An Energy Efficient Enhanced Hybrid Routing Protocol for MANET utilizing Artificial Bee Colony

Vandana, Navdeep Kaur

Abstract**: *Mobile Ad hoc Network (MANET) is a self-organized wireless network with no central control station or no rigid infrastructure. The main objective of the ad hoc network is that the nodes move arbitrarily that needs the routing protocols to rapidly counter the change of network topology. Limited energy resource availability is the core issue in MANET. For energy efficiency enhancement, this research has acquainted a hybrid routing algorithm which is an amalgamation of Ad hoc On-Demand Distance Vector Routing (AODV) and Temporally-Ordered Routing Algorithm (TORA) routing protocols for the route discovery process using Low Energy Adaptive Clustering Hierarchy (LEACH). Artificial Bee Colony (ABC) algorithm has been used for the optimization if some sort of distortion occurs within the network. The simulation has been executed in MATLAB simulation tool using QoS parameters, such as throughput, energy consumption, PDR and delay. Comparative analysis has been done to portray the proposed work effectiveness.***

Index Terms**: *ABC, Aoda ,Delay, Energy Consumption, Leach, Manet, Tora, Throughput.***

I. INTRODUCTION

MANET represents Mobile Ad-hoc Network. It is a self-configuring infrastructure-less network. The lack of Ad-hoc Network infrastructure provides great challenges in the performance of these networks [1]. Therefore, we refer to a wireless ad-hoc network with mobile nodes as Ad-hoc Network. In MANET, all devices are connected via wireless links. Every apparatus in MANET moves autonomously in all directions [2]. It frequently transforms its associates to other accessories. By means of random topology, the nodes are arbitrarily connected to each other. Nodes can function as both routers and hosts [3]. The main confrontation to design a MANET is to supply each device with the information needed to properly route the traffic. Frequent connections and re-associations lead to energy limitations in mobile nodes.

As MANETs correspond to inadequate bandwidth and mobility of nodes, so, there is a need for energy efficiency of the nodes [4]. The architecture of MANET is shown in Fig.1 Usually, the existing routing protocols are utilized to solve of finding the route within the network. But some protocols do not fulfil the desired issues, so, in this research, a combination of AODV and TORA are used. Utilization of ABC routing algorithm is there to optimize the route discovery procedure by routing and enhancement. QoS parameters, such as throughput, Delay, energy consumption and Packet Delivery Ratio (PDR) are computed and are compared with the existing work [22] to show the effectiveness.

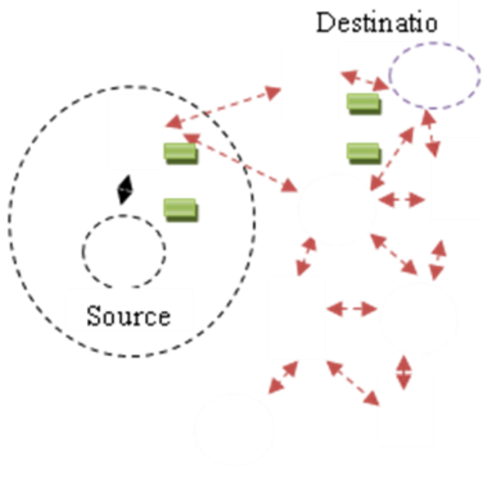

Fig 1. Mobile Ad-hoc network

A number of researches have elaborated their work in MANET for the enhancement of routing with the route discovery process.

Fazlullah Khan et al. (2016) has offered a cross-layer method to complete the TCP traffic competition on multi-hop ad-hoc networks. With the adjustment of the Contention Window (CW) and with the control of competition between stations, the presented technique has received efficient access for every station's access to an appropriate channel. Computation of bandwidth allocation for each flow is considered and is sent to the succeeding layer for each stream delivery to the corresponding layer for each stream delivery of better bandwidth distribution. Then, the flow rate is controlled for clearing the conflict among the streams. Every stream has equivalent efficiency and is being improved. The proposed work performance is executed with the NS-2 simulation tool in a number of multicast ad-hoc network topologies.

