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# A Comprehensive Review on Secure and Energy Efficient Routing Approaches for Large Scale WSNs

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**Abstract**

Large scale wireless sensor network (LS-WSN) is a network of self-directed tiny sensor devices. Sensor nodes collect data from their surrounding environment and send these data to sink for post data analysis. The current popular application domains of sensor networks are environment, health, home, military, security, and commercial areas. On the other hand, multi-sink WSNs have the potential to provide network performance through efficient data exchanges. In multi-sink phenomena, clusters of nodes are defined using distance vector and thereby specific node that lies at the center of the cluster is identified as a sink. The performance of multi-sink WSNs is significantly affected by sink node placement and routing of data packets within the cluster. This review examines the most recent routing protocols for WSNs and developing action plans for the various approaches pursued. One of the potential drawbacks in any LS-WSN is the energy requirement. Furthermore, several directions to extend the network's life expectancy have attracted in an expanding level of attention. Recently, a few achievements have emerged. Designing routing protocols is one of the most encouraging of these mechanisms, as demonstrated by the significant amount of energy required for the transmission of information.

**Keywords:** wireless sensor networks, energy efficiency, security protocols, multiple sink nodes.

## 1. Introduction

In recent years, there has been massive development in research of WSN, which are now commonly used in military, intelligent medical and monitoring applications. Data collection is the key task in WSN, and it gets attention from a large number of researchers [1]. In conventional data collection scheme, all nodes are fixed in position to collect data before being forwarded to the Sink through routing protocol. Currently, the most challenging unsolved problems with this process include (1) the energy hole problem, where data streams follow a many-for-one mode which subjects nodes near the Sink to greater traffic load, resulting in premature energy depletion and the creation of an energy hole around the Sink; (2) the communication overhead problem, where, because the self-energy of sensor nodes is limited, there is control overhead regardless of the routing protocol algorithm and thus an inherent need to control the energy consumption of network nodes [2].

In most application of WSNs, the nodes are battery-powered and located in unattended or harsh environment. It is difficult or even impossible for battery replacement. Once node's energy exhausts, the node is disabled. It will affect the network operation and split the network to shorten network lifetime [3]. Therefore, in WSNs, network lifetime is the important indicator of network performance. The data collection algorithms of WSNs should save energy and maximize the network lifetime. The researchers proved that the hierarchal data gathering algorithm achieves remarkable performance in extending network lifetime. One important parameter in hierarchical routing protocols is cluster size. With small size clusters, networks may encounter connectivity and coverage problems. In [4], the authors showed that if the cluster size is not properly chosen, the total energy consumption of the network will increase exponentially, either when the cluster size is smaller than the optimal value or when the cluster size is larger than the optimal size. Lian et al. [5] showed that up to 90% of the total energy of the network can be wasted when the entire network is subject to premature death. The equal size cluster and multi-hop routing is the main cause of energy hole problem, this can be solved by using mobile sink for data collection. When a single mobile sink is used for data collection, it has to travel a whole deployment area which is not feasible for large scale WSN, so multiple mobile sinks are used for energy efficient data collection. The key challenge in this design is how to balance the workload among mobile sinks and to balance energy consumption among sensor nodes through the control of the movement of mobile sinks.

