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Energy-Efficient Routing Over Mobile Ad-Hoc Networks Model and Protocol

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Abstract
This study explores the integration of Mobile Ad-hoc Networks (MANETs) and Wireless Sensor Networks (WSNs) within the Internet of Things (IoT) framework. It addresses challenges in energy optimization and routing by using clustering techniques like LEACH to improve network efficiency and longevity. Gateways connect the MANET-WSN clusters to the Internet, enabling real-time data collection and cloud storage. The work focuses on selecting optimal routes based on energy use, reliability, and hop count, enhancing communication in dynamic, resource-constrained environments. This review covers routing protocols improving MANET and IoT efficiency through clustering, energy-aware cluster head selection, and trust-based routing. Techniques optimize energy use, reliability, and network longevity but face challenges in load balancing and IoT-specific adaptations. The proposed approach combines clustering with trust-route selection to enhance energy efficiency and stable communication.
This study evaluates network performance based on total message transmission time, prioritizing paths with the fewest hops and shortest delays. The proposed method improves data throughput and channel efficiency significantly compared to existing techniques like EECHS-ISSA-DE and Butterfly and Ant, which suffer from node transmission losses and reduced performance. The new strategy extends network lifetime by up to 6800 cycles and achieves 75% higher average capacity and 12.2% overall performance improvement over EECHS-ISSA-DE.

Keywords: MANET, IoT, WSN, EECHS.

1. Introduction

The Mobile Ad-hoc Network (MANET) nodes are a collection of self-organizing mobile nodes that are placed arbitrarily and without following any predetermined patterns. In the case of unavailability of a router or other data transmission device, these mobile nodes adhere to adhoc modelling. centralised technology. For the purpose of detecting terrestrial irregularities like seismic events, forest fires, and other natural calamities, MANETs are frequently used. In order to detect remarkable natural objects, MANETs are often installed with a large number of adhoc nodes to cover a wide variety of geographic locations. The Internet of Things (IoT) is seen in this context as a decentralised MANET ecosystem[1]. IoT base, or any computing node (cloud system) placed outside the local network domain, is necessary to take MANET data into the internet domain. Similar to this, a WSN is a form of network that has homogenous core components and resource-constrained sensor nodes. In this study, WSN sensor nodes are more energy-limited than MANET nodes. In addition, a gateway node is required for sensor nodes installed in a WSN context to connect to the outside network.

When MANET and WSN are combined in an IoT setting, different network characteristics result. Energy optimizations as well as routing protocol optimization are difficult issues in this setting. This effort attempts to resolve this difficult research challenge. The MANET topology fluctuates between several nodes in a dynamic manner. A path from the beginning to the end is provided by the routing protocols[2]. A variety of networking attacks are simultaneously degrading system performance and lowering the rate at which packets are transmitted from sender to recipient. The trust route approach may be used to resolve this sort of issue. The route discovery procedure is first used to determine which routes are open. With the aid of optimization procedures, the finest and most reliable route is finally chosen among those that are offered. The wireless media connects geographically separated WSN nodes. The sensors gather information from the outside world and send it to a centralised place. The IoT grid's nodes are able to gather, manage, and keep track of climate data including temperature, forecasts, recognition algorithms, gas leaks, etc. The information gathered is analysed and saved in the cloud service in an IoT context. Although the WSN has more detectors than the MANET, the MANET holds more data. WSN sensor nodes are static in number, and they use fewer resources than MANET nodes. In comparison, MANET has greater node mobility than WSN. The MANET uses a variety of energy-saving routing methods to improve power usage and lengthen network lifetime. The MANET is a unique network that has high scalability and uses less energy[3].

Via the gateway node, the MANET links the nodes to the Internet. As a link, the gateway node joins the MANET node to the World Wide Web. The gateway network is intrinsically linked to the source MANET node or is supported in this connection by the neighbouring node. The MANET routing protocol and DNS server are used by the gateway node to interconnect the various network. The target node in this study collects information about the sensor nodes' location, motion rate (meters/second), and ip address. WSN, MANET, and the Internet are used to establish IoT connectivity in this case[4]. As a result, this type of network is shown as being diverse. The origin sensor nodes pick up the real-time data and send it in a multi-hop manner to the receivers. The MANET is created using the clustering approach. The cluster node minimises power consumption during data transmission and reception. In the process of getting to the internet server point, the information is finally passed to the gateway node. A cloud connection exists to the gateway node, and the cloud system gathers and uses the information.

Following circumstances are taken into account:

1. Cluster Network: In the MANET, several sensor nodes are linked together as a cluster.

By a chosen cluster head, every cluster is connected to the others.

2. Routing Protocol: In order to find the shortest distance between sensors and the gateway node, MANET takes into account an efficient routing procedure.

