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A Mobile-Sink Based Distributed Energy-Efficient Clustering Algorithm for WSNs

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ABSTRACT

Wireless sensor networks contain of a large number of limited capability Micro Electro Mechanical Systems capable of measuring and reporting physical variables related to their environment. Energy efficiency is an essential issue in the applications of wireless sensor networks (WSNs) all along. Energy efficient sensor state planning contains in determining an optimal task of states to sensors in order to maximize network lifetime. Clustering with data aggregation is a significant direction to improve energy efficiency through software. Then, the clustering algorithms for WSNs with a static sink frequently suffers from uneven energy consumption problems, where cluster heads (CHs) further away from sink consume more energy in a single hop communication, with the CHs sending its data directly to the sink. In order to solve such problem, we propose a Distributed Energy-efficient Clustering Algorithm for mobile-sink (MS) based WSNs, where the sink moves around the target area with a fixed path and speed. Thus, the controlled movement of the sink around the network helps in balancing the energy consumption of the sensor networks. The selection of cluster head (CH) is the key issue in the clustering algorithm, which is also a multiple criteria decision making procedure. In this work shows that the greatest prominent clustering routing algorithms that have been developed for WSNs

Key Words: Wireless sensor networks (WSNs),Distributed Energy (DE),Cluster Head (CH), Mobile-Sink (MS)and Clustering Algorithm (CA)

I. INTRODUCTION

Due to recent progress in technology, there is a growth in wireless sensor network which comprises of large figure of homogeneous and heterogeneous sensor nodes which communicate in wireless fashion to achieve common objective. Homogeneous nodes are preferred over heterogeneous nodes because of less complexity and better manageability. Each sensor node communicates with other nodes within its radio communication range. The nodes can be simply deployed in random or deterministic fashion and are normally battery operated. In DE Clustering Algorithm, each sensor node selects a CH within its communication range to forward its data to the sink by considering a cost factor[1].

1.1 WIRELESS SENSOR NETWORKS

The WSNs consists of a large number of tiny sensor nodes distributed over a large area with one or more powerful sinks or base stations (BSs) collecting information from these sensor nodes. All sensor nodes have limited power supply and have the capabilities of information sensing, data processing and wireless communication.

1.2 APPLICATIONS OF WSNs

- Military surveillance
- Environmental
- Traffic
- Temperature
- Pressure
- Vibration monitoring
- Agriculture monitoring
- Disaster areas.

II. ROUTING IN WSNs

Routing in sensor networks is a new area of research, with a limited, but rapidly growing set of research. Routing is one of the critical technologies in WSNs. Opposed to old-fashioned ad hoc networks, routing in WSNs is more challenging as a result of their inherent characteristics[2].

- Firstly, resources are greatly constrained in terms of power supply, processing capability and transmission bandwidth.
- Secondly, it is difficult to design a global addressing scheme as Internet Protocol. Internet Protocol can't be applied to WSNs, since address updating in a large-scale or dynamic WSN can result in heavy overhead.
- Thirdly, due to the limited resources, it is hard for routing to cope with unpredictable and frequent topology changes, especially in a mobile environment [8].
- Fourthly, the data collection by numerous sensor nodes generally results in a high probability of data redundancy, which must be considered by routing protocols.
- Fifthly, most applications of WSNs require the only communication scheme of many-to-one, i.e., from multiple sources to one particular sink, rather than multicast or peer to peer.
- Finally, in time-constrained uses of WSNs, data transmissions should be accomplished within a certain period of time. Thus, bounded latency for data transmissions must be taken into consideration in this kind of applications. Nevertheless, energy conservation is more important than quality of service (QoS) in most applications in that all sensor nodes are constrained with energy which is directly related to network lifetime.

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- Overall, the routing techniques are classified based on the network structure into three categories: flat, hierarchical, and location based routing protocols.

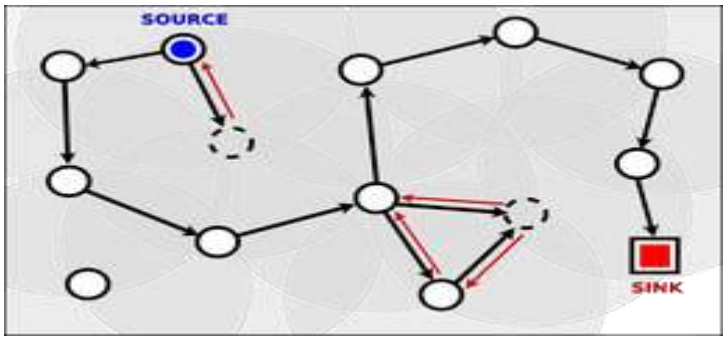

Fig.1. Network in which a node fails and a different path is chosen with a Single-path algorithm

III. CRITERIA FOR CLUSTERING IN WSNs

The criteria can be well understood using the topology of clustering approaches in WSNs illustrated in Fig.2. Clustering attributes in WSNs, generally, can be roughly classified into cluster characteristics, cluster-head characteristics, clustering process and entire proceeding of the algorithm [3].

