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Performance Comparison for AODV, DSR and DSDV W.R.T. CBR and TCP in Large Networks

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Abstract—Mobile Ad hoc Network (MANET) is a wireless ad hoc self-configuring network of mobile routers (and associated hosts) connected by wireless links, the union of which forms an arbitrary topology, cause of the random mobility of the nodes. In this paper, an attempt has been made to compare these three protocols DSDV, AODV and DSR on the performance basis under different traffic protocols namely CBR and TCP in a large network. The simulation tool is NS2, the scenarios are made to see the effect of pause times. The results presented in this paper clearly indicate that the different protocols behave differently under different pause times. Also, the results show the main characteristics of different traffic protocols operating on MANETs and thus select the best protocol on each scenario.

Keywords—Awk, CBR, Random waypoint model, TCP.

I. Introduction

RECENTLY there has been tremendous growth in the sales of laptop and handheld computers. These small computers come with hundreds of megabytes, high-resolution colour displays and wireless communication adapters. Therefore, since many of these small computers operate for hours with powered battery, users are free to move without being constrained by wires. As people begin to have mobile computers handy for whatever purposes, sharing information between the computers will become a natural requirement. However, in areas where there is little or no communication infrastructure or the existing infrastructure is expensive or cannot be used, users may still want to communicate through the formation of an Ad hoc Network. For example, a general group of people wishing to communicate and share information such as conferences, and electronic classrooms. In Ad hoc Networks, each mobile node can be a router or end user , routing packets between each other and sending packets from an end user to another end user it's a combination of mobile phones for the purpose of communication.. However, one of the Modern active fields today is Mobile ad hoc networks (MANETs).

II. Problem Statment

There are many routing protocols in mobile ad hoc networks; the popular ones are AODV, DSR and DSDV. Although a lot of research, work is done on individual protocols but not enough research is done on comparing these protocols in large networks under different environments such as CBR and TCP. This paper work also helps in choosing a protocol best suited to particular scenario by studying the pros and cons of the tested protocols.

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III. Previous Work

In this section we summarize the most relevant previous studies concerning ad hoc routing performance comparisons. The authors in [16], made an interesting approach using burst time as a new performance parameter and with a varying number of nodes but only on VBR traffic. The authors in [17] did the comparison on AODV, DSDV and the new protocol MDSDV as the first systematic evaluation for it, with many number of nodes but only using CBR traffic and with 10 UDP source connections. A very good work in [18], a comparison made in three conditions; speed, pause time and number of nodes, although the maximum number of nodes were 35 and the traffic used were CBR. Authors in [19], [20] used nearly the same evaluation model with a field of 500*500 m, 50 nodes, 100 sec of simulation time, CBR traffic and the same pause times. However these papers [19], [20] didn't include a large scale comparison with respect to TCP and CBR, this is also the case in [18]. From our knowledge the work we have done differs in that we extend our observations to large-scale deployments under different environments such as CBR and TCP with varying number of pause times. We observe and comment on the behavior of each traffic mode.

IV. Conventional Routing Protocols

A. Distance Vector Algorithm

In the distance vector algorithm, we assume that each router knows the identity of every other router in the network. The routers periodically send the distance vector information to all its neighbours. When a router receives a distance vector from its neighbour, it updates its distance vectors [1].

B. Link State Routing

In the Link State Routing scheme, the routers transmit the distance vector, to all the routers. Each router independently computes the optimal paths to every destination. Therefore unlike the Distance Vector scheme, the knowledge is distributed to the entire network by each router [1].

V. Mobile AD HOC Routing Protocols

"The limited resources in MANETs have made designing an efficient and reliable routing strategy a very challenging problem. An intelligent routing strategy is required to efficiently use the limited resources while at the same time be adaptable to the changing network conditions such as network size, traffic density, and network Partitioning" [2]. Routing in MANETs is classified in two main approaches:

A. *Proactive Protocols*

The proactive routing approaches designed for ad hoc networks are derived from the conventional distance vector and link state protocols, each node in the network has a route to all the nodes in the network at any time [3]. So there is no delay when wishing to send data to another node because it's always active in all times. The main mechanisms adopted in proactive protocols are the following [4]:

- Increasing the amount of topology information stored at each node to avoid loops and speed up convergence time.
- Varying dynamically the size of route updates and/or the update frequency
- Combining DV and LS features.