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Jigna Bavaliya et al. (2016) has proposed an algorithm that utilizes a filter for detecting malicious nodes and for lessening the network performance effect. The objective of the filter is to reduce the HELLO packet rate. Every node preserves a threshold value. Therefore, the flood attack prevention is introduced in this article. An efficient algorithm for the prevention and the detection that is IOLSR is presented. It decreases the HELLO messages congestion rate in the network and has prevented the malicious nodes from network flooding.

P.N. Pandey et al. (2017) has presented a novel method for decreasing the control overhead by maintaining OLSR throughput and then lessens the power consumption with prominent statistical apparatus that commonly considered as intelligent choice framework choice. Parameters, such as Routing overhead (RO) and Average throughput. A decrement has been noticed in the power utilization of the system. The statistical computation in TC and HELLO could lessen the appropriate control overhead. Additionally, throughput has been enhanced and power consumption is decreased.

R. Bhuvaneswari and R. Ramachandran (2018) has considered the active denial of service (DoS) attacks within the network layer OLSR routing protocol. The malicious node based DoS attack are presented with a different malicious node for appropriate network node and measures, such as PDR, Delay, throughput and average delay are implemented with network simulator and the contrast of outcome are computed. The malicious nodes needed for enhanced throughput of the specified network is ultimately computed.

Shanti Jaiswal and Navneet Kaur (2018) has presented a novel energy effective multipath routing algorithm, termed as, FF-AOMDV with NS-2 simulation tool using Dragonfly topology. Under three conditions, the simulation has been conducted, viz., packet size, node speed and simulation time. QoS parameters, such as Delay, PDR, throughput and energy consumption are considered to execute the proposed simulation work. It has been seen that the proposed FF-AOMDV technique has outperformed as contrasted to AOMDV and AOMR-LM. The novel mechanism has also executed well by means of energy conservation and network lifetime.

Lots of routing algorithms are already being developed by different researchers to solve the routing problem. But due to the pro-active nature of routing, the data loss rate is more because of the pre-defined route for data transmission. Suppose, if any distorted node is included in route the chances of data loss are more but in existing work, the concept of node replacement is not used. So, to solve this type of problem, this research has introduced a hybrid routing protocol with ABC algorithm using AODV and TORA routing protocol.

The organization of the paper is such that Section 2 describes the AODV routing protocol and TORA routing protocols are being explained in Section 3. Section 4 has elaborated ABC optimization algorithm and proposed framework is explained in Section 5. Section 6 depicts the results obtained after the evaluation of the proposed work and finally, Section 6 concludes the paper followed by the references

II. PROPOSED TECHNIQUES

The paper has been organized on the basis of two routing protocols, namely, AODV and TORA. The description for the same is given below.

A. AODV protocol

AODV is a reactive protocol or an On-Demand routing protocol [5]. AODV protocol utilizes the destination order number to provide a loop route and a fresh route to the destination. AODV does not maintain network status with continuous updates. This approach helps to reduce the number of messages and the magnitude of the routing tables.

AODV provides multilateral and uniquely connected ad-hoc environment. AODV also responds rapidly when a links break in an active way.

