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Congestion Aware Load Balancing for Energy Efficient Mobile Ad-hoc Network

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***Abstract*—**Mobile Ad Hoc Network is a set of nodes which can communicate each other through wireless links. The function of nodes in MANETs does not rely on base stations with fixed infrastructure. Many reasons act as a cause for mobile node failure such as hardware or software problem, draining of battery power, going out of the communication ranges of its neighbor nodes or leaving from the network range. In these reasons, draining of battery power is considered as the most important. Recently various protocols employed to decrease the energy consumption. But most of the routing protocols are not intended to adapt congestion and finest link quality. In this paper, the energy consumption in MANET is highlighted by employing the fitness function technique with load balance to optimize the energy consumption in AOMDV routing protocol. The fitness function with load balance is used to discover the best path from source node to destination node to lessen the energy consumption and to boost the throughput in multipath routing. The simulation outcome via ns2 expose that our proposed fitness function with load balancing scheme act superior than existing protocol in terms of Packet Delivery Ratio, End-to-End Delay, Throughput, Energy Consumption, Network Lifetime, Routing Overhead Ratio, Data rate, Packet Loss and Node Residual Energy.

***Keywords*—**MANET, Low power, AOMDV, Fitness Function, Ad-hoc, Energy efficient.

I. INTRODUCTION

Both fixed and mobile wireless systems have become a crucial part of communication infrastructure. The application of these wireless systems range from simple wireless systems which has low data rate transmitting sensors to complex real time systems which has high data rate transmitting sensors such as live broadcast of sport events or monitoring huge retail outlets [9]. Point-to-point technology was used in majority of wireless systems such as GSM communication system where mobile nodes communicating with central access point. Some networks such as MANETs (Mobile Ad-hoc Networks) cannot rely on centralized architecture. No fixed infrastructures for mobile nodes were used in MANETs [10]. MANETs are used many areas such as rescue operation or environmental monitoring. Availability of power i[1]s the main drawback of MANETs. We can reduce power consumption of nodes by spending minimum energy to transmit and receive data [8].

Different power-aware routing protocols have been projected by taking into account the energy consumption for the data transmission or the balance energy level of the mobile nodes or both [11]. By using such power-aware routing protocols, a variety of routing costs and also path selection algorithms have been examined for the intention of improving the energy efficiency in the Mobile Ad-hoc Networks [4], [7]. Numerous routing protocols have been built up recently to boost the lifetime of a route and also the lifetime of the overall network. One of these advancement is multipath routing protocols. Multipath routing protocols permit the source node to select the optimum path amongst various routes during a single path finding method [12], [19]. This procedure in multipath routing will reduce the amount of route finding method as there are backup paths already available and in case one route stop working then it will lessen the energy consumption, end-to-end delay and the network lifetime [14], [17].

Multipath routing protocols broadcast a request protocol to find out more than single route to the sink to send packets through them. It is not essential that the source will all the time discover the best or the shortest route available. As the power supply of the nodes is limited, the energy consumption by these nodes should be restricted to boost the overall network lifespan. Multipath routing protocols have numerous problems [15], [18], [20]. One of them is discovery of a best route from the sources to the sinks. The problems turn out to be more difficult with a huge number of nodes that are linked together for data transmission [13], [16]. In this case, the majority of the power is going to be consumed at the moment of inspecting for shortest paths. Afterward, the more power is wasted at data transmission.

This paper implements a multipath routing protocol called ad-hoc on demand multipath distance victor with the fitness function and load balance (AOMDV-FFLB). Our proposed employs the fitness function with load balance as an optimization technique. In this optimization, we look for three metrics in order to choose the best path on of them is power level of the path, path space and another one is the traffic of the path in order to transmit data to the sink more proficiently by consuming small amount of power and increasing the overall network lifetime. Based on the outcome of the simulation, the AOMDV-FFLB routing protocol outperformed fitness function without load balance in terms of Packet Delivery Ratio, End-to-End Delay, Throughput, Energy Consumption, Network Lifetime, Routing Overhead Ratio, Data rate, Packet Loss and Node Residual Energy.

The rest of the paper is ordered as follows: Section 2 presents the background and related works; Section 3 discusses the proposed AOMDV-FFLB; Section 4 discusses the results and evaluation, Section 5 presents the conclusion of the study.

