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QoS Parameters Analysis to Improve QoS in WSNs Routing Protocol

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Abstract: **Sensor networks consist of small, low-power, low-energy (stationary) nodes used for monitoring parameters such as temperature, humidity, and motion. Routing is a critical issue in WSN and hence the focus of this paper along with the performance analysis of routing protocols. The growing interest in WSN technique has resulted in many routing protocol proposal. The objective of this paper is to create taxonomy of the WSN routing protocols, and to survey and compare representative examples for each class of protocols. QoS concept used in traditional networks may not be sufficient in WSNs. Some non-end-to-end collective QoS parameters are envisioned due to this significant change All the routing protocols are explained in a deep way with QoS Parameters. The comparison analysis will be carrying out about these protocols.**

Index Terms: ***WSN, Q0S, Routing, Routing protocols.***

Introduction

A wireless sensor node (or simply sensor node) consists of sensing, computing, communication, actuation, and power components. These components are integrated on a single or multiple boards, and packaged in a few cubic inches. A WSN usually consists of tens to thousands of nodes that communicate through wireless channels for information sharing and cooperative processing [1]. WSNs can be deployed on a global scale for environmental monitoring and habitat study, over a battle field for military surveillance and reconnaissance, in emergent environments for search and rescue, in factories for condition based maintenance, in buildings for infrastructure health monitoring, in homes to realize smart homes, or even in bodies for patient monitoring.

Taxonomy for Routing Protocols in WSN

In general, routing in WSNs can classified in to flat-based routing, hierarchical-based routing, and location-based routing depending on the network structure. In flat-based routing, all nodes are typically assigned equal roles or functionality. In location-based routing, sensor nodes positions are exploited to route data in the network [2, 3]. A routing protocol is considered adaptive if certain system parameters can be controlled in order to adapt to the current network conditions and available energy levels. Furthermore, these protocols can be classified into multipath-based, query-based, negotiation based, QoS-based, or coherent-based routing techniques depending on the protocol operation. Another class of routing protocols is called the cooperative routing protocols. Many other protocols rely on timing and position information. In order to streamline this survey, we use a classification according to the **network structure and protocol operation** (routing criteria). The classification is shown in Figure 2 where numbers in the figure indicate the references.

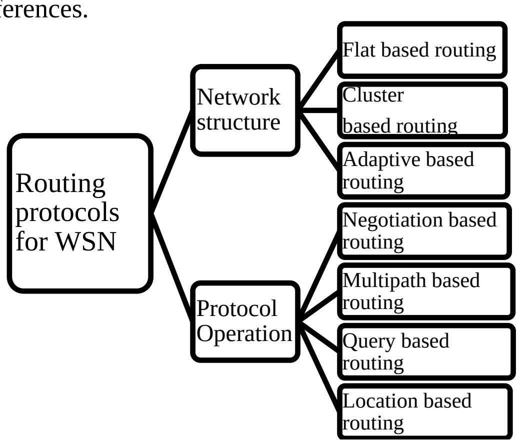

Figure 1: Taxonomy of routing protocols for WSN

1. Network Structure Based Protocols

The underlying network structure can play significant role in the operation of the routing protocol in WSNs. In this section, we survey in details most of the protocols.

Flat Routing

The first category of routing protocols is the multihop flat routing protocols. In flat networks, each node typically plays the same role and sensor nodes collaborate together to perform the sensing task. 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. Since data is being requested through queries, attribute-based naming is necessary to specify the properties of data. Early works on data centric routing, e.g., SPIN and directed diffusion was shown to save energy through data negotiation and elimination of redundant data. These two protocols motivated the design of many other protocols which follow a similar concept [4]. In the rest of this subsection, we summarize these protocols and highlight their advantages and their performance issues.

Sensor Protocols for Information via Negotiation (SPIN)

SPIN is a family of Flat protocols that use data negotiation and resource-adaptive algorithms. SPIN is a data centric routing protocol. It assumes:
A. all nodes in the network are base stations.
B. nodes in close proximity have similar data.

