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FABC-MACRD: Fuzzy and Artificial Bee Colony Based Implementation of MAC, Clustering, Routing and Data Delivery by Cross-Layer Approach in WSN

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Abstract This paper demonstrates the Fuzzy and Artificial Bee Colony Based Implementation of MAC, Clustering, Routing and Data delivery by Cross-Layer approach in WSN (FABC-MACRD). The protocols of cross layer mechanism links of both the media accessibility and the energy proficient hierarchical based cluster routing. Thus for the selection of nodes the approach makes use of the fuzzy dependent CH selection technique. The major problem with hierarchical dependent clustering methodology is the congestion occurrence in CHs which are nearer to MS. This congestion generates the coverage problems as well as the network connectivity issues. Thus to rectify this issues the proposed FABC-MACRD approach combines of the network into non-similar clusters. The proposed approach utilizes the ABC optimization algorithm thus for the energy efficient and flexible transmission of data onto the Master Station, also performs the inter cluster routing commencing from CHs over the Master Station. The proposed methodology mainly includes three phases namely network association, nearest node detection phase and consistent-state stride. The performance analysis is carried out with different methodologies such as "UCR", "ULCA", "EAUCF" and with "IFUC". After analysis our proposed FABC-MACRD approach shows better outcomes in terms of packet delivery, energy consumption and lifespan of the network.

Keywords WSN · Non-similar clusters · Cross layering · Artificial Bee Colony · Fuzzy logic · Routing

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1 Introduction

The WSN (Wireless Sensor Networks) elongates the ability of human thus to communicate as well as to observe the environment physically [1–3]. The node that corresponds to the WSN is shared among the sensing range without including the stable framework. The information is transmitted to the MS (Master Station) by means of WSN nodes that gathers the sensed information [4, 5]. The WSN node which is administered around the hostile situations may turns to be a dead node in because of limited supply of power [6].

Hence there is in need for the efficient energy protocols of WSN as well the nodes should have the capacity to adapt to distinctive environmental criteria. The efficiency of energy can be attained just by utilizing the cross layer methodologies which may deplete the communication onto the interaction layers. The interaction layers are employed for the generation of decisions [7].

Thus with the help of protocols pattern utilizing the cross layer methodologies, information that corresponds to the layers must be utilized for following layers advantageous. This is carried out in order to make decisions about routing towards the node (by chance if it possesses the weak signal, then the node should make use of another node for routing [8–14]. The main objective behind cross layer configuration is to accomplish improved system execution. The methodologies of cross layer configuration ought to be able to conserve the layered structure as well as ruptures the limitations of interaction among distinctive layers. This also establishes required QoS applications to the system. The cross-layer configuration has the capacity to vary the parameter pattern that belongs to distinctive layers [15].

In this paper, proposed the FABC-MACRD approach in which the protocols of cross layer mechanism links of both the media accessibility and the energy proficient hierarchical based cluster routing. Thus for the selection of nodes, the approach makes use of the fuzzy dependent CH (Cluster Head) selection mechanism. The proposed FABC-MACRD approach combines of the network into non-similar clusters. The proposed approach utilizes the Artificial Bee Colony optimization algorithm thus for the energy efficient and flexible transmission of data onto the Master Station (MS). The ABC algorithm also performs the inter cluster routing commencing from CHs (Cluster Heads) over the Master Station (MS). The proposed methodology mainly includes three strides namely network association, nearest node detection phase, and consistent-state stride.

The contribution of this paper is as follows:

In this paper, we propose an FABC-MACRD approach thus to diminish the coverage problems and the network connectivity issues. The works carried out behind this paper are summarized as follows:

- Here we present an FABC-MACRD approach to combine of the network into non-similar clusters.
- Derived the Artificial Bee Colony optimization algorithm thus for the energy efficient and flexible transmission of data onto the Master Station (MS).
- The inter cluster routing commencing from CHs (Cluster Heads) over the Master Station (MS) is being optimized using ABC approach.
- Hereby we will evaluate the simulation results of the proposed approach, analyzed and contrasted the outcomes together with the existing approaches.

The rest of this paper dealt with the following sections. Section 2 contributes our work together with existing works. Proposed approaches of this paper are depicted in zone 3. Results of our work are discussed in Sect. 4. This paper gets completed up with zone 5.

1.1 Background Model

1.1.1 Description of Cross Layer Approach

This segment describes the corresponding standards related to the protocol of routing design. The efficiency of the energy can be attained just by utilizing the approaches of cross layer which may deplete the information exchange over the interaction layers responsible in terms of the creation of decision [3]. Based on the protocols design of cross layer approach, the framework is being partitioned up into 5 layers. This layers is to be composed and should be implemented individually thus to attain the particular capabilities. The communications among distinctive layers turn to be stationary. The protocols administered to each and every layer has the capacity to handle the problems occurred in the layer depending upon the functions supplied by the bottom level layer [4]. This, in turn, provides the functions to the topmost layer. Figure 1 shows the interchange of information occurrence in cross layers onto distinctive layers that relate to the Wireless Sensor Networks (WSNs).

The paradigm of cross layer approach turns to be an important factor in terms of WSNs lifespan and energy optimization techniques [7]. The major goal behind cross layer approach is to handle and to interchange the data in between two or few layers. The interchange of information in between the layers is carried out for the enhancement of performance. Moreover, the cross layer configuration wouldn't dump the layered composition totally. The cross layer configuration, in turn, weakens the limits, therefore, maximizes the communication across distinctive layers.

2 Review of Related Works

The literature review has focused on much more issues in the routing of data as well the network connectivity problems. To resolve certain interruption conditions the objective functions aims of the selection of CHs within its scope. The ABC (Artificial Bee Colony) optimization algorithm was broadly defined in [16–18], whereas the optimization techniques [19] behind cross layer approach were administered in [20–23]. The enhancement

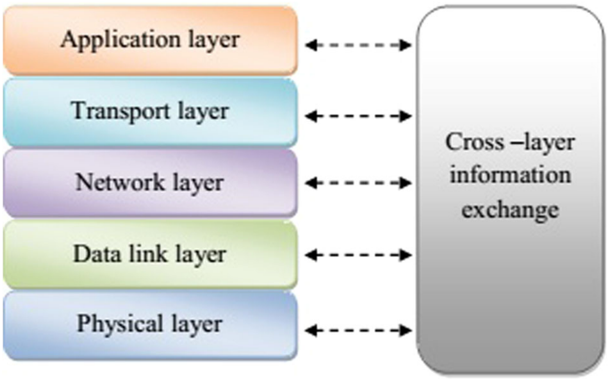


Fig. 1 Information interchanges across cross layer

of routing algorithm [17] was generated thus to update the routing of data onto the framework.

Singh et al. [20] have proposed the networks routing design with protocols that are distinctive and it was entirely dependent upon the threshold measure of the energy enhanced routing protocol design of cross layer approach. Thus to allocate the Cluster Heads (CHs) in the cluster the techniques behind weighted estimation was taken into account. Thus for effective transmission of data the reactive as well as proactive protocols were combined. These approaches when contrasted to the proposed approach FABC-MACRD it showed better performance as well the lifetime of the network was increased due to the efficient routing algorithm.

Xenakis et al. [21] have generated the enhanced optimization of energy aware routing protocol just for the transmission of packets and maintenance of topological framework onto WSN. These techniques formulate the topological satisfaction of coverage conditions, transmission of packets through ECC (Error Correcting Codes) etc. These when compared with the proposed technique, it was verified that it consumed the only little amount of energy for the transmission of data than the energy-aware problem.

