CHAPTER 2

LITRITURE REVIEW

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Literature Review

2.1 Background

Wireless sensor network is a kind of ad-hoc network that has become an interesting area for researchers and attracted more attention than ever before. Routing is an issue for these sensor nodes due to the limited availability of resources. The literature survey presented in this chapter is divided into five major sections; those are wireless sensor network, clustering, routing protocols, leach and its improvement.

2.2 Wireless sensor networks

Wireless sensor networks consist of a large number of low-power multifunctional sensor nodes with sensing limited computation and wireless communications capabilities. Recent advances in sensor technology have enabled the development of small, low-cost and low-power sensors, that can be connected via a wireless networks. Wireless sensor networks densely deployed so that it can be applicable to a variety of fields that include surveillance, military, national security, and chemical or biological detection. Each node typically consists of the four components: sensor unit, central processing unit (CPU), power unit, and communication unit. The primary component of the network is the sensor [1, 18].

❖ **Wireless Sensor network application classes**

The three application classes are have been selected: environmental data collection, security monitoring, and sensor node tracking [6].

- Environmental Data Collection:

    Research scientist wants to collect several sensor readings from a set of points in an environment over a period of time in order to detect trends and interdependencies [6].

- Security Monitoring

    Security monitoring networks are composed of nodes that are placed at fixed locations throughout an environment that continually monitor one or more sensors to detect like fire security system alarms.

    The Key difference between security monitoring and environmental monitoring is that security networks are not actually collecting any data [6].

- Node tracking scenarios

    A third usage scenario commonly discussed for sensor networks is the tracking of a tagged object through a region of space monitored by a sensor network [6].

❖ **Resources of WSN**

    In the fact that most of the sensor nodes are powered by non-replaceable batteries, the residual energy level, usually determines the lifetime of the network. Other resources can be used by sensor nodes are also very limited, including the bandwidth, memory, these constrains also limits the performance and the design of the network [1].

    Routing is main challenge faced by wireless sensor network; it is more complex in WSN due to dynamic nature of WSN, limited battery life, computational overhead, self-organization and limited transmission range of sensor nodes.

2.3 Clustering

Grouping sensor nodes into clusters to better scalability and to achieve high energy efficiency and prolong network lifetime in large-scale WSN environments.

Some of classification of the clustering process:

• Centralized Vs distributed: Sensor networks with central base station controlling the entire clustering process are centralized in nature the centralized version of LEACH is a very good example.

Distributed version is the more common example of clustering protocols At the beginning of the cluster formation phase the sensor nodes exchange some information such as the residual energy in elect themselves a cluster and announce it to their neighbors and The neighbor joins this node's cluster .

• Heterogeneous Vs Homogenous: Sensor networks can be classified into two different groups based on the homogeneity of the sensor nodes. Homogenous networks have nodes with similar initial energies. Since Cluster heads consume the maximum energy in the steady state phase, homogenous clustering protocols make use of techniques such as randomized rotation in the cluster head selection in order to evenly distribute the energy of the different nodes.

Heterogeneous networks on the other hand have a few selected set of nodes for becoming the cluster heads and therefore the cluster head selection is now based on minimizing the amount of energy required to transfer information from the sensor nodes to the cluster head rather than from the cluster head to the base station.

• Location Aware and Location Unaware Nodes: Sensor nodes that have knowledge of their absolute location as well of the other nodes in the network. Such kind of information is readily made available through the use of GPS locators. Such sensor network protocols generally make use

of the location specific knowledge of the sensor nodes to route and send their data to the Base Station. On the other hand in the location-unaware systems the sensor nodes do not have information about the absolute location of the other sensors or even of themselves, they basically rely on the information they receive from the other nodes and perform routing, clustering based on these relative distance information only [7].

❖ **Pros and Cons of clustering in WSNs**

- Pros of Clustering

1. Improve the system capacity Due to the fact that within a cluster, all the normal nodes send their data to the CHs so energy saving by routing.
2. Clustering enables efficient resource allocation.
3. Help in better designing of power control any changes of nodes behavior within a cluster affect only that clusters but not the entire network, which will therefore be robust to these changes [8].

- Cons of clustering

1. Some algorithm selects cluster heads only according to the ID number or residual energy of the sensor nodes.
2. Traffic near the base station is higher.
3. Energy is wasted by flooding in route discovery and duplicated transmission of data by multiple routes from the source to the destination [8].

