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An Intelligent Routing Protocol Based on DYMO for MANET

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***Abstract*- in this paper, intelligent routing protocols for mobile ad-hoc networks (MANET) will be proposed .Depending on the concepts of fuzzy and neural networks. The goal is to get good quality service by finding the most convenient data transfer paths, therefore a Fuzzy-based, Neural-Fuzzy based and Energy aware are three approaches have been proposed to enhance Dynamic Manet On-demand (DYMO),All approaches were implemented in ns-2 simulator and compared with original protocol in terms of performance metrics, which showed that there was an improvement in route efficiency.**

Keywords: DYMO, MANET, Fuzzy logic, Fuzzy Neural Networks, Intelligent Routing Protocol.

I. INTRODUCTION

MANETs are a collections of mobile Nodes that are grouped together to form network topology Without relying on a pre-configured communication infrastructure this kind of networks can be operate in very difficult places such as Disaster areas, conflict zones, war and places where people can not directly access them.[1] The mobile ad-hoc networks nodes are limited by the battery power due to the fact that the nodes operate with limited energy. This affects the longevity of the nodes [2]. In order to communicate between the source node and the target node, the nodes need to use multiple hops routing, if the two nodes are not in the same range of transmission for each. Protocols are therefore classified into two types. The first type is: Proactive routing protocols, because all paths are known before communication. The second type is referred to as reactive routing protocols, by Using this type, a routing request is sent to the network to learn about a route to the destination

A. Table-Driven :

1. **Destination Sequence Distance Vector (DSDV)** When this protocol is run on nodes, the protocol performs an initial delay, because the nodes need to store all available paths in the routing tables for each node to cover the available nodes. The protocol sends periodic messages to maintain paths for detecting any changes to the network, such as entering a new node or disrupting the node. [3].

2. **Wireless Routing Protocol (WRP)** Although the speed of finding the path to the available node, the protocol needs a primitive delay time and a large space of cache memory which is naturally limited, since the protocol configure a number of tables that help to maintain the paths, that consume the memory and the power of node. And also every node Sends hello messages regularly to neighbor nodes which consume the bandwidth [4].

B. On-Demand Routing:

1. **Dynamic Source Routing (DSR)** The Protocol is based on two successive procedures. Route discovery occurs when a source node is request to communicate with a target node where a path is created and the route is saved in the routing table. On the other hand, when a communication failure occurs or change of network topology, the routing maintenance procedure is activated. These two procedures contribute to reducing the overhead of the network because the number of messages decreases

2. **Ad-hoc On Demand Distance Vector (AODV)** creates and maintains routes by using route discovery and route maintenance. (AODV) has taken advantage of (DSR) features and has

benefited from the (DSDV) features such as a routing over hops, a unique sequence number for each destination and periodic hello messages. [6].

3. **Temporally Ordered Routing Algorithm (TORA)** There is a range of limitations that limit the effectiveness of the network and (TORA) works effectively with these limitations, it depends on maintaining the route information of the neighbor nodes. One of the protocol features is that it eliminates loops and outdated packets, and creates more of a route to the same destination node. On the other hand of the protocol that performance degrades with increased mobility. [7].

4. **DYMO (Dynamic MANET On-demand Routing)** is Successor of AODV and Reduced overhead in route discovery and route maintenance [8].

The paper is structured as follows: In section two describe in detail the working principle of DYMO protocol, Sections three and four evaluates the performance of the proposed methods

II. DYMO ROUTING PROTOCOL

The DYMO routing protocol uses hop by hop routing mechanism, if A Node (source) need to send data to D Node (destination), (A) will flood the network by broadcast RREQ packet to all the other neighboring nodes in the network, (B) Node (intermediate node) broadcast received RREQ packet after adds itself to RREQ packet, if the node (D) receives the RREQ packet, it passes the RREP packet to the sender node A by unicast RREP packet. as shown in figure1.(a). DYMO is the next generation of AODV and more simply, it also added new features to the routing request message; where each Intermediate node adds its address to routing message [8].