The key idea behind SPIN is to name the data using high-level descriptors or meta-data. Since all nodes can be assumed as base stations all information is broadcasted to each node in the network. So user can query to any node and can get the information immediately. Nodes in this network use a high level name to describe their collected data called meta-data. Figure shows how SPIN works.

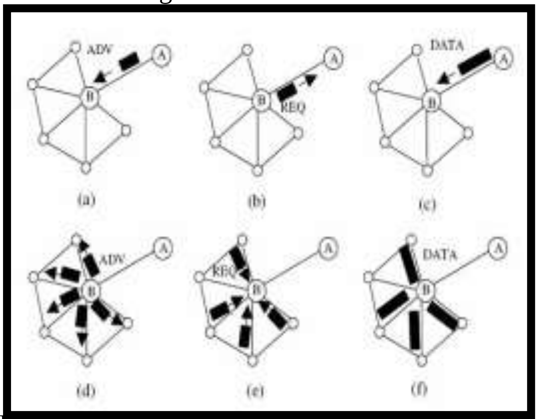

Figure 2: The SPIN protocol.

Before transmission, meta-data are exchanged among sensors nodes (meta-data negotiation) via a data advertisement procedure, thus avoiding transmission of redundant data in the network. After receiving the data each node advertises it to its neighbors and interested neighbors get this data by sending a request message. The format of this meta-data is not specified in SPIN and it depends on the used applications. This meta-data negotiation solves the classic problem of flooding and thus it achieves energy efficiency. SPIN uses three types of messages: ADV, REQ, and DATA for communication with each other. ADV is used for adverting new data, REQ is used for requesting for data and DATA is the actual message. According to this protocol first a node gets some new data and the node wants to distribute that data throughout the network, so it broadcasts an ADV message containing meta-data. The interested nodes request that data by sending a REQ message and the data is sent to the requesting nodes. The neighboring node repeats this process until the entire network gets the new data. The SPIN protocols include many other protocols. The main two protocols are SPIN-1 and SPIN-2. These two protocols incorporate negotiation before transmitting data so that only useful information will be transferred. Each node has its own resource manager that keeps track of resource consumption. SPIN-2 is an extension of SPIN-1, which incorporates threshold-based resource awareness mechanism in addition to negotiation. When energy in the nodes is abundant, SPIN-2 communicates using the 3-stage protocol of SPIN-1.

Advantages: -

- SPIN protocol is that each node only knows its single-hop neighbors therefore topological changes in network localized, i.e. does not affect whole network.
- Significantly reduce energy consumption compared to flooding.

Disadvantages: -

- SPIN protocol does not guarantee delivery of data Large overhead (Data broadcasting).
- Not good for applications requiring reliable data delivery, e.g., intrusion detection.

Directed Diffusion:

In spite of SPIN, where availability of data is advertised, in directed diffusion the BS broadcasts interest which describes a task required to be done by the network. Up on receiving the interest, each sensor node then stores the interest entry in its cache and sets up a gradient toward itself to the nodes from which it receives the interest. When a node has data for broadcasted interest, it sends data through the interest's gradient choosing only best paths to avoid further flooding.
First, directed diffusion issues on demand data queries as the BS send queries to the sensor nodes by flooding some tasks. All communication in directed diffusion is neighbor-to-neighbor with each node having the capability of performing data aggregation and caching. There is no need to maintain global network topology in directed diffusion.

Advantages: -

- Better energy efficiency, especially in highly dynamic network.
- It can reduce the bandwidth needed for sensor networks.
- Robust to failed path.

Disadvantages:-

- Matching data to queries might require some extra overhead at the sensor nodes.
- There is limit memory storage for data caching inside the sensor node.
- Directed diffusion may not be applied to applications (e.g., environmental monitoring) that require continuous data delivery to the BS.

