A survey on Routing Protocols in Wireless Sensor Networks

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***Abstract*—** In ad-hoc WSN is a collection of mobile nodes that are dynamically and randomly located in such a manner that the interconnections between nodes are changing on a continual basis. The dynamic nature of these networks demands new set of network routing strategy protocols to be implemented in order to provide efficient end-to end communication. Moreover, such issues are very critical due to severe resource constraints like efficient energy utilization, lifetime of network, and drastic environmental conditions in WSNs. Neither hop-by-hop nor neither direct reach ability is possible in case of WSNs. In order to facilitate communication within the network, a routing protocol is used. In this paper we have carried out an extensive survey on WSN protocols based on structure of network, routing protocol of network & clustering techniques of routing protocols.

Keywords*— *WSN, Routing protocols, clustering.

I. INTRODUCTION

Performance of MANETs depends on the routing protocol scheme employed. Traditional routing protocols do not work efficiently in MANETs due to its dynamic nature. Hence, designing an efficient and reliable routing protocol is very challenging to the changing network conditions such as network size, traffic density, and other network conditions. Earlier wireless sensor networks are only used for military purposes only but nowadays it is used in various other departments to such as weather forecasting, natural disastrous, automation and healthcare etc.

WSN is composed of wireless mobile sensor nodes; architecture of sensor node is shown in figure 1. The major components of a node [1] are: sensing unit, a microprocessor, a battery and a transceiver to transmit and receive signals from other node, ADC and storage device. In this paper we have reported a comprehensive survey on reactive, pro-reactive and clustering routing protocols in wireless sensor ad-hoc networks. We discussed advantages and disadvantage of all routing protocols and presents a comparison for the various approaches pursued.

II. ROUTING PROTOCOL AND ITS CHALLENGES

Routing is a method to find out a path between the source node and the destination node. It is difficult to design one routing protocol to fit in all requirements such as energy efficiency, shortest path, redundancy, load balancing, scalability and security. Due to mobile nature of sensor nodes in ad-hoc networks it is hard to follow fixed path and same environment all the time. There are some challenges in WSN:

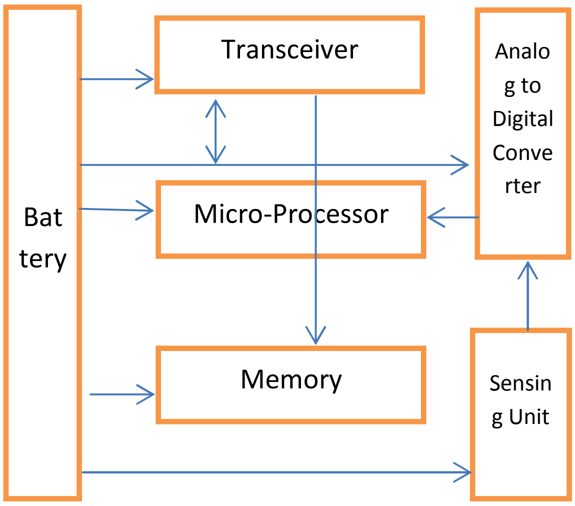

Fig.1: Architecture of Sensor node.

i. **Node Deployment:** Deployment is very application dependent and affects the performance of routing protocol. It can be manual or randomized. In manual strategy nodes are placed manually and data follows pre decided path but this method is not good for harsh weather and unapproachable places like war bases and natural calamities locations. While in randomized strategy nodes are deployed randomly and this way is a good choice for those applications which are related to event detection [2] [3].

ii. **Limited Energy:** Wireless sensor nodes have limited energy storage and once they are deployed, it is not practical to recharge or replace their batteries. Each sensing node uses power in sensing data, processing, transmitting and receiving data, but most of the energy is consumed in transmitting processed data. Energy depletion of nodes may results in breaking of path and searching the new path between source and destination which may effects performance in many aspects. So, a good energy efficient routing protocol is needed to overcome.

iii. **Scalability:** The no. of nodes deployed in the field may be variable i.e., from few hundred to thousands. When the no. of nodes is that much large it is infeasible for each node to maintain global knowledge.

iv. **Quality of Service (QoS):** Existing protocols for WSN mainly focus on providing energy efficient network utilization but pay less attention to QoS support in WSN. From an overall network standpoint, we can look at QoS requirements in WSNs. Many of these requirements are application dependant such as acceptable delay and packet loss tolerance. For example in applications such as habitat monitoring [4] [5]there is no bound on acceptable delay, however in military tracking [6], even a small delay is unacceptable. QoS metrics must be taken into account in the design process.

v. **Coverage:** In WSN's each node can cover a small view of the environment, a sensor view is limited in both accuracy and coverage range

III. CLASSIFICATION OF ROUTING PROTOCOL

Routing is a method to find out path between the source node and the destination node. There are various ways to find destination node some routing protocols find shortest path, some find location wise or some find strongest path. There are various ways to classify routing protocols in WSN. Classification of routing protocols is shown in figure 2.

