Performance analysis of Energy Efficient Routing protocols in Wireless Sensor Networks

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Abstract

Wireless Sensor Networks comprises of spatially distributed autonomous sensors has been employed in large extent as monitoring applications in remote environments. In order to provide quality of service, energy efficient routing protocol has to be designed to support mobility of node towards data collection as sensor nodes are energy constraint devices. In this paper, a performance analysis of energy efficient routing protocols to wireless sensor network on various aspects has been carried out. Energy efficiency is one of the important factors of the wireless sensor network as it operates with low power and small size multifunctional sensor nodes. Further energy efficient routing protocols has categorized on basis of routing structure which is termed as hierarchical based routing, flat based routing and location based routing. Additionally awareness of link weight and energy density of the node and mobile sink seems to be important aspect. The analysis of the protocols has been carried out on basis of design, implementation and performance. Moreover selection criteria for protocol analysis are to ensure relevancy of the quality validation. To be more specific, protocol such as LEACH based on Forward Aware Factor, Ring Routing and Source Traffic Defined Multiple Mobile Sink Routing Protocol has been analysed in depth as it belongs to hierarchical structure and it outperforms the routing structures in energy utilization and extending the lifetime. The performance is measured with respect to topology, clustering procedure, Mobile sink trajectory, data aggregation, location awareness, Scalability and network lifetime. Result of the analysis reveals the solutions for improvement of the protocol on optimizing the energy efficiency. Finally we conclude that protocol named as Source Traffic Defined Multiple Mobile Sink Routing Protocol extends the network lifetime without degrading the other critical factors through elaborating the weakness of the existing approaches on achieving the energy efficiency.

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1. Introduction

Wireless Sensor Networks (WSN) recognized a new generation of a multi-functional sensor able to capture various types of environmental and physical conditions and characterized by their low battery, low data processing capacity, small size and ability to move around and organize themselves into a network. Wireless Sensor Networks (WSN) consist of multiple sensors nodes which continuously record values to share with sink node via either node-to-node communication or cluster heads. The data is sent from sensor node to cluster head node which are then forwarded to BS for further communication. The sensor nodes are small devices and can perform many tasks, including event sensing, data processing, and data communication. Each node consists of four main parts. The first part is a sensing unit that senses a phenomenon and converts sensing data into a digital form using a sensor and Analog-to-Digital Converter (ADC). Processor unit is the second part that processes all data and controls operations of the other parties. The third part is a transceiver unit that is used to transmit and receive data with a limited transmission range. Power unit is the last part that supplies power to all components. Moreover, a sensor node might additionally have some specific components, such as the Global Positioning System (GPS), mobilizer, and power generator units. The GPS unit can help a sensor node to obtain its own location information while the mobilize unit offers the movement capability of a sensor node. The power generator unit is responsible for power generation.

A sensor node has limited on-board storage, processing, power, and radio capabilities due to its small size. Therefore, MWSNs require effective mechanisms to utilize and resolve the limited resources. Routing is one of these mechanisms that prolongs the lifetime of network by reducing the energy consumption in communication. The routing protocol should consider the network structure, data sending methods, node and link heterogeneity, node mobility, consumption energy, coverage, connectivity, data aggregation, and quality of service issues in order to be an efficient and reliable protocol. The developed routing protocols can be grouped based on the routing structure into hierarchical-based, flat-based, and location-based routing protocols. The hierarchical based routing protocols outperform the other routing types in saving energy, extending a lifetime of WSNs, and scalability. The hierarchical-based routing partitions the network into multiple groups. Each group contains one cluster head node and many member nodes (MNs). MN only senses and delivers its sensed data to its related cluster head node, while a head is responsible for collecting and aggregating data of its MNs and then transfers the aggregated data to sink.

Hierarchical-based routing is a feasible solution for reducing energy consumption in WSNs due to reduction of redundant data transmission. In addition, it can effectively balance the load among the sensor nodes via assigning different tasks for each sensor node according to its capabilities. Finally, it can easily achieve collision-free network by using a proper MAC protocol. The analysis of the protocols has been carried out on basis of design, implementation and performance. Moreover selection criteria for protocol analysis are to ensure relevancy of the quality validation. To be more specific, protocol such as LEACH based on Forward Aware Factor, Ring Routing and Source Traffic Defined Multiple Mobile Sink Routing Protocol has been analysed in depth as it belongs to hierarchical structure and it outperforms the routing structures in energy utilization and extending the lifetime. The performance is measured with respect to topology, clustering procedure, Mobile sink trajectory, data aggregation, location awareness, Scalability and network lifetime. Result of the analysis reveals the solutions for improvement of the protocol on optimizing the energy efficiency.

The paper is organized as follows. Section 2 is a detailed survey about various energy efficient clustering protocols of WSNs. Taxonomy criteria of the hierarchical-based routing protocols are explained in Section 3. Section 4 discusses the design analysis of energy efficient routing protocols based hierarchical-based routing. Experimental analysis of the hierarchical-based routing protocols of WSNs has been analysed along the performance comparison is described. Section 7 offers some conclusions and future directions.

