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# Efficient Routing Tree Formation to Reduce Energy in Lightweight Routing in Wireless Sensor Networks.

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***Abstract* - Wireless Sensor Network (WSNs) has many sensor nodes, each with communication and energy. In WSNs one or more events occur at a time. Instead of each event sending its data to the sink node, overlapping of paths is done in order to maximize the data aggregation. When two or more event occurs data aggregation is maximized but the performance of the network is less. There is no balance between data aggregation and energy of a sensor node. By just aggregating the data it will cause premature death of nodes which will lead to unstable network structure. Based on the problems, in this paper, a novel efficient routing tree formation algorithm for data aggregation is proposed to reduce energy. The algorithm maximizes the possible data aggregation by building a Hop-Tree and then updating the Hop-Tree. While building the Hop-Tree it first takes the local state of nodes and then maintains the Hop-Tree value to gain better adaptation. Then the algorithm compares with the new shortest path and also the aggregated path when two or more events occur, so that there is a load balance between the nodes and also the consumption of energy will be less. Thus the proposed systems shows that instead of aggregating the data without knowing how far the events are occurring ,it checks for the shortest path by comparing with new route path and aggregated path ,the one with less number of Hops to the sink is selected as an new path.**

***Keywords*—wireless sensor networks, hop-tree, cluster formation, data aggregation, energy balance.**

## I. INTRODUCTION

Wireless Sensor Networks (WSNs) consists of a huge number of sensor nodes. They can sense the environment, process the data and then communicate the data through wireless telecommunication. The applications of WSNs are used in different scenarios such as environmental monitoring, rescue or assistance systems, industrial control, localization of services and users, traffic monitoring, military systems etc. In WSNs the energy consumption for transmitting data is important. Wireless Sensor Networks (WSNs) consist of sensor nodes that are powered by batteries with very limited energy. These batteries are impossible or inconvenient to recharge. Due to large number of sensor nodes. Energy is very limited for WSNs.

In WSNs the density of networks is high. Therefore there is a large number of redundant data that is transmitted in network and is being collected with nodes which are spatially (nearly) close. In the process of data aggregation, routing has an important role to determine how the data is routed. It helps to achieve effective data aggregation, which is an important topic of WSN. When WSN is event driven it is not suitable to use fixed routing because the advantage of the correlation between data to reduce data redundancy is not considered which in turn results in large data load. For effective data aggregation it's essential to build routes overlapping dynamically as much as possible according to the events. In normal conditions, when nodes are closer the data, correlation is better and data aggregation is also high, and when events are farther then the data correlation and data aggregation is not efficient. Therefore when the events are far apart, over-overlapping of routes will not be useful for data aggregation because of the low correlation of data which prevents high degree and efficient aggregation of data. Therefore it results in uneven energy consumption which leads to unstable network structure. A good routing protocol is needed for data aggregation that overlaps routes according to data correlation and local state so that it provides a balance for energy consumption for the entire network in order to enhance the monitoring ability of WSNs. This paper proposes an Efficient Routing Tree Formation algorithm to Reduce Energy in Lightweight Routing in Wireless Sensor Networks. This algorithm constructs an efficient routing tree with shortest paths based on events and nodes local states, which can maximize data aggregation according to data correlation and balance node energy consumption and route data in a reliable way.

## II. RELATED WORK

For better aggregation of data, tree and cluster structure are mostly used. The Low-Energy Adaptive Clustering Hierarchy (LEACH) [1] is the algorithm that first worked based on the cluster, in this algorithm the cluster-heads act as aggregation nodes and the node that communicates directly with the Sink node. When the cluster head is elected as a aggregation node the load on that node will me more so to overcome this a Hybrid Energy-Efficient Distributed Clustering (HEED) [2] algorithm was used to periodically selects cluster heads based on their residual energy and as node degree so that it can balance load among cluster heads to extend the lifetime of WSN. For nonuniformly distributed clustering in WSNs an algorithm EADC [3] is used. To overcome the problem of coverage of nodes a CPCP [4] is a coverage-aware clustering algorithm that is designed for applications to preserve the coverage requirements. The most typical routing is Shortest Path Tree routing (SPT) [5] and its strategies are based on a tree in WSNs. In SPT algorithm, each node transmits its collected data through the shortest path from the nodes to the Sink, and data aggregation occurs at any intersection of paths from nodes to sink.

