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A MODIFIED ROUTE DISCOVERY APPROACH FOR DYNAMIC SOURCE ROUTING (DSR) PROTOCOL IN MOBILE AD-HOC NETWORKS

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ABSTRACT

Mobile Ad-hoc networks (MANETs) involved in many applications, whether commercial or military because of their characteristics that do not depend on the infrastructure as well as the freedom movement of their elements, but in return has caused this random mobility of the nodes many of the challenges, where the routing is considered one of these challenges. There are many types of routing protocols that operate within MANET networks, which responsible for finding paths between the source and destination nodes with the modernization of these paths which are constantly changing due to the dynamic topology of the network stemming from the constant random movement of the nodes. The DSR (Dynamic Source Routing) routing protocol algorithm is one of these routing protocols which consist of two main stages; route discovery and maintenance, where the route discovery algorithm operates based on blind flooding of request messages. blind flooding is considered as the most well known broadcasting mechanism, it is inefficient in terms of communication and resource utilization, which causing increasing the probability of collisions, repeating send several copies of the same message, as well as increasing the delay. Hence, a new mechanism in route discovery stage and in caching the routes in DSR algorithm according to the node's location in the network and the direction of the broadcast is proposed for better performance especially in terms of delay as well as redundant packets rate. The implementation of proposed algorithms showed positive results in terms of delay, overhead, and improve the performance of MANETs in general.

Keywords: MANET; DSR Protocol; Threshold, Broadcasting

INTRODUCTION

A wireless Ad-hoc network (WANET) is a decentralized type of wireless network (Lin, 1999), where WANET networks such as home and sensor networks have become an important part of our daily life and are expected to provide multimedia services, which increases the demand for higher data rates, higher link reliability, and longer battery life. The main feature of these types of networks is self-organization (distributed), and these features reduce the cost and effort of their configuration and maintenance.
Ad hoc networks have a wide range of applications for both the military and the civilian world. It is used for enhancing military communication in the battlefield or in areas hit

by natural catastrophes. Furthermore, are used to provide wireless communications infrastructure in different areas as a fast, deployable, temporary replacement for destroying fixed network or in areas where wired LANs are impossible or only cost-intensive to deploy such as protected historical. People are also using these networks in cafes, restaurants, malls, universities, and public gatherings such as conferences (Gibson, 2012; Rappaport, 1996; Tse & Viswanath, 2005).

Mobile Ad-hoc network (MANET) is considered one of WANET types, where the nodes in MANET has the capability to move freely and randomly, which result in changing the paths between the nodes and the topology of the network constantly (Gibson, 2012). The effect of high mobility of the nodes brings fundamental challenges to the routing protocols in MANET Network. The main function of routing protocols is to find the routes from the source to the destination, but will be more complicated in an environment where topology constantly changing as a result of the ongoing movement of the node causing the lasting change to all the routes that have already identified by the routing protocols. Therefore, routing protocols of MANET networks must have an effective mechanism to find constantly changing routes and notified them quickly about the constantly changing routes (Guevara, Jiménez, Prieto, & Seco, 2012; Yadav & Chavan, 2013). However, because of the constant movement of the nodes, the possibility of broken links increases and also with a possibility of the nodes destination goes out of the transmission range (Wu & Dai, 2005; Ali. S. et al, 2015).

In this paper, we propose a modified route discovery mechanism in order to reduce the effect of the mobility in the link transmission using efficient DSR protocol. The DSR protocol is very suitable to small and medium networks and can offer a quick and easy network solution comparing to any other routing protocols (Abolhasan, Wysocki, & Dutkiewicz, 2004; Royer & Toh, 1999). The proposed mechanism that will be clarified in detail in the methodology section depend on an update the DSR protocol algorithm on the part of route discovery to a destination node and adding a new technique for classifying and arranging routes stored in the node`s cache memory.

MANETS

Mobile ad hoc networks (MANETs) are infrastructure-less wireless networks, where it characterized in a number of properties, such as self-configuring, self-forming, self-healing network, random mobility for the nodes, transmission through multiple hops, in addition, to the decentralized nature which improves the scalability.

