



An Operative IoT Grounded AEEBLR (Ant-Founded Efficient Energy and Balanced Load Routing) Method for Path Conjunction in Mobile Ad Hoc Networks Approach

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Abstract

An architecture for a wireless network that is constantly developing, decentralized, and multi-hop is called a mobile ad hoc network. MANETs are able to function in many different contexts where regular networks are unable. As can be seen from the advantages listed above, these networks are well-suited for a wide variety of applications, some of which include military and commercial use, as well as applications relating to disaster management, rescue operations, and defense. Energy conservation is a standard factor that indicates the overall network lifetime in mobile ad hoc networks that operate on rechargeable or replaceable battery. This is because usage, battery power consumption in relation to transmission range, type of application running on each device, location, and other influences all play a part in determining the overall network lifetime. An earlier study used a method called ant colony optimization, which is a form of swarm intelligence enthused by the activity of foraging ants in colonies. The best possible travel plan was found using this strategy. Current MANETS routing systems face difficulties in load balancing and energy efficiency that must be overcome if optimal path convergence is to be achieved. When deciding on the next hop node, the IoT based AEEBLR method is recommended. The latency, energy consumption, congestion, and connection quality are all taken into account before making a final decision. The likelihood of selecting the next-hop node as the neighbor node is determined using these metrics. It is the following hop's probability that determines which ant agent goes forward and which goes backward. This paves the door for the creation of many paths, from which the most effective might be chosen for transmission. The results of the implementation show that the suggested AEEBLR technique outperforms the existing AESR approach when the number of packets, the number of nodes, and the mobility of nodes are all varied.

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1. Introduction

A MANET (Mobile Ad Hoc Network) is a assortment of mobile nodes that utilities as a impermanent system without a central management. Due to the constrained communication radius, nodes in an ad hoc network can function as both hosts and routers, and each node asks its neighbour node for assistance in forwarding messages. The use of MANETs is widespread in a variety of industries, including conferencing,

emergency response, disaster management, and the military [1]. Some operational locations have specific requirements for routing protocols of their own. The changing topology, limited battery life, and bandwidth of MANETs necessitate the use of resource-efficient network operations for routing, multicast address allocation, energy consumption, certification, and authorization. Thus, there is a need for specially designed routing protocols in order to find the best paths between nodes that are more than one hop apart [2].

The balancing of traffic loads and energy consumption are two concerns that are proportionally related. To maintain a balance in traffic, it is best to avoid using the same nodes and pathways. As a result, this enables energy conservation, extending the network's lifespan. Data can be sent from the source node to the destination node over a number of different paths when using a multi-path routing system [3]. Although the higher bandwidth pathways receive more packets, the lower bandwidth paths are blocked. It's known as load balancing. Using the network of connections, the ants assist in properly balancing the loads to identify a few underloaded and overloaded nests. By directly moving between the two nests, the load is transferred from the overloaded to the underloaded nests, preventing a significant amount of information from being transmitted across the network. Hence, load balancing can be accomplished using the ant-based technique [4].

When allocating with dismissed infrastructures links, load balancing might be advantageous. In order to increase throughput and decrease the typical end-to-end delay, the traffic between mobile nodes must be balanced. The control and data plane are parts of the reasoning [5-7]. The suggested technique determines how significantly, in terms of network delay operation, node energy ingestion can be condensed. To make the present network perform best, all inner movements are autonomously mixed in the network surroundings. The chosen weightiness element, however, causes issues for packet forward flow. As a result, AESR performs worse in terms of network interruption and excellence of provision [8-10].

Ad hoc networks experience capacity scalability issues. As the number of nodes in the network increases, specific functions like route finding, encryption, and key exchange procedures will require a large amount of overhead. Scalability now ranks as one of MANETs' most important difficulties and should be taken into justification when deploying MANETs. The occurrence of a multi-hop network architecture that frequently changes due to mobility is one of the crucial properties of MANETs [11]. This increases the difficulty of developing effective routing mechanisms that are necessary to investigate the best communication channels among the nodes. The computation of the routing methods should avoid placing an undue computational or routing burden on mobile devices [12].

Ad hoc network security is one of the major issues that need to be addressed.

