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# A REVIEW ON PROTOCOLS AND TECHNIQUES FOR ENERGY EFFICIENCY IN WIRELESS SENSOR NETWORK

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## ABSTRACT

In wireless sensor systems, lifetime improvement is a gigantic testing errand in light of the fact that the sensor hubs are furnished with restricted low power battery. The battery substitution or revive is impractical as hubs are sent in difficult to reach contaminated environment. At the point when the battery force of a sensor hub is depleted, then the sensor hub kicks the bucket. At the point when adequate number of sensor hubs kick the bucket, the entire system does not perform its wanted errand. In this manner the system lifetime improvement is most critical assignment of a remote sensor network.Various vitality effective protocolswas connected to upgrade system lifetime. This paper reviews the late vitality proficient conventions and their execution. Our study finishes up with issue detailing, its answer and the proposals to the future heading in the vitality productive model for remote sensor systems.

Key words: Wireless Sensor Network, Clustering, ClusterHead, Base Station, Low Energy, Energy Efficient Protocol.

## INTRODUCTION

Wireless sensors are electromechanical devices and today they are widely used in industry process control, healthcare applications, traffic control, home automation, environmental monitoring and battle field surveillance. Modern technologies in microelectronic mechanical systems (MEMS) [2][4] and wireless technologies have developed tiny sized, low-cost, low-power, and multifunctional smart sensor nodes in a wireless sensor network. Wireless sensor nodes are deployed and connected through internet and wireless links, which works for various industrial, scientific and military applications. Distributed nodes work together to monitor physical or environmental conditions such as temperature, humidity, light, radiation, motion, sound, vibration and pressure.

The modern wireless sensor networks are bi-directional, also sensor activities can be controlled. Unlike cellular systems and mobile ad hoc networks (MANET), WSNs [1] have unique characteristics such as denser level of node deployment, heterogeneity of nodes, severe energy, ability to withstand polluted environmental conditions, computation, and storage constraints, which present much modern advancement in the development and application of wireless sensor networks.

The WSN [1] is made up of thousands of "sensor nodes", where each node is connected to other sensors.

Each node has many components: a microcontroller, a digital circuit for interfacing with the sensors, a radio transceiver with an internal antenna or connection to an external antenna and an one time energy source (battery backup). The cost of the wireless sensor nodes varies with its functionality, complexity and applications of the individual sensor nodes. The energy usage, memory capacity, computational speed and communications bandwidth etc. these resources decide the size and cost of the sensor node. The topology of the WSNs [1] varies from astar network to an advanced multi-hop mesh network. The signal processing technique between the hops of the network are routing or flooding method.

In this paper we present an exploratory survey of energy efficient protocols and techniques used in wireless sensor networks. Our aim is to provide a better understanding of the current issues in this emerging field for energy conservation.

### SYSTEM MODEL OF WSN

Hundreds or thousands of sensor nodes form a wireless sensor network to receive qualitative and meaningful information about their environment [3].

The functionalities of sensor node like sensing, storing, processing, power consumption, location finding, data packet transmissionetc. are available in each of the sensor nodes. The major components of WSN [3] are:

*Sensor Node:* Sensor node is the prominent componentof a wireless sensor network. Sensor nodes have multiple functionalities in a network, like as sensing, data storing, processing,routing, route searching and data transmission.

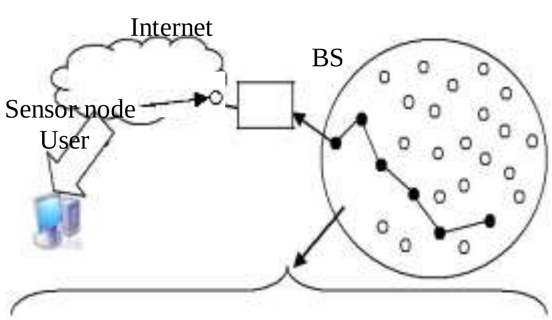
*Clusters:* Sensor nodes are grouped into clusters whenthey are deployed. Clusters of nodes are the organizational unit for wireless sensor networks. The large number of sensor networks are required them to be broken down into clusters or groups and the working tasksare distributed and simplified for a communication.