The devices in MANETs have the freedom to move randomly in all directions, which play the roles of both the client and router together during sending or receiving the data in the network, where it must depend on in its own information to take the decisions to choose the paths which lead to the destination, which that create the challenges on finding and updating that information constantly (Ayoob, Sulaiman, Mohammed, & Abdulsahib, 2014).

The fundamental objective of MANET is to permit a gathering of communication nodes to set up and keep up a network among themselves, without the backing of a base station or a focal controller. The absence of infrastructure in MANET requires the nodes to perform the network setup, administration, and control among themselves. Every node must act as a router and data forwarder in addition to playing the role of a data terminal.

Routing Protocols

As there are different types of networks, there are different types of routing protocols also which have similar aspects in the main task which is the routing, but they differ in a way to work, where each one has a special algorithm is different from the other. Routing protocols are originally designed for wired networks which are not adequate and sufficient to ad hoc networks, although there is a big difference in term of wired network topology that is more of stability compared with the topology of the ad hoc networks which changes constantly (Mauve, Widmer, & Hartenstein, 2001).

When designing a routing protocol that will work within the ad hoc network environment, it should be noted that the ad hoc network has to work within a limited bandwidth, in addition to limited resources in terms of node storage capacity, CPU capabilities, and energy resource since it depends mainly on batteries. We can infer from the above, the fundamental differences between routing protocols for wired networks that consume large amounts of bandwidth and resources of the nodes, like memory capacity, processor capabilities, also deal with the fixed and stable devices, topologies and routing protocols for ad hoc networks (Menchaca-Mendez & Garcia-Luna-Aceves, 2008; Moustafa, Kenn, Sayrafian, Scanlon, & Zhang, 2015). MANET routing protocols were classified into three major categories, Figure 1 presents the classification of routing protocols (Royer & Toh, 1999).

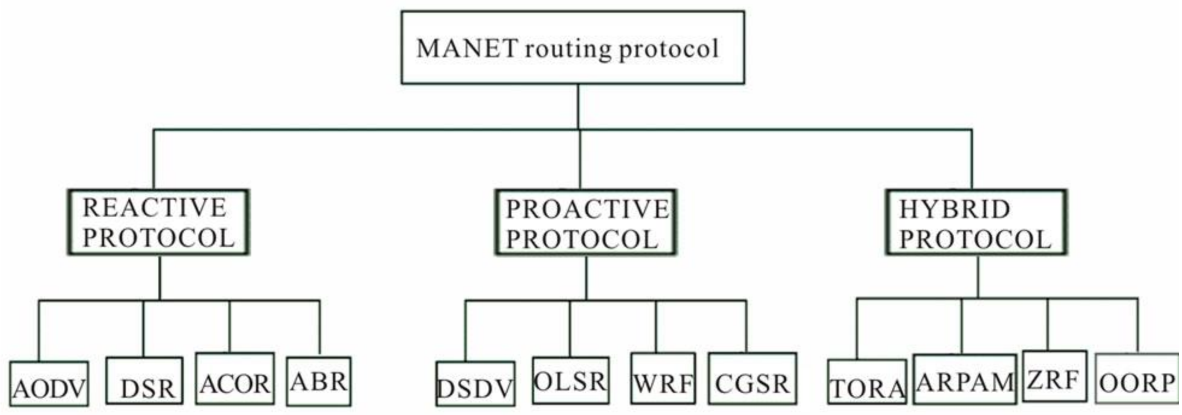

Figure 1. Classification of MANETs routing protocols

Reactive routing protocols

Also called on-demand protocols, where the general principle of these protocols depends on reducing the overhead, control messages, and updates messages that are exchanged between the nodes in the network as a requirement for other traditional routing protocols. In on-demand protocols, the nodes maintain only the active paths, which are required and used to send the data to specific destinations. When the node needs to send data to a specific destination, and it did not have any paths to that destination, thus in this case the source node sends broadcast message which is called request message (RREQ) to all nodes in the network, which in turn, these nodes re-broadcast this message until reach to the destination node, where it in turn responds by sending a reply message (RREP) to the source node using link reversal or piggy-backing (Abolhasan et al., 2004).