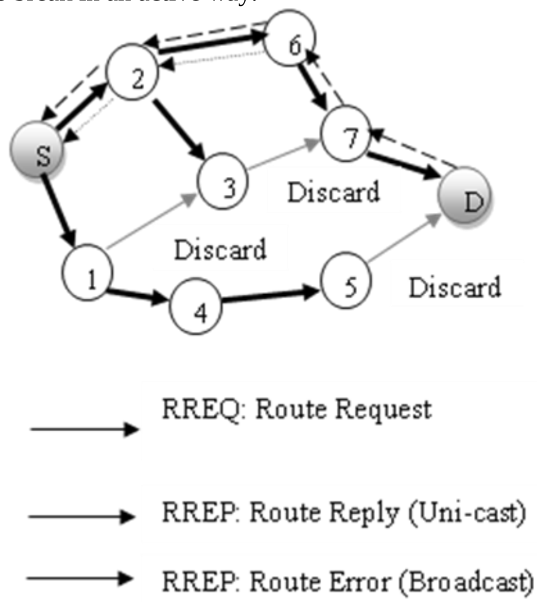

Fig.2 Representation of AODV protocol

This hop-on-hop inherits route with a number series and from time to time. A DSDV beacon opens the way to utilize the DSR and road maintenance. Also, the Routing of the mobile network is the major constraint in MANET. The routing problem is the most important research topics in MANET [6]. Ad-hoc networks (MANET) are non-centralized networks that can be formatted and do not require previously existing infrastructure. In the ad hoc network, each node operates as a router. Here, neighbours act as neighbouring junctions and track the roads. These networks communicate with the nodes that are not part of the transmission range.

Various features like open media, deficiency of clear lines for protection, and dynamic topology make MANET susceptible to security invasions.

AODV consists of two phases,

- Route Discovery process

- Route maintenance process

Fig.2 demonstrates the usage of the AODV routing protocol, namely, RREQ (Route Request), RREP (Route Reply) and RERR (Route Error). The routing request (RREQ) is sent by the source node as depicted in Fig.3 and Fig.4 as RREQ propagation and RREP propagation [7]. This RREQ has source address, source serial number, destination address, target inheritance number, communication ID and TTL (Time to live).

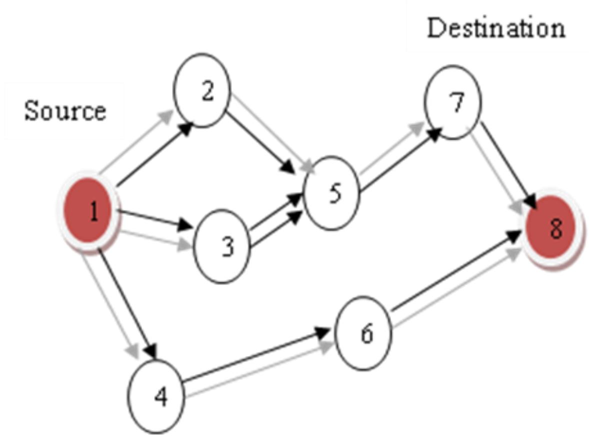

Fig.3 RREQ propagation

The source serial number is used to maintain a strategic distance from the loop. The source serial number and destination inheritance number are used to keep the latest data for the node.

The combination of (source address and communication ID) is used to identify RREQ anomalies. When a node discovers a link outage, it passes the routing error packet to its neighbour. As depicted, node 7 shifts and the failure of link happens among node 6 and node 7. Then, the node 6 discovers the link failure and sends the RERR packet.

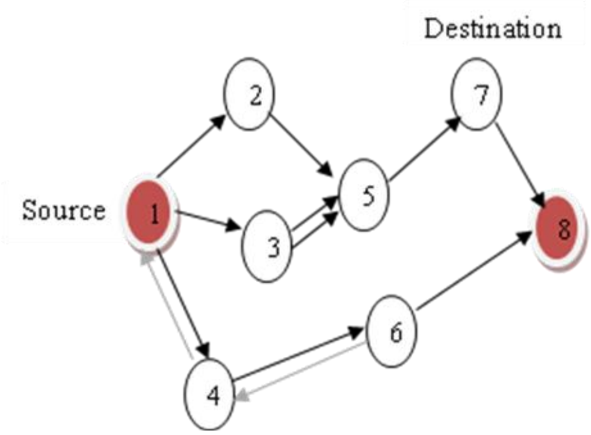

Fig.4 RREP propagation

B. TORA protocol

TORA is for multihop network and is an enhanced hybrid version of Lightweight Mobile Routing (LMR) and Gafni Bertsekas (GB) protocols. It offers different routes, loop-freedom and less communication overhead with algorithmic reaction topologically for variations in more dynamic surroundings [8]. It sustains a combination of proactive and reactive routing. The reactive routing is valuable for a dynamic network having comparatively fewer traffic patterns whereas the proactive routing is required inconsistent routing. This routing protocol preserves the routing state on the basis of every destination. It upholds a height value on the basis of link direction to the destination, the traffic flow is focussed from higher source nodes to less destination node. This method verifies that a node could only transfer the packet downstream [9].

