A Simulative Study of AODV, DSDV & DSR Routing Protocols for MANET

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Abstract*— *In the past few years we have witnessed a tremendous inflation in the world of mobile computing. Due to the rise of inexpensive and widely available wireless devices, Ad-hoc networks have now become one of the most vibrant and active field of communication and networks and it has captured an important part of the interest of researchers. Mobile Ad-hoc Network (MANET) is an infrastructure-less mobile wireless communication system, meaning that MANET nodes can function both as an end system and also as a router to forward data packets. These nodes are free to move about and change position frequently without a centralized control mechanism, hence the name of "multi-hop wireless network". As like any other wireless network, routing protocols are the primary strategy to its design. Route discovery and packet forwarding operations within a network need an efficient routing protocol. The main method for evaluating the performance of MANETs is simulation.

In this paper, we compare and evaluate the functionality and performance of the 3 widely used routing protocols in MANET which are AODV (Ad-Hoc On-Demand Distance Vector), DSDV (Destination Sequenced Distance Vector) and DSR (Dynamic Source Routing) routing protocols. Simulations are all conducted in Network Simulator 2.35 (NS2) running on Ubuntu 10.04 LTS (Linux). Performance evaluations are based on metrics such as end-to-end delay, throughput, packet delivery ratio and jitter as the number of nodes in a network change.

Keywords*—*AODV, DSDV, DSR, end-to-end delay, jitter, multi-hop wireless network, packet delivery ratio, throughput.

I. INTRODUCTION

A. MANET

Mobile Ad-Hoc Networks (MANETs) are networks that are comprised of interconnected nodes that are free to move about frequently and independently without the need of a centralized control mechanism. They are highly dynamic networks, characterized by the absence of physical infrastructure (infrastructure-less network). Each device (or node) in a MANET acts as both an end system and also as a router to forward data packets to its nearby discovered routes of neighboring devices. All nodes in this network are mobile and use wireless connections to communicate with other various networks. The primary challenge in building MANET is setting up each device to continuously maintain the required information to properly route traffic. Due to the constrained wireless transmission range of each node, data packets should be forwarded along multi-hops. Routing is one of the core problems of networking for delivering data from one node to another. Because of the complexity and difficulty in conducting performance analysis for such networks, simulation experiments are often conducted.

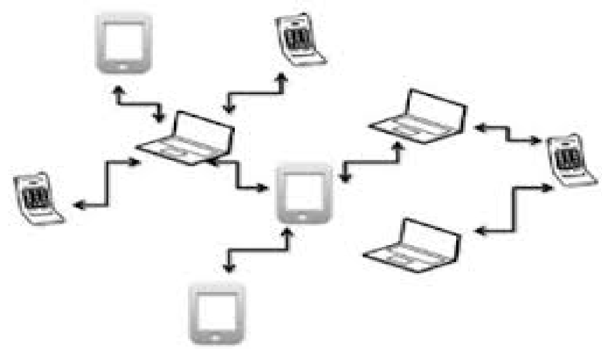

Fig. 1: Mobile Ad-hoc Network.

Wireless ad-hoc communication networks are also called Mobile ad-hoc multi-hop networks without a centralized control of predetermined topology. Because MANETs are characterized as having a dynamic, multi-hop, potentially rapid changing topology, therefore multiple network hops are required to deliver, receive and exchange data across a network. The aim of such network is to provide communication capabilities to locations or areas with limited to no communication infrastructures, but since the communication links in wireless network is unreliable, the need for an integrated design of physical, MAC and network layer is desired.

Several salient characteristics of MANETs are:

- Dynamic topologies
- Bandwidth constrained, variable capacity links
- Energy constrained operation
- Limited physical security

B. Applications of MANETs

When Some applications of MANET in the real world include:

- Military Scenarios
  - ✓ Tactical network for military communications
  - ✓ Automated battle fields
- Emergency Scenarios
  - ✓ Replacement of fixed infrastructure network in case of environmental disaster
  - ✓ Search and rescue operations
- Commercial Scenarios
  - ✓ E-commerce
  - ✓ Networks of visitors at airports
  - ✓ Shopping Malls
- Home and Enterprise

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- ✓ Meeting rooms
- ✓ Home/Office wireless networking conferences
- ✓ Personal Area Networks (PAN)
- Education
  - ✓ Universities and campus settings
  - ✓ Meetings or lectures
  - ✓ Virtual classrooms
- Entertainment
  - ✓ Gaming (multi-player ad-hoc share)
  - ✓ Wireless P2P networking
  - ✓ Outdoor Internet Access
- Device Network
  - ✓ Wireless connections b/w various mobile devices
  - ✓ Free internet connection sharing
- Sensor Network
- ✓ Smoke detectors
- ✓ Body Area Networks (BAN)
- ✓ Data tracking of environmental conditions.

