A survey of fuzzy-based energy efficient data gathering approaches in wireless sensor networks

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Abstract: Because of the high-energy efficiency and adaptability, the clustering routing algorithm has been broadly utilized in wireless sensor networks (WSNs). So as to assemble data all the more effectively, every sensor node transmits information to its Cluster Head (CH) to which it has a place, by multi-jump correspondence. As of late, such systems have appeared wide appropriateness in different territories. Generally, sensor nodes are little, cost-effective, memory compelled and having restricted handling abilities for detecting information in a specific region from the environment. In this paper, we talking about fuzzy based data gathering approaches, namely, Spawn multi-mobile agent itinerary planning (SMIP), Grid based approach (GBA), and Energy efficient distributed clustering algorithm based on fuzzy approach with non-uniform distribution (EEDCF), Fuzzy based geographic forwarding protocol (FuGeF). This paper shows a Literature study of the calculations clarifying the ideas of fuzzy based information gathering approaches in WSN. Different routing algorithms have been examined by creators to enhance the system lifetime, decrease the end to end delay, and increase the energy-delay performance.

Keywords: Mobile agent, data gathering, spawn mobile agent, wireless sensor network, fuzzy logic, distributed clustering, security, geographic forwarding, grid based approach.

I. Introduction

A wireless sensor network (WSN) is a circulation of hundreds or thousands of sensor nodes that can screen physical or ecological conditions, for example, temperature, sound, vibration, weight, movement, or pollutants [1,2]. These sensor hubs are commonly self-controlled (like batteries) and restricted in memory and handling. The principle reason for the sensor nodes is to detect the data in a zone of interest and forward the detected data occasionally to the base station (sink hub) for get-together and information handling.

A few energy-efficient routing protocols, for example, low energy adaptive clustering hierarchy (LEACH), hybrid energy-efficient distributed clustering approach (HEED), and energy-efficient opportunistic routing (EEOR) have been proposed to limit vitality utilization and increment the system's lifetime [3].

Entire system lifetime depends generally on sensor nodes control source. An effective utilization of clustering technique limits sensor nodes vitality utilization. In this method, just a few nodes permitted to speak with a base station [4– 6]. Nodes have this trademark called cluster head (CH). Controlling and overseeing vitality utilization in an effective way are a noteworthy test in WSNs. Data communication process is more vitality expending as for information preparing at nodes. Vitality utilization might be limited by making productive correspondence between nodes. To execute three thousands guidelines, energy consumption is comparable to one piece information transmission at one hundred meters [7].

Spatio-temporal attacks are attacks plotted in a system after broad connection examination of a current correspondence design in the system. As it were, attackers can decide transiently the nearness of

information in nodes and vitally, to foresee the position (spatially) of the following sending node [8]. Attackers fruitful in such attack can additionally choose to drop all (blackhole), partially drop (dark gap), or Insert information into the packet. Any of the attacks can radically corrupt the execution of a system to an unfortunate dimension.

II. Related work

In [9], creator recommended that the near-optimal itinerary design (NOID) calculation was proposed to find the ideal number of MAs in MIP. This calculation iteratively groups the sensor nodes in the system to isolate sub-trees that are associated continuously to the processing element (PE) or sink. After NOID finishes building sub-trees, the sink dispatches done MA to each sub-tree.

In [10], creator proposed, an upgraded variant of the NOID calculation named the second near-optimal itinerary design (SNOID) calculation was proposed in SNOID contrasts from NOID by considering the nodes' correspondence cost while building the MA agenda. The quantity of MAs in SNOID is dictated by dividing the region around the sink into concentric zones. The nodes lying with in the span of the first zone around the sink will be the beginning stages of every agenda.

In [11], creator proposed, a meta-heuristic strategy called iterated local search (ILS) was additionally proposed in This calculation resembles the other tree-based MIP calculations (NOID and SNOID), however it varies in considering the expansion in MA's packet measure just as the vitality utilization because of relocation over middle nodes when it develops the MA agenda.

In [12], creator proposed, LEACH gave a various leveled convention for WSN which is a standout amongst the most broadly utilized conventions by the vast majority of the analysts. In this, sensor nodes transmit to their cluster heads. Each cluster head totals and packs the information, and finally forward this information to a remotely found brought together base station (BS).

In [13], creator proposed, LEACH (Low Energy Adaptive Clustering Hierarchy) is a standout amongst the most traditional self-sorting out versatile clustering routing calculations for WSNs in the early time, which midpoints the energy load of the entire system to every sensor node through customary CH decision. It can enhance the versatility and vigor of dynamic systems to some degree.