Rumor Routing:
Rumor routing 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. 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 the number of events is small and the number of queries is large [7]. The key 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. In order to flood events through the network, the rumor routing algorithm employs long-lived packets, called agents. When a node detects an event, it adds such event to its local table, called events table, and generates an agent. Agents travel the network in order to propagate information about local events to distant nodes. When a node generates a query for an event, the nodes that know the route, may respond to the query by inspecting its event table. Hence, there is no need to flood the whole network, which reduces the communication cost. On the other hand, rumor routing maintains only one path between source and destination as opposed to directed diffusion where data can be routed through multiple paths at low rates. Simulation results showed that rumor routing can achieve significant energy savings when compared to event flooding and can also handle node's failure. However, rumor routing performs well only when the number of events is small. For a large number of events, the cost of maintaining agents and event-tables in each node becomes infeasible if there is not enough interest in these events from the BS. Moreover, the overhead associated with rumor routing is controlled by different parameters used in the algorithm such as time-to-live (TTL) pertaining to queries and agents. Since the nodes become aware of events through the event agents, the heuristic for defining the route of an event agent highly affects the performance of next hop selection in rumor routing.

Advantages: - Simulation results showed that rumor routing can achieve significant energy savings when compared to event flooding and can also handle node's failure.

Disadvantages: -

- Rumor routing performs well only when the number of events is small..
- It does not guarantee delivery. So we can not depend on this protocol.

Energy Aware Routing:

The objective of energy-aware routing protocol, 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. These paths are maintained and chosen by means of a certain probability. The value of this probability depends on how low the energy consumption of each path can be achieved. By having paths chosen at different times, the energy of any single path will not deplete quickly. This can achieve longer network lifetime as energy is dissipated more equally among all nodes. Network survivability is the main metric of this protocol. The protocol assumes that each node is addressable through a class-based addressing which includes the location and types of the nodes. The protocol initiates a connection through localized flooding, which is used to discover all routes between source/destination pair and their costs; thus building up the routing tables [6]. The high-cost paths are discarded and a forwarding table is built by choosing neighboring nodes in a manner that is proportional to their cost. Then, forwarding tables are used to send data to the destination with a probability that is inversely proportional to the node cost. Localized flooding is performed by the destination node to keep the paths alive. When compared to directed diffusion, this protocol provides an overall improvement of 21.5% energy saving and a 44% increase in network lifetime.

Advantages: -

- Increase the network lifetime and save energy.
- High Scalability and support mobility
- Nearly Stateless

Disadvantages: - The approach requires gathering the location information and setting up the addressing mechanism for the nodes, which complicate route setup.

Cluster-based routing /Hierarchical Routing

Hierarchical or cluster-based routing, originally proposed in wireline networks, are well-known techniques with special advantages related to scalability and efficient communication. In a hierarchical architecture, higher energy nodes can be used to process and send the information while low energy nodes can be used to perform the sensing in the proximity of the target. Hierarchical routing is an efficient way to lower energy consumption within a cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the BS. Hierarchical routing is mainly two-layer routing where one layer is used to select cluster heads and the other layer is used for routing.

LEACH (Low-Energy Adaptive Clustering Hierarchy) protocol:

LEACH is a cluster-based protocol, which includes distributed cluster formation. Here we assume two

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types of network nodes: a more powerful BS and a larger number of resource-scarce sensor nodes. In LEACH the role of the cluster head is periodically transferred among the nodes in the network in order to distribute the energy consumption. The performance of LEACH is based on rounds. Then, a cluster head is elected in each round. For this election, the number of nodes that have not been cluster heads and the percentage of cluster heads are used. Once the cluster head is defined in the setup phase, it establishes a TDMA schedule for the transmissions in its cluster [8]. This scheduling allows nodes to switch off their interfaces when they are not going to be employed. The cluster head is the router to the sink and it is also responsible for the data aggregation. A centralized version of this protocol is LEACH-C. This scheme is also based on time rounds which are divided into the set-up phase and the steady-phase. In the set-up phase, sensors inform the base station about their positions and about their energy level. With this information, the base station decides the structure of clusters and their corresponding cluster heads. Since the base station posses a complete knowledge of the status of the network, the cluster structure resulting from LEACH-C is considered an optimization of the results of LEACH.

Advantages:-

- Completely distributed
- No global knowledge of the network
- Increases the lifetime of the network

Disadvantages:-It is not applicable to networks deployed in large regions and no use of meta data.

