Comparative Analysis in Routing Protocol for Wireless Sensor Networks (WSN): An Overview

 Awanish Kumar Yadav

 Department of computer science and engineering

 Krishna institute of engineering and technology

 Ghaziabad (U.P.), India

 awanish.yadav13@gmail.com

***Abstract*—** **Recent development in the field of wireless sensor networks have attended to many new protocols built for sensor networks where awareness of energy is a first priority. Most of the interest, however, has been granted on the routing protocols and might be differ on the basis of network architecture and the application. This paper surveys routing protocols for WSNs and give a classification for the different approaches and method pursued. In this paper we are dividing routing protocols into few basic categories which are data-centric, hierarchical, location-based protocol, network flow and quality of service, coherent and non coherent based routing protocol. Routing protocols is explained under the different category. The paper concludes with open research issues.**

Keywords— Sensor networks; routing protocols; Energy-aware routing Classification of protocols

**1 INTRODUCTION**

Recent improvement in the field of micro-electro-mechanical systems technology, wireless communication, and digital electronics have inspired to development of tiny sensors. These types of sensors are provided with communication and data processing capabilities. The circuit of sensor is responsible for measuring of various parameters from the geographical area nearby the sensor and converts these parameters into an electric signal [1-5]. However, sensor nodes are involuntary in bandwidth and energy supply. Such constraints united with a normally deployment of huge amount of sensor nodes. The issues related to link and physical layers of network are generally same for every applications of sensors, therefore the explore on these subject has been drawn attention on system-level energy awareness such as system partitioning, radio communication hardware, dynamic voltage scaling, energy- aware media access control protocols and low duty cycle issues. At the network layer of networking, the main idea is to find procedure for setup of energy-efficient path and reliable delivery of information from the sensors to the interested destination also known as sink therefore life time of the network is increased [6-10]. Because of this, many new algorithms have suggested for the difficulty of routing data in wireless sensor network. Routing protocols can be divided as data-centric, hierarchical, location-based protocol, network flow, and quality of service (QoS), Coherent and Non-Coherent-Based Routing Protocols. Data-centric protocols are based on the query and naming of desirable data, which work in eliminating many unnecessary transmissions. The main aim of hierarchical protocol is to make cluster of the sensor nodes depend on the received signal strength. The transmission will only do by such cluster heads than all sensor nodes, so this will save energy. Location-based protocols use the position information to transmit the data to the desirable regions instead the entire network. The routing procedures that are depend on network-flow framework, protocols that effort for meeting some quality of service (QoS) requirements and routing function are categories as network flow, quality of service protocol. Coherent and Non-Coherent-Based routing protocols are based on the processing of the data at the node level. The sensor nodes trying to process the data within the sensor network.

1.1. **System design and architecture issues**

Different design and architectures issues have been considered for various applications of WSNs. As the performances of routing protocols are based on the architectural representation, in this division we are trying to focus on architectural issues and emphasize their significance.

**1.1.1. Network dynamics**

Mostly WSNs consist of three main components: base-station, sensor nodes and monitored events. There are few setups that use mobile sensors [11, 12], network architectures expect that sensor nodes are non-moving [13, 14, 15]. In contrast, supporting the mobility of CHs or sinks is sometimes deemed necessary [16]. Routing data to movable nodes (or from movable nodes) is more difficult task. So stability of route becomes an essential optimization factor, including bandwidth, energy etc. Sensed events can be either static or dynamic depending on the different application [17]. For example, in the field of battle for target detection, the event is dynamic whereas in the application of forest monitoring for prevention of fire is a static event. Network operates in a reactive mode for monitoring static event. Dynamic events create important traffic to be routed to the sink.

**1.1.2. Node deployment**

Another thought is the topological arrangement of nodes. This is based on the application and impact on the routing protocol performance. The deployment of nodes is either deterministic (manual) or self organizing. In deterministic methods of deployment of nodes, the sensors are placed by manually and data is traveled through predetermined path. But in self organizing systems, Sensor nodes are scattered randomly creating an ad hoc way infrastructure [18, 19– 21].

**1.1.3. Energy considerations**

The process of setting of path is highly impact by energy consideration during the creation of the infrastructure. Since the transmission power of a wireless radio is proportional to square of the distance or even higher order in the existence of barrier. Consumption of energy in Multi-hop routing will less than direct communication. Multi-hop routing brings out overhead in the establishment of topology and medium access control [22].

