iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** VIII **Month of publication:** August 2018

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VIII, August 2018- Available at www.ijraset.com

Implementation of DYMO Routing Protocol and its Comparative Performance Analysis with DSR Protocol

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Abstract: Mobile host is an autonomous host which is communicating with one another by making use of different wireless ad hoc network routing protocols. All hosts cannot communicate among themselves directly because of impediment of transmission range. Various routing protocols that differ in their nature and properties have been evolved so far to overcome such limitations and provide efficient routing. One of ongoing reactive Dynamic MANET On-demand (DYMO) protocol which is the successor to Ad hoc on Demand Distance Vector Protocol (AODV) and developed by Internet Engineering Task Force (IETF) is discussed here. In this paper, DYMO is modified by calculating the distance of neighboring nodes to the receiver node and selecting a best neighbour node that can retransmit the RREQ packets to the target host. This modified DYMO is evaluated and its performance is analyzed with Dynamic Source Routing (DSR) protocol against performance metrics such as throughput, end to end delay, bit error rate and packet delivery ratio on constant bit rate traffic load. This simulation work is done by Network Simulator (NS 2) tool where nodes were placed using random waypoint model. Clustering and data aggregation is also proposed in this paper. The network is sub-divided into many groups of clusters and for each cluster a leader or a cluster head is selected based on LEACH protocol. Then, a far away sink communicate with the leader node of each clusters to collect aggregated data directly through single hop communication.
Keywords: Clustering, DSR, DYMO, MANET, Routing Protocols

I. INTRODUCTION

A Wireless Sensor Network is constructed using one or more sensor nodes deployed in any desired environment for example airplanes (low-flying) are used to drop them. These sensing nodes are very small, low power devices and can convert the sensed data (ex. Temperature, noise or vibration) from the sensors into a meaningful form. The nodes vary in cost, size and quantity depending on applications. The device is made up of sensing unit, communication module, battery and memory to store the sensed data. The information is gathered and forwarded using intermediate nodes and transmitted to other networks using a gateway.

MOBILE ad hoc networks (MANETs) are self-arranging system made of cell phones, personal computers, mobile phones and Personal Digital Assistants (PDAs), etc connected by wireless link which moves freely in any direction. The mobile hosts themselves double up as routers to enable multi-hop communication and are used for various applications, e.g. Automated Battlefields, Disaster recovery, Smart office, Virtual Navigation. All nodes in this network behave both as host and router to take part in maintenance of discovered paths for data packet transmission to other nodes. This situation becomes complicated during increase in number of hosts within the network.

Clustering technique involves assembling many nodes into an assembly known as clusters. They use intra-cluster and inter-cluster as routing scheme. This method proves effective in data query and broadcasting. CH is a dedicated node that represents each group. A number of metrics are made use to find this node.

CH helps in coordinating cluster members, collects and broadcasts messages and sends collected messages to the base station. To minimize the routing table sizes and amount of messages exchanged, each host saves all the details of its clusters and some details from others. The efficiency of energy is distributed where CH is elected based on both transmitted power and residual energy. The node numbers to form a group are decided based on the size of network and transmitted power. The CH is the main and rotated to average the power consumption.

The CH collects the information of its multiple non-CH members and transmits to the sink node. This is because, sink is a far away node and it’s cheaper for members to reach CH than to directly transmit to the sink. It helps in removing redundancy within data that are spatially correlated due to closely spaced nodes. If sensors are deployed in hostile environment, then the issues like security, data integrity and confidentiality are some of the vital factors to be considered.

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II. MANET ROUTING PROTOCOLS

Routing protocols are required when data packets are to be transferred to the destination using multiple intermediate nodes among routers that are randomly distributed. Numerous types of routing protocols are proposed for ad hoc networks. They find a path from transmitter for data delivery to the right target. The examinations regarding different viewpoints in routing protocols are active area of study and research for quite a while and a number of protocols have been identified keeping applications and kind of system in view. Based on type of usage and mode of functioning they are broadly classified into three types as appeared in figure 1. They are:

1) Proactive or table driven protocols
2) Reactive or On Demand protocols
3) Hybrid protocols

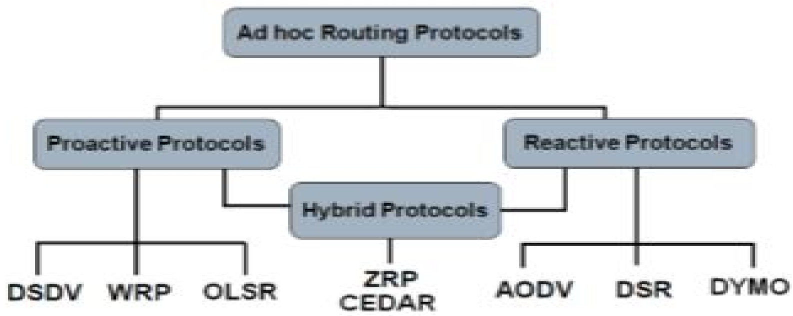

Figure ***Error! No text of specified style in document.*** Protocols classification

