



Survey on Routing Protocols of Wireless Sensor Networks

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Abstract- *Wireless technology is gaining attention from users and researchers. Wireless network is a network composed of large number of sensor nodes. These sensor nodes communicate with each other and hence routers are selected. Routing is selected on the basis of routing protocols which are application specific. Sensor nodes in the network are battery powered. Hence route must be selected to make the communication efficient. In this paper, I have done a survey on network based structure routing protocols i.e. Flat based routing, Hierarchical based and Location based in wireless sensor network for selecting optimal routes in the network for communication.*

Keywords- *WSN, flat based routing, hierarchical based routing, location based routing*

I. INTRODUCTION

Wireless sensor network composed from number of sensor nodes to form a large network. Environmental conditions like sounds, temperature, pressure, direction etc are measured by wireless sensor network [1]. These sensor nodes sense the environment & communicate with each other or an external base station. The size and weight of these sensor nodes are small and light. The progression of WSN [1, 2] initially motivated by the military applications. Now a day, WSN are also used in civilian applications. The diagram of sensor node is shown in fig 1. A sensor node has components are: processing unit, sensing unit, a battery, transceiver and microprocessor to communicate with the network.

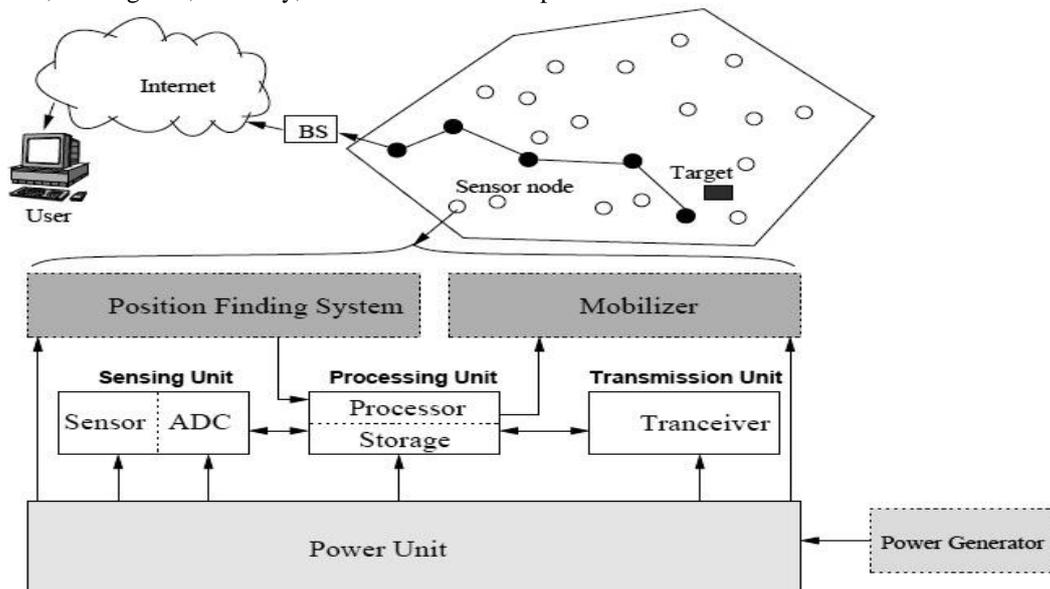


Fig. 1 Sensor node components [3]

A sensor unit is further divided into two sub units i.e. sensors and ADC. Sensors collecting the information from the surrounding environment & the ADC convert the analog information collected from the surroundings to digital output and pass it to the processing unit. Processing unit consists from storage, which is used for temporarily storage of information and passes the information to other nodes to perform sensing task. Transceiver passes data to the other nodes present in the network from the current node. Transceiver unit may be active, passive device or radio frequency device. Mostly, RF communication is preferred because in RF communication the size of transmitted packets is small, low data rate and frequency reuse is high. The power unit consists of energy sources such as batteries & solar cells [4]. To make nodes mobile, a mobilize device is used which makes the node adaptive to the environment.