3. Internet and IoT: Information gathered from different nodes is kept on an internet cloud server.

In our modern age, the IoT is a relatively new technology that is used extensively. Open wireless networks typically have weak security and require greater resources to detect data and transfer it to the closest gateway. Safe internet protocol features and transport layer features are used in current works created for data transfer over wireless networks[5]. This network is referred to as a cluster network because nearby sensor nodes are brought together by a single MANET node to create a compact group. MANET nodes serve as cluster heads (CH) in the cluster by relaying data between the sensors. The

longevity of the sensor node is being extended by this cluster creation, which is lowering the bandwidth use rate. In MANET, clusters are typically established to arrange the topology quickly. In this way, modern methodologies make advantage of numerous energy-efficient clustering strategies to enhance routing protocol performance. In terms of the scope, LEACH is an established clustering technique for selecting the cluster heads according to the most effective resource - constrained devices. In a network architecture that is built on trees (hierarchical), Low Energy Adaptive Clustered Hierarchy (LEACH) is a cluster creation technique. Particularly, mobile node and sensor node clusters form underneath the base station (centralized control centre) [6]. The network design is layered and is provided by clusters of nodes underneath each base station. Via a centralised base station, the Iot gateway of cluster nodes may connect with several other cluster nodes (control unit). In this situation, cluster heads can connect to the ground station to transmit the data. Similar to this, a number of research studies have made major mention of the real-time difficulties and flat topologies in building MANET clusters. For the dispersed scenario, flat network clusters can be established as opposed to top - down IoT structures. Specifically, flat networks use a number of gateway nodes to gather data from field nodes via cluster heads.
Every cluster deploys the selected gateway nodes. Using this approach, cluster heads and other cluster units that are located closer to neighbouring clusters' access points can interact with one another. So every cluster head has a device like this one that lowers energy overhead. Consequently, in IoT contexts, the proper development of clusters has a serious influence on energy-efficient data transfer (flat networks as well as hierarchical) [7]. Nodes with wireless sensors and MANET mobile nodes online are used to generate the virtual environment (cloud network). Mobile Ad-hoc nodes combine the Sensor nodes into smaller groups called clusters. When the energy levels have been verified, nodes are allocated as CH to command the sensor nodes. The MANET cluster as well as on-demand routing is used to find the paths from the sensor input to the gateway node. The energy consumption of the entire route, the travel time to the endpoint, and the least number of hops are used to determine the optimum route. Using node activation energy, IoT communication is stabilized using this way over an extended length of time[8].

Literature survey

A brand-new routing protocol to boost the efficiency of MANET and IoT settings has been proposed. In this part, the currently used methods are contrasted. The approaches now in use are compared in this chapter. To detect fusion nodes in a single topology, the DCNI technique manages the constantly shifting configuration. The DCNI's data help to identify the key nodes and outcomes with higher quality and more sophisticated timeframes[9]. Nevertheless, the DCNI method and the performance of MANET systems in IoT were only evaluated using straightforward DOS assaults. This is a fundamental MANET using an established IoT method. Programmers are used in this technology to manage the MANET, while some networks have a little more end devices. The power control techniques that maximise the efficiency of MANETs are implemented using the Dynamic Range Clustering (DRC) approach with learning-based routing system. This tactic enhances the handling of packet headers and energy. Using separate peers for learning-based routing, the cluster has improved system reliability and made non-congested advanced analytics at different network flow rates possible. The dynamic topology is increasing the latency of the LR approach[10]. As a multicharacteristics framework, a new multi-objective approach in a hybrid system is proposed. Throughput, energy use, packet delivery ratio, the number of node density across more cycles, and system longevity are all improved by this technique.

The network builds the routing path and sends the information coming from the source node towards the member nodes using a variety of network characteristics. Massive routing networks, nevertheless, in this scenario have low failover clustering and high delay times. The author developed the Energy Efficient Cluster Head Selection Employing Upgraded Sparrow Search Algorithm (EECHS- ISSA-DE) technique to escape the trap of becoming caught in local optima. This method selects CH based on leftover energy. Stability is strong despite the uneven distribution of the CH[10]. The overlap and CH selection processes are improved, and the outcomes for handling large volumes of data are faster. Nonetheless, this strategy's depth and connection are essential. The Butterfly and Ant method is recommended in WSN. Route creation and choosing the ideal CH are difficult jobs in WSN. The route is determined by the energy of the nodes, their separation among themselves and from the central node, as well as their degree. The localized base station as well as the global distribution simulation findings is considered in this technique.

A new variant of the Bellman-Ford algorithm has also been suggested by many authors for selecting the best power-saving nodes[12]. Several networks, both dynamic as well as static, were used to test this technique. According to this system, the stable network offered accuracy ranging from 34 to 48 percent while the dynamic network offered efficiency gains ranging from 35 to 42 percent. Yet, we discovered that the network's scope affects how much energy is conserved. Routing protocols also play a significant part in power-saving strategies. The Energy Efficient AODV (EE-AODV) in Mobile Ad-hoc Network has enhanced the amount of energy of the networks in contrast to Energy Quantized (EQ-AODV) routing protocols and Adhoc On-Demand Routing Protocol (AODV)[13]. The researchers presented a unique EED algorithmic technique and want to employ a biological algorithm to improve the linkages in their later work because the bonds in this method are less durable. The authors estimated an ideal load transfer routing mechanism using two factors, like hop count or residual node energy. This work anticipated results like ideal energy use, the highest packet delivery ratio, and the longest network lifetime. Nevertheless, this approach did not take into account IoT and instead created a load-balancing routing mechanism to the MANET[14]. To improve network efficiency, MANET and IoT networks with energy efficiency improvement protocols are recommended. The sensor cluster energy level is also used by the enhanced cluster technique for a communication system to choose the path. The little capacity of a network node uses more battery energy than the enormous network in its entirety due to improper load balancing.