II. RELATED WORK

O. Smail, B. Cousin, R. Mekki, and Z. Mekkakia proposed an energy-efficient multipath routing protocol, called AOMR-LM, which saves the remaining power of mobile nodes and stabilizes the consumed power to prolong the overall network lifespan. They used the remaining power of nodes for finding the node power level. The multipath selection method employs this power level to categorize the routes. Two metrics are examined: the coefficient and the energy threshold. These metrics are essential to categorize the mobile nodes and to make sure the conservation of mobile node power. The AOMR-LM protocol develops the efficiency of MANETs by increasing the lifespan of the network. This innovative protocol has been evaluated with both zone-disjoint ad-hoc on-demand multi-path distance vector (ZD-AOMDV) and AOMDV. The protocol efficiency has been estimated in terms of energy consumption, network lifetime and end-to-end delay. Even though it prolongs the lifespan, the data rate is very low [2].

D. Manickavelu and R. U. Vaidyanathan proposed a protocol which focused on the path finding process effect on the communication overhead, data loss and energy consumption. For these causes, they implemented a PSO based lifespan forecast algorithm for path finding in MANET. This method forecasts the lifespan of link and mobile node in the accessible bandwidth based on the metrics like the energy drain rate and mobility of nodes. Using forecasts, the metrics are fuzzy rules and fuzzified were created to choose on the mobile node condition. This data is made to swap among all the mobile nodes. Therefore, the condition of each mobile node is checked before data transmission. Even for a weak node, the performance of a route recovery mechanism is made in such a way that corresponding paths are diverted to the strong mobile nodes. The simulation outcomes show that the proposed method reduces the communication overhead and packet loss. It has high system complexity [3]

D. K. Sharma, A. N. Patra, and C. Kumar implemented a reactive routing protocol that utilizes the power status (PS) and received signal strength (RSS) of nodes. By Comparing the outcome of the proposed algorithm with the existing algorithms, in terms of link failure probability, energy consumption and retransmission of packets, the proposed algorithm clearly outperform the existing algorithms. As it concentrated link failure as main aim, it can't reduce the energy consumption of nodes to the significant level [4].

H. Nasehi, N. T. Javan, A. B. Aghababa, and Y. G.Birgani tried to find out the distinct routes among the source and sink nodes by using the Omni directional antennas, to send data through these paths concurrently. For this reason, the numbers of active adjacent nodes are calculated in all direction. These measures are efficiently used to find paths. The implemented algorithm was supported on AODV routing protocol and was evaluated with ad hoc on-demand distance vector multipath routing (AODVM), AOMDV and IZM-DSR. Simulation outcome showed that the implemented algorithm produced a significant development in power efficiency and dropping end-to-end delay. As it is based on AODV, it is not suitable for multipath networks [5]

P. Hiremath and S. M. Joshi implemented a routing protocol that preserves power of the nodes prolonging the lifespan of the MANET. It is one of the on demand routing protocol based on adaptive fuzzy threshold energy (AFTE). The experimental outcome was evaluated with the load-aware energy efficient protocol (LAEE) protocol. The outcome undoubtedly showed that AFTE outperforms LAEE. The overall network lifespan was improved upto 13% allowing for first node failure, 15% allowing for 50% node failure and 23% allowing for 100% node failure evaluated to LAEE. It has high system complexity [6]

Aqeel Taha, Raed Alsaqour, Mueen Uddin, Maha Abdelhaq, and Tanzila Saba implemented an energy efficient protocol called fitness function which reduces the overall energy consumption. They compared their fitness function algorithm with AOMDV. The result shows that the fitness function outperforms AOMDV in terms of energy consumption, packet delivery ratio, throughput and end to end delay. But this protocol little bit lack against AOMDV when compared to routing overhead ratio. Also this protocol does not considered route traffic as a metric in optimum route selection process [1]

As a conclusion all the protocols in literature concentrate on energy consumption but neglected the overall data rate since these protocols doesn't consider network and route traffic while choosing optimum path. The need for Load balanced multi path routing protocol is essential to increase the data rate as well as to reduce the overall energy consumption.

