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Cooperative Medium Access Control Protocol for Mobile Ad-hoc Networks using Spatial Diversity

Tazeem Ahmad Khan
Research Scholar, Department of ECE, F/o Engg & Tech., JMI, New Delhi-10025, India
E-mail: khan_taz@yahoo.com

M T Beg
Head, E & C Dept.,F/o Engg & Tech., JMI, New Delhi-110025, India
E-mail: mtbegjamia@yahoo.co.in

M A Khan
Hos/Prof., Electrical Engg Section, F/O Engg & Tech., JMI, New Delhi-110025, India
E-mail: makhan2@jmi.ac.in

Abstract— Enhancement the Performance of MANET (Mobile Ad-hoc Network) using spatial diversity. Spatial diversity implemented using cooperative transmission technique in Medium access control (MAC) layer level protocol. In noisy environment limit the network performance like coverage area, limit number of node, degrade packet transmission rate, increase packet loss rate etc. In this paper enhance the source to destination transmission range, minimize the packet loss, improve packet transmission rate and appropriate end to end delay. When direct link is fail to transmit packet then Cooperative scheme help to transmit packet. Cooperative scheme is to help the packet transmission with five handshakes instead of four. This scheme implemented in MANET network on MAC layer protocol. Cooperative scheme improve the performance with help of intermediate node between sources to destination. We are performance analysis using discrete simulator NS-2 in MANET. Our performance based on MAC layer level with cooperative scheme in IEEE WLAN standard CSMA/CA protocol.

Index Terms— 802.11, CSMA/CA, NS-2, MAC Layer, MANET

I. Introduction

In the world most demanded technology is wireless technology. Wireless technology is similar wired technology, the basic difference between wired network and wireless network is lower data link layer (MAC layer) and Physical layer protocol. In wireless network Medium access control protocol CSMA/CA instead of CSMA/CD and token ring, MAC mechanism is control the end to end transmission and reception process, also control performance parameters like throughputs, data loss, packets delivery ratio and share medium. In data transmission process MAC layer with RTS/TCS protocol to reduce collision rate using four way handshakes. In highly noise environment or fading channel condition RTS/CTS protocol less effective or transmission failed, if transmission fail due to atmospheric channel condition or distance, an intermediate nodes cooperate the transmission, it is called Cooperative transmission or cooperative medium access control protocol. Cooperative MAC is used five handshake process to avoid receiver frame decode problem, enhance the packet deliver ratio, throughputs and data loss rate. Cooperative technique based on the diversity technique, it is called spatial diversity. In this technique have a potential to improve the performance of wireless network, also appropriate for broadcast transmission. Our simulation this technique is implemented mobile ad-hoc network to enhance the performance of network [1, 2, 5, 6, 7].

This is hot area of Research cooperative transmission scheme. Researchers aim is enhancement wireless network parameters like throughputs, end to end delay, minimization energy consumption using cooperative scheme. The cooperative scheme is also implemented on physical layer level to improve the performance [11, 12, 13, 15].

This paper is organized as: Section-II Cooperative MAC scheme is help to data transmission using Spatial Diversity, Section-III Simulation and results using NS-2, Section- IV Conclusion of result analysis.

II. About the WLAN Cooperative MAC Scheme

Medium Access control is heart of wireless networks, either a centralized control or ad-hoc network. MAC is a lower sub- data link layer. MAC layer and Physical layer specification finalized by recommended

committee time to time as amendment or final report IEEE wireless standers [1, 212, 13, 15]. MAC layer base on Contention free and Contention oriented access. Contention free is a distributed channel access mechanism based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). CSMA/CA channel contention mechanism can also used with Request to send / Clear to Send (RTS/CTS) mechanism. The hidden node problem solved using RTS/CTS operation. DCF used different frame space DIFS, IFS, SIFS for transmission a frame. Time space depends on the channel condition (idle or busy). If the channel is busy, it enters a backoff procedure among contention window [1, 4,5,11, 12, 22].

Function of MAC layer mainly reliable transmission, access mechanism control, and also security [7,8, 9]. Procedure of data transmission and reception, data addressing, data fragmentation, packets formatting is depends on MAC sub-layer. Data link layer are divided upper sub layer logical link control and lower sub medium access control layer. Logical link layer is common line and wireless network. MAC layer receive data packet from logical link layer, send to physical layer [11, 12, 13,].

The cooperative scheme is based on a conventional MAC layer mechanism protocol. In centralized control wireless network is used cooperative scheme as known Coop MAC protocol. In our study is implemented this scheme to standard (IEEE 802.11) mobile wireless network to enhance the performance. In cooperative scheme procedure node transmit a packet, firstly identify cooperation scheme table to know about the rate of transmission, minimum time for one hop or two hop transmission via helper (intermediate node) and at instant select the appropriate helper. Instant selected helper received the packet from transmitting node at rate $R_1$and send to the destination node at rate R_2. Destination node is sending acknowledge to receiver node after successful reception. Cooperative scheme is extended form five-way handshake mechanism instead of four- way handshake using RTS-CTS to exchange data. When source node transmit need help to helper for transmission, it similar procedure as traditional RTS-CTS. The helper and destination node are send the message to transmitter node to use cooperative scheme. The helper node is idle, then helper inform a helper-ready to send, when it receive RTS [5, 6, 7].

