© 2014 IJSRSET | Volume i | Issue i | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

CROSS-LAYER CONGESTION CONTROL TO OPTIMIZE THE PERFORMANCE OF WIRELESS AD HOC NETWORK

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ABSTRACT

Wireless Ad hoc network become an emerging research area among researchers due to their flexibility and independence of network infrastructures. Ad hoc Networks are very useful in emergency search-and rescue operations, meetings or conventions in which persons wish to quickly share information, and data acquisition operations in inhospitable terrain. Also, in case of disaster or natural calamities, the deployment of a fixed infrastructure is neither feasible nor economically profitable for establishing communication among the rescue members, this paper briefly discusses the Rate Adaptation Scheme (RAS) and Congestion Control Scheme (CCS) using the DSDV Ad hoc routing protocol for wireless Ad hoc network.

To improve the performance for Wireless Ad hoc Network, we propose a cross-layer design for congestion control which includes MAC/PHY and Network protocol stack. The MAC layer adaptively selects a transmission data rate based on the channel signal strength information from PHY layer and congestion information from Network Layer. The MAC layer utilization gathered at MAC layer is sent to DSDV as a congestion aware routing metric for up-to-date route. Implementation of Congestion Control is in Network Simulator 2 (NS 2). Finally we simulate the performance evaluation of DSDV and DSR Ad hoc routing protocols in terms of Throughput, Packet Delivery Ratio and End-to-End Delay which shows the performance of the network benefited from overall.

Keywords
MAC, NS, DSDV, DSR, RTS, CTS, NAV, IEEE 802.11, AODV, RAS, CCS, CBR

I. INTRODUCTION

Wireless network is an emerging technology that allows users to access and share the information and services electronically regardless of their geographic location. Today there are many wireless devices are used like PDAs, laptops and mobiles etc.

Wireless networks can be classified in two types.

(1) Infrastructure based Network
(2) Ad hoc Network

In Infrastructure based network fixed structure is available with wired network and gateways. While in wireless Ad hoc [2] network does not have any fixed infrastructure. An Ad hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any standalone infrastructure or centralized administration. Mobile Ad-hoc networks are self-organizing and self-configuring multi hop wireless networks where, the structure of the network changes dynamically. This is mainly due to the mobility of the nodes.

Wireless network is inherently limited by battery power and bandwidth constraints. The factors affecting the wireless network are:

- Mobility
- Random changes in connectivity
- Fluctuations in channel
- Interference due to neighbouring nodes

In wireless network, it is very difficult to detect and control the congestion due to above factors. Due to these factors packet loss occurs mainly due to congestion in the network.

Congestion is a situation in Communication Networks in which too many packets are present in a part of the subnet, and the performance of wireless network degrades. So to control the congestion, we propose the cross-layer design for wireless network. 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. Inter-layer communication between layers is called the cross-layer. The cross-layer design provides the facility of information sharing.

In our propose cross-layer design, the PHY/MAC and Network layers are used. The physical layer propagates the electric or electromagnetic signal. The MAC Layer provides the means for data access mechanism and communication between mobile nodes. Currently Ad hoc routing protocols work mainly on the network layer. So to optimize the route discovery we have used the network layer with Destination-Sequenced Distance Vector (DSDV) Ad hoc routing protocol. There are a lot of research investigations being carried out in performance optimization of ad hoc networks concerning these issues.

II. METHODS AND MATERIAL

Here we describe our Rate Adaptation Scheme and Congestion Control Scheme for controlling the congestion. It consists of two schemes:

(1) 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.
(2) Congestion Control Scheme congestion exploits congestion information in network layer from MAC layer.

(1) Rate Adaptation Scheme (RAS)

Rate adaptation is the determination of the optimal data transmission rate most appropriate for current wireless channel conditions [28]. It consists of assessing channel conditions and accordingly adjusting the rate. 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 of the transmission channel. Our goal is to design a Rate Adaptation Scheme that provides high network performance in both congested networks and lightly-loaded networks. 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.

For rate adaptation scheme [13] 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.

(2) Congestion Control Scheme (CCS)

We measure the congestion information at a node by two congestion control metrics. 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 busy. To use congestion information in routing protocol DSDV [21], we modified the Routing Discovery mechanism. When an intermediate node receives a Route Request packet that is not directed to it, it then checks the congestion metrics. If the congestion metrics are higher than some thresholds, that indicates high level congestion around the node [19].

SIMULATION PROCESS

A. Simulation Process

Simulation is "the process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behavior of the network.

In a computer network simulation, a packet arrival process, waiting process, and service process are usually modelled as random processes. A random process is expressed by sequences of random variables. These random processes are usually implemented with the aids of a Random Number Generation (RNG).