- 1) Each authorized node should have access to all of the network's data and services. This is how security services should be designed.
- 2) Communication between two nodes is reliable. Key management, key distribution, and certification processes can all be used to accomplish this.
- 3) The packets can only be created, edited, or deleted by authorized nodes.
- 4) Neither the sender nor the receiver may retract their actions or information [13].

The maximization of battery life and the maximization of network lifespan are two important research areas that are almost identical. Hence, designing an energy-efficient system is a major difficulty for MANETs. Energy-efficient methods must be created so that: 1) The packets are forwarded using the least amount of energy possible, and Optimum pathways are used. 2) Routing overhead is decreased to prevent nodes from acting egotistically as a result of having their energy levels held constant. 3) A routing strategy that reduces lag time, boosts throughput and extends network lifetime is used. 4) A routing policy is adopted that incomes into account the nodes' residual energy for the successful conclusion of packet transfer. 5) Nodes that are inactive or asleep use less energy [14-16].

The outline for the remaining portions of the paper is presented below. In part 2, a brief description of the relevant work is provided, and in section 3, a description is given of the methodology as well as the theoretical foundations of the methods that were utilised. In section 4, both the results of the simulation and an analysis of them are presented. The most significant findings are summed up in the "key findings" section that comes at the end of the research paper.

2. Related Work Done:

Problems with MANET routing can be traced back to the scarcity of available bandwidth and power sources. Limited power at each node increases the likelihood of link failure and retransmission. Data transmission paths are determined, available energy is utilised efficiently, there is no cost to the user, the system may be scaled, and quality of service (QoS) is maintained using energy optimisation algorithms

[17]. Inadequately related monitoring sets were used by a limited group of researchers in their upgraded version of AOCR (Ant-based On-demand Clustering Routing) to bundle the system depending on the maximum node degree or the minimum ID. In order to select the optimal path, AOCR makes use of the natural behaviour of ants while maintaining compliance with QoS standards. Results from simulations indicate a decline in mean delay and a rise in packet delivery rate [18-20]. Each network node's total number of active links is something AESR aspires to reduce. The limitations of the proposed strategy decreased the delay performance of the network [21].

A route maintenance technique was established using the ABEAR, which integrated the route format of reactive appliances and the neighbour preservation of pre-emptive mechanisms [22]. WPAR is made up of several important components that were weighted, such as energy and hop count. WPAR used ACR (Ant Colony Routing), an optimization process with biological inspiration. Grounded on this impression, a movement energy-cognizant technique has been shown to be an opportunity in each node that includes the belongings of movement and energy in ACR. Nonetheless, link failure lowers the packet delivery ratio in every circumstance [23-25].

The study under discussion employed ant colony optimization (ACO), a swarm intelligence technique inspired by the foraging behaviour of ants, to determine the optimal travel path. This method proved effective in achieving the best travel plan by mimicking the natural process of ants laying pheromone trails to guide others. In the realm of Mobile Ad Hoc Networks (MANETs), current routing systems encounter significant challenges related to load balancing and energy efficiency [26]. To address these issues and achieve optimal path convergence, the IoT-based Adaptive Energy Efficient Balanced Load Routing (AEEBLR) method has been proposed. This method evaluates metrics such as latency, energy consumption, congestion, and connection quality to make informed decisions about the next hop node in the network. The selection probability of the next-hop node is influenced by these metrics, guiding the ant agents in their forward and backward movements [27-29]. This mechanism allows for the establishment of multiple potential paths, from which the most efficient one is chosen for data transmission. Comparative implementation results indicate that the AEEBLR method surpasses the performance of the existing Adaptive Energy-efficient Stable Routing (AESR) approach under varying conditions, including different packet numbers, node counts, and node mobility [30-31]. This highlights the efficacy of the AEEBLR technique in enhancing routing efficiency in MANETs by effectively balancing load and conserving energy, thereby paving the way for more reliable and optimized network communication.

3. The Objective Of The Work

- 1) To suggest effective MANET routing optimization algorithms that consider energy consumption.
- 2) To look for methods of network resource conservation.