2. Review of Literatures of structure based routing protocol

In this section, routing protocols has been analysed as limited characteristics of WSN bring the necessity to achieve efficient management of the routing task in order to the increase the network lifespan. Thereby, much recent research in this field aims to implement highly efficient routing protocols that will be able to overcome the severe resource constraints of sensors using network topology. In this work, hierarchical cluster based routing protocol for energy efficient has been analysed in depth.

2.1. Hierarchical Routing -Cluster Based Routing

Hierarchical schemas define a specifically structured topology. They divide the sensor nodes into many groups called clusters, with a specially selected node in each group called the cluster head (CH). Those CHs coordinate and communicate directly between them or with the BS. Hierarchical routing protocols use several strategies to select the CH, e.g., the highest energy node or the one having the maximum number of neighbors in a cluster can be selected as CH.

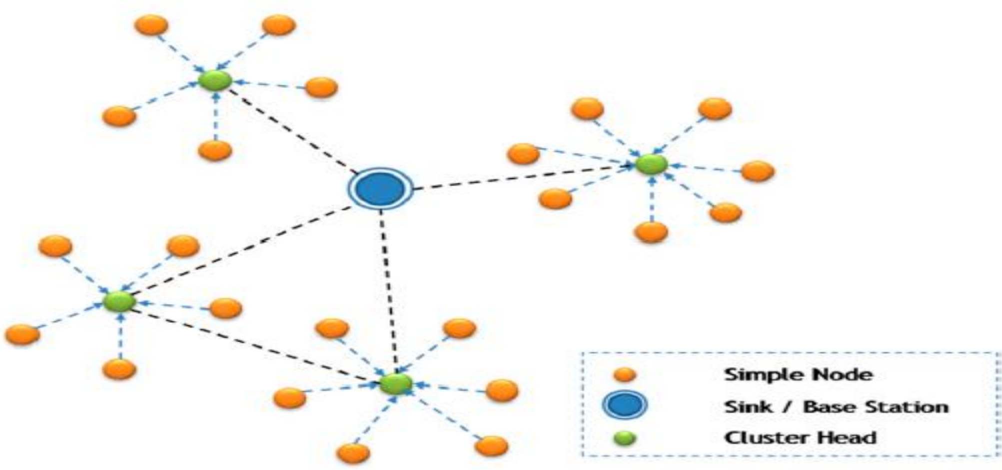

Figure.1: Hierarchical Routing Model

Hierarchical routing is an energy efficient method aiming to maximize the network lifespan and to ensure network scalability through the hierarchical structure. Figure 1 represents the hierarchical routing model. These protocols can be classified into block, grid and chain cluster-based protocols. . Some of the representative protocols in this category are as follows

- Low Energy Adaptive Clustering Hierarchy(LEACH)
- Hierarchical Geographic Multicast Routing

2.2. Flat Routing

FLAT routing is basically data-centric routing. Each node is assumed to equally participate into sensing task and is excited through queries generated by BS upon requirement of the user. These protocols are resource conscious and adaptive in nature. Each sensor node in the network is recognized as potential member that has enough data that can be accessed by BS. It is developed to minimize the amount of wireless sensor devices within the network and to reduce the consumption of energy of the nodes. Some of the representative protocols in this category are as follows

- **Sensor Protocols for Information via Negotiation(SPIN)**

2.3. Heterogeneity Routing

Heterogeneity-based protocols manage to route and take advantage of unlimited or highest energy of some nodes to extend the network lifetime. WSNs can have three or more levels of heterogeneity if the network contains three or more categories of sensors with different energy levels. Some of the representative protocols in this category are as follows

- Developed Distributed Energy-Efficient Clustering
- Threshold-Sensitive Stable Election Routing Protocol
- Enhanced Developed Distributed Energy Efficient Clustering

3. Taxonomies of Hierarchical Based Routing Protocol

The main aim of hierarchical-based routing in MWSNs is saving the residual energy of each sensor node, extending the network lifetime, and ensuring the connectivity among the sensor nodes. Here, we present a detailed taxonomy and classification of the hierarchical-based routing protocols based on different metrics. These metrics are routing approach, control manner, mobile element, mobility pattern, network architecture, clustering attributes, protocol operation, path establishment, communication paradigm, energy model, protocol objectives, and applications as shown in Figure 2.

3.1. Routing Approach.

The challenge of data routing can have two broad methods, namely, classical-based method and optimized-based method.

(a) Classical-Based Routing.

In the classical-based routing, head nodes are selected randomly using the timer function,

which causes an uneven traffic flow in different head nodes? Although they are suitable for applications of WSNs, they still have many challenges such as scalability, load balancing, connectivity, coverage, and robustness.

