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REVIEW ARTICLE

Review of Routing Techniques Driving Wireless Sensor Networks

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Abstract- ***In recent times wireless sensor networks (WSNs) have grown enormously and become progressively attractive in wide variety of applications. Wireless sensor networks contain tiny sensor nodes. These sensor nodes have the capability of sensing, communication and computation. Many new protocols are designed for wireless sensor networks where energy, congestion, lifetime, coverage etc are essential consideration. In this* paper survey of *routing protocols for WSN has been done and various categories of routing protocols get explored. The main categories of routing protocols in wireless sensor network are data-centric protocols, hierarchical protocols, location based protocols, QOS aware protocol. The main aim of this paper is to conclude various routing techniques and merits and demerits of routing techniques.***

Keywords- Routing techniques; Hotspot; Congestion; Wireless Sensor Network; sensor nodes

I. INTRODUCTION

Wireless Sensor Networks are [6] self-configured and infrastructure less networks to monitor various conditions, such as temperature, sound, pressure, motion, vibration etc. to move their data through the network to main sink can be analysed. These sensor network consist of various sensor nodes, these sensor nodes are small in size, communicate using short-range wireless transmitters.

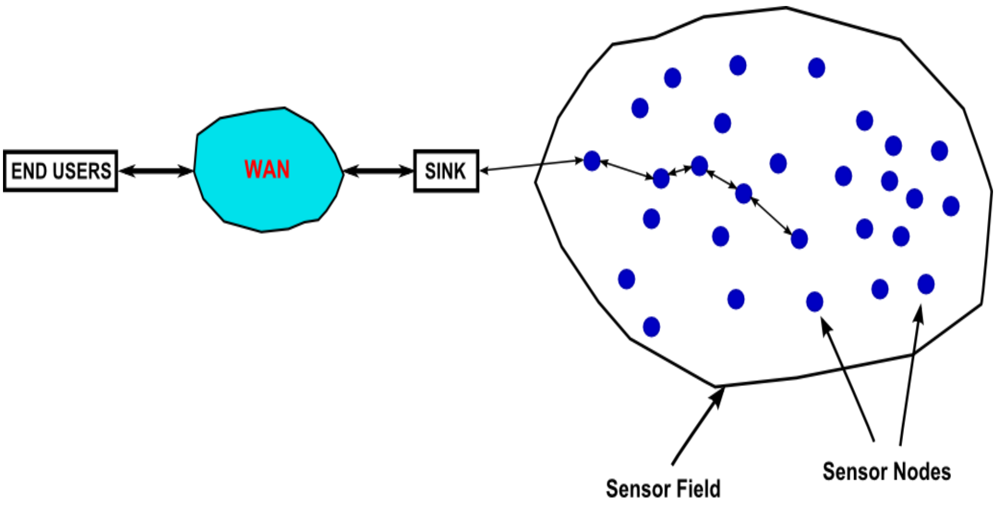

Fig 1: Wireless Sensor Network

WSNs are interesting from an engineer perspective, because they present serious key design challenges. The most important aspects related to our work are described. Sensor nodes [4] in the sensor network have the capability to communicate with each other or with the sink or base station directly. Sensor node consists of sensing, processing, transmission, power and mobilizer. Sensor nodes are battery driven and hence operate with a limited energy resource. In large-dense sensor networks it is infeasible to replace batteries when a sensor is down. In practice, it will be necessary in many applications to provide guarantees that a network with unattended wireless sensors can remain operational without any replacements for several years. For instance, in wild and unreachable areas, such the Antarctica or the deepest zones of the Atlantic Ocean, sensors can be easily deployed in order to form a large-dense sensor network and sense seismic waves, temperature or other parameters as well. In these scenarios, the replacement of the battery of a sensor node would be highly expensive.

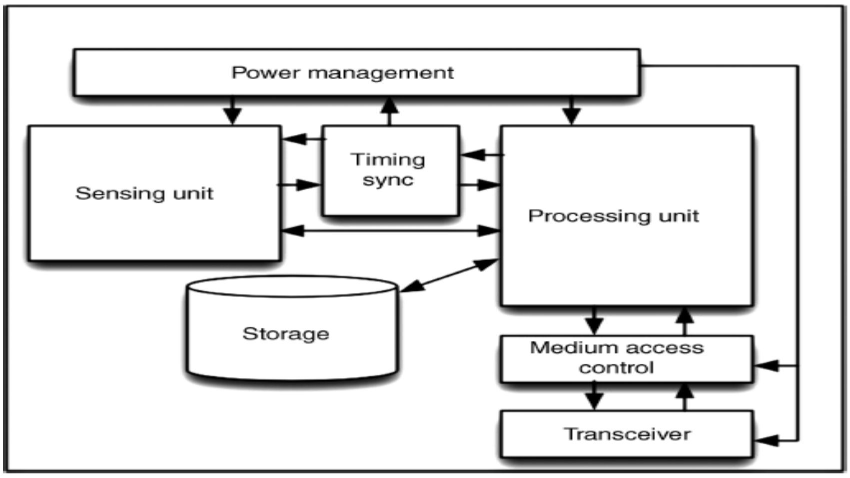

Fig.2: Simple schematic of a sensor node

Sensor nodes in a wireless sensor network have to be able to configure their own network topology; localize, synchronize, and calibrate themselves; coordinate inter-node communication; and determine other important operating parameters. Also they must be able to adapt themselves to the environmental conditions and unexpected situations in order to keep the performance negotiated and have a robust network. After deployment it is common in wireless sensor networks having topology changes due to changes in sensor nodes position, reachability, available energy, device failure or energy depletion.

