High performance Modified DSR with Power Consumption Optimization for Mobile Adhoc Networks.

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Summary

The chief limiting factor for current mobile devices is the amount of battery power. To improve this crucial factor, researchers have tried to optimize power consumption of every aspect of the mobile device. Power consumption can be optimized by disks, memory chips, CPU scheduling and efficient routing techniques.

Dynamic Source Routing (DSR) is a popular protocol for mobile adhoc routing and data forwarding over wireless networks. In this research an innovative mechanism is suggested for DSR that improves both the routing and data forwarding performance, with lesser power consumption. This mechanism involves intelligent use of the route discovery and route maintenance process thereby providing faster routing and reduced traffic as compared to the basic DSR. This mechanism enables faster data forwarding and reduced collisions with lesser power consumption. The basic DSR and modified DSR were studied and compared in GloMoSim simulation environment. Since one of our major goals was to reduce the routing overhead, the existing algorithm was modified to achieve this objective. To get a better idea of the generated overhead we considered the number of routing packets, which carry the overhead. The analysis shows that the performance of modified DSR is better than the performance of the basic DSR for the considered simulations scenarios. The modified algorithm was found to reduce the power consumption of the network by routing lesser routing load.

Key words : DSR, pause time, packet delivery ratio, route reply packets.

1. Introduction

In an ad hoc network, frequent link changes are expected since the nodes are constantly moving. In order to maintain updated routing tables, an adhoc routing protocol need to address some additional problems not present in wired network.

Conserving the power in order to make batteries last longer is becoming important. The reason for this is that mobile units are constantly decreasing in size and hence battery size also decreases. Even though the size/power/efficiency ratio for batteries has improved, the energy source for mobile units is still a limiting factor. Collision while routing packets should be reduced, which will not only increase the efficiency of the network but also conserved the power by avoiding unnecessary retransmissions. A routing protocol should not add up more to the total energy consumption than necessary. In DSR, this can be achieved by reducing the RREP packets, which form major portion of the control packets.

Research on multiple paths routing to provide improved throughput and route resilience as compared with single-path routing has been explored in details in the context of wired network. However, multi path routing has not been explored thoroughly in the domain of ad hoc networks.

In this reserach, we propose a multi-path routing protocol to improve the network throughput, decrease average end-to-end delay and reduce congestion in ad hoc networks. The proposed scheme is applied as an extension on top of existing dynamic source routing (DSR) and the performance is evaluated using simulation.

The advantage of having multiple paths is that if the primary link fails, the source has an additional option of selecting an alternate path to forward data traffic. The advantage of having multiple paths in DSR is minimized by the number of route reply packets that originate from the destination on receiving route requests from various non touching paths. In the proposed modification, the

Manuscript received May 5, 2007
Manuscript revised May 20, 2007

route reply packets are limited form the destination by sending route reply packets through certain paths only.
Aim of the research is to reduce the routing load of the existing Dynamic Source Routing (DSR) thereby achieving the overall goal of reducing the energy consumption of the network. For this purpose, the drawbacks of the existing dynamic source routing were analyzed and an efficient algorithm was proposed to reduce the route reply packets thereby achieving minimum end-to-end delay and high packet delivery ratio with lesser energy consumption.

This paper is organized as follows. In section 2 we give the essential background of the previous research effort, survey of the existing routing protocols, and the various power saving methods used in ad hoc network. Section 3 explains the mechanism and drawbacks of DSR protocol.

Section 4 brings out the collision avoidance issues in ad hoc network. It then gives the proposed modification of the DSR protocol and the algorithm to achieve it .It then outlines the various performance metrics that are necessary to evaluate the performance of a particular simulation. Section 5 discusses the simulated results and conclusion. Further work for the next phase is also discussed here. Further modification in DSR protocol can greatly enhance its performance as well as reduce the power consumption.