Gokturk et al. [22] have proposed the CO-MAC (Co-functioning Medium Access Control) approach thus for the enhancement of performance that relates to WSN after the fulfillment of certain constraints of flexibility. The reliability of energy is attained by means of relay preference as well as with the aid of energy allocation algorithm. These two techniques were functioned with the help of Co-MAC approach. It was verified that the throughput of the network can be enhanced significantly by the proposed approach FABC-MACRD than the COMAC approach.

In order to diminish the time delay (latency) of the WSN. Bagaa et al. [23] have examined the issues that relate to the aggregation of data. Thus to rectify these limitations, Inter Wined Path generation and Scheduling of MAC (IPS) was introduced. This cross layer approach evaluates the scheduling scheme of data aggregating, which permits the parent selection from entire neighbor nodes together with the scheduled nodes. These approach when contrasted to the proposed FABC-MACRD methods the latency of the system is reduced consequently.

Ebrahimnejad et al. [16] have examined several heuristics thus to optimize the weight of Shortest Path (SP). It also optimized the subsequent SP that relates to the network along with the weights of the fuzzy arc. These methodologies mainly make use of the LS (Least Squares) as well as α-strikes. To resolve the issues of shortest path fuzzy problems an algorithm namely ABC (Artificial Bee Colony) was proposed. The performance evaluation was done with other shortest path estimation algorithms. From the observation, it was detected that the proposed ABC routing algorithm shows enhanced performance than the other two compeering algorithms.

Hashim et al. [17] have proposed the enhanced versions of algorithms related to the ABC. These have been carried out for the assurance of maximized lifespan just by evaluating the parameters of networks. From the verification, it was proved that it maximizes the lifespan of the network with less consumption of resources. Additionally, Karaboga et al. [18] have examined the SI (Swarm intelligence) commonly referred to as the gathered characteristics of swarms. Altogether with these ABC (Artificial Bee Colony) was introduced to rectify the issues of real time environment. The focus towards ABC was rapidly maximized in the research field.

Chen et al. [8] have proposed the "UCR" (Unequal Cluster-based Routing) methodology thus to remove the issues of network problems. Here the nodes were grouped into unequal sized clusters. The CHs which were nearer towards the BS (Base Station) has the ability to conserve the energy in order to aid up the communication of inter-cluster routing. UCR could eliminate the network congestion problem to maximize the lifespan of the network. Furthermore, Xinyuan Zhao et al. [9] proposed the "ULCA" (Unequal Layered Clustering Advance) methodology just for the elimination of network connectivity issue in huge efficient WSN. The layers which are nearer to the BS possess only diminished size CH than which were far away from BS. The closer CHS has the ability to conserve more energy than those were in the long distance. These methodologies also increase the lifespan of the network.

Bagci et al. [15] have examined "EAUCF" (Energy-Aware Unequal Clustering Fuzzy) approach to resolve the issues of network coverage issues. He objective behind "EAUCF" methodology was to rectify the inter-cluster congestion over the BS as well as to resolve the consumption of more battery power. For the evaluation of CH radius a fuzzy logic approach was utilized. Moreover, Mao et al. [24] proposed the "IFUC" enhanced energy unequal clustering approach in order to equalize the lifespan of network as well as the power intake of nodes. To maintain the routing in between the BS and to the CHs ACO (Ant Colony Optimization) was utilized. These algorithms reduce the CHs power consumption as well as the network connectivity problems of multi-hop routing approach of WSN.

3 System Model

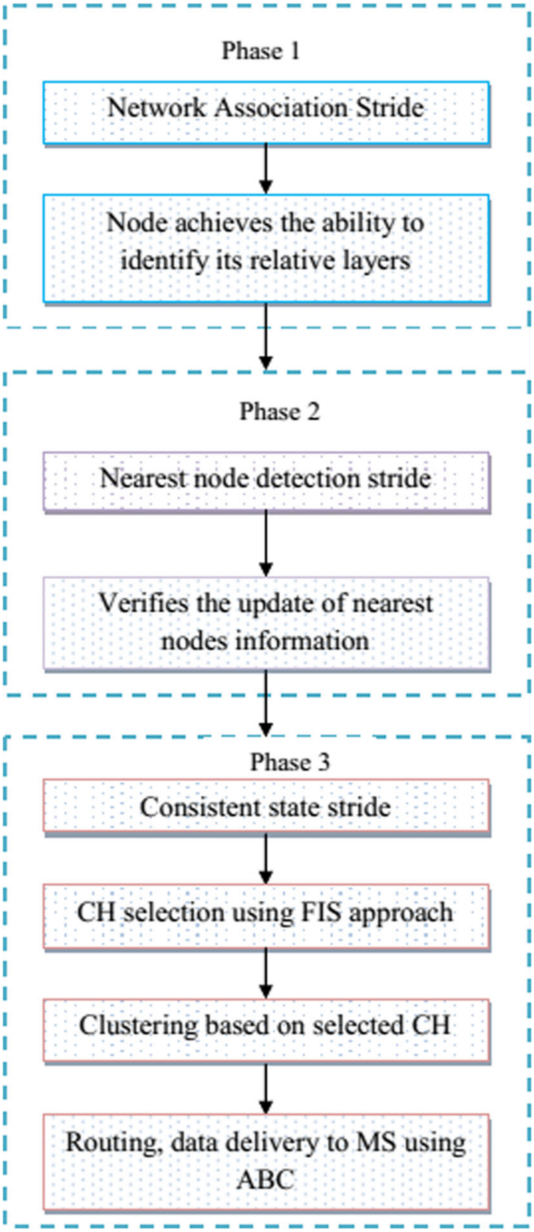
In this paper, proposed the FABC-MACRD approach in which the protocols of cross layer mechanism links of both the media accessibility and the energy proficient hierarchical based cluster routing. Thus for the selection of nodes, the approach makes use of the fuzzy dependent CH (Cluster Head) selection mechanism. The major problem with hierarchical dependent clustering methodology is the CHs (Cluster Heads) which are closer to the Master Station (MS) suffer from more congestion (traffic). The traffic occurrence is may be of two types namely the inter cluster congestion (packets relaying from the far most distant CHs) and intra cluster congestion (sensors (relays) packets from its individual members of the cluster).

This congestion generates the coverage problems as well as the network connectivity issues in because of the CHs death closer to the Master Station (MS) than that of the CHs far away from the MS. Thus to rectify this issues the proposed FABC-MACRD approach combines of the network into non-similar clusters. The clusters with a diminished size are much closer to the Master Station (MS) than that of bigger sized clusters. The smaller sized clusters will possess the CHs much closer to the Master Station (MS), these closer CHs avoids the maximized amount of intra cluster congestion, thus energy conservation is done for the relayed congestion (traffic).

The proposed approach utilizes the Artificial Bee Colony optimization algorithm thus for the energy efficient and flexible transmission of data onto the Master Station (MS). The ABC algorithm also performs the inter cluster routing commencing from CHs (Cluster Heads) over the Master Station (MS). The relay CH selection depends on the factors such as (1) the evaluation of distance measure from the present CH and also from the Master Station (MS). This evaluation is carried out for the efficient energy inter-cluster interaction. (2) Precipitant energy just for the circulation of energy over the network. (3) Length of the queue (evaluation is done for the management of traffic). (4)

Thus for the reliable and efficient interaction, the probability of delivery (DL) evaluation is performed. The proposed methodology mainly includes three phases namely network association, nearest node detection phase, and consistent-state phase. Figure 2 shows the operations of FABC-MACRD approach. These three phases are used for the performance of above-described functionalities. The functions behind three phases are discussed below.

