Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 28s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Brown Boosted Expectation Maximization Ensemble Node Clustering Based Energy Efficient And Reliable Data Routing In Manet With 5g And Nxtg Technology

Ms. S. Kalaichelvi[1], Dr. K. R. Ananth[2]

[1]Research Scholar, Department of Computer Science, Nandha Arts and Science College (Autonomous), Erode, India.

Email ID: sskalaichelvi06@gmail.com

[2]Associate Professor & Head, Department of Computer Science, Nandha Arts and Science College (Autonomous), Erode, India.

Email ID: sapujaa@gmail.com

Cite this paper as: Ms. S. Kalaichelvi, Dr. K. R. Ananth, (2025) Brown Boosted Expectation Maximization Ensemble Node Clustering Based Energy Efficient And Reliable Data Routing In Manet With 5g And Nxtg Technology. *Journal of Neonatal Surgery*, 14 (28s), 178-189.

ABSTRACT

MANET and fifth-generation mobile network (5G) are attained greater significance in next-generation because of their simplicity and efficiency in handling real problems in diverse applications. The data communication in 5G networks has improved the number of users and the information transmission rate among the nodes in network. Though, the connection among these nodes has to continually renew because of mobility, connection failure, routing overhead and low battery energy. Therefore, it utilizes more energy in searching and connecting the mobile nodes during the process of data routing. Therefore, Brown Boosted Expectation Maximization Ensemble Node Clustering (BBEMENC) Technique is planned in this paper with objective of decreasing the energy employment during the processes of reliable data sharing in MANET using 5G. In the BBEMENC Technique, more numbers of mobile nodes are taken as training samples. Furthermore, Expectation Maximization (EM) clusters are assumed weak clusters. In BBEMENC Technique, EM clusters is applied for grouping all the nodes in network as strong strength or weak node based on their residual energy, trust and bandwidth availability. Subsequently, weak clusters outcomes are united to get strong cluster results where it accurately finds strong strength and weak nodes in MANET. Finally, BBEMENC Technique choose the nearest strong strength nodes as optimal in order to efficiently route the data packets between the source and destination in 5G mobile network. From that, BBEMENC Technique gains a higher routing performance with better packet delivery ratio and latency. The simulation of BBEMENC Technique is done by considering the metrics such as energy utilization, packet delivery ratio, latency and scalability with varying numbers of input mobile nodes and data packets.

Keywords: *Bandwidth Availability, Brown Boosting, Expectation Maximization Cluster, Potential Loss, Residual Energy and Trust*

1. INTRODUCTION

MANET includes of collection of mobile nodes that are linked wirelessly without an assist of any fixed infrastructure. The mobile nodes are rapidly accessed and flexibly organized in network environment and also exposed an increase latent in applications i.e. battlefield monitoring, disaster recovering, emergency treatment, vehicular networking, etc. The performance for MANET have been impacted by their own intrinsic natures i.e. limited available resources, exposed communication medium, intermittent end-to-end links, and frequent changes in topology owing to users' mobility which are all prone to deserve diverse kinds of attacks. Therefore, energy-efficient and secure data communication is key problem to be resolved in MANET. MANET faces a lot of issues in achieving the energy efficiency and security for the routing the information.

In existing, Supervised Vector Machine with BrownBoost Classification (SVM-BBC) was implemented in [1] for accomplishing efficient data communication with lesser time complexity and better delivery rate. However, the trustworthiness of mobile nodes was not focused which increases the data loss during the delivery process. Game Theory Based Fuzzy Secure Clustering (GTFSC) Model was presented in [2] for attaining higher routing performance in terms of energy employment, throughput, packet delivery, latency, and routing overhead. But, the clustering performance was not effectual while taking a maximum number of mobile nodes as input.

An energy-efficient MANET relay node discovery and routing was carried out in [3] with the support of a fuzzy-based analytic hierarchy task. Though, end-to-end latency was not minimal. Hybrid Secure Cluster-Based Routing was performed in [4] with aiming at improving the security and efficiency in MANET. But, the energy usage for achieving reliable data transmission was higher. A saving energy routing protocol was utilized in [5] by considering routing metrics such as hops number and remaining battery capacity to find the best routes. However, the trust value of nodes was not concentrated which impacts the data delivery ratio in MANET.

Enhanced Energy Efficient-Secure Routing (EEE-SR) protocol was introduced in [6] to access secure information in hostile environment with better energy usage, packet loss and end-to-end delay. Though, the scalability of EEE-SR protocol was not higher while increasing the more number of mobile nodes to perform the simulation task. A well-organized energy-aware routing method was developed in [7] for cloud-supported MANETs in 5G. But, the bandwidth availability of node was not focused. An unsupervised learning based clustering method was designed in [8] with the goal of finding the highest traffic cluster in 5G environment. Though, node clustering performance was not sufficient.

2. LITERATURE SURVEY

The exhaustive literature investigations of diverse clustering algorithms for MANET were analyzed in [9] with the aid of their objectives, and challenges, and future directions. A Graph Kernel based Clustering Algorithm was utilized in [10] to achieve better packets delivery ratio, packets loss ratio, and average end-to-end delay. But, the amount of energy required for reliable data transmission was more. A randomly centralized and on-demand clustering protocol was introduced in [11] to get better clustered time and higher scalability and consistency with lesser energy cost.

The fuzzy clustering was employed in [12] to discover the best cluster head depends on the highest level of node confidence. However, the clustering efficiency was inadequate while considering a larger number of mobile nodes. The novel clustering algorithm was presented in [13] for efficient energy utilization in mobile ad-hoc networks. Though, scalability and security level of MANET was not higher. A dynamic energy-efficient clustering algorithm was constructed in [14] to boost the network lifetime through find cluster-heads based on metrics such mobility and residual energies. But, the bandwidth availability and trust level of node was remained unaddressed.