2.4 Routing protocols

- Routing is main challenge faced by wireless sensor network; it is more complex in WSN due to dynamic nature of WSN, limited battery life, computational overhead, self-organization and limited transmission range of sensor nodes.

- **Direct Transmission Protocols**

  The direct transmission protocols consists of only base station and normal sensor nodes. The sensor nodes work as senders and base station serves as the destination node to all the other sensor nodes in the network.

  The sensor nodes transmit their data to the base station and the base station received all data. The sensor nodes and base station is directly communicated without any intermediate communicator. The nodes only remain active during the data transmission to the base station.

  Since the nodes do not spend energy when receiving the messages from the other nodes, they will spend the minimum data on listening the channel and, then, they will spend their battery capacity on sending messages to the base station If a sensor node transmits data directly to the base station, the energy loss incurred depends on the location of the sensor nodes relative to the base station. As a result, the direct transmission protocol's complexity can be ignored, but it is the least energy efficient protocol in most cases [9].

- **Type of Routing protocols**

  According to network structure routing protocols classified into:-

1- Location based routing.

2- Data-centric.

3- Hierarchical [3].

  Some real time application needs to know about location of node before communication. Routing also called directional, geometric, position-based or Location based routing protocol find the geographical position of node and then transmit the packet [4].

  In data-centric routing, the sink sends queries to certain regions and waits for data from the sensors located in the selected regions. Since

data is being requested through queries, attribute-based naming is necessary to specify the properties of data [5].

Transmitting data from every sensor node within the deployment region might result in significant unnecessary redundancy in data and incur in unnecessary energy and traffic expenditure.

Hierarchical-Based Routing When network scalability and efficient communication is needed, hierarchical-based routing is the best match. It is also called cluster based routing ,very efficient method in which high energy nodes are randomly selected for processing and sending data while low energy nodes are used for sensing and send information to the cluster heads. This property of hierarchical-based routing contributes greatly to the network scalability, lifetime and minimum energy [4].

- **Hierarchical Routing Techniques**

Hierarchical routing is the procedure of arranging routers in a hierarchical manner.

Whole network is divided into multiple clusters; one node in each cluster play leading rule, Cluster head is the only node that can communicate to Base station.

This significantly reduces the routing overhead of normal nodes because normal nodes have to transmit to cluster-head only [3].

2.5 LEACH

Low-Energy adaptive clustering hierarchy (LEACH) by Heinezman et al. is application-specific protocol architecture; it is one of the most popular routing protocols in WSNs. LEACH associate the concept of Clustering and Hierarchy to achieve energy-efficiency.

- **Clustering in LEACH**

    In LEACH, the network is separated into clusters; all member nodes sent their data locally to their cluster heads. After the cluster head receives the data from all the member nodes, it processes the data, and transmits the processed data to the base station. However, a cluster head consumes a lot of energy than the other nodes.

- **LEACH algorithm**

    The operation of LEACH is separated into rounds, and each round is made up of an advertisement phase, a set-up phase and a steady-state phase. In order to be energy efficient, the steady-state phase should be a lot longer than the advertising and the set-up.

- **Advertisement phase**

    Initially, when clusters are being created, each node decides whether or not to become a cluster-head for the present round. This decision is based on the optional percentage of cluster heads (p) for the network (determined a priori) and the number of times the node has been a cluster-head so far. This decision is made by the node n choosing a random number between 0 and 1. If the number is less than a threshold T (n), the node becomes a cluster-head for the current round. The threshold is defined as:

$$
T(n) = \begin{cases} \dfrac{P}{1 - P * \left(r \bmod \frac{1}{p}\right)} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}
$$

    T(n) is the value of theroshold, where the p is the desired percentage of cluster heads, r is the current round; G is the set of the nodes that have not been cluster- heads in the last rounds.

- **Cluster Set-up Phase**

    After selecting cluster head, each node send request to it to be members and cluster head receiver must be on.

- **Schedule Creation**

    The cluster-head receives all the messages as request to be part of that cluster Based on the number of nodes in cluster, it would generate a TDMA schedule to tell nodes when they can send. This schedule is broadcasted to all nodes in that cluster.