*Cluster Heads:* Cluster heads (CHs) are the group leaderof a cluster. In the cluster, all sensor nodes send their data packets to the cluster head of that cluster. CHs organize the activities and tasks like data-aggregation and organizing the communication schedulingin a cluster. Cluster heads communicates directly with the base station.

*Base Station:* The base station is at the top level of thehierarchywireless sensor network. It provides communication link between the sensor network and the end-user. Base station receives data packets from cluster heads.

*End User:* The sensed data values from wireless sensornetwork is used for various applications. Therefore, a specific application uses the network data values over the internet, using a PDA, Laptop or desktop computer.

The system model of sensor network [3] is shown in figure 1. The four major components of sensor nodes are sensing unit, processing unit, transmission unit, and power unit they are assigned with their own jobs. Sensing unit traces and senses the physical environment and tells the processor to compute or process and store the data values in storage unit. The task of transmission unit is to receive the information from processor and transmit it to their cluster head or base station. Power unit regulates battery power supply to sensor node.



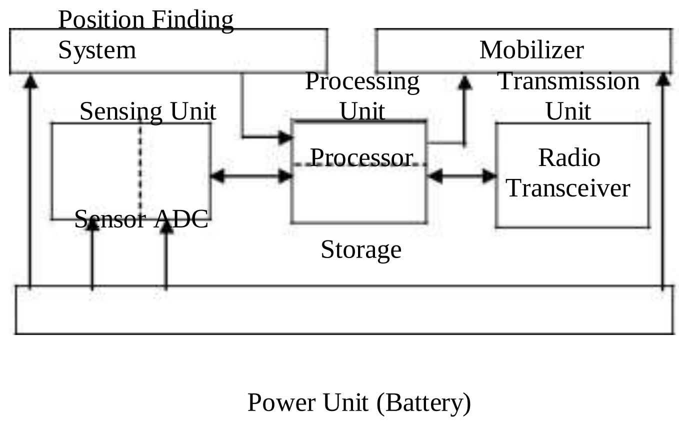




**Figure 1: System Model of Wireless Sensor Network [4]**

There are different protocols and techniques to achieve better network lifetime which include energy efficient routing. Routing in wireless sensor networks is a huge challenging task due to many characteristics that distinguish these networks from mobile ad hoc networks (MANET) or cellular networks. These difference include dense deployment of sensor nodes, limited bandwidth, limited transmission power and significant data redundancy. In the section III, various energy efficient routing protocols are discussed which helps in raising the energy efficiency of the node.

## LITERATURE REVIEW OF ENERGY EFFICIENT PROTOCOLS

In this section, we are surveying energy efficient protocols and techniques [1] based on their classifications. The sensor nodes are constrained to one time limited battery power resources itself, so the main focus is how to design an effective and energy efficient protocol and techniques in order to enhance the lifetime of the sensor network for specific application environment.

We classified the routing protocols [1] into four categories as shown in Table 1: Data Centric Protocols,

Hierarchical Based Routing Protocol, Location-Based Routing Protocol and Network Flow &QoS Aware Protocol depending on the network structure in wireless sensor networks.

**Table 1**
**Categories of Routing Protocols [1]**

| Category | Representative Protocols |
|---|---|
| Data Centric Protocols | Flooding and Gossiping, SPIN, Directed Diffusion, Rumor Routing, Gradient Based Routing, Energy-Aware Routing, COUGAR,CADR&ACQUIRE. |
| Hierarchical Protocols | LEACH, PEGASIS, H-PEGASIS, TEEN& APTEEN. |
| Location Based Protocol | MECN & SMECN, GAF & GEAR. |
| Network Flow &QoS Aware Protocol | Maximum LifetimeEnergy Routing, Maximum Lifetime Data Gathering, Minimum Cost Forwarding, SAR & SPEED. |

*(a). Data Centric (Flat Based Routing) Protocols:*

In data centric routing [6], all nodes have equal and same functions. Global identification to each sensor node is very difficult to assign in wireless sensor networks because the deployment of sensor network is very dynamic and dense.

