Reliable Dynamic Source Routing (RDSR) Protocol with Link Failure Prediction for Mobile Ad Hoc Networks (MANET)

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Abstract – Complexity of routing in Mobile Ad Hoc Network (MANET) is due to the fact that the network topology is temporarily arranged due to the mobility of the nodes. Therefore, one of the main challenges in MANET is how to create a routing algorithm is capable of providing high reliability in delivering data from a source node to a destination node and high level of service quality in intermittent networks. This paper proposes novel routing algorithm that takes into consideration the Cross-Layer Design (CLD) technique to achieve transmission of data with high reliability in MANET. The suggested routing algorithm is enhanced version of original DSR protocol, called Reliable DSR (RDSR). Where, during route discovery phase, route selection is based on the metric of signal strength of received route reply (RREP) packet among the intermediate nodes. Moreover, during route maintenance phase, the signal strength of exchanged data packets among nodes has been used to predict the route failure earlier, and then there an earlier chance for selecting another route before the loss of the exchanged data packets. Performance evaluation and comparison of RDSR against original DSR from point of viewof packet delivery fraction, end-to-end delay, routing load and throughput have been carried out by using NS-2 simulator. The results of simulation proved that performance of RDSR is outperforming of DSR in the above-mentioned performance criteria's except the routing load.

Index Terms – MANET, Routing Protocols, DSR, CLD and Reliable DSR,

1. INTRODUCTION

Mobile Ad-hoc Network is dynamic wireless network without infrastructure. The nodes of MANET have the ability to act as a host and a router at the same time, move freely and organize themselves with random manner, resulting in network dynamic topology [1]. Therefore the routing protocols of MANET are different from those in others wireless/wired networks, where they should have the ability to handle this dynamic topology environment [2], [3]. Routing protocols in MANET are classified into two classes: proactive protocols (e.g. DSDV and WRP) [4] and reactive protocols (e.g. DSR and AODV) [5], [6], [7]. Whereas, these routing protocols are multi-hops in their nature, the route selection is based on the minimum number of hops between the source node and the destination node.This metric (hop count) may be resulting in minimum end-to-end delay, but it is not sufficient for constructing a route with high reliability [8], [9].

To construct a route with a high reliability, the links along the route should have a high quality. Whereas, the quality of link (wireless channel) among the nodes normally varying with time and depending on the atmospheric phenomena, Doppler effect, fading, and path loss. Links that have weak quality usually have a low level of signal strength, which leads to a high rate of frame error, lower packet delivery fraction, and low throughput [10], [11], [12]. The weak point of the original reactive routing protocols (e.g. DSR and AODV) during the route selection is that they do not consider the factors which have a passive effect on the quality of links among the nodes and hence the route reliability [13], [14]. Therefore, it will be better for those routing protocols to be aware of the different links quality among the nodes during the route selection [15], [16].

Whereas, the link's quality between any two successive nodes depends on the received signal strength of exchanged packets between them [17], [18]. Hence, to create a route with a relatively high quality of links (i.e. reliable route), the received signal strength of exchanged packets among the nodes along the path is being usedas a metric for route selection [19], [20]. By using this metric the routing protocol will have the ability to provide coherent attitude regardless of the changes of network nodes mobility, changes of network topology and latent mobility of the node in a dynamic environment [21], [22]. Hence, the MANET will be able to provide better level of quality of service.

In this context, to get the routing layer aware of underlying layer's parameters, (e.g. the value of the signal strength of the received packet at the physical layer), the cross-layer approach should be incorporated with the routing protocol [23], [24], [25]. In this research, we introduce a novel version of the dynamic source routing (DSR) protocol, called Reliable DSR (RDSR), with the aim to enhance the reliability of the original DSR. The RDSR is based on a new mechanism in which signal strength of exchanged packets among nodes along the path is being used as a metric in route selection during route discovery phase. Also, in route maintenance phase, signal strength of exchanged data packets among nodes is being used to predict link failure in early time, and then there is an early chance for selecting another route before the loss of the exchanged data packets.

The roadmap for the research has been completed with the following sections: Related work is given in Section 2. The suggested algorithm is presented in Section 3. Simulation milieu and performance criteria are shown in Section 4. Simulation results and discussion are given in Section 5. The paper conclusion is presented in Section 6.

2. RELATED WORK

One of the carried out studies in this field is Wuetal's work [26]. This study refers to different techniques for route selection in mobile ad hoc network, such as DSR, ZRP, SSA and AODV. Wuetal suppose that MANET has a messy receive mode of wireless devices to discover the route. The criticism of these mechanisms is concerned with consuming of more power and decreasing the rendering quality of the wireless network cards output. These mechanisms concern to enhance energetic routes, through adjusting overhead of packets and routing tables of MANET routing protocols.