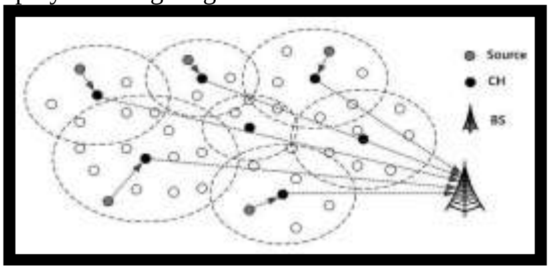

Fig 3: The Leach Protocol.

Power-Efficient Gathering in Sensor Information Systems (PEGASIS):

PEGASIS is an enhancement over LEACH protocol was proposed. The protocol is a near optimal chain-based protocol. The basic idea of the protocol is that in order to extend network lifetime, nodes need only communicate with their closest neighbors and they take turns in communicating with the base-station. When the round of all nodes communicating with the base-station ends, a new round will start and so on. This reduces the power required to transmit data per round as the power draining is spread uniformly over all nodes. PEGASIS avoids cluster formation and uses only one node in a chain to transmit to the BS instead of using multiple nodes. Simulation results showed that PEGASIS is able to increase the lifetime of the network twice as much the lifetime of the network under the LEACH protocol. PEGASIS assumes that each sensor node can be able to communicate with the BS directly. In addition, PEGASIS assumes that all sensor nodes have the same level of energy and they are likely to die at the same time.

Advantages: -

- Extend network lifetime.
- Bandwidth consumed in communication is reduced.

Disadvantages: -

- Delay incurred for packets during transmission to the BS.
- To obtain a global knowledge is difficult.
- Very long delay.

Threshold-sensitive Energy Efficient Protocols (TEEN and APTEEN):

It is a LEACH based routing protocol for reactive network, having a smart data transmission which saves power. Here nodes have dynamically reconfiguring capability. At any cluster change time, the cluster-head broadcasts the following parameters: Attributes and Threshold values (Hard threshold and Soft threshold). The nodes transmit only if the perceived value is greater than the Hard Threshold (HT), or value differs from the last transmitted value (SV i.e. sensed value) by more than the Soft Threshold (ST). After transmission SV is set to the currently transmitted value. Here the time-critical data reaches the user almost instantaneously. In APTEEN cluster-heads are decided in each cluster period and the cluster-heads have to broadcast the following parameters: Attributes, Thresholds (Hard Threshold and Soft threshold), Schedule and Count-Time (TC).Nodes transmit in time slot only if the sensed value is greater than the Hard Threshold (HT), or value differ from the last transmitted value (SV) by more than the Soft Threshold. If a node transmits for a maximum time TC, or if required by some sink, it transmits and after transmission SV is set to the current transmitted value. By sending periodic data it gives user a complete picture of the network. It can also respond immediately to drastic change, thus making it responsive for time-critical situations. Energy consumption can be controlled by the Count-Time and Thresholds.

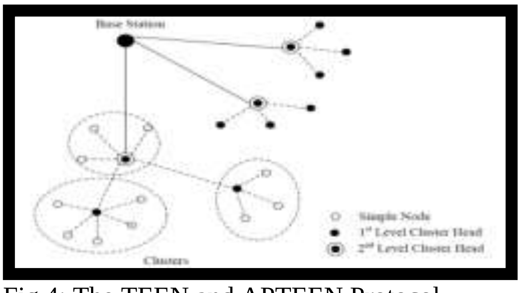

Fig 4: The TEEN and APTEEN Protocol.

Advantages:-

- Suitability for time critical sensing applications.
- Offers a lot of flexibility.

Disadvantages:-

- If the thresholds are not received, the nodes will never communicate, and the user will not get any data from the network at all.
- Energy consumption in this scheme is less.
- The additional complexity required to implement the threshold functions and the count time.

Self Organizing Protocol (SOP):

Self Organizing Protocol (SOP**)** is 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. Router nodes are stationary and form the backbone for communication. Collected data are forwarded through the routers to the more powerful BS nodes. Each sensing node should be able to reach a router in order to be part of the network. A routing architecture that requires addressing of each sensor node has been proposed. The routing architecture is hierarchical where groups of nodes are formed and merge when needed [9]. This protocol, however, is not an on-demand protocol especially in the organization phase of algorithm.