Centric routing protocols classified as node centric, data centric and geo-centric (location centric) [7]:

- **a) Node Centric Routing Protocol:** Node centric nodes are those which are identified using numerical addresses.
- **b) Date Centric Routing Protocol:** Sink nodes send the queries to the member node for data and wait for reply from the member nodes to further process data.
- **c) Geo-centric Routing Protocol:** In this type of routing protocols nodes location is specified and nodes location can be used to improve the performance.

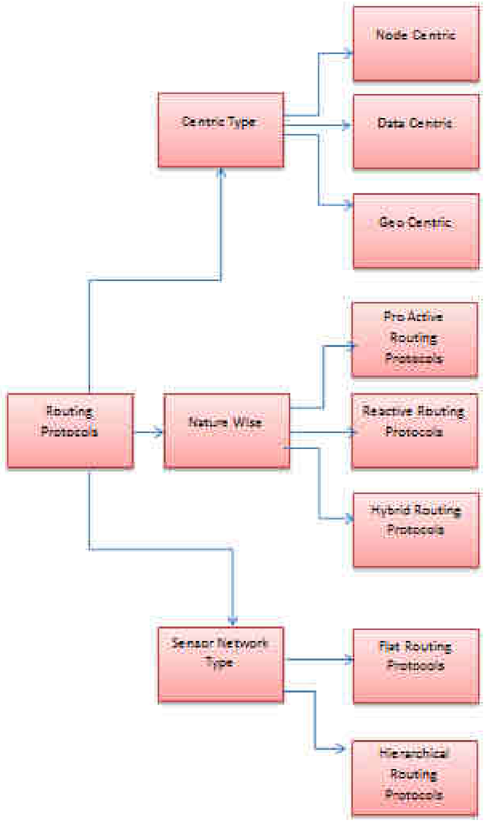

Fig.2: Classification of Routing Protocol

Nature wise protocols classified as Proactive, Active and Hybrid:

- a) **Proactive Routing Protocol:** These protocols are also called as table driven routing protocols since they maintain the routing information even before requiring of this information. Each and every node maintains routing information to every other node in the network. Routes information is generally kept in the routing tables and is periodically updated as the network topology changes. The protocols under this category maintain different number of tables. Furthermore, they are not suitable for large networks, as they need to maintain entries for each node in the routing table.
- **b) Reactive Routing Protocol:** These protocols are also called as On-Demand routing protocols as in these kind of routing protocols node searches for route on-demand i.e., whenever a node wants to send data it searches route for destination node and establishes the connection.
- **c) Hybrid Routing Protocol:** The Combination of both reactive and proactive is called hybrid routing protocol.

Sensor Network type protocols classified as Flat and Hierarchical routing protocols:

a) **Flat Routing Protocols:** In flat routing protocol node wants to send the data to the sink through several intermediate node or multi-hop [8].

b) **Hierarchical Routing Protocols:** In hierarchical routing, Cluster made of group of nodes is used to send data out of cluster only cluster head sends data to other cluster heads. It reduces the energy consumption of the network. Hierarchical routing protocol is more energy saving protocols of sensor node in WSNs. Hierarchical routing protocol is also known as clustering routing protocols [9].

However, in this paper we reviewed proactive, reactive and clustering routing protocols for ad hoc wireless sensor networks and presents a comparison for the various approaches pursued.

IV. PROACTIVE ROUTING PROTOCOL (TABLE DRIVEN PROTOCOLS)

In proactive protocols, each node maintains individual routing table containing routing information for every node in the network. Each node maintains consistent and current up-to-date routing information by sending control messages periodically between the nodes which update their routing tables. The proactive routing protocols use link-state routing algorithms which frequently flood the link information about its neighbour's. The drawback of proactive routing protocol is that all the nodes in the network always maintain an updated table. Some of the existing proactive routing protocols are DSDV, WRP and OLSR.

