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Modeling and Substantiation of Mobile Adhoc Hierarchical Protocols for Wireless Adhoc Networks

Jagbir Singh[1]
[1]Department of Information Technology,
Adesh Institute of Engineering & Technology,
Faridkot, Punjab, India
jagbir.sidhu@hotmail.com

Rashpinder Pal Sharma*[2]
[2]Assistant Professor
Department of Computer Science & Engineering,
GNDEC, Ludhiana, Punjab, India
rashpindersharma@gndec.ac.in

Dr. R. Malhotra[3]
[3]Director-Principal
AIT, Gharuan, Punajab, India
blessurrahul@gmail.com

Abstract: Ad hoc networks (MANET) are networks which routing is based on multi-hop routing from a source to a destination node or nodes. There are abundant pertinent protocols for ad hoc networks. This work deals with a classification of ad hoc routing protocols The prominence of this work is not to present protocols in detail but to present main features of wide variety of different protocols and evaluate their suitability and tradeoffs.

The networks can be tested for different state of affairs by isolating some network part or by deactivating crucial network links. The simulation time can be adjusted for better understanding of parameters behavior and for desired performance of the network.

***Keywords*:** MANET, Protocols, Classification, performance check.

I. INTRODUCTION

Numerous factors associated with technology, business, regulation and social behavior naturally and logically speak in favour of wireless ad hoc networking. Mobile wireless data communication, which is advancing both in terms of technology and usage/penetration, is a driving force, thanks to the Internet and the success of second-generation cellular systems. As we look to the horizon, we can finally glimpse a view of truly ubiquitous computing and communication. In the near future, the role and capabilities of short-range data transaction are expected to grow, serving as a complement to traditional large-scale communication: most man-machine communication as well as oral communication between human beings occurs at distances of less than 10 meters; also, as a result of this communication, the two communicating parties often have a need to exchange data. As an enabling factor, license-exempted frequency bands invite the use of developing radio technologies (such as Bluetooth) that admit effortless and inexpensive deployment of wireless communication.

In terms of price, portability and usability and in the context of an ad hoc network, many computing and communication devices, such as PDAs and mobile phones, already possess the attributes that are desirable. As advances in technology continue, these attributes will be enhanced even further. Finally, we note that many mobile phones and other electronic devices already are or will soon be Bluetooth-enabled. Consequently, the ground for building more complex ad hoc networks is being laid. In terms of market acceptance, the realization of a critical mass is certainly positive. But perhaps even more positive as relates to the end-user is that consumers of Bluetooth enabled devices obtain a lot of as-yet unravelled ad hoc functionality at virtually no cost. In ad hoc network communication between nodes is done through the wireless medium. Because nodes are mobile and may join or leave the network, MANETs have a dynamic topology. Nodes that are in transmission range of each other are called neighbours. Neighbours can send directly to each other. However, when a node needs to send data to another non-neighbouring node, the data is routed through a sequence of multiple hops, with intermediate nodes acting as routers.

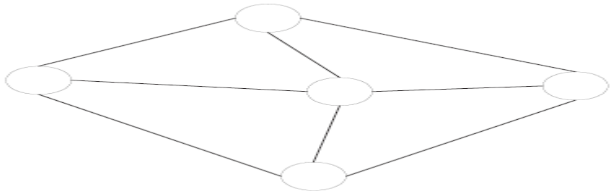

Figure 1: An example ad hoc network, with circles representing nodes.

Two nodes that are in transmission range of each other are connected by a line.

There are numerous issues to consider when deploying MANETs. The following are some of the main issues.

a. Unpredictability of environment
b. Unreliability of wireless medium
c. Resource-constrained nodes
d. Dynamic topology

As a result of these issues, ad hoc networks are prone to numerous types of faults including,

a. Transmission errors
b. Node failures
c. Link failures
d. Route breakages
e. Congested nodes or links

An ad-hoc routing protocol is a convention, or standard, that controls how nodes decide which way to route packets between computing devices in a mobile ad hoc network .In ad-hoc networks, nodes are not familiar with the topology of their networks. Instead, they have to discover it. The basic idea is that a new node may announce its presence and should listen for announcements broadcast by its neighbours. Each node learns about nodes nearby and how to reach them, and may announce that it, too, can reach them.

The following is the list of some ad hoc network routing protocols

a. Table-driven (Pro-active) routing
b. On Demand (Reactive) routing
c. Flow-oriented routing
d. Hybrid (both Pro-active and reactive) routing
e. Hierarchical Routing Protocols

II. RELATED WORK

Rafique, M.Z. et.al. (2011) Proposed the design of a generic vulnerability exploits detection system xMiner to detect malformed messages in real time for avoiding any network hazard. The system was evaluated on real-world datasets pertaining to three different protocols - HTTP, FTP and SIP. Five different classifiers were deployed to establish the effectiveness of the proposed system. On evaluation they found that the decision tree classifier performs well for HTTP and FTP datasets whereas, SVM show highest performance in case of SIP packets.

Jianhua Sun et.al. (2010) presented here a data-base firewall to prevent from attacks against MySQL back-end data-base of web applications. Here they used a special method to analyze the SQL queries, not only analyzed the structure of the queries but also the user inputs with some models, all of which allow for the detection of known and unknown attacks with low false positives and false negatives. From the experiments, they see that it had a low performance overhead.

Sapna et.al. (2010) presented the performance evaluation of hybrid network using RIP & IGRP routing protocols for different applications in low load campus network. This model was tested against various types of applications (Email, FTP, & Print Server) in Hybrid Networks. Two routing protocols RIP and IGRP are used to check the performance of Hybrid Network for different applications. This OPNET simulation shows the impact of IP routing protocol for hybrid networks for different types of applications.

Qian Tan et.al. (2009) proposed a novel structure and realization scheme of digital noise monitoring system based on B/S (Browser/Service) architecture and floating-point DSP. In the B/S architecture, the noise data was transmitted through GPRS with SIM300, stored in the server computer using socket communication technology and displayed in the remote Web browser in a multi-terminal, multi-channel and real-time way. Regardless of ambient temperature changes, the system were worked accurately form -40 to 85 degrees, which was much better than the analog devices.

Ayari. N. et.al. (2008) worked on Fault-tolerant frameworks, it provide highly available services by means of fault detection and fault recovery mechanisms. Most of the proposed frameworks are not transport-level- or session-level-aware, although the concerned services range from regular services like HTTP and FTP to more recent Internet services such as multimodal conferencing and voice over IP. This paper shows how the redundancy of application servers can be invested to ensure efficient failover of Internet services when the legitimate processing server goes down.

