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Energy Efficient Flat and Hierarchical Routing Protocols in Wireless Sensor Networks: A Survey

Ramesh Patil[1], Dr.Vinayadatt V. Kohir [2]
[1]*(CSE Department, G.N.D Engineering College, Bidar, India)*
[2]*(ECE Department, PDA Engineering College, Kalaburagi, India)*

Abstract: *Wireless sensor network (WSN) is an emerging technology for exchanging data in various real-time monitoring systems. The WSN has distributed nature and dynamic topology which introduces very special requirements in routing the data. Various protocols developed for routing in WSNs are broadly classified in to four categories i.e. based on Network Structure, Communication Model, Topology and Reliable Routing. Many energy efficient routing protocols are proposed for WSNs in recent years. Network structure based routing protocols are more commonly used in various applications. To save the energy and for providing the extension of the network life time network structure based protocols are used. The routing protocols based on network structure can be further classified as flat or hierarchical. Finally, a comparison on flat and hierarchical protocols is done, which shows for the energy efficiency hierarchical protocols are more suitable in larger WSNs applications.*
Keywords: *Energy efficiency, network lifetime, routing protocols, WSN.*

I. Introduction

Wireless Sensor Networks (WSN's) is the most popular existing wireless technology all over the world. In comparison to other wireless compunction techniques such as ad-hoc network or mesh network etc., sensor network has its own limitation in exchanging data from a measuring point to the destination. In WSN, sensor units are deployed at various locations in the network, and they continuously measures the physical parameters such as temperature, humidity, pressure etc. Typically, a sensor node is a small device that includes four main components namely a sensing unit, microcontroller unit, communication unit and a power source. The major advantage of such network is the deployment of nodes at any location and exchange of data via supportive intermediates nodes which act as routers to switch data from one to other node. Due to wireless mode of communication, sensors could be deployed at any corner and could be easily monitored from different locations. WSN have less maintenance, economical, and easily deployable in comparison to its counter parts. Application scenarios for WSNs often involve battery-powered nodes which are active for a long period, without human control after initial deployment. In the absence of energy efficient techniques, a node would drain its battery within few days. To minimize energy consumption and enhancing the network life time researchers had designed various protocols for routing. These protocols are broadly classified in to four categories i.e. based on Network Structure, Communication Model, Topology and Reliable Routing. This paper provides a complete survey on the energy-efficient routing protocols for WSNs based on Network structure. The focus is on the techniques these protocols use in order to route messages, based on the energy they consume so that the lifetime of the network is extended.

The rest of this paper is organized as follows. In Section 2, a brief discussion of the WSNs is presented. Section 3 presents the information related to the work. Section 4 discusses the various Routing protocols in WSN. In section 5 comparisons of flat and hierarchical routing protocols is discussed and finally in section 6, a summary of the work with future research directions on energy efficient routing in WSNs is discussed.

II. Wireless Sensor Network

Wireless Sensor Network (WSN) consists of a group of sensor nodes working together to sense the environment, communicate over a short distance using wireless link and perform simple data processing. These sensor nodes are typically small in size, battery powered, low cost and deployed randomly. WSN has various important applications in military, environmental monitoring and target tracking. The design of a WSN depends significantly on the objectives of the applications and it must consider factors such as the environment, cost, hardware and system constraints. The number of nodes in WSN varies from few to several hundreds or even thousands, where each node is connected to one sensor. In WSN sensor nodes continuously measures the physical parameters such as temperature, humidity, pressure etc. and exchange the data with the neighboring nodes so that finally it reaches to the sink. Each sensor node in the network has typically several parts such as radio transceiver with antenna, a microcontroller, interface for connecting the sensors and an energy source. Below figure 1 shows the typical wireless sensor network.

