MANET Routing Protocols Performance Evaluation with TCP Taho, Reno and New-Reno

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Abstract

The paper aims to investigate the performance of the TCP variants in MANET and its behavior with respect to different routing protocols. In the performance evaluation two different routing protocols On-Demand Distance Vector (AODV) and Optimized Link State Routing (OLSR) have been considered with three different TCP variants Tahoe, Reno and New-Reno. Different scenarios that can achieve scalability, mobility and http traffic loading investigation in MANET have been considered in the evaluation. Depending on the variables delay and throughput the performances parameters of the routing protocols are graded. Conclusions are drawn based on the evaluation results using OPNET simulator. The results clearly show that the both AODV and OLSR achieve acceptable performance. However, the merits of AODV over OLSR or vise versa depend on the network environment such as TCP variant used, traffic load, number of nodes and mobile speed together with the required parameter in the evaluation delay or the throughput. The results clearly demonstrate that the AODV and OLSR achieve the same performance under low http traffic, small size network and low mobile speed. However, as the network size increases the OLSR achieves higher throughput whereas AODV achieves lower delay. The effect of Taho, Reno and New-Reno is small compared with the effect of routing protocol. Thus the paper recommends the use of expert system that can choose the optimum routing protocol for the required condition.

Keywords: *MANET, MANET Routing Protocols, AODV, OLSR, OPNET, TCP Taho, TCP Reno and TCP New-Reno.*

1. Introduction

MANET has been gradually exploited the world as one of the most familiar wireless communication network. This achievement makes the communication companies and many of research and development institutes to introduce many development in MANET in an attempt to enhance the performance and put more features to this service [1]. However, the dynamic topology of such network suggests the use and development of various routing protocols that will enhance the reliability of such advanced communication network. This is because routing protocols play an important role in the enhancement of MANET reliability. Thus different routing protocols have been proposed and have witnessed a remarkable development over the years [1]. In the development always MANET performance have been investigated for different number of nodes, different mobile speed and different traffic load and types [2, 3].

The distributed nature of the MANET and their link stability posed critical challenges in the design of routing protocols [4]. Furthermore, in the investigation of routing protocol, it is necessary to select best candidate from proactive and reactive routing protocols, such as OLSR and AODV, respectively [5]. In the performance evaluation, it is important to compute the delay and throughput metrics by using OPNET simulation. In the simulation, the paper presents the design and implementation of network scenarios by varying the number of nodes in the networks, the mobile node speed and HTTP traffic loads to investigate its impact on the protocols performance. This will identify the merits of each routing protocol in each case investigated. Finally, since HTTP traffic uses TCP as its transport protocol, the paper will investigate the impact of different variants of TCP transport layer protocol, Taho, Reno and New-Reno on the performance of MANET routing protocols [6].

2. TCP variants

TCP is transport layer is the reliable connection orientated protocol that provides reliable transfer of data between the nodes. It ensures that the data is reached the destination correctly without any loss or damage [7]. The data is transmitted in the form of continuous stream of octets. The reliable transfer of octets is achieved through the use of a sequence number to each octet. Another aspect of TCP is the tree way handshakes mechanism to establish a connection between the nodes. Furthermore, TCP uses the port assignment as an addressing mechanism to differentiate each connection for the cases of more TCP connection between nodes are required. After the introduction of first version of TCP several different TCP variants exist. The most famous implementation of TCP called Tahoe, Reno and New-Reno [3].

2.1 TCP Tahoe

Congestion control plays an important role in flow control objective in transport layer protocol TCP. In the TCP Taho, congestion control algorithm is introduced in the original TCP with slow start, congestion avoidance and fast retransmits procedures [7]. Initially, slow-start procedure is initiated after a packet loss had been detected with the congestion window set to 1. This will work as a TCP connection starts or re-starts to avoid the initial burst and the connection might never get started. After each acknowledgment received, the congestion window CWD will be increased by 1 and the congestion condition is raised as the number of packets sent is increased exponentially. Having encountered congestion, the sending rate is decreased and the CWD is reduced to one to start over again. Thus, Tahoe can detect packet losses by time-outs. With occasionally checks for timeouts, costly repeated interrupt will be avoided. This can be used to retransmit packet before a packet loss is observed [7].