Cooperative scheme is also enhance control schedule, all the helpers to contain required information in the cooperative scheme table. Appropriate MAC address is indexed in the table, one of them selected as a helper. The 3rd and 4th field in the table source and Destination table is store the information related helper. The cooperative scheme implemented to Mobile Ad-hoc Network is not similar as conventional wireless network. It is used cooperative diversity. MAC layer operation response time is better as compare to conventional MAC layer and information easily access from physical layer [5, 20, 23].

When a node has M bytes data send to another node, first check the table and find all helper to transmission time and select minimum time transmission helper. Total transmission time is source-to-helper and helper-to-destination. If source-to-helper at rate Ra_1 and helper-to-destination Ra_2 then total transmission time is

$$Total\ transmission\ time = \frac{8*W}{Ra1} + \frac{8*W}{Ra2} \quad (1)$$

If source-to-destination at rate Ra, transmission time 8*W/Ra, then we want to transmission time less than 8*W/Ra.

$$\frac{8*W}{Ra1} + \frac{8*W}{Ra2} < \frac{8*W}{Ra} \quad (2)$$

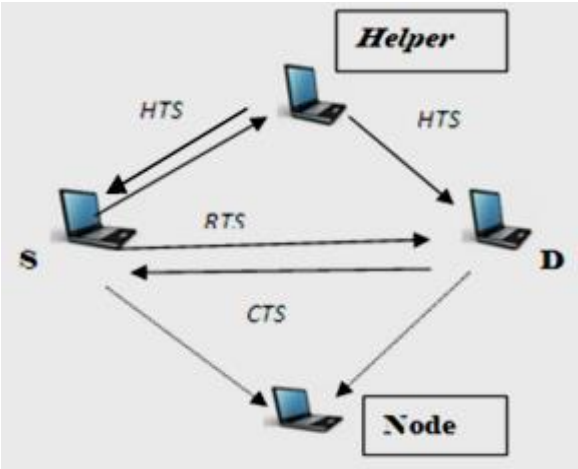


Fig. 1: Cooperative scheme of control packet Exchange technique

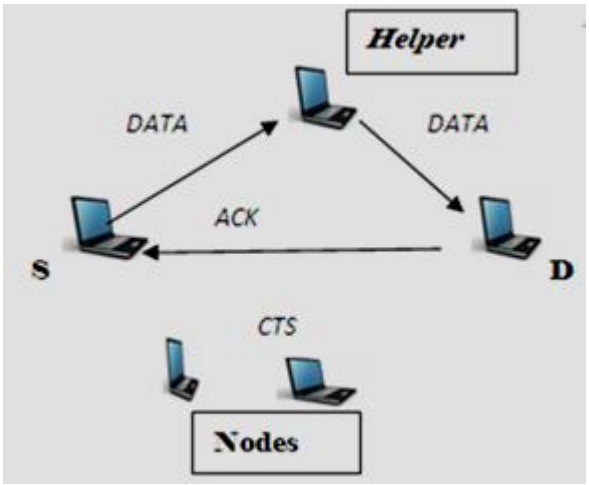


Fig. 2: Cooperative scheme of data and exchange technique ACK packet

Cooperative scheme procedure is show in the Figure 1 and Figure 2 In the figure1.shows control packet exchange procedure, when source node send a control packet RTS and helper received RTS, then helper reply

helper-ready-to-send to source and destination. In Figure 2 show data and acknowledge packet exchange procedure, when source node send a data packet via helper to destination, then destination acknowledge directly to source node after successful received packet [5, 6,7,13, 20, 21].

III. Simulation and Performance Evaluation

The cooperative scheme implemented and in mobile ad-hoc network by mean of NS-2 simulator. A network model for MANET show in Figure 3 it consist of 7 nodes, all nodes are mobile except source node. The movement of node for 40 sec is defining as follow:

$ns at 0.0 "$node_(0) setdest 100.0 100.0 500.0"

$ns at 0.0 "$node_(1) setdest 150.0 250.0 500.0"

$ns at 0.0 "$node_(2) setdest 300.0 300.0 500.0"

$ns at 0.0 "$node_(3) setdest 500.0 300.0 500.0"

$ns at 0.0 "$node_(4) setdest 400.0 300.0 500.0"

$ns at 0.0 "$node_(5) setdest 100.0 400.0 500.0"

$ns at 0.0 "$node_(6) setdest 600.0 150.0 500.0"