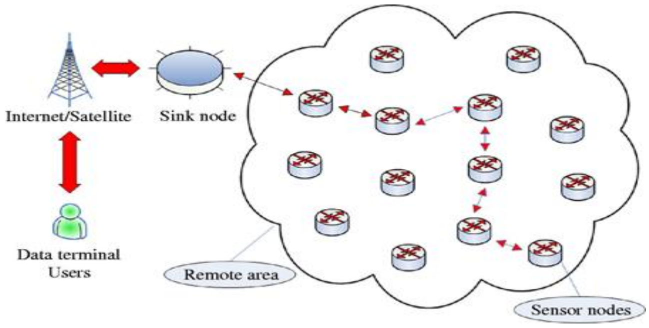

Figure 1 Wireless Sensor Network

The topology of WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The cost of sensor nodes is variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The efficiency of WSN depends on the energy of the sensor node. In WSNs, the energy is dispersed while sensing, processing, transmitting or receiving data. The sensing subsystem is used for data acquisition. It is obvious that minimizing data extracted from transducer will save energy of constrained sensors. Various experimental results confirm that communication subsystem is a prominent source of energy dissipation. Even in communication, large amount of energy is wasted in states, such as collision, overhearing, control packet overhead, idle listening, interference etc. [1].There are five main classes identified for energy efficient techniques i.e. data reduction, protocol overhead reduction, energy efficient routing, duty cycling and topology control. There are some terms associated to the energy efficiency on WSN and they are used to evaluate the performance of the routing protocols. In[2] some of the most important ones are discussed they are energy per Packet, network life time, average energy dissipated, low energy consumption, average packet delay, packet delivery ratio, idle listening, packet size and distance between the sender and receiver etc. The most common factors which affect the design of routing protocols [3] are node deployment, node/link heterogeneity, data reporting model, scalability, fault tolerance etc.

III. Related Work

A wireless sensor network (WSNs) consists of large number of nodes. Each node behaves as a small computer, which is capable and primarily equipped to measure physical quantities of the surrounding environment and transmitting them using a radio link. In WSNs each node has limited memory and processing power. Energy consumption is a major constraint in WSNs, since nodes are usually battery powered. It is often very difficult, if not impossible to recharge or replace once a battery is exhausted and the node is considered as dead [4]. The most challenging concern in WSN design is how to save node energy while maintaining the required performance of the network. Any WSN can only fulfill its mission as long as it is considered alive, but not after that hence the goal of energy efficient technique is to maximize network lifetime. In [5], a survey on routing protocols in WSNs is presented. It classifies the routing techniques, based on the network structure, into three categories: flat, hierarchical, and location-based routing protocols. Furthermore, these protocols are classified into multipath-based, query-based, negotiation-based, and QoS-based routing techniques depending on the protocol operation. In [6], the authors classify the routing algorithms in the MEB/MEM (minimum energy broadcast/multicast) problem and the MLB/MLM (maximum lifetime broadcast/multicast) problem in wireless ad hoc networks. In [7], the authors present a survey that is focused on the energy consumption based on the hardware components of a typical sensor node. The design issues of WSNs and classification of routing protocols are presented in [8]. Furthermore, without providing details on each of the defined protocols few routing protocols are presented based on their characteristics and the mechanisms they use in order to extend the network lifetime. In this work the authors do not present a direct comparison of these discussed protocols. The paper in [9] presents the challenges in the design of the energy-efficient Medium Access Control (MAC) protocols for the WSNs. However, the paper neither discusses the energy-efficient routing protocols developed on WSNs nor provides a detailed comparison of the protocols. In [10], few energy-efficient routing techniques for Wireless Multimedia Sensor Networks (WMSNs) are presented. In wireless sensor network, the exchange of data is most critical requirement for its usage. As the data measured are critical for its monitoring and controlling, the measured are to be transmitted over the network at the fastest rate, with highest level of accuracy. Towards the objective of achieving these requirements, in [11] a cluster-based communication was suggested. Cluster based communication, has emerged as an optimal solution to long-range communication using multi hop communication, with resources dynamically placed. Towards achieving power optimization, a distributed cluster head scheduling (DCHS) algorithm to achieve maximization in network lifetime in WSN was outlined in [11]. With a similar objective in [12] an analysis on investigation of direct minimum transmission energy (MTE), Low Energy Adaptive Clustering Hierarchy (LEACH) is proposed. An energy efficient zone clustering called EZone was developed based on single and multiple gateway scenarios. The Approach of zone based coding was observed to be significant in service area coverage as compared to other routing approaches. In [13] an unequal clustering approach based on energy aware coding was developed. The suggested energy aware distributed unequal clustering protocol (EADUC), was defined to solve the issue of energy hole problem in WSN. The approach defines the cluster formation based on the location of the nodes and residual energy available. The head selection is based on the coverage range of the node and the data exchanges are performed via a mini and major time slot. In [14], for clustering an energy and proximity based approach was suggested. Although, there are a good number of surveys for wireless sensor networks based on routing and MAC algorithms, this paper provides survey emphasizing on the energy-efficient routing protocols in WSNs using the network structure.