Sheng Zhong et.al. (2007) described that a challenging problem is how to provide incentives to stimulate cooperation. In this paper, they study ad-hoc games—the routing and packet forwarding games in wireless ad-hoc networks. Unlike previous work which focuses either on routing or on forwarding, this paper investigated both routing and forwarding. Then they defined a novel solution concept called cooperation-optimal protocols. They presented Corsac, a cooperation-optimal protocol which consists of a routing protocol and a forwarding protocol. The routing protocol of Corsac integrates VCG with a novel cryptographic technique to address the challenge in wireless ad-hoc networks that a link’s cost (i.e., its type) is determined by two nodes together. Corsac also applies efficient cryptographic techniques to design a forwarding protocol to enforce the routing decision, such that fulfilling the routing decision is the optimal action of each node in the sense that it brings the maximum utility to the node.

Venkatesh Rajendran et.al. (2006) worked on TRAMA, The traffic-adaptive medium access protocol (TRAMA) was introduced for energy-efficient collision-free channel access in wireless sensor networks. Using traffic information, TRAMA avoids assigning time slots to nodes with no traffic to send, and also allows nodes to determine when they can switch off to idle mode and not listen to the channel. An analytical model to quantify the performance of TRAMA was presented and the results were verified by simulation. The performance of TRAMA was evaluated through extensive simulations using both synthetic-as well as sensor-network scenarios. The results indicate that TRAMA outperforms contention-based protocols (CSMA, 802.11 and S-MAC) and also static scheduled-access protocols (NAMA) with significant energy savings.

van Beek, P. et.al. (2006) presented two new schemes for server-side management of play out delays due to receiver buffering, extending existing techniques such as stream acceleration and adaptive media playout. The proposed schemes reduce playout delay without decreasing playout robustness. They had performed simulations with wireless IEEE 802.11 channels with varying bandwidth, where the end-to-end delay is dynamically grown from 100 to 500 ms using the proposed schemes.

Chen, K. et.al. (2006) described protocols such as HTTP and FTP are designed for downloading or uploading files from/to servers. In this paper, the file transfer is considered in the context of connecting distributed applications, what is an output of a data producer on one node would be an input of a data consumer on another node. Distributed File Streamer a.k.a. DFS, as its name implies, uses data streaming to couple distributed applications. This paper described the architecture of the DFS framework, gives its performance model analysis, and provides results demonstrating DFS advantages over the traditional way on several examples.

Mohsen Bahramgiri et.al. (2006) concluded that the topology of a multi-hop wireless network can be controlled by varying the transmission power at each node. The lifetime of such networks depends on battery power at each node. This paper presented a distributed fault-tolerant topology control algorithm for minimum energy consumption in multi-hop wireless networks. The main advantage of this algorithm is that each node decides on its power based on local information about the relative angle of its neighbors and as a result of these local decisions, a fault-tolerant connected network is formed on the nodes. It was done by preserving the connectivity of a network upon failing of, at most, k nodes (k is a constant) and simultaneously minimize the transmission power at each node to some extent.

Douglas S.J.De Couto et.al. (2005) Suggested the design and implementation of ETX as a metric for the DSDV and DSR routing protocols as well as modifications. This paper presented the expected transmission count metric (ETX), which found high throughput paths on multihop wireless networks.

William Allcock et.al. (2005) described GridFTP extensions to the File Transfer Protocol defined a general-purpose mechanism for secure, reliable, high-performance data movement. They report here on the Globus striped GridFTP framework, a set of client and server libraries designed to support the construction of data-intensive tools and applications. They shown that this server was faster than other FTP servers in both single-process and striped configurations.

Christian Bettstetter et.al. (2005) Analyzed the connectivity of multihop radio networks in a log- normal shadow fading environment. They derived an explicit expression for this bound and verify its tightness by simulation. The numerical results were used for design and simulation of wireless sensor and ad hoc networks.

Chao-Tung Yang et.al. (2005) demonstrated the Data Grid enables the sharing, selection, and connection of a wide variety of geographically distributed computational and storage resources for solving large-scale data intensive scientific applications. In this paper, they build a Grid environment based on three existing PC Cluster environments and perform performance analysis of data transfers using Grid FTP protocol over these systems. Based on experimental results, it was proposed a cost model to pick the best replica, in real and dynamic network situations.

JN Laneman et.al. (2004) Analyzed space time coded cooperative diversity protocols for combating multipath fading across multiple protocol layers in a wireless network. They demonstrated that these protocols achieve full spatial diversity in the number of cooperative terminals and can be used effectively for higher spectral efficiencies.

Feng Xue et.al. (2004) evaluated the problem of number of neighbours needed for each node to be connected in order such that overall network was connected in a multihop fashion. They concluded that if each node was connected to more than 5.1774log n nearest neighbours then the network was connected with probability approaching one as n increases.

III. PROBLEM FORMULATION

A mobile ad hoc network is a collection of autonomous mobile nodes that communicate with each other over wireless links. Such networks are expected to play increasingly important role in future civilian and military settings, being useful for providing communication support where no fixed infrastructure exists or the deployment of a fixed infrastructure is not economically profitable and movement of communicating parties is possible. However, since there is no stationary infrastructure such as base stations, mobile hosts need to operate as routers in order to maintain the information about the network connectivity. Therefore, a number of routing protocols have been proposed for ad hoc wireless networks. In this work, we study and compare the performance of the following routing protocols, TORA, DSR, and DSDV. A variety of workload and scenarios, as characterized by mobility, load and size of the ad hoc network were simulated. Our results indicate that despite its improvement in reducing route request packets, CBRP has a higher overhead than DSR because of its periodic hello messages while AODV's end-to-end packet delay is the shortest when compared to DSR and TORA. TORA has shown little improvements over AODV.

a. ***Application Response Time*****: -** It is defined as the interval from when a user initiates a request to the instant at which the first part of the response is received at by the application. The definition of response time must incorporate the behavior, design and architecture of the system under test.
b. ***Utilization:*** **-** Utilization is the percent of data throughput relative to the maximum capacity of the router interface. The channel efficiency, also known as bandwidth utilization efficiency, in percentage is the achieved throughput related to the net bit rate in bit/s of a digital communication channel. Channel utilization is instead a term related to the use of the channel disregarding the throughput. It counts not only with the data bits but also with the overhead that makes use of the channel. The transmission overhead consists of preamble sequences, frame headers and acknowledge packets. In a simplistic approach, channel efficiency can be equal to channel utilization assuming that acknowledge packets are zero-length and that the communications provider will not see any bandwidth relative to retransmissions or headers. Therefore, certain texts mark a difference between channel utilization and protocol efficiency (Rappaport, Theodore S. 2002).

