

# Survey on Energy Efficient Clustering and Routing Protocols of Wireless Sensor Network

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**Abstract-** The past few years have witnessed increased interest in the potential use of wireless sensor networks (WSNs) in a wide range of applications and it has become a hot research area. However, the resource constrained nature of sensors raises the problem of energy. This paper focus on the detailed survey on major clustering techniques. This article strongly examines about the advantages and limitations of different routing protocol with its recent research issues. Here research work carried out by different researcher in this field of WSN is also detailed. This paper summarizes all set of routing algorithms with comparison of on the basis advantage and disadvantages of each algorithm.

**Keywords-** Cloud Computing, Load balancing, Machine Learning, Soft Computing, Virtual machines.

## I. INTRODUCTION

The significance of Wireless Sensor Networks is observing and gathering information from the earth. A WSN ordinarily comprises of sensor nodes as well as sink(s) that can move inside the system. These sensor nodes are dissipated in the sensor field and it can gather the nearby ecological data, process them into helpful information bundles, and send the parcels to the sink node by multi-jump appeared in fig. 1. The sink node transmits the parcels to head through web or GPRS. A large portion of these sensor nodes having constrained battery life, restricted transmission control, low memory and restricted preparing capacities [1].

With the emotional advancement of hard-product innovation, the CPU and glimmer memory are ending up extremely littler, all the more dominant and less expensive. Subsequently, the memory and handling capacities of sensor nodes won't be the most essential issue for the utilization of WSNs. Not with standing, the battery innovation has neglected to get an achievement yet. Clearly, the vitality volume of sensor nodes will be the key bottlenecks for the advancement of WSNs in an exceptionally prolonged stretch of time. So the examination going on enhance the vitality effectiveness of WSNs, in order to drag out the system lifetime, is as yet the concentration at present and later on.

The specialized ways and strategies for enhancing vitality productivity of WSNs for the most part include the vitality proficient steering calculations and grouping calculations. In this way, WSNs require powerful instruments to use and resolve the restricted assets [2]. Clustering is a standout amongst the best procedures [1,

3] for bringing down energy utilization. In a bunched Wireless Sensor Network, sensor nodes are gathered into a specific number of groups, every one of which comprising of a group head (CH) and some non-bunch head nodes (non-CHs).

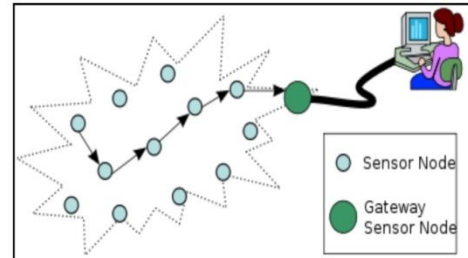


Fig. 1 Multi-Head data transfer in WSN.

CH gathers data from all the group nodes and after that advances to different CHs or base station (BS), while non-CHs nodes are in charge of detecting condition and transmitting data to the relating CH [3]. The looks into have been led for accomplishing high energy effectiveness in grouped calculation WSNs.

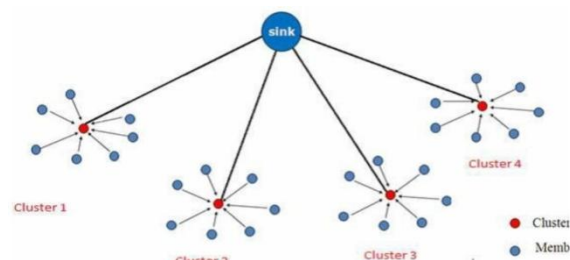


Fig. 2 Clustering architecture of WSN nodes.

## II. RELATED WORK

In this literature, different techniques about WSN are studied. Earlier research has tried up to a certain extent to overcome the problem of energy consumption and network stability using energy efficient techniques. However, still, energy consumption and network stability is the primary challenging issue in Wireless Sensor Network. Therefore, this work propose a technique of energy harvesting in clustering based Wireless Sensor Network to prolong network lifetime and network stability.