Every node n is linked with height h illustrated as quintuple ($\propto n$, $ond n$, $ς n$, ∂n , n). The initial three quintuple value shows the reference level whereas the left two shows the variation by means of reference the level. Table 1. sum up the the height metrics.

Table 1.Height metrics description

Height Metrics	Explanation
$\propto$	Link failure logical time
ond	Novel level unique ID
$ς$	Reflection indicator bit
∂	Propagation ordering parameters
n	Node unique ID

Three general functions are performed by On-demand TORA routing protocol:

- Creation of routes,
- Maintenance of routes
- Deleting routes

The accomplishment of these functions is with below control packets:

- QRY as QUERY
- UPD as UPDATE
- CLR as CLEAR

The initialization of the route creation function is possible only of the nodes with some directed links needs a route to reach the destination. The procedure could be completed with query following reply method with the exchange of QRY and UPD packets among the routers. At the end of the process of route creation, (Directed Acyclic Graph) DAG is developed with the destination being a root. The performance of route maintenance is probably only if the network topology varies. It verifies the route toward the destination that could be established later as well in a limited time [10]. In this procedure, every node with no downstream connection changes its height on the basis of five probable cases. For instance, because of the link failure, the nodes defines by describing the novel reference level. When the detection of node takes place, the links in the partitioned network portion are noticeable as undirected and each invalid route is deleted. While deleting the route procedure, the node manages the height and the height entry of every NULL neighbour and sends CLR packets.

C. Artificial Bee Colony (ABC)

ABC is considered to be one of the most used algorithms by Dervis Karaboga and is stimulated by bee behaviour. It is as simple as the Particle Swarm Optimization (PSO) and Differential Evolution (DE) algorithms and uses only general control metrics such as a maximum number of cycles and colony size [11]. ABC is known as an optimization tool that provides a process for group-based searches by which an individual refers to a food location and is changed by artificial bees over time in order to find a food source location with more nectar. In the ABC system, artificial bees fly in multidimensional search spaces, and few bystanders and bees use food sources to build nests and correct positions based on their own experience. Without experience, few scouts fly and arbitrarily determine the source of food [12]. If the number of nectars is compared to the existing nectar in memory, they remember the location of the novel and do not remember the previous position. As a result, ABC integrated the onlooker's local search method and used bees through scouts and bystanders' global search methods, which later balanced the development and exploration process.

The implementation steps of the ABC algorithm are described beneath [13]:

Step 1: Begin
Step 2: Calculate the solution population, $y_m, i = 1,2, \ldots\ldots, SN$
Step 3: Calculate Population
Step 4: Cycle=1
Step 5: Iterate
Step 6: Calculate the narrative solution, u_{mi} for employed bees with step using equation ii and later onncompute them.
Step 7: Obtain an improved solution with candidate and current.
Step 8: Organize the apparent solution for the onlooker bees with equation ii and estimate them.
Step 9: Frequent novel solution u_{mi} for the onlooker bees with equation ii and estimate them.
Step 10: Obtain an enhanced solution along with candidate and current.
Step 11: Discover a neglected food source subsists and modify it with scout bee.
Step 12: Save in memory the better solution.
Step 13: Cycle=Cycle+1
Step 14: Until cycle=Maximum number of cycles

III. PROPOSED FRAMEWORK

The proposed framework of the network structure combines the AODV protocol with TORA protocol along with the implementation of ABC for the optimization of the route discovery process [14]. The proposed work is categorized into two sections namely routing and enhancement. The proposed framework initiates with node deployment and node simulation properties [15-16].