2. Related Work

Dynamic Source Routing is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration [1]. Power control is a solution to the multiple access problems in contention-based wireless ad-hoc networks [2].By efficient power control we can save the power thereby increasing the battery life of the network. Various power conservation techniques for mobile ad hoc network are discussed in [3]. Performance metrics and scenario metrics are described in detail in [4].Performance metrics determine the performance of a particular simulation. A scenario metric is calculated from the input data to the simulation, or might even be an input variable. These metrics are interesting since their value will not be dependent of the routing protocol or the simulation process. Various route discovery features and route maintenance features are given in[5].Route discovery features namely caching overhead routing information, replying to route requests using cached routes, preventing route reply storms are described. Route maintenance features like packet salvaging, automatic route shortening features are also described. The concept of various routing methods for both wired and wireless communication s studied and analyzed in [6].The way expanded-ring search concept is implemented in ad hoc network is examined in detail. Review of the performance of various routing protocols in terms of the performance metrics and scenario metric is analyzed in [7, 8].They examines the behavior of the network under different scenarios using different routing protocols. The various challenges faced by MANET are studied in [9]. Energy management in ad hoc networks is dealt in detail in [10]. The various power efficient routing methods are studied in detail. The power efficient routing methods namely Minimum total transmission power routing(MTPR), Minimum Battery Cost routing (MBCR),Minimum Maximum cost routing (MMBCR),Conditional Maxi-Min battery capacity routing (CMMBCR) are studied. Some of the optimized power aware routing is discussed in [11].

3. DSR Protocol

3.1 Mechanism of the Protocol

The DSR protocol [1] is composed of two mechanisms that work together to allow the discovery and maintenance of source routes in the adhoc network. The operation of Route Discovery and Route Maintenance in DSR are designed to allow uni-directional links and asymmetric routes to be easily supported.

3.2 Drawbacks of DSR Protocol

Through the dynamic source protocol has many advantages; it does have some drawback, which limits its performance in certain scenarios. The various drawbacks of DSR are as follows:-
Dynamic Source Routing (DSR) does not support multicasting.

The data packet header in dynamic source routing (DSR) consist of all the intermediate route address along with source and destination, thereby decreasing the throughput.

DSR sends route reply packets through all routes from where the route request packets came. This increases the available multiple paths for source but at the same time increases the routing packet load of the network.

Current specification of DSR does not contain any mechanism for route entry invalidation or route prioritization when faced with a choice of multiple routes. This leads to stale cache entries particularly in high mobility. DSR is a source routing method so as the size of the network increases the size of the header may increase which increases the routing overhead.

Dynamic source routing protocol is designed for use in multi-hop wireless ad hoc networks of mobile nodes. DSR uses source routing and does not depend on timer based activities .So it is a fully reactive protocol which initiates a route discovery process only when it has data to send. Though there are some disadvantages of this protocol, it is a robust protocol for use in mobile ad hoc network.

4. Collision avoidance in DSR

In an ad hoc network, frequent link changes are expected since the nodes are constantly moving. These differences between wired and wireless networks make it obvious that an ad hoc routing protocol need to address some additional problems not present in wired network. Below are lists of things that a routing protocol should take into account.

The goals of routing protocol design in general are to make the protocol: -

- Scale as the network topology changes.
- Respond quickly to topology changes
- Provide loop free routes.
- Minimize delay (short routes)
- Present multiple routes to avoid congestion.
- Have decentralized execution.
- Be bandwidth efficient (minimize routing overhead).
- Avoid collisions.
- Act power conservative.

4.1 Proposal I

In the first proposal, the destination is made to decide in which route it wants to send route reply through than the first route request comes in a different path with the number of hops more than the first route requests sends route reply through that path but if another route request, it simply drops the packet. The other route request packets with same or lesser number of hops than the first request are entered in route cache and route replies initiated for that particular route request.

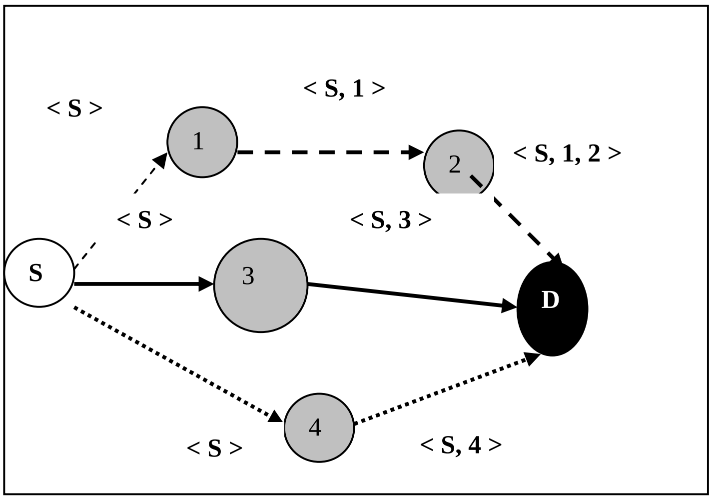

Fig 4.1 Route request packets reaching destination through various paths

Here in Fig 4.1, there are at three paths through which route request packet can flow. They are S->3->D, S->4->D and S->1->2->D. Here the destination will receive the first two paths faster than the third by the criteria of number of hops. It will send the route reply packet through that route. But as soon as it receives the third route request, it knows that this route has more hops than the first two requests so it will simply discard that route and will not initiate route reply for that route.