In congestion avoidance procedure Additive Increase Multiplicative Decrease will be employed. The procedure is started when congestion is noticed after packet loss is observed. In this case half of the current window will be saved as a threshold value. Next, slow start phase will be operated with CWD set to 1 until it reaches the threshold value. The CWD will be incremented linearly until it encounters a packet loss. On the receipt of 3 duplicate ACK's, a sign that the segment was lost is indicated. The segment can be retransmitted without waiting for timeout. In this case the Taho enters the fast retransmit procedure [7]. Finally, whenever segment loss is indicated, fast retransmit procedure started. This is occurred whenever 3 duplicate ACK's received.

2.2 TCP RENO

The TCP Reno can be considered as an enhancement of the TCP Tahoe. In the enhancement fast retransmit procedure has been enhanced through the inclusion of fast recovery [7]. TCP Reno improves the TCP Taho performance for the single packet loss within a window of data except multiple packet losses case within a window data. The congestion window size is halved and linearly increased like congestion avoidance case. The increase in transmission rate is slower than that observed in slow start adopted in Taho to relieve congestion [8]. Finally, the enhancement prevents the communication path from going empty after fast retransmit procedure. This will avoid the need for the slow start procedure.

Due to buffer overflow, packet may be lost in congested link. In this case which, the sender will receive three duplicate acknowledgments or the sender retransmission timeout (RTO) timer will be expired. In the former case, fast retransmit and recovery algorithm will be used by the sender to reduce the congestion window to half size. Next, the congestion window will be increased linearly and can assist in congestion treatment. On the other hand and for the case of single packet loss in a window, TCP Reno can improve the performance through the use of fast recovery, whereas for multiple packet loss, TCP Reno performance will be degraded [8].

2.3 TCP New-Reno

TCP New-Reno is a modification of the TCP Reno through the use of retransmission process. This is occurred in the fast recovery phase of the TCP Reno. In the improvement, TCP New Reno can detect multiple packet losses. Furthermore, through the period the fast recovery, all unacknowledged segments received and the fast recovery phase is terminated [9]. Having achieved this modification, several reductions in the congestion window size will be avoided in the cases of multiple packet losses occurrence. Furthermore, the congestion window size is set up to slow start threshold the congestion avoidance phase will be resumed and next segment will be retransmitted when partial acknowledgment is received [8, 10]. It is worth to mention that, in partial acknowledgments, all outstanding packets at the onset of the fast recovery are not necessarily acknowledged [8, 11].

3. Routing in ad hoc networks

In mobile ad hoc networks (MANET), each node is responsible to handle its operation independently with a dynamic topology. This makes MANET flexible and easily deployed [7]. Furthermore, it has been shown that TCP performances are also very poor in mobile ad hoc network [12]. Thus there will be need of an efficient routing protocol to enhance the performance and increase its reliability [7]. Routing protocols might be reactive or proactive protocols. With reactive routing protocols permanent routing information is not kept by these protocols and routes are built when the source needed since route request is sent across the network to achieve this. Reactive routing protocols, such as AODV, are well planned for MANET [7]. However, proactive protocols have to construct and maintain fresh routing information for the whole nodes in the network. One of the main advantages of proactive routing is easily routing information session set up are obtained. These proactive protocols have two main disadvantages that include the large size of data to be stored in the node to protect the route and the slow restructuring at the failure in link exaction [7]. Furthermore, Proactive routing protocols, such as OLSR, are not well organized in bandwidth [13].