A. Dynamic on-Demand MANET Routing Protocol (DYMO)

DYMO is multi hop reactive protocol. It is the successor of AODV and shows some of its important characteristics, hence also known as AODVv2. The routes are computed only when it is required. It is undergoing development by IETF. For providing loop free paths it uses sequence numbers. It enables unicast, multi-hop, on-demand routing among nodes in network. It's useful in VANET and MANET scenarios. It was developed to adapt to network topology changes by maintaining uni-cast paths between nodes.

Path discovery and path maintenance are the basic operations. Path disclosure is utilized when initiator node has packet to send but it doesn't have a route to the target host. Path maintenance is used to evade obliterated paths from table and avoid packet drops due to active route breakage. DYMO also maintains a unique unsigned integer known as the sequence number. It guarantees packet delivery in correct order to the target and ensures freshness of the routing information.

Route Discovery: It is same as AODV but different due to the feature of path accumulation. If the transmitting host does not have any entry to the receiving host, message RREQ is broadcasted to all its inter-mediate neighbors. If suppose any neighbour knows the path to the target, it sends a message RREP as the reply. Otherwise it just rebroadcasts the RREQ. During the broadcast phase, the intermediate host attaches its own address in the message. Any in-between host that circulates the RREQ saves the backward route.

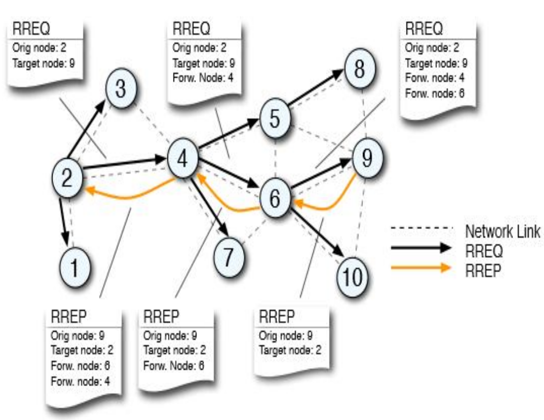

Figure 2 Route discovery in DYMO

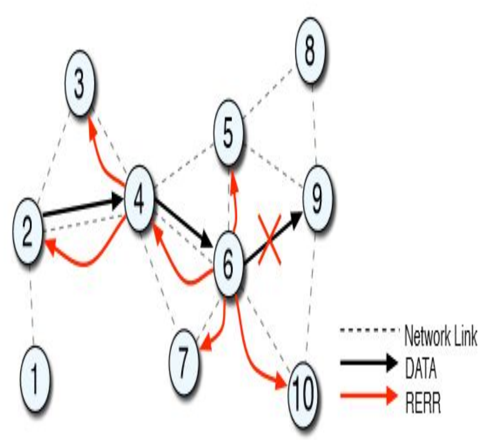

Figure 3 Maintenance process of DYMO

As in figure 2, host 2 is the transmitting host and receiving node is 9. RREQ packet is generated by node2 containing its own particular address, incremented sequence number, hop count of source and details of destination address which is broadcasted throughout the network. The addresses are grouped into address block and rest attributes into TLV block. All intermediate hosts which have a genuine route to target keep appending its address, seq number to RREQ packet till target is found, as seen with nodes 4 and 6. When node9 gets the RREQ, it will have four addresses and three hops. RREP packet is sent by the target.

In the backward route path accumulation feature takes place. It is to make sure that forward route is built and all in-between nodes know the path to every other node. If the transmitter node doesn't get RREP within specified value TTL, then the RREQ is resent. Node9 responds the RREQ by adding its address etc and RREP is sent using the reverse route to node2.

Route Maintenance: There should be continuous monitoring of routes status, links and the RT should maintain updates in it. This maintenance mechanism can be accomplished using two steps. First is, to preserve routes that are existing, lifetime of path should be extended when there is successful delivery of packets. The lifetime of path is automatically extended so that it can be used in further transmission.

Second, process is accomplished using the RRER messages. If link to any another nodes break then this message has to be generated. The generated node multi-casts this packet to those nodes only that are connected with the failed link. The RT is updated with removing the broken link. The discovery process has to be initiated, if any host wishes to transmit along the removed path.

Maintenance process is as illustrated in figure 3, the link from node6 to node9 is broken and node6 has a packet to transfer to node9. Hence, node6 generates a RRER message and propagates backwards to node2. Rest of the in-between nodes instantly updates their RT entries regarding link breakdown and new routing change. As in figure, nodes next to node 2 and 4, that is, node 3, 5, 7 and 10 also receives this message.

