WSN Energy Proficient Routing Algorithms and Protocols: A Literature Survey

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***Abstract* - A wireless sensor network (WSNs) is composed of sensor nodes having a set of processor and limited memory unit embedded in it. The most important task for such network is to provide reliable routing of packets from the sensor nodes to its base station. In Wireless Sensor Networks, routing is much more complex than other wireless networks. In WSN routing strategy should be the energy efficient. This survey paper gives an overview of the different routing protocols used in wireless sensor networks and gives a brief working of energy efficient routing protocols in WSN. This study presents the comparison among different routing protocols based on various parameters towards the energy efficiency for WSNs.**

***Index Terms* - Wireless Sensor Networks (WSN), Routing Protocols, Energy Efficiency.**

I. INTRODUCTION

The basic suggestion of anytime and anywhere computing leads to the new field called mobile computing. The major stimuli for the growth of mobile computing are due to advancement in wireless technology. The improvement in wireless transmission techniques lead to the development of the WSN. A wireless Sensor network includes various application areas like environment monitoring, military applications and context aware computing environments etc.
All the sensor nodes are battery powered devices, and energy consumption of these nodes affects the life-time of the entire network during transmission or reception of packets. Presently number of energy efficient routing protocols has been developed like LEACH protocol, PEGASIS protocol etc. These protocols have achieved efficiency for static sensor network only. This paper presents the survey on energy efficient routing algorithms and protocols in Wireless Sensor Networks (WSNs). The section II describes the existing routing protocols in WSN and section III gives an overview of energy efficient routing protocols like LEACH, PEGASIS, HEED, and DECA . The section IV concludes our paper with the future direction in WSNs.

II. ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORKS

A There are number of routing protocols have been developed for wireless sensor networks. These protocols have been characterized based to its constraints in the processing power and limited battery power. These protocols fall under following three categories: 1.Direct approach, 2. Location based routing, 3.Data centric routing. The classification of WSN routing protocols is shown in figure 1.

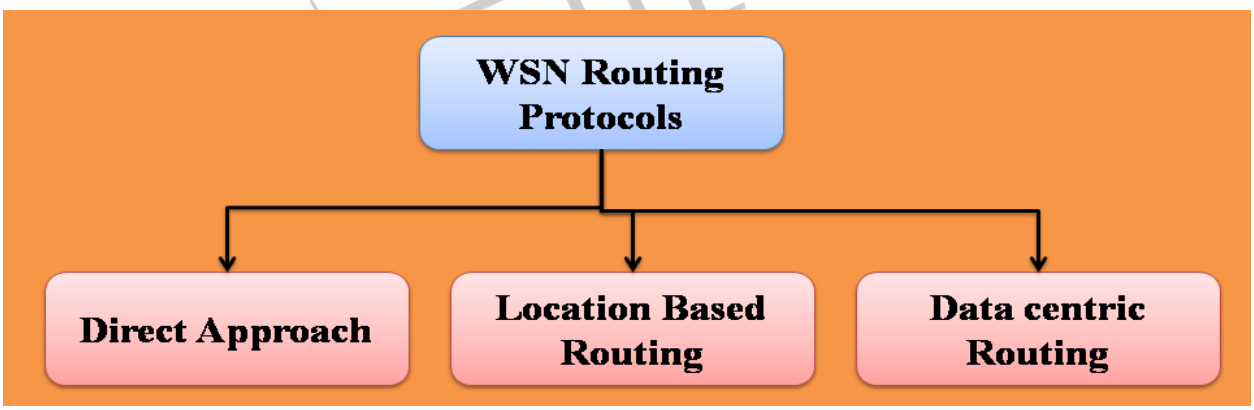

Figure 1: Routing Protocols in WSN

2.1 Direct Approach:

The Direct approach routing protocols are simple flooding type routing protocols which are ease in its implementation but not an energy efficient protocol for the sensor networks. However in Location based routing protocols the base station communicates with sensor nodes based on its locality information. All the nodes are conscious of their location through GPS (Global Positioning System) receivers in the network. Data centric based routing uses the information gathering technique and collect information from the sensor nodes which satisfies its interest. Direct diffusion and rumor routing are the examples for data centric approach based routing.