4. THE PROPOSED WORK:

Load balancing in traffic and energy use are directly proportional. In order to distribute traffic evenly, redundancy in the use of the same nodes and pathways should be minimised. This allows for reduced energy consumption, which in turn extends the service life of the network. While sending data from one node to another, a multi-path routing method allows for more than one possible route to be taken. There is no traffic on the higher-bandwidth paths since the lower-bandwidth ones are inaccessible. The process is known as load balancing.

The ants use their interconnected network to identify a few under loaded and overloaded nests, allowing them to more accurately balance the weights. By executing load transfer between the overloaded and under loaded nests via unmediated transferring between the two nests, a large amount of network traffic can be avoided. Thus, the ant-based approach can be used for the purpose of load balancing. Both the control and data planes are a part of the reasoning. All incoming traffic are aggregated in a way that optimises the current network infrastructure. This causes a drop in A-performance ESR's with respect to latency and QoS in the underlying network. Figure 1 is an early version of the AEEBLR prototype.

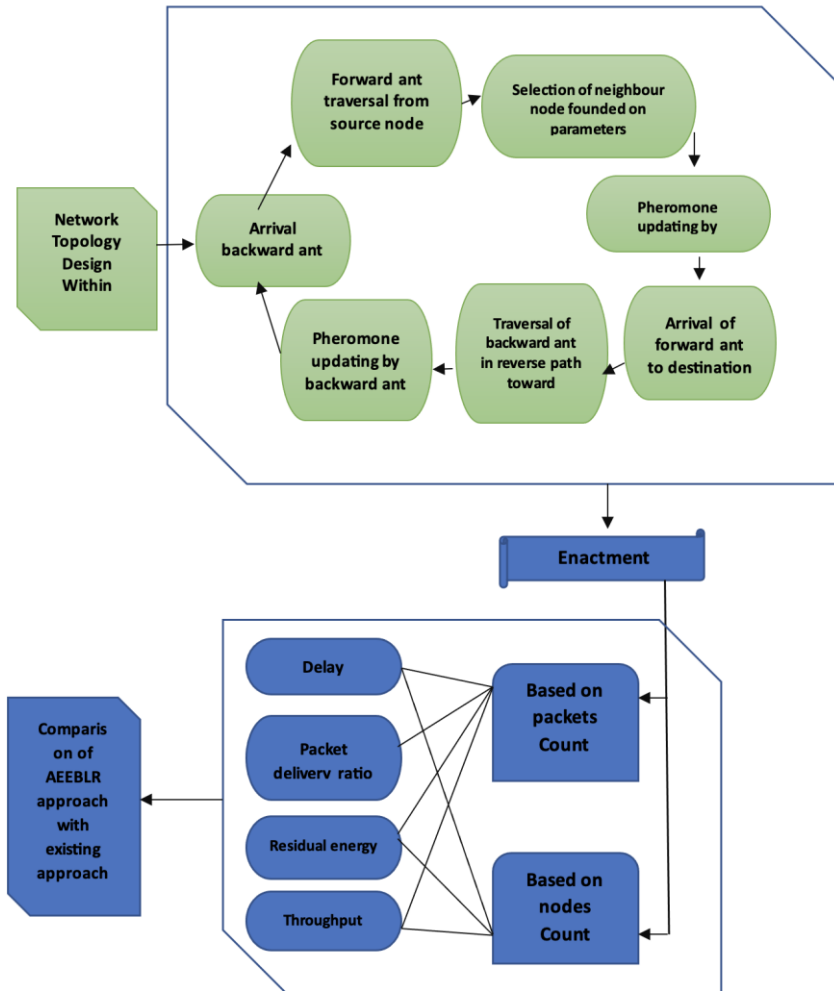


Figure 1: Prototype model of AEEBLR approach.

In this case: Information classification: Low-pass filters reduce high-frequency noise from detection data. The Gaussian filter standard deviation is

$$x(t) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{\infty} x(\tau) e^{-\frac{(t-\tau)^2}{2\sigma^2}} d\tau \quad (1)$$

Where $x(t)$ is the raw sensor data and $x(t)$ is the filtered data.

Laying: Sensor data is normalized using the following method to maintain scale: The formula

$$x_{norm}(t) = \frac{x(t) - \mu}{\sigma} \quad (2)$$

Shows the mean, standard deviation, raw data, and normalized data.