3.1 Ad Hoc On-demand Distance Vector (AODV)

AODV is a reactive routing protocol designed to reduce the control traffic messages overheads via maintaining information for active routes only. This has been achieved at the cost of increased latency to find the new routes. In AODV routes are determined and maintained for nodes that require sending data to a particular destination. Having found the route to the destination, a route reply is sent back to the source node [1]. The route discovery is achieved via flooding (route request packets through the network). In AODV, source routed on-demand protocol; each data packets carry the complete source to destination address. Furthermore, each intermediate node forwards the packets according to the information kept in the packet header. This will avoid the storage and update of routing information for each active route and avoiding the forwarding of packet towards the destination. Thus, it can be said that AODV is table based with all the information about the routes in the network is stored in this table. The routing table has the following entries i.e. DSN, flag, next hop, IP address, State, hop count, the list of precursors, Life time and network interface [1]. Furthermore, nodes do not need to maintain neighbor connectivity through periodic beaconing messages. The major benefit of this type of reactive routing is that routes are adaptable to the dynamically changing environment such as MANETs. This is because AODV is based on Dynamic Source Routing DSR algorithm and each packet carry the full address from source to the destination. This suggest that AODV has an advantages since each node can update its routing table when they receive fresher topology information and hence forward the data packets through the new and better routes. However, the performance in large networks is bad. This is because the number of intermediate nodes in each route grows and the raise of the probability of route failure. AODV uses the periodic beaconing and sequence numbering procedure of Dynamic Source Distance Vector DSDV and a similar route discovery procedure as in DSR. Finally, the AODV protocol is a loop free that avoids the counting to infinity problem by the usage of the sequence numbers [5].

The transmission of data traffic in AODV is first initiated by source node through a route discovery process by broadcasting a Route Request (RREQ) packet. The forwarding of packet is continued to their neighbors until an active route is found or the maximum number of hops is reached. The Time-To-Live TTL is used to give the number of hops for a particular routing message. When an intermediate node knows an active route to the requested destination node, it sends a Route Reply (RREP) packet back to source node to open the route. However, when source node receives a route error (RERR), it can reinitiate route if the route is still needed. Neighborhood information is obtained from broadcast Hello packet to detect and monitor links to neighbors. In this case, each active node periodically broadcasts a Hello message to all its neighbors receive. A link break can be detected if a node fails to receive several Hello messages from a neighbor [13].

3.2 Optimized Link State Routing protocol (OLSR)

OLSR uses flooding in its simplest form to diffuse topology information throughout the network. This makes all the nodes in the network should retransmit received packets. However, this may lead to loop. This can be avoided by using a sequence number in each packet transmitted. The sequence number is used to guarantee that the packet is not transmitted more than once time. Furthermore, the sequence number must registered by receiving nodes to achieve the reliable transmission. However, the packet will not transmitted when the node receives a packet with a sequence number lower or equal to the last registered retransmitted packet from the sender. With multi-hop wireless network, nodes may retransmits packets on the same interface that it arrived. This is because of condition and properties of wireless multi-hop networks [7]. However, duplicated packet may be received from symmetric neighbor.

OLSR is a part of link state algorithm with proactive routing protocol optimized for mobile ad hoc networks. It has an advantage of having routes available when needed due to its proactive nature [14]. The Multipoint Relay (MPR) can be used to retransmit control messages with the aid of selected nodes. This will reduce the overhead in the OLSR and the number of retransmissions in the flooding. Other feature of OLSR, shortest path routes is computed using partial link state provided. The reactivity in to topology change can be optimized in OLSR via maximum time interval for periodic control message transmission reduction. It is worth to mention about the good features of OLSR that the protocol is performing very well with heavy and dense network. This is because OLSR routes to all destinations in the network are continuously maintained. Furthermore, overhead and complexity in OLSR have been reduced since there is no need for sequenced transmission of messages. In stead, OLSR have a control message for each message with a sequence number increased by one. Therefore, the receiver can rearrange the messages according to the control messages, HELLO and Topology Control (TC) messages, received in the case of any reordering occurred [14]. The main difference between these two control messages is that Hello message is sent only one hop away whereas TC message is flooding the messages throughout the entire network [14].

In OLSR, link status and neighbors nodes can be checked through the HELLO messages which to form the MPR selector. The importance of MPR is in the identification neighbor nodes that selected the node to act as MPR. Having found that, it is possible to compute own set of MPRs. Finally, details on the self advertised neighbors that contain MPR elector list can be found through the control message TC. This control messages sent to all nodes periodically and the associated MPR hosts can forward the TC messages [14].

