ISSN: 2321-2152

IJMECE

International Journal of modern electronics and communication engineering

E-Mail
editor.ijmece@gmail.com
editor@ijmece.com

www.ijmece.com

ISSN2321-2152www.ijmece .com
Vol 6, Issue 3Aug 2018

Comparing the effectiveness of table-driven versus on-demand routing methods in mobile ad hoc networks.

NagaRaju, S.Raghavendra, K Purushotham,

Abstract—Mobileadhocnetworkisacollectionofmobilenodescommunicatingthroughwirelesschannelswithoutanyexistingnetwork infrastructure or centralized administration. Because of thelimited transmission range of wireless network interfaces, multiple"hops" may be needed to exchange data across the network. In orderto facilitate communication within the network, a routing protocol isused to discover routes between nodes. The primary goal of such anadhocnetworkroutingprotocoliscorrectandefficientrouteestablishment between a pair of nodes so that messages may bedelivered in a timely manner. Route construction should be donewithaminimumofoverheadandbandwidthconsumption.Thispaperexamines two routing protocols for mobile ad hoc networks–theDestination Sequenced Distance Vector (DSDV), the table- drivenprotocolandtheAdhocOn-DemandDistanceVectorrouting(AODV), an On –Demand protocol and evaluates both protocolsbased on packet delivery fraction, normalized routing load, averagedelay and throughput while varying number of nodes, speed andpausetime.

Keywords—AODV,DSDV,MANET,relativeperformance

INTRODUCTION

II. \sOBILEWithout a previous communication infrastructure or centralized management, ad hoc networks are built by an independent system of mobile nodes linked through wireless connections. Direct communication between nodes or communication through intermediary nodes serving as routers is used. Fast rollout, reliability, adaptability, and built-in mobility assistance are just some of the benefits of such a system. Military operations, collaborative and distributed computing, emergency operations, wireless mesh networks, wireless sensor networks, and hybrid networks are only few of the areas where ad hoc networks may be useful because of their fast and economically less demanding implementation. The path between any two nodes in a network may shift if any of the nodes in that network are mobile. Due to this, it is impossible to set up direct routes for data transmission across networks. Therefore, routing is the Professor Narendra Singh Yadav works in the field of electronics and communication engineering at the Malaviya National Institute of Technology in Jaipur, 302017, India, where he serves as a research scholar.
(Phone: 91-141-2780457; e-mail: narensinghyadav@yahoo.com).
Dr. R. P. Yadav is a faculty member in the Electronics and Communication Engineering Department of the Malaviya National Institute of Technology in Jaipur, 302017, India. (Write to me at rpyadav@mnit.ac.in) is the most researched issue in mobile ad hoc networks, with several suggested solutions [1-13] based on distance-vector [14] or link-state [15] routing algorithms. There are two major types of routing protocols used in mobile ad hoc networks: proactive (also called table-driven) and reactive (also called on-demand). Proactive protocols rely on regular communication between nodes to ensure that accurate routing tables accurately reflect the current state of the network. Among them are the Cluster-head Gateway Switch Routing protocol (CGSR) [4], the Source-Tree Adaptive Routing (STAR) [5, and the Destination Sequenced Distance Vector (DSDV) [2]. However, reactive protocols like the Ad hoc On-demand Distance Vector (AODV) [7], Temporally Ordered Routing Algorithm (TORA) [8], and Associativity Based Routing (ABR) [10] only retrieve routes when they are needed.

The remaining sections of the paper are structured as follows: In the second section, we'll take a high-level look at the two broad classes of mobile ad hoc routing protocols and compare and contrast them. In Part III, we compare and contrast the various routing protocols that were used during the research. Section IV describes the simulation environment and performance measures, whereas Section V presents the findings. The last section of the report, Section VI, sums up the findings and draws the conclusions. Thirdly, Mobile Ad Hoc Network Routing Protocols

Figure.1 illustrates the two primary groups into which Mobile ad hoc network routing techniques fall.

There are two main types of routing protocols: proactive (also known as table-driven) and reactive (also known as on-demand).

Department of ECE
nagaraju84@gmail.com, raghav_isl@gmail.com, purushotham_isl@gmail.com
ISL Engineering College.
International Airport Road, Bandlaguda, Chandrayangutta Hyderabad - 500005 Telangana, India.

