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A Type-2 Fuzzy Control Traffic Policing Mechanism Schemes Model over High Speed Network Using Backpressure Technique.

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Abstract

A traffic policing mechanism scheme is a method helps monitor the amount of ingress traffic, and drops incoming frames judged by a set policing bandwidth. If congestion occurs at the buffer before entering the network. Another approach must drop incoming frames from which buffer is not available and has to rely on the end-to-end protocols for the recovery of lost frames. In this way, it may not be able to cope their quality-of-service (QoS) requirements because it must have more delay time. However, one way to solve this problem, we use backpressure to control network congestion but it is suitable for low traffic. In deed, the telecommunication traffic is always fluctuation. A type-2 fuzzy control is suitable for uncertain traffic, especially in alternative burst and silence. So we have propose a model for type-2 fuzzy control policing mechanism scheme using backpressure.

It could help to improve the performance in policing mechanisms much better than conventional policing one while various types of burst/silence traffic are being generated.

Keywords: type-2 fuzzy control, policing mechanism scheme.

1. Introduction

In high speed networks, the traffic sources always become activated at the reaching peak rate. Network congestion have occurred this point. To prevent this condition, policing mechanisms were introduced. It can degrade the main performance measures such as dropped frame, bandwidth allocation, frame delay, throughput and other grade of service measures. There have been a lot of previous studies involving traffic policing mechanisms [1], [2],[10],[11],[12].

Currently, the policing mechanism scheme is wildly used to control network congestion. The previous papers have been proposed involving traffic policing mechanism schemes. But they are difficult to obtain the proper and understandable modeling representations. This difficulty has simulated the development of alternative modeling and control techniques which include fuzzy logic based ones. Type-2 Fuzzy control may show the way to the models that express the behavior of systems suitably for their application in fuzzy control. Thus due to the requirement for low-cost but reliable models, the type-2 fuzzy modeling approach may be a useful complement to traditional modeling. The type-2 fuzzy control approach is suitable for both the complexity and uncertainty during the increase of the system. This is of great practical significance, since modeling is usually the bottleneck for the application of effective control.

There are a number of previous studies involving fuzzy control traffic policing mechanism schemes. In type-1 fuzzy control is not suitable for alternative burst and silence. In this paper, we have proposed a model for type-2 fuzzy control policing scheme using backpressure over high speed network which it is not mention.

This paper is organized as follows. In Section 2, we describe policing mechanisms in literature. In Section 3, we propose backpressure in this paper. Section 4, we define the model of a type-2 fuzzy control policing mechanism scheme. Section 5, we define the simulation model. Section 6 some conclusion and recommendation for future research are drawn.

2. Description and modeling of traffic policing

Policing mechanism schemes monitors the maximum rate of traffic received on an interface during the entire active phase and must operate in real time. In this section are described in policing mechanism schemes.

In addition to these requirements, mechanism of parameter violations must be short to avoid flooding of the relatively small buffers in the network. To eliminate these conflicting requirements, several policing mechanisms have been proposed [3], [4] as described in the following sections.

2.1 Traffic source models

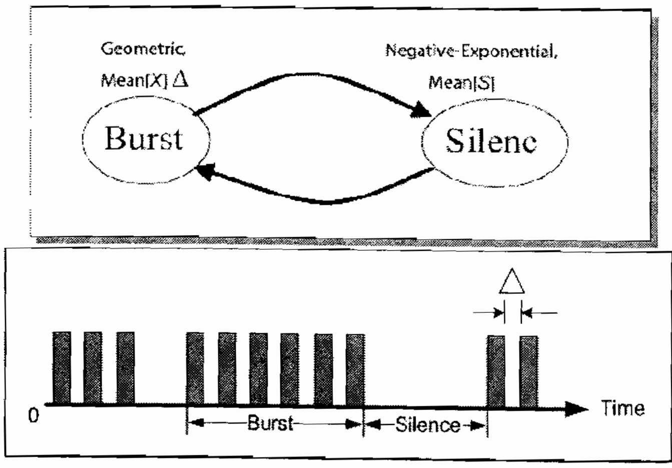

Figure 1. The burst/silence traffic model using in this study.

In this section, we describe the traffic model used in the our model. The traffic source model is based on burst/silence traffic stream. A burst is transfer of data without interruption from another. A silence is no data to transfer. The burst /silence ratio is strictly alternating.