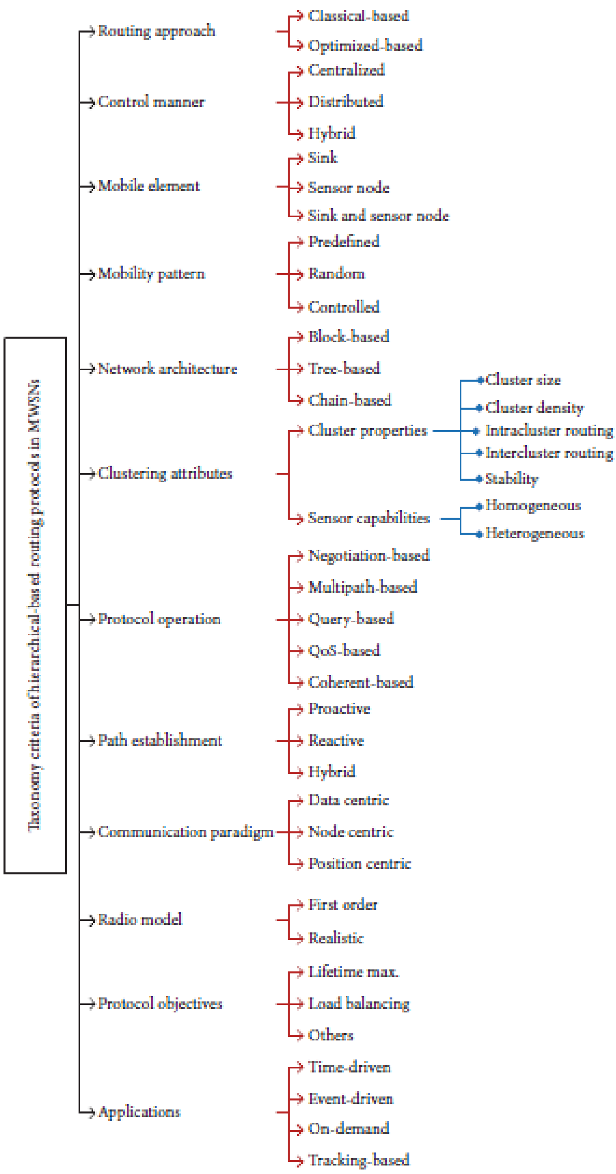

Figure 2: Taxonomy of the Hierarchical Based routing protocols

(b) Optimized-Based Routing.

Routing in WSNs puts new challenges for researchers as various classical protocols lack fault tolerance, energy-efficiency, connectivity, robustness, and scalability. Researchers have developed some robust routing protocols based on optimization algorithms such as Particle Swarm Optimization (PSO), Fuzzy Logic (FL), Genetic Algorithm (GA), and Artificial Bee Colony (ABC), which provide optimal solutions to the mentioned problems.

$$f(x= \sum_{k=0}^{n} V)x)r^{k} d^{n-k})$$

Thus in the optimized-based routing, the head nodes are determined based on multicriteria to achieve the requirements of QoS.

3.2. Control Manner.

On the basis of control manner, routing approaches of MWSNs can be centralized, distributed, or hybrid approaches.

(a) Centralized Approaches.

In the centralized approaches, a sink/head node requires global information (e.g., energy level, geographical position) of the network/group to control the network/group. These approaches are used to organize the network into clusters and assign a head node for each one.

(b) Distributed Approaches.

In the distributed approaches, the sensor nodes collaborate with each other to build routes without need for the global information of the network. Each sensor node can execute its own algorithm and takes the decision of becoming a head node or not.These approaches are used for coordination between the head nodes.

(c) Hybrid Approaches.

Hybrid approaches combine the features of being centralized and distributed.

3.3. Mobile Element.

Since the network consists of a large number of sensor nodes and sink nodes, the mobility can apply to the sensor nodes and/or the sink node(s) depending on the applications. Therefore, the routing protocols can be classified based on the mobile elements into protocols supporting sink node(s) mobility, protocols supporting sensor nodes, and protocols supporting mobility of both sensor nodes and sink node(s).

3.3. Mobility Pattern.

One of the main challenges in routing of MWSNs is determining the moving pattern of the mobile element (i.e., sensor nodes or sink node). Depending on the application and network size, there are different mobility patterns.

(a) Predefined Mobility Pattern.

In this pattern, the mobile element moves along a predefined path within the sensor field and stops at predefined positions to perform a specific task. This pattern can be used for the mobile sink.

(b) Random Mobility Pattern.

The random mobility pattern can be used for the mobile sensor nodes and the mobile sink. In this pattern, the mobile element moves randomly within the sensor field. The synthetic mobility models are used for simulating the random mobility of a mobile element such as Random WayPoint mobility model (RWP) and Reference Point Group Mobility Model (RPGM) [17–19].

(c) Controlled Mobility Pattern

In the controlled mobility, the mobile element is guided based on the control of the routing protocol. The movement of the mobile element is controlled based on some factors such as energy level, avoiding energy groups called clusters. Each one has a head node called Cluster Head (CH) node that is responsible for collecting and aggregating the data of its MNs and then transfers the aggregated data to the sink node. The main problem with these protocols is how to select CH and the limited range of sensor nodes to connect directly with sink.