The stable zone-based clustering was performed in [15] with the aiming at decreasing the delay and loss in MANET. However, the throughput was not more. Weight-Based Trust Estimation (WBTE) and the Fuzzy-Based Clustering (FBC) algorithm was employed in [16] to increase the network performance via finding a more stable trust-aware and energy-aware node as cluster leader. But, the clustering performance was not better while getting the higher number of nodes as input. An On-demand One-hop Cluster Management was performed in [17] for providing the better MANET Services. However, the end-to end delay was very higher. An improved Energy-efficient Clustering-based algorithm was implemented in [18] for wireless communication network in order to get better aggregation and congestion control performance. Though, scalability of network was remained open issue. With the intention of resolving the above problems in MANET using 5G and next technology, a new BBEMENC Technique is intended in this article.

The vital contribution of BBEMENC Technique is described as follows,

- To increase the clustering efficiency of mobile nodes with lesser complexity while defining a larger size of MANET, brown boosted ensemble clustering algorithmic concept is applied in proposed work on the contrary to conventional systems.
- To boost the energy effectiveness of data communication and routing with minimal latency in MANET using 5G, BBEMENC Technique considered three significant constraints of each mobile node such as residual energy, trust and bandwidth availability on the contrary to traditional research works.
- To carry out reliable data delivery without any loss in MANET while utilizing more number of 5G users and next technology, BBEMENC Technique choose strong strength node with minimal distance as optimal in order to significantly route the data packets. Thus, BBEMENC Technique obtains higher packet delivery ratio and scalability.

The rest of article structure is presented as follows. In Section 3, proposed methodology is explained with the support of the architecture design. In Section 4, simulation criteria are described and the comparative simulation testing outcomes of BBEMENC Technique is shown in Section 5. Section 6 reveals the conclusion of the paper.

3. PROPOSED RESEARCH METHODOLOGY

The BBEMENC Technique is implemented in this research with the inspiration of increasing the performance of energy efficiency and security level of data communication in MANET with 5G and NxtG Technology. On the contrary to state-of-the-art works, the designed BBEMENC Technique improves the clustering performance or accuracy of mobile nodes in network based on the constraints such as residual energy, trust level, bandwidth availability. The BBEMENC Technique is proposed via utilizing the brown boosting concepts in Expectation Maximization (EM) clustering algorithm. The architecture presentation of the BBEMENC Technique for reliable data communication is revealed in Figure 1.

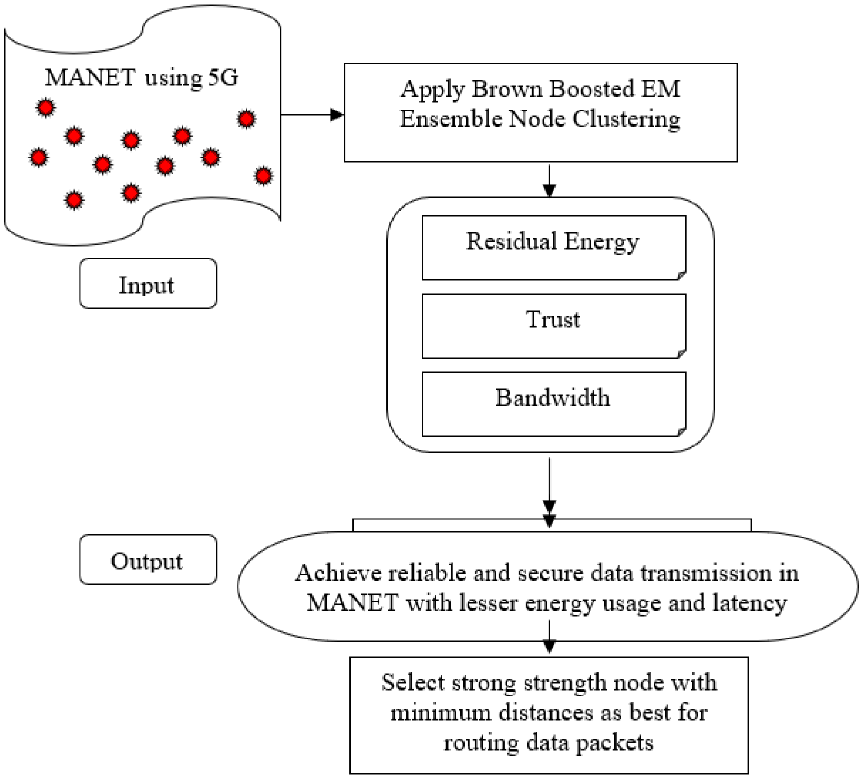

Figure 1 Architectural Design of BBEMENC Technique

Figure 1 presents the overall processes is involved in proposed BBEMENC Technique to perform energy efficient and secure data delivery in MANET using 5G. As displayed in the above processing diagram, BBEMENC Technique initially defines a more number of mobile nodes in MANET which are taken as input during the simulation evaluation. For all the nodes in network, then BBEMENC Technique applies Brown Boosted EM Ensemble Node Clustering concept with the aiming at grouping the mobile nodes based on their four attributes. During the clustering task, BBEMENC Technique estimates residual energy, trust and bandwidth availability for each node. From that, BBEMENC Technique precisely clusters each mobile node in network as strong or weak node with a lesser time complexity. After completing clustering process, BBEMENC Technique chooses the strong nodes which include a minimum distance to route the data between the source and destination nodes. As a result, BBEMENC Technique performs reliable data delivery in MANET. Consequently, BBEMENC Technique achieves better routing performance in terms of energy efficiency, security, data delivery rate, scalability and latency when compared to state-of-the-art clustering algorithms.