Distance Sequenced Distance Vector Routing (DSDV):

The Destination-Sequenced Distance-Vector Routing protocol (DSDV) is a table-driven algorithm based on the classical Bellman-Ford routing mechanism. In this routing protocol each and every node contains information of every node. Each entry is marked with a sequence number assigned by the destination node. The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops. Routing tables are updated periodically in order to maintain table up to date. To decrease the potentially large amount of network overload that such updates can generate, route updates can employ two possible types of packets. The first is known as a full *dump.* This type of packet carries all available routing information. During periods of Occasional movement, these packets are transmitted infrequently and second is smaller *incremental* packets are used to relay only that information which has changed since the last full dump [10]. New route broadcasts contain the address of the destination, the number of hops to reach the destination, the sequence number of the information received regarding the destination, as well as a new sequence number unique to the broadcast [11]**.**

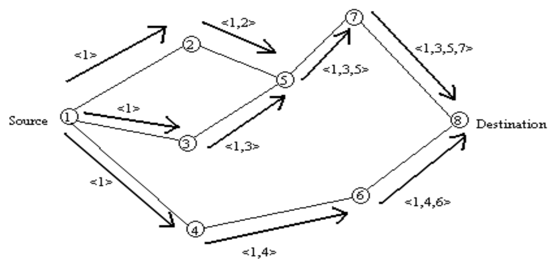

Fig.3(a): Route discovery

The route labelled with the most recent sequence number is always used. In the event that two updates have the same sequence number, the route with the smaller metric is used in order to optimize (shorten) the path. As shown in figure 3(a) new route discoveries contain the address of the destination, the number of hops to reach the used.

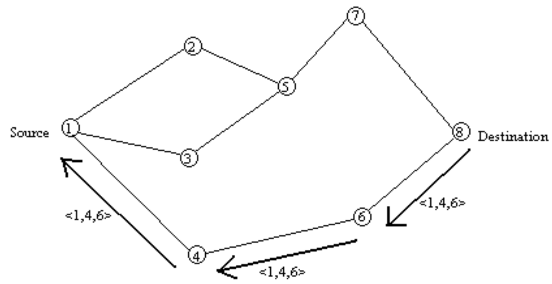

Fig.3(b): Route Reply

Destination, the sequence number of the information received regarding the destination, as well as a new sequence number unique to the broadcast. The route labelled with the most recent sequence number is always As shown in figure 3(b) in event that the route with the smaller metric is used in order to optimize (shorten) the path.

Wireless Routing Protocol (WRP):

The Wireless Routing Protocol (WRP) supports loop freedom [12]. It requires each node to maintain four routing tables which causes a significant overhead at each node as the size of the network increases.

i. **Distance table**
ii. **Routing table**
iii. **Link-cost table**
iv. **Message re-transmission list (MRL) table.**

Each entry of the MRL contains the sequence number of the update message, a re-transmission counter, an acknowledgment-required flag vector with one entry per neighbour, and a list of updates sent in the update message. The MRL records which updates in an update message need to be retransmitted and which neighbours should acknowledge the re-transmission.

Furthermore, WRP ensures its connectivity by using of hello messages. These messages are exchanged whenever there is no recent packet transmission. This process consumes a lot of bandwidth as well as power since each node is required to stay active at all times. If a new node sends a hello message than this new node is added to the mobile's routing table and the mobile sends the new node a copy of its routing table information. Part of the novelty of WRP stems from the way in which it achieves loop freedom.

Optimized Link state Routing Protocol (OLSR):

Optimized Link State Protocol (OLSR) is a proactive routing protocol, so the routes are always immediately available when needed. OLSR is an optimization version of a pure link state protocol. So the topological changes cause the flooding of the topological information to all available hosts in the network. To reduce the possible overhead in the network, protocol uses Multipoint Relays (MPR). The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network [13]. Another use of MPR is to provide the shortest path. The reducing the time interval for the control messages transmission can bring more reactivity to the topological changes.

OLSR uses two kinds of the control messages: Hello and Topology Control (TC). Hello messages are used for finding the information about the link status and the host's neighbours. With the Hello message the Multipoint Relay (MPR) Selector set is constructed which describes which neighbours has chosen this host to act as MPR and from this information the host can calculate its own set of the MPRs. The Hello messages are sent only one hop away but the TC messages are broadcasted throughout the entire network. TC messages are used for broadcasting information about own advertised neighbours which includes at least the MPR Selector list. The TC messages are broadcasted periodically and only the MPR hosts can forward the TC messages [14].