The number of packets per burst is assumed to have a geometric distribution with mean E[X]; the duration of the silence phases is assumed to be distributed according to a negative-exponential distribution with mean E[S]; and inter-packet arrival time during a burst is given by Δ. With

$$\textit{mean burst duration} = E[X]\,\Delta \quad (1)$$

$$\textit{mean silence duration} = E[S] \quad (2)$$

$$\textit{mean cycle duration} = E[X]\,\Delta + E[S] \quad (3)$$

2.2 Policing mechanism models

The policing mechanism scheme monitors an arriving traffic at the edges of the network for frame-based traffic. This mechanism decides whether to accept a unit of incoming drop frames or remarked to a lower class of service (see Figure. 2). The policing mechanism scheme allows us to control the maximum rate of traffic received during the active phase. So it prevents excessive data-rate connections from bottleneck the source network transmission, and improve the quality of service (QOS).

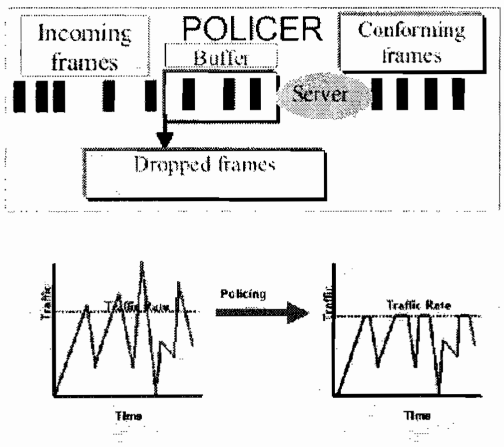

Figure2. The policing mechanism scheme.

2.3 Leaky bucket process model

This study selected the Leaky Bucket (LB) only.
The high speed networks must need a large bandwidth and hold the high quality of service (QoS) guarantees. The Leaky Bucket (LB) mechanism (see Figure. 3) ensures that the source traffic does not go over the negotiated rate. The bucket-size can be represented as a buffer with capacity N. If the frames go to buffer until overflowing, then the frames are discarded. The server generates at a specific data rate, R. The LB is a commonly used for traffic control in high-speed network [5], [6].

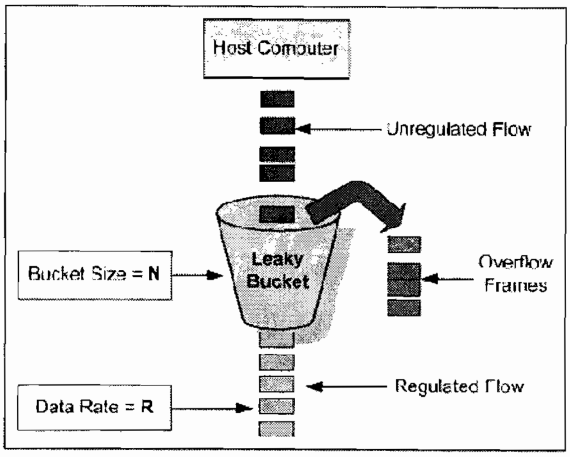

Figure 3. Leaky bucket mechanism.

3. Backpressure algorithm

The backpressure algorithm works like XON/XOFF techniques with a purpose to avoid buffer overflows and temporary network congestion. The XOFF flow control message is sent to source when buffer of destination is filled up frame until overflow. When the Source receives a XOFF message, it stop sending frames until it receives a XON message from the same destination. The XON message is triggered when the buffer of destination has decreased below the lower threshold.

In the backpressure algorithms, when frames arrives at destination' buffer, the backpressure algorithm is activated. If destination' buffer is below the threshold, it sends message to the source. The source can increase a half the transmission rate. If destination' buffer reaches the upper threshold, then destination sends a message to source to reduce a half the transmission rate. The backpressure is suitable for a connection-oriented network that allows hop-by-hop flow control. The backpressure algorithm is showed with the pseudo code as follows.

```
// The goal of backpressure algorithm wants to control the
//traffic rate. If the buffer is filled up frames until reaching
//threshold then the destination hop sends the message to the
//source and it reduces to half transmission rate.

Start Check:

IF buffer of destination exceeds the upper threshold

THEN GOTO Stop:

ELSE {

        IF Q_DESTN >= Q_THRESHOLD

        THEN Destination sends feedback to source and
              source reduces traffic rate to half.

              GOTO Start Check:
```

ELSE Destination sends feedback to source and source increases traffic rate to half.

GOTO Start Check:

}

Stop:

4. Type-2 Fuzzy control prior buffer

In this section, we initially first describe the concept of type-2 fuzzy and type-2 fuzzy control prior buffer in policer which meets the requirements of performance implementation of high speed networks.