Dynamic source routing protocol (DSR)

The DSR protocol is classified as one of the reactive routing protocol used in multi hop wireless Ad-hoc networks. It consist two main stages one is route discovery, second is route maintenance. The route discovery stage begins when the source node want to send the data to a node not exists in its routing table. The route maintenance stage begins when one of the identified routes is broken or failed.

DSR uses source routing, which allows routing of packets to be loop free and also allows caching of routes in nodes for future use (Kant & Kumar, 2012; Mohammed & Sulaiman, 2014; Unnikrishnan, 2004). When the source node decides to send data to the destination node, it will first searches in the in its cache memory to find any valid routes to destination node, if didn’t find any it will initiates route discovery process (Gavrilovska & Prasad, 2006).

RELATED WORK

The (Ayoob et al., 2014) presented new proposal in order to mitigate the negative effects resulting from the continuous mobility of the nodes and lasting change in the network topology. The proposal includes providing a new algorithm consist of two mechanisms (route status checker, route order) and make a change to the mechanism of keeping the routes in the cache memory by setting up two tables (Master route cache and Index Route Cache). While (Yu & Kedem, 2004) proposed a distributed adaptive cache update algorithm for DSR, and defined a new cache structure, cache table without limiting the capacity. The result showed significant improvement in TCP throughput and achieved a large reduction of normalized routing overhead. Moreover, the (Manjhi & Patel, 2012) proposes to find a mechanism to determine the best routes and their updates as well as the acceptance or rejection of the new routes based on measuring the signal strength of the nodes, which will reflect positively on the performance of the entire network and measure the positive results related to end-to-end delay, packet delivery ratio, throughput, routing overhead.

METHODOLOGY

In this paper, the processes are divided into two main parts, the first part will be focusing on dissecting the DSR route discovery algorithm. While the second part will cover the proposed adjustments to improve DSR protocol performance in the both processes of discovering the routes and sending the data. In other words, it would be reflected in practice to improve the performance of overall MANET networks, where the importance of routing protocols in controlling the performance of all kinds of networks as well as representing the backbone and network analyzer, which measure the performance of any network.

Dissection DSR Route Discovery

Figure 2 illustrates the steps of the basic route discovery algorithm for DSR protocol. There are two main disadvantages in such route discovery. In the first instance, the step indicated with the number 2 in figure 2 is the mechanism used by intermediate nodes to re-propagate the RREQ message to all its neighboring nodes in all directions. Figure 3 shows the node S initiating a route discovery by flooding RREQ message to all its neighbor nodes. When the intermediate nodes receive the RREQ message and after each of them applied all the checks described in figure 2, which indicated by A and B. After that, each node reaches to the stage number 2 as described in figure 2, then each one re-broadcast the RREQ to all neighboring nodes in all directions without the organization of the process. The process continued whereby other intermediate nodes perform the same process until the RREQ message reaches to the destination node.

Through the analysis represented in figure 3, the following disadvantages can be observed:

a) There is a great possibility for the majority of the intermediate nodes to receive the RREQ message from more than one node at the same time, which increases the probability of occurrence the collisions and that leads to discarding the messages, which causes an additional consumption of bandwidth, in addition, to increase the overhead, delay, and latency because of the need to re-send the messages.

b) A large proportion of the nodes receive more than one copy of the same message from multiple nodes, although the algorithm has addressed this issue through tests which are performed by each node as explained in figure 4 for instant A and B. However, so many of these non-required messages can cause consumption of capabilities and resources of nodes by increasing the node battery consumption and increase the load on the processor, in addition to what have been mentioned in the previous point such as additional consumption of bandwidth, increase the overhead, delay and latency.

