A Literature Survey on Congestion Control Schemes for Wireless Ad hoc Networks

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Abstract – **This paper briefly discusses performance optimization challenges of Ad hoc networks and cross layer congestion control in Ad hoc network. To improve the performance of wireless network, the MAC layer uses transmission data rate based on the channel signal strength information from physical layer and congestion information from network layer. Utilization of MAC layer is sent to DSDV as a congestion aware routing metric for optimal route discovery. The simulations show that rate adaptation in MAC layer improves the network performance in terms of throughput, delivery ratio and packet transfer delay; using congestion information from MAC layer in routing discovery improves the performance of the network benefited from overall network load balance.**

***Keywords* -** MAC, NS, DSDV, DSR, RTS, CTS, NAV, IEEE 802.11, AODV, RA, CBR

I. INTRODUCTION

An Ad hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any established infrastructure or centralized administration. In such an environment, it may be necessary for one mobile host to enlist the aid of other hosts in forwarding a packet to its destination, due to the limited range of each mobile host's wireless transmissions. In the past, ad hoc networks have been primary used for the communications at battlefields and disaster arena, where a centralized infrastructure is expensive, or inconvenient, or even impossible. For instance, the sensor networks based on ad hoc multi-hop networking are applied in environmental monitoring, surveillance, and security. Now, as the novel radio technologies are growing, e.g., Bluetooth, the applications of ad hoc networking extend to commercial sectors through the interaction among various portable devices such as cellular phones, laptops. The trends of next generation wireless systems, characterized by the convergence of fixed and mobile networks and realization of the seamless and ubiquitous communications are moving to ad hoc networking.

There are a lot of research investigations being carried out in performance optimization of ad hoc networks concerning these issues. Such as efficient flooding [2], load aware routing [3], and Selective Intermediate Nodes algorithm [4], which improve the scalability and throughout of the on-demand routing protocols by avoiding unnecessary routing overhead.. However, most of the research works are based on optimization at individual layer. Optimizing a particular layer might improve the performance of that layer locally but might produce non-intuitive side effects that will degrade the overall system performance. Thus, the idea of cross-layer or interlayer networking is proposed. A number of routing protocols like Dynamic Source Routing (DSR), Ad Hoc On-Demand Distance Vector Routing (AODV) and Destination Sequenced Distance Vector (DSDV) have been implemented.

Congestion Control

Congestion is a situation in Communication Networks in which too many packets are present in a part of the subnet, performance [5] degrades. In other words when too much traffic is offered, congestion sets in and performance degrades sharply.

Factors Causing Congestion

- The input traffic rate exceeds the capacity of the output lines.
- The routers are too slow to perform bookkeeping tasks (queuing buffers, updating tables, etc.).
- The routers' buffer is too limited.
- Packet arrival rate exceeds the outgoing link capacity.
- Bursty traffic
- Slow processor

How to correct the Congestion Problem

Increase the Resource

- Using an additional line to temporarily increase the bandwidth between certain points.
- Splitting traffic over multiple routes.
- Using spare routers.

Decrease the Load

- Denying service to some users,
- Degrading service to some or all users, and

Having users schedule their demands in a more predictable way.

II. MATERIAL AND METHOD

Here we describe our congestion control scheme and cross-layer system. It consists of two schemes: (i) The Rate Adaptation scheme adapts data rate in the MAC layer based on the channel estimation information from physical layer and congestion information from network layer; (ii) Congestion Scheme congestion exploits congestion information in network layer from MAC layer.

A. Rate Adaptation Scheme

Rate adaptation is the determination of the optimal data transmission rate most appropriate for current wireless channel conditions [13]. It consists of assessing channel conditions and accordingly adjusting the rate. Rate adaptation is fairly challenging due to channel conditions fluctuations.

Channel Information

The rate adaptation scheme is implemented with a minor modification to the IEEE 802.11 MAC protocol. In this scheme, a source node sends a RTS packet before it transmits any data. When the destination node receives this RTS, it estimates the signal strength instead of SNR [6] of the transmission channel since signal strength is a more practical parameter we can get than SNR in NS-2 simulation [7]. Our goal is to design a rate adaptation scheme that provides high network performance in both congested networks and lightly-loaded networks. A preliminary step required before we can develop a new rate adaptation scheme is to identify and measure network congestion levels in real-time.

Our modification of the source code MAC 802.11 model in NS-2 can be described as following.

Bits:	4	12
	Rate	*Length*

Octets: 2	2	6	6	4
Frame Control	*Duration*	Dest Address	Source Address	FCS

(a) RTS control packet frames

Bits:	4	12
	Rate	*Length*

Octets: 2	2	6	4
Frame Control	*Duration*	Dest Address	FCS

(b) CTS control packet frames

Figure 1. RTS/CTS Frame Formats Used in RA Scheme

For the rate adaptation algorithm, we used a simple threshold based technique. In this scheme, the rate is chosen by comparing the channel quality estimation against a series of thresholds related to the available M-QAM modulation schemes [8] Power-received indication (Pr), which is the receive signal strength over received threshold, presents the channel quality estimation in the simulation. The rate is given by bi = log2 (M_i), where M_i is the constellation size of M-QAM. We set supported rate in the units of 500 kbit/s by adapting the IEEE 802.11 MAC standard. The thresholds we used in the simulation are listed in Table 1.

