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Routing & Energy Conservation Protocols in WSN- A Review

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Abstract

The most important task of a sensor network is to forward the sensing data collected by sensor nodes to the base station. One simple approach to the complete this task is direct data transmission. In this case, each node in the network directly sends sensing data to the base station. However, if the base station is far from the sensor node, the node will die after a short time due to large amount of energy consumption for delivering data. In designing routing algorithms for WSN, the significant factor that must be taken into account is how to save energy of a sensor node while meeting the all needs of users as the sensors are battery limited. To solve this problem, some algorithms focus on saving energy have been proposed. This paper surveys routing protocols related to energy of nodes and network.

Keywords: Wireless Sensor Networks, Energy consumption, limited battery, routing protocols.

Introduction

The growing field of wireless sensor networks combines sensing, computation, and communication into a single small device. The power of wireless sensor networks lies in the ability to deploy large numbers of very small nodes that assemble and configure themselves. Unlike traditional wireless devices, wireless sensor nodes do not need to communicate directly with the nearest high-power control tower or base station, but only with their local peers. Instead, of relying on a pre-deployed infrastructure, each individual sensor or actuator becomes part of the overall infrastructure. Sensor nodes are resource-constrained in terms of the radio range, processor speed, memory size and power. Recharging or replacing batteries is expensive and may not even be feasible in some situations and their sizes are too small to accommodate a large battery, they are constrained to operate using an extremely limited energy budget. Therefore, WSN applications need to be extremely energy-aware.

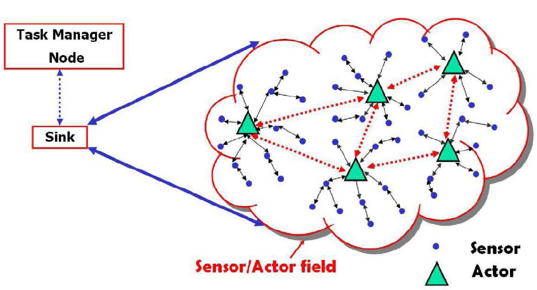

Fig. 1 Sensor network architecture

Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy consumption is an essential design issues. Since wireless sensor network protocols are application specific, so the focus has been given to the routing protocols that might differ depending on the application and network architecture. The study of various routing protocols for sensor networks presents a classification for the various approaches pursued. Each of the routing schemes and algorithms has the common objective of trying to get better throughput and to extend the lifetime of the sensor network.

Routing Protocols in WSNs

Sensor networks introduce new challenges that need to be dealt with as a result of their special characteristics. Their new requirements need optimized solutions at all layers of the protocol stack in an attempt to optimize the use of their scarce resources [1]. In particular, the routing problem has received a great deal of interest from the research community with a great number of proposals being made.

The categories are:

1. Data-Centric or Flat based
2. Hierarchical or Cluster based
3. Location or position based Protocols
4. Network flow and QoS Aware Protocols

Data-Centric Protocols: In data-centric routing, the sink sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute based naming is necessary to specify the properties of data [1].