**1.1.4. Data delivery models**

Depending on the various application of the wireless sensor network, the data delivery model to the sink can be event driven, hybrid and continuous query-driven. In the continuous delivery model, each sensor transmits data periodically. In both query-driven and event-driven models, transmission of data is activated when an event happens or a query is produced by the sink. Some networks usage a hybrid model using a group of uninterrupted query-driven and event-driven data delivery. The routing protocol uses the data delivery model, to the route stability and minimization of energy utilization. For example, it has been finalized in [23] that hierarchical routing protocol is the most effective substitute in case of habitat monitoring application.

**1.1.5. Node capabilities**

In a sensor network, sensor nodes can be associated with different functionalities. In earlier works [5, 24, 25], all sensor nodes are assumed to be homogeneous, having equal capacity in terms of communication, computation and power. On the other hand, depending on the application a sensor node can be dedicated to a particular special function such as sensing, relaying and aggregation since engaging the three functionalities at the same instant on a sensor node might speedily consume the energy of that node. Some of the hierarchical protocols proposed in the literature assign a cluster-head different from the normal sensors. While some networks have selected cluster- heads from the deployed sensors [26, 27, 28], in other applications a cluster-head is more powerful than the sensor nodes in terms of bandwidth, energy and memory. In such cases, the load of transmission to the sink and aggregation is handled by the cluster-head. Inclusion of various set of sensors raises several technical issues related to data routing.

**1.1.6. Data aggregation /fusion**

Since sensor nodes might generate significant redundant data, related packets from many nodes can be aggregated so that the number of transmissions would be reduced. Data aggregation is the combination of data from different sources by using functions such as suppression (eliminating duplicates), min, max and average [29]. Some of these functions can be performed either partially or fully in each sensor node, by allowing sensor nodes to conduct in-network data reduction. Recognizing that calculation would be a reduced amount of energy consuming than communication[19], considerable energy savings can be obtained through data aggregation. This technique has been used to accomplish traffic optimization and energy efficiency in routing protocols. All aggregation functions are assigned to powerful and specialized nodes [11]. Signal processing techniques is uses for data aggregation. In that case, it is referred as data fusion where a node is capable of producing a more accurate signal by reducing the noise and using some techniques such as beam forming to combine the signals [19].

**1.2. Literature review**

The growing significance in wireless sensor net-works and the frequent emergence of new architectural techniques inspired some previous efforts for surveying the characteristics, communication and applications protocols for such a technical area [1, 17]. In this subsection we emphasize the features that differentiate our survey and hint the difference in scope. The goal of [1] is to make a comprehensive survey of design issues and techniques for sensor networks describing the physical constraints on sensor nodes and the protocols planned in all layers of network stack. We summarize different architectural design issues that may have an effect on the performance of routing protocols.

**2. Data-centric protocols**

In various applications of sensor networks, it is not feasible to allocate global identifiers to each node due to the sheer number of nodes deployed. Such be short of global identification along with random deployment of sensor nodes make it hard to select a concern has led to data-centric routing, which is dissimilar from conventional address-based routing where routes are created between addressable nodes managed in the network layer of the communication stack. The sink sends queries to certain regions and waits for data from the sensors placed in the selected regions. After that, various other protocols have been proposed either based on Directed Diffusion or following a similar concept [24]. In this section, we will illustrate these protocols in details and bring to light the key ideas.

**2.1. Flooding and gossiping**

Flooding and gossiping [30] are two standard mechanisms to send data in sensor networks without the requirement for any topology maintenance and routing algorithm. In flooding, each sensor nodes receiving a data packet send it to all of its neighbor’s nodes and this process continues until the packet delivers at the destination node. Gossiping is a slightly enhancement mechanism of flooding where the receiving node sends the packet to randomly selected neighbor nodes, which picks another random neighbor node to forward the packet to and so on.

Even though flooding is very easy to implement, it has numerous draw backs, see Figs. (1) Redrawn from [31]. Such drawbacks include implosion caused by duplicated messages sent to same node overlap when two nodes sensing the same region send similar packets to the same neighbor and resource blindness by consuming large amount of energy without consideration for the energy constraints [31]. Gossiping avoids the problem of implosion by just selecting a random node to send the packet rather than broadcasting. However, Gossiping cause delays in propagation of data through the nodes.



Fig.1. the implosion problem. Node 1 starts by flooding its data to all of its neighbors. 6 get two same copies of data in time, which is not essential.