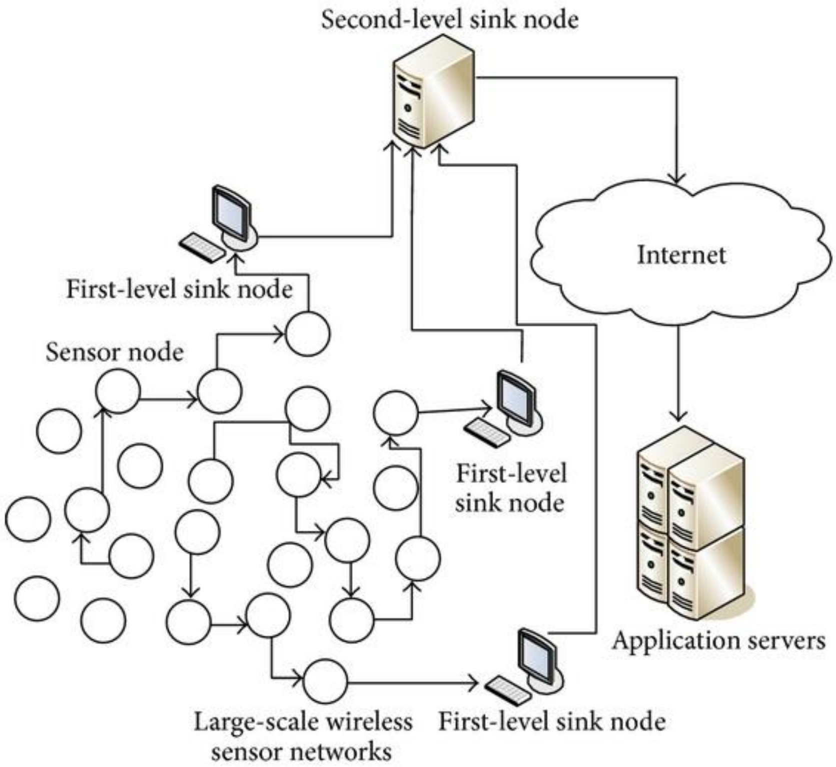


Figure 1: Example of LS-WSNs.

**2. Related work**

Several studies of deploying mobile sinks for data collection in literature have been conducted in the past. Grouping the nodes into optimal clusters is known as an NP-hard problem [6]. Consequently, one effective method for optimizing the cluster size is to use optimization algorithms. In [7] used Particle Swarm Optimization (PSO) in their proposed protocol in order to determine the optimal cluster size by minimizing the distance between member nodes and CHs and decreasing the energy consumption of the network. In [8] used GA to create optimal clusters for energy efficiency in WSNs. The authors of [9] proposed a self-clustering method for heterogeneous WSNs using a GA that optimized the network lifetime. In addition, there are other methods which adjust cluster size with different objectives. The authors of [10] aim to construct a routing tree such that the network lifetime is maximized while keeping the routing path from each sensor to the sink is minimized. A generic cost model of energy consumption for data gathering is proposed, and a routing tree is used for the query evaluation [11].

The work in [12] aims to find an optimal trajectory for each mobile sink and to determine the sojourn time of each mobile sink at each sojourn location in the trajectory such that the network lifetime is maximized. The use of a single mobile sink to prolong the network lifetime has also been explored in [13]. The work in [14] proposes the route of mobile base station and balances the network load to prolong network lifetime. Similarly [15,16] propose the maximum residual energy of greedy algorithm to control the mobile base station. In the case of limited base station stationary point, joint mobility and routing of base station are proposed [17-19]. Finally, [20-22] uses mobile sink routing protocol to manage the path. However, the usage of mobile sinks has many limitations in practical applications. On one hand, a WSN is usually deployed in traffic inconvenience regions, so the movable area in the regions by the mobile sinks is limited.

On the other hand, the mobile sinks are usually installed on mobile tools such as unmanned vehicles; the speeds of these mobile vehicles are constrained by many factors such as road conditions and mobile tools, where the mobile tools also have energy limit, so their maximum moving distance per tour is limited, too. Thus, when dealing with routing protocol design under this scenario, we must take these constraints on mobile sinks into account, in order to prolong the network lifetime efficiently and effectively.