4.2 Proposal II

In the second method; the decision is left to the source on what route it should take so that data packets are delivered to destination with less delay and maximum packet delivery ratio. In this, the source on receiving the first route reply form the destination send data packets through that way but if another path comes up with a better route after this, the source node changes the route of the data packets to that new route. Here, in this report the selection criteria have been taken as the number of hops.

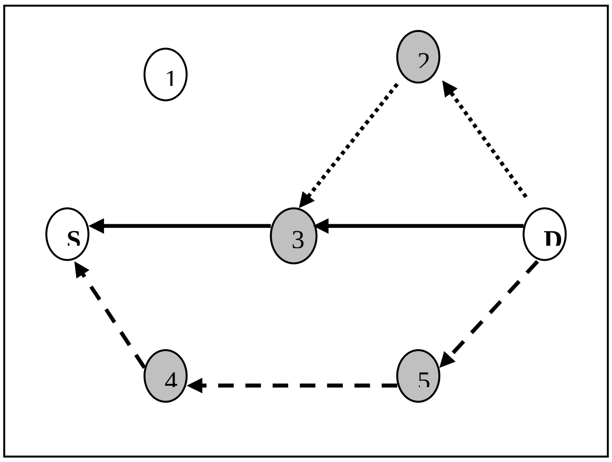

Fig 4.2 Route reply packet reaching source through various routes

In Fig 4.2, the route reply from destination comes to source through path D->5->4->S first. On receiving the route reply packet through D->5->4->S the source starts sending data packets through that path. Next it receives RRep through the path D->3->S which got delayed due to congestion in the network. It then finds that the new route has lesser number of hops so it next sends data packets through that path. This proposal greatly improves the efficiency of the network by reducing the time delay as well as reducing the energy consumption by the network. Since the alternative route has lesser number of hops so lesser number of nodes will be processing the data, so lesser energy will be spent.

4.3 Algorithm used in the new proposal I

These steps are performed at the destination node.

Step 1: All Route Request packets are accepted with the destination address as the node address.

Step 2: Check for the sequence number to find whether request already seen or not.

Step 3: If request is not seen before, insert it into request seen table and initiate route reply.

Step 4: If request is seen before, check whether the path matches with request seen table or not.

Step 5: If path is different, check whether number of hops is less than or equal to the hops in the table.

Step 6: If path hop count is greater than available path, drop the packet else initiate route reply and insert it into route cache.

4.4 Algorithm used in the new proposal II

These steps are performed at the source node.

Step1: All route reply packets are accepted from a particular destination.

Step2: Source sends data packets based on the first route reply arrival.

Step3: On receiving other route replies arrival it will compare their hop count with the original path and will select the new path if hop count is less than the original path.

Step4: If hop count is same or more than the original path, it will keep it in its route cache.

