Simulation and Analysis of AODV and DSDV protocols in MANETs

Thesis submitted in partial fulfillment of the requirements for the award of degree of

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in

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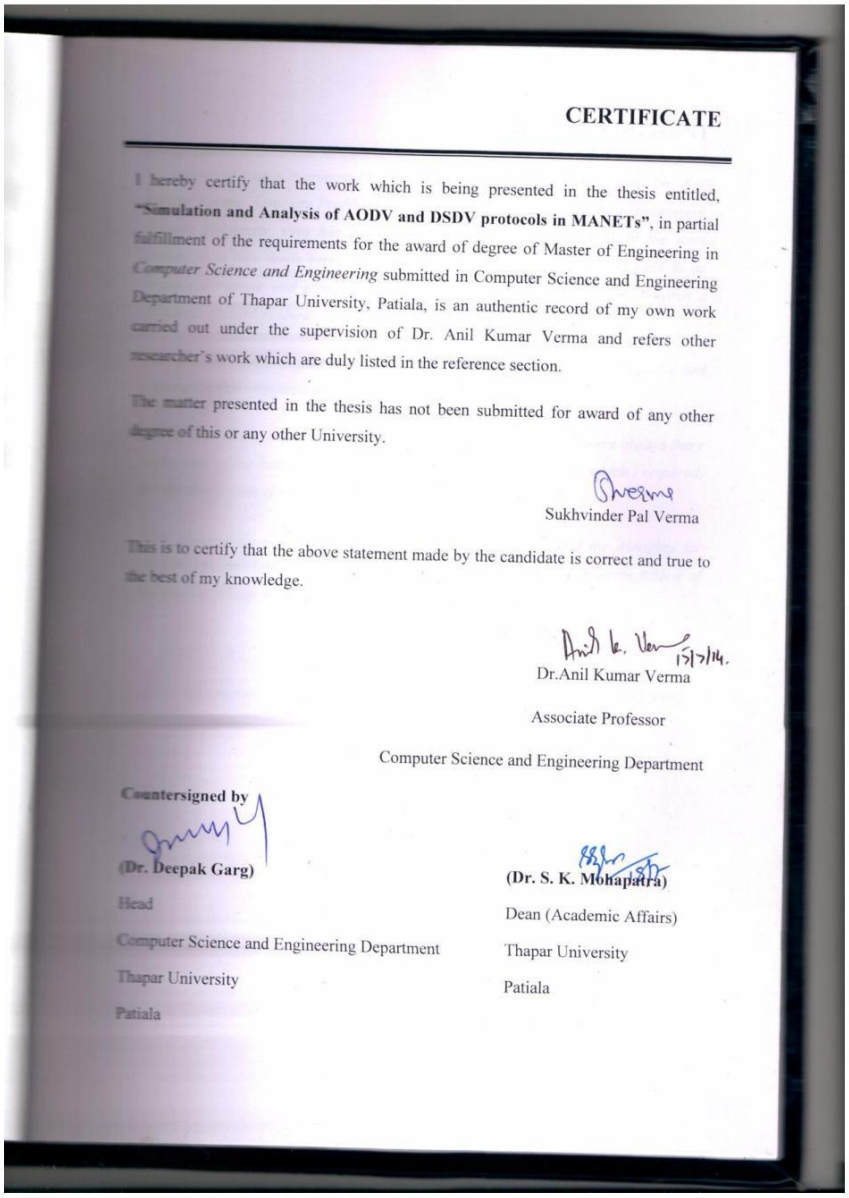

CERTIFICATE

I hereby certify that the work which is being presented in the thesis entitled, **"Simulation and Analysis of AODV and DSDV protocols in MANETs"**, in partial fulfillment of the requirements for the award of degree of Master of Engineering in *Computer Science and Engineering* submitted in Computer Science and Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of Dr. Anil Kumar Verma and refers other researcher's work which are duly listed in the reference section.

The matter presented in the thesis has not been submitted for award of any other degree of this or any other University.

Sukhvinder Pal Verma

This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge.

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ABSTRACT

Wireless MANETs are categorized as networks without any direct connections. In these networks there is no fixed topology due to the movability of nodes, intrusion, and path loss. A dynamic routing protocol is required for these networks to function accurately. Various Routing protocols have been established for completing this job. The objective of this research is to investigate, comprehend, evaluate and deliberate two mobile ad-hoc routing protocols DSDV and AODV while the first is a proactive protocol depending on routing tables which are preserved at every node. The second is a reactive protocol, which find a route to a destination on request, when communication is required. DSDV is most suitable for only smaller networks and AODV is suited for general Ad-hoc networks by considering the bandwidth, throughput and packet loss, in both DSDV and AODV routing protocols.

As the requirement of such network increases the execution of various issues related with it are being taken into account. They are broadcasting, routing, priority scheduling, scheduling, security and privacy. In this thesis, routing is considered as the research factor.

