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A review of Hierarchical energy Protocols in Wireless Sensor Network

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Abstract: *This paper attempts to provide an overview of various protocols used in wireless sensor network which include data dissemination and data gathering protocols .Wireless network is any type of computer network which uses wireless communication between nodes. Wireless network of autonomous sensors is used to monitor physical and environmental conditions like pressure, temperature, air pollution, water quality etc. and pass them through the network to the desired location. Each sensor network has several parts – a radio transceiver with antenna, a microcontroller, an electronic circuit for interfacing with sensors and energy source which is generally a battery or an embedded form of energy harvesting. Wireless sensor network are having limitation of storage space, computing power and energy. Therefore various protocols are used to design energy efficient wireless network. This paper reviews all hierarchical routing protocols .Energy consumption and network lifespan are primary issues considered in this paper.*

Keywords:*Wireless Sensor network, battery, routing protocols,energy efficient, Energy consumption, network lifetime.*

I. Introduction

Efficient design and implementation of wireless sensor networks has become a hot area of research in recent years, due to the capability of sensor networks to enable applications that connect the physical world to the virtual world. WSNs are useful on the area or environment where it is difficult to stay long time or mostly not possible to stay. WSNs[1] sense the network and also make communication between nodes. Sensor nodes of WSNs collect the data for particular events and transfer it to BS from where user can get data.A sensor network has main components [2]:-Sensor unit, Analog digital converter, CPU central processing unit, Power unit and Communication unit.

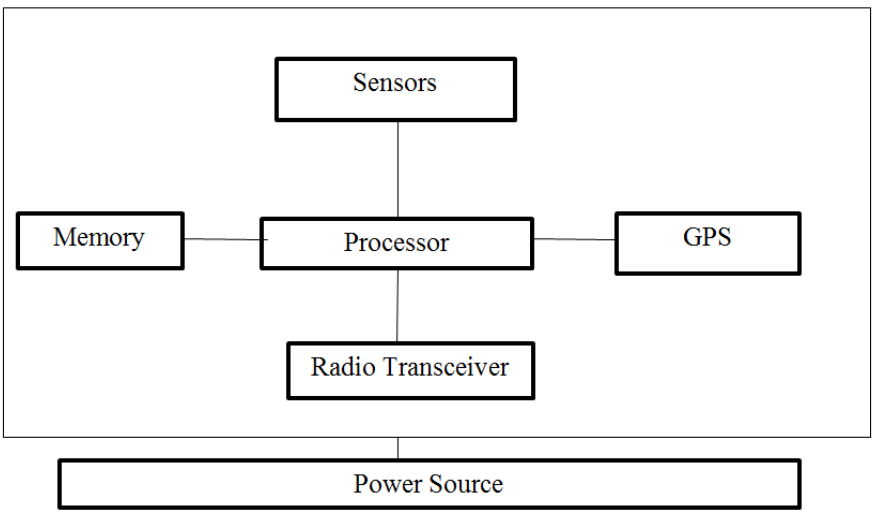

Fig.1.1Basic components of wireless sensor network [1]

Wireless Sensor Networks (WSN) [3]provides a bridge between the real, physical and virtual worlds. It allows the ability to observe the previously unobservable at a fine resolution over large spatial-temporal scales. It has a wide range of potential applications to industry, science, transportation, civil infrastructure, and security.

The WSNs can contain thousands of sensor nodes. These sensor nodes have characteristic like limited battery life time, heterogeneity, mobility. All this things affects the lifetime of WSNs. Each sensor nodes contains a wireless sender/receiver, a microcontroller and a battery or energy source. In WSNs each sensor nodes collect data for particular events and are then send it to the cluster head. Cluster head is the node which is the leader of a particular cluster of sensor node and responsible for all matter happen in its own cluster. After data collection all sensor heads pass the data to base station. And finally, end user gets the aggregated data from base station. Here base station is defined as main data collection node and it is the link between sensor node and end user. Base station does not have power limitations. It has information about the entire sensor node in network. The cluster heads are selected on basis of two criteria, first one is energy level of node and second one is distance of sensor node from base station. The applications of WSNs are inventory management, environment monitoring, medical monitoring, biological, transportation and logistics, entertainment, security, healthcare etc.

II. Issues In Wireless Sensor Network

Various issues are related to wireless sensor network [4][5].Energy Efficiency is the most important factor for any issue in the sensor networks. A good WSN [6]protocol supports changes in density, architecture and size of network..The scalability concept involves several dimensions, like the number of nodes, the data load, the application number etc. and act as basis to break up the cellular concept modifying it by multi hop communications**.** In traditional wireless networks, each user, receive and send packets for their own applications. However, in sensor networks, all nodes work for a single task and only one application run at any time. Hence fairness is not important as long as application-level performance is not decreased. Latency is one of the important factors which need to be handled.Latency can be significant or insignificant it depends on what application is running and the state of node. When there is no sensing occurs, then very less data flows in a network and node remains in ideal state. We can save the energy by allowing the node to switch off their radios to decrease energy consumption.