Fig. 2 FABC-MACRD operations



3.1 Network-Association Phase

At the network association stride, the nodes situated among the whole sensing area is sorted out into layers which are delineated onto the Fig. 3. The network association strides succession steps are described below.

Stride 1 The "NETWORK-ASSOCIATION" message is transmitted by the Master Station (MS), the "NETWORK-ASSOCIATION" message includes the information about the nodes such as ID, the co-ordinates of location referred to as (x, y), transfer of power information *z* referred to as P_{MSZ} along with the strength of signal as much as necessary to meet R_{maxr} referred to as nodes maximized transmission range.

Stride 2 The distance is estimated by each and every node i towards the Master Station (MS) with the help of two-beam ground radio transmission pattern which is administered as,

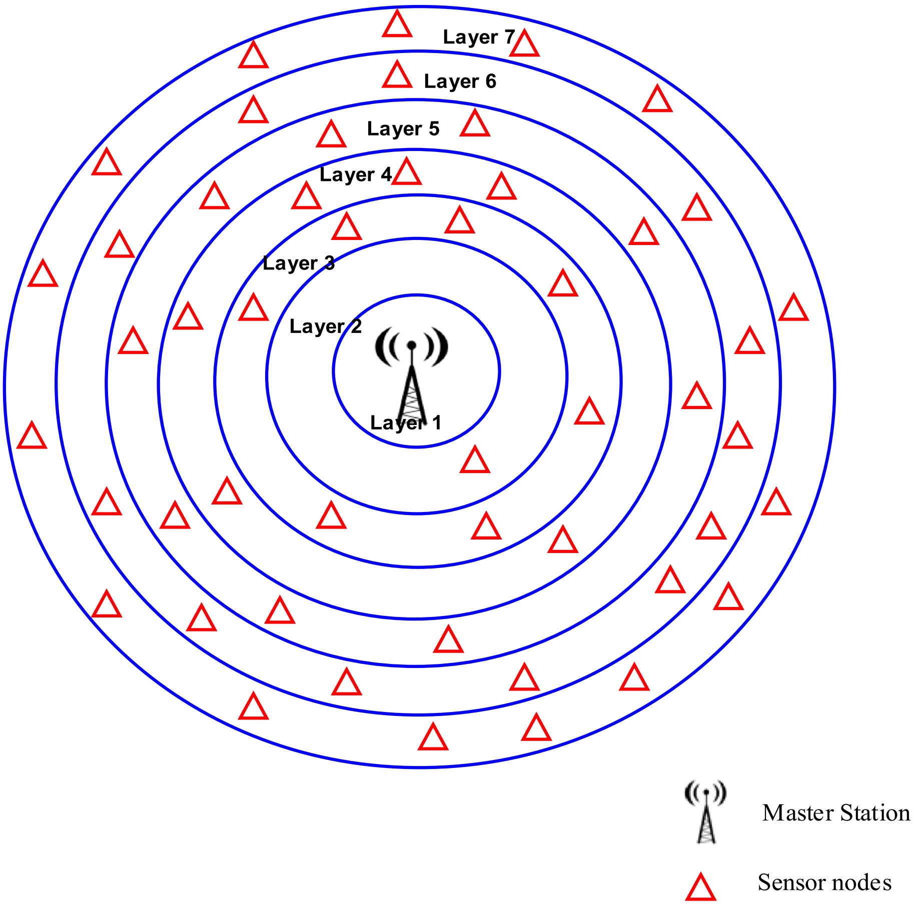


Fig. 3 Formation of layers in FABC-MACRD

$$dist_{(i)} = \sqrt[4]{P_{MSZ} G_{MSZ} G_{lq} h_{MSZ}^2 h_{lq}^2 / P_{lq} L} \quad (1)$$

Hence, P_{lq} and P_{MSZ} is referred to as power, G_{MSZ} and G_{lq} denoted as gain, h_{lq} and h_{MSZ} is denoted as height beyond the ground in order to transfer receiver (antenna) towards the Master Station (MS) as well as to gain the receiver onto the node i correspondingly. L is termed as loss of path.

Thus to identify its corresponding layer each and every node utilizes its evaluated distance measure. The layer 1 is notified as a rounded ring occupying Master Station (MS) as its center as well as its radius is being termed as R_{MAX_l}. The layer 2 is notified as a round ring occupying Master Station (MS) as its center and its external radius is being termed as $R_{MAX} \times 2l$ and its internal radius is being termed as $R_{MAX} \times (2-1)l$.

More basically, n_{th} layer considered as a co-centric ring accompanying MS as its center, external radius as $R_{MAX} \times nl$ and its internal radius is termed as $R_{MAX} \times (n-1)l$. The termination of layering occurs at the criteria $R_{MAX} \times n \geq \frac{l}{2}$, this shows that the whole sensing field is partitioned up into distinctive layers. Over each and every iteration the stride 1 and stride 2 are rehashed, so that the Master Station (MS) maximize the Network-Association messages signal strength in order to attain the successive layers as well as it wraps up the entire detection field. On the completion of “NETWORK-ASSOCIATION” stride, each node attains the capacity to detect its layer.

3.2 Nearest Node Detection Phase

Every node may utilize a type of protocol namely CSMA-MAC thus to transmit “NODAL-INFORMATION” such as the ID of the node, ID of the layer as well as the distance of the node from the Master Station (MS) together by means of a signal strength more over to meet the nearest node along with its layer. If a node attains the “NODAL-INFORMATION” from its nearest node, then the information about the nearest node is preserved in Nodal Detail Table (NDT). This table includes the information about the nodal position, ID, distance, layer as well as the distance is measured in between from the Master Station (MS) along the nearest node.

In the event that the distance is lesser for the nearest node when compared to the distance of Master Station (MS) then the node is closer to MS, if the distance of neighbor node is greater when compared to the distance of Master Station (MS) then the node is not closer to MS. Nodal failures as well as the link failures may lead to the modification in nearest node. Thus to generate FABC-MACROW adaptable to the failure of nodes or links, the nearest node detection stride is being operated again only after the end up of consistent-state strides numerous rounds. If the lifetime of a node is in the considerable state, the detection of the nearest node as well as modification over neighborhood node will occur more frequently. Nearest node detection stride verifies that each and every node updates the corresponding neighborhoods information.

3.3 Consistent-State Phase

It is being partitioned up into various nodes comprising of CH selection, Clustering as well as routing of data to Master Station (MS).

3.3.1 CH Selection

In order to form a cluster head, the nodes will generate the decisions individually with the help of FIS (Fuzzy Inference System).