Park and Voorst [27], [28] proposed an algorithm called Anticipated route maintenance. This algorithm predicts the link failure between any two successive nodes along the route within predefined time, depending on using nodes' velocities and locations, which are determined using GPS. The proposed algorithm includes two phases, Expanding phase and Shrinking phase. The Expanding phase prevents the route from failure by inserting a node working as a bridge into the weak link before its failure. On another hand, the Shrinking phase eliminates the unnecessary nodes from the route to reduce hops count.

There is another solution mechanism GPS-based present by Park and Voorst', Sjaugi et al. [29]. It is based on location information for network nodes to be able to detect critical links, which has longer distance than a certain threshold one. The nodes' information about its location is piggybacking into packets' headers. When found unsafe link, local broadcasting (1 hop) activated to locate a bridge node, which has the ability to serve as an intermediate one between two nodes having unsafe link between them. This processes is a path expanding phase; which was proposed in Park and Voorst [27],[28]. However, this author did not comment on the shrinking phase, which leads to the proposed technique may have disadvantage of making route to be arbitrarily and unnecessarily long.

Qin et al. [30] proposed a link failure prediction algorithm, based on change of signal strength of two consecutive data packets received by intermediate node along the route. Hence, when the signal strength of currently received data packet is less than that one of previously received data packet by a certain threshold, intermediate node sends a "Broken route message" to source node. On receiving this message, source node tries to find alternative route through route discovery process. This mechanism does not mitigate necessity of route discovery process, but it tends to decrease number of lost data packets when route failure is imminent to occur.

3. PORPOSED ALGORITHM

This section presents the proposed modification of DSR protocol. The proposed modification includes two main phases of DSR protocol, (route discovery and route maintenance).

3.1 The Modified Route Discovery Phase

In this phase, two control packets are used for route selection: Route request (RREQ) packet andRoute reply (RREP) packet. Androute selection betweensource nodeand destination nodeis being based on maximum-minimum of the measured signal strength of the RREP packets.

Like original DSR, as illustrated in Figure 1, when source node needs to transmit data to destination node, it checks of routing table. If it founds route to destination node, it sends its data through this route. Otherwise, source node activatesroute discoverymechanism by broadcasting RREQ packet to neighbors. When intermediate node receives RREQ packet it tests routing table. If it has route to destination node it sends RREP packet to source node through same path on which it received RREQ packet. Otherwise, it rebroadcasts RREQ packet to neighbors. This process repeated until RREQ packet reaches destination node.

When same RREQ packet reaches from different paths to destination node, it sends same RREP packet through each path on which it received RREQ packet to source node. In the proposed algorithm, format of RREP packet is slightly modified by adding an extra field to record the packet signal strength. Based on that, for each transmitted RREP packet, destination node records a high default value in signal strength field, called RSS.

As illustrated in Figure 2, when any intermediate node receives RREP packet, it measures the value of packet signal strength, this value is named MSS, and compares this value with RSS. If MSS < RSS, signal strength field is updated with MSS, and RREP packet is transmitted to next node. Otherwise, the RREP packet is transmitted without updating signal strength field.