In this thesis, attempt has been done to analyse behaviour of proactive routing (DSDV), reactive routing (AODV), by simulating on simulators which allow users to generate real world mobility model. For this purpose, simulation tool such as NS-2 has been used. In this thesis performance of DSDV, AODV has been analyzed and evaluated under different node densities and connections. Three different sets of node density would be used to compare the performance of the said protocols. Simulation results in the form of graphs are then compared under various parameters like normalized routing protocol, average throughput, average end to end delay and PDF.

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Chapter 1

INTRODUCTION

1.1 Network

A Network is several groups of self-governing systems that interacts with each other over a common network path. A computer network is a combination of two or more linked computers. When these computers are combined in a network, people can share files and devices.

Two types of networking is possible:-

- Wireless
- Wired

1.2 Wireless Network

Any type of computer network that uses wireless data connections for connecting network nodes is a wireless network.

A method by which homes, telecommunications networks and business installations evade the expensive process of installing cables into a building, or as a connection between different equipment sites is called a wireless network. Wireless telecommunications networks are usually applied and managed using radio waves. This execution takes place at the physical layer of the OSI model network structure.

Wireless networks examples are cell phone networks, Wi-Fi local networks and land-dwelling microwave networks.

1.3 Types of Wireless Network

- **PAN (Personal Area Network)**

  This network type provides connectivity within an area of about 10 meter. These networks allow communication among the devices which are very close to one another. For example Connectivity between computer and printer which are placed very close to each other or connectivity between cell phone and cell phones hand's – free headset. One important aspect of WPAN is that participating devices establish ad-hoc network.

- **LAN (Local Area Network)**

  Local Area Network is a network which connects a small number of machines in a comparatively close geographical area. E.g. Network in office or in a university. WLAN's use radio waves or infrared waves to allow communication among devices in a fixed area. **Ethernet** has turn out to be the industry standard for LANs.

- **MAN (Metropolitan Area Network)**

  This type of network is set up to provide linking of numerous networks in a urban area such as dissimilar buildings in a city.

- **WAN (Wide Area Network)**

  Two or more local-area connected networks over a potentially large geographic distance is called Wide Area Network .For example a continent via several satellite systems or antenna locations looked after by an Internet Service Provider.

Table 1.1 Wireless Network Types Comparison

Type	Coverage	Performance	Technology
WPAN	Inside reach of a person	Modest	Bluetooth, IEEE 802.15, and IrDa
WLAN	Within reach of apartment or site	High	IEEE 802.11, Wi-Fi
WMAN	Within city	High	IEEE 802.16, WIMAX
WWAN	World wide	Low	CDPD,TDMA, Cellular 2G, 3G

1.4 Advantages of Wireless Network

- **Convenience**

  Network resources can be accessed from any site inside your wireless network's coverage area or from any Wi-Fi hotspot.
- **Movement**

  There is no need to tie to your desk, as in wired connection. Anyone can go online anywhere.
- **Efficiency**

  Accessibility to the wireless to your company's key applications and assets provide you and your employees get the work done and encourage cooperation.
- **Stress-free setup**

  No string cables needed, so installation can be stress free and cheaper.
- **Elastic**

  Wireless networks are more elastic than a wired network which required extra wiring.
- **Price**

  Wiring price is less than wired network.

1.5 The Disadvantages of Wired Technology

Cost is a major factor to differentiate wireless and wired technology in an organization. Wireless purchasing is more beneficial. Purchase hard-wired technology products, a review are must before purchasing.

Chapter 2

Literature Survey

Proactive Routing protocol: - It performs reliable and accurate routing information to all the nodes maintained at every node.

Reactive Routing protocol: - This protocol find route by swamping the network on demand with Route Request packets.

2.1. Proactive vs. Reactive Routing

Proactive protocols govern the routes in advance to different nodes in the network to decide the route presence whenever required. Discovery overheads are larger in proactive protocols because it has to discover all paths. When needed Reactive methods determine the route. Reactive protocols have smaller overheads e.g. AODV (Ad Hoc On Demand Distance Vector) routing protocol.

2.2 Ad-hoc on demand Vector Protocol (AODV)

AODV associate the properties of DSR and DSDV. It uses on demand route discovery process. Routing table is used to maintain route information. Being reactive protocol AODV doesn't need to maintain non-communicating routes to nodes. It handles Route Request messages with route discovery process. This is aired to neighbor nodes. Till the desired route is reached, the message is continuously sent. For route reversal route Request message bypass node to allocate route table entries. The Route Reply is sent back to the source node by the destination node. For forward route, node transmitting a RREP message creates routing table entries. Pre-defined messages are periodically sent for route maintenance. A particular node failing to receive three consecutive pre-defined messages from a neighbour indicates that particular node is down. Node detecting a broken link sends a Route Error message to upstream node.

2.2.1 Advantages:

- On demand routes are established and to find the latest destination route, sequence numbers are used.
- There is minimum delay for setting up the connection.

2.2.2 Disadvantage:

- Handling unidirectional links are not allowed.
- Multiple Route Reply packets results in overhead.
- Needless bandwidth consumption.