**2.2. Directed Diffusion**

Directed Diffusion [24, 25] is an important mechanism

in the data- centric routing research of sensor networks. Naming scheme is used for the data for diffusing data through sensor nodes. The main motive behind using such an idea is to get rid of unessential operations of network layer routing for saving energy. Direct Diffusion proposes the make use of attribute-value pairs for the data and then queries with the sensors by demand basis. The nodes can do in-network data aggregation, which is modeled as a minimum Steiner tree problem [32]. The interests in catches compare the data which have received, with the values in the interests.

**2.3. Energy aware routing**

Shah and Rabaey [33] defined to use a set of sub-optimal paths rarely to increase the life-time of the network. These paths are selected by means of a probability function, which based on the energy consumption of all paths. Survival of network is the main metric that the approach is concerned with. The approach disputes that using the least energy path every the time will reduce the energy of nodes on that path. This protocol is based on three phases:

1. Setup phase:

Localized flooding happens to find the routes and create the routing tables. As doing this, the entire energy cost is calculated in each node. For example, if the request is sent from node Ai to node Aj, Aj calculates the cost of the path as follows:

C(Aj, Ai)=COST(Ai)+Metric(Aj,Ai)

2. Data communication phase: Each node forwards the packet by randomly choosing a node from its forwarding table using the probabilities.

3. Route maintenance phase: Localized flooding is performed rarely to remain all the paths alive.

**2.4. Rumor routing**

Rumor routing [33] is another variant of Directed Diffusion and is generally proposed for contexts in which geographic routing criteria are not valid. Normally Directed Diffusion floods the query to the whole network when there is no geographic criterion to diffuse tasks. Though, in some cases there is only a small amount of data requested from the nodes and thus the use of flooding is needless. Another approach is to flood the events if number of queries is large and number of event is small. Rumor routing is between query flooding and event flooding. The suggestion is to route the queries to the nods that have examined a particular event rather than flooding the whole network to get back information about the occurring events.

**2.5. Gradient -based routing**

Schurgers et al. [34] have suggested a little changed version of Directed Diffusion, called Gradient-based routing (GBR). The initiative is to maintain the number of hops when the interest is diffused through the network. Therefore, every node can find out the minimum number of hops to the sink known as node's height. The dissimilarity between a node's height and its neighbor is considered the gradient on that link. Then forward the packet on a link with the largest gradient.

**2.6. CADR**

Constrained anisotropic diffusion routing (CADR) [35] is a protocol, which efforts to be a general kind of Directed Diffusion. There are two methods namely constrained anisotropic diffusion routing and information-driven sensor querying (IDSQ) are proposed. The scheme is to query sensors and route data in a network in order to maximize the information grow, while minimizing the latency and bandwidth. This is attained by activating only the sensors that are close to a particular event and dynamically changing data routes. The information effectiveness measure is modeled using standard estimation theory. In the IDSQ protocol the querying node can find out which node can provide the good number of useful information while balancing the cost of energy. However IDSQ provides a method of choosing the best possible order of sensors for maximum incremental information grow, it does not particularly specify how the query and the information are dispatch between sensors and the sink.

**2.7. COUGAR**

A data- centric protocol that sights the network as a vast distributed database system is suggested. The main scheme is to use declarative queries for abstract query processing from the network layer functions as example selection of related sensors etc. and make use of in-network data aggregation for saving the energy. The concept is supported through with a new query layer between the application layers and network. COUGAR suggested architecture for the sensor database system in which sensor nodes choose a leader node to do aggregation and send out the data to the sink. The sink is responsible for create a query plan, which determine the essential information about the flowing of data and in-network computation for the incoming query and then send it to the related nodes. The query plan illustrates how to select a leader for the query. The architecture gives in-network computation facility for all the sensor nodes. Such facility ensures energy- efficiency particularly when the number of sensors generating and sending data to the leader is vast [36].

**2.8. ACQUIRE**

A new data-centric method for querying sensor networks is Active Query forwarding In sensor networks (ACQUIRE) [37]. The approach views the sensor network as a distributed database and is compatible for complex queries which consist of many sub queries. The querying method works as follows: the query is forwarded by the sink and each node receiving the query, tries to respond in part by using its pre-cached information and forward it to another sensor. If the pre-cached information is not newest current, the nodes collect information from its neighbors. If the query is being solved completely, it will send back through either the reverse manner or by shortest-path to the sink node.

