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A Survey on Routing Protocols in Wireless Sensor Networks

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Abstract:- *Wireless sensor network is emerging field because of its wide applications. It is a wireless network which subsist a group of small sensor nodes which communicate through radio interface. These sensor nodes are composed of sensing, computation, communication and power as four basic elements. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. But limited energy, communication capability, storage and bandwidth are the main resource constraints. The network should have self-organizing capabilities as the positions of individual nodes are not predetermined. The flexibility, fault tolerance, high sensing fidelity, low cost, and rapid deployment characteristics of sensor networks create many new and exciting application areas for remote sensing. Our survey is based on various aspects of routing protocols in wireless sensor networks.*

Keywords:-*WSN, Sensor nodes, Routing, Ad hoc networks*

I. INTRODUCTION

Wireless ad-hoc sensor networks have recently emerged as a premier research topic. They have great long-term economic potential, ability to transform our lives, and pose many new system-building challenges. Sensor networks also pose a number of new conceptual and optimization problems. Some, such as location, deployment, and tracking, are fundamental issues, in that many applications rely on them for needed information.

A wireless sensor network composed of hundreds to thousands of sensor nodes with much shorter distance between adjacent nodes and low application data rate.

In recent years WSN becomes emerging field in wide range of applications like health monitoring applications, environmental observation, forecasting system, battlefield surveillance, robotic exploration, monitoring of human physiological data etc. The sensors can be deployed at various places with different usages and each have different capability to sense different attributes like temperature, moisture, pressure humidity etc. But these sensors have limited power sources and also it is not cost effective to recharge the batteries. The batteries are usually irreplaceable. Therefore, there lifetime will depends on respective batteries of sensors. So the life time of wireless sensor network can be prolonged by using effective energy balancing methods.

Wireless sensors have become an excellent tool for military applications involving intrusion detection, perimeter monitoring, information gathering and smart logistics support in an unknown deployed area. Some other applications: sensor-based personal health monitor, location detection with sensor networks and movement detection. Routing in wireless sensor networks differs from conventional routing in fixed networks in various ways. There is no infrastructure, wireless links are unreliable, sensor nodes may fail, and routing protocols have to meet strict energy saving requirements [5]. Many routing algorithms were developed for wireless networks in general.

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II. Routing Protocols in Wireless Sensor Networks

1. Flat Routing Protocol

The first category of routing protocols are the multihop flat routing protocols. [1] Usually WSN consists of sensor nodes and base station. In flat topology all sensor nodes are treated uniformly.[19] In flat networks, each node typically plays the same role and sensor nodes collaborate together to perform the sensing task.[2,3] Due to the large number of such nodes, it is not feasible to assign a global identifier to each node. This consideration has led to data centric routing, where the BS sends queries to certain regions and waits for data from the sensors located in the selected regions.

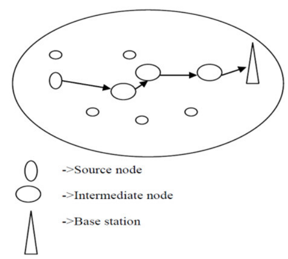

Figure 1.1: Example of flat routing

In Figure1.1 the source node senses their data like tracking object and sends the data to the base station through intermediate nodes.[20,21] Early works on data centric routing, e.g., SPIN and directed diffusion [18] were shown to save energy through data negotiation and elimination of redundant data.

Minimum Cost Forwarding Algorithm (MCFA): The MCFA algorithm [1, 3] exploits the fact that the direction of routing is always known, that is, towards the fixed external base-station. Hence, a sensor node need not have a unique ID nor maintain a routing table. Instead, each node maintains the least cost estimate from itself to the base-station.

Directed Diffusion: In [5], C. Intanagonwiwat et. al. proposed a popular data aggregation All sensor nodes in a directed diffusion-based network are application-aware, which enables diffusion to achieve energy savings by selecting empirically good paths and by caching and processing data in the network. [21]Caching can increase the efficiency, robustness and scalability of coordination between sensor nodes which is the essence of the data diffusion paradigm. At this stage, loops are not checked, but are removed at a later stage.