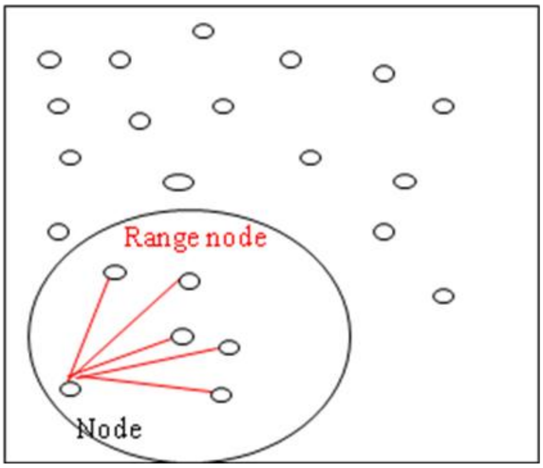

Fig.5 Calculation of Node range

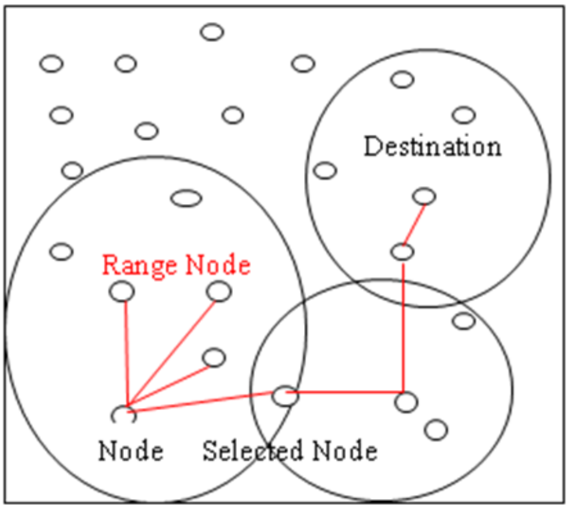

Fig.6 Route Discovery

Fig.5 depicts the calculation of the node range and the process of route discovery is shown in Fig.6. The nodes are deployed with a random network model and the two structures [17]. The first structure is when the node is acting normally and another is when the node is not acting normally. The coverage range of each mobile node is identified by a coverage calculator algorithm [18].

Algorithm 1: Node Deployment
Input: Number of nodes (n) and Area of network
Output: Network with nodes
For 1→n
Xlocation=Area of network X Random
Ylocation=Area of network X Random
Node_property=[Packet drop rate, energy consumption]
Plot (Xlocation, Ylocation)
End
Return Node_property of the network with nodes
End

Fig.6 represents the node movement from place 1 to place 2 and Node movement from place 1 to place 2 goes out of the boundary is depicted in Fig.8.

Algorithm 2: The range Calculator

Input: Node Number (n), Xlocation (x), Ylocation (y), Area of network and range

Output: Node range list

Distance_Evaluator=[ ]

For i=1→n

For j=1→n

If i≠ j

$$dist = \sqrt{((x(j) - x(i))^2 + (y(j) - y(i))^2}$$

If dist<range

Distance_Evaluator=n

End

End

End

Return Node range list

End

The range evaluator computes the distance from one end to another. Each node is evaluated with other node utilizing the distance formula. The range function assures that the correct node is selected for processing [19].

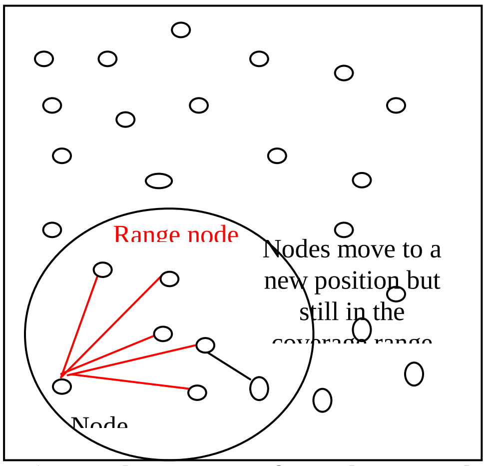

Fig.7 Node movement from place 1 to place 2

In such a situation a reconstruction utilizing AODV is performed. The route discovery process covers the nearby node and reaches the destination. When it comes to OLSR routing, initially the discovery process takes place and then the fixed route process is followed for next iterations. This process discontinues if the node moves out of the region [20].

