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Comparison between two on-demand protocol and one demand for mobile ad hoc network

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Abstract

An ad-hoc network is a collection of wireless mobile nodes dynamically forming a temporary network without the use of any existing network infrastructure or centralized administration. A number of routing protocols likes Dynamic Source Routing (DSR), Ad Hoc on-Demand Distance Vector Routing (AODV) and Destination-Sequenced Distance-Vector (DSDV) Routing Algorithm has been implemented. In this paper an attempt has been made to compare the performance of two prominent on-demand reactive routing protocols for mobile ad-hoc networks: DSR and AODV, along with the traditional proactive DSDV protocol for different simulation times and connectivity sources using ns-2 simulator. The performance differentials are analyzed using varying network load, mobility, simulation times, connectivity sources and network size. The selected measuring criteria used to evaluate the routing protocols are: packet delivery ratio, average end-to-end delay of data packets, normalized routing load, routing packet overhead. The On-demand protocols, AODV and DSR perform better than the table-driven DSDV protocol. Although DSR and AODV share similar on-demand behavior, the differences in the protocol mechanics can lead to significant performance differentials.

Keywords: *Ad-hoc networks, wireless networks, mobile networks, routing protocols, simulation and performance evaluation.*

INTRODUTION

Wireless networking is an emerging technology that allows users to access information and services electronically, regardless of their geographic position. Wireless networks can be classified in two types first is infrastructure networks consists of a network with fixed and wired gateways. A mobile host communicates with a bridge in the network called base station within its communication radius. The mobile unit can move geographically while it is communicating. When it goes out of range of one base station, it connects with new base station and starts communicating through it. This is called handoff. In this approach the base stations are fixed [5]. Second infrastructure less ad-hoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network.

Ad-hoc networks are very useful in emergency search and rescue operations, meetings or conventions in which persons wish to quickly share information and data acquisition operations in inhospitable terrain. The Mobile ad-hoc network MANET's is a collection of wireless mobile nodes d

dynamically forming a temporary network without the use of any existing network infrastructure or centralized administration [1]. There are a number of characteristics in MANET's. Dynamic topologies, bandwidth constrain, energy-constrained and limited physical security [2]. The Applications are tactical military, Emergencies, Disaster relief, Sensor and Meetings /conferences. the main challenges in the design of MANET's [8] is there, dynamic topologies, bandwidth-constrained variable capacity links, energy-constrained, limited physical security and Scalability [2].

I. OVERVIEW OF AD-HOC ROUTNG PROTOCOLS

There are a number of routing protocols have been developed for MANET's as shown in Table I [8]. They can be divided into three categories: the table-driven protocols, the source-initiated on-demand protocols and the Hybrid protocols. DSDV [5], [6] belongs to the table-driven protocols. The most popular protocols nowadays are AODV [4] and DSR [3] routing protocols. Both of them belong to the source-initiated on-demand protocols. We will briefly describe DSR, AODV and DSDV protocols in the following.

TABLE I: ROUTING PROTOCOLS CATEGORIS FOR MANETs

Table driven (proactive)	**On-demand (reactive)**	**Hybrid**
Destination sequenced distance vector (DSDV) wireless routing protocol (WRP) source tree adaptive routing (STAR)	Dynamic source routing (DSR) Ad-hoc on demand distance vector (AODV) Signal stability routing (SSR) Temporary ordered routing algorithm (TORA) Associativity based routing protocol (ABR)	Zone routing protocol (ZRP)

A. DSDV

The Destination Sequenced Distance Vector Routing protocol described in [5] is a table-driven algorithm based on the classical Bellman-Ford routing mechanism [2]. Every mobile node in the network maintains a routing table in which all of the possible destinations within the network and the number of hops to each destination are recorded. Each entry is marked with a sequence number assigned by the destination node. The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops.

Routing table updates are periodically transmitted throughout the network in order to maintain table consistency. In order to reduce the amount of information carried in these packets, two types will be defined. One will carry all the available routing information, called a "full dump". The other type will carry only information changed since the last full dump, called an "incremental".
First the full dump. This type of packet carries all available routing information and can require multiple network protocol data units (NPDUs). During periods of occasional movement, these packets are transmitted infrequently.
Second Smaller incremental packets are used to relay only that information which has changed since the last full dump. Each of these broadcasts should fit into a standard-size NPDU, thereby decreasing the amount of traffic generated. The mobile nodes maintain an additional table where they store the data sent in the incremental routing information packets. New route broadcasts contain the address of the destination, the number of hops to reach the

destination, the sequence number of the information received regarding the destination, as well as a new sequence number unique to the broadcast [5].

The route labeled with the most recent sequence number is always used. In the event that two updates have the same sequence number, the route with the smaller metric is used in order to optimize (shorten) the path. Mobiles also keep track of the settling time of routes, or the weighted average time that routes to a destination will fluctuate before the route with the best metric is received. By delaying the broadcast of a routing update by the length of the settling time, mobiles can reduce network traffic and optimize routes by eliminating those broadcasts that would occur if a better route was discovered.