| Author Name | Technique | Description | Benefits | Drawbacks |
|---|---|---|---|---|
| [23] | New iterative random algorithm | It helps for reducing the node failures in the neighbourhood of the sink node. It quickly finds the best route and uniformly balances the optimal load. | • Uniformly balance the load of sensor nodes.<br>• Better system life span | Less suitability in multi-hop environment. |
| [24] | Flooding and Gossiping method for forwarding data packets in WSN to improve the QoS | This technique introduces a technique that uses the flooding concept to send the data packets in dynamic way by using the best route. In addition, different machine learning approaches are used for forwarding the data packets. | • Better energy consumption.<br>• Improve network lifetime.<br>• Reduce delay time. | Less Area coverage of sensor nodes in network |
| [25] | An energy efficient clustering approach to find the best optimized path in WSN-IoT applications. | Introduced the mobile sinks are used to collect sensed information from the cluster heads and then sink locations are evaluated on the basis of weighted vertex cover problem | • Enhanced performance of WSN network.<br>• Removed energy hole problem | Average energy consumption. |
| [26] | Reliability and Multi-way Encounter Routing | Firstly, a small number of nodes are selected in hotspot areas that are near to sink node and most of the nodes are chosen in non- | • Meeting reliability.<br>• Reduced energy consumption. | Average energy saving |

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| | | hotspot areas which can prompt the network lifetime | • Improved network performance. | |
| [27] | Dijkstra algorithm and greedy algorithm | Introduced a method for predicting delay called DIM, as well as a strategy called REPC, which is used to manage network load by focusing on node residual energy. | • Battery delay estimation.<br>• Balance network load | • Average energy consumption<br>• Energy consumption is considered in small scale |
| [29] | Proposed an energy efficient distributed routing technique named Dual decomposition technique. | In this scheme the transmitters as it were utilized local data to broadcast packets with the help of their cooperative nodes, and a mathematical optimization issue is also added. | • Improved network, throughput etc.<br>• Modifications in network properties and channel conditions are supported. | Not in consideration the void region problem for sending packets. |
| [30] | Introduced energy interoperable for throughput optimization-based routing technique in clustered IoT. | Introduces the proactive-in network processing methodologies and demonstrates performance efficiencies to increase system throughput. | • Enhance network lifetime.<br>• Better end-to-end delay.<br>• Less packet drop ratio. | • Less improvement in cluster formation.<br>• Adaptability in relating to bio-inspired computing can be improved |

**3. Illation**

Traditional routing strategies are inadequate to meet the needs of the current situation since they fall short of basic requirements such as energy usage, network cost, and so on. To address the problems of traditional routing strategies, an energy-efficient approach must be developed. Furthermore, for the improvement of sensor routing, the following points should be observed for the development of energy efficient techniques:

- When a sensor's ability to make choices increases, the energy consumption of the sensor will increase. The battery level can deplete over time as more energy is consumed. This can cause network execution problems in the system or cause the entire framework to shut down. To deal with this basic circumstance, the network should have some sort of energy efficient routing protocols that can make mitigate the energy consumption.
- There are a few energy efficient routing techniques available, but the majority of them have the drawback of using fixed static routing, which means that if any area of interest event occurs between network sensors, the entire network may shut down. Although sensor devices have energy requirements, researchers have required to maintain the sensors' energy levels for longer periods of time.
- The routing of sensors in existing works is fixed. A decision node is required to make the sensors' routing dynamic, which will guide how a sensor will route to the next sensor in the routing process. If there are any hotspots between sensors as a result of internal or external

environment difficulties, the routing process will fail. The hotspot problem could be solved by adding more energy-efficient nodes that make decisions about which paths are the shortest between the sensor nodes. Therefore, the proposed energy efficient sensor routing should represent a significant change from previous work.

## 4. Conclusion

Routing protocols have a vital role in the operation of energy efficient WSNs, as demonstrated by their adaptability and effectiveness. As a result, they are a promising research area. Different routing protocols have been created that ensure energy-efficiency to extend the network lifetime, taking into consideration of energy consumption and network design. This paper provides a concise survey of secure and energy-efficient routing protocols for LS-WSNs. The key points, architecture, and frameworks of various energy efficient sensor routing techniques were presented in this study. Furthermore, this research focuses on several secure and energy-efficient strategies.

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