B. Dynamic Source Routing

DSR is mainly based on the approach of source routing, which means, the transmitter has an idea about hop-by-hop path to the target. All these known paths are saved in the cache and it is updated as and when new paths are found. The route information to be used is carried by data packets in the packet header. Here HELLO packets are not broadcasted periodically as this protocol is beaconless.

Another distinguishing feature is source routing helps in avoiding storing of routing details by the intermediate hosts. It supports asymmetric links and uni-directional links. To identify the link failure, it requires support of the MAC layer. It uses two mechanisms which together work to discover maintain the source routes to target. Unlike AODV, it does not flood the network in case of node breakage, instead it uses an alternative path to re-establish transmission.

III. PURPOSED METHODOLOGY

A. Purposed Method

In the proposed system DYMO Routing protocol is selected and modified by calculating distance of the node to the target node in the routing strategy. A best neighboring node is selected to retransmit the RREQ packets whose distance to the target is less compared to other nodes. Its performance is compared with DSR protocol using performance metrics like packet delivery ratio, end to end delay, throughput and bit error rate. Also cluster formation, cluster head formation and data gathering between member nodes to the leader and leader to the sink node is done. The proposed system is working on following steps as shown in flow chart 4.

1) Creating Scenarios on Random Waypoint Model: - Each host chooses any random location and heads towards it using any random velocity. 101 nodes are placed randomly and hello packets are transmitted to all nodes.
2) Clustering: Group of nodes form a cluster. i.e., the whole network is subdivided into a group of clusters. Only a single sensor host in each and every cluster serves as a Cluster Head (CH) which is selected energy wise.
3) Selecting application statistics like CBR (Constant Bit Rate) traffic and apply from initiator node to the destination node.
4) Applying Modified DYMO routing protocol.
5) Data aggregation of each clusters and transmission of collected packets to the sink node.
6) Measuring Throughput, packet delivery ratio, bit error rate and end to end delay and simulating the network scenario using NS2.
7) Comparing parameters of modified DYMO and Dynamic Source Routing protocol (DSR).
8) Viewing the final results.

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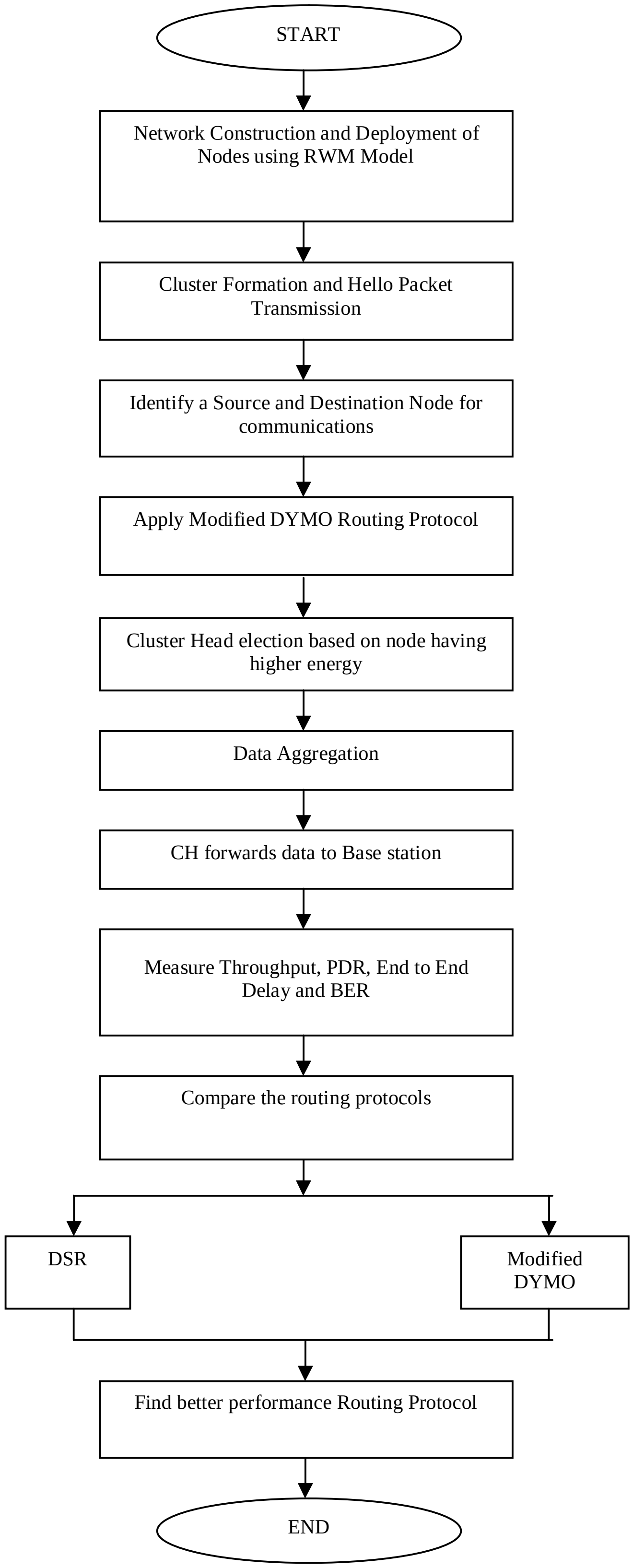