Similar findings have been made about the cluster approach's energy conservation and safe weight when WSN and MANET are coupled. The cluster-weighted quantities from the origins towards the destination in this study serve as a representation of all paths' costs. In MANET, the energy, location, accessibility, and delay of each node are used to establish the dynamic architecture using the dynamic genetic algorithm. The precision of a wide network is, nevertheless, poorer. Using a number of strategies, including remaining energy calculations and clustering approaches, the previously discussed current methodology has enhanced system performance. It has additionally optimised link failures, enhanced bandwidth, ratio of packet delivery, node density and duration. Moreover, a high-performing, low-cost diverse network has been created. The level of service has reduced due to the fact that each author in this technique concentrates on a different attribute. To enhance the network's efficiency, the existing studies combine heterogeneous networks with various methods, such as cluster generation and evolutionary algorithms[15]. The current effort, though, has fallen short of expectations. In this concept, clustering as well as a trust route selection approach are used to increase the energy efficiency of network nodes.

Applying cluster approaches, the network's nodes become separated into manageable chunks. Mobile ad hoc nodes plus sensors make up the cluster nodes. Connected to nearby mobile ad hoc nodes are the sensors. The mobile ad hoc node would otherwise function as a neighboring node between the sensor (origin) and destination. The node's remaining energy chooses the CH again[16]. The procedure of route discovery involves choosing the many paths from the beginning to the end. The total amount of energy used by the nodes as well as the duration between the source and the destination, though, are used to determine the most reliable and efficient path.

The Measurement Tools of Network Topology

The system effect's vast scale is managed by clustering methods, which also regulate flow and raise each node's energy density. An appropriate algorithm may quickly identify defective nodes in a cluster to replace them on their own. The graphical approach C (n, p) is shown in the cluster network. P is the total power used to transport the signal from node a to node b and a,b ∊ N. Here, N represents the total amount of nodes in the cluster. The remaining power of the node P_{ra} is used to assess CH energy. From the node's total energy to its consumed energy, the remaining power P_{ra} is determined. The length Lab is the amount of time needed to deliver every packet from point a to point b at the same speed. P_s, the amount of power needed to transmit a single signal, and S_n, the overall number of signals.

$$PCH = P_{ra} / \sum n\ a{=}1\ ((L_{ab} + (P_s \times S_n))$$

The packet of data is considerably noticed in the network as it moves from one sensor node to another. Especially, the quantity of information transported between both the source and destination inside a second is used to assess the channel's data throughput. Based on the node's status, the time is taken into account. The node eventually behaves as though it is active, standby, and inactive. The entire period is referred to as:

$$T_{Total} = T_{Active} + T_{Dormant} + T_{inactive}$$

Nodes begin transferring and receiving packets more quickly in active mode. Nevertheless, few nodes go into standby mode due to a lack of energy, while some nodes behave in an inactive state. The signal transfer and reception process requires a little bit extra time. The sender-to-receiver channel's overall frequency and the channel's overall node count are used to calculate the active time:

$$T_{Active} = \sum n\ 1F_{ab} / N_{ab}$$

The routing protocol takes length into account heavily; a smaller length expedites the delivery of data to its target. The length in this research is determined by adding the length between neighbouring nodes from a to b and the packet's entire transmission and reception times. The capacity of the route to carry the data is known as the frequency.

$$L_{ab} = \sum b\ i{=}1\ L_{ab}\text{per Seconds } (T_{Total}\ (\text{Sec}) \times 1\ \text{min} / 60\ \text{Seconds})$$

$$P_T = \sum n\ r{=}1\ (P_{CH} + P_{MANET})$$

The power of the cluster network as well as the leftover energy of the MANET route are added together to get the network's overall remaining power where PCH is the CH residual energy and r is the path between the sender and the one receiving it. By adding the power levels of the nearby links, the MANET computed the route's leftover power.

The energy level of each link is calculated from the residual energy of the packet sent and received. On each route found in MANET, the number of hops from the origin sensor node to the target sensor node is assessed. From the source to the endpoint, the number of hops is calculated between the neighbouring consecutive nodes. Information about sequential counts is gathered throughout the route finding phase.

Many paths to the gateway node found in any of the routing protocol are provided by various kinds of routing protocol. Yet, the trustworthy route (Rt) delivers a long lifespan, shorter lag time, fewer packet drop, and improved network speed. The remaining power output of the node, length Lab, and number of hops are used in this study to assess the MANET-optimized power effecient routing method for the Internet of Things.

Proposed work of MANET-ESO in IOT

In the Internet of Things, the MANET uses the recommended method of MANET-ESO, which boosts the level of credibility and subsequent message transfer among sensor nodes. WSN technologies with internet connectivity make up the Internet of Things. Advanced network systems are expanding the electronics industry's global online community[17]. The Internet of Things sensors are collecting physical happenings and converting them into virtual information over the course of time. However, because sensor nodes are unpredictable, IoT data transfer latency and power consumption continue to rise. In Fig.1, the suggested model maximises efficiency and decreases energy considerations. Using trust and the optimum route optimization technique, this MANET algorithm has increased network throughput. The nearby mobile nodes have links to several sensor nodes. With the channel's high sensor concentration, mobile nodes have been creating the cluster.

