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PERFORMANCE EVALUATION AND COMPARISON OF DSR, MDSR AND RDSR ROUTING PROTOCOLS

[1]M. A. Al-Shora, [2]S. A. Nouh, [3]A. R. Khalifa
[1,2,3]Systems & Computers Department, Al-Azhar University, Cairo, Egypt
[1] M_a_m_al_shora@yahoo.com; [2] Sayed.nouh07@gmail.com; [3] khalifah2@hotmail.com

Abstract— Mobile Ad Hoc Network (MANET) have many complex problems, one of this problems is routing. The main sources of routing complexity come from nodes mobility, limited power source and bandwidth, and jamming that lead to frequent changed topology of network. Many research articles have been done to mitigate the effect of the dynamic topology on the route stability among nodes of network. One of the well-known routing protocols of MANET is Dynamic Source Routing protocol (DSR). It is reactive routing scheme, where the route is selected based on the minimum hop counts, as a metric, between the source and destination node. In this context, most research papers showed that the route selection based on minimum hop counts, as a criteria, have little positive effect on the route stability of DSR protocol. Therefore, there are various enhancements have been carried out on the original DSR protocol to obtain more stable routes among the nodes in the dynamic environment of MANET. This paper presents performance evaluation and comparison between the original DSR and two enhanced versions of DSR. The two enhanced versions are called Modified DSR (MDSR) and Reliable DSR (RDSR), and their operation is based on Cross Layer Design (CLD) technique which allows information sharing between the routing layer and the physical layer. MDSR is concerned with modification of the route discovery phase, where the route selection is based on the measured signal strength of route reply packets on the route links instead of the number of hops count. Also, unlike DSR, the route is selected by the source node instead of the destination node. On the other hand, RDSR is concerned with modification of route maintenance phase, where any intermediate node, along the route, has the ability to early predict the route failure before data packets lose resulting in the reduction of routing control packets. The comparison and performance evaluation of MDSR and RDSR versus DSR have been carried out using network simulator NS2 (ver. 2.35), under Ubuntu 10.4.

Keywords— MANET, Routing Protocols, CLD, DSR, MDSR, RDSR

1-INTRODUCTION

The structures of Mobile Ad hoc Network (MANET) is significantly different from the others wire/wireless networks. This is due to the absence of centralized management, and the nodes are allowed to freely move at any time and any direction. Hence, there is no any way to build permanent routes among the nodes in this dynamic environment using the traditional routing protocols. Therefore, the function of routing protocols of MANET should be distributed among the nodes in the sense that the nodes in the MANET should act as a host and router. Moreover, routing protocols must be adaptive to the dynamic topology of MANET [1],[2]. Routing protocols in MANET have two classes: proactive protocols (e.g. DSDV and WRP) [3] and reactive protocols (e.g. DSR and AODV) [4], [5]. In proactive protocols, each node continually keeps the most recent paths to each node in network whether it has data to send or not. In contrast, reactive protocols create the route solely when it is required (i.e. on demand).Many studies showed that, the reactive routing protocols are superior to proactive routing protocols in terms of higher packet delivery ratio, less consumed bandwidth and power consumption, and less routing overhead. Whereas DSR protocol is one of the most common reactive protocols; this paper is concerned with performance analysis and comparison of DSR protocol and its two modified versions (MSDR, RDSR). Like any reactive routing protocol, DSR protocol includes two phases: Route discovery phase and route maintenance phase. In route discovery stage, route selection between any two nodes is based on the shortest path metric (i.e. minimum hop count). Although the shortest path between any two communicating nodes satisfies minimum end to end delay, it is not sufficient criteria to establish a stable route with high quality (i.e. Reliable route) [6], [7], [8], [9].

To construct a route with a high reliability, the links along the route must have a high quality. Whereas, the link's quality among the nodes normally change with time, where it depends on many factors such as the atmospheric phenomena, nodes mobility, Doppler effect, fading, and path loss factor. So, the exchanged packets between any two successive nodes, over bad quality of link , will have low level of signal strength, resulting in unstable route with a high rate of packets error, lower packet delivery fraction, and low throughput [10], [11]. The weak point of the original reactive routing protocols (e.g. DSR and AODV), during the route selection, is they do not take into consideration the abovementioned factors which have a passive effect on the quality/stability of links among the nodes and hence the route reliability [12], [13]. Therefore, it will be better for those routing protocols to be aware of the different links quality among the nodes during the route selection [14], [15].