A. Routing Protocols Based on a Table

The goal of table-driven routing protocols is to ensure that all network nodes always have accurate and up-to-date routing information. Each table stores a separate piece of the routing puzzle, and as the network topology changes, the tables notify each other and spread the news to the rest of the network.

perspective of a network. The protocols vary in their methods of routing information updating and detection, as well as the data they store in their own routing tables.Demand-Based Routing Protocols

By just keeping track of currently used routes, On-Demand routing protocols aim to decrease the resource consumption of Table-Driven protocols. A node will start a route discovery process when it needs to go there and can't immediately figure out how to get there. Once a route is discovered or all feasible route combinations have been checked, the procedure is complete. Once a route has been constructed, it will continue to be kept in place by a route maintenance operation until the destination is no longer reachable via any path leading there, or until the route is no longer wanted. The standard method of route discovery involves sending out several packets asking the network for a certain route. When a node having a route to the destination (or the destination itself) is reached, a route reply is sent back to the originating node through link reversal (in the case of bi-directional connections) or flooding (in the case of uni-directional links).

Source routing and hop-by-hop routing are the two main types of On-Demand routing technologies. Each data packet in a protocol that uses source routing on demand includes the whole path from source to destination. Because of this, the header information in each packet is used to determine which intermediary node should send the message. The main issue with source routing systems is their poor efficiency in big networks. There are two basic causes for this. The first is that the likelihood of route failure increases with the size of the route (i.e. the number of intermediary nodes). For another, the overhead in data packet headers will increase proportionally with the number of intermediary nodes in each path.

In hop-by-hop routing, just the final destination and the next hop address are stored in each data packet. As a result, each node along the route utilizes its routing table to direct data packets to their final destination. This tactic is advantageous because it allows routes to evolve with the ever-changing conditions of MANETs.

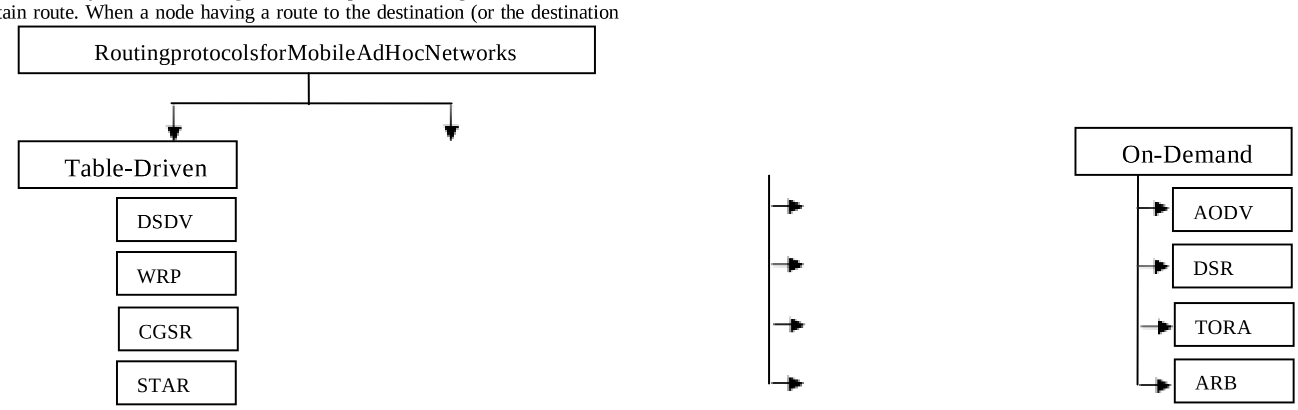


Fig.1Classificationsofmobileadhocroutingprotocols.

A. Comparison of Table-Driven and On-Demand RoutingProtocols

The table-driven ad hoc routing approach is similar to theconnectionlessapproachofforwardingpackets,withnoregard to when and how frequently such routes are desired. Itrelies on an underlying routing table update mechanism thatinvolvestheconstantpropagationofroutinginformation.Thisis not the case, however, for on-demand routing protocols.Whenanodeusinganon-demandprotocoldesiresaroutetoanew destination, it will have to wait until such a route can bediscovered.Ontheotherhand,becauseroutinginformationisconstantly propagated and maintained in table-driven routingprotocols,aroutetoeveryothernodeintheadhocnetworkisalways available, regardless of whether or not it is needed.Thisfeature,althoughusefulfordatagramtraffic,incurssubstantial signaling traffic and power consumption. Sinceboth bandwidth and battery power are scarce resources inmobile computers, this becomes a serious limitation. Table 1listssomeofthebasicdifferencesbetweenthetwocategoriesofmobileadhocroutingprotocols.

As each protocol has its own merits and demerits, none ofthem can be claimed as absolutely better than others. Twomobile ad hoc routing protocols – the Destination SequencedDistance Vector (DSDV), the table- driven protocol and theAdhocOn-DemandDistanceVectorrouting(AODV),anOn –Demandprotocolareselectedforstudy.

A. Destination-SequencedDistanceVector(DSDV)

DSDV[2],anenhancedversionofthedistributedBellman-Fordalgorithm,belongstotheproactiveortabledrivenfamilywhere a correct route to any node in the network is alwaysmaintainedandupdated.