**1. LEACH (Low-energy adaptive clustering hierarchy)** is a well-known clustering based protocol [2]. In LEACH sensor nodes are organised into the cluster. Each cluster has cluster head and member nodes. Cluster heads in each cluster are selected randomly. The main disadvantage of LEACH is that if a sensor node with less residual energy is selected as cluster head would die quickly; ultimately the whole cluster would become non-functional. LEACH performs local processing to reduce the amount of data being transmitted to the BS, therefore reducing energy consumption and improving network lifetime.

In [3] this study, a game theory-based dispersed Energy Harvesting-Aware (EHA) algorithm is proposed, which represents the behaviors of sensors as a game. This effort analyses the energy expenditure rate and energy-harvesting rate of every sensor node at different times. In this approach, the high harvesting energy sensor nodes assist with the low harvesting energy sensor nodes to keep the connectivity of the sensor network. The proposed algorithm first builds a beginning topology based on the Directed Local Spanning Subgraph (DLSS) algorithm. Then every sensor node tries to and an adjacent node that covers up the remote neighbour of sensor node by adjusting the communication power stepwise.

In this paper [4] Audit-based Misbehavior Detection (AMD) can construct paths consisting of highly trusted nodes, subject to a desired path length constraint. When paths contain misbehaving nodes, these nodes are efficiently located by a behavioral audit process. AMD detects selective dropping behaviors by allowing the source to perform matching against any desired selective dropping patterns. This is particularly important when end to end traffic is encrypted. In the latter scenario, only the source and destination have access to the contents of the packets and can detect selective dropping.

In [5] researcher proposed algorithm that base station can be situated at focal point of the algorithm and system is working in two dimensions. System group development is finished in the 1st and in second dimension the determination of circulated bunch heads is performed.

For the choice of CH parameters utilized are node situating and the energy of remaining.

In [6], researcher proposed another IDS system utilizing cross breed inconsistency recognition, by utilizing an information mining algorithm, the algorithm utilized is K-implies Clustering. For location the interruption, the K-implies algorithm of the Clustering assembles the examples of interruptions consequently over prepared information. Coordinating the exercises of the system against these examples of recognition the interruptions are identified. The researcher assessed the methodology over a remote sensor arrange dataset that was made by OpNet modeler, that contained different characteristics, for example, traffic got traffic sent a start to finish delay, the point of the introduced EAFCA is to give a skillful decision procedure of the CH concerning all the imperative favorable circumstances that helped alongside a straightforward hand-off model between group. From the outcome that was taken from HNA and FND methodologies demonstrated that the sensor organize life span and consequently guaranteed the heap all through dissemination the system working.

In [7] (Hbrid bunching energy mindful steering convention) H-CERP has been proposed to shape the effectiveness of the groups with lesser head check of the group than the ideal estimations and utilizing the correspondence of multihop with passages nodes for correspondence alongside the base station. This cutting edge procedure gives the frameworks more preferences that the inclusion of the sensors and system lifetime are much essential at no extra expenses.

In [8], scientist give a energy proficient Clustering strategy, in view of fake honey bee settlement algorithm and factional math. MFABC try to augment the system energy and life time of nodes by half breed ideally choosing group head. This algorithm created to control the union rate of Artificial Bee Colony with the recently structured wellness work which considered three targets like, energy utilization, remove ventured out and deferrals to limit the general goal. The execution for bunch head determination of MFABC is contrasted and three conventions; LEACH, PSO and ABC-based steering as indicated by energy and life time. The reenactment results appeared, FABC is amplifies the energy and life time of nodes as contrasted and existing conventions.

In this paper [9], they proposed two possible solutions to study black hole attack. The first solution is to study several route to the destination. The second is to apply the packet sequence number contained in any packet header. In study to AODV routing scheme, the second solution is superior and of the route to the destination rely

upon on the pause time at a lowest cost of the delay in the networks.

In this paper [10], they have proposed a solution the requesting node wait and check the replies from all neighboring node to find a safe route. It is provide better performance than the conventional AODV in the existence of Black holes with smallest additional delay and overhead.

