Abstract:
Wireless sensor networks (WSNs) are an emerging technology that has potential applications in surveillance, environment and habitat monitoring, structural monitoring, healthcare and disaster management. The major problem in WSN is fast changing nature of the network due to the random movement of the nodes. Routing is the process of moving information across the network from a source to a destination. Routing is challenging in this type of networks due to the mobility of nodes, energy and limited resources etc. This type of networks has difficult to find a path between the communicating nodes. In this paper we are studying the new swarm based Artificial Bee Colony (ABC) optimization technique which is useful for solving the problem of routing. The location based ABC algorithm has also been studied which makes use of RSSI to estimate the location. The use of ABC algorithm is also studied for the method of clustering.

Keywords: wireless sensor network, artificial bee colony, rssi, routing, clustering.

1. INTRODUCTION

Wireless Sensor Networks (WSNs) have been widely considered as one of the most important technologies for the twenty-first century. Enabled by recent advances in wireless communication technologies, tiny, cheap, and smart sensors deployed in a physical area and networked through wireless links and the Internet provide unprecedented opportunities for a variety of civilian and military applications. A WSN typically consists of a large number of low-cost, low-power, and multifunctional sensor nodes that are deployed in a region of interest [1]. The architecture of the node is shown in Fig 1.

![Architecture of Node](image)

**Figure 1. The architecture of node**

The sensor node has limited resources like energy, size, memory, computational power, communication range, bandwidth, so a large no of sensor nodes are required to distribute over an area of interest for collecting that particular information. These sensor nodes communicate over a short distance via a wireless medium and collaborate to accomplish a common task, for example, environment monitoring, battlefield surveillance, and industrial process control. So these nodes communicate with each other either directly or through intermediate nodes and thus form a network. So each node work as a router. Routing means providing the path for the data to flow in the network i.e. sending information from source to the sink via intermediate nodes.

2. ROUTING IN WSN

The central goal of the routing in the network layer is to find out the minimum cost path for the packets from source to the sink. Data are routed from one node to other node using routing protocols. Routing protocols specifies how routers (sensor nodes) communicate with each other. Routing algorithm chooses the routes between nodes. There are number of routing protocols available with some of the advantages and disadvantages over other. Proactive protocols [2] maintain the routing information of each mobile node and broadcast it to the network. Hence this is called as table-driven. In proactive method, when a source node wants to send or forward a packet, it only has to read its routing table for sending the data via the mentioned interface in the routing table. It is then easy and fast but the prohibitive bandwidth overhead in order to continuously exchange routing information is pitfall of this method. Reactive routing protocols are also known as on demand routing algorithms. Reactive protocols [3] does not need to continuously maintaining a route between all pairs of network nodes, but route from source node to destination node is established when two nodes wants to communicate with each other. The disadvantage of reactive routing protocol is the introduction of route acquisition latency. When a route is needed by a source node, there is some finite latency while the route is discovered. The idea of hybrid protocols is using both proactive and reactive approaches, each one with a different scope. The network is divided into smaller groups (or clusters). Then, a proactive paradigm is used to collect information about nodes within the cluster, while a reactive paradigm is used for communications with nodes in distant clusters. The difficult part is deciding how the clusters are formed and how to handle changes in the topology [4]. To overcome the problems associated with the existing routing protocols many...
researchers are taking interest in swarm based routing which is based on collective behavior of ants, bees. In the below session the swarm intelligence is explained. In 3 we are explaining the swarm based artificial bee colony algorithm followed by ABC based routing in section 4. In section 5 location based ABC is explained along with the localizations technique named received signal strength indication (RSSI) and in further section the ABC based clustering is explained and the conclusion has been made.

3. SWARM INTELLIGENCE

Swarm Intelligence is a meta-heuristic methodology used to solve numerical optimization problems by simulating swarm behaviors found in nature. These techniques demonstrate the desirable properties of interpretability, scalability, effectiveness, and robustness. The term swarm means move somewhere in large numbers. The concept of swarm intelligence was introduced as the collective behavior of decentralized, self-organized systems, natural or artificial [5].

1. Self-organization is process where some form of overall order arises out of the local interactions between individuals when the initial state of the swarm is highly disordered.

2. Decentralization means no authorized individual exists in the swarm. The modern science of complexity shows that collective behavior in animal groups is based on a set of very simple rules for interactions between neighbors. Swarm Intelligence based algorithms have potential to achieve optimal solutions in real world problems. The most popular swarm intelligence frameworks include Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Bacterial Foraging Optimization (BFO), Artificial Bee Colony (ABC) and other swarm optimizations [6].

