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Enhancing energy of nodes in Wireless Sensor Network- A Review

Er. Kanwardeep Singh
Student, M-Tech (CSE) 4th Semester
CSE Department
Global Institute of Management & Emerging Technologies, Amritsar (PUNJAB)

Ms. Jasjit Kaur
Assistant Professor
CSE Department
Global Institute of Management & Emerging Technologies, Amritsar (PUNJAB)

***Abstract- I*n wireless sensor networks (WSNs) improving the lifetime of sensor nodes is directly related to the energy efficiency of computation and communication operations in the sensor nodes. Compressive sensing (CS) theory suggests a new way of sensing the signal with a much lower number of linear measurements as compared to the conventional case provided that the underlying signal is sparse. This result has implications on WSN energy efficiency and prolonging network lifetime. This paper is basically designed to suggest how WSN network can be improved in terms of efficiency. As clustering also plays an important role in energy consumption in WSN. If proper clustering is not done then the energy consumption of all nodes will increased due to improper clustering and overload. So in this paper first part covers the clustering in terms of its advantages, its parameters and various algorithms of clustering. The second part is about enhancing energy of WSN.**

I. Introduction

A wireless sensor network (WSN) is a wireless network consisting of distributed autonomous devices using sensors to handle physical conditions. A wireless sensor network is a collection of various number of sensor nodes that are connected to each other. To ensure increase the efficiency of the network operation, sensor nodes are often combined into clusters. As each node depends upon the energy for its activities, this has become a big issue in wireless sensor networks.

The failure of any one node can change the entire system. In idle mode, the nodes consume almost the same amount of energy as in active mode. While in sleep mode, the nodes shutdown the radio to save the energy. Energy constraints end up creating computational and storage limitations that lead to a new set of architectural issues. In many cases (e.g. surveillance applications), it is undesirable to change the batteries that are depleted or of energy. [1]

A typical sensor node consists of 4 main parts.

- The Sensing unit.
- The Processing unit.
- The Power unit
- The Transceiver unit

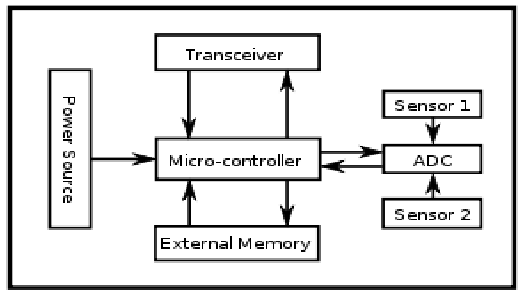

Fig. 1- Architecture of Sensor Node

Sensing unit
This unit explains the collects the data and convert analog to digital.

Processing unit
This unit manages the list and procedures to collected with other sensor nodes

Power unit
The power unit manages generates the power using solar cells. The sensor circuitry can transform physical quantities into an electric signal.

Transceiver
The transceiver unit sends and receives the data sensors.

The important components of wireless sensor network are discussed below:

Sensor Node
A sensor node is a component of a WSN. Sensor nodes contain multiple roles.

Clusters
Clusters are the unit for WSNs. The networks need to be divided into clusters to simplify tasks such a communication.

Cluster heads
Cluster heads are the organization leader of a cluster. These tasks are not use limited data-aggregation the communication schedule of a cluster.

End User
The sensor network can be used for a large-range of applications.

II. Wireless Sensor Network Model

The Wireless Sensor Network model is as follows:

The wireless sensor network is considered that contains sensor nodes in scattered manner in a sensor field. The operation situation is illustrated in fig. 2, here the sensor field is a square area of side **L** at a distance $\mathbf{d_{BS}}$ from a lone fixed base-station.

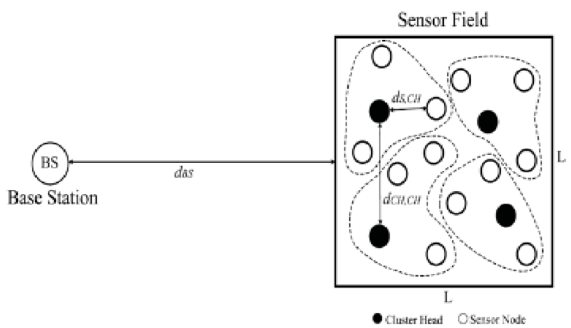

Fig. 2- Wireless Sensor Network model [2]

The sensor nodes consume energy for sensing, computations and communications purposes. The routing protocols for WSNs are designed to minimize the energy consumption of nodes in perform of communication. In WSN, energy efficiency and lifetime of sensors have a significant impact on applicability and network performance. One of the key characteristics of sensor nodes is that they are energy constrained. If the diameter of the network is large, the power of sensor nodes will be drained very quickly. [3]

III. Clusters in WSN

Grouping sensor nodes into clusters has been widely adopted by the research community to satisfy the above scalability objective and generally achieve high energy efficiency and prolong network lifetime in large-scale WSN environments. The corresponding hierarchical routing and data gathering protocols imply cluster-based organization of the sensor nodes in order that data fusion and aggregation are possible, thus leading to significant energy savings. In the hierarchical network structure each cluster has a leader, which is also called the cluster head (CH) and usually performs the special tasks referred above (fusion and aggregation), and several common sensor nodes (SN) as members.