In this research work, Brown Boosted EM Ensemble Node Clustering at first consider a MANET with 5G and NxtG Technology where it contains a larger numbers of mobile nodes indicated as '$mb_1, mb_2, mb_3, \ldots.. mb_z$'. Here, '$z$' describes the total number of mobile user devices or nodes in 5G network connection. After that, the EM Clustering algorithm is applied where it considered as weak cluster. Here, EM Clustering algorithm is utilized in proposed research methodology defines number of clusters '$a_1, a_2, a_3, \ldots. a_n$' and the cluster centroid '$b_1, b_2, b_3, \ldots. b_m$'. The mobile nodes in this network utilize energy while transmitting data packets to intermediate nodes and when this intermediate node choose this node as the router, its energy usage raises more quickly. The nodes of exceptional energy are therefore significant for finding the direction without disturbance. Thus, the energy consumption $en_c mb_i$ of mobile node at a time (T) is mathematically estimated as,

$$en_c mb_i(T) = < (k_t * a) + (k_r * b) > \qquad (1)$$

In the equation (1), 'k_t', 'k_r' represents the number of packets transmitted and received a time T respectively whereas $\langle a, b \rangle$ describes an energy utilized from the transmitter and receiver. Then, the residual energy $en_r mb_i$ of mobile node at a time (T) is mathematically obtained as,

$$en_r mb_i(T) = en_i mb_i(T) - en_c mb_i(T) \qquad (2)$$

In the expression (2), $en_i mb_i(T)$ demonstrates the primary energy of node. Followed by, the average residual energy $en_N mb_i(T)$of the network with 'N' number of mobile nodes is mathematically determined as,

$$en_N mb_i(T) = \sum_{i=1}^{z} \frac{en_r mb_i(T)}{z} \qquad (3)$$

The mobile node in 5G network can communicate with other nodes based on their trustworthy. If the trustworthy of node is higher, then nodes can communicate in the network. Let define two nodes mb_u and mb_v in the network, the node mb_u can determine the trust value of node mb_v depends on the successful and unsuccessful interaction using following equation,

$$T_{mb_u,mb_v} = \left[\frac{S_{mb_u,mb_v}}{S_{mb_u,mb_v}+U_{mb_u,mb_v}}\right] \quad (4)$$

In the above formulation (4), T_{mb_u,mb_v} presents the trustworthy of mobile node and S_{mb_u,mb_v} refers total number of successful exchanges whereas 'U_{mb_u,mb_v}' shows total number of un- successful exchanges the communication between node mb_u and node mb_v. During the data communication process, mobile node with maximum bandwidth availability is selected in order to lessen the traffic and data loss. As a consequence, bandwidth availability of mobile node is mathematically determined as,

$$bnd_a mb_i(T) = \left(bnd_t mb_i(T) - bnd_u mb_i(T)\right) \quad (5)$$

From the description (5), '$bnd_a mb_i(T)$' explains the bandwidth availability of node at a time 'T' whereas $bnd_t mb_i(T)$ refers a total bandwidth and '$bnd_u mb_i(T)$' shows bandwidth utilized for transmitting and receiving a data packet a time 'T'. Subsequently, the expected probability is discovered between each mobile nodes 'mb_i' and centroid 'b_i' with the aid of below equation,

$$Exp\,\{P\,(b_i|mb_i)\} = \log\left(\prod_{i=1}^{z} \frac{e^{-\frac{1}{2}\frac{(mb_i-x)^2}{vr^2}}}{\sqrt{2\pi vr^2}}\right) \quad (6)$$

In formulation (6), '$Exp\ \{P\,(b_i|mb_i)\}$' shows the expected probability between the mobile nodes 'mb_i' and centroid 'b_i'. Here, 'x' describes a mean value of cluster centroid and 'vr' portrays a variance among the cluster centroid and mobile nodes. In this work, EM Clustering algorithm finds the expected probability among each mobile node and centroids and thus significantly groups all the mobile nodes in MANET into related clusters (i.e. strength node or weak node). Next, the EM Clustering algorithm finds the maximization probability for each node to become a member of the cluster. Here, maximization function is used where it enhances the expected probability with the support of MAP calculation with aiming at clustering the more interrelated mobile nodes together with a minimal time complexity. Thus, maximum a posteriori is mathematically obtained as,

$$\omega_{MAX} = \arg\max\ Exp\,\{P\,(b_i|mb_i)\} \quad (7)$$

$$\omega_{MAX} = \arg\max\ \log\left(\prod_{i=1}^{z} \frac{e^{-\frac{1}{2}\frac{(mb_i-x)^2}{vr}}}{\sqrt{2\pi vr^2}}\right) \quad (8)$$

In the above mathematical equations (7) and (8), 'ω_{MAx}' illustrates the maximum a posteriori function which helps to enhances the expected probability among mobile nodes and centroid in order to exactly group a more related mobile nodes together with respect to their residual energy, trustworthy and bandwidth availability. The above processes of weak EM Clustering is repetitive until the all mobile nodes in 5G network are clustered into the relevant clusters. The weak EM cluster predicts strong nodes in network to perform data transmission. Though, clustering efficiency or accuracy was not adequate in order to identify optimal route path with a minimal time requirement for reliable and secure data delivery in MANET. For that reason, Brownboost ensemble concept is employed in this research work. The proposed Brown Boosted EM Ensemble Node Clustering algorithm gives strong cluster result via summing the outcomes of all weak clusters using following equation,

$$S = \sum_{i=1}^{n} EM_i(mb_i) \quad (9)$$

In the formula (9) 'S' provides strong cluster result and '$EM_i\ (mb_i)$' symbolizes the weak cluster outcome for each mobile node 'mb_i'. Subsequently, proposed algorithm allocates weight to each weak cluster along with the residual time after clustering the mobile nodes and margin of the information. In Brown Boosted EM Ensemble Node Clustering algorithm, a positive margin mentions the node is being correctly clustered based on residual energy, trust and bandwidth availability whereas the negative value designates the node is being incorrectly clustered. Accordingly, the magnitude of the margin value demonstrates that how much the weak cluster groups the nodes into particular class in an accurate manner. In Brown Boosted EM Ensemble Node Clustering algorithm, each weak EM cluster takes a different amount of time to efficiently group the nodes as strong or weak node which is directly consistent to the weight given to the weak cluster. From that, weight is mathematically assigned as,