(b) Tree-Based Hierarchal Routing.

In the tree-based hierarchical routing protocols, a routing tree is formed among all sensor nodes and the sink is the root of this tree. Leaf nodes in the routing tree send data to their parent. Each parent node aggregates the received data and sends it to the next level parent node towards the sink.

(d) Chain-Based Hierarchical Routing.

In the chain-based hierarchical routing protocols, one or more chains are constructed to connect the nodes for data transmission. A head node for each chain called leader is chosen to collect data from the chain members.

$$\beta_{ij\leftarrow k} = 1 - \sum_{i=0}^{n}(V_{kj}(p) - V_{ij}(p))$$

Data is delivered from the farthest node from sink along the chain until the leader node forwards the final packet toward the sink. However, the data packet reaches the sink via a large number of hops, which increases the packet delay. Moreover, the chain-based routing has less ability of robustness because the failure of one node breaks the chain and data will be dropped.

3.6. Clustering Attributes.

The attributes of the clustering process have an important effect on the performance of hierarchical-based routing. The cluster properties and the sensor capabilities are the two main issues in the clustering attributes [21, 22].

3.6.1. Cluster Properties.

In the hierarchical-based routing protocols, the characteristics of the formed clusters are used to differentiate between these clusters in terms of saving energy, load balancing, and lifetime.

(a) Cluster Size.

From the point of cluster size, the hierarchical-based routing protocols in MWSNs can be grouped into equal and unequal clustering. In the equal clustering protocols, all clusters have the same size, while in the unequal clustering protocols, clusters have different sizes. In general, unequal clustering protocols are used to balance the load among the nodes and solve the energy hole problem.

(b) Cluster Density.

Cluster density is the number of cluster members. Density of cluster affects the energy consumption of CH. Clustering protocols can be static clustering protocols and dynamic clustering protocols. In the former one, clusters have fixed density, but the cluster density in the second one is variable.

(c) Intracluster Routing.

Intracluster routing is the communication between MNs and CH.This communication can be a single-hop or a multihop routing. In the single-hop routing, MNs directly deliver their data to CH. However in the multihop routing, member nodes transmit their data to CH via relay nodes.

(d) Intercluster Routing.

Intercluster routing is the communication between the sensor nodes/CHs and sink node. The intercluster communication can be a single-hop or a multihop routing. In the single-hop routing, sensor nodes/CHs send their data directly to sink.

$$T_{ij} = \sum_{x=1}^{n} w_i(p_x) * V_{ij}(p_x) \quad \forall i,j \in C, px \in P$$

In contrast to it, sensor nodes/CHs transmit their data to sink using intermediate nodes in the multihop routing.

(e) Stability.

The stability of routing process depends on the cluster density. If the cluster density is fixed, the stability of routing is said to be fixed. Otherwise, the routing stability is considered variable because the cluster density varies throughout the routing process.

3.6.2. Sensor Capabilities

Based on the resources of the sensor nodes, MWSNs can be classified into homogeneous and heterogeneous networks.

(a) Homogeneous Network. In the homogenous network, all sensor nodes have the same energy, computation, and communication resources. In this type of networks, CHs are assigned according to a random manner or other criteria.

(b) Heterogeneous Network. In the heterogeneous network, sensor nodes have unequal capabilities in heterogeneous environment. Therefore, the role of CHs is specified to sensor nodes that have more capabilities.

3.7. Protocol Operation.

Depending on the protocol operation, the hierarchical-based routing protocols are divided into negotiation-based, query-based, multipath-based, coherent based and QoS-based routing.

(a) Negotiation-Based Routing.

In this type of routing, a high level of descriptors is utilized for the negotiation between the sensor nodes to minimize the duplicated information and avoid the redundant data. Generally, this negotiation should be done before real data transmission between the source and the relay node or the sink node.

(b) Query-Based Routing

This type of routing depends upon queries from a destination. The source node transmits its data in response to the received query from the destination node.

(c)Multipath-Based Routing

In the multipath routing, multiple paths are constructed between a source and a destination to increase the fault tolerance and enhance the network performance.

(c) Coherent-Based Routing.

Different data processing mechanisms are presented to save the processing computations that consume a significant part of the node energy. Coherent and noncoherent are the two main data processing approaches that are used to save the consumption energy in data computations. In the noncoherent data processing technique, the sensor node processes the data locally and then forwards it to the aggregator. Aggregator is a node, which aggregates the received data from many sensor nodes and forwards the aggregated packets to sink. In the coherent method, a sensor node performs minimum data processi ng aggregator is responsible for the major and complex part of processing.

(d) QoS-Based Routing.

The used algorithm in this type of routing ensures the QoS requirements of the data. These requirements can be reliability, delay, or bandwidth. The task of routing protocol is balancing the dissipated energy while achieving the QoS conditions.

3.8. Path Establishment.

The path establishment mechanism is responsible for identifying or discovering routes from

a source to the intended receiver. This mechanism can also be used to distinguish between different types of the hierarchical-based routing protocols.