B. *Reactive Protocols*

Reactive protocols are also called on-demand routing protocols. In MANETs link connectivity can change frequently and control overhead is costly, so the idea of reactive routing by not continuously maintaining a route between all pairs of network nodes. Instead, routes are only discovered when they are actually needed [3]. So there is a delay before starting the sending, reactive protocols are lazy, and active when needed. A reactive protocol is characterized by the following procedures, used to manage paths [4]:

1. Path Discovery

The discovery procedure is based on a query reply cycle and accomplished on demand when there is no path to the destination is known, the destination is eventually reached by the query and at least a reply is generated.

2. Path Maintenance

Routing entries are maintained by a maintenance procedure until it is either no longer used or completely deleted.

3. Path Deletion (Optional).

VI. Wireless AD HOC Routing Protocols

A. *Destination-Sequenced Distance Vector (DSDV)*

DSDV [5]. is based on a conventional Distance Vector routing protocol, adapted for use in ad hoc networks. Routing is achieved by using routing tables maintained by each node. The bulk of the complexity in DSDV is in generating and maintaining these routing tables. In DSDV, packets are routed between nodes of an ad hoc network using routing tables stored at each node. Each routing table, at each node, contains a list of the addresses of every other node in the network. Along with each node's address, the table contains the address of the next hop for a packet to take in order to reach the node. In addition to the destination address and next hop address, routing tables maintain the route metric and the route sequence number. Periodically, or immediately when network topology changes are detected, each node will broadcast a routing table update packet. The update packet starts out with a metric of one. This signifies to each receiving neighbor they are one hop away from the node. The neighbors will increment this metric (in this case, to two) and then retransmit the update packet. This process repeats itself until every node in the network has received a copy of the update packet with a corresponding metric. If a node receives duplicate update packets, the node will only pay attention to the update packet with the smallest metric and ignore the rest. DSDV requires nodes to periodically transmit routing table update packets, regardless of network traffic. These update packets are broadcast throughout the network so every node in the network knows how to reach every other node. As the number of nodes in the network grows, the size of the routing tables and the bandwidth required to update them also grows. This overhead is DSDV's main weakness.

B. *Dynamic Source Routing Protocol (DSR)*

The Dynamic Source Routing (DSR) [6]. protocol is an on-demand routing protocol based on source routing, which allows nodes to dynamically discover a route across multiple network hops to any destination. Source routing means that each packet in its header carries the complete ordered list of nodes through which the packet must pass. DSR uses no periodic routing messages (e.g. no router advertisements), thereby reducing network bandwidth overhead, conserving battery power and avoiding large routing updates throughout the ad-hoc network. In designing DSR, we sought to create a routing protocol that had very low overhead yet was able to react very quickly to changes in the network. The DSR protocol provides highly reactive service in order to help ensure successful delivery of data packets in spite of node movement or other changes in network conditions. The DSR protocol mainly consists of two main mechanisms:

1. Route Discovery

Is the mechanism by which a node S wishing to send a packet to a destination node D and does not already know a route to D.

2. Route Maintenance

When originating or forwarding a packet using a source route, each node transmitting the packet is responsible for confirming that data can flow over the link from that node to the next hop . Route Maintenance is used only when there is an actual sending of packets.

C. *Ad Hoc on Demand Distance Vector (AODV)*

AODV [7]. routing algorithm is a routing protocol designed for ad hoc mobile networks. It is capable of both unicast and multicast routing. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes.