In [14], creator proposed, one of the soonest deals with hub choice utilizes the Most Forward within Range (MFR) or avaricious sending methodology to choose next hop nodes. The methodology chooses a node that makes the most astounding advances (remove) towards a goal inside its range, amid the routing procedure.

III. Spawn Multi-Mobile Agent Itinerary Planning (SMIP) Approach:

Huthiafa Q. Qadori, Zuriati A. Zulkarnain, Zurina Mohd Hanapi and Shamala Subramaniam [15], the creator displayed, a spawn multi-mobile agent itinerary planning (SMIP) is proposed to lessen the considerable increment in expense of vitality just as time utilized in the information gathering forms. The proposed methodology [15], depends on the specialist bringing forth to such an extent that the fundamental MA can produce different MAs inside a solitary segment. The bringing forth MA has diverse undertakings allotted from the principle MA, with the end goal that it just returns the gathered information to the sink. The primary objective of the proposed SMIP approach is to reduce the issue of outstanding burden because of various MAs conveying a similar total code inside a solitary segment.

A. Spawn Mobile Agent (SMA) Algorithm in SMIP

Operator bringing forth is the capacity to make another specialist that has distinctive limits and abilities that are in opposition to the first operator. The bringing forth specialist's assignment is to deal with a piece of the jobs that needs to be done of the first operator. Consequently, in this work, we receive this trademark (specialist bringing forth) so as to circulate the information gathering task among the MAs with the end goal that a few MAs have diverse relegated assignments from others. The sink node assigns one principle MA to each segment. The primary undertaking of the fundamental MA is to gather the information from the source nodes, and it likewise can produce the new MA (SMA) to complete an alternate errand at one point. Here, the task of the SMA is just to convey the gathered information of the principle MA back to the sink. Because of this bringing forth activity, two sorts of agendas are defined: principle MA schedule and SMA schedule.

It should be noticed that the SMA is an element worked inside the fundamental MA packet. The packet structure of the fundamental MA is portrayed in Figure 1. The principle MA packet is defined as an element of six properties: MA ID, MA agenda, information payload, SMA code, SMA schedule, and information accumulation code.

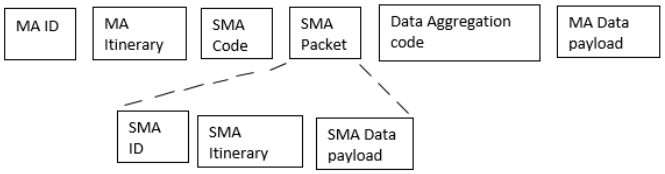

Fig1: Main MA packet structure. SMA: spawn mobile agent.

The description of these attributes is as follows:

- MA ID: is the identification number of each MA dispatched by the sink node.
- MA Itinerary: contains the itinerary information (source nodes' visited order list) assigned by the sink node when dispatched.
- Data payload: MA's data buffer which carries the aggregation data results.
- SMA code: is the code of the spawning carried by MA.
- SMA Packet: includes the SMA ID, the itinerary information of the SMA (visited sensor nodes) to get back to the sink node, and SMA payload data. Note that the MA could carry more than one SMA.
- Data aggregation code: is the implementation of the data aggregation algorithm.

We noticed that in the proposed SMIP approach, the strategy of deciding the quantity of fundamental MAs, SMAs, and their relating it interiorise used for information gathering process is executed midway at the sink. The pseudo-code of SMIP approach is detailed in algorithm 1.

Algorithm 1: Pseudo-code of SMIP approach

1. Initialization:
2. N ← Number of sensor nodes
3. MA_{DP} ← The threshold value of the main MA data payload
4. Partitioning the network using x-means algorithm by calculating the distance among N:
5. Z ← Number of Partitions
6. for p=1 to Z do
7. S ← Number of source nodes in p
8. Assign one main MA to p
9. TDSP ← The total data size of S in p
10. if TDSP > MA_{DP} then
11. Calculation Number of SMA's(p)

12. Determine the itinerary of the main MA and SMAs using LCF algorithm

13. end

14. end

15. Return the itineraries of the main MAs and the SMAs.

IV. A Grid-Based Approach to Prolong of WSN's Lifetime:

Ajai Kumar Mishra, Rakesh Kumar, Vimal Kumar and Jitendra Singh [16], the creator displayed a grid based way to deal with draw out WSN's lifetime. Grid head selection approach using fuzzy logic is non-probabilistic and fully distributed. Disseminated grid head selection fixed directing plan lessens additional correspondence cost with base station. No randomized capacity is utilized to produce a number to settle on choice to choose matrix head like other probabilistic methodologies. Fuzzy logic is utilized to ascertain fitness esteem for nodes for choosing as network head. Remaining vitality of sensor node, remove from base station, is taken as a parameter to register framework head likelihood esteem.

