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A Review Paper on Energy Efficient Hierarchical Protocols in Wireless Sensor Networks

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Abstract: **Wireless sensor Network comprises of a large number of sensing devices. A sensor network can be built with at least one Base station and a number of sensors. The sensor nodes are deployed on different locations, whose job is to monitor the network in real time. The monitoring and analyzing of the data that is sometimes selective parameter of same or different environment or system. In recent years, more and more sensors are deployed. Due to the limited power backup, processing capability, communication range, these sensors should be used more efficiently since transmission and reception costs loss of energy at rapid rate. To improve the efficiency, some routing protocols have already been proposed. In this survey paper, we have reviewed various routing protocols such as LEACH, TEEN, APTEEN protocols on the basis of their functionality, complexity and energy [1]. In these protocols, the sensor nodes react not only to time critical applications but also give response to periodic intervals. The time criticality response makes the protocol an efficient protocol.**

Keywords: TEEN, WSN, energy efficiency, Routing Protocols, complexity.

I. INTRODUCTION

There was a time when network solely depended on wired technology but these days the network, with ever increasing quantity of nodes and the advancement of technology, can be connected wirelessly.

In wireless network, nodes are distributed over strategic location in any environment such as a small building, an office etc. Now-a-days, with increasing remoteness in the wireless network, sensors are deployed to monitor the nodes and transfer the information to their recipient. This type of network is known as WSN or sometimes also known as WS&AN (Wireless Sensor & Actuator Network).

It is a distributed network of thousands of sensors of various types attached to monitor the environment conditions such as temperature, sound, vibration, etc. Most of the modern WSNs are bidirectional and also enable user to control the sensor's functionality. The functionality mainly depends on the energy consumption. The main difference between traditional networks and sensor networks is that sensors are so sensitive that even a small amount of energy can activate them.

There are various applications of WSNs. Some of them are listed below:

1. Industrial processing and monitoring.
2. Machine monitoring
3. Health care.
4. Traffic control and so on.

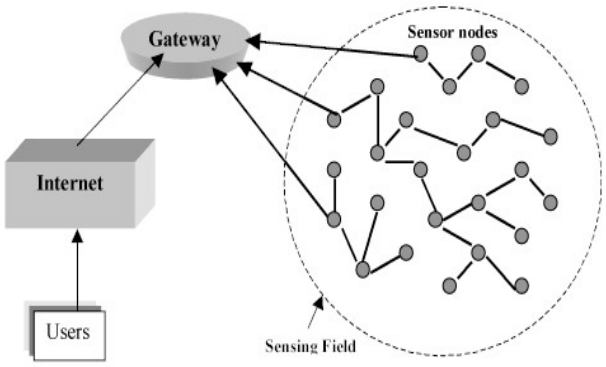

Figure 1. A sample WSN [2]

WSN has several to thousands of nodes attached and each node is linked to one or several sensors. A typical sensor can be comprised of following parts:

- Transceiver with an internal or external antenna,
- A micro controller,
- An interfacing circuit.
- A power source.
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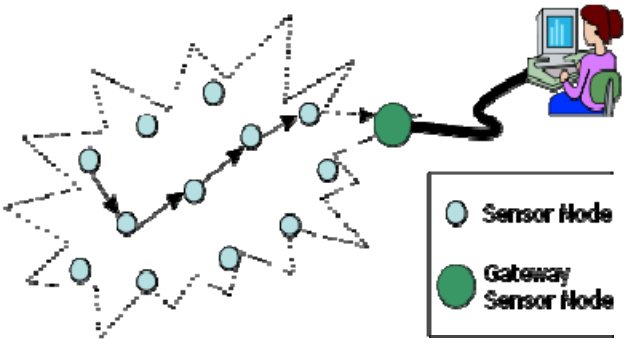

Figure 2. Typical multi-hop network architecture [4]

Some aspects of WSNs are

- Node mobility
- Node heterogeneity
- Scalability
- Easy to use
- Battery operated
- Node resilience
- Cross-layer design.

Consider the following case:

Temperature sensors be placed around a factory (such as military, automotive, etc.)

Typical queries posted by the user are:

- Report instantly if the temperature in X Quadrant goes below 400 F
- Retrieve the average temperature in Y quadrant over the last 5 hours
- For the next one hour, report if the temperature goes above 2100 F.
- Find areas having temperature between 400 F and 2100 F in the past one hour.

The user can query the sensor network from the Base station to get the data.

II. LITERATURE REVIEW

Some of the major contribution of the researches along the line of research are briefed.

Heinzelman et.al. [5] introduced a hierarchical cluster based Routing Protocol. This shall be discussed in detail in the next section A.

Manjeswaret et.al. [7] proposed a protocol which is not dependent on periodic sensing of environment. It is appropriate for time-critical applications since it pays continuous attention to the rapid changes in the perceived attribute.

Estrin et.al [9][11] presented a hierarchical clustering method where emphasis was laid on localized behavior along with the need for asymmetric communication and energy conservation in wireless sensor networks.

