers (the low value of used consistency in the fuzzy logic) avoid the congestion in the network by limiting the queue for DT algorithm and by changing the intensity of traffic and the bandwidth of the links to maintain the router.

3-3 Fuzzy Method for Network Edges and Router Bottleneck

The proposed work by fuzzy logic is to use the dynamic and nonlinear congestion control on the router queue edge for the network. In this control strategy, an introduced new queue for traffic flows, to avoid the packet loss and to optimize the congestion control of this outcome will determine the productivity level of the queue and to prepare the appropriate level of the congestion control; in addition, the fuzzy method can receive the natural explosion from the traffic by changing dynamically the network operators. To evaluate, this intelligent fuzzy controller base was a method in comparison with 5 conventional applications of the congestion control in Red, FIFO, PQ, WFQ, WRED. The results show a significant improvement is made in the queue delay time at router edge. The loss of the packets causes to improve and stabilize the network. These results show clearly that the presented fuzzy congestion controller will have the efficiency output compared to the conventional congestion control.

3-4 TCP Proposed Algorithm

This part offers a new approach, is called the unknown controller to select the congestion window size in TCP sender dynamically based on the network capacity. This approach may be included in all previous protocols instead of AIMD strategy to improve their performance. In other words, the unknown controller can be used instead of both slow start and congestion avoidance phases. This main idea of the proposed unknown controller is that the congestion window size in TCP sender is determined dynamically based on traffic load in the network at any time. The unknown controller of the exponential congestion window behavior which is increased during slow start and a constant line are changed during the congestion avoidance for dynamic non-analytical approaches and more insight behaviors that are based on the base of network traffic load and the distance between the congestion window and SSTHRESH. The following sections give the basic concepts of the unknown logic and describe the proposed unknown controller.

3-4-1 Unknown Logic

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The unknown logic is a computational intelligence tool that will be used in the situations where traditional control theory methods can't be used because of the analytical model problems. The control of unknown logic may be considered as a response design controller method, that analytical models are not easily accessible or aren't the model themselves, If they are too complicated, they may be very non- linear. Unknown logic control has been accepted successfully to control the systems. Basically it consists of four sections including: unknown maker, another unknown maker, an inference engine and an unknown rule base which is shown in Figure 2. Just in many applied programs, the unknown control of input data is generally fragile; thus, making unknown is required for conversion of fragile input data into a suitable set of linguistic value which is necessary for the inference engine. In the legal base, a set of unknown control rules which personalizes the system dynamic behavior has been defined. The inference engine is used to form inferences and conclusions from the unknown control rules.

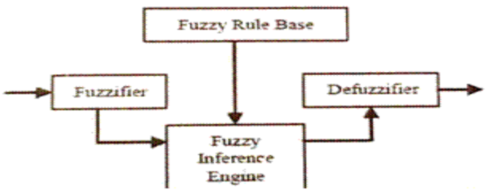

Figure 2: Basic configuration of an unknown system

3-4-2 Proposed Unknown Controller

The proposed unknown controller selects the congestion window size which an unknown system uses it; the system is based on the current congestion, ssthresh, RTT average and the network traffic load which has been seen with RTT last time. The proposed unknown controller has 2 input parameters dr, sr and the output unknown controller dcwnd which is sc = (ssthresh-cwnd)/ssthresh & dr = (average RTT-RTT) / (0.5(average RTT+RT). The parameter Sc is the first applied member of unknown logic control. This implies that the distance between ssthresh and the congestion window and the sizes of 0 to 1 are shown in Figure 1. The value 0 means that ssthresh equals to the congestion window (which has been specified with L). The value 1 means that the congestion window is equal to 0 (which has been identified with H). The value 0.5 means that ssthresh equals to two congestion windows (which has been identified with M).

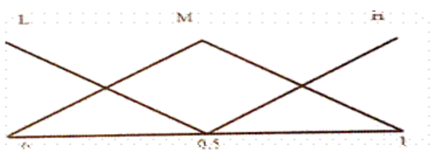

Figure1: sc member performance

The parameter dr is the second FLC MSF that represents the network traffic and the sizes of 0 to 2, as shown in Figure 2. In this figure, 0 states the low traffic and 2 represents the high traffic.