Figure 4: Flow chart of the proposed methodology

B. *Modified DYMO procedure*

When an initiator sends a data packet to its desired target whose path is not yet established i.e., if the routing table has no entry regarding the required route, initiator will broadcast RREQ. According to this paper, initiator node's position and target node's position is added in RREQ.

1) *Identifying Neighboring Nodes:* Neighbouring nodes are identified using the Euclidian formula. If the distances between nodes are within the proximity of 250mm, then they are considered as neighbouring nodes. Only these neighbouring nodes receive the RREQ packets.
2) *Best Neighboring Node Selection:* Nodes within 150mm proximity are the best participants and those who received RREQ will calculate distance between it and target node. The node whose distance to the destination node is less compared with other nodes, is considered as the best participant to retransmit the RREQ. Rest nodes will just discard the packet. As shown in flowchart figure 5.

a) When nodes receive a packet, it identifies whether it's a control message.
b) If it's not a control message, the packet is discarded.
c) Else it checks whether the host is the target of the control message.
d) If yes, the source host is responded using a RREP.
e) If no, the host first tries to identify whether the receive message is RREP.
f) If so, the message is resent.
g) Else, it calculates its own distance to determine whether it's the best neighbouring node.
h) If that node is not an fwd node, the message is discarded.
i) Else the node resends the RREQ.

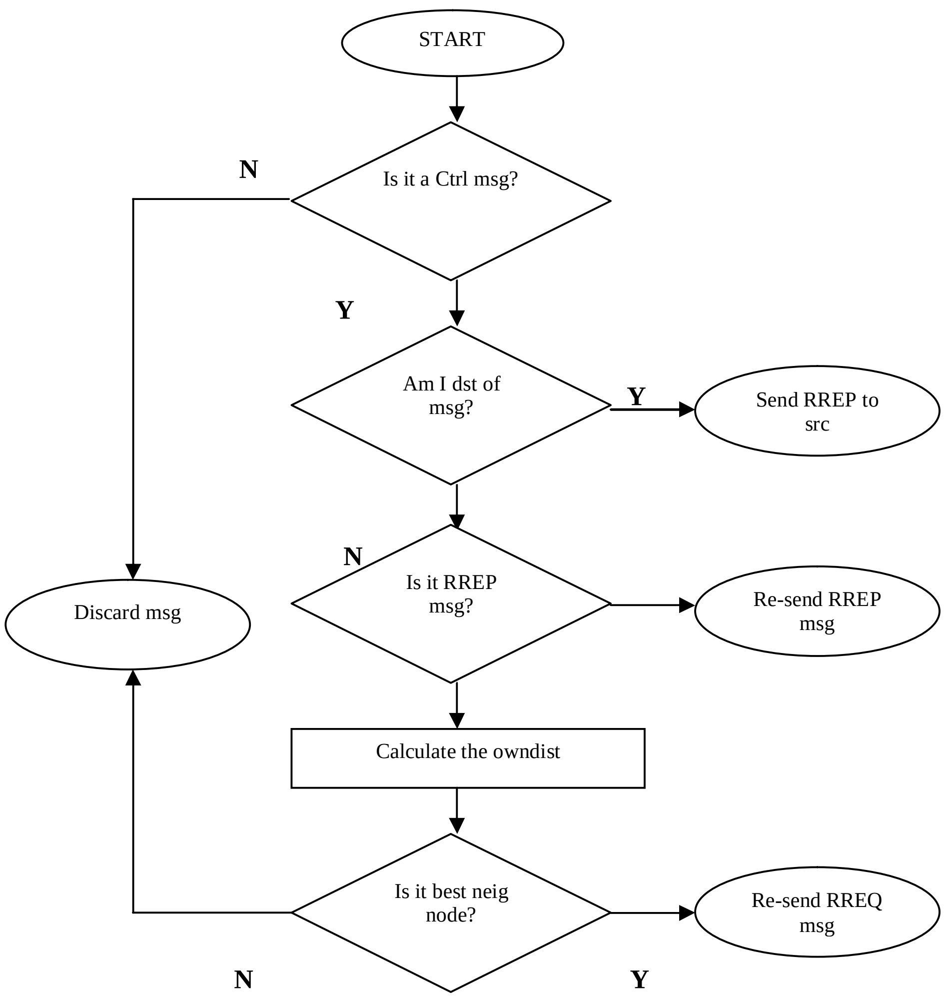

Figure 5: Flow chart of modified DYMO Algorithm

IV. SIMULATION SETUP

A. *Simulation Setup Table*

Table 1 Specifies the important parameters used in the simulation using Network Simulator NS-2. This simulation work is done by Network Simulator (NS 2) tool. DYMOUM is an implementation of DYMO protocol for NS2.34 network simulator.

