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Review Paper on Hierarchal Energy- Efficient Protocols in Wireless Sensor Networks

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Abstract: - A WSN is a specialized wireless network made up of large number of sensors and at least one base station. One of the limitations of wireless sensor nodes is their inherent limited energy resource. As well maximizing the lifetime of the sensor node, it is better to allot the energy dissipated throughout the wireless sensor network in order to minimize maintenance and maximize overall system performance. Wireless sensor networks are harshly restricted by storage space, computing power and energy. Therefore it is necessary to design effective and energy aware protocol in order to increase the network life span. In this paper, we present a comparative study of hierarchical based routing protocols and their advantages and disadvantages which is a sub-type of the network structure based routing protocol in WSNs is carried out. Primary issues which are considered in WSNs are Energy consumption and network life time.

Keywords: -Wireless Sensor network, battery, routing protocols, life, energy efficient, Energy consumption, network life time.

1. I. INTRODUCTION

The improvement in sensor technology has made it possible to have highly small, low powered sensing devices assembled with multiple parameter sensing, programmable computing, and wireless communication competence. Also, the small cost makes it feasible to have a network of hundreds or thousands of these sensors, thereby increasing the reliability and correctness of data and the area coverage. Wireless sensor networks provide information about distant structures, widespread environmental changes, etc. in unknown and inhospitable landscape.

The sensor nodes are usually dispersed in a sensor area as shown in Fig. 1.Every of those dispersed sensor nodes has the ability to collect information and route information back to the sink and also to the end users. Information is routed back to the end user by multihop framework design over the sink as given in Fig. 1. The sink could communicate with the task manager node via web/internet or Satellite [3].

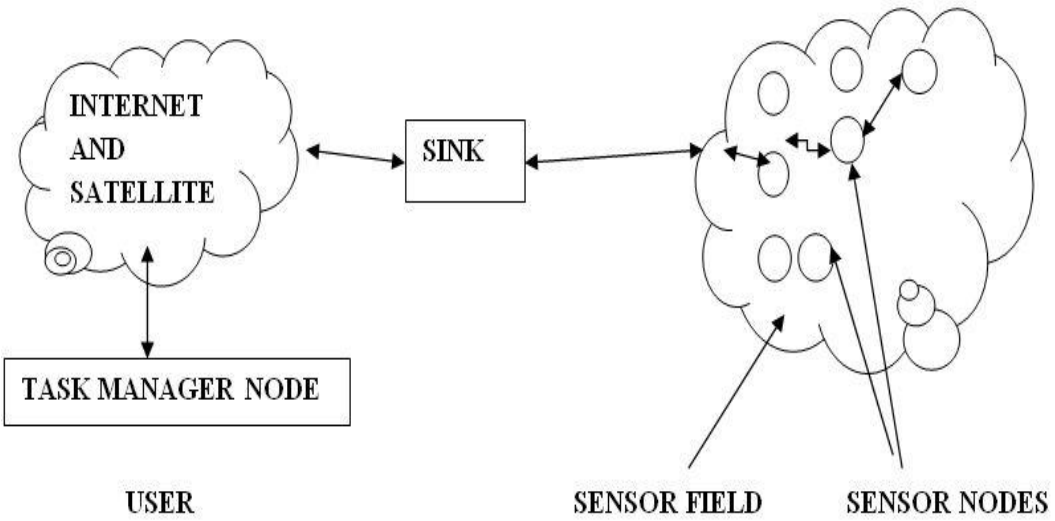
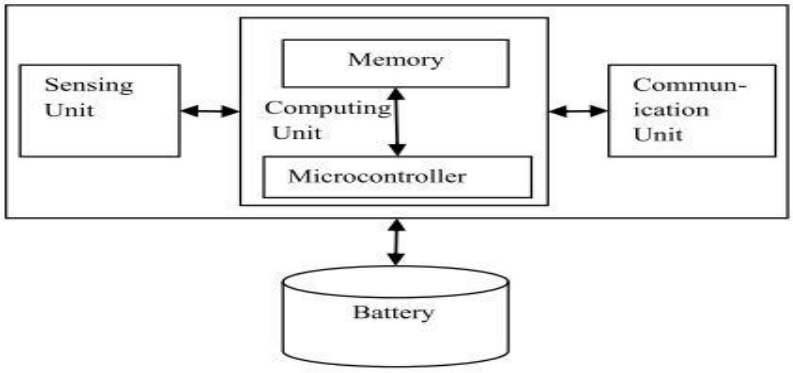


Fig: 1 Sensor nodes spread in a sensor field [9].