Wireless sensor network have many characteristics egg they have dense node deployment. The number of sensor nodes in the wireless sensor network can be several order of magnitude higher than that in a MANTES. Sensor nodes are self-configurable i.e. they are randomly deployed without careful planning. Once the nodes get deployed they have to configure themselves into a communication network.

Wireless sensor network play an important role in the environmental monitoring to monitor various environmental parameters or conditions. In habitat monitoring sensor nodes are used to monitor the condition of wild animals or plants. These sensor nodes are deployed in such a way that they gather all the information of the animal's habitat. Sensor nodes are severely used in military applications in the battle fields or in hostile regions. Sensor nodes play important role in the hazard monitoring, nodes get deployed in such a way that they can sense the change in parameters and provide signals so that actions can be taken accordingly.

This paper is organised as follows: Section II describe literature review. Section III contains routing challenges and design issues in WSN. Section IV contains some routing approaches. This paper ends with conclusion and future work which is given in Section V.

II. LITERATURE REVIEW

My research work has been proposed to deal with routing challenges and issues and routing techniques. Various routing techniques get analysed and classified on different behaviours in Wireless Sensor Network e.g. Flat, hierarchical and location based routing protocols.

Naveen Sharma and Anand Nayyar [7] The author discusses basic and important concepts related to routing techniques, clustering process etc. To provide energy efficiency, various techniques can be used at different layers like MAC layer energy consumption can be minimized by avoiding collisions, overhearing, idle listening, control packet overrun etc., at network layer energy efficiency can be provided by using efficient routing algorithms and reliable communications among the sensor nodes. In this paper we discuss some energy efficient routing protocols depend on average energy, location, density etc.

Jamal N. Al-Karaki and Ahmed E. Kamal [4] mention various routing issues and challenges and their main focus in to routing techniques. By describing various categories of routing techniques one can easily understand the routing protocols. They have explained various functionality of the routing techniques in wireless sensor network.

S. Lindsey and C.S. Raghavendra [10] describe the PEGASIS. PEGASIS is the main routing technique in sensor network. In it no cluster formation took place only chain gets maintained in the network environment for routing. So in this paper the authors have conclude that how we can increase the functionality of the PEGASIS. With the improvement in PEGASIS many overheads get removed and problem of no cluster formation get sorted out.

Shuchi Sharma and Anand Nayyar [9] conclude the various routing challenges and issues in wireless sensor network, and various approaches to recover these routing challenges. These challenges and issues create many problems in the sensor network, so the mentioned approaches in the paper lead to rectify these issues.

III. ROUTING CHALLENGES AND DESIGN ISSUES IN WSN

Wireless sensor network have an innumerable applications that provide very good services to the network but instead of that WSN have several restrictions and issues like limited power supply, coverage problem, congestion in the network. Deployment of node in the network etc. The design of routing protocol in WSN is influenced by many challenging factors. Here we are going to summaries some routing challenges and design issues of wireless sensor network.

Sensing range- Every sensor node in the network has a particular sensor range and it can transmit its packet in that particular range. [9] Sensing range of the node is restricted to certain radius which cause coverage problem. To enhance the coverage of the sensor node, sensor nodes having large sensing range get used but this sensor node cost high. The issue of coverage arise due to random deployment of nodes. Due to random deployment of nodes sometimes nodes get deployed very close to each other and sensing range or coverage of the nodes get overlapped. So to remove this issue deterministic deployment of sensor nodes should be done.

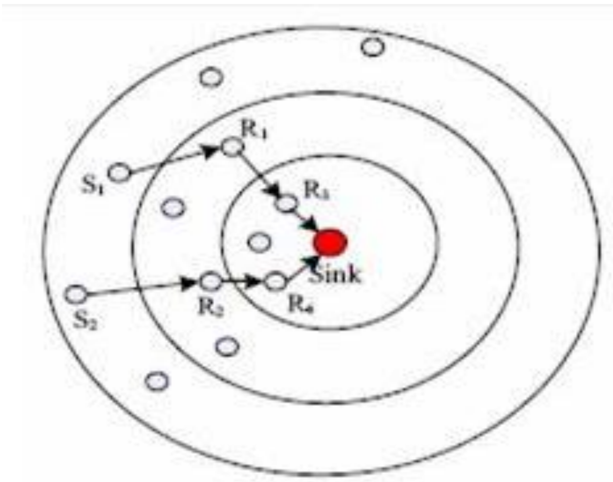

Fig 3: Sensing range of the sensor node

***Data aggregation*- [1]** Sensor nodes may generate redundant data; similar packets from multiple sensor nodes get aggregated (gathered) to reduce the number of transmissions. Data aggregation is the combination of data from different sources according to a certain aggregation function. Aggregation functions are duplicate suppression, minima, maxima, and average. This technique has been used to achieve energy efficiency and data transfer optimization in a number of routing protocols. Signal processing methods can also be used for data aggregation. In this case, it is referred to as data fusion where a node is capable of producing a more correct output signal by using some techniques such as beam forming to combine the incoming signals and reducing the noise in these signals.