4. MANET Simulation and Evaluation

In this section, the simulation model of the new opportunistic routing protocol is introduced. The simulated MANET consists of mobile nodes that change their locations. Thus causing disruption of the communication between nodes. An intermittent connectivity and knowledge about the nodes' relative movement can be exploited in order to achieve an efficient, reliable routing. The implemented opportunistic routing model performance must be analyzed. Power consumption, data packet end-to-end delays, route length, throughput and data packet loss are the main statistics which must be taken into account when evaluating the model.

In order to ensure that this model is built according to a delay, reliability and energy efficiency tolerant opportunistic routing scheme, the comparison of simulation results with the well known AODV routing protocol is provided. A computer network simulation tool OPNET is used for finding factor which influence the network in this paper. OPNET is network simulation and analysis application software which makes a virtual simulated network environment. It provides various network protocols, topologies and devices which have been used in the real network design. It can design and simulate the network by using network components and easily compare certain network by multiple scenarios OPNET provides when designing the network, OPNET can reduce the cost and risk by implementing the virtual network before making a real network.

4.1 Simulation Scenarios

In simulation there are three type of different scenarios based on the number of nodes. In this paper, the throughput and delay of each variant of TCP have been investigated to find out which TCP variants perform better and with what type of routing protocol. In the investigation a comparison between two routing protocols AODV and OLSR with different types of TCP variants Reno, New-Reno and the Tahoe based on ad-hoc wireless networks of 3, 20 and 50 nodes with different mobility speed, and traffic load are investigated. The investigation involves the measurement of delay and throughput of the network in each of the above cases. Finally, the results achieved for each case of routing algorithm with different TCP variants, mobile speed, traffic load and number of nodes in the networks will be assessed. Table 1 shows a summary for the scenarios' considered in the investigation. To keep clear analysis, each scenario has been considered separately.

Table 1 Simulation Scenarios

TCP Variants	Routing Algorithm		No. of Nodes	Speed M/s	Traffic
Reno	AODV	OLSR	3, 20, 50	10 /28	Heavy, Light
New-Reno	AODV	OLSR	3, 20, 50	10 /28	Heavy, Light
Tahoe	AODV	OLSR	3, 20, 50	10 /28	Heavy, Light

4.2 Simulation Results and Evaluation

4.2.1 Scalability effect evaluation

In the scalability evaluation, throughput and delay measurement have been investigated with different scale network (3, 20 and 50 nodes) and different TCP variant. The throughput and delay performance comparison between AODV and OLSR with Taho TCP variant for approximately 150 seconds was measured. From the measurement, a summary table (Table 2) have been driven that show the other form of comparison between the routing algorithms. In Table 2, minimum and maximum delays and throughput in second and Mbps, respectively were tabulated to be assessed. It is clear that as the network scale is increased, the throughput decreases sharply especially with the AODV whereas slight change in the delay. However, OLSR shows more delay as the number of nodes is increased. From the summary Table 2, it is clear that the OLSR have less delay for small scale networks whereas as the network size increase AODV becomes less delay compared to OLSR. This is very clear when comparing the results of 3 and 50 nodes networks for both AODV and OLSR. From the throughput point of view, the matter is opposite. The AODV achieves better throughput for small sized network, whereas OLSR achieves better throughput as the network size is increased.

Table 2 Scalability evaluation with TCP Taho

Protocol	Nodes	Max. Delay	Min. Delay	Max. Throughput	Min. Throughput
AODV	3	0.0052	0.0024	1025	770
OLSR	3	0.0029	0.0011	1000	570
AODV	20	0.012	0.004	980	780
OLSR	20	0.025	0.007	1180	800
AODV	50	0.002	0.002	780	650
OLSR	50	0.021	0.006	1180	970

Comparison between AODV and OLSR with Reno TCP variant for approximately 150 seconds have been carried out the same as Taho. The throughput and delay performance is also measured. From the results a summary table (Table 3) have been driven that shows the other form of comparison between the routing protocols. The results for Reno are very close to that of Tahoe except the delay at high number of nodes. It is clear from Table 3 that the OLSR have less delay for small scale networks whereas as the network size increase AODV becomes less delay compared to OLSR. This is very clear when comparing the results of 3 and 50 nodes networks for both AODV and OLSR.