**2.9. Sensor protocols for information via negotiation (SPIN)**

SPIN is based on data centric routing mechanism. The main idea behind SPIN is naming the data by using any high level descriptors or meta-data. The key feature of SPIN is first it exchange the meta- data among sensors with the help of data advertisement mechanism. Each node after receiving new data, send advertisement messages it to its neighbor’s node and interested neighbors node, i.e. nodes that do not have such data, recover the data by sending a request message. SPIN can solve the classic problem of flooding.

SPIN contain three messages to exchange data between nodes. These are: ADV message to allow a sensor to advertise a particular meta-data, REQ message to request the particular data and DATA message that hold the actual data.

**3. Hierarchical protocols**

The hierarchical routing protocol maintain the energy consumption of sensor nodes by concern them in multi-hop communication within a specific cluster. It performs data aggregation and fusion for decreasing the number of transmitted messages to the sink. It forms the cluster for the minimization of energy utilization.

**3.1. LEACH**

Low-Energy Adaptive Clustering Hierarchy (LEACH): The LEACH protocol is one of the first hierarchical protocols. It is cluster based protocol and randomly finds out the Cluster-heads for each cluster. LEACH protocol consists of two phases:

The Setup Phase: In this phase cluster heads are selected from the clusters. Cluster heads aggregate, compress, and forward the data to the base-station. It forms the cluster heads by using a stochastic algorithm at each round. If a node becomes a cluster head for one round, it will not become cluster head for next R rounds, where R is the desired percentage of cluster heads. Therefore, the chances of a node to become a cluster head in each round will be one out of R. Due to rotation of cluster heads longer lifetime of the network

The Steady State Phase: The Steady State Phase, the data is sent to the base-station. After certain of time period spent on the steady State Phase, the network goes into the set-up phase again and enters into another round of selecting the cluster-heads [10].

**3.2. PEGASIS**

Power-efficient Gathering in Sensor Information Systems (PEGASIS) [27] is an enhancement of the LEACH protocol. Instead of forming many clusters, PEGASIS forms chains from sensor nodes so that each node transmits and receives from a neighbor and only one node is chosen from that chain to transfer to the base station (sink). Collected data moves from node to node, aggregated and at last sent to the base station. Gathered data moves from node to node, aggregated and finally sent to the base station. Construction of chain is performed in a greedy way. As shown in Fig. 2, redrawn from [27]. Node n0 passes its data to node n1. Node n1 aggregates node c0’s data with its own and then send out to the leader. After node n2 send the token to node n4, node n4 transmits its data to node n3. Node n3 aggregates node n4’s data with its own and then transmits to the leader. Node n2 waits to receive data from both neighbors and then aggregates its data with its neighbor’s data. Finally, node n2 transmits one message to the base station.



 Fig.2. Chaining form in PEGASIS

**3.3. TEEN and APTEEN**

Threshold sensitive Energy Efficient sensor Network protocol (TEEN) [21] is a hierarchical protocol designed to be approachable to rapid changes in the sensed attributes such as temperature. Responsiveness is important for time-critical applications, wherein the network function in a reactive mode. TEEN follows a hierarchical approach along with the use of a data-centric method. The sensor network architecture is based on a hierarchical grouping where closer nodes form clusters and this process goes on the second level until base station (sink) is reached. The model is show in Fig. 3, which is redrawn from [21].

 

Fig.3. Hierarchical clustering in TEEN and APTEEN.

The Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN) [38] is an addition to TEEN and intend to both reacting to time-critical events capturing periodic data collections. The architecture is similar to TEEN. When the base station forms the clusters, the cluster heads broadcast the threshold values, the transmission schedule and the attributes to all nodes. Cluster heads also do data aggregation with the intention of save energy. APTEEN supports three different query types: one-time, to take a snapshot view of the network; historical, to analyze past data values; and persistent to monitor an event for a period of time.

**3.4. Energy- aware routing for cluster- based sensor networks**

Younis et al. [22] have suggested a different hierarchical routing algorithm based on three-tier architecture. Sensors are grouped into clusters earlier to network operation. The algorithm make use of cluster heads, namely gateways, which are less energy confined than sensors and supposed to know the location of sensor nodes. Gateways preserve the states of the sensors and sets up multi- hop routes for collecting sensors data. A TDMA based media access control is used for nodes to send data to the gateway. The gateway updates each node about slots in which it should listen to other nodes slot and transmission, which the node can use for its own transmission. Sink communicates only with the gateways.