All the above algorithms do not consider the correlation of data while is clustering or building tree. DACP [6] makes use of full data that are predicted so that it helps cluster heads decide whether to send the aggregated data or not, so that it improves the efficiency of data aggregation. In event-driven situation, the Information Fusion-based Role Assignment (InFRA) algorithm [7] the nodes that detect the same event maximizes by overlapping shortest paths from the clusters to the Sink. A clustering technique algorithm is proposed [8] that are based on the status of the network so that the data aggregation and energy efficiency can be improved. The Dynamic and Scalable Tree (DST) algorithm reduces the number of nodes based on the correlation and maximizes the overlap of routes regardless of the order of event occurrence [9].

The perfect aggregation for both intra- event data and inter- event data, a routing algorithm was proposed for data aggregation with the aim to reduce the number of messages for setting up a routing tree, maximize the number of overlapping routes, improve the aggregation rate, and provide a reliable data aggregation and transmission. But DRINA as following disadvantage:

a) When the path is built earlier, the load on the nodes will be heavier. This will cause death of those premature nodes.

b) Sometimes the data have to be transmitted along longer paths, which would increase the total energy consumption.

c) It does not consider the data correlation of events, therefore assumes that the data from different event areas could be aggregated perfectly.

In this paper, the main goal is to improve DRINA and propose a novel Efficient Routing Tree Formation to Reduce Energy in Routing Algorithm for data aggregation. This algorithm uses the local states of nodes to build and update a Hop-Tree for data routing and aggregation, balancing energy consumption. It builds shortest paths from the events area of the Hop-Tree or the Sink based on the correlation between the events. It can maximize the overlapping of routes to achieve better data aggregation when events are close, shorten the data transmission paths while the correlation of events is far, and further balance the energy consumption of the Hop-Tree to enhance the network monitoring capabilities. Theoretical results confirm the effectiveness of Efficient Routing Tree Formation to Reduce Energy in Routing Algorithm.

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## III. Materials And Methodology

In this paper, the main focus is to be to build an efficient routing tree (Hop-Tree) for in-networking data aggregation according to the local states of nodes and based on correlation of events which can maximize the data aggregation and also balances energy consumption, to improve the monitoring capability of WSNs.

### *A) Modules in Implementation*

The proposed approach consists of following steps:-

1) Hop-Tree Building.
2) Cluster Formation.
3) Routing formation and Hop Tree updates.
4) Routes Maintaining

### *1) Hop-Tree Building*

The efficient routing tree formation algorithm considers the following roles in the routing infrastructure creation:

- Collaborator: A node that detects an event, then gathers data and sends data to the coordinator node.
- Coordinator: A node that also detects an event and is responsible for gathering all the gathered data sent by collaborator nodes, aggregating them and sending the result toward the sink node.
- Sink: A node interested in receiving data from a set of coordinator and collaborator nodes.
- Relay: A node that forwards data toward the sink.

In this step, the distance from the sink to each node is computed in hops. A Hop-Tree rooted at Sink is formed after deploying sensor nodes, with the shortest paths (in hops) that connect all source nodes to the Sink while maximizing the possible data aggregation and balancing energy consumption. Each node has two parameters: HTT (Hop-To-Tree) and HTS (Hop-To-Sink), recording the minimum number of hops from the node to the Hop-Tree and to the Sink respectively. The value of HTT for a node might be changed when the Hop-Tree updates because of some new events, while the value of HTS for each node does not change. At the beginning, the HTT and the HTS are the same, then different as events occur one after another. The HTT of the Sink and any node on the backbone of the Hop-Tree is 0. The farther the node is away from the backbone of the Hop-Tree, the larger the HTT is. The HTT of any node changes in 2 cases: (a) it becomes a backbone node of the Hop-Tree, or (b) it receives a Hop Configuration Message (HCM) which announces better distance. HCM is a four-tuple as < Type, ID, HTT, State>, where Type specifies HCM message, ID is the identifier of a node that started or retransmitted the HCM message, HTT is the distance by which an HCM message has passed, and State records the State of the sender.

At the beginning, the Sink set its HTT 0, and other nodes infinity. This phase is started by the Sink flooding an HCM with HTT 1. On receiving an HCM message, each node compares its HTT with the HTT in the HCM message. If there is a shorter way to the Sink, the node will update the relevant information and retransmit the HCM. If there are several nodes which are next hop candidates, a node with better state will win. Otherwise, the node will take no action but discard the received HCM. This process runs repeatedly until a Hop-Tree rooted at the Sink is built.