In this paper [11], they apply a reactive routing protocol called as Ad hoc On-demand Distance Vector (AODV) routing for examine of the outcome of the black hole attack when the destination sequence number is altered via simulation. Then, they determine characteristic in order to define the normal state from the character of black hole attack. They proposed training scheme for huge accuracy detection by modifying the training data in every given time intervals and adaptively specifying the normal state according to the changing network environment.

**Bouachir Ons (2016) et. al** [13] present that an ORP and data dissemination protocol for energy harvesting IOT (EH-IOT) depend on cross-layer constructs that allow across the layers synchronization and coordination among the routing protocol and the application layer service. The OMNET++ based extensive simulation of this protocol showed promising results in terms of meeting application requirements of handling urgent traffic and delay tolerant traffic seamlessly and insuring energy usage efficiency.

## II. WSN ROUTING TECHNIQUES

### 1. Data-Centric Protocols

In data-centric routing, the sink 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. SPIN is the first data-centric protocol, which considers data negotiation between nodes in order to eliminate redundant data and save energy [13]. Later, Directed Diffusion has been developed . Then, many other protocols have been proposed either based on Directed Diffusion or following a similar concept [14]. This section describes these protocols in details.

**2. Sensor Protocols for Information via Negotiation (SPIN)** -The idea behind SPIN is to name the data using high level descriptors or meta-data. Before transmission, meta-data are exchanged among sensors via a data advertisement mechanism, which is the key feature of SPIN. Each node upon receiving new data, advertises it to its neighbors and interested neighbors, means those who do not have the data, retrieve the data by sending a request message. SPIN's meta-data negotiation solves the classic problems of flooding such as redundant

information passing, overlapping of sensing areas and resource blindness thus, achieving a lot of energy efficiency. There is no standard meta-data format and it is assumed to be application specific. There are three messages defined in SPIN to exchange data between nodes. These are: ADV message to allow a sensor to advertise a particular metadata, REQ message to request the specific data and DATA message that carry the actual data. Details of it can be studied from [13]. In SPIN, topological changes are localized since each node needs to know only its single-hop neighbors. SPIN is not used for applications such as intrusion detection, which require reliable delivery of data packets over regular intervals.

**3. Directed Diffusion (DD)** - DD is an important milestone in the data-centric routing research of sensor networks. The idea aims at diffusing data through sensor nodes by using a naming scheme for the data. DD suggests the use of attribute-value pairs for the data and queries the sensors in an on demand basis by using those pairs. In order to create a query, an interest is defined using a list of attribute-value pairs such as name of objects, interval, duration, geographical area, etc. The interest is broadcast by a sink through its neighbors. Each node receiving the interest can do caching for later use. The nodes also have the ability to do in-network data aggregation.

The interests in the caches are then used to compare the received data with the values in the interests. The interest entry also contains several gradient fields. A gradient is a reply link to a neighbor from which the interest was received. Hence, by utilizing interest and gradients, paths are established between sink and sources. Several paths can be established so that one of them is selected by reinforcement. DD is highly energy efficient since it is on demand and there is no need for maintaining global network topology. However, DD cannot be applied to all sensor network applications since it is based on a query-driven data delivery model. Details of DD can be studied from [13].

**4. Rumor Routing (RR)**- RR is a compromise between flooding queries and flooding event notifications. The main idea of this protocol is to create paths that lead to each event, unlike event flooding which creates a network-wide gradient field. Thus, in case that a query is generated it can be then sent on a random walk until it finds the event path, instead of flooding it throughout the network. As soon as the event path is discovered it can be further routed directly to the event. On the other hand, if the path cannot be found, the application can try re-submitting the query or flooding it. The RR can be a good method for delivering queries to events in large networks [12].

**5. Location-Based Protocols**- In this section, location-based protocols for WSNs, is presented. They are based on two principal assumptions [12]:

- It is assumed that every node knows its own network neighbors positions.
- The source of a message is assumed to be informed about the position of the destination.

