International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 12 (2018) pp. 10394-10405
© Research India Publications. http://www.ripublication.com

Weighted Multi-Objective Cluster Based Honey Bee Foraging Load Balanced Routing in Mobile Ad Hoc Network

C.Daniel Nesa Kumar[1] and Dr. V. Saravanan[2]

[1]*Ph.D-Research Scholar, Department of Computer Science, Hindusthan College of Arts and Science, Coimbatore, Tamil Nadu, India.*

[2]*Professor and Head, Department of Information Technology, Hindusthan College of Arts and Science, Coimbatore, Tamil Nadu, India.*

Abstract

Cluster-based routing plays an imperative role in mobile ad hoc network (MANET). The conventional techniques designed for cluster based routing are not appropriate for large-scale networks as node dead too early due to their limited energy. Besides, existing route discovery techniques in MANET may result in traffic overflow because where balancing loads on nodes were not solved. In order to overcome such limitations, a Weighted Multi-objective Cluster based Honey Bee Foraging Load balancing (WMC-HBFLB) Technique is proposed. The WMC-HBFLB Technique is designed for performing energy efficient and load balanced routing in MANET. The WMC-HBFLB Technique developed a Weighted Multi-objective Clustering (WMC) algorithm where grouping of mobile nodes based on weights of residual energy and bandwidth to minimize the energy consumption during data transmission process. After clustering process, the mobile node which has a higher weight is taken as cluster head (CH) for routing the collected information to destination with minimal energy consumption. During the routing process, load in all CH has to be balanced. In order to balance the load across CHs, WMC-HBFLB Technique designed a Honey Bee Foraging Load Balancing (HBFLB) Algorithm. The HBFLB algorithm choose nearest load optimal CH based on fitness function in order to broadcast the data packets to sink node in MANET without any traffic. By this way, WMC-HBFLB Technique attains energy efficient and load balanced routing in MANET. The simulation of WMC-HBFLB Technique is carried out on factors such as load balancing efficiency, energy utilization rate, data loss rate and end to end delay with respect to number of mobile nodes. The simulation result demonstrates that the WMC-HBFLB Technique is able to improve the load balancing efficiency and also lessens the energy consumption of data transmission in MANET as compared to state-of-the-art works.

Keywords: Honey Bee Foraging, Load Balancing, Load Weightage, MANET**,** Multi-objective**,** Residual energy**,** Weight

INTRODUCTION

A mobile ad hoc network (MANET) is an infrastructure less network. The mobile node in MANET moves in every direction and connects its links to other nodes. Routing in MANET is the process of transmitting the information from source to destination node. The mobile nodes that are inside the transmission range routes the information directly. The mobile nodes that are not in the transmission range transmit the data to sink node using intermediate nodes. During the routing process, energy consumption and load balancing is assumed as essential problem to be addressed to prolong the lifetime of network.

A Weight Based Clustering (WBC) protocol was intended in [1] in order to minimize the cluster formation overhead and packet loss during routing in MANET. The WBC protocol does not considered energy for cluster formation. Hence it takes more amount of energy for data packet transmission in MANET. An Ant Based Multipath Backbone Routing for Load Balancing (AMBRLB) was designed in [2] where network load on the routes is balanced by means of sharing the data traffic equally on the links from source to destination in MANET. The AMBRLB does not consider balancing loads on large -scale MANET.

A hybrid multipath routing scheme was presented in [3] for performing energy-efficient and load balanced routing in MANETs. This routing scheme was not appropriate for large-scale network deployments. An ant colony-based energy control routing (ACECR) protocol was developed in [4] for minimizing energy consumption and thereby attaining longer network lifetime. The load balanced routing was not solved in ACECR protocol which increases the data loss during transmission.

An Intelligent Energy-aware Efficient Routing protocol (IE2R) was introduced in [5]. The route discovery latency and heavy traffic conditions was not considered in IE2R. A Device-Energy-Load Aware Relaying framework (DELAR) was intended in [6] to get minimum energy and balancing the loads of node in MANET. The end-to-end delay of DELAR was higher.

An Energy-efficient stable multipath routing was presented in [7] for identifying the path to broadcast the packets between nodes in MANET. Balance the load on ad hoc networks was remained unaddressed hence this method increases the delay. A load balancing ad hoc on-demand multipath distance vector (LBAOMDV) protocol was designed in [8]. The computational efficiency of load balancing using LBAOMDV was lower.

Load balanced congestion adaptive routing (LBCAR) was introduced in [9] in which the traffic load is balanced and the probability of packet loss is minimized. The amount of energy consumed for data packet routing using LBCAR was very higher. A cluster-based trust-aware routing protocol (CBTRP) was designed in [10] with objective of preserving packets from malicious nodes in MANET. The CBTRP does not solve energy efficiency and load balancing issues in MANET.

In order to solve the above said existing issues, WMC-HBFLB Technique is introduced. The main contributions of WMC-HBFLB Technique is formulated as follows,

- To improve the node clustering performance of routing in large scale MANET with minimum energy utilization, Weighted Multi-objective Clustering (WMC) is designed in WMC-HBFLB Technique. The WMC considers residual energy and residual bandwidth of mobile nodes as multi-objectives to perform efficient node clustering process in MANET. In WMC, the weight value is estimated for each mobile node based on residual energy and residual bandwidth. This weight value assists for WMC to group the mobile nodes in network efficiently and to attain energy efficient routing in MANET.
- To increase the load balancing efficiency of large scale MANET, Honey Bee Foraging Load balancing (HBFLB) is intended in WMC-HBFLB Technique. The HBFLB developed from foraging behaviours of honey bees. The honey bees find quality food sources based on fitness function. During foraging process, honey bees identifies food source which have higher fitness function as quality food to collect the more amount of nectar. By using these concepts, load balancing is carried out in WMC-HBFLB Technique. The HBFLB is designed in WMC-HBFLB Technique, at first computes fitness function for all CHs in network with help of their load weightage and distance between them. After measuring fitness function, WMC-HBFLB Technique identifies CH which fitness function value is lesser than predefined threshold fitness as load optimal CH for data transmission.

The rest of paper is ordered as follows: Section 2 shows the background and reviews the related works. In Section 3, the proposed WMC-HBFLB Technique is explained with assist of architecture diagram. In Section 4, Experimental settings are presented and the analysis of results is explained in Section 5. Section 6 provides conclusion of the paper.

RELATED WORKS

A Traffic aware load balancing was performed in [11] by sharing load among nodes in network. The energy efficient data routing was remained unaddressed in this method. In [12], load-aware cooperative routing algorithm was presented for transmitting video data in MANET.