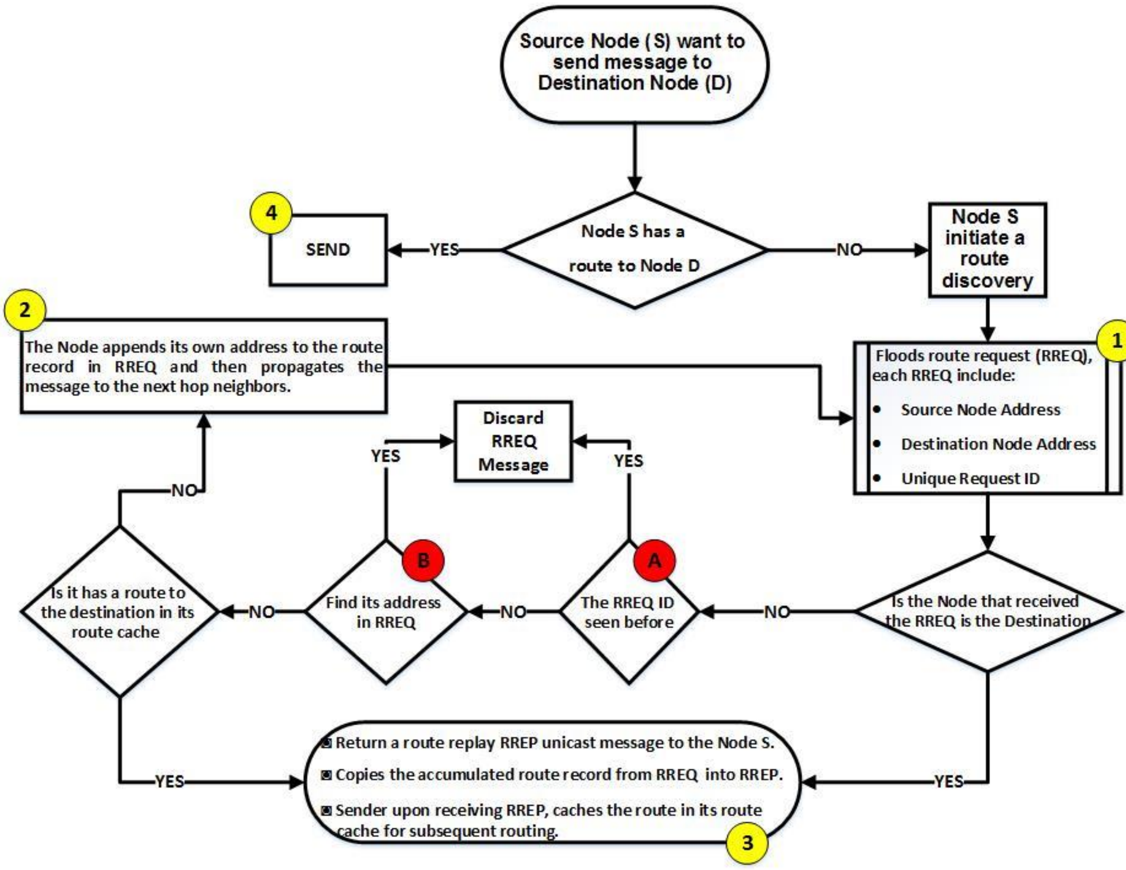

Figure 2. Basic DSR Route Discovery Algorithm

When the source node S receive the desired route through the reply message RREP, it keeps this route in its cache memory for use to send in the next times to the node D as shown in Figure 2 in stages 3 and 4. The default mechanism for arrangement the routes according to the minimum of hop count (Manjhi & Patel, 2012). However, the path with a minimum number of hop count can be a low performance in terms of bandwidth and speed, and especially that the routes between a spaced nodes and the hop count factor with totally ignoring the other most important factors like distance and signal strength will cause an increased the probability of sending the messages via stale or fewer quality routes than other available and this certainly will lead to what the previous mention of the past points of an additional consumption of bandwidth, increase the overhead, delay, and latency.