- **Data Transmission**

    When TDMA schedule is fixed, data transmission scan start. In the steady state data aggregation occurred before transferring the data to the base station, the compressed data is sent to the base station by the cluster-head. After certain time these four phases would be repeated [1, 3, 10].
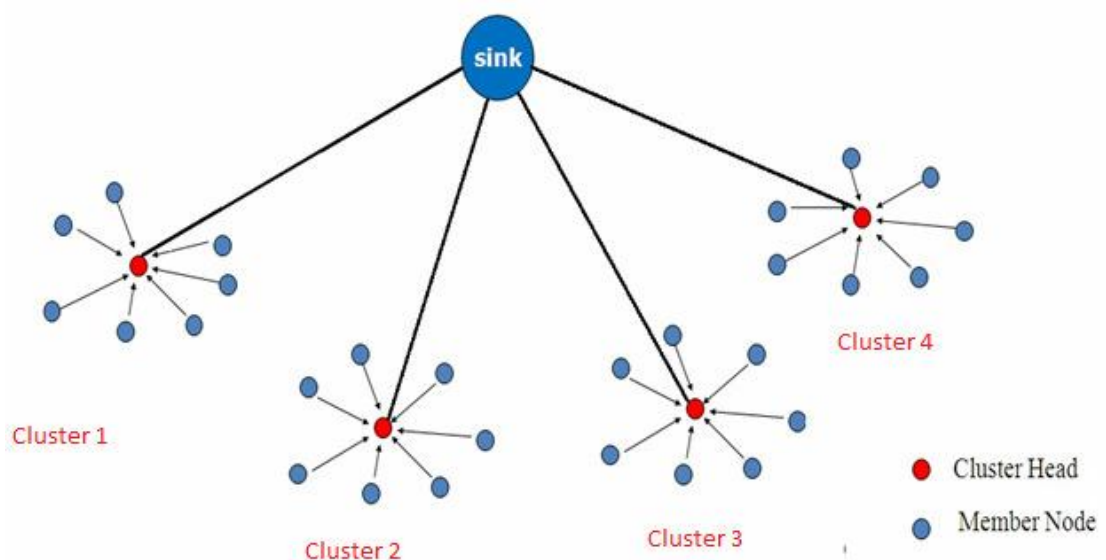

Figure 2.1: Cluster head formation [11].

❖ **Pros and Cons of LEACH**

- Pros of LEACH

1) LEACH is a fully distributed approach and requires no global information of network. So it is Powerful and simple.

2) Network lifetime can be increased by the rotation of cluster-Head, aggregating the data by CHs, TDMA assigned to Cluster members by the CH, so that most of the nodes in sleep mode.

3) Localized co-ordination and control for cluster setup and procedure The CHs aggregates the data collected by the nodes and this leads to a limit on the traffic generated in the network [12].

- Cons of LEACH

1) In LEACH, CH is responsible for transfer data to BS directly. thus Failure of CHs leads to lack of robustness.

2) LEACH support Single Hop Routing, therefore it does not work well in large scale networks which need high energy for transmitting data from CH to BS directly.

3) Selection of CH is random, which does not consider energy Consumption.

4) Leach uses dynamic clustering which results in extra overhead such as the head changes, advertisement that reduces the energy consumption gain.

5) Finally, it is not suited for the applications that cover a large area that funding multi hop routing [12].

2.6 Improvement of LEACH

Many protocols, and much research has been done to make leach perform better Some of these pieces of research are discussed below:-

- **LEACH-C**

    It involves a centralized clustering algorithm. The steady state will remain the same in setup phase of the LEACH-C.

    Nodes send information about the current location and energy level to the base position.

    Base station utilizing the global information of the network produces better clusters that require the less energy for data transmission.

    It needs GPS or the other location tracking method.

    The base station has to make sure that only nodes with enough energy are allowed to participate in the selection of the cluster head. The base station then broadcasts the information to all nodes in the network.

    The central control algorithm can be used to form the clusters which may produce better clusters through the distribution of the cluster head nodes throughout the network [13].

- **V-LEACH**

    In our new version of LEACH protocol, the cluster contains; CH (responsible only for sending data that is received from the cluster members to the BS), vice-CH (the node that will become a CH of the cluster in case of CH dies), cluster nodes (gathering data from environment and send it to the CH).

    In the original LEACH, the CH is receiving data from cluster members, aggregate these data and then send it to the BS that might be located far away from it. The CH will die earlier than the other nodes in the cluster because of its operation of receiving, sending and overhearing. When the CH die, the cluster will become useless because the data gathered by cluster nodes will never reach the base station.

    In our V-LEACH protocol, besides having a CH in the cluster, there is a vice-CH that takes the role of the CH when the CH dies

because the reasons we mentioned above by doing this cluster nodes data will always reach the BS no need to elect a new CH each time till the CH dies. This will extend the overall network life time [14,6].