An Energy-Aware Routing Protocol was developed in [13] with aid of route energy comprehensive index for lessening the energy consumption and extend the network lifetime in MANET. A novel technique was intended in [14] to diminish the energy utilization in multipath routing. The packet delivery ratio of this technique was poor.

An energy efficient load aware routing was designed in [15] to enhance QoS performance and increasing the network lifetime in MANET. The load balancing performance of this method was not effective. An Energy & Load Balancing Multipath Routing Protocol (ELB-MRP) was designed in [16] with objective of prolong the routing performance in MANET. The delay and data loss rate of ELB-MRP was not addressed.

A Weighted Clustering Algorithm was introduced in [17] to balance the load between Cluster Heads with computation cost. The energy utilization of data routing was not considered. A dynamic energy-efficient clustering algorithm was designed in [18] to enhance the network lifetime. The data load balancing was remained an open issue.

Load Sharing in Weighted Clustering Algorithm (LS-WCA) was intended in [19] to provide better performance in terms of throughput, E2E delay and Load balancing in MANET. Load balancing efficiency of LS-WCA was lower. A novel Approach was presented in [20] in order to carry out load balancing in MANET. But, the throughput of this approach was lower.

WEIGHTED MULTI-OBJECTIVE CLUSTER BASED HONEY BEE FORAGING LOAD BALANCING TECHNIQUE

Designing an energy efficient routing protocol is one of the foremost issues in MANETs because of it dynamic characteristics and mobile nodes with minimum capacity of batteries. Besides, if load on mobile node is increased, it cause packet loss and buffer overflow which results in more end-to-end delay, degradation in throughput. Thus, energy and load optimized routing is significant issue is to be solved in MANET. In order to solve these problems, Weighted Multi-objective Cluster based Honey Bee Foraging Load balancing (WMC-HBFLB) Technique is introduced in MANET. The WMC-HBFLB Technique is intended with applications of Weighted Multi-objective Clustering (WMC) and Honey Bee Foraging Load balancing (HBFLB) mechanisms.

On the contrary to conventional cluster based energy efficient routing techniques, the proposed WMC-HBFLB Technique used WMC because it considers the multi-objective such as residual energy and residual bandwidth of mobile node to perform clustering. This multi-objective of WMC algorithm helps for WMC-HBFLB Technique to efficiently group the mobiles nodes in MANET according to weight assigned based on residual energy and residual bandwidth with minimal time. After clustering, the mobile node with higher weight among other cluster members and within a cluster is chosen as CH to perform energy efficient routing in MANET.

The WMC-HBFLB Technique employs HBFLB algorithm on contrary to existing load balanced routing techniques as it strong robustness, fast convergence and high flexible and it represent specific knowledge of the problem by observing nature. Also, Bees use a direct strategy by dancing in the nest. This dance gives direction towards a food source to find quality food (i.e. load optimal CH) for routing data packets in MANET without any traffic congestions. Moreover, HBFLB algorithm efficient when finding load optimal CH for data packet transmission as it takes less number of steps as compared to existing optimization techniques. Therefore, HBFLB algorithm assists for WMC-HBFLB Technique to perform load balanced routing in MANET. The architecture diagram of WMC-HBFLB Technique is shown in below Figure 1.

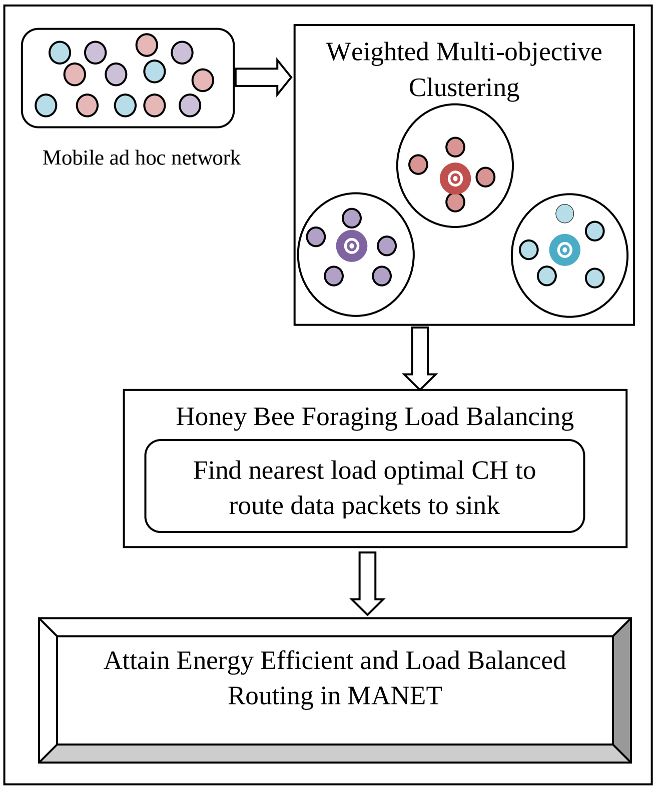

Figure 1. Architecture Diagram of WMC-HBFLB technique for Energy Efficient and Load Balanced Routing in MANET

Figure 1 depicts the overall processes of WMC-HBFLB technique to achieve energy efficient and load balanced routing in MANET. As illustrated in figure, WMC-HBFLB technique at first applies Weighted Multi-objective Clustering (WMC) with aiming at grouping mobile nodes in network based on residual energy and residual bandwidth. After completing clustering process, WMC-HBFLB technique chooses the mobile node which contains higher weight within cluster as CH to collect and to transmit the data packets to sink node in MANET. During the processes of data packet transmission, WMC-HBFLB technique identifies the nearest load optimal CH with aid of Honey Bee Foraging Load balancing (HBFLB) in order to route the gathered sensed information of cluster members without any congestions. Thus, WMC-HBFLB technique significantly carried outs the energy efficient and load balanced routing in MANET. As a result, WMC-HBFLB technique minimizes the energy consumption, data loss rate and gets higher load balancing efficiency as compared to state-of-the-art works. The exhaustive processes of WMC-HBFLB technique is described in below subsections.

Weighted Multi-objective Clustering

The limited resources and dynamic nature of MANET create an issue in presenting energy efficient and stable routing protocol. While solving the residual energy issues at the routing level in MANET, it is imperative to know the energy model which denotes the power utilization behavior of the nodes during data packet transmission. Selecting the intermediate nodes with higher residual energy to transmit the data packets between the nodes is significant to lessen energy consumption and to increases lifetime of network. When residual energy of nodes is low, the routing of the data packets fails which results in lacking of network's efficiency. In addition to that, the link breakage occurred in MANETs owing to a node dying of energy. Besides, residual bandwidth of mobile node is significant to attain efficient data delivery in MANET. Therefore there is a requirement for efficient clustering technique to group mobile nodes in MANET based on residual energy, bandwidth and prolonging the lifetime of network. As a result, WMC-HBFLB designed a Weighted Multi-objective Clustering (WMC) algorithm in MANET.