B. DSR

The Dynamic Source Routing, is an on-demand routing protocol that is based on the concept of source routing Mobile nodes are to perform a Route Discovery, the source node S broadcasts a ROUTE REQUEST packet with the Time-to-Live field of the IP header initialized to 1. This type of RREQ is called a non-propagating RREQ and allows node S to inexpensively query the route caches of each of its neighbors for a route to the destination. If no REPLY is returned, node S transmits a propagating RREQ that is flooded through the network in a controlled manner and is answered by a ROUTE REPLY packet from either the destination node or another node that knows a route to the destination. To reduce the cost of Route Discovery, each node maintains a cache of source routes it has learned or overheard, which it aggressively uses to limit the frequency and propagation of RREQ.

Route Maintenance is the mechanism by which a packet's sender S detects if the network topology has changed such that it can no longer use its route to the destination D because two nodes listed in the route have moved out of range of each other. When Route Maintenance indicates a source route is broken, S is notified with a RERR packet. The sender S can then attempt to use any other route to D already in its cache or can invoke Route Discovery again to find a new route [7].

C. AODV

The Ad-Hoc On-Demand Distance Vector routing protocol described in [4] builds on the DSDV algorithm previously described. AODV is an improvement on DSDV because it typically minimizes the number of required broadcasts by creating routes on a demand basis, as opposed to maintaining a complete list of routes as in the DSDV algorithm.

The authors of AODV classify it as a pure on-demand route acquisition system, since nodes that are not on a selected path do not maintain routing information or participate in routing table exchanges [4]. When a source node desires to send a message to some destination node and does not already have a valid route to that destination, it initiates a path discovery process to locate the other node. It broadcasts a RREQ packet to its neighbors, which then forward the request to their neighbors, and so on, until either the destination or an intermediate node with a "fresh enough" route to the destination is located [6].

The destination/intermediate node responds by unicasting a RREP packet back to the neighbor from which it first received the RREQ. As the RREP is routed back along the reverse path, nodes along this path set up forward route entries in their route tables which point to the node from which the RREP came. These forward route entries indicate the active forward route. Associated with each route entry is a route timer which will cause the deletion of the entry if it is not used within the specified lifetime. Because the RREP is forwarded along the path established by the RREQ, AODV only supports the use of symmetric links. Routes are maintained as follows.

If a source node moves, it is able to reinitiate the route discovery protocol to find a new route to the destination. If a node along the route moves, its upstream neighbor notices the move and propagates a link failure notification message an RREP with infinite metric to each of its active upstream neighbors to inform them of the erasure of that part of the route [4]. These nodes in turn propagate the link failure notification to their upstream neighbors, and so on until the source node is reached. The source node may then choose to reinitiate route discovery for that destination if a route is still desired.

II. SIMULATION SETUP

The simulation environment consists of a set of wireless and mobile networking extensions, we are using ns-2 simulator because the network simulator (NS-2) is a popular and powerful simulation environment, and the number of NS-2 users has increased greatly in recent years. Although it was originally designed for wired networks, NS-2 has been extended to work with wireless networks, including wireless LANs, MANET's, and sensor networks and can simulate several network protocols such as TCP, UDP, multicast routing, etc; however, the Network Animator (NAM) for NS-2 used as visualization tool [18] were ns-2 widely used, see paper [19]. More recently, support has been added for simulation of large satellite and ad-hoc wireless networks. Ns-2 is an open-source discrete event simulator used by the research community for research in networking. The ns-2 simulation software was developed at the University of California at Berkeley and the Virtual Inter Network Test bed (VINT) Project Fall 1997 [10].

The standard ns-2 distribution runs on Linux. However, a package for running ns-2 on Cygwin Linux Emulation for Windows is available [20]. The latest version of ns-2 is ns-2.31. These extensions provide a detailed model of the physical and link layer behavior of a wireless network and allow arbitrary movement of nodes within the network. At the physical layer, we provide realistic modeling of factors such as free space and ground reflection propagation, transmission power, antenna gain, receiver sensitivity, propagation delay, and carrier sense. At the link layer, with model the complete Distributed Coordination Function (DCF) Media Access Control (MAC) protocol of the IEEE 802.11 wireless LAN protocol standard IEEE 1997 [11], along with the standard Internet Address Resolution Protocol (ARP) [12].

These wireless and mobile networking extensions are available from the Carnegie Mellon University Monarch Project web pages [13] and have been widely used by other researchers; a version of them have also now been adopted as a part of the standard VINT release of ns-2. That have done a simulation ns-2 studies with this environment, analyzing the behavior and performance of routing protocols and comparing it to other proposed routing protocols for ad-hoc networks [1, 14], the parameters used for our simulation are given in Table II.

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TABLE II: SCENARIO FOR Ns-2 EXPERIMENTS

parameter \ scenario	First	second	third
Number of node	10,20,30,40,50	50	50
Topology area (x,y)meter	500*500 meter	500*500 meter	500*500 meter
Traffic type	cbr	cbr	cbr
Wireless range (m)	150 meter	150 meter	150 meter
Number of traffic source	8 source	15 source	15source
Send rate of traffic	1 packet/sec	1 packet/sec	1 packet/sec
Speed m/sec	15 meter/sec	1,5,10,15,20,25	25 meter/sec
Packet size (byte)	512 bytes	512 bytes	512 bytes
Simulation time (sec)	200s,500s,900s	200s,500s,900s	200s,500s,900s
Pause time (sec)	0 sec	0 sec	10,30,50,70,100,200 0,100,200,300,400,500 0,100,300,500,700,900

The traffic sources model called [15] communication model as the goal of our simulation was to compare the performance of each routing protocol; we chose our traffic sources to be constant bit rate (CBR) sources. The Mobility Model used the random waypoint model; we run the implementation of paper random waypoint model. in ns-2, obtained freely from [16] to generate the Scenario mobility files for different pause time for all simulation time as shown in Table II.