2.2 Location Based Routing:

Location based routing involves the routing of data to the nodes by the geographic location of the nodes (i.e.) nodes are identified by its location only. The low power GPS receivers are embedded in sensor nodes to obtain the location information of the individual nodes in the network. Numerous "Location based routing" are

- Greedy approach
- Compass routing
- DREAM
- GPSR
- GEAR

2.2.1 Greedy approach:

In **[1]** I.Stojmenovic et al. stated that the node Y is the inter-mediate node nearer to the node D from the source or intermediate node S , sends the data packet to the destination D. The data packet flows through the intermediate nodes as shown in following figure 2 until it reaches to the destination node D.

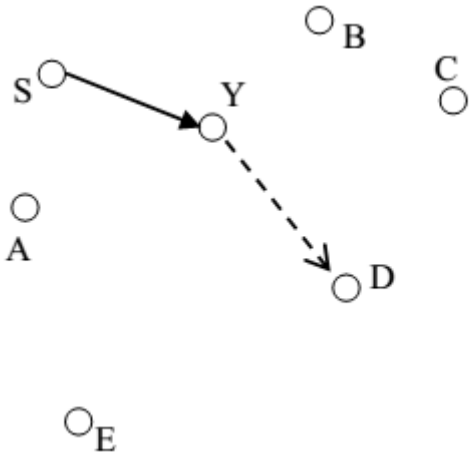

Figure 2: Greedy approach

2.2.2 Compass routing:

In **[2]** E.Kranakis et.al stated that the S is the source node which calculates the direction of the destination D and the neighboring node Y which is having closest direction to the destination than S.As shown in figure 3, D is selected as the next eligible intermediate node to route the data from the source node.

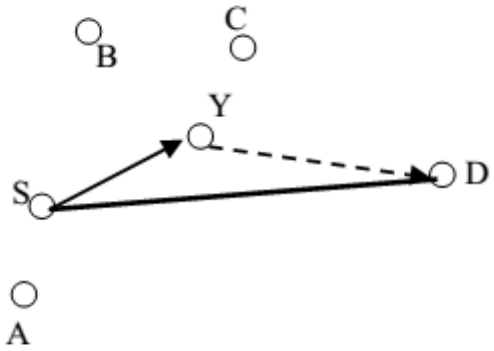

Figure 3: Compass routing approach

2.2.3 DREAM [A distance Routing Effect Algorithm for Mobility]

In **[3]** S.Basangi considered the model of flooding packets to all the neighboring nodes of node x, here a different approach was considered. The data is only flooded to the limited number of nodes under the area of tangents from source node S to the circle centered at destination D as shown in figure 4. Since data has been forwarded to limited number of nodes, so this scheme gives better transmission of data than its predecessors schemes.

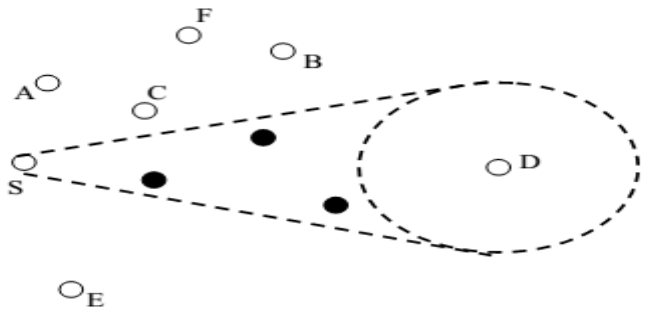

Figure 4: Routing structure in DREAM protocol [3]

In the Figure 4 source node S receives data messages towards area dotted nodes under the tangents connecting the circle.