The WMC algorithm used residual energy and residual bandwidth of mobile node as multi-objective in order to cluster the mobile node in MANET. As depicted in below figure 2, WMC algorithm measures residual energy and bandwidth for each mobile node in network. Using these measurements, then weight is assigned. After that, the mobile nodes with similar weight value are grouped to form cluster. Each cluster has one cluster head. In each cluster, the mobile node with higher weight is taken as cluster head for routing the information with minimal energy consumption. The process involved in WMC algorithm is shown in below Figure 2.

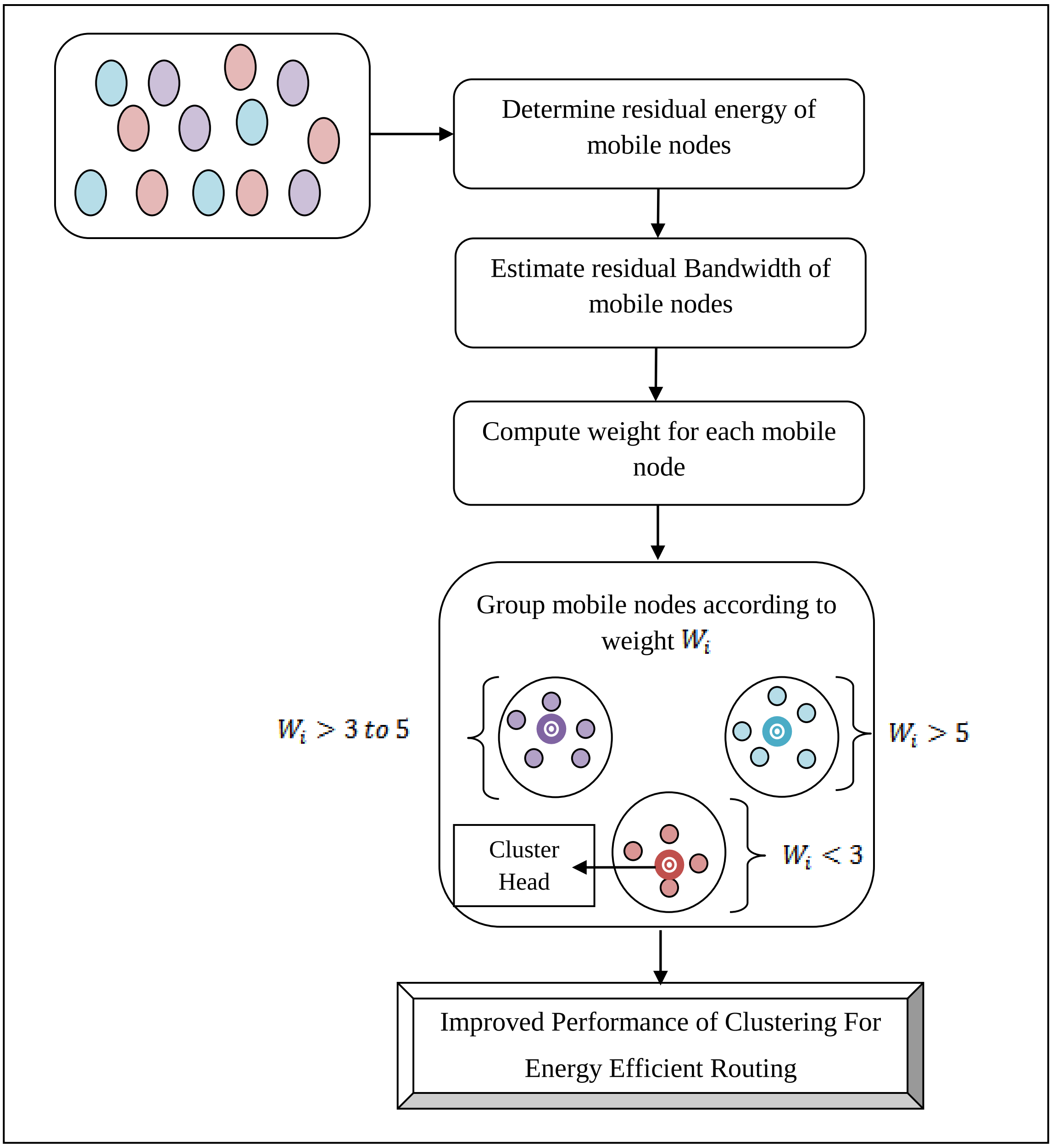

Figure 2 Processes of Weighted Multi-objective Clustering For Energy Efficient Routing MANET

Figure 2 presents the flow processes of WMC algorithm to carry out energy efficient routing in MANET. Let us consider mobile nodes $MN_i = MN_1, MN_2, \dots MN_n$ in network have same energy level. During the data transmission, the energy level of each mobile node gets reduced based on the distance between mobile nodes. Thus, energy level ω of mobile node is evaluated as,

$$\omega = P \times T \tag{1}$$

From equation (1), P indicates transmission power of node and T refers the time utilized for transmission. Followed by, the residual energy of mobile node ω_{RES} is determined as,

$$\omega_{RES} = \omega_I - (\omega_T + \omega_R) \tag{2}$$

From equation (2), ω_I indicates initial energy of mobile node. Here, ω_T and ω_R are energy consumed by mobile node for transmitting and receiving the data packets respectively. From that, energy utilization ω_U of node to transmit data packets or receive the data packets is mathematically obtained as,

$$\omega_U = \omega_{total} - \omega_{RES} \tag{3}$$

From equation (3), ω_{total} denotes the total energy of mobile node. The bandwidth utilization of mobile node is another significant routing metric considered in proposed WMC-HBFLB technique. Each mobile node computes its bandwidth requirement depends on its expected data transmission requirement. The residual bandwidth of mobile node RB_{MN_i} is obtained as,

$$RB_{MN_i} = B_I - B_C \quad (4)$$

From equation (4), 'B_I' is an initial bandwidth of mobile node and 'B_C' denotes an amount of bandwidth consumed to transmit the gathered data packets to neighbour node. After evaluating residual energy and bandwidth, a mobile node computes its weight as,

$$W_i = \omega_{RES} + RB_{MN_i} \quad (5)$$

From equation (5), W_i is the computed weight of mobile node MN_i. With help of determined weight value, the mobile nodes with similar weight value in MANET are grouped to construct clusters. The algorithmic process of weighted multi-objective clustering is shown in below,