Table 1: Simulation Setup

Parameters	values
Channel type	Wireless Channel
Radio-propagation model	Two Ray Ground
Network interface type	Wireless Phy
MAC type	802_11
Interface queue type	Queue/Drop Tail/Pri Queue
Antenna model	Omni Antenna
Max packet in ifq	50
Number of mobile nodes	101
Routing protocol	DYMO, DSR
X-Y dimension of topography	1000*1000
Time of simulation end	50.0
Initial energy in Joules	20

B. *Simulation Steps in NAM Window*

Snapshot 6 shows a total of 101 nodes in yellow colour, that are created randomly numbering from node 0 to node 100 and are placed at random distance from each other. Nodes in the network are about to form clusters. In snapshot 7 nodes are formed into clusters based on Low Energy Adaptive Clustering Hierarchy (LEACH). Ten clusters are made with each cluster having 10 nodes. Hello packet transmission is done to check if all the nodes created are active.

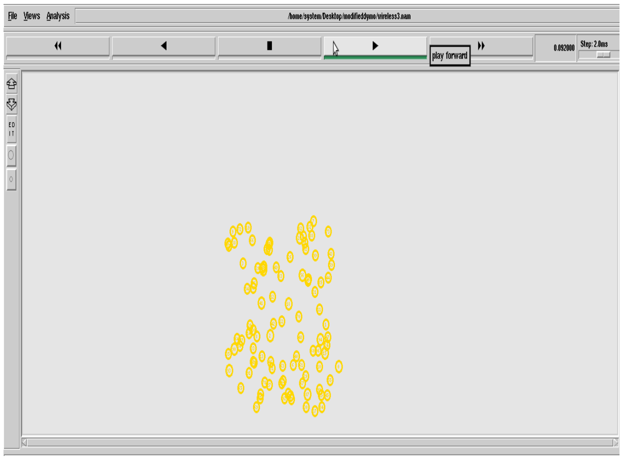

Figure 6: Dynamic Creation of Nodes

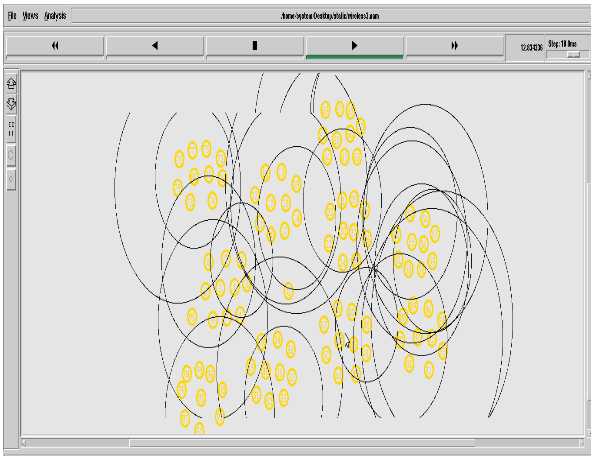

Figure 7: Dynamic formation of clusters and hello packet transmission

The entered source and destination nodes can be viewed in NAM window which is highlighted in colour red and labeled in color green as shown in snapshot 8. Snapshot 9 shows the best neighbour node as node 18 which is selected based on Euclidean formula. Node 18 receives the control packet from source node 12.