IV. PERFORMANCE METRICS

All protocols were run on identical movement and communication scenarios. Four performance metrics are computed for each simulation run. The first metric is the packet delivery ratio (*PDF*) which defined as the ratio of the data packets delivered to the destinations to those generated by the CBR sources and calculated as [14, 17]:

$$PDF = \frac{Number of\ packet received by destination}{Number of\ packet\ received}$$

The second metric is the average end-to-end delay (AED) of data packets which includes all possible delays caused by buffering during route discovery, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. It calculated as [14, 17]:

$$AED = \frac{\sum_{i=0}^{n} Time\ packet\ received - time\ packet sent}{Total\ number of\ packet received}$$

The third metric is the normalized routing load (NRL) which means the number of routing packets transmitted per data packet delivered at the destination and calculated as [14]:

$$NRL = \frac{Number\,of\ routing\ packets\ sent}{Total\ number\,of\ \ packets\ received}$$

The fourth metric is the Routing Packet overhead (RPO) which means the total number of transmissions routing packets and calculated as [1, 3].

$$RPO = Total\ number\,of\ transmissions\ routing\ packets$$

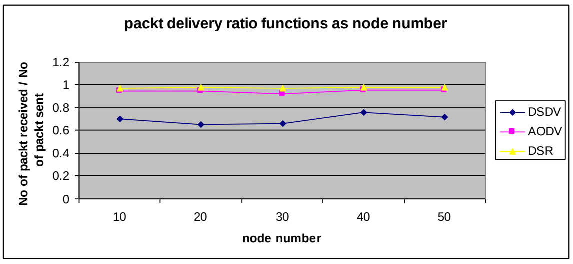
V. DISCUSSION AND EXPERMINTAL RESULTS

This section reports the results obtained to compare the performance of the three routing protocols for different simulation time using Ns-2 network simulator. Each run of the simulator accepts as input a scenario file that describes the exact motion of each node and the exact sequence of packets originated by each node, together with the exact time at which each change in motion or packet origination is to occur. We pre-generated six different scenario files of each speed and pause time for each simulation time with varying movement patterns of mobility model used random waypoint model [16], and then run all three routing protocols for each of these scenario files using Ns-2. The input of Ns-2 was prepared using Tool command language (Tcl) script files [21] which include the set up of the wireless simulation components with movement patterns generated for six different pause times, six different node speed and five different node number shown in Table II.

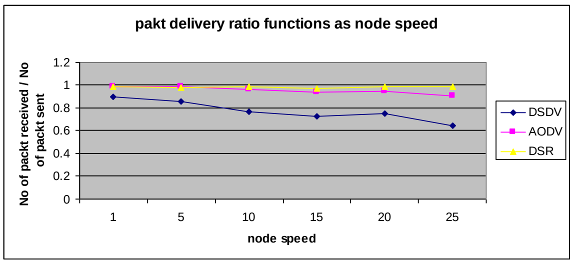
We implemented a JAVA code to extract the performance metrics from the generated trace files that output from Ns-2 simulator for three routing protocols at different simulation times. The format of this trace file depending on the packet type, the trace file may log additional information [22].

1. Packet delivery Comparison

Fig1 shows the packet delivery ratio for the three routing protocols as functions of node number, node speed and pause time at simulation time 200 sec. It could be noticed that, the DSR and AODV performed particularly well, delivering over 98% of the data packets regardless of mobility rate. As shown in Fig.1.a the successful delivery rate of DSR and AODV is obviously higher than DSDV. It could conclude from fig. 1.b if the node speed increase, the DSDV protocol loss of data packet about 60% that's means some node are sleep. If the pause time increases to end of simulation time, all packets delivered correctly in case of the DSDV protocol as shown in Fig 1.c.



(a)



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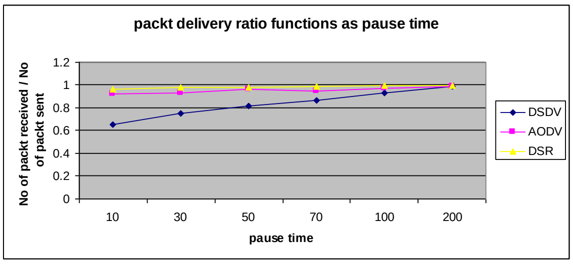
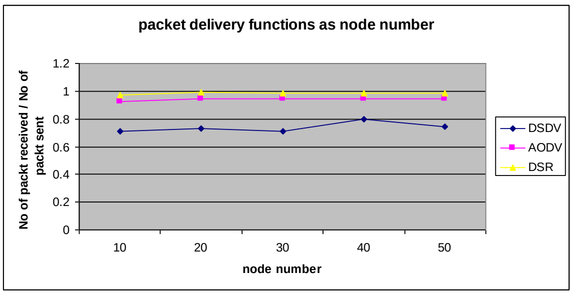


(c)

Fig.1.packet delivery ratio comparison, the duration of simulation time is 200 sec, as a function of: (a) node number (b) node speed (c) pause time.