A Mobile Ad hoc Network is one that comes without existing infrastructure or fixed stations.

- No centralized server or arbitrator is needed.
- In MANET each mobile node is moving with same speed in random direction, so there is no guaranteed path from any node to another node.
- MANET Applications- Flooding Relief, Military operations, gaming.

2.3 Characteristics of MANET

- Network is not dependent on any fix infrastructure for its operation.
- Nodes can act as routers and hosts.
- No Static network topology
- Multiple hop network
- Continuous routing updates
- Internal mutual trust
- Restricted Bandwidth & Restricted Power

2.3.1 Routing in MANET

- The sharing of information between the hosts in a network is routing.
- The most suitable path for forwarding packet to destination is routing.
- Traffic, No. of hops etc. decide the efficiency of the path.
- Each host node behaves as expert router itself.

2.3.2 Routing Problems

- **Routing Overhead:** Due to the changing position of nodes, false routes are generated leads to routing overhead.

- **Interference:** Transmission of one node might interfere with another can corrupt the total transmission.

2.3.3 Routing Protocols

- A set of rules define the journey of message packets from source to destination by the Routing protocols in a network.

  There are three categories of MANET:

  - Proactive Protocols
  - Reactive Protocols
  - Hybrid Protocols

Proactive routing protocol

- In this routing scheme each node constantly maintains whole routing information of the network.
- This can be achieved by continuously sending network signals to fins any change possible change in network topology.

Reactive routing protocol

- Only working paths to the destination nodes maintain the information.

  Every new destination route search is needed to reduce the communication overhead
- Randomly changing wireless network topology can discontinue active route and divert the route.
- E.g. AODV

Hybrid routing protocol

- **Main features:**
  - For short distances it is proactive and for long distances it is reactive.
- **Advantages:**
  - For short distance connections it is inactive.
  - For distant destinations, routing overheads are lower.

- **Disadvantages:**
  - Complexity is more.

Proactive protocols have high overhead and lower potential while reactive protocols have lower overhead and high potential. Hybrid protocol is used for to remove disadvantages of proactive and reactive routing protocols. It is mixture of proactive and reactive routing protocol. It is suitable for bigger networks where huge numbers of nodes are present. Bigger network is divided into set of zones inside the zone.

2.3.4 Comparison of Protocols

Table 2.1 Pro and Cons Comparison

Protocol	Advantages	Disadvantages
Proactive	Expectancy is condensed in the network.	More overhead.
Reactive	Path is always.	Expectancy is higher.
Hybrid	Used for bigger networks.	More Complex.

2.4 AD-HOC APPLICATIONS

Tactical networks: Military Operations.

Sensor Network: For weathers forecast, earthquakes operations.

Emergency Services: Rapid Action Force, earthquakes.

Educational Applications: Artificial Intelligence

Entertainment: Robotics, Animation & Multimedia

Location Aware Services: GPS

2.5 Ad-hoc On-Demand Distance Vector (AODV) Protocol

AODV is a very efficient routing protocol for non-fixed Mobile Ad-hoc Networks. It has restricted bandwidth used for wireless communications. It borrows most of the advantageous concepts from DSR and DSDV algorithms.

2.5.1 Working of AODV

Each mobile node is available on demand and behaves as expert router as creating the network self-starting. Each node maintains a routing table in the network with the routing information entries to its neighbouring nodes, broadcast-ID and a node sequence number. When a node communicates with other node, it initiates path recovery and increases its broadcast-ID and sends Route Request packet to its neighbors.

The RREQ contains the following fields:

- Source Address
- Source
- Destination Address
- Destination Sequence
- Hop Count

Route Request sets the reverse path from all the destination nodes back to the source node. Every node records the address of the receiving node on receiving the packet. The nodes maintain this information for sufficient time and produce a reply to the source. If the node has entry in its routing table, it compares the destination sequence number with the request Reply. If it is lower, routing table is less than that in the, it rebroadcasts the Request Reply to its neighbors. Otherwise, it unicasts a route reply packet to source. As the Request Reply moves back to source, every node along this path sets a forward pointer to the receiving node and records the newest destination sequence number to the requesting destination. The intermediate node modifies routing information and broadcasts new Request Reply only.

2.5.2 Route Table Management

A route table entry for each destination is maintained by every mobile node in the network in its route table. Every mobile node holds the following info:

- Destination sequence number
- Destination
- Number of hops
- Next hop
- Lively neighbors for this route
- Ending time for the route table entry

2.5.3 Interesting concepts of AODV

The desirable concepts for MANETs with restricted bandwidth comprise the following:

- **Minimum space complexity:** The nodes in the non-active path should not contain information about this route. After a node sets a reverse path and receives the Reply Request, it does not receive any request Reply from its neighbors and deletes the routing information that it has recorded.