(a) Proactive Routing.

This type of routing is also often described as table-driven, because each node selects the best

path and forwards its data based on the contents of a routing table. This table contains a list of paths between a node and one or more next-hop neighbors and also cost associated with each path. In this type of network, nodes periodically switch on their sensors and radios to sense the data and transmit it

to the destination via a certain route from the routing table. This routing type is suitable for periodic data monitoring applications like collecting data about temperature change over a particular area.

(b) Reactive Routing.

In the reactive routing, the node reacts immediately to sudden changes in the sensing event and does not already have a route established. This type of routing adds some delay for discovering the route before transmitting the data. Also, it is well suited for time-critical applications, for example, explosion detection and intrusion detection.

(c) Hybrid Routing.

In this routing type, nodes not only react to sudden changes in the sensing event but also send
their data at periodic intervals in an efficient method to the destination.

3.9. Communication Paradigm

The communication between the sink and the sensor nodes can be node centric, data centric, or location centric.

(a) Node Centric

In the node-centric protocols, destinations are specified using numerical addresses (or identifiers) of nodes. In this type, sensor node can forward its data to specific destination via its ID.

(b) Data Centric

In the data centric technique, sink forwards queries to a particular area within a sensor field and waits for data of the sensors that are located in the selected region. The source sensors of the selected region send their data to the sink via intermediate nodes. These intermediate sensor nodes aggregate the collected data frommultiple sources and forward the aggregated packets to the sink.This process saves the dissipated energy in the redundant data.

(c) Location Centric

In the location-centric routing, the sensor nodes should know their locations in the sensor field. Location information is used to construct best routing,which enhances the network performance.

3.10. Radio Model.

The major task of the hierarchical-based routing protocols is saving the residual energy of each sensor node and extending the network lifetime. Since the energy consumed by the radio of the sensor node represents the largest portion of the consumed energy [23], the routing protocols can be surveyed according to the model of the sensor radio. The radio of the sensor node is simulated as the
first-order model [24] or as the realistic radio model such as CC2420 [25].

3.11. Protocol Objectives.

The hierarchical-based routing protocols have been developed to save the dissipated energy and extend the lifetime of MWSNs. Accordingly; the hierarchical based routing protocols of MWSNs can be classified according to the above criteria based on different objectives. These objectives can be data aggregation, load balancing, lifetime maximization, stability period extension, guarantee of connectivity, fault tolerance, avoiding hotspot, and so forth. The routing protocol can develop to achieve one or more objectives at the same time.

3.12. Applications

Since there is not a routing protocol appropriate for all applications, this survey specifies the suitable applications for each hierarchical routing protocol. Applications of MWSNs can broadly be split into event driven, time-driven, on-demand, and tracking-based applications [26].

(a) Event-Driven Applications.

Sensor nodes deployed for such type of applications are expected to be inactive most of the time and bursting into activity when an event is detected. Then, the detected event is reported to the sink. This type of application can be found in forest fires, grass fires, volcanic eruptions, and so forth.

(b) Time-Driven Applications.

In this type of applications, each sensor is expected to constantly produce some amount of data, which has to be conveyed periodically to the sink. The time-driven applications include monitoring the environmental conditions like affecting crops, temperature, humidity, and lighting.

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(c) On-Demand Applications.

In some applications, the sink is not interested in data updates from all the nodes in the network. This is done via sending queries to a set of sensor nodes at different times from different regions.This results in a more energy-efficient use of resources.

(d) Tracking-Based Applications.

This class is helpful when the source of an event is mobile. The sensor nodes can report the event source's position to the sink, potentially with estimates about speed and direction. The tracking applications combine some of the above three classes. This class can be used in the military application (e.g., tracking an intruder), the environmental applications (e.g., tracking the movements and patterns of insects and birds), and the intelligent applications (e.g., tracking of vehicles).

4. Design Analysis of Energy Efficient Routing Protocol

The energy efficient routing protocols has been analysed on basis of design of the architecture which listed as follows

4.1. LEACH

LEACH is self-organizing, adaptive clustering protocol which does energy load distribution equally in all the nodes of a cluster. Setup and steady-state are two main phases in the protocol. In setup phase SNs organizes into local cluster where CH is declared based on energy, probability function.

4.1.1. Set Up Phase

In the setup phase, each node choose a random number between 0 and 1, if this number is less than a certain threshold T(n), the node will broadcast itself as the cluster head. The noncluster head node chooses the cluster head with greater signal strength and joins the cluster, and then the cluster head node receives data from all of the cluster members and transmits data to the remote sink.

4.1.2. Steady State Phase

In the steady-state phase, data are transferred from the nodes to the cluster head and on to the sink. After each round, a new cluster head will be chosen, and in this way the energy load of being a cluster head is evenly distributed among the nodes.

