EAI Endorsed Transactions on Wireless Spectrum

Research Article **EAI.EU**

Enhanced Jumper Firefly Approach for Multi Attribute Depletion Measure in Wireless Sensor Networks

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Abstract

INTRODUCTION: Wireless Sensor Network is an interesting technology, which has great deal of node power, which affects the quality of various service parameters. The sensor nodes have been built with fixed energy and spend certain amount of energy for each data transmission. The user cannot access the sensor nodes once they are deployed.
OBJECTIVES: In this paper, we proposes the multi attribute depletion measure using enhanced jumper fire fly algorithm which is based on various parameters of the nodes like location, the number of nodes around the node, number of transmissions it involved, energy value it has.
METHODS: Based on the factors the method computes the multi attribute depletion measure, which represents the lifetime of the nodes, which serves as the cluster head. The Enhanced Jumper Firefly algorithm is to select the cluster head at each time interval, which computes the multi attribute depletion measure to choose the cluster head.
RESULTS: This method performs 90% of delivery ratio then minimizes the average end-to-end delay up to 149.19 ms and improves the clustering performance.
CONCLUSION: The MADM-FF method achieves the highest throughput compared to LODE-LEACH.

Keywords: Wireless Sensor Networks, Cluster head, LEACH, Firefly, sensor node, Energy consumption, jumper firefly algorithm, multi attribute depletion measure.

Received on 09 January 2020, accepted on 20 March 2021, published on 14 April 2021

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doi: 10.4108/eai.14-4-2021.169189

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1. Introduction

The wireless sensor networks have different network conditions where the nodes are grouped in the form of clusters. The biggest challenge in a wireless sensor network is the lifetime maximization so that the service provided could be continued. However, the lifetime maximization depends on various parameters, but among them, the most important factor is the cluster head selection, which has to coordinate the data transfer for various time windows. There are a number of approaches that have been discussed but suffers from the problem of a lifetime due to the scarcity of energy parameters.

To overcome the above -mentioned issues, this work proposes a combined approach of jumper firefly cluster head selection algorithm with the jumper approach to increase the duration of the Wireless Sensor Network (WSN). The method starts with initial cluster formation performed by the base station and later the base station applies the firefly cluster head selection algorithm to stipulate the duration of the WSN where the jumper algorithm has been used to compute the fitness of the sensor node to be selected as cluster head. The MADF algorithm is much efficient than another bio-inspired algorithm because it works based on hydrodynamics and network strategies.

The cluster-based routing is a method where the nodes are formed in the form of layers and the nodes present in the lower layer sends the packet to the parent layer node. Similarly, the packet will be transferred through a set of nodes to reach the cluster head and the cluster head transmits the packet to the base station to deliver the packet to the destined node. Therefore, to perform routing in the wireless sensor network the cluster of nodes has to be formed. To construct the cluster of nodes there are many approaches available and each has its own advantages. The least energy adaptive cluster hierarchy (LEACH) routing is one among them, which uses cluster-based routing.

LEACH routing protocol, constructs clusters of nodes and selects the cluster head based on the energy parameter. The LEACH protocol performs routing using cluster-based routing. The nodes of the network form a number of clusters according to the energy of the cluster heads. The node sends packets to the base station through the cluster head.

Consider a network condition that there exists an N number of nodes with varying residual energy μ. If there are p number of clusters formed by standard leach protocol where each cluster has N/p number of nodes in an equally distributed cluster. Each cluster head CH_i receives a minimum of (N/p)-D number of packets at each time slot where D is the number of sleeping nodes. In such condition if ((N/p)- D)-T) is the number of nodes that are involved in the cooperative transmission, the nodes which are participating in the transmission lose certain energy at each transmission. This decreases the overall energy of all the nodes and the lifetime of the network.

The LEACH protocol considers only the energy parameter as the key for the cluster head selection and this introduces a frequent change of cluster heads. The selection of cluster head and formation of clusters has to be optimized so that the cluster formation can be efficient. The firefly algorithm is the technique of choosing a single output by performing the continuous function. The output of a single instance is verified with the earlier output of the function and finally, a well optimal result can be identified. In the case of cluster-based routing the problem of cluster formation and selection of cluster, the head can be performed using the firefly algorithm. The method initialized with N swarms where each swarm is considered as cluster heads, the nodes of the network is given as input and the function computes the optimal fitness value of each node to adapt or joining to the cluster.