2.5.4 Advance uses of AODV

- **Maximum use of the bandwidth:** The increased sequence number counter is maintained by each node in order to overtake any out-of-date cached routes. In the active path all the intermediate nodes update their routing tables to make sure of maximum use of the bandwidth. Any received Request Reply by the nodes are compared using the destination sequence numbers and are rejected if they are not improved than the already broadcast Request Replies.
- **Ease:** Each node maintains easy and simple routing table, behaves as a router, and makes the network self-starting.
- **Most efficient routing information:** If a node receives a Request Reply with lesser hop Count after broadcasting an Request Reply, it modifies its routing information with better routing path and broadcasts it.
- **Loop-free routes:** The nodes dump the non performing packets for the same broadcast-ID.

- **Highly Accessible:** Because of the restricted space complexity, AODV is highly accessible and broadcasting is avoided.

2.4.5 Shortcomings of AODV

- **No recycle of routing info:** Even for normal traffic, it has non-efficient route maintenance technique.
- **It is susceptible to misuse**: The messages can be hacked for insider attacks including node separation, a route interruption, and route attack and resource depletion.
- **AODV lacks support for high output routing metrics:** It supports for long and low bandwidth instead of short and higher bandwidth links.

2.6 Destination Sequenced Distance Vector (DSDV) Protocol

DSDV is a proactive routing protocol. DSDV adds sequence number at every node to every route table. At each node routing table is maintained so that the node sends the packets to other nodes in the network area. This protocol is useful for data exchange between distant base stations.

2.6.1 Protocol Overview and activities

The routing table is maintained by every node in the network for connection of various stations in the network. Each routing entry is marked with a sequence number created by the destination to know the no. of hops required to reach a specific station. This method is to ensure the lesser no. of hops for a source to destination. By using this information the nodes can share its data in case of no direct communication link between them. The data transmission by every node will contain its latest sequence number.

The receiving node increases the metric upon receiving the route info and broadcast information. The broken route is marked by an infinity metric to determine non-hop and to update the sequence no. For identification sequence numbers generated are odd numbers for infinity metrics and even numbers generated from the mobile hosts.

2.6.2 Operation at Layer2

The DSDV protocol is operated corresponding to the layer address stored in routing table at mobile host. Layer two will use MAC address for operation Layer three will use network address for destination and next hop address.

To avoid the loss of bandwidth provide layer two information along with the layer three information at the layer two information. Otherwise, rebroadcasting will require by each mobile node.

Chapter 3

Problem Statement

3.1 Problem Statement

Because of many applications MANET has fascinated many research institutes. Various types of challenges in MANET communications have been identified and addressed. Main issue of concern is implementation of an appropriate routing protocol because of several issues. Routing protocol is an algorithm used to determine an appropriate path to destination along which messages can be forwarded. MANET routing protocol is classified into topology based and position based. It will be interesting to evaluate the performance of AODV (reactive routing), DSDV (proactive routing) with realistic mobility model for MANET. Analysis of these two protocols from different category will help in better understanding of these two categories (proactive, reactive).

The performance of the different protocols can be evaluated using simulation tools – Network Simulator (NS2) [26].

3.2 Objectives

The primary motive of this thesis is the analysis and simulation of DSDV, AODV routing protocol with realistic mobility model for MANETs. The variation in the number of nodes is done as 3 nodes, 5 nodes and 10 nodes. The results are evaluated in all cases and compared with each other.

- To simulate AODV, DSDV Protocols for MANETs
- To compare and analyze their performance under different scenarios
- Report and analysis of the result obtained

3.3 Methodology

(i) Firstly, simulation environment is to be setup. NS2 tool is used for rapid generation of realistic mobility model.

(ii) The performance comparison is made with different number of nodes. Three different sets of node density would be used to compare the performance of the said protocols.

(iii) Awk scripts are used to get the value from trace file and MS-Excel is used to generate graphs.

(iv) Results are compared under different parameters like End to End delay, Packet delivery ratio throughput etc.

Chapter 4

Simulation and Implementation

4.1 Simulation

Simulation is the process of building a model of a actual system and performing experiments with this design for the purpose of knowing the behavior of the system and assessing different plans for the job to be performed.

Developing a MANET in practical application is too costly therefore to test and to evaluate the protocols simulators are used .Simulation of protocol is the initial step of implementation of MANET protocols. Many communications network simulator are there to provide a platform for testing and accessing network protocols. Node mobility is the most important parameter in simulating ad-hoc network.

In this thesis, to generate real world mobility models for MANET simulations a tool NS2 (Network Simulator version 2) has been used. NS2 output is a trace file. NS2 also provides Graphics User Interface to understand the user about real world situations.

A brief introduction about used simulators has been given in below sections.

4.1.1 NS-2

Network Simulator NS2 (version 2) is an event driven tool that has proved helpful in observing the varying nature of communication networks. Simulation of TCP, UDP routing algorithms can be performed by using NS2. NS2 has gained constant popularity due to its flexibility and modular nature in the networking research.