Case study 1:- In this case, DSR is implemented using FTP Server, DB Server and Application Server with the help of router; switch and IP cloud. It contains 8 nodes.

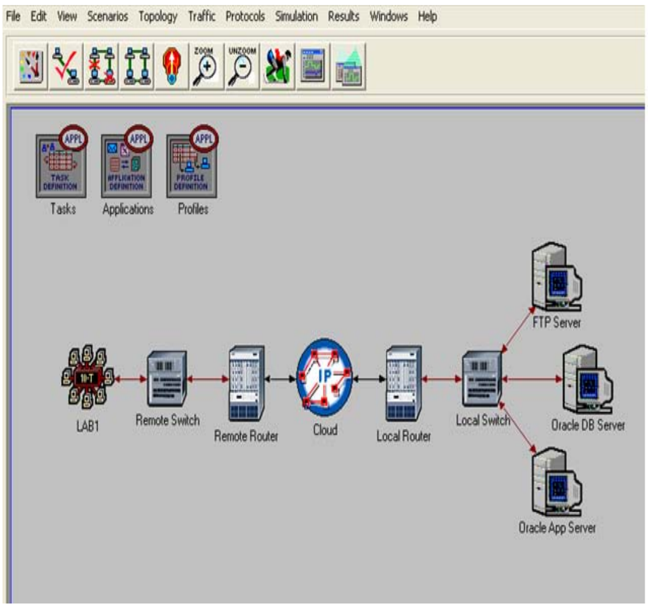

Figure 2: DSR Protocol

Case study 2:- In this case, TORA is implemented using FTP Server, DB Server and Application Server with the help of router; switch and IP cloud. It contains 8 nodes.

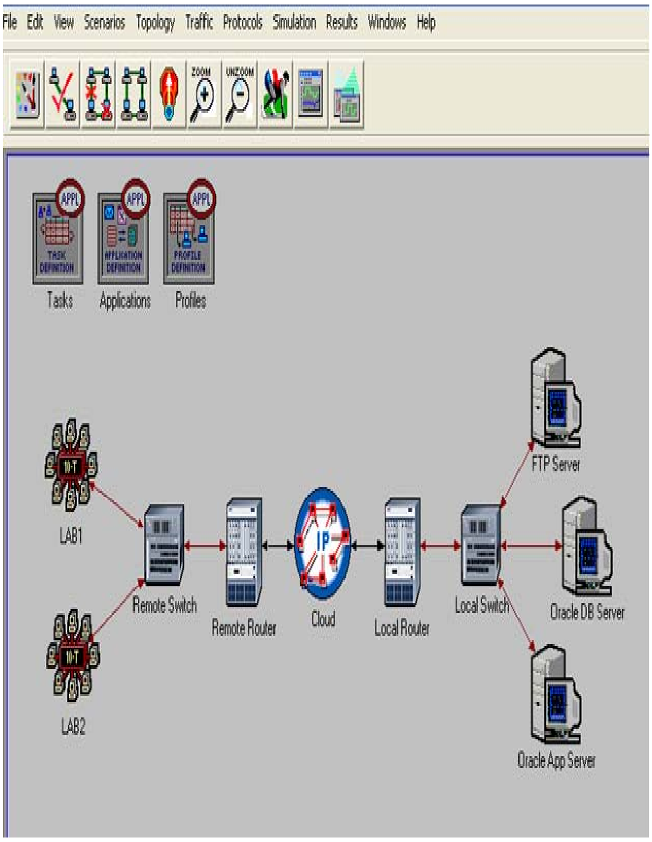

Figure 3: TORA Implementation

Case Study 3: - In this case, DSDV is implemented using FTP Server, DB Server and Application Server with the help of router; switch and IP cloud. It contains 8 nodes.

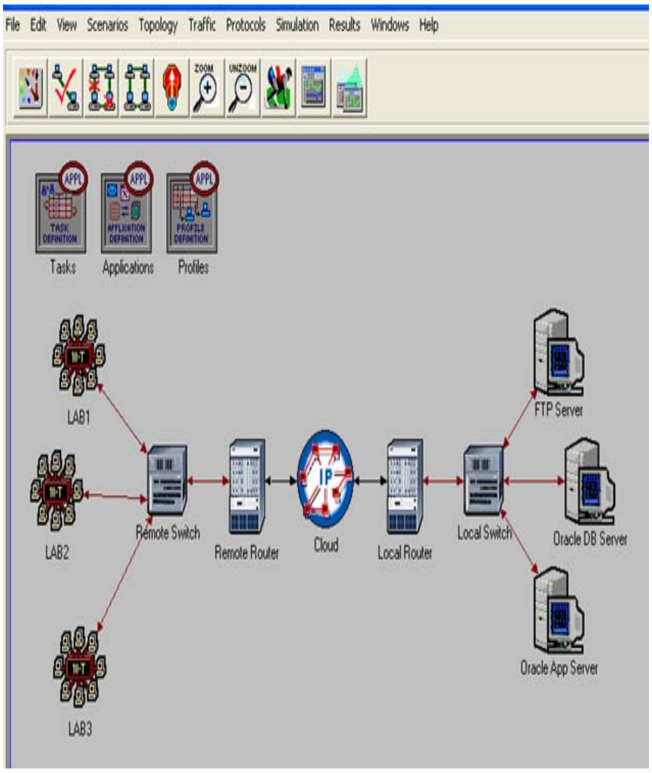

Figure 4: DSDV Implementation.

IV. RESULTS AND DISCUSSIONS

We conducted our experiments using parameters listed in last section.