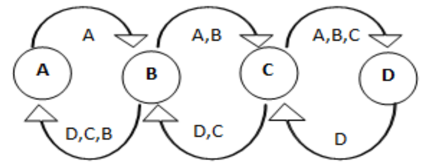

Figure1.(a) : DYMO protocol

DYMO protocol and AODV protocol uses route discovery and route maintenance by following same basic operations. When node wants to send data to destination that is not in its routing table. The originating node create a route request message and broadcast the message, each intermediate node receiving the RREQ, and search in his route table to find destination if not founded With each new hop, the intermediate node adds its address to the routing request packet, therefore the packet size is increasing each time it is forwarded, then adding to its route table a path for the sender node , and finally the RREQ broadcasting again, While RREQ reaches its destination or an intermediate node that has a path to it, the RREP packet is created and sent back to the source. When RREP packet reaches the originator of the routing request packet, the path is recorded to its routing table. Each node has only one routing entry for each destination stored in the routing table, If the node receives more than one route for the same destination, it chooses the freshest sequence number and if the sequence number for all routes does not differ, the node will choose the path with fewer hop counts .On other hand When a source node receive a route error (RERR) packet this mean there is link break. Upon receiving the RERR the source node initiate new RREQ to find path again if the source want to send data to that destination. [9][17], the path accumulation adds some improvement such as: a reduced number of RREQ packets. The flowchart of the basic operations of the DYMO protocol is shown in Figure.1 (b).

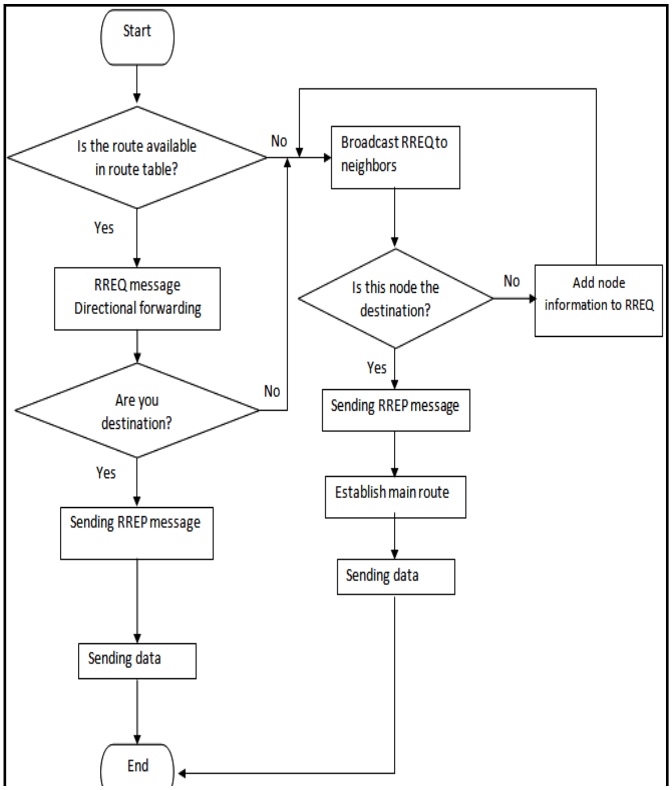

Figure1.(b) : flowchart for DYMO protocol

III. Proposed model

The following three approaches have been proposed to improve the DYMO routing protocol.

1. EDYMO (Energy-DYMO)

EDYMO introduces two new fields in DYMO's Route messages: Energy and Total energy fields. The EDYMO routing protocol is introduced, which is modified to make the network life more efficient.

The drawback of a model based on energy is that the origin itself can leak; since the calculation of energy is based on the rate of transmission and reception of nodes.

A. Energy and Total Energy Fields

In most cases, there is more than one route between the source and the distention. For each route there is a certain number of nodes (N) and each node has different values of energy. The Energy field in the RREQ is the battery energy of node, and Total energy is a summation of total power of all nodes of route as (1) shows.

$$\text{Total energy}= \sum_{n=1}^{n=N} Energy_{\ n} \qquad (1)$$

B. Route Selection Process

When a destination node receives several (RREQ) s from different routes, it determine the best route depend on who has freshest route ,minimum Hop Count and maximum Total energy .each intermediate node who receives an RREQ adds its own energy to Total energy value .

2. FDYMO (Fuzzy - DYMO)

FDYMO introduces new field in EDYMO's Route messages: Fuzzy filed. The field value is selected by applying the fuzzy logic theory, in order to choose the most suitable path from source to destination. The advantages of using fuzzy logic to model any system are : easy to understand using natural language , flexible, can use it to model nonlinear functions, and the experiences of professional experts are main part for build any system.[10][11] A fuzzy system is a group of "if-then" rules where maps the inputs membership functions to the output variable. The values of ambiguous inputs form curves called membership functions where each value is reflected to a fuzzy value. These actions are controlled by the fuzzy logic controller as illustrated by the figure 2.