- **SPIN (Sensor Protocols for Information via negotiation)** is a unique set of protocols for energy efficient communication among wireless sensors [4,5]. The authors propose solutions to traditional wireless, communication issues such as network implosion caused by flooding and overlapping transmission ranges. The SPIN protocols incorporate two key ideas to overcome implosion, overlap, and resource blindness: negotiation and resource adaptation. Using very small meta-data packets to negotiate, SPIN efficiently communicates with fewer redundancies than traditional approaches, dealing with implosion and overlap.
- **Directed Diffusion:** Directed Diffusion [19] [20] is an important milestone in the data-centric routing research of sensor networks. The idea aims at diffusing data through sensor nodes by using a naming scheme for the data. The main reason behind using such a scheme is to get rid of unnecessary operations of network layer routing in order to save energy. Direct Diffusion suggests the use of attribute-value pairs for the data and queries the sensors in an on demand basis by using those pairs. In order to create a query, an interest is defined using a list of attribute-value pairs such as name of objects, interval, duration, geographical area, etc. The interest is broadcast by a sink through its neighbors. Each node receiving the interest can do caching for later use.
- **EAP (Energy Aware Protocol)** Achieves a good performance in terms of lifetime by minimizing energy consumption for in-network communications and balancing the energy load among all the nodes[9]. EAP introduces a new clustering parameter for cluster head election, which can better handle the heterogeneous energy capacities. Furthermore, it also introduces a simple but efficient approach, namely, intracluster coverage to cope with the area coverage problem. In EAP, a node with a high ratio of residual energy to the average residual energy of all the neighbor nodes in its cluster range will have a large probability to become the cluster head. This can better handle heterogeneous energy circumstances than existing clustering algorithms which elect the cluster head only based on a node's own residual energy. After the cluster formation phase, EAP constructs a spanning tree over the set of cluster heads. Only the root node of this tree can communicate with the sink node by single-hop communication. Because the energy consumed for all communications in in-network can be computed by the free space model, the energy will be extremely saved and thus leading to sensor network longevity. EAP also utilizes a simple but efficient approach to solve the area coverage problem. With the increase in node density, this approach can guarantee that the network lifetime will be linear with the number of deployed nodes, which significantly outperforms the previous works designed for data gathering application.
- **Rumor Routing :** Rumor routing [21] is another variation of Directed Diffusion and is mainly intended for contexts in which geographic routing criteria are not applicable. Generally Directed Diffusion floods the query to the entire network when there is no geographic criterion to diffuse tasks. However, in some cases there is only a little amount of data requested from the nodes and thus the use of flooding is unnecessary. An alternative approach is to flood the events if number of events is small and number of queries is large. Rumor routing is between event flooding and query flooding. The idea is to route the queries to the nodes that have observed a particular event rather than flooding the entire network to retrieve information about the occurring events.
- **Gradient - Based Routing** : Schurgers et al. [22] have proposed a slightly changed version of Directed Diffusion, called Gradient-based routing (GBR). The idea is to keep the number of hops when the interest is diffused through the network. Hence, each node can discover the minimum number of hops to the sink, which is called height of the node. The difference between a node's height and that of its neighbor is considered the gradient on that link. A packet is forwarded on a link with the largest gradient. The authors aim at using some auxiliary techniques such as data aggregation and traffic spreading along with GBR in order to balance the traffic uniformly over the network. Nodes acting as a relay for multiple paths can create a data combining entity in order to aggregate data.
- **CADR(Constrained anisotropic diffusion Routing)** [23] 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. The idea is to query sensors and route data in a network in order to maximize the information gain, while minimizing the latency and bandwidth. This is achieved by activating only the sensors that are close to a particular event and dynamically adjusting data routes. The major

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difference from Directed Diffusion is the consideration of information gain in addition to the communication cost. In CADR, each node evaluates an information/cost objective and routes data based on the local information/cost gradient and end-user requirements. The information utility measure is modeled using standard estimation theory.

- **COUGAR :** A data- centric protocol that

views the network as a huge distributed database system is proposed in [24]. The main idea is to use declarative queries in order to abstract query processing from the network layer functions such as selection of relevant sensors etc. and utilize in-network data aggregation to save energy. The abstraction is supported through a new query layer between the network and application layers. COUGAR proposes an architecture for the sensor database system where sensor nodes select a leader node to perform aggregation and transmit the data to the gateway (sink). Although COUGAR provides a network layer independent solution for querying the sensors, it has some drawbacks: First of all, introducing additional query layer on each sensor node will bring extra overhead to sensor nodes in terms of energy consumption and storage. Second, innetwork data computation from several nodes will require synchronization, i.e. a relaying node should wait every packet from each incoming source, before sending the data to the leader node. Third, the leader nodes should be dynamically maintained to prevent them from failure.