B. Simulation Parameters

TABLE I
SIMULATION PARAMETERS

Sr.No	Name of Parameter	Value
1	Type of Channel	Wireless Channel
2	Channel Model	Rician Model
3	MAC Protocol	IEEE 802.11
4	Routing Protocol Studied	DSR
5	Routing Protocol Implemented	DSDV
6	Interface Queue Type	CMUPriQueue
7	Antenna Type	Omni Antenna
8	Simulation Time	200 Sec.
9	Simulation Area	500 m X 500 m

10	Transmission Range	250 m
11	Node Movement Model	Random Way Point
12	Traffic Type	CBR
13	Packet Size	512 Bytes/Packet
14	No. of Nodes	20, 30, 40, 50, 60
15	Interface Query Length	50
16	Node Mobility	20, 30, 40, 50, 60 (metre/s)

C. Traffic Scenarios

We can also define the traffic and movement pattern in separate files called CBR traffic file and **mobility file** respectively**. CBR file** can be created by using a tcl program called CBRgen.tcl.

Manually giving traffic connections for a large number of nodes would be cumbersome. So random traffic connections of CBR can be setup between mobile nodes using a traffic scenario generator script. Using this script we can generate random traffic connections between any numbers of nodes. We need to define the following to generate random traffic connections:

```
ns cbrgen.tcl [-type ##] [-nn ##] [-seed ##] [-mc ##][-rate ##]
```

D. Mobility Scenarios

The movement files are generated by using the following commands in the appropriate directory respectively.

```
./setdest -n <num_of_nodes> -p pausetime -s <maxspeed> -t <simtime> <maxx> -y <maxy>
```

The mobile nodes move according to the random waypoint model. Each mobile node begins the simulation by remaining stationary for pause time seconds. It then selects a random destination in the defined topology area and moves to that destination at a random speed. The random speed is distributed uniformly between zero (zero not included) and some maximum speed. Upon reaching the destination, the mobile node pauses again for pause time seconds, selects another destination, and proceeds there as previously described. This movement pattern is repeated for the duration of the simulation.

E. NAM file and TRACE file

After simulating the program using CBR and scenario files we can get the output in form of two files. One is called as the network animator file (NAM) and the other is called the trace file. These two files are created in the due course of running the program. Basically the two files stores the same things but in different format. NAM file stores the output in such a way that it can be used by the animator to show an animated result, and the trace file stores the output so that it can be analysed [22]

F. Simulation Results

The simulation results under various offered load of different Rate Adaptation Scheme and Congestion Control schemes

III. RESULT AND DISCUSSION

G. Performance Metrics

The second goal of this thesis is to compare the performance of the two protocols under different scenario. Comparing the different methods is done by simulating them and examining their behaviour.

The evaluation could be done in the following three metrics:

1. **Throughput** represents the total number of bits (in bits/sec) forwarded from wireless LAN layers to higher layers in all WLAN nodes of the network.
2. **Packet Delivery Ratio** defined as the number of received data packets divided by the number of generated data packets
3. **End- to- End Delay** is defined as the time a data packet is received by the destination minus the time the data packet is generated by the source.
4. **Packet Loss** is defined as dropping of packets due to congestion

H. Performance Evaluation

Performance Evaluation of DSR, DSDV Mobile Ad-Hoc Protocols on Different Scenarios: An Analytical Review [29]

1. Packet Loss Vs. No. of Nodes

Packet Loss		
No. of Nodes	**RA_DSR**	**RA_DSDV**
20	155	137
30	225	199
40	275	223
50	299	275
60	312	289

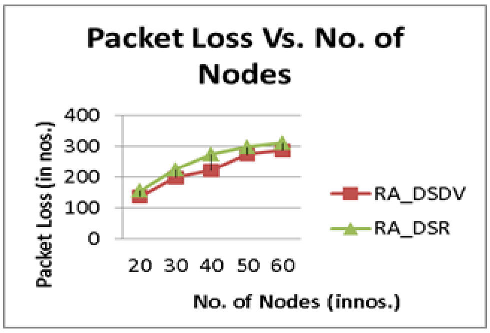

Figure1: Data Packet Loss (Dropped Packets) for DSR and DSDV

2. Throughput, Packet Delivery Ratio, End-to-End Delay vs. No. of Nodes

Throughput

Throughput		
No. of Nodes	**RA_DSR**	**RA_DSDV**
20	134.44	160.21
30	156.43	178.34
40	168.89	190.16
50	189.12	212.23
60	201.32	218.56

