# Wireless Sensor Networks –A review on Routing Methods with Renewable Energy Management

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**Abstract:**

Energy management in Wireless Sensor Network architecture has become a crucial topic in recent years, due their existence in hazardous and difficult locations where it becomes difficult to augment Traditional source of energy through human interaction .A lot work on Energy optimization has been done in past through various routing methods.In fact the energy optimization is a must for survival of the WSN for longer span of life. Hence renewable energy source attached with individual node has to utilized more intelligently through different routing methods.This paper reviews and compares research papers on various routing methods adopted to achieve optimum utilization of energy sources engaged in WSN.

Keywords: WSN, LEACH, TEEN , BS (Base Station),

**1.Introduction:**

WSN: it is a combination of nodes which gather various environmental conditions like pressure of wind, temperature , humidity , movement of objects, etc, and therefore process the information and transmit the detected information to the client.BS gathers the information and connects to physical world, where the information is broken for exhibition via various applications.Wirereless Sensor Network are energized with Renewable Energy Source ( like solar energy, Wind Energy ,etc) generally these sources get depleted with time and WSN requires recouping of energy which is done automatically by intelligent routing techniques. The need here arises to optimize these existing renewable energy resources. Numerous routing methods have been expedited in recent past since introduction of WSN. The paper illustrates catagories of routing methods and Tools to implement the routing programs. It also explains techniques introduced in individual paper . The review paper finally compares the results/ conclusion of each Paper reviewed in previous sections. Conclusion gives overview of study and Future scope is this field of energy optimization .

**2: Routing of Wireless Sensor Networks**

UDG model defines a circle with optimum redii 1 unit arropunt esch node in WSN , it is good method to explain WSN model in theory but not good for practical networks because the transmission range of nodes might be different fro different nodes sue various environmental factors.So UDG widely used in literature widely to define WSN , so different Algorithm are used to know the neighboring nodes to relay the data from source to sink.With the advent of GPS technology we can easily get the feographical information of nodes at very low cost.AODV(AODV (Ad-hoc On-demand Distance Vector)[7] is a loop-free routing protocol for ad-hoc networks. It is designed to be self-starting in an environment of mobile nodes, withstanding a variety of network behaviors such as node mobility, link failures and packet losses.) and DSR (Dynamic Source Routing Protocol (DSR) is an on-demand protocol designed to restrict the bandwidth consumed by control packets in ad hoc wireless networks by eliminating the periodic table-update messages required in the table-driven approach.)are

very popular routing protocols , in these protocols the source node basically discovers the node through flooding of short messages in multihope WSN.

**2.1:Types of Wireless adhoc network routing protocols (Based on routing information update**)

2.1.1:Proactive routing protocols: in this type each node maintains own routing table so it is table driven routing protocol.DSDV, STAR, CGSR, LEACH. PEGASIS Advantage is minimum time to find the route & Disavantages are , requirement of periioding information update, high network overload, Hugh bandwirh requirement , so suitable for large WSN.

2.1.2:On demand routing protocol, here no node maintains routing table .they obtain path when required.TSR, AODV,TEEN DSR Main advantage are less broadcast message required,Low network overlaod, Low bandwidth wasrtage, Hence suitable for large WSN.Time to discover route is non predictable .

2.1.3:Hybrid Routing Protocol:Combination of both of above , where whole network is divided into Zone.CEDAR, ZRV, APTEEN The main advantage is it requires less memory and processing power, suitable for both proactive and reactive protocol. Disadvantage is that when boarder node run away , re-establishment of connection takes longer time.

**3:Types of Wireless adhoc networks**

3.1: Types of Wireless adhoc network routing protocols (Based on Temporal information update)

3.1.1:Based on past history : DSDV, AODV

3.1.2:Based on future data: LBR

3.2:Types of Wireless adhoc network routing protocols (Based on Topology information update)

3.2.1:Direct communication protocol: Node directly send information to base station ex: SPIN

3.2.2:Flat protocol: Node first searches valid path than sends data to BS, EX; DSR, AODV, Romer

3.2.3:Cluster based protocol: Network is devided into clusters and cluster head transmits data to BS. Ex: TEEN, CGSR

3.3:Types of Wireless adhoc network routing protocols (Based on network)

3.3.1:Data centric: Based on query , BS sends query and node will reply to BS , EX: SPIN

3.3.2:Heirarchical: Nodes with lower energy capture information while nodes with higher energy process and transmit data to BS, ex; TEEN, APTEEN

3.3.3Location based : Here location must be known to know the optimal path for flooding Ex: GEAR

**4:Need for Energy Efficiency:**

Energy efficiency means doing the same amount of task with less amount of energy i.e. eliminating the wastage of energy or it is a method of consuming lesser energy to attain same amount of output-task.reducing energy means reducing energy cost i.e. financial cost saving to Service provider and consumer as well.In WSN nodes having limited power are non replicable and non rechargeable, which make energy CONSUMPTION a signifinant issue for the designer of WSN.Also it is not easy to replace a node hence generates necessity of power saving to prolong the lifetime of the node.