$$wt_i = \exp\left(-\frac{(m_i(mb_i)+y)^2}{v}\right) \quad (10)$$

In the above formulation (10), 'wt_i' illustration the weight assigned to the weak cluster at iteration 'i'. Here, 'm_i' presents margin of the information for mobile nodes 'mb_i' and 'y' point outs residual time of the weak cluster '$(y = w)$'. Next, the potential loss for each clustered mobile node with margin 'm_i' is calculated as,

$$loss = 1 - \varepsilon rr\sqrt{w} \quad (11)$$

In the computation (11), '$loss$' defines a potential loss of the function, 'εrr' illustrates an error functions, 'w' describes a positive real valued constraint. Consequently, margin of the each weak cluster is updated according to the loss value using,

$$m_i(y+1) = m_i(mb_i) + \sum_{i=1}^{n} wt_i\, m_i(mb_i)EM_i \quad (12)$$

In the equation (12) '$m_i(y+1)$' presents the updated margins of the input mobile nodes, 'wt_i' defines a weight, $m_i(mb_i)$ illustrates a predicted weak cluster result, 'EM_i' is the actual outcome of the weak classifier. From that, the strong cluster outcome of mobile nodes is mathematically get as,

$$S = sign\{\sum_{i=1}^{n} wt_i\, EM_i(mb_i)\} \quad (13)$$

In the expression (13), 'S' demonstrates a final strong cluster results, 'wt_i' refers a weight whereas $EM_i(mb_i)$ signifies an outcome of the weak cluster. Through creating the strong cluster, the proposed Brown Boosted EM Ensemble Node Clustering correctly clusters all the mobile nodes into a corresponding clusters i.e. strong node or weak node with better accuracy and lower time. After predicting the strong nodes in MANET, proposed algorithm finds nearest nodes using Mahalanobis distance estimation where it accurately determines the distance between two mobile node 'mb_i' and mb_j in network using,

$$Dt(mb_i, mb_j) = \left\{\left[(x_j, y_j) - (x_i, y_i)\right]^T * v^{-1} * \left[(x_j, y_j) - (x_i, y_i)\right]\right\}^{1/2} (14)$$

From the above calculation (14), '$Dt(mb_i, mb_j)$ ' defines the distance between mobile node mb_i and mb_j whereas (x_i, y_i) and (x_j, y_j) shows the location coordinates of mobile node mobile node mb_i and mb_j and v signifies covariance matrix. With the support of measured distance values, then BBEMENC Technique finds nearby strong strength nodes for communicating the data between the users in MANET. The step by step process of proposed Brown Boosted EM Ensemble Node Clustering is given in below,

// proposed Brown Boosted EM Ensemble Node Clustering Algorithm
Input: Number of Mobile nodes '$mb_1, mb_2, mb_3, \ldots.. mb_z$' in MANET using 5G
Output: Achieve higher data delivery ratio with minimal energy usage
Step 1:Begin
Step 2: **For** each input node 'mb_i'
Step 3: Estimate residual energy $en_r mb_i(T)$ using (2)
Step 4: Determine trust T_{mb_u, mb_v} using (4)
Step 5: Evaluate bandwidth availability $bnd_a mb_i(T)$using (5)
// Apply EM clustering algorithm (weak cluster)
Step 7: Initialize number of clusters '$a_1, a_2, a_3, \ldots. a_n$'
Step 8: Initialize cluster centroid '$b_1, b_2, b_3, \ldots. b_m$'
Step 9: Calculate $Exp\ \{P\ (b_i \vert mb_i)\}$ using (6)
Step 10: Estimate ω_{MAX} using (8)
Step 11: Group node as strong strength or weak
Step 11: **End For**
// Apply Brown Boosted Ensemble Clustering
Step 12: **For** each input node 'mb_i'
Step 13: Form 'n' number of weak cluster using (9)
Step 14: Unite all weak cluster results
Step 15: Define the margin '$m_i = 0$'
Step 16: **For** each weak cluster result '$EM_i\ (mb_i)$'
Step 17: Assign weight ' wt_i' using (10)

Step 18: Calculate potential loss 'loss' using (11)

Step 19: Update margin 'm_i $(y + 1)$' using (12)

Step 20: Return strong cluster result using (13)

Step 21: **End For**

Step 22: **For** each strong strength mb_i in network

Step 23: Estimate Mahalanobis distance between two node 'mb_i' and mb_j using (14)

Step 24: Consider strong strength node with lesser distance as optimal nodes

Step 25: Select optimal nodes for routing the data packets from source to destination

Step 26: Perform energy efficient and reliable data transmission

Step 27: **End for**

Step 28: **End For**

Step 29:End

Algorithm 1 Brown Boosted EM Ensemble Node Clustering

Algorithm 1 describes the step by step procedure of Brown Boosted EM Ensemble Node Clustering algorithmic concept. By using the above algorithmic steps, BBEMENC Technique achieves reliable data distribution and communication in MANET with minimal amount of energy utilization using 5G and next technology via clustering as compared to state-of-the-art research works.

4. SIMULATION CRITERIA

The simulation parameters are assumed during the implementation of proposed and conventional two research methodologies are presented in this section. The proposed BBEMENC Technique is implemented in NS2.34 simulator with MAC/IEEE 802.11g communication system via considering 250 mobile nodes in network area of 1100 m * 1100 m. The diverse constraints considered for performing the simulation evaluation is listed in Table 1.