InDSDV,eachnodemaintainsaroutingtablethatcontainsthe shortest distance and the first node on the shortest path toevery other node in the network. A sequence number createdby the destination node tags each entry to prevent loops, tocounterthecount–to-infinityproblemandforfasterconvergence. The tables are exchanged between neighbors atregular intervals to keep an up to date view of the networktopology. The tables are also forwarded if a node finds asignificant change in local topology. This exchange of tableimposes a large overhead on the whole network. To reducethis potential traffic, routing updates are classified into twocategories. The first is known as “full dump” which includesall available routing information. This type of updates shouldbe used as infrequently as possible and only in the cases ofcompletetopologychange.Inthecasesofoccasionalmovements, smaller “incremental” updates are sent carryingonlyinformationaboutchangessincethelastfulldump.Eachof these updates should fit in a single Network Protocol DataUnit(NPDU),andthussignificantlydecreasingtheamountoftraffic.

Tableupdatesareinitiatedbyadestinationwithanewsequence number which is always greater than the previousone.Uponreceivinganupdatedtableanodeeitherupdatesitstables based on the received information or holds it for sometime to select the best metric received from multiple versionsofthesameupdatefromdifferentneighbors.

The availability of routes to all destinations at all timesimplies that much less delay is involved in the route setupprocess.Themechanismofincrementalupdateswithsequencenumbertagsmakestheexitingwirednetworkprotocols adaptable to mobile ad hoc networks. Hence, anexisting wired network protocol can be applied to mobile adhoc networks with fewer modifications. DSDV suffers fromexcessive control overhead that is proportional to the numberofnodesinthenetworkandthereforeisnotscalableinmobileadhocnetworks.Anotherdisadvantageisstaleroutinginformationatnodes.

B. AdHocOn-DemandDistanceVectorRouting(AODV)

AODV [7] is an improvement on the DSDV. AODV usesan on- demand approach for finding routes. Since it is an on -demandalgorithm,a route isestablishedonly whenit isrequiredbyasourcenodefortransmitting datapacketsanditmaintainstheseroutesaslongastheyareneededbythe sources.

AODV uses a destination sequence number, created by thedestination,todetermineanuptodatepathtothedestination.A node updates its route information only if the destinationsequencenumberofthecurrentreceivedpacketis greaterthanthedestinationsequencenumberstoredatthenode.Itindicatesthefreshnessoftherouteacceptedbythesource.Toprevent multiple broadcast of the same packet AODV usesbroadcastidentifiernumberthatensureloopfreedomsincetheintermediate nodes only forward the first copy of the samepacketanddiscardtheduplicatecopies.

To find a path to the destination, the source broadcasts a*RouteRequest*(RREQ)packetacrossthenetwork.ThisRREQcontainsthesourceidentifier,thedestinationidentifier,thesourcesequencenumber,thedestinationsequencenumber, the broadcast identifier and the time to live field.NodesthatreceivesRREQeitheriftheyarethedestinationoriftheyhaveafreshroutetothedestination,canrespondto theRREQbyunicastinga*RouteReply*(RREP)backtothesourcenode.Otherwise,thenoderebroadcaststheRREQ.

When a node forwards a RREQ packet to its neighbors, italsorecordsinitstablesthenodefromwhichthefirstcopyofthe request came. This information is used to construct thereversepathfortheRREPpacket.AODVusesonlysymmetric links because the route reply packet follows thereverse path of route request packet. When a node receives aRREPpacket,informationaboutthepreviousnodefromwhichthe packet was received is also stored in order toforward the data packets to this next node as the next hoptowardthedestination.OncethesourcenodereceivesaRREPitcanbeginusingtheroutetosenddatapackets.

The source node rebroadcasts the RREQ if it does notreceiveaRREPbeforethetimerexpires.Itattemptsdiscoveryup to some maximum number of attempts. If it does notdiscover a route after this maximum number of attempts, thesessionisaborted.

If the source moves then it can reinitiate route discovery tothedestination.Ifoneoftheintermediatenodesmovethenthemoved nodes neighbor realizes the link failure and sends alinkfailurenotificationtoitsupstreamneighborsandsoontillit reaches the source upon which the source can reinitiateroutediscoveryifneeded.

ThemainadvantageofAODVisthatroutesareobtainedondemandanddestinationsequencenumbersareusedtofindthelatest route to the destination. One of the disadvantages ofAODV is that intermediate nodes can lead to inconsistentroutes if the source sequence number is very old and theintermediatenodeshaveahigherbutnotthelatestdestinationsequencenumber,therebycausingstaleentries.Alsomultiple*Route Reply* (RREP) packets in response to a single *RouteRequest* (RREQ) packet can lead to heavy control overhead.Another is that periodic *hello* message leads to unnecessarybandwidthconsumption.

Table 2 lists some of the basic differences between the tworoutingprotocols.