The jumper firefly algorithm can be well adapted for the problem of cluster head selection in wireless sensor networks. The jumper firefly approach is a much better option than other bio-inspired algorithms like ACO, and Honey bee.

The lifetime of the wireless sensor network is depending on the performance parameters being achieved. Even though there are many parameters, energy efficiency is the most one, which affects the lifetime of the network. In such a way the LEACH protocol gets the better performance, in this work, the method adapts the multi-attribute depletion-based jumper firefly algorithm for the cluster head selection.

In this paper, related works, problem definition is stated in section 2, the proposed method for depletion measure and cluster formation is stated in section 3, results and discussion are discussed in section 4, and conclusions are stated in section 5.

2. Related Works

Several scientists assessed and submitted WSN Routing protocol comparative study. By assessing the efficiency of routing protocols, several conclusions were drawn. In paper [4], the calculation suggested in Wireless Sensor Networks (WSNs) to enhance network life. The course for information move is chosen so that the complete energy devoured along the course is least. For high adaptability and great information collection, sensor hubs are gathered into non- covering gatherings called clusters. The Cluster will create productive usage of constrained assets (control) of sensor hubs, which will improve the lifetime of the system. The energy-efficient routing protocols suggested by [4] are intended based on the clustering framework. It is also possible to use the clustering method to conduct data aggregation that incorporates data from source nodes into a tiny collection of significant info. The fewer messages are transferred, the more energy is saved, under the condition of reaching an adequate data rate indicated by apps. Localized algorithms, therefore, make big networks more scalable than centralized algorithms that are performed in a global structure. Wireless Sensor Network requires upgrading to introduce a few application-specific specific sensor nodes [5]. The sensor nodes are highly configured and the sensor nodes are lowly configured. The Source Nodes (SN) are the high configuration sensor nodes that possess high memory, processing and communication range with these abilities provided they can sense, store, process, and communicate data up to the large range.

The suggested cluster heads are selected in paper [6] Based on a probability value obtained from the ratio between the energy consumption of the ensemble present in each node and the average energy of the network calculated. The amount of cycles of each node's rotating period varies depending on its original energy rate and energy consumption. The nodes with elevated original energy consumption rates and lower energy consumption have more opportunities of being the cluster heads than the nodes with low original energy and elevated energy consumption that prolonged the lifetime of the network and made stable networks. In paper [7] evaluated for specific benefits in terms of efficient communication and scalability. A significant issue is the collection of information from each sensing node and the proper transmission of this information to the base station. It requires a long time for all sensed information to be collected separately from all sensor nodes. It will improve the time the information receives and decrease the battery effectiveness of the sensor node.

In paper [8] given a short introduction in WSNs to routing problems and some design problems. This work also included the comparative evaluation of different routing protocols along with the most energy-efficient protocol (LEACH) along with some of its enhanced versions. In paper [9] examined LEACH's various hierarchical routing protocols. This article outlined LEACH problems and disadvantages and addressed a comparative analysis of all hierarchical protocol characteristics and performance problems.

A survey was conducted on various cluster-based hierarchical routing protocols that were given in paper [10] on how nodes are organized by protocols into clusters. A comparison has been made between clustering protocols that take characteristics such as their mode of transmission and CH selection algorithms. In paper [11] provided a comparative evaluation for LEACH based on the descendant's mobility, reliability, and hop count. In paper [12] provided a taxonomy of energy-efficient clustering algorithms in WSNs with the help of the timeline and description of LEACH and its descendants.