III. THE PROPOSED AOMDV-FFLB

In this paper, we implemented a new multipath routing protocol named the AOMDV-FFLB routing protocol, which is a mixture of Fitness Function with load balance and the AOMDV's protocol. In an ordinary situation, when a RREQ is transmitted by a source node, more than single path to the sink will be establish and the packets will be transmitted through these paths without knowing the path's quality. By applying the proposed algorithm on the same situation, the path finding will be completely dissimilar. When a RREQ is transmit and received, the source mobile node will have four (4) types of information in order to discover the shortest and best path with reduced power consumption. This information consists of:

- Information about every node's energy level in the network
- The space of each path
- The power consumed in the course of path finding.
- Traffic on each path.

The path, which uses low power, maybe (a) the path that has the minimum distance; (b) the path with the maximum level of power, or (c) both. The source mobile node will then transmits the packets through the path with maximum power level, later than which it will compute its power consumption. The same to other multipath wireless routing protocols, our protocol will also begins new path finding procedure when all paths to the sink are failed. In the incident when the chosen path fails, the source mobile node will then chooses a substitute path from its routing table, which stands for the shortest path with least power consumption. The best path with low distance to sink will consume low power and it can be computed as follows:

$$Optimumroute1 = \frac{\sum v(n) \in rene(v(n))}{\sum v \in Vene(v)} \tag{1}$$

In the above equation, v stands for the vertices (nodes) in the best path r and V stands for all the vertices (nodes) in the network. It evaluates the power level among every path and selects the path with the maximum power level. The substitute path will be computed according to its distance. And the AOMDV upholds the path with the minimum hop count. Then AOMDV-FFLB implements the identical methods after choosing the path with the maximum power level, the routing table maintains data about the path with the minimum distance. The computation of the shortest path is as follows:

$$Optimuroute2 = \frac{\sum e\,(n) \in rdist\,(e\,(n))}{\sum e \in E} \tag{2}$$

Where *e* stands for the edges (links) in the best path *r* and *E* stands for every edge in the network. It evaluates the distance of the node links in the best path and contrasts it with all of the node links in the network. Also our algorithm chooses route with low traffic to increase the data rate and also to reduce the packet drop.

$$Optimuroute\mathbf{3} = \frac{\sum \boldsymbol{t}\,(n) \in rtraf(\boldsymbol{t}\,(n))}{\sum \boldsymbol{t} \in \mathbf{N}} \tag{3}$$

Where t stands for traffic, t(n) stands for traffic in route and N stands for traffic in overall network.

The algorithm for the fitness function with load balance is presented as follow:
1: Choose the Source and Sink.
2: Source starts the path finding.
3: Broadcast (transmit) the Routing Packet to all direct nodes.
4: Update the routing data in the Source Routing Table.
5: Source starts the Beacon.
6: Broadcast (transmits) the Routing Packet to all direct nodes.
7: Update the power and position data in the Source Energy Table for each mobile node in the whole network.
8: check If(*ene*>DHigh&&*dist*<DLow&&*hop Count*<DLow&&*traffic*<DLow). . . (Eq. 1, 2 & 3)
Choose that path for Data transmition.
Else if (*ene* >D High &&*dist* >D high &&*hop Count* <DLow&&*traffic*<DLow) . . . (Eq. 1 & 3)
Choose that path for Data transmition.
Else if (*ene* <D Low&&*dist* <D Low &&*hop Count* <DLow&&*traffic*<DLow) . . . (Eq. 2 & 3)
Choose that path for Data transmition
Else if (*ene* <D Low&&*dist* <D Low &&*hop Count* <DLow&&*traffic*>DLow) . . . (Eq. 2)
Choose that path for Data transmition
9: Transmit the periodic path finding.
10: Transmit the periodic beacon message.

Replications are carried out to run the AOMDV-FFLB routing protocol. In this simulation, a Tcl script has been written to describe the network metrics and topology, such as number of nodes, traffic source, queue size, routing protocols used, node speed and many other parameters. Two different files are created while running the simulation: a network animator (NAM) to picture the simulation and a trace file for processing. To understand better of how the fitness function with load balance method works with AOMDV routing protocol, the figure number 1 shows the path choosing process of AOMDV-FFLB based on specific metrics.