II. ROUTING PROTOCOLS IN WSN

Routing is a method to finding out a path between the source node and destination node [5]. For routing purposes a device is used, called router. Router helps the message or packet to be sent to move from one node to another node and

reach to the destination. In routing mechanism, a routing table is used to finding the best path & sends the message or packet over the path. With the help of these routing table's intermediate nodes passes the data. But routing is preferred at high level because it is performed with software and a very complex process. Because analyzing the best path for the packets to be transmitted is preferred with the help of routing table. Routing protocols in WSN's are also classified into three types based upon the source find route to the destination i.e. proactive, reactive and hybrid routing. In proactive routing, before there is a demand for routing traffic, it sets a routing path. Even there is no traffic flow paths are maintained. In reactive routing, paths are set up on demand basis. Hybrid routing is the combination of both. Wireless sensor network routing protocols are divided as following:-

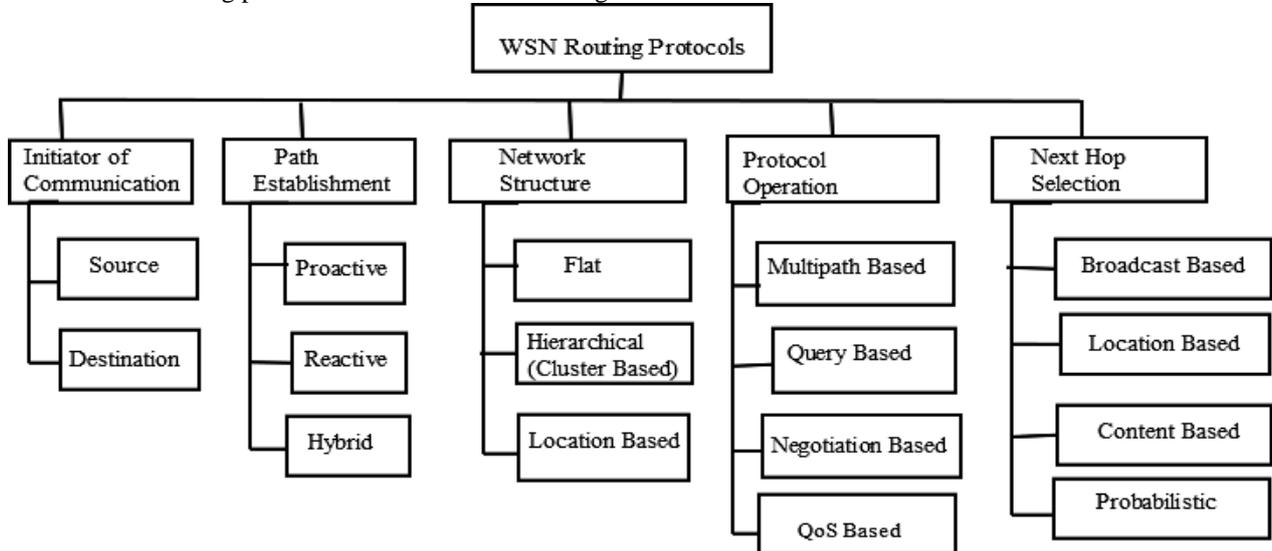


Fig. 2 Taxonomy of WSN routing protocols [6]

In this paper, study only the routing protocols based on network structure. Which are classified into three types: **Location based routing, hierarchical based routing and Flat based routing.** In Flat based each node have their own functionality or role. In hierarchical based each node plays different role in network. In location based the tracking of node location by the sensor node.

A) Location based routing - Location based routing protocols are using location information to guide the route discovery. In this the nodes are equipped with GPS and scattered in a particular network. The position of nodes can be determined with the help of GPS. On the basis of incoming signal strengths the distance between the neighboring nodes can be estimated. When the distance between any two nodes in the network is determined with the help of signal strength, we can know about the co-ordinates with the exchange of information or data with the neighboring nodes. Protocols come under location based routing are GEAR, GAF, GOAFR, GDIR, MECN and SMECN.

a) GAF (Geographic adaptive fidelity) - GAF is an energy aware algorithm designed for ad-hoc networks & also be applicable to sensor networks. In this algorithm firstly, the network area is divided into fixed number of zones & form a virtual grid. In each zone, nodes play different roles with collaborating to each other.