II. MANET Routing Protocols

There are many routing protocols available today for Mobile Ad-Hoc Network, and they are broadly divided into 3 categories:

A. Proactive or Table-Driven Routing Protocols

Proactive is a table-driven protocol, meaning that each node (or device) maintains one or more tables containing routing details about nodes in the network. It maintains the information of destinations and their routes by periodically sending routing tables throughout the network. Because of the dynamically changing topology of ad-hoc networks, each node updates the routing tables whenever significant new information is presented, in order to maintain its consistency. Here are some examples of proactive routing protocols:

- DSDV (Destination Sequenced Distance Vector)
- WRP (Wireless Routing Protocol)
- CGSR (Cluster-head Gateway Switch Routing)
- GSR (Global State Routing)
- FSR (Fisheye State Routing)
- HSR (Hierarchical State Routing)
- STAR (Source Tree Adaptive Routing)

B. Reactive Routing Protocols

Reactive is an on-demand protocol, as unlike proactive protocols, the routing tables are created as and when required and each node only maintains the routes for active destinations. These protocols have higher latency but lower overhead of route maintenance due to the fact that a route search is needed for every new destination. Here are some examples of reactive routing protocols:

- AODV (Ad-hoc On-Demand Distance Vector)
- DSR (Dynamic Source Routing)
- CBR (Cluster Based Routing)
- AOMDV (Ad-hoc Multipath Distance Vector Routing)

C. Hybrid Routing Protocols

This protocol incorporates the merits of proactive as well as reactive routing protocols. Nodes are grouped into zones based on their geographical locations or distances from each other. Inside a single zone, routing is done using table-driven mechanisms while an on-demand routing is applied for routing beyond the boundaries of the zone. The routing table size and update packet size are reduced by including in them only part of the network; thus, control overhead is reduced. ZRP (Zone Routing Protocol) is a hybrid routing protocol.

III. Overview of Routing Protocols

A. AODV (Ad-hoc On-Demand Vector)

AODV is a source-drive type routing protocol. It is considered as the most well-known routing protocol for MANET, which is a hop-by-hop reactive (on-demand) source routing protocol where communication only takes place when needed and distance vector means a link-state protocol. This routing protocol floods the network with Route Request (RREQ) sending it to each and every node in the network. When all intermediate nodes have a valid and appropriate route to the destination node, then the Route Reply (RREP) packet is sent to the source by the nodes or by the destination node itself. The shortest route (least number of hops) is considered for data exchange. If no valid route is found, then the Route Error (RRER) packet is sent back to the source node.

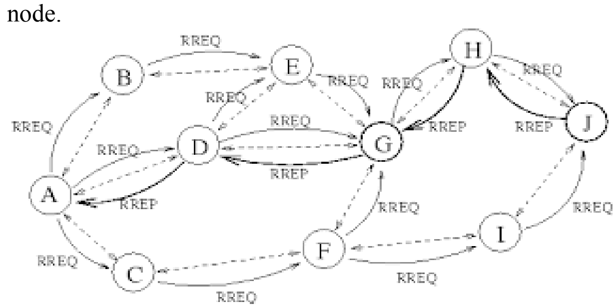

Fig. 2: AODV Data Flow Diagram.

B. DSDV (Destination Sequenced Distance Vector)

DSDV takes a table-driven approach meaning that routing tables (or routes) are preinstalled or predetermined from source to destination, so there is no need for route discovery. DSDV guarantees a loop free path to each destination without requiring nodes to participate in any complex updating protocols. DSDV updates its paths randomly or whenever new significant information presents itself, so data packets won't go through the same route every time they are sent form one node to another. But the downfall of DSDV updating its paths randomly is that it would consume more bandwidth and more power. Sometimes updating can fully dump the network.

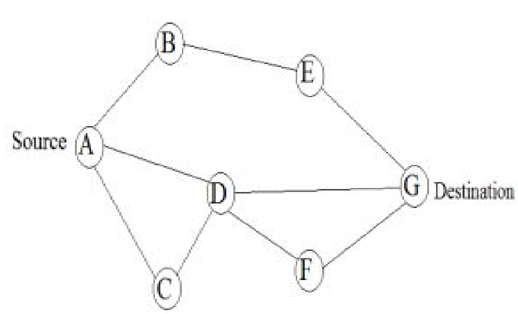

Fig. 3: DSDV Data Flow Diagram.