- **ACQUIRE (ACtive Query forwarding In**

sensoR nEtworks - A fairly new data-centric mechanism for querying sensor networks is ACQUIRE [25]. The querying mechanism works as follows: The query is forwarded by the sink and each node receiving the query, tries to respond partially by using its pre-cached information and forward it to another sensor. If the pre-cached information is not up-to-date, the nodes gather information from its neighbors within a look-ahead of d hops. Once the query is being resolved completely, it is sent back through either the reverse or shortest-path to the sink.

Hierarchical Protocols- The main aim of hierarchical routing is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication within a particular cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink. Cluster formation is typically based on the energy reserve of sensors and sensor's proximity to the cluster head [26][27].

- **LEACH (Low-EnergyAdaptive Clustering**

Hierarchy) is a communication protocol that tries to evenly distribute the energy among the network nodes by randomly rotating the cluster head among the sensors [2, 3]. This assumes that we have a finite amount of power and aims at conserving as much as possible despite a dynamic network, as well as data compression to reduce the amount of data that must be transmitted to a base station. Performing some calculation and using data fusion locally conserves much energy at each node.

- **PEGASIS (Power-Efficient Gathering in**

Sensor Information Systems), an algorithm related to LEACH was Proposed [9]. These authors noticed that for a node, within a range of some distance, the energy consumed for receiving or sending circuits is higher than that consumed for amplifying circuits. In order to reduce the energy consumption of sensor nodes, PEGASIS uses the GREED algorithm to form all the sensor nodes in the system into a chain. According to its simulation results, the performance of PEGASIS is better than LEACH, especially when the distance between sensor network and sink node is far large.

- **TEEN(Threshold sensitive Energy efficient**

sensor Network) protocol [28] is a hierarchical protocol designed to be responsive to sudden changes in the sensed attributes such as temperature. Responsiveness is important for time-critical applications, in which the network operated in a reactive mode. TEEN pursues a hierarchical approach along with the use of a data-centric mechanism. 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. After the clusters are formed, the cluster head broadcasts two thresholds to the nodes. These are hard and soft thresholds for sensed attributes. Hard threshold is the minimum possible value of an attribute to trigger a sensor node to switch on its transmitter and transmit to the cluster head. Thus, the hard threshold allows the nodes to transmit only when the sensed attribute is in the range of interest, thus reducing the number of transmissions significantly. Once a node senses a value at or beyond the hard threshold, it transmits data only when the value of that attribute changes by an amount equal to or greater than the soft threshold. As a consequence, soft threshold will further reduce the number of transmissions if there is little or no change in the value of sensed attribute. One can adjust both hard and soft threshold values in order to control the number of packet transmissions. However, 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.

- **APTEEN (The Adaptive Threshold**

sensitive Energy Efficient sensor Network) protocol [29] is an extension to TEEN and aims at both capturing periodic data collections and reacting to time-critical events. The architecture is same as in TEEN. When the base station forms the clusters, the cluster heads broadcast the attributes, the threshold values, and the transmission schedule to all nodes. Cluster heads also perform data aggregation in order to save energy. 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.

- **Energy- aware routing for cluster-based**

sensor networks: Younis et al. [30] have proposed a different hierarchical routing algorithm based on a three-tier architecture. Sensors are grouped into clusters prior to network operation. The algorithm employs cluster heads, namely gateways, which are less energy constrained than sensors and assumed to know the location of sensor nodes. Gateways maintain the states of the sensors and sets up multi-hop routes for collecting sensors' data. A TDMA based MAC is used for nodes to send data to the gateway. The gateway informs each node about slots in which it should listen to other nodes' transmission and slots, which the node can use for its own transmission. The command node (sink) communicates only
with the gateways.

- **Self-organizing protocol**: Subramanian et al.