Table 3 Scalability evaluation with TCP Reno

Protocol	Nodes	Delay (max)	Delay (min)	Throughput (max)	Throughput (min)
AODV	3	0.0052	0.0023	1025	770
OLSR	3	0.0043	0.0012	1000	570
AODV	20	0.010	0.0042	840	780
OLSR	20	0.007	0.027	1140	799
AODV	50	0.002	0.002	780	700
OLSR	50	0.036	0.011	1090	800

From the throughput point of view, the matter is opposite. The AODV achieve better throughput for small sized network, whereas OLSR achieves better throughput as the network size is increased. It can also be observed that the performance with Tahoe is as that with Reno variant except that at large network size Tahoe achieve less delay and better throughput. Comparison between AODV and OLSR with New-Reno TCP variant for approximately 150 seconds has been carried out in the same manner as that achieved with TCP Taho. The throughput and delay performance is also measured. From the results a summary table (Table 4) have been driven that shows the other form of comparison between the routing protocols. The results with Reno are very close to that with New-Reno. Furthermore, it is clear from Table 4 that the OLSR have less delay for small scale networks whereas as the network size increase AODV becomes less delay compared to OLSR. This is very clear when comparing the results of 3 and 50 nodes networks for both AODV and OLSR.

Table 4 Scalability evaluation with TCP New-Reno

Protocol	Nodes	Delay (max)	Delay (min)	Throughput (max)	Throughput (min)
AODV	3	0.0052	0.0023	1025	770
OLSR	3	0.0043	0.0012	1000	570
AODV	20	0.015	0.005	970	880
OLSR	20	0.020	0.005	1180	800
AODV	50	0.002	0.002	780	690
OLSR	50	0.020	0.006	1090	780

From the throughput point of view, the matter is opposite. The AODV achieve better throughput for small sized network, whereas OLSR achieves better throughput as the network size is increased. It can also be observed that the performance with Tahoe is as that with New-Reno variant except that at large network size Tahoe achieve less delay and better throughput. Furthermore, It can be observed that New-Reno is better than that of Reno but can not be as good as that of Tahoe.

4.2.2. HTTP traffic effect evaluation

In the simulation environment of HTTP traffic effect evaluation, two scenarios have been implemented separately HTTP heavy traffic load and HTTP light traffic load. HTTP traffic has been selected because of its importance in the Internet applications. It has been used with Web to provide secure communication. The simulation attempts to show the effect of HTTP traffic load on the routing protocols and together with the TCP variants performance. It is assumed that the network includes 50 nodes with speed of 10 m/s. For each investigated scenarios, the performance parameters throughput and delay have been computed and tabulated as shown in Tables 5-7. The results presented show that there is a little difference in delay and throughput for the cases of light and heavy http traffic with different numbers of nodes 50. The results also clearly show that the great difference can be observed with 50 nodes in delay except with New-Reno. It is clear from Table 5 that the OLSR have less delay for small scale networks whereas as the network size increase AODV becomes less delay compared to OLSR. This is very clear when comparing the results of 3 and 50 nodes networks for both AODV and OLSR. From the throughput point of view, the matter is opposite. The AODV achieve better throughput for small sized network, whereas OLSR achieves better throughput as the network size is increased. It can also be observed that the performance with Tahoe is as that with New-Reno variant except that at large network size Tahoe achieve less delay and better throughput. Furthermore, it can be observed that New-Reno is better than that of Reno but can not be as good as that of Tahoe.