The cluster formation process eventually leads to a two-level hierarchy where the CH nodes form the higher level and the cluster-member nodes form the lower level. The sensor nodes periodically transmit their data to the corresponding CH nodes. The H nodes aggregate the data (thus decreasing the total number of relayed packets) and transmit them to the base station (BS) either directly or through the intermediate communication with other CH nodes. However, because the CH nodes send all the time data to higher distances than the common (member) nodes, they naturally spend energy at higher rates. A common solution in order balance the energy consumption among all the network nodes, is to periodically re-elect new CHs (thus rotating the CH role among all the nodes over time) in each cluster. A typical example of the implied hierarchical data communication within a clustered network.

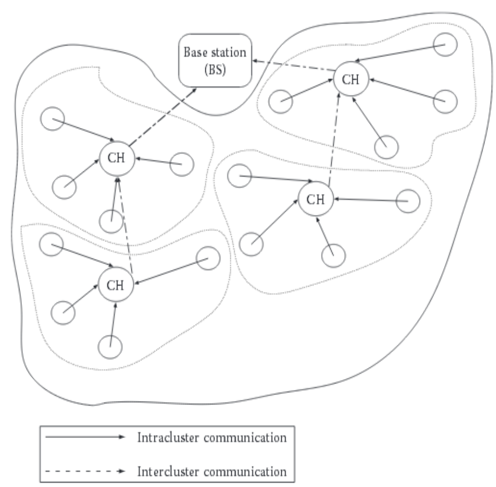

Fig. 3- Data communication in clustered network

The BS is the data processing point for the data received from the sensor nodes, and where the data is accessed by the end user. It is generally considered fixed and at a far distance from the sensor nodes. The CH nodes actually act as gateways between the sensor nodes and the BS. The function of each CH, as already mentioned, is to perform common functions for all the nodes in the cluster, like aggregating the data before sending it to the BS. In some way, the CH is the sink for the cluster nodes,
and the BS is the sink for the CHs. Moreover, this structure formed between the sensor nodes, the sink (CH), and the BS can be replicated as many times as it is needed, creating (if desired) multiple layers of the hierarchical WSN (multi-level cluster hierarchy).

IV. Advantages & Objectives of Clustering

I. More Scalability
In clustering routing scheme, sensor nodes are divided into a variety of clusters with different assignment levels. The CHs are responsible for data aggregation, information dissemination and network management, and the MNs for events sensing and information collecting in their surroundings. Clustering topology can localize the route set up within the cluster and thus reduce the size of the

routing table stored at the individual sensor nodes. Compared with a flat topology, this kind of network topology is easier to manage, and more scalable to respond to events in the environment

II. Data Aggregation/Fusion

Data aggregation/fusion, which is the process of aggregating the data from multiple nodes to eliminate redundant transmission and provide fused data to the BS, is an effectual technique for WSNs to save energy. The most popular data aggregation/fusion method is clustering data aggregation, in which each CH aggregates the collected data and transmits the fused data to the BS. Usually CHs are formed a tree structure to transmit aggregated data by multi-hopping through other CHs which results in significant energy savings.

III. Less Load: Since sensors might generate significant redundant data, data aggregation or fusion has emerged as an important tenet and objective in WSNs. The main idea of data aggregation or fusion is to combine data from different sources to eliminate redundant data transmissions, and provide a rich and multi-dimensional view of the targets being monitored. Many clustering routing schemes with data aggregation capabilities require careful selection for clustering approach. For clustering topology, all cluster members only send data to CHs, and data aggregation is performed at the CHs, which help to dramatically reduce transmission data and save energy. In addition, the routes are set up within the clusters which thus reduce the size of the routing table stored at the individual sensor nodes.

IV. Less Energy Consumption

In clustering routing scheme, data aggregation helps to dramatically reduce transmission data and save energy. Moreover, clustering with intra-cluster and inter-cluster communications can reduce the number of sensor nodes performing the task of long distance communications, thus allowing less energy consumption for the entire network. In addition, only CHs perform the task of data transmission in clustering routing scheme, which can save a great deal of energy consumption.