The basic units of a fuzzy logic controller have been explained as follows:

A. **Fuzzication Module:** convert each crisp input into a fuzzy set, for this purpose membership functions are used, It is proposed here that Route metrics that are used to make a decision are Total energy available in a path, and hop count. On another hand the output linguistic variable is Fuzzy route.

B. **Rule Base :** this module contains rules of IF-THEN linguistic rules , Table 2 shows the fuzzy linguistic rules used in the FDYMO simulation .

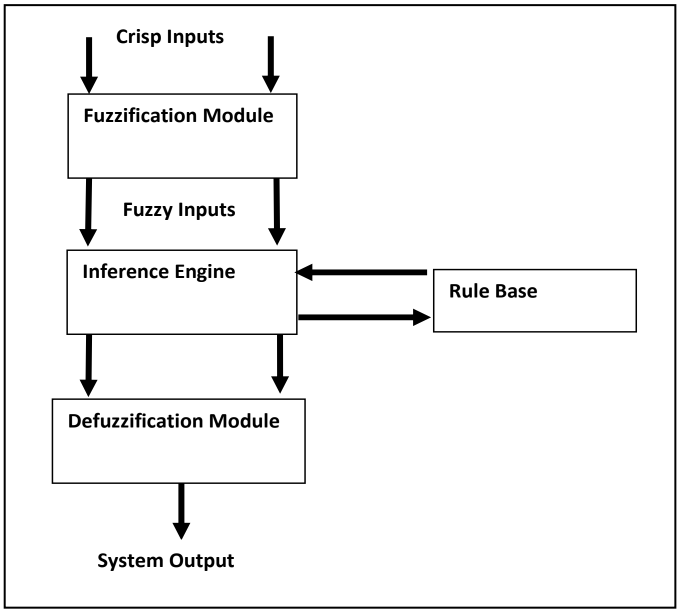

Figure.2. Block Diagram of fuzzy logic controller

C. **Defuzzification Module:** which is a module, converts fuzzy sets into a crisp set, a crisp value in accordance with its membership function and a operator set, for example ,Mean of Maximum as (2) shows.:

$$\text{MOM} = \frac{\sum_{x`\in T} x`}{T} \qquad (2)$$

$$T = \{x \mid \mu(x`) = Support\ \mu(x)$$

Where T is the set of output x that has highest degree [12][13].

3. NFDYMO (NEURO -FDYMO)

A fuzzy system with good realization is not an easy task. Since for the development of the system it is necessary to find membership functions, and the corresponding rules are often a boring process of trials. This leads to the conception of using neural networks, where the Simplified mathematical model of the brain systems, that serve as a widely distributed computing network, they are not a program to perform a specific task, But are depend on trained and learning. The utility of the neural network enables its continuous support of the fuzzy system in order to determine the required variables values. In some cases, it is difficult for the fuzzy control unit to measure the inputs in a desired way. Therefore, the neural network helps the fuzzy system to effectively increase the performance level. There are several neuro-fuzzy architectures one of them is Adaptive Network based Fuzzy Inference System (ANFIS) [15][16] which contains five layers where the first is responsible for assigning the input variable relative to all membership functions. The second layer calculates the precedents of the rules. The third layer settles the strengths, the fourth layer determines the results of the rules and the last layer calculates the summation of all the signals that arrive to this layer to create system output.
NFDYMO operation can be modeled by the pseudo code in Algorithm 1

IV. PERFORMANCE EVALUATION

The protocol DYMO was implemented in C++ language using DYMOUM version and simulated using NS2 Table 1 shows the significant parameters selected for the NS2 simulation to perform comparison between DYMO, EDYMO, FDYMO, and NFDYMO.
The proposed studies were compared with DYMO, and were focused on three performance indicators, which are Throughput, End to End Delay, and Packet Delivery ratio.
Various performance metrics analyzed are as follows:

1. **Throughput:** Is the average number of bits delivered per second, or the amount of data per unit of time delivered successfully.

2. **End to End Delay**: Is the average time of delivery of data packets to the delivery to the destination, which includes all delays.

3. **Packet Delivery Ratio:** The ratio of the number of packets received in the receiver and the number of packets sent from the origin.