Table 1 Simulation Metrics

Metrics	**Values**
Network Simulator	NS2.34
Square area	1100 m * 1100 m
Number of mobile nodes	250
Queue Size	50 packets
Speed of nodes	0 – 20 m/s
Simulation time	250sec
Packet Size	64,128,256,512, 1024 bytes
The initial battery level of all nodes	100J
Transmission range	250m
Communication system	MAC/IEEE 802.11g
Routing Protocol	DSR

The simulation testing outcomes of proposed BBEMENC Technique is compared against with two state-of-the-art Supervised Vector Machine with BrownBoost Classification (SVM-BBC) [1] and Game Theory Based Fuzzy Secure Clustering (GTFSC) Model [2]. The performance of proposed BBEMENC Technique is tested using the following metrics,

- Energy Utilization
- Packet delivery ratio

- Latency
- Scalability

5. RESULTS

The comparative simulation testing results of proposed BBEMENC Technique and existing Supervised SVM-BBC [1] and GTFSC Model [2] are presented in this section with the help of tabulation and graphical diagram for the performance evaluation.

a) Test Case 1: Energy Utilization

The energy usage (EU) in proposed BBEMENC Technique estimates amount of energy utilized for reliably routing data from the one node to the another node in the MANET using 5G. While the lesser amount of energy is consumed for successful data transmission, technique is said to be higher energy efficiency. Thus, energy utilization is mathematically observed as,

$$EU = z * energy\ (Smb) \tag{15}$$

In the above mathematical estimation (15), '$energy\ (Smb)$' expresses energy taken by single node for reliably delivering the data in network and 'z' depicts a number of nodes assumed in a network during the experimental process. The energy consumption is computed in terms of a joule (J).

Table 2 Performance Result of Energy Utilization Vs Number of Mobile Nodes

Number of mobile nodes (z)	**Energy Utilization (J)**		
	SVM-BBC	**GTFSC**	**BBEMENC**
50	31	26	21
100	34	30	27
150	38	35	32
200	44	39	36
250	51	47	40

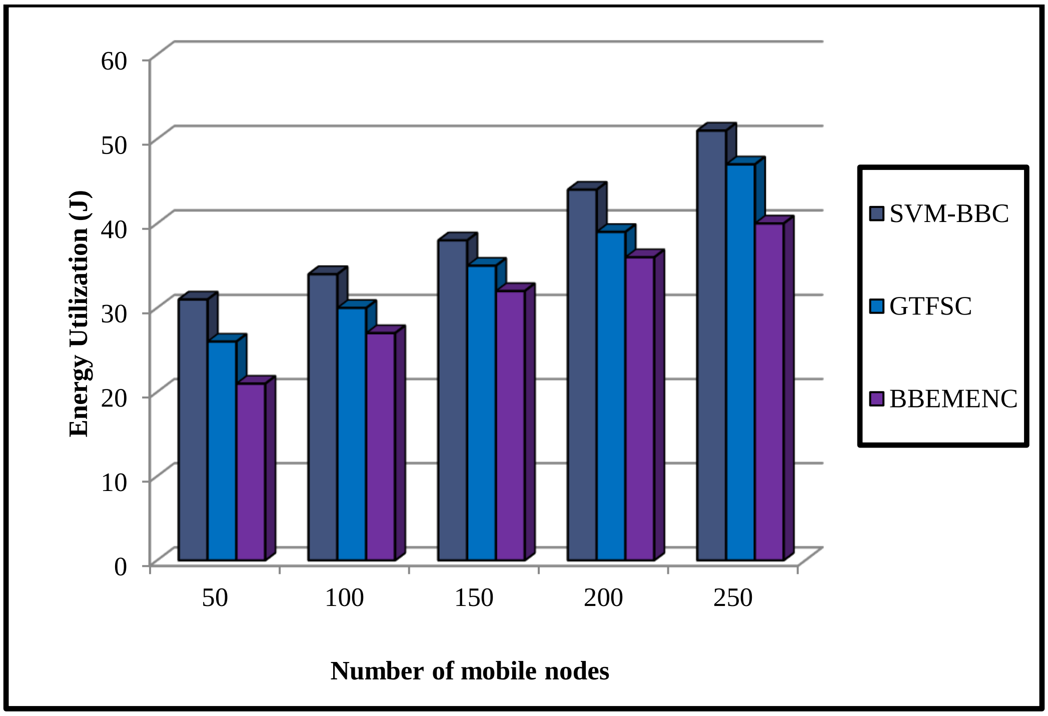

Figure 2 Comparative Graphical Presentation of Energy Utilization

Table 2 and Figure 2 presents simulation performance of energy usage result is measured during the reliable data communication in MANET using 5G versus dissimilar number of mobile nodes in the range of 50 to 250 using BBEMENC Technique and existing SVM-BBC [1] and GTFSC Model [2]. As presented in the above graphical results comparison, proposed BBEMENC Technique achieved better energy consumption to securely and reliably delivers the data packets in MANET using 5G and Next technology while assuming the raising number of input nodes when compared to existing SVM-BBC [1] and GTFSC Model [2]. This is due to introduction of Brown Boosted EM Ensemble Node Clustering algorithmic concept in proposed research methodology on the contrary to state-of-the-art algorithms. Here, BBEMENC Technique produces 'n' weak clusters results for every nodes in network. Consequently, BBEMENC Technique calculates potential loss for each weak cluster and thus identifies a strong cluster outcome for rightly clustering the each mobile node in network as strong strength or weak node. During the node clustering, the BBEMENC Technique groups the mobile nodes according to their residual energy and also another two constraints. From that, BBEMENC Technique finds the mobile nodes with maximum residual energy for broadcasting the data packets. For that reason, proposed BBEMENC Technique proficently decreases the path failure due to the energy loss and there by avoilds more amout of energy requirement for successful data communication in MANET using 5G. As a result, BBEMENC Technique lessens the energy utilization by 22 % and 12 % when compared to SVM-BBC [1] and GTFSC Model [2] respectively.