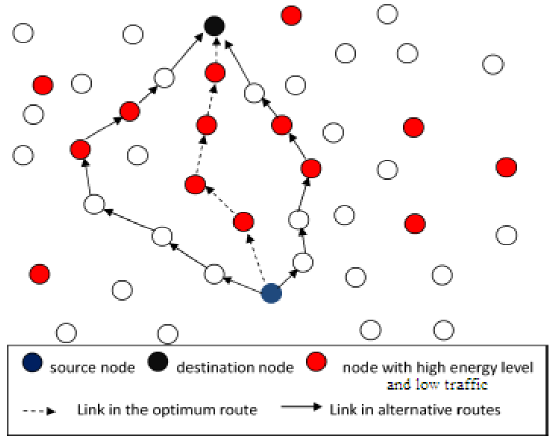

Fig.1 Best path selection in AOMDV-FFLB.

The AOMDV-FFLB originally broadcasts (transmits) a RREQ in order to collect information about the accessible paths towards the sink as shown in figure number 1 where the fitness function with load balance act upon a scan on the network to find position of mobile nodes that have a maximum level of power (red color nodes). The source will then get a RREP that consist information on the available paths towards the sink along with their power levels. Computing all path power level, the fitness function with load balance will then contrast to finding the path with maximum power level. The distance of this path will be considered.

The best path refers to the path that has the maximum power level and the minimum distance. Priority is given to the power level, as seen on the path with the blinking arrow (Figure 1). In another situation, if the path has the maximum power level, but does not have the minimum distance, it can also select with lesser priority. In some other situation, if the middle mobile nodes situated between the source and sink with lower power levels compared to other mobile nodes in the network, the fitness function with load balance will choose the path based on the minimum distance accessible. In all the scenarios, with these two metrics, only those paths will be selected by the fitness function with load balance which has low power consumption and will increase the lifespan of the network.

IV. RESULTS & EVALUATION

To estimate the efficiency of our proposed AOMDV-FFLB protocol, we created a wireless ad-hoc networks which consists of 40 mobile nodes using NS-2 software. We compared the performance of AOMDV-FFLB with AOMDV-FF only based upon Packet Delivery Ratio, End-to-End Delay, Throughput, Energy Consumption, Network Lifetime, Routing Overhead Ratio, Data rate, Packet Loss and Node Residual Energy.

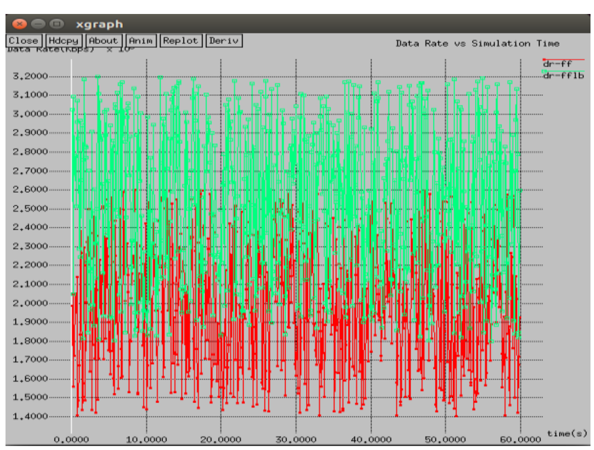

Fig. 2 Comparison of data rate of proposed AOMDV-FFLB with Fitness Function only

By analyzing the above figure, we can clearly find out that the overall data rate in AOMDV-FFLB is significantly higher when compared to the data rate of Fitness Function alone.

Fig. 3 Comparison of End to end delay of proposed AOMDV-FFLB with Fitness Function only

The above figure shows the end to end delay comparison of proposed AOMDV-FFLB with Fitness Function only. It shows that the end to end delay in AOMDV-FFLB was significantly lower when compared with Fitness function alone.

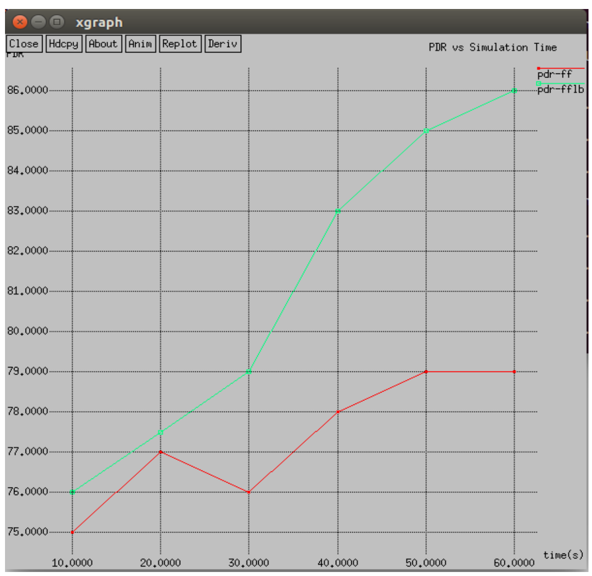

Fig. 4 Comparison of Packet Delivery Ratio of proposed AOMDV-FFLB with Fitness Function only