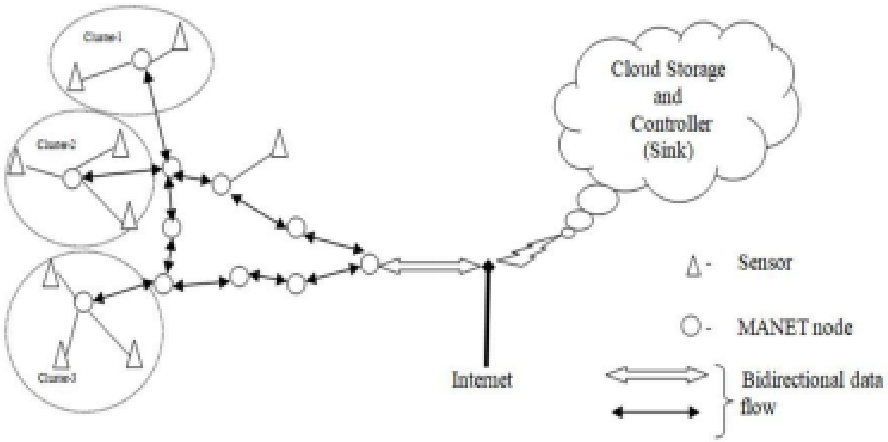

Fig-1 Heterogeneous Network Constructed by Sensor, MANET and Cloud storage through the Internet.

The CH manages, observes, and gathers sensor information. Regarding the length between the sensor and the mobile node and thus the power level of the mobile node, the CH is forever evolving in the channel. Via the CH node, neighbouring nodes, and gateway nodes in the MANET, the data is connected to the gateway node utilising the online cloud service. Energy is maximised and trustworthy route pathways are enabled by the route defined in MANET.

The MANET also uses the Internet connection to communicate with and send orders, as well as to transfer and process information. As a result, a hybrid network is developed to transmit or receive data across the cloud systems (across gateways) across the internet and MANET. The gateway nodes have established a connection between the cloud routing protocol and the MANET.

In this scenario, employing MANET-ESO, the channel's total efficiency is greater than a straightforward Iot environment with the highest efficiency parameters (bandwidth, power, latency, ratio of packet delivery, and routing overhead).

Algorithm

Initialized: Simulation area considered with S_n—number of sensor nodes

CH—Cluster Head

M_n—number of mobile nodes

GW—Gate Way nodes

P_r—remaining power of CH

r = number of discovered routes

P_t = Total remaining power of the node

P_{th} = Power Threshold Level

P_{min} = Route total Energy threshold level

L_{ab} = length between sensor nodes

H_p = destination sequential count

If M_n is in direct contact with more than one number of S_n, //cluster head selection

Then, M_n = CH

else,

M_n- act as a neighbor node in the channel

End if

if M_n is connected to Internet service, // gateway node identification

Then, M_n = GW

else,

M_n–act as an neighbor node in the channel

End if

if P_{CH}>= P_{th}, // CH is reelected by power level of the node

Then, retained as a CH

else,

CH is re-elected

End if

ri=1 // all discovered routes are being checked

While ri $\leq$ r

Power = P_t

Length = L_{ab}

Hop Count = HP

If $P_t \leq P_{min}$ then

If $L_{ab} \leq$ Threshold-D, then

If H_p < Threshold–H, Then

r_i = Trusted //All the conditions are satisfied then

// act as trusted route

else

ri = ri++

Repeat the Trust condition

End while;

Simulation and Result of MANET-ESO in IoT Techniques

Ns-3 was used on the Ubuntu 20 platform to emulate MANET-ESO utilising IoT techniques. An internet-connected wireless sensor network, cloud, and MANET are all taken into account in the testing arrangement. The model size is thought to be 1500 m^2 due to the channel's complexity and 3 distinct network protocols. The channel's mobile nodes are all assumed to have the same quantity of storage and random mobility. As a result, CH in the MANET node is linked to additional sensor nodes. Table 1 displays the simulator settings that were taken into account. Internet Gateway nodes are used to achieve this circumstance. The IoT devices are positioned on the left side of the communication range, the gateway node is positioned in the centre of the right side, and MANET nodes are positioned in various locations between the sensor and gateway nodes[19]. Each node that makes up a network has its inclination and rotation changed dynamically. The dynamic routing tools, node mobility, infrastructure organizational design, and transportation control designs generate an actual channel in a simulated environment. The arbitrary packet transmission technique was developed with a Poisson traffic model, as shown in table 1. Depending on the kind of endpoints in the IoT ecosystem, the quantity of the packets created by the modelling techniques range from 500 bits to 1500 bits (sensor nodes or mobile adhoc). In contrast to mobile adhoc nodes, sensor networks typically produce signals of a small size. Corresponding to this, the mobility model's probabilistic graphical processes have been set up to enable mobile adhoc nodes to travel independently at different speeds (meters/seconds). Moreover, the frequency-time allotment concepts form the foundation of the channel allocation models utilised in 802.11 contexts. In a ns-3 simulation platform, the uniform bandwidths for the Internet of Things is set up as shown in Table 2. In this Internet of Things environment, a composite architecture that combines mesh and star topologies is used. The ns3 structure has been set up with star topology to coordinate managing greater cloud based touch points with several other regional locations. Mobile ad hoc nodes as well as sensor network are used with grid architecture at the lesser level since they are actively interacting for signal transmission. Throughout this experiment, the dual-topology approach is regarded as the best option for building the full IoT environment. In any case, the random packet dispersal algorithms used by the mobile sensor nodes are centered on their first and last power values.

