

# A Survey Analysis of Routing Protocols in Wireless Sensor Networks

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**Abstract-** Wireless sensor network (WSN) is a developing technology, which has the promise of reforming the methods of collecting, processing and distributing information. The WSN becomes particular promising technology for the future. Due to technology development and availability of small, smart and economical sensors, WSN turns to productive, easily deployable, useful and powerful technology. It is necessary to classify architectures for routing protocols so that they can associate data delivery and storage type. This paper is an overview of wireless sensor network and its routing protocols and challenges. It demonstrates and categorizes routing protocols into number of classifications relying on set of measures like their functionalities, performance, types of security and its application. This study is based on the reliability, authenticity, availability and energy utilization of each type of routing protocols.

**Keyword-** Wireless Sensor Networks, Routing Protocols, Data Communications

## I. INTRODUCTION

Wireless Sensor Network is a developing technology that restructuring the approaches of collecting, processing and distributing data. The WSN system is capable of deploying in large number of unchained sensors in areas without any infrastructure for monitoring sound, vibration, pressure, motion, pollutants or target tracking. Sensor network facilitate to monitor, discipline, control, or instruct numerous real-time environment domain such as buildings, homes, cities, and forest. In the beginning WSN was developed for military applications like battlefield control [1], [2]. Presently WSN is applicable in many civilian administrations, like monitoring environment and healthcare applications. The major concerning of this research and exploitation of WSNs are data communication and event detection through sensor coordination.

Nowadays, the modification of sensor performance brings a range of new multifunctional applications, which embody modern microelectronics and wireless communication technology, to achieve purposes other than merely sensing measurements [3]-[5]. This small peripheral even incorporates multifunctional sensors. It deploys with an average processor and does not have a large memory for processing through a wireless transceiver in communication with the support of the batteries. Sensor networks can be used for physical asset value measurement to monitor or detect particular areas and to evaluate the occurrence of the events.

In wireless sensors networks because of potentially uncertain and dynamic environments, there are general challenges in data processing, communication, and sensor management [6]. Also with energy and bandwidth constraints, sensor networks have additional technical challenges in network control and routing, data processing, querying, and tasking.

The WSNs must deal with resources like energy, bandwidth, and the processing power, which are dynamically changing, and the system should operate autonomously, changing its configuration as required. Since communication links are unreliable and shadow fading may eliminate links, the software and system design should generate the required reliability [7], [8]. This requires research into issues such as network size or the number of links and nodes needed to provide adequate redundancy. In the routing protocols depending on the applications, the communication distance and energy must be well managed.

The paper is managed into further three sections to discuss types of data and classification of routing protocols for WSNs and conclude the reviewed research.

## II. NATURE OF DATA IN SENSOR NETWORKS

According to the types of applications in wireless sensor network the data sensed by sensors have particular characteristic [9], and reviewed categorized are as follow:

**Streaming:** Sensors sense data continuously. For large network, the total data will be too much to store, thus, processing these data needs to be online and in-network, and data should be properly pre-compute and store in a suitable format for future query.

**Interrelationship:** The correlation exists between sensors observations. As a wireless sensor networks have need of an exclusively dense deployment of sensors to complete satisfactory coverage because of the limitation on communication range. Therefore, in the environment application a single event can be observe by multiple sensors and the data are interrelated.

**Unreliability:** The instability of nodes and links in wireless sensor networks drives to unreliable data. This type of data occurs when data are not delivered at reliable rate, as effect of sensors may damage data be incorrect, data loss in loosylink, or inaccurate data due to environmental interface. To avoid indefinitely, data techniques have been developed to achieve certain data.

**Heterogeneously:** Different sensors will be deployed to collect data from various sources. In this way data processing should have different data formats.

Individual sensing devices are evolving to be increasingly complex and, at the same time, more reliable. In addition, it is economical to influence as many applications onto existing motes. Sensor networks will progressively go from simple homogeneous to complicated heterogeneous deployment with many different sensing tasks. Keeping these considerations in mind, the proposed techniques and solutions are designed to be applicable for both homogeneous and heterogeneous networks that might serve for tasks not limited to ordinary data reading but also to include complex data processing.