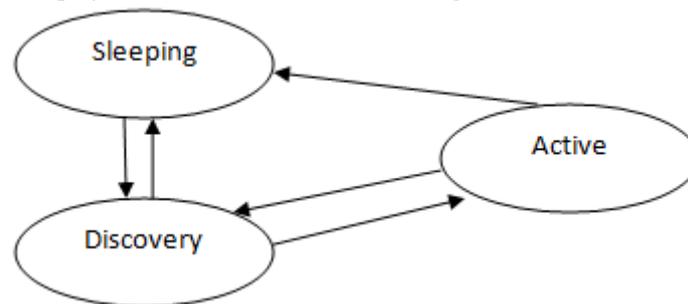


Fig. 3 Transition state diagram for GAF [8]

When sensor node enters the sleeping mode for energy saving, it turns off radio. In the discovery state, a sensor exchanging discovery messages to learning about other sensors in a grid. In the active state sensor continuously sends its discovering messages to inform equivalent sensors about its state [7,8].

b) GEAR (Geographic & energy aware routing) - GEAR [9] is an energy efficient routing protocol proposed for routing queries to target regions in the sensor field. In GEAR, sensors are supposed to have localization hardware equipped a GPS unit to know their current positions [9, 10]. GEAR uses energy aware mechanism that is based on the geographical information to select sensors to route a packet towards destination. Each node keeps an estimated cost and learning cost of reaching to the destination through neighbors. Estimated cost is the combination of the distance to the destination and residual energy. When a node does not have any closer neighbor to the target, a hole occurs. If there are no hole present, then the estimated cost equal to the learned cost.

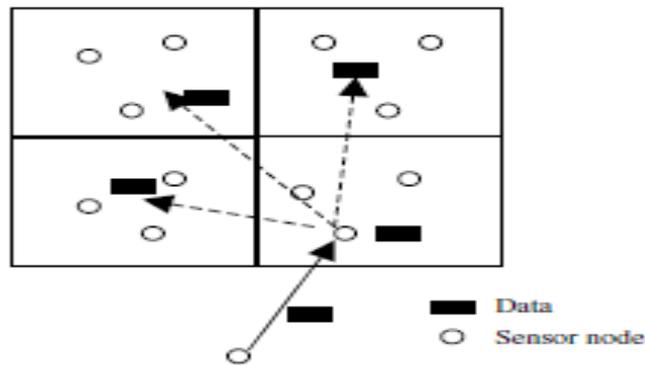


Fig. 4 Geographical forwarding in GEAR

c) **MECN & SMECN (Minimum energy communication network & Small minimum energy communication network)** - MECN sets up and maintains a minimum energy network by utilizing low power GPS for wireless network [11]. It is based on two phases. Firstly, it takes the positions of a two dimensional plane and constructs an enclosure (sparse) graph, which consists of all the enclosures in the graph from each transmit nodes. Secondly, finds the optimal links on the enclosure graph. It uses distributed Bellman ford shortest algorithm with power consumption as cost metric. SMECN (small minimum energy communication network) is an extension to the MECN. In MECN, at every time it is not possible to have every node can transmit to every other node [11,12].

B) Flat based routing - In flat based network every node plays the same role & collaborates together to perform sensing task. Due to the presence of large number of nodes, it is not feasible to assign global identifier for every node, data centric routing is used where the queries are performed to the sender and data is transmitted to the receiver node. BS (base station) sends the queries to the selected regions and waits for the data response from the selected regions of sensor nodes. Protocols come under flat based routing SPIN, directed diffusion, EAR, SAR, ACQUIRE, MCFA, CADR, RR, MCFA, GBR, IDSQ [13].

a) SPIN (Sensor protocol for information via negotiation) - SPIN is a protocol that broadcast all the information to every node in the network. Each node has similar data with the neighboring node. This protocol distributes information to all nodes when user doesn't require exchanging data between nodes. SPIN is 3-stage protocol. It uses three messages i.e. ADV, REQ & DATA. ADV is advertising new data, REQ is request for data & DATA is the message itself. When a node wants to share data it broadcast an ADV message containing data. If the neighbor node is interested for receiving the data then it sends a REQ message back to the node for data transmission & DATA is send to the node. Then the neighboring nodes repeat this process with its neighbors & the whole sensor area network will receive copy of the data.