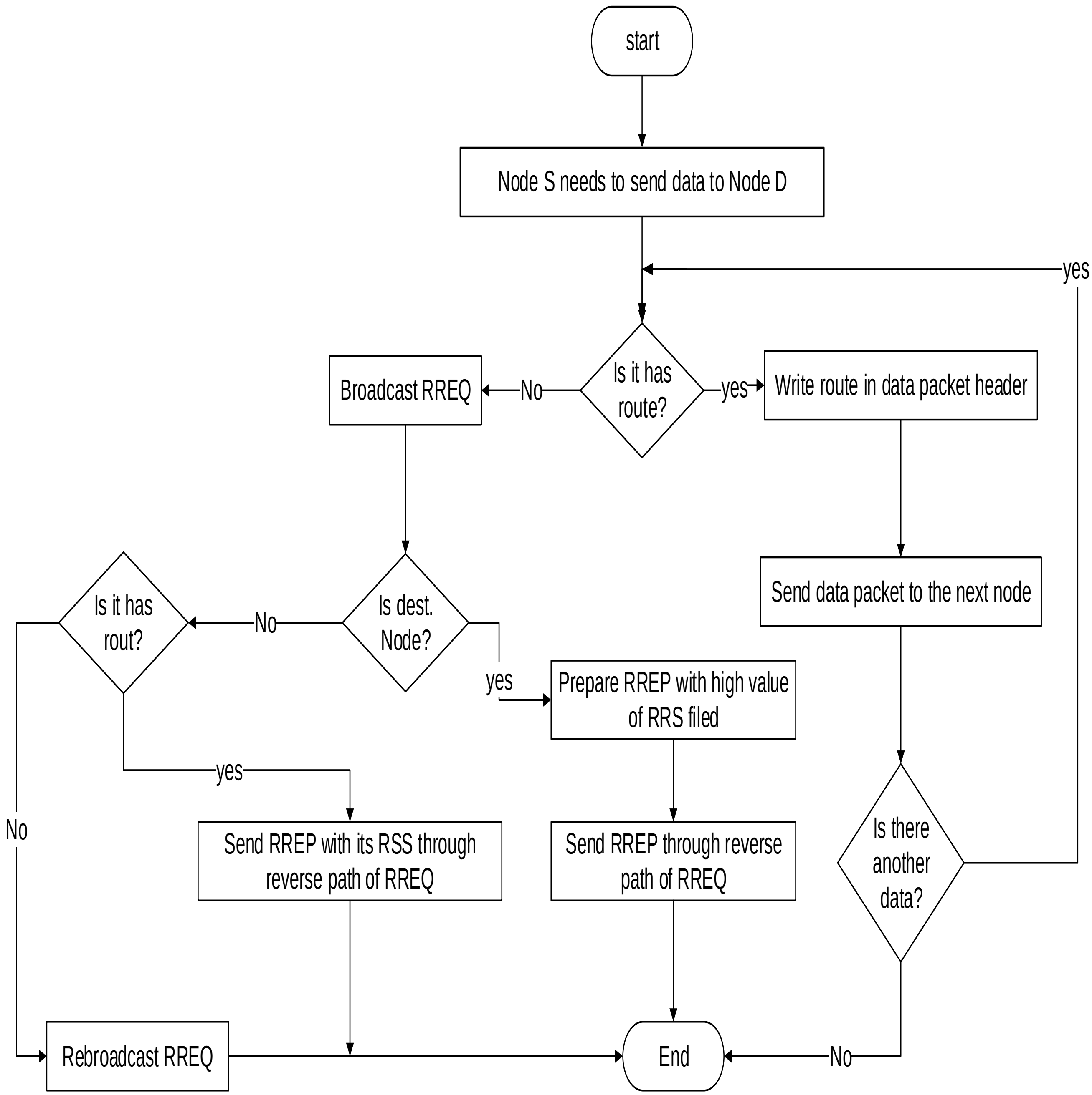

Figure 1. Node Response When It Receives RREQ

This process repeated until RREP packet reaches source node. According to this approach, we can say that final value of signal strength field, (RSS), indicates lowest link quality in route. Therefore, on receiving multiple RREP packets from destination node, source node organizes the different routes in descending order based on value of signal strength field,(RSS), and selects route with the highest value of RSS, (i.e. the route of relatively high quality), for transmitting the data.