Scalability- [4] The number of sensor nodes deployed in the sensing area is in huge number. Any routing scheme must be able to work with this huge number of sensor nodes. In addition, sensor network routing protocols should be scalable to respond to events in the environment. Until an event occurs, most sensors can remain in the sleep state, with data from the few remaining sensors providing coarse quality.

Node deployment- Node deployment in [4] WSNs is application-dependent and can be either deterministic or non-deterministic (randomized). In deterministic deployment, the sensor nodes are manually placed and data is routed through predetermined paths. However, in random node deployment, the sensor nodes are scattered randomly, creating an ad hoc routing infrastructure. If the resultant distribution of sensor nodes is not uniform, optimal clustering becomes necessary to allow connectivity and enable energy-efficient network operation. Inter sensor communication is normally within short transmission ranges due to energy and bandwidth limitations. Therefore, it is most likely that a route will consist of multiple wireless hops.

***Energy consumption without losing accuracy*- [4]** Wireless Sensor nodes can use up their limited supply of energy performing computations and transmitting information and data in a wireless environment. As such, energy-conserving forms of communication and computation are essential. Sensor node lifetime shows a strong dependence on battery lifetime. In a multihop WSN, each node plays a dual role as data sender and data router. The malfunctioning of some sensor nodes due to power failure can cause significant topological changes, and might require rerouting of packets and reorganization of the network.

***Quality of service*:** In some applications of sensor environment, [4] data should be delivered within a certain period of time from the moment it is sensed, or it will be useless. Therefore, bounded latency for data delivery is another condition for time-constrained applications. However, in many applications, conservation of energy, which is directly related to network lifetime, is considered relatively more important than the quality of data sent. As energy is depleted, the network may be required to reduce the quality of results in order to reduce energy dissipation in the nodes and hence lengthen the total network lifetime. Hence, energy-aware routing protocols are required to capture this requirement.

IV. ROUTING TECHNIQUES IN WSN

1. ***Flat Routing*** — The first category of routing protocols are the multihop flat routing protocols. [8] In flat networks, each and every node typically plays the same role and sensor nodes collaborate to perform the sensing task. Due to the large number of such sensor nodes, it is not feasible to assign a global identifier to every node. This consideration has led to data-centric routing, where the BS sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute-based naming is necessary to specify the properties of data. Early work on data centric routing was shown to save energy through data negotiation and elimination of redundant data. These two protocols motivated the design of many other protocols that follow a similar concept. In the rest of this subsection, we summarize these protocols, and highlight their advantages and performance issues.

1.1 ***Sensor Protocols for Information via Negotiation (SPIN)-*** Sensor Protocols for Information via Negotiation (SPIN) is an adaptive protocol . [4] SPIN disseminates all the information at each node to every node in the network assuming that all nodes in the network are potential BSs. This enables a user to ask any node and get the required information immediately. These protocols make use of the property that nodes in close proximity have similar data, and hence there is a need to only distribute the data other nodes do not posses. The SPIN family of protocols uses data negotiation and resource-adaptive algorithms. Nodes running [7] SPIN assign a high-level name to completely describe their collected data (called meta-data) and perform metadata negotiations before any data is transmitted. This ensures that there is no redundant data sent throughout the network. The semantics of the meta-data format is application-specific and not specified in SPIN. For example, sensors nodes might use their unique IDs to report meta-data if they cover a certain known region. In addition, SPIN has access to the current energy level of the node and adapts the protocol it is running based on how much energy is remaining. These protocols work in a time-driven fashion and distribute the information all over the network, even when a user does not request any data. The SPIN family is designed to address the deficiencies of classic flooding by negotiation and resource adaptation.