Fig2 shows the packet delivery ratio for the three routing protocols as functions of node number, node speed and pause time at simulation time 500 sec. the packet delivery ratio is independent of offered traffic load, with both protocols DSR and AODV delivering between 97% and 99% It could be noticed that in fig.2.a, DSR and AODV outperforms DSDV by about 20 percent in fig.2.c, at lower pause time (higher mobility). For higher pause times (low mobility), however, all protocols do the best performance of data packets.



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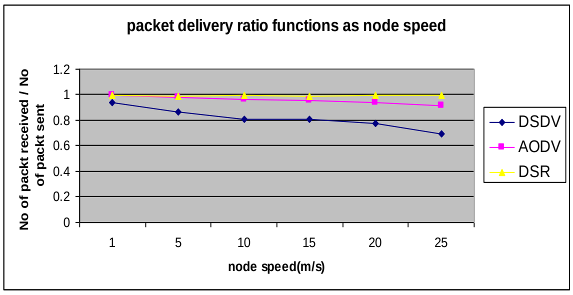

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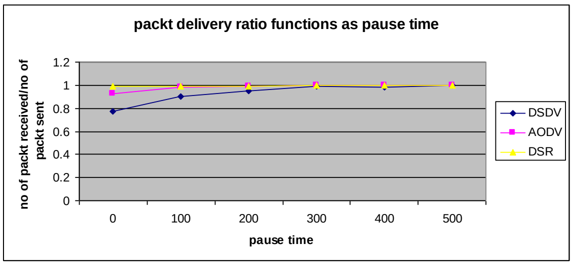
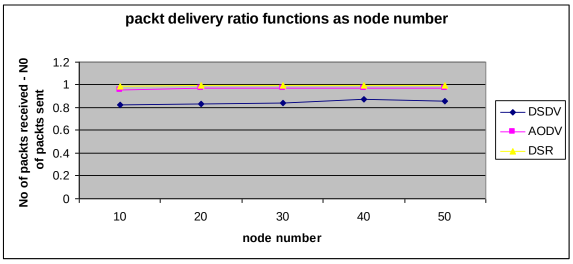


(c)

Fig.2.packet delivery ratio comparison, the duration of simulation time is 500 sec, as a function of: (a) node number (b) node speed (c) pause time.

Fig3 shows the packet delivery ratio for the three routing protocols as functions of node number, node speed and pause time at simulation time 900 sec. At pause time 200 sec to end of simulation time (900 sec) the three protocols DSR, AODV, and DSDV are stable results and delivery all data packets, It could be noticed that in fig.3.c.

The strategy of periodical update is used in the table-driven routing protocols. So, there is only one route for every destination node and when the route is unavailable there is no route can be used to replace it. So, the packet delivery rate is lower. From fig (1, 2 and 3), we concluded that the successful packet delivery rate of on-demand routing protocols is higher than the table-driven routing protocols because of the routing maintenance and the strategy of multi-route.



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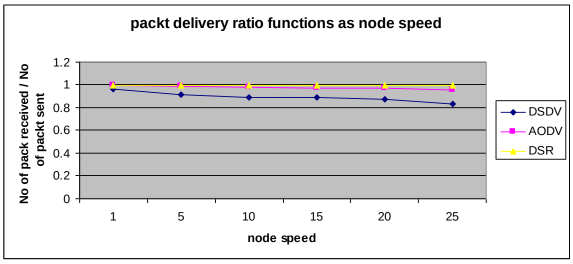

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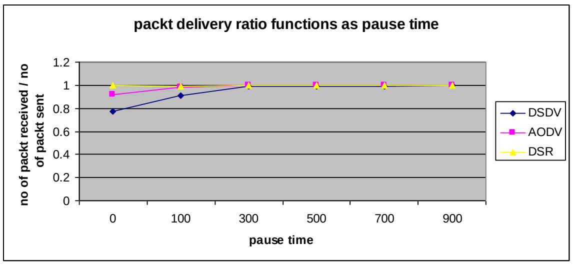
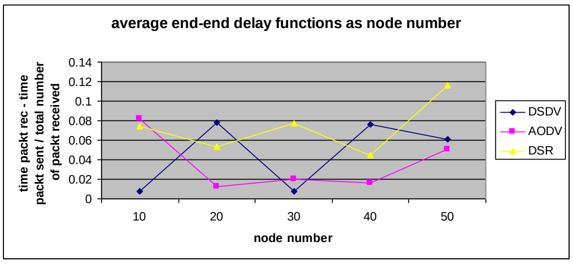


(c)

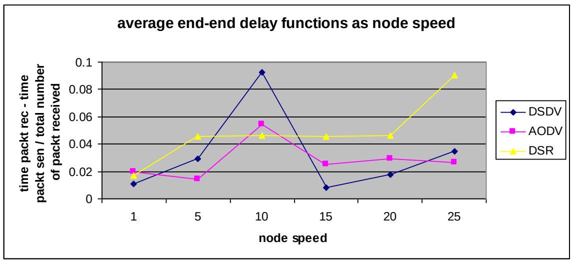
Fig.3.packet delivery ratio comparison, the duration of simulation time is 900 sec, as a function of: (a) node number (b) node speed (c) pause time.