Sensing is a very valuable technique that is used to collect information about a physical object or process along with change in the state such as decrease in temperature or pressure. The object that generally perform sensing task is called as sensor. It consists of primary elements. Following are the primary elements of sensor node as shown in figure below:



For example, the body of the human being is equipped with sensors that is they are able to capture optical data from the surroundings (eyes), acoustic information or data like sounds (ears), and smells (nose). These are the examples of remote sensors, which do not require touching the supervised object to gather data. If we watch from a technical viewpoint, a sensor may be a device that translates parameters or events from the physical world into signals that may be calculated and evaluated. Another used term is transducer, that commonly used to represent a tool or device which converts energy from one kind into another.

II. RESEARCH ISSUE IN WSN

A. Energy Efficient: This is the most important factor for any issue in the sensor networks.

B. Scalability: a good MAC protocol easily entertains changes in density, topology and network size. Some nodes may die over time and new nodes may join later and some nodes may move to other locations.

C. Fairness: in traditional wireless data or voice networks, each user wants time to access the medium and equal opportunity means, receiving and sending packets for their own applications. However, in sensor networks, all nodes cooperate for a single task and normally there is only one application running at any time. In this case fairness is not important as long as application-level performance is not degraded.

D. Latency*:* latency can be significant or insignificant it depends on what application is running and the state of node. At the time when there is no sensing event, normally there is very little data flowing in the network and nodes are in idle state most of the time. We can trade off for energy savings by allow the node to turnoff their radios to decrease the energy consumption due to idle listening.

III. SOME HIERARCHAL PROTOCOLS IN WSN

1. Leach:

Leach is usually called as Low Energy Adaptive Clustering Hierarchy protocol.

W.R. Heinzelman, A.P Chandrakasan and H. Balakrishnan [5] projected LEACH protocol in 2000. The nodes in LEACH are branched into clusters and each cluster reside of members called Cluster Members and a administrator node called the Cluster Head, CH. The cluster heads are not picked in the static manner because that leads to fast die of sensor nodes in the network. However, the randomised protocol has been used in order to balance the energy consumption between the nodes by allocating the CH's role to the other nodes in the network. In addition, LEACH uses Time Division Multiple Access (TDMA) protocol in order to manage the channel approach within a cluster.

LEACH attempt to send the data over short distances and decrease number of the transmissions, where the energy consumptions rely upon on the distance and data size.

The election of cluster head rely upon on decision made 0 and 1.Whenever number is lower than the threshold value, then the node turn into a cluster head for the present round. The threshold is mostly given as:

$$T(n)=\begin{cases}\dfrac{P}{1-p*(r*\bmod 1/p)} & \text{if } n \in G\\ \text{Zero} & \text{else}\end{cases}$$

Where, P is that the desired percentage of cluster heads (e.g. is like 4% or 5%), r describes the current round, and G describes the set of nodes that have not been cluster heads within the last 1/p rounds.

Advantages OF the LEACH protocol are:

- It restricts most of the communication within the clusters, and therefore provides scalability in the network.
- The cluster heads combine the data gathered by the nodes and due to this the traffic generated in the network is limited. Thus, a large-scale network without traffic burden could be deployed and improved energy efficiency in comparison to flat-topology could be attained.
- In LEACH there is a Single-hop routing from node to cluster head, thus energy is saved..
- Leach Protocol does not need location information of the nodes to build the clusters. therefore, it is powerful and simple.

- Leach is dynamic clustering and appropriate for applications where constant monitoring is required and data gathering occurs periodically to a centralised location.

Disadvantages of LEACH protocol are:

- It is very much depend on cluster heads and face robustness issues such as failure of the cluster heads.
- Additional burden due to cluster head changes and calculations in every round leading to energy incompetence for dynamic clustering in large networks.
- CHs directly communicate with sink in between there is no inter cluster communication, and for this high transmission power is needed. Therefore, it does not well suited for large- scale networks that require single-hop communication with sink.
- CHs are not consistently distributed; CHs could be located at the edges of the cluster.
- Selection of CH is random, In which energy consumption is not accounted.
- Leach does not work well in the applications where large area is covered that requires multi-hop inter cluster communication.