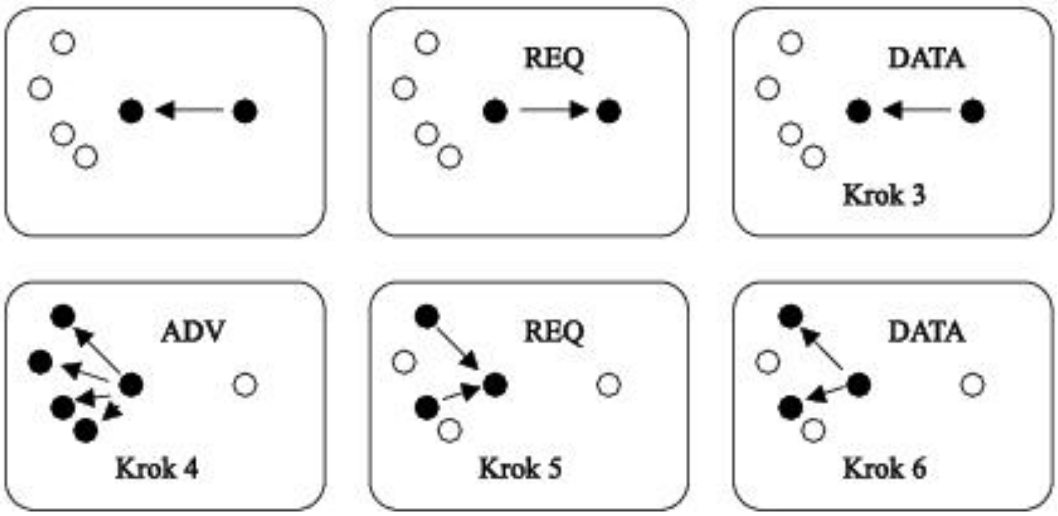

Fig 4: Data transferring in SPIN

1.2 ***Directed diffusion***- Directed diffusion [4] is a data-centric (DC) and application-aware paradigm in the sense that all data generated by sensor nodes is named by attribute-value pairs. The main idea of the DC paradigm is to combine the data coming from different sources en route (in-network aggregation) by eliminating redundancy, minimizing the number of transmissions, thus saving network energy and prolonging its lifetime. Unlike end-to-end routing, DC routing finds routes from multiple sources to a single destination that allows in-network consolidation of redundant data. In directed diffusion, sensors nodes measure events and create gradients of information in their respective neighborhoods. The BS requests data by broadcasting interests. An interest describes a task required to be done by the network. An interest diffuses through the network hop by hop, and is broadcast by each node to its neighbors. As the interest is propagated throughout the network, gradients are set up to draw data satisfying the query toward the requesting node (i.e., a BS may query for data by disseminating interests and intermediate nodes propagate these interests). Each sensor node that receives the interest sets up a gradient toward the sensor nodes from which it receives the interest. [7] This process continues until gradients are set up from the sources back to the BS. More generally, a gradient specifies an attribute value and a direction. The strength of the gradient may be different toward different neighbors, resulting in different amounts of information flow.

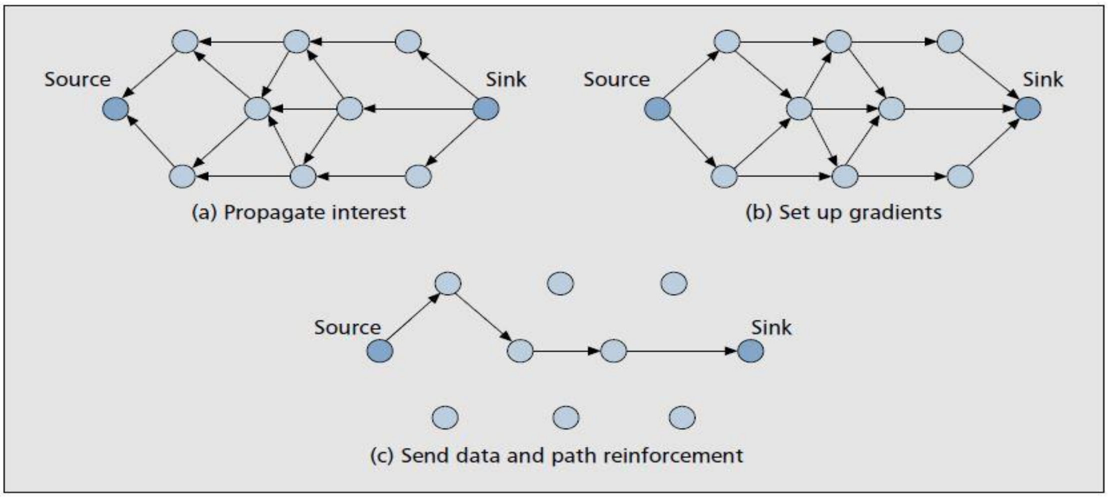

Fig 5: Interest diffusion in wireless sensor network [4]

1.3 ***Energy-Aware Routing-* [8]** Energy Aware Routing (EAR) protocol is very similar to directed diffusion; it differs from Directed diffusion only in the sense that it maintains a set of paths instead of maintaining or enforcing one optimal path at higher rates. With some probability these paths get chosen and maintained. The value of this probability depends on how low the energy consumption is that each path can achieve. By having paths chosen at different times, the energy of any single path will not deplete quickly. This can achieve longer network lifetime as energy is dissipated more equally among all nodes. Network survivability is the main metric of this protocol. The protocol assumes that each node is addressable through class-based addressing that includes the locations and types of the nodes. The protocol initiates a connection through localized flooding, which is used to discover all routes between a source/ destination pair and their costs, thus building up the routing tables. High cost paths are discarded, and a forwarding table is built by choosing neighbouring nodes in a manner that is proportional to their cost. Then forwarding tables are used to send data to the destination with a probability inversely proportional to the node cost. Localized flooding is performed by the destination node to keep the paths alive. Compared to directed diffusion, [4] this protocol provides an overall improvement of 21.5 percent energy saving and a 44 percent increase in network lifetime. However, the approach requires gathering location information and setting up the addressing mechanism for the nodes, which complicate route setup compared to directed diffusion.