In data-centric routing [6], base station (BS) sends queries to certain area and waits for the data values from sensors located in that selected area. To specify the properties of data,an attribute-based naming scheme is used to provide facilities in data-centric characteristics of sensor queries.

*(i). Flooding and Gossiping:*

Flooding and gossiping [5] are the old traditional network routing techniques. In flooding routing, each sensor node works as a transmitter as well as a receiver. Each sensor node transmits every data packet to its neighbors except the source node. When the data packet is received at the destination node or the maximum number of hops is reached, the process of data packet sendingis stopped. Although flooding technique is easier, but it has many drawbacks like implosion (duplicate data packet transmission to same node), overlap (two nodes sense the same area send same data packets to the same neighbor nodes) and resource blindness problem (consumes massive amount of energy without considering the energy constraints).

*(ii). SPIN (Sensor Protocols for Information via Negotiation):*

SPIN [8] is based on negotiation between the sensor nodes by data advertisement through meta-data (a high-level name to the data). SPIN [8] performs meta-data negotiations before the transmission of any data packet. SPIN avoids the flooding problems like implosions, overlaps and resource-blindness.

The drawback of SPIN [8] is that it is not sure whether the data packet will certainly arrive to the target or not and it is inefficient for very dense distribution of sensor nodes.
So, SPIN [8] is not better option for applications.

*(iii). Directed Diffusion:*

Directed diffusion [7] is data-centric; in a directed diffusion-based network,all the sensor nodes are application-oriented. This protocol saves energy by selecting better routing paths and data aggregation (caching and processing data) in the sensor network. SPIN protocol instructsthe sensors nodes to send advertisement packets for the availability of data and the sensor nodes who are interested [8], sends query back for that data packet. But in Directed Diffusion the base station (BS) sends queries to the sensor nodes only if a specific packet is available or not.

The main benefits of directed diffusion [7] are:

1) It is a data centric technique, so all data packet transfer is neighbor-to-neighbor without a node recognition or identification addressing method. Each sensor node is able to do aggregation and caching for sensing. Caching is a massivebenefit for energy efficiency and time delay.

2) Since it is on demand technique and there is no global network topology mechanism in it, so Direct Diffusion [7] is quietly energy efficient.

Directed Diffusion [7] is not a better option for the environmental monitoring applications since it requires continuous data delivery to the base station which will not work effectively and efficiently with a query-driven on-demand data model.

*(iv). Energy-Aware Routing:*

Energy aware routing [10] protocol is power efficient technique to reduce the energy cost for data packet transmission and can enhance lifetime of the network. Unlike directed diffusion [7], data packet is transmitted through several low cost optimal routing paths but at higher rates instead of transmitting through one optimal path. The transmission routing path is selected by probability value of each routing path. The probability values make a balance for initial network load and increase the lifetime of the network.

The drawback of energy-aware routing [10] is that the local information exchange is needed among neighborsensor nodes and each sensor node has a unique address, which enhances the cost of routing paths.

*(v).Gradient-Based Routing:*

Gradient-Based routing [9] is amodification and improvement of Directed Diffusion, for achieving total minimum number of hop rather than total shortest time. In the old gradient protocol, hop count is the only metric, which measures the route quality of the path. The new proposed, gradient routing protocol [9] is considered as hop count as well as the remaining energy of each node, while transmitting data from source node to the base station. This protocol [9] is used in handling the frequently change of the topology of the sensor network due to failure of the node in wireless sensor network.