2.2.4 GPSR [Greedy Perimeter Stateless Routing]

Greedy perimeter stateless routing is the modified version of greedy-face-greedy algorithm **[4]**. GPSR uses the combination of two approaches; greedy approach and perimeter approach. In the beginning the data is forwarded by using greedy approach and if the packet gets jammed at any point in the network, then only perimeter approach is used. The main point in this protocol to be noted is that perimeter approach is continued till a node closer to the destination is found than the node at which the data packet got jammed. It ensures the guaranteed delivery of packets to the destination node.

2.2.5 GEAR [Geographic & Energy Aware Routing]

In **[5]** Y.Yu et.al considerd the least cost path to route the data packets to the destination node identified through its location information. GEAR routing used the different approach than its previous routing protocols.

2.2.6 GAF [Geographic Adaptive Fidelity]

In **[6]** Y.Xu, D.Estrin et. al proposed that all the nodes will be associated with a particular grid coming under the particular geographical range . For the nodes which are under same grid network have the same communication cost. During the routing decision any one node from the particular grid will awaken and takes part in routing; while rest of the nodes in the same grid will inactive to avoid needless energy diminution.

2.3 Data centric routing

A wireless sensor network can be different from the other wireless networks in terms of address of the node and the content of the node. The Location based routing utilizes the entire sensor nodes in the particular region as the whole system rather than as the individual nodes. This concept leads to Data centric routing in sensor network; where routing decisions is based on content of data held by the nodes in the network rather than their locality information. Following are some of data centric routing protocols,

- Directed diffusion
- SPIN
- Rumor routing

2.3.1 Directed Diffusion

In direct diffusion **[7]** the data generated in the nodes is identified by its attribute-value pair. At first, the base station discharges the data packet of "interest" throughout the network. The issued user interest is compared with the event record in the concerned node while flooding throughout the network. If the event record matches with the packet of "interest" is sent to the base station otherwise the "interest" is passed to the nearest nodes. In the direct diffusion technique, the use of gradients is an important factor. The base station have to select the gradient having least delay time than others whenever the source node is responding to the base station during the receiving of data from multiple routes. The Directed Diffusion technique uses fundamental essentials are,

Interest propagation: This assignment is represented by the attribute value pair and diffused through the network.

Data propagation: This assignment is represented when the user "interest" matches with the event record, the data are forwarded back to the base station.

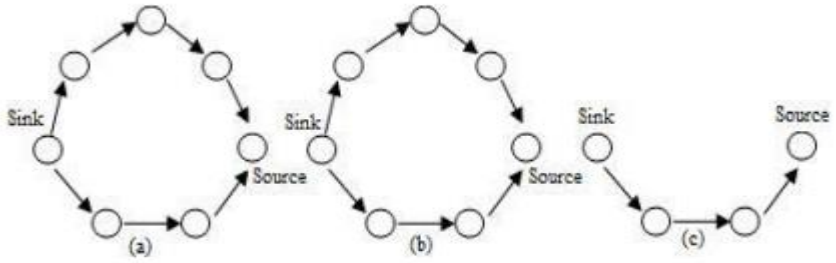

Figure 5: Directed Diffusion- (a) Interest Propagation, (b) gradient formation and (c) selection of optimum return path. [7]

2.3.2 SPIN

SPIN protocol stands for "Sensor Protocols for Information Negotiation" **[8].** It is a protocol based on data centric approach. It involves three subsequent steps in data transformation between the nodes; and hence called as the three-stage protocol. At first stage, node generates information which is closely acquainted to its one-hop neighbors using ADV (advertisement) packet as shown in figure 6. At second stage, if the neighbor node needs of the information then it requests the data through REQ (request) packet. At last third stage, the original DATA packet will be sent to the neighbor node. SPIN protocol removes redundancy of data packets from the sensor networks. The disadvantage of this routing method is that if a node which is in need of the data can't receive the data when it is not coming transmission range of one-hop neighbor node to the source node which generates the data packet.