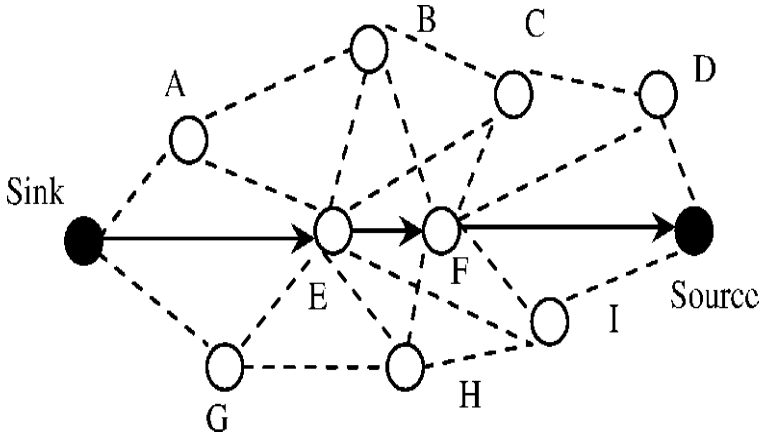

Fig 6: Energy aware routing

2. ***Hierarchical Routing*** — [7] Hierarchical routing or cluster based routing methods, originally proposed in wire line networks, are well-known techniques with special advantages related to scalability and efficient communication. As such, the concept of hierarchical routing is also utilized to perform energy-efficient routing in WSNs. In a hierarchical architecture, higher-energy nodes can be used to process and send the information, while low-energy nodes can be used to perform the sensing in the proximity of the target. The creation of clusters and assigning special tasks to cluster heads can greatly contribute to overall system scalability, lifetime, and energy efficiency. Hierarchical routing is an efficient way to lower energy consumption within a cluster, performing data aggregation and fusion in order to decrease the number of transmitted messages to the BS. Hierarchical routing is mainly two-layer routing where one layer is used to select cluster heads and the other for routing. However, most techniques in this category are not about routing, but rather "who and when to send or process/ aggregate" the information, channel allocation, and so on, which can be orthogonal to the multihop routing function.

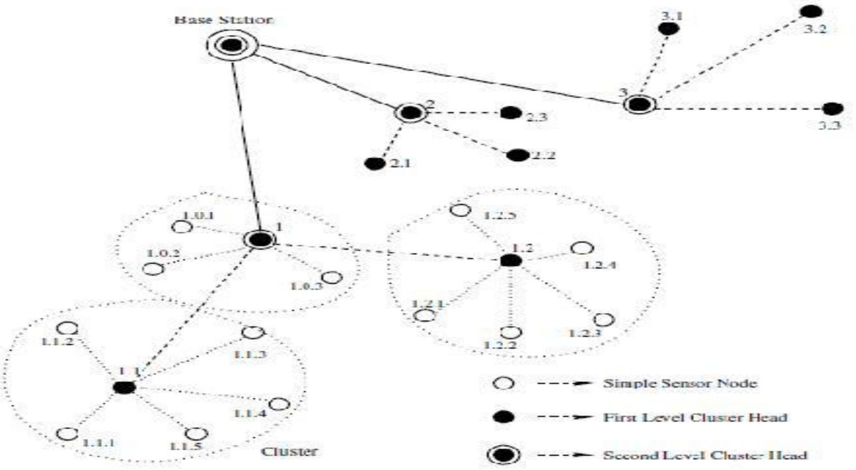

Fig 5: Hierarchical Routing

2.1 ***LEACH*** – It is a clustering based protocol. In which the network is divided into clusters. Each cluster has some number of nodes where each cluster has a cluster head. Cluster Head (CH) [4] is chosen from the sensor nodes in the network based on their receiving signal strength. After each round the cluster head is changes which collects the data from other nodes in the cluster and send the data to the sink. 5 percentage of total number of nodes are chosen as cluster head. The aggregation is performed in each cluster. Each node selects a random value 0 and 1. The nodes whose random value is less than the threshold those nodes are chosen as cluster head for current round only where P=desired percentage of cluster heads, r=current round and G is the set of nodes that have not been cluster heads in the last 1/P rounds. The nodes that are cluster head in round 0 cannot be cluster head for the next 1/P rounds.