IV. Energy Efficient Routing Protocols In WSN

Routing in WSNs may be more demanding than other wireless networks, like mobile ad-hoc networks or cellular networks. In general, routing in WSNs can be divided into flat-based routing, hierarchical-based routing, and location-based routing depending on the network structure [5]. In flat-based routing, all nodes are typically assigned equal roles or functionality. In hierarchical-based routing, however, nodes will play different roles in the network. In location-based routing, sensor nodes positions are exploited to route data in the network. A routing protocol is considered adaptive if certain system parameters can be controlled in order to adapt to the current network conditions and available energy levels. Furthermore, these protocols can be classified into multipath-based, query-based, negotiation-based, QoS-based, or coherent-based routing techniques depending on the protocol operation. In addition to the above, routing protocols can be classified into three categories, namely, proactive, reactive, and hybrid protocols depending on how the source finds a route to the destination. In proactive protocols, all routes are computed before they are really needed, while in reactive protocols, routes are computed on demand. Hybrid protocols use a combination of these two ideas. Routing protocols based on network structure are more energy efficient and scalable. Hence a detailed survey of these protocols is carried out.

4.1 Network Structure Scheme

The structure of a network can be classified according to node uniformity. The nodes in some networks are considered to be deployed uniformly and be equal to each other, or other networks make distinctions between different nodes. More specifically, they route the information based on the networks architecture. This addresses two types of node deployments, nodes with the same level of connection and nodes with different hierarchies. Therefore, the schemes on this category can be further classified as follows:

Flat Protocols: All the nodes in the network play the same role. Flat network architecture presents several advantages, including minimal overhead to maintain the infrastructure between communicating nodes.

Hierarchical Protocols: To achieve energy efficiency, stability, and scalability, the routing protocols in this scheme are based on the hierarchical structure in the network. In these types of protocols, network nodes are organized in the form of clusters. The node with higher residual energy, assumes the role of a cluster head. The cluster head takes the responsibility for coordinating activities within the cluster and forwarding data between clusters. Use of the clustering reduces energy consumption and extends the lifetime of the network. Clustering have high delivery ratio and scalability and can balance the energy consumption. The nodes around the base station or cluster head will deplete their energy sources faster than the other nodes.

4.1.1 Flat Networks Routing Protocols

Flat Networks Routing Protocols for WSNs in general, can be classified according to the routing strategy, into three main categories: Pro-active protocols, Re-active protocols and Hybrid protocols [15]. Even though they have been designed for the same network, all these protocols differ in many ways and do not present the same characteristics; the following sections discuss these protocols and classify them according to their characteristics.

Pro-active or Table-Driven Routing Protocols: Pro-active (or table-driven routing protocols) work in a way similar to wired networks: based on the periodically exchanging of routing information between the different nodes, each node builds its own routing table which can be used to find a path to a destination. Each node is required to maintain one or maybe more tables by storing routing information. They also respond to any changes in network topology by sending updates through the wireless network and thus maintain a consistent network view. As the route is already known so, there does not exist, extra delay when a path to some destination is needed to forward the packets. Lot of bandwidth and extra battery power is needed to keep the information up-to-date. Some of the existing table-driven routing protocols are Wireless Routing Protocol

(WRP), the Topology Dissemination Based on Reverse-Path Forwarding Protocol (TBRPF) discussed in [16], [17]. Normally, battery power is limited in WSNs so these protocols are not energy efficient.