Table 1 Simulation parameters

Parameters	**Values**
Field Area	1500 × 1500 m2
Number of sensors nodes	50
Number of Mobile nodes	100
Percentage of cluster head	10%
Radio Propagation model	Free space
Mini. And Max Position of 5G BS	[0, 200]
Antenna Model	Omni directional Antenna

Initial Energy of the sensor node	0.5 Jules
Packet Size	500–1500 bits
MAC	802.11
Packet Scheduling Model	802.11
Mobility model	Random way
Traffic generation Mode	Random Poisson Traffic Model
Initial Energy of the mobile adhoc node	1.25 Joules
Wireless Channel Allocation Models	Frequency and Time Division Model
Node’s mobility	10, 15, 20, 25 and 30 m/s (Variable)
IoT Frequency Band	2.4–5 GHz
Proposed Method	MANET-ESO
Adhoc Routing Protocol	AODV
Simulation Tool	Network Simulator (NS-3)

The suggested system's components, current methods (EECHS-ISSA DE, Butterfly, and Ant), and channel features are all included in the ns-3 model testbed's analysis part. The nodes in the Iot ecosystem have performed process 2 in the modeled network environment (Table 1). Parallel to this, the test data are evaluated independently using EECHSISSA DE, Butterfly, and Ant. distributed LEACH protocol, Adhoc On-Demand Routing Protocol (AODV), energy patterns and random Poisson event procedures are the technologies and traffic models employed in the study. Specifications including the amount of operational nodes, bandwidth rate, remaining energy, packet transmission percentage, and average routing latency are computed using this research testing ground. The aforementioned metrics are determined by repeatedly changing network variables such node count, assessment round count, and suspect node count. C++ packages have been used to build the recommended ns-3 simulation environment (Initial network deployment). Moreover, Python programmes are utilised to import the traffic patterns and routing protocol built - in functions.

Results and Analysis in Terms of Node Alive Node vs. Number of Rounds

The cluster life time of MANET-ESO is contrasted with current methods as the EECHS-ISSA DE and Butterfly and Ant technique when employing IoT technologies. Figure 2 shows how the suggested algorithm and the current algorithm were tested in the ns-3 simulator utilising 50 sensor nodes, 100 MANET nodes, and one iot gateway. This demonstrates that the amount of living nodes performs superior to the present approach in various numbers of rounds. A WSN built with MANET nodes that

used 10% of networks was evaluated for 1800 cycles without experiencing any dead nodes and performed well.
Nonetheless, the MANET-ESO protocol obtained high alive nodes up to 4500 rounds in comparison to other current methods.

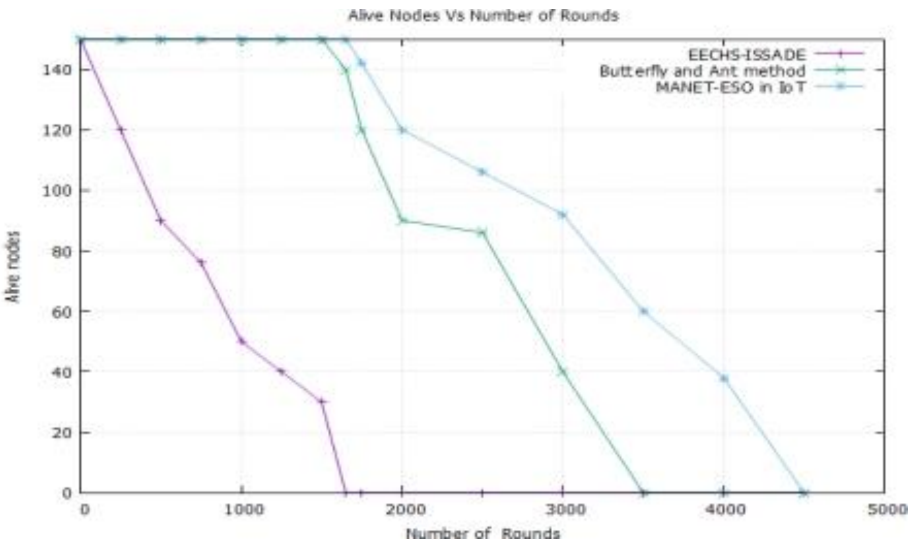

Fig 2. Live nodes vs. number of rounds

The EECHS-ISSA DE methodology employs a clustering strategy to link all the nodes, however finding the best path needs more energy during the cluster head selection phase. Live nodes are therefore restricted after 1800 rounds.
The connection to the BS station is found by two separate methods in the Butterfly and Ant technique. It first creates clusters and finds pathways. Compared to EECHS-ISSA DE techniques, each uses less power. The effectiveness, unfortunately, falls short of the suggested task. The clustering technique in the proposed study reduces the channel's power usage. All of the cluster's nodes are under the cluster head's management. As a result, all nodes save the cluster head are using less power and are becoming more active in the network.