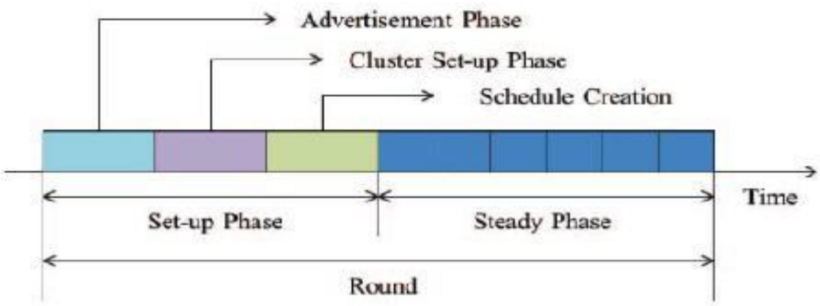

Fig 7: Phases of LEACH

2.2 ***Threshold-sensitive energy-efficient sensor network protocol (TEEN)*** **- [4]** TEEN protocol is used for precipitous changes in the sensed attributes in the network. A data centric mechanism and makes cluster in a hierarchical fashion is used by TEEN. Two threshold values are broadcast to the nodes: hard threshold and soft threshold etc. [7] The hard threshold is the minimum possible value of an attribute. Sensor nodes send data to the cluster head only if they found the sensed value is greater than the hard threshold. If sensor nodes found that the sensed value is less than the attribute value of threshold than they do not send the data to the cluster head. By this way only relative data is send by the sensor nodes. Next time when sensor node again sense value greater than the hard threshold value than they check the difference between current and earlier value with soft threshold. If the difference is again greater than the soft threshold than the sensor nodes will send recent sensed data to the cluster head. This process will remove burden from the cluster head.

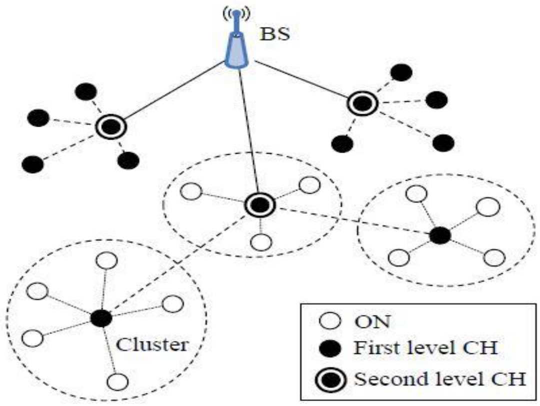

Fig 8: Clustering of TEEN

Adaptive TEEN- This protocol is used to capture the data periodically. [4] Three types of data query are made: historical, one time, persistent etc. In historical, the previous recorded values are analyzed and further decisions are also being taken based on their value (previous value). In one time, the snapshot of current network is taken and also envisioned (visualized). In persistent, when a event takes place than it monitors the network.

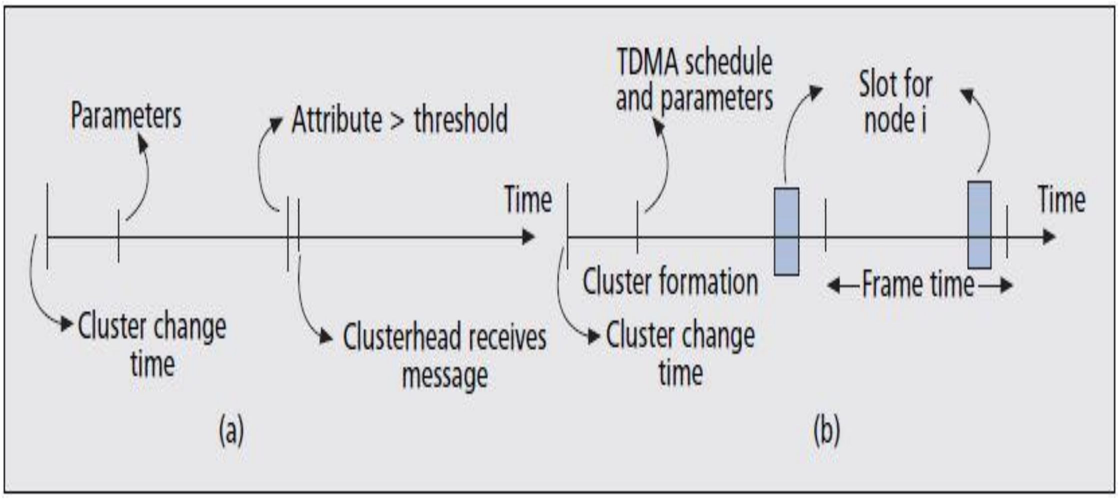

Fig 9: Time line for the operation (a) TEEN (b) APTEEN [4]

2.2 ***Power-efficient gathering in sensor information system (PEGASIS)-*** In PEGASIS a chain of sensor nodes is made instead of clusters. [8] Data get transmitted and received from its neighbor nodes in a chain. The node that starts transmitting data is called as an end node. Than the other nodes in the chain starts receiving data and send the data to its next neighbor after aggregating data. This process continues till the last node in the chain which is elected as leader node Leader node sends data to the sink. Multi-hop routing is done in PEGASIS. There is delay for the nodes which are far away from the leader node in the chain. The bottleneck problem occurs at the leader node. When numbers of transmissions among the non-leader nodes are less than that leads to overall energy efficiency.