Re-active or Source-Initiated On-Demand Routing Protocols: A different approach from table-driven routing is the source-initiated on-demand routing. Unlike pro-active (table-driven) routing protocols, re-active protocols (on-demand protocols) only start a route discovery procedure when needed [18]. When a route from a source to a destination is needed, a kind of global search procedure is started. This task does not request the constant updates to be sent through the network, as in pro-active protocols, but this process does cause delays, since the requested routes are not available and have to be found. In some cases, the desired routes are still in the route cache maintained by the sensor nodes, which reduces the additional delay since routes do not have to be discovered. The whole process is completed as soon as a route is found or all possible route combinations have been examined. Some of the existing on-demand routing protocols are

Temporarily Ordered Routing Algorithm (TORA): This is an adaptive loop-free distributed routing algorithm based on the concept of link reversal. Each node i know its own height and the height of each directly connected neighbor j in this algorithm [19, 20]. TORA was designed to minimize the communication overhead associated with adapting to network topological changes and thus, to minimize the energy consumption. In addition, it supports multiple routes and multicast. However, TORA does not incorporate multicast into its basic operation.

Gossiping: When the individuals are connected by means of the communication network, gossiping and broadcasting are two main problems of information dissemination [21]. In gossiping, every person in the network knows a unique item of information. This information is required to be communicated to everyone else in the network. In broadcasting, one individual has an item of information, which needs to be communicated to everyone else in the network. Actually, gossiping is a derivative of flooding in which nodes do not broadcast the information but send the incoming packets to a randomly selected neighbor. Although this approach avoids the implosion problem by just having one copy of a message at any node, it takes long to propagate the message to all sensor nodes in the network.

Flooding: Flooding is an old and but very simple technique, which is used for routing in WSNs [22]. In flooding, copies of incoming packets are sent by every link except the one by which the packets arrived. This procedure generates an enormous amount of superfluous traffic. Flooding is an extremely robust technique but as long as there is a route from source to destination, the delivery of the packet is guaranteed. Flooding is a reactive technique, and does not require costly topology maintenance and complex route discovery algorithms. However, it has several drawbacks, such as implosion, overlay and resource blindness. As the extra packets are sent this technique is not energy efficient. There have been some protocols developed that use flooding as a part of their routing [23].

Rumor Routing (RR): The Rumor Routing is in between flooding queries and flooding event notifications [24]. 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.

Energy-aware Temporarily Ordered Routing Algorithm (E-TORA): The E-TORA is an alteration of TORA and its focus is to minimize the energy consumption of the nodes [51]. The classic TORA chooses the routes with the least hops as long as the network topology does not change. This may cause to the nodes that are on the main route heavy load. In addition, if some routes repeatedly include the same node, the node will run out of its energy much earlier than the other nodes. Thus, the use of nodes in the shorter path without considering their power leads to the decrease of the network lifetime. Thus, E-TORA was proposed in [25] to solve this problem. E-TORA takes into consideration the level of power of each node and avoids using nodes with low energy. In addition, the energy consumption of nodes is balanced in order to avoid that some nodes exhaust their energy earlier if they are used too frequently.

Hybrid Routing Protocols: Hybrid protocols combine the advantages of both pro-active and re-active routing protocols; they locally use pro-active routing and inter-locally use re-active routing.

Zone Routing Protocol (ZRP): The ZRP is a hybrid routing scheme that combines not only the advantages of pro-active but also the advantages of re-active protocols in a hybrid scheme [26]. According to this scheme, the network is divided into zones and the zones proactively maintain the topology of the zone, however, there is no periodic exchange of the topology change throughout the network. The neighboring nodes are informed only at periodic intervals. If there is need for ZRP to search for a particular node, then it initiates the route query and broadcasts it to the neighboring sensor nodes.

4.1.2 Hierarchical Networks Routing Protocols

Unlike flat protocols, where each node has its unique global address and all the nodes are peers, in hierarchical protocols nodes are grouped into clusters. Every cluster has a cluster head the election of which is based on different election algorithms. The cluster heads are used for higher-level communication, reducing the traffic overhead. Clustering may be extended to more than just two levels having the same concepts of communication in every level. The use of routing hierarchy has many advantages. It reduces the size of routing tables providing better scalability. The various hierarchical protocols are