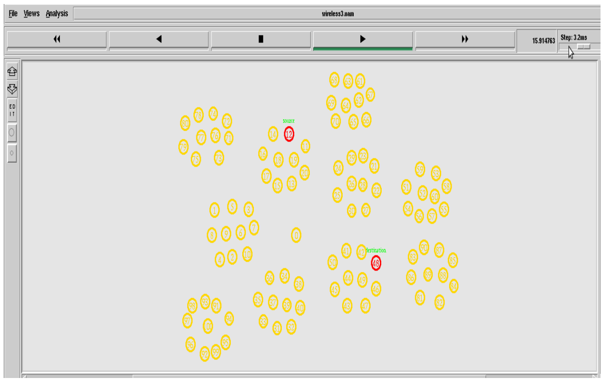

Figure 8: Dynamic selection of Source and Destination nodes

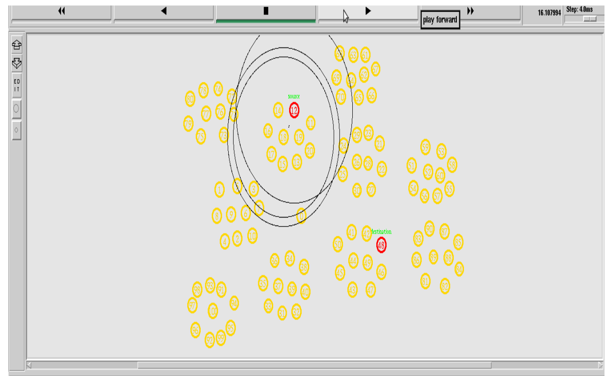

Figure 9: Packet transmission between Node 12 to node 18

Packet received by node 18 from source node 12 is retransmitted by node 18 to node 50 as seen in figure 10. Snapshot 11 shows destination node 48 receiving the packet from node 50.

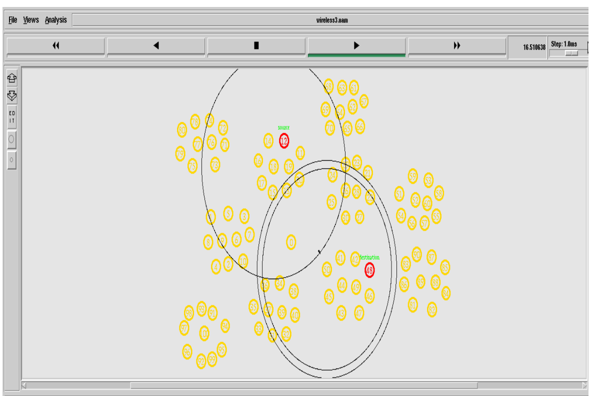

Figure 10: Packet transmission between Node 18 to node 50

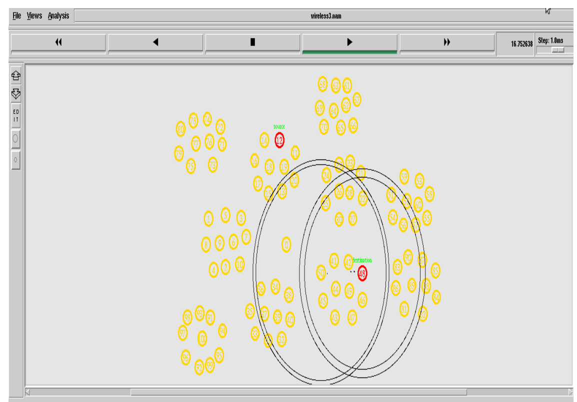

Figure 11: Packet transmission between Node 50 to node 48

Snapshot 12 shows CH selection in each cluster. This is based on highest received energy level. Based on highest energy level cluster head is elected. CH role is rotated among all nodes. A clustering algorithm called LEACH is adopted. In this, nodes having more residual energy have higher probability to become the leader. It incorporates randomized rotation of high-energy CH position such that CH role rotates among other nodes in order to avoid draining battery of any one host in the network. Cluster Head should be reachable in a single hop from their cluster members. Primary function of CH is data aggregation where CH collects data from its cluster members as shown in figure 13 and transfers it to the sink node far away.

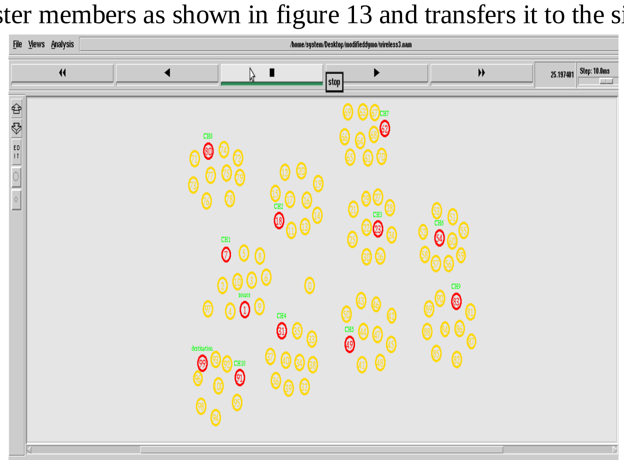

Figure 12: Formation of Cluster heads

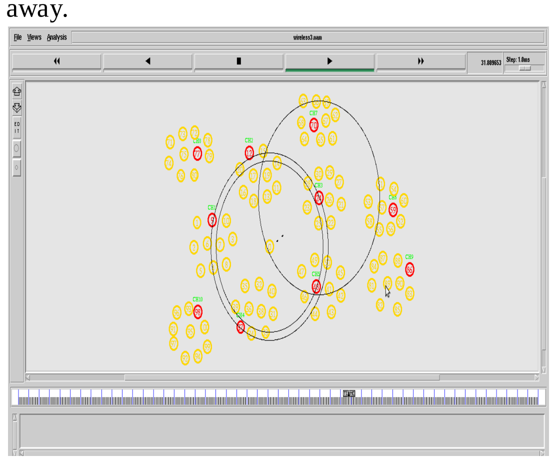

Figure 13: Data aggregation and transmission to sink by CHs

V. RESULTS

The graph of Performance is as shown below. The parameters are Packet drop, Packet delivery ratio and Throughput.