2. PEGASIS

S. Lindsey and C. Raghavendra [6] introduced Power Efficient Gathering in Sensor Information Systems (PEGASIS) protocol in 2002. PEGASIS is a near optimal chain-based power efficient protocol based on LEACH [7].According to this protocol, all the nodes have information about all other nodes and each node has the capability of transmitting data to the base station precisely. PEGASIS presume that all of the sensor nodes have the same level of energy and they are possibly to die at the same time. As all nodes are static and have overall knowledge about the network, so the chain can be build up easily by using greedy algorithm. Chain creation is started at a node distant from base station. Every node receives and transmits data from the only one closest node of its neighbors. To detect the closest neighbor node, signal strength is used by each node to measure the distance from the neighbors and then fine-tune the signal strength so the only one node cab is heard. From both side node passes token over the chain to leader. Each node merges the received data with their own data at the time of constructing the chain. In each round, a randomly chosen node (leader) from the chain will transmit the aggregated data to the BS. Node i (mod N) is the leader in i round. The chain resides of those nodes which are closest to each other and form a path to the base station. The leader sends the aggregated to the base station.

Advantages of the PEGASIS protocol are:

- It is an improved version of LEACH.
- This protocol is in position to outgo LEACH for different or various network sizes and topologies cluster creation in LEACH, so decreases the number or quantity of data transmission volume through the chain of information aggregation.

Within the network the energy load is distributed consistently. So that the subsequent early deaths of sensor nodes are prevented .successively all sensor nodes act as leader.

Disadvantages of the PEGASIS protocol are:

- In PEGASIS sensor nodes usually or probably die early.
- It is assumed that every sensor node are often able to communicate with sink directly, despite in practical cases nodes use multi-hop communication with the sink. Furthermore, long-range communication directly from the node to the sink will breed an excessive amount of energy consumption.
- The communication manner suffers from excessive delays caused by the one or single chain for distant nodes and a high probability for any node to become a bottleneck.

3. TEEN

In 2001, A. Manjeshwar and D. P. Agarwal [7] projected Threshold sensitive Energy Efficient sensor Network Protocol (TEEN) protocol. TEEN stands for Threshold Sensitive Protocol Developed for reactive networks and TEEN protocol is based on the LEACH protocol, TEEN is based on hierarchical organization in which sensor nodes are divided twice for grouping cluster in order to identify the scene of rapid changes in the sensed characteristic like temperature. After forming the clusters, TEEN divide the Cluster Head into the second level Cluster Head and uses Hard model.

Thus, the hard threshold tries to decrease the number of transmissions by granting the nodes to transmit only when the sensed attribute is in the range of interest. The soft threshold additionally decrease the number of transmissions by eliminating all the transmissions which might have alternatively happened when there is small or no change in the sensed attribute once in the hard threshold.

Advantages of TEEN protocol are:

- TEEN protocol is supported by the thresholds, data transmission are usually controlled accurately, i.e. , only the sensitive data we have a tendency to demand are usually transmitted, so that it decrease the energy transmission consumption and boost the effectiveness and adequacy of the receiving data.
- TEEN is complement for reacting to large changes in the sensed attributes that is convenient for reactive scenes and time crucial applications.

Disadvantages of TEEN protocol are:

- TEEN protocol is not well suited for applications where the user needs to get data on a consistent basis.

- If cluster head don't seem to be within the communication range of each other, the data may be disappeared, because information transmission is completed only at CHs.

4. APTEEN

Manjeshwar and D. P. Agarwal [8] projected Adaptive Threshold sensitive Energy Efficient sensor Network Protocol (APTEEN) protocol in 2002. The Adaptive Threshold Sensitive Energy Efficient Sensor Network Protocol (APTEEN) is an extension of TEEN and objective to both capturing periodic data collections and reacting to time crucial events. The architecture of APTEEN is same as in TEEN. In APTEEN once the cluster heads are decided, in each cluster duration, the cluster head broadcasts the parameter such as attributes, threshold, schedule and count time to all nodes. The performance of APTEEN lies between TEEN and LEACH in terms of energy consumption and durability of the network. While sensing the environment, TEEN only transmits time crucial data. APTEEN makes an improvement over TEEN by supporting periodic report for time crucial events.

Advantages of APTEEN protocol are:

- APTEEN combines both proactive and reactive policies, proactive polices are same as that of LEACH, and reactive policies same as that of TEEN. Finally, it is convenient in both proactive and reactive application.
- It demonstrates number of flexibilities and by changing the count as well as the threshold values it can set the count-time interval and the threshold values for the energy consumption.

Disadvantages of APTEEN protocol are:

- There exist additional complexity which is necessary to implement threshold functions and the count time.
- Literally, each TEEN and APTEEN has the same drawbacks of additional burdens and complexity of cluster construction at different levels.
- The burden and complexity of making clusters.