**3.5. ELCH**

ELCH (Extending Life Time of Cluster Head) [39] routing protocol based on hierarchical and self-organization properties. It builds clusters on the basis of number of nodes in the cluster and radius of radio. The clusters in the network are distributed in equally way. In this protocol the sensors vote for their neighbors in order to choose suitable cluster heads. This protocol accomplishes to consume low energy and thus increase the life of the network utilizing a hybrid protocol, which is based upon the architecture of cluster, with multi-hop routing. This protocol has two phases:

Setup Phase. In this phase, formation of cluster and selection of cluster-head is carrying out. The nodes vote their neighbor sensors. The sensors which have the most votes become the cluster-head.

Steady-State Phase. In this phase, the creation of clusters, the transmitting to the head and forwarding to the sink are performed. The clusters are organized in such a way that they consist of one cluster-head and few sensors. These sensors have been selected based on their place. This means that the sensors located in a radius less than the radio radius are elected. Then, the time slot TDMA for each cluster member in each round is used. Furthermore, each cluster-head maintains a table with maximum power for each node at each selection round. As soon as the above process is completed, the transmission of data can start. When the clusters have been formed, the CH can form a multi-hop routing backbone. The data are forwarded to the cluster head by each node. Furthermore, for the communication between the cluster heads and the sink, a multi-hop routing is adopted. This method can decrease the transmitted energy and the network can be more balanced in perspective of energy efficiency.

**3.6. Weighted Election Protocol (WEP)**

Wireless Sensor Networks (WEP) Md. G. Rashed et al. [40] suggested an energy efficient protocol (WEP) for enhancing the stability period of sensor network. Author presents a clustering scheme with the help of chain routing algorithm to improve the energy and stable period constraints. In this protocol a weight is allotted to the optimal probability for each node. It is necessary that weight must be same to the ratio between initial energy of each node to the initial energy of the normal node. After assignment of weighted probability, selection of the cluster heads and cluster number will be the same manner as in LEACH protocol. By using the algorithm a chain among the selected cluster heads have been build. After this from the selected cluster heads, a chain leader is selected randomly. Each non cluster head nodes transfer their data to their respective cluster head nodes. After that cluster head nodes in each cluster then consolidated the data and finally send it to base station

**3.7**. **DHAC**

Distributed hierarchical agglomerative clustering (DHAC) [41: DHAC is based on the single hope neighbor to form the clusters. There are following steps in the DHAC to form clusters

1. Find out input data set and build resemblance matrix. In this a step node chooses itself as a cluster head and after that information is exchanges via HELLO messages to its neighbors.

2. Execution of the DHAC algorithm. In this step, each cluster form its own local resemblance matrix and the minimum coefficient can be easily found. Also, each cluster then find out its minimum cluster head.

3. Cut the hierarchical cluster tree. In this step if predefined upper bound size of clusters is reached, the control conditions match to the step of cutting the hierarchical cluster tree.

4. Control the minimum cluster size. The next is to formation of the clusters by running DHAC, the minimum cluster size can also be used to limit, the lower bound of cluster size by performing the process ”MERGE CLUSTERS”.

5. Select CHs. To select the CHs, the DHAC determine the lower id node between the two nodes that join the cluster at the first step. The CH chosen does not call for extra processing. The DHAC uses the sequence of nodes merging into the current cluster as the schedule. Each cluster member gets its allotted role and beginning to send data to the CH in turns.

**3.8. Low-Energy Adaptive Clustering Hierarchy Centralized (LEACH-C):**

LEACH-Centralized [42] is an improvement of LEACH protocols, it uses the same steady phase protocol as of LEACH but, it uses a centralized clustering algorithm. LEACH-C utilizes the base station for formation of cluster, unlike LEACH where nodes form the cluster themselves. During the setup phase, the Base Station (BS) receives information regarding the energy level and location of each node in the network. After that, by using this information, the base-station tries to find out the prearranged number of cluster heads and make the network into clusters. The formations of cluster are selected to minimize the energy required for non-cluster-head nodes to transmit their data to their respective cluster heads. Comparisons of this advancement of this algorithm with the LEACH are given below:

In LEACH-C base-station usages its global information of net-works to form the cluster so it want less energy for the transmission of data, in LEACH-C the amount of cluster heads in each round equals a predetermined optimal value.

Advantages of the LEACH-C protocols are given below.

1. The energy utilization of CH can be minimized by efficiently selecting the CH using the location information of the member nodes.