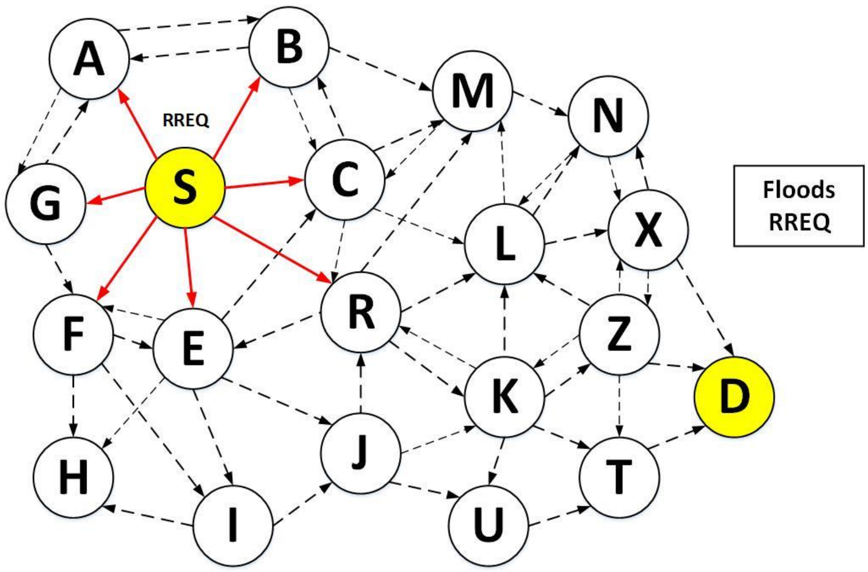

Figure 3. Re propagate RREQ between Intermediate nodes

Proposed Algorithm

The first proposed solution provides is to perform adjustments in the mechanism of re-send the RREQ broadcast messages by intermediate nodes to their neighboring nodes, which has been explained previously with clarified the negative results from them. The proposed adjustments are:

a) In normal case, the intermediate node sends an RREQ message to all neighboring nodes in all directions. In the proposed algorithm, each node forms two route search zones (RSZ): right and left. Each node keeps in a special table in its cache memory the data of all its neighboring nodes with identified the RSZ where this node belongs to, with continuous updating of this table when receipt of any message from any of these nodes later. Each node uses the GPS system to determine its location in addition to its neighboring nodes location to determine in any RSZ resides as well as updating their locations continuously. The intermediate node resends the broadcasting message to all nodes located in RSZ which opposite to the RSZ where the neighboring node that sent the message located, for example: when the node receives the message from the right RSZ, then it will resend this messages to all nodes located in left RSZ and vice versa. The basic idea relies on determining the RSZ on the concepts of geographic routing where each node knows of its own location using GPS in outdoor and infrared in indoor, like LAR, DREAM, and GRID protocols.

b) The second proposed solution provides to perform adjustments in the mechanism of arrangement the routes in the cache memory, according to best signal strength (SS) of routes, where the total SS of the route is the sum of SS of every node on the route. The node will first be judged by a threshold to determine if it is overloaded. If so, the RREQ message will be dropped and the established route will not contain this overload node. By using this new mechanism and when there is more than one path to the destination node, the source node S will choose the path with highest signal strength and ignore the hop count default factor as shown in Figure 4 and 5.

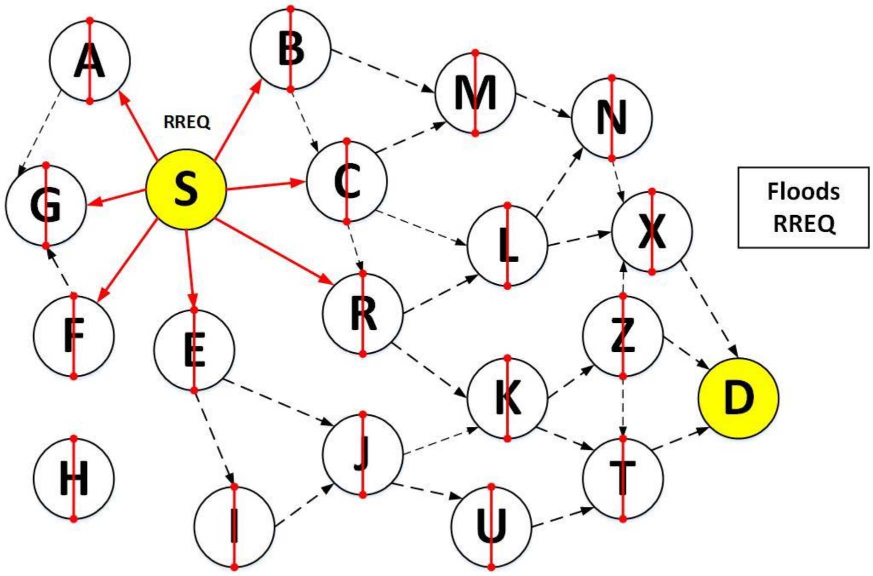

Figure 4. The Modified Re-propagate RREQ between Intermediate nodes.