(a) Fuzzification of sources (inputs) and yields (outputs)

FIS-Input Factors

1. Precipitant-Energy ("PRE-ENERGY"):
   The intake of energy among nodes is due to the factors such as (1) data acquirement (conversion from analog to digital, sensing, preservation, preprocessing), (2) transmission (packetization, operation for determination of address, framing, encoding, supply in terms of RF circuitry as well as for baseband); (3) reacceptance (minimized interference amplifier, top down converter oscillator, decoding, filtering, identification, fault detection at the time of decoding, verification of address); (4) maximized hearing (by chance if it is not a deliberated receiver the node possess the capacity to receive the information). "PRE-ENERGY" refers to the residual amount of energy settled in the node. In order to participate in any of the network function, the node should possess a tremendous amount of "PRE-ENERGY". To function as a cluster head, the node is ought to possess a huge amount of "PRE-ENERGY", when contrasted to its nearest nodes energy level.
2. Nearer Adjacency ("NR-ADJ"):
   NR-ADJ (j) that relates to a node is characterized as follows,

$$NR\text{--}ADJ(j) = \frac{1}{N_{Tot}}\left(\sum_{f=1}^{f=N_{Tot}-1} dis(j,f)\right) \tag{2}$$

   Hence, N_{Tot} refers to total amount of nearest nodes it means that the nodes can be attained by j possessing that the highest signal power acquired over the similar layer equal to j, $dis(j,f)$ denotes the distance calculated in between the node j over its nearest node f. Thus to form a CH (Cluster Head), the node should possess a huge amount of nearest nodes thus to minimize its expense of intra-cluster interaction as well as it ought to possess the minimized measure of Nearer Adjacency. Each and every node determines the "NR-ADJ" by utilizing the Eq. (2) and also utilizing the nearest nodal information preserved over NDT (Nodal Detail Table) at the time of Nearest Node Detection stride.
3. Linkage Superiority Pointer ("NR-LSP"):
   LSP (Linkage Superiority Pointer) states the superiority of packet transmission towards the link. "NR-LSP" is termed as the average measure of LSP that relates to the links administered in between the node as well as the nearest node along the occupied interior of its layers. Drop in the packet superiority (quality) is indicated by the abatement in LSP. In order to make up the node as a Cluster Head (CH), the node should posses a maximized measure of NR-LSP.

FIS-Output Factors

1. *Efficiency to turn as a CH (Cluster Head)—termed as "EFFICIENCY"* An expansive estimation of EFFICIENCY illustrates the tremendous likelihood to turn a node into a CH (Cluster Head). Semantic factors denoting "PRE-ENERGY", "NR-ADJ" as well as "NR-LSP" that corresponds to the node is classified as High, Medium and Low. In

Table 1 Fuzzy rule base utilized for CH preference

Sl. no	PRE-ENERGY	NR-ADJ	NR-LSP	Efficiency
1	Low	Low	Low	Low
2	Low	Low	Medium	Mild Low
3	Low	Low	High	Medium
4	Low	Medium	Low	Low
5	Low	Medium	Medium	Mild Low
6	Low	Medium	High	Medium
7	Low	Low	Low	Very Low
8	Low	Low	Medium	Low
9	Low	Low	High	Mild Low
10	Medium	Medium	Low	Mild Large
11	Medium	Medium	Medium	Mild Large
12	Medium	Medium	High	Low
13	Medium	Low	Low	Low
14	Medium	Low	Medium	Mild Large
15	Medium	Low	High	Low
16	Medium	Medium	Low	Mild Low
17	Medium	Medium	Medium	Medium
18	Medium	Medium	High	Mild Large
19	High	Low	Low	Mild Large
20	High	Low	Medium	Low
21	High	Low	High	Very Large
22	High	Medium	Low	Low
23	High	Medium	Medium	Mild Large
24	High	Medium	High	Low
25	High	Low	Low	Medium
26	High	Low	Medium	Mild Large
27	High	Low	High	Low

terms of Efficiency the nodes are classified as Very Low, Low, Mild Low, Mild High, High, and Very High.

2. *Illustration of membership specifications* Triangle membership operation is being utilized to demonstrate the Medium with the help of fuzzy inputs and trapezoid is utilized to represent the High and the Low characteristics. Correspondingly, to illustrate the output factors such as Low, mild low, Very Low the Triangle membership specifications are utilized, thus to represent the Very low and the very large functions the Trapezoid Membership Specifications are utilized.
3. *Functions based on an assessment of fuzzy rule and fuzzy administrators* Related to 3 input factors and to the 3 degrees for each level, the available combinations included to the rule base are $3^3 = 27$. Table 1 demonstrates the fuzzy rule base used in terms of CH (Cluster Head) preference.

By utilizing the if–then rule of fuzzy approach each and every node determines its "EFFICIENCY". The nodes that possess the highest "EFFICIENCY" are converted as a

Cluster Head (CH). By the chance, if it includes a tie, node that acquires the elevated (maximized) ID turns to be a Cluster Head (CH).

3.3.2 Clustering

The diminishing of intra-cluster congestion occurrence in Cluster Head (CH) closer to the Master Station (MS), there is no chance to form a cluster inside the layer 1. In turn, the node that belongs to the layer 1 interacts in a direct manner and also it transfers their individual data towards Master Station (MS) including the outermost layers relay packets. The remaining layers that belong to the Cluster Head (CH) establish their responsibilities by propagating the "CH-ESTABLISHMENT" message (including the nodal ID as well as a slighter header to recognize it as a declaration message) inside its Establishment range R_{EST} utilizing the non-determinant CSMA-MAC rule. Clustering is done in Un-similar form.

The Cluster Head CH_n determines R_{EST} to utilize the Eq. (3)

$$R_{EST}(CH_n) = \left[\left(1 - G\frac{dis_{\text{maximum}} - dis(CH_n, MS)}{dis_{\text{maximum}} - dis_{\text{minimum}}}\right) \times \left(\frac{E_{n_{pre}}(CH_n)}{E_{n_{ini}}(CH_n)}\right)\right] \overset{\max}{\underset{EST}{R}} \tag{3}$$

Hence, dis_{maximum} as well as dis_{minimum} is referred to as the minimum and maximum distance onto the Master Station (MS) and nodes correspondingly, $dis(CH_n, MS)$ refers to the distance onto the MS and CH_n, the present and the initial energy are termed as $E_{n_{pre}}$ and $E_{n_{ini}}$ respectively, $\overset{\max}{\underset{EST}{R}}$ is referred to as the ESTABLISHMENT radius to a maximum extend (maintained over 2 distinctive layers). G is a parameter that makes a decision about the cluster size total quantity of inequality and is being maintained at a range of 0-0.99.

The "ESTABLISHMENT" range will be lower for CHs (Cluster Heads) which is closer to MS and it is in a higher range which is far distance from MS. In turn, fewer members in the cluster will stick together to the Cluster Heads (CHs) closer to the MS thus minimize the congestion of intra-clustering. By utilizing this fewer member of the cluster, the CHs which is nearer to the Master Station (MS) conserve their energy in order to transmit the packets from the far most CHs (Cluster Heads). CHs which is at far most distance when compared to MS includes more members of clusters as well as it contributes a tremendous amount of intra-cluster congestion but it includes an only minimum number of inter-cluster traffic in because of they includes only diminished number of transmitted (relay) packets.

Due to this function the networks entire energy consumption is balanced. The usual node prefers its CH (Cluster Head) together with the highest signal strength which is being received of as "CH-ESTABLISHMENT" message considering it as the nearest CH (Cluster Head). If it includes certain restrictions then the CH with diminished ID is selected. Nodes will then transmit the "CLUSTMEM-DEMAND" message (including the ID and ID of the node of the CH) onto their corresponding Cluster Heads (CHs).

The CH arranges their corresponding member of the cluster depending upon their "EFFICIENCY" and related to that it generates the "TDMA" (Time Division Multiple Access) slots for the interaction between intra-cluster. The cluster member which posses the higher "EFFICIENCY" will be allotted to the "TDMA" slot 1. This, in turn, removes the necessity of transmitting "CH-ESTABLISHMENT" message which is being transmitted by the CH preserving the nodes energy and time at the time of each and every round. Each and every member of the cluster evaluates the diminished transmission power necessary to transmit the packets of data to CH depending upon the distance estimated from CH. Thus for the transmission of messages, it conserves its required energy as well as it diminishes the closer clusters interfering occurrences. The CH then gains the packets of data; aggregation of data is being performed as well as transmits the collected (aggregated) data towards the Master Station (MS) through few distinctive CHs at the time of routing data to the Master Station (MS).