// Weighted Multi-objective Clustering Algorithm
Input: Collection of Mobile Nodes $MN_i = MN_1, MN_2, \ldots MN_n$ in network
Output: Reduced energy consumption for routing in MANET
Step 1: Begin
Step 2: **For** each mobile node MN_i
Step 3: Evaluate residual energy ω_{RES} using (2)
Step 4: Estimate residual bandwidth RB_{MN_i} using (4)
Step 5: Determine weight W_i of mobile node using (5)
Step 6: **End for**
Step 7: Group the mobile nodes in network according to weight value
Step 8: Select mobile node which has higher weight within a cluster as a CH to transmit collected data packets to sink node
Step 9:End

Algorithm 1 Weighted Multi-objective Clustering

Algorithm 1 depicts the step by step processes of WMC algorithm to attain energy efficient routing in MANET. As shown in algorithm, WMC algorithm first computes residual energy and bandwidth for all mobile nodes in MANET. Based on evaluated residual energy and bandwidth of nodes, then WMC algorithm determines weight value for each mobile in network. Afterward, the mobile nodes with similar weight values are grouped to make number of clusters in MANET. Finally, the mobile node with higher weight is taken as cluster head for routing the information with minimal energy utilization.

To balance the load on mobile node during data transmission with higher efficiency, Honey Bee Foraging Load balancing (HBFLB) algorithm is proposed in WMC-HBFLB technique which detailed processes is shown in forthcoming subsection.

Honey Bee Foraging Load Balancing

The Honey Bee Foraging Load balancing (HBFLB) algorithm is applied in WMC-HBFLB technique with objective of attaining load optimized routing in MANET. The HBFLB algorithm is an optimization technique designed from the foraging behavior of honey bees. The honey bees start flying for the intention of foraging in diverse directions. The journey taken by bees may be a short distance or longer distances. The bees gather nectar from food sources. The bee carry outs a type of dance such as the ''waggle dance''. This dance helps for bees to find food sources in particular direction. In this manner, bee identifies food sources without any map, guide, or any other instruction.

The HBFLB algorithm based on foraging strategy of honey bees provides best solutions for a load balancing issue in MANET. Let us consider a population of n bees (i.e. number of cluster Heads (CHs)) to search the solution. Each time bee evaluates its fitness function to find out the food sources. This fitness function provides direction towards a food source to find quality food. This helps for HBFLB algorithm to find out the load optimal CH to broadcast data packets in MANET. The flow processes of HBFLB algorithm for load balancing in MANET is shown in below,

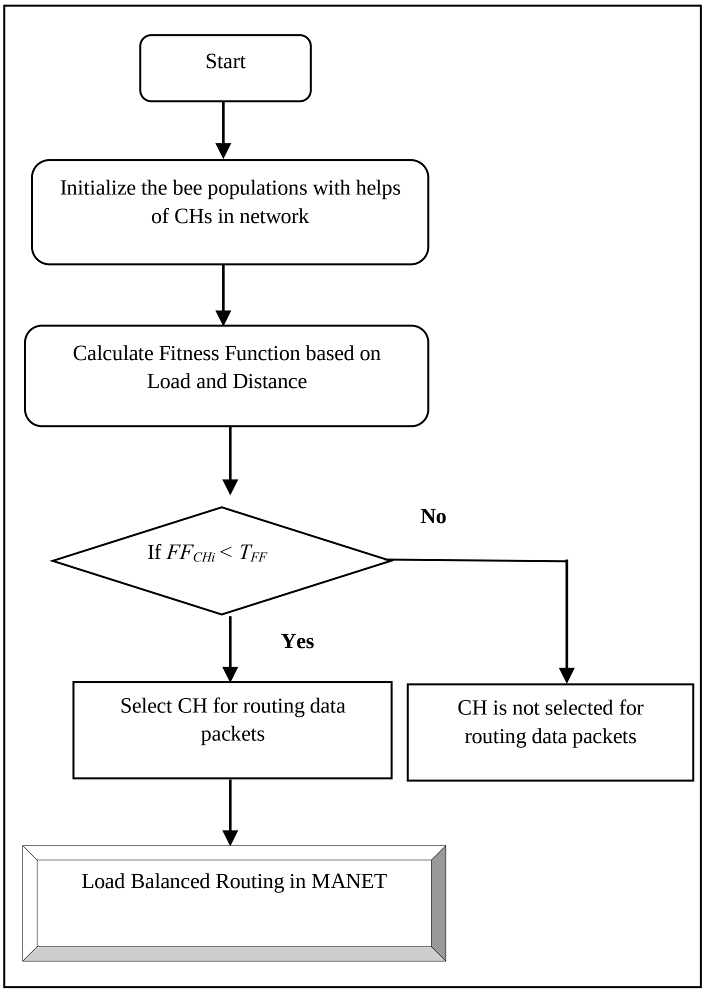

Figure 3. Processes of Honey Bee Foraging For Load Balancing In MANET

Figure 3 demonstrates the flow processes of HBFLB algorithm in order to balance the load of CH across MANET. As shown in Figure, the HBFLB algorithm at first initializes the populations with aid of number of Cluster Heads (CHs) in network. Then, the HBFLB algorithm computes the fitness function for each CH in network based on measurement of load and distance. During the process of foraging, bee looks for the food source to collect more nectar based on fitness evaluation. By using this concepts, source node choose the load optimized CH to route the data packets. Therefore, the HBFLB algorithm checks the fitness function of CH is lesser than a threshold fitness function. If CH satisfies the above condition, HBFLB algorithm select that CH as load optimal node to transmit the data packets from source to destination or sink node in MANET. As a result, proposed WMC-HBFLB Technique obtains load balanced routing in MANET.

Let us consider a MANET consisting of set of N mobile nodes and clusters formation results from WMC algorithm. Each cluster includes numerous cluster members and one CH. The CH gathers all sensed data from it cluster members and then transmit collected data to the corresponding destination or sink node in MANET. The CH sent the gather data to sink via nearest CHs in network. During routing process, load in all CH has to be balanced to prolong network lifetime and to minimize data loss rate. In order to balance the load across CH, let us consider the M/M/1 queuing model for packet arrivals and departures in CH. From that, congestion over CH_i is evaluated as,

$$\delta_n = \frac{1}{TC-N} \qquad (6)$$

From equation (6), δ_n denotes the congestion on CH_i whereas TC refers the total capacity of CH and N indicates existing traffic flow. The congestion incremented on CH through an additional amount of data traffic flow ΔD_n which is obtained as,

$$\Delta\delta_n \approx \frac{1}{(TC-N)^2}\Delta D_n \qquad (7)$$

From equation (7), the load weightage increased on CH is measured. Followed by, load weightage on LW_{CH_i} is determined as,

$$LW_{CH_i} = \frac{N_{CH_i}}{TC_{CH_i}} \qquad (8)$$

From equation (8), TC_{CH_i} denotes the total capacity of CH and N_{CH_i} refers the amount of data packets being carried by CH_i. After determining the load weightage of CH, the Honey Bee foraging algorithm measures the distance between two cluster heads CH_1 and CH_2 in order to select the nearest CH for routing data packets. The HBFLB algorithm employed the Mahalanobis distance in order to identify the nearest CH. The Mahalanobis distance d estimates the distance between two cluster heads CH_1 and CH_2 in MANETs which is formulated as,

$$d(CH_1, CH_2) = \left\{\left[(x_j,y_j)-(x_i,y_i)\right]^T * Cv^{-1} * \left[(x_j,y_j)-(x_i,y_i)\right]\right\}^{1/2} \qquad (9)$$