B. Method for deleting traits

Feature extraction is necessary to turn sensor data into identification algorithm-friendly models [20]. These temporal and spectral properties are removed:

MAD (Mean Absolute Deviation): MAD calculates the average deviation of sensor data from its mean as

$$MAD = \frac{1}{N} \sum_{i=1}^N |x_i - \mu| \quad (3)$$

Where N is the number of data points, x_i is each data point, and μ is the mean.

FFT stands for Fast Fourier Transform. The FFT is used to extract the frequency domain representation of sensor data, allowing cyclic patterns to be captured. It is calculated as follows:

$$X(f) = \int_{-\infty}^{\infty} x(t) e^{-j2\pi f t} dt \quad (4)$$

C. Algorithms for Recognizing Activities

We use three unique algorithms for activity recognition:

Algorithm of Random Forests: The Random Forest algorithm is an ensemble approach for improving classification accuracy by combining numerous decision trees. A decision tree's prediction function is stated as:

$$f(x) = \text{majority class in } \{M_1(x), \dots, M_m(x)\} \quad (5)$$

Where $f(x)$ is the expected activity, cm is the m -th tree's output value, and R_m is the region specified by the m -th tree.

Network using Long Short-Term Memory (LSTM): The LSTM is a sort of recurrent neural network that works well with sequential input. The cell dynamics of the LSTM are defined as follows:

$$f_t = \sigma(W_f \cdot [h_{t-1}, x_t] + b_f) \quad (6)$$

$$i_t = \sigma(W_i \cdot [h_{t-1}, x_t] + b_i) \quad (7)$$

$$o_t = \sigma(W_o \cdot [h_{t-1}, x_t] + b_o) \quad (8)$$

$$c \sim t = \tanh(W_c \cdot [h_{t-1}, x_t] + b_c) \quad (9)$$

$$c_t = f_t \cdot c_{t-1} + i_t \cdot c \sim t \quad (10)$$

$$h_t = o_t \cdot \tanh(c_t) \quad (11)$$

Ku-Nearest Neighbours (K-NN): K-NN groups data by proximity. The class with the most members among its k nearest neighbors classifies instance x . As illustrated by the equation

$$y(x) = \operatorname{argmax}_{(i=1 \dots k)} I(y_i), \quad (12)$$

$y(x)$ is the projected activity for instance x , y_i is the neighbor's class name, and k is the number of neighbors. Data transmission using the ACO algorithm. The ant builds a pheromone table with the data from the nodes it visits during its search. Data transfer latency is used as the delay metric. The drain rate and index value are used to determine the energy loss per second. The protocol's workload is distributed in this way. Successful transmission rate is used to calculate a congestion metric and determine the quality of the link, preventing the network from being congested.

Each node in ant colony founded routing will keep a pheromone table in RAM. The basis node initiates the path setup stage, which involves the broadcast of forward ants F_{ant} to identify the track from the source to the terminus node. Depending on whether or not the forward ant has path information, it is either unicast or announcement from separately middle nodule to the final destination nodule.

Tables 1 and 2 detail the forward ant F_{ant} packet format and the reverse ant B_{ant} packet format, respectively. The collection of traversed nodes in the path field is stored in the forward ant F_{ant} . The addresses of all intermediate nodes along the path between the source and the target are stored in the path field. In order to obtain the whole forward ant, destination must wait till time d_t .

Table 1: Packet organization of Forward ant.

Cradle ID	Terminus ID	Sequence Numeral	Hop Numeral	Energy Cesspit Degree	Flinch time	Path Arena	Link Excellence
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Table 2: Packet organization of Backward ant.

Terminus ID	Exclusive Cradle ID	Flinch Time	Recognized Path Arena	Path Predilection Probability
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Several forager ants depart for their predetermined destinations at irregular intervals. The forerunner ant takes information from each node along the path it discovers. At the terminal node, the forward ant transfers its data to the backward ant, which then continues its journey back to the nest. Meanwhile, the lagging node is responsible for the pheromone table and delay statistics for the nodes that have been uncovered.