2. LEACH-C is more efficient than LEACH protocol because it delivers 40% more data per unit energy.

**4. Location-based protocols**

Most of the routing protocols for wireless sensor networks need location information for sensor nodes. In most cases location information is desired in order to calculate the distance between two particular nodes so that energy consumption can be predictable. Some of the protocols explained here are designed primarily for mobile ad hoc networks and consider the mobility of nodes during the design. However, they are also well relevant to sensor networks where there is less or no mobility.

**4.1. MECN and SMECN**

Minimum energy communication network (MECN) [43] sets up and preserve a minimum energy network for wireless networks by utilizing low power GPS. Though, the protocol supposes a mobile network, it is best appropriate to sensor networks, which are static. A minimum power topology for stationary nodes including a master node is found. MECN take for granted a master-site as the information sink.

The protocol has two phases:

1. It takes the positions of a two-dimensional plane and build a sparse graph, that consists all the enclosures of every transmit node in the graph. This construction requires local computations in the nodes. The enclose graph contains globally optimal links in terms of energy consumption.

2. Finds optimal links on the enclosure graph. It uses distributed Bellman-Ford shortest path algorithm with power consumption as the cost metric. In case of mobility the position coordinates are updated using GPS.

The small minimum energy communication network (SMECN) [44] is an extension to MECN. In MECN, it is supposed that every node can transmit to every further node that will be not possible every time. In SMECN possible obstructions between any pair of nodes are judge. However, the network is still supposed to be fully attached as in the case of MECN. The sub-net work constructed by SMECN for minimum energy conveying is provably smaller (in terms of number of edges) than the one constructed in MECN if broadcasts are able to reach to all nodes in a circular region around the broadcaster. Thus, the number of hops for transmissions will decrease. SMECN uses a lesser amount of energy than MECN and maintenance cost of the links is fewer. However, finding a sub-net work with smaller number of edges introduces more overhead in the algorithm.

**4.2**. **GAF**

Geographic adaptive fidelity (GAF) is an energy- aware location-based routing algorithm designed mainly for MANET, but may be related to sensor networks as well. GAF save energy by turning off needless nodes in the network without relating the level of routing fidelity. It develops a virtual grid for the covered area. Every node makes use of its GPS-indicated location to link itself with a point in the virtual grid. Nodes linked with the same point on the grid are considered the equal in terms of the cost of packet routing. Such equality is exploited in keeping a few nodes located in a particular grid area in sleeping state for saving energy. Thus, GAF can significantly increase the network lifetime as the number of nodes increases. Nodes change states from sleeping to active in turn so that the load is balanced. There are three states in GAF. These states are discovery, for determining the neighbor nodes in the grid, active reflecting participation in routing and sleep when the radio is turned off and active reflecting participation in routing.

GAF is implemented both for mobility and non mobility of nodes. However GAF is a location-based protocol, it may also be supposed as a hierarchical protocol, and where the clusters are depends on geographic location.

**4.3. GEAR**

The protocol, that is geographic and energy-aware routing (GEAR) [45], uses energy aware and geographically informed neighbor selection heuristics to route a packet to-wards the target region. The idea is to control the number of interests in Directed Diffusion by only considering a certain region rather than sending the interests to the entire network. GEAR compliments Directed Diffusion in this way and thus conserves more energy. There are two phases in the algorithm:

1. Forwarding packets in the direction of the target region: Upon receiving a packet, a node confirms its neighbors to see if there is one neighbor, which is nearer to the target region than itself. If there is more than one, the nearest neighbor to the target region is chosen as the next hop. If they are all further than the node itself, this indicates that there is a hole.

2. Forwarding the packets surrounded by the region: If the packet has reached the region, it can be diffused in that region by either recursive geographic forwarding or restricted flooding. Restricted flooding is fine when the sensors are not densely deployed. In the case of high-density networks, recursive geographic flooding is more energy efficient than restricted flooding. In that case, the region is separated into four sub regions and four copies of the packet are created.
 In the case of GPSR, the packets pursue the perimeter of the planar graph to find their route. While GPSR decrease the number of states a node should remain, it has been proposed for general mobile ad hoc networks and requires a location service to map locations and node identifiers. GEAR not only diminishes energy consumption for the route setup, other than also performs better than GPSR in terms delivery of packet. The simulation results show that for an uneven traffic distribution, GEAR delivers 70–80% more packets than (GPSR) for uniform traffic pairs GEAR delivers 25–35% more packets than GPSR.

**5. Network flow and QoS-aware protocols**

Although most of the routing protocols suggested for sensor networks fit our categorization, some follow somewhat dissimilar approach such as QoS and network flow. In some approaches, route setup is modeled and solved as a network flow problem. QoS-aware protocols suppose end-to-end delay requirements while setting up the paths in the sensor network. We discuss example of these protocols in this section.