4.1.1.1 Basic Architecture

NS2 uses TCL simulation scripting file. NS2 uses C++ and Object-oriented Tool Command Language C++ defines the backend, while the OTCL sets up simulation by accumulating and arranging the objects at frontend. Both are joined together using TCLCL. Occasionally OTCL domains are referred as handles. A handle is a string in the OTCL domain, and has no functionality. The functionality is defined in the mapped C++ class Connector. A handle acts as a frontend in the OTCL domain to interact with users and other OTCL objects. NS2 output is either animation based or

text based simulation results. To get results graphically Network Animator (NAM) and XGraph are used.

4.1.1.2 NAM

NAM is a actual analysis of the network topology produced.

4.1.1.3 Installation

NS2 is a free downloadable simulation tool. It runs on different platforms like Windows, Linux, and Mac. NS2 is easy to install. NS2 source codes are available in all-in one suite and the component wise. In all-in one package, users get optional components along the desired modules. This package provides an install script and executable file.

All-in one package can be installed with C++ compiler in the UNIX based machines by running the install command and validate command.

Chapter 5

Results and Analysis

Results obtained by simulation are shown in this chapter. The analysis is being performed on the basis of the results of *.tr files by executing TCL scripts. The .TCL files were generated for the following cases,

- 3 nodes
- 5 nodes
- 10 nodes

5.1 Simulation Setup

All tests have been performed on different scenarios having 3, 5, 10 nodes. With the help of simulator NS2 a grid view map has been created.

5.2 Performance Metrics and Results

Routing protocols can be analysed and compared by observing their behavior under some performance metrics. To analyse the behavior of AODV, DSDV following performance metrics has been used. Simulation has been performed on each protocol for 3, 5, 10 nodes. Results obtained are mentioned below:

Average End to End delay- The average time taken by data packet to broadcast from source to destination through network is average end to end delay including several intervals introduced because of route discovery, queuing, propagation and transfer time. It can be concluded form the figure 5.1 that in DSDV e2e delay is less in comparison to AODV, but still better than AODV as the no. of nodes increasing, because DSDV maintain entire routing path route at source, whereas AODV is reactive routing protocol which means it requests for the path only when a node has something to send, which introduce extra delay in AODV.

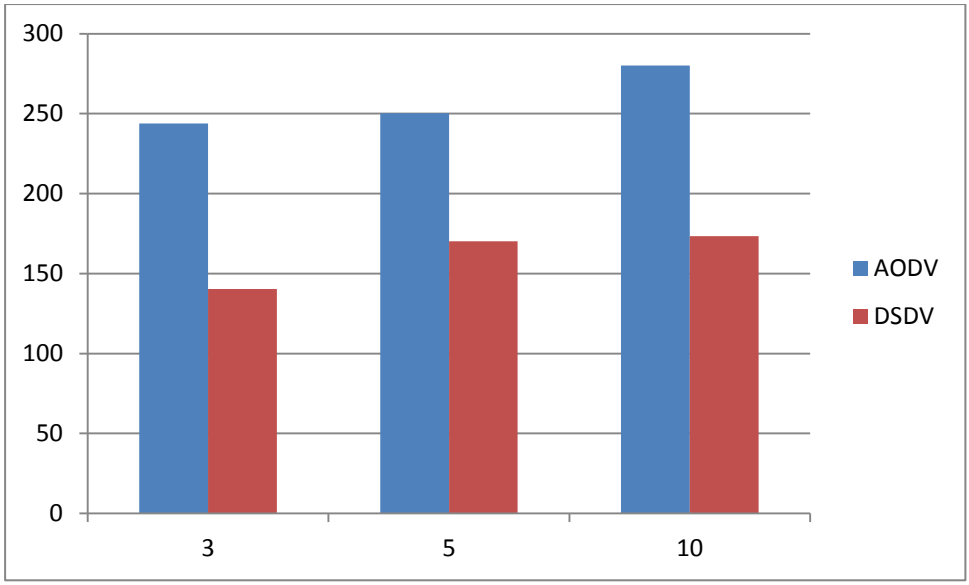

Fig. 5.1 Average E-to-E Delay

Packet Delivery Fraction- It is defined as the ratio of the data packets received by the destinations to those generated by the sources. From the figure 5.2, 5.3, 5.4, 5.5 it can be concluded that packet delivery fraction of AODV is better than DSDV. With the help of Packet Delivery Fraction one can understand how well a protocol can transfer packet from source to destination. More is the PDF more will be throughput, as it has been concluded from figures 5.2-5.5 throughput of AODV is better, it is all because of better PDF in AODV whereas PDF of DSDV is low. The value of AODV is almost constant for all the nodes (3, 5, and 10) whereas value of DSDV is decreasing as nodes are increasing.