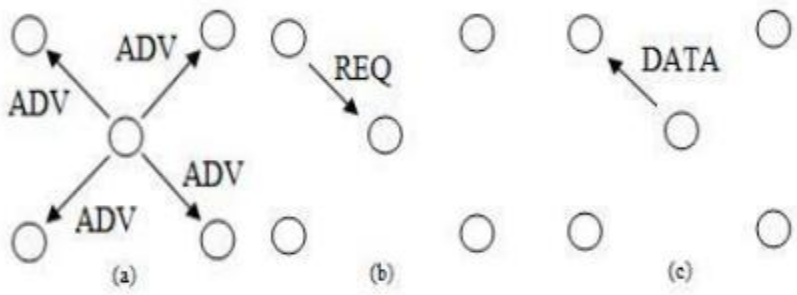

Figure 6: SPIN Protocol-(a) Data advertisement (ADV), (b) request (REQ) and (c) transferring of original DATA

2.3.3 Rumor routing

As in previous method base station is the initiator which gathers the information of data. Another approach could be adopted where the source node may acts as the initiator in passing sensed data to the base station; and this approach is called as the rumor routing **[9].** In Rumor Routing approach sensor nodes collects the information i.e. sensed data which is sent to its neighboring nodes till it reaches the concerned region of the network.

III. RELATED WORK IN ENERGY EFFICIENT ROUTING

This Wireless sensor networks have several issues to consider; energy efficient routing is one of those. Many researchers have proposed various methods to perform energy efficient routing in WSN. Whenever sensor nodes transmit data, their battery power gets reduced and hence we can say that data transmission in wireless communication takes more power than data processing. We can use data fusion or aggregation techniques to reduce the data size. Data fusion technique is one in which the sensed data are fused at certain point from different nodes suitable for the transmission in its reduced size. Data aggregation techniques are of two types. The first type of data aggregation technique fuses the data collected from different sources and sends the final fused data in reduced size. This approach has limitation that it is deficient in accuracy and precision of data from various sensor nodes. The second type of data aggregation technique merges the data to form single unit from different sources under the single header and forwards it to the base station. This approach consolidates the header packets and passes it to the base station without any modification to the original data from the sensors. This improves the accuracy and precision. WSN Energy efficient routing classified based on two approaches:

- Clustering approach
- Tree based approach

3.1 Clustering approach:

The approach of dividing the networks into small controllable units is called as clustering. The clustering technique advances the scalability of network through ease of implementation and results energy efficient routing within the sensor networks. The clustering approach has some other advantages also like conserving communication bandwidth, avoiding redundant message transfer, localizing energy efficient route setup etc. LEACH, HEED, DECA, etc. are the energy efficient routing protocols based on clustering technique.

3.1.1 LEACH:

LEACH stands for Low energy adaptive clustering hierarchy **[10]**. It uses the clustering technique to distribute the energy consumption beside its network. LEACH protocol divides the network in the form of cluster heads and clusters to gather the data packet information. The cluster heads do get together with cluster nodes to collect the data information. Each round of LEACH protocol performs following steps:

Advertisement phase: It is the first step. The cluster head issues a notification to the nodes to become a cluster member in its cluster within its transmission range. The nodes recognize the information based upon the Received Signal Strength [10].

Cluster set-up phase: Nodes within cluster respond to their cluster heads.

Schedule creation: After receiving reaction from the cluster nodes the cluster head (CH) construct TDMA scheme and send it back to cluster node member to intimate them when they have to pass their information to it [10].

Data transmission: The data collected by the individual sensors will be transmitted to the cluster head during its time interval and on all other time the cluster members radio will be off to reduce it energy consumption [10].

In LEACH protocol cluster head (CH) is responsible for collecting data from its cluster members and fuse it. Finally each cluster head will be forwarding the fused data to the base station. This protocol solves the problem of multi cluster interference problem by using unique TDMA scheme for each cluster. This protocol also helps to avoid energy depletion for the same sensor nodes which has been elected as the cluster leader, using randomization for each time cluster head would be changed. LEACH protocol has shown a considerable improvement when compared with its other energy efficient protocols [10].