TABLEII

COMPARISONOFDSDVANDAODVROUTINGPROTOCOLS

Parameter	DSDV	AODV
Routingstructure	Flat	Flat
Hellomessages	Yes	Yes
Frequencyofupdates	Periodicandasneeded	As required
Criticalnodes	No	No
Loop–free	Yes	Yes
Multicastingcapability		
Routingmetric	Shortestpath	Freshestandshortest path
Utilizessequencenumber		
Timecomplexity	O(D)	O(2D)
Communicationcomplexity	O(N)	O(2N)
Advantages	Smalldelays	Adaptable to highlydynamictopology
Disadvantages	Largeoverhead	Largedelays

PerformanceMetrics

Thefollowingperformancemetricsareconsideredforevaluation: *PacketDeliveryFraction(PDF):*Theratioofthedatapacketsdeliveredtothedestinationstothosegeneratedbythesources.*Averageend-to-enddelay:*Thisincludesallpossibledelays

causedbybufferingduringroutediscoverylatency,queuingat theinterfacequeue,retransmissiondelaysattheMAC,and

propagationandtransfertimes.

*Normalizedroutingload:*Thenumberofroutingpackets "transmitted"perdatapacket"delivered"atthedestination.

metricsarelistedinTable4.

TABLEIVSIMULATIONMETRICS

ID	metrics	definition	formula	Example value
PS	packetsent	totalnumberof packets sent bythesourcenode	computed fromtracefile	

Abbreviations:
D=Diameterofthenetwork
N=NumberofnodesintheNetwork

SIMULATIONANDPERFORMANCEMETRICSThesimulationswereperformedusingNetworkSimulator2 (NS-2) [16], particularly popular in the ad hoc networkingcommunity. The traffic sources are CBR (continuous bit –rate).Thesource-destinationpairsarespreadrandomlyover

Received Press Kit

Packet Size and Time Required for PDF Delivery Fraction Time of Delivery TD Total

Quantity of datagrams that have been received by the target node The ratio of incoming packets to outgoing packets Transportation time for packages (PR)

Derived from a trace file's computations

The formula for the probability distribution function is:

Determined by using the trace file

600

88.5%

1567.2

something which connects us all together, the internet. Packet rates of 4 bps for 15 and 30 sources, and 3 bps for 45 sources, are supported. There is a 512-byte limit on data packets. Using a random waypoint model, the mobility simulation takes place in a 500 m by 500 m rectangular field with 50 nodes. Each node in our mobility model embarks on its trip from a completely arbitrary starting point and arrives at its final destination completely arbitrarily. When the last destination is reached, another is picked at random after some delay.

Routing Load Normalized, or NRL

The amount of time it takes to send each individual data packet.

You may choose the node speed from 0 to 25m/s and the pause time from 0 to 100 seconds. Network scenarios are constructed with varying node counts, delay times, and transfer rates. What are simulations?

Delay Time Interval AD Average End-to-End

Packet Radio Frequency Routing

Total amount of packets sent or routed by a router Packets-per-data-packet ratio for routing protocols

AD = 6.235 * TD * PR
Computed with 44 trace files
Calculating NRL: RF/PR = 2.5

sprint for a whole minute. The two-way ground model is used for propagation [17]. All of the simulation settings may be found in Table 3.

TABLE IIISIMULATIONPARAMETERS

Parameter	Value
Simulator	ns-2
Studiedprotocols	DSDVandAODV
Simulationtime	100seconds
Simulationarea	500mx500m
Transmissionrange	250m
Nodemovementmodel	Randomwaypoint
Speed	0–25m/sinstepsof5m/s
Traffictype	CBR(UDP)
Datapayload	512bytes/packet
Packetrate	4packets/secfor15and30sources 3packets/secfor45sources
Nodepausetime	0-100sinstepsof20s
Bandwidth	2Mb/s

I. RESULTS

Thesimulationresultsareshowninthefollowingsectionintheformoflinegraphs.Graphsshowcomparisonbetweenthetwo protocols by varying different numbers of sources on thebasis of the above-mentioned metrics as a function of pausetimeandspeed.

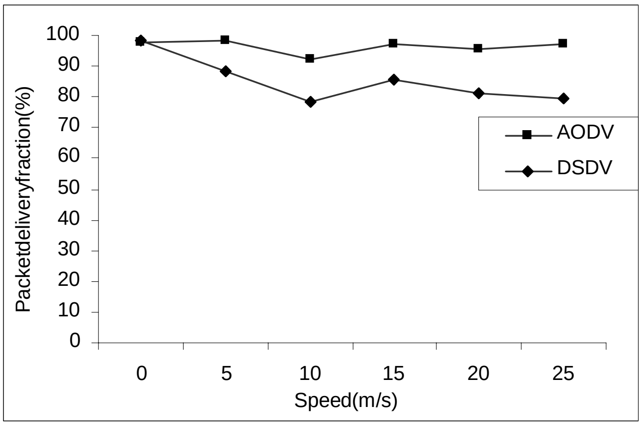
A. PacketDeliveryFraction(PDF)

Figure 2 provides a comparison of the two routing methods based on the percentage of packets delivered while employing a varying number of traffic sources. The AODV protocol excelled, with almost 100% packet delivery regardless of the mobility rate. However, the number of sources does not significantly affect AODV's packet delivery performance.