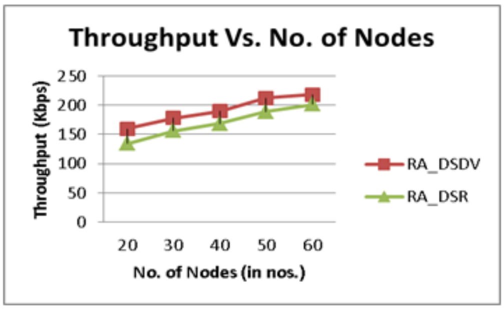

Figure2: Throughput for DSR and DSDV

Packet Delivery Ratio

Packet Delivery Ratio		
No. of Nodes	**RA_DSR**	**RA_DSDV**
20	96.43	93.77
30	92.37	89.15
40	89.23	80.47
50	85.21	79.65
60	80.33	72.18

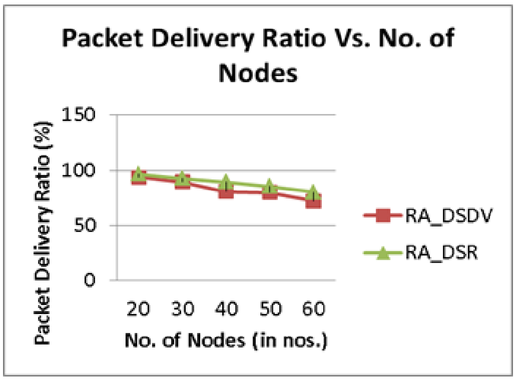

Figure 3: Packet Delivery Ratio for DSR and DSDV

End-to-End Delay

End-to-End Delay		
No. of Nodes	**RA_DSR**	**RA_DSDV**
20	171.67	174.70
30	127.75	146.895
40	173.34	193.11
50	206.10	140.519
60	233.40	142.523

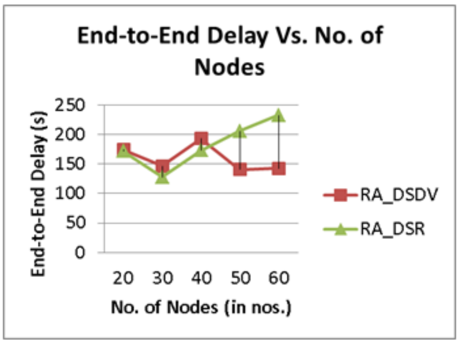

Figure 4: Average End-to-End Delay for DSR and DSDV

IV. CONCLUSION

The proposed schemes 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 Rate Adaptation Scheme and Congestion Control Scheme. Using congestion information in both sender and receiver sides along with signal strength helps maximizing network capacity at MAC layer. The results show that the Rate adaptation in MAC layer improves the network performance. Using congestion information from network layer provides up-to-date path which improves the performance of the overall network. We implemented a cross-layer congestion control in NS-2 which is a packet level simulator. We evaluated the performance comparison of DSDV and DSR Ad hoc routing protocols in terms of Throughput, Packet Delivery Ratio and End-to-End Delay performance criteria. Also we conclude that DSDV Ad hoc routing protocol provides optimized result in small area wireless Ad hoc network. At the same time, it is also true that any of the single protocol does not supersede the other one, their performance depends upon the different scenarios.

V. REFERENCES

[1] D. Bertsekas and R. Gallager, *Data Network*, 2nd ed. Upper Saddl River, NJ: Prentice Hall, Inc., 1992. [3] S. Boyd and L. Vandenberghe, *Convex Optimization*. New York: Cambridge

[2] Jochen H. Schiller, “Mobile Communications”, Pearson Education, ISBN 978-81-317-2426-2

[3] Hemant Kumar Rath Electrical Engineering IIT Bombay, Anirudha Sahoo KReSIT, Dept. of IIT Bombay, “Cross Layer based Congestion Control in Wireless Network”, 2006.

[4] S. Shakkottai, T. S. Rappaport and P. C. Karlsson, “Cross-layer Design for Wireless Network,” *IEEE Communications Magazine*, pp.74-80, October 2003.

[5] R. J. Punnoose, P. V. Nikitin, and D. D. Stancil, “Efficient Simulation of Ricean Fading within a Packet Simulator,” *IEEE Vehicular Technology Conference*, pp.764-767, September 2000.

[6] Yang, Ning,, "Congestion-aware cross-layer design for wireless ad hoc network" (2004).

[7] Guoyou He, Networking Laboratory Helsinki University of Technology “Destination-Sequenced Distance Vector (DSDV) Protocol”.

[8] T. S. Rappaport, A. Annamali, R. M. Buehrer, and W. H. Tranter, “Wireless Communications: Past events and a future perspective,” *IEEE Communications Magazine*,pp. 148-161, May 2002.

[9] A. J. Goldsmith, S.-G. Chua, “Variable-rate variable-power M-QAM for fading channels”.

[10] J. Broch, D. A. Maltz, D. B. Johnson, Y.-C. Hu, and J. Jetcheva, “A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols,” In *the Fourth Annual ACM/IEEE International Conference on Mobile Computing and Networking* (MobiCom'98), pages 85~97, October 1998.