4.1:Need For Energy Efficient Routing Protocol:

Energy efficient routing protocols are required to minimize the utilization of energy resources and thereby prolonging the network lifetime while processing and transferring the data.Various routing strategies are required for energy efficiency to transmit the data from nodes to base station .Finally energy conservation is very important for prolonging the lifetime the WSNs.

Routing protocols based on function mode are Proactive, Reactive & Hybrid whileRouting protocols based on participation style are Direct, Flat & Clustering and Routing protocols based on Network Structure are Data centric, Hierarchical and Location Based.

**5:Energy Efficient Routing Protocols:**

Energy efficient protocols are developed to reduce power consumption in data collection , processing , sampling & transmission to enhance the lifetime of

the wireless sensor network. Review of Most popular energy efficient routing protocols are explained in this section .

5.1: LEACH(Low energy Adaptive Clustering Hierarchy) [1],[2]

This is a hierarchical type of protocol here most of nodes communicate with CH( Cluster Head ) in two important phases.

a) The Setup phase: In this phase clusters are directed to select their select C.H. amongst the neighboring members nodes, The task of CH is to collect , cumulate, access, process the data and forward the information to base station.(Sink)
b) The steady state Phase: this phase is longer to communicate the dta to base station, To minimize the overhead , each node transfer the dta to CH , than CH schedule the data before forwarding to BS
c) In the set-up phase, clusters are formed and a CH is selected for each cluster. The CH is selected from the sensor nodes at a time with a certain probability. Each node generates a random number from 0 to 1. If this number is lower than the threshold node [T(n)] then this particular node becomes a CH. T(n) is given as follows:

T(n)=p/(1-p) [r mod(1/p)] , Where n ∈ **G=0 otherwise,**

where p is the percentage of nodes that are CHs, r is the current round and G is the set of nodes that have not served as cluster head in the past 1/p rounds

5.2: PEGASIS(Power Efficient GAthering in Sensor Information System)

It is the chain based protocol an up gradation of LEACH protocol , In PEGASIS every node transmit the data only with neighboring node to direct or obtain the information.BS can transmit or receive the information with this chain based leader node.If any node found dead , a new chain is developed keeping the universal information with each node.PEGASIS [3][6] is a near optimal chain-based power efficient protocol based on LEACH [2]. According to this protocol, all the nodes have information about all other nodes and each has the capability of transmitting data to the base station directly. PEGASIS assumes that all the sensor nodes have the same level of energy and they are likely to die at the same time. Since all nodes are immobile and have global knowledge of the network, the chain can be constructed easily by using greedy algorithm. Chain creation is started at a node far from BS. Each node transmits and receives data from only one closest node of its neighbors. To locate the closest neighbor node, each node uses the signal strength to measure the distance from the neighbors and then adjusts the signal strength so the only one node cab is heard. Each node requires global Sensors , information about the network. This is a drawback of this protocol because at any time it can be collected from the network.

5.3: TEEN( Threshhold sensitive Energy Efficient sensor Network )[4]

Hierarchical protocol used handle sudden change in environment parameters like temperature, it allows the node to transmit the parameter only when its is within hard threshold level.TEEN reduces number of transmission by soft threshold therby quite application in time important problems hence quite efficient in terms of saving energy and response time for SV ( Sensed Value)TEEN [4] is a cluster based hierarchical routing protocol based on LEACH. This protocol is used for time-critical applications. It has two assumptions,The BS and the sensor nodes have same initial energy, The BS can transmit data to all nodes in the network directly, In this protocol, nodes sense the medium continuously, but the data transmission is done less frequently. The network consists of simple nodes, first-level

cluster heads and second-level cluster heads. TEEN uses LEACH's strategy to form cluster. First level CHs are formed away from the BS and second level cluster heads are formed near to the BS. A CH sends two types of data to its neighbors—one is the hard threshold (HT) and other is soft threshold (ST). In the hard threshold, the nodes transmit data if the sensed attribute is in the range of interest and thus it reduces the number of transmissions. On the other hand, in soft threshold mode, any small change in the value of the sensed attribute is transmitted. The nodes sense their environment continuously and store the sensed value for transmission. Disadvantage is that the time slot may be wasted if a node has no data for transmission, Cluster heads always wait for data from nodes by keeping its transmitter on.