C. DSR (Dynamic Source Routing)

DSR, like AODV, is a type of reactive routing protocol, meaning it is also an on-demand protocol designed for use in multi-hop wireless networks. It allows the network to be completely self-organizing and self-configuring without the need for any existing network administration of infrastructure. The two major phases of DSR is route discovery and route maintenance. DSR is one of the purest examples of an on-demand routing protocol that is based on the concept of source routing.

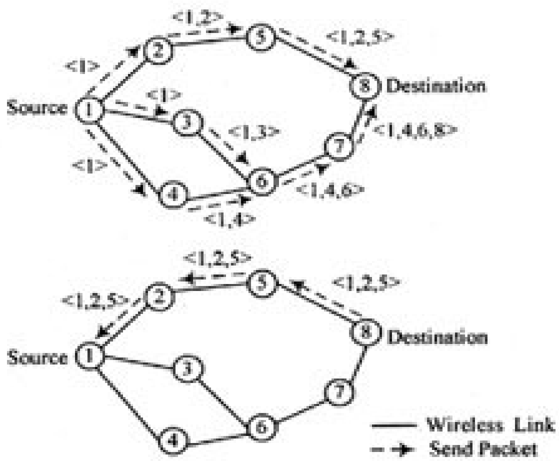

Fig. 4: DSR Data Flow Diagram.

IV. Network Simulators

All simulations in this paper are conducted on Network Simulator 2.35 (NS2) running on Ubuntu 10.04 LTS (Linux OS). MANETs simulators exhibit different features and models. As there is more than one available simulator, the choosing of the simulator should be influenced by the requirements. If high-precision PHY layers are needed, then NS2 is clearly the wisest choice as it provides generous support for simulation of TCP, UDP, routing and multicast protocols over wired and wireless networks. It contains packages of tool to simulate the behavior of different networks. It also includes scripting languages, new network protocols and it evaluates performances well. More complex functionality depends on C++ code that either comes with NS2 or is provided by the user. It creates network topologies log events that happen under any load and analyze events to understand the network behavior.

Languages used in NS2 are C, C++, TCL. C and C++ are programming languages used for coding purposes whereas TCL is used as a scripting language. One of the components used in NS2 is Network Animator (NAM). NAM is a Tcl/AWK based animation tool for viewing network simulation traces and real world packet trace data. The first step to using NAM is to produce the trace file from the TCL script.

To investigate network performance like end-to-end delay, packet delivery ratio and throughput between the nodes in MANET, users can simply use and easy-to-use scripting language to configure a network and observe results generated by NS2.

V. Simulation Parameters

There are multiple number of metrics or parameters that can be used to analyze a protocol performance in MANETs. In this paper, we will consider the metrics; throughput, end-to-end delay and packet delivery ratio to evaluate the network performance.

A. Throughput

It is defined as the total number of packets successfully received by the destination node over elapsed time.

Throughput = Data Transmitted / Unit of Time

It is used to calculate the average throughput of the application traffic between the nodes.

B. End-to-End Delay

It is the time taken by the data packet to transmit from source to destination across the network.

End-to-End Delay = Transmission Delay + Propagation Delay + Processing Delay + Queuing Delay

Only the data packets that were successfully delivered are counted.

C. Packet Delivery Ratio (PDR)

It is the percentage of successfully delivered packets to the total number of sent packets to the destination by the source.

PDR = received packets / total sent packets * 100

D. Jitter

It is the time difference in packet inter-arrival time to their destination. If latency equals the time taken for one packet to move from Point A to Point B, the jitter equals the change in the amount of time it takes for a packet to move from Point A to Point B. Jitter is sometimes referred to as “Packet Delay Variation”, or PDV.

VI. Simulation Results

In this paper, the routing performances for AODV, DSDV and DSR routing protocols for MANET were conducted in running simulation-based scenarios of 5, 10, 15, 20 and 25 nodes communicating through TCP connections. Performances are analyzed on the following metrics: throughput, end-to-end delay, packet delivery ratio and jitter. The figures below show simulation animations generated from running the NAM files.

A. NAM Generated Files of AODV

Fig. 5: AODV with 5 nodes.