Rumor Routing: Rumor routing [3] is a variation of directed diffusion and is mainly intended for applications where geographic routing is not feasible. In general, directed diffusion uses flooding to inject the query to the entire network when there is no geographic criterion to diffuse tasks.[4] However, in some cases there is only a little amount of data requested from the nodes and thus the use of flooding is unnecessary.

Sensor Protocols for Information via Negotiation (SPIN): Heinzelman et.al. in [3] and [5] proposed a family of adaptive protocols called Sensor Protocols for Information via Negotiation (SPIN) that disseminate all the information at each node to every node in the network assuming that all nodes in the network are potential base-stations. The SPIN family of protocols is designed based on two basic ideas:

1. Sensor nodes operate more efficiently and conserve energy by sending data that describe the sensor data instead of sending all the data; for example, image and sensor nodes must monitor the changes in their energy resources.
2. Conventional protocols like flooding or gossiping based routing protocols [19] waste energy and bandwidth when sending extra and un-necessary copies of data by sensors covering overlapping areas.

Gradient-Based Routing: Schurgers et al. [2, 21] proposed another variant of directed diffusion, called Gradient-Based Routing (GBR). In GBR, three different data dissemination techniques have been discussed (1) Stochastic Scheme, where a node picks one gradient at random when there are two or more next hops that have the same gradient, (2) Energy-based scheme, where a node increases its height when its energy drops below a certain threshold, so that other sensors are discouraged from sending data to that node, and (3) Stream-based scheme, where new streams are not routed through nodes that are currently part of the path of other streams. A packet is forwarded on a link with the largest gradient.

Cougar: Another data-centric protocol called Cougar [3] views the network as a huge distributed database system. The key idea is to use declarative queries in order to abstract query processing from the network layer functions such as selection of relevant sensors and so on.

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Acquire: In [4], Sadagopan et al. proposed a technique for querying sensor networks called Active Query forwarding in sensor networks (Acquire). Similar to Cougar, Acquire views the network as a distributed database where complex queries can be further divided into several sub queries.

Information-driven sensor querying (IDSQ) and Constrained anisotropic diffusion routing (CADR) two routing techniques, namely, information-driven sensor querying (IDSQ) and constrained anisotropic diffusion routing (CADR) were proposed in [4]. CADR aims to be a general form of directed diffusion.

Energy Aware Routing: The objective of energy-aware routing protocol [5], a destination initiated reactive protocol, is to increase the network lifetime. Although this protocol is similar to directed diffusion, it differs in the sense that it maintains a set of paths instead of maintaining or enforcing one optimal path at higher rates.

2. Location Based Routing Protocol

In location-based protocols, [2] sensor nodes are addressed by means of their locations. Location information for sensor nodes is required for sensor networks by most of the routing protocols to calculate the distance between two particular nodes so that energy consumption can be estimated. [7] Alternatively, the location of nodes may be available directly by communicating with a satellite, using GPS (Global Positioning System), if nodes are equipped with a small low power GPS receiver.[13] To save energy, some location based schemes demand that nodes should go to sleep if there is no activity. In order to stay with the theme of the survey, we limit the scope of coverage to only energy-aware location based protocols.

Geographic Adaptive Fidelity (GAF): GAF [3, 8] is an energy-aware routing protocol primarily proposed for MANETs, but can also be used for WSNs because it favors energy conservation. The design of GAF is motivated based on an energy model [12, 13] that considers energy consumption due to the reception and transmission of packets as well as idle (or listening) time when the radio of a sensor is on to detect the presence of incoming packets.

Geographic and Energy-Aware Routing (GEAR): GEAR [2] is an energy-efficient routing protocol proposed for routing queries to target regions in a sensor field. In GEAR, the sensors are supposed to have localization hardware equipped, for example, a GPS unit or a localization system [14] so that they know their current positions. Each node in GEAR keeps an estimated cost and a learning cost of reaching the destination through its neighbors. [7] There are two phases in the algorithm:

1. Forwarding packets towards the target region: Upon receiving a packet, a node checks its neighbors to see if there is one neighbor, which is closer to the target region than itself.
2. Forwarding the packets within the region: If the packet has reached the region, it can be diffused in that region by either recursive geographic forwarding or restricted flooding.

Span: [1] Coordination of Power Saving with Routing is a routing protocol also primarily proposed for MANETs, but can be applied to WSNs as its goal is to reduce energy consumption of the nodes. [7] A node should become a coordinator if two neighbors of a non-coordinator node cannot reach each other directly or via one or two coordinators (3 hop reach ability) [8].