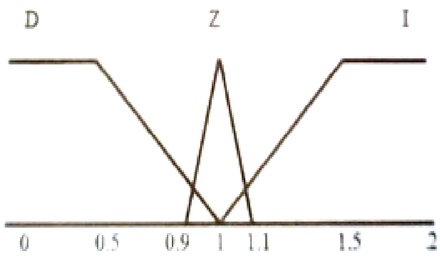

Figure2: dr member performance

In the proposed unknown method, the parameter dr reflects the following points.

If it is 0.5 to 1 means that network traffic is reduced, D, if it is 1 to 1.5 means that the network traffic is increased, I, the network traffic is constant from 0.9 to 1.1, Z. The proposed unknown controller uses a single unknown maker, a product inference engine, another unknown maker of central average.

Table 1: Unknown rules

sc			dr			dcwnd	
L	M	H	D	Z	I		
1	0	0	1	0	0	S-	1
1	0	0	0	1	0	S	1.5
1	0	0	0	0	1	S+	2
0	1	0	1	0	0	M-	3
0	1	0	0	1	0	M	4
0	1	0	0	0	1	M+	5
0	0	1	1	0	0	L-	6
0	0	1	0	1	0	L	7
0	0	1	0	0	1	L+	8

The results of the simulation indicate that the proposed unknown approach improves the main interrelated congestion control protocols against the performance, size, packet loss and packet delay and show that the unknown method gives better results than TCP Tahoe, TCP Reno, TCP Noreno and TCP Sack methods.

3-5 Single - purpose Fuzzy Rate based Congestion Control

In this section, we explain about the specific mechanisms used by FARCC. First this method is consisted of the mechanisms of the transmitter part to access the congestion control and effective and reliability. Every time, FARCC transmitter transfers a packet, a header 3 is attached to it. Its rate string equals to the transmitter sending rate that is never changed during the transfer. br string is the channel occupancy rate that all middle nodes on the transmission path may change it to control the transmittance rate of source packages. The delay

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string in the header equals to the average delay of the queues that all middle nodes may change it in the transmission path. The destination node is similar to TCP receiver with this difference that when it receives the confirmation of a package, the header copies the congestion from the data package on its ACK. This node also works as the congestion information collator obtained from the middle nodes before the information is returned to the transmitter. The destination node provides the reliability, flow control and combined congestion control information by sending the periodic messages. FARCC transmitter is the responsible for the connection management and the transmittance initial rate and controls the transmittance rate of each flow by a simple feedback inside ACK.

3-5-1 Transmitter Node

In the initial phase of the connection, the transmitter node sends an inspection packet to the receiver. In the transmission queue sequence, the inspection packet is put on the next data packet. When a new path is used, the connection doesn't know about the available bandwidth for the path passage. The inspection packet estimates the bandwidth that allows the connection to work in the actual available bandwidth instead of using the resources less or more. The transmitter node also computes the pause time to send the packets using the transmittance rate.

3-5-2 Middle Node

delay(q(t)) is the queuing delay that is tolerated by each packet to pass through the middle node. The middle nodes of the average queuing delay avg-delay(q(t)) protect the type of the flow independently. This averaging is applied to all packets which pass through these nodes. The average queuing delay is influenced by the competition between the different flows that pass through the nodes. This value is retained by the exponential averaging according to Equation (1). For each output packet, a middle node reveals the values of avg-delay(q(t)) and delay(q(t)):

(1) $$ave-delay(q(t)) = \alpha * ave-delay(q(t)) + (1-\alpha) * delay(q(t))$$

Each package includes a delay string that refers to avg-delay(q(t)) maximum in the upstream nodes that the packets have passed them. When the package is removed from the queue for the transfer, the middle node will reveal the delay string in a sent package with avg-delay(q(t)), if this string is smaller than avg-delay(q(t)). The middle node activates a periodic timer with the period E. This value of E must be greater than the travel time of a connection period and meanwhile it must be small enough to follow the path dynamic features. E has been selected a second empirically in our simulations. In addition, the middle node calculates the channel occupancy ratio for all communication channels. The middle nodes keep the maximum channel occupancy ratio br (t) in the network. Each packet contains a br string that refers to a value br (t) in the upstream nodes. When the package is removed from the queue for the transfer, the middle node will reveal a br string in the sent packet with br (t), if this string is smaller than br(t).