3.1 Artificial Bee Colony

Artificial Bee Colony (ABC) principle is based on biological process natural behavior of real honey bees in food foraging. Mechanism principle of honey bees utilizes numerous processes like waggle dance to locate food sources and to search new ones. It is observed that Artificial Bee Colony (ABC) is an exceptional kind of optimization technique [7] [8] which is highly suitable for finding the adaptive routing for networks. The minimal set-up of artificial bee intelligence comprises three essential roles – employed bees, onlooker bees and scout bees. These three roles are all played by worker bees. Employed bees are always associated with particular food sources that they are currently gathering nectar from. They share information about the food sources with onlooker bees every time they return to the hive. Onlooker bees are not related to any food source. Their job is to gather information from employed bees and make a self-decision on which food source to go. Considering the effectiveness of foraging, worker bees are not supposed to waste too much energy and time on an exhausted food source. So a specific limit must be put on the amount work on current food sources. Each time the number of times that a food source being exploited without improvement reaches the limit, the associated employed bee would abandon it and turn into a scout bee. Then, the scout bee will randomly choose a new food source to exploit. The exchange of information among bees is the most important occurrence in the formation of collective knowledge. The most important part of the hive with respect to exchanging information is the dancing area. Communication amongst bees related to food sources takes place through dance in dancing area. This dance is called Waggle dance.

3.1.1 ABC Algorithm

The general algorithmic structure of the ABC optimization approach is given as follows [9]:

Initialization Phase
REPEAT
Employed Bees Phase
Onlooker Bees Phase
Scout Bees Phase
Memorize the best solution achieved so far
UNTIL (Cycle=Maximum Cycle Number or a Maximum CPU time).

In the initialization phase, the population of food sources(solutions) is initialized by artificial scout bees and control parameters are set. In the employed bees phase, artificial employed bees search for new food sources having more nectar within the neighborhood of the food source in their memory. They find a neighbor food source and then evaluate its fitness. After producing the new food source, its fitness is calculated and a greedy selection is applied between it and its parent. After that, employed bees share their food source information with onlooker bees waiting in the hive by dancing on the dancing area. In the onlooker bees phase, artificial onlooker bees probabilistically choose their food sources depending on the information provided by the employed bees. For this purpose, a fitness based selection technique can be used, such as the roulette wheel selection method. After a food source for an onlooker bee is probabilistically chosen, a neighbourhood source is determined, and its fitness value is computed. As in the employed bees phase, a greedy selection is applied between two sources. In the scouts phase, employed bees whose solutions cannot be improved through a predetermined number of trials, called “limit”, become scouts and their solutions are abandoned. Then, the scouts start to search for new solutions, randomly. Hence, those sources which are initially poor or have been made poor by exploitation are abandoned and negative feedback behaviour arises to balance the positive feedback. These three steps are repeated until a termination criteria is satisfied, for example a maximum cycle number or a maximum CPU time.

3.1.2 Pseudo code for ABC

The pseudo code is given as follows [10]:

Generate initial population Xi, i = 1…SN
Set cycle to 1
Repeat
FOR each employed bee
Produce new solutions vi by using (1)
Calculate the fitness
Apply the greedy selection process

FOR each onlooker bee
Choose a solution xi depending on pi (2)
Produce new solutions vi
Calculate the fitness
Apply the greedy selection process

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If there is an abandoned solution then
Replace it with a new solution produced by a scout using (3).

Memorize the best solution achieved so far

\[ \text{cycle} = \text{cycle} + 1 \]
\[ \text{Until cycle} = \text{MCN} \]

In the ABC algorithm, the first half of the colony consists of employed bees and the second half consists of onlooker bees. The first positions of food sources randomly generated where each employed bee is nominated to a food source. Then, every employed bee determines a new neighboring food source of its currently associated food source by Eq. (1), and computes the nectar amount of the new food source for each iteration. If the nectar amount of the new food source is higher than the previous one, then employed bee moves to the new food source, otherwise it continues with the old one [11].

\[ v_{ij} = x_{ij} + \theta_{ij} (x_{ij} - x_{kj}) \]  

where \( \theta \) is a random number between [-1, 1], \( v_i \) is a candidate solution, \( x_i \) is the current solution and \( x_k \) is a neighbour solution and \( j = \{1,2,\ldots,D\} \) is randomly chosen index where D is the dimension of the solution vector.