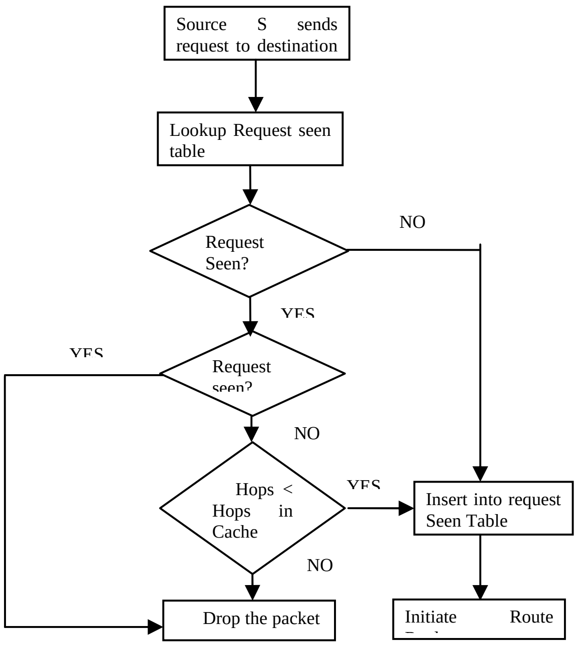

Fig 4.3 Flowchart for Proposal I: Steps Performed At Destination Node

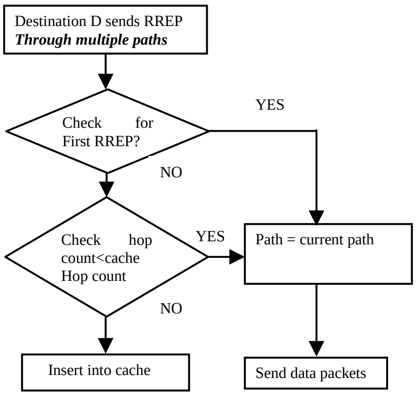

Fig 4.4 Flowchart for Proposal II: steps performed at source node

4.5Metrics

4.5.1 Performance Metrics

The performance metrics determine the performance of a particular simulation. In mobile ad hoc network, the various performance metrics used are as follows: Packet Delivery Ratio, Routing Overhead, End-To-End Delay.

Routing overhead is an interesting metric. It reveals how bandwidth efficient the routing protocol is. In DSR, the source finds a route to the destination entirely on-demand. By storing packet information about all intermediate nodes in a packet header as the route discovery packet traverses it knows the full route once the route discovery packet returns. This source routes cause the packet headers to grow and produce more routing overhead.

4.5.2 Scenario Metrics

A scenario metric is calculated from the input data to the simulation or might even be an input variable (such as the pause time).These metrics are interesting since their value will not be dependent of the routing protocol or the simulation process, as the performance metrics might be. It is critical that non-biased metrics exists in order to provide a truthful comparison between the different routing protocols.

Mobility

Larsson, Hedman [4], introduced the mobility metric. It is an attempt to measure the mobility in the network by calculating the relative node movement between all pairs of nodes in the network. The mobility metric is proportional to the number of link changes in a model where nodes move in a random fashion. Pause time is also a simulation input variable. When used as a metric, the mean pause time of all the nodes throughout the simulation is used as a measure similar to the mobility metric. The longer the average pause time is the lesser node movement within the network. Even though nodes are pausing for extended periods at one spot they could be moving very rapidly in the next movement, causing many link breakages. Still pause time is an important metrics. Density metric is solely dependent on the scenario input variables. The use of this metrics is to find out whether the density of the nodes in an ad hoc network would influence the performance of the routing protocols used in the network. If so, it should be expected that an increased density of nodes in the network would decrease the routing protocols performance as a direct effect of less bandwidth and higher congestion.

The reduction in route reply packets guarantees two things: - one that the routing load gets decreased which increases the effective bandwidth utilization and secondly the reduction in reply packets reduces the end-to-end delay and increases the packet delivery fraction congestion in the network gets reduced.

5. Simulation Result and Conclusion

5.1 Simulation Environment

The basic DSR [1] and modified DSR were studied in GloMoSim [12] simulation environment.. The total number of nodes was fixed at 50 for the simulation. The nodes move inside a simulation area of 1500 m_300 m. The simulation time is 900 seconds. The nodes move with a maximal velocity of 20 m/s and according to the random waypoint mobility model. In this model, a node randomly chooses a point in the simulation area and a speed for the next move, which is uniformly distributed between 0 and the maximal velocity. Subsequently, the node drives to the selected point at constant speed. After arriving at the end point the node remains there for a certain time. Subsequently, the node repeats the operation by selecting a new end point and new speed. The simulation was performed with 9 different pause times of 0,100,200,300,400,500,600,700,800 and 900 seconds. When the pause time is 0 seconds, the nodes move constantly. In contrast, when the pause time is 900 seconds the nodes do not move at all. Simulation was done

for 5 CBR connections with a transmitted power of 15 dBm. The other simulation parameters are described in Table 5.1.
The next set of simulations takes varying nodes in a fixed simulation area. The simulation area is fixed at 1500m_300m.The transmission power was kept constant at 5 dBm. The simulation time was fixed at 900S.The nodes were made to move with a maximal velocity of 20 m/s and according to random waypoint mobility model. The pause time was fixed at 0S.Both in actual DSR as well as the modified DSR the promiscuous mode was kept on. The receiver sensitivity was fixed at -91.0 dBm. The path loss model chosen for our simulation is free space model and the noise figure was fixed at 10 dBm. The frequency of simulation is fixed at 2.4 GHz. This is the free ISM (Industrial, Scientific and Medical) band. The main aim of this simulation is to find the scalability of our modified algorithm. For this simulation, one CDR connection was taken with a transmission power of 5 dBm.