4.2. RING Routing

Ring Routing is a hierarchical routing protocol for wireless sensor networks with a mobile sink. The protocol imposes three roles on sensor nodes: ring node, regular node, and anchor node. Ring nodes form a ring structure which is a closed loop of single-node width**.** The basis of Ring Routing is

(i) Advertisement of sink position to the ring,

(ii) Regular nodes obtaining the sink position information from the ring whenever necessary,

(iii) Nodes disseminating their data via the anchor nodes, which serve as intermediary agents connecting the sink to the network.

4.2.1. Ring Construction

The ring consists of a one-node-width, closed strip of nodes that are called the ring nodes. As long as the ring encapsulates the pre-determined network center, it can change. The shape of the ring might be imperfect as long as it forms a closed loop. The ring is initially constructed by the following mechanism: An initial ring radius is determined.

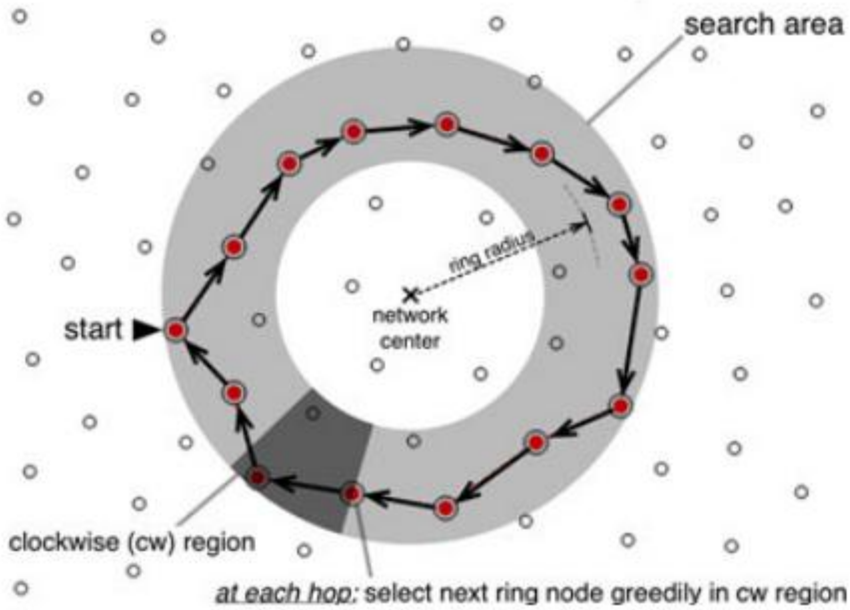

Figure 3: Ring routing representation

The nodes closer to the ring, which is defined by this radius and the network center, by a certain threshold are determined to be ring node candidates. Starting from a certain node (e.g. the node closest to the leftmost point on the ring) by geographic forwarding in a certain direction (clockwise/counterclockwise), the ring nodes are selected in a greedy manner until the starting node is reached and the closed loop is complete.

$V_{ij}(p))_{0\rightarrow t} = (V_{ij}(p))_0 * e^{-\lambda t}$

$((p))0\rightarrow t$ is the current value of $(Vij(p))0$ after time tof no interactions between iand j

λt is the terminating condition

If the starting node cannot be reached, the procedure is repeated with selection of different neighbors at each hop. If after a certain number of trials the ring cannot be formed, the radius is set to a different value and the procedure above is repeated. The initial ring construction procedure is straightforward and energy-efficient. It does not require a centralized decision entity, hence it is applicable to a pure WSN architecture with a single type of nodes.

4.2.2. Neighbour Discovery

After the construction of the ring, neighbor discovery is performed to mark the neighboring ring nodes of each regular node. This step is crucial for the regular nodes to be able to access the ring. Moreover, each node should determine its position with respect to the ring (namely inside or outside the ring). Advertisement of Sink Position is carried out using a Monte-Carlo analysis to determine the successful ring construction probability under varying degrees of localization error. As the sink moves, it selects anchor nodes (ANs) among its neighbors.

The AN serves as a delegate managing the communications between the sink and the sensor nodes. Initially, the sink selects the closest node (e.g., the node with the greatest SNR value) as its AN, and broadcasts an AN Selection (ANS) packet. Before the sink leaves the communication range of the AN, it selects a new AN and informs the old AN of the position and the MAC address of the new AN by another ANS packet. Since now the old AN knows about the new AN, it can relay any data which is destined for it to the new AN.

The current AN relays data packets directly to the sink. This mechanism is referred to as the follow-up mechanism. The AN selection and follow-up mechanisms are based on progressive footprint chaining [18]. Progressive AN selection poses a challenge in terms of determining when and how a new AN should be selected, which is closely dependent on continuous link quality estimation. Although in ideal radio channel conditions, distance to the neighboring nodes, calculated via their geographic coordinates, may be indicative of the status of the link, it is rarely the case, since radio link quality is usually affected by many factors other than distance. One of the more resilient methods of link quality estimation is beaconing.

In this approach, the sink periodically broadcasts beacon messages, and a link quality estimation metric (e.g., RSSI) is calculated from the reply messages originating from the neighboring nodes. Depending on the value of this metric, the sink can decide whether to change the current AN and which node to select as the new AN. The period of the beacon messages should be tuned according to the mobility and speed of the sink, which are assumed to be known since the sink itself usually makes the mobility decisions.