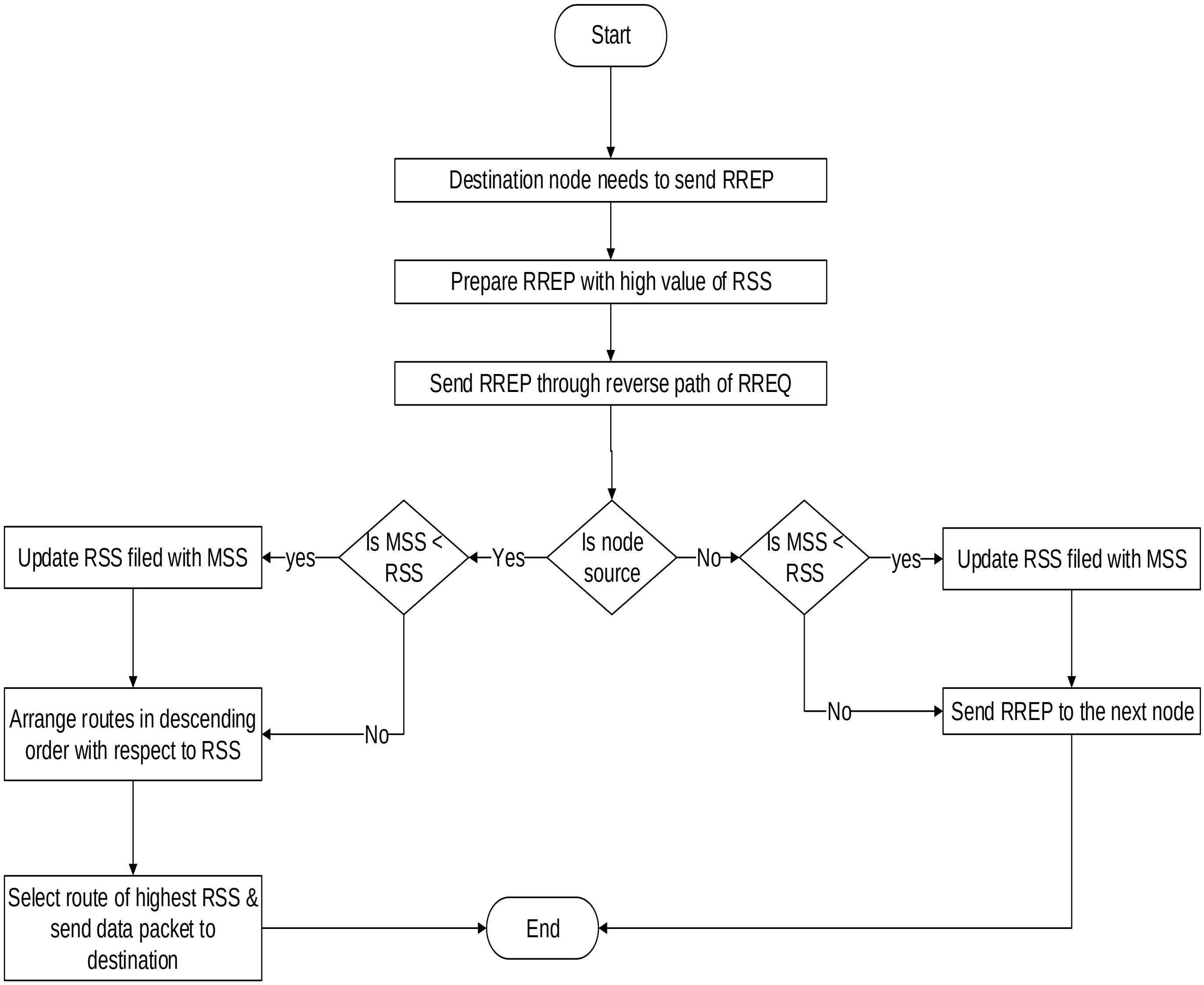

Figure 2. Node Response When It Receives RREP

3.2. The Modified Route Maintenance Phase

Unlike route maintenance mechanism of original DSR, the main aim of the proposed method for route maintenance is to predict route failure early before its breakdown; hence, probability to startuproute discovery processisminimized. This will leads to prolonging route stability lifetime and minimize data packets loss.

The proposed method for route maintenance requires light modification for data packet format by adding an extra field in its header to record data packet signal strength, called RSS. The complete steps of modified route maintenance scheme are as follow:

1- Before data packet transmission, source node inserts value of RSS field of selected route into corresponding RSS field of data packet and transmits data packet to the next downstream intermediate node.

2- On receiving data packet by any intermediate node along route, it measures value of signal strength of data packet, named MSS, and obeys to the following rules, as shown in Figure 3:

- In case of MSS>0.5RSS: If intermediate node has another route in the routing table, with higher value of RSS than the corresponding value of RSS in currently used route to the same destination node. It updates data packet with the new value of RSS and the new route in route field, and sends data packet to next node along the new route. Also, it sends message, on the reverse path, with the new route to source node. On other hand, if the intermediate node has not new route, it forwards data packet on currently used route to next node.

-In case of MSS<0.5RSS: If intermediate node has another route in its routing table, with a higher value of RSS than the corresponding value of RSS in currently used route to the same destination node. It will follow the same procedures as in the previous case and sends route error (RERR) packet, on the reverse path on which it received data packet, to source node. Otherwise, it forwards data packet on the currently used route to next node and sends route error (RERR) packet, on the reverse path, to source node.

3- On receiving RERR packet, source node searches for another alternative route in routing table. Otherwise, it initiates route discovery mechanism.