Whereas, the link's quality/stability, between any two successive nodes, depends on the received signal strength of exchanged packets between them [3], [5]. Therefore, to create a route consists of a relatively high quality/stability links (i.e. reliable route), the signal strength of exchanged packets among nodes along the path is used as a metric for route selection [16]. By using this metric the routing protocol will have the ability to provide coherent attitude regardless of the changes of nodes mobility and changes of network topology [14], [16]. Hence, the MANET will be able to provide better level of quality of service.

The main difference between the original DSR and its two enhanced versions (MDSR, RDSR) is the metric by which the route is being selected between any two communicating nodes. In DSR, route selection is based on minimum hop count along the route, while in both MDSR and RDSR, route selection is based on the received signal strength of exchanged control packets among intermediate nodes along the route. MDSR is concerned with the modification of route discovery mechanism of DSR. While RDSR is concerned with modification of route maintenance mechanism of MDSR. For performance evaluation and comparison among the three routing protocols, network simulator (NS2) have been used and the performance criteria are based on delivery ratio of successfully received packets (PDR), end-to-end delay, throughput and routing load.

The paper organization is as follows: Section 2 presents the related work. In Section 3, DSR and its advantage/disadvantages are presented. Section 4 discusses the MDSR protocol. Section 5 presents RDSR routing protocol. Simulation environment setup and results of simulation are demonstrated in Section 6. Section 7 concludes the paper.

2- RELATED WORK

One of the carried out studies in this field is Wuetal’s work [17]. 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 [18], [19] 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. [20]. 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 [18],[19]. 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. [21] 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.

Mohamed A. Al-Shora et al. [22] proposed a link failure prediction algorithm, based on change of signal strength of data packet than route signal strength. It depends on change of received packet signal strength than signal strength of full route witch route selection is based on if received packet signal strength is less than half of route signal strength(minimum signal strength of full route) that is mean route will be fail and begin to find alternate route.

3-DYNAMIC SOURCE ROUTING (DSR)

In DSR, as a node wants to communicate to other one, it investigates its routing cache to find a route. If it does not have route, it initiates route discovery scheme by preparing and broadcasting a rout request packet, RREQ, to neighbouring nodes. On receiving RREQ, if an intermediate node does not have path for destination node [23], it adds its address in the RREQ header and rebroadcasts. This process is repeated until RREQ arrives to destination node. Due to rebroadcasting transmissions, same RREQ will arrive to destination node through different paths. On receiving 1stRREQ, destination node transmits route reply packet, RREP, through reverse path of this RREQ, to source node as illustrated in fig.1[24], [25],[26].When the 1st RREP arrives source node, it stores in its routing cache the full path through which RREP have been received and starts sending the data packet to destination node through this route. Whereas, the route selection is based the minimum hop counts [27], [28]. On receiving later, the same RREQ through another path with hop counts less than that one in 1st RREQ, destination node will sent another RREP to source node through reverse path of the lately received RREQ. On other hand, in situation of receiving RREQ at any intermediate node having a valid route to destination node, it sends RREP containing this route, to source node through the back direction [29], [30], [31].