Figure 14 show that DYMO exhibited highest throughput as compared to DSR. DYMO has ability to search route quickly as it avoids expiring good route by updating route lifetime appropriately while DSR uses stale routes. Performance of DSR is weak as it doesn't have proper technique to update stale routes. Figure 15 show that DYMO have a higher packet delivery fraction whereas the packet delivery ratio of DSR is low due to stale routes.

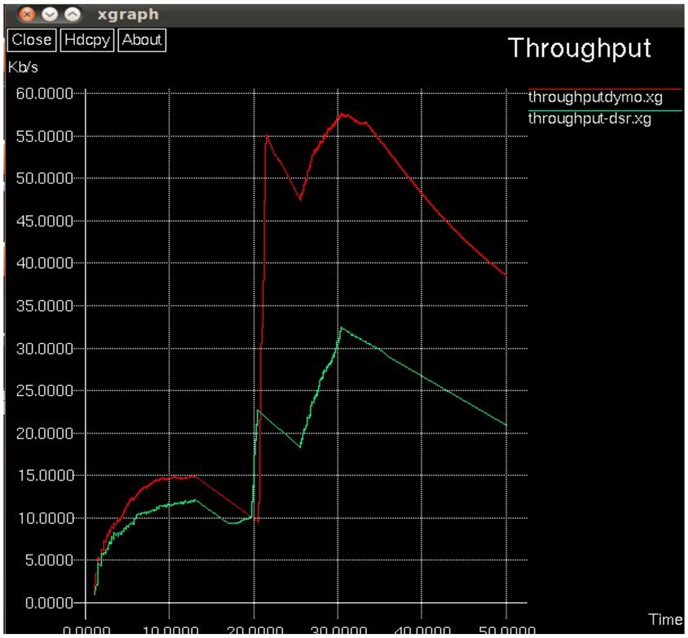

Figure 14: Graph output showing Throughput vs time

Figure 15: Graph output showing PDR vs time

Figure 16 showed Average end to end delay of DSR is more than DYMO. Due to the presence of stale caches in DSR, delay is more than DYMO. Average end to end delay of DYMO protocol is the less. Figure 17 shows that the BER of DSR is more compared to DYMO.

Figure 16: Graph output showing Delay vs time

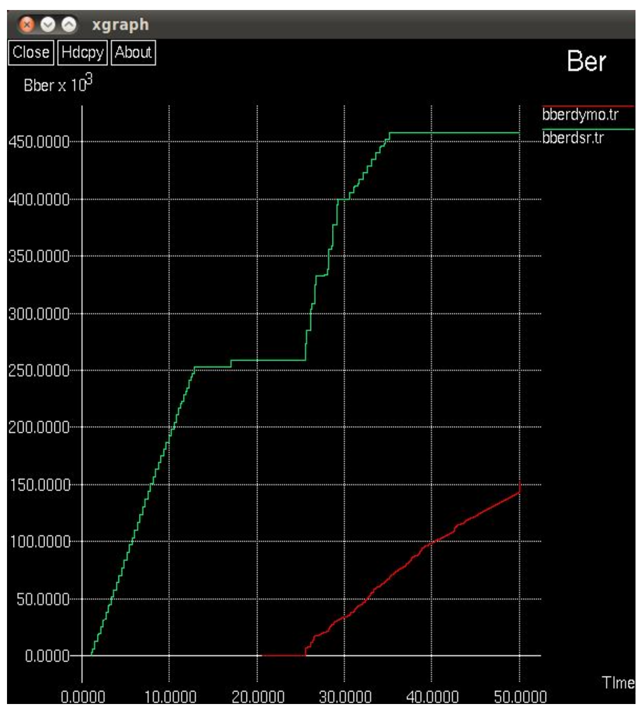

Figure 17: Graph output showing BER vs time

Table 2: Comparative analysis of Network parameters

Protocol	Time	Throughput	Packet Delivery ratio	Delay	BitError Rate
Modified DYMO	10	14.700000	0.987500	1.15826	00000
	30	57.066118	0.640408	1.15832	34349
	50	38.560000	0.727599	1.6533	152601
DSR	10	11.600000	0.560000	1.17009	192471
	30	30.664452	0.558052	3.71076	399762
	50	20.920000	0.575301	2.04074	458264

As shown in table 2 the parameters for example throughput, delay, bit error rate and packet delivery ratio are compared between protocols modified DYMO and DSR with respect to simulation time.