AODV does not identify the new node if the node is in the cluster region in such a scenario; Artificial Bee Colony is used to select the Optimized Node which is other than the non-active node.

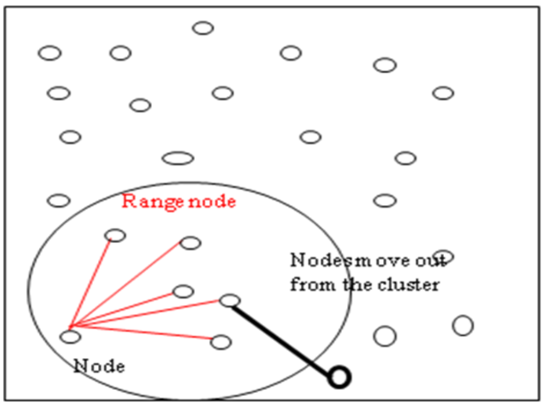

Fig.8 Node movement from Place 1 to Place 2 and goes out of boundary

Algorithm 3: ABC for alternative node

Input: NodeStructure, Noderangelist and fitness function of bee (Bee_fit)

Output: Best node for communication

For i=1→ NodeStructure element

Total_Bees=Node_Locations, Energy_Model

$Bee\_Onlooker = \sum_{i=1}^{n} Energy\_Model(i)$

Bee_Onlooker=(Bee_Onlooker)/n

Possible_Nodes=Bee_fit(Bee_Onlooker, Total_Bees(i))

End

[Node_range,BestNode]=Range_Evaluator (Possible_Nodes)

Return: BestNode as a best node for communication within the network

End

Table 2. BeeFitnessTable

1	$If\ Onlooker\_Bee < Employed\_Bee$
0	$Otherwise$

Table 2. shows the bee fitness table [21]. Algorithm 3 takes the node structure and finder node as input. The finder node is the node which requires the route discovery. The onlooker is the average energy utilization of the remnant nodes. If the node energy value is greater than that of the average onlooker value, the node is dumped and the fitness function returns 0 otherwise it will return 1. The combinational architecture of AODV and TORA with ABC is now termed as AOT-ABC [22].

Table 3.Throughput computation

Number of rounds	LEACH	I-LEACH
1	640.323	720.456
2	462.505	542.725
3	400.605	485.452
4	250.501	330.66
5	162.75	240.95

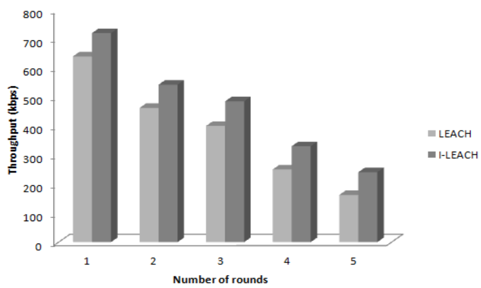

Fig.9 Throughput Vs number of rounds

Table 3. and Fig.9 illustrate the throughput for the designed network. The numbers of rounds are shown in X-axis and the obtained values for throughput computed for LEACH and I-LEACH are shown in Y-axis. The graph shows that the throughput value computed for a network with I-LEACH is more as contrasted to LEACH. The

mathematical expression for its computation is outlined below:

$$\text{Throughput} = \frac{\sum_{k=1}^{node} \text{Successful packet delivered} \times \text{Average packet size}}{\text{Total sent packet}} \quad (1)$$

Table 4. PDR computation

Number of rounds	LEACH	I-LEACH
1	92.982	98.901
2	90.323	95. 821
3	91.321	97.325
4	89.100	96.365
5	93.352	95.997

PDR for the proposed simulation model is showed in Fig.10 and Table 4.