It has been found after surveying that among the issues in WSN one of the most important issue is energy consumption. Hierarchical routing protocols are found to have upper-hand in terms of energy efficiency. Clustering technique minimizes the consumption of energy broadly in gathering and disseminating data.

It is a challengeable task to design routing protocols. Despite numerous applications of WSN, various restrictions come in way such as limited power, computing capability, bandwidth.

Our main idea is to create a network which can carry out communication for longer time i.e. maximum attainable work can be done. These above factors must be overcome so as to make an efficient communication in WSN.

Since a lot of data is generated and effectively communicated thus requires a lot of energy. Hence, to save power, data is aggregated and then transmitted. An efficient routing protocol makes the maximum utilization of the sensors by managing its parameters such as power consumption, processing power, etc. It sometimes poses a challenge in hostile environment. Consequently when the power is drawn, energy of sensor reaches threshold, it affects performance of network. We explain the following energy efficient protocols that work in reactive and proactive network.

A. LEACH:

W. Heinzelman et.al. [5] introduced a family of hierarchical cluster based Routing Protocols. A protocol which falls in this family includes cluster formation called LEACH(Low Energy Adaptive Clustering Hierarchy). The basic idea is to form clusters. The sensor nodes collectively form a cluster, based on energy strength. A Cluster Head is elected dynamically to sink the data. Having elected a cluster head, all sensor nodes do not fall in the category of transmitting data to sink, thus saving energy. This method also reduces collision (inter cluster/intra cluster) by following TDMA/CDMA schemes.

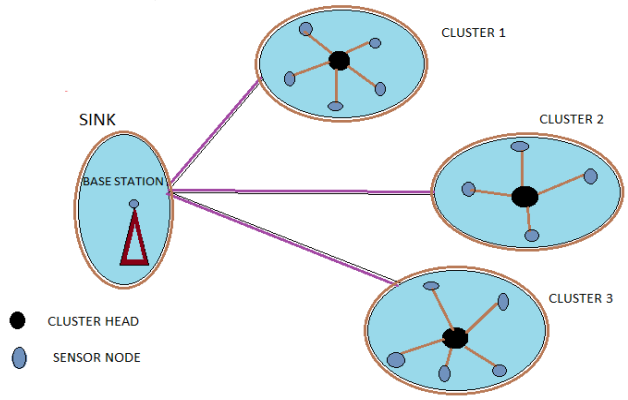

Figure 3. LEACH Protocol

Leach Protocol operates in two steps:

- It is also the setup phase where election of CH takes place. CH is chosen randomly based on its energy level. This is done so as to balance energy dissipation. Under TDMA/CDMA scheme, CH broadcasts schedule in which sensor nodes transmit data in their respective order. When schedule is completed the total time calculated is known as frame time. Each sensor node has its local slot in the frame.
- In steady phase also known as second phase, sensor nodes transmit data to CH. CH receives all the data and then after aggregation, transmits to BS. Steady phase has longer duration since its job is to manage overheads so that these overheads can be minimized.

B. PEGASIS:

It is also known as Power Efficient Gathering in Sensor Information System. It is an enhancement over LEACH protocol [6]. Here, we form a chain of nodes rather than multiple clusters. Here, we have a Base station BS, and sensor nodes. Since we do not form clusters, we do not have Cluster Heads. Each Sensor node has the ability to transmit and receive data from its neighbors. Although all sensor nodes have global knowledge which is primarily concerned with the position of each sensor node in the network. The condition of overheads is eliminated since only one node broadcasts the aggregated data. Hence, sometimes it is also called Optimal Chain Protocol.

The few steps involved in PEGASIS protocol are:

- Chain Construction: Here we construct a chain by linking all the nodes. The node which is at furthermost location from the sink is selected as the starting point of the chain.

PEGASIS Protocol:

- Here, random selection occurs between the nodes, to select the leader. Leader has the ability to transmit the gathered data to the sink.
- If somehow any node in the chain dies, chain is reconstructed leaving that dead node.
- All the data from the sensor nodes is sent to the Leader/Head and that data is gathered, fused and sent to BS.

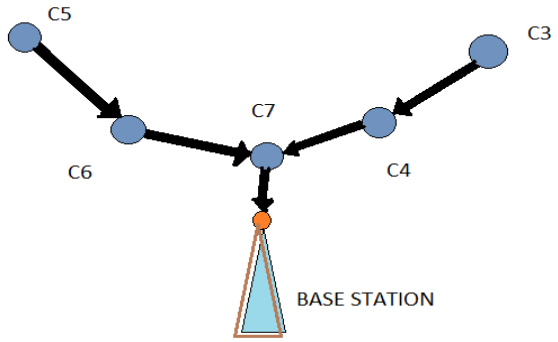

Figure 4. PEGASIS Protocol

C. TEEN:

Manjeswaret. et. al. [7] proposed a protocol which is not dependent on periodic sensing of environment but senses continuously. It also belongs to the family of hierarchical clustering protocols. Nodes which are closer to each other form cluster, and transmit data to CH (Cluster Head). The CH aggregates the data and sends this data to the sink. If a second level CH exists, the data is first transmitted to second level CH and finally sinks. Here nodes sense sudden difference in the set of values and report to CH, when there is strict need for controlling trade-off between defined parameters dynamically. These parameters can be energy efficiency, data accuracy and response time. It uses hierarchical approach with data centric methods. Also sensing requires less energy as compared to transmission so energy consumption is also less in this scheme. One major drawback is that while sensing application if thresholds are not reached, it cannot generate reports. CH sends two types of data to its neighbors, Hard Threshold and Soft Threshold.