A. Analysis of the Case Studies:

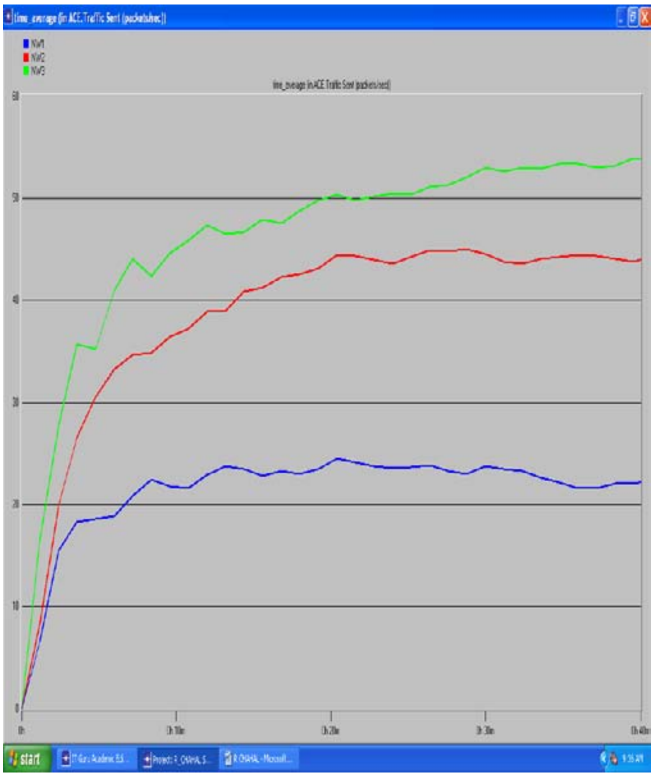

Figure 5: Shows FTP with loss.

The results indicate that the traffic sent in TORA is more as compared to DSR and DSDV.

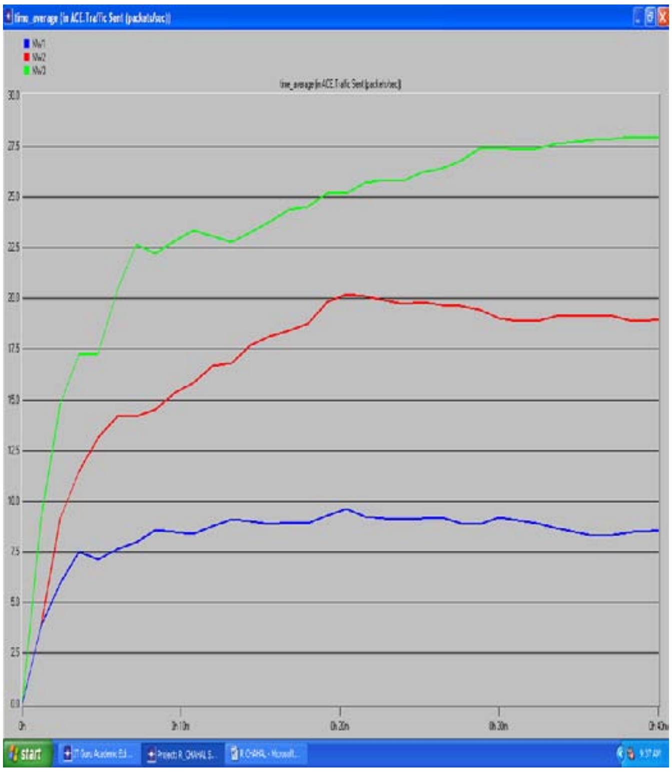

Figure 6: Shows Oracle DB with loss.

The results indicate that the traffic sent in TORA is more as compared to DSR and DSDV.

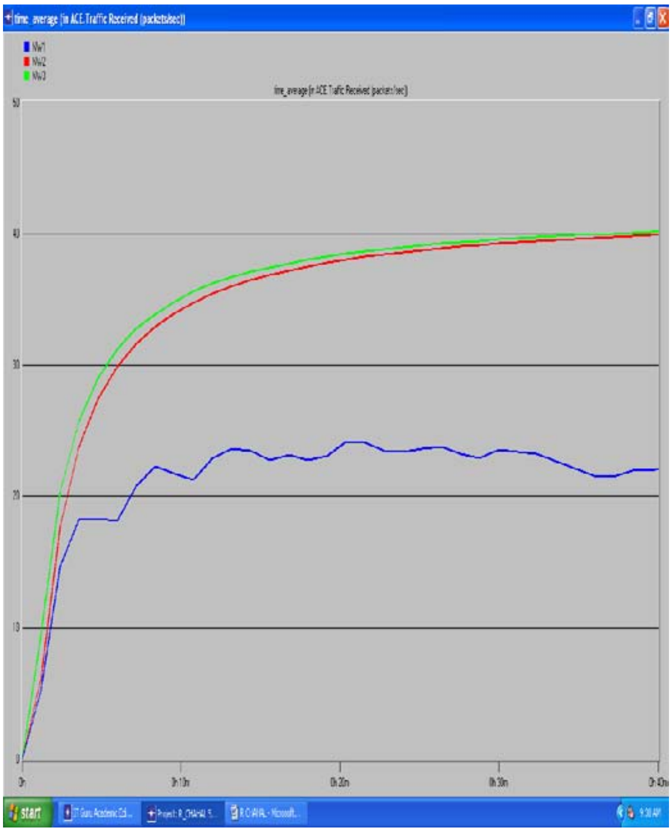

Figure 7: Shows the FTP with loss results.

The results indicate that the traffic received in TORA is more as compared to DSR and DSDV.

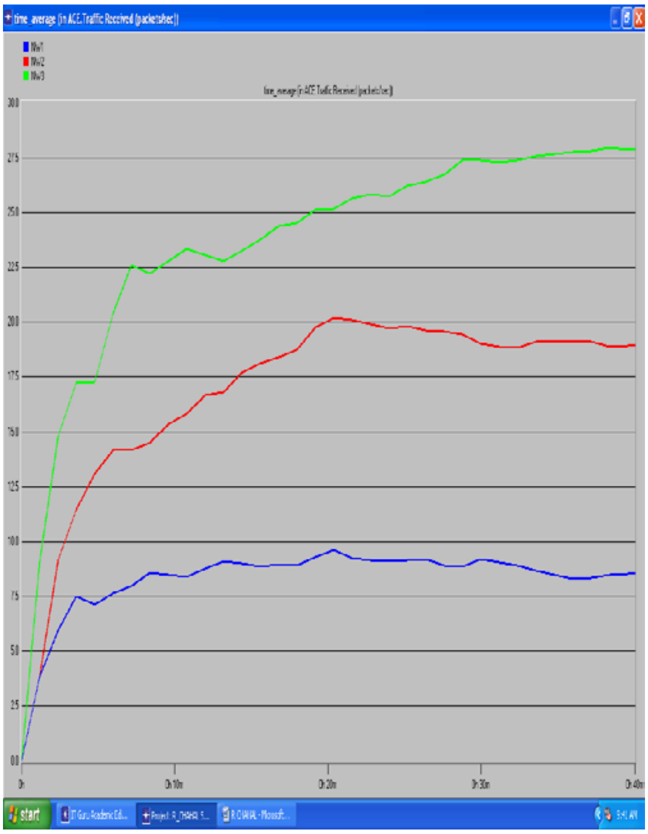

Figure 8: Shows Oracle DB with loss.