Advantages:-

- Suitable for applications where communication to a particular node is required.
- Energy consumed for broadcasting a message is less.
- Small cost of maintaining routing tables.
- Keeping routing hierarchy strictly balanced.

Disadvantages:-

- Introducing extra overhead.
- It could happen that there are many cuts in the network, and hence the probability of applying reorganization phase increases, which will be an expensive operation.

Small Minimum Energy Communication Network (SMECN):

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. The main idea of MECN is to find a sub-network, which will have less number of nodes and require less power for transmission between any two particular nodes. In this way, global minimum power paths are found without considering all the nodes in the network. The small minimum energy communication network (SMECN) 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. The energy required to transmit data from node u to all its neighbors in sub graph G is less than the energy required to transmit to all its neighbors in graph G'.

Advantages: - Simulation results show that SMECN uses less energy than MECN and maintenance cost of the links is less.

Disadvantages: - Finding a sub-network with smaller number of edges introduces more overhead in the algorithm.

Location based routing protocols

In this kind of routing, sensor nodes are addressed by means of their locations. The distance between neighboring nodes can be estimated on the basis of incoming signal strengths. Relative coordinates of neighboring nodes can be obtained by exchanging such information between neighbors. 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. To save energy, some location based schemes demand that nodes should go to sleep if there is no activity. More energy savings can be obtained by having as many sleeping nodes in the network as possible.

***Geographic and Energy Aware Routing (GEAR)**:*

The key 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. Each node in GEAR 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.

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. If there is more than one, the nearest neighbor to the target region is selected as the next hop.

(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.
In that case, the region is divided into four sub regions and four copies of the packet are created.
This splitting and forwarding process continues until the regions with only one node are left.

Advantages: -

- This protocol conserves more energy and delivers more packets.
- Increases the lifetime of the nodes.
- The transmission power is considerably reduced because the clusters are not too far away from each other.
- The clusters can cross check the information and aid in the distributed processing.

Disadvantages:-

- GEAR faces a problem of limited scalability.
- Difficulty in utilizing the route cache.

SPAN:

Another Location based algorithm called SPAN selects some nodes as coordinators based on their positions. The coordinators form a network backbone that is used to forward messages. 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 reachability). New and existing coordinators are not necessarily neighbors which, in effect, make the design less energy efficient because of the need to maintain the positions of two or three hop neighbors in the complicated SPAN algorithm.

Advantages: - Avoid coordinator contention.

Disadvantages: - Complicated algorithm.

2. Routing Protocols based on Protocol Operation

In this section, we review routing protocols that different routing functionality. It should be noted that some of these protocols may fall below one or more of the above routing categories.

Multipath routing protocols

In this subsection, we study the routing protocols that use multiple paths rather than a single path in order to enhance the network performance. The fault tolerance (resilience) of a protocol is measured by the likelihood that an alternate path exists between a source and a destination when the primary path fails. This can be increased by maintaining multiple paths between the source and the destination at the expense of an increased energy consumption and traffic generation. These alternate paths are kept alive by sending periodic messages. Hence, network reliability can be increased at the expense of increased overhead of maintaining the alternate paths. Multipath routing was used to enhance the reliability of WSNs. It is known that network reliability can be increased by providing several paths from source to destination and by sending the same packet on each path. The idea is to split the original data packet into subpackets and then send each subpacket through one of the available multipath. It has been found that even if some of these subpackets were lost, the original message can still be reconstructed. .

Advantages:-

- Multipath routing was used to enhance the reliability of WSNs.
- Decrease the cost of network.

Disadvantages: -Traffic will increase significantly.

Query based routing

In this kind of routing, the destination nodes propagate a query for data (sensing task) from a node through the network and a node having this data sends the data which matches the query back to the node, which initiates the query. Usually these queries are described in natural language, or in high-level query languages [10].
Directed diffusion is an example of this type of routing. To lower energy consumption, data aggregation (e.g., duplicate suppression) is performed en-route.

Advantages: -

- Better energy efficiency and robust to failed path.
- It can reduce the bandwidth needed for sensor networks.