*(b)Hierarchical-Based Routing (Clustering):*

Hierarchical-Based routing [11] is a technique for point-to-point routing with minimum routing state. It has certain benefit of efficient data packet transmission and scalability.

Hierarchical routing [11] maintains the energy consumption of the nodes and performs aggregation of data for helping in reducing the number of data packets transmitted to the base station. Some hierarchical protocols are reviewed here.

*(i). LEACH:*

LEACH (Low-Energy Adaptive Clustering Hierarchy) [13] is the foremost hierarchical-based routing protocol. When the node in the WSN fails or its battery backup goes down then LEACH [13] protocol is used in the network. In LEACH, [13] wireless sensor nodes are grouped into local clusters and the cluster members select their cluster head (CH) to avoid extra energy consumption utilized by sensor nodes and incorporate data aggregation which reduces the number of data packet sent to the base station, to enhance the lifetime of the network. Therefore this protocol has an effect upon battery power saving.

Two-Level Hierarchy LEACH (TL-LEACH) is a modified and improved form of the LEACH protocol which has of two levels of cluster heads namely primary and secondaryinstead of a single cluster head. The advantage of two-level structure of TL-LEACH is that it minimizes the amount of sensor nodes that transmit data packets to the base station, soit minimizes the total energy consumption.

*(ii). PEGASIS and Hierarchical-PEGASIS:*

PEGASIS [12] (Power-Efficient Gathering in Sensor Information Systems) is chain-based routing technique that is an improvement and modification of LEACH. When sensor nodes are deployed randomly in the environment then PEAGSIS [12] designs a node chain and each sensor node communicates only with a neighbor nearer to it, which take its turns and transmit data packet to the base station, so it minimizes the amount of energy consumed per round.

By elimination of taking dynamic cluster formation, PEGASIS [12] performs better than LEACH [13] since the transmission time will be too long and data packet transmission is asynchronous. Hierarchical-PEGASIS makes a further modification and improvement; it allows concurrent parallel data packet transmission when the nodes are not adjacent.

*(iii). TEEN and APTEEN:*

TEEN [15] (Threshold Sensitive Energy Efficient Sensor Network) protocol and it was first implemented for reactive networks. It is mostly used in temperature sensing applications.

TEEN [15] is based on hierarchical clustering that divide the sensor nodes twice for clustering group to detect the sudden changes in the sensed data values such as minor changes in temperature.TEEN [15] divides the cluster head (CH) into the second-level cluster head after the clusters formation and uses Hard and Soft threshold values to detect the sudden changes in the environment.

Hard threshold minimizes the number of data packet transmissions.It allows the sensor nodes to transmit packet only when the sensed value is in the high range of hard threshold value. The soft threshold also minimizes the number of packet transmissions.It allows all packet transmissions when there is minimum change in sensed value.

The drawback of TEEN [15] is that it is not suitable for applications where regular data is needed on regular basis. The practical implementation is not certain because there is no collision in the cluster. TDMA scheduling can be applied for this problem but it creates a time delay to reportfor the time-critical data. CDMA may be possible solution to overcome this problem. TEEN [15] is best suitable for time critical applications such as explosion detection, intrusion detection, radiation detection etc.

The Adaptive Threshold Sensitive Energy Efficient Sensor Network protocol (APTEEN) is an improvement and modification of TEEN and focused at both capturing periodic sensed data collections and reacting to time critical events. The architecture of APTEEN is similar to TEEN. In APTEEN, when the cluster heads are selected, in each cluster period, then the cluster head broadcasts the parameter such as sensed data values, threshold values and count time to all its cluster nodes.

The performance of APTEEN lies between TEEN and LEACH in terms of power consumption of sensor node and network lifetime.TEEN protocol transmits only the time critical sensing data, whereas APTEEN supports periodically recorded report for time-critical events. The drawback of these twoprotocols are the overhead and

complexity of forming clusters.