	3	5	10	Cbrs
AODV	9087	9090	9095	
DSDV	8805	8705	8670	

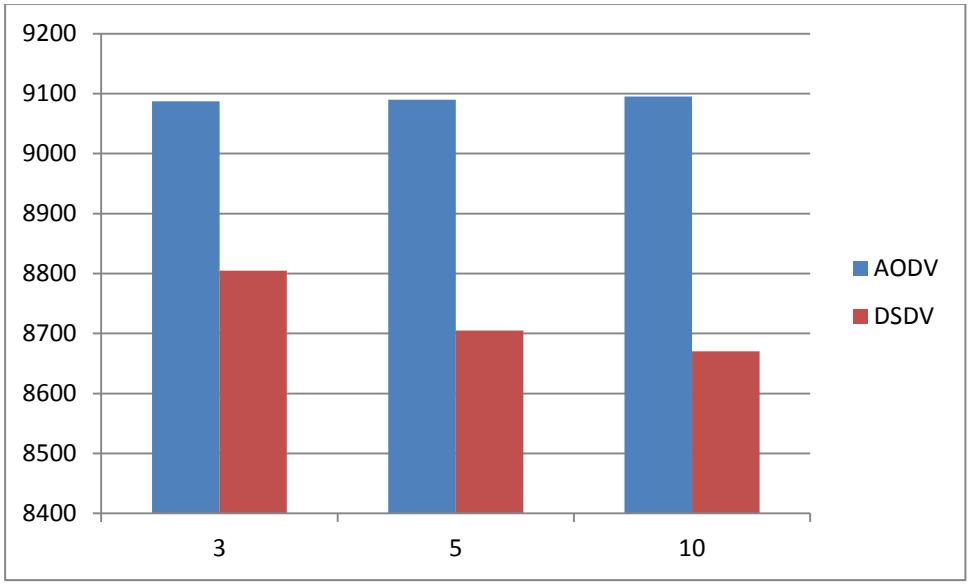

Fig. 5.2 Cbrs

	3	5	10	s
AODV	9062	9075	9050	
DSDV	8790	8200	8005	

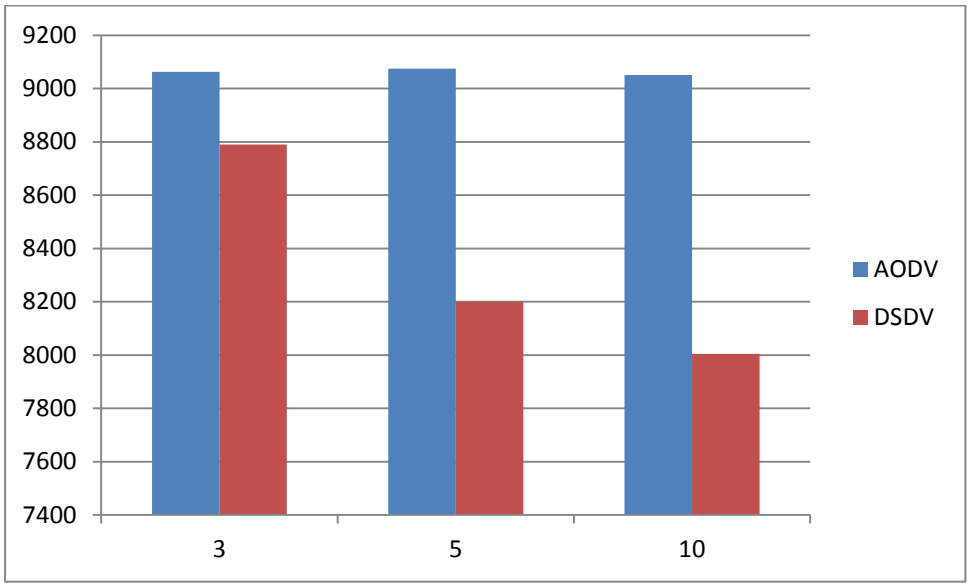

Fig. 5.3 s

	3	5	10	r/s Ratio
AODV	0.9972	0.9972	0.9951	
DSDV	0.9971	0.996	0.9956	

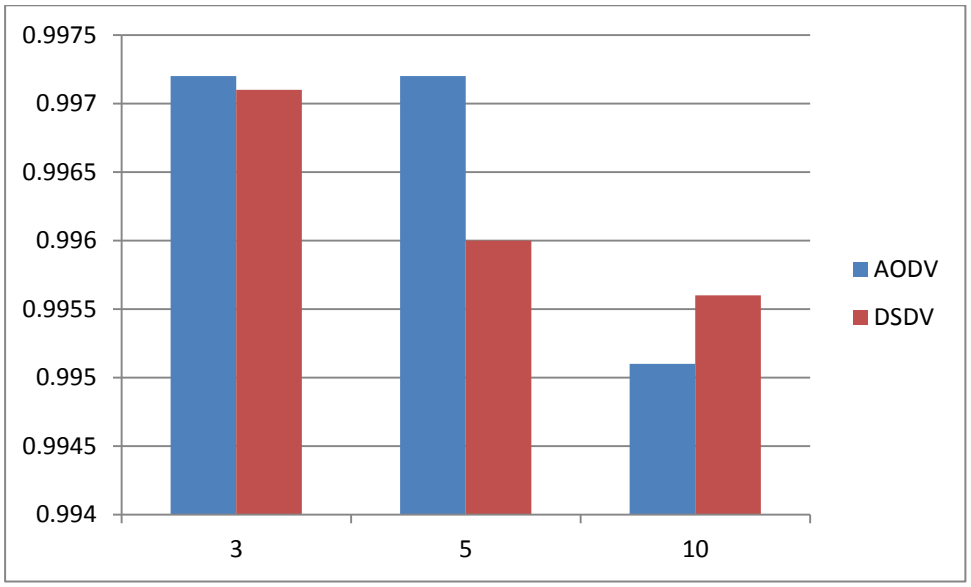

Fig. 5.4 r/s Ratio

	3	5	10	f
AODV	9075	9078	9200	
DSDV	4000	3142	2700	

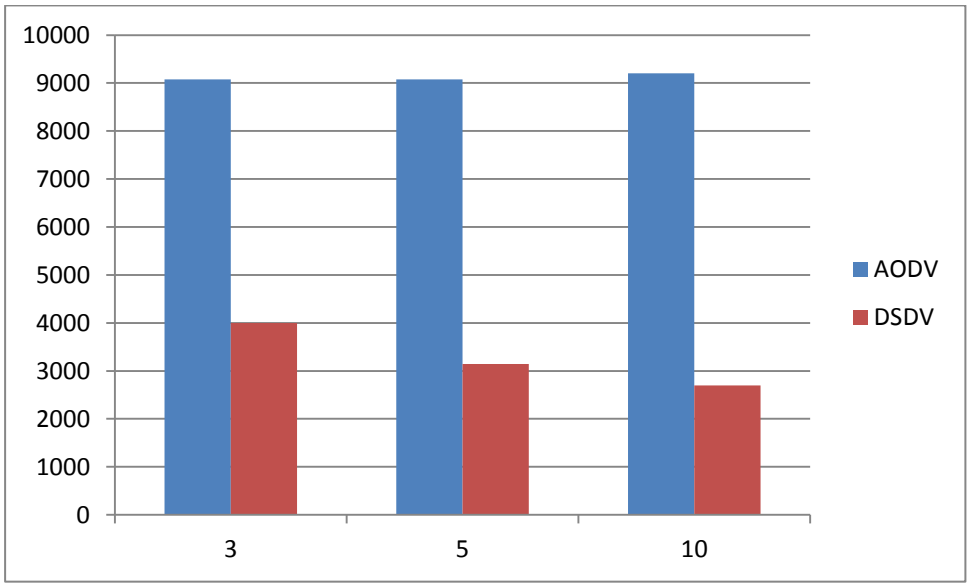

Fig. 5.5 f

Chapter 6

Conclusion and Future Scope

6.1 Conclusion

Behavior of reactive routing protocol (AODV), proactive routing protocol (DSDV) has been analyzed under the microscopic mobility model. The evaluations made on these protocols bring out some important characteristics of these protocols when they are used in MANET.

From the obtained results, it is detected that reactive protocol (AODV) performed well because mechanisms of route discovery, route maintenance and elimination of periodic broadcasting are used by AODV and by almost all reactive protocols. It is observed from the result that e2e delay of DSDV is least which is one of the main requirement in real time system, end to end delay in DSDV is less because of table driven approach used by almost all proactive protocols, but because of this approach extra overhead in the network is introduced which degrades it's performance with respect to NRL, Throughput and PDF.

6.2 Future Scope