The centralized version of LEACH, LEACH-C, was proposed in paper [12]. Unlike LEACH, where nodes configure themselves into clusters, the base station in LEACH-C will organize the network into clusters. There are also two stages in LEACH-C: the phase of configuration and the phase of the stable condition. During the LEACH-C setup stage, the base station will receive data on the location and power level of each node in the network. The base station discovers a determined amount of cluster heads and uses the data obtained to configure the network into clusters. The cluster sets are selected in such a manner that the energy needed to convey their information to their corresponding cluster heads is minimal for non-cluster head nodes. Although LEACH-C's remaining activities are the same as LEACH's, the findings described show continuous improvement over LEACH. Two primary reasons for enhancement are the writers are:

- The base station uses its worldwide network understanding to create better clusters requiring less information transmission power.
- The no. of cluster heads in each LEACH-C round is equal to the optimal value predetermined, whereas the no. of LEACH cluster heads differs from round to round due to the lack of global node coordination.

3. Multi Attribute Depletion Measure (MADM) Based Jumper Firefly Approach

The proposed multi-attribute depletion-based approach performs cluster formation using a control message and then the method computes multi-attribute depletion weight for each node of the cluster to perform cluster head selection. The method performs cluster head selection using the jumper firefly approach. The entire process can be split into a number of stages namely Cluster Formation, Multi-Attribute Depletion Computation, Jumper Firefly Algorithm, and cluster-based routing. We discuss each of the functional components in detail in this section.

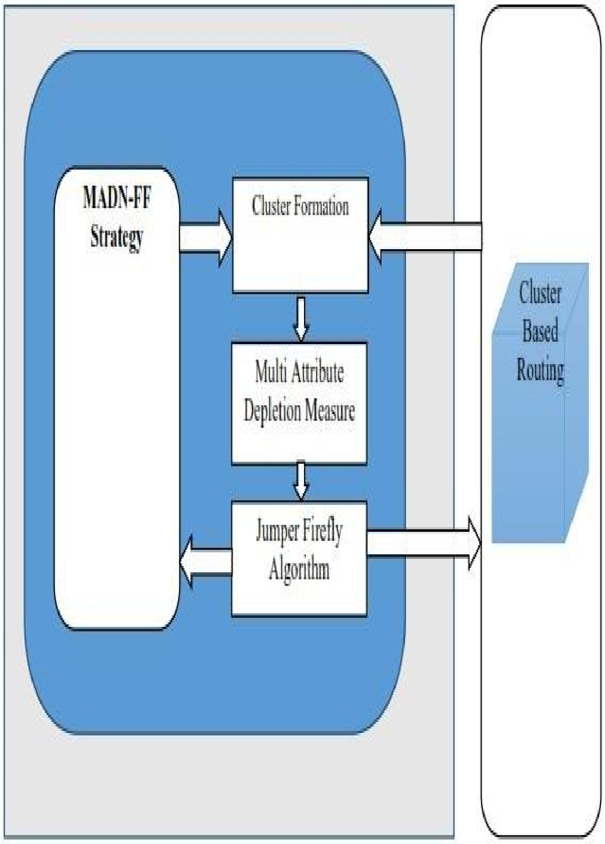

Figure 1. Architecture of proposed MADM-FF Algorithm

Figure 1 shows the architecture of the multi-attribute depletion-based jumper firefly approach and shows the functional components in detail. To optimize the cluster selection and to improve the performance of cluster head selection with high-quality routing, the firefly cluster head selection algorithm can be used. By applying the firefly technique, the nodes with higher suitability will be selected as the next cluster head so that to reduce the frequency of cluster head selection with improved lifetime.

3.1 Cluster Formation

At first, the base station starts with generating cluster head formation requests and broadcast into the network. By receiving the cluster head reply from the nodes of the network the method selects a subset of nodes, which are located within the transmission range of the base station with higher energy parameters. The node which receives the request from the base station replies with its location, energy parameters with the neighbors to the base station. Based on the energy parameter the base station selects the number of cluster heads it requires for the transmission. This will be further extended to the next level, which is performed by the cluster heads also.

Pseudo Code of Cluster Formation

Input: Null

Output: Cluster Heads C H se

Start

Generate Cluster Head Selection Request CHSR.

Initialize Broadcast Timer Bt.

Initialize Node Set Ns.

While Bt==True

Receive cluster head selection reply CHSRep.