[18] not only describe a self-organizing protocol but develop taxonomy of sensor applications as well. Based on such taxonomy, they have proposed architectural and infrastructural components necessary for building sensor applications. The architecture supports heterogeneous sensors that can be mobile or stationary. Some sensors, which can be either stationary or mobile, probe the environment and forward the data to designated set of nodes that act as routers. Router nodes are stationary and form the backbone for communication. Collected data are forwarded through the routers to more powerful sink nodes. Each sensing node should be reachable to a router node in order to be part of the network.

- **CODA**, a new clustering algorithm was

proposed [7] in order to relieve the imbalance of energy depletion caused by different distances from the sink. CODA divides the whole network into a few groups based on node's distance to the base station and the routing strategy. Each group has its own number of clusters and member nodes. CODA differentiates the number of clusters in terms of the distance to the base station. The farther the distance to the base station, the more clusters are formed in case of single hop with clustering. It shows better performance in terms of the network lifetime and the dissipated energy than those protocols that apply the same probability to the whole network. However, the work of CODA relies on global information of node position, and thus it is not scalable.

- **HEED(hybrid energy-efficient distributed),**

a clustering algorithm was proposed which periodically selects cluster head according to a hybrid of the node residual energy and a secondary parameter such as node proximity to its neighbors or node degree[8]. Heed terminates in 0 (1) iterations and incurs low message overhead. It achieves fairly uniform cluster head distribution across the network.

- **RCC (Random Competition Based Clustering):**

Although, RCC [16] is designed for mobile ad-hoc networks, it is also applicable to WSNs. RCC mainly focuses at cluster stability in order to support mobile nodes. The RCC algorithm applies the First Declaration Wins rule, in which any node can ''govern'' the rest of the nodes in its radio coverage if it is the first to claim being a CH. After hearing the claim which is broadcasted by the first node, neighbouring nodes join its cluster as member and give up their right to be a CH. Periodically every CH in the network broadcast a CH claim packet to maintain clusters. Since there is a time delay between broadcasting a claim packet and receiving it, concurrent broadcast can possibly create a conflict. Being unaware of on-going claims, many neighbouring nodes may broadcast CH claim packets concurrently. To avoid such a problem RCC explicitly employs a random timer and uses the node ID for arbitration. Each node in the network reset its random time value, every time before broadcasting its CH claim packet. During this random time if it receives a broadcast message carrying CH claim packet from another node, it simply ceases the transmission of its CH claim. Since random timer is not a complete solution, RCC resolve further the concurrent broadcast problems by using the node ID. If the conflict persists, node having lower ID will become the CH. A CH in adaptive clustering abandons its role when it hears a node with a lower ID, while, a CH in RCC only gives up its position when another CH moves near to it.

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- **Banerjee and Khuller:** The goal of Banerjee

and Khuller is to form a multi-tier hierarchical clustering [17]. Figure 3 illustrate the concept of hierarchy of clusters. A number of cluster's properties such as cluster size and the degree of overlap, which are useful for the management and scalability of the hierarchy, are also considered while grouping the nodes. In the proposed scheme, any node in the WSN can initiate the cluster formation process. Initiator with least node ID will take precedence, if multiple nodes started cluster formation process at the same time.

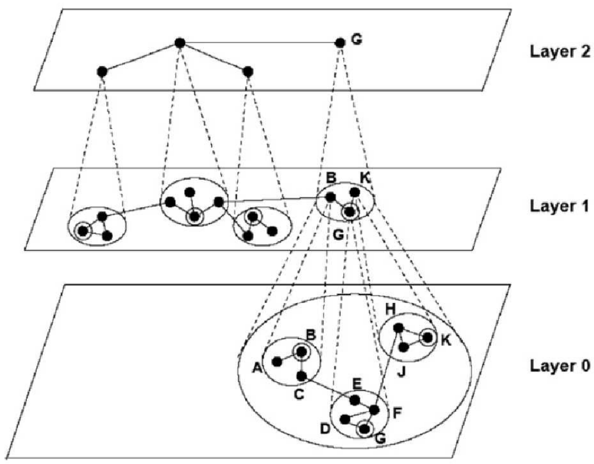

Fig. 2 An Example of a Three Layer Cluster Hierarchy [17].