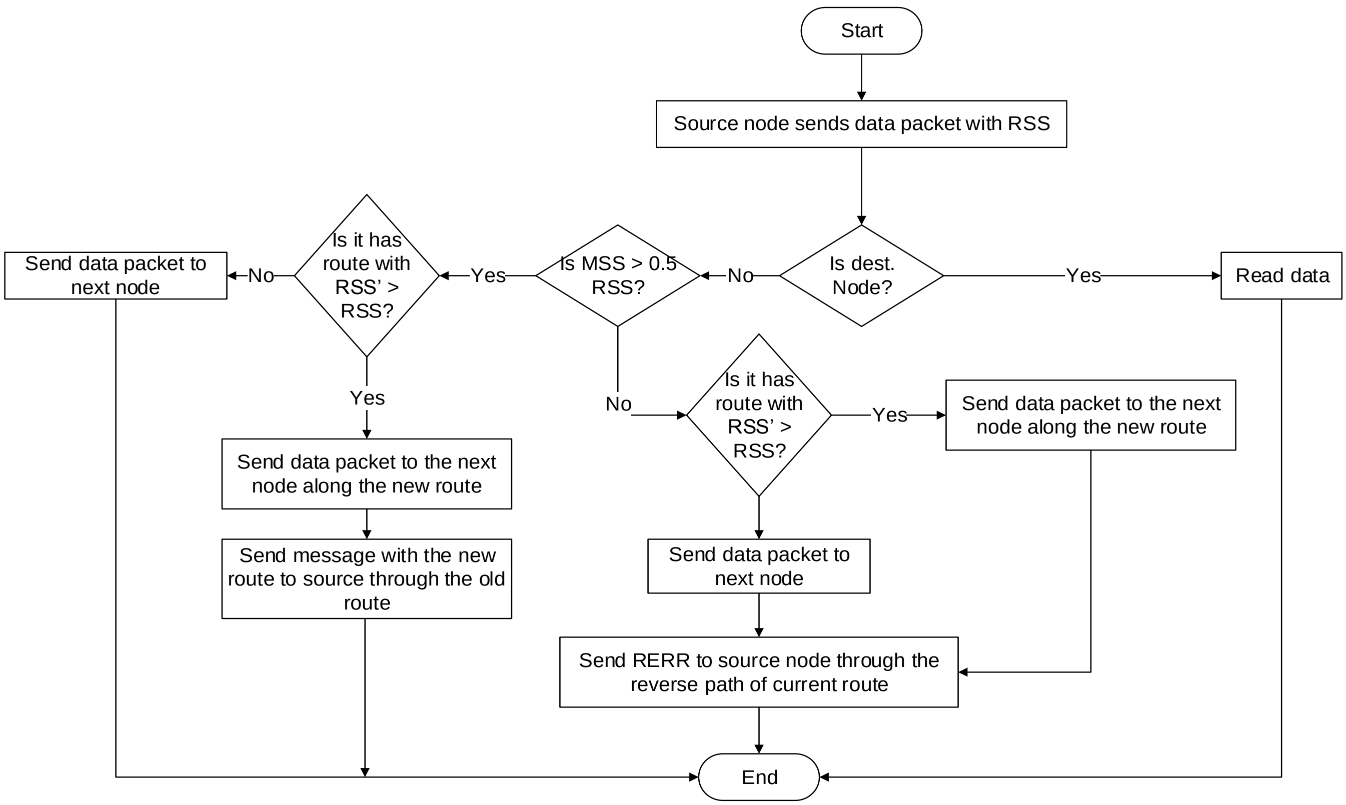

Figure3. Route Maintenance Scheme

4. SIMULATION MILIEU

Performance assessment and comparison of proposed scheme, RDSR, against original DSR have been done using network simulator NS2. The metrics that have been used for performance assessment and comparison are Packet Delivery Fractions (PDF), Average End to End Delay (E-to-E Delay), Normalized Routing Load (NRL) and Throughput. Simulation parameters are illustrated in Table 1.

Simulation Parameters	Values
Simulation tool	Ns-2.35
Node number	50 node
Simulation time	500 second
Simulation area	400*800 m
pause time	50-500 s
maximum connection	50 % of nodes
Mobility model	Random waypoint model
Routing protocol	DSR – RDSR
Packets Rate	4 packet/second
Mobility Speed	5 m/s
Channel Type	Wireless
MAC Layer	802.11
Traffic Type	CBR
Antenna type	Antenna/Omni Antenna

Table 1: Simulation Parameters

5. RESULTS AND DISCUSSIONS

Whereas, the node movement level, which affected with the pause time of node, has a strong effect on the measured signal strength of the received data/reply packet at any node.Therefore, the all above-mentioned performance metrics are presented as a function of pause time. In simulation environment, the pause time has been varied between 50 and 500 seconds. Where 50 sec. means high node mobility and 500 sec. means static node.