### III. CLASSIFICATION OF WSNs ROUTING PROTOCOLS

Routing is a mechanism of discovers a path at the time of data transmission from source node to destination node. Mostly the network layer of WSNs is applicable to perform the transmission data routing. In the multi-hop network, generally, data from the source cannot reach directly to the sink node. Thus, the intermediate sensors broadcast and transmit data packets. The performing of routing tables [10], which including the list of preference nodes for transmit data to the destination, gives the solution. Structure and development of routing table is the role of routing algorithms.

According to organizing the techniques of routing path, the routing protocols of WSNs can be categorized into four types:

- A. Path Organization
- B. Network Architecture
- C. Protocol Functioning
- D. Next-hop Communication

#### A. Routing Protocol based on Path Organization

Path of the routing can be established on either proactive, reactive or hybrid [9]. *Proactive routing protocols* are accurate and keep up certain routing tables of all network sensors, with broadcasting nodes at the fixed time intervals. Before any requirement of nodes information, all tables are updated. In the both type of flat and hierarchical network architecture can use proactive routing. This type of routing is capable to estimate optimal path, so, hierarchical proactive routing is applicable for large networks. But there is disadvantage of overhead for this amount of estimation.

In *Reactive routing protocol* [9], according to the request, the compute route take place and do not keep up the information of all nodes of network. Depend on the query concerning the route is discovered, and reverse path is used for transfer information from destination to source. In case of any failure path, re-computing the route will be solution. In this type of routing protocol, communication overhead decrease by flooding on networks.

*Hybrid routing protocol* [9] is used for large networks. It adapts clustering techniques and uses both ideas of proactive and reactive protocols. The network divides into several dynamic clusters, and there is possibility of adding or leaving nodes from clusters. The proactive routing performs within the clusters, and establishes reactive routing across the clusters for communication between nodes. This type needs clusters managing.

#### B. Routing Protocol based on Network Architecture

According to the architecture of networks, the protocols divided into flat based, hierarchical based and location based routing protocol categories.

*Flat based protocol* [11] is used when huge amount of nodes with same performance required. In this type data-centric routing make advance to send query through base station to a group of nodes. Because of large amount of nodes, it is not possible to assign ID (particular Identification) to each node. The examples of flat routing protocol are:

Sensor Protocols for Information via Negotiation (SPIN) [12]: is designed for data with high-level descriptors, and meta-data exchanged between sensors. This protocol is designed to address the deficiency of flooding and gossiping.

Active Query forwarding in sensor network (ACQUIRE) [13]: works like distributed database, which require information obtain by flood name data queries within the network and receive respond from nodes.

Minimum Cost Forwarding Algorithm (MCFA) [14]: In this routing when the queries forwarded to sensors, if each node find itself on the optimal path, which it is depend on dynamic cost, broadcast query and information.

Directed Diffusion (DD) [15]: also work on distribution protocols, but cannot provide balance of energy consumption nor time-sensitive traffic.

Energy Aware Routing (EAR) [16]: is able to consider the energy consumed by network nodes. It contains some complexity in forwarding information.

Sequential Assignment Routing (SAR) [17]: is a multi-path routing, which routing path take place by energy resources. The SAR also provides Quality of Service (QoS) on path and packet's priority factors with considering QoS weight of each path. Multi-paths are created and produce a tree from source to destination.

*Hierarchical protocol (Cluster-based routing)* [18] is useful for scalable and efficient communication network. It is an energy-efficient protocol, and the nodes with more energy are randomly selected for processing and transmitting data, and nodes with low energy are used for sensing and send data to cluster head. This feature of clustering routing come through consider-ability of the scalability, minimum energy utilization and extend lifetime of network. Some hierarchical routing protocols are as follows:

Hierarchical Power-Active Routing (HPAR) [19]: is used for ad-hoc networks, which work as global metric by expands the time where information has to be transfer at the high rate.