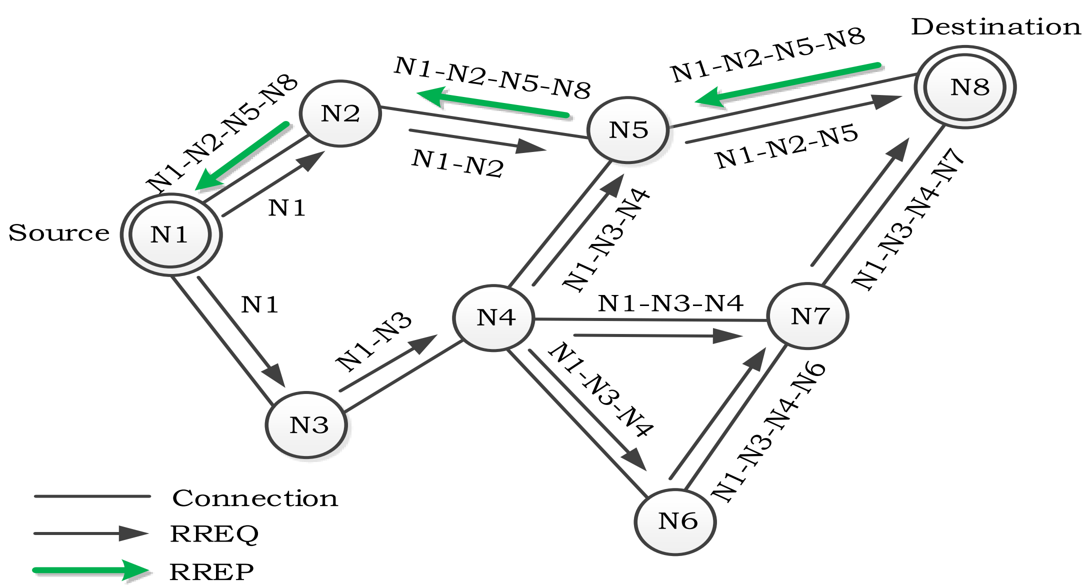

Figure 1. Route Discovery Mechanism of DSR

4-MODIFIED DYNAMIC SOURCE ROUTING (MDSR)

Since the selected route by the destination node, in standard DSR protocol, is only based on the minimum hops count between the source node and destination node, due to nodes mobility and the limited wireless transmission range, it is easy this short route to be broken during the journey of RREP from the destination node to source node, resulting in unnecessary RREP transmission and failure of route discovery process as shown in fig.2. Moreover, atmospheric phenomena, Doppler effect, fading, and path loss factor, have a passive effect on the quality/stability of the selected short path, causing a performance degradation of the network lifetime, reliability, and the overloaded to re-establish the route.

To avoid the unnecessary RREPs transmission and failure of route discovery process, in addition to mitigate the passive effect of the other factors on quality/stability of selected route, the MDSR have been proposed, which is concerned with modification of route discovery mechanism for standard DSR. Main difference of MDSR and DSR, during path discovery, includes the following points:

- Unlike DSR, the route selection is determined by source node instead of destination node.
- RREP packet format have been slightly modified by adding extra field named, recorded signal strength (RSS), as indicated in fig. 3.
- The main metric for route selection have been based on value of recorded signal strength (RSS) field of RREP packet at source node.

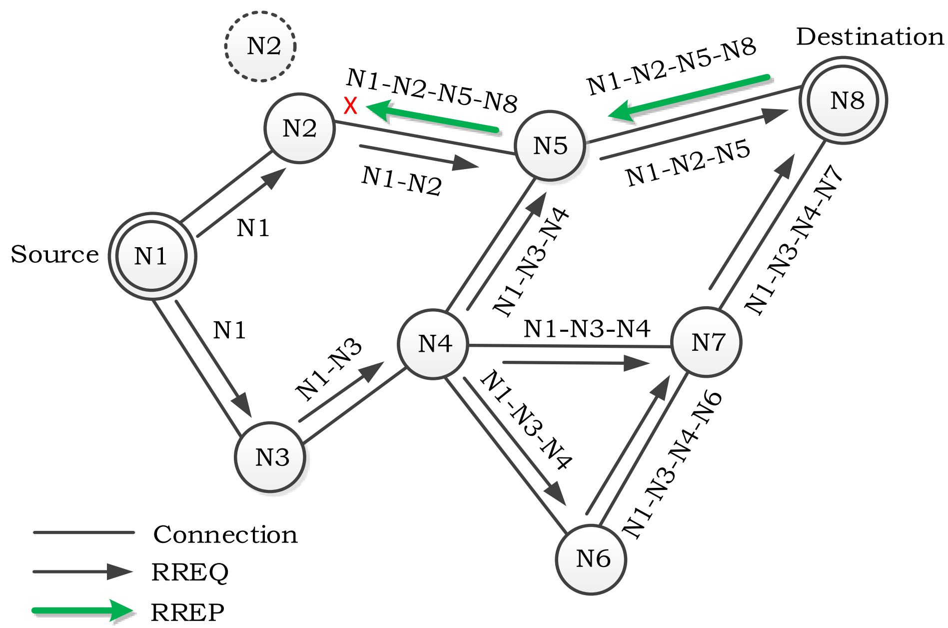

Figure 2. RREP Missing Due to the Mobility of Node 2

Next Header (8 bits)	Reserved (8 bits)	Payload Length (16 bits)	
Options (8 bits)	Data	RecordedSignal Strength (RSS)	

Figure 3. Modified Route Reply packet format.