It maintains these routes as long as they are needed by the sources. AODV takes the interesting parts of DSR and DSDV. It has the basic route-discovery and route-maintenance of DSR and uses the hop-by-hop routing, sequence numbers and beacons of DSDV [8]. During a route discovery process, the source node broadcasts a route query packet to its neighbors. If any of the neighbors has a route to the destination, it replies to the query with a route reply packet; otherwise, the neighbors rebroadcast the route query packet. Finally, some query packets reach the destination, or nodes that know a route to the destination. At that time, a reply packet is produced and transmitted tracing back the route traversed by the query packet. To handle the case in which a route does not exist or the query or reply packets are lost, the source node rebroadcasts the query packet if no reply is received by the source after a time-out. A path maintenance process is used by AODV to monitor the operation of a route being used. If a source node receives the notification of a broken link, it can re-initiate the route discovery processes to find a new route to the destination. If a destination or an intermediate node detects a broken link, it sends special messages to the affected source nodes [9].

VII. Simulation

A. Platform

All the simulation, implementation and analysis work was done on Linux platform, Ubuntu in particular. Ubuntu which is a computer operating system based on the Debian GNU/Linux distribution and distributed as free and open source software. The Linux platform worked on a computer with 3 GB ram and Intel Core 2Duo processor (2.40 GHz).

B. Simulator

Network Simulator - (NS-2) Ns-2 is a discrete event simulator targeted at networking research. It provides substantial support for simulation of TCP, routing and multicast protocols over wired and wireless networks. It consists of two simulation tools. The network simulator (ns) contains all commonly used IP protocols. The network animator (nam) is use to visualize the simulations. Ns-2 fully simulates a layered network from the physical radio transmission channel to high-level applications [10].

C. Essential tools

1. The Mobility Generator

Setdest is CMU's movement generator for wireless scenarios, based on random waypoint model, a model that includes pause times between changes in destination and speed [11].

2. The Traffic Generator

Cbrgen.tcl Is CMU's connection-generator. for wireless scenarios, in this paper we did use it to generate TCP and CBR traffic in files

TABLE I
CBR Scenarios

Parameter	Value
Number of nodes	100
Simulation time	300
Pause time	10,30,50,100,200
Environment range	1000x1000
Traffic type	CBR
Packet size	512 byte
Packet rate	4 packets/s
Maximum speed	20 m/s
Minimum speed	10 m/s
Queue length	50
Ns2 version	2.34
Antenna	Omnidirectional
Max connections	50
Source initiators	31

TABLE II
TCP Scenarios

Parameter	Value
Number of nodes	100
Simulation time	300
Pause time	10,30,50,100,200
Environment range	1000x1000
Traffic type	TCP
Packet size	1460 byte
Maximum speed	20 m/s
Minimum speed	10 m/s
Queue length	50
Ns2 version	2.34
Antenna	Omnidirectional
Max connections	50
Source initiators	31

3. The Analyzing Tool (Awk)

From the original Awk paper published by Bell Labs, Awk is "Awk is a programming language designed to make many common information retrieval and text manipulation tasks easy to state and to perform" [12]. The basic function of Awk is to search files for lines (or other units of text) that contains certain patterns. The original version of Awk was written in 1977 [13].

VIII. Scenarios

We did the simulation using these scenarios, CBR and TCP.

IX. Performance Metrics

A. Packet delivery fraction (PDF)

The ratio of the data packets delivered to the destinations to those generated by the sources. For example, the generated packets from the CBR or the TCP [14].

B. Average end-to-end delay of data packets (AEED)

This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times [14].

C. Normalized routing load (NRL)

The number of routing packets transmitted per data packet delivered at the destination. Each hop-wise transmission of a routing packet is counted as one transmission. "The first two metrics are the most important for best-effort traffic. The routing load metric evaluates the efficiency of the routing protocol." [14].

D. The Number of dropped data (NDD)

This will calculate the number of the dropped data in megabytes in the simulation time, in other words the number of dropped packets in megabytes.

X. Results

A. CBR scenario results

Fig. 1 shows the PDF of the three protocols, with different five pause times, as we can see the three protocols are not having good results, the best result is about 27 %, but the competition between the AODV and the DSDV is clear, the protocols didn't start well in the 10 and 30 pause times but DSDV takes the lead as the pause times get bigger meaning as the network get more to the static mode, DSR is the worst in this scenario, it's clear that DSDV and AODV works better in higher pause times.