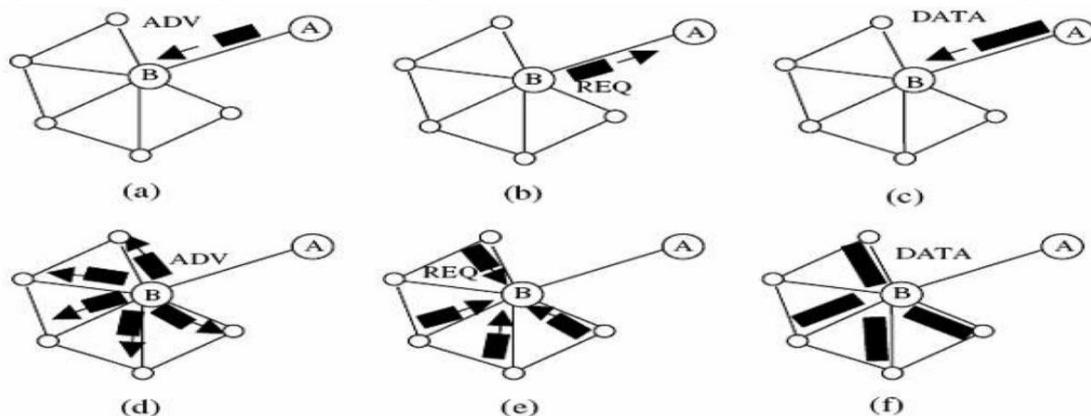


Fig. 5 (a) node A starts by advertising its data to node B, (b) node B responds by sending a request to node A, (c) after receiving the requested data, (d) node B then sends out advertisements to its neighbors, (e)(f) who in turn send requests back to B

SPIN family also includes of many protocols. Two main are SPIN 1 & SPIN 2, for transferred only useful information it incorporate negotiation before transmission. SPIN 1 is three stage protocols, which works in the same manner as describe in above. SPIN 2 protocols is the extension to SPIN 1 which incorporate. These protocols are good for an environment where sensors are mobile because they base their decisions on local neighboring information. [14]

b) Directed diffusion - Diffusion directed routing [15] is data centric. The main function of data centric is to combine the data from different sources & enroots by saving energy, eliminating redundancy, increases lifetime, minimizing number of transmissions. In the beginning, the sink specifies low data rate for the incoming events. After that sink can reinforce a particular sensor to sends events with higher data rate. If a neighboring sensor receives this message & finding that the sender's interest has higher data rate than before & this data rate is higher than that of existing gradient. The following fig 6 describes the directed diffusion working. (i) Sending interests (ii) building gradients (iii) data dissemination

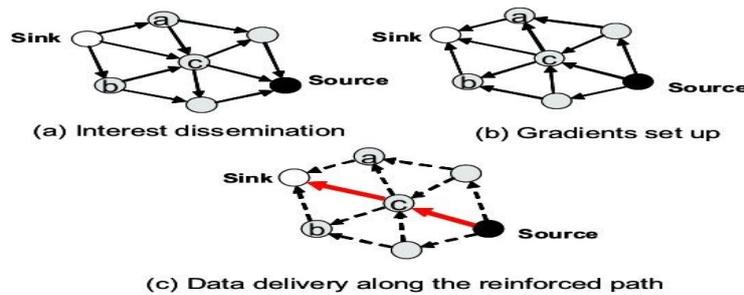


Fig. 6 Working of directed diffusion

When paths of information flow are formed from multiple paths & then the best path reinforced so as to prevent flooding. To reducing communication costs, data is aggregated on the way. The goal is to finding a good aggregation tree which gets data from source nodes to the base station. The base station periodically re-sends and re-freshes the interest, when it starts to receiving data from the source. Interests are not reliably transmitted throughout the network so it is necessary [15, 16].