**6. Distance Routing Effect Algorithm for Mobility (DREAM):** It is a proactive protocol and each Mobile Node (MN) maintains a location table for all other nodes in the network [12]. To maintain the table, each MN transmits location packets to nearby MNs in the sensor network at a given frequency and to far away MNs in the sensor network at another lower frequency. Since far away MNs appear to move more slowly than nearby MNs, it is not necessary for a MN to maintain up-to-date location information for far away MNs. Thus, by differentiating between nearby and far away MNs, DREAM attempts to limit the overhead of location packets.

**7. Geographic and Energy Aware Routing (GEAR):** Unlike previous geographic routing protocols, GEAR does not use greedy algorithms to forward the packet to the destination [18]. Thus, it differs in how they handle communication holes. The GEAR uses energy aware and geographically informed neighbor selection heuristics to route a packet towards the target region.

**8. Minimum Energy Relay Routing (MERR) - Location:** It is based on the idea that the distance between two nodes that transmit data is very important [19]. This distance is closely related to the energy consumed on the entire path, from the source to the base station, Thus, in MERR each sensor seeks locally for the downstream node within its maximum transmission range whose distance is closest to the characteristic distance.

As soon as a sensor has decided to use the next hop, it adjusts its transmission power to the lowest possible level such that the radio signal can just be received by the respective node. This can minimize the energy consumption. If the distances between each pair of sensors are all greater than the characteristic distance, each sensor will select its direct downstream neighbor as the next hop node.

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| Spin [17]  | Eliminates The Redundancy Of Data [17].  | It Cannot Guarantee The Delivery Of Data [15].                             |
| Gear [15]  | Energy Consumption Is Balanced. [15]   | The Routing Table Exchange Periodically [15]                               |
| Mwe[15]    | Each Sensor Node In The Network Has A Set Of Minimum Energy Path To Each Source Node | More Delay<br>Larger Overhead<br>Less Scalability.                         |
| Tag [17]   | It Reduces The Amount Of Traffic Transmitted In The Sensor Network.                  | Overhead Increases.  |

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#### IV. WSN CLUSTERING TECHNIQUES

##### 1. Hierarchical Clustering

##### 1.1 Greedy Hierarchical Virtual Protocol (HVP)

Greedy Forwarding with Hierarchical Virtual Position (HVP) [23] algorithm uses the combination of all K-level virtual positions ( $K \geq 1$ ) and the geographic positions of nodes in a down-hill fashion. HVP requires nodes to store the geographic positions as well as all the K-level virtual positions of itself and its direct neighbors. A flag level is added to the packets to indicate the current level of virtual position.

The down-hill process is uni-directional to ensure that HVP is loop-free. HVP fails if the lowest level virtual position (the geographic position) is already used and there is no neighbor to make further progress towards the destination of a packet. The down-hill process does not need to have a fixed decrement of 1. When using larger decrements, less levels of virtual position are needed, that implies less information storage on nodes. Dynamic decrements can be used when certain level of virtual

position is missing.

##### 2. LEACH (Low Energy Adaptive Clustering Hierarchy)

A proposed protocol [4] is an adaptive clustering protocol for distributing energy load among the sensor nodes in network. LEACH uses single-hop routing in which each sensor node transmits information directly to the cluster head or the sink. It works in two phase: 1) The setup phase- In the setup phase, the cluster are organized and the cluster heads are selected and each round stochastic algorithm is used by each node to determine whether it will become a cluster head. 2) The steady state phase- The data is sent to the base station the duration of the steady state phase is longer than the duration of the setup phase in order to minimize overhead. Cluster head creates a TDMA (Time Division Multiple Access) schedule based on the number of nodes in the group. CDMA (Code Division Multiple Access) code is used for random communication inside the cluster. LEACH is not suitable for large network areas.