MECN Minimum Energy Communication Network (MECN): MECN [12] is a location-based protocol for achieving minimum energy for randomly deployed ad hoc networks, which attempts to set up and maintain a minimum energy network with mobile sensors.[12] It computes an optimal spanning tree rooted at the sink, called minimum power topology, which contains only the minimum power paths from ach sensor to the sink. A minimum power topology for stationary nodes including a master node is found.

Small minimum energy communication network (SMECN) [7]. In MECN, it is assumed that every node can transmit to every other node, which is not possible every time. In SMECN possible obstacles between any pair of nodes are considered.[9] The subnetwork constructed by SMECN for minimum energy relaying 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.[14] Then, a sensor starts broadcasting a neighbor discovery message with some initial power and checks whether the theoretical set of immediate neighbors is a subset of the set of sensors that replied to that neighbor discovery message.

Geographic Random Forwarding (GeRaF): GeRaF was proposed by Zorzi and Rao [7], which uses geographic routing where a sensor acting as relay is not known a priori by a sender. After a certain number of attempts, the sending sensor either finds a relay sensor or discards the data packet if the maximum allowed number of attempts is reached.[10]This means that the neighbors of the sending sensor are not active.

3. Data Centric Routing Protocol

Data-centric protocols differ from traditional address-centric protocols in the manner that the data is sent from source sensors to the sink [7]. In many applications of sensor networks, it is not feasible to assign global identifiers to each node due to the sheer number of nodes deployed [13]. Such lack of global identification along with random deployment of sensor nodes make it hard to select a specific set of sensor nodes to be queried. In address-centric protocols, each source sensor that has the appropriate data responds by sending its data to the sink independently of all other sensors. [14] Since this is very inefficient in terms of energy consumption, routing protocols that will be able to select a set of sensor nodes and utilize data aggregation during the relaying of data have been considered.

Flooding and Gossiping: Flooding and gossiping [8] are two classical mechanisms to relay data in sensor networks without the need for any routing algorithms and topology maintenance.

In flooding, each sensor receiving a data packet broadcasts it to all of its neighbors and this process continues until the packet arrives at the destination or the maximum number of hops for the packet is reached.

1. **Implosion**: [19] If Sensor node sends data through multiple links duplicate messages may be retrieved (implosion). In Figure4 source node (1) sends the sensed data through all its outgoing links (2, 3). Hence destination node (4) receives duplicate copies of that packet which causes implosion.
2. **Overlap:** When the two sensor nodes sense the same information, it sends the overlapped data to the same node. [20] Eventually, Flooding wastes the available energy and bandwidth by sending duplicate copies. It produces high control overhead.

In Gossiping: Gossiping is the alternative to the flooding method where this technique uses randomization in selecting the neighbors.[8] In gossiping the sensor nodes select the relay nodes randomly instead of forwarding packets through every node. Hence it reduces the control overhead.

Sensor Protocols for Information via Negotiation (Spin): Spin [13] protocol was designed to improve classic flooding protocols and overcome the problems they may cause, for example, implosion sand overlap.[14] The SPIN protocols are based on two key mechanisms namely negotiation and resource adaptation. The sensors running the SPIN protocols are able to compute the energy consumption required to compute, send, and receive data over the network. [12].Therefore, SPIN is not a good choice for applications such as intrusion detection, which require reliable delivery of data packets over regular intervals.

Directed Diffusion: Directed diffusion [13] is a data-centric routing protocol for sensor query dissemination and processing. It meets the main requirements of WSNs such as energy efficiency, scalability, and robustness. Directed diffusion has several key elements namely data naming, interests and gradients, data propagation, and reinforcement.[10]The interests in the caches are then used to compare the received data with the values in the interests.

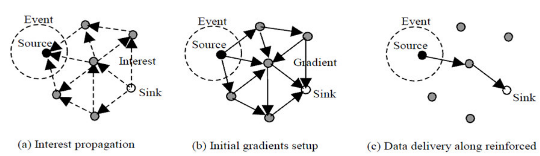

Fig. 4: Directed diffusion protocol phases

Fig.4, redrawn from [14], summarizes the Directed Diffusion protocol. The interest entry also contains several gradient fields. A gradient is a reply link to a neighbor from which the interest was received. It is characterized by the data rate, duration and expiration time derived from the received interest's fields.[12] In Directed Diffusion the sink queries the sensor nodes if a specific data is available by flooding some tasks. In SPIN, sensors advertise the availability of data allowing interested nodes to query that data.