In figure 4, the Packet delivery ratio was displayed. From this we can find out that our proposed AOMDV-LB outperforms the existing fitness function alone.

Fig. 5 Comparison of overall energy consumption of proposed AOMDV-FFLB with Fitness Function only

By analyzing the above figure, we can clearly find out that the overall energy consumption in AOMDV-FFLB is significantly lower when compared to the energy consumption of Fitness Function alone.

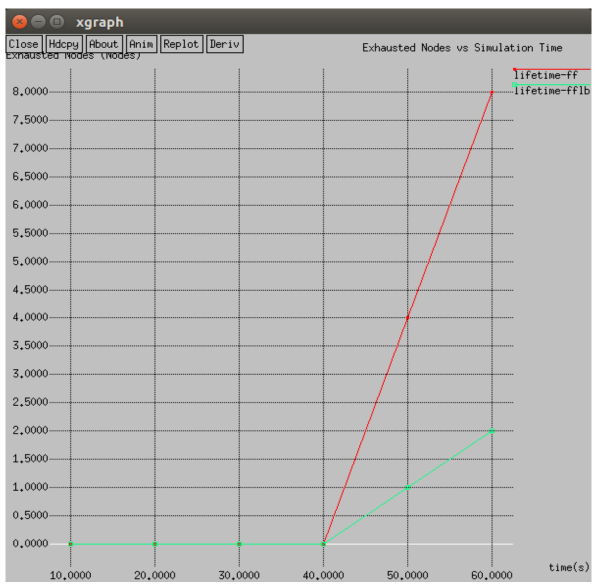

Fig. 6 Comparison of life time of network of proposed AOMDV-FFLB with Fitness Function only

The above figure shows the life time of network comparison of proposed AOMDV-FFLB with Fitness Function only. It shows that the lifetime of network in AOMDV-FFLB was enhanced when compared with Fitness function alone.

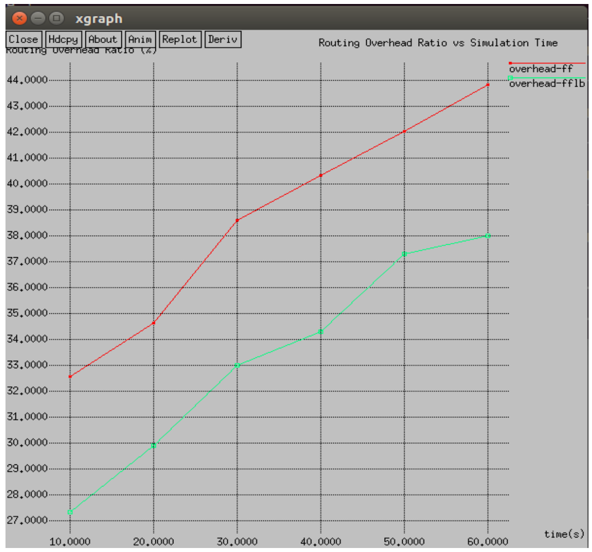

Fig. 7 Comparison of Routing Overhead Ratio of proposed AOMDV-FFLB with Fitness Function only

In figure 4, the Routing overhead ratio was displayed. From this we can find out that our proposed AOMDV-LB outperforms the existing fitness function alone.