The algorithm proceeds in two phases: Tree discovery and Cluster formation. The tree discovery phase is basically a distributed formation of a Breadth-First-Search (BFS) tree rooted at the initiator node. Each node 'u' broadcast a signal once every 'p' units of time, carrying the information about its shortest hop-distance to the root 'r'. A neighboring node 'v' of 'u' will choose 'u' to be its parent and will update its hop-distance to the root if the route through 'u' is shorter. Broadcast signal carry the information such as source ID, parent ID, root ID and sub-tree size. Every node updates its sub-tree size when its children sub-tree size change. The cluster formation phase starts when a sub-tree on a node crosses the size parameter, 'k'. The node initiates cluster formation on its sub-tree. It will form a single cluster for the entire sub-tree if sub-tree size is 2 , or else, it will form multiple clusters. It is crucial for clusters to keep cluster information after the cluster creation phase whereas maintenance of BFS tree is not so important.

- **Energy Efficient Hierarchical Clustering**

(EEHC)

Bandyopadhyay and Coyle [32] proposed EEHC which is a distributed, randomized clustering algorithm for WSNs with the objective of maximizing the network lifetime. CHs collected the sensors' readings in their individual clusters and send an aggregated report to the base-station. Their technique is based on two stages - initial and extended. In the initial stage, also called single-level clustering, each sensor node announces itself as a CH with probability 'p' to the neighbouring nodes within its communication range. These CHs are named as the volunteer CHs. All nodes that are within 'k' hops range of a CH receive this announcement either by direct communication or by forwarding. Any node that receives such announcements and is not itself a CH becomes the member of the closest cluster. Forced CHs are nodes that are neither CH nor belong to a cluster. If the announcement does not reach to a node within a preset time interval 't' that is calculated based on the duration for a packet to reach a node that is 'k' hops away, the node will become a forced CH assuming that it is not within 'k' hops of all volunteer CHs.

In the second stage, the process is extended to allow multi-level clustering, i.e. building 'h' levels of cluster hierarchy. Like [17], the clustering process is recursively repeated at the level of CHs to form an additional tier. The algorithm opts to ensure h-hop connectivity between CHs and the base-station. Assumed that level 'h' is highest, sensor nodes transmit the collected data to level-1 (lowest level) CHs. The CHs at the level-1 transmit the aggregated data to the level-2 CHs and so on. At the top level of the clustering hierarchy, CHs transmit the aggregated data report to the base station. Energy consumption in various network operations like sensor data collection, transmission of aggregated information to base station etc. will depend on the parameters 'p' and 'k' of the algorithm. The authors have specified the mathematical expression for the values of 'p' and 'k' to achieve minimal energy consumption. The derivation is based on periodic generation and transmission of sensors data and employs stochastic geometry to estimate communication energy. Simulation results confirmed that by using optimal parameter values energy consumption in the network can be reduce significantly.

Location Based Protocols: Most of the routing protocols for sensor networks require location information for sensor nodes. In most cases location information is needed in order to calculate the distance between two particular nodes so that energy consumption can be estimated. Location information can be utilized in routing data in an energy efficient way.