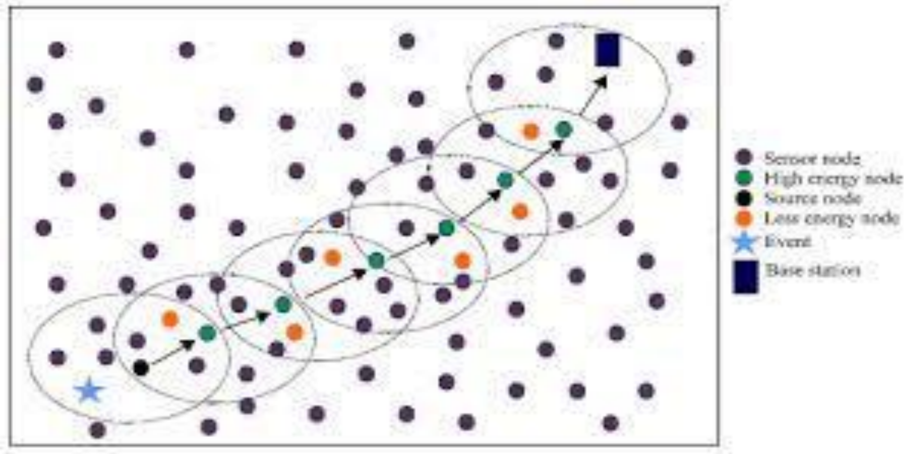

Fig 10: Operation of PEGASIS

3. ***Location-Based Routing Protocols*** — Sensor nodes are addressed by means of their locations in Location Based Routing protocol. [4] The distance between neighboring nodes can be estimated on the basis of incoming signal strengths. Relative coordinates of neighboring nodes can be obtained by exchanging such information between neighbors. Alternatively, the location of nodes may be available directly by communicating with a satellite using GPS if nodes are equipped with a small low-power GPS receiver. To save energy, some location-based schemes demand that nodes should go to sleep if there is no activity. More energy savings can be obtained by having as many sleeping nodes in the network as possible. Geographic based routing protocol locates nodes in the network and makes the best use of them to have a better fidelity. All the nodes use a location identification technique to locate itself with its nearest neighbors by using location-information systems like GPS.

3.1 ***GAF-*** All the nodes arrange themselves according to grids also. All the nodes divide themselves in grids and all nodes which are under a same grid coordinate among themselves to see who will go into sleep state and for how long. [8] Nodes in grid A can communicate with all the nodes in grid B that are adjacent. The time for sleeping is decided or depends on the application. GAF has three state states, discovery, active and sleeping. Every node starts with the discovery state. In this state the node turns on its radio and starts sending discovery messages. A node can fall into sleep state if there are other nodes in the grid which are equivalent in handling the fidelity before falling into the active state. In the active state the node sets a timeout value Ta which shows the remaining amount of time for which a node is intended to stay in active state. A node enters into sleeping state either from the discovery state or from the active state where Td is discovery time, Ta is active time and Ts is sleep time.

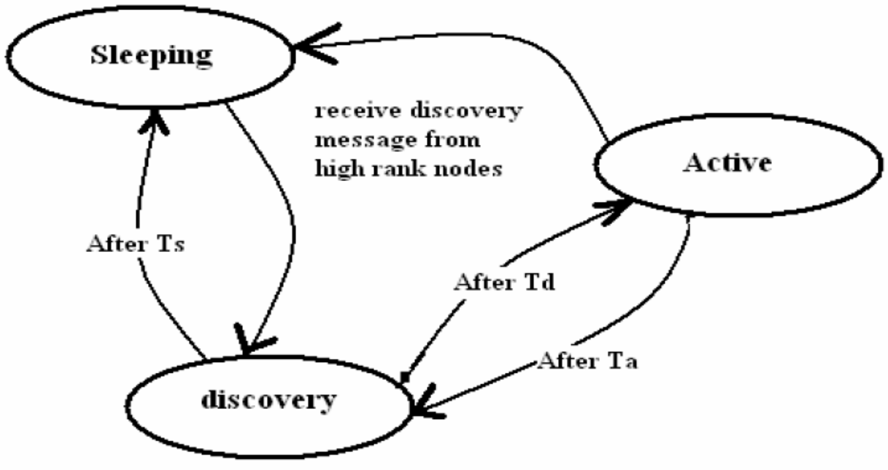

Fig 11: Transition states of GAF

3.2 ***Geographic and Energy Aware Routing***- The protocol, [7] Geographic and Energy Aware Routing (GEAR), uses energy- aware and geographically informed neighbor selection heuristics to route a packet toward the destination region. The key idea is to restrict the number of interests in directed diffusion by only considering a certain region rather than sending the interests to the whole network. By doing this, GEAR can conserve more energy than directed diffusion.