$ns at 1.0 "$node_(1) setdest 050.0 250.0 500.0"

$ns at 1.0 "$node_(2) setdest 200.0 250.0 500.0"

$ns at 6.0 "$node_(2) setdest 300.0 300.0 500.0"

$ns at 3.0 "$node_(4) setdest 500.0 250.0 500.0"

$ns at 1.0 "$node_(5) setdest 200.0 400.0 500.0"

$ns at 3.0 "$node_(5) setdest 400.0 300.0 500.0"

$ns at 5.0 "$node_(5) setdest 350.0 150.0 500.0"

$ns at 6.0 "$node_(5) setdest 250.0 150.0 500.0"

$ns at 7.0 "$node_(5) setdest 250.0 100.0 500.0"

$ns at 8.0 "$node_(5) setdest 100.0 400.0 500.0"

$ns at 4.0 "$node_(6) setdest 500.0 100.0 500.0"

……..continue to 40 sec.

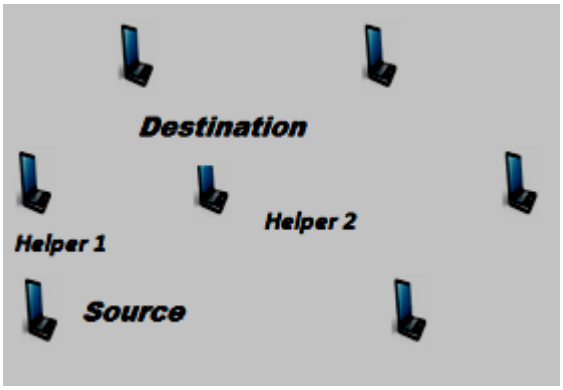
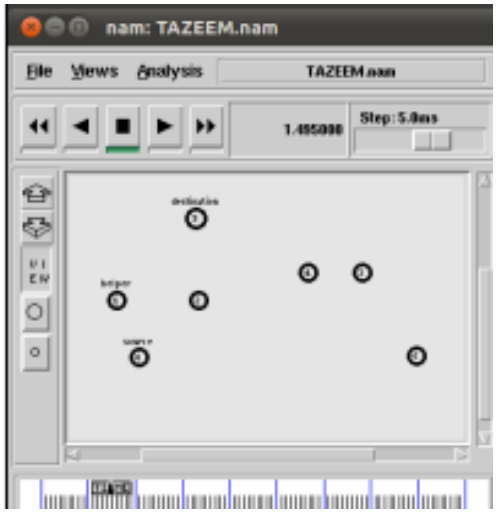
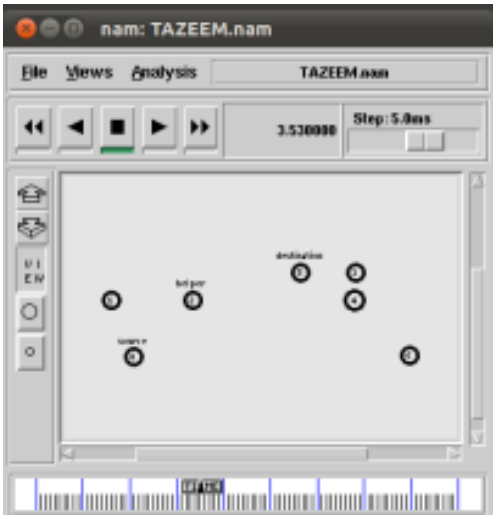


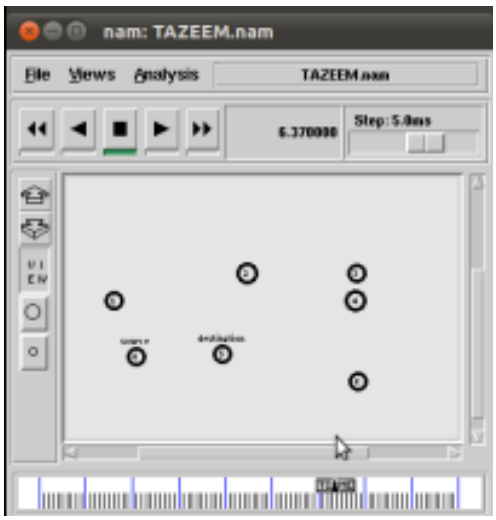
Fig. 3: Network model of Mobile Ad-hoc Network



(a) Node 0 to 5 with helper Node 1



(b) Node 0 to 5 with helper Node 2



(c) Node 0 to 5 with direct transmission

Fig. 4: The cooperation is initiated when the potential cooperative link can satisfy the target data rate which the direct link cannot satisfy. Therefore, it will be automatically connect appropriate helper

Open source and commercial simulator are available for different network & protocol. NS-2 is a open source and wireless IEEE 802 standard supported [21]. Recently NS-2 added Extension of MAC and PHYICAL layer module, which have major modification and higher level accuracy [4]. New module has been added to enhance the performance and accuracy. In NS-2 also specified receiver threshold and carrier threshold as per carrier sense ranges & bit error frames. In this simulator have different class Error-Model, error precise in term of bits or frames. About the error bits or frames will know receiver agents and its handle. It is also randomly generate specific error using TCL script.