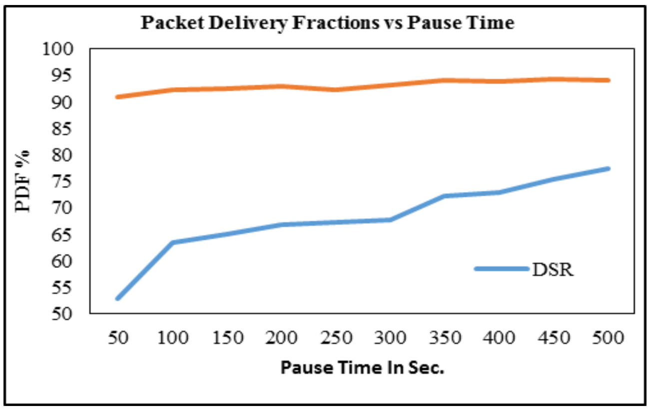

Figure 4.PDFvs. Pause Time

PDF vs. pause time for both RDSR and DSR is presented in Figure 4. We note that the RDSR has a higher PDF than that one of DSR. Whereas, PDF of RDSR varies in a narrow range (from 90.8 to 94.3), with average 93%, while PDF of DSR varies in wide range (from 52.8 to 77.4), with average 68%. This is because route selection of RDSR is based on the maximum -minimum signal strength criteria as well as the proposed link failure mechanism which predicts of the link failure in an earlier time before the dropping of data packets. All of this resulting in high PDF of the proposed RDSR.

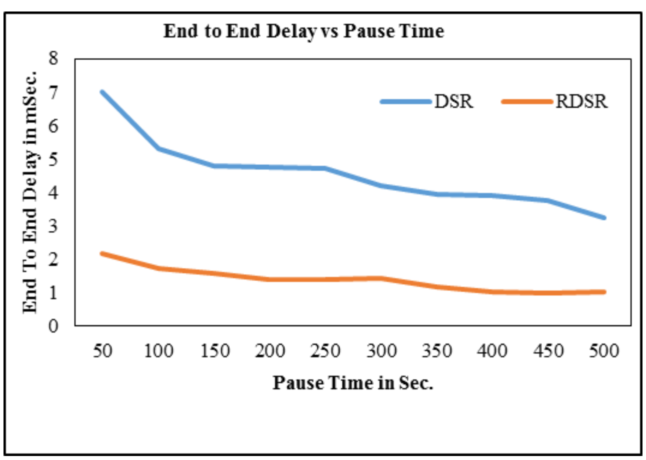

Figure 5 End-to-End Delay vs.Pause Time

Figure 5 illustrates end-to-end delay (E2E delay) against pause time. It is lucid that, the RDSR has a lower E2E delay than that one of the original DSR. Whereas, E2E delay of RDSR varies in a narrow range (from 1.7ms to 1.0ms), with average 1.4ms, while the E2E delay of DSR varies in wide range (from 7.0ms to 3.2ms), with average 4.6ms. This is due to prolong route stability lifetime in addition to early link failure mechanism which reduces the probability of repetition of route discovery process, resulting in minimization of E2E delay.

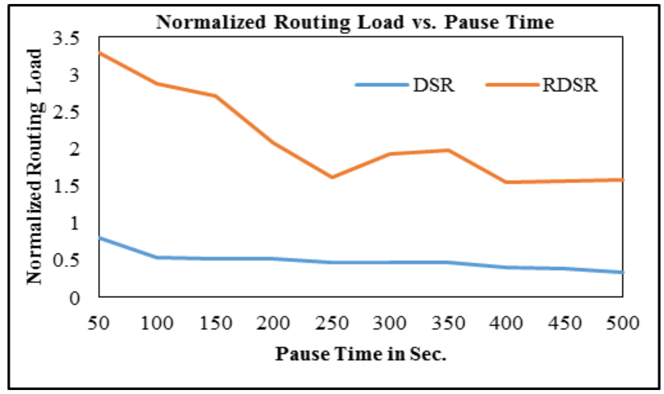

Figure 6 Normalized Rouring Load vs. Pause Time

Normalized routing load (NRL) against pause time is given in Figure 6. We observe that the proposed RDSR has a higher NRL than of original DSR. Whereas, NRL of RDSR varies in wide range (from 3.2 to 1.5), with average 2.1, while the NRL of DSR varies in narrow range (from 0.8 to 0.3), with average 0.5. The proposed RDSR has a high value of NRL because of the additional field, MSS, in both of the RREP packet and data packet. Also, during data packet transmission, if an intermediate node has new route better than the currently used route, it sends a control message, which may occur more frequently, to inform the source node with the new route.