Table 5.1: Simulation parameters for the modified DSR protocol

SIMULATION PARAMETER	VALUE	SIMULATION PARAMETER	VALUE
SIMULATION TIME	900S	NUMBER OF NODES	50
MOBILITY	RANDOM	MINIMUM SPEED	0
MAXIMUM SPEED	20 m/s	PATH-LOSS	FREE-SPACE
TEMPERATURE	300K	NOISE FIGURE	10 dBm
RADIO TYPE	ACCNOISE	RADIO FREQUENCY	2.4 e9Hz
RADIO BW	2000000 bits	RADIO FREQUENCY	15 dBm
RADIO-RX SENSITIVITY	-91.0 dBm	MAC PROTOCOL	802.11
NETWORK PROTOCOL	IP	ROUTING PROPOCOL	DSR
PROMISCOUS MODE	YES	TERRIAN DIMENSION	1500m-300m

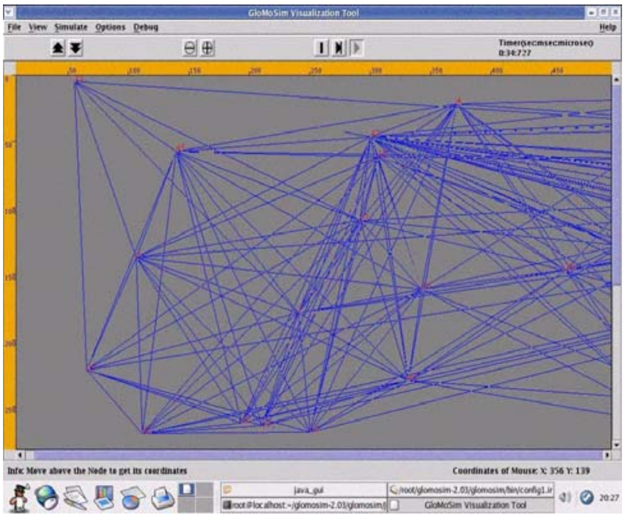

Fig 5.1: Snapshot of Simulation

5.2 *Performance Comparison with Basic DSR*

To get a better idea of the performance of modified DSR protocol it is compared with the basic DSR. The performance metrics described in chapter 4 was taken for evaluation purpose.

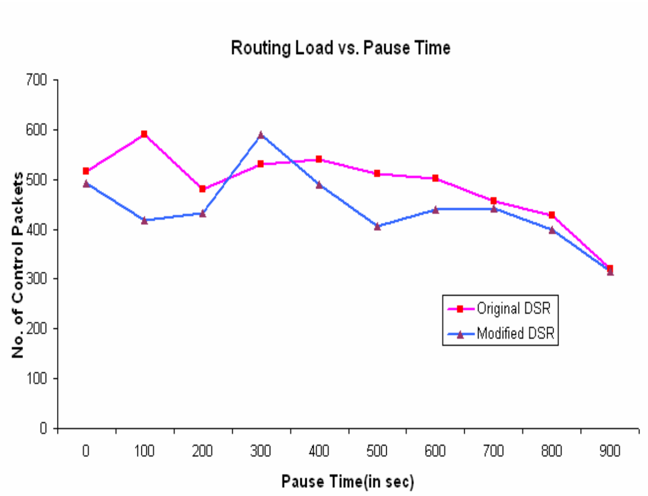

Fig 5.2 Comparison of the actual and modified DSR protocol by the number of control packets as a function of pause time .

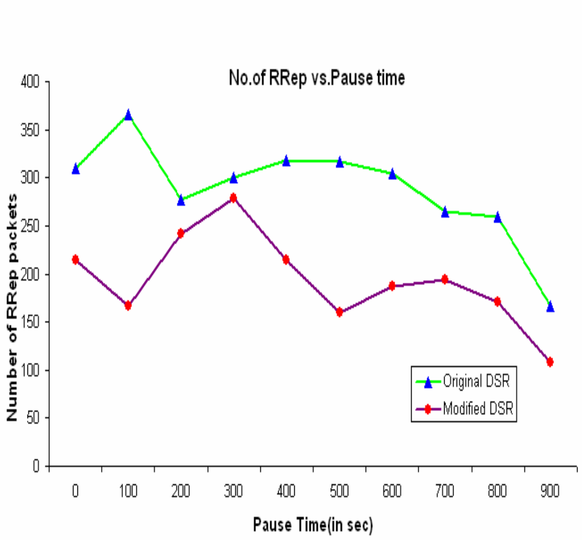

Fig 5.3 Comparison of DSR and modified DSR with respect to route reply packets as a function of pause time.