From equation (9), $d(CH_1, CH_2)$ represents the distance between two cluster heads in MANET. Here, (x_i, y_i) and (x_j, y_j) indicates the location coordinates of two cluster heads and Cv is the sample covariance matrix. From the measurement of load weightage and distance, fitness function of CH is determined as,

$$FF_{CH_i} = \{LW_{CH_i}, d(CH_1, CH_2)\} \qquad (10)$$

By using the above equation (10), honey bee foraging algorithm computes the fitness function for each CH to perform load balanced routing in MANET. The HBFLB algorithm defines the threshold fitness function value T_{FF} for finding the load optimal CH to broadcast the collected data packets from source to sink node in networks. The algorithmic processes of HBFLB algorithm to balance load among CHs in MANET is shown in below,

//Honey Bee Foraging based Load Balancing Algorithm

Input: Mobile Nodes $MN_i = MN_1, MN_2, \ldots MN_n$ in network

Output: Improved load balancing efficiency

Step 1:Begin

Step 2: Initialize the bee populations with assists of CHs in network

Step 3: **For** each Cluster Head CH_i

Step 4: Estimate load weightage on CH using (8)

Step 5: Compute distance between the source and CH using (9)

Step 6: Measure fitness function using (10)

Step 7: **If** (FF_{CH_i} < Threshold 'T_{FF}') **then**

Step 8: Choose CH for transmitting data packets

Step 9: **Else**

Step 10: Select another neighbour CH

Step 11: **End If**

Step 12: **Go to Step 3** until the data packets reaches the destination node

Step 13: **End For**

Step 14:End

Algorithm 2 Honey Bee Foraging based Load Balancing

Algorithm 2 demonstrates step by step algorithmic process of HBFLB algorithm to attain higher efficiency for load balanced routing in MANET. As depicted in Algorithm 2, the HBFLB algorithm initializes the bee populations with help of number of CHs in network. Subsequently, the HBFLB algorithm evaluates the fitness function for each CH in network with aid computed of load weightage and distance between them. If fitness function value of CH is lesser than predefined threshold value, then source node choose the CH as load optimal node in order to route the collected data packets to destination node. Otherwise, the source node selects another nearest neighbour CH which fulfils the above fitness condition to broadcasts data packets in MANET. This process of HBFLB algorithm is repeated until the data packets reaches the destination node from source node. By distributing the load equally among all CHs in MANET, the data loss due to collision and traffic congestions and extra energy utilization for retransmitting data is significantly reduced in MANET. This helps for WMC-HBFLB Technique to increases lifetime of the network. Therefore, WMC-HBFLB Technique increases the load balancing efficiency of MANET in an effective manner.

SIMULATION SETTINGS

In order to estimate the performance of proposed, WMC-HBFLB Technique is implemented in NS-2 simulator with network area of 1200m * 1200m. The WMC-HBFLB Technique used Ad hoc On-Demand Distance Vector (AODV) protocol as routing protocol for performing simulation process. The table 1 depicts simulation parameters utilized in WMC-HBFLB Technique

Table 1 Simulation Parameters

Simulation factor	Value
Simulator	NS2.34
Network area	1200m * 1200m
Protocol	AODV
Mobility model	Random Way Point
Transmission range	300m
Number of Mobile Nodes	50, 100, 150, 200, 250, 300, 350,400,500
Number of Data Packets	10, 20,30,40,50,60,70,80,90,100
Maximum speed for mobile nodes	2–10 mps
Simulation time	100s
Pause time	10s

The simulation of WMC-HBFLB Technique is conducted for many instances with respect to diverse number of mobile nodes and data packets for determining proposed performance. The performance of WMC-HBFLB Technique is measured in terms of energy utilization rate, end to end delay, data loss rate and load balancing efficiency. The performance of WMC-HBFLB is compared with existing Weight Based Clustering (WBC) protocol [1], Ant Based Multipath Backbone Routing for Load Balancing (AMBRLB) [2].

RESULT AND DISCUSSIONS

In this section, the results of WMC-HBFLB Technique are discussed. The efficiency of proposed WMC-HBFLB Technique is compared with Weight Based Clustering (WBC) protocol [1], Ant Based Multipath Backbone Routing for Load Balancing (AMBRLB) [2] respectively. The performance of WMC-HBFLB Technique is analyzed along with the following metrics with the help of tables and graphs.

Performance Result of Energy Utilization Rate

In WMC-HBFLB Technique, the Energy Utilization Rate (EUR) estimates amount of energy taken for transmitting data packets from a source to sink node in MANET. Thus EUR is measured as product of energy utilized by a signal mobile node for broadcasting data packet and total number of mobile nodes in MANET. The energy utilization rate is evaluated in terms Joules (J) and obtained as,

$$EUR = N * EU_S \tag{11}$$

From equation (11), energy utilization rate of data packet transmission in MANET is determined with respect to different number of mobile nodes (N). Here, EU_S represents the energy utilized for single mobile node for data transmission in MANET. When EUR is lower, the technique is said to be more effective.

Let us consider the technique with diverse number of mobile nodes in the range of 50-500 to perform simulation processes in NS-2 simulator. When considering 200 mobile nodes for simulation process, proposed WMC-HBFLB Technique utilized 33J energy for data packet transmission whereas existing WBC [1], AMBRLB [2] obtains 51J and 41J respectively. From these results, it is clear that the energy utilization rate of data packet broadcasting in MANET using proposed WMC-HBFLB technique is lower than other existing protocol [1], [2]. The tabulation result of energy utilization rate using three methods with respect to varied number of mobile nodes is shown in below Figure 4.