Extract Node ID NID =

Extract Location Details LD =

Extract Energy details Ed =

Add to node set Ns.

Ns =

End

For each node Ni from Nd

Compute energy weight EW =

μ - transmission power constant for single neighbor

End

For each region of network

Choose the node with more energy weight for the location falls into the region.

Ch =Add to Chset.

End For each selected node

Send Confirmation Message. End

Stop.

The above-discussed algorithm computes the energy weight for each node, which is interested in becoming the cluster head based on the energy and number of neighbors who are going to share the energy parameters of the cluster head. The energy weight is computed based on the energy of the node and the number of neighbors it has with the transmission power constant value. For the node selection, the method identifies the nodes with maximum energy weight, minimum location displacement, and maximum number of neighbors.

3.2 Multi Attribute Depletion Measure

The multi-attribute depletion measure is computed based on various parameters of the nodes like location, number of nodes around the node, number of transmissions it involved, energy value it has. Based on all the above- mentioned factors the method computes the multi-attribute depletion measure which represents how long the node can serve as the cluster head. Based on the measure computed the base station selects a single node as the cluster head.

Pseudo Code of MADM: Input: Node

Details Nd Output: MADM

Start

For each node Ni from Nd

Compute Number of nodes around the Node Ni. NN =

Compute a number of times the Node has involved in transmission.

Nt =

Compute MADM = End

Stop

The above-presented algorithm computes the multi-attribute depletion measure which represents how long the node can be able to work as the cluster head. The depletion measure is computed based on the number of nodes around any node, the number of times a node has been involved in the transmission, the energy of the node, and the transmission constant.

3.3 Jumper Firefly Algorithm

The jumper firefly algorithm selects a set of cluster heads by iterating a number of times. Initially, the method is given with a set of preselected cluster heads, and then the method iterates a number of times with the cost function being used. In this case, the cost functions are about computing the multi-attribute depletion measure. In the third stage, the method ranks the cluster heads according to their MADM value. This will be iterated a number of times until the closest most costly node to be found for the cluster.

```
Pseudo Code of Modified Jumper Firefly Algorithm:
Input: Cluster Nodes CN, Cluster head Ch, Location Loc1
Output: Cluster Head CH. Start
For each Node Ni from the CN Compute MADM
        threshold.
End
Rank the nodes according to MADM. Select a single
node as cluster head. Loc = Change the position value.
Identify the nodes around the selected head. Invoke the same
        procedure.
If Loc=Loc1 then
Stop. End
Stop
```

The above-discussed algorithm performs cluster head selection according to the parameter of multi-attribute depletion measure and the process is iterated many times till the location does not change more. In cluster-based routing, the nodes at different layers would be scheduled for transmission at the same time. So that to sustain the incoming traffic, the cluster head selection must be performed based on the depletion measure of nodes. Also, if there exist a large number of nodes in the leaf layer then the energy depletion will be there in a greater number of nodes. This also reduces the lifetime of the network. All these must be considered in cluster head selection and the cluster head selection must be performed based on the multi-attribute depletion measure of nodes at each layer.

3.4 Cluster Based Routing

At this stage, the method starts with the cluster initialization and then the method performs the Enhanced Jumper Firefly algorithm to select the cluster head at each time interval. The Jumper firefly algorithm in turn computes the multi-attribute depletion measure to select the cluster head. Based on the computed MADM value and the location of the cluster head the firefly algorithm iterates for repeated times. The packets sent from the leaf node are forward through the cluster head to reach the destination node.

```
Pseudo code of CBR:
Input: Node Details Nd
Output: Null
Start
Perform Initial Cluster Formation. At each Time
        window Ti
For each cluster Ci
Perform Jumper Firefly Algorithm.
Choose the best Cluster head and Location. End
End
Receive an incoming packet. Perform cluster based
        routing.
Stop
```

The above-presented algorithm performs cluster-based routing by selecting the cluster heads in each time window. The cluster formation is performed at each time window of simulation time and the method selects a better cluster head using the jumper firefly algorithm.