This simulation result of Fig 5.2 shows that modifying the present routing algorithm reduces the routing load packets. In the case of low pause timeline. Frequent moves and consequently frequent topology changes, therefore the number of control packets are higher than in case with higher pause period. When pause period is high it means that the nodes are more or less stationery.

So, in almost static environment the modified algorithm is comparable with the basic DSR routing protocol. With less dynamic the difference between the basic DSR and our modified DSR is not significant. This is because the number of routing load reduces as the mobility decreases since fewer link breaks occur. But in a high mobility scenario the difference is significant .This is because at high mobility the number of control packets are more as compared to less mobility. The number of route reply reduces by a wide margin in the scenario as seen in the Fig 5.3.

The packet delivery ratio is total number of packets delivered successfully to the total number of packets sent. Here in Fig 5.4 it is seen that our algorithm performs better than the basic DSR. This effect is due to the reduced congestion in the path. When the mobility is high due to more number of link breakages the path is congested, as more route request packets are present whereas when mobility is less reducing the alternate path does not make much difference as the total number of routing packets as whole is less.

In Fig 5.5 it is found that the end-to-end delays of both protocols not differing by a large margin. This is because the congestion is not sufficient whereby it can make a large impact. It is found that due to lesser number of collisions in the path, the delay in traveling from the source to the destination is not much. The reduction in delay in terms of absolute value is not much but in terms of percentage of the total delay it is appreciable. Thus it is seen that the modified DSR performs better than the basic DSR in many performance metrics.

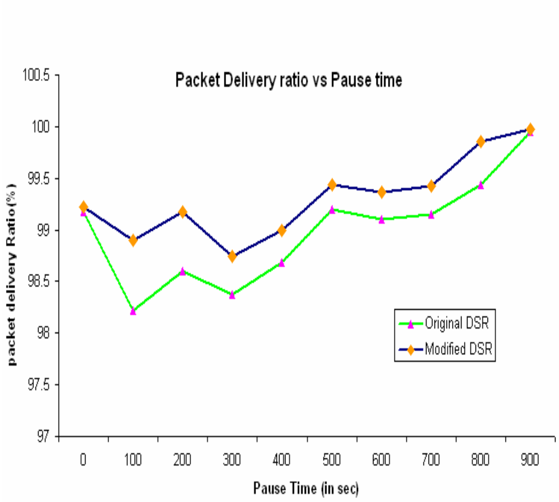

Fig 5.4 Comparison of DSR and modified DSR with respect to packet delivery ratio as a function of pause time.

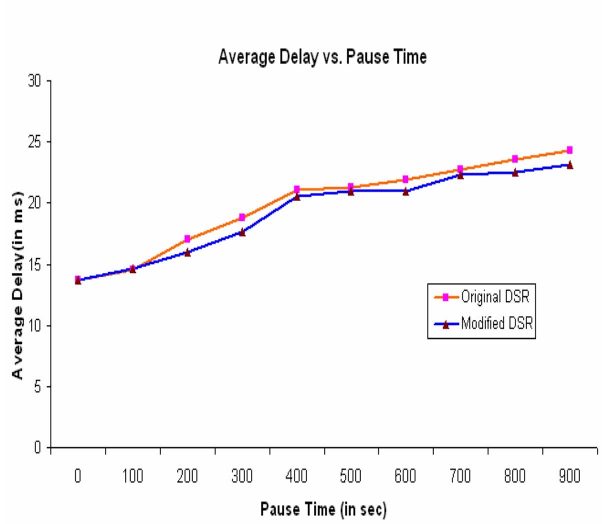

Fig 5.5 Comparison of DSR and modified DSR with respect to average delay as a function of pause time

To check the robustness of our algorithm we performed simulation by varying the number of nodes.