- **Minimum Energy Communication Network (MECN)** [32] sets up and maintains a minimum energy network for wireless networks by utilizing low power GPS. Although, the protocol assumes a mobile network, it is best applicable to sensor networks, which are not mobile. A minimum power topology for stationary nodes including a master node is found. MECN assumes a master-site as the information sink, which is always the case for sensor networks. MECN is self-reconfiguring and thus can dynamically adapt to node's failure or the deployment of new sensors. Between two successive wake-ups of the nodes, each node can execute the first phase of the algorithm and the minimum cost links are updated by considering leaving or newly joining nodes.
- **Small minimum energy communication network (SMECN)** [33] is an extension to MECN. 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. However, the network is still assumed to be fully connected as in the case of MECN. 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. As a result, the number of hops for transmissions will decrease. Simulation results show that SMECN uses less energy than MECN and maintenance cost of the links is less. However, finding a sub-network with smaller number of edges introduces more overhead in the algorithm.
- **GAF: Geographic Adaptive Fidelity** [34] is an energy-aware location-based routing algorithm designed primarily for mobile ad hoc networks, but may be applicable to sensor networks as well. GAF conserves energy by turning off unnecessary nodes in the network without affecting the level of routing fidelity. It forms a virtual grid for the covered area. Each node uses its GPS-indicated location to associate itself with a point in the virtual grid. Nodes associated with the same point on the grid are considered equivalent in terms of the cost of packet routing. Such equivalence is exploited in keeping some nodes located in a particular grid area in sleeping state in order to save energy. Thus, GAF can substantially increase the network lifetime as the number of nodes increases.
- **GEAR (Geographic and Energy Aware Routing):** Yu et al. [35] have suggested the use of geographic information while disseminating queries to appropriate regions since data queries often includes geographic attributes. The protocol uses energy aware and geographically informed neighbor selection heuristics to route a packet towards the target region. The idea is to restrict the number of interests in Directed Diffusion by only considering a certain region rather than sending the interests to the whole network. GEAR compliments Directed Diffusion in this way and thus conserves more energy. In GEAR, each node keeps an estimated cost and a learning cost of reaching the destination through its neighbors. The estimated cost is a combination of residual energy and distance to destination. The learned cost is a refinement of the estimated cost that accounts for routing around holes in the network. A hole occurs when a node does not have any closer neighbor to the target region than itself. If there are no holes, the estimated cost is equal to the learned cost. The learned cost is propagated one hop back every time a packet reaches the destination so that route setup for next packet will be adjusted.

Network flow and QoS Aware Protocols: In some approaches, route setup is modeled and solved as a network flow problem. QoS-aware protocols consider end-toend delay requirements while setting up the paths in the sensor network.

- **Energy-Aware QoS Routing Protocol**[12]

It is an energy-aware QoS routing protocol that could find energy-efficient path along which the end-to-end delay requirement can be met. The proposed protocol extends the routing approach in [17] and finds a least cost as well as delayconstrained path for real-time data considering nodes' energy reserve, transmission energy and other communication parameters. Moreover, it maximizes the throughput for non-realtime data by adjusting the service rate for both real-time and non-real-time data at sensor nodes.

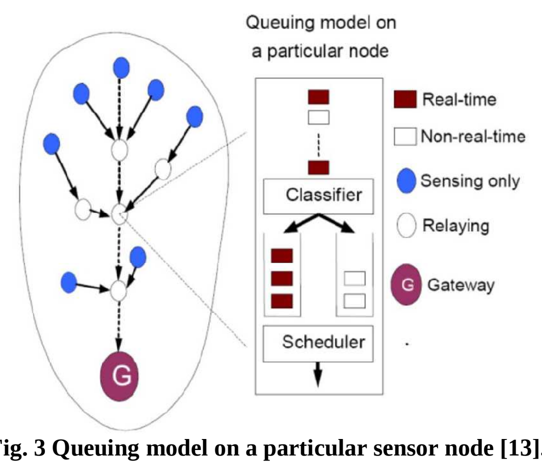

Fig. 3 Queuing model on a particular sensor node [13].