The analysis of AODV, DSDV in MANET environment in this thesis has been performed by using offline simulation. It would be interesting to simulate and analyze their behavior in realistic scenario by specifying acceleration, deacceleration, maximum speed and other movement characteristic of protocol under real map with large number of nodes and by generating a scenario where protocols can exchange messages that will change their speed, lane etc., hence communication scenario can be totally different from offline.

References

[1] E. Spaho, M. Ikeda, L. Barolli, F. Xhafa, M. Younas, and M. Takizawa, “Performance Evaluation of OLSR and AODV Protocols in a VANET Crossroad Scenario”, In Advanced Information Networking and Applications (AINA), 2013 IEEE 27th International Conference on, pp. 577-582. IEEE, 2013.

[2] Ikeda, Makoto, Elis Kulla, Masahiro Hiyama, Leonard Barolli, Muhammad Younas, and Makoto Takizawa. "Performance Evaluation of AODV Protocol for Single and Multiple Traffic in MANETs Considering Packet Delivery Fraction Parameter." In Emerging Intelligent Data and Web Technologies (EIDWT), 2012 Third International Conference on, pp. 74-80. IEEE, 2012.

[3] Yang, Tao, Tetsuya Oda, Leonard Barolli, Jiro Iwashige, Arjan Durresi, and Fatos Xhafa. "Investigation of Packet Loss in Mobile WSNs for AODV Protocol and Different Radio Models." In Advanced Information Networking and Applications (AINA), 2012 IEEE 26th International Conference on, pp. 709-715. IEEE, 2012.

[4] Nosaka, Yohei, Tao Yang, Gjergji Mino, Leonard Barolli, Fatos Xhafa, and Arjan Durresi. "Comparison Evaluation of Single and Multi Mobile Events Wireless Sensor Networks Using AODV Protocol." In Complex, Intelligent and Software Intensive Systems (CISIS), 2011 International Conference on, pp. 168-175. IEEE, 2011.