2. Average End-End Delays Comparison

Fig4 shows the average end-end delays for the three routing protocols as functions of node number, node speed and pause time at simulation time 200 sec. the delays for DSDV are smaller than DSR and AODV by a factor of about 0-2 for 10 nodes networks, It could be noticed that in fig.4.a.for the 50-node experiments, we have used 15 service source when lower speed the delays of DSDV is shortest that shown in fig.4.b.if increase in pause time (decrease in mobility) the DSDV protocols is shortest delays then DSR and AODV It could be noticed that in fig.4.c.



(a)



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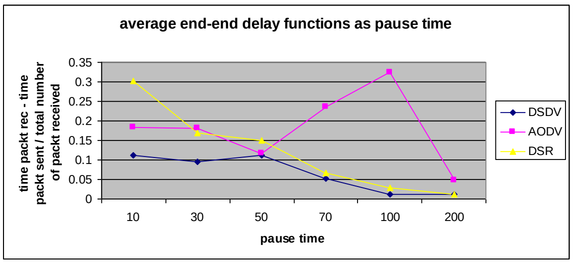
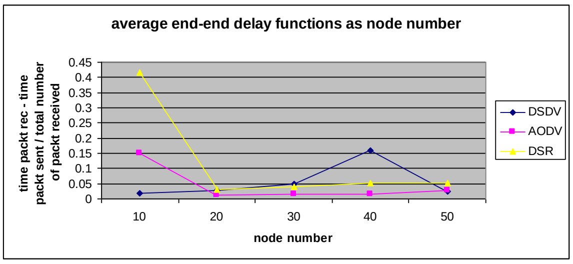


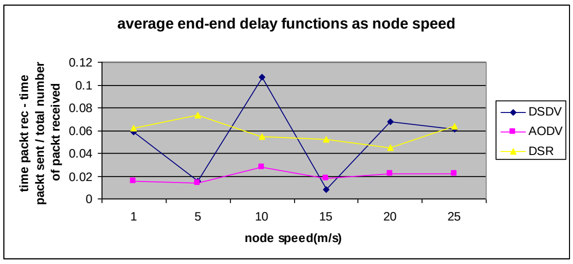
(c)

Fig.4.average end-to-end delay, the duration of simulation time is 200 sec, as a function of: (a) node number (b) node speed (c) pause time

Fig5 shows the average end-end delays for the three routing protocols as functions of node number, node speed and pause time at simulation time 500 sec. When increase in pause time at end of simulation time (decrease in mobility) the DSDV, DSR and AODV.are the shortest delays at the 15 service sources .It could be noticed that in fig.5.c.



(a)



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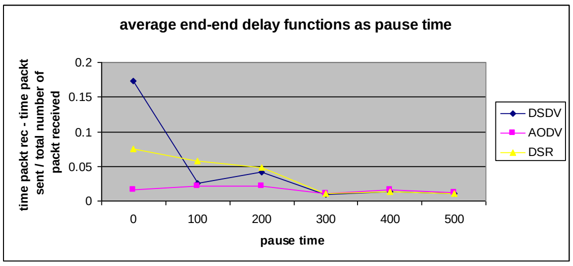
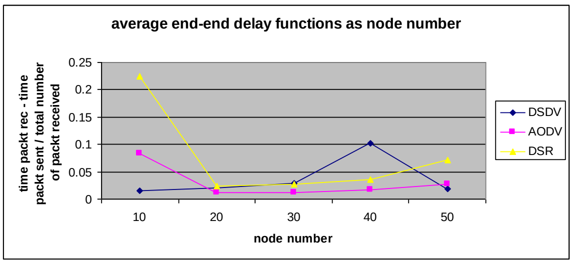


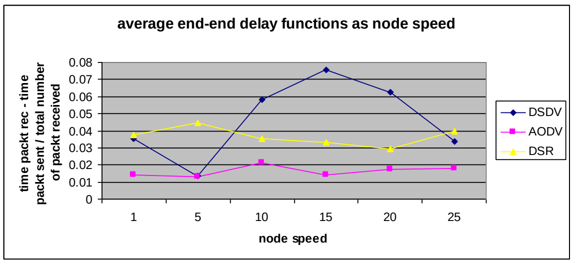
(c)

Fig.5.average end-to-end delay, the duration of simulation time is 500 sec, as a function of: (a) node number (b) node speed (c) pause time.

Fig6 shows the average end-end delays for the three routing protocols as functions of node number, node speed and pause time at simulation time 900 sec. the DSDV, DSR and AODV has the same delays at end of simulation time. It could be noticed that in fig.6.c.
From fig (4, 5 and 6), we concluded that, the even delay of table-driven protocols is shorter than the delay of on-demand protocols. The delay of DSR is the longest and the delay of DSDV is the shortest. The delay increases along with the increase of the node speed because the change of topology structure is frequent.