In MDSR [32], [33], source node starts up route discovery by generating and broadcasting RREQ packet to its neighbouring nodes. On receiving RREQ, each intermediate node handles the RREQ with same manner as the original DSR. Whereas, the same RREQ packet arrives at destination node through different paths, destination node generates RREP packet with setting a high default value of RSS field and replies by sending RREP packet through the posterior path from which each RREQ have been received. On receiving RREP, every intermediate node measures the value of signal strength of the received RREP packet, named MSS. If MSS<RSS, the RSS field is updated with MSS, and RREP packet is transmitted to next node. Otherwise, the RREP packet is transmitted without updating recorded signal strength field. This process repeated until RREP packet reaches source node. According to this approach, we can mention that final value of recorded signal strength field, (RSS), refers to the link of lowest quality along the route. Therefore, on receiving numerous RREP packets from destination node, source node arranges the various routes in descending order based on value of recorded signal strength field,(RSS), and selects route of the highest value of RSS, (i.e. the route of relatively high quality), for data transmission. In situation of more than one path with same value of RSS, source node chooses the route of minimum hop counts, and arrange others in cache. Action of nodes on receiving RREQ and RREP are shown in figs 4, 5 respectively.

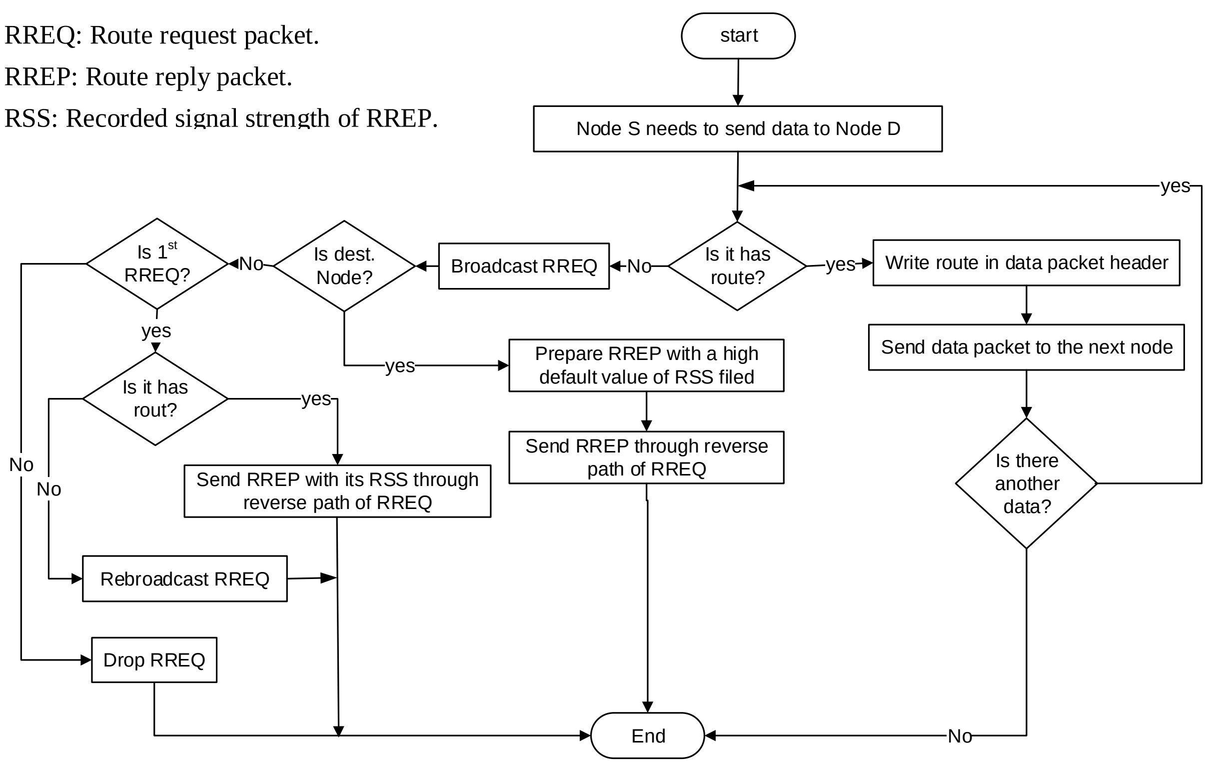

Figure 4. Node Response When It Receives RREQ

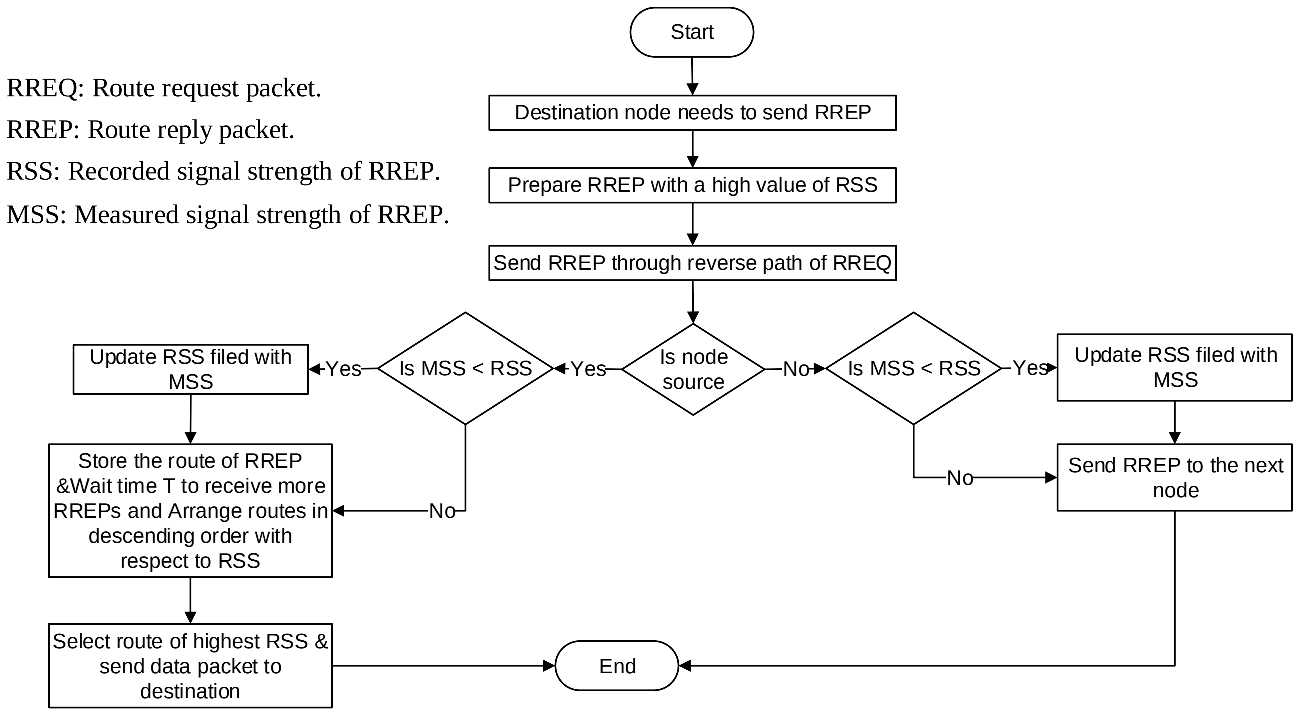

Figure 5. Node Response When It Receives RREP

5-Reliable Dynamic Source Routing (RDSR) Protocol

RDSR is concerned with the modification of route maintenance mechanism of DSR. The main aim of enhanced route maintenance approach [22], is to predict route failure early before its breakdown; hence, probability to start up route discovery mechanism is minimized. This will leads to prolonging route stability lifetime and minimize data packets loss. Rule of route discovery mechanism of RDSR is exactly the same of that used in MDSR. The proposed method for route maintenance requires light modification for data packet format by adding an extra field in its header named, recorded signal strength (RSS), to record data packet signal strength. The detailed function of modified route maintenance scheme is as follow:

Before data packet transmission, source node inserts value of RSS field of selected route into the RSS field of data packet and transmits data packet to next downstream intermediate node. On arriving data packet at any intermediate node along route, it measures value of signal strength of the received data packet, named MSS, and obeys to the following rules, as shown in fig. 6:

MSS: Measured signal strength of data packet.

RSS: The value of recorded signal strength field of the current route.

RSS': The value of recorded signal strength field of the new route.