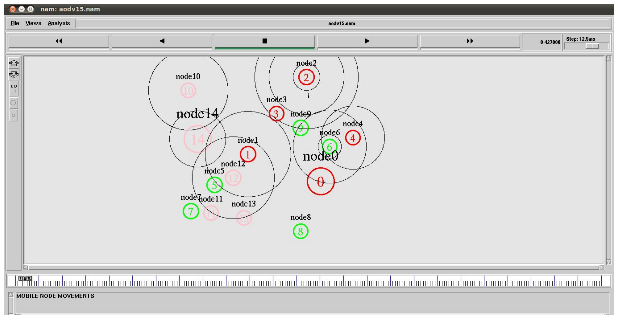

Fig. 6 AODV with 15 nodes.

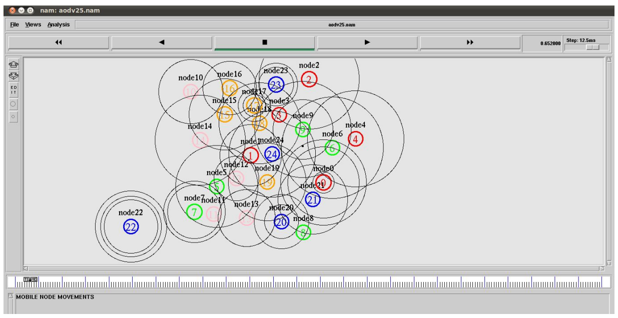

Fig. 7: AODV with 25 nodes.

B. NAM Generated Files of DSDV

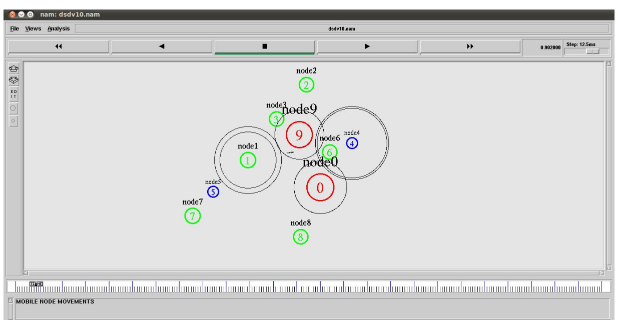

Fig. 8: DSDV with 10 nodes.

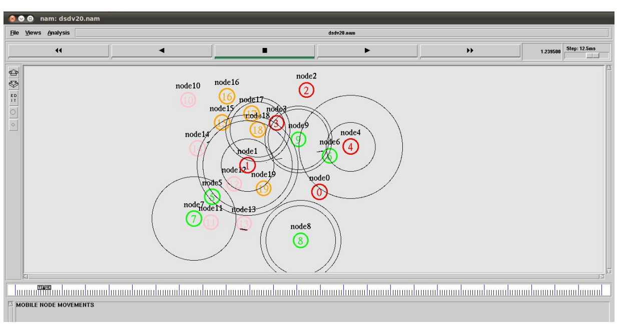

Fig. 9: DSDV with 20 nodes.

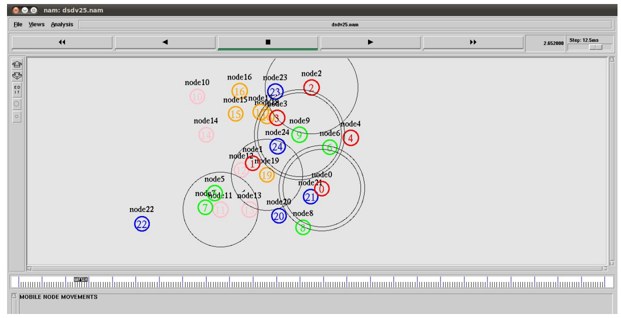

Fig. 10: DSDV with 25 nodes.

C. NAM Generated Files of DSR

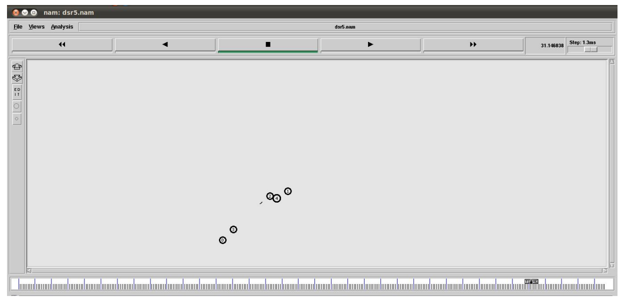

Fig. 11: DSR with 5 nodes.