Given a set of N nodes, each has fixed residual energy e, with transmission range r, generating the clusters according to the LEACH protocol is as follows: First, the protocol generates cluster head selection request, which is replied by the set of all nodes, which has the intention to become the cluster head. The protocol reads the location information of all the nodes and receives the reply from the nodes. Based on the residual energy identified, the protocol selects a small set of nodes as the cluster head. On the other side, the selected cluster heads generate cluster formation request to group the nodes.

In the core LEACH protocol, the above-discussed method of cluster formation is performed. What happens in forming a cluster in such a manner is if there is a region where the density of the nodes is less but a node has been selected as cluster head. Then there will be no data transfer through the cluster head. On the other side, if under a cluster head, there exist a large number of nodes under the coverage, then there will be a higher frequency of cluster head selection and the energy depletion at the cluster head also will be higher. Overall, this reduces the lifetime of the network, and to avoid this, the level-based cluster head selection can be enforced.

4. Result & Discussion

Here, the simulation results produced by the projected method in network simulator NS 2 are displayed. The Firefly applies for cluster head is shown in Figure.2.

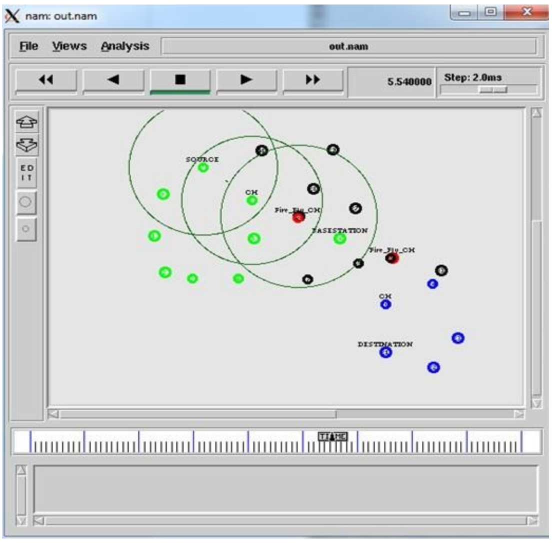

Figure 2. Firefly apply for cluster head

Figure 2, shows the calculated results of one set of simulations in network simulator.

```
$ gawk.exe -f paper2.awk out.tr
 MADM-FF Performance Report
**************************
Throughput ratio = 0.93
send = 1777
recv = 1615
Dropped Packets = 162
Packet Delivary Fraction= 90.00
Average e-e delay(ms)= 149.19
****************************
```

Figure 3. Sample result of one simulation

The above figure shows the throughput ratio of the overall network. In this graph associates three existing methods, there are KCC-ant, FZ-leach, and LODE-leach. Compare to these existing methods the proposed MADM-FF gives a better result. The above graph has two axes like X-axis and Y-axis. The x-axis denotes simulation time the Y-axis represents throughput performance in percentage.

Then the above figure has four types of color lines (blue, green, red, and yellow), the Redline indicates KCC- ant, Greenline indicates FZ- leach, and the blue line denotes the Lode leach and the yellow line represent our proposed system MADM-FF. The network throughput or aggregate throughput is the sum of the information prices supplied to all terminals through a network. Throughput is essentially synonymous with the consumption of digital bandwidth; it can be analyzed mathematically by applying the queuing theory, where the load in packets per unit of time is denoted as the arrival rate and the departure rate in packets per unit of time.