4.1. Basic concepts of type-2 fuzzy set [7], [8], [9].

The type-2 fuzzy set appears to be handled more uncertainly than fuzzy set. A type-2 fuzzy set incorporates uncertainly with the membership function into the fuzzy set theory. If there is no uncertainty, then a type-2 fuzzy set will reduces to a type-1 fuzzy set. In order to distinguish between a type-1 fuzzy set and a type-2 fuzzy set, A denotes a type-1 fuzzy set, whereas Ã denotes the comparable type-2 fuzzy set. The feature of Ã versus A is the membership function values. They have a continuous range of values between 0 and 1.

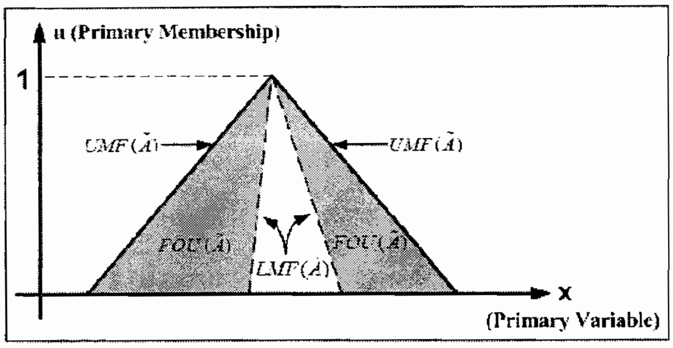

Figure 4. FOU for an interval type-2 fuzzy set. Many other shapes are also possible for the FOU.

The FOU is described by its two bounding functions (Figure. 4), a lower membership function (LMF) and an upper membership function (UMF), both of which are type-1 fuzzy sets. We can use type-1 fuzzy set mathematics to characterize and work with interval type-2 fuzzy sets. It can be said that Type-2 Fuzzy Sets are suitable for ***rule-based fuzzy logic systems*** (FLSs) because they can handle uncertainties whereas Type-1 fuzzy cannot handle uncertainties. A diagram of a type-2 FLS is depicted in Figure. 5.

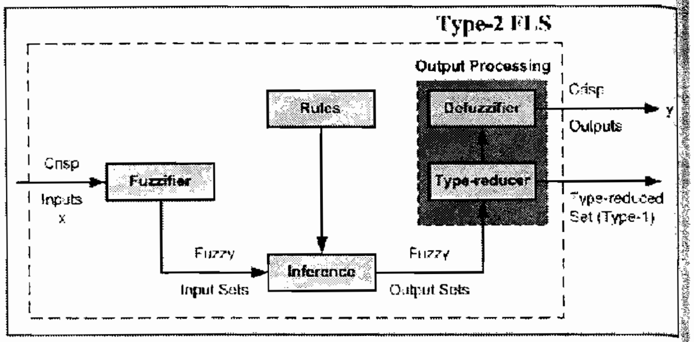

Figure 5. Type-2 fuzzy logic systems.

Fuzzy sets are associated with the terms of IF THEN ELSE rules, and with the inputs to and the outputs of the Fuzzy set. Membership functions are used to describe these fuzzy sets. The Type-2 Fuzzy sets have an interval membership functions.

In output processing of a type-1 Fuzzy Sets which is called ***Defuzzification*** maps a type-1 fuzzy set into a number. Nevertheless, it is more complicated for an interval type-2 Fuzzy Set because it is going from an interval type-2 fuzzy set to a number which (usually) requires two steps (Fig. 4). The first step, called ***type-reduction*** is where an interval type-2 fuzzy set is reduced to an interval-valued type-1 fuzzy set. There are as many type-reduction methods as there are in type-1 defuzzification methods. The second step of Output Processing, which occurs after type-reduction, is still called ***defuzzification***. Since a type-reduced set of an interval type-2 fuzzy set is always a finite interval of numbers, the defuzzified value is just the average of the two end-points of this interval.

4.2. Regulator input fuzzification

Input variables are transformed into fuzzy set (fuzzification) and manipulated by a collection of IF-THEN fuzzy rules, assembled in what is known as the fuzzy inference engine, as shown in the Fig. 5.

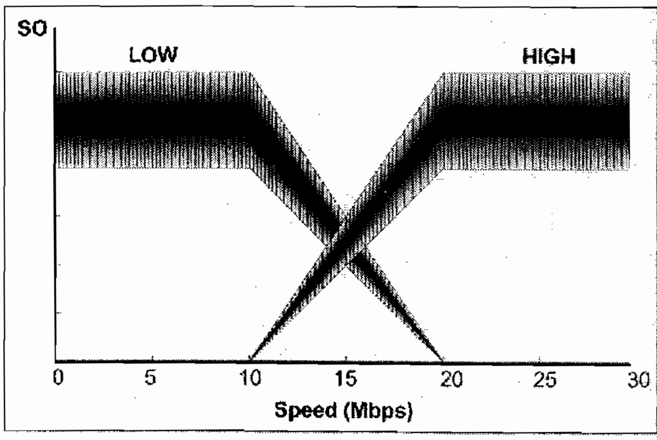

Figure 6. Membership function of SO input variable.