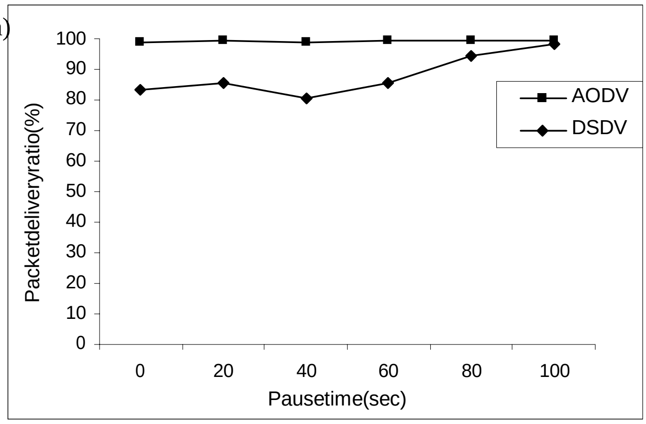
When people are very mobile, DSDV fails miserably. Due to the fact that DSDV is not an On demand protocol and maintains just a single route per destination, packet failures are inevitable if nodes are moving at a rapid rate of speed and there are no available other routes. As can be seen in Figure 2, the DSDV protocol's packet delivery is dependent on the total number of sources.

In Figure 3, we see a contrast between the two routing protocols based on the percentage of packets successfully delivered during each pause period and with varying numbers of traffic sources.

(b)



(a)



(c)

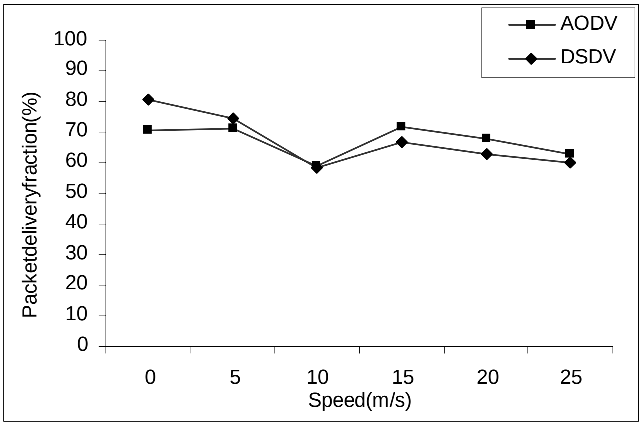
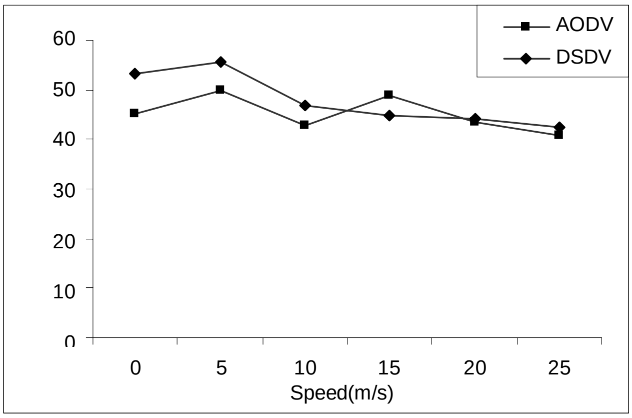
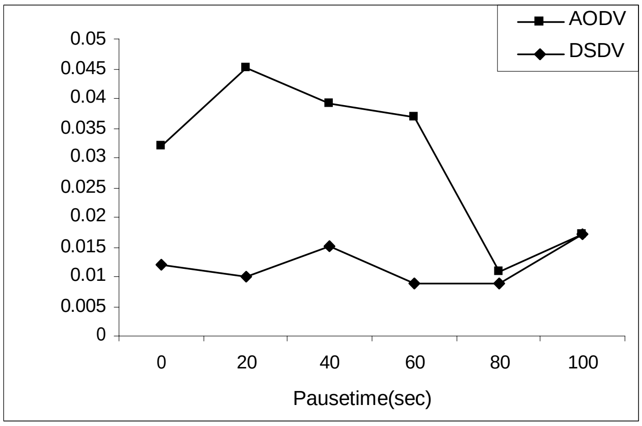


Fig.2Packetdeliveryfractionvs.Pausetimefor50-nodemodelwith(a)15sources,(b)30sourcesand(c)45sources.

