# Computer Network Congestion and use of Fuzzy Logic

*Kusumbar Baishya*
*Asstt. Prof., Dept. of Mathematics*
*Amitabh Sarma*
*Asstt. Prof., Dept. of Comp. Science*

**Abstract**

"Computer network congestion" plays an important role in packet switched communication and occurs when a node or link is bearing higher data than its quality of service. As a result network loss its packet, delay in service or disturbing in new connections. Therefore Congestion control could be understood of mechanisms and techniques to control the congestion and maintain capacity below of its load. Computer network congestion control problems are vital issues and a high priority, especially given the growing size and demand of networks, despite the many years of research efforts. Designing effective congestion control mechanism for computer networks is a hard work because of the difficulty of realistic, cost effective, tractable analytical models of congestion. But Computational Intelligence using Fuzzy Logic Control methodology is trying to offer effective solutions for certain classes of control problems. In this article we propose discuss a fuzzy based congestion control mechanism to address the congestion control problem.

**Keywords:**

Network congestion, Congestion Control, Congestion avoidance, FERM, FERM2, CI.

**Introduction:**

Since many years of research efforts, the problem of network congestion control is still a critical issue and a high priority that is the growing size, demand, and bandwidth speed of the networks. By growing packet switched Network congestion is becoming a critical threat. Congestion is caused by saturation of network resources means when the demand is greater than the available resource that means the packets send load is higher than its network

handling capacity. In network congestion incremental increase in carrying data or packets leads to minimum network throughput or reduction in network throughput. Network congestion result in loss of packets delay in service or bottleneck in new connection. Network congestion may become unmanageable unless effective, robust, and efficient methods of congestion control are developed. Currently there is an ongoing discussion between the active members of the networking community as to give the right definition of congestion. Existing solution to control congestion are now becoming ineffective due to the growing size of the network and can't scale up. But computational intelligence could play an important role in this issue. The Fuzzy Logic is one of the tools of what is commonly known as Computational Intelligence (CI). Therefore, Computational Intelligence is an area of fundamental and applied research involving numerical information processing.

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- **Demand > Available resource**

Thus we can say that depending on resource availability congestion problem classify as single or distributed resource problem. For example in dumb resource such as LAN medium where all the effort need to solve the congestion problem by the single users. It seems that all access method of LAN like token access, carrier sense multiple access with collision detection (CSMA/CD) are single problem solution. But the intelligent resource can manage itself. In case of distributed resource it is so complex to handle. For example when a users demand is unlimited than the available capacity of a link (resource) is said to be distributed resource problem.

From the above discussion we can classify congestion schemes as resource creation schemes and demand reduction schemes. In resource creation schemes reconfigure dynamically to increase the capacity of the resource. For example added dial up links scheme in high usage, increases power on satellite link scheme, splitting of path for extra traffic sending scheme etc. All these schemes are not aware of congestion problem where only network is deal with the congestion

The demand reduction schemes indicate that they try to reduce amount of demand of the available resources. The basic demand reduction schemes are service denial schemes, service degradation schemes and scheduling schemes. The service denial schemes stop new connection or sessions to begin in congestion period. For

example when someone is busy with a telephone line than nobody is allowed to connect to that person and signalling a busy beep sound. The service degradation schemes indicate to all the users signalling to minimise their load. The scheduling schemes point to the users to schedule their demand to keep below the capacity. In resource creation schemes or demand reduction schemes the network computes the total load on the network and farther go for some avoidable action. A feedback signal that is based on the load is sent from the resource which is congested to one or more control point. Some proposed feedback mechanism are discuss bellow-

• Feedback in routing messages: The intermediate resource despatch its overload to neighbouring nodes and respectively all receiving nodes share the load level.

• Feedback message: Feedback message may also called chock point message or source quench message or permits message where explicit messages are sent from the congested resource to the control point.

• Probe packets: It is send from the sources via network to adjust their load depending

on the delay.

• Rejecting further traffic: In this mechanism a back pressure is create where the incoming packets are lost or un-acknowledge and thus queues are create at the other nodes. In the demand reduction mechanism the control node performs as source node on the network.

***Some alternatives to the location of the control discuss as-***

• Transport layer: End system is the best suited to adjust the traffic load in transport layer. But when the network and end system running under different administrative then the control is balanced only first and last intermediate node.

• Network access: When the network is not congested then only the access control in the source node allow to in new traffic in the network layer.

• Data link layer: The data link level flow control techniques can be applied at data link level to the control.

• Network layer: Using fair queuing technique or buffer class technique or leaky bucket algorithm technique we can take steps to control the congestion when the router and gateways fall in congested. But such of technique are only beneficial for public networks.

Fuzzy logic is mainly known as Computational Intelligence (CI). Computational Intelligence is an area where fundamental and applied research involves numerical information processing. In recent time Computational Intelligence research is most active and simultaneously its uses are seen in some end user products. The Computational Intelligence mainly concerned with Fuzzy Logic, artificial neural network and

evolutionary. While these techniques are not a panacea, it seems that demand of these techniques is not only from the academic research community but also from telecommunication companies. Fuzzy Logic Control (FLC) is viewed as an alternative way of designing feedback controllers when rigorous control theoretic approaches cannot be used because of difficulties in obtaining a formal analytical model.