VI. CONCLUSION

The modification of algorithm of DYMO presented in this project keeps the important characteristics of DYMO while trying to obtain reduction of control packets. There is an improvement in throughput. The presented results show better performance of DYMO in NAM window. The proposed routing protocols methodology is applied to random waypoint model with CBR traffic load from the initiator node to the target node. Performance of modified DYMO is compared with DSR by measuring performance metrics. Results showed performance of DYMO is better than DSR in case of throughput, delay, bit error rate and packet delivery ratio.

DYMO can be modified further by adding Dynamic forward delay to all nodes. It will make sure that only the best node's RREQ reaches the destination first. Also modified DYMO can be compared with other routing protocols based on various performance metrics.

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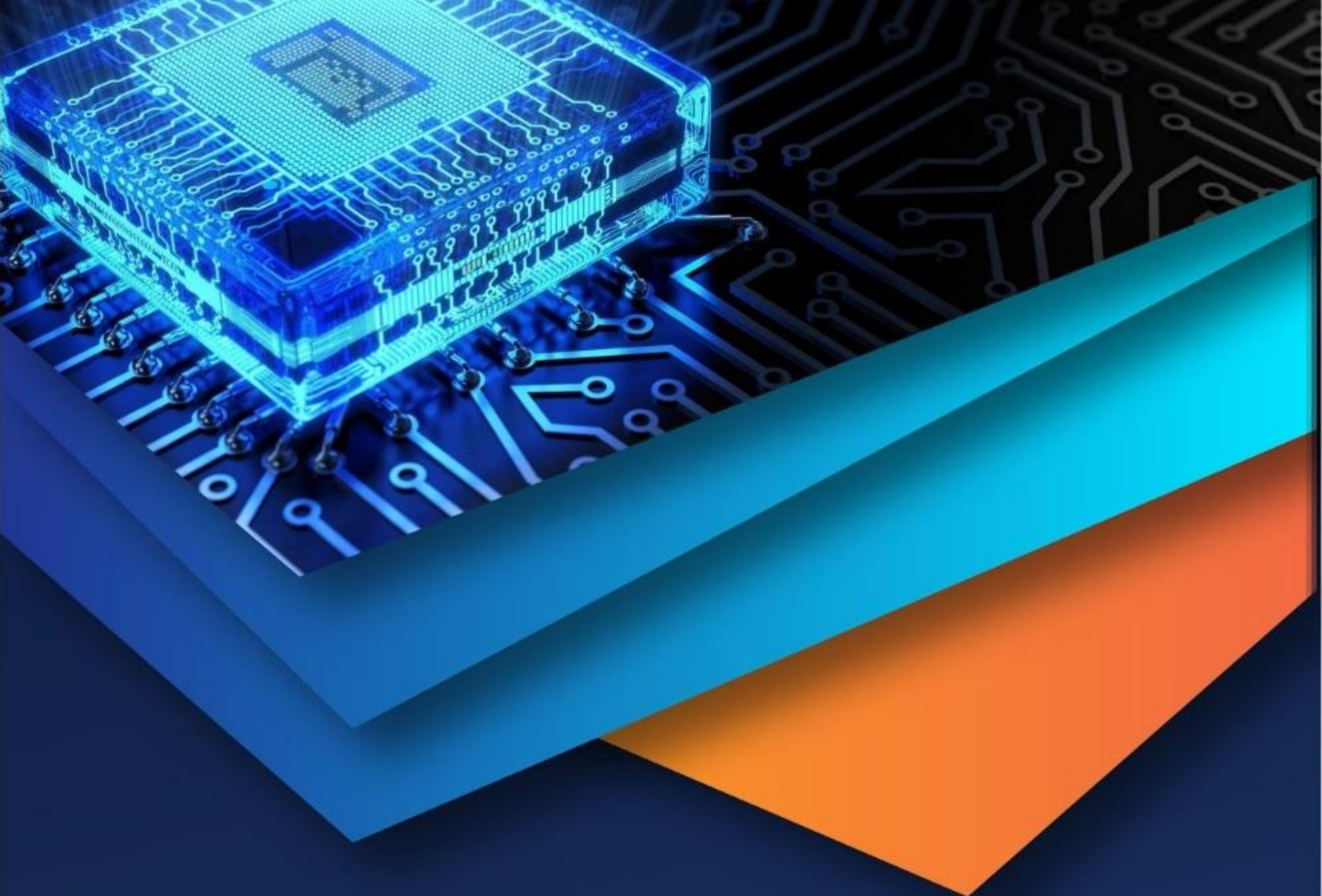

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