Bothoftheprotocolsdeliveragreaterpercentageofthe





(c)

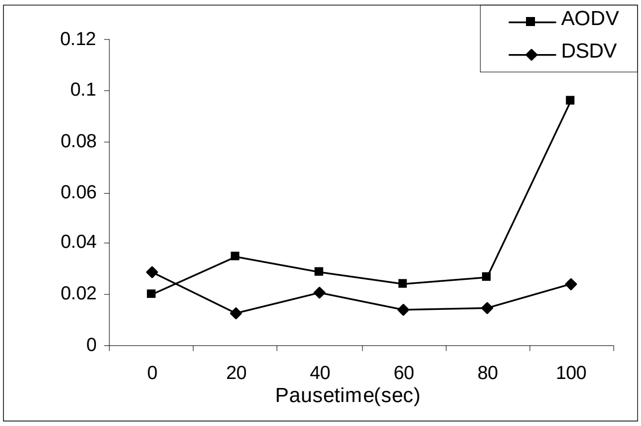
Fig. 3 Packet delivery fraction vs. Speed for the 50-node modelwith(a)15sources,(b)30sourcesand(c)45sources.

As expected, Packet delivery fraction for AODV decreasesas speed increases, since finding the route requires more andmore routing traffic. Therefore less and less of the channelwill be used for data transfer, thus decreasing the packetdelivery.Furthermore,asthenumberofnodesincreases, moreroutingtrafficwillbegenerated(becauseAODVusesfloodingforroutediscovery),whichmakesthepacketdeliveryfractiondecreaseasthenumberofnodesincreases.

ForDSDV,aswasthecasewithAODV,packetdeliveryfractiondecreasesasspeedincreases,sincefindingtherouterequires moreandmoreroutingtrafficasspeedincreasesthusmakingalesserportionofthechannelusefulfordatatransfer.Althoughthe packetdelivery fractionofboththeprotocolsdecreasesasspeedincreases,but DSDV’spacketdeliveryfractiondecreasesinamoresteeperandmorerapidfashion.Thisisduetoexcessivechannelusedbyregularroutingtableupdates.Furthermore,asmobilityspeedincreases,moreevent-triggered updates are generated, resulting in even morepacketdeliveryfractiondecrease.Thisproblemisnotpresent inAODVsinceroutesareonlygeneratedon-demand.

B. AverageEndtoEndDelay

Figure4showscomparisonbetweenboththeroutingprotocolsonthebasisofaverageend-to-enddelayasafunctionofpausetime,usingdifferentnumberofsources.



(b)

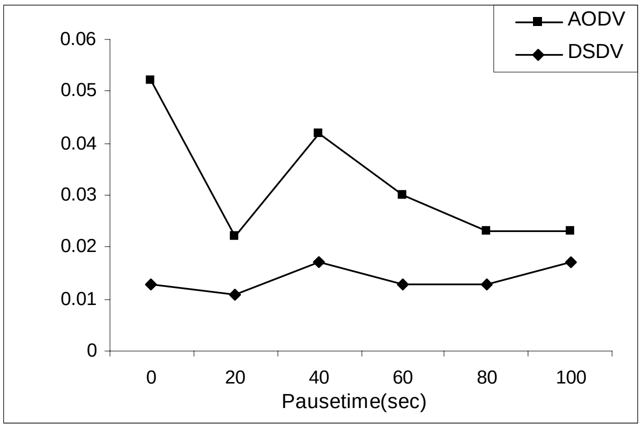


Fig.4AverageEnd-to-EndDelayvs.Pausetimeforthe50-nodemodelwith(a)15sources,(b)30sourcesand(c)45sources.

Although the pause duration went from 0 to 100 seconds, DSDV's performance was very consistent, and the delay remained at about 0.04 seconds throughout. The protocol is table driven, so a node doesn't have to choose a path before sending data, which is why it's so efficient. Therefore, the lag is pretty consistent.
The lag time for AODV is substantially longer than that of DSDV. Since AODV is a "on-demand" protocol, new routes will be discovered when there are more sources and more people moving about. AODV's route discovery process is slower since it uses a hop-by-hop approach to finding the path and a back-and-forth method to return to the starting point. It's a perfect storm for sluggish data packet transmission.