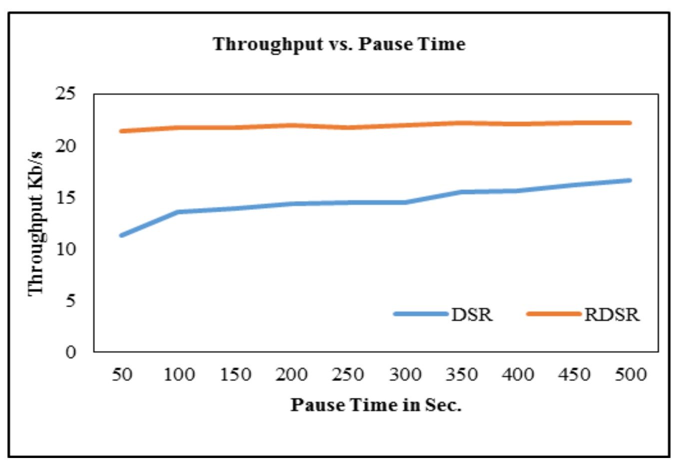

Figure 7. Throughput vs. Pause Time

Figure 7 illustrates throughput against pause time. It is obvious that the throughput of RDSR, with average 22Kb/s, is higher than other of the original DSR, with average 14.6Kb/s, and it is nearly constant. This due to, route selection of RDSR is based on maximum-minimum signal strength criteria which result in prolonging route lifetime, as well as the proposed link failure mechanism which predicts the link failure in an earlier time before dropping of data packets. All of this resulting in a high throughput of the proposed RDSR.

6. CONCLUSION

In this paper, we have proposed a refined version of original DSR, called RDSR, with the aim to get a stable route through prolonging the route lifetime. Therefore, during the route discovery phase, route selection is based on measured value of signal strength of RREP packet. Also, to avoid frequent link failures due to nodes mobility, a new route maintenance scheme has been proposed by using link failure mechanism which predicts the link failure in an earlier time before dropping of data packets. Performance evaluation and comparison of RDSR against original DSR have been done usingnetwork simulator, NS2. The results of simulation proved that proposed RDSR has a superior performance than DSR from point of viewof packet delivery ratio, end-to-end delay,and throughput, with an increase of 37%, 69%, and 50% respectively.

REFERENCES

[1] A. R. Khalifa, R. A. Sadek and M. A. Al-Shora, “Performance Analysis Of DSR, SEA-DSR And Modified DSR Routing Protocols”, International Journal of Computer Science and Mobile Computing, Vol.5 Issue.7,pp. 204-209, July- 2016.

[2] Fuad Alnajjar, Tarek Saadawi,“Social-stratification Probabilistic Routing Algorithm in Delay-Tolerant Networks”, The International Conference on Wireless Algorithms, Systems and Applications (WASA'09), Boston, MA,pp. 579–591, August 2009.

[3] G. Shankara Rao, E. Jagadees wararao et al, “Performance Analysis of Manet Routing Protocols - DSDV, DSR, AODV, AOMDV using NS-2”, Global Journal of Computer Science and Technology: E Network, Web & Security, Vol. 15, Issue 6, Version 1.0, 2015.

[4] Rjab Hajlaoui, Sami Touil and Wissemachour,” O-DSR: OPTIMIZED DSR ROUTING PROTOCOL FOR MOBILE AD HOC NETWORK”, International Journal of Wireless & Mobile Networks (IJWMN) Vol. 7, No. 4, August 2015.

[5] Saima Zafar, Hina Tariq and Kanza Manzoor,” Throughput and Delay Analysis of AODV, DSDV and DSR Routing Protocols in Mobile Ad Hoc Networks”, International Journal of Computer Networks and Applications (IJCNA), Vol. 3, Issue 2, March, April 2016.

[6] B.Soujanya, T. Sitamah Alakshmi and CH.DIVAKAR,” Study Of Routing Protocols In Mobile Ad-Hoc Networks”, International Journal of Engineering Science and Technology (IJEST), Vol. 3, No. 4, April 2011.

[7] Priyaganga Guruswamy and Madhumita Chatterjee,” A Novel Efficient Rebroadcast Protocol for Minimizing Routing Overhead in Mobile Ad-Hoc Networks”, International Journal of Computer Networks and Applications (IJCNA), Vol. 3, Issue 2, March, April 2016.

[8] Mamoun Hussein Mamoun,"A Proposed Route Selection Technique in DSR Routing Protocol for MANET",International Journal of Engineering & Technology IJET-IJENS, Vol. 11, No. 02, April 2011.

[9] Aman Kumar and Rahul Hans, ”Performance Analysis of DSDV, I-DSDV, OLSR, ZRP Proactive Routing Protocol in Mobile Ad Hoc Networks in IPv6”, International Journal of Advanced Science and Technology Vol.77,pp.25-36, 2015.

[10] Mamoun Hussein Mamoun, “Location Aided Hybrid Routing Algorithm for MANET,” Int. Journal of Engineering& Technology IJET/IJENS, Vol. 11, No. 01, pp. 51- 57, Feb. 2011.