V. More Robustness

Clustering routing scheme makes it more convenient for network topology control and responding to network changes comprising node increasing, node mobility and unpredicted failures, etc. A clustering routing scheme only needs to cope with these changes within individual clusters, thus the entire network is more robust and more convenient for management. In order to share the CH responsibility, CHs are generally rotated among all the sensor nodes to avoid the single point of failure in clustering routing algorithms.

VI. Collision Avoidance

In the multi-hop flat model, the wireless medium is shared and managed by individual nodes, thus this model can result in low efficiency in the resource usage. On the other hand, in the multi-hop clustering model, a WSN is divided into clusters and data communications between sensor nodes comprise two modes, i.e., intra-cluster and inter-cluster, respectively for data collection and for data transmissions. Accordingly, resources can be allocated orthogonally to each cluster to reduce collisions between clusters and be reused cluster by cluster. As a result, the multi-hop clustering model is appropriate for large-scale WSNs.

VII. Latency Reduction

When a WSN is divided into clusters, only CHs perform the task of data transmissions out of the cluster. The mode of data transmissions only out of the cluster helps avoiding collisions between the nodes. Accordingly latency is reduced. Furthermore, data transmission is performed hop by hop usually using the form of flooding in flat routing scheme, but only CHs perform the task of data transmission in clustering routing scheme, which can decrease hops from data source to the BS, accordingly decrease latency.

VIII.Load Balancing

Load balancing is an essential consideration aiming at prolonging the network lifetime in WSNs. Even distribution of sensor nodes among the clusters is usually considered for cluster construction where CHs perform the task of data processing and intra-cluster management. In general, constructing equal-sized clusters is adopted for prolonging the network lifetime since it prevents the premature energy exhaustion of CHs. Besides, multi-path routing is a method to achieve load balancing.

IX. Fault-Tolerance

Due to the applicability of WSNs in a good many dynamic scenarios, sensor nodes may suffer from energy depletion, transmission errors, hardware malfunction, and malicious attacks and so on. With applications such as hurricane modeling and tracking envisioned to utilize a large number of small sensor nodes, the cost of each sensor node is constrained. Owing to significant constraints on the cost, and therefore on the quality of sensor motes, and the often hostile environments in which they are deployed, sensor networks are prone to failure. Thus, fault-tolerance is an important challenge in WSNs. In order to avoid the loss of significant data from key sensor nodes, fault-tolerance of CHs is usually required in this kind of applications, thus effective fault-tolerant approaches must be designed in WSNs. Re-clustering is the most intuitive method to recover from a cluster failure, though it usually disarranges the on-going operation. Assignment of CH backup is a viable scheme for recovery from a CH failure.

X. Guarantee of Connectivity

Sensor nodes usually transmit data to one or more BSs via a single-hop or multi-hop routing in WSNs, thus whether or not the data is successfully delivered to the BS is mainly determined by the connectivity of each node to its next hop node along the path. Furthermore, sensor nodes that cannot communicate with any other sensor node will get isolated and their data can never be transmitted to the BS. Therefore, guarantee of connectivity is an essential goal of clustering routing protocols in WSNs. An important example is when some information concerning all the sensor nodes needs to be collected by a designated fusion node in clustering routing protocols.

XI. Energy Hole Avoidance

Generally, multi-hop routing is used to deliver the collected data to a sink or a BS. In those networks, the traffic transmitted by each node includes both self-generated and relayed traffic. Regardless of MAC protocols, the sensor nodes closer to the BS have to transmit more packets than those far away from the BS. As a result, the nodes closer to the BS to deplete their energy first, leaving a hole near the BS, partitioning the whole network, and preventing the outside nodes from sending information to the BS, while many remaining nodes still have a plenty of energy. This phenomenon is called energy hole. Mechanisms of energy hole avoidance, i.e., energy consumption balancing, can be classified into three groups: node deployment, load balancing, as well as energy mapping and assigning. Especially, uneven clustering is one of the methods of load balancing. In this method, a smaller cluster radius near the sink and a larger cluster radius away from the sink are defined respectively, so the energy consumption of processing data in inter-cluster is less for cluster with smaller radius, and thus more energy can be used to relay data from remote nodes [54]. On the other hand, it is not easy to analyze the optimization of cluster radius theoretically.