5. RESULT AND DISCUSSION:

Packet delivery, output, residual energy, and latency are evaluated between the proposed AEEBLR and the ant-based energy saving routing (AESR) method to determine which is more effective. The simulation backgrounds and standards are sketched in Table 3.

Table 3: Simulation Constraints

Parameter	Value
Dimension	1250X1250 sq. m.
Node Count	30-110
Connection Count	25
Source Type	CBR
Transmission assortment	250 m
package Size	512 packets
MAC layer	IEEE 802.11
Degree	250 kb
Primary Energy	10.3 J
Spread Power	0.660

Receipt Power	0.395
Movements	2-10
Speed	10-50

5.1. Throughput refers to the rate at which data is successfully transmitted from the source to the destination in a network. It is typically measured in bits per second (bps) or packets per second (pps). High throughput indicates efficient data transfer and network performance.

5.2. Residual Energy is the remaining energy in a sensor node's battery. It is a critical metric in WSNs, where nodes are usually battery-powered and energy-constrained. Monitoring residual energy helps in optimizing energy consumption and prolonging the network's operational lifetime.

5.3. Ratio of Packet Delivery, also known as Packet Delivery Ratio (PDR), is the ratio of the number of packets successfully received by the destination nodes to the number of packets sent by the source nodes. It is expressed as a percentage and indicates the reliability and efficiency of the network in delivering data. A high PDR means that most of the transmitted packets are reaching their destinations.

5.4. Delay, or End-to-End Delay, refers to the time taken for a data packet to travel from the source node to the destination node across the network. This includes all possible delays caused by route discovery, transmission time, propagation time, and processing time at intermediate nodes. It is usually measured in milliseconds (ms) or seconds (s). Lower delay signifies a faster and more responsive network.

These metrics are crucial for evaluating the performance of WSNs, as they directly impact the network's efficiency, reliability, and longevity.

Table 4: Comparison of Evaluation parameters of AEEBLR with AESR founded on the numeral of packages

Packet Count	Throughput (Bytes/S)		Residual energy (J)		Ratio of packet delivery (%)		Delay (S)	
	AESR	AEEBLR	AESR	AEEBLR	AESR	AEEBLR	AESR	AEEBLR
2	2200	6200	5.8	7.8	75	110	8	1
4	1700	11500	5.9	6.7	35	105	15	4
6	1800	12500	5.7	6.2	30	75	14	5.2
8	3200	13500	5.6	5.6	40	65	13.2	7.1
10	2900	16500	5.7	6.4	35	70	14.3	6.3

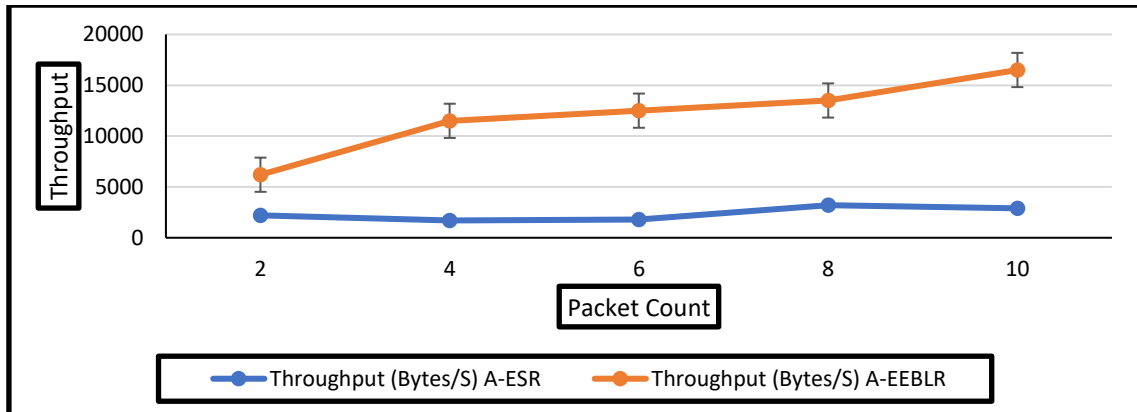


Figure 2: Assessment of throughput of AEEBLR with AESR founded on the numeral of packets