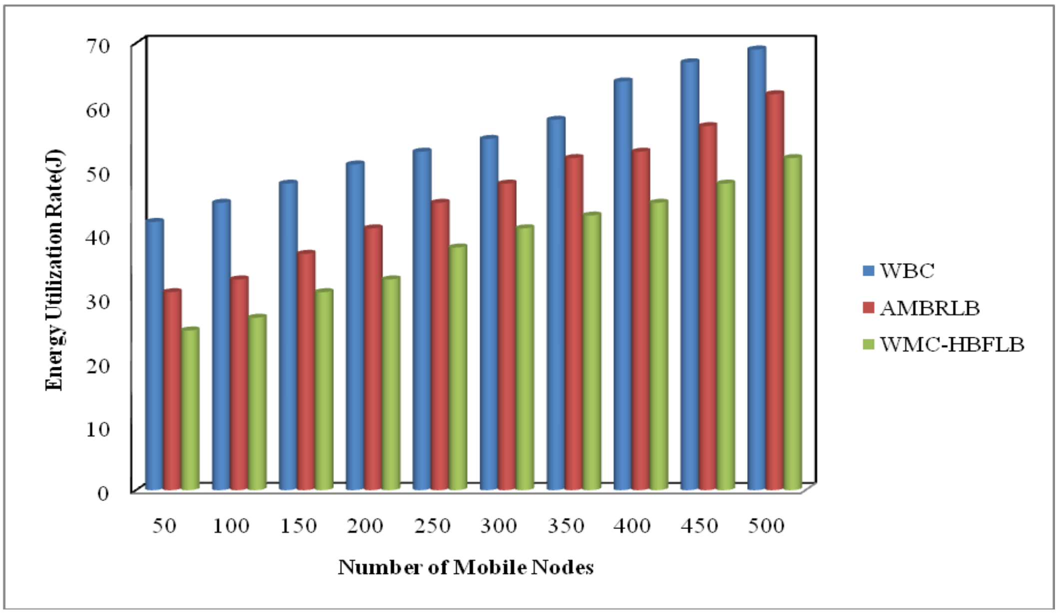

Figure 4. Performance Result of Energy Utilization Rate versus Different Numbers of Mobile Nodes

Figure 4 presents performance result analysis of energy utilization rate based on various numbers of mobile nodes which is ranges from 50-500. As shown in above table, the proposed WMC-HBFLB Technique takes minimum energy utilization rate for routing data to sink in MANET when compared to WBC [1], AMBRLB [2]. In addition, while increasing the number of mobile nodes, the energy utilization rate is also increased. But comparatively energy utilization rate using proposed WMC-HBFLB is lower than other existing [1] and [2]. This is due to application of WMC in WMC-HBFLB where it employs residual energy to compute weight values for mobile nodes in network. Afterward, WMC groups the mobile nodes in MANET according to weight values. Then, mobile node with higher weight within a cluster is elected as CH for routing the information. This CH utilizes minimum amount of energy as compared to other nodes in cluster for transmitting data packets to sink. Hence, proposed WMC-HBFLB technique decreases the energy consumption of routing by 31 % and 17 % when compared to existing WBC [1], AMBRLB [2] respectively.

Performance Result of Data Loss Rate

In WMC-HBFLB Technique, Data Loss Rate (DLR) measured as ratio of number of data packets dropped to the total number of data packets transmitted by source node in MANET. The DLR is determined in terms of percentages (%) and evaluated as,

$$DLR = \frac{d}{n} * 100 \tag{12}$$

From equation (12), the data loss rate during transmission is estimated with respect to different numbers of data packets. Here, n refers the total number of data packets sent by source node whereas d_D indicates number of data packets dropped. When DLR is lower, the technique is said to be more efficient.

Let us assume the technique with varied number of data packets in the range of 10-100 to conduct simulation processes in NS-2 simulator. The proposed WMC-HBFLB Technique acquires 30 % data loss rate with 50 numbers of data packets considered for simulation works whereas existing WBC [1], AMBRLB [2] attains 48 % and 40% respectively. From these results, it is expressive that the data loss rate during data packet broadcasting using proposed WMC-HBFLB technique is lower than other existing protocol [1], [2]. The simulation result of data loss rate using three methods based on diverse number of data packet is portrayed in below Table 2.

Table 2 Tabulation for Data Loss Rate

Number of Data Packets	Data Loss Rate (%)		
	WBC	AMBRLB	WMC-HBFLB
10	40	31	20
20	42	33	23
30	44	35	25
40	46	38	28
50	48	40	30
60	52	42	31
70	54	48	35
80	57	50	38
90	59	51	41
100	61	53	42

The performance result analysis of data loss rate with respect to different numbers of data packets in the range of 10-100 using three methods is illustrated in Table 2. As demonstrated in above table, the proposed WMC-HBFLB Technique attains minimum data loss rate when compared to WBC [1], AMBRLB [2]. As well, while increasing the number of data packets, the data loss rate is also increased. But comparatively data loss rate using proposed WMC-HBFLB is lower than other existing [1] and [2]. This is because of application of HBFLB algorithm in WMC-HBFLB technique where it select the CH which have minimum load weightage as load optimal node to broadcast the data packets to destination node in MANET. Through distribution of the equal load among all CHs in MANET, the data loss owing to collision or traffic congestions are minimized in MANET. Therefore, proposed WMC-HBFLB technique lessens the data loss rate of routing in MANET by 39 % and 26 % when compared to existing WBC [1], AMBRLB [2] respectively.

Performance Result of Load Balancing Efficiency

In WMC-HBFLB Technique, Load Balancing Efficiency (LBE) is measured as the number of load optimal CHs selected for data packet transmission to the total number of CHs in MANET. LBE is measured in terms of percentages (%) and mathematically obtained as,

$$LBE = \frac{load\ optimal\ CHs\ selected\ for\ routing}{Total\ number\ of\ CHs} * 100 \quad (13)$$

From equation (13), the load balancing efficiency during data transmission in MANET is determined with respect to different numbers of mobile nodes taken for simulation processes. When LBE is higher, the technique is said to be more effective.

Whenever employing 400 mobile nodes for accomplishing simulation processes in MANET, WMC algorithms forms numerous numbers of clusters based on residual energy and bandwidth. Then, WMC select CH for each clusters in MANET to transmit data to sink. During data transmission, HBFLB balance load of all CHs in MANET by means of selecting load optimal CH for data packet transmission. Hence, proposed WMC-HBFLB Technique attains 91 % load balancing efficiency while considering 400 mobile nodes for simulation processes whereas existing WBC [1], AMBRLB [2] obtains 71% and 81 % respectively. Accordingly, load balancing efficiency using proposed WMC-HBFLB technique is higher than other existing protocol [1], [2]. The comparative result analysis of load balancing efficiency using three methods namely WBC [1], AMBRLB [2] and proposed WMC-HBFLB technique with respect to diverse number of mobile nodes is demonstrated in below Figure 5.

