# A Survey on routing protocols for mobile sink based WSN

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**Abstract -** ***The performance of WSN can be increased by deploying mobile nodes in the network. The mobile sink based WSN would improve the lifetime of the entire network by equalizing transmission energy among the nodes in the network. Due to the deployment of mobile sink based nodes, efficient routing protocols have been studied in recent past. Most of these routing protocols consider mobile sink based WSN. This paper focuses on the study of various routing protocols currently available in the market. It has been found that the Elastic Routing protocol performs better compared to other protocols.***

***Key Words:*** *MWSN, Mobility models, Mobile Sink*

## 1. INTRODUCTION

Wireless Sensor Network (WSN) has gained lot of attention in recent past due to wide development in sensor network technology. A typical WSN consists of sensor nodes deployed in large area, to monitor various physical events from environment, process those events and transfer them to a base station (sink) node. Each node in the network is a small sensor with low processing, storage and energy capacity[3]. Sensors are battery powered and consume large energy during communication. Hence the lifetime of the network is a major concern in wireless sensor network. In a typical WSN, all the nodes deployed in the network will be static.
WSNs are mostly used for low bandwidth, delay tolerant applications which includes battlefield surveillance, habitat monitoring, traffic monitoring and security applications. Some other real time applications include military target tracking and surveillance, natural disaster relief, bio-medical and health monitoring, and hazardous environment exploration and seismic sensing. WSN would help many of these applications to process those information without delay. A WSN consists of large number of sensor nodes deployed with more than one sink (base station) deployed for processing the sensed data. There are several unique features for WSNs like unique network topology, diverse applications, unique traffic characteristics and resource constraints.

A typical node in a WSN consists of low power sensing devices, embedded processor, and communication channel and power module. The processor is used for processing the sensed data collected from the environment during sensing and transmits them to the base station (sink). The power module will be usually battery embedded within the sensing module. There can be optional power module added to the node. A transceiver is also included in the module for transmission and reception process. Power will get depleted soon during communication process and hence efficient protocols must be designed for the network that would increase its lifetime. The communication channel that is used in most of the WSN is based on IEEE 802.15.4 standard. A traditional WSN consists of sensor nodes deployed in such a manner that all nodes remain static. A major limitation with such a system is that the energy of the nodes closer to the sink will get depleted soon, since they usually consume lot of energy for routing the packets coming from almost all nodes in the network. This would decrease the lifetime of the entire network. Hence there is a need for powering up the nodes to improve the network life time. A mobile WSN would help to resolve such issues. A typical mobile WSN consists of sensor nodes deployed in a wide area that have the ability to move within the network. MWSNs are more versatile compared to static WSN, since they can be deployed in any scenario and cope with rapid topology changes. The mobility can be achieved by equipping the sensor nodes with mobilizers for changing their locations or the sensors can be made to self-transport via springs or wheels or they can be attached to transporters like vehicles, animals, robots etc. In some cases, the sensor nodes may move due to the environment in which they are placed.

There are many advantages of using mobile wireless sensor network over static wireless sensor network. One major advantage is that the lifetime of the entire network can be increased. Moreover, mobility can reduce energy consumption during communication. The sensor nodes in the mobile WSN are deployed randomly in the network. There are wide range of applications for using mobile WSN. Many applications require the use of mobile sinks such as for soldiers in the battlefield for enemy detection and a rescuer could move in the disaster area searching for survivals. The sensors can also be attached to people for monitoring their health for tracking heart rate, blood pressure etc. Animals can have sensors attached to them in order to track their movements for detecting their migration patterns and feeding habits. Other major applications come in the field of military surveillance, fire and safety and animal migration monitoring.

There is no fixed topology for mobile WSN and hence routing the data from source to destination is quite a challenging task. The protocols designed specifically for MWSNs are almost always multi hop. There are two sets of challenges in MWSNs; hardware and environment. The main hardware constraints are limited battery power and low cost requirements. The challenges due to environment is caused due to sand, wind etc. Due to varying network topology, the multi hop paths from sensors to the sink are not stable.