The employed bees share the information about their food sources with onlooker bees after all of them complete the search process. An onlooker bee evaluates the nectar information taken from all employed bees and chooses a food source with a probability related to its nectar amount by Eq. (2), known as roulette wheel selection method which provides better candidates to have a greater chance of being selected.

\[ p_i = \frac{\text{fit}_{ij}}{\sum_{j=1}^{\text{SN}} \text{fit}_n} \]  

where \( \text{fit}_i \) is the fitness value of the solution \( i \) proportional to the nectar amount of the food source in the position \( i \) and \( \text{SN} \) is the number of food sources equal to the number of employed bees. Once all onlookers have selected their food sources, each of them determines a new neighboring food source of its selected food source and computes its nectar amount. The bee memorizes the new position and forgets the old one whether its nectar is higher than that of the previous one; otherwise it keeps that. Once all onlookers have selected their food sources, each of them determines a new neighboring food source of its selected food source and computes its nectar amount. The bee memorizes the new position and forgets the old one whether its nectar is higher than that of the previous one; otherwise it keeps that. The employed bee becomes a scout when a food source is exhausted by the employed and onlooker bees. Any position cannot be improved further through a predetermined number of cycles which is called limit parameter, the food source is assigned as abandoned and employed bee of that source becomes scout. In that position, a new solution is randomly generated by the scout, given in Eq. (3), where abandoned source is represented by \( x_i \) and \( j = \{1,2,\ldots,D\} \).

\[ x_{ij} = x_{ij}^\text{min} + (x_{ij}^\text{max} - x_{ij}^\text{min}) \times \text{rand} \]  

The flow chart of the ABC algorithm is given in Fig.

4. ABC BASED ROUTING

The routing protocols are responsible for establishing path between the source and the destination. It is also responsible for maintaining path between two nodes until the communication gets over. There are multiple paths available from the source to destination but it is the responsibility of routing protocol to find the optimum one and carry out communication through that path.

4.1 Bee Sensor

BeeSensor protocol is multipath, reactive and event driven. BeeSensor aims at energy efficiency, scalability, and long network time. Paths are prioritized on the basis of their remaining energy levels to extend the network lifetime. In addition to forward and backward scout agents, BeeSensor makes use of additional agents such as packers, foragers and swarms. Packers receive data packets from the upper layers of the node architecture, and hand them over to a forager for transportation to a sink node. In turn, swarms transport a group of foragers back from the sink to the source node. Foragers are the main agents that transport events from the source to a sink node. Forward scouts carry the data, and are therefore launched on reactive basis. The outputs are compared with AoDV and it is found that the BeeSensor delivered approximately 85% packets as compared to 60% of AoDV [12].

4.2 BeeAdHoc

Authors in [13] proposed an energy efficient routing algorithm for mobile Ad-hoc networks. Architecture of BeeAdHoc is shown in figure.
In this scheme every node is consider as the hive with three floor entrance, dance floor and packet floor. Now we describe the working of these three floors separately. In the ad hoc network the protocols for routing is defined as in the transport layer. So according to the diagram the node hive is lye in between network layer and application layer. So entrance floor is work as the interface for the media access control protocol of the network layer and deals with incoming and outgoing packets. If the hive node is the internal node then at the entrance scout received the packet if it has live time and broadcast it further. In a table the scout id and source node information is stored. If replica is already receive then killed it. If in dance floor forager has the same destination then scout has been appended to it. If current node is the destination node then forager sends it to packing floor otherwise forward it to MAC layer to the next node. Packing layer is providing the interface to the transport layer and received data from it. At once the data is come then it the packer to it. Packer stores the data packet. And it locket the new forager to it form the dance floor. If packer finds the perfect forager then it will hand over the data to it and dismiss.

5. LOCATION BASED ABC

The basic ABC algorithm can be improved using the hybrid mechanism with the location estimation schemes. Authors in [14] used ABC algorithm along with the DV-hop algorithm for locating the nodes whereas authors [15] proposed a hybrid of artificial bee colony along with RSSI for the dynamic deployment of RSSI. This combination of ABC along with RSSI can be useful for the routing as well. Since the location information of sensor node can be useful for finding the shorter path between the nodes. There are number of routing schemes which are based on artificial bee colony but one of the problems with it is that it does not consider the location information and therefore leads to more energy consumption [new]. For using the existing ABC algorithm with the help of location information we can use different types of localization techniques to get the location of the node.

5.1 Localization Techniques

Localization is the process of discovering a position of all sensor nodes within a sensor network. There are number of localizations techniques like ToA, AoA, RSSI, Trilateration [16]. Out of which we are considering the RSSI method since it is most suitable for WSN due to low cost, low power consumption, simple hardware.