2.1. Routing Protocol Classification

Routing in WSN differs from conventional routing .There is no infrastructure, wireless links are unreliable, sensor nodes may fail ,and routing protocols have to meet strict energy saving requirements. So many routing algorithms were developed for wireless networks .Routing protocols [7][8] are classified into various categories. Based on mode of functioning and type of target applications into Proactive, Reactive and Hybrid. When sensor nodes are non-movable i.e. static, it is desirable to have table driven routing protocols rather than using reactive protocols. A huge amount of energy is used in route discovery and setup of reactive protocol. In a Proactive Protocol the nodes maintain the information about the other node all the mobile nodes of this protocol have to relay its entries to its adjacent nodes.The Low Energy Adaptive Clustering hierarchy protocol (LEACH) utilizes this type of protocol. Reactive Protocol has the ability of choice, due to frequent node mobility.Reactive protocols support data on demand and are simple in design. This type of protocol is used in time critical applications. The Threshold sensitive Energy Efficient sensor Network (TEEN) is an example of a reactive protocol.Hybrid Protocols Incorporate both Proactive and Reactive concepts. They first compute all routes and then improve the routes at the time of routing. Adaptive Periodic TEEN (APTEEN) is an example of Hybrid Protocols.

On basis of participation styles of node into direct communication, flat and clustering protocols[8][26]. In Direct Communication Protocols, any node can directly send information to the base station. This has a disadvantage that when we have a large numbers of network consisting of various nodes then, the energy of the sensor node.When this is applied in a large network, the energy of sensor nodes may be lost quickly. It is not very scalable. SPIN is an example of this type of protocol. In the case of Flat Protocols, node which want to send data first searches for a valid route to the BS and then transmits the data .nodes around the base station may drain their energy quickly. Its scalability is average.Rumors routing is an example of this protocol.

2.2. Some Hierarchical Routing Protocols

W.R. Heinzelmanet.al [9] [10] projected LEACH protocol. LEACH (Low Energy Adaptive Clustering Hierarchy) is the first and most popular energy-efficient hierarchical clustering algorithm for WSNs that was proposed for reducing power consumption. In LEACH, based on time, the clustering task is rotated among the node.**LEACH**is a TDMA-based MAC protocol which is integrated with clustering and a simple routing protocol

inwireless sensor networks (WSNs). The goal of LEACH is to lower the energy consumption required to create and maintain clusters in order to improve the life time of a wireless sensor network. It uses clusters to prolong the life of the wireless sensor network.LEACH is an example of hierarchical protocol in which most nodes transmit to cluster heads, and the cluster heads combine and abbreviate the data and forward it to the base station (sink). Each node uses a stochastic algorithm at each round to determine whether it will become a cluster head in this round. LEACH assumes that each node has a sufficient energy to directly reach the base station or the nearest cluster head, but using this radio at full power all the time would waste energy.

LEACH is a cluster based protocol, which include distributed cluster formation. This protocol randomly selects a few sensor nodes to cluster head and rotate this role to evenly distribute the energy load among sensors.In LEACH,the cluster head node compress data arriving from nodes that belong to the respective cluster and sends an aggregate packet to the base station in order to reduce the amount of information that must be transmitted to base station.

The operation of leach is serrated into two phases, the setup phase and steady up phase. In **Setup phase**, the clusters are organized and clusterhead are selected.In **steady state phase**, the actual data transfers to the base station take place.Duration of steady phase is longer than setup phase. Nowadays, Round Robin algorithm is used for cluster head selection but in future may be power based technique is used.LEACH [8] is completely distributed in nature and requires no global knowledge of network. Cluster head communicates with sink. 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, which saves energy. Leach Protocol does not need location information of the nodes to build the clusters. Therefore, it is powerful and simple. Further LEACH is extended for privacy preservation in secure data aggregation However,CHs directly communicate with sink in between there is no inter cluster communication, and for this high transmission power is needed. Therefore, it is not suitable for large- scale networks that require single-hop communication with sink.For data privacy preservation ,LEACH is further extended in secure data aggregation[11][12]

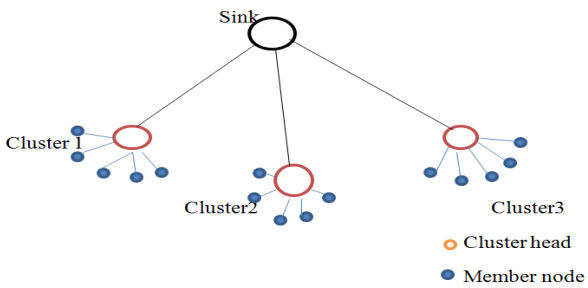

Fig3.1 LEACH [10]