[11] Rupinder Kaur, Paramdeep Singh et al, ” Performance Enhancement of AODV with Distributed-DSR Routing Protocol in Manet”, Indian Journal of Science and Technology, Vol. 8, No. 28, October 2015.

[12] P. Srinivasan and K. Kamalkkannan, “Signal Strength And Energy Aware Reliable Route Discovery in Manet”, International Journal of Communication Network Security, Vol. 1, Issue 4, 2012.

[13] Y. Ramesh, Usha Ch. andJagadishGurrala," CBR based Performance Evaluation on FSR, DSR,STAR-LORA, DYMO Routing Protocols in MANET", International Journal of Engineering Research and Development, Vol. 2, Issue 9, PP. 17-27, (August 2012).

[14] ViveкSoi, and Dr. B.S. Dhaliwal,“ Performance comparison of DSR and AODV Routing Protocol in Mobile Ad hoc Networks”, International Journal of Computational Intelligence Research Volume 13, No. 7, pp. 1605-1616, 2017.

[15] R. F. Sophia Pearlin and G. Rekha,“ Performance Comparison of AODV, DSDV and DSR Protocols in Mobile Networks using NS-2”, Indian Journal of Science and Technology, Vol 9(8), February 2016.

[16] Ravneetkaur, Dr. Neeraj Sharma, “Dynamic node recovery in MANET for high recovery probability”, International Journal of Computer Networks and Applications (IJCNA), Vol 2, Issue 4, July - August 2015.

[17] Rajeshwar Singh, Dharmendra K Singh and Lalan Kumar,” Performance Evaluation of DSR and DSDV Routing Protocols for Wireless Ad Hoc Networks”, Int. J. Advanced Networking and Applications 732 Volume: 02, Issue: 04, pp. 732-737 2011.

[18] H.M. Tsai, N. Wisitpongphan, and O.K. Tonguz, “Link-Quality Aware AODV Protocol”, in Proc. IEEE International Symposium on Wireless Pervasive Computing (ISWPC) 2006, Phuket, Thailand, January 2006.

[19] V. RAJESHKUMAR, P.SIVAKUMAR, ”Comparative Study of AODV, DSDV and DSR Routing Protocols in MANET Using NetworkSimulator-2”, International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 12, December 2013.

[20] Rjab Hajlaoui, Sami Touil and Wissemachour,” O-DSR: Optimized DSR Routing Protocol For Mobile Ad Hoc Network”, International Journal of Wireless & Mobile Networks (IJWMN) Vol. 7, No. 4, August 2015.

[21] Rohan Gupta, Harbhajan Singh and Gurpreet Singh,” Performance Evaluation of Routing Protocols for Mobile Adhoc Networks ”, Indian Journal of Science and Technology, Vol 10, No. 31, August 2017.

[22] Merlinda Drini and Tarek Saadawi, ”Modeling Wireless Channel for Ad-Hoc Network Routing Protocol”, ISCC Marakech Marocco, pp. 549-555, July 2008.

[23] John Novatnack , Lloyd Greenwald and Harpreet Arora, “Evaluating ad hoc routing protocols with respect to quality of service”, Wireless And Mobile Computing, Networking And Communications, Volume 3, pp. 205-212,Aug.2005.

[24] Frank Aune, “Cross-Layer Tutorial”,NTNU 2014.

[25] Zeki Bilgin, Bilal Khan, "A Dynamic Route Optimization Mechanism for AODV in MANETs", Journal of Computer Science, 2014

[26] S. Wu, S. Ni, Y. Tseng, and J. Sheu, “Route Maintenance in a Wireless Mobile Ad Hoc Network”, 33rd Hawaii International Conference onSystem Sciences, Maui, 2000.

[27] Rohan Gupta, Harbhajan Singh and Gurpreet Singh, ” Performance Evaluation of Routing Protocols for Mobile Adhoc Networks”, Indian Journal of Science and Technology, Vol. 10, No. 31, August 2017.

[28] M. Al-Shurman, S.-M.Yoo, and S. Park, “A Performance Simulation for Route Maintenance in Wireless Ad Hoc Networks”, in ACM-SE 42:Proceedings of the 42nd annual Southeast regional conference, New York, USA: ACM, pp. 25–30, 2004.

[29] M. F. Sjaugi, M. Othman, and M. F. A. Rasid,“A New Distance Based Route Maintenance Strategy for Dynamic Source Routing Protocol”, Journal of Computer Science, Vol. 4, No. 3, pp. 172–180, 2008.

[30] L. Qin and T. Kunz,“Pro-active Route Maintenance in DSR”, SIGMOBILE Mob. Comput. Commun. Rev., Vol. 6, No. 3, pp. 79–89, 2002.

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