Disadvantages:-

- Matching data to queries might require some extra overhead at the sensor nodes.
- There is limit memory storage for data caching inside the sensor node.

Negotiation based routing protocols

These protocols use high level data descriptors in order to eliminate redundant data transmissions through negotiation. Communication decisions are also taken based on the resources that are available to them. The SPIN family protocols are examples of negotiation based routing protocols. The motivation is that the use of flooding to disseminate data will produce implosion and overlap between the sent data; hence nodes will receive duplicate copies of the same data. This operation consumes more energy and more processing by sending the same data by different sensors. Hence, the main idea of negotiation based routing in WSNs is to suppress duplicate information and prevent redundant data from being sent to the next sensor or the base-station by conducting a series of negotiation messages before the real data transmission begins.

Advantages:-

- SPIN protocol is that each node only knows its single-hop neighbors therefore topological changes in network localized.

Disadvantages: -

- SPIN protocol does not guarantee delivery of data.
- Large overhead (Data broadcasting).

QoS-based routing Protocol

In QoS-based routing protocols, the network has to balance between energy consumption and data quality. In particular, the network has to satisfy certain QoS metrics, e.g., delay, energy, bandwidth, etc. when delivering data to the BS.

Sequential Assignment Routing (SAR)

Sequential assignment routing (SAR) is the first protocol for sensor networks that includes the notion of QoS in its routing decisions. Routing decision in SAR is dependent on three factors: energy resources, QoS on each path, and the priority level of each packet. To avoid single route failure, a multi-path approach is used and localized path restoration schemes are used. To create multiple paths from a source node, a tree rooted at the source node to the destination nodes (i.e., the set of base-stations (BSs)) is built. The paths of the tree are built while avoiding nodes with low energy or QoS guarantees. At the end of this process, each sensor node will be part of multi-path tree. For each packet in network, SAR calculates weighted QoS metric, which is the product of the additive QoS metric and a weight coefficient associated with the priority level of that packet. Lower the average weighted QoS metric, higher the levels of QoS achieved. The objective of SAR algorithm is to minimize the average weighted QoS metric throughout the lifetime of the network and make the network energy-efficient and fault tolerant. If topology changes due to node failures, a path re-computation is needed. To handle failure within network, a handshaking process is used that enforces routing table consistency between the upstream and downstream neighbors on each path so that any local failure will automatically trigger a recomputation procedure locally.

Advantages: -

- Less power consumption.
- Fault-tolerance and easy recovery.
- Minimize the average weighted QoS metric throughout the lifetime of the network.
- SAR maintains multiple paths from nodes to BS.

Disadvantages: - The main disadvantage of this protocol is the overhead involved in maintaining tables and states at each node.

SPEED (Stateless Protocol for Real-Time Communication in Sensor Networks)

Another QoS routing protocol for WSNs that provides soft real-time end-to-end guarantees was introduced. The protocol requires each node to maintain information about its neighbors and uses geographic forwarding to find the paths. 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 BS by the speed of the packet before making the admission decision.

The routing module in SPEED is called Stateless Geographic Non-Deterministic forwarding (SNFG) and works with four other modules at the network layer. Delay estimation at each node is basically made by calculating the elapsed time when an ACK is received from a neighbor as a response to a transmitted data packet. By looking at the delay values, SNGF selects the node, which meets the speed requirement. If it fails, the relay ratio of the node is checked, which is calculated by looking at the miss ratios of the neighbors of a node (the nodes which could not provide the desired speed) and is fed to the SNGF module.

Advantages: -

- Less power consumption.
- SPEED can provide congestion avoidance when the network is congested.

Disadvantages: - It does not consider the metric of energy in routing decisions.

Energy-aware QoS routing protocol

This protocol finds least-cost, delay-constrained path for real time data based on node's energy reserve, transmission energy, error rate and other communication parameters. Moreover, the throughput of non real-time traffic is maximized. This protocol ensures guaranteed bandwidth through the duration of connection while providing the use of most energy efficient path.The protocol consists of two steps. The first step consists of calculating candidate paths in ascending order of least costs using an extended version of Dijkstra's algorithm without considering end-to-end delay [14]. In second step, it is checked which path fulfills the end-to-end QoS constraints and the one that provides maximum throughput is selected. Simulation results have shown that the proposed protocol consistently performs well with respect to QoS and energy metrics.