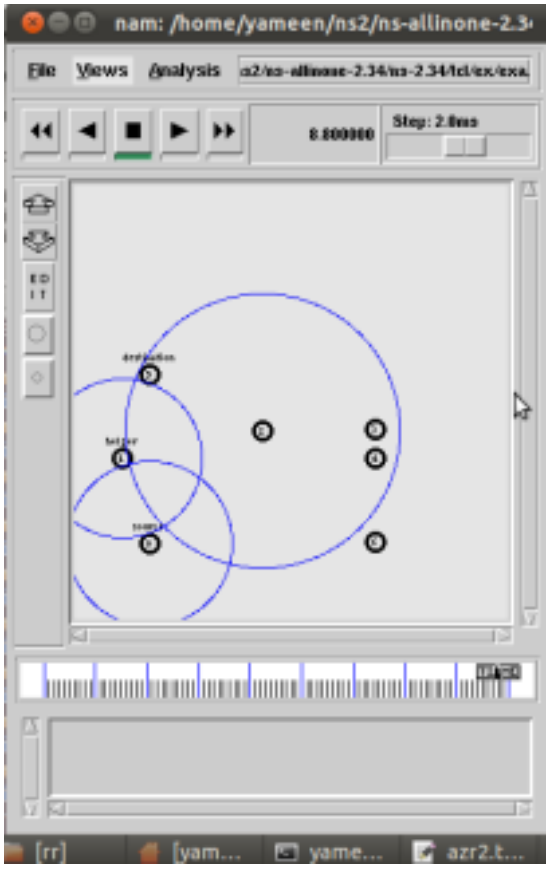
$err set rate_ 0.05, .10 and 0.15

Our experiment conduct is based on a standard 802.11g mobile ad-hoc network and set the simulation parameters. MAC layer are set payload 2500 and 2000 bytes, RTS 37bytes, CTS 31 bytes. Physical layer are set basic rate 6Mbps, data rate 802.11g standard, acknowledgement 31 bytes. We are use recently added module MAC layer and Physical layer in NS-2 simulator, which is supported cooperative scheme to enhance the performance of mobile Ad-hoc network using five handshake. Our experiment some modification in the files as signal-to interference –noise ratio, monitoring in respect to power. Format parameters in MAC and physical protocol listed in table 1.

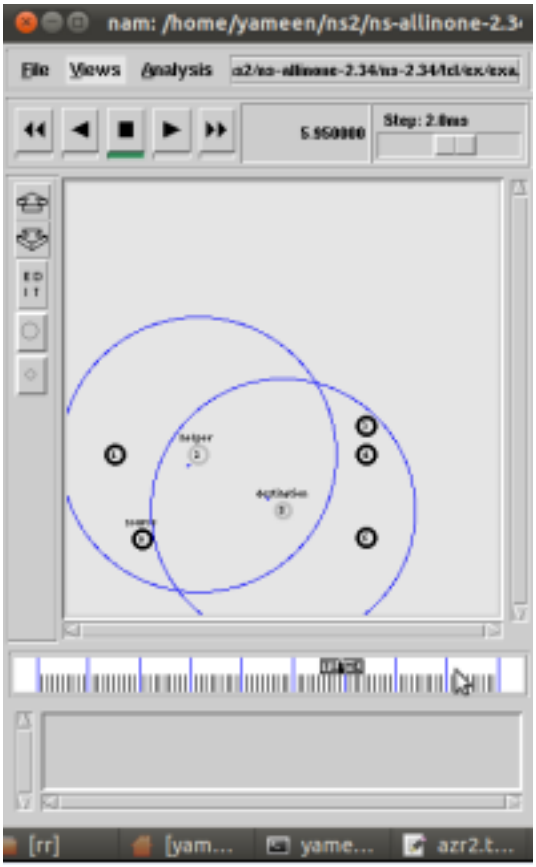
Table 1: Simulation Parameters

No of nodes	07
Slot time	9us
CCA time	3us
SIFS	16us
DIFS	28us
Preamble Length	96 bit
PLCP Header Length	40 bit
PLCP Data Rate	6 Mbps
Max Propagation Delay	5us
Short Retry Limit	7
Long Retry Limit	4
Header Duration	40us
Symbol Duration	8us
RTS Threshold	2346
CW Min	15
CW Max	1023
Rx Tx Turn around Time	2us
Data Rate	54 Mbps