Rumor routing: Rumor routing [7] is another variation of Directed Diffusion and is mainly intended for contexts in which geographic routing criteria are not applicable. Rumor routing is an efficient protocol if the number of queries is between the two intersection points of the curve of rumor routing with those of query flooding and event flooding. [13] Rumor routing is based on the concept of agent, which is a long-lived packet that traverses a network and informs each sensor it encounters about the events that it has learned during its network traverse.[9,15] An alternative approach is to flood the events if number of events is small and number of queries is large.

Active Query Forwarding in Sensor Networks (Acquire): Acquire [13] is another data centric querying mechanism used for querying named data. It provides superior query Optimization to answer specific types of queries, called one-shot complex queries for replicated Data. [7] ACQUIRE mechanism provides efficient querying by adjusting the value of parameter d. On the other hand, the query has to travel more hops if d is too small. In ACQUIRE, the next node to forward the query is either picked randomly or the selection is based on maximum potential of query satisfaction [12, 9].

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Gradient-Based Routing: Schurgers et al. [8] have proposed a slightly changed version of Directed Diffusion, called Gradient-based routing (GBR). [10] The idea is to keep the number of hops when the interest is diffused through the network. Nodes acting as a relay for multiple paths can create a data combining entity in order to aggregate data. [12]

Energy-Aware Data-Centric Routing (EAD): [13] EAD is a novel distributed routing protocol, which builds a virtual backbone composed of active sensors that are responsible for in-network data processing and traffic relaying.[7] In this protocol, a network is represented by a broadcast tree spanning all sensors in the network and rooted at the gateway, in which all leaf nodes' radios are turned off while all other nodes correspond to active sensors forming the backbone and thus their radios are turned on. [8, 9]

Cadr: Constrained anisotropic diffusion routing (CADR) [8] is a protocol, which strives to be a general form of Directed Diffusion. Two techniques namely information-driven sensor querying (IDSQ) and constrained anisotropic diffusion routing (CADR) are proposed. [10]This is achieved by activating only the sensors that are close to a particular event and dynamically adjusting data routes.

Cougar: A data-centric protocol that views the network as a huge distributed database system is proposed in [7]. A network can be viewed as a huge distributed database stem, where every sensor possesses a subset of data [9]. The leader node gets all the readings, calculates the average and if it is greater than a threshold sends it to the gateway (sink).The architecture is depicted in Fig. 5, which is redrawn from [9]. The gateway is responsible for generating a query plan, which specifies the necessary information about the data flow and in-network computation for the incoming query and send it to the relevant nodes. [14] Hence, current distributed management approaches cannot be applied directly, but need to be modified accordingly.

4. Hierarchical Routing Protocol

In hierarchical or clustered topology various nodes are combined together to form clusters [19]. Hierarchical or cluster-based routing, originally proposed in wire line networks, are well-known techniques with special advantages related to scalability and efficient communication [1]. A single-tier network can cause the gateway to overload with the increase in sensors density. [8] Such overload might cause latency in communication and inadequate tracking of events. Nodes are grouped into clusters with a cluster head that has the responsibility of routing from the cluster to the other cluster heads or base stations.

Low-energy adaptive clustering hierarchy (LEACH): LEACH [3] is the first and most popular energy-efficient hierarchical clustering algorithm for WSNs that was proposed for reducing power consumption LEACH uses a TDMA/CDMA MAC to reduce inter-cluster and intra-cluster collisions. [13]The operation of LEACH is divided into rounds having two phases each namely (i) a setup phase to organize the network into clusters, CH advertisement, and transmission schedule creation. ii) In the steady state phase, the actual data transfer to the base station takes place. [7]

Pegasis & Hierarchical-Pegasis: Power-Efficient Gathering in Sensor Information Systems (PEGASIS) [7] is an improvement of the leach protocol. The chain construction is performed in a greedy way. PEGASIS has two main objectives. [14] First, increase the lifetime of each node by using collaborative techniques and as a result the network lifetime will be increased. Second, allow only local coordination between nodes that are close together so that the bandwidth consumed in communication is reduced.