c) ACQUIRE (Active query forwarding in sensor network)- ACQUIRE is a new data centric mechanism for querying sensor network [18]. Active query forwarding in sensor network view the network as a distributed database, where the compiles queries can be divided further into sub-queries. The working of ACQUIRE is descried as follows: base station sends a query which is forwarded by each node receiving the query. During this process, each node using its pre-cached information tries to respond the query partially and then forwarded it to another sensor nodes. If pre-cached information is not update then the nodes gather information from its neighbors with in a look-ahead of d hops. Once the query is resolved completely it is sent back either through the reversre path or the shotest path to the sink. ACQUIRE can also be deal with the complex queries by allowing many nodes to send response back [17, 3].

C) Hierarchical based routing-Hierarchical routing is also called as cluster based routing. The main idea of developing the cluster based routing protocol is to reduce the network traffic towards the sink [19]. The main objective of hierarchical routing is minimization of energy consumption of sensor nodes. In which higher energy nodes can be used to process and send the information while the low energy nodes can be used to perform sensing task. Only low energy nodes are participate for generating network path. Hierarchical routing is two layered routing mechanism where the one layer is used for selecting the cluster heads and other is used for routing [20, 21]. Protocols comes under hierarchical based are: LEACH, PEGASIS, TEEN, APTEEN & HEED

a) LEACH (Low energy adaptive clustering hierarchy) - LEACH is a cluster based protocol [22]. It randomly selects few sensor nodes as cluster heads and rotate evenly distribute the energy among the sensor in network. Cluster head node compress the data which are arriving from nodes that belong to respective cluster and send an aggregated packet to base station to reduce the amount of transmitted information. LEACH uses TDMA/CDMA MAC for reduce the intra-cluster & inter-cluster collisions. Where there is a need for constant monitoring by sensor network this protocol is most appropriate [23].

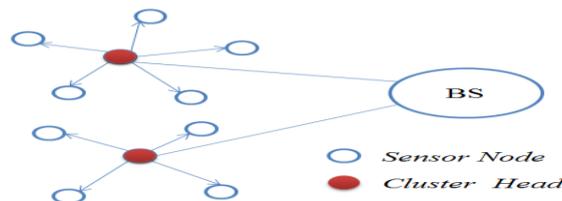


Fig. 7 Clustering in LEACH

In order to balanced the energy dissipation of nodes cluster heads change randomly over time. The decision is made by choosing a random number between 0 and 1 by the node. For the current round, node becomes a cluster head if the number is less than following threshold values:-

$$T(n)=[P/1-P *(r \text{ mod } 1/P)] \quad n \in G \quad [32]$$

Where P desired percentage of cluster heads, r is the current round; G is set of nodes that have not any cluster heads in $1/p$ rounds [19]. LEACH performs two tasks i.e. setup phase & steady state phase. In setup phase cluster heads are selected. In steady state phase transmission of data to the base station takes place. To minimize the overhead the duration of the steady state phase is larger than the duration of the setup phase.

b) PEGASIS (Power efficient gathering in sensing information systems) - PEGASIS is the enhancement over LEACH protocol. The main aim of this protocol in order to extend network lifetime, sensor nodes only communicate with their nearest neighbors & take turns in communication with base station [24]. A new round will start when the round of all nodes communicate with the base station ends. This also includes the factor that the power required to transmit per round is reduced. Main objective of PEGASIS-

1. Using collaborative technique increase the lifetime of each node, thus network lifetime will be increased.
2. To reduce bandwidth consumption in communication, allow only local coordination between nodes that are close together [25].

In the fig C0 passes its data to C1. Node C1 fuses with its own data & node C0's data and transmit to the leader. C2 passes the token to the node C4, node C4 transmits its data to the C3. Node C3 fuses its own data with C4's data and then transmit to the leader [31].