This paper provides a literature survey for various routing protocols studied in recent past for routing the data form source node to a mobile sink and their comparative study. The rest of the paper is organized as follows. Section 2 provides a description about how mobility can be incorporated in WSN. Section 3 provides a survey of various routing protocols utilized by the mobile sink based WSN. Section 4 concludes the paper.

## 2. MOBILITY IN WSN

Introducing mobility to some or all nodes in a WSN, improves the network lifetime. It also provides more channel capacity and enhances coverage and targeting. The basic architecture of a three tier Mobile Wireless Sensor Network. The sensor nodes are deployed randomly in the network. These nodes can communicate with each other and the mobile agents. The mobile agents can move anywhere and at any time and they are responsible for collecting the sensed data and forward them to the fixed network consisting of Access Point.

There are various approaches for studying the mobility for data collection in WSNs. Mobility pattern of various nodes in the network must be modeled[4], which could be incorporated for various routing protocols. According to [ref a survey of mobility models for WSN], the mobility model can be mainly categorized into two *Homogeneous/Group* mobility and *Heterogeneous/individual* or entity mobility models. The homogeneous mobility model is the one in which a group of mobile sensor nodes move according to the same model in the given deployment area. They can be further categorized into two - Random model and Controlled model. The Random mobility model can be further categorized into Partially Random and Totally Random models. In Partially mobility model, the mobile nodes depend on each other to specify the movement direction in the network. Totally Random mobility model will allow the group of mobile nodes moving in a random direction. The Controlled mobility model will allow a set of nodes to move in a specified direction.

In heterogeneous mobility model[5], the mobile nodes will move independently without depending on any other node in the network. Various nodes in the network will move according to their adopted mobility model. Thus in a network, various mobility models are adopted. Heterogeneous mobility model can be further categorized into four categories - Random mobility model, Controlled mobility model, Predictable mobility model and Geographic mobility model. The Random mobility model will divide the motion of the mobile node into pause period and motion period. They will allow the nodes to move in the network in a random pattern. In Controlled mobility model, the mobile nodes would visit the sensor nodes based on the predefined schedule that is built based on the sampling rate of the sensors and event occurrence rate. The next classification of mobility model, Predictable mobility model where the sensor nodes know the path in which the mobile sinks will use. Until the predicted time of data transfer, the sensor nodes will be in sleep mode, thus saving a large amount of energy. After that, the sensor nodes go to active mode and will start sending data to the mobile sink. The geographic mobility model is the one in which the mobile nodes movement can be restricted according to the geographic nature of the environment in which a mobile node or sink is deployed.

- Mobile base station (MBS)-based
- Mobile data collector (MDC)-based
- Rendezvous based solutions

In a classic WSN, where all the nodes are static, lot of energy get depleted for the node close to the sink. This excessive energy expenditure is due to the continuous transmission and response by the sensor node close to the sink. The primary aim of MBS based solutions is increasing the lifetime of the network by evenly distributing the energy consumption. In case of MDC based solutions, the data are gathered from sensors by visiting them individually. Based on the mobility pattern of the MDCs, there can be Random mobility, Predictable mobility, and Controlled mobility.

## 3. ROUTING PROTOCOLS

Routing is the process in which the data packets are forwarded to the base station. The data are routed to the destination in an efficient manner without delay and packet loss. Usually the network layer handles the process of routing the data. The best routing protocol is the one that covers all states of a specified network and will not consume too much network resources. In a mobile based wireless sensor network, minimizing the power consumption is very important. Hence efficient routing protocols must be designed irrespective of overhead, delay and throughput.