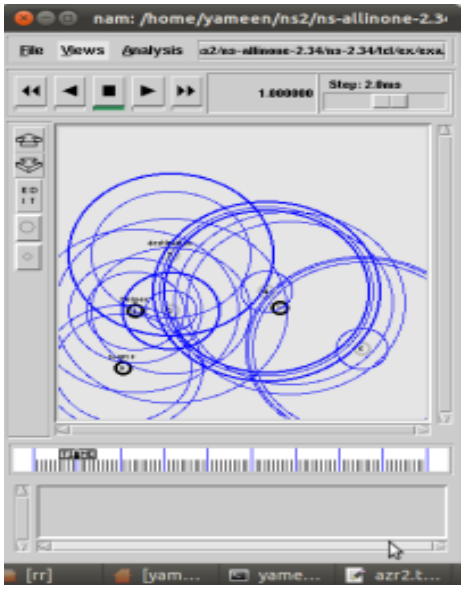
We simulate the purposed scheme as per given parameters, Figiure4 shows NS-NAM Screen shot cooperative scheme.



(a) Node 0 to 5 with helper Node 1



(b) Node 0 to 5 with helper Node 2



(c) Node 0 to 5 with direct transmission

Fig. 4: NS-NAM Simulated Network Topology (a) Node 0 to 5 with helper Node 1 (b) Node 0 to 5 with helper Node 2 (c) Node 0 to 5 with direct transmission

Table 2: End-To-End Delay for Different Error Rate

Simulation Time	E-T-E_ delay=5% error_rate	E-T-E_ delay=10% error_rate	E-T-E_ delay=15% error_rate
0s	0	0	0
2s	0.0050803	0.005040555	0.00505366
4s	0.0050648	0.005051855	0.00531692
6s	0.0049973	0.004998888	0.00185388
8s	0.0050645	0.005061663	0.00479468
10s	0.0049989	0.005014699	0.00500013
12s	0.0052526	0.00525175	0.00527779
14s	0.0050785	0.005068383	0.00503774
16s	0.0049996	0.004997165	0.00504957
18s	0.0050587	0.005046725	0.00502494
20s	0.0050261	0.005039693	0.00505276
22s	0.0052501	0.005251201	0.00530739
24s	0.0050508	0.005049315	0.00504703
26s	0.0050028	0.005001313	0.00500554
28s	0.0050349	0.005036436	0.00503213
30s	0.0050262	0.005039517	0.00503757
32s	0.00524	0.00523915	0.00523743
34s	0.0050662	0.005052313	0.00510202
36s	0.0049975	0.004999981	0.00500152
38s	0.0050462	0.00504563	0.00503489
40s	0.0050392	0.005041054	0.00502807

3.1 End-to-End Delay

We conduct cooperative scheme experiment to analysis end to end delay for different error rate & different packet size in mobile ad-hoc networks. The effect of error model and packet size shown in Table II, Table III or in Figure 5 and Figure 6 for employed 5% error data bits, 10% error data bits & 15% error data bit and Packet size 2500 & 2000 bytes respectively in terms of end to end delay.

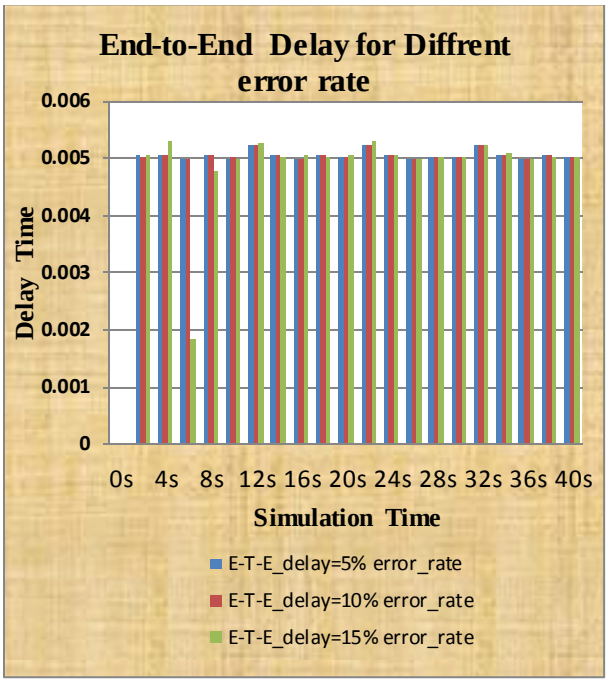


Fig. 5: Performance of mobile ad-hoc network using cooperative scheme in the form of end to end delay for different error rate