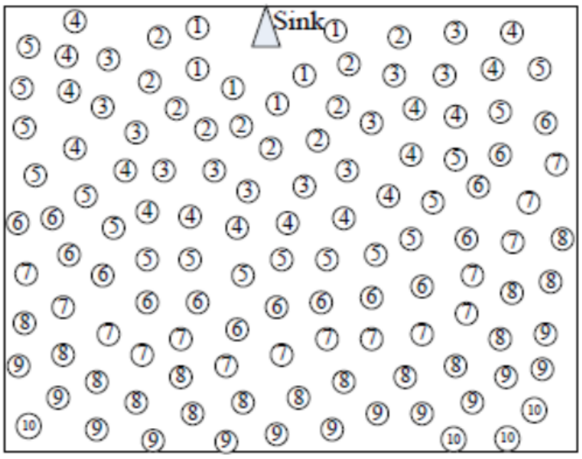


**Fig 1: Initial state of Hop Tree**

Before the first event taking place, there is no established path that is the Sink constructs the backbone of the Hop-Tree as shown in Fig 1, the HTT has the same meaning with the HTS. So the HTS of each node is set equal to its initial HTT. After event occurrence, HTT which is the smallest hops to the available backbone of the Hop-Tree becomes different from HTS.

***2) Cluster formation***

When an event occurs, a cluster based on the nodes which detect it is called event nodes will be formed. The key process of the cluster formation step is the election of the leader node called Coordinator for the cluster, and the information delivery in this phase is by means of Cluster Configuration Message (CCM). CCM is also a four-tuple: < Type, ID, HTT, State>, where ID is the identifier of the node that started the message, HTT and State fields store the HTT and State value of the node with the identifier ID separately.

At the beginning, all event nodes are eligible candidates. Any node that has detected the event sets its role Coordinator, constructs a CCM message and sends it out. The node with the shortest path to the Hop-Tree will become the Coordinator. If there are several nodes have the smallest HTT value, the one with the best state will be the final victor. Other nodes in the event area will be the Collaborators as shown in Fig 2.

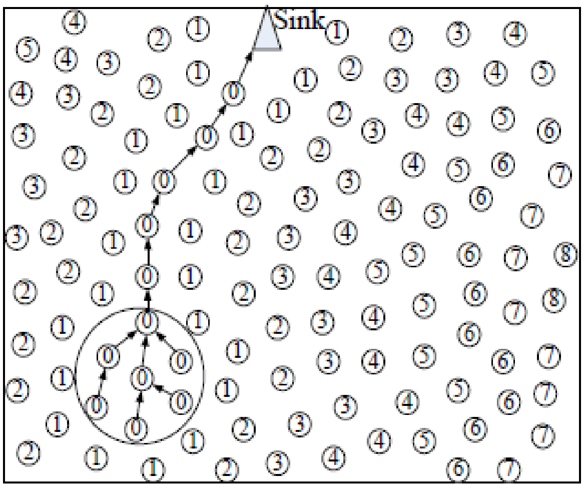


**Fig 2: Cluster formation and state of the Hop Tree when event occurs**

***3) Routing formation and Hop Tree updates.***

The elected group leader (coordinator), starts establishing the new route for the event dissemination. For that, the Coordinator sends a route establishment message to its NextHop node. When the NextHop node receives a route establishment message, it retransmits the message to its NextHop and starts the hop tree updating process. These steps are repeated until either the sink is reached or a node that is part of an already established route is found. A Hop-Tree should be updated for gaining shortest paths connecting all source nodes while maximizing data aggregation and balancing energy distribution as events occur one by one. The HTT value of each node is updated properly.

Data aggregation is based on the correlation among data. The more correlated the data are, the better the result of data aggregation is (that is the less aggregated data and the more accurate reconstructed data from the aggregated data). Often, spatial correlation of data sensed by nodes depends on the spatial distance between events. The closer the two events are apart, the more correlation the sensed data are, and the farther apart, the less correlation. Usually, data from two far apart events could not be aggregated. So, if the Hop-Tree is updated to force the paths from the two distant events to overlap as early as possible and the data from the two corresponding coordinators are aggregated forcedly, the data reconstruction will be very poor, or if the data are not aggregated, energy consumption for transmitting these data will increase because of a non-shortest path to the Sink and the load of the nodes on the overlapping path will be heavier resulting in uneven energy consumption as shown in Fig 3.