Low-Energy Adaptive Clustering Hierarchy (LEACH): The LEACH is a hierarchical protocol in which most nodes transmit to cluster heads [27], [28]. The operation of the LEACH protocol consists of two phases mainly *setup phase* and *steady state phase*. In the Setup Phase, the clusters are organized and the cluster heads are selected. The cluster heads are responsible for data aggregation, compressing and forwarding to the base station. Each node determines whether it will become a cluster head, in this round, by using a stochastic algorithm. When a node becomes a cluster head for one time, it cannot become cluster head again for next P rounds, where P is the desired percentage of cluster heads. Thereafter, the probability of a node to become a cluster head in each round is 1/P. This rotation of cluster heads leads to a balanced energy consumption to all the nodes, which leads to longer lifetime of the network. In the steady state phase, the data is sent to the base station. Normally time spent in the steady state phase is more than setup phase. When compared with other protocols LEACH has advantage in terms of energy dissipation, ease of configuration, and system lifetime of the network [29]. LEACH uses single-hop routing, where each node can transmit directly to the cluster head and then to the sink. Therefore, it is not suitable for the networks that are deployed in large regions. LEACH uses the dynamic clustering which may results to extra overhead, e.g. head changes, advertisements etc., which may reduce the gain in energy consumption.

Low-Energy Adaptive Clustering Hierarchy Centralized (LEACH-C): The LEACH-C uses the base station for cluster formation. However, in LEACH nodes self-configure themselves into clusters [30]. Initially information regarding the location and energy level of each node in the network is received from the Base Station (BS). Using this information, the BS finds a fixed number of cluster heads and configures the network into clusters. The cluster groupings are chosen to minimize the energy required for non-cluster-head nodes to transmit their data to their respective cluster heads. The enhancements of this algorithm as compared with LEACH are the following: The BS uses global knowledge of the network to produce clusters so that it requires less energy for data transmission. Whereas, in LEACH the number of cluster heads varies from round to round due to the lack of global coordination among nodes.

Power-Efficient Gathering in Sensor Information Systems (PEGASIS): The PEGASIS protocol is an improvement of the LEACH. PEGASIS is a chain-based protocol [31]. Here, each node communicates only with a nearby neighbor in order to send and receive data. It takes turns transmitting to the base station, which reduces the amount of energy spent per round. The nodes are organized in such a way as to form a chain. Either the sensor nodes themselves, using a greedy algorithm starting from some node, can accomplish this or the BS can compute this chain and broadcast it to all the sensor nodes. In general, the PEGASIS protocol presents twice or more performance in comparison with the LEACH protocol [32], [33]. However, the PEGASIS protocol causes the redundant data transmission since one of the nodes on the chain has been selected. Unlike LEACH, the transmitting distance for most of the nodes is reduced in PEGASIS. PEGASIS provides improvement by factor of two as compared to LEACH protocol.

Threshold sensitive Energy Efficient sensor Network protocol (TEEN): The TEEN is a hierarchical protocol designed for the conditions in which sudden changes in the sensed attribute occurs for ex. temperature [34]. The responsiveness is important for time-critical applications. Here the network is operated in a reactive mode. The architecture in TEEN is based on a hierarchical grouping. TEEN tends to consume a lot of energy for long distance transmission in large area networks and when the number of layers in the hierarchy is small

Adaptive Threshold sensitive Energy Efficient sensor Network (APTEEN): The APTEEN is an improvement of TEEN and aims at both capturing periodic data collections and reacting to time-critical events [35]. As soon as the base station forms the clusters, the cluster heads broadcast the attributes, the threshold values and the transmission schedule to all nodes. After that, the cluster heads perform data aggregation, which has as a result to save energy. The main advantage of APTEEN, compared to TEEN, is that nodes consume less energy. However, the main drawbacks of APTEEN are the complexity and that it results in longer delay times.

Virtual Grid Architecture Routing (VGA): The VGA combines data aggregation and in-network processing to achieve energy efficiency and maximization of network lifetime [36]. The main advantage of this protocol is that it may achieve energy efficiency and maximization of network lifetime, but the problem of optimal selection of local aggregators as master aggregators is NP-hard problem.

Two-Tier Data Dissemination (TTDD): The TTDD assumes that the sensor nodes are stationary and location aware and sinks are allowed to change their location dynamically [37]. The TTDD can be used for multiple mobile sinks in a field of stationary sensor nodes. The main drawback is that each source node builds a virtual grid structure of dissemination points to supply data to mobile sinks.