Algorithm 1: operation model to NFDYMO

```
// Method for  broadcast of RREQ
messages
route_discovery (Destination_node)
{
// Get info from routing table (if
there exists an entry)
IF (routing_entry) { SET  seq_num=
rt_seq_num , thopcnt= rt_hopcnt,
Energy=rt_Energy,FUZZY=rt_FUZZY }
ELSE    SET  seq_num= 0,thopcnt= 0,
Energy=Local_Energy
,FUZZY=Local_FUZZY
BROADCAST  RREQ  to Neighbors }

//Method for handling RREQ messages
Receive_RREQ (RREQ,
Destination_node) {
IF (Destination_node ==
target_node) {
IF (routing_entry) UPDATE
ROUTE,Send_RREP(Source_node)
ELSE  INSERT ROUTE,
Send_RREP(Source_node, RREQ) }
IF (Destination_node != target_node
){
IF (seq_num> rt_seq_num) OR
((seq_num= rt_seq_num) AND
(FUZZY> rt_FUZZY) ) UPDATE Route,
FORWARD_PATH_ACCUMULATION_RREQ }}

 // Method for broadcast RREP
messages
Send_RREP(Source_node, RREQ)
{SET rrep_seq_num= seq_num ,
thopcnt=0
BROADCAST RREP}

// Method for handling RREP
messages
Receive_RREP (RREQ ,Source_node)
{ IF (Source_node== target_node)
UPDATE  Route, SEND Data
IF (Source_node!= target_node ){
IF (rrep_seq_num> rt_seq_num) OR
((rrep_seq_num= rt_seq_num) AND
(FUZZY> rt_FUZZY) ) UPDATE Route,
FORWARD  RREP }}
```

TABLE 1: Simulation Parameters

Parameters	values
Simulation time	900s
Channel type	Wireless channel
Mobility model	Random way point
Type of antenna	Omni directional
Topology area	5000m x 1000m
Number of Nodes	20,30,50,100
Speed	10 to 30 m/s
Routing protocol	DYMO,EDYMO,FDYMO
Traffic type	CBR
Initial energy	10J

TABLE 2: The Rule Base of FDYMO

Hop Count	Energy	Optimal value
Low	Low	Low
Low	Low-med	med
Low	High	VeryHigh
Low	High-med	VeryHigh
Low-med	Low	Low
Low-med	Low-med	Low
Low-med	High	VeryHigh
Low-med	High-med	High
High-med	Low	VeryLow
High-med	Low-med	Low
High-med	High	High
High-med	High-med	med
High	Low	VeryLow
High	Low-med	Low
High	High	High
High	High-med	Low

In Figure.3 (a) and Figure.3 (b) shows the throughput of DYMO, EDYMO, FDYMO, and NFDYMO where in Figure .3(a) the throughput of NFDYMO is the best at low speed, EDYMO and FDYMO are better than DYMO. On Figure.3 (b) NFDYMO throughput is increased, when number of nodes increased also that happened to all protocols, and NFDYMO has the best throughput, on another hand EDYMO and FDYMO are better than DYMO at 5, 10, and 15mps.