Table 3: End-To-End Delay for Different Packet Size

Simulation Time	E-T-E_ delay=Packet_ size-2500 Bytes	E-T-E_ delay=Packet_ size-2000 Bytes
0s	0	0
2s	0.0050803	0.005054403
4s	0.0050648	0.005037466
6s	0.0049973	0.005001093
8s	0.0050645	0.005035724
10s	0.0049989	0.005053049
12s	0.0052526	0.005251718
14s	0.0050785	0.005037416
16s	0.0049996	0.00499991
18s	0.0050587	0.005049728
20s	0.0050261	0.005052642
22s	0.0052501	0.005249865
24s	0.0050508	0.00503926
26s	0.0050028	0.005002726
28s	0.0050349	0.005032421
30s	0.0050262	0.005027577
32s	0.00524	0.00523768
34s	0.0050662	0.005037602
36s	0.0049975	0.005000022
38s	0.0050462	0.0050366
40s	0.0050392	0.005026532

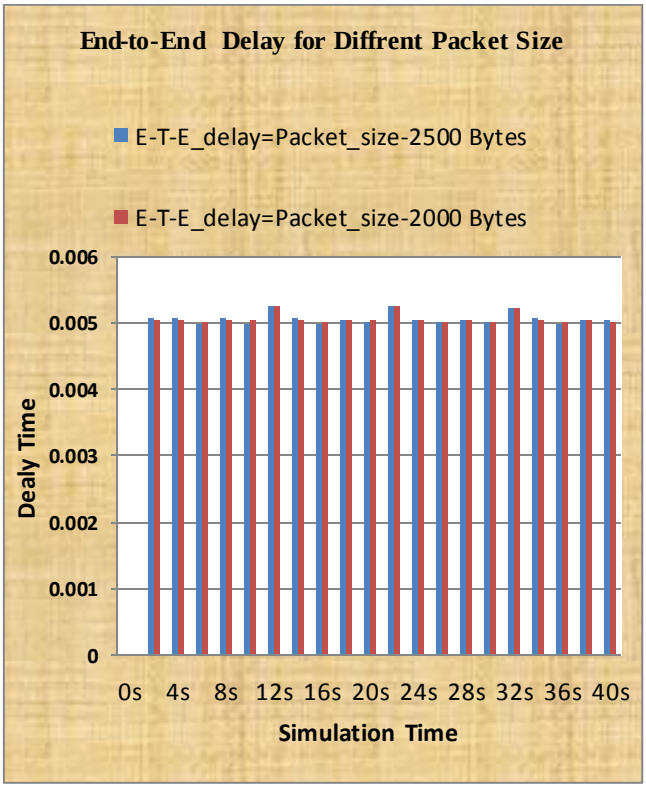


Fig. 6: Performance of mobile ad-hoc network using cooperative scheme in the form of end to end delay for different Packet Size

Table 4: Packet Loss Ratio for Different Error Rate

Simulation Time	loss_ratio1 =5% error_rate	loss_ratio2 =10% error_rate	loss_ratio3 =15% error_rate
0s	*0*	*0*	*0*
2s	*0*	*0*	*0*
4s	*0.0320197*	*0.017369727*	*0.1425486*
6s	*0.0174564*	*0.231067961*	*0.61149653*
8s	*0*	*0*	*0.19656357*
10s	*0.0031486*	*0.003140704*	*0.00764818*
12s	*0*	*0.000508388*	*0.22231172*
14s	*0*	*0*	*0.00257069*
16s	*0.0032538*	*0.00288913*	*0.16178304*
18s	*0*	*0*	*0.03331218*
20s	*0.0014057*	*0.00112328*	*0.28715107*
22s	*0.0027912*	*0.005309735*	*0.00233402*
24s	*0*	*0*	*0*
26s	*0.0027432*	*0.001477729*	*0.02372379*
28s	*0*	*0*	*0.12421053*
30s	*0.0005429*	*0.000542495*	*0.01264895*
32s	*0.0003388*	*0.001015057*	*0.01672355*
34s	*0*	*0*	*0.04894241*
36s	*0.000746*	*0.00059657*	*0.01492762*
38s	*0*	*0*	*0.0061755*
40s	*0.0005335*	*0.000533262*	*0.00054645*

3.2 Packet Loss Ratio

We conduct cooperative scheme experiment to analysis packet loss ratio for different error rate & different packet size in mobile ad-hoc networks.

The effect of error model and packet size shown in Table IV, Table V or in Figure 7 and Figure 8 for employed 5% error data bits, 10% error data bits & 15% error data bit and Packet size 2500 & 2000 bytes respectively in terms of packet loss ratio.