Hard Threshold HT: It is the absolute value for the sensed attribute. The node must switch on the transmitter when the sensed value crosses the threshold and report to CH.

Soft Threshold ST: Any small variance in the value triggers switching on of its transmitter and then transmits.

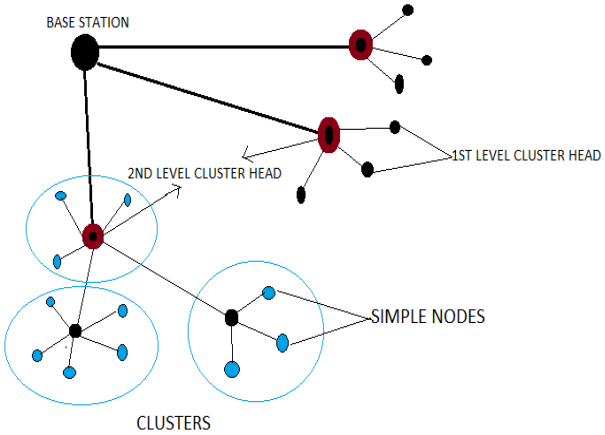

Figure 5. TEEN Protocol

D. APTEEN :

This protocol is also known as Adaptive TEEN. It is an advancement over TEEN protocol [8]. This protocol is widely used for comprehensive information retrieval. Unlike TEEN, it not only reacts to time critical situations, but also gives idea about periodic time intervals about a particular wireless sensor network. Thus, it is a hybrid clustering protocol. It has an upper hand over previous routing protocols since we can request data in the form of persistent queries.

Example:

- Report instantly if the temperature in X Quadrant goes below 400 F
- Retrieve the average temperature in Y quadrant over the last 5 hours.

APTEEN is a query based protocol which has the following types of queries.

- Historical query
- One-time query
- Persistent query

Historical query: It analyses historical data stored in the sink. (E.g. What was the pressure in X quadrant before 3 hours?)

One-time query: This query is used to give the overview of the network. (e.g. What was the pressure in X quadrant?)

Persistent query: This query monitors a network with respect to some parameters over a time period. (e.g. Report the pressure in X quadrant for the next 3 hours.)

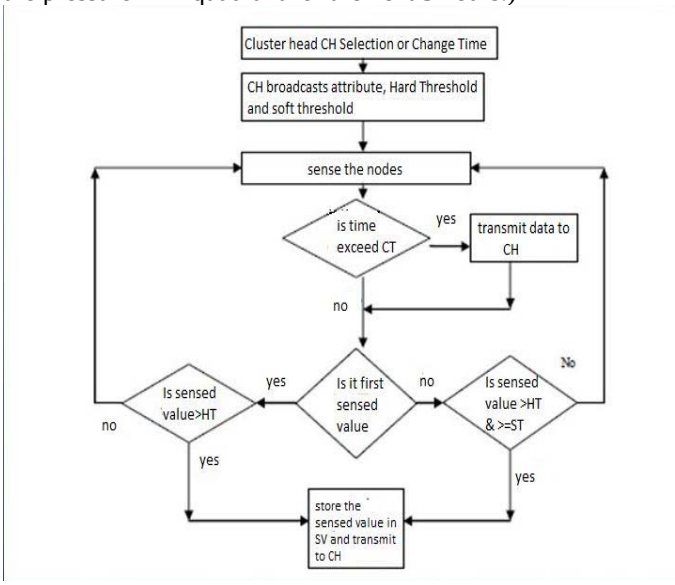

Figure 6: Operational Flow of APTEEN

III. CONCLUSION

One of the main challenges for WS&AN is its energy efficiency. Due to scarce and limited energy resources of sensors, it becomes a milestone to develop efficient routing protocols. One thing is to be kept into consideration while designing routing protocol is to extent lifetime of sensor network so that sensor can operate at full potential. This reviewed and surveyed work has been done so as to focus on enhancing its energy efficiency, in a family of hierarchical routing protocols. We have covered protocols and found out that TEEN protocol has shown great response for time critical application. Its energy efficiency is good in terms of energy consumption and response time [13]. The future scope will be to make the protocols more energy efficient, so that they can withstand longer and utilize that energy more efficiently by prolonging life of network. Another major parameter can be to address QOS issues.

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