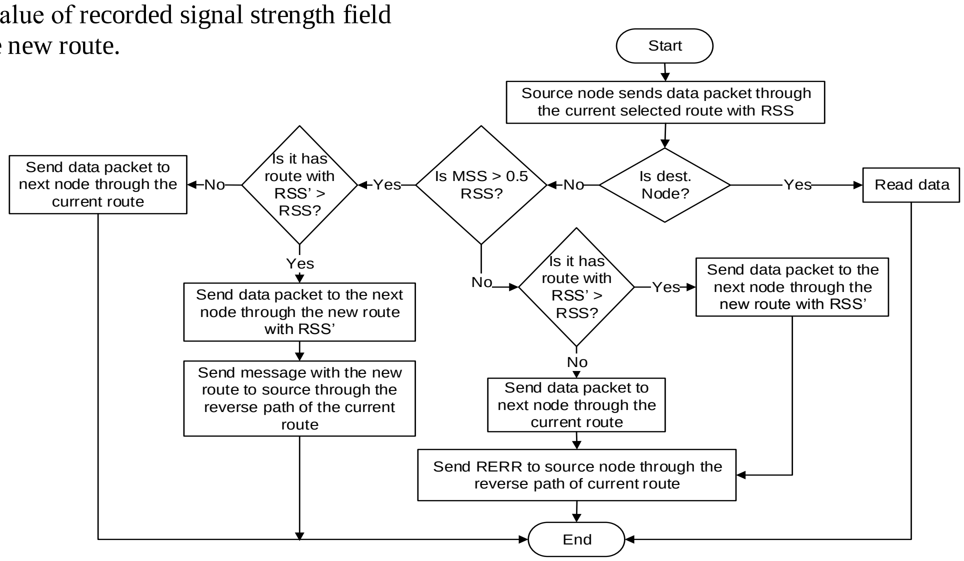

Figure 6. Route Maintenance Scheme

- In situation of MSS>0.5RSS: If the intermediate node has another route in the routing cache with a value of RSS' higher than the value of RSS of the currently used route to 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 to same destination node. Also, it sends message to the source node on reverse path of the currently used route, which includes the new route of destination node. On other hand, if intermediate node does not has new route, it forwards data packet on currently used route to next node.

-In situation of MSS<0.5RSS: If the intermediate node has another route in the routing cache with a value of RSS' higher than the value of RSS of the currently used route to 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 to same destination node.And sends route error packet, RERR, on reverse path of the currently used route to source node. Otherwise, it forwards data packet on the currently used route to next node and sends route error (RERR) packet, on reverse path, to source node.

- On reception of RERR packet, source node searches for another alternative route in the routing cache. Otherwise, it initiates route discovery mechanism.

6-SIMULATION MILIEU

Performance assessment and comparison between DSR and its two enhanced versions (MDSR, RDSR) was carried out using network simulator NS2. The used metrics for performance assessment and comparison are: packet delivery fraction (PDF), end to end delay (E-to-E delay), normalized routing load (NRL) and throughput. Parameters of simulation are presented in Table 1.

Table 1: Simulation Parameters

Simulation parameters	Values
Network simulator	Ns-2.35
Node number	50 node
Simulation time	500 second
Simulation area	400*800 m
pause time	50-500 s
maximum connection	90 % 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

7-RESULTS AND DISCUSSIONS

The results of the abovementioned performance metrics are presented as a function of pause time, which has a strong effect on the measured signal strength of the received data/reply packet at any node. In simulation environment, the pause time has been varied (from 50 sec. to 500 sec.). Where 50 Sec. means high mobility of node, but 500 sec. means static node.