In order to provide both real-time and best possible traffic at the same time, a classbased queuing model is employed. The queuing model is depicted in Figure 3 [13]. There is a classifier at each node to divert real-time and non-real-time traffic to different priority queues according to the type of incoming packets. The bandwidth ratio ‘r’ (actually an initial value set by the gateway) specifies the amount of bandwidth to be dedicated to both the realtime and non-real-time traffic on a particular outgoing link in case of congestion. The classes can borrow bandwidth from each other when one type of the traffic is nonexistent or under the limits. The protocol is based on a two-step strategy incorporating both link-based costs and endto- end constraints. First of all the k-least cost paths are calculated by using an extended version of Dijkstra’s algorithm without considering the end-to-end delay. Secondly, one of the path from the candidate paths is determined that meets the end-to-end QoS requirements and also maximizes the throughput for non-real-time traffic. The simulation results show that their proposed protocol consistently performs well with respect to real-time and energy metrics but it is not scalable well in large WSNs because the routing protocol is an extended version of Dijkstra’s algorithm. To support end-to-end guarantee, their approach however does not consider the delay that occurs due to channel access at the MAC. In addition, the r-value is initially set same for all the nodes, which does not provide adaptive bandwidth sharing for different links. The main drawback of this approach is that it does not support multiple priorities for the real-time traffic. The protocol is extended in [10] by assigning a different r-value for each node in order to achieve better utilization of links.

- **SPEED:** A QoS routing protocol for sensor

networks that provides soft real-time end-to-end guarantees is described in [36]. The protocol requires each node to maintain information about its neighbors and uses geographic forwarding to find the paths. In addition, 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. Moreover, SPEED can provide congestion avoidance when the network is congested.

- **RPAR (Real-time Power-Aware Routing)**

protocol [10] varies from the previously mentioned protocols in many ways:

1.It is the only protocol that combines power control and real-time routing to support energy-efficient, real-time communication.

2. It allows the application to control the trade-off between energy utilization and communication delay by specifying packet deadlines.

3. It is designed to handle faulty links.

4. It utilizes a novel neighbourhood management mechanism that is more efficient than the periodic beacons scheme adopted by SPEED and MMSPEED.

5. It uses dynamic transmission power adjustment and routing decision in order to minimize miss ratios. The transmission power has a large impact on the delivery ratio as it improves wireless link quality and decreases the required number of transmissions to deliver a packet. The authors also perform a set of experiments using XSM2 [11] motes to demonstrate that transmission power control may be an effective mechanism for controlling communication delays under the light workloads by improving link quality and reducing the number of transmissions needed to deliver a packet. A trade-off can be made between energy consumption and communication delay by specifying packet deadlines. Moreover, a novel on-demand neighbourhood management mechanism is proposed to reduce energy consumption in contrast to periodic beacon exchanging scheme adopted by SPEED and MMSPEED. The neighbourhood manager is invoked only when there are no eligible forwarding choices in the neighbour table for forwarding a packet. The simulations show that the forwarding policy and neighbourhood management of RPAR together can introduce significantly reduction in energy consumption with desired real-time guarantee. However, the reaction time of the neighbour discovery is a potential problem to the real-time performance. Moreover, transmitting a packet at a high power level has a side effect of decreasing throughput due to increased channel contention and interference.

- **Energy - Efficient Real - Time Routing**

Protocol

An energy-efficient real-time routing protocol[15] was proposed for WSNs based on SPEED. They put forward a novel concept of Effective Transmission (ET) that ensures that the forwarding candidates are not only nearer to the sink but also farther from the source node with respect to its preceding node. It can therefore limit the area of the candidate nodes and efficiently improve the transmission. Moreover, they separated the whole path’s end-to-end delay guarantee into the sum of point-to-point Constrained Equivalent Delay (CED). Each intermediate node can independently decide its next forwarding node according to the value of this link’s CED. It can greatly reduce the overhead and simplify the route discovery process because there is no need to calculate the sum of each link's delay on the whole path.

Summary

An attempt has been made to present an overview of all the existing protocols in the WSNs .There is a need to make them more energy efficient and robust to adapt to the demanding requirements of these networks. This paper concludes that research on routing and energy related protocols is still a challenging issue.

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