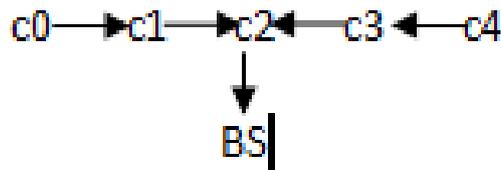


Fig. 8 Token passing in PEGASIS

Node C2 waits to receiving data from both neighbors & fuses its data with neighbor's data. Finally, node C2 transmits a message to the base station (BS) [26,4]

c) TEEN & APTEEN (Threshold sensitive energy efficient sensor network & Adaptive periodic threshold sensitive energy efficient sensor network) - TEEN is responsive to sensed the physical variations such as temperature, pressure etc. In this the sensor node continuously senses the medium but the actual data transmission is done less frequently [27, 30]. Nodes which are closer to each other form clusters and this process is continuous in the network until the sink node is reached. Where periodic reports are needed TEEN is not suitable. The nodes can't communicate with each other if the threshold is not received & user does not get any data. Cluster head nodes broadcasts two threshold in their cluster i.e. HARD THRESHOLD & SOFT THRESHOLD. HARD THRESHOLD- Hard threshold is the absolute value beyond which node sensing this value & switch to its transmitter when node sensing this value & report to cluster head. This threshold is used for reducing the number of transmissions by allowing the nodes only to transmit when the sensed attribute is in range of interest. SOFT THRESHOLD- Soft threshold is a small change in value of sensed attribute which triggers the node to switch on its transmitter & transmit [3, 28].

APTEEN (Adaptive periodic threshold sensitive energy efficient sensor network) - APTEEN is the advancement to TEEN that changes the threshold value or periodicity of TEEN protocol according to the type of application and users conditions or needs. In APTEEN protocol cluster head broadcasts the transmission in addition with the threshold values as in TEEN. If sensor node can't send data beyond the count time then TDMA scheme is used & each node is assigned a transmission slot [29, 3].

III. COMPARISON OF ROUTING PROTOCOLS

Table 1. Comparison of different routing protocols

Routing protocols	Classification	Power usage	Data aggregation	Scalability	Multipath
GAR	Location based	Limited	No	Good	No
GEAR	Location based	Limited	No	Limited	No
ACQUIRE	Flat based	Low	Yes	Limited	Yes
SPIN	Flat based	Limited	Yes	Limited	Yes
LEACH	Hierarchical based	High	Yes	Limited	No
PEGASIS	Hierarchical based	Maximum	No	Good	No
DIRECTED DIFFUSION	Flat based	Limited	Yes	Limited	Yes
TEEN	Hierarchical based	High	Yes	Good	No
APTEEN	Hierarchical based	High	Yes	Good	No
COUGAR	Flat based	Limited	Yes	Limited	Yes
SOP	Hierarchical based	Low	No	Good	No
GBR	Flat based	Low	Yes	Limited	No
Rumor routing	Flat based	Low	Yes	Good	No
TTDD	Hierarchical based	Limited	No	Low	Possible
MCFA	Flat based	N/A	No	Good	No
VGA	Hierarchical based	N/A	Yes	Good	Yes
HPAR	Hierarchical based	N/A	No	Good	No
Sensor aggregate	Hierarchical	N/A	Yes	Good	No

	based				
MFR	Location based	N/A	No	Limited	No
GOAFER	Location based	N/A	No	Good	No

IV. CONCLUSION & FUTURE WORK

In recent years, routing in sensor network has attracted a lot of attention by the researchers and users. In wireless sensor network's there is still ongoing research on routing protocols as sensor nodes are finding various new applications day by day in different fields. In this paper, we summerized research results on routing in sensor network based on network structure. This work may be well focused in future, on modifying any routing protocols, such that the modified protocol may minimize energy of sensor network and may enhancing the performance [33]. Sensor network may becomes an integral part of our lives because of wide range of applicatin areas.

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