Results and Analysis in Terms of Residual Energy vs. Number of Rounds

The remaining part of the network after 'n' rounds is addressed in this chapter. The outcomes are compared to the current methods. The findings of the suggested approaches are matched to those of the EECHS-ISSA DE as well as Butterfly and Ant method in Figure 3, which illustrates the findings of remaining energy relative to the amount of cycles. The optimum route to reduce the route's remaining energy is calculated and determined using both the cluster energy technique and the MANET trustworthy route technique. The amount of nearby nodes along the path determines how much energy is used overall[20]. When MANET-performance ESO's in the Internet of Things is compared to previous research, it is shown that the EECHS-ISSA DE and Butterfly-Ant approaches waste a substantial amount of power. The Butterfly and Ant technique, which has sustained an amount of energy for as many as 8200 cycles, employs an energetic equilibrium methodology. Last but not least, the recognized path energy efficiency improvement technique selects the optimum route according to the overall power use of the node, minimal length, and lowest number of hops as opposed to the suggested approach. So, as opposed to other techniques, the chosen route requires fewer resources to finish the job and improves signal strength. As opposed to EECHS-ISSA DE and Butterfly and Ant methods, this suggested approach increases the remaining power of nodes by an average of 75% and 7.1%, respectively.

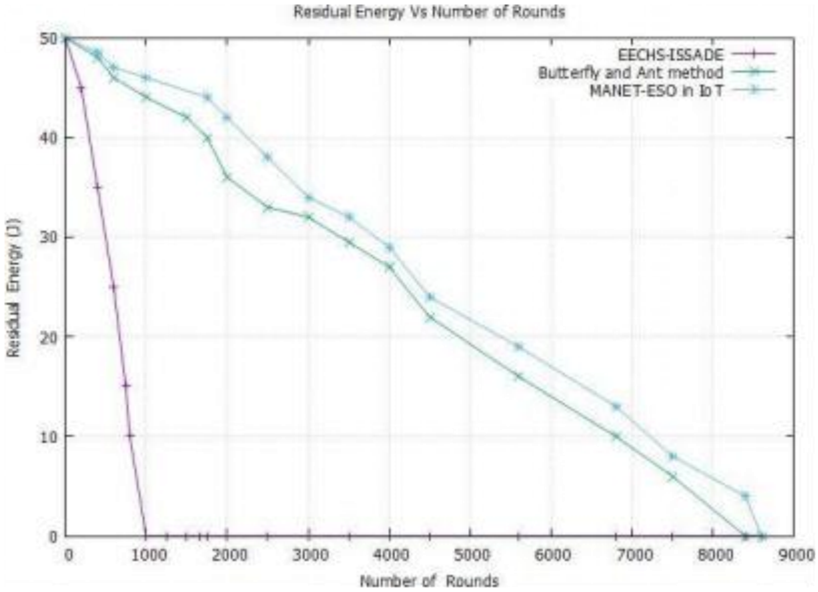

Fig 3 Residual Energy vs. number of rounds.

Results and Analysis in Terms of Throughput vs. Number of Rounds

The entire duration required to carry all messages from the beginning to the end is used to compute performance. This method determines the paths with the fewest hops and the shortest path according to the overall duration required to transmit data. In a shorter amount of time, it is transporting more information. As a result, in comparison to previous work already done, it boosts the channel's performance. Efficiencies are lowered in the EECHS-ISSA DE and Butterfly and Ant techniques owing to node transmission losses. As a consequence, nodes start to die and the channel's performance is reduced. Nonetheless, the suggested strategy has surpassed current studies by up to 6800 cycles in the network. Compared to EECHS-ISSA DE, this approach averages a capacity that is 75% greater and 12.2% higher overall.

Performance Evaluation of Packet Delivery Ratio (PDR) and Routing Overhead

This discussion contrasts the effectiveness of the suggested work in regards to the ratio of packet delivery as well as high latency to that of the EECHS-ISSA DE and Butterfly and Ant techniques. The assessment of the packet delivery ratio with regard to 50, 100, and 150 nodes is shown in Figure 4,5 and 6. When compared to current methods, this one's packet transmission ratio is significant. The channel's clustering technique and trust routing protocol cut down on message delivery latency and expedited package delivery. Therefore, there's a smaller waste compared to various approaches for all signals to reach the target node. In the 50 and 100 node situations, the suggested technique's packet delivery ratio increases by around 8% when compared to EECHS-ISSA DE and by about 4% when opposed to the Butterfly and Ant approach.

