CHAPTER 1
INTRODUCTION

In today’s knowledge era, most of the people are connected through Internet. There is a high demand for sending voluminous information across computer systems. Though the networking technology is getting sophisticated in terms of its profile, ease of access, and Quality of Service (QoS) hiding many details of its intricacies, still the question is reliability and availability. With the advent of Integrated Services Digital Network (ISDN) in the Internet, the volume of traffic is increasing exponentially at a higher rate than that of technological growth. Recently a number of empirical studies on the traffic measurement showed that a variety of network traffic exhibit self-similarity and long-range dependency (J. Beran, R. Sherman, M. S. Taqqu, and W. Willinger, 1995). These network traffic characteristics, which imply time-invariant bursts, can cause serious performance degradation such as longer queuing delay and higher packet loss rate at the congested routers. Hence it makes congestion control quite complex. In addition, millions of Internet users have recently experienced Denial of Service (DoS) due to severe network congestion, which is attributed not only to traffic dynamics and volume but also due to malicious users or software. Therefore, developing an efficient mechanism that handles network congestion, whether it is naturally formed or maliciously intended, is essential for not only improving the network performance but also for providing Quality of Service (QoS) in the Internet. Although congestion issues have traditionally been considered in wired network, the need for efficient congestion control in wireless networks is quite obvious.
Recently, wireless networks based on the IEEE 802.11 standard have been widely deployed in enterprises and university campuses mostly to provide wireless data access to Laptops, Personal Digital Assistants (PDAs), etc., connected to the wired infrastructure such as Internet. However, the available bandwidth in IEEE 802.11 networks is much smaller than in wired local area networks. Therefore, the disparity in the link speed between wired and wireless networks makes the wireless access point a significant potential bottleneck in the downstream direction. Finding solutions, considering wireless networks characteristics such as longer delay and higher packet loss rate, is critical for successful deployment of wireless services. Owing to the advent of WiMax, each user could be provided with Broadband access to the air interface enabling them easy access to Internet from their mobile instruments. This in turn causes huge traffic leading to heavy congestion. Also the air interface causes the loss of data. Hence the need of the hour is to have control over the congestion and differentiate the congestion losses and air losses present in the network. The main motivation of this research is to design and analyze a novel Fuzzy logic based Active Queue Management schemes for better congestion control.

1.1 CONGESTION CONTROL MECHANISMS

Internet architects addressed congestion problems by extending the Transmission Control Protocol (TCP) scheme to incorporate congestion control mechanisms such as slow start and fast retransmit. The main idea of the TCP congestion control mechanism is to regulate the packet injection rate according to the estimated level of congestion. A TCP source detects packet loss (i.e, congestion) by monitoring the transmitted and acknowledged packets, and backs off the transmission rate to avoid successive packet
loss. If all the packets are successfully delivered, the sender slowly increases the transmission rate until it reaches the maximum rate. However, the TCP congestion control mechanism often results in congestion collapse due to delayed congestion detection and activation of the back-off mechanism, and synchronized packet transmission from different senders (V. Jacobson, 1988). Along with the TCP’s congestion control mechanism, the Internet Engineering Task Force (IETF) recommended to deploy an Active Queue Management (AQM) scheme such as Random Early Detection (RED) as documented in RFC 2309 (R. Braden., et.al 1988). Since then, several AQM schemes have been proposed to minimize the packet loss rate, to stabilize buffer occupancy, and to prevent global synchronization in the Internet (S. Floyd and V. Jacobson, 1993) (W. Feng, D. D. Kandlur, S. Debanjan, and Kang Shin, 1999). The main role of an AQM scheme is to inform senders about the onset of any congestion in order to activate the TCP congestion control mechanism before the queue overflows. The congestion control can be achieved by detecting the level of congestion accurately and deploying a packet drop mechanism. However, none of the above mentioned schemes are very effective due to the limited information about the level of congestion to quantify and inefficient design of the drop mechanism. Hence, in this thesis, it is proposed to use the linguistic variables using Fuzzy logic to specify the queue parameters and congestion control.

1.2 DIFFERENTIATED SERVICES

The next-generation Internet is expected to support a wide variety of services, such as voice, video, and data applications. Voice and video communications induce far more stringent QoS requirements than the typical sort of data applications, which
currently account for the bulk of the Internet traffic. The integration of heterogeneous services thus raises the need for differentiated QoS, catering to the specific requirements of the various traffic flows. One potential approach to achieve service differentiation is through the use of discriminatory scheduling algorithms, which distinguish between packets of various traffic streams. Because of scalability issues, it is practically infeasible to manipulate packets at the granularity level of individual traffic flows in the core of any large-scale high-speed network. To avoid these complexity problems, traffic flows may instead be aggregated into a small number of classes with roughly similar features, with scheduling mechanisms acting at the coarser level of aggregate streams. With a little simplification, the majority of applications are broadly categorized into just two classes, one containing streaming traffic (e.g., audio and video communications), and the other one comprising elastic traffic (e.g., file transfers). This is a crucial element of the Differentiated Services (DS) model proposed by S.Blake et.al (S. Blake, D. Black, M. Carlson, E. Davies, Z.Wang, and W.Weiss, 1998), which defines the Expedited Forwarding (EF) class for delay-sensitive traffic and the Assured Forwarding (AF) class for traffic with some degree of delay tolerance. In view of the delay requirements, it is desirable that streaming applications receive some sort of priority over elastic traffic, at least over short time scales. However strict priority scheduling is not ideal, since it may lead to starvation of the best-effort traffic. Even temporary starvation effects may cause end-to-end flow control mechanisms such as TCP to suffer a severe degradation in throughput performance.