5.1.1 RSSI

RSSI-based localization algorithm is a range-based technique that utilizes the built in RSSI circuitry inside the sensor’s transceivers chipsets. It is an economical and cost effective localization technique that is gaining an increasing acceptance as a handy technique to solve the localization problem. The strength of received power from a signal can be used to estimate distance because all electromagnetic waves have inverse-square relationship between received power and distance as shown in the following expression:

\[ P_r = \frac{1}{d^2} \]  

where \( P_r \) is the received power at a distance \( d \) from transmitter. It can be said from above expression that RSSI decreases with increase in distance.

Suppose that \( \text{RSSI}_{ij} \) is a signal strength value, which is send from node \( j \) to node \( i \), and measured from the node \( i \). Then [17]

\[ \text{RSSI}_{ij} = A - 10n \log \left( \frac{P_i}{P_0} \right) \]

When \( D_o = 1m \), the formula can be simplified as,

\[ D_{ij} = \frac{A - \text{RSSI}_{ij}}{10n} \]  

The unit for \( \text{RSSI}_{ij} \) is \( \text{dBm} \). \( D_{ij} \) is the actual distance between node \( i \) and node \( j \). The radio parameter \( A \) is defined as the absolute value of the average power in \( \text{dBm} \) received at a close-in reference distance of one meter from the transmitter.

6. CLUSTERING

Clustering is an automatic learning technique which aims at grouping a set of objects into clusters so that objects in the same clusters should be similar as possible, whereas objects in one cluster should be as dissimilar as possible from objects in other clusters. The energy of the nodes can be consumed using the method of clustering since a node has to send the data only to the cluster head and not to base station. The cluster head (CH) aggregates the data and pass over to the base station [18].

Clustering has number of advantages such as reducing volume of transmitted data, decreasing the count of nodes which taking part in data transmission, network lifetime prolonged, scalability in large-scale WSNs, communication overhead reduction (for both single and multi-hop communications), delay reduction (than flat networks), load balanced distribution [19]. There are number of clustering protocols for the wireless sensor networks. Following is the clustering based on ABC algorithm

6.1 BEE-SENSOR-C

Bee-Sensor-C is an improved version of Bee-Sensor [20]. This protocol is multipath, reactive and event driven. Bee-Sensor-C is hierarchical unlike Bee-Sensor. This protocol uses clustering scheme to transfer data. Bee-Sensor-C works in three stages namely as cluster formation, multipath construction and then transmitting the data. In first stage when any event is detected then the sensor nodes which are involved in sensing the event forms a cluster. In this an extra agent is present called as HiveHeader.

HiveHeader’s major responsibility is to claim if any sensor node wants to be CH. CH is chosen on the basis of first declaration. Sensor node which declares in the beginning becomes CH. Other node joins the CH on the basis of RSS. In second stage multipath are constructed in better way than Bee-Sensor. Then in third stage data is transmitted. The figure for the working of BEE-Sensor-C algorithm is shown below:
Authors in [21] proposed the energy efficient clustering protocol for mobile learning where the members of cluster receive and send data to the cluster head. The main server can be accessed by CHs only. Since CHs are very important, the number and selection of CHs have to be carefully determined. The ABC algorithm is used to select CHs. Firstly number of CHs is estimated by considering the nodes’ mobility, the communication radiuses of WLAN and Bluetooth as well as the maximum cluster size. By dividing the network into K stable areas which have low relative velocity and proper number of nodes, the distribution of the network and how many clusters are suitable are realized. Then the K CHs are selected based on the (1) the distances to CHs from their member nodes and to the base station from CHs; (2) the mobility so as to select K stable CHs; (3) the residual energy in the meantime and the number of single-node clusters which have to communicate with the base station directly through WLAN.

Figure 4. Workflow of Bee-Sensor-C

The BeeCup protocol also includes two cluster maintenance mechanisms during re-clustering intervals: one is locally reclustering if a node is no longer appropriate for being a CH due to its low residual energy and the second one is to balance local load by adjusting the RNs. The flowchart of Bee-cup clustering protocol is shown in Fig.

Figure 5. Flowchart of Bee-cup Protocol

7. CONCLUSION

In wireless sensor networks, the battery lifetime of the nodes is limited and therefore data should be pass over the network with the minimum energy. Routing algorithms plays a vital role to pass the data over a network. In this paper we have described the artificial bee colony algorithm and how this swarm based algorithm is useful in routing. The location based artificial bee colony algorithm is seen which makes use of a received signal strength indication (RSSI) localization schemes. The clustering routing based on artificial bee colony has also been seen. It has been clear that this swarm based algorithm is helpful in case of routing and clustering so as to make efficient use of battery and make network energy efficient.

8. REFERENCES