(a)



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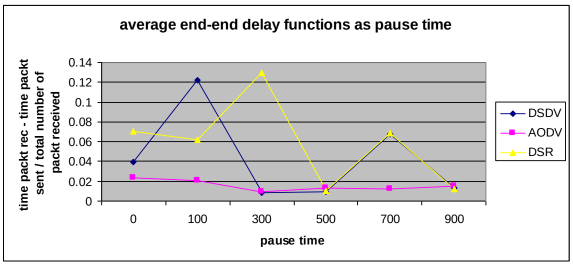
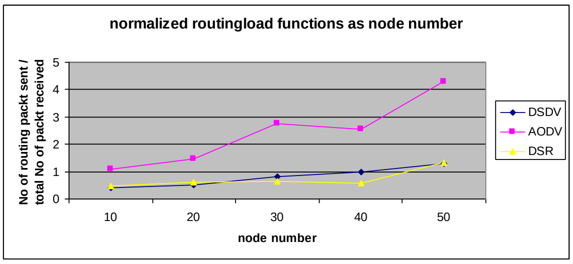


(c)

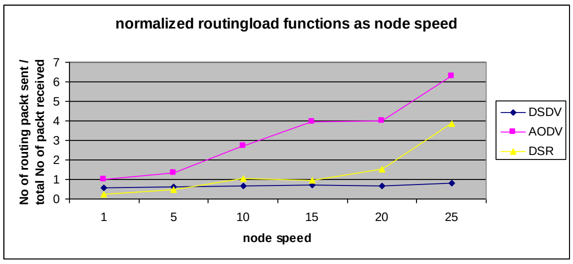
Fig.6.average end-to-end delay, the duration of simulation time is 900 sec, as a function of: (a) node number (b) node speed (c) pause time

3. Normalized routing load Comparison

Fig7 shows the normalized routing load for the three routing protocols as functions of node number, node speed and pause time at simulation time 200 sec. It could be noticed that, AODV have a good performance because near to 1 that's means all packet sent by source received by destination at node number 10 and node speed 1m/sec, At the higher node number and node speed the AODV demonstrates significantly higher routing load than DSR and DSDV as shown in fig.7.a and fig.7.b. When the simulation time has been finished the AODV and DSDV good performed the DSR as shown in fig.7.c.



(a)



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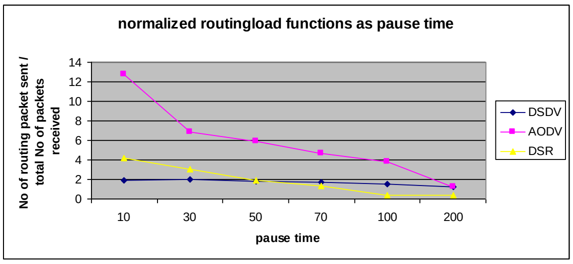

(c)

Fig.7.normalized routing load, the duration of simulation time is 200 sec, as a function of: (a) node number (b) node speed (c) pause time.

Fig8 shows the normalized routing load for the three routing protocols as functions of node number, node speed and pause time at simulation time 500 sec. AODV has a higher normalized routing load then DSR and DSDV, when increase of node number and node speed . It could be noticed that in fig.8.a and fig.8.b.

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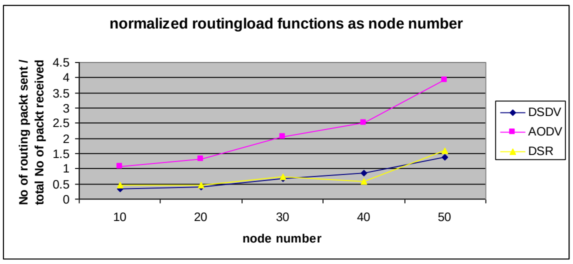
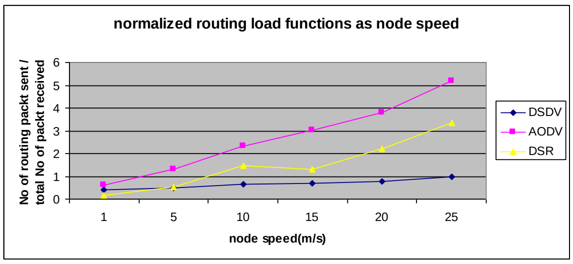


(a)



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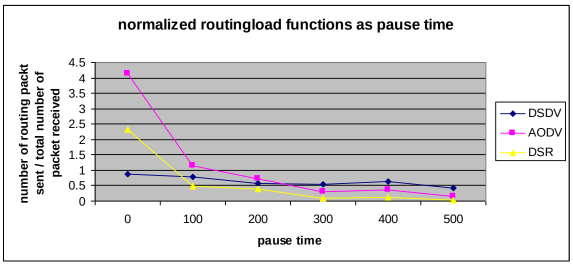
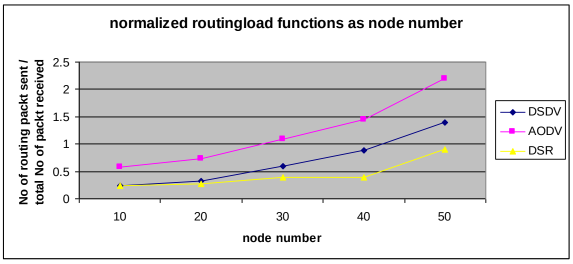


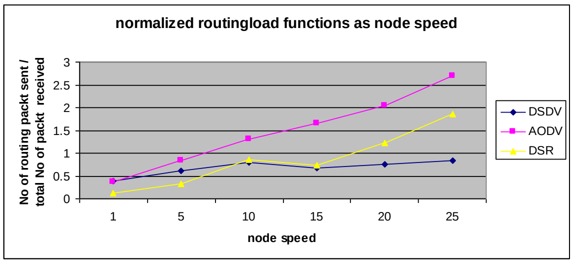
(c)

Fig.8.normalized routing load, the duration of simulation time is 500 sec, as a function of: (a) node number (b) node speed (c) pause time.