b) Test Case 2: Packet Delivery Ratio

The packet delivery ratio in this proposed BBEMENC Technique estimates the number of packets reliably acquired by the destination to the number of packets forwarded by the source. The packet delivery ratio gives information's regarding packet distribution in the network. While packet delivery ratio is higher, the network performance is more effectual. From that, data delivery ratio observes ratio of number of data that are precisely received to the total number of data sent using below,

$$PDR = \left(\frac{Number\ of\ data\ packets\ \text{reliably}\ received}{\alpha}\right) * 100 \quad (16)$$

In the mathematical determination (16), 'α' describes a total number of packets sent. The data delivery ratio is observed in the terms of percentage (%).

Table 3 Tabulation Result of Packet Delivery Ratio

Number of data packets	Packet Delivery Ratio (%)		
	SVM-BBC	**GTFSC**	**BBEMENC**
25	82.21	86.79	90.88
50	85.65	88.09	91.56
75	88.74	89.47	92.13
100	89.11	90.47	93.41
125	90.05	90.23	94.55

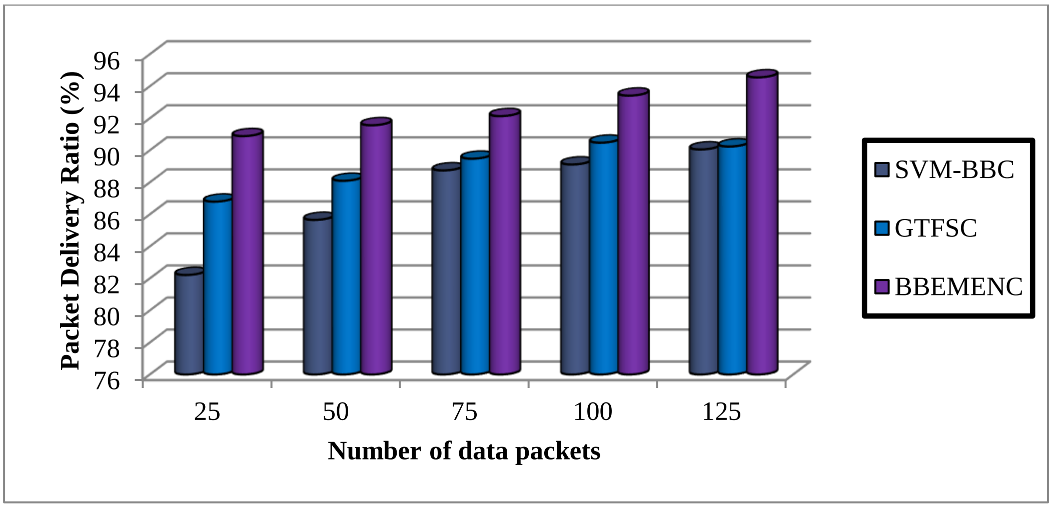

Figure 3 Comparative Graphical Presentation of Packet Delivery Ratio

Table 3 and Figure 3 gives tabulation and comparative graphical presentation of packet delivery ratio versus number of input data packets in the range of 25 to 125 using BBEMENC Technique and conventional SVM-BBC [1] and GTFSC Model [2]. As discussed in the above comparative performance investigation, proposed BBEMENC Technique obtained maximum packet delivery ratio in MANET using 5G while taking the larger number of data packets as input during the experimental evaluation when compared to traditional SVM-BBC [1] and GTFSC Model [2]. This is owing to implementation of Brown Boosted EM Ensemble Node Clustering in this paper. The proposed BBEMENC Technique presents a strong cluster to significantly predict the strong strength or weak nodes in network. Thus, then BBEMENC Technique carry outs reliable and secure data distribution. As a result, proposed BBEMENC Technique boosts the ratio of number of packets reliably gets by the destination as compared to other existing SVM-BBC [1] and GTFSC Model [2]. Hence, proposed BBEMENC Technique maximizes the packet delivery ratio in MANET while using 5G and next technology by 6 % and 4 % when compared to SVM-BBC [1] and GTFSC Model [2] respectively.

c) Test Case 3: Performance Testing Results of Latency

In proposed BBEMENC Technique, latency is observed by considering the amount of time the data packets taken to reliably reach their destination via the network. Network latency in this work may incorporate queuing, delayed propagation, buffer delays and transmission delays. Latency evaluates the distinction between the transmitting and receiving time of data packets in MANET while using 5G using below,

$$L = (d_{rect} - d_{sent}) \quad (17)$$

In the above mathematical definition (17), 'L' illustrates a latency results,'d_{rect} depicts data packets receiving time, 'd_{sent} 'describes a data packet sent time. The latency during the energy efficient and reliable data communication in MANET is calculated in the terms of milliseconds (ms).

Table 4 Tabulation Result of Latency Vs Number of Data Packets

Number of data packets	Latency (ms)		
	SVM-BBC	GTFSC	BBEMENC
25	16	13	11
50	19	16	14
75	25	21	15
100	27	24	17
125	30	28	20