**5.1**. **Maximum lifetime energy routing**

Chang and Tassiulas [46] give an interesting solution to the problem of routing in sensor networks based on a network flow approach. The main purpose of the approach is to maximize the network lifetime by carefully defining link cost as a function of node remaining energy and the required transmission energy using that link. Finding traffic distribution is a possible solution to the routing problem in sensor networks and based on that, comes the name ‘‘maximum lifetime energy routing’’. The clarification to this difficulty maximizes the possible time the network lasts. For find out the best link metric for the stated maximization problem, two maximum residual energy path algorithms are presented and simulated. The two algorithms differ in their definition of link costs and the incorporation of nodes residual energy. Rather than using ejk, the energy consumed when a packet is transmitted over link j– k, the following link costs are used:

 * (1)*

 * (2)*

 Where Ri is the residual energy at node j.

Bellman–Ford shortest path algorithm is used for finding the least cost paths to the destination (gateway).The least cost path obtained is the path whose residual energy is largest among all the paths. The algorithms utilizing these link costs are match to Minimum transmitted energy (MTE) algorithm, which considers ejk as the link cost.

**5.2**. **SPEED Protocol**

It is Qos routing protocol for WSNs. It provides soft real-time end-to-end guarantees. It also provides congestion avoidance whenever it find congested network. The routing module in SPEED is known as Stateless Geographic Non-Deterministic forwarding (SNFG) [47]. SPEED delivers more packets to the destination than the other protocols when heavily congested. So SPEED has slightly higher energy consumption. The major advantage of SPEED is that it performs well in terms of miss ratio and end-to-end delay.

**5.3. Multi-Path and Multi-SPEED (MMSPEED) Protocol**

It gives the probabilistic QoS guarantee in WSNs. It is based on two domains i.e. reliability and timeliness domain [48]

The main advantage of MMSPEED is that it guarantees end-to-end requirements in a localized way, which is wanted for scalability and adjust ability to large-scale dynamic sensor networks. It can offer QoS discrimination in both reliability and timeliness domains and improves the effective capacity of a sensor network in terms of number of flows that meet both reliability and timeliness requirements.

**5.4. QuEst Protocol**

The QoS-based energy-efficient sensor routing (QuESt) protocol [49] find out application- specific, near-optimal sensory-paths by improvements on multiple QoS parameters such that band width requirements, end-to-end delay and energy consumption, based on the Multi-Objective Genetic Algorithm (MOGA). The QuESt protocol is able to find out collection of QoS based, near optimal paths even with inaccurate network information.

**5.5. EQSR Protocol**

It is one of the recently proposed QoS based routing protocols, One of the recently proposed QoS based routing protocols. It is designed specifically for wireless sensor networks, EQSR is an energy-efficient and QoS aware multi path based routing, which provides service differentiation by giving real-time traffic independent preferential treatment over the non-real-time traffic. EQSR is based on the multi-path prototype collectively with a Forward Error Correction (FEC) technique to recover from failures of node, without bring up network-wide flooding for path-discovery. The EQSR protocol uses buffer size, signal-to-noise ratio and residual energy, to find out the next hop through the paths construction phase. EQSR divided the transmitted message into an equal size of the segments, after that adds correction codes, and then at the same time transmits it over multiple paths to increase the probability that is very necessary portion of the packet is received at the destination without acquisition of excessive delay. The EQSR protocol manages both real-time and non real-time traffic efficiently. It does so by apply a queuing model that gives service differentiation [50].

**6. Coherent and Non-Coherent-Based Routing Protocols**

Coherent and Non-Coherent-Based routing protocols are based on the processing of the data at the node level. The sensor nodes try to process the data within the sensor network. The routing method which initiates processing of the data is proposed in [2]. This mechanism is divided into two categories:

**Coherent Data Processing-Based Routing:**

In this mechanism only minimum processing is done by the sensor node. Some tasks such that Time stamping, duplicate suppression are completed in minimum processing. When the minimum processing is over the data is send to the aggregators.

**Non Coherent Data processing-based routing**:

In this mechanism sensor nodes process the actual data by local manner and then send that data to other node for next processing are known as aggregators. There are three stage of data processing in non-coherent routing [51].

(!) Target detection, data collection, and preprocessing:

In this phase, events are detected, gather the information of this event and preprocessed.