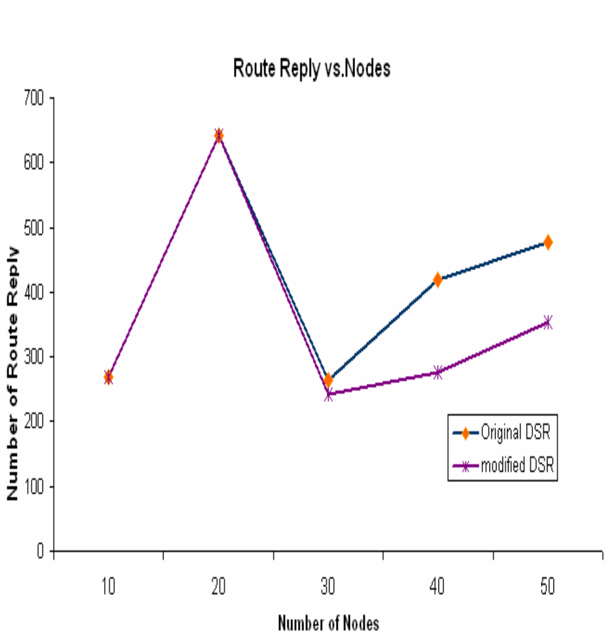

Fig 5.6 Comparison of DSR and modified DSR with respect to Route reply packets as a function of number of nodes.

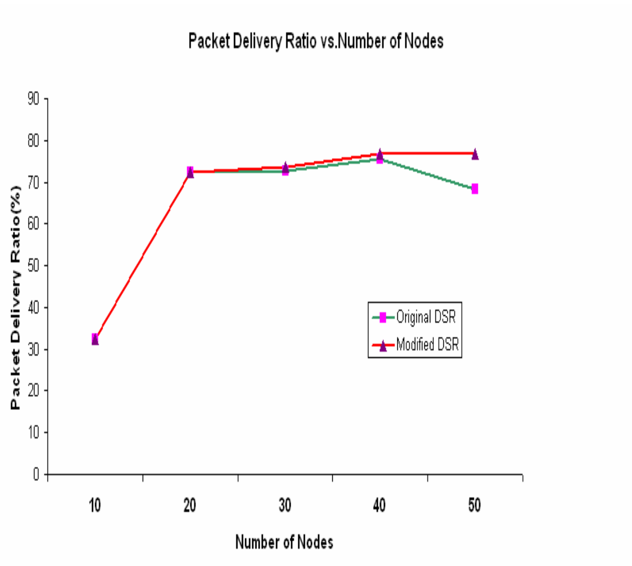

Fig 5.7 Comparison of DSR and modified DSR with respect to packet delivery ratio as a function of number of nodes.

We did simulation on our modified DSR protocol varied number of nodes that participated in the node. We did simulation by varying the nodes from 10 to 50.the decrease in the number of nodes meant that the connectivity also decrease, each node has a fewer neighbors. The results of the simulation did not give any new information regarding the performance of the simulated protocols. The relative difference between the protocols was the same.

Decreased connectivity meant that we did not get as many packets through the network as in mobility situation. The worst results for each protocol happened when the mobility was 0.The reason for this result is because the nodes are standing still in the randomized scenarios. If a randomized scenario has poor connectivity, these connectivity nodes are not moving and hence cannot affect the connectivity. In a moving scenario the connectivity will vary during the whole simulation. So, even if the node is unreachable in the beginning, there is a chance that it will be reachable some time later. In Fig 5.6 we find that when the number of nodes is less the difference is not there. This is because the simulation is for one CBR connection only. But the route reply packets decrease in modified algorithm as the number of nodes increases. It is found in the simulation result as in fig 5.7 that the packet delivery ratio is not varying much when density of nodes is less but variation is appreciable at higher density.

When talking about the size of the network, it is not only the number of nodes in the network that is of interest. The area that the nodes are spread out over is also interesting. This basically decides the connectivity of the network. A large area with many nodes may mean longer routes than for a smaller area with the same number of nodes. At the same time, many nodes close to each other mean a higher collision probability.

Fig 5.8 and 5.9 shows that the average delay and the number of control packets do not vary much where the node density is less but appreciable difference is found when the node density increases.

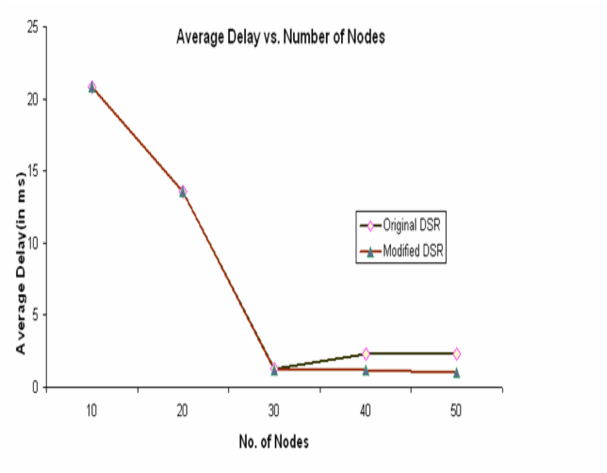

Fig 5.8: Comparison of DSR and modified DSR with respect to average delay as a function of number of nodes.