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Table 1. Comparison of Pro-active Routing Protocols

Parameter	DSDV	WRP	OLSR
Routing Structure	Flat	Flat	Flat
No. of routing tables	2	3	4
Frequency of updates	Periodic and when needed	Periodic	Periodic
Updates transmitted to	All Neighbouring nodes	All Neighbouring nodes	MPR's Multipoint Relays
Advantages	Loop Free	Loop Free but not instantaneous	Loop Free
Disadvantages	High Overhead	High Memory Overhead	High bandwidth usage

Selector list. The TC messages are broadcasted periodically and only the MPR hosts can forward the TC messages.

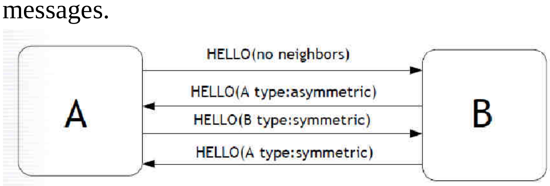

Fig.4: Node Sensing in OLSR

The link in the ad hoc network can be either unidirectional or bidirectional so the host must know this information about the neighbours. The Hello messages are broadcasted periodically for the neighbour sensing. The Hello messages are only broadcasted one hop away so that they are not forwarded further. As shown in figure 4. when the B host receives the Hello message from the A host, it sets the A host status to asymmetric in the routing table. When the B host sends a Hello message and includes that, it has the link to the A host as asymmetric, the A host set B host status to symmetric in own routing table. Finally, when A host send again Hello message, where the status of the link for the B host is indicated as symmetric, then B host changes the status from asymmetric to symmetric. In the end both hosts knows that their neighbour is alive and the corresponding link is bidirectional [15] [16].

Comparison of Pro-active Routing Protocols: Table 1 shows few comparisons of the above discussed protocols. As Table 1 shows all discussed protocols are flat in structure, with different no. of tables in routing table and DSDV has high overhead because it broadcasts message to all neighbouring nodes as network size increases overhead also increases, while in WRP overhead is less than DSDV but memory overhead increases because increase in number of routing tables. OLSR has minimum overhead but it consumes more bandwidth.

V. REACTIVE ROUTING PROTOCOL (ON DEMAND ROUTING PROTOCOL)

In Reactive routing protocols, when a source wants to send packets to a destination, it invokes the route discovery mechanisms to find the route to the destination. The route remains valid till the destination is reachable or until the route is no longer needed. Unlike table driven protocols, all nodes need not maintain up-to-date routing information.

Ad Hoc On-Demand Distance Vector Routing (AODV):

The Ad Hoc On-Demand Distance Vector (AODV) routing protocol is based on the DSDV. AODV is improved version of DSDV because it broadcasts only on demand, whereas in DSDV broadcasts are periodic. When a source node desires to send a message to some destination node and does not already have a valid route to that destination, it initiates a *path discovery* process to locate the other node.

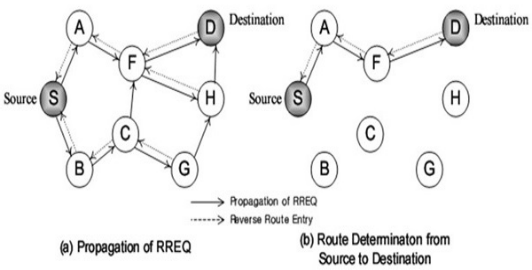

Fig.5: Propagation and route determination in AODV

It broadcasts a route request (RREQ) packet to its neighbours, which then forward the request to their neighbours, and so on, until the destination located. Figure 5a shows the propagation of the broadcast RREQs across the network.

Figure 5 Propagation and route determination in AODV

AODV utilizes destination sequence numbers to ensure all routes are loop-free and contain the most recent route information. Each node maintains its own sequence number, as well as a broadcast ID. The broadcast ID is incremented for every RREQ the node initiates, and together with the node's IP address, uniquely identifies an RREQ. Along with its own sequence number and the broadcast ID, the source node includes in the RREQ the most recent sequence number it has for the destination. Intermediate nodes can reply to the RREQ only if they have a route to the destination whose corresponding destination sequence number is greater than or equal to that contained in the RREQ. During the process of forwarding the RREQ, intermediate nodes record in their route tables the address of the neighbour from which the first copy of the broadcast packet is received, thereby establishing a reverse path. If additional copies of the same RREQ are later received, these packets are discarded. Once the RREQ reaches the destination or an intermediate node with a fresh enough route, the destination intermediate node responds by uni-casting a route reply (RREP) packet back to the neighbour from which it first received the RREQ Figure. 5b. As the RREP is routed back along the reverse path, nodes along this path set up forward route entries in their route tables. Which point to the node from which the RREP came? [8].