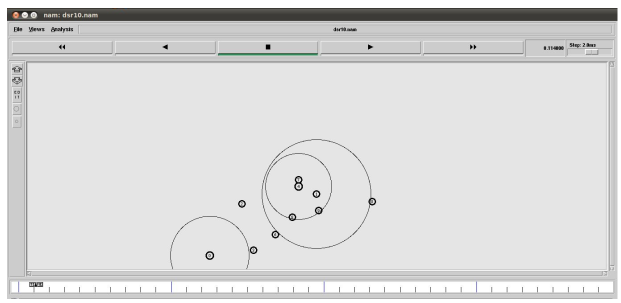

Fig. 12: DSR with 10 nodes.

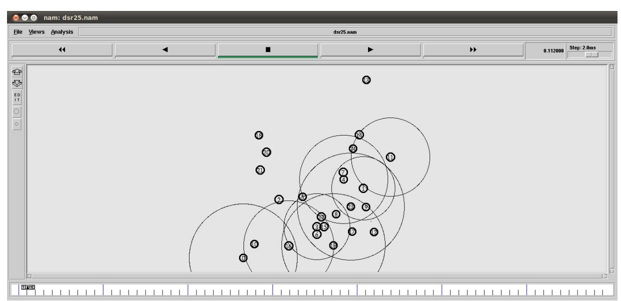

Fig. 13: DSR with 25 nodes.

VII. Result Analysis

After running the simulations on NS2, the TCL script file outputs a trace file log of all conducted simulations. The trace file can be analyzed and broken down into specific variables using a short script in awk or perl language. For this paper, a perl script was written and was used to analyze the trace files from each simulation giving the results for the investigated parameters. These results are plotted onto graphs using XGraph to provide visual aids for the results analysis. The results from each simulation are shown below:

A. Throughput

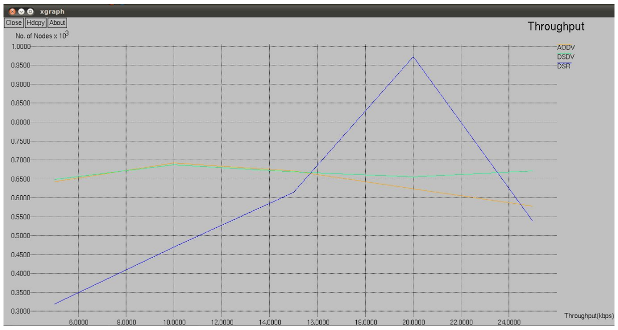

Fig. 14: Throughput for AODV, DSDV and DSR.

The throughput result for the simulations of the 3 routing protocols are plotted onto a graph using XGRAPH. In Fig. 14 above, DSDV shows a steady and consistent throughput as the number of nodes increase. AODV shows a small throughput drop compared to DSDV as the network increases while DSR shows an inconsistent pattern with a sharp increase at 20 nodes, and a fast decrease at the 25 nodes mark for its throughput. The analysis shows that DSDV is the better performer with AODV coming in second place.

B. End-to-End Delay

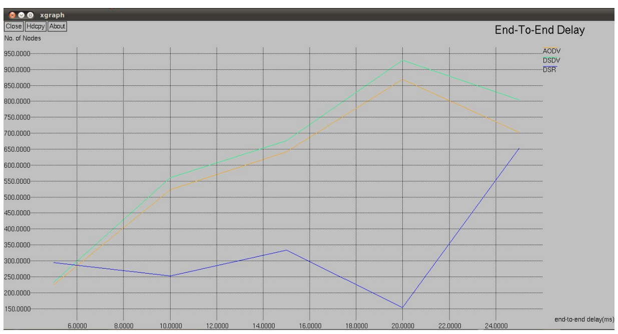

Fig. 15: End-to-End Delay for AODV, DSDV and DSR.

Dividing the total time difference over the total number of received packets gave the average end-to-end delay. The lower the end-to-end delay the better the performance of a routing protocol. AODV and DSDV shows an almost identical pattern while DSR gives low end-to-end delay except in the 25 nodes mark with a huge increase. In terms of end-to-end delay, DSR is the best performer out of the 3, with AODV coming in second place.