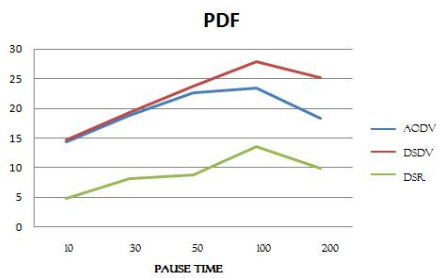

Fig. 1. PDF for CBR scenarios.

Fig. 2 shows the AEED to the three protocols in five different pause times, AODV has the least value here with 2 seconds as we see the AODV curve is consistent through the five pause times, in the second place comes the DSDV starting with more than 3 seconds, and as the pause time reaches to 200, the pause time goes to a high level to 6 seconds because the nodes were still with no move 200 seconds from 300 seconds of time so when there was some movement, the tables route's needed to be updated , DSR is the worst here starting in 9 seconds and then reaching the peak value of about 10 seconds.

Fig. 3 shows the NRL for the protocols in five different pause times DSDV wins the less percentage with 20% then

Fig. 2. AEED for CBR scenarios.

comes the AODV both in a consistent way, DSR is the worst case here it just get better in the final two pause times 100 and 200, but its clear that is DSR is suffering in highly mobility scenarios, the source routing is not effective in high mobility scenarios.

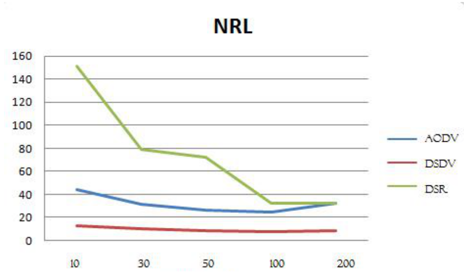

Fig. 3. NRL for CBR scenarios.

Fig. 4 shows the NDD for the three protocols in five different pause times, AODV is the least with 21 MB of dropped data, then the DSR with the 23 MB, the worst here is the DSDV with 27 MB to 24 MB as the pause time reaches to 200, the DSDV is the worst protocol in consuming the battery charge on dropped data

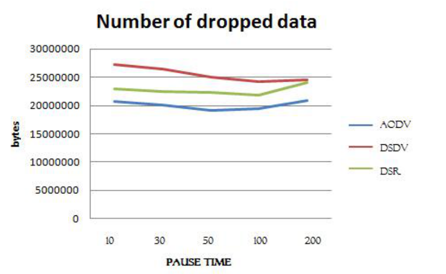

Fig. 4. NDD for CBR scenarios.

B. TCP scenario results

Fig. 5 shows the PDF in three different protocols in five different pause times, DSDV is the best with a consistent curve mainly because we are not sending streams of data, then in the second place AODV is starting good from 93% to 96.1%, DSR is the worst at 89% and then at the pause time 100 and

200 it reaches to 98% as the best percentage in the figure, and it proofs what had been said on DSR that it doesn't work good in high mobility networks.

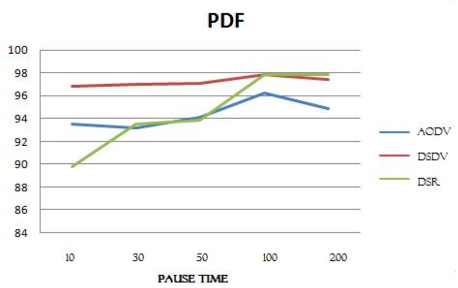

Fig. 5. PDF for TCP scenarios.

Fig. 6 shows the AEED for the three protocols in five different pause times, AODV has the lowest value with 240 ms and it reaches 350 ms at the pause time 200, in the second place comes the DSDV with 290 ms and it reaches 419 ms at the pause time 200, DSR is the worst here starting with pause time 910 ms and it doesn't stay stable throughout the pause times.

Fig. 6. AEED for TCP scenarios.