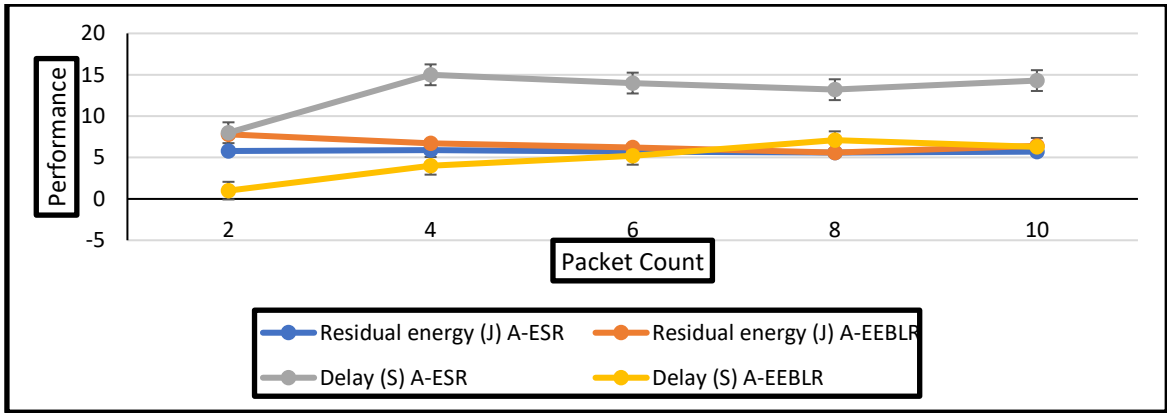


Figure 3: Assessment of Residual energy and Delay of AEEBLR with AESR founded on the numeral of packages

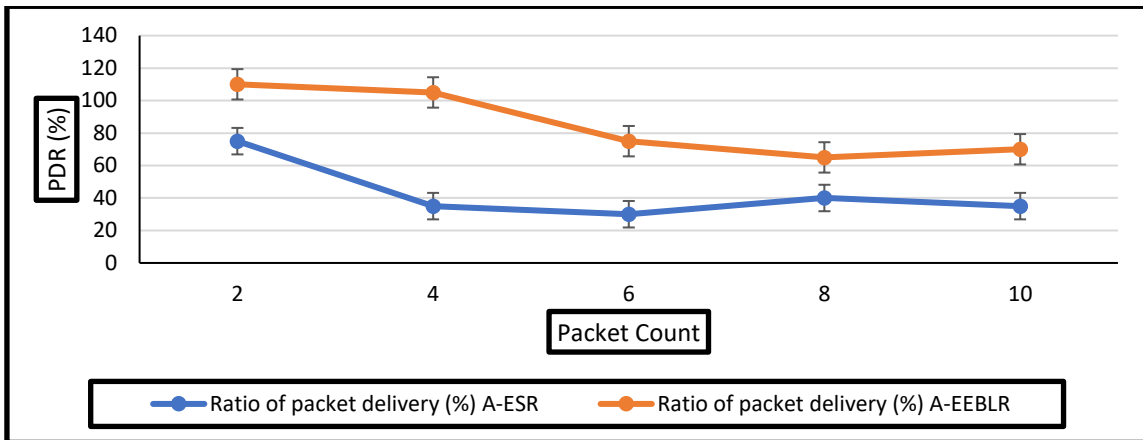


Figure 4: Assessment of PDR (%) of AEEBLR with AESR founded on the numeral of packages

The first experiment tried out four different packet amounts: two, four, six, eight, and ten. Delay for the AEEBLR and AESR techniques under varying packet densities is depicted in Figure 3. Delivery rates for the AEEBLR and AESR techniques are shown for a range of packet densities in Figure 4. The packet delivery ratio of the proposed AEEBLR method is judged to be 73% higher than that of the AESR method. Figure 3 shows the AEEBLR and AESR residual energy for the various packet numbers. Compared to the AESR approach, the residual energy is 14 % more when using the proposed AEEBLR method. In Figure 2, we compare the performance of the AEEBLR and AESR protocols under varying packet-count conditions. Compared to the AESR approach, it can be determined that the output of the proposed AEEBLR method is 85% lower.