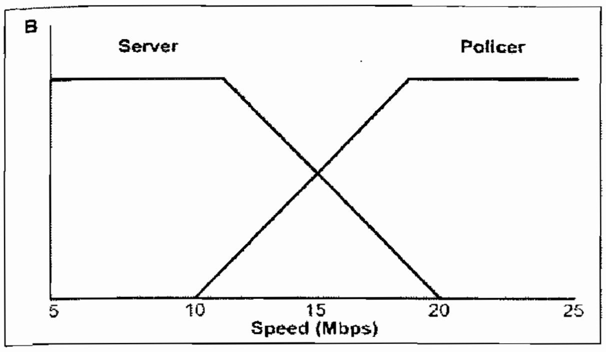

Figure 7. Membership function of B output variable

4.3. Inference, Fuzzy Rules and Defuzzification

Fuzzy sets are involved only in rule premises. Rules consequences are crisp functions of the output variables. There is no separate defuzzification step. Based on our defined measurement of input variables and their membership functions, the fuzzy system can be described by five fuzzy IF-THEN rules, each of which locally represents a linear input-output relation for the regulator. In Figure. 8, it shows simple fuzzy rules used in the experiment.

IF So is Low (L) AND various types of burst/silence is narrow THEN go to server
IF So is Low (L) AND various types of burst/silence is wide THEN go to PLC
IF So is High (H) THEN go to PLC

Figure 8. The fuzzy rules.

Figure. 6 and 7 respectively show the membership functions of the linguistic values of the input variables So and also the output variables B being taken. Analysis of the fuzzy system rules (Figure. 8) shows that sources are Low (L) and various types of burst/silence is narrow THEN they go to server. If sources are Low (L) and various types of burst/silence is wide THEN they go to PLC (Policing Mechanism). If sources are High (H) THEN they go to PLC.

In our models, Type-2 Fuzzy Control (T2F) uses a set of rules (Fig. 6, 7 and 8). The selection of basic rules is based on our experience and beliefs on how the system should carry out. Input traffics allow a burst traffic stream (burst/silence stream) to fluctuate the network controlled by fuzzy controller.

5. A MODEL OF TYPE-2 FUZZY CONTROL BACKPRESSURE

The following Figure. 9 shows a model used in this paper.

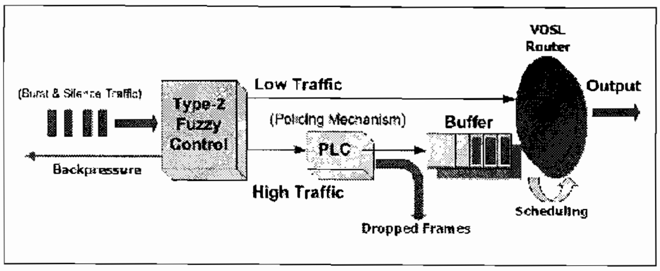

Figure 9. Simulation model.

The souce sends traffic to receiver which it has a mechanism to reduce high speed traffic. When input traffic arrives at receiver. The type-2 fuzzy makes decission. If low traffic is sent to server, High traffic go to policing mechanism(PLC). If PLC'buffer reaches the upper threshold, then the receiver sends a backpressure to source to reduce a half the transmission rate.

5.1. Input traffic

This paper confines the discussion mainly on data. Data sources are generally bursty in nature whereas voice and video sources can be continuous or bursty, depending on the compression and coding techniques used [10].

5.2. Characteristics of Queuing Network Model

There are three components with certain characteristics that must be examined before the models are developed.

5.2.1. Arrival characteristics

The pattern of arrival input traffic mostly is characterized to be *Poisson Arrival Processes* [11]. Like several random events, Poisson arrivals occur such a manner that for each increment of time (*T*), no matter how large or small, the probability of arrival is independent of any previous history. These events may be individual labels, a burst of labels, label or packet service completions, or other arbitrary events. The probability of the inter-arrival time between event t, is defined by the inter-arrival time probability density function (pdf). The following formulae give the resulting probability density function (pdf), which theinter-arrival time t is larger than some value x when the average arrival rate is λ events per second:

$$F_x(t) = P(X \le t) = \int_0^t e^{-\lambda x} dx \quad (4)$$

$$f_x(t) = \begin{cases} e^{-\lambda t}, & for \quad t \ge 0 \\ 0, & for \quad t < 0 \end{cases} \quad (5)$$

In this paper, we adopt the ON/OFF burst/silence model [12].