Advantages: -

- Least cost and delay constrained and energy efficient path.

Disadvantages: - Maximize Traffic.

QoS

The aim of WSN QoS routing is to select one or multi-routes which can meet the demand of Quality of Service, also can supply enough route resources to support management-control mechanism. Then we can make the best use of network resources. In recent years, the rapid development in miniaturization, low power wireless communication, micro sensor, and microprocessor hardware; small-scale energy supplies in conjunction with the significant progress in distributed signal processing, ad hoc networks protocols, and pervasive computing have made wireless sensor networks (WSNs) a new technological vision [12]. Potential applications of WSNs include environmental monitoring, industrial control, battlefield surveillance and reconnaissance, home automation and security, health monitoring, and asset tracking. While a lot of research has been done on some important aspects of WSNs such as architecture and protocol design, energy conservation, and locationing, supporting Quality of Service (QoS) in WSNs is still a largely unexplored research field. This is mainly because WSNs are very different from traditional networks. Thus far, it is not entirely clear how to properly describe the services of WSNs, much less to develop approaches for QoS support. It is well known that QoS is an overused term with various meanings and perspectives. Different technical communities may perceive and interpret QoS in different ways. QoS refers to an assurance by the Internet to provide a set of measurable service attributes to the end-to-end users/applications in terms of delay, jitter, available bandwidth, and packet loss. The network is required to provide better services than original best effort service, such as guaranteed services (hard QoS) and differentiated services (soft QoS), for end-to-end users/applications. However, QoS requirements generated by the applications of WSNs may be very different and traditional end-to-end QoS parameters may not be sufficient to describe them. As a result, some new QoS parameters are desired for the measurement of the delivery of the sensor data in an efficient and effective way. Further, by measuring these parameters, network designers are also able to investigate which QoS architecture or mechanism can be exploited to provide QoS support for the applications.

QoS parameters in WSN

Following performance metrics are considered to evaluate the QoS in WSN networks:-

1. Packet delivery ratio (PDR): It is the ratio of number of data packets successfully received by the PAN Coordinator to the total number of data packets sent by RFD.

2. Average End-to-End delay: It indicates the length of time taken for a packet to travel from the CBR (Constant Bit Rate) source to the destination. It represents the average data delay an application experiences when transmitting data.

3. Throughput: It is the number of bits passed through a network in one second. It is the measurement of how fast data can pass through an entity (such as a point or a network).

4. Energy Consumption: This is amount of energy consumed by MICAZ Mote devices during the periods of transmitting, receiving, idle and sleep. The unit of energy consumption used in the simulations is m Joule.

5. Energy per goodput bit: It is the ratio of total energy consumed to total bits received. It is used as a figure of merit to compare the performance of various network methods based on battery powered devices.

6. Network Lifetime: This is defined as the minimum time at which maximum numbers of sensor nodes are dead or shut down during a long run of simulations.

Comparison of routing protocols in wireless sensor networks

Hierarchical and geographic routing protocols are considered scalable solutions. Keeping a hierarchical structure demands the coordination of nodes by means of transmitted messages. In dense networks, the use of the cluster-based structure makes up for this cost. However, this benefit does not hold in small networks. When the network is composed of a significant number of nodes in an extended area, the exchange of messages to establish the location of neighbors becomes negligible compared to the reduction of transmissions that the geographic algorithm achieves. In these two approaches, the topology of the network must be stable. On the contrary, the cluster structure and the geographic information must be frequently updated which leads to additional costs.