[11] W. H. Yuen, H.-no Lee and T. D. Andersen, “A Simple and Effective Cross Layer Networking System for Mobile Ad Hoc Network,” *IEEE PIMRC,* Vol.4, pp.1952–1956, September 2002.

[12] E. M. Royer, S. J. Lee, and C. E. Perkins, “The effects of MAC protocols on ad hoc network communication,” *Proc. of IEEE WCNC'00*, Vol. 2, pp. 543-548, September 2000.

[13] G. Holland and N.Vaidya, P. Bahl, “A Rate-Adaptive MAC Protocol For Multi-Hop Wireless Network,” *Mobicom*, pp.236-251, Rome, Italy, July 2001.

[14] P. Chaporkar, A. Bhat, and S. Sarkar, “An Adaptive Strategy for Maximizing Throughput in MAC layer Wireless Multicast,” *MobiHoc’04,* pp.256-267 , Roppongi, Japan, May 2004.

[15] S.-J. Lee, M. Gerla, and C. -K. Toh, “A Simulation Study of Table-driven and On-Demand Routing Protocols for Mobile Ad Hoc Network,” *IEEE Network Magazine*, pp. 48-54, August 1999.

[16] E. M. Royer, S. J. Lee, and C. E. Perkins, “The effects of MAC protocols on ad hoc network communication,” *Proc. of IEEE WCNC'00*, Vol. 2, pp. 543-548, September 2000.

[17] Teerawat Issariyakul • Ekram Hossain,” Introduction to Network Simulator NS2” ISBN: 978-0-387-71759-3, Library of Congress Control Number: 2008928147

[18] Network Simulator Notes and Documentation, UCB/LBNL,http://www.isi.edu/nsnam/ns

[19] Lijun Chen, Steven H. Low, Mung Chiangand John C. Doyle, “Cross-layer Congestion Control, Routing and Scheduling Design in Ad Hoc Wireless Network”, & Applied Science Division, California Institute of Technology, Department of Electrical Engineering, Princeton University, USA, IEEE Journal.

[20] Kalyani Satone Bhawa Chilke M.E(E.S.C) M.E(C.S.E) M.Tech(Electronics) Suresh Deshmuk College Engineering, Wardha-42001, India. “Implementation DSDV routing protocol for wireless mobile *ad-hoc* network, using NS-2”, simulator Madhuri Pal, International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 8, October – 2012

[21] Rajeshwar Singh, Dharmendra K Singh, Lalan Kumar, “Performance Evaluation of DSR and DSDV Routing Protocols for Wireless Ad Hoc”, Network, Int. J. Advanced Networking and Applications 732, Volume: 02, Issue: 04, Pages: 732-737 (2011)

[22] Ratish J. Punnoose, Pavel V. Nikitin, and Daniel D. Stancil, “Efficient Simulation of Ricean Fading within a Packet Simulator”, Department of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh PA 15213.

[23] J.-H. Lee, S. Singh, and Y.-S. Roh, “Interlayer Interactions and Performance in Wireless Ad Hoc Network,” IRTF ANS Working Group, Internet-Draft, *draft-irtf-ans interlayer performance - 00.txt*, September 2003.

[24] C. E. Perkins and P. Bhagwat, “Highly dynamic Destination-Sequenced Distance-Vector routing (DSDV) for mobile computers,” In *Proceedings of the SIGCOMM ’94 Conference on Communications Architectures, Protocols and Applications*, pp. 234-244, August 1994.

[25] Smt. Meeta V. Prajapati ME Scholar, Dr. S. M. Shah Associate Professor, “ A Literature Survey on Congestion Control Schemes for Wireless Ad hoc Network”, INTERNATIONAL JOURNAL OF ENGINEERING DEVELOPMENT AND RESEARCH | IJEDR , ISSN: 2321-9939, Dec-2013.

[26] Marc Greis, “Tutorial for the network simulator NS2”.

[27] The Network Simulator ns-2. http://www.isi.edu/nsnam/ns/ index.html.

[28] Dzmitry Kliazovich, Fabrizio Granelli , "Cross-layer congestion control in ad hoc wireless networks", 2005 Elsevier B.V.

[29] Prof. Mohit Dua, Prof. Virender Ranga, Ms. Krishma Mehra, Mr. Pawan Kardam, Ms. Snehal Mohan Bahsakhetre,IPAJOURNALS, February 2012, ISSN 2277 – 9140

[30] Nor Surayati Mohamad Usop, Azizol Abdullah and Ahmad Faisal Amri Abidin, “Performance Evaluation of AODV, DSDV & DSR Routing Protocol in Grid Environment”, IJCSNS International Journal of Computer Science an Network Security, VOL.9 NO.7, July 2009.