S. Lindsey et.al[13][14] introduced Power Efficient Gathering in Sensor Information Systems (PEGASIS) protocol. PEGASIS is a near optimal chain-based power efficient protocol based on LEACH .The basic idea of this protocol is that in order to extend network lifetime node needs to communicate with their closest neighbors and the take turn in communicating with base station. PEGASIS has two main objectives:First increase the lifespan of each node by using collaborative technique and as a result the network lifetime will increase.Second, allow only local coordination between nodes that are close together so that bandwidth consumed in communication is reduced. Unlike LEACH, PEGASIS [15]avoid cluster formation and use only one node in achain to transmit the base station instead of using multiple nodes. 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 consequently early deaths of sensor nodes are prevented .Successively all sensor nodes act as leader**.**

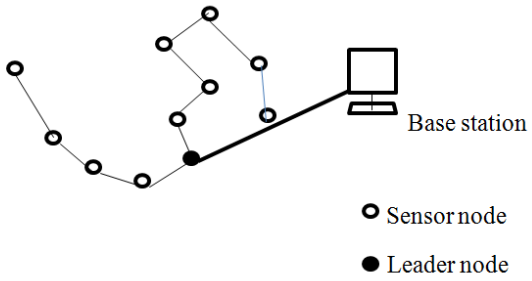

Fig 3.2 PEGASIS [14]

A.Manjeshwaret.al[16][17]projected Threshold sensitive Energy Efficient sensor Network Protocol (TEEN) protocol. TEEN protocol is based on the LEACH protocol, this protocol was proposed for time critical applications. In TEEN sensor node senses the medium continuously, but the data transmission is done slowly. TEEN[13] is based on ordered configuration 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 divides 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 number of transmission decreases by soft threshold 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.

In TEEN [18] time critical data reaches the user almost instantaneously.The soft threshold can be discrete, depending on the criticality of the sensed attribute and the target application.A smaller value of the soft threshold gives a more precise picture of the network but energy consumption increased. After every cluster change time, the attributes are declared afresh so, the user can change them as required.If data is need on consistent basis then TEEN protocol is not suitable.If cluster head are not within the communication range of each other, the data may be disappeared, because information transmission is completed only at CHs.

Manjeshwar et.al projected Adaptive Threshold sensitive Energy Efficient sensor Network Protocol (APTEEN) protocol[19]. The APTEEN is an extension of TEEN and objective to both capturing periodic data collections and reacting to time crucial events. APTEEN is a hybrid protocols that changes the periodicity or threshold values used in TEEN protocol according to the user need and type of application. It combine both proactive and reactive protocols.it offers a lot of flexibility by allowing the user to set the cunt timer interval and the threshold values for the energy consumption can be controlled by changing count time as well as threshold values. 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 important and required data. APTEEN is better than TEEN as it support periodic report for time crucial events.TEEN and APTEEN can be improved by using an advance scheme that is adaptive clustering[20].

O. Younis et.al Hybrid Energy Efficient Distributed Clustering Protocol (HEED) protocol [21]. HEED uses residual energy as a primary parameter and network topology features such as node degree, distances to neighbors are secondary parameters which are used to shatter the tie between the candidate cluster heads. The clustering process is done in various iterations and in every iteration nodes that are not covered by any cluster head doubles their probability of becoming a cluster head. The main advantage of HEED algorithm is that in this low power levels of cluster endorse an increase in spatial reuse while high power level of clusters are needed for inter cluster communication. This gives uniform cluster head distribution across the network and provide load balancing. However it is having a disadvantage that tentative cluster head that do not become final cluster head leave some uncovered nodes which then forcefully become cluster headhavingno member associated to them. Hence more cluster head are generated then the expected number and is also responsible for unbalanced energy consumption in network. Due to the over workload in clusterhead particularly which are near the sink, might die earlier. To extend the network lifetime we use H-HEED[22]which is extension of HEED in terms of non –homogeneity.

III. Conclusion

For designing routing protocols for WSN,energy efficiency is biggest challenge.Hence the protocol designed for WSN should be energy efficient so that they can increase the lifespan of a network.However the sensor nodes also satisfy the constraints like fault tolerance, scalability, cost,topological change, hardware and power consumption. The protocols discussed over here have their own advantages and disadvantages, depending on the routing strategies and topology of network various protocols can be implemented.

All the above protocols we have discussed in this paper have special advantage of efficient scalability and communication.By using these routing protocols, energy consumption of a network and data aggregation can be carried out. Although Performance of these protocols is promising in terms of energy efficiency, further research would handle the issues such as quality of service given by video, imaging and real time application. Also in future we can integrate the sensor network with wired network.

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