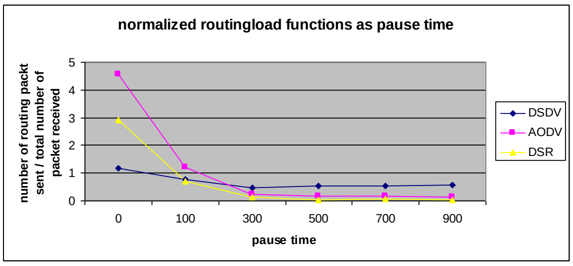
Fig9 shows the normalized routing load for the three routing protocols as functions of node number, node speed and pause time at simulation time 900 sec. when increase of node number and node speed increase dramatically routing load .It could conclude from fig.9.a and fig.9.b.but when increase of pause time (decrease mobility) at end of simulation time decrease the routing load. It could be noticed that in fig.9.c



(a)



(b)



(c)

Fig.9.normalized routing load, the duration of simulation time is 900 sec, as a function of: (a) node number (b) node speed (c) pause time.

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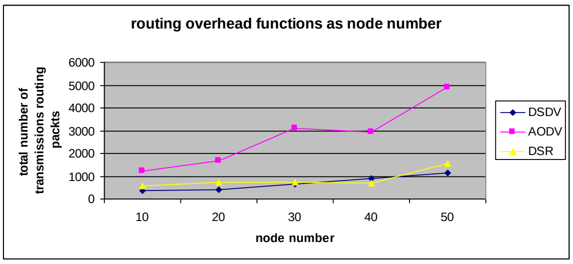
4. Routing overhead Comparison

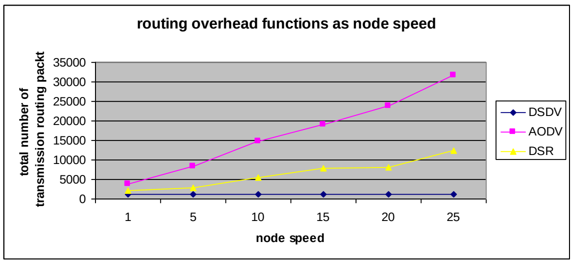
Fig10 shows the routing overhead for the three routing protocols as functions of node number, node speed and pause time at simulation time 200 sec.

The routing overhead is the number of routing overhead packets generated by routing protocols to achieve this level of data packet delivery.

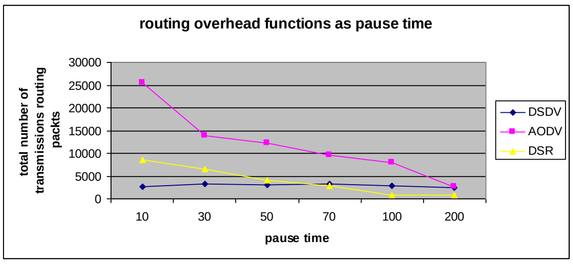
When node number as parameter the DSR and DSDV are very similar scale plotted has lower overhead then AODV. It could be noticed that in fig.10.a. DSDV is plotted the lower overhead when change of speed as shown in fig.10.b. All protocols DSR and DSDV and AODV have lower overhead at end of simulation time when maximum pause time 200sec. It could be noticed that in fig.10.c.



(a)



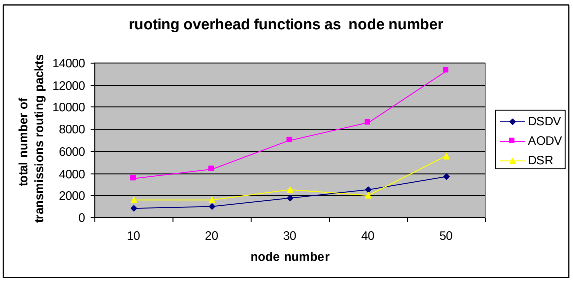
(b)



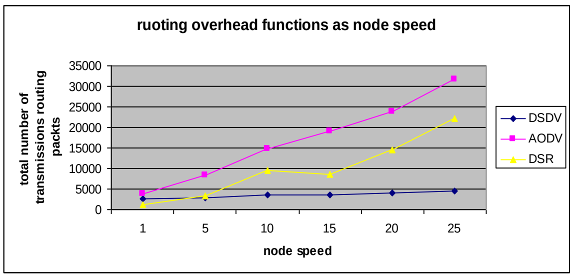
(c)

Fig.10.routing overhead, the duration of simulation time is 200 sec, as a function of: (a) node number (b) node speed (c) pause time.