Self Organizing Protocol (SOP): Subramanian et al. [1] describes a self-organizing protocol and an application taxonomy that was used to build architecture used to support heterogeneous sensors. Furthermore, these sensors can be mobile or stationary. Some sensors probe the environment and forward the data to a designated set of nodes that act as routers [8].

Energy-aware routing for cluster-based sensor networks: Younis et al. [9] have proposed a different hierarchical routing algorithm based on a three-tier architecture. Sensors are grouped in to clusters prior to network operation. A cost function is defined between any two nodes in terms of energy consumption, delay optimization and other performance metrics.

Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN): TEEN [7, 8] is a hierarchical clustering protocol, which groups sensors into clusters with each led by a CH. The sensors within a cluster report their sensed data to their CH. [2,4] In Teen, sensor nodes sense the medium continuously, but the data transmission is done less frequently. Teen is not good for applications where periodic reports are needed since the user may not get any data at all if the thresholds are not reached. The nodes sense their environment continuously. [9] The first time a parameter from the attribute set reaches its hard threshold value, the node switches its transmitter on and sends the sensed data. The sensed value is stored in an internal variable, called Sensed Value (SV).

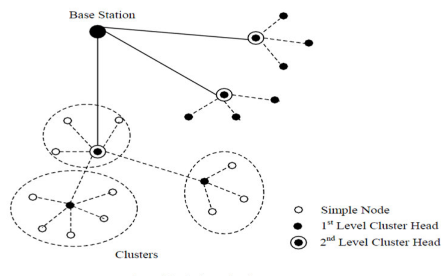

Fig. 8: Hierarchical Clustering in TEEN & APTEEN

Adaptive Periodic Threshold Sensitive Energy Efficient Sensor Network Protocol (APTEEN): [3] APTEEN is a hybrid clustering-based routing protocol that allows the sensor to send their sensed data periodically and react to any sudden change in the value of the sensed attribute by reporting the corresponding values to their CHs.[9] When the base station forms the clusters, the cluster heads broadcast the attributes, the threshold values, and the transmission schedule to all nodes.[13,14] APTEEN supports three different query types: historical, to analyze past data values; one-time, to take a snapshot view of the network; and persistent to monitor an event for a period of time.

Hybrid, Energy-Efficient Distributed Clustering (HEED): HEED [14, 15] extends the basic scheme of LEACH by using residual energy and node degree or density as a metric for cluster selection to achieve power balancing. In HEED, the proposed algorithm periodically selects CHs according to a combination of two clustering parameters.[17] HEED was proposed with four primary goals namely (i) prolonging network lifetime by distributing energy consumption, (ii) terminating the clustering process within a constant number of iterations, (iii) minimizing control overhead, and (iv) producing well-distributed CHs and compact clusters.

Small Minimum Energy Communication Network (MECN): In [2, 4], a protocol is proposed that computes an energy-efficient subnetwork, namely the minimum energy communication network (MECN) for a certain sensor network by utilizing low power GPS. MECN identifies a relay region for every node. The relay region consists of nodes in a surrounding area where transmitting through those nodes is more energy efficient than direct transmission.

Sensor Aggregates Routing: In [1], a set of algorithms for constructing and maintaining sensor aggregates were proposed. Three algorithms were proposed in [3, 5]. First, a lightweight protocol, Distributed Aggregate Management (DAM), for forming sensor aggregates for a target monitoring task. Second, Energy-Based Activity Monitoring (EBAM) algorithm estimate the energy level at each node by computing the signal impact area, combining a weighted form of the detected target energy at each impacted sensor assuming that each target sensor has equal or constant energy level. The third algorithm, Expectation-Maximization like Activity Monitoring (EMLAM), removes the constant and equal target energy level assumption.

5. Mobility-Based Routing Protocols

Mobility brings new challenges to routing protocols in WSNs. Sink mobility requires energy efficient protocols to guarantee data delivery originated from source sensors toward mobile sinks [13, 12]. Mobility of sink nodes requires energy –efficient protocols as well garmenting of data delivery from source sensor node to mobile sink node.[11] While designing mobility based protocol designer must keep these parameter in mind such as error , noise ,interference, random topology, guaranteed of data delivery and shortest route etc.