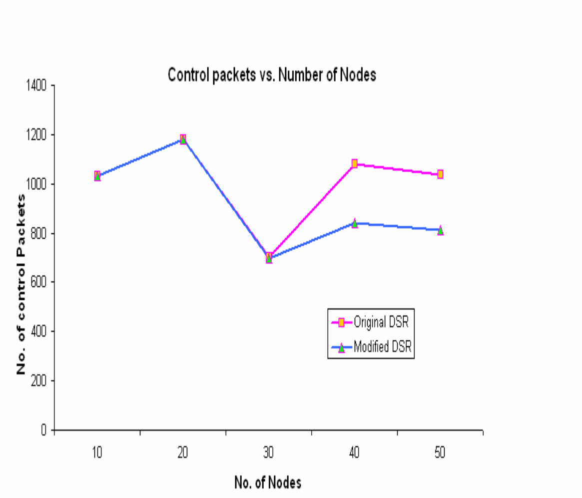

Fig 5.9: Comparison of DSR and modified DSR with respect to number of control packets as a function of number of nodes.

5.3 Conclusion

Mobile multi-hop ad-hoc networks are flexible networks, which do not require a pre-installed infrastructure. With the upcoming wireless transmission technologies and highly sophisticated devices their application will increase. However, the routing is a major challenge in mobile multi-hop ad-hoc networks, which is aggravated by the node mobility. In this research a modified DSR routing algorithm is presented for mobile ultimo ad hoc networks. Further, a performance evaluation is performed by comparing the modified DSR protocol it with the basic DSR routing protocol. Since one of our major goals was to reduce the routing overhead, the existing algorithm was modified to achieve this objective. To get a better idea of the generated overhead we considered the number of routing packets, which carry the overhead. The analysis shows that the performance of modified DSR is better than the performance of the basic DSR for the considered simulations scenarios. The modified algorithm was found to reduce the power consumption of the network by routing lesser routing load.

5.4 Scope for Future Work

Future work will extend to finding out the optimal routing load for a given scenario. The reduction in certain alternate paths can still reduce the routing load of the network. Reducing the route error packets and route request packets can also bring down the routing load. This aspect can also be analyzed further. Further reduction in collisions can be achieved by fixing optimal queue length. This aspect can be taken up in next phase.

References

[1] Stallings, W. Cryptography and Network Security: Principles and Practice, New Jersey: Prentice Hall, 1999
[2] Amor, D, The E-Business(R) evolution, New Jersey: Prentice Hall, 1999.
[3] Stallings, W., High-Speed Networks, TCP/IP and ATM Design Principles, New Jersey: Prentice Hall, 1998.
[4] The DSL Forum, General Introduction to Copper Access Technologies, URL.
[5] Jackson, K.M., & Hrucka, J. (Eds.)., Computer Security Reference Book, Florida.
[6] Roback, E. & Dworkin, M.,"First Advanced Encryption Standard (AES) Conference,"CryptoBytes, vol.4, pp.6-14, Winter 1999.
[7] Stein,L.D.,and Web Security: A Step-by-Step Reference Guide, Reading, Massachusetts: Admission-Wesley, 1998.
[8] Greenstein,& Feinman,T.M.Electronic commerce:Secutity,Risk Management and Control, New York: Irwin McGraw-Hill,1999
[9] Knudsen, J., JAVA Cryptography.Cambrige: O' reilly,1998.
[10] IMC Organisation,URL:http://www.imc.org/ietf-pkix/

[11] Lubbe,J.C.A.vander.,BasicMethodsof Cryptography,Cambridge:Cambridge University Press,1998.
[12] Rhee, M.Y., Cryptography and Secure Communications.Singapore:MacGraw-Hill Book Co.,1994.
[13] Identrus Official Website,URL:http://www.identrus.com.
[14] Elizabeth.M.Royer,Chai-Keong Toh.A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks.RFC 2409,IIE Personal Communications, 1999.
[15] Mobile ad hoc networks (Manet) charter. Web page 1999-09-11.
[16] Dileep Kumar, Energy Management in Ad hoc Networks, Department of Computer Science, Vassa University-Finland.
[17] Jorge Nuevo, INRS – Universite du Quebec, ”A Comprehensible GoMoSim Tutorial”,September 4,2003.

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