Threshold sensitive energy efficient sensor network protocol (TEEN) [20]: works with proactive networks, reply shortly to change in the related parameters of concern, and performs well when the energy consumption is matter.

Low Energy Adaptive Clustering Hierarchy (LEACH) [21]: is the dynamic clustering, which one node with some probability is chosen as cluster head and broadcast its condition and position to entire network. In the homogeneous network all nodes have chance to become cluster head during network lifespan. In heterogeneous network mostly use protocols to decide nodes with more energy capacity become cluster head. The drawback of LEACH is high transmission power is require in the large area of networks. The C-LEACH (Centralize LEACH) [22] solves the deficiency of LEACH protocol, which cluster heads select by base-station. The nodes remain energy information receive by base-station, if energy of a node is equal or greater than average node energy, the node is a candidate for the cluster head.

Minimum energy communication network (MECN) [23]: is a minimum energy consumption routing for distributed position-based network protocol, which support peer-to-peer communication. Also, it has capability of self-reconfiguring for local optimization, and randomly gives ID to nodes for connectivity of entire network.

Self-Organization Protocol (SOP) [24], [25]: is the routing protocol, which coordinates network with large number of sensors to achieve large sensing communication. The particular subsets of nodes are unmovable to generate infrastructure components for self-organizing architecture of sensor applications.

In *Location-based protocol* [23], the network architecture is like throw nodes in various random directions in interest area, and the nodes identify by their geographical position (GPS). The coordinate and distance between sensors calculated by exchange data among neighboring nodes. The protocols undertake into this architectures are:

Ad-hoc positioning system (APS) [26]: is aimed for some situation when GPS is not accessible, or in case of power limitation GPS cannot be used. APS is a hop-by-hop positioning of distributed routing that provide approximate position of network nodes and distance vector, and perform ability of self-location.

Geographic adaptive fidelity (GAF) [27]: reduces the utilization of energy through cut out the radio of nodes, those use same functionalities with other nodes.

Geographic and energy aware routing (GEAR) [28]: uses energy aware of nodes next to them to transmit data towards the selected area. Generally, this protocol uses forward flooding algorithm to broadcast the packets. This routing is suitable for flexible traffic distribution.

Greedy other adaptive face routing (GOAFR) [29]: through combining greedy forwarding and face routing, guarantees data delivery to sink with low cost. GOAFR uses boundary circle instead of neighbors location information, then root extra development of boundary circle repeatedly.

Geographic distance routing (GEDIR) [30]: is a self-sufficient routing that uses geographical information, and control energy consumption in broadcasting packets to explore the optimum routing path dynamically. This routing uses convex theory to reduce radio energy to decrease the total communication energy consumption.

### C. Routing Protocol based on Functioning

According to the functionality of WSN applications the protocols are categorized. Therefore, routing protocols are organized corresponding to their procedure to fit these functionalities. The logic and belief behind their coordination is to attain optimum performance and to protect and maintain the limited resources of the network.

In *Multipath routing*, for transfer messages from source to sink there are several paths. The disadvantage of this model is keep communication path awake by sending repeatedly messages to achieve reliability of network, therefore it use great amount of energy. The MMSPEED and SPIN are the multipath routing protocol.

Multipath and MultiSPEED (MMSPEED) [31]: is a routing protocol, which is expected efficient and extensible protocol for sensor networks where the resources are limited in environment applications. The protocol intended for real-time applications and also concern delay in the communication. MMSPEED protocol supports distinctive delivery velocity and also works on reliability of quantities. It provides QoS and differentiates it in two quality domains; it uses static communication power.

In *Query-based routing* [13], the transmission of data occurs depending on the queries. The queries can be suggested by user, and propagate through the network, and sensors represent the required data according to the queries. For minimize energy consumption the queries can be broadcast to some nodes in the specific part of network that information is required. Also, queries can be broadcast through a flooding method or routing protocols that either provides low energy utilization, or shortest path routing protocols. The SPIN, DD and COUGAR are some types of query-based protocol.