The control algorithm is a non-linear law and packed as a set of commonsense rules. Fuzzy Logic have been implemented smoothly to the controlling systems where difficultly has faced to obtain analytical models, even though it is available is too complex and highly nonlinear.

In recent times, numbers of research papers have been popularised and successful using fuzzy logic investigating solutions to congestion control issues in ATM networks where facing the complexity of ATM networks, varieties of traffic sources operating on them, and for depth analysis obtaining difficulty of formal models, it is still favoured by many of researchers that are deal with ATM network. Fuzzy Logic is recently applied to TCP/IP networks, and also TCP/IP Differentiated Services Networks providing in either case, handful congestion control in diverse networking technologies. The Transmission Control Protocol (TCP) is one of the key Internet protocols and is responsible for managing end-to-end connections across the Internet. Since that time and still today, TCP remains one of the most important congestion control mechanisms in use in the Internet.

The congestion control algorithms as FERM and FERM2 explicit rate congestion control schemes are very similar except in FERM desired queue length is implicit and in FERM2 queue length is set by higher level control module. FERM scheme is complaint with the ATM Forum Traffic Management Specification. FERM strictly maintain the current queue length and growth rate when in the calculation of Explicit Rate. The FERM scheme performs the Explicit Rate and Flow Rate Correction based on the current queue length and queue growth at the ATM switch. FERM is a non-linear controller where for certain queue length it performs different flow rate limits based on queue length different rate. FERM2 is very common to FERM. FERM2 is an improved scheme over the earlier or original scheme (FERM). The difference is that in the original scheme the desired queue length is implicit, but in FERM2 scheme desired queue length is set by higher level control module and gives flexible use of resources across the virtual connection. FERM2 scheme is also complaint with the ATM Forum Traffic Management Specification. The parameters used in the FERM2 are PCR, ICR, AIR, MCR and Nfn. The Resource Management cells are periodically evaluated by traffic sources and forward to the destination end systems.

### Origin f of the Problem

Its seems that the origin of "congestion" problem in the Internet observed to the work of Leonard Kleinrock. He was the first person to focus on the problems of congestion in large multi-node networks with queuing. Later he works with Larry Roberts at ARPA where they implement analytic basis and theoretical feasibility of communication and thus it has been an important area in congestion control, congestion research and congestion management for the network researchers. In congestion when sending packets are more than the handling capacity of intermediate routers, then the intermediate routers fail to carry packets and waits for having retransmit the information. In earlier sending and receiving rate of applications was primarily maintained by TCP congestion control and when a packet loss is detected an inference is made that the loss occurred because of congestion. The basic cause of the congestion is too much demand from the collection of users that share the network resources. The pattern of demand and the capacity, architecture, and management of network resources all contribute to determining a congestion state.

### Methodology Applied

This article is mainly based on secondary data. The secondary data is collected from various sources, such as-books, journals, internet source and some research topic.

### Simulative Evaluation / Discussion

Extensive simulations using OPNET, on a representative ATM network and have compared the performance of FERM against enhanced proportional rate control algorithm (EPRCA), where we have seen that FERM offers excellent transient behaviour with good rise time, good settling time, and insignificant, if any, oscillations. FERM2 yields yet better throughput results than FERM in an overloaded network for both LAN and WAN networks. Its transient behaviour is much better than EPRCA, in the sense that FERM attains steady-state much faster, and that it offers 'smooth'. FERM2 performs still better throughput results than FERM in an overloaded network for both LAN and WAN network.

### Conclusions

In this paper we have presented a fuzzy logic control methodology that is applied in two diverse technologies: ATM and TCP/IP networks for congestion control. The design of the fuzzy knowledge base is kept simple, using a linguistic interpretation of the system behavior. We have presented an illustrative example of using

CI intelligence to control congestion using Fuzzy Logic and have addressed limitations of existing alternative mechanisms. This is clearly shown from the extensive simulative evaluation. Both Fuzzy Logic based controllers are shown to exhibit many desirable properties, like robustness, fast system response and fairness, with capabilities of adapting to highly variability and uncertainty in network. From the results presented, using simple designs, we are optimistic that th e Fuzzy Control methodology can offer significant improvements on controlling congestion in computer networks. Various enhancements of the proposed fuzzy based congestion control designs, such as adaptively, as well as the formal evaluation of the properties of the controllers are currently being investigated

***References:***

*[1]A. Pitsillides, 'Control Structures and Techniques for Broadband-ISDN Communication Systems', PhD Dissertation, Swinburne University of Technology, 1993.*

*[2] L. Roberts, 'Enhanced Proportional Rate Control Algorithm', Tech. Report, AF-TM 94-0735R1, August 1994.*

*[3] R. Jain, S. Kalyanaraman, R. Goyal, S. Fahmy, R. Viswanathan, 'ERICA switch algorithm; a complete description', ATM FORUM, AF/96-1172, August 1996.*