Figure 4. Throughput parameters of MADM-FF

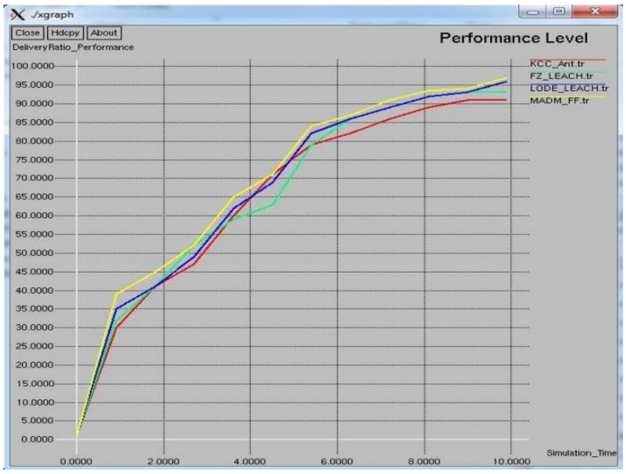

Figure 5. Delivery ratio parameters of MADM-FF

The above figure shows the delivery ratio of the overall network. In this graph associates three existing methods, there are KCC-ant, FZ-leach, and LODE-leach. The danger is to have traffic management that strives to keep the PDR high by so much restricting traffic that it suffers from throughput. From a user's point of view, a significant thing is throughput. From a network design point of view, however, PDR is important in identifying issues that may result in poor performance. PDR is like checking the compression on an automobile engine. If things are going well and your gasoline mileage is good, there is no point. But if mileage goes down, it is a good check because it can help you figure out what might be wrong. Compare these current approaches the proposed MADM-FF gives a better result.

Figure 6. Average delay parameters of MADM-FF

The above figure shows the average packet delay of the overall network. This graph associates three existing methods, there are KCC-ant, FZ-leach, and LODE-leach. Packet delay variation is the difference between successive packets that does specify the selection criteria — and this is usually loosely referred to as "jitter," although sometimes jitter is also the term used for the packet delay variance. For example, every 20ms packets are transmitted. If after the first packet, the second packet receives 30ms, Packets delivery PD= −10ms. This is known as dispersion. If after the first packet, the second packet is received 10ms, PD= + 10ms. This is known as clumping. Compare this existing method the proposed MADM-FF gives a better result.

Figure 7. Clustering accuracy parameters of MADM-FF

The above figure shows the clustering accuracy of the overall network. In this graph associates three existing methods, there are KCC-ant, FZ-leach, and LODE-leach. Clustering middleware, a software layer that sits on top of the nodes and permits users to handle the cluster as by and huge orchestrates the activities of the computer node. Clustering is based on a centralized approach to management that makes nodes available as orchestrated shared servers. Then the above figure has four types of color lines (blue, green, red, and yellow), the Redline indicates KCC-ant, Greenline indicates FZ-leach and the blue line denote the Lode leach and the yellow line represent our proposed system MADM-FF.

Figure 8. Energy depletion parameters of MADM-FF

The above figure shows the energy depletion of the overall network. In this graph associates three existing methods, there are KCC-ant, FZ-leach, and LODE-leach. Energy resources can be categorized as primary resources where the resource can be utilized substantially in its novel form or as secondary resources when converting the source of energy into a more convenient form is necessary. Human use considerably depletes non-renewable resources while renewable resources are formed through continuing procedures that can maintain unlimited human exploitation. The proposed MADM-FF gives a better result in comparing these existing methods.

Figure 9. Node lifetime parameters of MADM-FF

The above figure shows the throughput ratio of the overall network. Generally defined as the time during which the network is operational. In other words, the lifetime of the network is defined as the operational time of the network during which it is able to perform the dedicated task(s). In this graph associates the three existing methods, there are KCC-ant, FZ-leach, and LODE-leach. Compare to these existing methods the proposed MADM-FF gives a better result.

In the result part, the MADM-FF algorithm is discussed in the network environment and measures the resulting performance. The method achieves the highest throughput compared to LODE-LEACH. Then the method performs 90% of the delivery ratio then minimizes the average end-to-end delay up to 149.19 ms. Also, the proposed algorithm has improved the performance of the clustering performance then a detailed comparison of the results is given in the results and discussion section of the thesis.

5. Conclusion

In this study, several characteristic reduction actions are calculated based on various parameters such as location, number of nodes around the node, number of transactions involved, and energy value. The jumper firefly algorithm selects a set of cluster heads by iterating a number of times. Then the method performs the Enhanced Jumper Firefly algorithm to select the cluster head at each time interval. The Jumper firefly algorithm, in turn, computes the multi-attribute depletion measure to choose the cluster head. The MADM-FF method achieves the highest throughput compared to LODE-LEACH. Then the method performs 90% of delivery ratio then minimizes the average end to end delay up to 149.19 ms and also improves the performance of the clustering performance.

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