4.3. Source Traffic Defined Multiple Mobile Sink Routing Protocol

The STDMM protocol is to mitigate the hotspot issue towards improving the energy efficiency and network lifetime on extraction of multiple parameters including energy, coverage, data collection points, data fusion degree, schedule patterns, data redundancy transmission success ratio in the trace file of the particular topology. Particular network topology achieves good scalability, long network lifetime and low data collection latency. In addition, Source traffic defined Clustering techniques projected in this work will self organize the sensor nodes into effective clusters on generation of multiple cluster head to facilitate the data transmission.

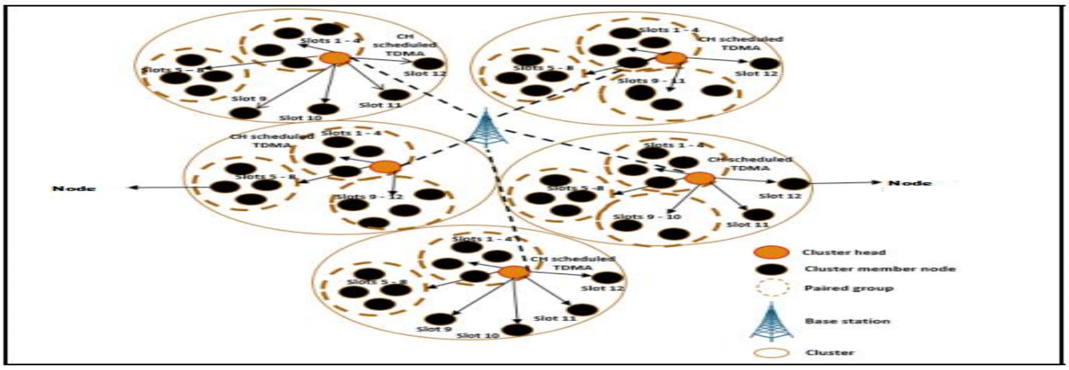

Figure 4: Source Traffic Defined Multiple Mobile Sink Routing Architecture

Cluster head along with information of data collection points plans the trajectory of the multiple mobile sinks for effective data collection from the sensor nodes. Trajectory of the multiple mobile sinks can be enabled using particle swarm optimization to reduce the energy depletion and moving distance of the sink nodes for data collection.

4.3.1. Distributed optimal Movement prediction of Mobile Sink

Optimal Movement strategies of the mobile sink establishes great energy saving and shortened data collection latency, which has the potential for different types of data services. To collect data as fast as possible, multiple mobile sink has been employed with some strategies to gather sensor information. In this mobile sink should stop at positions inside a cluster that can achieve maximum capacity[13].

In optimization models, mobile sink is considered as mobile, it has the freedom to choose any preferred position for data collection. However, this is infeasible in practice, because it is very hard to estimate channel conditions for all possible positions.

Thus, we only consider a finite set of locations. To mitigate the impact from dynamic channel conditions, mobile sink measures channel state information before each data collection tour to select candidate locations for data collection. We call these possible locations mobile sink can stop to perform concurrent data collections prediction path using particle swarm optimization

4.3.2. Particle Swarm optimization

In this model, Effective collection point and path for traversing for mobile sink can be computed effectively. In this, mobile sink moving around the available path is considered search space is looking for best solution for path traversing [14]. In this mobile sink is considered as particle in the search space composed of cluster and cluster members of sensor nodes. Particular model compute the g best and p best for the mobile sink traversing on basis of fitness function. In addition, velocity of mobile sink is also computed to determine the solution. Algorithm 1 describes the working of PSO model towards identifying the effective path

Mobile sink that visit all the collection points can be computed on basis of pbest and gbest best values. Instead, it calculates some collection points which are accessible. In addition, fitness function determines the sequence for mobile sink to visit these selected collection points such that data collection latency is minimized. On employment of the algorithm, mobile sink has pre-knowledge about the locations of collection points and it can determine a good trajectory with the shortest route to collect the sensor information.

5. Experimental analysis of energy efficient routing protocol

In this Section, we simulate detail description of proposed source traffic defined multiple mobile sink routing protocol, Ring Routing Protocol and Leach Protocol towards Throughput Maximization in the Wireless Sensor Network using NS2 Simulator[19]. Extensive experiment explores various performances on its comparison with existing techniques. . In the Simulation, the set up of the network along its parameter is described in the following table 1

Table 1: Simulation Parameters

Simulation Parameter	**Value**
Simulator	NS2
Topology Size	1000m *1000m
Initial energy Bound	0.5joules
Number of Nodes	200
Bandwidth of the Network	2Mbps
Traffic Type	CBR
Pause Time	10s,20s
Data Packet length	512 bytes
Buffer Size	30 packets
Simulation Time	30 minutes

5.1. Trajectory of Mobile Sink for data aggregation and Traffic Elimination

The duration of mobile sink's moving trajectory on the various path of sensor region has been divided into several consecutive time slots on reference to the cluster head. The data collection hop count m = 3 is defined and use the nearest neighbor algorithm to find the shortest path and clustering the sensor nodes [20]. Node energy consumption at different rates during mobile sink selection, transmission, reception, idle waiting and sleeping has been calculated for evaluation of the proposed model.