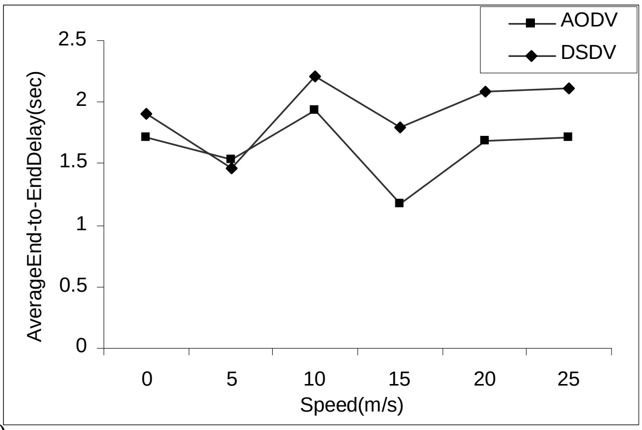
The average end-to-end latency as a function of speed for a variety of source counts is shown in Figure 5 to illustrate how the two routing methods compa

Fig.5AverageEnd-to-EndDelayvs.Speedforthe50-nodemodelwith(a)15sources,(b)30sourcesand(c)45sources.

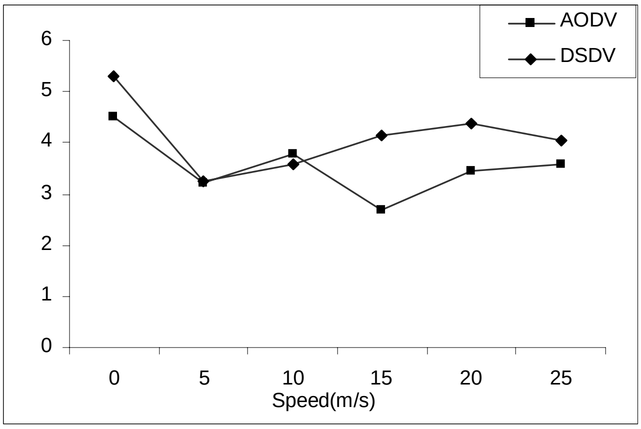
AODV has less average end-to-end delay when comparedto DSDV. This poor performance of DSDV is because of thereason that DSDV is not a On demand protocol and it keepsonly one route per destination, therefore lack of alternateroutes and presence of stale routes in the routing table whennodesaremovingathigherrateleadstolargedelay.

C. *NormalizedRoutingLoad*

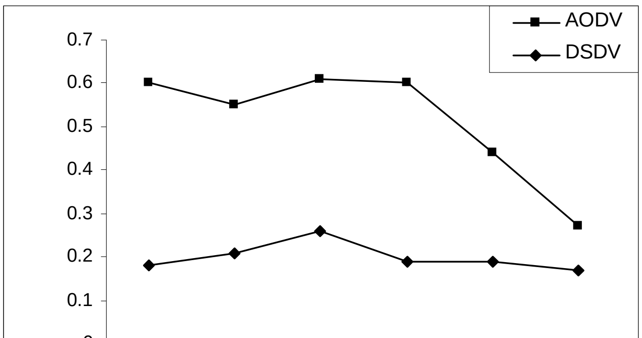
Figure 6 shows a comparison between both the routingprotocolsonthebasisofnormalizedroutingloadasaf unctionofpausetime,usingadifferentnumberofsources.

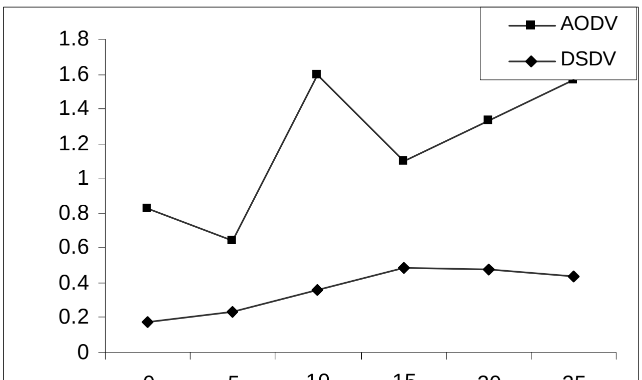


(a)



(b)





(a)Fig. 6 Normalized routing load vs. Pause time for the 50-nodemodelwith(a)15sources,(b)30sourcesand(c)45sources.

As DSDV is a table driven routing protocol its overhead isalmostthesamewithrespecttonodemobility.

IncasesofAODV,asthepausetimeincreases,routestability increases, resulting in a decreased number of routingpacket routing packet transmissions, and therefore a decreaseintheroutingoverhead.Arelativelystablenormalized routingloadisadesirablepropertyforscalabilityoftheprotocols.

Figure 7 shows a comparison between both the routingprotocolsonthebasisofnormalizedroutingloadasafunctionofpausetime,usingadifferentnumberofsources.In case of AODV the normalized routing load drasticallyincreases as the number of nodes increases. The routing loadalso increases as the node mobility increases. As the numberof nodes increases, more nodes will be flooding the networkwith route request and consequently more nodes will be ableto send route reply as well. As the node speed increases, asource node will have to generate more route requests to findafreshenoughroutetodestinationnode.

In case of DSDV the normalized routing load is almost thesamewithrespecttonodespeed.Thereasonisthatitisatable drivenprotocol,soanodedoesnotneedtofindaroutebeforetransmittingpackets.

