A Review Paper on Congestion Control in MANETs

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Abstract*-Congestion control is a huge problem in MANET because without proper congestion control mechanisms, the quality of service deteriorates. Basically, Congestion occurs when a node is carrying so much data that the throughput (or network) may be reduced considerably under heavy load. Typical effects include packet loss or the blocking of nodes that can cause problems like deadlock or slow down the network. Many approaches have been proposed to overcome this. In this paper, we give an overview over existing proposals for congestion control approaches, explain their key Ideas and show their interrelations. The goal of this paper is to refine the congestion control technique for the differentiated services network by introducing concept of fuzzy logic to calculate packet drop probability and refining its rule-base. Fuzzy rule-base has been designed through different fuzzy based control strategies. Tuning of rule-base has been carried out with the help of neural network to incorporate changing network conditions.*

Keywords-Quality of Service (QoS), MANET, Soft Computing.

I. INTRODUCTION

Congestion Control: Congestion occurs when routers receives packets faster than they can forward. In simple terms, if, for any time interval, the total um of demands on a resource is more than its available capacity, the resource is said to be congested for that interval.

Mathematically speaking: Demand > Available Resources.

1.1. Classification of Congestion control algorithms:

There are many ways to classify congestion control algorithms:

1. By the type and amount of feedback received from the network: Loss, delay, single-bit or multi-bit explicit signals.
2. By incremental deploy ability on the current Internet: Only sender needs modification: sender and receiver need modification; only router needs modification; sender, receiver and routers need modification.
3. By the aspect of performance it aims to improve: high bandwidth-delay product networks; loss> links; fairness; advantage to short flows; variable-rate links.
4. By the fairness criterion it uses: max-mm, proportional, "minimum potential delay". [18]

1.2. Types of Congestion:

It is further divide into two types:

- Single Source
- Distributed Source

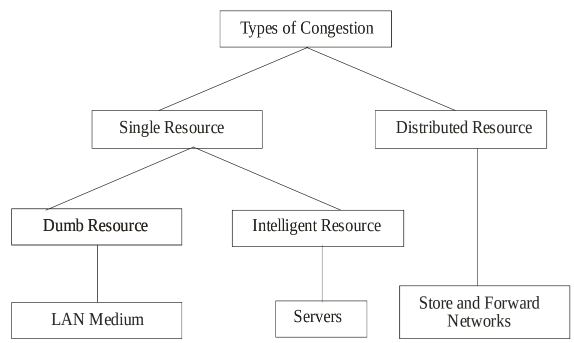

Fig. 1.1 : Types of Congestion

Congestion control is concerned with allocating the resources optimally and effectively in a network even at low load and it becomes more important as the load increases.

Ad hoc wireless networks are composed of mobile nodes communicating through wireless links, without any fixed backbone infrastructure. Frequent topology changes due to node mobility make routing in such dynamic networks a challenging problem. Moreover, successful message routing implies every mobile node is potentially capable of acting as a router, thus supporting store- and-forward mechanisms. However, resource limitations on these nodes also require a control on congestion due to message forwarding [1].

Store and forward is a technique in which information is stored to an intermediate node and sent at a later time to the final destination or to another intermediate node. The intermediate node in a networking context, verities the integrity of the message before forwarding it. In general, this technique is used in the environments requiring high mobility, and also preferable in networks where long delays in transmission and variable and high error rates, or if a direct, end-to-end connection is not available.

Bandwidth and traffic control have immerged as issues of great importance in ad-hoc wireless networks, requiring sophisticated managing techniques. Moreover, due to the increasing variety of applications and consequently respective need for bandwidth control, such issues are expected to become even more critical in the near future. Main characteristics of MANETs such as multi-hop communication and supporting dynamically varying topologies rapidly and unpredictably change or remain static over long periods of time augments the complexity of the problem as well as the need to efficiently handle it. In order to circumvent those problems, many researchers turn their attention to cross-layer design which provides the possibility to create lightweight and flexible substrate for the demanding ad-hoc wireless networks [2].

II. FRAMEWORK FOR DESIGN OF AD-HOC WIRELESS NETWORKS

In Cross-layer framework for design of ad-hoc wireless networks to support delay-critical applications, such as conversational voice or real-time video. The framework incorporates adaptation across all layers of the protocol stack to leverage the flexibility offered by joint optimization of design parameters.