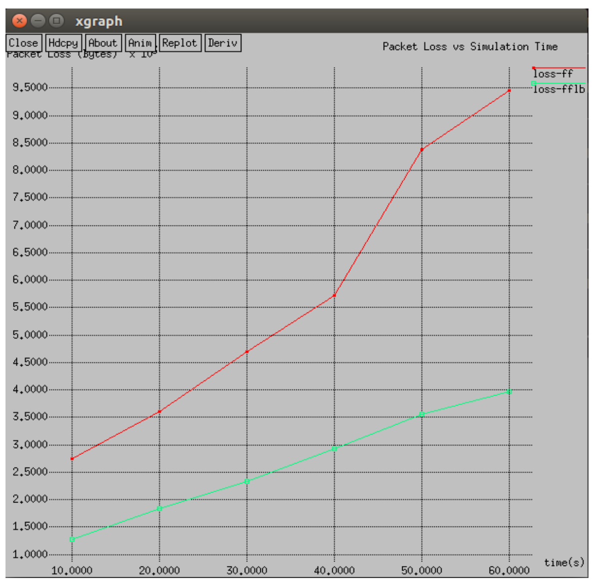

Fig. 8 Comparison of packet loss of proposed AOMDV-FFLB with Fitness Function only

By analyzing the above figure, we can clearly find out that the overall packet loss in AOMDV-FFLB is significantly lower when compared to the packet loss of Fitness Function alone.

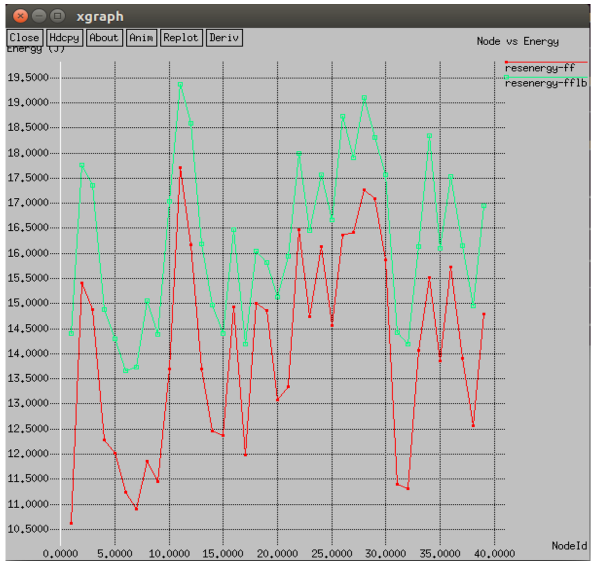

Fig. 9 Comparison of energy consumption of nodes of proposed AOMDV-FFLB with Fitness Function only

The above figure shows the comparison of energy consumption of nodes of proposed AOMDV-FFLB with Fitness Function only. It shows that the energy consumption of nodes in AOMDV-FFLB was lower when compared with Fitness function alone.

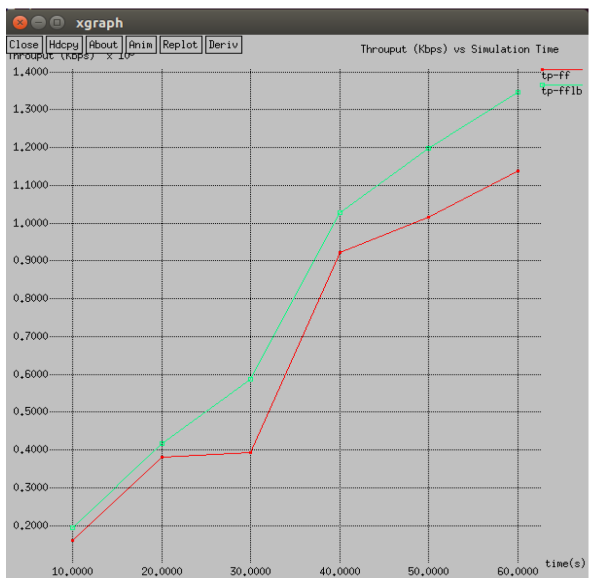

Fig. 10 Comparison of throughput of proposed AOMDV-FFLB with Fitness Function only

In figure 4, the throughput of network was displayed. From this we can find out that our proposed AOMDV-LB outperforms the existing fitness function alone.

V. CONCLUSION

In this research, we implemented a novel energy efficient multipath routing algorithm named AOMDV-FFLB simulated using the software NS-2. The simulation outcome showed that the proposed AOMDV-FFLB algorithm has performed much better than Fitness function without load balance in terms of Packet Delivery Ratio, End-to-End Delay, Throughput, Energy Consumption, Network Lifetime, Routing Overhead Ratio, Data rate, Packet Loss and Node Residual Energy. Also our proposed technique upholds node's transmission on best path and increases the efficiency of network.

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