XII. Maximizing of the Network Lifetime

Network lifetime is an inevitable consideration in WSNs, because sensor nodes are constrained in power supply, processing capability and transmission bandwidth, especially for applications of harsh environments. Usually it is indispensable to minimize the energy consumption for intra-cluster communication by CHs which are richer in resources than ONs. Besides, sensor nodes that are close to most of the sensor nodes in the clusters should be prone to be CHs. Additionally, the aim of energy-aware idea is to select those routes that are expected to prolong the network lifetime in inter-cluster communications, and the routes composed of nodes with higher energy resources should be preferred.

XIII. Quality of Service

The network applications and the functionalities of WSNs prompt the requirement of quality of service (QoS). Usually, effective sample, less delay and temporary precision are required. It is difficult for all the routing protocols to satisfy all the requirements of QoS, because some demands may breach one or more protocol principles. Existing clustering routing approaches in WSNs mainly focus on increasing energy efficient rather than QoS support. QoS metrics must be taken into account in many real-time applications, such as battle-target tracking, emergent-event monitoring, and etc.

V. Clustering Parameters

A. Number of clusters (cluster count)

In most recent probabilistic and randomized clustering algorithms the CH election and formation process lead naturally to variable number of clusters. In some published approaches, however, the set of CHs are predetermined and thus the number of clusters is preset. The number of clusters is usually a critical parameter with regard to the efficiency of the total routing protocol.

B. Intra-cluster communication

In some initial clustering approaches the communication between a sensor and its designated CH is assumed to be direct (one-hop communication). However, multi-hop intra cluster communication is often (now a days) required, i.e., when the communication range of the sensor nodes is limited or the number of sensor nodes is very large and the number of CHs is bounded.

C. Nodes and CH mobility

If we assume stationary sensor nodes and stationary CHs we are normally led to stable clusters with facilitated intra-cluster and inter-cluster network management. On the contrary, if the CHs or the nodes themselves are assumed to be mobile, the cluster membership for each node should dynamically change, forcing clusters to evolve over time and probably need to be continuously maintained.

D. Nodes types and roles

In some proposed network models (i.e., heterogeneous environments) the CHs are assumed to be equipped with significantly more computation and communication resources than others. In most usual network models (i.e., homogeneous environments) all nodes have the same capabilities and just a subset of the deployed sensors is designated as CHs.

E. Cluster formation methodology

In most recent approaches, when CHs are just regular sensors nodes and time efficiency is a primary design criterion, clustering is being performed in a distributed manner without coordination. In few earlier approaches a centralized (or hybrid) approach is followed; one or more coordinator nodes are used to partition the whole network off-line and control the cluster membership.

F. **Cluster-head selection**

The leader nodes of the clusters (CHs) in some proposed algorithms (mainly for heterogeneous environments) can be pre-assigned. In most cases however (i.e., in homogeneous environments), the CHs are picked from the deployed set of nodes either in a probabilistic or completely random way or based on other more specific criteria (residual energy, connectivity etc.).

G. **Algorithm complexity**

In most recent algorithms the fast termination of the executed protocol is one of the primary design goals. Thus, the time complexity or convergence rate of most cluster formation procedures proposed nowadays is constant (or just dependent on the number of CHs or the number of hops). In some earlier protocols, however, the complexity time has been allowed to depend on the total number of sensors in the network, focusing in other criteria first.

H. **Multiple levels**

In several published approaches the concept of a multi-level cluster hierarchy is introduced to achieve even better energy distribution and total energy consumption (instead of using only one cluster level). The improvements offered by multi-level clustering are to be further studied, especially when we have very large networks and inter-CH communication efficiency is of high importance.

I. **Overlapping**

Several protocols give also high importance on the concept of node overlapping within different clusters (either for better routing efficiency or for faster cluster formation protocol execution or for other reasons). Most of the known protocols, however, still try to have minimum overlap only or do not support overlapping at all.

VI. Classification of Clustering Algorithms

There have been substantial amount of research on clustering protocols for WSNs. These clustering protocols are classified according to different criteria.