*[4] A. Pitsillides, J. Lambert, 'Adaptive Connection Admission and Flow Control: Quality of Service with High Utilization', IEEE INFOCOM Õ94, Canada, June 1994, pp. 1083-1091.*

*[5] A. Pitsillides, J. Lambert, 'Adaptive Congestion control in ATM based Networks: Quality of Service with High Utilization', J. of Comp. Commun. 20, 1997, pp. 1239-1258.*

*[6] 'ATM Forum, Traffic Management specification version 4.0', Tech. Report AF-TM-0056.000, April 1996.*

*[7] B. Braden et al, 'Recommendations on Queue Management and Congestion Avoidance in the Internet', IETF RFC2309, April 1998.*

*[8] S. Floyd, V. Jacobson, 'Random Early Detection gateways for congestion avoidance', IEEE/ACM Trans. on Networking, Aug. 1993.*

*[9] K.K. Ramakrishnan, and S. Floyd, A proposal to add explicit congestion notification (ECN) to IP, draft-kksjf-ecn-03.txt, October1998. (RFC2481, January 1999).*

*[10] Hadi Salim, Internet draft-salim-jhsbnns-ecn-00.txt, A proposal for Backward ECN for the Internet Protocol (IPv4/IPv6), June 1998.*

*[11] ATM Forum, Traffic management specification version 4.0, Tech. Rep. AF-TM-0056.000, April 1996.*

*[12] W. Stevens, "TCP Slow Start, Congestion Avoidance, Fast Retransmit, and Fast Recovery Algorithms", RFC 2001, January 1997.*

*[13] V. Jacobson, Congestion Avoidance and Control, ACM SIGCOMM88, 1988.*

[14] G. M. Woodruff, et al "A congestion control framework for high speed integrated packetized transport", GLOBECOM'88.

[15] D. Mitra, J. B. Seery, "Dynamic adaptive windows for high speed networks with multiple paths and propagation delays", INFOCOM'91.

[16] K. K. Ramakrishnan and R. Jain, A Binary Feedback Scheme for Congestion Avoidance in Computer Networks, ACM Transactionson Computer Systems, Vol. 8, No. 2, pp. 158-181, 1990. (Also K.K. Ramakrishnan and R. Jain, "A binary feedback scheme forcongestion avoidance in computer networks with a connectionless network layer", ACM SIGCOMM, 1988).

[17] N. Yin, M. G. Hluchyj, "A dynamic rate control mechanism for source coded traffic in a fast packet network", IEEE JSAC, Sept.1991.

[18] Osama Aboul-Magd and Henry Gilbert, 'Incorporating congestion feedback in B-ISDN traffic management strategy' ISS'92International Switching Symposium, Osaka, Japan, October 1992 [19] Peter Newman, 'Backward explicit congestion notification for ATM local area networks', GLOBECOM'93, Houston, USA,December, 1993.

[20] S. Floyd, R. Gummadi, S. Shenker, 'Adaptive RED: An Algorithm for Increasing the Robustness of REDÕs Active Queue Management', Technical report, ICSI, August 2001. [21] C. V. Hollot, V. Misra, D. Towsley, W.-B. Gong, 'Analysis and Design of Controllers for AQM, Routers Supporting TCP Flows" IEEE Trans. on Automatic Control, vol. 47, no. 6, pp. 945-959, June 2002.

[22] S. Athuraliya, V. H. Li, S. H. Low, Q. Yin, 'REM: Active Queue Management', IEEE Network Magazine, 15(3), pp. 48-53, May 2001.

[23] K. Ramakrishnan, and S. Floyd, 'The Addition of Explicit Congestion Notification (ECN) to IP', IETF RFC 3168, September 2001.

[24] W.Pedrycz, 'Computational Intelligence: An Introduction', CRC Press, 1998.

[25] A. Sekercioglu, A. Pitsillides, A. Vasilakos, 'Computational intelligence in management of ATM networks', Soft Computing Journal, 5(4), pp. 257-263, 2001. [26] B. Azvine, and A. Vasilakos, 'Application of soft computing techniques to the telecommunication domain', ERUDIT Roadmap, (G. Tselentis, Ed.), pp. 89-110, 2000, http://www.erudit.de/erudit/papers/Roadmap.pdf.

[27] E. Morales, M. Polycarpou, N. Hemasilpin, J. Bissler, 'Hierarchical Adaptive and Supervisory Control of Continuous Venovenous Hemofiltration', IEEE Transactions on Control Systems Technology, Vol. 9, No. 3, pp. 445-457, May 2001.

[28] A. Pitsillides, A. Sekercioglu, 'Congestion Control', Computational Intelligence in Telecommunications Networks, (Ed. W. Pedrycz, A. V. Vasilakos), CRC Press, ISBN: 0-8493-1075- X, September 2000, pp- 109-158. [29] Sekercioglou A, Pitsillides A, Egan GK, 'Study of an adaptive fuzzy controller based on the adaptation of relative rule weights', in Proceedings of ANZIISÕ94, Brisbane, Queensland, Australia,1994, pp 204-208.