3-5-3 Destination Node

The destination node provides an alternative feedback for the sender for combined congestion data obtained from the middle nodes (through br strings and the delays on the packages). When the destination node receives a package, the delay and br strings on it indicate the maximum average queuing delay and channel occupancy ratio for middle nodes. For each obtained package belonging to a flow, the destination node averages br and delay string values exponentially.

The destination node in an average network fixes br and delay. To send the feedback alternatively, the destination node activates a periodic timer with period T. Notice that T must be greater than the period travel time of a connection and at the same time, it must be so small to follow the dynamic features of the path. T has been selected in the simulations a second empirically.

In FARCC method, there are three levels of low, medium and large congestion. The destination node determines the network congestion level using the secondary fuzzy system in each sampling period. The transfer rate is set by one of the three following phases: Multiplicative increase, mass increase and multiplicative decrease. Two fuzzy logic congestion control system inputs are considered at time T is where T is the sampling period. Prob (T) input is the probability of congestion and the initial fuzzy system output. Rate (T) input is the present data rate in the closed congestion header.

Plant Model

The plant based on one of the congestion levels which is determined in the second fuzzy system output, performs one of the three phases of multiplicative increase, mass increase and multiplicative decrease on the current transfer rate respectively.

If the specified congestion level is low, it will implement the multiplicative increase phase plant according to equation (2) to improve the network output.

(2) $$new-rate = old-rate * \left(\frac{th-br}{avg(br-stamp)}\right)$$

If the congestion level is mean, it will implement the mass increase phase plant according to equation (3) to increase the transfer rate belonging to the average queuing delay in the path of the nodes.

(3) $$new-rate = old-rate + \left(\frac{1}{avg(delay-stamp)}\right)$$

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If the congestion level is high, the probability of the congestion is high. Therefore, it will implement the multiplicative decrease plant and control the transmission rate using the average queuing delay and the average channel occupation ratio according to equation (4).

$$new - rate = \frac{old - rate * avg(br - stamp)}{avg(delay - stamp) * th - br} \quad (4)$$

The destination node compares the new transfer rate with the current rate. If the difference is greater than E, the new transfer rate will be sealed on ACK and sent to the sender because the increase in the number of feedbacks leads to the increase in the congestion and network load.

The results of the Evaluation show that FARCC method is better than both ATP and ITP methods and offers a higher accuracy percent.

4- Conclusions

Fuzzy techniques create a new and flexible framework to develop the algorithms and avoid the congestion in the network. Theses nonlinear methods which are based on knowledge are extremely efficient and fuzzy techniques provide a new and flexible framework to develop the congestion control algorithms. The congestion control is important and is used to avoid the overload in the network and to prevent the network collapse. Fuzzy methods indicate that the improvement of increasing the power, reducing the delay and losing the packets can be used effectively and this method is effective to control the congestion in the core in addition to the router bottleneck. The existence of the congestion is a nonlinear and dynamic problem in the internet; the congestion control is a complex problem in the network that requires the strength, the power and control methodology to obtain a satisfactory performance which uses intelligent computations. The congestion can be controlled in different ways in the core, the router bottleneck and the input window in the Fuzzy Logic Control methodologies in which the effective solutions for the certain groups of the control problems especially in complex and nonlinear systems where the analytic models aren't satisfactory, or are expensive or aren't performable were reported. To obtain a better quality of service for the best colloquial network, multiple queues can be used by the management algorithms. Fuzzy logic helps to increase the capacity and reduce the loss of sent and delayed packets in order to avoid the congestion in the network. Also unknown logic controller avoids the congestion to select the size of the congestion window dynamically based on the network capacity. The conclusions indicate that the congestion in the network is avoided in FARCC method in MANET networks using the determination of the suitable data rate to send the packets.

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