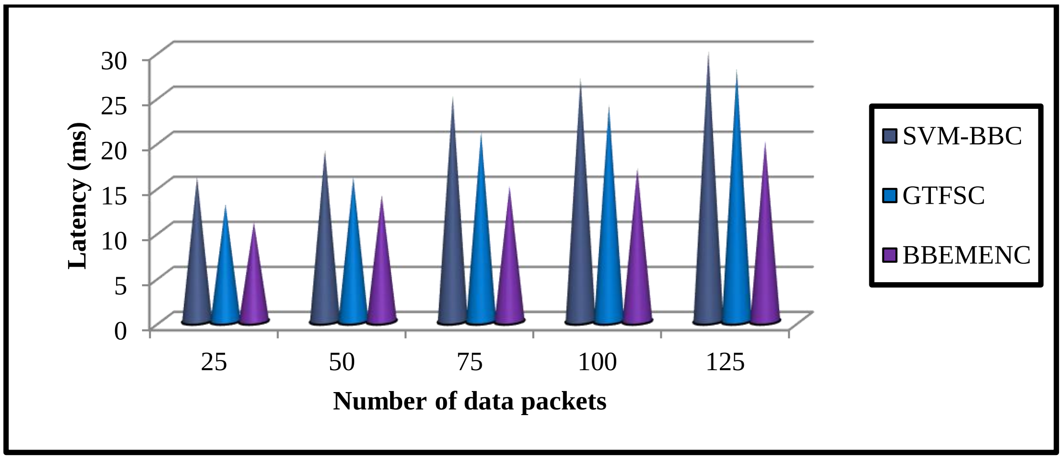

Figure 4 Comparative Graphical Presentation of Latency

Table 4 and Figure 4 describe simulation testing results of latency versus number of input data packets in the range of 25 to 125 using BBEMENC Technique and conventional SVM-BBC [1] and GTFSC Model [2]. As demonstrated in the above testing performance examination, proposed BBEMENC Technique gained better latency in MANET using 5G while defining the bigger number of input data packets when compared to existing SVM-BBC [1] and GTFSC Model [2]. This is because of designing of Brown Boosted EM Ensemble Node Clustering in this work where a strong cluster accurately performs node clustering task based on residual energy, trustworthiness and bandwidth availability and thus picks the strong strength nodes in network for data communication. As a consequence, BBEMENC Technique accomplishes reliable and energy efficient data delivery with lesser amount of time usage. As a result, proposed BBEMENC Technique lessens the amount of time desired to achieve the trustworthy data transmission as compared to other existing SVM-BBC [1] and GTFSC Model [2]. Hence, proposed BBEMENC Technique lowers the latency in MANET while using 5G and next technology by 34 % and 23 % when compared to SVM-BBC [1] and GTFSC Model [2] respectively.

d) Test Case 4: Performance Testing Results of Scalability

Scalability in the proposed BBEMENC Technique determines the ability of a network or system to efficiently manage an increase in users, devices, or data and also ensuring that performance remains stable and reliable. The scalability is observed in terms of percentages (%).

Table 4 Tabulation of Scalability Vs Node of Mobile Nodes

Number of Mobile Nodes (z)	Scalability (%)		
	SVM-BBC	**GTFSC**	**BBEMENC**
50	85.69	88.47	91.45
100	87.11	88.90	92.03
150	88.58	89.39	92.93
200	89.40	90.02	93.56
250	91.21	91.95	94.44

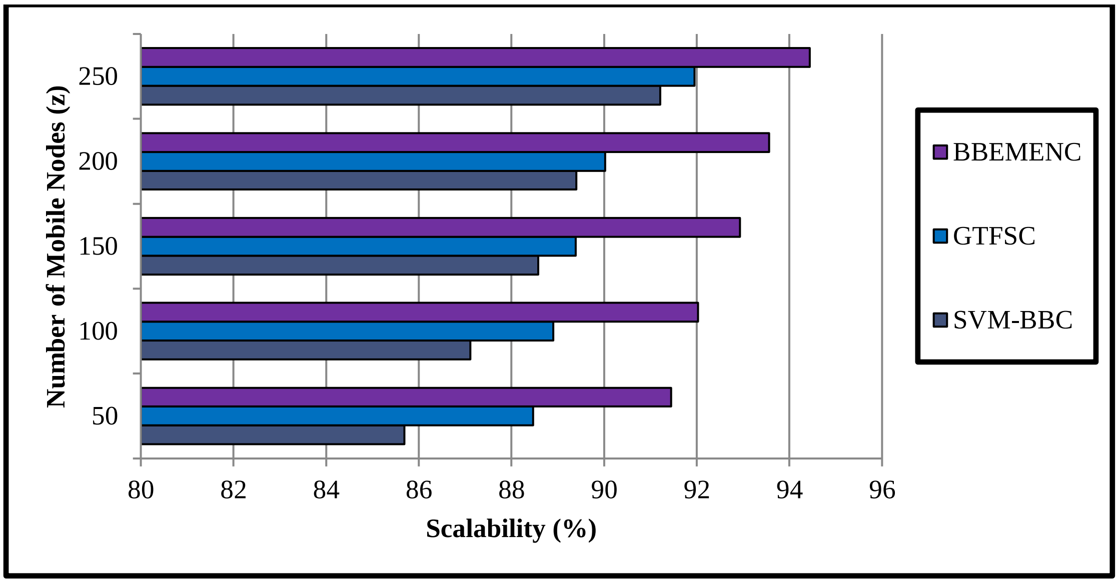

Figure 4 Comparative Graphical Presentation of Scalability

Table 4 and Figure 4 provide performance results comparison of scalability versus number of input mobile nodes in the range of 50 to 250 using BBEMENC Technique and conventional SVM-BBC [1] and GTFSC Model [2]. As illustrated in the above performance assessment, proposed BBEMENC Technique acquired enhanced scalability in MANET using 5G while getting the more number of input nodes when compared to existing SVM-BBC [1] and GTFSC Model [2]. This is due to application of Brown Boosted EM Ensemble Node Clustering in this proposed research methodology. Here, ensemble clustering algorithmic concept is employed with aiming at increasing the node clustering performance. On the contrary to state-of-the-art algorithms, Brown Boosted ensemble clustering concept gives improved node clustering accuracy while taking a larger number of mobile nodes as input. Thus, proposed BBEMENC Technique effectively performs reliable data routing while considering a big size of MANET environment as input. For this reason, proposed BBEMENC Technique attained higher scalability in MANET while utilizing 5G and next technology by 5 % and 4 % when compared to SVM-BBC [1] and GTFSC Model [2] respectively.