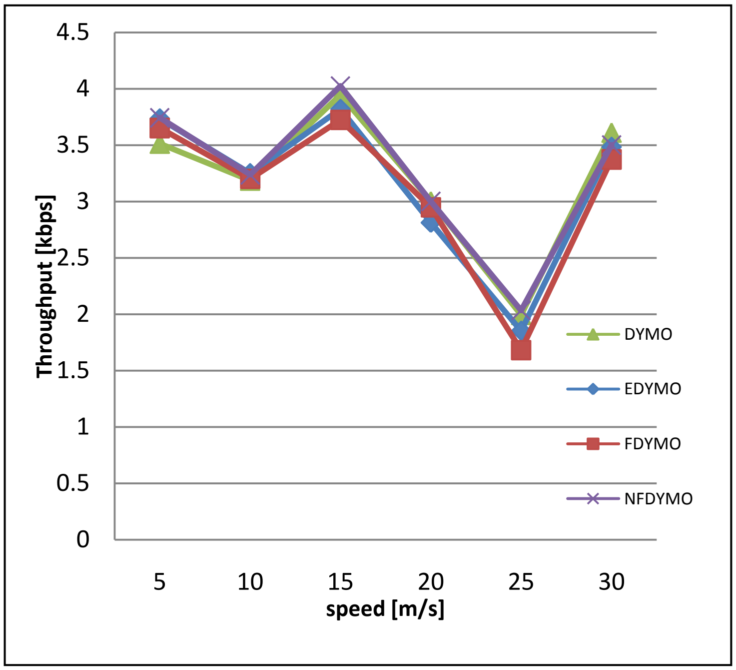

Figure.3 (a) Throughput for 50 nodes in different speeds

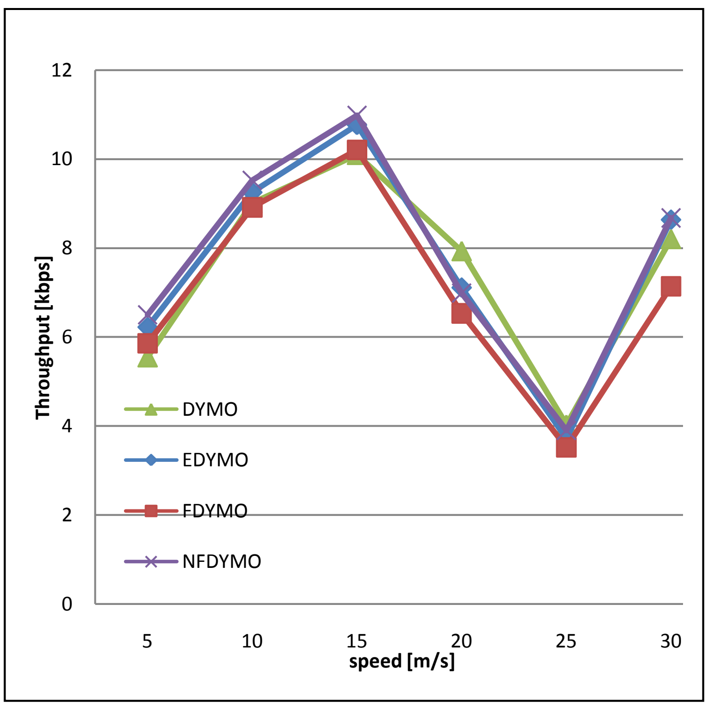

Figure.3 (b) Throughput for 100 nodes in different speeds

After evaluating performance parameters, performance (NFDYMO) is generally more efficient than the traditional routing protocol.

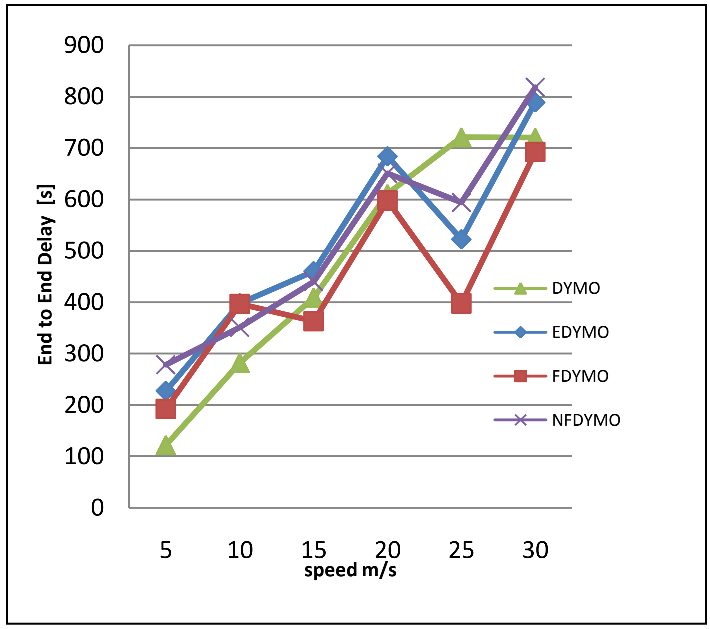

Figure.4 (a) End to End Delay for 50 Nodes in different speeds

The End to End Delay of DYMO, EDYMO, FDYMO, and NFDYMO appears in Figure.4 (a) and Figure.4 (b), where in Figure 4(a) number of nodes is fifty nodes. at 15, 25 and 30 mps speeds, FDYMO is better than DYMO, EDYMO, But on Figure .4 (b) EDYMO and FDYMO are better than DYMO at 5, and 30 mps speeds, on another hand NFDYMO Remains almost similar to DYMO effectiveness on both cases.
Figure.5 (a) and Figure.5 (b) shows the Packet Delivery ratio of all proposed models where (NFDYMO) is more efficient than conventional routing protocol, in Figure. 5(a) at 5, 10, and 15 mps speeds EDYMO and FDYMO are better than DYMO .but on Figure .5 (b) EDYMO is better than DYMO and FDYMO at 15 mps