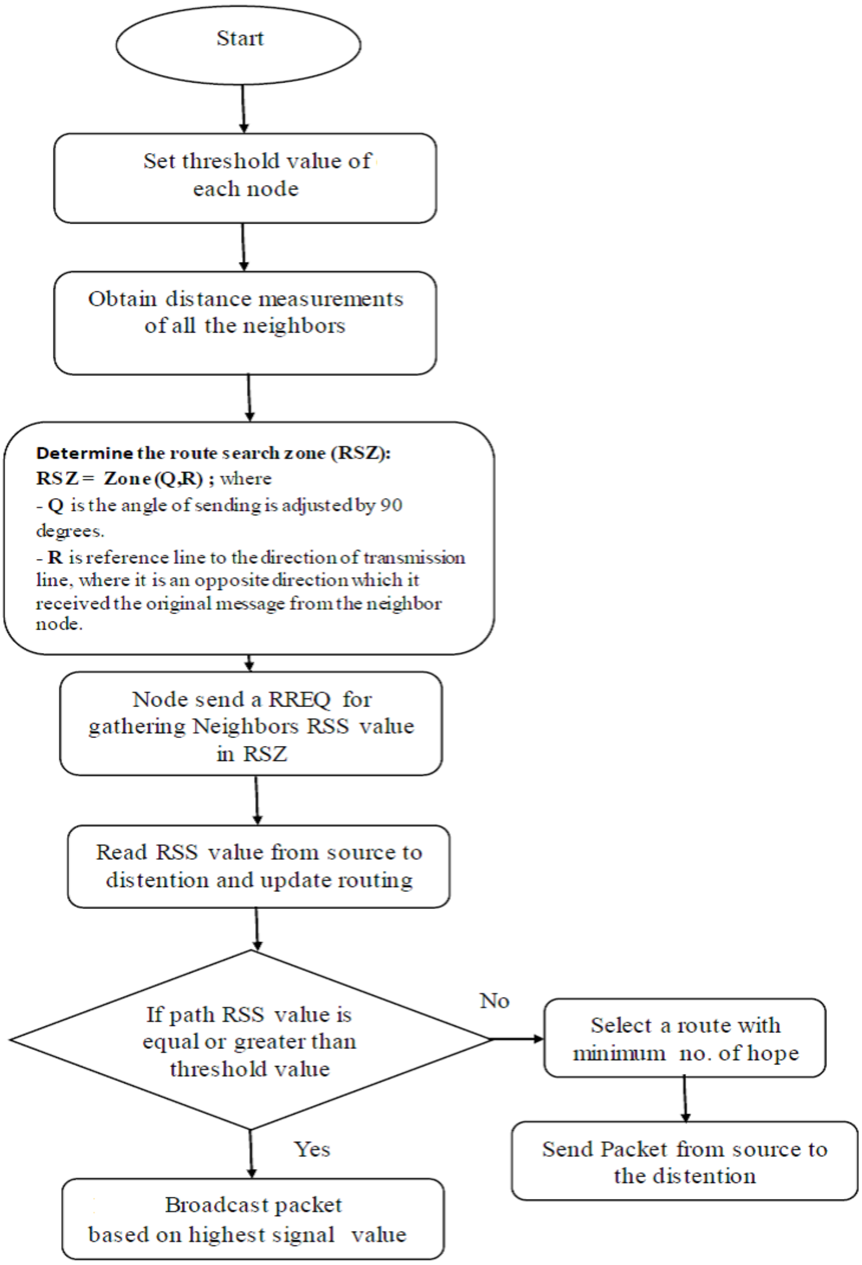

Figure 5. The proposed algorithm

IMPLEMENTATION

In this section, the comparison between the results of the modified algorithm and the standard algorithm of DSR protocol will be presented, as well as provide a discussion of these results, in order to determine the efficacy of the modified algorithm with the degree of the improvement which was added on the DSR performance of the MANETs. In the simulation programs, both the standard and modified algorithms have been applying on three different scenarios in terms of network size (5 nodes, 10 nodes, and 20 nodes), while the nodes are moving in all scenarios on speed 5 m/s.