II. CONCLUSION

This paper compared the two ad hoc routing protocols.AODV an On – Demand routing protocol, and DSDV a tabledrivenprotocol.

Simulationresultsshowthatbothoftheprotocolsdeliveragreaterpercentageoftheoriginateddatapacketswhenthereislittlenodemobility,convergingto100%deliveryrationwhenthere is no node motion. The packet delivery of AODV isalmostindependentofthenumberofsources.DSDVgenerates less routing load then AODV. AODV suffers fromendtoenddelays.DSDVpacketdeliveryfractionisverylowforhighmobilityscenarios.

Packet delivery fraction of both the protocols decreases asspeedincreases,butDSDV'spacketdeliveryfractiondecreasesinasteeperandmorerapidfashion.AODVhaslessaverageend-to-enddelaywhencomparedtoDSDV.ThenormalizedroutingloadforAODVincreasesdrasticallyasthenumberofnodesincreases.Theroutingloadalsoincreasesasthenodespeedincreases. ButforDSDVthenormalizedroutingloadisalmostthesamewithrespecttonodespeed

REFEREN

CES

[1] According to [1] IEEE Personal Communications, April 1999, pages 46-55, E. M. Royer and C. K. Toh wrote a survey of existing routing methods for mobile wireless ad hoc networks.

[2] In the Proceedings of ACM SIGCOMM 1994, August 1994, pages 234-244, authors C. E. Perkins and P. Bhagwat present "Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers."

[3] According to [3] "An Efficient Routing Protocol for Wireless Networks," written by S. Murhty and J. J. Garcia-Luna-Aceves and published in the ACM Mobile Networks and Applications Journal's Special Issue on Routing in Mobile Communication Networks (October 1996), pages 183-197.

[4]

[5] Routing in Clustered Multi-Hop Mobile Wireless Networks with Fading Channel, by C. C. Chiang, H. K. Wu, W. Liu, and M. Gerla, was published in the Proceedings of IEEE SICON 1997 in April 1997, pages 197-211.

[6] [5] "Source-Tree Routing in Wireless Networks," by J. J. Garcia-Luna-Aceves and M. Spohn, in Proceedings of IEEE ICNP 1999, October 1999, pages 273-282.

[7] Mobile Computing, Kluwer Academic Publishers, vol. 353, 1996, pp. 153-181; D. B. Johnson and D. A. Malta, "Dynamic Source Routing in Ad Hoc Wireless Networks."

[8] "Ad Hoc On-Demand Distance Vector Routing," by C. E. Perkins and E. M. Royer, was published in the Proceedings of the 1999 IEEE Workshop on Mobile Computing Systems and Applications in February, on pages 90-100.

[9] A Highly Adaptive Distributed Routing Algorithm for Mobile Wireless Networks, by V. D. Park and M. S. Corson, in Proceedings of IEEE INFOCOM 1997, April 1997, pages 1405-1413.

[10] "Location-Aided Routing (LAR) in Mobile Ad Hoc Networks," by Y. Ko and N. H. Vaidya, was published in the Proceedings of the ACM Mobile Computing and Communications Conference (MOBICOM) in October 1998, pages 66–75.

[11] Associativity-Based Routing for Ad Hoc Mobile Networks, by C. K. Toh, Wireless Personal Communications, volume 4, issue 2, March 1997, pages 1-36.

[12] [11] "CEDAR: A Core Extraction Distributed Ad Hoc Routing Algorithm," P. Sinha, R. Shivkumar, and V. Bharghavan, IEEE Journal on Selected Areas in Communications, volume 17, issue 8, pages 1454-1466, August 1999.

[13] In Proceedings of ICUPC 1997, vol. 2, October 1997, pages. 562-566, we find the following paper by Z. J. Haas: "The Routing Algorithm for the Reconfigurable Wireless Networks."

[14] "A Preferred Link- Based Routing Protocol for Ad Hoc Wireless Networks," by R. S. Sisodia, B. S. Manoj, and C. Siva Ram Murthy, was published in the March 2002 issue of the Journal of Communications and Networks (vol. 4, no. 1).

[15] Reference: [14] Andrew S. Tanenbaum, Computer Networks, Fourth Edition, Prentice Hall, ch. 5, pp. 357–360.

[16] The following is a direct quote from page 360 and page 366 of Andrew S. Tanenbaum's Computer Networks (4th ed., Prentice Hall).

[17] For further information on this topic, see [16] K. Fall and K. Vardhan, The Network Simulator (ns-2). This information is at your

disposal at http://www.isi.edu/nsnam/ns

[18] Wireless Communications: Principles and Practices by T. S. Rappaport [17]. Refer to pages 70–74 of the 1996 edition published by Prentice Hall for further information.