Table 2. Comparison of Reactive Routing Protocol

Protocol	**AODV**	**DSR**	**TORA**	**ABR**
Multiple Routes	No	Yes	Yes	No
Route Metric Method	Freshest and Shortest Path	Shortest Path or Next Available	Shortest Path or Next Available	Strongest Associatively and Shortest Path
Route reconfiguration strategy	Erase route then source notification or local route repair	Erase route then source notification	Link Reversal and Route Repair	Localized broadcast Query
Routing Strategy	Flat	Flat	Flat	Flat
Loop-Free	Yes	Yes	Yes	Yes
Advantage	Adaptive to highly dynamic topologies, Low Overhead	Multiple routes	Multiple routes	Route Stability

Dynamic Source Routing (DSR):

Dynamic Source routing protocol is a source of AODV routing protocol, In other words AODV is an improved version of DSR. There are three main differences in DSR and AODV, first difference is that in DSR RREQ (route request) is broadcasts through the network while in AODV, RREQ is sends only to neighbours. Second main request is intermediating nodes add its address to RREQ and continue broadcasting until RREP received whereas in AODV intermediating nodes just forwards the signal simply by incrementing broadcasting ID. Third main difference is that in DSR each packet carries full routing information whereas in AODV the packets only carry the destination address meaning that AODV has potentially less routing overheads than DSR.

Temporally Ordered Routing Algorithm (TORA):

TORA is adaptive and scalable routing algorithm based on the concept of link reversal. It finds multiple routes from source to destination in a highly dynamic mobile networking environment. An important design concept of TORA is that control messages are localized to a small set of nodes nearby a topological change. Nodes maintain routing information about their immediate one-hop neighbours. The protocol has three basic functions: route creation, route maintenance, and route erasure. Nodes use a "height" metric to establish a directed cyclic graph (DAG) rooted at the destination during the route creation and route maintenance phases. The link can be either an upstream or downstream based on the relative height metric of the adjacent nodes. TORA's metric contains five elements: the unique node ID, logical time of a link failure, the unique ID of a node that defined the new reference level, a reflection indicator bit, and a propagation ordering parameter. Establishment of DAG resembles the query/reply process discussed in Lightweight Mobile Routing (LMR) [8]. Route maintenance is necessary when any of the links in DAG is broken. The main strength of the protocol is the way it handles the link failures. TORA's reaction to link failures is optimistic that it will reverse the links to re-position the DAG for searching an alternate path. Effectively, each link reversal sequence searches for alternative routes to the destination. This search mechanism generally requires a single-pass of the distributed algorithm since the routing tables are modified simultaneously during the outward phase of the search mechanism. Other routing algorithms such as LMR use two-pass whereas both DSR and AODV use three pass procedure. TORA achieves its single-pass procedure with the assumption that all the nodes have synchronized clocks (via GPS) to create a temporal order of topological change of events. The "height" metric is dependent on the logical time of a link failure.

Associativity-Based Routing (ABR):

The ABR protocol uses a query-reply technique to determine the routes to the destinations. However, in ABR route selection is primarily based on stability. In order to select stable route each node maintains an associativity tick with its neighbours and the links with higher associativity tick are selected in preference to the ones with lower associativity tick. The disadvantage of ABR is that it does not maintain multiple routes or a route cache so the alternate routes will not be immediately available. However, ABR is compensated this drawback to some extent by initiating a localized route discovery procedure.

Comparison of Reactive Routing Protocols: Table 2 shows few comparisons of the above discussed reactive routing protocols. As Table 2 shows all discussed protocols are flat in structure, loop free with different route reconfiguration strategy and route metric method. TORA has multiple routes which gave advantage of link reversal over AODV and DSR, while ABR uses strongest associatively path.

VI. HIERARCHICAL ROUTING PROTOCOLS OR CLUSTERING ROUTING PROTOCOLS

Clustering is especially important for sensor network applications where a large number of ad-hoc sensors are deployed for sensing purposes. If all sensor node starts to communicate and engage in data transmission in the network, great network congestion and data collisions will be experienced. This will result to drain limited energy from the network. Node clustering will address these issues. In cluster networks, sensors are partitioned into smaller clusters and cluster head (CH).Sensor nodes in each cluster transmit their data to the respective CH and CH aggregates data and forward them to a central base station. Although sensor nodes in clusters transmit messages over a short distance (within clusters), more energy is drained from CHs due to message transmission over long distances (CH's to the base Station) compared to other sensor nodes in the cluster. Periodic re-election of CHs within clusters based on their residual energy is a possible solution to balance the power consumption of each cluster.