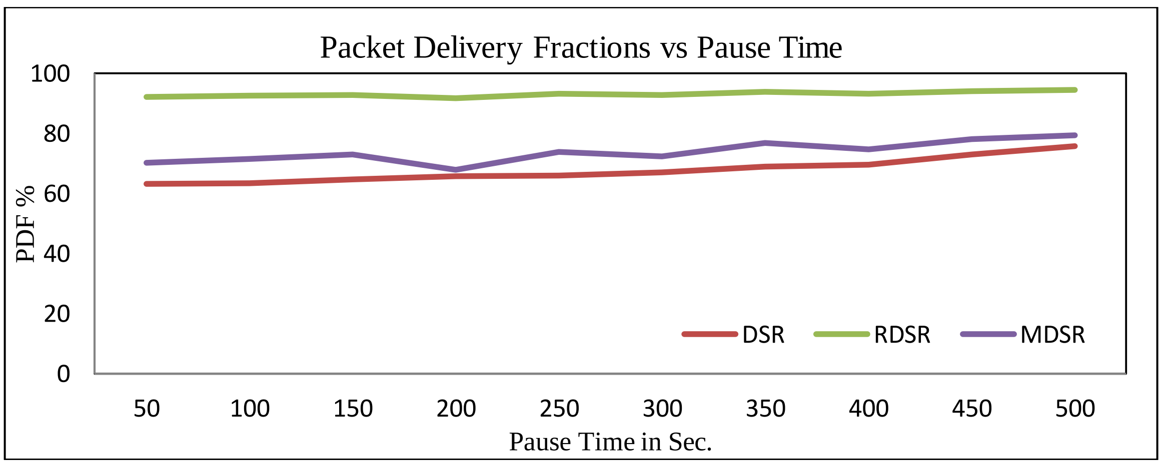

Figure 7.PDFagainst Pause Time

PDF against pause time for RDSR, MDSR and DSR is presented in Figure 7. We note that the RDSR has the highest PDF, which varies in narrow range (from 91.7 to 94.4), with average 93%.This because RDSR takes into consideration the approach of MDSR, during route discovery, in addition to the enhanced route maintenance mechanism which predicts the link failure in an earlier time before the dropping of data packets. On the otherhand, PDF of MDSR is higher than that oneof DSR,while it is lower than that one of RDSR, which varies in range (from 67.9 to 79.3), with average 73.7%. This is because MDSR is consernced only with the modification of route discovery mechanism. Also, we note that PDF of DSR is the lowest one, where varies in a wide range (from 63.1 to 75.8), with average 67.7%.

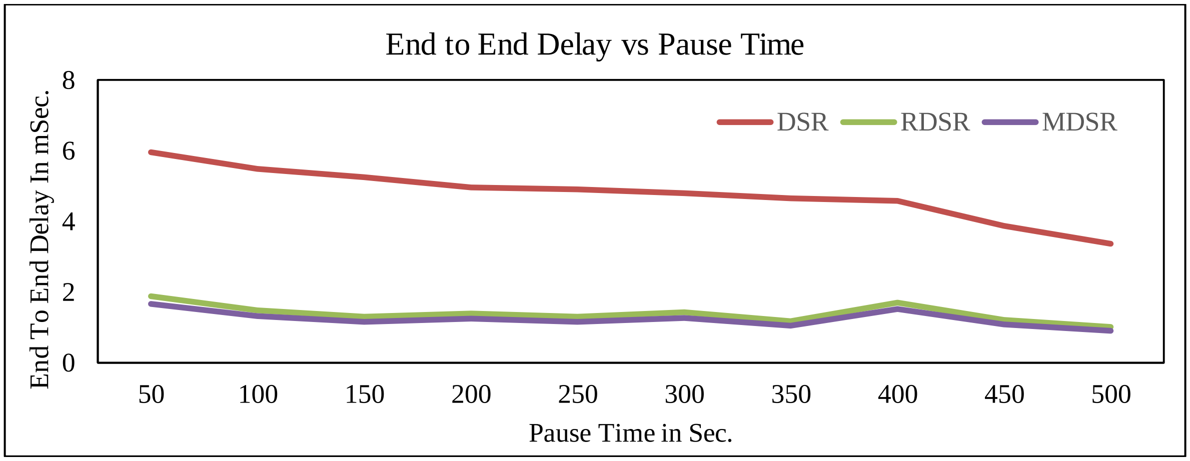

Figure 8. End-to-End Delay against Pause Time

Figure 8 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 original DSR, which varies in a narrow range (from 1.9ms to 1.0ms), with average 1.4 ms. This is because RDSR takes into consideration the approach of MDSR, during route discovery, resulting in prolong route stability lifetime, in addition to the enhanced route maintenance mechanism which predicts the link failure in an earlier time before the route failure and hence reducesprobability of repetition of route discovery process, resulting in minimization of E2E delay. On the otherhand, E2E delay of MDSR is relaviely (with small difference) lower than that one of RDSR, which varies in range (from 1.7ms to 0.9ms), with average 1.2 ms. This is due to, the needed time to select alternative route during route maintenance of RDSR. Also, DSR has the lowest E2E which varies in a wide range (from 6ms to 3.4ms), with average 4.8 ms.