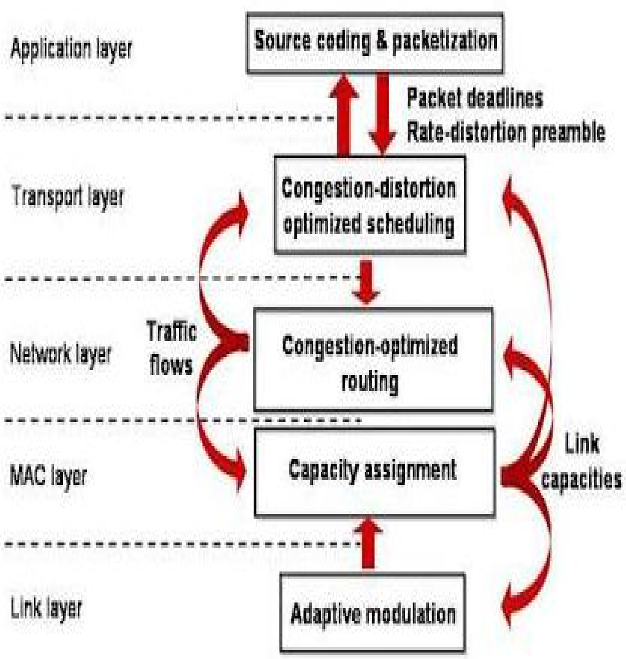

Fig. 2.1 : System diagram for the cross-layer design framework

As Fig. 2.1 shows, adaptive link layer techniques will be used to adjust the capacity of individual wireless links to support delay-constrained traffic, possibly in multiple service classes; dynamic capacity assignment in the media access (MAC) layer will optimally allocate resources among various traffic flows; a congestion-optimized routing algorithm will provide multiple paths to real-time media streams; finally at the transport and application level, intelligent packet scheduling and error-resilient audio/video coding will be optimized for low-latency delivery over ad-hoc wireless networks.

In contrast to short-term packet forwarding, medium and long-term multimedia and real-time traffic may benefit from ‘flow’-based transmission due to the reduction in the packet-level control overhead [3].

2. How to deal with this problem?

Fuzzy logic is a powerful problem-solving methodology with a myriad of applications in embedded control and information processing. Fuzzy provides a remarkably simple way to draw definite conclusions from vague, ambiguous or imprecise information. In a sense, fuzzy logic resembles human decision making with its ability to work from approximate data and find precise solutions. Unlike classical logic which requires a deep understanding of a system, exact equations, and precise numeric values, Fuzzy logic incorporates an alternative way of thinking, which allows modeling complex systems using a higher level of abstraction originating from our knowledge and experience. Fuzzy Logic allows expressing this knowledge with subjective concepts such as very hot, bright red, and a long time which are mapped into exact numeric ranges.

2.1. Using fuzzy logic-based system

A fuzzy logic-based system is proposed to deal with the congestion control and policing problem in ATM networks. There are four types of different mechanisms, Jump Window (JW), Exponentially Weighted Moving Average (EWMA), Leaky Bucket (LB) and modified Fuzzy Leaky Bucket (FLB) techniques to be identified, analyzed and simulated by the traffic parameters. The Fuzzy Leaky Bucket (FLB) modifies the token rate in accordance with the peak rate, mean rate and the burst time, which characterize the source behavior [4]. The fuzzy logic approach for congestion control allows the use of linguistic knowledge to capture the dynamics of nonlinear probability marking functions, and uses multiple inputs to capture the (dynamic) state of the network more accurately[5]. Although many Active Queue Management (AQM) has been widely used for congestion avoidance in Transmission Control Protocol (TCP) networks. Numerous AQM schemes have been proposed to regulate a queue size close to a reference level; most of them are incapable of adequately adapting to TCP network dynamics due to TCP's non-linearity and time-varying stochastic properties [6].

2.2. Using neuro-fuzzy system

A neuro-fuzzy system is based on a fuzzy system which is trained by a learning algorithm derived from neural network theory. The learning procedure operates on Local information, and causes only local modifications in the underlying fuzzy system. Rule generation from artificial neural networks is gaining in popularity in recent times due to its capability of providing some insight to the user about the symbolic knowledge embedded within the network. Fuzzy sets are an aid in providing this information in a more human comprehensible or natural form, and can handle uncertainties at various levels. The Neuro–fuzzy approach, symbiotically combining the merits of connectionist and fuzzy approaches, constitutes a key component of soft computing at this stage. To date, there has been no detailed and integrated categorization of the various neuro–fuzzy models used for rule generation. The author proposed to bring these together under a unified soft computing framework. Moreover, it include both rule extraction and rule refinement in the broader perspective of rule generation. Rules learned and generated for fuzzy reasoning and fuzzy control are also considered from this wider viewpoint. Models are grouped on the basis of their level of Neuro–fuzzy synthesis. Use of other soft computing tools like genetic algorithms and rough sets are emphasized. Rule generation from fuzzy knowledge-based networks, which initially encode some crude domain knowledge, are found to result in more refined rules. Finally, real-life application to medical diagnosis is provided.[7]

Problems with current router algorithm that use FIFO based tail-drop (TD) queue management are drawbacks with TD: lock-out, full- queue. Lock-out: a small number of flows monopolize usage of buffer capacity, Full-queue: The buffer is always full (high queuing delay). And the possible solution for these is AQM

2.3. AQM:

AQM is A group of FIFO based queue management mechanisms to support end-to-end congestion control in the Internet.