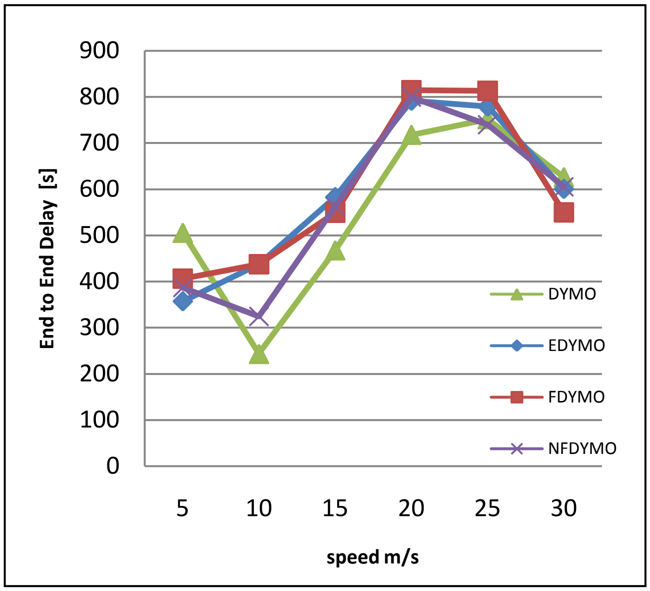

Figure.4 (b) End to End Delay for 100 Nodes in different speeds

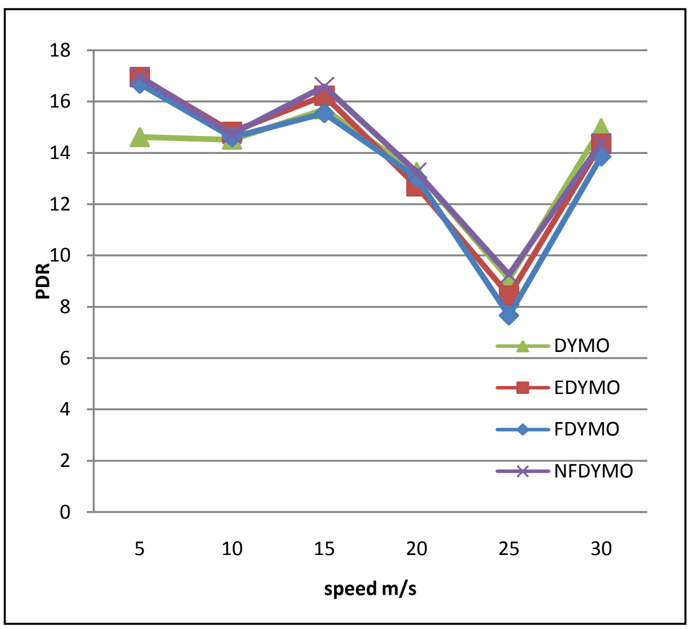

Figure.5 (a) Packet Delivery ratio for 50 Nodes at different speeds

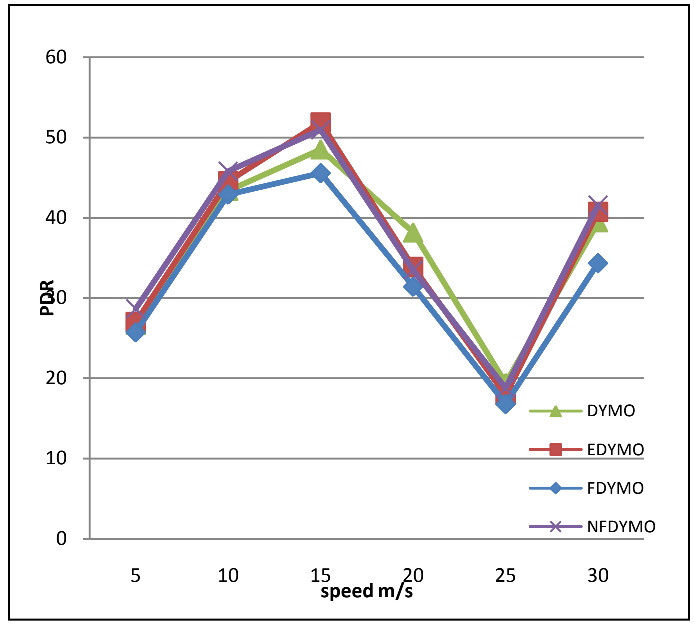

Figure.5 (b) Packet Delivery ratio for 100 Nodes at different speeds

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V. CONCLUSION

This paper shows EDYMO, FDYMO, and NFDYMO as extensions for DYMO, to ensure that the conditions of choice of routes are effective and have a positive impact on the efficiency of the use of battery power. The simulation results show that the NFDYMO, EDYMO and FDYMO have improved the performance of DYMO.

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