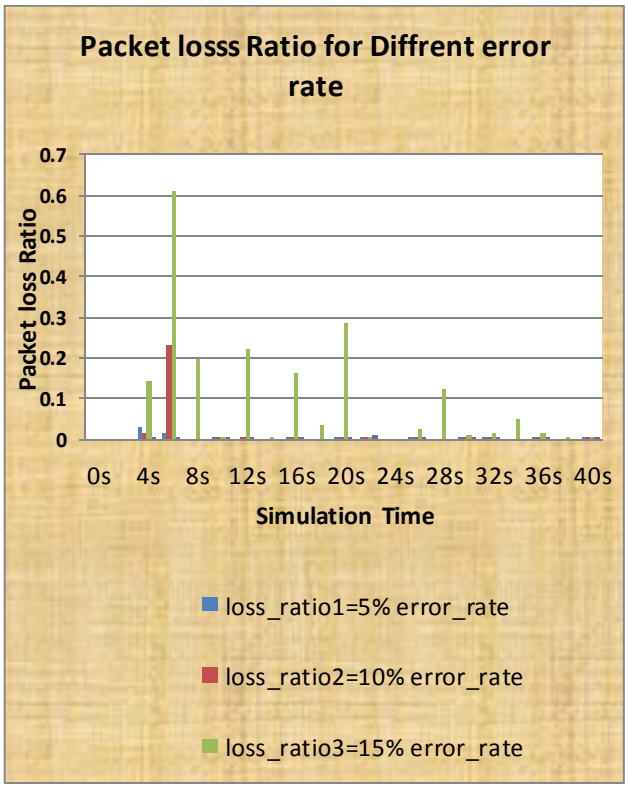


Fig. 7: Performance of mobile ad-hoc network using cooperative scheme in the form of packet loss ratio for different error rate

Table 5: Packet Loss Ratio for Different Packet Size

Simulation Time	loss_ratio= Packet_size-2500 Bytes	loss_ratio= Packet_size-2000 Bytes
0s	*0*	*0*
2s	*0*	*0*
4s	*0.0320197*	*0.0075*
6s	*0.0174564*	*0.0075*
8s	*0*	*0*
10s	*0.0031486*	*0.001882058*
12s	*0*	*0.004052685*
14s	*0*	*0*
16s	*0.0032538*	*0.001805706*
18s	*0*	*0*
20s	*0.0014057*	*0.001122334*
22s	*0.0027912*	*0.008060453*
24s	*0*	*0*

26s	*0.0027432*	*0.000633179*
28s	*0*	*0*
30s	*0.0005429*	*0.000542005*
32s	*0.0003388*	*0.000338238*
34s	*0*	*0*
36s	*0.000746*	*0.000893655*
38s	*0*	*0*
40s	*0.0005335*	*0.000532765*

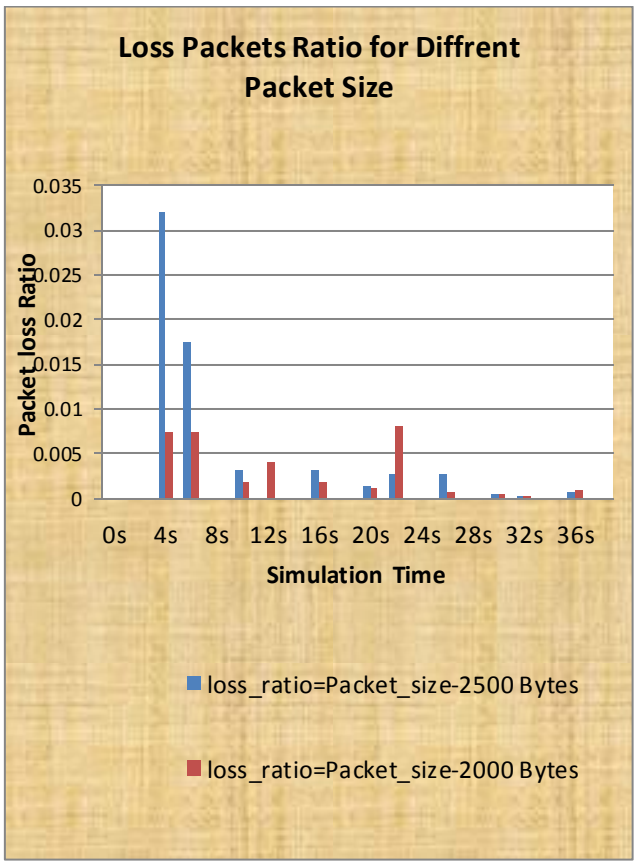


Fig. 8: Performance of mobile ad-hoc network using cooperative scheme in the form of packet Loss ratio for different Packet Size

3.3 Packets Deliver vs. Received Packets

We conduct cooperative scheme experiment to analysis Packets Deliver vs. Received Packets for different packet size in mobile ad-hoc networks. The effect of packet size shown in Table VI or in Figure 9 for employed Packet size 2500 & 2000 bytes respectively in terms of Packets Deliver vs. Received Packets.