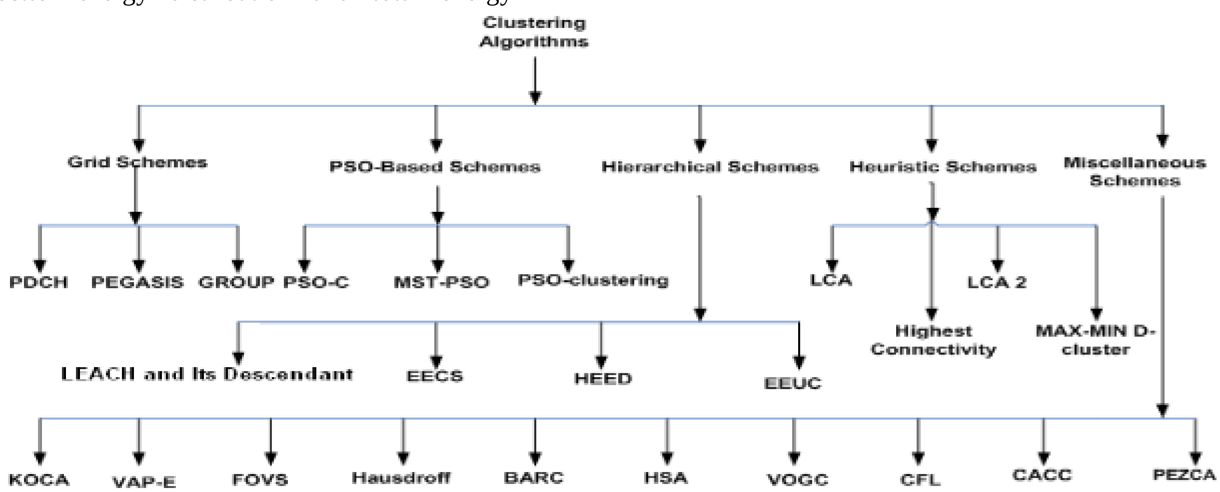

Fig.4- Clustering Algorithms

VII. Enhancing Energy in WSN

As each node depends on energy for its activities, this has become a major issue in wireless sensor networks. Failure of one node can interrupt the entire system or application. Every sensing node can be in active, idle and sleep modes. In active mode, nodes consume energy when receiving or transmitting data. In idle mode, the nodes consume almost the same amount of energy as in active mode. While in sleep mode, the nodes shutdown the radio to save the energy. Energy constraints end up creating computational and storage limitations that lead to a new set of architectural issues. A wireless sensor network platform must provide application. Support for a suite of application-specific protocols that drastically reduce node size, cost, and power consumption for their target applications.

Following steps can be taken to save energy which is caused by communication in wireless sensor networks.

- To schedule the state of the nodes (i.e. transmitting, receiving, idle or sleep).
- By changing the transmission range between the sensing nodes.

- Using efficient routing and data collecting methods.
- Avoiding the handling of unwanted data in the case of overhearing.[6]

In WSNs, the only source of life for the nodes is the battery. Communicating with other nodes or sensing activities consumes a lot of energy in processing the data and transmitting the collected data to the sink. In many cases (e.g surveillance applications), it is undesirable to replace the batteries that are depleted or drained of energy. Many researchers are therefore trying to find energy-aware protocols for wireless sensor networks in order to overcome such energy efficiency problems as those stated above. All the protocols that are designed and implemented in WSNs should provide some real-time support as they are applied in areas where data is sensed, processed and transmitted based on an event that leads to an immediate action. A protocol is said to have real-time support if and only if, it is fast and reliable in its reactions to the changes prevailing in the network. It should provide redundant data to the base station. The base station or sink using the data that is collected among all the sensing nodes in the network. The delay in transmission of data to the sink from the sensing nodes should be small, which leads to a fast response.

Basic model to improve WSN lifetime includes:

- Study of Wireless Sensor Network.
- Study of different energy efficient protocols in WSN.
- To minimize the energy consumption of sensors.
- To improve network lifetime and network throughput

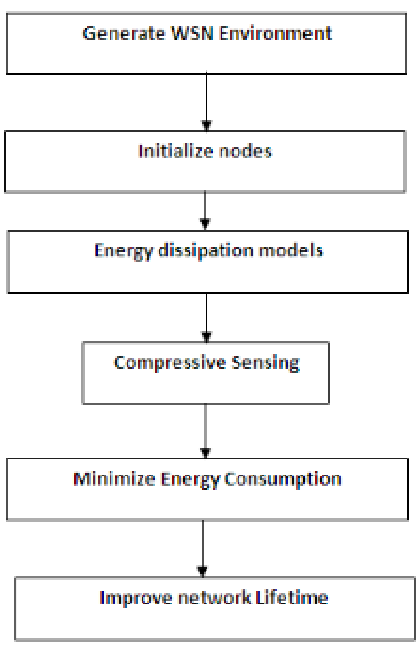

Fig. 5- Model to enhance WSN lifetime

VIII. Conclusion

Improving network efficiency and life of nodes is an endless process. Many approaches have been designed and many are under development. All the approaches are useless until proper region are not mentioned in WSN. Clustering is all about dividing the regions in the network by mentioning its range. This review paper reflects various parameters of clustering and its advantages as well. So by performing proper clusters and by implementing a proper method, energy of WSN can be increased. Proper clustering will reduce the unnecessary load on the node and methods such as real time support, compressive sensing will further enhance energy.

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