The results indicate that the traffic received in TORA is more as compared to DSR and DSDV.

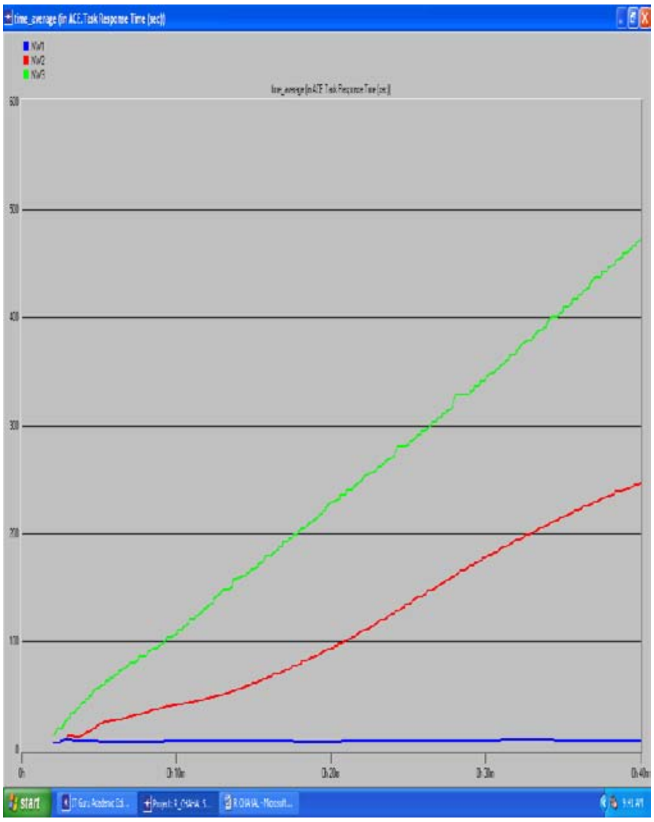

Figure 9: Shows the FTP with loss results.

The results indicate the task response time of the TORA is more as compared to DSR and DSDV.

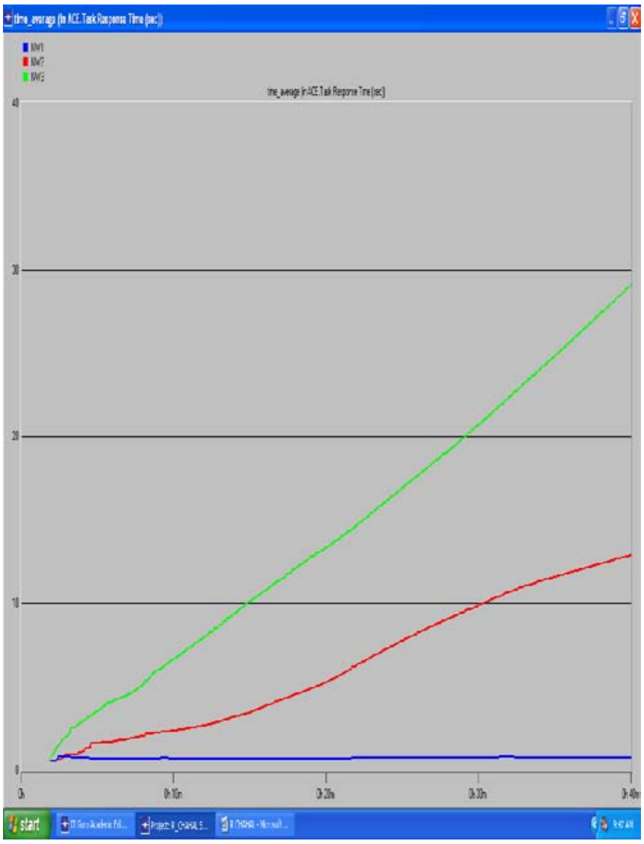

Figure 10: Shows Oracle DB application results.

The results indicate that the task response time of TORA is more as compared to DSR and DSDV.

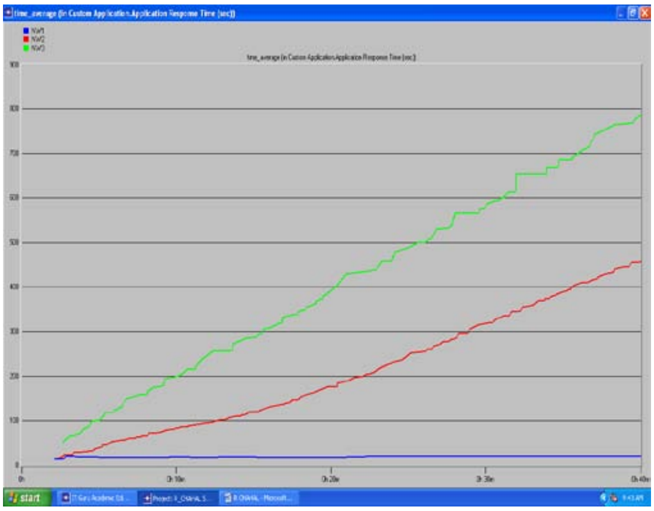

Figure 11: Application Response Time Results.

The result shows the application response time of TORA is more as compared to DSR and DSDV.

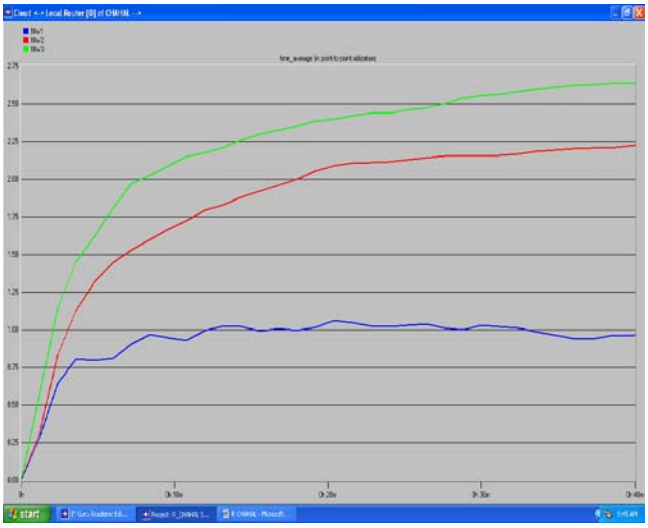

Figure 12: Results of Local Router.