Simulation Parameters

Table 1 presents the simulation parameters which was used in this experiment.

Table 1. Simulation parameters

<table>
<tr><th colspan="2">Parameters</th><th>Value</th></tr>
<tr><td colspan="2">Simulation Area</td><td>100 m x 100 m</td></tr>
<tr><td colspan="2">Simulation Time</td><td>300 seconds</td></tr>
<tr><td colspan="2">Node movement model</td><td>Random</td></tr>
<tr><td colspan="2">Number of Nodes</td><td>5, 10, 20</td></tr>
<tr><td colspan="2" rowspan="2">Routing Protocol</td><td>Standard DSR,</td></tr>
<tr><td>Enhanced DSR</td></tr>
<tr><td rowspan="7">Traffic Generation Parameters</td><td>Traffic type</td><td>Explicit traffic</td></tr>
<tr><td>Start time [seconds]</td><td>100</td></tr>
<tr><td>Packet inter-arrival time</td><td>Exponential (1) s</td></tr>
<tr><td>Packet size [bits]</td><td>Constant (1024)</td></tr>
<tr><td>Source Node</td><td>1</td></tr>
<tr><td>Destination Node</td><td>5, 10, 20</td></tr>
<tr><td>Stop time [seconds]</td><td>End of simulation</td></tr>
</table>

Performance Metrics

Performance metrics are used to measure and analysis the performance of the networks in order to make a comparison between different network models and systems. There are three performance metrics within this designed simulation that are related to the modified and proposed algorithms in this paper, which they are:

1. Route Discovery Delay: It is the delay time elapsed in route discovery process from the first moment which the source node initiates the route discovery process until it receives the responses from the destination node.
2. Routing Traffic: It is the total routing traffic sent and received by all nodes in the MANET, which is equal in the route discovery process the sum of both RREQ messages and RREP messages.
    - Number of RREQ Messages: It is the total number of RREQ messages which distributed from all nodes in the network during route discovery process until reaching the destination node.
    - Number of RREP Messages: It is the total number of RREP messages which sent from the destination node to the source node as a response to the RREQ messages during the route discovery process.

SIMULATION RESULT AND OBSERVATIONS

This section presents the results obtained from the simulation program for all scenarios, where will provide and discuss these results for each of the selected performance metrics separately, and then will be thrown an analytical look at these results as a whole for both standard and enhanced algorithms.

Route Discovery Delay

This metric determines the amount of time spent in the process of route discovery. Table 2 shows with Figure 6 the results of the route discovery delay for all scenarios.

Table 2. Route discovery delay

DSR Algorithm	5 Nodes	10 Nodes	20 Nodes
STANDARD DSR	9 ms	22 ms	30 ms
ENHANCED DSR	8 ms	17 ms	25 ms
IMPROVEMENT %	11.11111	22.72727	16.66667

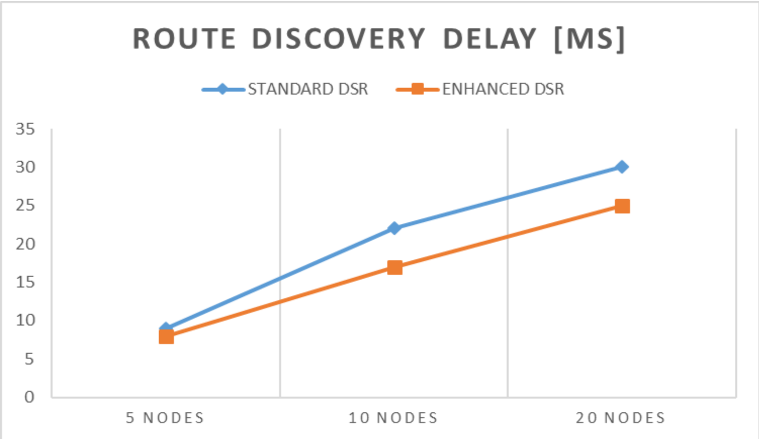

Figure 6. Route discovery delay

Number of RREQ Messages

Table 3 and Figure 7 show the simulation results of the number of RREQ messages in all scenarios.