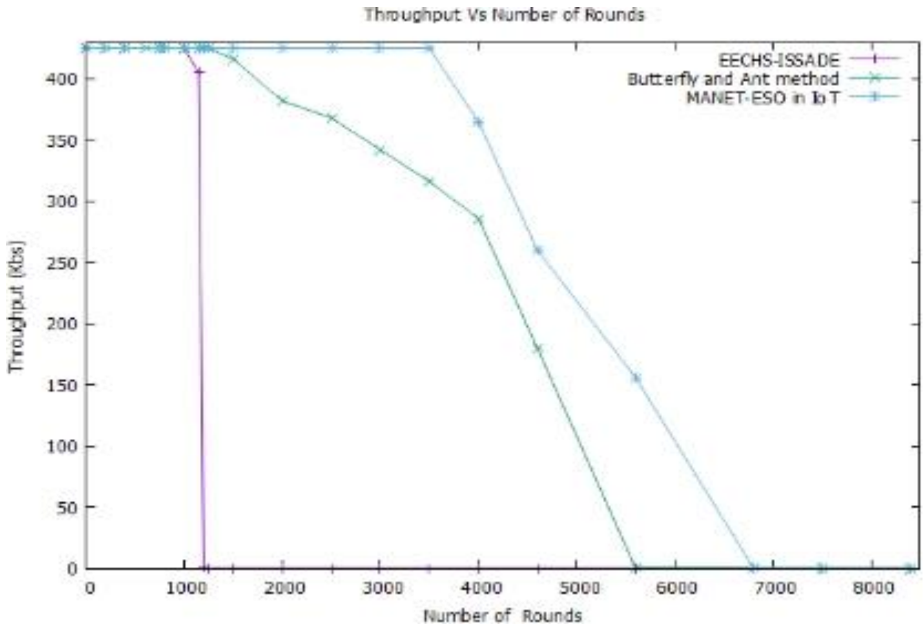

Fig 4. Throughput vs. number of rounds.

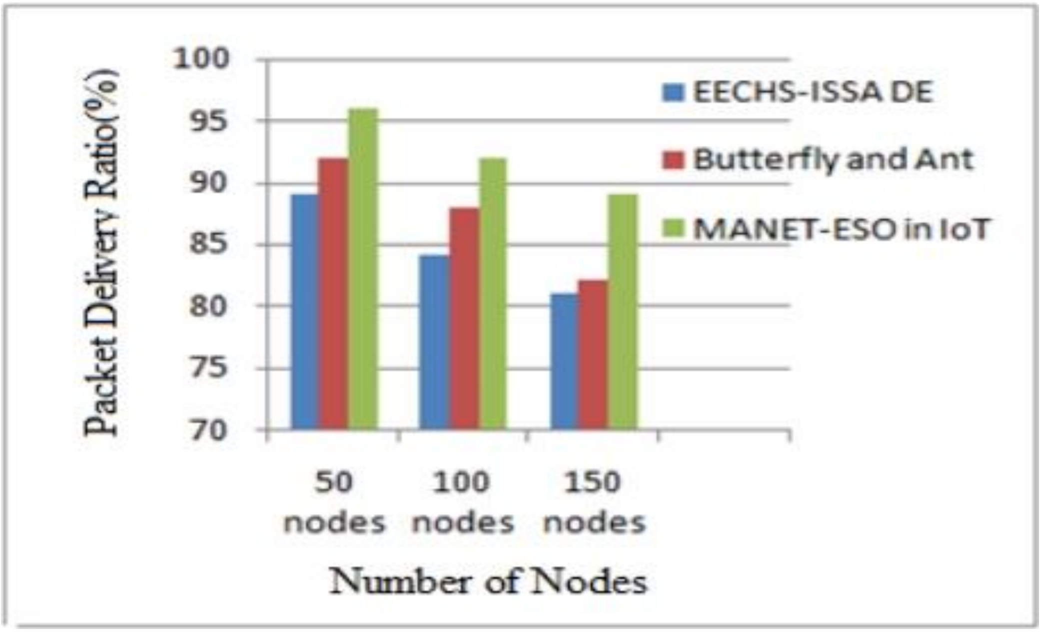

Fig 5. Packet Delivery Ratio vs. Number of Nodes.

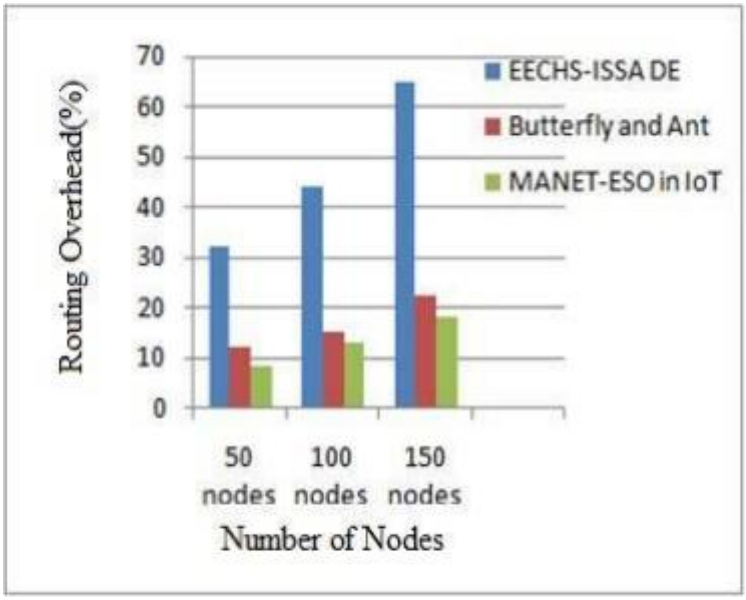

Fig 6. Routing Overhead vs. Number of Nodes.