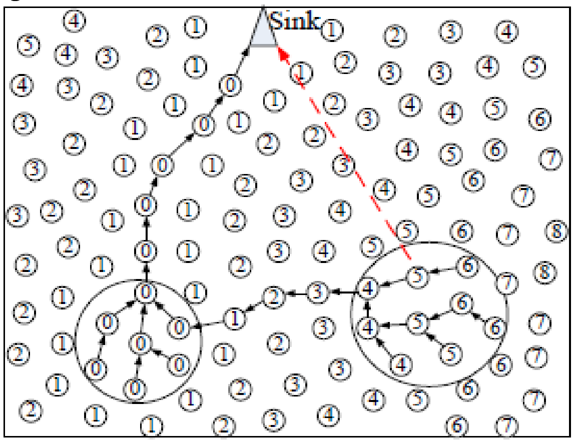


**Fig 3: When two events occur the distance is calculated from 1) coordinator to aggregation node and 2) coordinator node to sink in Hops.**

The routes are created by choosing the best neighbor at each hop. The choices for the best neighbor are twofold: 1) when the first event occurs, the node that leads to the shortest path to the sink is chosen; and 2) after the occurrence of subsequent events, the best neighbor is the one that leads to the closest node that is already part of an established route that is done by selecting aggregation node D1, this process tends to increase the aggregation points, ensuring that they occur as close as possible to the events.

A new shortest path is built from the second event or subsequent events to the sink node with connect to the sink with less number of Hops. This path is D2. Once path is built the efficient routing tree formation to reduce energy algorithm will calculate both D1 and D2 in terms of hub count. In next step both path that is D1 and D2 is compared. The best path is the selected as the one which as less number of hub counts as shown in Fig 4. Next that shortest path is selected and data is routed to the sink and also the Hop Tree value is updated with new values.

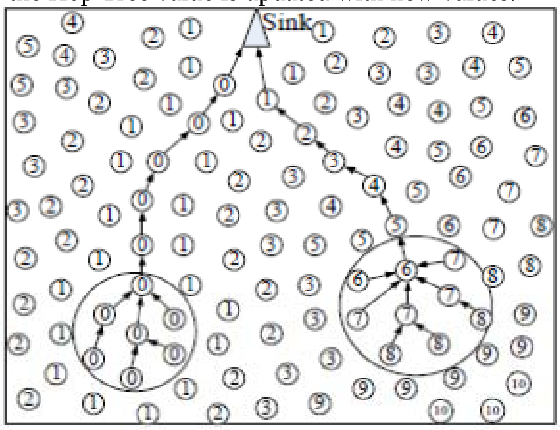


**Fig 4: The shortest path with less hop count is selected.**

***4) Routes maintaining***

The Hop-Tree is unique, and any failure of nodes will cause disruption in data transmission. The route repair mechanism in efficient routing tree formation algorithm takes a pretreatment for route repair to settle those problems. By means of periodic MAC communication, nodes can determine whether a neighbor dies or not. Any node that finds its next hop died chooses a neighbor which has lower HTT level and better state as its next hop. If a node could not find a neighbor as its next hop, the node will set its HTT infinity (called abnormal node) and inform its neighbors to change their next hop if necessary. When such case appears, it shows the local state around the node is poor.

## IV. THEORETICAL ANALYSIS

Efficient Routing Tree Formation to Reduce Energy in Routing Algorithm is an improved algorithm based on DRINA. So, the proposed algorithm is here compared with DRINA.

1) Efficient Routing Tree Formation to Reduce Energy in Routing Algorithm is more suitable than DRINA for heterogeneous WSNs.

In the Hop-Tree building and update phases, when there are several candidates for a node choosing next hop, Efficient Routing Tree Formation to Reduce Energy in Routing Algorithm makes the node with best local state win in the competition while DRINA only chooses the node whose HCM first reaches not considering the state of nodes. Efficient Routing Tree Formation to Reduce Energy in Routing Algorithm is more suitable than DRINA for heterogeneous WSNs.

2) Efficient Routing Tree Formation to Reduce Energy in Routing Algorithm leads to less transmission energy than DRINA when the correlation of events is low.

For DRINA, longer paths are often formed because of over-overlapping paths from events which are far apart from each other and with low correlation, and it wastes much energy to transmit data along non-shortest paths. But the proposed algorithm selects the shortest path which has less number of Hop counts in order to maximize the data aggregation and also provide energy balance between the nodes.

## V. CONCLUSION

In this paper, the routing problems are studied for facilitating data aggregation in event-driven WSNs, and propose a novel Efficient Routing Tree Formation to Reduce Energy in Routing Algorithm to improve the DRINA algorithm. The Efficient Routing Tree Formation to Reduce Energy in Routing Algorithm builds a Hop-Tree based on sensor local state calculated with residual energy and memory which is more appropriate to heterogeneous WSNs. It calculates the distance to select shortest path with less Hop count, making the paths for the events with high correlation overlap as early as possible to maximize the degree of data aggregation and ones for the events with low correlation avoid over-overlapping and curving to save data transmission energy.

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