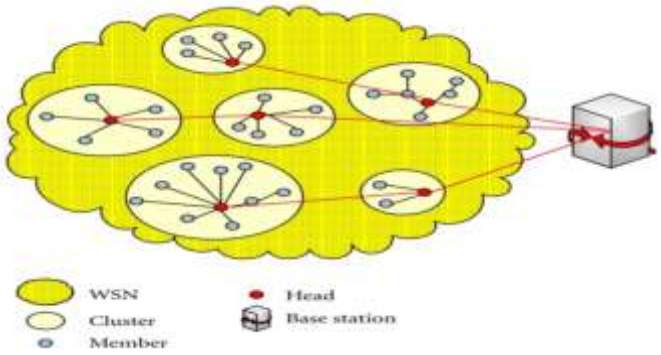

Fig.2. Topology of Cluster Based WSNs

3.1.1 CLUSTER CHARACTERISTICS

- Changeability of Cluster Count: Based on changeability of cluster count, clustering schemes can be categorized into two types: fixed and variable ones. In the former scheme, the set of cluster-head are predetermined and the number of clusters is fixed. Though, the number of clusters is variable in the latter scheme, in which CHs are selected, randomly or based on some rules, from the deployed sensor nodes [4].
- Uniformity of Cluster Sizes: In the light of uniformity of cluster sizes, clustering routing protocols in WSNs can be classified into two classes: even and uneven ones, respectively with the same size clusters and different size clusters in the network. In general, clustering with different sizes clusters is used to achieve more uniform energy consumption and avoid energy hole.
- Intra-Cluster Routing: In the methods of inter-cluster routing, clustering routing manners in WSNs also include two classes: single-hop intra-cluster routing methods and multiple-hop ones. In the method of

intra-cluster single-hop, all MNs in the cluster transmit data to the corresponding CH directly. Instead, data relaying is used when MNs communicate with the corresponding CH in the cluster.

- Inter-Cluster Routing: Based on the manners of inter-cluster routing, clustering routing protocols in WSNs include two classes: single-hop inter-cluster routing manners and multiple-hop ones. In the method of inter-cluster single-hop, all CHs communicate with the BS directly. The data relaying is used by CHs in the routing scheme of inter-cluster multiple-hop.

3.1.2 CLUSTER HEAD CHARACTERISTICS

- Mobility: According to the mobility attributes of CHs, clustering approaches in WSNs also can be grouped into mobile and stationary manners. In the former ways, CHs are mobile and membership dynamically change, thus a cluster would need to be continuously maintained. Contrary to it, CHs are stationary and can keep a stable cluster, which is easier to be managed. Sometimes, a CH can travel for limited distances to reposition itself for better network performance [7].
- Existence: Based on whether there exist cluster heads within a cluster, clustering schemes can be grouped into cluster-head based and non-cluster-head based clustering. In the former schemes, there exist at least one CH within a cluster, but there aren't any CHs within a cluster in the latter schemes, such as some chain based clustering algorithms.
- Difference of Capabilities: Based on uniformity of energy assignment for sensor nodes, clustering schemes can be grouped into homogeneous or heterogeneous ones. All the sensor nodes are assigned with equal energy, computation and communication resources and CHs are designated in homogeneous schemes, according to a random way or other criteria. However, sensor nodes are assigned with unequal capabilities in heterogeneous environment, in which the roles of CHs are pre-assigned to sensor nodes with more capabilities.
- Role: A CH can simply act as a relay for the traffic generated by the sensor nodes in its cluster or perform aggregation/fusion of collected information from sensor nodes in its cluster. Sometime, a cluster head acts as a sink/BS that takes actions based on the detected phenomena or targets. It is worth mentioning, sometimes a CH acts in more than one role.