(2) Declaration of membership:

In this phase, sensor node selected to participate in a cooperative function and state this aim to all neighbors.

(3) Election of central-node

In this phase, a central node is chosen to perform better information processing.

1) **Single Winner Algorithm (SWE):**

In this algorithm, a single aggregator node is selected for complex processing [52]. This node is Central Node that is selected based on the computational capabilities and energy reserves of that node. For selecting the Central Node, all nodes broadcast a selected message and declare itself as a Central Node candidate. In effect to the first batch of selected messages, the nodes that have accepted them will compare the proposed Central Node candidate with it and reply for the second batch of selected messages that contains the outcome of initial comparison. After that message passing will be create for second batch. Registry is used for record the messages that present better candidate. If message present the better candidate it will store in registry and forward to all neighbors otherwise message will be discard.

**2) Multiple Winner Algorithms (MWE):**

Multiple Winner Algorithms (MWE) is improvements of SWE [52]. In this algorithm each node keeps a record of up to n nodes of candidate. The MWE process makes minimum-energy energy path for each sensor to each sensor node (SN). After this process SWE is used to find the node that gives the minimum-energy consumption. Now this node can react as central-node for coherent processing.

**7**. **CONCLUSION**

Routing in sensor networks has drawn a lot of attention as compared to conventional data routing and categorized the approaches in to different categories, that is to say data-centric, location-based and hierarchical. Some of the protocols based on the traditional network flow and QoS modeling method. Still, we have also observed that there are some hybrid protocols that fit under more than one group which is shown in Table 1.The table summarizes the classification of the protocols which is in this survey.

Protocols, which based on the naming of the desirable data and query the nodes based on attributes of the data are classified as data-centric. This paradigm is followed in order to prevent the overhead of formation of the clusters, the use of specialized nodes etc. Yet the naming schemes might not be enough for complex queries.

On the other side, cluster-based routing protocols based on the clustering of the sensor nodes to send the data to the sink. Cluster-head performs data aggregation and then sends it to the destination (sink). The most crucial research issues about such protocols are formation of the clusters of nodes so that the latency is optimized.

Location based Protocols are based on the position information and topological deployment of sensor. In order to assist energy efficient routing in this is the main research issue.

Further research would be needed to resolve few issues regarding service of video quality, imaging sensors and real-time applications. Energy-aware QoS routing in sensor networks will assure guaranteed bandwidth. Another interesting issue for routing protocols is the movements of node. New routing algorithms are needed in order to handle the overhead of mobility and topology change. In coherent-based routing protocol minimum processing is done by sensor node and it is based on the energy efficient mechanism. Other hand non-coherent data processing based on routing, first sensor nodes process the actual data in locally manner then it to other data for perform the next processing

Table 1: Classification of routing protocols

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Routing protocols | Data -centric protocols | Hierarchical Protocols | Location Based Protocols | QoS Based Protocols | Network -flow based protocols | Coherent and Non Coherent Protocols |
| FLOODING | YES |  |  |  |  |  |
| GOSSIPING | YES |  |  |  |  |  |
| SPIN | YES |  |  |  |  |  |
| DIRECTED DIFFUSION | YES |  |  |  |  |  |
| Shah and Rabaey | YES |  | YES |  |  |  |
| RUMOR ROUTING | YES |  |  |  |  |  |
| GBR | YES |  |  |  |  |  |
| CADR | YES |  |  |  |  |  |
| COUGAR | YES |  |  |  |  |  |
| ACQUIRE | YES |  |  |  |  |  |
| LEACH |  | YES |  |  |  |  |
| PEGASIS  |  | YES |  |  |  |  |
| TEEN |  | YES |  |  |  |  |
| APTEEN |  | YES |  |  |  |  |
| ELCH |  | YES |  |  |  |  |
| WEP |  | YES |  |  |  |  |
| DHAC |  | YES |  |  |  |  |
| LEACH-C |  | YES |  |  |  |  |
| MECN  |  |  | YES |  |  |  |
| SMECN |  |  | YES |  |  |  |
| GAF |  | YES | YES |  |  |  |
| GEAR |  |  | YES |  |  |  |
| Chang and Tassiulas |  | YES |  |  | YES |  |
| SPEED |  |  | YES | YES |  |  |
| MMSPEED |  |  |  | YES |  |  |
| QuEst |  |  |  | YES |  |  |
| EQSR |  |  |  | YES |  |  |
| SWE |  |  |  |  |  | YES |
| MWE |  |  |  |  |  | YES |

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