The result shows the point to point utilization of TORA is more as compared to DSR and DSDV.

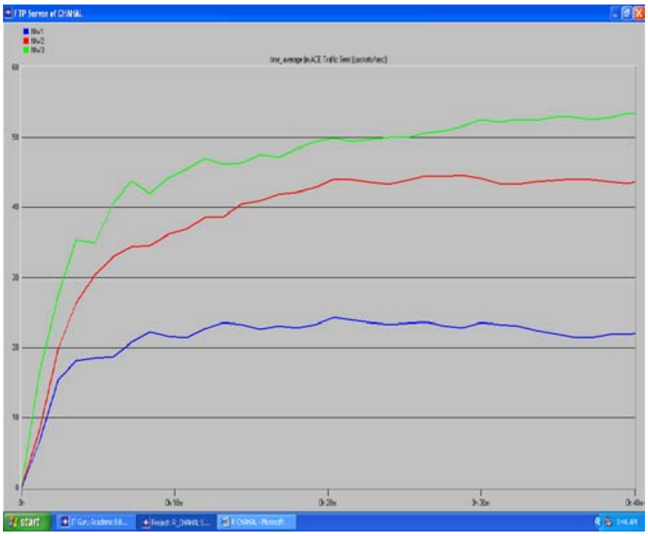

Figure 13: Shows the results of FTP server.

The result shows that traffic sent in TORA is more as compared to DSR and NW 2.

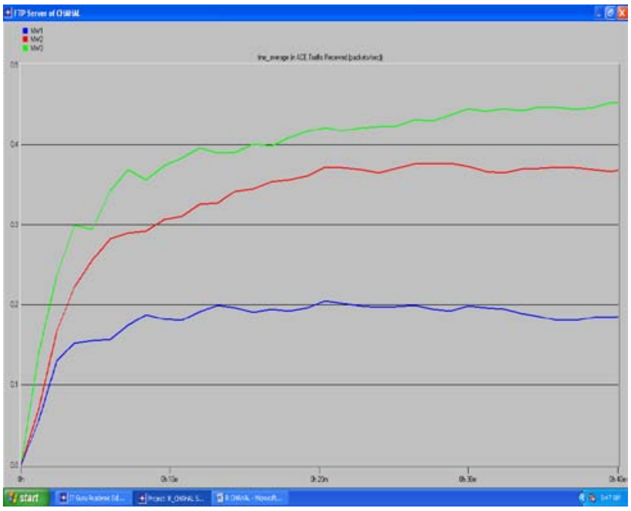

Figure 14: Shows the results of FTP server.

The result shows that the traffic received in TORA is more as compared to DSR and DSDV.

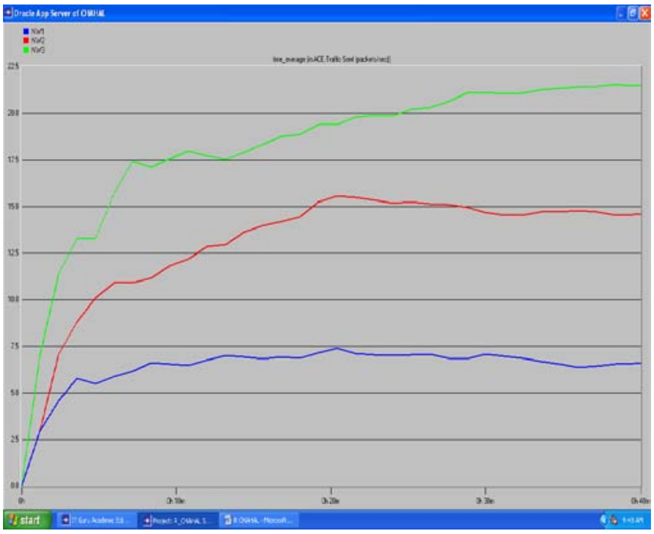

Figure 15: Shows the results of Oracle app server.

The result shows that traffic sent in TORA is more as compared to DSR and NW 2.

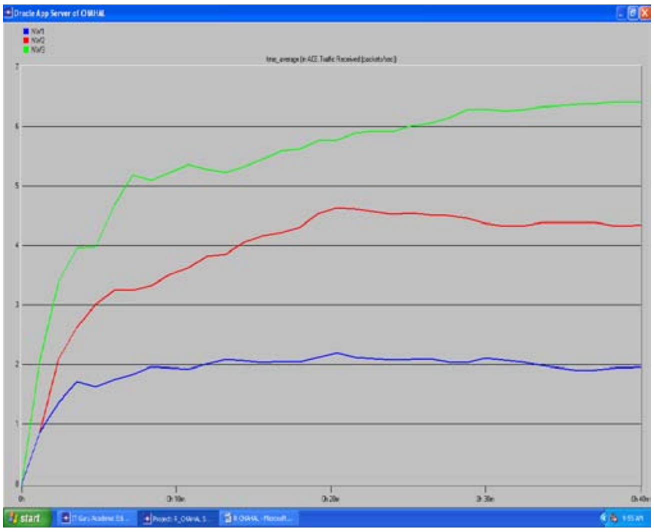

Figure 16: Shows Oracle app server results.

The result shows traffic received in TORA is more as compared to DSR and DSDV.

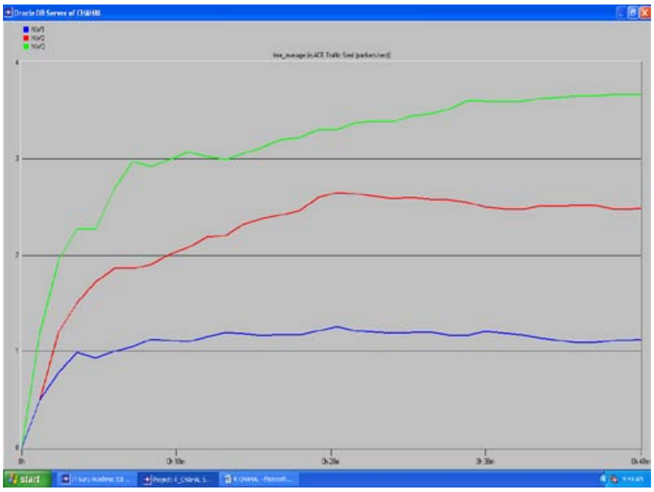

Figure 17: Shows the results of Oracle DB server.