Joint Mobility and Routing Protocol:[15]A network with a static sink suffers from a severe problem, called energy sink-hole problem, where the sensors located around the static sink are heavily used for forwarding data to the sink on behalf of other sensors.[2, 13]In this concept the sensor node surrounding the sink node changes over the time by giving to all sensor node to act as relay node and thus maintaining load balancing of data routing among the sensor nodes. The trajectory with a radius equal to the radius of the sensor field maximizes the distance from the sink to the centre of the network that represents the hot spot.

Scalable Energy-Efficient Asynchronous Dissemination (SEAD): SEAD [14] is self-organizing protocol, which was proposed to trade-off between minimizing the forwarding delay to a mobile sink and energy savings.[14] SEAD considers data dissemination in which a source sensor reports its sensed data to multiple mobile sinks and consists of three main components namely dissemination tree (d-tree) construction, data dissemination, and maintaining linkages to mobile sinks. Every sensor node creates it d-tree rooted at itself and for all nodes it is built separately.[13] SEAD can be viewed as an overlay network that sits on top of a location-aware routing protocol, for example, geographical forwarding.

Dynamic Proxy Tree-Based Data Dissemination:[1, 6]A dynamic proxy tree-based data dissemination framework [48] was proposed for maintaining a tree connecting a source sensor to multiple sinks that are interested in the source.[14] Due to mobility of sink node source node changes from time to time as new sensor closer to target mobile node become source node. Each source is represented by a stationary source proxy and each sink is represented by a stationary sink proxy.

Low Energy Adaptive Cluster Hierarchy (LEACH) [8] is a cluster based approach [4]. LEACH works in rounds. Each round begins with set up phase followed by steady phase. In set up phase, Cluster Head (CH) is selected. Each node generates random number between 0 and 1.[9] In steady phase, all Non-CH nodes send data to CH and then CH aggregate all data and send it to the base station.

6. Multipath Routing Protocols

Considering data transmission between source sensors and the sink, there are two routing paradigms: single-path routing and multipath routing. In single-path routing, each source sensor sends its data to the sink via the shortest path. In multipath routing, each source sensor finds the first k shortest paths to the sink and divides its load evenly among these paths.[1,2] The primary path will be used until its energy falls below the energy of the backup path at which the backup path is used. [25]Using this approach, the nodes in the primary path will not deplete their energy resources through continual use of the same route, hence achieving longer life. The path with the largest residual energy when used to route data in a network, may be very energy- expensive too. [15]Various techniques have been proposed in efficient multipath routing protocol design, for example, network coding is used, where data at the source node is fragmented and transferred into chunks to different discovered paths, and controlled flooding is used to find proficient neighbors.

Directed diffusion [3, 4] is a good candidate for robust multipath routing and delivery. Based on the directed diffusion paradigm, a multipath routing scheme that finds several partially disjoint paths is studied in (alternate routes are not node disjoint, i.e., routes are partially overlapped). It has been found that the use of multipath routing provides viable alternative for energy efficient recovery from failures in WSN. The motivation of using these braided paths is to keep the cost of maintaining the multipath low.

N-to-1 Multipath Discovery: [18] N-to-1 multipath discovery is based on the simple flooding originated from the sink and is composed of two phases, namely, branch aware flooding (or phase 1) and multipath extension of flooding (or phase 2). Both phases use the same routing messages whose format is given by {mtype, mid, nid, bid, cst, path}, where mtype refers to the type of a message.

7. Heterogeneity-Based Routing Protocols

In heterogeneity sensor network architecture, there are two types of sensors namely line-powered sensors which have no energy constraint, and the battery-powered sensors having limited lifetime, and hence should use their available energy efficiently by minimizing their potential of data communication and computation[13,14]. Cluster head node gather all the data from other sensor nodes in cluster, aggregates it and transmit to the sink node. Thus, only few nodes are required to transmit the data over a long distance while rest of them are required to transmit in a short range of distance result in saving more energy and enhancing the overall network lifetime period [12,3].