3.1.2 HEED:

The main drawback of LEACH protocol is the random selection of cluster head nodes. In worst case scenario the CH nodes may not be uniformly distributed among the nodes which may affect on the data gathering process. A new algorithm called HEED **[11]** (Hybrid Energy Efficient Distributed clustering approach) was developed to avoid the random selection of CHs which selects the CHs based on both residual energy level and communication cost. This protocol executes three phases:

Initialization phase: Initialize CHs nodes along with other nodes in percentage. It is represented by the variable Cprob. Each sensor node computes its probability to become CH by, CHprob=Cprob * Eresidual/Emax

Where, Eresidual is residual energy level of node, Emax is maximum battery energy. Because this approach supports heterogeneous property of network of sensor nodes; Emax may vary for different nodes according to its functionality and capacity.

Repetition phase: This phase is iterated till the CH node is found with the least transmission cost. If the node cannot locate the suitable CH, then the apprehensive node itself selected as the cluster head.

Finalization phase: The selection of CH is finalized at this phase. The provisional CH now becomes the final CH node.

3.1.3 DECA:

DECA stands for Distributed Efficient Clustering Approach **[12]**. In DECA nodes take the decision and the score computation value. DECA involves following phases:

Start Clustering: Initialize all the nodes to compute its score using following equation.

Score = w1E+w2C+w3I

E is the residual energy, C is the node connectivity, and I is the node identifier. After some interval of time the Score value computed with respect to the neighboring nodes with the node ID and cluster ID.

Receive Clustering Message: When the receiving node has higher Score value higher than it, then it is not attached to any cluster accepts the sender node as its CH.

Actual announcement: In this phase all the node are broadcasted with CHs ID, cluster ID and score value.

Finalize Clustering: This phase is same as HEED protocol that the provisional node with its cluster head is finalized for all other nodes.

3.2 Tree Based Approach:

Another way of energy efficient routing in WSN is tree based approach. In this approach a hierarchical manner of tree structure is formed with aggregation points. The leaves are the source nodes and the root is the sink node. In this literature survey we are discussing with only one and popular tree based approach protocol named as PEGASIS protocol.

3.2.1 PEGASIS:

PEAGASIS stands for "Power Efficient Gathering in Sensor Information System" **[13].** This is the improved version of LEACH protocol by forwarding the data packets to only one neighbor of the node. It forms a chain structure towards the base station and data packets would be forwarded to this BS node in hierarchical manner.

Table 1 Comparison of the protocols in terms of its related parameters data.

Protocols	Distributed Cluster Heads	Cluster Stability	Mobility support	Latency in Sensor Network
Direct Approach	N/A	N/A	NIL	LOW
Direct Diffusion	N/A	N/A	NIL	HIGHER
Rumor Routing	N/A	N/A	NIL	ACCEPTABLE
LEACH	MODERATE	MODERATE	NIL	ACCEPTABLE
HEED	GOOD	GOOD	NIL	ACCEPTABLE
DECA	GOOD	GOOD	NIL	ACCEPTABLE
PEGASIS	N/A	N/A	NIL	HIGHER

In PEGASIS collected data is merged and the merged data will be forwarded to its one hop neighbor directly. It achieves the energy efficiency because all the nodes are performing the data fusion at its place there is no quick reduction of power for the nodes available near the Base station. Every node gets a chance to forward the gathered data to the base station. Whenever the sensor node measurements are aggregated to be a single packet, then only fraction of the data generated by the sensor is given to the base station where the collective stuffs of data are present in the root node and the better-quality data can be achieved by further tree traversal algorithms.

Although the Directed Diffusion **[14]** and Rumor routing **[15]** techniques are also tree based approach in terms of energy efficiency but it lacks behinds compared with PEGASIS protocol. Following table1 represents the comparison of energy efficient routing protocols in terms of related parameters for WSN.

IV. CONCLUSION & FUTURE WORK

In this literature survey, the existing routing strategies in the wireless sensor networks (WSNs) and their corresponding protocols had been explained. Although all the protocol mentioned above are proved to be energy efficient than its previous protocols, but all these protocols assume the nodes to be static and stationary. Further the comparative analysis among these energy efficient routing protocols has been stated. Future works may concentrate on achieving better energy efficient routing mechanism for wireless sensor nodes with mobility.

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