3.3.3 Routing and Data Delivery to MS

ABC (Artificial Bee Colony) optimization algorithm is just utilized in terms of "inter-cluster" routing and data delivery to Master Station (MS).

3.3.3.1 Overview of standardized ABC Algorithm The ABC algorithm is moderately an enhancement approach that emulates interlinking characteristics related to the honey bees. The flow chart that relates to the proposed ABC thus for routing and for delivery of data to MS is delineated in Fig. 4. The ABC algorithm includes three strides namely the Employed bees stride, Onlooker bees Stride as well as the Scout bees Stride. The functionalities of each stride are discussed below: (1) The function of Employed Bees is to take over the advantage of food resource as well as to distribute the data regarding the abundance of food resource and the direction together by means of Onlooker Bees in form of wave movement. (2) THE function of Onlooker Bee is to choose probability measure of the food resource that corresponds to the specific food resource fitness measure. (3) Scout honey Bees persistently investigate currently generated food resources arbitrarily allocated onto the hive region then again, when it identifies the current food resource it turns to be an Employed Bee. By chance if a food resource is being entirely depleted, entire Employed Bees related to it go away from the location, and it will turns to be a Scout Bee over again. The brief methodology of ABC can be delineated below:

3.3.4 Proposed ABC for Routing and Data Delivery to MS

It is in need for the enhanced routing algorithm after the cluster formation. The specified routing algorithm should take over the diminished energy along with minimized hop measure thus to transmit data as of from nodes to the Cluster Heads (CHs) afterward to the Master Station (MS).

(a) Initialization phase
Here in this stride, it obtains the PN resources of food (food resources relates to the possible solutions). The solutions are being randomly administered over the particular geographical domain thus to begin up each and every food resource. It is represented as $Zj, d = \{zj, 1, zj, 2, \ldots zj, D\}, 1 \le d \le H,$ along with the range r in between the limit 0 to 1.

(b) Evaluation of Fitness Measure (Employed bee phase)
The Employed Bee is administered to obtain a new fitness measure for the generated solution. In order to transmit (deliver) the particular information (data) towards the Master Station (MS), the broadcasting of data occurs by means of each and every Cluster Head (CH) [25]. The CH transmits the "PATH- MESSAGE" in order to meet the nodes located in between the 2 layers corresponding to the network domain. The "PATH-MESSAGE" includes the ID of the node, Precipitant-Energy, Length of the Queue, probability (that defines the effective packet delivery towards

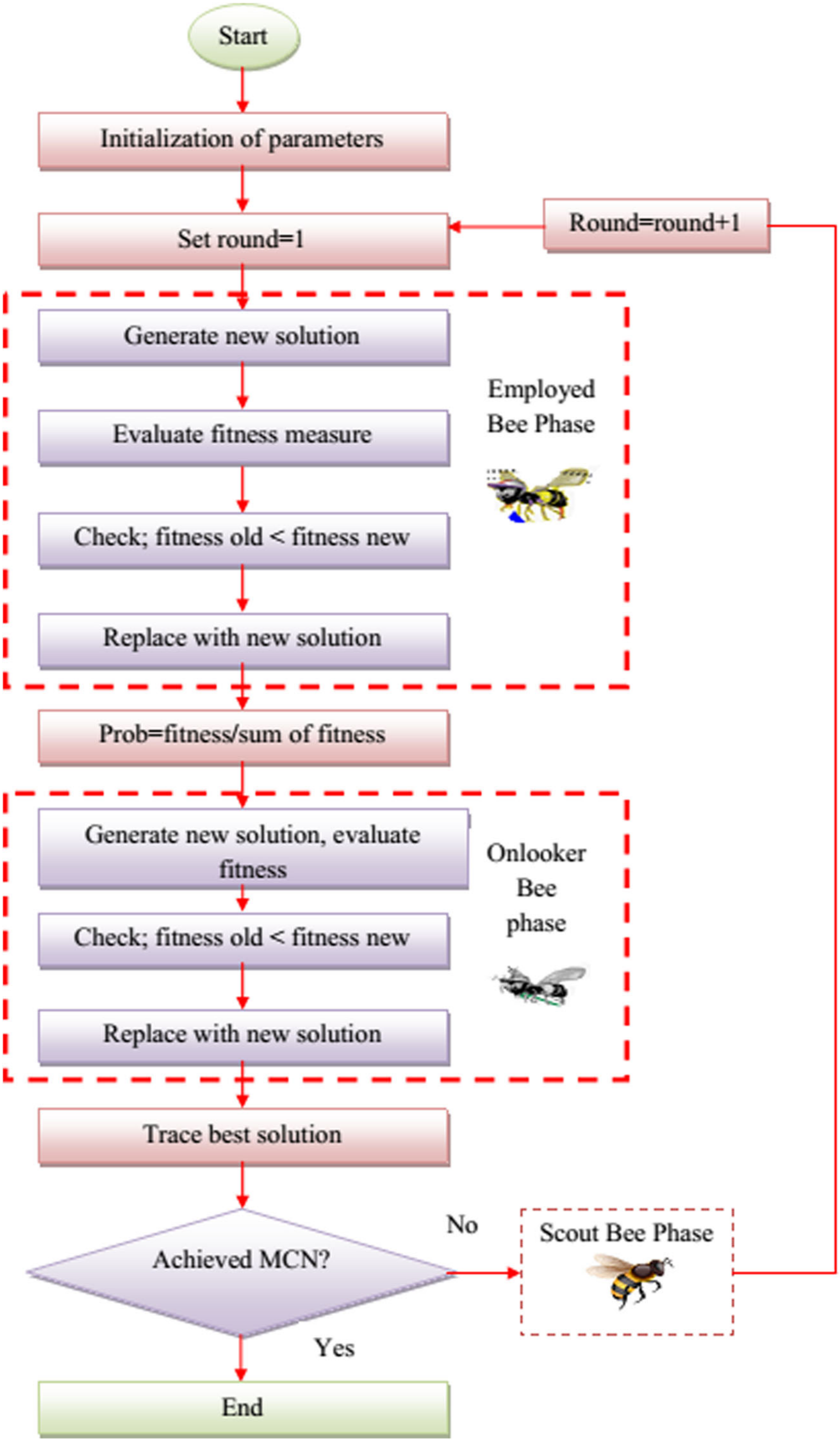


Fig. 4 Flow chart of proposed ABC

the Master Station (MS). The CH in turn stores the necessary information's onto the table referred as Relay Table. The CH h_i afterward establishes unsure relay group SR_{CH} thus to pick up the relay CH, which is described as,

$$SR_{CH}(h_i) = \{h_j | \text{distant}(h_i, h_j) \leq \text{minimum} \times R_{EST}(h_i); \text{distant}(h_j, MS) < \text{distant}(h_i, MS)\} \tag{4}$$

In which minimum refers to a diminished integer, $SR_{CH}(h_i)$ includes a minimum number of item, therefore, it is defined as $2 \times R_{\text{maximum}_l}$. The Eq. (4) relays on two different conditions. Condition 1: the initial state that belongs to Eq. (4) ensures that the relay CH lies within the CH specified range. Moreover, making use of the suitable minimum variable, it is possible to guarantee the condition 2 which includes a significant group of relay CHs (Cluster Heads). From this, the relayed cluster heads are picked off. This also determines the greatest possible distance in between the relayed CH (Cluster Head) and to the present CH. On the off chance that a provided measure has no capacity to fulfill the initial condition, then $SR_{CH}(h_i)$ turns to be an empty set together with that the CH in turn directly transmits the data towards the Master Station (MS). 2. The condition 2 determines about the relay node which is closer to the Master Station (MS), from this it selects the relay node. Thus mixing up of both the conditions prompts to the similar preference of CH over the layer administered onto the Master Station (MS).