Table 5: Assessment of Evaluation constraints of AEEBLR with AESR founded on the numeral of nodes.

Node Count	Throughput (Bytes/S)		Residual energy (J)		Ratio of packet delivery (%)		Delay (S)	
	AESR	AEEBLR	AESR	AEEBLR	AESR	AEEBLR	AESR	AEEBLR
30	3500	4500	8.3	9.2	20	23	22	26
50	3000	8500	6.1	6.3	22	52	25	14
70	2500	6500	5.2	6.1	21	45	16	13
90	2000	10500	5.5	6.4	20	72	15	8
110	1500	10000	6	6.2	21	75	13	7

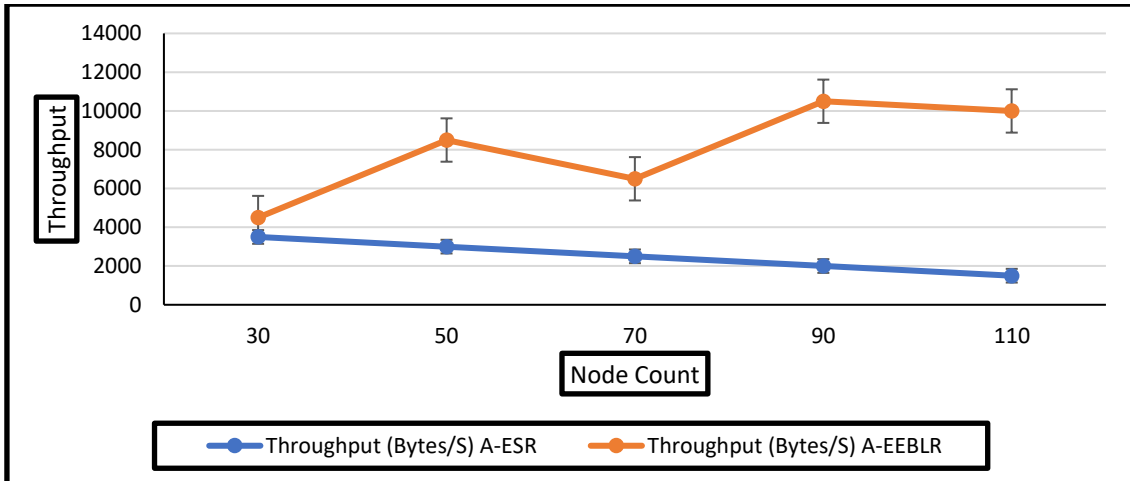


Figure 5: Assessment of throughput of AEEBLR with AESR founded on the numeral of nodes.

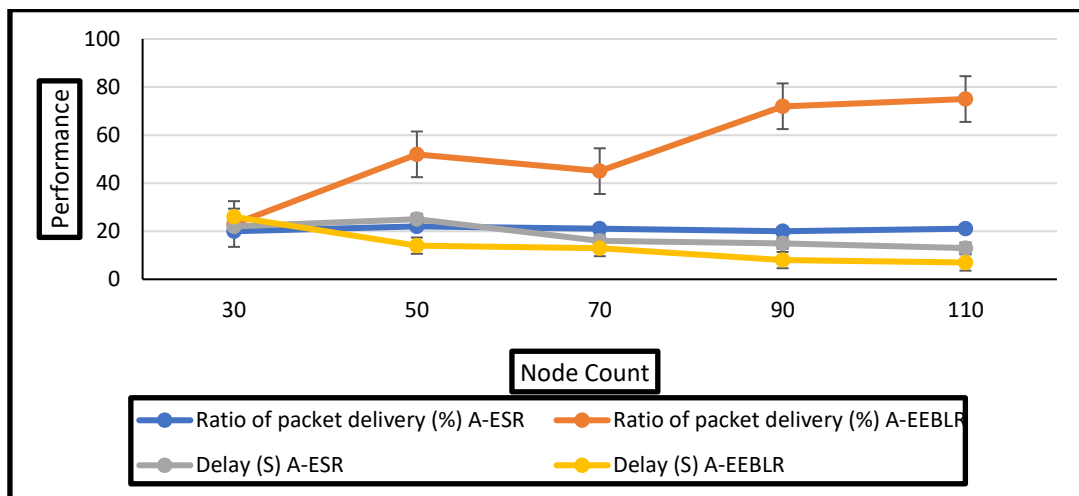


Figure 6: Assessment of PDR (%) and Delay of AEEBLR with AESR founded on the numeral of nodes.