Base-Station Controlled Dynamic Clustering Protocol (BCDCP): The BCDCP sets up clusters based on the main idea that they will be balanced [38]. In this case, the base station is considered a high-energy node with a large amount of energy supply.

Multihop Virtual Multiple Input Multiple Outputs (MIMO): In the Multihop Virtual MIMO the data are collected by multiple source nodes and transmitted to a remote sink by multiple hops [39]. In order to improve the energy saving performance, the Multihop Virtual MIMO presents that the average attenuation of the channel between each cluster node and cluster head can be estimated during the formation of the clusters, so it uses an equal Signal to Noise Ratio (SNR) policy to allocate the transmit power due to its spectral efficiency and simplicity.

Hierarchical Power Aware Routing (HPAR): The HPAR is a power aware routing protocol that divides the network into a group of sensors called zones [40]. The main advantage of this protocol is that it takes into consideration both the transmission power and the minimum battery power of the node in the path. In addition, it makes use of zones to take care of the large number of sensor nodes. On the other hand, the discovery of the power estimation may consult on the overhead to the network.

Sleep/Wake Scheduling Protocol: The sleep/wake scheduling protocol conserves energy as it puts the radio to sleep during idle times and wake it up right before message transmission/reception [41]. The important part for a sleep/wake protocol is the synchronization between the sender and the receiver, so that they can wake up simultaneously to communicate with each other.

Grid Based Data Dissemination (GBDD): In GBDD the size of the cell is determined by dual radio range of a sensor node [42]. Unlike TTDD, where the source initiates grid construction, in GBDD the sink that first was interested in sending or receiving data starts the grid construction process.

Extending Lifetime of Cluster Head (ELCH): In ELCH in order to elect the cluster head the sensors vote for their neighbors [43]. This protocol consumes low energy and thus extending the life of the network utilizing a hybrid protocol, which combines the cluster architecture, with multi-hop routing. This technique can minimize the transmission energy and the network can be more balanced in terms of energy efficiency.

Novel Hierarchical Routing Protocol Algorithm (NHRPA): The NHRPA [44] algorithm can adopt the suitable routing technology for the nodes that is relative to the distance of nodes to the base station, the density of nodes distribution and the residual energy of nodes.

Scaling Hierarchical Power Efficient Routing (SHPER): The SHPER protocol supposes the coexistence of a base station and a set of homogeneous sensor nodes [45]. The main advantage of this protocol is that it performs the cluster leadership by taking into account the residual energy of nodes and energy balance is achieved and the power depletion among the nodes is performed in a more even way. Moreover, the data routing is based on a route selection policy, which takes into consideration both the energy reserves of the nodes and the communication cost associated with the potential paths. However, it does not support the mobility of the nodes.

Distributed Hierarchical Agglomerative Clustering (DHAC): DHAC provides a bottom-up clustering approach by grouping similar nodes together before the cluster head (CH) is selected. DHAC can accommodate both quantitative and qualitative information types [46].

V. Comparison of Flat And Hierarchical Routing Protocols

In case of flat routing protocols the simulation results in [47] show that, WRP provides about 50 percent improvement in the convergence compared to the Bellman-Ford. A protocol that reduces its complexity, compared to WRP, is TORA. The simulation results in [48] show that TORA was found to have a worse delivery ratio and better delay, compared to WRP. However, E-TORA compared to TORA can balance effectively energy consumption of each node and increase evidently the lifetime of the network [25]. On the other hand, the simulation results in [22] show that Flooding has a delivery ratio up to 100 percent and the delay varies from 100ms to 180ms. However, the TBRPF achieves up to a 98 percent reduction in communication cost in a 20-node network and the ZRP can reduce up to 95 percent the control packets compared to Flooding.