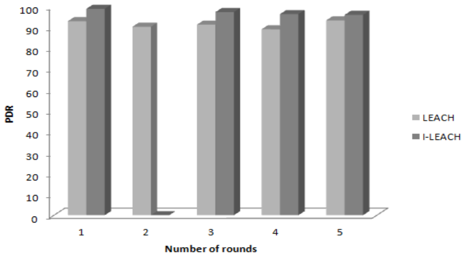

Fig.10 PDR Vs number of rounds

It is evident from the obtained results that the PDR obtained for I-LEACH are more than that of LEACH. It is defined as a proportion of packet being received and the packet beingg sent within the network. Below mathematical equation has been used to compute PDR in the proposed scenario.

$$\text{PDR} = \frac{\sum_{k=1}^{node} \text{Successful packet deliver rate}}{\text{Total sent packet for transmission}} \quad (2)$$

The average value of proposed I-LEACH is 97.147.

Table 5.Delay computation

Number of rounds	LEACH	I-LEACH
1	6.937	3.585
2	7.852	5.987
3	13.785	6.589
4	21.949	8.256
5	23.587	9.654

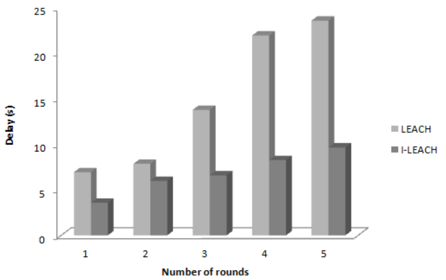

Fig.11 Delay Vs number of rounds

Table 5. and Fig.11 illustrates the delay for the designed network. A number of rounds are shown in X-axis and the obtained values for delay computed for LEACH and I-LEACH are shown in Y-axis. It can be seen that the delay value computed for I-LEACH is less as contrasted to LEACH. The mathematical expression for its computation is outlined below:

$$\text{Delay} = \sum_{k=1}^{node} \text{Packet transmission time} + \text{Packet receiving time} + \text{waiting time} \quad (3)$$

The average value of proposed I-LEACH is 6.81s.

Table 4.Energy Consumption computation

Number of rounds	LEACH	I-LEACH
1	52.262	20.165
2	65.874	42.759
3	69.565	45.658
4	77.257	54.897
5	80.162	56.478

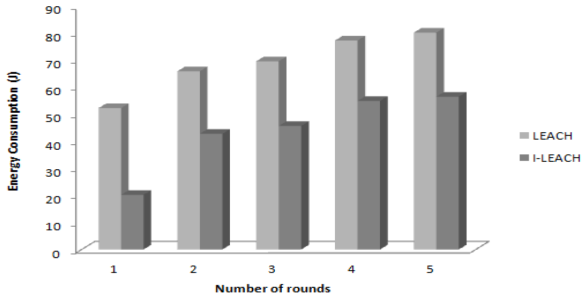

Fig.12 Energy consumption Vs number of rounds

The computation of energy consumption by sensor nodes is depicted in Fig.12 and the tabular form is also shown in table 4. It is apparent from the figure that the energy consumption of I-LEACH is less as contrasted to LEACH. It can be computed mathematically as:

$$\text{EnergyConsumption} = \sum_{k=1}^{node} \text{total}_{energy} + \text{receiver}_{energy} + \text{waiting}_{enery} \quad (4)$$

As depicted in equation (4), total_{energy} is the total consumption of energy while transmission of pakets, receiver_{energy} is the total consumption of energy received by receiver and waiting_{enery} is the waiting energy consumption. The average value of proposed I-LEACH is 43.99J.

IV. COMPARATIVE ANALYSIS OF PROPOSED AND EXISTING WORK

This section describes the comparison of existing work with the novel mechanism. The comparison has been done with [22] to show the proposed work efficiency. For the comparison, computing measure such as Throughput, PDR, Delay and energy consumption are considered and the authentication has been depicted in graphical and tabular form.