- **LEACH-F**

    In Leach-F once the clusters are formed they are fixed and there is no setup overhead at the beginning of each round. It uses the same centralized cluster formation algorithm as Leach-C for deciding the clusters. In Leach-F new nodes cannot be added to the system and do not adjust their behavior based on nodes dying. Furthermore, the node mobility cannot be handled by the Leach-F. Only the cluster head position is rotated among the nodes within the cluster. Leach-F may or may not be provided energy saving. A stable cluster and rotating cluster head concept is used by Leach-F in which cluster once formed is maintained stable throughout the network lifetime in order to avoid re-clustering[1].

- **Mobile leach**

    The LEACH-Mobile operation is broken up into rounds. Each round is divided into two phases, namely setup phase and steady state phase. In setup phase clusters are organized and in steady state phase data are transferred to the base station. The vital concept in LEACH-Mobile protocol is to confirm whether a mobile node is capable of communicating with specific cluster head within the time slot allotted in TDMA schedule. In LEACH algorithm, the cluster head waits to gather the sensed data from non cluster head nodes according to TDMA scheduling during the steady state phase. There is a slight modification in steady the state phase of the LEACH protocol to support mobility of nodes. The cluster head in LEACH mobile first sends the req. message for data transmission to non-cluster head node for gathering the sensed

data at each time slot. When the data sensed are sent by non-cluster head nodes, the cluster head will make the time slot list of nodes from which the data is received according to the TDMA time slot at all the time when a frame ends. It also makes note of the nodes from which the data are not received in the time slot at the end of each frame. If the data is not received again from same node when the next frame ends, then it is considered to be removed from the cluster. The time slot of removed node is assigned to a newly arrived node. The sensor node which is removed is considered as node gone out of cluster region due to mobility. Then the TDMA is rescheduled and transmitted to all cluster members by the cluster head. The node which moved away from cluster region or the node which didn't get the req. message for data transmission from the cluster head for two successive frames should join the new cluster head. That node will broadcast cluster joint req. message. The cluster head which receives cluster joint req. message transmits cluster head advertisement message to that node as a reply. Depending on the signal strength of received cluster head advertisement message, the node will decide to join the new cluster. After deciding which cluster to join, the node will inform the corresponding cluster head. The new cluster head will revise the cluster membership list and TDMA schedule, and then broadcast the new TDMA schedule to its cluster members. The newly joined member works according to the new schedule. LEACH Mobile Protocol could be used in mobility centric wireless sensor network as it organizes the hierarchical clustering dynamically without GPS information [15].

▪ **MOD LEACH**

Basically, in MODLEACH, two modifications/ enhancements are made to leach, these enhancements are :

Efficient cluster head replacement technique.

Dual amplification power levels.

For every round, protocol will check if energy of Cluster Head has fallen a defined threshold than it will undertake CH and cluster formation process. Else same CH will continue its operations.

This is how much of energy that goes wasted in cluster head formation process can be saved. Moreover, control overhead is also limited.

In an adaptive clustering hierarchic, there can be three kinds of communications:

❖ Inter cluster communication.

❖ Intra cluster communication.

❖ Cluster head to base station/ sink communication.

Using equal signal amplification energy for all of above communications is not needed. Hence multi power levels are adjusted for all three kinds of communication to preserve energy.

- Implementation of hard and soft threshold in MODLEACH gives much better results Reactive nature of routing protocol not only result in lower routing over head but also better network life time. Applying thresholds in MOD-LEACH make the protocol reactive in nature[16].

Table 2.1: Performance comparison of different LEACH protocol [12,13,14,15,16].

Clustering Routing protocol	Classification	Mobility	Scalability	Self organisation	Randomized RotatioN	Centralized	Energy efficieny	Use of location information	Data aggrgation
Leach	Hierarchical	fixed BS	Limited	Yes	Yes	NO	High	NO	Yes
mode Leach	Hierarchical	fixed BS	Very good	Yes	Yes	Yes	Very High	Yes	Yes
Leach-C	Hierarchical	fixed BS	Good	Yes	Yes	Yes	Very High	Yes	Yes
Leach-F	Hierarchical	fixed BS	Limited	NO	Yes	Yes	Very High	Yes	Yes
Leach-M	Hierarchical	Mobile BS and nodes	Very good	Yes	Yes	NO	Very High	Yes	Yes
Leach-V	Hierarchical	fixed BS	Good	Yes	Yes	NO	Very High	NO	Yes