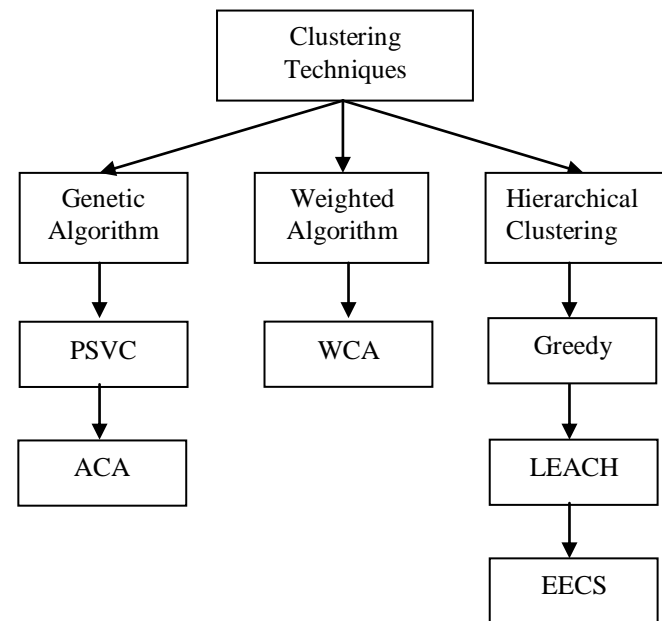


Fig. 3 Classification of block diagram of clustering algorithms.

##### 3. EECS: An Energy Efficient Clustering Scheme (or EECS)

is a clustering algorithm in which cluster-head candidates compete for the ability to elevate to cluster head for a given round. This competition involves candidates broadcasting their residual energy to neighboring candidates. If a given node does not find a node with more residual energy, it becomes a cluster head. Cluster formation is different than that of LEACH. LEACH forms clusters based on the minimum distance of nodes to their corresponding cluster-head. EECS extends this algorithm by dynamic sizing of clusters based on cluster distance from the base station[4]. The

result is an algorithm that addresses the problem that clusters at a greater range from the base station require more energy for transmission than those that are closer. Ultimately, this improves the distribution of energy throughout the network, resulting in better resource usage and extended network lifetime.

#### 4. Weighted Schemes

Weighted Clustering Algorithm (WCA) [6]: The algorithm explained in this section is a non periodic procedure to the cluster-head election, invoked on demand every time a reconfiguration of the networks topology is unavoidable.[6]. This clustering algorithm tries to find a long-lasting architecture during the first cluster-head election. When a sensor loses the connection with any cluster-head, the election procedure is invoked to find a new clustering topology.

This is an important feature in power saving, as the reelection procedure, which consumes energy, occurs less frequently. This algorithm is based on a combination of metrics that takes into account several system parameters such as: the ideal node degree; transmission power; mobility; and the remaining energy of the nodes. Depending on the specific application, any or all of these parameters can be used as a metric to elect cluster-heads. Another important aspect of the algorithm is that it is fully distributed; meaning that all the nodes in the mobile network share the same responsibility acting as cluster-heads.

#### 5. Particle Swarm Virtual Coordinates (PSVC)

PSVC [24] is a distributed virtual coordinate assignment algorithm that employs Particle Swarm Optimization to compute virtual coordinates for geographic routing. The selection of the reference nodes and the relaxation steps are similar to GSpring. PSVC computes the coordinates of the reference nodes by modeling the hop counts between the reference nodes as a spatial distance in a manner similar to No Geo. The election of each reference node floods the network, but the cost per reference node is approximately  $O(D) \approx O(\sqrt{n})$ , where  $D$  is the diameter of the network and  $n$  is the network size. PSVC uses 4 reference nodes for 2D networks and 6 reference nodes for 3D networks. PSVC converges faster, achieves a lower hop stretch, and scales well up to large networks of 3,200 nodes compared to No Geo. Also, PSVC makes no assumptions on the network topology and can naturally be extended to three-dimensional (3D) IOT.