Proposed conspire is started by legitimacy and fault of above examined approaches. In all past powerful grouping plans, we have two major demerits.

- Decide the cluster territory by picked cluster head in each round. This procedure expends significant vitality asset in preparing and imparting among node to fix cluster head and cluster region.
- Overlapping of cluster head go. It might conceivable that two nodes picked as cluster head, close with one another.

In our proposed methodology, we have tried to wipe out these two inadequacies of existing plans by proposing a novel matrix based unique cluster head determination conspire in WSN. In our proposed methodology, as appeared in algorithm 2, organize territory is isolated into matrices where remote sensor nodes are haphazardly conveyed. The upside of doing such sort of game plan is that all sensor nodes have one of a kind lattice, which implies that there will be no sensor nodes which have a place with more than one framework. It reduces the energy utilization occurred at the season of dynamic clustering approach. In proposed approach, every matrix contains practically measure up to number of homogeneous remote sensor nodes, however we may likewise utilize this methodology where every framework contains diverse quantities of remote sensor nodes with heterogeneous nature of nodes.

Algorithm 2:

1. Consider network area n × n meters
2. Divide network area into small size area (kxl in meters) called as grid
3. Randomly deployed sensor nodes each predefined grid
4. For each round r = 1 tor_max
5. Node having the maximum grid head chance selected as grid head
6. Grid head receives data and forwards to next appropriate grid head or base station
7. Go to step 4 until last node died.

V. Fuzzy-Logic Based Distributed Energy-Efficient Clustering:

Ying Zhang, Jun Wang, Dezhi Han, Huafeng Wuand Rundong Zhou [17], the Author introduced a dispersed grouping calculation EEDCF dependent on TSK fuzzy model for WSNs to adapt to the issues referenced previously. For every node, we think about node's remaining vitality, node's degree and residual energy of node's neighbor nodes as the information parameters to figure the likelihood of being CH by TSK fluffy model distributed when CH race happens.

A. EEDCF Algorithm:

The proposed EEDCF calculation joins fuzzy rationale with grouping calculation for remote sensor systems and thinks about node leftover vitality, node degree, and neighbor nodes' vitality as info esteems for every node, which are defined as pursues: Node lingering vitality: The present vitality of every node. Because of the need to attempt information gathering mission inside the group and speak with the BS, the vitality utilization of CH is undeniably more than the other part nodes in the cluster. Along these lines, choosing the nodes with higher remaining vitality to be the CHs can incredibly enhance the execution of the entire framework and increment the lifetime of the systems. Node degree: The quantity of neighbor nodes inside correspondence sweep "R". The more noteworthy the node degree is, the higher the efficiency of information transmission will be, and the littler the mutual outstanding task at hand of information sending gone up against by each neighbor node of CH will be likewise, which is useful for the whole framework vitality advancement. Neighbor nodes' normal lingering vitality: Due to the multi-jump correspondence display for information transmission inside the bunch, the nodes closer to the CH require more vitality to actualize information sending than the more distant ones. Subsequently, there is no uncertainty that presenting neighbor nodes' normal lingering vitality as one of the choice variables is a powerful answer for the heap adjusting issue for the entire framework. In this paper, we define four states for the nodes: (1) initial state; (2) competing CH state; (3) elected CH state; and (4) member node state. Pseudo code of the proposed algorithm describing every CH election process is shown in Algorithm 3.

Algorithm3: The Proposed Clustering Algorithm for EEDCF

1 Begin
2 N=Total number of nodes
3 i=ID of living sensor node in current round
4 node[i].statement=initial_ state
5 for each node[i]
6 receives Node_ MSG from Neighbor_ Node
7 node[i].Info_ table updates 5 Input para meters: Residual Energy (R E), Node Degree (ND), Neighbor nodes' Residual
Energy (N R E)
8 node[i].RE=residual energy of node[i]
9 node[i].ND=number of nodes within communication "R"
10 node[i].NRE=residual energy of neighbor nodes of node[i] 5 Analysis through fuzzy inference system (FIS)
11 probability=FIS (node[i].RE, node[i].ND, node[i].NRE)
12 Send Head_ compete to all neighbor nodes
13 Neighbor_ Node[j] =list of Head _compete from neighbor node 5 Comparing the result
from FIS (Fuzzy Inference System) with
neighbor nodes '
14 If (node[i].probability>Neighbor_ Node[j]. probability)
15 node[i].statement=CH
16 advertise CH_ Message
17 else
18 on receiving CH_ Message
19 select the nearest CH
20 send Node_ JOIN to the nearest CH
21 end
22 end
23 End