*(c). Location-Based Routing:*

Location-Based routing protocols need location information of other nodes in wireless sensor networks. Location information is needed to calculate the distance between two nodes on the basis of signal strength, so that energy consumption can be calculated. There are many location-based protocols in Ad Hoc networks and it makes huge effects when those research techniques are deployed and protocols for wireless sensor networks in same ways.

*(i). MECN and SMECN:*

Minimum Energy Communication Network (MECN) [14] constitutes a minimum energy network for wireless sensor networks by using low power GPS. In this protocol, network is treated as a mobile network, it is best applicable to sensor networks that are not mobile. MECN assumes a master site region as an information base station, which is always the case of the wireless sensor networks.

MECN [14] identifies a relay region for each node. The relay region contains nodes in a surrounding area where data packet transmissionthrough those nodes is more energy efficient than direct transmission.

MECN [14] is dynamic, robust and self-reconfiguring, thus can dynamically deploy to nodes failure or the additional deployment of new sensors.

The small minimum energy communication network (SMECN) [14] is an improvement and enhancement of MECN. In MECN, it is assumed that each sensor node can send data packets to other nodes, which is not possible practically every time. The sub-network of SMECN for minimum energy relaying is the one constructed in MECN if broadcasts is reachable to all nodes in a circular area around the sender node. SMECN [14] uses less energy consumption than MECN and low maintenance cost of the links. However, finding a sub-network with smaller number of edges produces more overhead in MECN.

*(ii). GEAR:*

GEAR [17] uses energy aware and geographically informed neighbor selection mechanism to route a data packet to the target sensor nodes or base station. GEAR [17] balancespower consumption and enhances lifetime of the network. When a neighbor node is closer to the destination node exists, then GEAR [17] passes the data packet to the destination by selecting next-hop among all neighbor nodes that are nearer to the destination. When all neighbor nodes are at long distance, then there is a „hole‟ problem, GEAR [17] passes the data packet by choosing a next-hop node that reduces some cost value of neighbor node. Recursive Geographic Forwarding protocol is used to broadcast the data packet within that area.

GEAR [17] is compared to similar non-energy aware routing protocol like GPSR, which is earlier works in geographic routing protocol and planar graphs are used to solve the problem of holes. GEAR delivers 70% to 80% more packets compared to GPSR. GEAR delivers 25 - 35% more packets than GPSRfor uniform traffic pairs.

*(iii). GAF and HGAF*

Huge numbers of sensor nodes are deployed in GAF

**A** (Geographical Adaptive Fidelity) Protocol in observed region and only few nodes in the observed region are selected for packets transmission, but the other nodes do not work. In this technique, GAF [18] minimizes the number of nodes required to make a sensor network and maximizes the lifetime of the sensor node.

Hierarchical Geographical Adaptive Fidelity (HGAF)

**B** protocol saves much more battery energy by enlarging the cell of GAF with the help of adding a layered structurefor selecting an active node in each cell. GAF [18] improves battery power by making large size of the previous cell.

The limitation of HGAF [19] is the position of active sensor node in a cell and it synchronizes the position in each cell among other cells. With the help of this improvement, the connectivity among active nodes in the adjacent cells can be certainly stronger for a large size cell than in GAF.

HGAF [19] has better performance than GAF in terms of survived sensor nodes and the packet delivery ratio when the density of the sensor node is very high in WSN. The network lifetime of randomly distributed dense networks with HGAF is very longer compared to GAF.

*(d). Network-flow-based routing / Quality-of-Service based routing:*

Main target of network-flow-based routing protocols is to balance the network traffic and to maximize the network lifetime [16]. Maximum lifetime energy routing presents link costs depending on remaining energy and required energy for packet transmission, which are utilized to make even out the energy expenditures of the sensor nodes. Quality-of-Service (QoS) functions as end-to-end ensures and further examination of solid data packet transmission are modern advanced feature of routing protocols. An example for a Quality-of-Service approach is the location-based protocol SPEED, which allows the estimation of end-to-end delays by ensuring a higher data packet speed.