Fig. 7 shows the NRL for the three protocols in five different pause times, DSDV starts from 3% and the curve stays consistent through the different pause times, AODV starts from 5% and its curve is mimicking the DSDV's curve throughout the different pause times, DSR is the worst starting from 62% and it goes down till it reaches the AODV at the pause time 200.

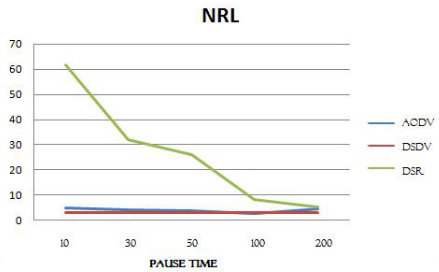

Fig. 7. NRL for TCP scenarios.

Fig. 8 shows the NDD for the three protocols in five different pause times, DSR starts well with 6 MB at the pause time 10, because it's NRL highest values are at the lowest pause time. As a result we can see that it has the least dropped data, but DSDV have a very good value too comparing with DSR starting from 8 MB and reaching to 11 MB, DSR starts to drop more MBs as there is an increase in the pause time, AODV is the worst here with 14 MB to 19 MB ending with 16 MB.

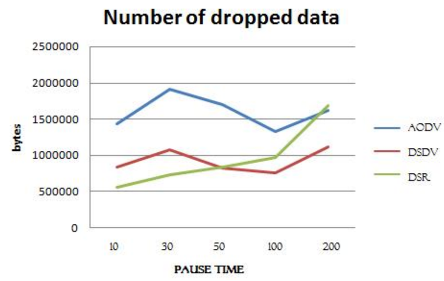

Fig. 8. NDD for TCP scenarios.

XI. Conclusions

This paper work presents a detailed comparative analysis of three MANET protocol AODV, DSR and DSDV under two different environments CBR and TCP in five pause times 10, 30, 50, 100, 200 and both in 100 nodes, the simulation time for the three scenarios was 300 seconds. When simulating with 100 nodes it was very difficult to import the trace files and also make some operations on them, we did use about 35 GB as memory storage for the trace files.

A. The CBR Results

From the observations and results, we can conclude that the AODV protocol performs better than the other protocols but this doesn't mean it's performing in a good way, just in comparison with the other protocols. All the three protocols can be implemented in a MANET CBR applications. In 100 nodes AODV and DSDV are taking the lead but DSDV has very high rate of dropping data which is not acceptable at all in the CBR connections, AODV leaves both of the protocols behind in the AEED. DSR is the worst as the results had been shown, it's clear that DSR is not working good in high mobility networks and in a large networks like 100 nodes.

B. The TCP Results

When it comes to TCP, the results are completely different. It really identifies the gap between streaming data and TCP connections and the effect of TCP connections on high mobility networks. The three protocols in PDF are showing very good results for 100 nodes which is not expected in a MANETs networks with a changing topology, the worst value of PDF was 90% and DSDV showed a consistent curve in the 98% which is very good as working in 100 node. The AEED is acceptable for DSDV and AODV but DSR has a severe delay, this comes from the nature of source routing and also it's based on a reactive scheme, the NRL for the DSDV and the AODV is very efficient, in contrast DSR, which is very weak in the high mobility scenarios, the number of dropped data is acceptable when the AEED and the PDF are having good results. Finally our conclusion here is that DSDV is the best performer then AODV and DSR are last choice, an Application based on TCP traffic protocols can be implemented and efficiently work very good.

C. The Comparison Concluded

Thus we can conclude that under different mobility scenarios, every protocol behaves differently depending on its way of building its routing table and how it can maintain the routes so they can be valid during the simulation time. from the above discussion, it can be concluded that the three protocols cannot be used in an application based on a CBR traffic protocol , but from the TCP scenarios DSDV is the best recommended protocol and then AODV.

Simulating large networks with different traffic protocols requires memory storage enough for the trace files and when thinking of simulating a large number of nodes especially over 100 it's recommended to use the Fast ns-2 simulator which is designed to simulate up to 3000 nodes, and the simulating is faster 30 times than the original version which will be very useful to simulate protocols in the Wide Area Networks [15].

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