Clustering algorithms can be classified as Distributed Clustering & Centralized Clustering. Distributed clustering techniques are further classified into four sub types based on the cluster formation criteria and parameters used for CH election as Identity based, Neighbourhood information based, Probabilistic, and Iterative respectively. In centralized clustering approach base station is used for selecting cluster heads based on sensor nodes with energy level above predetermined threshold, by applying residual energy and predetermined energy threshold as a criteria.

- **Identity Based Clustering:** Unique identifiers which are uniformly assigned is the key parameter for selecting CHs in Identity-based clustering algorithms. A sensor node is CH only if it has the highest identity among all one hop sensor nodes. These type algorithms not favour the energy limited sensor networks since they drain the more power of some nodes in the network. These algorithms are coming under static clustering algorithms and do not change the CHs once selected.
- **Neighbourhood Clustering: In** neighbourhood information based clustering algorithms; sensors should have information about their neighbours and should be able to decide on number of neighbours within a pre-specified cluster range. Based on connectivity-based considering number of neighbours, some algorithms elect sensors with maximum number of 1-hop neighbours as the CHs. Some other algorithms under this category use a combination of metrics in addition to node degree such as: transmission power; mobility; and the remaining energy of the nodes [18].
- **Probabilistic Clustering:** In this type clustering algorithm, a prior probability is assigned to each sensor node and this probability is used to determine CHs. The probabilities assigned to individual node in the cluster facilitate individual node to decide on their election as a CH in the cluster while considering some other parameters. In addition to the probability assigned to each node, residual energy at nodes or node degree is taken as the parameter to elect CH.
- **Iterative Clustering:** This type of clustering algorithm uses swarm intelligence techniques which follows the collective behaviour of ants. In these clustering algorithms, colonial closure model which has been derived based on ant colonies are used.

Low Energy Adaptive Clustering Hierarchy (LEACH):

Low-Energy Adaptive Clustering Hierarchy (LEACH), proposed by Heinzelman [19], is one of the pioneering clustering routing approaches for WSNs. It gives a balancing of energy usage of sensor nodes by using random rotation of CHs. By using random rotation of cluster heads lots of energy is which dissipates in communicating with the base station.

The operation of LEACH is divided into lots of rounds, where each round is separated into two phases, the set-up phase and the steady-state phase. In the set-up phase the clusters are organized, while in the steady-state phase data is delivered to the BS. During the set-up phase, each node decides whether or not to become a CH for the current round. This decision is based on the suggested percentage of CHs for the network and the number of times the node has been a CH so far. This decision is made by the node choosing a random number between 0 and1. The node becomes a CH for the current round if the number is less than the following threshold:

$$T(n) = \begin{cases} \dfrac{P}{1 - P\left(r mod \frac{1}{P}\right)}, & if\ n \in G \\ 0, & otherwise \end{cases} \quad [20]$$

Where P is the desired percentage of CHs, r is the current round, and G is the set of nodes that have not been elected CHs in the last 1/P rounds. When a node is selected for CH successfully, it sends broadcasts signal to all other nodes. According to the received signal strength other nodes decide to which cluster it will join for this round and send a membership message to its CH. During the steady-state phase, the sensor nodes sense and transmit data to the CHs. The CHs compress data and send an aggregated data to the BS directly. Figure 6. shows the basic topology of LEACH.

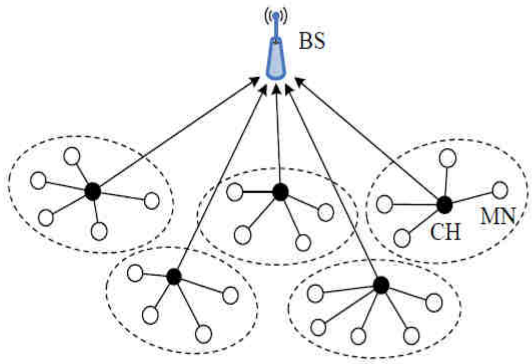

Fig.6: Basic Topology of LEACH

Hybrid Energy Efficient Distributed Clustering (HEED):