5.2.2. Service facility characteristics

In this paper, service times are randomly distributed by the *exponential probability distribution.* This is a mathematically convenient assumption if arrival rates are Poisson distributed. In order to examine the traffic congestion at output of VDSL (Very High Speed Digital Subscriber Line) downstream link (15Mbps) [12], the service time in the simulation model is specified by the speed of output link, giving that a service time is 216 μs per frame where the frame size is 405 bytes [14].

5.2.3. Source traffic descriptor

The source traffic descriptor is the subset of traffic parameters requested by the source (user), which characterizes the traffic that will (or should) be submitted during the connection. The relation of each traffic parameter used in the simulation model is defined below.

PFR(peak frame rate) = λa = 1/T in units of frames/second, where T is the minimum inter-frame spacing in seconds.

6. CONCLUSIONS

In this paper, we purposed the type-2 fuzzy control traffic policing mechanism schemes model over high speed network using backpressure technique. We are sure that this technique appears to be the best outperforming compared to the others (type-1 fuzzy control and traditional policing mechanism scheme) in terms of maximizing the number of conforming frames; less non-conforming frame. It is also believed that type-2 fuzzy control in policing mechanism scheme seem to be suitable for data and multimedia under various types of burst/silence traffic condition. The type-1 fuzzy does not concern with various types of burst/silence traffic condition, it determines speed of traffic only. In fact, various types of burst/silence traffic condition are very importance because it causes conforming frames and dropped frames. If the destination drops a lot of frame, source must retransmit frames. The network occurs a lot of delay time.

7. References

[1] A. AlWehaibi, A. Agarwal, S. AlWakeel, N.-E. Rikli, and A. ElHakeem, "Performance behavior evaluation of Internet congestion control policing mechanisms, " IEEE CCECE, vol. 2,2003, pp. 1017-1020.

[2] T. Gouda, L. Barolli, K. Sugita, A. Koyama, A. Durresi, and G. De Marco, "Application of policing mechanisms for broadband networks: issues and difficulties," AINA 2005, vol.1,2005, pp. 183-188.

[3] A. Niruntasukrat,W. Benjapolakul, "A novel scheme for policing mechanism in ATM networks: feedback fuzzy leaky bucket," IEEE International Symposium on Circuits and Systems, vol. 2,2001, pp. 161-164.

[4] K. Dimyati, and Y.T. Chin, "Policing mechanism and cell loss priority control on voice cells in ATM networks using fuzzy logic," IEE Proceedings Communications, vol.147, issue 4,2000, pp. 239-244.

[5] W. Cheng-Shong, H. Ming-Hsien, and C. Kim-Joan, "Traffic shaping for TCP networks: TCP leaky bucket," Proceeding of IEEE Region 10 Conference on Computers, Communications, Control and Power Engineering, vol.2,2002,pp.809-812.

[6] S. Lekcharoen, et. al, "Performance Evaluation of VDSL Network with Fuzzy Control Policing Mechanisms," Proceeding of International Conference on Telecommunications and Computer Netwo*rks (TCN'04)*,200, pp. 56-60.

[7] Q. Liang, N.N. Karnik, and J.M. Mendel, "Connection admission control in ATM networks using survey-based type-2 fuzzy logic systems," IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews, vol. 30,2000, pp. 329-339.

[8] L. Li, W.-H. Lin, and H. Liu, "Type-2 fuzzy logic approach for short-term traffic forecasting," IEE Proceedings, vol. 153, issue 1,2006, pp. 33-40.

[9] E. Jammeh, M. Fleury, C. Wagner, H. Hagras, and M. Ghanbari, "Interval type-2 fuzzy logic congestion control of video streaming," IET 4th International Conference on Intelligent Environments,2008, pp. 1-8.

[10] P. Koutsakis, M. Paterakis, S. Psychis, "Call admission control and traffic policing mechanisms for the wireless transmission of layered videoconference traffic from MPEG-4 and H.263 video coders", Personal, Indoor and Mobile Radio Communications, 2002. The 13th IEEE International Symposium on, Vol. 5, 2002, pp. 2155 - 2159

[11] N.L.S da Fonseca, S.A. Yunes, "On the need for frame discard in ATM networks", Communications, 2003. ICC '03. IEEE International Conference on,vol.3,2003,PP. 1927 – 1931.

[12] S. Buchegger, Le Boudee," Self-policing mobile ad hoc networks by reputation systems", IEE Communications Magazine, Communications Magazine,vol.43,2005,pp.101-107.