(c) Updation (Onlooker bee phase)

The function of Onlooker Bee is to prefer a food resource (solution) depending upon the probability measure as well as it executes a local seeks on $SR_{CH}(h_i)$ based on the Eq. (4). If the newly obtained solution from Eq. (4) acquires the maximum fitness measure then the newly obtained solution possibly overwrite $SR_{CH}(h_i)$. Thus to develop the fitness measure in order to assess the single routes fitness measure, the proposed ABC routing algorithm aims at the objective forms. They are described as follows: In order to prefer a route towards the Master Station (MS), the corresponding Onlooker Bee should be administered over each and every CH at specific interims. The Onlooker Bee identifies the relayed CH based upon the accompanying equation.

$$\Pr o_{lm}^{w} = \frac{[\lambda_{lm}(t)]^{\beta}[\gamma_{lm}]^{\alpha}}{\sum_{h \in SR_{CH_{(h_i)}}} [\lambda_{lm}(t)]^{\beta}[\gamma_{lm}]^{\alpha}} \tag{5}$$

The probability $\Pr o_{lm}^{w}$ in which the bee w likes to relocate from the node l and then to the node m respectively. $SR_{CH}(h_i)$ refers to the group in which the relayed CH ought to be selected with the help of w^{th} bee. The trial measure is termed as $\lambda_{lm}(t)$ from the node l to node m. γ_{lm} refers to the heuristic data that is noted as

$$\gamma_{lm} = \frac{pQ_j}{\sum h \in SR_{CH}(h_i) PQ_s} \times \frac{Del_j}{\sum_{h \in SR_{CH}(h_i)} Del_s} \tag{6}$$

The weight of routing pQ_j is referred to as the proportion between the Precipitant-Energy j as well as the present nodes queue length s. Del_j refers to the proportion between the delivery rate from energy $_j$ onto the queue length s.The likelihood of delivery refers to the estimation of effective packet delivery towards the Master Station (MS). In turn, if the Master Station (MS) achieves the data packet, the Acknowledgement (ACK) is then transmitted repeatedly onto the transmitter (sender) CH aided with one (delivery probability). The Update of delivery likelihood occurs only after when the CH gain an Acknowledgement (ACK) message.

$$Del(CH_l)' = \frac{Del(CH_m) + Del(CH_l)}{2} \tag{7}$$

Here $Del(CH_l)$ refers to the Cluster Head (CH_l) delivery likelihood transmitting the data, $Del(CH_l)'$ refers to the nodes updated version of nodes delivery likelihood. β and α denotes the heuristic data and the trial respectively. The Onlooker Bees transmitting over nodes gathers the data about the path and attains the Master Station (MS). The Master Station starts to verify the information only after reaching wth bee. The data gathered by the wth bee is determined by $\{(Ko, d(k0.k1)), (K1, d(k1, k2)), (K2, d(k2, k3))\ldots(Kl-1, d(kl-1, km))\}$. The sender CH is determined by $K0$ and the destination is determined by means of Km referred to as the MS. $K\{k0, k1, k2\ldots kl\}$ denotes the group of discrete node determining the route.
The path worthiness f is determined by the function W

$$W_f = \frac{G}{rt_s \times vr_i} \tag{8}$$

G is termed as a constant, rt_s refers to the path f communication cost, Vr_i refers to the variance denoting the balanced energy over path edges. Thus for a minimized distance over receiver and the transmitter, consumption of energy is directly proportional onto the transmission distances square measure. It is derived as follows

$$rt_s = \sum_{a=1}^{k} R_a = \sum_{a=1}^{k} adis^2(S_{a-1}, S_a) \tag{9}$$

where a is referred to as the intermediate nodes coefficient among the receiver and the transmitters path. R_a refers to the consumption of energy over the edge (S_{a-1}, S_a). The minimized distance over the transmitter as well as the receiver (S_{a-1}, S_a) the consumption of energy is directly proportional to the transmission distance square over (S_{a-1}, S_a), and to (S_a) which is being computed as,

$$R_a = dis^2(S_{a-1}, S_a) \tag{10}$$

The distance evaluated in between the edge pairs are obtainable onto the NDT. The variance is computed as follows,

$$vr_i = \frac{1}{k} \times \sum_{a=1}^{k} \left(R_a - \frac{1}{k} \times \sum_{a=1}^{k} R_a \right)^2 \tag{11}$$

Moreover, with the aid of W_f measure, the Master Station MS obtains the optimal path towards the initial step itself. The Master Station (MS) in turn then transmits the information including the details about the path, path worthiness onto the nodes together besides its optimal path [26]. Additionally, after a few cycles of employed bee phase as well as with onlooker bee phase, each and every CH node identifies the optimal relay and the data transmission is being carried out. This process is being repeated until the data attains the Master Station (MS).

(d) Scout Bee phase
If it does not attain the optimal solution after MCN (Maximum Cycle Number), then

that solution is being left by the Employed Bee and turns into a Scout Bee. The Scout bee after certain process looks for the currently generated solution (new solution) just by utilizing again the Eq. (4). Each path (routes) fitness measure is computed for the following hop measure towards each Sensor Node (SN) then to the Master Station (MS). Based on algorithm 1 the phases such as Employed Bee, Onlooker Bee, Scout Bee is being executed in order to derive the optimal path towards the Sensor Node (SN) and then to the Master Station (MS). Figure 5 illustrates the possible routes from Sensor Nodes (SNs) to Master Station (MS).

Algorithm 1: Pseudo-code for proposed routing algorithm

Step 1: Initialization of parameters:

i)PN (Population Number)

ii)MCN (Maximum Cycle Number)

iii)D: Dimension

iv)Upper and Lower bounds of each node

Step2: The population is initialized $z_i \forall i \in SN, 1 \leq i \leq H$

Step 3: Evaluate the fitness measure for $PR_{CH}(S_i)$

Step 4: Generate round = 1

Step 5: Repeat

Step 6: Acquire the new solution using Eq. (4) for each employed bee

Step 7: Evaluate the fitness measure for newly generated solution

Step 8: Check if (old fitness measure < newly generated fitness measure)

Step 9: Then set old fitness = new fitness measure

Step 9: Evaluate the probability measure for $PR_{CH}(S_i)$ *using Eq. (5)*

Step 10: For each and every onlooker bee obtain the new solution using the probability by Eq. (5, 6)

Step 11: Evaluate the new fitness measure obtained with the previously determined fitness measure

Step 12: Update the solution with newly obtained fitness measure

Step 13: If there exist a tremendous number of solutions, then replace it with Eq. (4)

Step 14: Maintain the record for fitness measure

Step 15: Set Round = Round + 1

Step 16: If satisfied Round = MCN (Maximum Cycle Number) in scout bee

Step 17: Termination achieved.

According to the above discussion, a new Routing Algorithm (ABC) is proposed in this paper. Figure 4 demonstrates the flow diagram of proposed Routing Algorithm (ABC). It is necessary to obtain the routing algorithm thus to make up an inter-cluster routing among CHs. Here the fitness measure is evaluated by utilizing the Eq. (4). Then generate the new solution for each and every employed bee utilizing the Eq. (5). The newly generated fitness measure should be compared with the previous fitness measure, if it is found to be best then update the previous fitness measure with newly generated function for each onlooker bee. If the solution obtained is in tremendous amount then replace it with the Eq. (4). Finally if it satisfied the MCN (Maximum Cycle Number) then a termination criterion is achieved.