The performance of APTEEN lies between TEEN and LEACH with respect to energy consumption and longevity of the network. TEEN only transmits time-critical data, while APTEEN performs periodic data transmissions. In this respect APTEEN is also better than LEACH because APTEEN transmits data based on a threshold value whereas LEACH transmits data continuously. Again PEGASIS avoids the formation of clustering overhead of LEACH, but it requires dynamic topology adjustment since sensor energy is not tracked. PEGASIS introduces excessive delay for distant nodes on the chain. The single leader can become a bottleneck in PEGASIS. PEGASIS increases network lifetime two-fold compared to the LEACH protocol. In directed diffusion the base station sends queries to sensor nodes by the flooding technique but in SPIN the sensor nodes advertise the availability of data so that interested nodes can query that data. In Directed diffusion each node can communicate with its neighbors, so

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it does not need the total network information, but SPIN maintains a global network topology. SPIN halves the redundant data in comparison to flooding. Since SPIN cannot guarantee data delivery, it is not suitable for applications that need reliable data delivery. SPIN, directed diffusion and rumor routing use meta-data whereas the other protocols don't use it. Since they are flat routing protocols routes are formed in regions that have data for transmission, but for the others, as they are hierarchical routing methods they form clusters throughout the network. GEAR limits the number of interests in Directed Diffusion by considering only a certain region rather than sending the interests to the whole network. GEAR thus complements Directed Diffusion and conserves more energy.Therefore, they are not appropriate for networks critically constrained by their reduced batteries. However, they become necessary when reliability is a strong requirement in the application business.

Table 1 and 2: Classification and comparison of routing protocols in wireless sensor networks.

Routing Protocols	**QoS**	**Overhead**	**Energy Efficiency**	**State Complexity**	**Data Aggregation**	**Query Based**
SPIN	No	Low	No	Low	Yes	Yes
DD	No	Low	No	Low	Yes	Yes
RR	No	Low	No	Low	Yes	Yes
COUGAR	No	High	No	Low	Yes	Yes
ACQUIRE	No	Low	No	Low	Yes	Yes
LEACH	No	High	Yes	CHs	Yes	No
PEGASIS	No	Low	Yes	Low	No	No
TEEN & APTEEN	No	High	Yes	CHs	Yes	No
SOP	No	High	Yes	Low	No	No
GEAR	No	Mod	Yes	Low	No	No
SPAN	No	High	No	Low	Yes	No
SAR	Yes	High	No	Moderate	Yes	Yes
SPEED	Yes	Less	No	Moderate	No	Yes

Routing Protocols	**Routing Structure**	**Power Requirement**	**Latency**	**Scalability**	**Topology Dissemination**	**Network lifetime**	**Multi path**
SPIN	Flat	Ltd.	Moderate if the network is large	Ltd.	Event driven	Good	Yes
DD	Flat	Ltd.	Low	Ltd.	Demand driven	Good	Yes
RR	Flat	Low	Low	Good	Demand Driven	Very Good	No
COUGAR	Flat	Ltd	Low	Ltd	Query driven	Good	No
ACQUIRE	Flat	Low	Low	Ltd	Complex query	Good	NO
LEACH	Hierarchical	High	Low	Good	Cluster-head	Very good	No
PEGASIS	Hierarchical	Max	High	Good	Chains based	Very good	No
TEEN & APTEEN	Hierarchical	High	Low	Good	Active threshold	Very good	No
SOP	Hierarchical	Low	Low	Good	Continuously		No
GEAR	Location	Ltd	Moderate	Ltd	Demand driven	Very Good	No
SPAN	Location	Ltd		Ltd	Continuously		Yes
SAR	QoS	High	Low, Multipath exists	Ltd	Continuously	Good	Yes
SPEED	QoS	Low	Low	Ltd	Geographic		No

CONCLUSION

Few efforts have been made in the research field of QoS support in WSNs so far. In this survey paper, we analyzed the QoS requirements imposed by the main applications of WSNs, and we claim that the end-to-end QoS concept used in traditional networks may not be sufficient in WSNs. Some non-end-to-end collective QoS parameters are envisioned due to this significant change. Further, we list many challenges posed by the unique characteristics of WSNs and report on the state of the art in terms of a few current research efforts in this field. Finally, we are convinced that the QoS support in WSNs should also include QoS control besides QoS assurance mechanisms, and some exciting open issues are identified in order to stimulate more creative research in the future Since the sensor networks are application specific, we can't say any particular protocol is better than other. We can compare these protocols with respect to some parameters only. Future perspectives of this work are focused towards modifying one of the above routing protocol such that the modified protocol could minimize more energy for the entire system.

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