5.4:APTEEN( AdaPtive TEEN)[5]

It is an expansion of TEEN , Perfroms two functions gathering data and responding time critical events through algorithms . The main advantage w.r,t. to TEEN is that node utilize less power .Disadvantages are complications and lengthier different times,

5.5:DD( Direct Diffusion )[6][7]

It is type of Data Centric protocol for collecting and publishing the information from Source TO Sink.The main objective the extending the life of network by saving energy through continuous interaction amongst each node within limited environment by message exchange.Unique feature is localized interaction with multipath delivery makes respond the query from node to sink thus saving energy .

5.6:EESR( Energy –Efficient Sensor Routing )

It is a Flat routing algorithm to minimize power utilization and data latency also provide scalability to WSN, Mainly it contains Gateway, Base station Manager node, and sensor node. Manager and Sensor node collect the data from environment and send it to each other in one hop distance till the base station.

5.7: Rumor Routing :

Rumor routing [9] is a kind of directed diffusion and is used for applications where geographic routing is not feasible. It combines query flooding and event flooding protocols in a random way. It has the following assumptions: The network is composed of densely distributed nodes., Only bi-directional links exits. Only short distance transmissions are allowed. It has fixed infrastructure. In case of directed diffusion flooding is used to inject the query to the entire network. Sometimes the requested data from the nodes are very small and thus the flooding is unnecessary, so we can use another approach which is to flood the events when the number of events is small and the number of queries is large. The queries are rooted to that particular nodes that are belongs to the interested region. In order to flood events through the network, the rumor routing algorithm employs long-lived packets, called agents. When a node detects an event, it adds such event to its local table (events table), and generates an agent. Agents travel the network on a random path with related event information. Then the visited nodes form a gradient towards the event. When a node needs to initiate a query, it routes the query to the initial source. If it gets some nodes lying on the gradient before its TTL expires, it will be routed to the event, else the node may need to retransmit, give up or flood the query. Unlike directed diffusion, where data can be routed through multiple paths at low rates, Rumor routing only maintains one path between source and destination. Rumor routing performs well only when the number of events is small. For a large number of events, the cost of maintaining agents and event-tables in each node becomes infeasible if there is not enough interest in these events from the BS. Moreover, the Sensors 2010, 10 10518 overhead associated with rumor routing is controlled by different parameters used in the algorithm such as time-to-live (TTL) pertaining to queries and agents.

5.8: Geographic and Energy-Aware Routing (GEAR)

Location based routing protocols for sensor network need location information of all the

sensor nodes to calculate the distance between any two nodes. GEAR [10,11] is a location based routing protocol which uses GIS (Geographical Information System) to find the location of sensor nodes in the network. According to this protocol, each node stores two types of cost of reaching the destination: estimated cost and learning cost. The estimated cost is a combination of residual energy [22] and distance to destination. The learned cost is a modified estimated cost and it accounts the routing around holes in the network. When a node does not have any closure neighbors towards the target region, a hole occurs. In case where no holes exit, the estimated cost is equal to the learned cost. The GEAR protocol only considers a certain region rather than sending the interests to the whole network as happens in Directed Diffusion [6,7] and thus restricting the number of interests. There are two phases in this protocol: Phase-I: In this phase, packets are forwarded towards the target region. After receiving a packet, a node searches for a neighbor which is closer to the target region then itself. The neighbor is then selected as the next hop. If there are more than one suitable nodes then there exists a hole and in this case one node is picked to forward the packet based on the learning cost function. Phase-II: In this phase, the packets are forwarded within the region. If the packet reaches the region, it is diffused in that region by either recursive geographic forwarding or restricted flooding. If the sensors are not densely deployed, then restricted flooding is used and if the node density is high, then geographic flooding is used. In geographic flooding, the region is divided into four sub regions and four copies of the packet are created. This process continues until the regions with only one node are left.

5.9. Geographic Adaptive Fidelity (GAF)

GAF is an energy efficient location-based routing protocol. This protocol was initially conceived for mobile ad hoc networks, but it can also be applied to sensor networks. GAF can be implemented both for non-mobile and mobile nodes. Although GAF [10]is a location based protocol, it may also be implemented as a hierarchical protocol where the clusters are based on geographic location. Initially the area of interest is split into some fixed zones forming a virtual grid for the covered area. Nodes in each zone have different functionalities and each node uses its GPS-indicated location to associate itself with a point in the grid. Nodes which are positioned at the same point on the grid are considered equivalent in terms of the cost of packet routing. Such equivalence is exploited in keeping some nodes located in a particular grid area in a sleeping state in order to save energy. Thus GAF can increase the network lifetime as the number of nodes increases. GAF conserves energy by turning off unnecessary nodes in the network without affecting the level of routing fidelity. GAF defines three states: discovery, active, sleep. The ‘discovery’ state is used for determining the neighbors in the grid; the ‘active’ state participates in routing process and at the time of ‘sleep’ state, the radio is turned off. In order to handle the mobility, each node in the grid estimates it’s leaving time of grid and sends this Sensors 2010, 10 10519 to its neighbors. The sleeping neighbors adjust their sleeping time accordingly in order to keep the routing fidelity. Before the leaving time of the active node expires, sleeping nodes wake up and one of them becomes active.