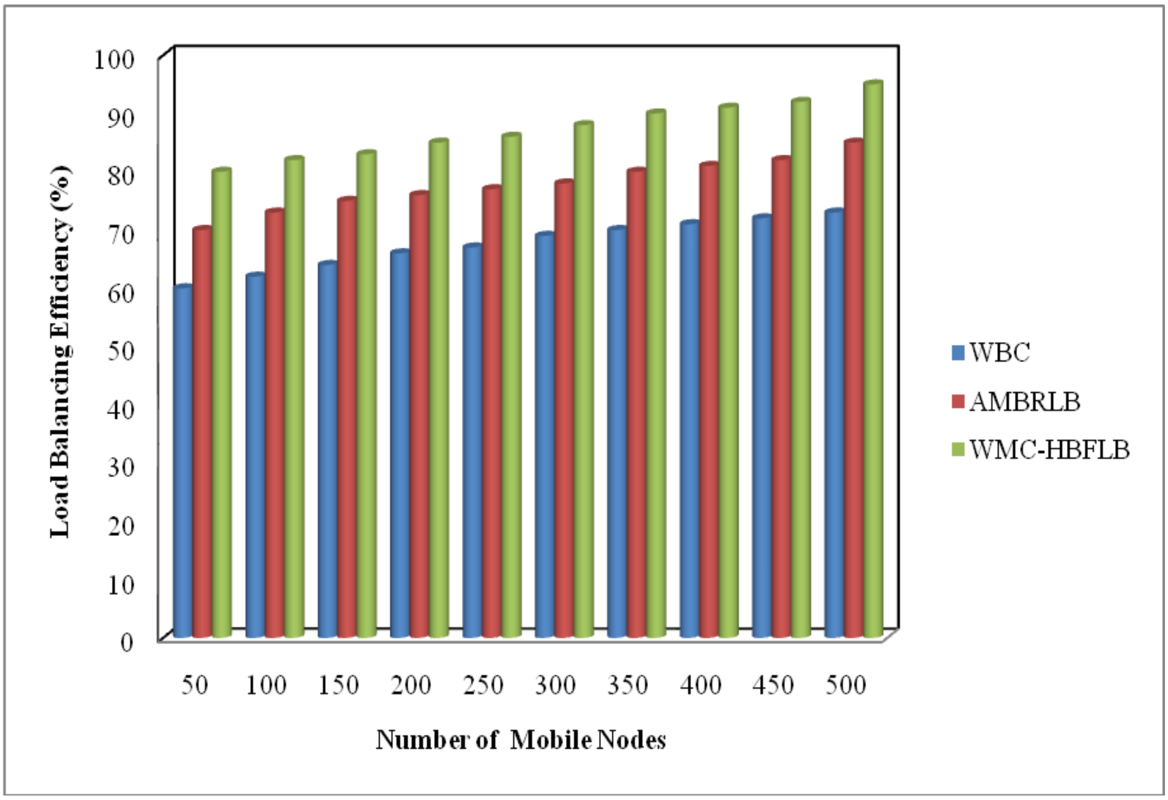

Figure 5. Performance Result of Load Balancing Efficiency versus Different Numbers of Mobile Nodes

The simulation results of load balancing efficiency based on varied numbers of mobile nodes in the range of 50-500 using three methods is depicted in Figure 5. As exposed in above table, the proposed WMC-HBFLB Technique attains higher load balancing efficiency when compared to WBC [1], AMBRLB [2]. Additionally, while increasing the number of mobile nodes, the load balancing efficiency is also improved. But comparatively load balancing efficiency using proposed WMC-HBFLB is higher than other existing [1] and [2]. This is due to application of HBFLB algorithm in WMC-HBFLB technique. For balancing the load of CHs during data transmission, HBFLB algorithm initializes the populations with supports of number of CHs in MANET. Followed by, HBFLB algorithm computes the fitness function for all CH in network using their load weightage and distance. Then, HBFLB algorithm chooses the CH which satisfies predefined threshold condition as load optimal node to perform data transmission in MANET. This helps for WMC-HBFLB technique to attain load balanced routing in large scale network. Therefore, proposed WMC-HBFLB technique enhances the load balancing efficiency of routing in MANET by 29 % and 12 % when compared to existing WBC [1], AMBRLB [2] respectively.

Performance Result of End to End Delay

In WMC-HBFLB Technique, end–to-end delay EED is evaluated as differences between receiving time of data packet at the sink node REC_T and sending time of packet at source node SEN_T. The end to end delay is measured in terms of milliseconds (ms) and formulated as,

$$EED = REC_T - SEN_T \tag{14}$$

From equation (14), the end to end delay of data routing in MANET is computed with respect to diverse numbers of data packets. When EED is lower, the technique is said to be more effectual. While taking 80 data packets for simulation process, proposed WMC-HBFLB Technique gets 25 ms end to end delay whereas existing WBC [1], AMBRLB [2] obtains 33 ms and 28 ms respectively. As a result, end to end delay using proposed WMC-HBFLB technique is lower than other existing protocol [1], [2]. The performance result of end to end delay using three methods is presented in below Table 3.

Table 3. Tabulation for End To End Delay

Number of Data Packets	End To End Delay (ms)		
	WBC	AMBRLB	WMC-HBFLB
10	15	13	12
20	18	16	14
30	22	19	16
40	27	24	18
50	28	25	22
60	30	26	23
70	31	27	24
80	33	28	25
90	34	29	26
100	36	31	27

The results of end to end delay is obtained with respect to diverse numbers of data packets in the range of 10-100 using three methods is explained in Table 3. As illustrated in above table, the proposed WMC-HBFLB Technique gets lower end to end delay when compared to WBC [1], AMBRLB [2]. Also, while increasing the number of data packets, the end to end delay is also improved. But comparatively end to end delay using proposed WMC-HBFLB is lower than other existing [1] and [2]. This is owing to processes of WMC and HBFLB algorithm in WMC-HBFLB technique. With aid of WMC algorithmic process, WMC-HBFLB Technique builds clusters with higher residual energy. This helps for WMC-HBFLB to perform stable routing for longer times. Therefore, retransmission of data due to link failure is avoided in MANET which results in minimum delay time for data broadcasting in MANET. Furthermore, WMC-HBFLB Technique applies HBFLB algorithm for balancing load on CHs in MANET in which load optimal CH is taken for routing data. Therefore, there is a no need to wait at queue for longer time for data transmission. Thus, proposed WMC-HBFLB technique lessens the end to end delay of routing in MANET by 32 % and 13 % when compared to existing WBC [1], AMBRLB [2] respectively.