VI. FuGeF: A Resource Bound Secure Forwarding Protocol

Idris Abubakar Umar, Zurina Mohd Hanapi, A. Sali and Zuriati A. Zulkarnain [18], in this creator introduced a Fuzzy-based Geographic Forwarding protocol (FuGeF) to enhance node determination. The protocol first uses three parameters: remaining vitality, network cost, and dynamic separation. For node

determination, at that point, utilizes a Fuzzy Logic System (FLS) for basic leadership. The objective of FuGeF is to distinguish fitting sending nodes that would moderate packet loss just as give a superior exchange off among security and base execution. Broad recreation tests have been directed to assess the execution of the proposed FuGeF with the DWSIGF convention. The outcomes acquired demonstrate that the FuGeF accomplishes a higher execution regarding packet delivery ratio and limits the likelihood of picking an attacker when contrasted with DWSIGF convention.

A. The Proposed FuGeF Protocol

As opposed to DWSIGF, the proposed FuGeF utilizes singular CTS answer gotten by the ORTS sender S, which contains area data and remaining vitality. The sender S utilizes the area data to figure a node's dynamic separation and availability cost. The registered qualities, together with the rest of the vitality, are passed as contributions to the FLS for preparing as appeared in Figure 2.

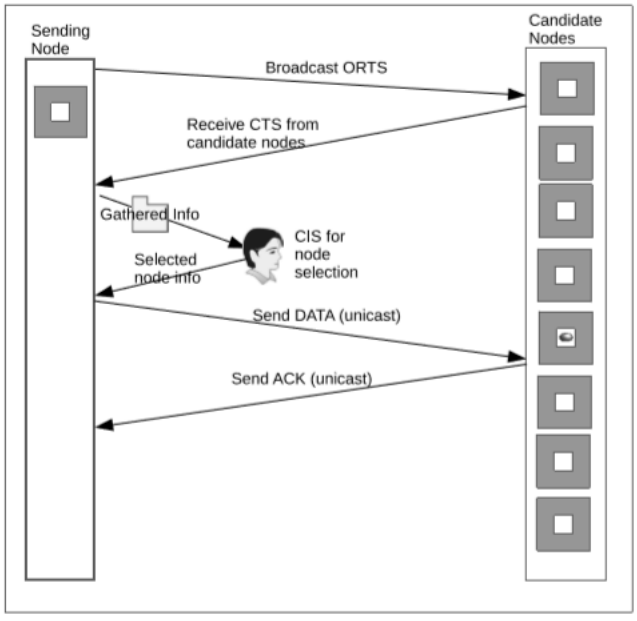

Fig2: Forwarding process.

VII. Comparison of Fuzzy-based Energy Efficient Data Gathering Approaches in WSN

S.NO.	Author	Title	Analysis
1.	Huthiafa Q Qadori, Zuriati A Zulkarnain, Zurina Mohd Hanapi, and Shamala Subramaniam.	'A spawn mobile agent itinerary planning approach for energy-efficient data gathering in wireless sensor networks. Sensors'.	Energy increased and Delay reduced.
2.	Ajai Kumar Mishra, Rakesh Kumar, Vimal Kumar, and Jitendra Singh. 2015.	'A grid-based approach to prolong lifetime of wsns using fuzzy logic. In Advances in Computational Intelligence: Proceedings of International Conference on Computational Intelligence'.	High Energy Efficiency, and Lifetime increased.
3.	Ying Zhang, Jun Wang,	'Fuzzy-logic based	High Energy

	Dezhi Han, Huafeng Wu, and Rundong Zhou.	distributed energy-efficient clustering algorithm for wireless sensor networks. Sensors'.	Efficiency, Scalability, Energy consumption is reduced and Lifetime increased.
4.	Idris Abubakar Umar, Zurina Mohd Hanapi, Aduwati Sali, and Zuriati A Zulkarnain.	'Fugef: A resource bound secure forwarding protocol for wireless sensor networks. Sensors'.	Packet loss is minimized, and Packet Delivery Ratio increases.

VIII. Conclusion

This paper shows a point by point writing of the fuzzy based information gathering approaches in WSN. We represent the probabilistic methodology by which framework based ways to deal with drag out the remote system lifetime. The utilization of network based methodology and fixed routing scheme results in decrease of intensity utilization in additional transmission and preparing of information. The recreation results demonstrate that, contrasted and existing plans, the proposed methodologies can delay sensor node's normal life time, broaden the existence cycle of the entire system by reducing the vitality utilization of the framework, and enhance the data transmission efficiency, which makes the entire framework more vitality proficient, particularly for the systems with higher hubs densities.

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