**6: Comparative Study**

Now we compare the above mentioned routing protocols according to their performance depending on different parameters. Table below shows the comparison.

| **Protocol> Feature** | LEACH | TEEN | APTEEN | PEGASIS | SPIN | DD | RR | GEAR | GAF |
|---|---|---|---|---|---|---|---|---|---|
| Classification | Clustering | Reactive & Cluste | Hybrid | Reactive & Clustering | Proactive & Flat | Proactive& Flat | Hybrid & Flat | Location | Location |

| | | ring | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Network lifetime | Very Good | Very good | Very Good | Very Good | Good | Good | Very Good | Good | Good |
| Power Management | Maximum | Maximum | Maximum | Maximum | Limited | Limited | Unsupported | Limited | Limited |
| Mobility | Fixed BS | Fixed BS | Fixed BS | Fixed BS | Supported | Limited | Very Limited | Limited | Limited |
| Energy Awareness | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Scalability | Good | Good | Good | Good | Limited | Limited | Good | Limited | Limited |
| Query-Based type | No | No | No | No | Yes | Yes | Yes | No | No |
| Multi-Hop type | No | No | No | No | Yes | Yes | Yes | No | No |
| Network-Life | Very Good | Very Good | Very Good | Very Good | Good | Good | Very Good | Good | Good |

Table-1:Comparison of Different Routing protocols.

**6.1: Analysis of Routing Protocol**

As shown in table-1 , LEACH, TEEN, APTEEN and PEGASIS have similar features and their architectures are to some extent similar. They have fixed infrastructure. LEACH, TEEN, APTEEN are cluster based routing protocols, whereas PEGASIS is a chain-based protocol. The performance of APTEEN lies between TEEN and LEACH with respect to energy consumption and longevity of the network [9]. TEEN only transmits time-critical data, while APTEEN performs periodic data transmissions. In this respect APTEEN is also better than LEACH because APTEEN transmits data based on a threshold value whereas LEACH transmits data continuously. Again PEGASIS avoids the formation of clustering overhead of LEACH, but it requires dynamic topology adjustment since sensor energy is not tracked. PEGASIS introduces excessive delay for distant nodes on the chain. The single leader can become a bottleneck in PEGASIS. PEGASIS increases network lifetime two-fold compared to the LEACH protocol. In directed diffusion the base station sends queries to sensor nodes by the flooding technique but in SPIN the sensor nodes advertise the availability of data so that interested nodes can query that data. In Directed diffusion each node can communicate with its neighbors, so it does not need the total network information, but SPIN maintains a global network topology. SPIN halves the redundant data in comparison to flooding. Since SPIN cannot guarantee data delivery, it is not suitable for applications that need reliable data delivery. SPIN, directed diffusion and rumor routing use meta-data whereas the other protocols don't use it. Since they are flat routing protocols routes are formed in regions that have data for transmission, but for the others, as they are hierarchical routing methods they form clusters throughout the network. In case of hierarchical routing energy dissipation is uniform and it can't be controlled; but in the case of Sensors 2010, 10 10520 flat routing energy dissipation depends on the traffic pattern. For the previous case data aggregation is done by cluster heads but in the later case, nodes on multi-hop path aggregates incoming data from neighbours. GEAR limits the number of interests in Directed Diffusion by considering only a certain region rather than sending the interests to the whole network. GEAR thus complements Directed Diffusion and conserves more energy. According to simulation results, GAF performs at least as well as a normal ad hoc routing protocol in terms of latency and packet loss and increases the lifetime of the network by saving energy. Since the sensor networks are application specific, we can't say a particular protocol is better than other.

**7: Conclusions**

The past few years have witnessed a lot of attention on routing for wireless sensor networks and introduced unique challenges compared to traditional data routing in wired networks. Routing in sensor networks is a new area of research. Since sensor networks are designed for specific applications, designing efficient routing protocols for sensor networks is very important. In our work, first we have gone through a comprehensive survey of routing techniques in wireless sensor networks. The routing techniques are classified as proactive, reactive and hybrid, based on their mode of functioning and type of target applications. Further, these are classified as

direct communication, flat and clustering protocols, according to the participating style of nodes. Again depending on the network structure, these are categorized as hierarchical, data centric and location based. In this document we have discussed eight routing protocols and their comprehensive survey in Section 2. These eight protocols are LEACH, TEEN, APTEEN, PEGASIS, SPIN, DD, RR and GEAR. Since the sensor networks are application specific, we can't say any particular protocol is better than other. We can compare these protocols with respect to some parameters only. Future perspectives of this work are focused towards modifying one of the above routing protocols such that the modified protocol could minimize more energy for the entire system.

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