Table 6: Packets Deliver Vs Received Packets For Different Packet Size

Simulation Time	Received Packets= Packet_size-2500 Bytes	Received_ packets= Packet_size-2000 Bytes	Expected _packets
0s	0	0	0
2s	393	397	400
4s	788	794	800
6s	1188	1194	1200
8s	1583	1591	1600
10s	1963	1966	1980
12s	2363	2366	2380
14s	2757	2764	2780
16s	3157	3164	3180
18s	3552	3560	3580
20s	3930	3938	3960
22s	4330	4338	4360
24s	4726	4735	4760
26s	5126	5135	5160
28s	5523	5532	5560
30s	5902	5911	5941
32s	6302	6311	6341
34s	6697	6708	6741
36s	7097	7108	7141
38s	7493	7504	7541
40s	7890	7902	7941

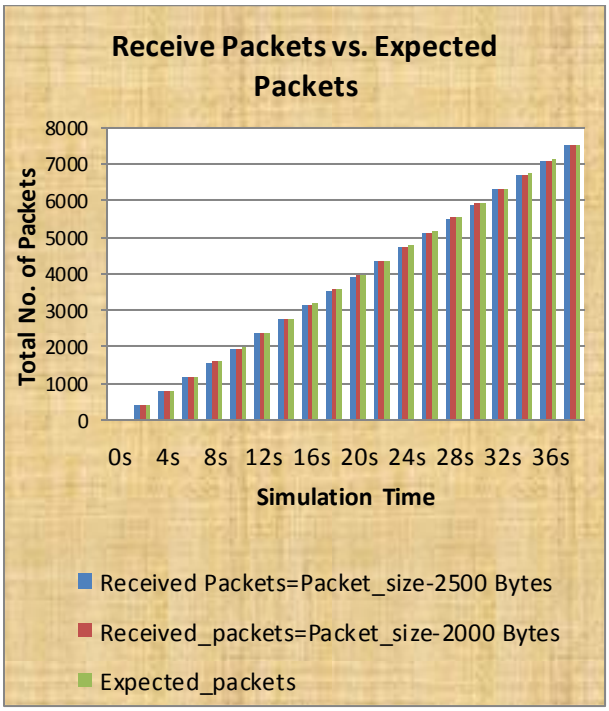


Fig. 9: Performance of mobile ad-hoc network using cooperative scheme in the form of receive packet s for different packet size vs. expected packets

IV. Conclusion

Spatial diversity implemented in Mobile Ad-hoc network using Cooperative scheme. Mobile ad-hoc network design and simulate using NS-2 simulator. Results are shown in numeric form (Tables) and graph. Results are given parameters in the form of end to end delay, packet loss ratio and packets delivers versus received packets. Performance analysis from simulation results are given in the tables, mobility of node not affected end to end delay and packet loss ratio even different error rate & different packet size shown in table II & III and tables IV & V respectively, also receive packet versus expected packets are superior in different packet size shown in table VI or figure9. Our simulation analysis taken, when direct link transmission failed, so with help of Spatial diversity using MAC layer protocol with cooperative scheme enhance the performance of mobile Ad-hoc network.

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Authors' Profiles

Mr. Tazeem Ahmad Khan is currently pursuing his Ph.D from department of Electronics & Communication Engg, Jamia Millia Islamia. He is B.E (Electronics and Communication) from Jamia Millia Islamia, New Delhi and M.TECH (Communication and Information System) from Aligarh Muslim University, Aligarh in 2001 and 2006 respectively from India. He is currently associated with AFSET as Assistant Professor in ECE Deptt.

Prof. (Dr.) Mirza Tariq Beg is currently working as a Head of Department (ECE) at Jamia Millia Islamia University, New Delhi, India. He has received B.Sc. Engg. (Electrical-low current) from Aligarh Muslim University, M. Tech. (Microwave Electronics) from Delhi University, Delhi and Ph.D. from Jamia Millia Islamia, New Delhi in 1985, 1987 and 2003 respectively from India. He has having more than 26 Years of experience in teaching & Research. He is having many publications to his credit in various international/national Journals and conferences. He had served in King Saud University, KSA also for a period of five years. His areas of interest are wireless communications, Computer Networks, Soft Computing Applications etc.

Prof. (Dr.) Mumtaz Ahmad Khan has received his B. Tech. (Electrical Engineering) from Jamia Millia Islamia, New Delhi, M. Tech. (Electrical Engineering) from Aligarh Muslim University, Aligarh and Ph.D (Electrical Engineering) from Jamia Millia Islamia, New Delhi in 1992, 1995 and 2005 respectively from India. Before joining to the academics in 1998, he served in the industry in India and in KSA around 4 ½ Years. He is involved in teaching and research since then.

Dr Khan had served BITS, Pilani-Dubai for Five years, from 2005 to 2010 as Assistant Professor, EEE and currently he is the Professor/Head of Electrical Engineering in Electrical Engineering Section, Faculty of Engg. & Technology, JMI Central University, Govt. of India. New Delhi, India. Dr Khan is having many publications to his credit in the national and international Journals and conferences. He has supervised one Ph.D. in BITS-Pilani, Dubai on Intelligent Buildings and three are under supervision in India. His areas of research are Intelligent applications in Electrical & Computer Engg, Intelligent and Energy Efficient Buildings, Wireless communications etc. He is an active member of IEEE and other national & International bodies.

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