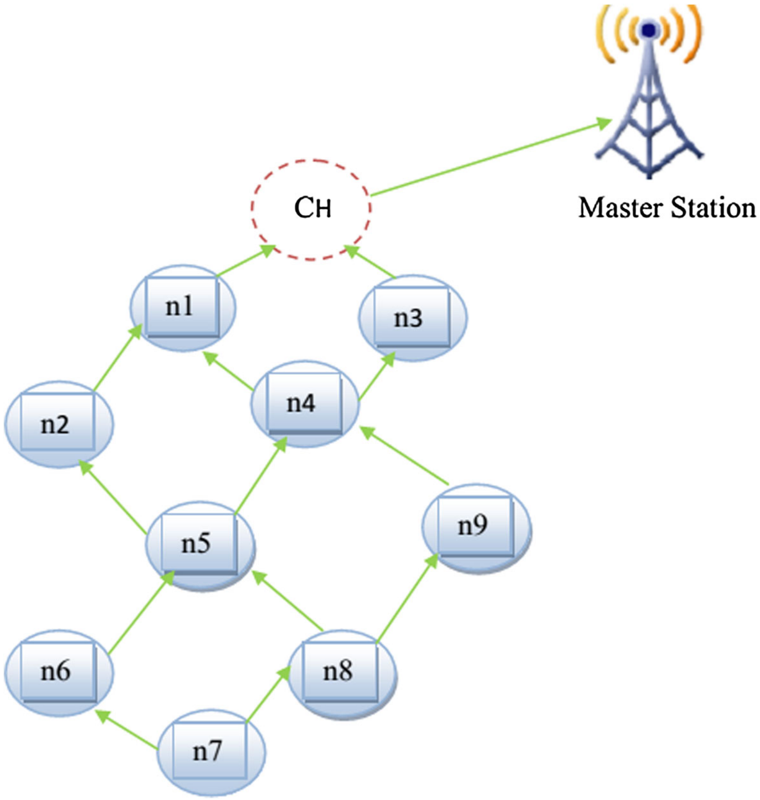


Fig. 5 Possible routes from Sensor Nodes (SNs) to Master Station (MS)

4 Simulation and Analysis of FABC-MACRD

The performance measure of FABC-MACRD is just evaluated by the comparison of different methodologies such as "UCR" [8], "ULCA" [9], "EAUCF" [15], as well as "IFUC" [24]. Figure 6 depicts the non-similar clustering; inter cluster routing to the Master Station and the formation of clusters for FCABC with single run. The comparison is carried out with these methodologies in because of the characteristics that try to withstand the issues of non-similar (unequal) clustering. The system approach includes about 1000 nodes which are being arbitrarily distributed in the area of about 1000 m $\times$ 1000 m scope. The nodes initial energy is administered to about 0.5 J, rate of data packet is evaluated to 6400 bits, and rate of control packets is arranged of about 100 bits. Transmitting and receiving power of each node is 0.660 and 0.395 W.

4.1 Performance Analysis

The total precipitant energy, Energy consumption of CHs, Amount of data received by MS for each and every set of nodes is assessed just after the finishup of total network rounds. The lifetime of the network is compared with distinctive methodologies such as FND,

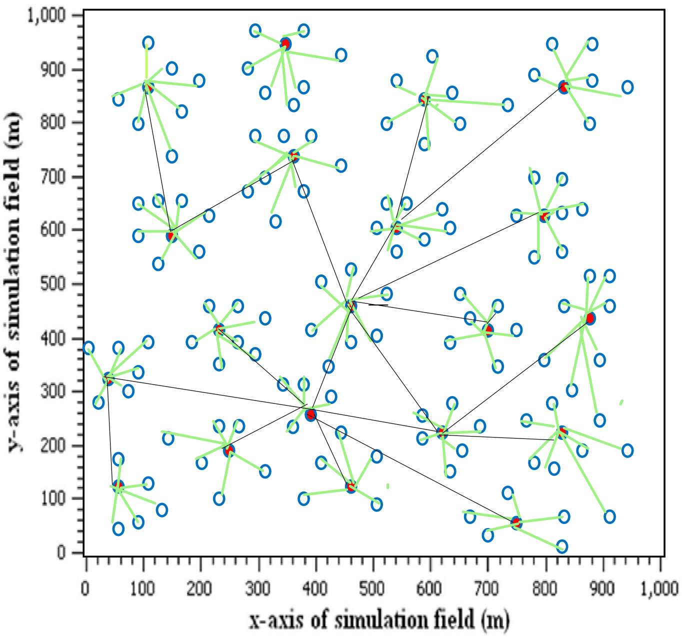


Fig. 6 An example for non-similar clustering and routing of data

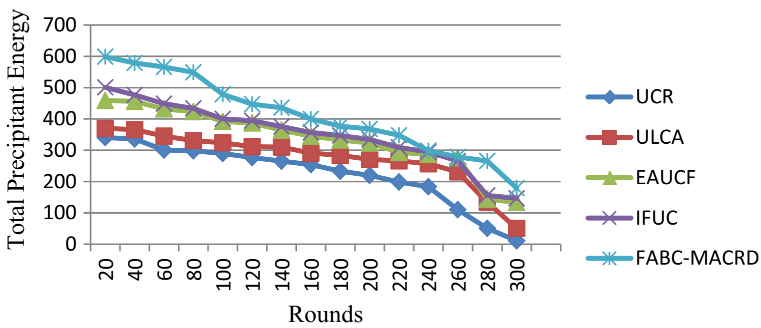


Fig. 7 Number of rounds versus total precipitant energy

HNA, LND. The scalability of the network is evaluated for the consumption of energy per node, delivery ratio and data latency.

(a) Efficiency of Energy

Thus to verify the protocols energy effectiveness the total precipitant energy that belongs to the network nodes is evaluated over an interim of about 20 cycles (rounds). Figure 7 illustrates that the proposed FABC-MACRD attains about 60% of precipitant (residual) energy than the other methodologies such as "UCR" [8], "ULCA" [9], "EAUCF" [15], as well as "IFUC" [24]. Figure 8 shows the illustration of Cluster Heads (CHs) consumption of energy contrasted to other methodologies energy consumption. From the verification it is observed that total

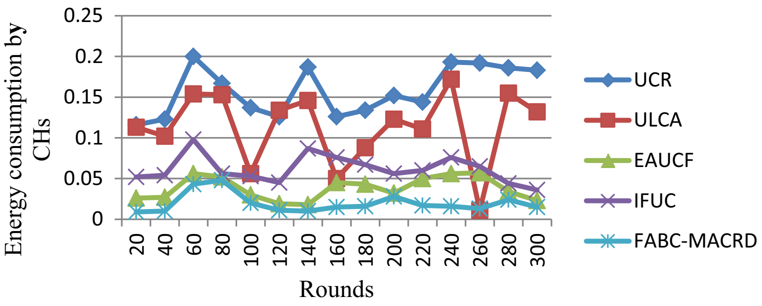


Fig. 8 Number of rounds versus energy consumption of CHs

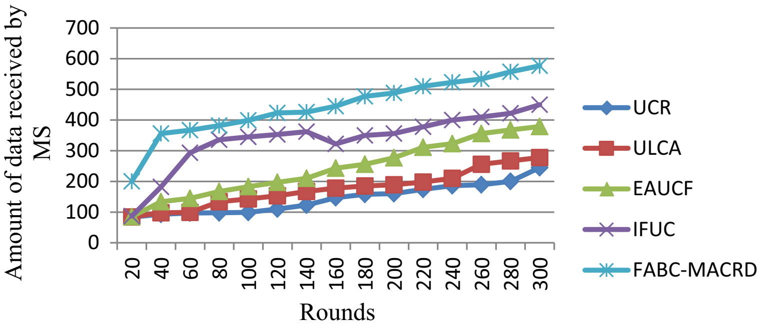


Fig. 9 Number of rounds versus amount of data received by MS

consumption of energy by CHs at FABC-MACRD is only about 20%. This proposed approach when compared to other methodologies it shows only diminished amount of energy intake. The consumption of energy by CHs is low in because of fuzzy based CH selection. The fuzzy approach guarantees that the node that possess maximum precipitant energy as well as the nodes that includes maximized amount of nearest nodes is being chosen as CHs (Cluster Heads). By this technique, the energy intake at the time of inter-cluster interaction is diminished just by the selection of CH depending upon the distance evaluated from the Master Station then onto the newly generated CH.