5.2. Redundancy Elimination

The sensor nodes generate different types of traffic depending on its sensing capacity and configuration in terms of number of packet size. The observations indicate that the proposed protocol can find predict optimal states in short span of time in case of sudden node failure, they aspect increase the throughput of the system. Therefore, the number of participating node for data sensing and transmission in a cluster towards throughput is calculated.

6. Performance Comparison of the Energy Efficient Routing Protocols

The performance of the work has been demonstrated with the properties and measures of the network performance in terms of Throughput, Packet delivery ratio, Network Overhead and Packet Los for various Energy Efficient Routing Protocols

6.1. Analysis of Energy Utilization

The energy efficient routing protocol has been analysed through inclusion of Traffic and Redundancy management Constraints. The evaluation of the proposed multiple mobile sink data gathering and scheduling on bandwidth requirement against the different network traffic on the heterogeneous sensor nodes is demonstrated and its comparison in terms of energy utilization and network utility is described in the figure 5.

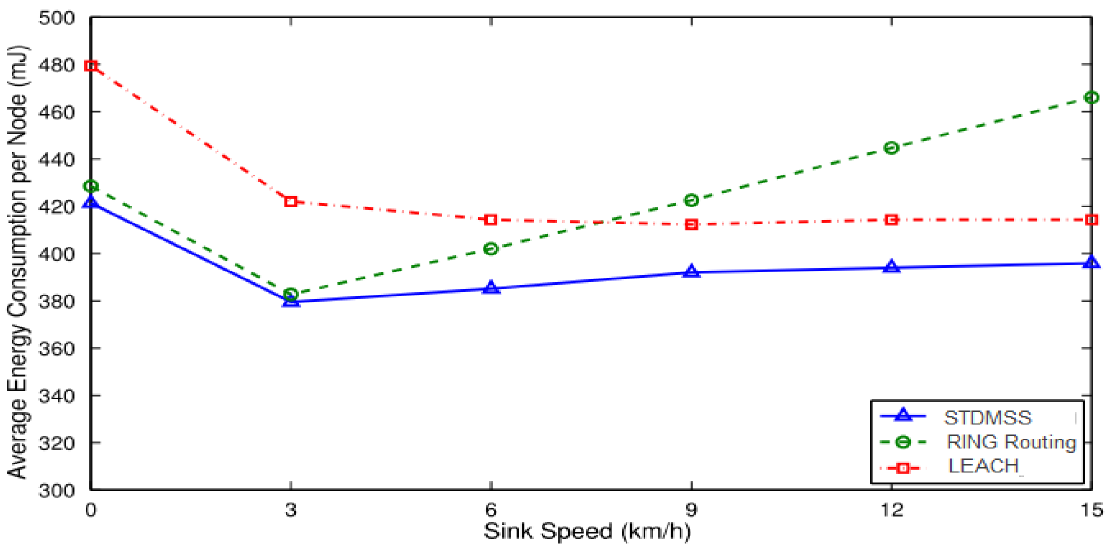

Figure 5: Performance Analysis of Energy Utilization

Energy utilization is important to ensure the operation of the network in the sense that no sensor would have drained its battery energy during data transmission. There is excessive energy consumption of 0.03mJ per data in transmission.

Table 2 – Performance Evaluation of the different mechanism on Multiple Mobile Sink Scheduling against Various data traffic of the network

Technique	Throughput in mbps	Overhead in mbps	Packet Delivery Ratio	Energy Utilization	Routing Latency
LEACH	63.25	15.01	97.14	35 joules	0.36
Ring Routing	65.58	15.23	97.78	36joules	0.35
STDMSS-	69.26	12.59	99.85	48joules	0.26

On Simulation analysis, energy utilization of various energy efficient routing protocols has been compared and results have been depicted. Table 2 concludes the performance values of the different metrics on evaluating the mobile sink data collection towards improving energy efficiency. The network size in terms of the number of deployed sensor nodes also affects the WSN performance significantly since the density of the network and the total traffic loads depend on the network size.

Conclusion

We analysed different energy efficient routing protocols to wireless sensor network on various aspects as Energy efficiency is an important factors of the wireless sensor network routing protocols, it has been analysed on basis of design, implementation and performance to ensure relevancy of the quality validation. To be more specific, protocol such as LEACH based on Forward Aware Factor, Ring Routing and Source Traffic Defined Multiple Mobile Sink Routing Protocol has been analysed on routing structures to achieve energy utilization Result of the analysis reveals the solutions for improvement of the protocol on optimizing the energy efficiency. Finally we conclude that protocol named as Source Traffic Defined Multiple Mobile Sink Routing Protocol achieves high energy efficiency.

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