CONCLUSION

An effective WMC-HBFLB technique is developed with the key aim of attaining energy efficient and load balanced routing in MANET. The aim of proposed technique is obtained with designing of WMC and HBFLB algorithm in WMC-HBFLB. The algorithmic processes of WMC supports for WMC-HBFLB technique to carry out the data transmission in MANET with lesser amount of energy utilization as compared to existing cluster based routing methods. The HBFLB algorithm assists for WMC-HBFLB technique to balance identical load among all CHs in MANET. Therefore, data loss because of collision, traffic congestions and additional energy consumption for retransmission of data and delay time during the routing in MANET is considerably minimized in proposed WMC-HBFLB technique when compared to existing load balancing techniques. This supports for WMC-HBFLB Technique is also to prolong lifetime of the network as compared to state-of-the art works. The effectiveness of WMC-HBFLB Technique is evaluated in terms of energy consumption, load balancing efficiency, end to end delay, data loss rate and compared with state-of-the-art works. The simulation result of WMC-HBFLB Technique provides better performance with an enhancement of load balancing efficiency and minimization of energy consumption when compared to the state-of-the-art works.

REFERENCES

[1] Sunil Pathak, Sonal Jain, "A novel weight based clustering algorithm for routing in MANET", Wireless Networks, Springer, Volume 22, Issue 8, Pages 2695–2704, November 2016

[2] Pitchaimuthu Francis Antony Selvi, Moola Seetharamaiyer Kasiviswanathan Manikandan, "Ant based multipath backbone routing for load balancing in MANET", IET Communications, Volume 11, Issue 1, Pages 136 – 141, 2017

[3] Waheb A. Jabbar, Mahamod Ismail and Rosdiadee Nordin, "Energy and mobility conscious multipath routing scheme for route stability and load balancing in MANETs", Simulation Modelling Practice and Theory, Elsevier, Volume 77, Pages 245–271, 2017

[4] Jipeng Zhou, Haisheng Tan, Yuhui Deng, Lin Cui and Deng Deng Liu, "Ant colony-based energy control routing protocol for mobile ad hoc networks under different node mobility models", EURASIP Journal on Wireless Communications and Networking, Springer, Volume 2016, Issue 105, Pages 1-8, 2016

[5] Santosh Kumar Das and Sachin Tripathi, "Intelligent energy-aware efficient routing for MANET", Wireless Networks, Springer, Pages 1-21, 2017

[6] Wei Liu, Chi Zhang, Guoliang Yao, Yuguang Fang, "DELAR: A Device-Energy-Load Aware Relaying Framework for Heterogeneous Mobile Ad Hoc Networks", IEEE Journal on Selected Areas in Communications, Volume 29, Issue 8, Pages: 1572 – 1584, September 2011

[7] A. Pratapa Reddy and N. Satyanarayana, "Energy-efficient stable multipath routing in MANET", Wireless Networks, Springer, Volume 23, Issue 7, Pages 2083–2091, October 2017

[8] Saleh A. Alghamdi, "Load balancing ad hoc on-demand multipath distance vector (LBAOMDV) routing protocol", EURASIP Journal on Wireless Communications and Networking, Springer, Volume 242, December 2015

[9] Jung-Yoon Kim, Geetam S. Tomar, Laxmi Shrivastava, Sarita Singh Bhadauria, Won-Hyoung Lee, "Load Balanced Congestion Adaptive Routing for Mobile Ad Hoc Networks", International Journal of Distributed Sensor Networks, Volume 10 issue 7, Pages 1-10, 2014

[10] Haidar Safa, Hassan Artail, Diana Tabet, "A cluster-based trust-aware routing protocol for mobile ad hoc networks", Wireless Networks, Springer, Volume 16, Issue 4, Pages 969–984, May 2010

[11] Gaurav Pathak, Krishan Kumar, "Traffic aware load balancing in AOMDV for mobile Ad-hoc networks", Journal of Communications and Information Networks, Springer, Volume 2, Issue 3, Pages 123–130, September 2017

[12] Oh Chan Kwon, Hyung Rai Oh, Zae-Kwun Lee, GyeongCheol Lee, Youngho Park and Hwangjun Song, "Entire network load-aware cooperative routing algorithm for video streaming over mobile ad hoc networks", Wireless Communications And Mobile Computing, Wiley Online Publications, Volume 13, Pages 1135–1149

[13] Chao Gu, Qi Zhu, "An Energy-Aware Routing Protocol for Mobile Ad Hoc Networks Based on Route Energy Comprehensive Index", Wireless Personal Communications, Volume 79, Issue 2, Pages 1557–1570, 2014

[14] Aqeel Taha, Raed Alsaqour, Mueen Uddin, Maha Abdelhaq, Tanzila Saba, "Energy Efficient Multipath Routing Protocol for Mobile Ad-Hoc Network Using the Fitness Function", IEEE Access, Volume 5, Pages 10369 – 10381, 2017

[15] Mahdi Abdulkader Salem, Raghav Yadav, "Efficient Load Balancing Routing Technique for Mobile Ad Hoc Networks", International Journal of Advanced Computer Science and Applications, Volume 7, Issue 5, Pages 249-254, 2016

[16] Sujatha P Terdal, V.D.Mytri, A.Damodaram, "A Load Aware Routing Mechanism for Improving Energy Efficiency in Mobile Ad Hoc Networks", International Journal of Computer Applications, Volume 10, Issue 3, Pages 6-11, November 2010

[17] Labdah ALGhafran and Zulkefli Bin Muhammed Yusof, "An Efficient Load Balancing Clustering Algorithm for Mobile Ad Hoc Networks", International Journal of Computing, Communications & Instrumentation Engineering (IJCCIE), Volume 2, Issue 2, Pages 215-219, 2015

[18] H. Safa, andO. Mirza, "A load balancing energy efficient clustering algorithm for MANETs", International Journal of Communication Systems, Online Willey Publications, Volume 23, Issue 4, Pages 463–483, April 2010

[19] Ratish Agarwal, Roopam Gupta, and Mahesh Motwani, "Energy Aware Load Balancing Clustering in Mobile Ad Hoc Networks", International Journal of Computer Science and Electronics Engineering (IJCSEE), Volume 2, Issue 1, Pages 38-43, 2014

[20] Junaid A. Khan, M. Nasir Iqbal, Farooq Umer, Muhammad Adnan, Zeeshan A.Khan and Mustafa Shakir, "Achieving Energy Efficiency in MANETs by Using Load Balancing Approach", International Journal of Computer Networks and Communications Security, Volume 3, Issue 3, Pages 88–94, 2015