## PROBLEM FORMULATION

The sensor nodes of wireless sensor network are electronic or electromechanical device and they are equipped with one time limited power source only. For these reasons, researchers are currently concentrating on the implementation of energy saving protocols and techniques for sensor network.

The problem formulationhare is not problems in the energy efficient protocols but these are limitations of the protocols and techniques. In this survey, we are pointing out limitations of modern energy efficient protocols which was analyzed in the section of literature review are as follows.

*4.1 Equal Sized Clustering:*

In modern energy efficient protocols like LEACH, TEEN and APTEEN protocols, equal sized clusters are formed, the cluster heads (CHs) nearer to the base station (BS) have more work load than other cluster heads which are farther away from base station (BS) because cluster heads nearer to base station receive packets from sensor node of his cluster as well as it receives packets from other cluster head through multi-hopping and they work with huge traffic.

As a result, the battery power of the cluster head nearer to the base station will die earlier as compared to other cluster heads. This concept of equal sized clustering creates unbalancing condition in wireless sensor network for enhancement of network lifetime point of view. Also attribute values can be changed at the time of cluster head selection in equal sized clustering technique according to the requirements.

*4.2 Probability Based Cluster Head Selection:*

The selection of cluster head (CH) in modern protocols is totally on the bases of the probability. There are no calculations of contained energy level of the nodes from cluster while the cluster head selection. Because the ratio of current energy to initial energy among the sensor nodes are not similar they are different so probability based cluster head selection cancreate unbalancing in cluster head selection.

*4.3 Proactive Routing Protocol:*

Modern protocols work as a proactive routing protocol, here all nodes continuously sense their environment and continuously send data packets to the base station. Because data packets transmission consumes more energy than sensing so this is the limitation of proactive routing protocol.

The sensed data packets continuously received have same repeated attributes or values in the data this is useless for the observer or user of the sensor network.

*4.4 Limitation of Heterogeneity:*

Many modern protocols are heterogeneity aware protocols that improve stability period and network lifetime but limitation of heterogeneity is that the throughput is also increased which minimizes network lifetime.

## PROPOSED METHODOLOGY

Clustering provides an effective and efficient way to maximize the network lifetime of a wireless sensor network. The clustering algorithms in our proposed methodology can be implemented with two techniques, first the selection of cluster heads with more residual energy in nodes and second rotating cluster heads (CHs) periodically on the basis of probability, for even distribution of energy consumption among sensor nodes in each cluster and for network lifetime enhancement. When cluster heads cooperate with other cluster heads to transmit and forward their packets to the base station, the cluster heads nearer to the base station are loaded with heavy traffic of data packet transmission and tend to die earlier, leaving other areas of the network uncovered and creates network partition.

To address these limitations, the concept of unequal clustering technique can be implemented for periodical data packet gathering in wireless sensor networks. It makes the groups of sensor nodes into unequal sized clusters and clusters closer to the base station are formed smaller in size than those farther away from the base station. Thus cluster heads nearer to the base station can preserve some battery power for the inter-cluster data packet transmission and forwarding.

## CONCLUSION

In this overview, we exhibited the exploratory extensive survey and hypothetical investigation of various vitality productive conventions by which organize lifetime of the remote sensor systems can be boosted and moved forward. Steering is the most imperative methodology that gives vitality productivity, and improveslifetime of the system. Numerous proposed steering conventions arenot appropriate for all kind of utilizations in remote sensor networks.Many issues, change, improvement and testing errands, for example, adequacy, versatility, flexibility and so forth still exist that should be unraveled and connected in the remote sensor systems.

Albeit a hefty portion of these steering systems look viable, there are still numerous testing errands that should be enhanced in the sensor systems like equivalent estimated bunching, group head choice, static base station and so forth. We highlighted those testing undertakings and highlighted future examination bearings in this exploration area.The study will help toorient the advancement of future recommendations very much adjusted in all region of sensor systems.

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