Hybrid Energy-Efficient Distributed clustering (HEED) introduced by Younis and Fahmy, is a multi-hop WSN clustering algorithm which brings an energy-efficient clustering routing with explicit consideration of energy. HEED is a multi-hop clustering algorithm for Wireless Sensor Networks. Two important parameters of choosing CHs are: residual energy and intra-cluster communication cost. In HEED, elected CHs have relatively high average residual energy compared to mobile nodes. One of the main goals of HEED is to get even-distributed CHs throughout the networks. Moreover, despite the phenomena that two nodes, within each other's communication range, become CHs together, but the probability of this phenomena is very small in HEED. Initially, in HEED, a percentage of CHs among all nodes, C_{prob}, is set to assume that an optimal percentage cannot be computed. The probability that a node becomes a CH is:

$$CH_{prob} = C_{prob} \frac{E_{residual}}{E_{max}} \quad [20]$$

Where, $E_{residual}$ is the estimated current energy of the node, and E_{max} is a reference maximum energy, which is typically identical for all nodes in the network.

Position Based Aggregator Node Election protocol (PANEL):

Position-based Aggregator Node Election protocol (PANEL) , presented by Buttyan and Schaffer, is a position-based clustering routing protocol for WSNs. With respect to other CH election protocols, PANEL supports asynchronous sensor network applications where the sensor node readings are fetched by the BSs. The main goal of PANEL is to elect aggregators, i.e., CHs, for reliable and persistent data storage applications.

PANEL assumes that the nodes are deployed in a bounded area, which is partitioned into geographical clusters. The clustering is determined before the deployment of the network, and each node is pre-loaded with the geographical information of the cluster to which it belongs. PANEL introduces a notion of reference point. At the beginning of each epoch, a reference point Rj is computed in each cluster j by the nodes in a distributed manner in terms of the epoch number, as follows:

$$\vec{R_j} = \vec{Q_j} + \vec{Q}$$

Where $\vec{Q_j}$ is the position of the lower-left corner of cluster j. Furthermore, the current epoch number e is known by every node and the computation consists in calling a pseudo-random function H(e) that maps e to a relative position $\vec{Q}$ inside the cluster, i.e.,:

$$H(e) = \vec{Q}$$

Where $\vec{Q} \in (-\delta d, d + \delta d) * (-\delta d, d + \delta d)$, d is the size of the cluster, and $\delta<1$ is a parameter which expresses the magnitude of this re-sizing operation in percent of the original cluster size d. Once the reference point is computed, the node that is the closest to the reference point will be elected the CH for the given epoch. The reference points of the clusters will be re-computed and the CH election procedure will be re-executed in next epochs. This CH election procedure ensures load balancing in PANEL because each node of the cluster can become CH with almost the same probability. The illustration of the geographical clustering in PANEL is shown in Figure 7 [20].

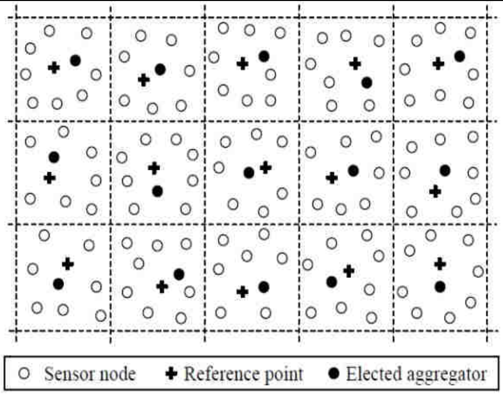

Fig.7: Illustration of Geographical clustering in PANEL

Power-Efficient Gathering in Sensor Information Systems (PEGASIS): This protocol is proposed by Lindsey, is an improvement of LEACH. In PEGASIS only closing nodes communicate with each other and take turns being the leader for transmission to the sink. In PEGASIS, the position of nodes is random, and each sensor node has the ability of data detection, wireless communication, data fusion and positioning. Energy load is distributed evenly among the sensor nodes in the network. In PEGASIS, the nodes are arranged in order to form a chain, which can either be concentrated assigned by the sink and broadcast to all nodes or formed by the nodes themselves using a greedy algorithm. If the chain is formed by the nodes themselves, they can first get the location data of all nodes and locally compute the chain using the same greedy algorithm. During the process of chain formation in PEGASIS, it is assumed that all nodes have global knowledge of the network and the greedy algorithm is employed. The chain construction is started from the furthest node from the sink and the closest neighbour to this node will be the next node on the chain. When a node on the chain dies, the chain will be reconstructed in the same manner to bypass the dead node. For collecting data from sensor nodes in each round, each node receives data from its neighbour, fuses the data with its own, and transmits to the other neighbour on the chain. By moving from node to node, the fused data eventually are sent to the sink by the leader at a random position on the chain. The scheme of data transmission in PEGASIS is shown in Figure 8. In this figure, if node C2 is the leader, it will pass the token along the chain to node C0 at first. Then, node C0 will pass its data toward node C2. After node C2 receives data from node C1, it will pass the token to node C4, and node C4 will pass its data towards node C2 with data fusion taking place along the chain [20].