Table 3. Number of RREQ messages

DSR Algorithm	5 Nodes	10 Nodes	20 Nodes
STANDARD DSR	14	86	362
ENHANCED DSR	6	28	74
IMPROVEMENT %	57.14286	67.44186	79.55801

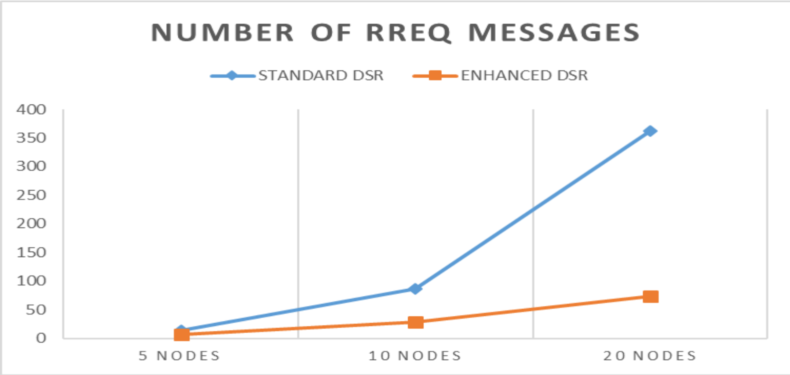

Figure 7. Number of RREQ messages

Number of RREP Messages

Table 4 and Figure 8 show the simulation results of the number of RREP messages in all scenarios.

Table 4. Number of RREP messages

DSR Algorithm	5 Nodes	10 Nodes	20 Nodes
STANDARD DSR	4	24	48
ENHANCED DSR	3	14	28
IMPROVEMENT %	25	41.66667	41.66667

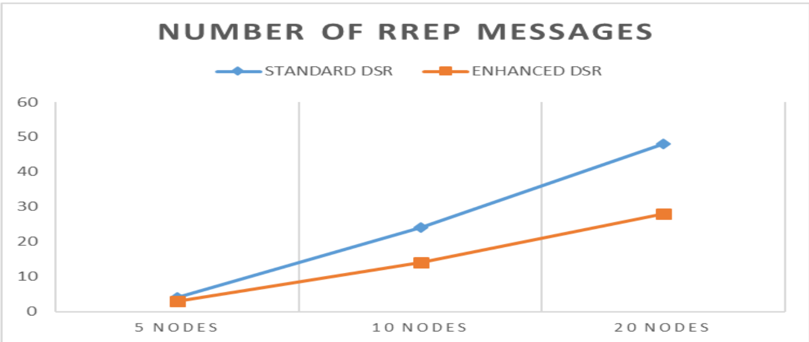

Figure 8. Number of RREP messages

It can be observed positive results from applied the modified algorithm, which can be summarized thus:

- Significantly reduce the number of broadcast messages (RREQ), where each node became sends on one direction instead of the four directions. Where the number of RREQ which exchanged between the nodes decreased by 50-80% when using the modified algorithm.
- The number of RREP messages decreased by 28-41% when using the modified algorithm.

- Due to the significant decline in routing traffic (RREQ and RREP), so a decline in the value of the delay occurred using the modified algorithm by 11-22%.
- Dramatically reduces the problem of the node which receives more than one copy of the same message.
- Generally, the modified algorithm provides better performance as the number of nodes in the network has increased.
- From the results of the previous points, there is a significant reduction in the probability of collision which resulting from the receipt of the node more than one message from different nodes at the same time.

CONCLUSION

The constant motion of the nodes is one of the key challenges faced by MANET networks. The negative effects of not dealing with this challenge, such as High consumption of bandwidth, overhead, delay and latency. The proposed modified algorithm for DSR protocol providing for performing two adjustments, and are: firstly, perform adjustments in the mechanism of re-send the intermediate nodes to RREQ broadcast messages to neighboring nodes according to the direction and signal strength. Secondly, perform adjustments in the mechanism of arrangement the routes in the cache memory, according to best signal strength (SS) of routes.

After applied of the proposed adjustments of a DSR protocol algorithm, we got the following results:

- General decline in the network overhead includes the RREQ and RREP messages
- Alleviate the problem of collision and repeating received the same message.
- Improve the speed of convergence
- Increase the probability of discovering the route to the destination in less time.

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