The *Negotiation-based routing* [16] use meta-data negotiation over the network to eliminates redundant data transmission. Based on communication decision for specific applications, nodes have knowledge of data and resource availability. These information support the sensor to broadcast data in the limited energy afford by nodes. The SPIN, SAR and DD routing protocols are working on negotiation-based protocol also.

*QoS routing protocols* [32] provide satisfaction for Quality of Service (QoS) requirements for bandwidth and delay constraints. In this type, routing needs QoS and energy knowledge in various layers of protocol stack. Similarly, cost function calculation for the QoS demands is required to be considered. The SAR and MMSPEED are kind of protocols, which worked on QoS routing protocols.

### D. Routing Protocol based on Next-hop Communication

*Content routing* has the capability to forward messages depend on one or more values within the message. This routing provides service aggregation and priority routing based on the message contains and the logic based on the queries. The content routing is appropriate protocol for most sensor networks architectures [33].

*Gradient-Based Routing (GBR)* protocols are proper for those networks that nodes control and provide its gradient, and suggest the direction of approaching next node to forward messages to the destination. In GBR, nodes recognize only their next-hop to send packets and cannot identify the whole network [34].

The other protocol that is in the next-hop routing category is *Energy Aware Routing* [16], [35]. As consider the name of the routing, it can quite reduce energy consumption and effect on energy balance in network. Energy aware routing in terms of query-based protocol can offer an acceptable trade-off between energy saving and balancing, to support real-time communication.

*Probabilistic routing* is functioning for homogeneous networks, which nodes are deployed randomly. Generally, it is suitable for control and restrains delay tolerant. Sensors select next-hop randomly for each message to be transferred. The selection of next-hop in communication is depending on forwarding cost [36]. The Energy Aware Routing is an example of this routing type.

*Location-based routing* [23] is the form of next-hop protocol category, which selection of hop to forward messages is based on nodes locations. In this routing each sensor know about the position of neighbors and destination node. Therefore, location-based routing can avoid overhead of messages flooding on communication, but the drawback is calculation of neighbors' position. Also, every protocol use different routing techniques for some cases, which intermediate nodes are at the long distance from destination node. The GEAR is a type of location-based routing protocol.

*Hierarchical-based routing* has aggregator (cluster head) nodes, which all the other nodes send data to the higher-level node known as cluster head [37]. Therefore, with the well-balance network the communication overhead and energy consumption is reduced and routing increase the lifespan of network. The set of nodes that forward the data to the same cluster head is known as Cluster, and generally, cluster head is in more energy level in comparison to other nodes. The hierarchical models generally are in two layers that one is selection of cluster heads, and the next is transmission routing model. The LEACH protocol is the well-known type of hierarchical-based routing.

*Broadcast-based routing* is performing straightforward model for routing [38]. Accordingly, each node makes a determination that either forwards the data or not, depends on the used algorithm for the routing; the

nodes decide for broadcast the message. The techniques rely upon the minimization of routing cost. The one of protocol that works with this routing is MCFA protocol.

The specifications of different types of WSNs routing protocols are summarized in Table1.

TABLE I WSNs Routing Protocols Classification

Routing Protocol	Data aggregation	Data-Centric	Hierarchical	Location-based	Network flow	QoS	Energy Efficient
ACQUIR	✓						
APS				✓			
DD	✓	✓					
EAR			✓			✓	✓
GAF	✓						
GEAR				✓			
GEDIR				✓			✓
GOAFR	✓			✓			
HPAR			✓		✓		
LEACH	✓		✓				
MCFA	✓	✓					
MECN				✓			✓
MMSPEED				✓		✓	
SAR		✓				✓	✓
SPIN	✓	✓					
SOP	✓		✓				
TEEN	✓	✓	✓				✓

#### IV. CONCLUSIONS

In the recent years attention on routing in wireless sensor networks has the interest of researchers for suggesting special challenges compared to traditional wired networks routing. In this paper, recent researches on WSN data routing protocols and their classifications are discussed. The performances of these routing protocols are compared in terms of their various parameters, especially energy efficiency status. There are some routing protocols, which are only specific to particular applications only, and some routing protocols are functional for many applications.

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