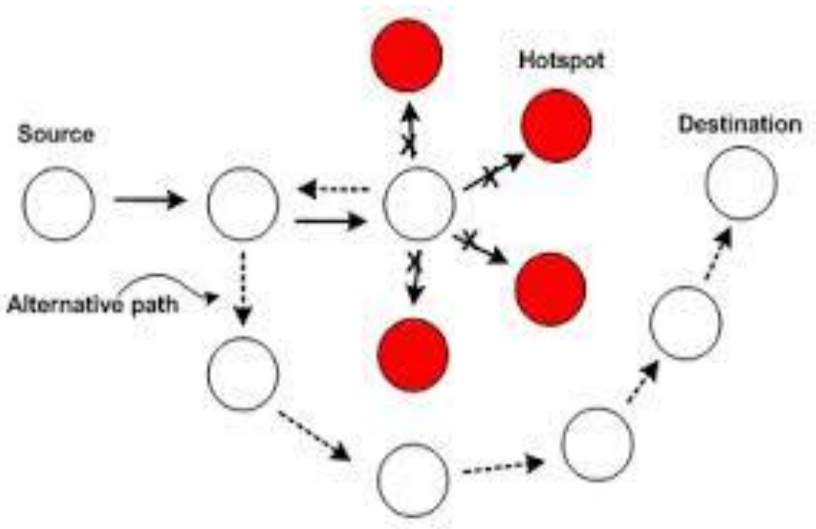

Fig 12: Geographic and Energy Aware Routing

3.3 ***The Greedy Other Adaptive Face Routing***- The greedy algorithm of GOAFR always picks the neighbor closest to a node to be next for routing. However, it can easily be stuck at some local minimum (i.e., no neighbor is closer to a node than the current node). Other Face Routing (OFR) is a variant of Face Routing (FR). [4] The FR algorithm is the first that guarantees success if the source and destination are connected. However, the worst case cost of FR is proportional to the size of the network in terms of number of nodes. The first algorithm that can compete with the best route in the worst case is Adaptive Face Routing (AFR). Moreover, by a lower bound argument, AFR is shown to be asymptotically worst-case optimal. But AFR is not average-case efficient. OFR utilizes the face structure of planar graphs such that the message is routed from node s to node t by traversing a series of face boundaries. The aim is to find the best node on the boundary (i.e., the closest node to the destination t) by using geometric planes. When finished, the algorithm returns to s the best node on the boundary. The simple greedy algorithm behaves well in dense networks, but fails for very simple configurations. It was shown that GOAFR can achieve both worst-case optimality and average-case efficiency. Based on the simulation results of GOAFR, there are several ways to further improve the average-case performance. It was also shown that GOAFR outperforms other prominent algorithms, such as GPSR and AFR.

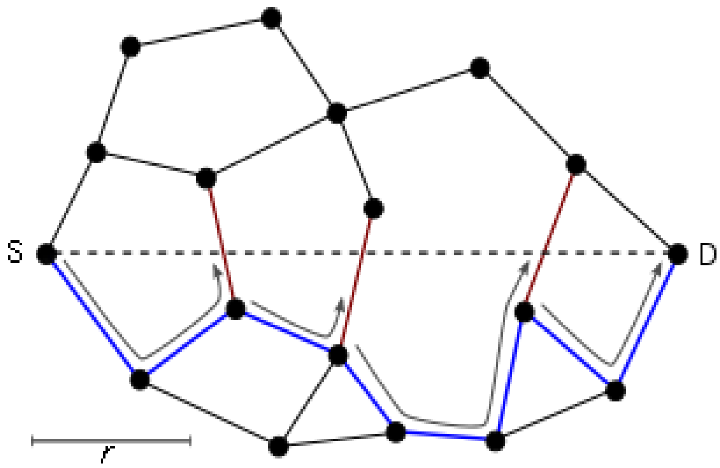

Fig 13: The Greedy Other Adaptive Face Routing

V. CONCLUSION AND FUTURE WORK

In last recent years, wireless sensor network increases so fast and a huge work has been done on energy conservation of sensor nodes in WSN. The main motive to design routing protocols to keep sensor nodes alive so that lifetime of network gets increase. This paper concluded some routing protocols based on energy efficiency in WSN. Their clustering techniques, routing performances etc get calculated in terms on energy efficiency. These routing techniques in sensor network provide a wide scenario that how we can proceed in this field of sensor network to make routing techniques more efficient.

Although these routing protocols shows the improvements but still there is possibility of improvements in Wireless sensor networks. Energy efficiency is one of the major design issues in wireless sensor networks. As most of the energy is consumed in communication than any other task so the need is to develop energy efficient routing protocols. In future the topics like cluster head communication, cluster formation, less energy consumption; data fusion etc topics may get covered by the researchers in the field of wireless sensor network. QoS parameters may get analysed and researcher can show their interest in improvement of QoS parameters. Various work related to efficiency, delay, packet overhead etc can be taken out by the researchers.

Table 1
Comparison of routing protocols in Wireless Sensor Network

	Classification	**Mobility**	**Position awareness**	**Power usage**	**Localiz -ation**	**QOS**	**Complexity**	**Scalability**	**Multipath**
SPIN	Flat	Poss	No	Ltd	No	No	Low	Ltd	Yes
Direct Diffusion	Flat	Ltd	No	Ltd	Yes	No	Low	Ltd	Yes
EAR	Flat	Ltd	No	N/A		No	Low	Ltd	No
LEACH	Hierarchical	Fixed BS	No	Max	Yes	No	CHs	Good	No
TEEN	Hierarchical	Fixed BS	No	Max	Yes	No	CHs	Good	No
APTEEN	Hierarchical	Fixed BS	No	Max	Yes	No	CHs	Good	No
PEGASIS	Hierarchical	Fixed BS	No	Max	Yes	No	Low	Good	No
GAF	Location	Ltd	No	Ltd	No	No	Low	Good	No

GEAR	Location	Ltd	No	Ltd	No	No	Low	Ltd	No
GOAFR	Location	No	No	N/A	No	Low	Good	Low	No

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