In comparison to certain other current techniques, the trusted networking approach extends the life of the path and reduces routing overhead. The final value is 71% greater in comparison to EECHS-ISSA DE and 20% better compared to the Butterfly and Ant approach in the simulation experiments compared with 50, 100, and 150 nodes.

Figure 7 compares the MANET-ESO in the IoT system's percentage of packets delivered with that of the EECHS-ISSA DE, Butterfly, and Ant algorithms in terms of the proportion of compromised nodes. The channel now has 10 more faulty nodes, and PDR performance has risen.

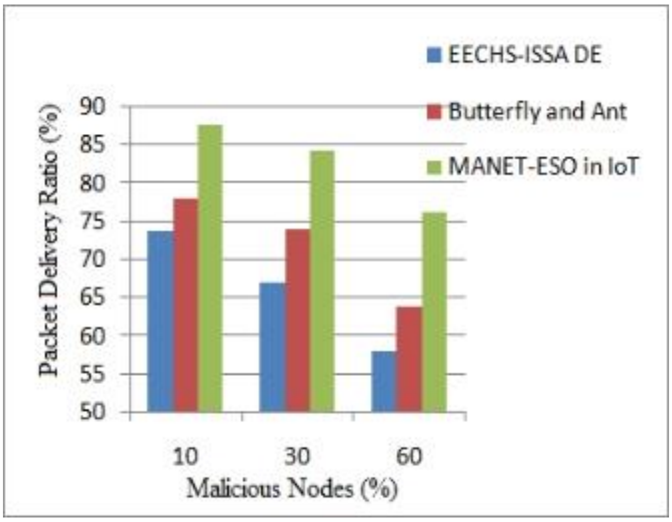

Fig 7. Packet Delivery Ratio vs. Malicious Nodes (%).

Another rise in compromised nodes brings the total to 30% and 60%, correspondingly. The PDR ratio of the suggested method has now decreased as a result of numerous packet losses from the point of origin to the destination.

The outcome of PDR is raised by 14% as opposed to the Butterfly and Ant technique and by 24% as opposed to EECHS-ISSA DE when compared to the currently used methods. Figure 5.8 illustrates how the suggested strategy for routing overhead performs as the amount of harmful nodes in the network rises. Since there is a lot of path breakdown in the channel, the routing inefficiency increases. The optimum path finding method takes longer to finish every packet delivery due to the rise in harmful activity.

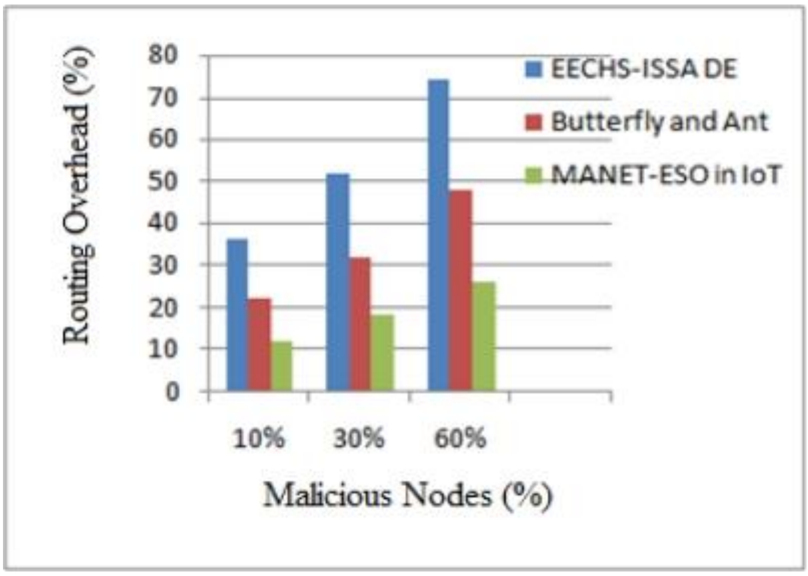

Fig 8. Routing Overhead vs. Malicious Nodes (%).

Conclusion

In the IoT, the suggested MANET-ESO algorithm outperforms the EECHS-ISSA DE algorithm, Butterfly technique, and Ant method in terms of capabilities while consuming less energy per node. A hybrid network system, such as a mix of a WSN, internet cloud network and MANET creates the modelling approach. The clustering technique is used to link the sensor nodes to MANET. The CH has outstanding balance and is coupled to several different sensors. In contrast to prior techniques, the classification technique increased the network nodes' remaining energy. As a result, the channel has more active nodes after further rounds have been completed than with the current approach[21]. Taking into account the overall node energy, the length of the path, and the amount of hops along the path, the trusted path method selects the optimal route out of all identified routes. The suggested technique generated a higher ratio of packets delivered, optimum performance, and little to no transportation cost in both hostile and harmless circumstances. As a consequence, the total outcomes surpass those of the current techniques.

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