Table 5 Impact of HTTP traffic on the routing protocol performance with TCP Taho and 50 Nodes in MANET

Protocol	Delay (max)	Delay (min)	Throughput (max)	Throughput (min)
AODV (High)	0.0021	0.0017	730	680
AODV (Light)	0.0030	0.0024	750	700
OLSR (High)	0.0021	0.006	1150	900
OLSR (Light)	0.0012	0.007	1150	890

Table 6 Impact of HTTP traffic on the routing protocol performance with TCP Reno and 50 Nodes in MANET

Protocol	Delay (max)	Delay (min)	Throughput (max)	Throughput (min)
AODV (High)	0.0020	0.0017	750	730
AODV (Light)	0.0026	0.0014	680	630
OLSR (High)	0.036	0.011	1300	800
OLSR (Light)	0.015	0.008	1350	770

Table 7 Impact of HTTP traffic on the routing protocol performance with TCP New-Reno and 50 Nodes in MANET

Protocol	Delay (max)	Delay (min)	Throughput (max)	Throughput (min)
AODV (High)	0.0018	0.0016	720	690
AODV (Light)	0.0011	0.0009	690	640
OLSR (High)	0.0018	0.0016	1150	800
OLSR (Light)	0.0011	0.0009	1150	700

4.2.3 Mobility effect evaluation

In the simulation environment of mobile speed effect evaluation, two mobile speed have been considered 10 and 28 m/s. The same simulation scenarios used for OLSR and AODV routing protocols evaluation for network size and HTTP traffic effect were also used in mobile speed evaluation. It is worth to mention that the campus area under investigation is 1000 meters x 1000 meters dimension. The results of these simulation scenarios are as shown in Tables 8-10. In all the simulation scenarios, the delay and throughput performance metrics are computed and assessed. To give a clear idea about the performance all the aspects of parameters that might affect have been considered together. However, for presentation point of views, only the results of 50 nodes, heavy http traffic are considered. In Tables 8-10, the delay and throughput are presented with mobile speed 10 and 28 m/s for the OLSR and AODV protocols with Tahoe TCP variant. The same performance is measured for Reno and New-Reno TCP variants The results show that as the mobile speed increased from 10 to 28 m/s, the throughput is not that affected. However, the delay is significantly affected especially with Reno and New-Reno. It is clear, that the OLSR achieves better performance than the AODV routing protocol and that the mobile speed affect more the throughput compared to the delay. Furthermore, the maximum throughput obtained with OLSR is higher than that with AODV and the minimum delay with AODV is better than that with OLSR. The above observations are with Tahoe TCP variants whereas the results with Reno is as shown in Table 9. It is clear that the mobile speed has more impact on the OLSR compared with the AODV.

Table 8 Impact of mobile speed on routing protocol performance with TCP Taho and heavy traffic

Protocol	Delay (max)	Delay (min)	Throughput (max)	Throughput (min)
AODV(10m/s)	0.0040	0.0020	750	690
AODV (28m/s)	0.0025	0.0020	720	690
OLSR(10m/s)	0.031	0.008	1170	770
OLSR (28m/s)	0.032	0.013	1100	850

Table 9 Impact of mobile speed on routing protocol performance with TCP Reno and heavy traffic

Protocol	Delay (max)	Delay (min)	Throughput (max)	Throughput (min)
AODV(10m/s)	0.0020	0.0016	690	670
AODV(28m/s)	0.0026	0.0020	710	680
OLSR(10m/s)	0.011	0.004	1150	570
OLSR (28m/s)	0.005	0.003	1150	640

Table 10 Impact of mobile speed on routing protocol performance with TCP New-Reno and heavy traffic

Protocol	Delay (max)	Delay (min)	Throughput (max)	Throughput (min)
AODV(10m/s)	0.0023	0.0017	700	670

AODV(28m/s)	0.0022	0.0015	650	590
OLSR(10m/s)	0.017	0.005	1050	800
OLSR (28m/s)	0.027	0.014	1050	900

5. Conclusions

In this paper the performance analysis of routing protocols OLSR and AODV protocols in MANET have been investigated. The investigation consider the impact of scalability, mobility, network http traffic load on together with the Tahoe, Reno and New-Reno TCP variants on the network performance. In the performance assessment delay and throughput are adopted for the whole scenarios considered. The simulation using OPNET consider different scenarios that attempt to cover all of the aspects on network evaluation required. The following outcomes can be extracted from the simulation results;