#### 6. Ant-Based analysis

Proposed protocol [8] which is based on the Ant Colony Optimization heuristic. Initially the forward ants are sent to no specific destination node, which means that sensor nodes must communicate with each other and the routing tables of each node must contain the identification of all the sensor nodes in the neighborhood and the correspondent levels of pheromone trail. For large networks, this can be a problem since nodes would need

to have big amounts of memory to save all the information about the neighboring nodes. The algorithm can be easily changed to save memory. If the forward ants are sent directly to the sink, the routing tables only need to save the neighbor nodes that are in the direction of the sink. This reduces the size of the routing tables and, in consequence, the memory needed by the nodes. The quality of a given path between a sensor node and the sink-node, should be determined not only in terms of the distance, but also in terms of the energy level of that path.

## V. WIRELESS SENSOR NETWORK ROUTING ISSUES

The design of routing protocols in WSNs is influenced by many challenging factors. These factors must be overcome before efficient communication can be achieved in WSNs. In the following, we summarize some of the routing challenges and design issues that affect routing process in WSNs.

**1. Node deployment-** Node deployment in WSNs is application dependent and affects the performance of the routing protocol. The deployment can be either deterministic or randomized. In deterministic deployment, the sensors are manually placed and data is routed through pre-determined paths. However, in random node deployment, the sensor nodes are scattered randomly creating an infrastructure in an ad hoc manner. If the resultant distribution of 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.

**2. Energy consumption without losing accuracy-** sensor nodes can use up their limited supply of energy performing computations and transmitting information in a wireless environment. As such, energy conserving forms of communication and computation are essential. Sensor node lifetime shows a strong dependence on the battery lifetime [20]. In a multi hop 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.

**3. Fault Tolerance-** Some sensor nodes may fail or be blocked due to lack of power, physical damage, or environmental interference. The failure of sensor nodes should not affect the overall task of the sensor network. If many nodes fail, MAC and routing protocols must accommodate formation of new links and routes to the data collection base stations. This may require actively adjusting transmit powers and signaling rates on the existing links to reduce energy consumption, or rerouting

packets through regions of the network where more energy is available [21]. Therefore, multiple levels of redundancy may be needed in a fault-tolerant sensor network.

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

**5. Network Dynamics-** Most of the network architectures assume that sensor nodes are stationary. However, mobility of both BS's or sensor nodes is sometimes necessary in many applications [19]. Routing messages from or to moving nodes is more challenging since route stability becomes an important issue, in addition to energy, bandwidth etc. Moreover, the sensed phenomenon can be either dynamic or static depending on the application, e.g., it is dynamic in a target detection/tracking application, while it is static in forest monitoring for early fire prevention.

**6. Transmission Media-** In a multi-hop sensor network, communicating nodes are linked by a wireless medium. The traditional problems associated with a wireless channel (e.g., fading, high error rate) may also affect the operation of the sensor network. In general, the required bandwidth of sensor data will be low, on the order of 1-100 kb/s. Related to the transmission media is the design of medium access control (MAC). One approach of MAC design for sensor networks is to use TDMA based protocols that conserve more energy compared to contention based protocols like CSMA (e.g., IEEE 802.11).

**7. Connectivity** - High node density in sensor networks precludes them from being completely isolated from each other. Therefore, sensor nodes are expected to be highly connected [22]. This, however, may not prevent the network topology from being variable and the network size from being shrinking due to sensor node failures. In addition, connectivity depends on the, possibly random, distribution of nodes.

**8. Coverage-** In WSNs, each sensor node obtains a certain view of the environment. A given sensor's view of the environment is limited both in range and in accuracy; it can only cover a limited physical area of the environment. Hence, area coverage is also an important design parameter in WSNs.

## VI. CONCLUSION

To make an energy efficient design for routing protocol in WSN is the major challenge faced now a days. The main aim is to make the sensor to work for long time with less usage of energy. Generally the major energy

consumption is due to data transfer and reception. Consequently, many innovative security protocols and techniques have been developed to meet this challenge. It was obtained that use of dynamic algorithm which handle real time situation without any prior training is highly demanding. Here one has to separately work for clustering and routing as each module will improve WSN life span. Use of hierarchical routing algorithm leads to packet loss which ultimately require extra energy to transfer same data. In future a flawless calculation is with great component blend is wanted by investigating new load balancing calculations which adjusts the load much better and furthermore helps in green processing.

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