In Hierarchical protocols, the protocol that is most popular is LEACH, which can reduce the total number of transmissions, compared to that of direct communication. However, LEACH-C outperforms LEACH in terms of energy efficiency. Moreover, the PEGASIS performs better than LEACH by about 100 percent to 300 percent when 1 percent, 20 percent, 50 percent and 100 percent of nodes die for different network sizes and topologies [32], [33]. TEEN outperforms LEACH and LEACH-C in terms of energy efficiency [34]. The performance of APTEEN lies between TEEN and LEACH with respect to energy consumption and longevity of the network [35]. TEEN only transmits time-critical data while sensing the environment continuously. To overcome the drawbacks of TEEN, the APTEEN has a periodic data transmission. In addition, the BCDCP has a more desirable energy expenditure curve than those of LEACH, LEACH-C and PEGASIS [38]. BCDCP reduces overall energy consumption and improves network lifetime compared to LEACH, LEACH-C and PEGAGSIS. The SHPER outperforms TEEN concerning the mean energy consumption by 9.88 percent (the distance between the base station and the node is 100m), 18.77 percent (the distance between the base station and the node is 200m), 26.23 percent (the distance between the base station and the node is 300m) [45]. TTDD increases the energy gradually but sub linearly as the number of sinks increases and for a specific number of sinks (e.g., 4 sinks), energy consumption increases almost linearly as the number of sources increases [37]. Moreover, the delay ranges from 20msec to 80msec and the delivery ratio can be up to 90 percent. The TTDD is compared to Directed Diffusion and the results show that TTDD scales better than Directed Diffusion to the number of sources. If there are 1 or 2 sources, Directed Diffusion uses less energy, but if there are more than 2 sources, TTDD consumes much less energy. However, the GBDD has 43 percent overall energy savings compared to TTDD. Moreover, GBDD shows 30 percent improvement compared to TTDD in average delay computed across all source-sink pairs for a data packet to reach the destination. Moreover, two protocols, compared to LEACH, are the MIMO and the ELCH. The MIMO outperforms LEACH in terms of energy consumption. The first node at the network runs out of power at 700sec [39]. The ELCH outperforms LEACH in terms of energy efficiency and the first node at the network runs out of power at 270sec [43]. The NHRPA outperforms TEEN and Direct Diffusion in terms of packet latency and average energy consumption [44]. The HPAR performs better than 80 percent of optimal for 92 percent of the experiments and performs within more than 90 percent of the optimal for 53 percent of the experiments and the sleep/wake can achieve at least 0.73 of the optimal performance [40]. The DHAC outperforms LEACH and LEACH-C in terms of energy consumption. While the sink moves further, the network lifetime of LEACH-C decreases very quickly compared to DHAC. DHAC gains much better performance when the network has light traffic [46].

Flat Routing protocols are simple, all the nodes are at the same level and it uses the global information for the routing. However, these protocols are having large amount of control packet overhead, less scalable and they consume more power when the size of the network increases. Hence, these protocols are not energy efficient. Hierarchical routing is mainly two-layer routing where one layer is used to select cluster heads and the other for routing. 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. 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 base station. The creation of clusters and assigning special tasks to cluster heads can greatly contribute to overall system scalability, consumption of less energy and hence the life time of the network is improved.

VI. Conclusion And Future Scope

In this paper, an attempt is made to summarize many of the Flat and hierarchical based routing protocols. While flat based routing techniques are simple and fair these protocols have large amount of control packet overhead and low scalability and they are less energy efficient. Hierarchical routing protocols greatly increase the scalability of a sensor network. The overall energy consumption of the nodes is reduced, leading to prolonged network lifetime. Better utilization of the channel bandwidth occurs when the network is organized into clusters. In this approach, the whole network is arranged into multiple clusters, where each cluster is defined by the node proximity. In the process of power conservation, each node registered to a cluster head, and a scheduling algorithm is used to schedule for a wake up and sleep period to exchange data among all other nodes. Hence, cluster based routing is an optimal solution to energy conservation in WSN. To achieve efficient energy conservation, multiple clustering, multi-Head clustering and zone oriented clustering were suggested also suggested in the past. However, these approaches focus on power conservation at the node level.

In real time application, in WSN, with long network lifetime, data precision and refreshment rate are the two critical factors to be linked. Wherein, clusters are defined for power optimization, not much focus is made on the characteristic of data flow. As in WSN, data precision and the refreshment rate of the continuous monitoring data is mainly required, other communicating factors such as interference among the nodes, and data relevancy are also the effecting factor. A longer data packet buffered in the propagation due to congestion, or loss of interference due to high trafficking at the head or gateway, could severely degrades the performance.

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