The Generalized Processor Sharing (GPS) discipline provides a potential mechanism for implementing priority scheduling in a tunable way, with strict priority
scheduling as an extreme option as presented by A. K. Parekh and R. G. Gallager (1993). In GPS-based scheduling algorithms, such as Weighted Fair Queuing (WFQ), the link capacity is shared in proportion to certain class-defined weight factors. By setting the weight factor for the best-effort class relatively low, one can still provide some degree of priority to the streaming applications, while avoiding starvation of the elastic traffic. Clearly, networks offering this priority services will charge users based on the priority of their traffic chosen by the user; otherwise, all users would declare their traffic as high priority and hence the above priority model would degenerate to a best-effort service. Users accessing a network might run different applications and therefore, have different service requirements regarding throughput, packet loss, and delay. User's service requirements can be characterized through utility functions. Roughly, submitting more high-priority traffic will increase the utility of an individual user. However doing so will also increase the cost that the user has to pay to the network.

1.3 DIFFERENTIATION OF CONGESTION AND WIRELESS LOSS

In a computer network with both wired and wireless environment, end-to-end loss differentiation is needed for use with congestion-sensitive video transport protocols for networks with either backbone or last-hop wireless links. Video transport protocols can take advantage of loss differentiation in two key ways. The first is the well-known performance optimization where only congestion losses are used as congestion signals, and wireless losses do not restrict the sending rate (A. Bakre and B. Badrinath, 1995) (H. Balakrishnan, S. Seshan, and R. Katz, 1995) (R. Yavatkar and N. Bhagwat, 1994). The second is to provide useful feedback to the video encoder. For example, if wireless losses are dominating, the encoder can adjust the balance between bits devoted to source
coding (representing the video) and bits devoted to channel coding (protecting the source coded bits). Song Cen et al (Song Cen, Pamela C. Cosman, and Geoffrey M. Voelker, 2003) in their research paper had focused on exploring and evaluating end-to-end Loss Differentiation Algorithms (LDA) for improving transport protocol performance. They have used User Datagram Protocol (UDP) as their basic video transport protocol, in conjunction with a congestion control mechanism extended with an LDA. For congestion control, they used the TCP-Friendly Rate Control (TFRC) algorithm as proposed by S. Floyd et al (S. Floyd, M. Handley, J. Padhye, and J. Widmer, 2000).

1.4 FUZZY LOGIC

Fuzzy logic is a branch of Computational Intelligence (CI). CI (J. C. Bezdek, 1994) (W. Pedrycz, 1998) is an area of fundamental and applied research involving numerical information processing (in contrast to the symbolic information processing techniques of Artificial Intelligence). Nowadays, CI research is very active and consequently its applications are appearing in many of the end user products. CI exhibits the properties: Computationally adaptive; Computational fault tolerance; Speed approaching human-like turnaround; Error rates that approximate human performance. The major building blocks of CI are artificial neural networks, fuzzy logic, and evolutionary computation. While these techniques are not a panacea (and it is important to view them as supplementing proven traditional techniques), a lot of interest from the academic research community (A. Sekercioglu, A. Pitsillides, A. Vasilakos, 2001), and industry (B. Azvine, and A. Vasilakos, 2000) is seen. Fuzzy Logic Controllers (FLCs) may be viewed as an alternative, non-conventional way of designing feedback controllers where it is convenient and effective to build a control algorithm without relying on formal models of the system and control theoretic tools. The control algorithm is
encapsulated as a set of commonsense rules. FLCs have been applied successfully (S. Yasunobu, S. Miyamoto, 1985) (E. Morales, M. Polycarpou, N. Hemasilpin, J. Bissler, 2001) for controlling systems in which analytical models are not easily obtainable or the model itself, if available, is too complex and highly nonlinear. In recent years, a number of research papers have been published using fuzzy logic investigating solutions to congestion control issues, especially to Asynchronous Transfer Mode (ATM) networks. A detailed survey is given in (A. Sekercioglu, A. Pitsillides, A. Vasilakos, 2001).

1.5 SCOPE AND OBJECTIVES OF THE THESIS

1.5.1 Objective

The objective of this thesis is to explore the causes and impact of congestion in the network and formulate mechanisms to avoid the congestion by introducing fuzzy rule based Active Queue Management schemes at the router and to extend to differentiated services model. Also the objective is to differentiate the congestion losses and wireless losses to have better congestion control and to make Linear Increase Multiplicative Decrease added with Fast Convergence.

1.5.2 Scope of the Thesis

The experiments conducted on the networking elements are simulated with the help of NS2 network simulation software by modifying the personality of the NS2 structure and rebuilding. However the modules that are developed could easily be migrated to the real world network environment with appropriate modifications incorporated.
1.6 OVERVIEW OF THE THESIS

Chapter 2 describes the overview of the Networking System as applicable to congestion control study and outlines the literature survey made in the relevant topics.

Chapter 3 presents the effect of Fuzzy Inference Rule applied on Adaptive Queue Management schemes such as RED, AVQ.

Chapter 4 describes the architecture of Differentiated Services Network model and the applications of Fuzzy Inference Rule on it for congestion control.

Chapter 5 outlines the procedure for differentiating the congestion losses and the wireless losses to tune the network performance in accordance with the kind of applications.

Chapter 6 presents the enhancement of LIMD model with fast convergence

Chapter 7 concludes the thesis work and suggests the directions for future work

1.7 CONCLUSION

This chapter presented the introduction to the Internet environment and the effect of excess traffic causing congestion. The types of congestion control schemes and the congestion avoidance procedures are outlined. The need for the differentiated service model is addressed. Also the distinction of the congestion losses from wireless losses is emphasized as today’s Internet has a blend of both wired and wireless connections. The next chapter presents the overall structure of the system under consideration for studying the effect of congestion control schemes and provides the brief survey of the literature in the relevant field.