5. EECS

In 2005, M. Ye, C. Li, G. Chen and J. Wu [10] projected Energy Efficient Clustering Scheme (EECS) protocol. In which cluster head candidates compete for the ability to become to cluster head for a present round. This event involves candidates broadcasting their residual energy to adjacent candidates. In case that a given node does not find a node with more residual energy, it becomes a cluster head. The competition method is localized and without repetition. Moreover in the cluster formation phase, to balance the load among cluster heads a unique approach is introduced. Still, on the other side, it will increment the need of global knowledge regarding the distances between the cluster-heads and the base station.

Advantages of EECS protocol are

- The clusters with a large distance to the BS require more energy for transmission than those with a shorter distance, therefore the message overhead is small and CHs are uniformly distributed as compared to LEACH.
- Clustering is performed by dynamic sizing based on cluster distance from the BS.

Disadvantages of EECS protocol are

- EECS produces more control overhead complexity because all nodes have to compete with each other for becoming CHs.
- EECS needs large global knowledge about their distances between the Base Station and Cluster Heads, thus the task of the global data aggregation adds overheads to all sensor nodes.
- Communication in EECS, long-range transmissions in single hop from CHs to the BS may lead to large energy consumption. Thus, it is not good for large-range networks.

6. SEP

In 2004, G. Smaragdakis, I. Matta and A. Bestavros [9] projected Stable Election Protocol (SEP) protocol. SEP is a protocol for two-level heterogeneous network; heterogeneity in terms of initial energy deployment in Sensor Nodes. SEP assumes that in real environment nodes has different energy, therefore in SEP there is two types of nodes (two tier in-clustering), i.e., advance nodes and normal nodes. Advance nodes have an amount of more energy than normal nodes. Based on its initial energy SEP assign a weighted probability to each node .Furthermore, it improves the cluster formation of LEACH by decreasing the CH epoch interval of advance nodes, i.e., to become the CH advance nodes get more chances. A weight is assigned for individual probabilities for election of CHs for advance and normal nodes

Advantage of SEP protocol are:

- SEP does not need any global knowledge of energy level at each election round.

Disadvantage of SEP protocol are*:*

- Election of the cluster heads from the two type of nodes is not dynamic, Due to which the nodes which are far from the strong nodes will get die first.

7. HEEDO.

Younis and S. Fahmy projected [4] Hybrid Energy Efficient Distributed clustering Protocol (HEED) protocol in 2004. HEED extends the fundamental scheme of LEACH by using residual energy and node degree as a main parameter for cluster election to achieve power balancing. By using an adaptive transmission power in the inter-clustering

communication, it works in multi-hop networks. In HEED, the proposed algorithm periodically chooses CHs depend upon the combination of two clustering parameters. The one parameter is their residual energy of each sensor node and the second parameter is the intra-cluster communication cost act as the node degree (i.e. number of neighbors). The one parameter is used to select an initial set of CHs and the second parameter is used for breaking ties.

Advantages of HEED protocol are:

1. The HEED clustering improves network lifetime than the LEACH clustering because LEACH randomly selects CHs, which may result in quicker death of some nodes.
2. The nodes only require local (neighborhood) information to form the clusters.
3. In HEED due to distribution of energy enhance the lifetime of the nodes within the network results in stabilizing the neighboring node.

Disadvantage of HEED protocol are:

1. Some Cluster heads, mainly which are near to the sink, might die earlier because these Clusters heads have very large workload.
2. Same as the LEACH protocol, the clustering in each round appoint significant burden in the network. This burden causes remarkable energy dissipation which results in decline the network lifetime.
3. HEED suffers from a consecutive burden since it needs several iterations to form the clusters. Therefore due to several iterations lot of packets are broadcasted.

IV. CONCLUSION

Energy efficiency is one of the major challenges in the design of routing protocols for WSNs. The energy utilization of the sensors is decreased by data sending and reception. Hence, the protocols designed for WSNs should be as energy efficient as much as possible so that it will extend the lifetime of each sensor, and hence the lifetime of network . Protocols which are discussed above each have individual advantages and disadvantages. Depending upon the topology, the routing strategies and protocols can be applied.

In this paper, some of the hierarchical based routing protocols are discussed and they have special advantage of efficient communication and scalability. Every routing protocol have major objective to reduce the energy consumption and increase the lifetime of the network. By the use of hierarchical routing, energy consumption of sensor nodes are maintained in the network and carries out data aggregation by which the number of transmitted messages to base station gets decreased. Hence, we have concluded that hierarchical routing protocols are much efficient than the location based routing protocols in making more energy efficient WSNs maintaining energy consumption.

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