C. Packet Delivery Ratio

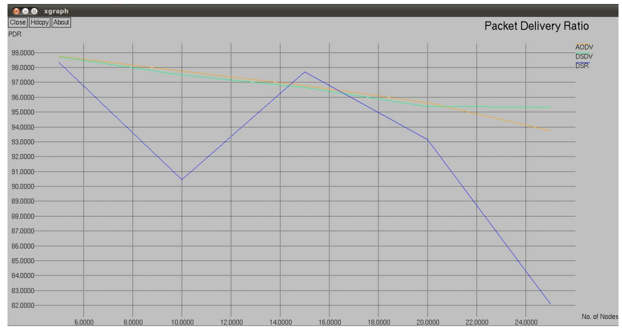

Fig. 16: Packet Delivery Ratio for AODV, DSDV and DSR.

The packet delivery ratio metric is simply the total number of successfully delivered and received packets divided by the number of the total sent packets including the dropped packets from source to destination. The higher the percentage the better the performance of a routing protocol. In Fig. 16 above, DSDV shows a consistent pattern with AODV also showing a consistent pattern from beginning but slightly decreasing towards the 25 nodes mark. DSR however shows a significant decrease as the network increases. In terms of PDR, DSDV and AODV are the best performers.

D. Jitter

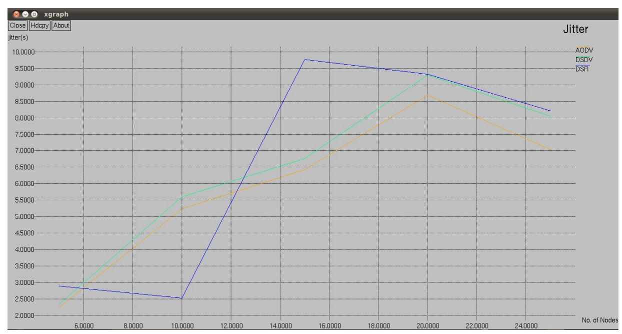

Fig. 17: Jitter for AODV, DSDV and DSR.

Jitter is simply the time difference in packet inter-arrival time to their destination, it is the time delay between the arrival of packages from source to destination. The less jitter the better the performance of a routing protocol. Fig. 17 above shows DSR with the least jitter at the 10 nodes mark, but as the network increased, it also increased significantly but it slowly decreases towards the end. AODV and DSDV shows a steady increase and then a decrease at the last 2 simulations (20 and 25 nodes). Overall, AODV performs the best in terms of jitter performance.

Table 1: Parameter Results for AODV, DSDV and DSR.

Protocols	Parameters	5 nodes	10 nodes	15 nodes	20 nodes	25 nodes
AODV	Throughput	642.24	692.42	670.16	623.77	577.29
	End-to-End Delay	224.81	523.49	641.41	869.21	702.58
	PDR	98.75	97.76	96.78	95.62	93.76
	Jitter	2.24	5.23	6.42	8.69	7.03
DSDV	Throughput	648.82	686.87	667.88	655.75	670.70
	End-to-End Delay	233.60	560.39	676.01	929.03	804.71
	PDR	98.72	97.49	96.66	95.38	95.33
	Jitter	2.34	5.60	6.76	9.30	8.05
DSR	Throughput	318.96	469.28	613.93	973.04	538.46

	End-to-End Delay	293.78	252.92	333.31	153.35	652.98
	PDR	98.33	90.44	97.70	93.15	82.07
	Jitter	2.89	2.53	9.77	9.32	8.21

CONCLUSION AND FUTURE WORK

The simulations of MANETs routing protocols; AODV, DSDV and DSR, were conducted and the investigated parameters were obtained from the trace files that were generated from each simulation. The simulations of each routing protocol were carried out in 5 different network sized scenarios; 5 nodes, 10 nodes, 15 nodes, 20 nodes and 25 nodes. Each of these simulations produced trace files which were then analyzed using a script written in perl and it gave results specific to each of the investigated metrics. From the results, it showed that in terms of throughput, DSDV showed the most consistent while also AODV showed consistency in the beginning simulations but decreased a bit in the final simulations. DSR proved to be the better routing protocol in the end-to-end delay metric but failed in the PDR and Jitter tests. Taking all the results for comparison, AODV and DSDV proved to be the better routing protocols. While neither one showed superiority over the other, they are both capable of handling big sized networks. DSR is more suitable for low power and low bandwidth networks. It is suitable for networks with moderate mobility rate. While these are the results obtained for this paper, other results may vary depending on different scenarios and number of nodes.

Suggestion for future work would be to increase the network size (add more nodes) and add more parameters for testing. Of course, simulation scenarios can never fully represent real world implementations of MANET routing protocols but it’s the best we can do to fully understand and try to develop better routing protocols.

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