[5] Kulla, Elis, Makoto Ikeda, Leonard Barolli, Rozeta Miho, and Vladi Kolici. "Effects of Source and Destination Movement on MANET Performance Considering OLSR and AODV Protocols." In Network-Based Information Systems (NBiS), 2010 13th International Conference on, pp. 510-515. IEEE, 2010.

[6] Kulla, Elis, Masahiro Hiyama, Makoto Ikeda, Leonard Barolli, Vladi Kolici, and Rozeta Miho. "MANET performance for source and destination moving scenarios considering OLSR and AODV protocols." Mobile Information Systems 6, no. 4 (2010): 325-339.

[7] Yang, Tao, Leonard Barolli, Makoto Ikeda, Fatos Xhafa, and Arjan Durresi. "Performance analysis of olsr protocol for wireless sensor networks and comparison evaluation with aodv protocol." In Network-Based Information Systems, 2009. NBIS'09. International Conference on, pp. 335-342. IEEE, 2009.

[8] Aggarwal, Akshai, Savita Gandhi, and Nirbhay Chaubey. "Performance Analysis of AODV, DSDV and DSR in MANETs." arXiv preprint arXiv:1402.2217 (2014).

[9] Kanigoro, Bayu, Andreas Calvin Gotandra, and Yansen Jayawinata. "Mobile Ad-Hoc Network Based Child Monitoring with DSDV Routing." Journal of Networks 9, no. 3 (2014): 629-634.

[10] Kabiwa, M. S., Karim Djouani, and A. Kurien. "Performance Evaluation of the IBETX Routing Metric Over DSDV Routing Protocol in Wireless Ad hoc Networks." Procedia Computer Science 19 (2013): 1108-1115.

[11] Wasiq, S., Nadeem Javaid, M. Ilahi, R. D. Khan, U. Qasim, and Z. A. Khan. "Evaluating and Comparing Probability of Path Loss in DSDV, OLSR and DYMO at 802.11 and 802.11 p." arXiv preprint arXiv:1306.0761 (2013).

[12] Mohammad, S. N., S. Wasiq, W. Arshad, Nadeem Javaid, S. Khattak, and M. J. Ashraf. "Modeling Probability of Path Loss for DSDV, OLSR and DYMO above 802.11 and 802.11 p." In Broadband and Wireless Computing, Communication and Applications (BWCCA), 2013 Eighth International Conference on, pp. 534-538. IEEE, 2013.

[13] Wasiq, S., Nadeem Javaid, M. Ilahi, R. D. Khan, U. Qasim, and Z. A. Khan. "Evaluating and Comparing Probability of Path Loss in DSDV, OLSR and DYMO at 802.11 and 802.11 p." arXiv preprint arXiv:1306.0761 (2013).

[14] Razouqi, Qutaiba, Ahmed Boushehri, Mohamed Gaballah, and Lina Alsaleh. "Extensive Simulation Performance Analysis for DSDV, DSR and AODV MANET Routing Protocols." In Advanced Information Networking and Applications Workshops (WAINA), 2013 27th International Conference on, pp. 335-342. IEEE, 2013.

[15] Abri, Rahem, and Sevil Sen. "A Lightweight Threshold-Based Improvement on DSDV." In Ad Hoc Networks, pp. 135-145. Springer International Publishing, 2014.

[16] Majumder, Koushik, Sudhabindu Ray, and Subir Kumar Sarkar. "Hybrid Scenario Based Analysis of the Effect of Variable Node Speed on the Performance of DSDV and DSR." In Advances in Computing and Information Technology, pp. 797-806. Springer Berlin Heidelberg, 2012.

[17] Singh, Sunil Kumar, Rajesh Duvvuru, and Jyoti Prakash Singh. "Performance Impact of TCP and UDP on the Mobility Models and Routing Protocols in MANET." In Intelligent Computing, Networking, and Informatics, pp. 895-901. Springer India, 2014.

[18] Zafar, Sherin, and M. K. Soni. "Trust based QOS protocol (TBQP) using meta-heuristic genetic algorithm for optimizing and securing MANET." In Optimization, Reliabilty, and Information Technology (ICROIT), 2014 International Conference on, pp. 173-177. IEEE, 2014.

[19] Krishna Gorantala , "Routing Protocols in Mobile Ad-hoc Networks", A Master' thesis in computer science, pp-1-36, 2006.

[20] M. Greis, "Ns Tutorial," [Online]. Available: http://www.isi.edu/nsnam/ns/tutorial/

[21] R. E. Shannon, "Introduction to the art and science of simulation," in 30th conference on Winter simulation, 1989.

List of Publications

[1] S.P. Verma, Anil K. Verma, "Harnessing MANETs for better Technology", Communicated to International Conference on Harnessing Engineering, Technology and Invitation for Sustainable Growth, PU Chandigarh (Under TEQIP).