Table 5. Parametric comparison of proposed and existing work

Researches	Throughput	PDR	Delay	Energy consumption
Proposed	464.04	97.147	6.81	43.99
Existing [22]	359.45	83.12	10.78	74.25

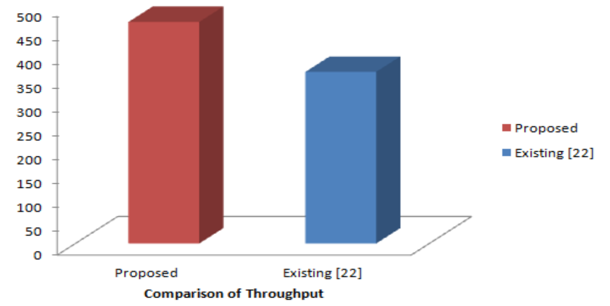

Fig.12 Comparison of throughput

Fig.12,13,14 and 15 and Table 5. shows the comparison of [22] with existing work. From the assessment, it is clear that the proposed work has outperformed in terms of QoS parameters as compared to existing work. There is an enhancement of 22.54% in throughput, 14.43 % enhancement in PDR, Delay is 36.82% less than existing and there is a decrement of is 40.75% in energy consumption.

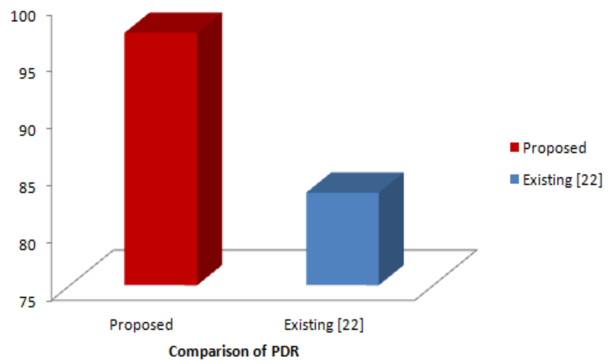

Figure 13.Comparison of PDR

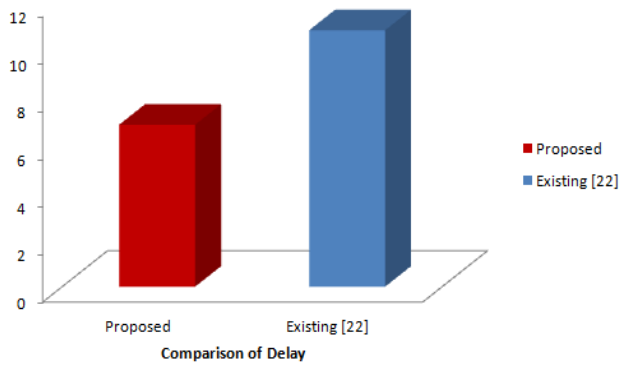

Fig.14 Comparison of Delay

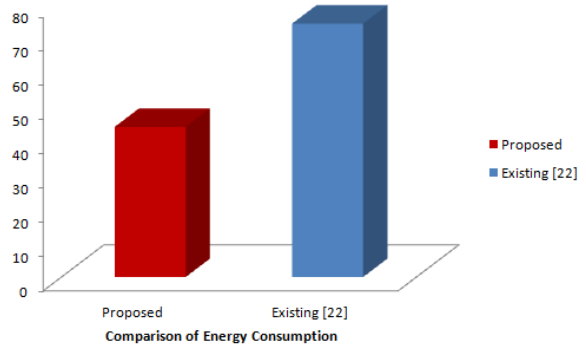

Fig.15 Comparison of Energy Consumption

V. CONCLUSION

This paper illustrates a hybrid routing algorithm of AODV and TORA routing protocols. The proposed protocol utilizes both the frameworks in which when the node crosses the boundary limit it demands AODV otherwise it demands TORA protocol. To develop the proposed algorithm, node failure or distortion was also implemented. For alternate route discovery and selection process, ABC algorithm was implemented. The proposed framework is also evaluated for Throughput, PDR, Delay and Energy Consumption. The comparative analysis of proposed and existing work has also been drawn to depict the proposed work effectiveness. The enhancement rate of throughput is 22.54%, PDR is 14.43%, the delay is 36.82% less than existing and there is a decrement of is 40.75% in energy consumption.

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