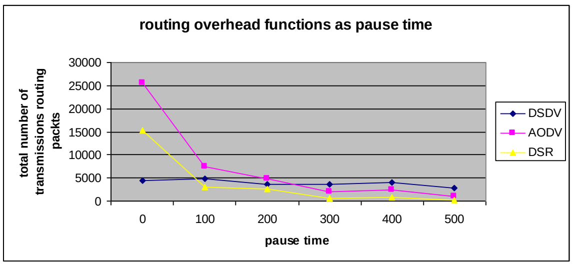
Fig11 shows the routing overhead for the three routing protocols as functions of node number, node speed and pause time at simulation time 500 sec. It could be noticed that, the DSR and AODV increase routing overhead dramatically when change of speed as shown in fig.11.b.to high, but DSDV has stable routing overhead.



(a)



(b)

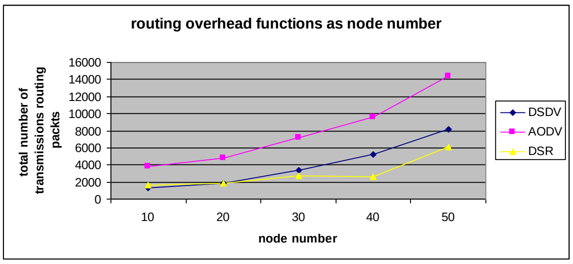


(c)

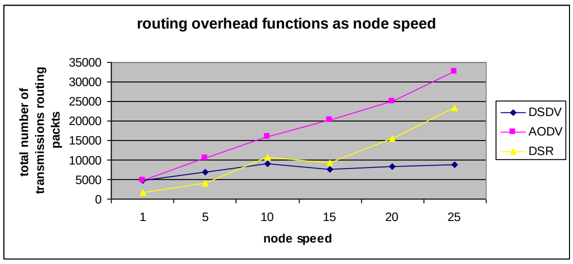
Fig.11.routing overhead, the duration of simulation time is 500 sec, as a function of: (a) node number (b) node speed (c) pause time.

Fig12 shows the routing overhead for the three routing protocols as functions of node number, node speed and pause time at simulation time 900 sec. when increase the number of service source to 15 source the DSDV increase routing overhead. It could conclude from fig.12.a

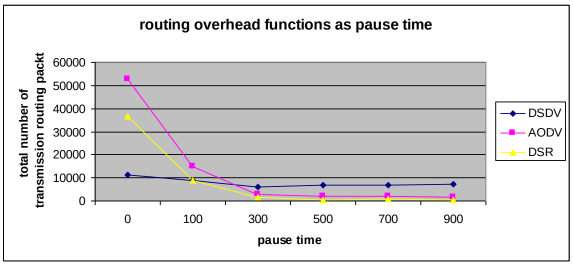
From fig (10, 11 and 12), we concluded that the periodical update process is carried out to maintain the routing information in the table-driven Protocols. The table-driven routing Protocols are shortest and will not change until the next update process. So the even route length is shorter. In the on-demand routing protocols, the route will be rebuilt when the topology of the network changes. Even if the shortest route is found during the original process of routing discovery, it can not be maintained because of the nodes are moving all the time. So that the even route length of DSR and AODV is longer than that of DSDV.



(a)



(b)



(c)

Fig.12.routing overhead, the duration of simulation time is 900 sec, as a function of: (a) node number (b) node speed (c) pause time

VI. CONCLUSION

This paper compared the performance of DSDV, AODV and DSR routing protocols for ad hoc networks using ns-2 simulations with different simulation times and connectivity sources. First the simulation results bring out some important characteristic differences between the routing protocols, the presence of high mobility implies frequent link failures and each routing protocol reacts differently during link failures. The different basic working mechanism of these protocols leads to the differences in the performance.

The lower and higher speeds of 1m/s and 25m/s, with differences simulation times (200s &500s& 900s), when the number of sources is low, the performance of DSR and AODV is similar regardless of mobility. With low numbers of sources, AODV starts outperforming DSR for high-mobility scenarios. As the data from the varying sources demonstrate, AODV starts outperforming DSR at a lower load with a higher speed. DSR always demonstrates a lower routing load than AODV.

The major contribution to AODV routing overhead is from route requests, while route replies constitute a large fraction of DSR routing overhead. Furthermore, AODV has more route requests than DSR. At the lower and higher speeds of 1m/s and 25m/sthe DSDV is plotted a low routing overhead packet generated to achieve this level of data packet delivery at 8 sources with comparison of routing overhead for DSR and AODV protocols. DSDV fails to converge below lower pause times.

At higher rates of mobility (lower pause times), DSDV does poorly, dropping to a 70% packet delivery ratio and 60% packet delivery ratio at the higher speeds of 25m/s for simulation time (200s&500s), were at simulation time 900s dropping to a 80% packet delivery ration. Nearly all of the dropped packets are lost because a stale routing table entry directed them to be forwarded over a broken link. DSDV uses table-driven approach of maintaining routing information; it is not as adaptive to the route changes that occur during high mobility. In lower mobility scenarios, DSR often performs better than AODV, because the chances of find the route in one of the caches is much higher. The better performance of DSR over AODV couldn't be observed, were in higher mobility scenarios the routing overhead of DSDV protocol perform better than AODV and DSR. Third Routing Load Effect DSR has a lower in normalized routing load in all cases of sources than AODV and DSDV protocols. This can be attributed to the caching strategy used by DSR. DSR is more likely to find a route in the cache, and hence resorts to route discovery less frequently than AODV and DSDV.

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