Rate b_i (Mbps)	Power-received indication Pr
0 (discard)	<1
1	$1 \le Pr < 40$
2	$40 \le Pr < 150$
2.5	$150 \le Pr < 1e4$
3	$1e4 \le Pr < 2e5$
3.5	$2e5 \le Pr < 1e8$
4	$1e8 \le Pr < 1e9$
6	$\ge 1e9$

Table 1. The Thresholds Used in Rate Adaptation

Accurate estimation of transmission rate usually reduces the probability of collision. Instead of using one instantaneous sample of the received signal strength of the current RTS packet [9], we estimated the signal strength by a simple moving average window (window length is 5 in our simulation) of the previous and current samples of RTS to smooth deep fading. This results in better channel usage efficiency and higher total throughput especially when the communicating nodes are moving.

Congestion Information

For rate adaptation scheme based on congestion information, we use the queue length as the congestion metric. At the sender (who sends RTS) side, when congestion happens, MAC layer try to quickly send out the packets, so it prefers to select high data rate. But the receiver (who receives RTS) side is prone to reduce the data rate to avoid more incoming packets waiting in its already congested queue.

B. Modified Congestion Scheme

Congestion Metrics

We measure the congestion information at a node by two congestion metrics [10]. One is average MAC layer utilization. The instantaneous MAC layer utilization is considered as 0 only when the medium around the node is available for beginning a transmission. We consider instantaneous MAC layer utilization at a node is 1 when the node is not idle, such as detecting physical carrier or deferring or backoff due to virtual carrier sensing. Since the instantaneous MAC layer utilization is either 1 (use) or 0 (idle), we average the value within a period (1 second in our simulation) to indicate the use percentage of the wireless medium around the node. We sample the value per 0.01 second and get the average MAC layer utilization over 100 latest samples.

Congestion Information

To use congestion information in routing protocol DSDV with QoS Routing[11], though QoS routing can manage the bandwidth resources at call setup time, network congestion due to the dynamics of mobility and of traffic patterns has to be controlled via applying selective packet dropping and input rate control, etc.

III. RESULTS AND DISCUSSION

The simulation results of stationary scenario and the pedestrian scenario under various offered load of different rate adaptation and congestion aware schemes are shown in Figure 2.

Comparison of Two Rate Adaptation Schemes

To demonstrate the performance of our MAC layer rate adaptation scheme based on both congestion information and signal strength, we compare two metrics, signal strength only and congestion aware, used in rate adaptation with the original DSDV. The dimension of the network boundary in this simulation is 300 meters × 1000 meters, the number of CBR connections is 20.

Throughput

Throughput of the routing protocol means that in certain time the total size of useful packets that received at all the destination nodes. The unit of throughput is MB/s, however we have taken Kilo bits per second (Kb/s). The throughput values obtained for the simulation is tabulated in Table-2. The graph shown in figure-2 indicates the throughput comparison of routing protocols, DSDV and DSR.

Throughput in Kbps with varying number of Nodes				
DSDV	1740.16	1733.69	1976.17	2052.04
DSR	6855.53	7935.53	8151.34	7316.86
No. of Nodes	20	50	80	100

Table.2 Throughput with varying number of Nodes.

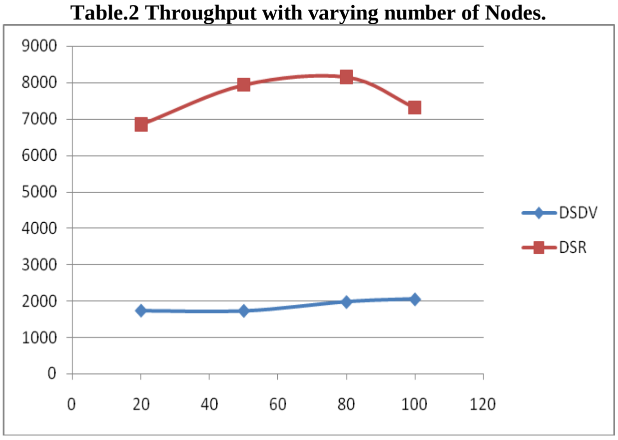

Figure 2 No. of Nodes versus Throughput

IV. CONCLUSION

The proposed model in our work is an innovative way to deal with performance optimization design challenges of ad hoc networks and how network performance can be improved by using DSDV (Ricean Fading), Rate Adaptation and Congestion Control Scheme. The results show that the rate adaptation in MAC layer improves the network performance. Using congestion information in both sender and receiver sides along with signal strength helps maximizing network capacity at MAC layer. Using congestion information from MAC layer in routing discovery improves the performance of the overall network. We reviewed the throughput comparison of DSDV and DSR Ad hoc routing protocols.

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