3.1.3 CLUSTERING PROCESS

- Control Manners: Based on control manners of clustering, clustering routing methods in WSNs can be grouped into centralized, distributed and hybrid ones. In centralized methods, a sink or CH requires global information of the network or the cluster to control the network or the cluster. In distributed approaches, a sensor node is able to become a CH or to join a formed cluster on its own initiative without global information of the network or the cluster. Hybrid schemes are composed of centralized and distributed approaches. In this environment, distributed approaches are used for coordination between CHs, and centralized manners are performed for CHs to build individual clusters [6].
- Implementation Nature: Considering the implementation nature of cluster creation, clustering modes in WSNs can be classified into two classes: probabilistic or iterative ones. In probabilistic clustering, a probability assigned to all sensor nodes is used to determine the roles of the sensor nodes. Or each

sensor node can self-sufficiently decide on its own roles. Nevertheless, every node must wait until a certain number of iterations is achieved or for certain nodes to decide their roles before making a decision in iterative clustering manner.

- Convergence Time: Considering the convergence time, clustering methods in WSNs can be grouped into variable and constant convergence time ones. Convergence time depends on the number of nodes in the network in variable convergence algorithms, which accommodate well to small-scale networks. After a fixed number of iterations, constant convergence time algorithms certainly converge regardless of the scale of the networks [10].
- Parameters for CH Election: Based on the parameters used for CH election, clustering approaches can be categorized as deterministic, adaptive, and random ones. Special inherent attributes of the sensor nodes are considered, such as the identifier (ID), number of neighbors in the first deterministic schemes. The Second adaptive manners, CHs are elected from the deployed sensor nodes with higher weights, which includes such as residual energy, communication cost, and etc. The third random modes, mostly used in secure clustering algorithms, CHs are elected randomly without regard to any other metrics like residual energy, communication cost, etc.
- Proactivity: According to the proactivity of clustering routing, clustering routing methods can be grouped into proactive, reactive, and hybrid ones. In this network, all the routes between source and the BS are computed and maintained before they are really needed regardless of the data traffic. Once a message arrives, it travels through a predetermined route to the BS. The dissimilarity, no predetermined routes exist in reactive networks, in which the routing is chosen when a message needs to be delivered from source to the BS. Hybrid methodologies use a combination of the above two ideas. For this kind of clustering routing, sometimes proactive clustering mode is adopted, but at other times reactive mode is used. For instance, APTEEN is a classical hybrid approach. According to the needs of consumers, this protocol adjusts some parameters and switches between proactive and reactive modes to transmit data.
- Purposes: As described previously, a few purposes have been pursued for cluster construction, such as data aggregation/fusion, load balancing, fault-tolerance, guarantee of connectivity, lifetime extension, quality of service, etc. It is worth mentioning that a clustering algorithm, generally, has more than one objective.

3.2 PROPOSED CLUSTERING ALGORITHM

- Suppose an unclassified WSNs area of (X*Y) meter having N number of routers and M number of agents [5].
- The Sink node dispatch mobile agents with requirement of specific task to WSNs. Mobile agent migrate from first to last sensor node to perform specified task.
- Route table of agents is created corresponding to their routers.

- The matrix $\{A_{ij}\}$ called router-agent incidence matrix is made which has i rows of routers and j columns of agents. An element aij of matrix $\{A_{ij}\}$ is 1 if agent j requires operation to be performing on router i, otherwise a_{ij} is 0.
- On route table and incidence matrix of router-agent family, agents are divided into clusters. Agents perform operations on some specific routers are put into clusters.
- The little entries outside the diagonal blocks represent operations to be performed out-side the assigned group router cells. These elements are called exceptional elements.

3.3 ADVANTAGES OF CLUSTERING

- It reduces the energy consumption as only CHs participate in long range transmission to sink.
- It conserves bandwidth by eliminating the redundant information's at each cluster level.
- More scalability
- Less Load
- More Robustness

IV. DISTRIBUTED ENERGY EFFICIENT CLUSTERING

It is designed to deal with nodes of heterogeneous WSNs. For Cluster heads selection, distributed energy efficient clustering uses initial and residual energy level of nodes. In DE efficient Clustering, the procedure of cluster head election is divided into two phases [9].

- In first phase shows the, tentative cluster heads are elected with the probabilities which are decided by the relative levels of initial and residual energy.
- In second phase, the tentative cluster heads are substituted by their cluster members to form the final set of cluster heads if any member in their cluster has more residual energy.
- Employing two phases for cluster-head election ensures that the nodes with more energy have a higher chance to be cluster heads. Energy consumption is well-distributed in the proposed protocol; show that DE efficient Clustering achieves longer stability periods than other typical clustering protocols in heterogeneous scenarios.

V. CONCLUSIONS

In this paper, shows that the clustering algorithm called Distributed Energy-efficient clustering routing algorithms for the MS based WSNs have been proposed. The proposed algorithm is completely distributed in nature, where each node makes its decisions based on local information only. Moreover, we have formulated an effective method, where each CH can track the position of the MS independently.

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