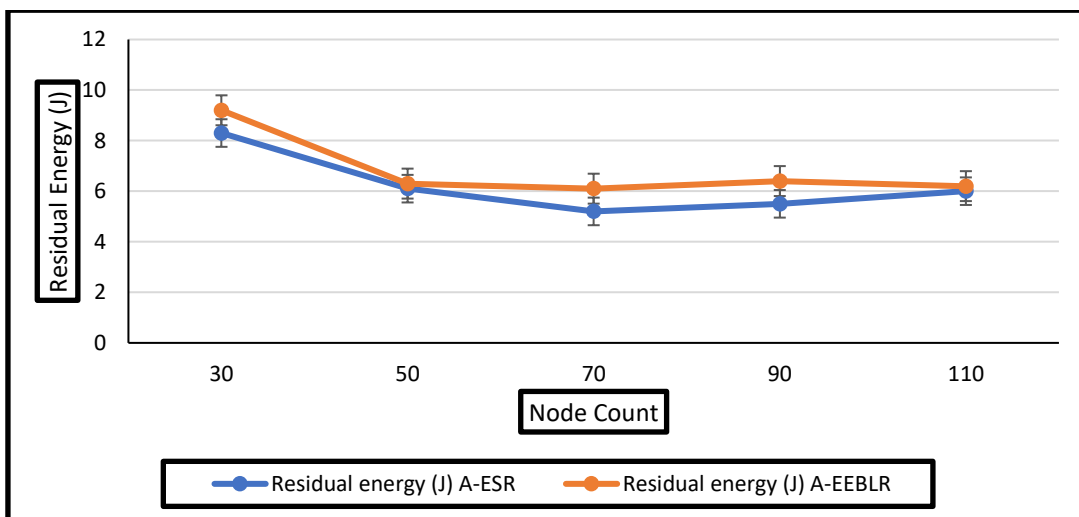


Figure 7: Assessment of Residual Energy of AEEBLR with AESR founded on the numeral of nodes.

After this, experiments were conducted with varying numbers of nodes, including 30, 50, 70, 90, and 110. Figure 6 depicts the delay of the AEEBLR and AESR approaches for the various numbers of nodes. Compared to the AESR approach, the deferral of the proposed AEEBLR method is 39% lower. The ratio of delivery for the AEEBLR and AESR approaches in the case of varying numbers of nodes is shown in Figure 6. It may be deduced that the proposed AEEBLR approach has a 67% higher packet delivery ratio than the AESR method.

Figure 7 depicts the AEEBLR and AESR residual energy for the varying node number case. The proposed AEEBLR methodology is shown to have a 12% higher residual energy than the AESR method. In Figure 5, we compare the throughput of the AEEBLR and AESR approaches under varying node densities. Compared to the AESR method, it can be determined that the output of the proposed AEEBLR method is 72% lower.

6. Conclusion

Cell power is often used by the nodes that make up a MANET. This is due to the fact that the nodes' computing resources are limited by their energy supply. These nodes may be installed in locations that make routine charging difficult, shortening their service life. Because of these restrictions, we've had to come up with new approaches that are effective while still conserving energy. This could potentially reduce bandwidth availability if nodes are unable to sacrifice the power needed to run at full link rate. We used these numbers to figure out how likely it is that we'll choose a surrounding node as our next hop. The purpose of this effort is to maximise energy efficiency and load balancing in a MANET. It has been proposed to use an ant-based energy-efficient and balanced-load routing approach. By altering the number of nodes, the degree to which each node is mobile, and the rate at which packets are transmitted, a comparison was made between the AEEBLR technique and other ant-based systems. The AEEBLR technique increases both throughput and the proportion of successfully delivered packets. When compared to other approaches, AEEBLR shortens transmission times and uses less power at each node. More experiments with real-time analysis of the discussed approach are planned for the future.

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