(b) Receiving data packets by MS

The protocols of Wireless Sensor Network (WSN) are considered as an applicative form. An application form is taken in order to evaluate the amount of packets which is received by the Master Station (MS). If MS receives tremendous amount of packets, the evaluation of specific environment turns to be tedious process. From Fig. 9 it is verified that the proposed FABC-MACRD achieves more number of data packets by Master Station (MS) than the other methodologies such as "UCR" [8], "ULCA" [9], "EAUCF" [15], as well as "IFUC" [24]. FABC-MACRD achieves more numbers of packets in because of this proposed FABC-MACRD approach takes in account the Linkage Superiority Pointer (NR-LSP) which shows the quality of interactive link that turns to be a necessary parameter in terms of CH selection. This guarantees for the flexible delivery of data at the time of intra-cluster interaction. The parameters required for the inter-cluster interaction are length of

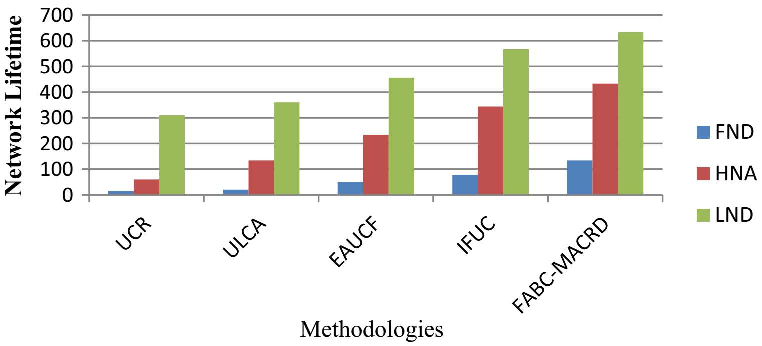


Fig. 10 Methodologies versus network lifetime

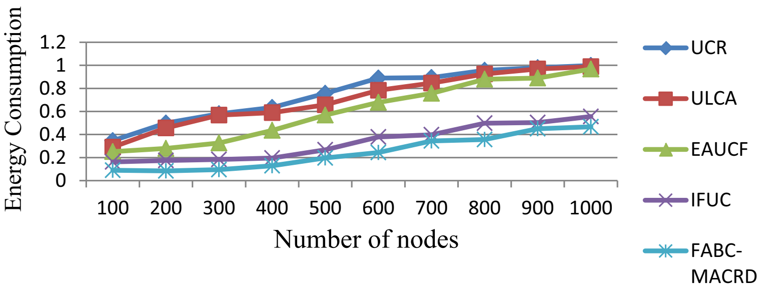


Fig. 11 Number of nodes versus energy consumption

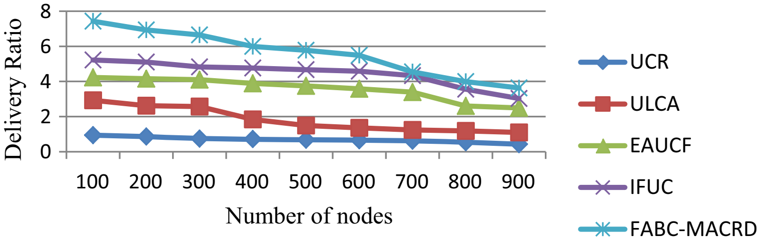


Fig. 12 Number of nodes versus delivery ratio

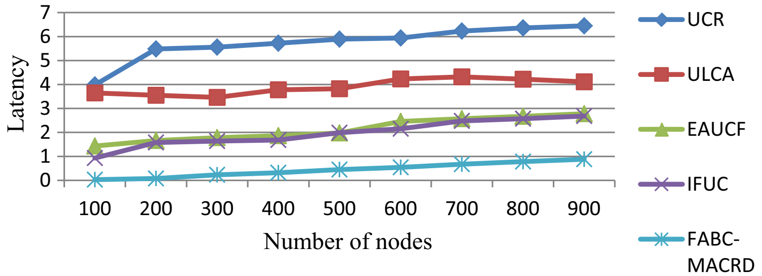


Fig. 13 Number of nodes versus latency

queue, precipitant energy, probability of packets delivered to the Master Station (MS).

(c) Lifetime of Network
The performance of networks lifespan is evaluated by means of certain cycles (rounds) such as, FND (First Node Death), HNA (Half of the Nodes Alive) as well as LND (Last Node Death), which is delineated in Fig. 10. In because of its energy efficiency function FABC-MACRD achieves about 63% of lifespan when compared to other methodologies such as "UCR" [8], "ULCA" [9], "EAUCF" [15], as well as "IFUC" [24].

(d) Scalability
Thus to evaluate the protocols scalability, a number of nodes ought to be assorted for about 10-100 as well as the each and every nodes energy consumption, delivery proportion and delay (latency) are being computed. Figures 11, 12 and 13 delineates that if a number of nodes is exceeded consumption of energy for each and every node, as well as the latency, also goes beyond the limit. But if the number of nodes is maximized then the delivery ratio is decreased in terms of entire protocols. Hence in the proposed FABC-MACRD consumption of energy for each node is low as well as it attains maximum delivery ratio for about 79%. This occurs in because of FABC-MACRD's CH (Cluster Head) chose the relay node depending upon the precipitant energy and length of queue. FABC-MACRD delivery proportion is in higher level when contrasted to other methodologies such as "UCR" [8], "ULCA" [9], "EAUCF" [15], as well as "IFUC" [24]. The latency is low in terms of proposed FABC-MACRD due to the time required for the computation of delivery probability as well as the iterations of ABC inter-cluster routing approach.

5 Conclusion

In this paper, the Fuzzy and Artificial Bee Colony Based Implementation of MAC, Clustering, Routing and Data delivery by Cross-Layer approach in WSN (FABC-MACRD) has been proposed. The proposed approach utilizes the Artificial Bee Colony optimization algorithm thus for the energy efficient and flexible transmission of data onto the Master Station (MS). The ABC algorithm also performs the inter cluster routing commencing from CHs (Cluster Heads) over the Master Station (MS). The proposed methodology mainly includes three phases namely network association, nearest node detection phase and consistent-state stride. The performance analysis is carried out with different methodologies such as "UCR" (Unequal Cluster dependent Routing) [8], "ULCA" (Unequal Layered Clustering Advance) [9], "EAUCF" (Energy Aware Unequal Clustering utilizing Fuzzy logic) [15], as well as with the "IFUC" (Improved Fuzzy Unequal Clustering) [24]. The proposed FABC-MACRD approach increases the lifespan of the network by the elimination of nodal congestion among the clusters by the means of efficient routing algorithm (ABC). The future scope is to develop flexible protocols for the evaluation of congestion occurrence among the layers utilizing complex functions.

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