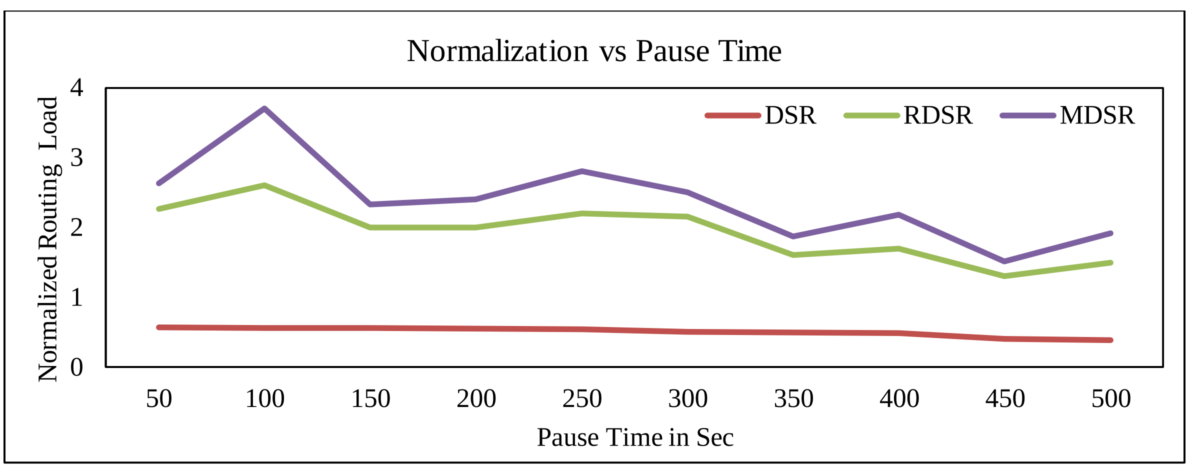

Figure 9. Normalized Routing Load against Pause Time

Normalized routing load (NRL) against pause time is illustrated in figure 9. We observe that RDSR has a higher NRL than another oneof original DSR and lower than that one of MDSR, which varies in moderate range (from 2.6 to 1.3), with average 1.9.While the NRL of MDSR varies inwide range (from 3.7 to 1.5), with average 2.4. On the otherhand, DSR has the lowest NRL, whichvaries in narrow range (from 0.6 to 0.4), with average 0.5. We note that, NRL of both MSDR and RDSR is higher than another one of original DSR. This is because, the modified route dicovery mechanism,where destination node sends more RREP packets (more overheads)to source node to choose the best route. Also, NRL of RDSR is lower that that of MDSR. This is due to the enhanced route maintenance schemewhich predicts the link failure in an earlier time before the route failure and hence reduces probability of repetition of route discovery process, resulting in minimization of overhead packets.

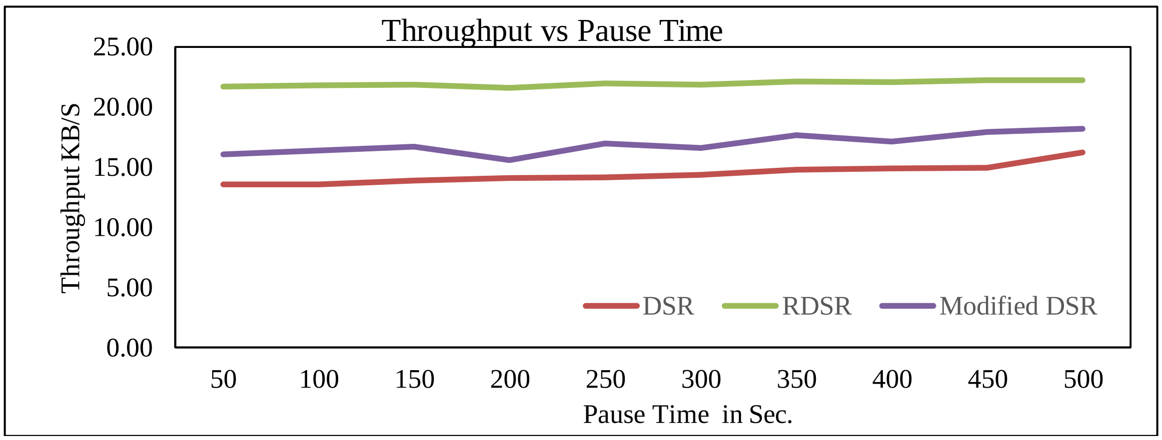

Figure 10. Throughput vs. Pause Time

Figure 10 illustrates throughput against pause time. It is obvious that the throughput of RDSR, with average 22Kb/s, is higher than other of the Modified DSR, with average 16.9 Kb/s, and original DSR, with average 14.4Kb/s, and it is nearly constant. This is because, pathselection of RDSR based on maximum-minimum signal strength criteria which results 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.

8-Conclusion

This article presents performance evaluation and comparison between original DSR and its two refined versions (MDSR and RDSR) by using network simulator, NS2. Ver.2.35 under Ubuntu 10.4 OS. The results of simulation proved that RDSR has a superior performance than the original DSR and MDSR from point of view of packet delivery fraction with 37.4% and 26.2% respectivly, end-to-end delay with 243% and -11.1% respectivly, and throughput, with an increase of51.9%, 29.8% respectively. But in routing load point of view RDSR is better than MDSR with 19% and worth than DSR with 73.8% .

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