The result shows that traffic sent in TORA is more as compared to DSR and DSDV.

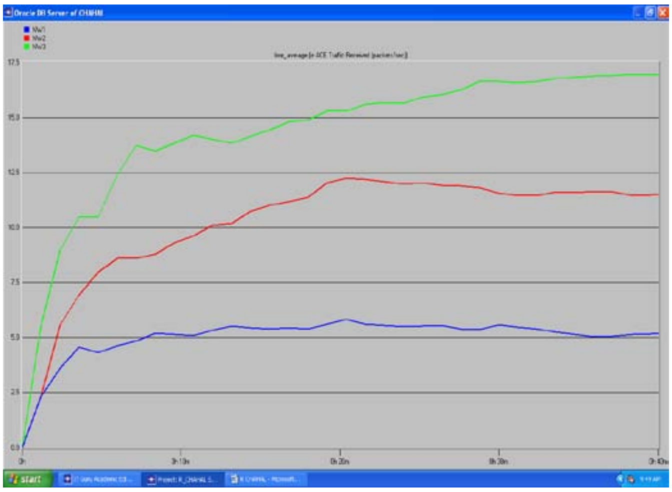

Figure 18: Shows the results of Oracle DB server.

The result shows that the traffic received in TORA is more as compared to DSR and DSDV.

V. CONCLUSIONS

This work study time average, application response time and point to point utilization of various servers like FTP server, DB server and Oracle application server.

In this work DSR, DSDV, TORA are connected to various servers; FTP Server, Oracle App Server and Oracle DB Server through local switch and analyze time average, application response time and point to point utilization. LAB 1, LAB 2 and LAB 3 makes the networks DSR, DSDV and TORA respectively. The results of FTP with loss indicate that the traffic sent in TORA is more as compared to DSR and DSDV. The results of oracle DB server with loss indicate that the traffic sent in TORA is more as compared to DSR and DSDV. The results of FTP with loss indicate that the traffic received in TORA is more as compared to DSR and DSDV. The results of oracle DB server with loss indicate that the traffic received in TORA is more as compared to DSR and DSDV.The results of FTP with loss indicate that the task response time of the TORA is more as compared to DSR and DSDV.. The results of Oracle DB application indicate that the task response time of TORA is more as compared to DSR and DSDV.

The results of application response time shows that the application response time of TORA is more as compared to DSR and DSDV. The results of Local Router shows that the point to point utilization of TORA is more as compared to DSR and DSDV.The result of FTP server shows that traffic sent in TORA is more as compared to DSR and NW 2. The results of FTP server shows that traffic received in TORA is more as compared to DSR and NW 2. The results of Oracle app server shows that traffic sent in TORA is more as compared to DSR and NW 2. The results of Oracle app server results shows traffic received in TORA is more as compared to DSR and DSDV.. The results of Oracle DB server shows that traffic sent in TORA is more as compared to DSR and DSDV. The result of Oracle DB server shows that the traffic received in TORA is more as compared to DSR and DSDV.

VI. REFERENCES

[1] Rafique, M.Z.; Abulaish, M. (2011), "xMiner: Nip the Zero Day Exploits in the Bud", Network Computing and Applications (NCA), 2011 10th IEEE International Symposium, pp. 99 – 106.

[2] Jianhua Sun; Hao Chen ; Chunmei Niu (2010), "A New Database Firewall Based on Anomaly Detection", Parallel and Distributed Computing, Applications and Technologies (PDCAT), 2010 International Conference , pp. 399 – 404.

[3] Sapna ,Sharma M. , Kaur H (2010), "Performance evaluation of hybrid network using RIP & IGRP for different applications", High-Capacity Optical Networks and Enabling Technologies (HONET), pp. 38 – 46.

[4] Qian Tan , Xiaoning Liu , Xiaodong Chen , Daoyin Yu (2009), "Digital Environmental Noise Monitoring System Based on B/S Architecture and Floating-Point DSP", Image and Signal Processing, 2nd International Conference, pp.1-5.

[5] Ayari N., Barbaron D. , Lefevre L. , Primet P. (2008), "Fault tolerance for highly available internet services: concepts, approaches, and issues", Communications Surveys & Tutorials, IEEE, vol. 10, 2, pp. 34 – 46.

[6] Sheng Zhong, Li Erran Li, Yanbin Grace Liu , Yang Richard Yang (2007), "On designing incentive-compatible routing and forwarding protocols in wireless ad-hoc networks", Wireless Networks, vol. 13, 6, pp. 799-816,

[7] Venkatesh Rajendran , Katia Obraczka, J. J. Garcia-Luna-Aceves (2006), "Energy-efficient, collision-free medium access control for wireless sensor networks", Wireless Networks, vol. 12, 1, pp. 63 – 78.

[8] Van Beek P., Kerofsky L.J. (2006),"Server-Side Playout Delay Management for Video Streaming", Image Processing, IEEE International Conference , pp. 3077 – 3080.

[9] Chen, K. , Huang, Z. , Li, B. , Huang, E. , Rajic, H.L. , Kuhn, R.H. , Chen, W. (2006), "Distributed File Streamer: A Framework for Distributed Application Data Coupling", Grid Computing, 7th IEEE/ACM International Conference , pp. 168 – 175.

[10] Mohsen Bahramgiri, Mohammadtaghi Hajiaghayi , Vahab S. Mirrokni (2006), " Fault-tolerant and 3-dimensional distributed topology control algorithms in wireless multi-hop networks",Wireless Networks archive, vol. 12, 2, pp. 179 – 188.

[11] Douglas S.J.,De Couto,Daniel Dguayo,John Bicket,Robert Morris (2005) ,"A high throughput path metric for multi hop wireless routing", Wireless Networks ,vol. 11, 4, pp. 419-434.

[12] William Allcock , John Bresnahan , Rajkumar Kettimuthu, Michael Link , Catalin Dumitrescu, Ioan Raicu (2005) ,"The Globus Striped GridFTP Framework and Server", Title SC '05 Proceedings of the 2005 ACM/IEEE conference on Supercomputing ,pp. 54.

[13] Christian Bettstetter and Christian Hartmann (2005), "Connectivity of wireless multihop networks in a shadow fading environment", Wireless Networks, vol. 11, 5, pp. 571-579.