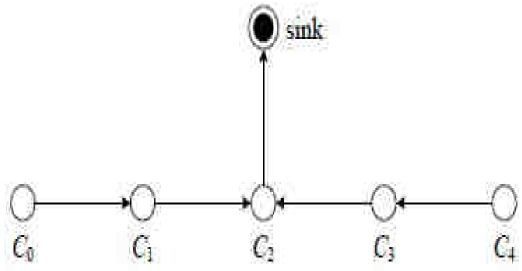

Fig.8: Data Transmission scheme in PEGASIS

Concentric Clustering Scheme (CCS): The Concentric Clustering Scheme (CCS) has been proposed by Jung et al. to reduce the energy consumption loopholes in PEGASIS. The main idea of CCS is to consider the location of the BS to enhance its performance and to prolong the lifetime of the network.

In CCS, the network is divided into a variety of concentric circular tracks which represent different clusters and each circular track is assigned with a level. Level-1 is the track which is closest to BS and the level number increases with the increase of the distance to the BS. Thus, each node in the network is assigned with its own level. Besides, chains are constructed within the track as that in PEGASIS. One of the nodes on the chain at each level area is selected as a CH.

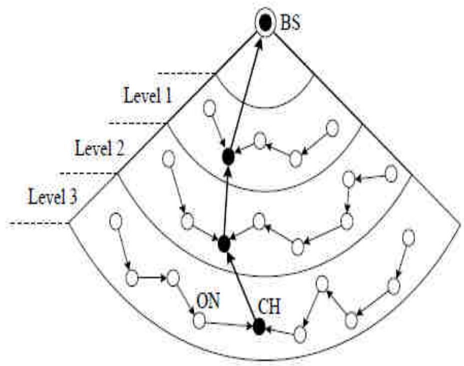

Fig.9: Data Transmission scheme in PEGASIS

Data transmission in CCS is based on the process of PEGASIS protocol. After CH selection, each CH transmits the data of its own location to both the upper and lower level CH in one grade. In the process of the data transmission, all nodes in each level transmit the data to the nearest node from themselves along the chain. The node receives the data and fuses its own data and transmits these data to the next node. Therefore, the CH receives at most two data messages. Subsequently, the CH in each level transmits the data to the lower CH. At last, level 1 CH transmits these data to the BS. The data transmission scheme in CCS is shown in Figure 9.

Table 3 Comparison of Hierarchical Routing Protocols

Algorithm	Energy Efficiency	Delivery Delay	Cluster Stability	Scalability	Load Balancing	First CH	Next CH election Procedure	Clustering	Algorithm Complexity
LEECH	Very Low	Very Small	Medium	Very Low	Medium	Random	Nearest Node	Block Cluster	Low
HEED	Medium	Medium	High	Medium	Medium	Random	Maximum Energetic	Block Cluster	Medium
PANEL	Medium	Medium	Low	Low	Good	Closest to reference point	Closest to new reference point	Grid Cluster	High
PEGASIS	Low	Very Large	Low	Very Low	Medium	Random	Nearest Node	Chain Cluster	High
CCS	Low	Large	Low	Low	Very Bad	i mod M_L^*	Same process for electing 1st CH	Chain Cluster	Medium

*M_L represents the no. of nodes that have the same level in i round.

VII. CONCLUSION AND FUTURE SCOPE

In this paper we studied proactive, reactive and hierarchical routing protocols. In proactive protocols sensor nodes always have information about all nodes of whole network, while in reactive protocols nodes collect information about network nodes only when needed i.e., on-demand on the hand in hierarchical routing protocols nodes collect information about only selected nodes i.e., nodes in cluster. We summarized and compare their performances. Hierarchical routing protocols are better than proactive and reactive protocols in terms of energy efficiency because only selected nodes communicate with whole network while others communicate with selected nodes with in cluster, better load balancing, less delay than reactive protocols. All routing protocols work with different principle, still it is really difficult to design a routing protocol which satisfies all the issues. Due to lots of issues in routing protocols of adhoc MANETS there is lots of future scope in this, as most of the routing protocols did not consider QoS in their process.

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