The Goals of AQM are:
1) Reducing the average queue length.
2) Decreasing end-to-end delay.
3) Reducing packet losses: More efficient resource allocation.

And the Methods are Drop packets before buffer becomes full. Use (exponentially weighted) average queue length as an congestion indicator. These are the examples for this RED, BLUE, ARED, SRED, FRED.

2.4. Random Early Detection (RED):

Random Early Detection (RED) Use network algorithm to detect incipient congestion. These are the Design goals: 1) Minimize packet loss and queuing delay. 2) Avoid global synchronization. 3) Maintain high link utilization. 4) Removing bias against busty source. And the achieve goals by RED are 1) randomized packet drop. 2) queue length averaging. The Random Early Detection (RED) algorithm for Active Queue Management (AQM) and then standardized as a recommendation from IETF. It claimed that RED is able to avoid global synchronization of TCP flows, maintain high throughput as well as a low delay and achieve fairness over multiple TCP connections. The introduction of RED stirred considerable research interest in understanding its fundamental mechanisms, analyzing its performance and configuring its parameters to fit in various working environments. [8] Active queue management (AQM) scheme that provides congestion control in TCP/IP networks using a fuzzy logic control approach.

It was implemented within the differentiated services (Diff-Serv) framework, providing quality of service (QoS). It is based on the fuzzy logic based controller proposed to provide congestion control in TCP/IP best-effort networks.[9]

III. PROBLEMS IN CONGESTION

When the Internet was first deployed many years ago, it lacked the ability to provide Quality of Service guarantees due to limits in router computing power. It therefore ran at default Q0S level, or "best effort". There were four "Type of Service" bits and three "Precedence" bits provided in each message, but they were ignored. These bits were later re-defined as DiffServ Code Points (DSCP) and are largely honored in peered links on the modern Internet.

When looking at packet-switched networks, Quality of Service is affected by various factors, which can be divided into "human' and "technical" factors. Human factors include: stability of service, availability of service, delays, user information. Technical factors include: reliability, scalability, effectiveness, maintainability, Grade of Service, etc. Many things can happen to packets as they travel from origin to destination, resulting in the following problems as seen from the point of view of the sender and receiver:

2.5. Dropped packets

The routers might fail to deliver (*drop*) some packets if they arrive when their buffers are already full. Some, none, or all of the packets might be dropped, depending on the state of the network, and it is impossible to determine what will happen in advance. The receiving application may ask for this information to be retransmitted, possibly causing severe delays in the overall transmission.

2.6. Delay

It might take a long time for a packet to reach its destination, because it gets held up in long queues, or Lakes a less direct route to avoid congestion. In some cases, excessive delay can render an application such as VoIP or online gaining unusable.

2.7. Jitter

Packets from the source will reach the destination with different delays. A packet's delay varies with its position in the queues of the routers along the path between source and destination and this position can vary unpredictably. This variation in delay is known as jitter and can seriously affect the quality of streaming audio and/or video.

2.8. Out-of-order delivery

When a collection of related packets is routed through the Internet, different packets may take different routes, each resulting in a different delay. The result is that the packets arrive in a different order than they were sent. This problem requires special additional protocols responsible for rearranging out-of-order packets to an isochronous state once they reach their destination. This is especially important for video and VoIP streams where quality is dramatically affected by both latency and lack of isochronicity.

2.9. Error

Sometimes packets are misdirected, or combined together, or corrupted, while *en route*. The receiver has to detect this and, just as if the packet was dropped, ask the sender to repeat itself.

IV. PROPOSED WORK

The goal of this paper is to refine the congestion control technique for the differentiated services network by introducing concept of fuzzy logic to calculate packet drop probability and refining its rule-base. Fuzzy rule-base has been designed through different fuzzy based control strategies. Tuning of rule-base has been carried out with the help of neural network to incorporate changing network conditions.

The other issues which have been investigated are: performance issue; Fairness, throughput, performance under various operating conditions.

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