[14] Chao-Tung Yang, Chun-Hsiang Chen, Kuan-Ching Li, Ching-Hsien Hsu (2005), "Performance Analysis of Applying Replica Selection Technology for Data Grid Environments", PARALLEL COMPUTING TECHNOLOGIES, vol. 3606/2005, pp. 278-287.

[15] JN Laneman and GW Wornell (2004), "Cooperative diversity in wireless networks: efficient protocol and outage behavior", Information Theory, IEEE Transactions, vol. 50, 12, pp. 3062-3080.

[16] Feng Xue and P.R.Kumar (2004), "The number of neighbors needed for connectivity of wireless networks", wireless networks, vol. 10, 2, pp. 169 – 181.

[17] Bianchini, R. and Rajamony, R. (2004), "Power and energy management for server systems", Computer, vol. 37, 11 , pp. 68 – 76.

[18] Yongguang Zhang, WenkeLee, Yi-Az Huang (2003), "Intrusion detection technique for mobile wireless networks", Wireless networks, vol. 9, 5, pp. 545-556.

[19] Almudena Konral,Ben Y. Zhao, Anthony D. Joseph, Reiner Ludwig (2003) ,"A Markov-Based Channel Model Algorithm for Wireless Networks", Wireless Networks ,vol. 9, 3, pp. 189-199.

[20] Thanasis Korakis, Gentian Jakllari, Leandros Tassiulas (2003) ,"A MAC protocol for full exploitation of directional antennas in ad-hoc wireless networks",MobiHoc 2003 proceedings of the 4th ACM international symposium on mobile ad hoc networking and computing , pp. 98-107.

[21] Prasun Sinha, Thyagarajan Nandagopal, Narayanan Venkitaraman,Raghupathy Siva Kumar, Vaduvur Bharghavan (2002) ,"WTCP: a reliable transport protocol for wireless wide-area networks", Wireless Networks,vol. 8 , 2/3, pp. 301 – 316.

[22] Adrian Perrig, Robert Szewczyk, J. D. Tygar, Victor Wen, David E. Culler (2002),"SPINS: security protocols for sensor networks", Wireless Networks, vol. 8, 5, pp. 521 – 534.

[23] Chakareski, J. ,Chou, P.A. , Girod, B. (2002), "Rate-distortion optimized streaming from the edge of the network", Multimedia Signal Processing, IEEE Workshop , pp. 49 – 52.

[24] Gavin Holland ,Nitin Vaidya (2002)," Analysis of TCP performance over mobile ad hoc networks", Wireless Networks - Selected Papers from Mobicom'99 archive ,vol. 8, 2/3, pp. 275 – 288.

[25] Stockinger, H.; Samar, A. ; Allcock, B. ; Foster, I. ; Holtman, K. ; Tierney, B. (2001), "File and object replication in data grids", High Performance Distributed Computing, Proceedings. 10th IEEE International Symposium , pp. 76 – 86.

[26] M.Scott Corson and Anthony Ephremides (2001), "A distributed routing algorithm for mobile wireless networks", Wireless networks, vol. 1, 1, pp.61-81.

[27] Yaxin Cao , Li, V.O.K. (2001), "Scheduling algorithms in broadband wireless networks ", Proceedings of the IEEE, vol. 89, 1, pp. 76 – 87.

[28] Prosenjit Bose, Pat Morin, Ivan Stojmenovic ,Jorge Urrutia (2001) ,"Routing with Guaranteed Delivery in Ad Hoc Wireless Networks", Wireless Networks , vol. 7, 6, pp. 609-616.

[29] Christine E. Jones, Krishna M. Sivalingam, Prathima Agrawal, Jyh Cheng Chen (2001) ,"A Survey of Energy Efficient Network Protocols for Wireless Networks", Wireless Networks, vol. 7, 4, pp.343-358.

[30] Sonah, B. (2000), "Modeling rate-based dynamic cache sharing for distributed VOD systems", Information Technology: Coding and Computing, Proceedings, International Conference, pp. 489 – 494.

[31] Young Bae Ko and Nitin H.Vaidya (2000), "Location Aided Routing in Mobile ad hoc networks", Wireless networks, vol. 6, 4, pp. 307-321.

[32] Garrett Roman Lanzy, Francis Alan Pflug, Gary Herbert Stange (2000), "System and method for enabling and controlling anonymous file transfer protocol communications", Wireless networks, pp. 1-14.

[33] Benjie Chen, Kyle Jamison, Hari Balakrishnan, Robert Morris (2000), "An energy efficient coordination algorithm for topology maintains in ad hoc wireless network", Wireless networks, vol. 6, 4, pp. 502-531.

[34] Brad Karp and H. T. Kung (2000), "GPSR: greedy perimeter stateless routing for wireless networks", MobiCom '00 Proceedings of the 6th annual international conference on Mobile computing and networking, pp. 243-254.

[35] EM Royer and Chai-Keong Toh (1999), "A review of current routing protocols for ad hoc mobile wireless networks", Personal Communications, IEEE, vol. 6, 2, pp. 46-55.

[36] David Mosberger, Tai Jin (1998), "httperf—a tool for measuring web server performance", SIGMETRICS, ACM SIGMETRICS Performance Evaluation, vol. 26, 3, pp. 31-37.

[37] Carlos Maltzahn, Kathy J. Richardson, Dirk Grunwald (1997), "Performance issues of enterprise level web proxies", Proceeding SIGMETRICS '97 Proceedings of the 1997 ACM SIGMETRICS international conference on

Measurement and modeling of computer systems, vol. 25, 1, pp. 13 - 23 .

[38] Shree Murthy, J. J. Garcia-Luna-Aceves (1996), “An efficient routing protocol for wireless networks”, Mobile Networks and Applications , vol. 1, 2, pp.183-197.

[39] David B. Johnson, David A. Maltz (1996), “Dynamic Source Routing in Ad Hoc Wireless Networks”, Wireless Networks, vol. 353, pp. 153-181.

[40] Ender Ayanoglu, Sanjay Paul, Thomas F. Sabnami, Richard D. Gitlin (1995), “AIRMAIL: A link-layer protocol for wireless networks”, Wireless Networks, vol. 1, 1, pp. 47-60.

[41] Rose, O. (1995), “Statistical, pp. 397 - 406.

[42] Rappaport, Theodore S. (2002) Wireless Communications, Principles and Practice second edition, Prentice Hall. properties of MPEG video traffic and their impact on traffic modeling in ATM systems”, Local Computer Networks, proceedings of 20th conference