1. In the investigation of the impact of scalability, the results conclude that small sized network has no significant different between all the scenarios considered in the investigation. However, as the number of nodes increased to 50, the OLSR protocol achieves better performance compared to AODV protocol from the throughput points of view. The matter is different when considering the delay as a performance parameter.
2. The AODV will be the recommended protocol when traffic load is increased.
3. The mobile speed increase has no effect on the behavior of routing protocols and TCP variants.
4. It is hard to say which routing protocol is best since this depends on the network conditions. Thus, the investigation suggests the importance of intelligent system usage in the network operating system. The intelligent system will select the routing protocol according to the network conditions that include TCP variant used, HTTP traffic load type, network size and mobile speed. This is because as the results and mentioned that AODV performs better in certain conditions and with other condition the OLSR achieves better. Furthermore, which performance parameter required need to be the optimum, delay or throughput?

References

[1] Y. Kim, IL. Moon and S. Cho: A Comparison of Improved AODV Routing Protocol Based IEEE802.11 and IEEE802.15.4", Journal of Engineering Science and Technology Vol. 4, No. 2, 2009, pp. 132 - 141

[2] V. Talooki and K. Ziarati, "Performance Comparison of Routing Protocols For Mobile Ad Hoc Networks" *Asia-Pacific Conference on Communications, APCC,* 2006.

[3] A. Wierman and T. Osogami "A Unified Framework for Modeling TCP-Vegas, TCP-SACK, and TCP Reno", Technical Report CMU-CS-03-133, School of Computer Science Carnegie Mellon University Pittsburgh, May 2003.

[4] S. A. Kulkarni and G. R. Rao, "Mobility and Energy –Based Analysis of Temporally Ordered Routing Algorithm for Ad Hoc Networks, IETE Technical Review, Vol. 25, Issue 4, 2008.

[5] A. Zahary, A. Ayesh, "Analytical Study to Detect Threshold Number of Efficient Routes in Multipath AODV Extensions", *proceedings of International Conference of Computer Engineering and Systems, ICCES,* 2007.

[6] C. Mbarushimana, and A. Shahrabi, "Comparative Study of Reactive and Proactive Routing Protocols Performance in Mobile Ad Hoc Networks," in *Proc. AINAW*, 2007, pp. 679-684.

[7] M. Ijaz, "TCP Performance Evaluation in MANET", MSc Thesis, Blekinge Institute of Technology, Sweden, 2009.

[8] L. Subedi, M. Najiminaini, and L. Trajkovic "Performance Evaluation of TCP Tahoe, Reno, Reno with SACK, and NewReno Using OPNET Modeler NewReno Using OPNET" *http://www.cs.sfu.ca/~ljilja/papers/subedi_najiminaini_trajkovic_opnetwork2008_final.pdf*

[9] T. Janevski and T. Petrov "Cross-layer Analysis of Mobility Impact on TCP Protocols in IEEE 802.11 Wireless Networks" *17th Telecommunications forum TELFOR, Serbia, Belgrade, November 24-26, 2009.*

[10] G. Boggia and et al, "Modeling the AIADD Paradigm in Networks with Variable DelaysA Survey of TCP over Ad Hoc Networks " *Proceedings of the ACM CoNEXT06 conference, Lisboa, Portugal, December 2006.*

[11] K. Sinha and P. K. Srimani, 'Deterministic Broadcast and Gossiping Algorithms for Ad hoc Networks', The Journal of Supercomputing , Volume 37, Number 2, 2006.

[12] R. Cheng, H. Lin, "A Cross-layer Design for TCP End-to-End Performance Improvement in multi-hop wireless networks", ELSEVIER, Computer communication Vol. 31, issue 14, pp. 3145-3152, Sep. 2008.

[13] M. K. Mishra and et al, "Measure of Impact of Node Misbehavior in Ad Hoc Routing : A Comparative Approach, IJCSI, International Journal of Computer Science Issues, Vol. 7, No. 8, July 2010.

[14] M. Frikha and M. Maamer "Implementation and simulation of OLSR protocol with QoS in Ad Hoc Networks", Proceedings of the Second International Symposium on Communications, Control and Signal Processing (ISCCSP'06), Marrakech, Morocco, 2006.

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