Information-Driven Sensor Query (IDSQ): [15] IDSQ addresses the problem of heterogeneous WSNs of maximizing information gain and minimizing detection latency and energy consumption for target localization and tracking through dynamic sensor querying and data routing.[2,3] Useful information can be sought based on predicting the space and time interesting events would take place.

Cluster-Head Relay Routing (CHR): [12] CHR routing protocol uses two types of sensors to form a heterogeneous network with a single sink: a large number of low-end sensors, denoted by L-sensors, and a small number of powerful high-end sensors, denoted by H-sensors. [13]The H-sensors, on the other hand, are responsible for data fusion within their own clusters and forwarding aggregated data packets originated from other cluster heads toward the sink in a multihop fashion using only cluster heads. While L-sensors use short-range data transmission to their neighboring H-sensors within the same cluster, H-sensors perform long-range data communication to other neighboring H-sensors and the sink.

8. QOS –Based Routing Protocol

QOS-aware protocols consider end-to end delay requirements while setting up the paths in the sensor network. In QOS-based routing protocols, the network has to balance data quality [3]. In particular, the network has to satisfy certain QOS metrics, e.g., delay, energy, bandwidth, etc.[13,11] when delivering data to the BS. In addition to minimizing energy consumption, it is also important to consider quality of service (QOS) requirements in terms of reliability, and fault tolerance in routing in WSNs.

Sequential Assignment Routing (SAR) [13] SAR is one of the first routing protocols for WSNs that introduces the notion of Qos in the routing decisions. Routing decision in SAR is dependent on three factors: energy resources, Qos on each path, and the priority level of each packet.[2,3] The paths of the tree are built while avoiding nodes with low energy or QoS guarantees. [7,8]Failure recovery is done by enforcing routing table consistency between upstream and downstream nodes on each path. Any local failure causes an automatic path restoration procedure locally.

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Speed: [12] Speed is another QoS routing protocol for sensor networks that provides soft real time end-to-end guarantees. SPEED strive to ensure a certain speed for each packet in the network so that each application can estimate the end-to-end delay for the packets by dividing the distance to the sink by the speed of the packet before making the admission decision. [19]And finally, the backpressure-rerouting module is used to prevent voids, when a node fails to find a next hop node, and to eliminate congestion by sending messages back to the source nodes so that they will pursue new routes. When compared to Dynamic Source Routing (DSR) and Ad-hoc on-demand vector routing, SPEED performs better in terms of end-to-end delay and miss ratio.[3] Moreover, the total transmission energy is less due to the simplicity of the routing algorithm, i.e., control packet overhead is less.

Energy-Aware QoS Routing Protocol: In this QoS aware protocol [5, 7] for sensor networks, real time traffic is generated by imaging sensors. The proposed protocol extends the routing approach in [6, 2] and finds a least cost and energy efficient path that meets certain end-to-end delay during the connection. The link cost used is a function that captures the nodes' energy reserve, transmission energy, error rate and other communication parameters. The queuing model allows service sharing for real-time and non-real-time traffic.[14] The bandwidth ratio r, is defined as an initial value set by the gateway and represents the amount of bandwidth to be dedicated both to the real-time and non-real-time traffic on a particular outgoing link in case of a congestion.

III. Conclusion

Wireless Sensor Network is one of the emerging fields in research area. The flexibility, fault tolerance, high sensing fidelity, low-cost and rapid deployment characteristics of sensor networks create many new and exciting application areas for remote sensing. In the future, this wide range of application areas will make sensor networks an integral part of our lives. Wireless sensor network has a remarkable feature to monitor environmental and physical conditions. In this paper we discussed various types of routing protocols wireless sensor networks. In the future, the wide range of application areas will make sensor networks an integral part of our lives. Wireless sensor network energy efficient is one of the great areas for future work.

One of the main challenges in the design of routing protocols for WSNs is energy efficiency due to the scarce energy resources of sensors. The ultimate objective behind the routing protocol design is to keep the sensors operating for as long as possible, thus extending the network lifetime. The energy consumption of the sensors is dominated by data transmission and reception. Therefore, routing protocols designed for WSNs should be as energy efficient as possible to prolong the lifetime of individual sensors, and hence the network lifetime. In this paper, we have surveyed a sample of routing protocols by taking into account several classification criteria, including location information, network layering and in-network processing, data centricity, path redundancy, network dynamics, QoS requirements, and network heterogeneity.

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