6. CONCLUSION

This paper proposes a BBEMENC Technique with the purpose of boosting the routing performance of MANET using 5G and next technology with better energy efficiency and scalability. The goal of BBEMENC Technique is attained in this research work by the application of Brown Boosted EM Ensemble Node Clustering process. The developed BBEMENC Technique precisely detects the strong strength and weak nodes in MANET via node clustering. Thus, BBEMENC Technique chooses the optimal shortest path through selecting the strong strength with lesser distance as best to effectively route the data packets in network. Hence, BBEMENC Technique significantly reduces the path failure because of the energy loss and there by avoilds more amout of energy desired for reliable data communication in MANET using 5G. Besides to that, BBEMENC Technique attained reliable and secure data distribution with better data delivery ratio. As well, BBEMENC Technique effectively decreases the amount of time needed for achieving the trustworthy data communication in MANET while using 5G. As a consequence, simulation result confirms that the proposed BBEMENC Technique provides better communication and routing performance in MANET with 5G and next technology with better energy usage, packet delivery ratio, latency and scalability when compared to conventional research works.

REFERENCES

[1] A. Sangeetha, T. Rajendran, “Supervised vector machine learning with brown boost energy efficient data delivery in MANET, Sustainable Computing: Informatics and Systems, Volume 35, 2022

[2] Ujwala Ravale, Gautam M. Borkar, “Secure and efficient trust enabled routing in mobile ad hoc network using game theory and grey wolf optimization techniques”, IET Wireless Sensor Systems, 2024; Pages 1–26

[3] Devi, E.A., Radhika, S. & Chandrasekar, A. An energy-efficient MANET relay node selection and routing using a fuzzy-based analytic hierarchy process. *Telecommun Syst* 83, 209–226 (2023)

[4] S, A., & A, R. (2024), Hybrid Secure Cluster-Based Routing Algorithm for Enhanced Security and Efficiency in Mobile Ad Hoc Networks, *Applied Artificial Intelligence*, *38*(1)

[5] Vu, K.Q., Solanki, V.K., Le, A.N. (2022). A Saving Energy MANET Routing Protocol in 5G. In: Velliangiri, S., Gunasekaran, M., Karthikeyan, P. (eds) Secure Communication for 5G and IoT Networks, EAI/Springer Innovations in Communication and Computing, Springer, pp 213–220

[6] Rajendra Prasad P, Shivashankar, “Enhanced Energy Efficient Secure Routing Protocol for Mobile Ad-Hoc Network”, Global Transitions Proceedings, Volume 3, Issue 2, 2022, Pages 412-423

[7] H. Riasudheen, K. Selvamani, Saswati Mukherjee, I.R. DivyasreeAuthors Info & Claims, “An efficient energy-aware routing scheme for cloud-assisted MANETs in 5G”, Ad Hoc Networks, Volume 97, Issue C, 2020

[8] M. Umar Khan, M. Azizi, A. García-Armada and J. J. Escudero-Garzás, "Unsupervised Clustering for 5G Network Planning Assisted by Real Data," in *IEEE Access*, vol. 10, pp. 39269-39281, 2022

[9] M. Ahmad, A. Hameed, A. A. Ikram and I. Wahid, "State-of-the-Art Clustering Schemes in Mobile Ad Hoc Networks: Objectives, Challenges, and Future Directions," in *IEEE Access*, vol. 7, pp. 17067-17081, 2019

[10] Y. Song, H. Luo, S. Pi, C. Gui and B. Sun, "Graph Kernel Based Clustering Algorithm in MANETs," in *IEEE Access*, vol. 8, pp. 107650-107660, 2020

[11] X. Chen, G. Sun, T. Wu, L. Liu, H. Yu and M. Guizani, "RANCE: A Randomly Centralized and On-Demand Clustering Protocol for Mobile Ad Hoc Networks," in *IEEE Internet of Things Journal*, vol. 9, no. 23, pp. 23639-23658, 1 Dec.1, 2022

[12] N. Veeraiah *et al*., "Trust Aware Secure Energy Efficient Hybrid Protocol for MANET," in *IEEE Access*, vol. 9, pp. 120996-121005, 2021

[13] Seyed Ali Sharifi, Seyed Morteza BabamirAuthors Info & Claims, “The clustering algorithm for efficient energy management in mobile ad-hoc networks”, Computer Networks: The International Journal of Computer and Telecommunications Networking, Volume 166, Issue C, 2020

[14] H. Safa, O. Mirza, “A load balancing energy efficient clustering algorithm for MANETs”, International Journal of Communication Systems, International Journal of Communication Systems, 2010

[15] Alghamdi, S.A. Stable zone-based 5G clustered MANET using interest-region-based routing and gateway selection. *Peer-to-Peer Netw. Appl.* 14, 3559–3577 (2021)

[16] Rajeswari AR, Lai W-C, Kavitha C, Balasubramanian PK, Srividhya SR. A Trust-Based Secure Neuro Fuzzy Clustering Technique for Mobile Ad Hoc Networks. *Electronics*. 2023; 12(2):274

[17] Reza Sookhtsaraei, Mohsen Nejadkheirallah, Mohammad Saber Iraji, “MMF Clustering: A On-demand One-hop Cluster Management in MANET Services Executing Perspective”, Wireless Personal Communications, Volume 125, Issue 2, Pages 1973 – 2002, 2022

[18] Ibrahim Aqeel, “HarborSync: An Advanced Energy-efficient Clustering-based Algorithm for Wireless Sensor Networks to Optimize Aggregation and Congestion Control”, (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 15, No. 1, Pages 799-808, 2024