The routing protocols for MWSN can be mainly classified based on the network structure, state of information, mobility and energy efficient techniques. Based on the mobility of nodes, various routing protocols have been studied. The major challenge for defining the routing protocol
in MWSN occurs due to the fact that the topology of the network is periodically changing. In this paper, routing with only mobile sinks is considered. Due to the mobility of the sink, the set of sensors located near the sink changes over time. This would help in balancing the energy consumption and thereby prolonging the network life time. As discussed earlier, the sink can follow three types of mobility patterns in MWSN.

- Random mobility
- Predictable/fixed path mobility
- Controlled mobility

In case of Random mobility[5], the sink follows a random path in the sensor field and implements a pull strategy for data collection from the sensor nodes. Data can be requested from either one hop or *k* hop neighbors of the sink. In Predictable/fixed path mobility, mobile trajectory of sink is along a known fixed path. The main challenge in Controlled mobility is to design the sensor network protocols that can exploit mobile components effectively and solve the navigational problems for mobile elements.

Several routing protocols have been proposed in many papers depending on various criteria. The utility of these protocols vary depending on various applications and they have their own pros and cons. Generally, the routing protocols of MWSN can be classified based on their network structure, state of information, mobility and energy efficiency techniques. Based on the mobility of nodes in the network, the routing algorithms are categorized into many. Among those protocols, only when the sink is mobile is considered as a special case. A comparison of all those protocols referred from various papers is described below:

### 1. Quorum-based location service

Quorum-based location service [6] is an efficient mechanism for updating the location of the mobile sink in the network. When a node wants to update its location information, it would propagate its location information in both north and south directions and finally reaches its boundaries. All the nodes that receive the update packet form a north-south column. When a querying node wants the position of the destination node, it will first check whether the location recorded in the database is out-dated. If so, the node propagates its search packet in both east and west directions to reach the boundaries. All nodes involved form an east-west row. The search packet is bound to obtain the required location from a rendezvous node between a pair of column and row quorums. The requests after reaching the ends of the row can be forwarded to the destination according to the information obtained from the rendezvous node. The destination will reply back its accurate location to satisfy the search request. This protocol is a location based strategy.

### 2. LBDD Protocol

The LBDD called the Line Based Data Dissemination protocol works on the basis of rendezvous region, which is a vertical line dividing the network into two parts. The major operation of LBDD consists of two main steps-Dissemination and Collection. The nodes which are in the boundary of the rendezvous line are called in-line nodes, while other nodes are called ordinary nodes. The first in-line node that receives the query propagates it in both directions along the line until it reaches the in-line node storing the data. The data will be then transferred directly to the sink.

### 3. Gradient Broadcast (GRAB)

Gradient Broadcast Protocol [8] is a sink triggered full network based flooding solution, where the sink floods its location information continuously to the network. GRAB usually builds and maintains a cost field, providing each sensor with the direction to forward the sensed data. The sink first builds a cost field by propagating advertisement (ADV) packets in the network. The cost at a particular node is the minimum energy overhead to forward the packet to the sink along a path.

Each node can estimate the cost of sending data to nearby neighbors. The cost of all nodes in the network forms the cost field. When a node forwards a packet, it will not designate which nodes are at the next hop. It will simply include its own cost in the packet. Only its neighbors with smallest cost will continue forwarding the packet. Neighbors with higher or equal costs drop the packet. Thus the packets travel in a cost field like water flowing down to the bottom of the funnel; i.e., they flow in the direction of decreasing cost to reach to the bottom of the cost field, which is the sink.

### 4. Grid-Based Energy-Efficient Routing Protocol (GBEER)

GBEER [9] reduce the frequency of transmitting the control packets which build the grid structure and advertise and request packets in order to reduce the battery power consumption. Here, they divide the sensing field into several grid structures using global location information. A header will be randomly chosen and it forwards the data to the sink. As the source detects the event, it sends the data to the header. The header then advertises the data to the network via data announcement packets to other headers. When a sink requires the data, it sends the data request packet to the nearest header with local flooding. The data request packet is then send to the source’s header and the data is then sent back to the sink.

### 5. Two-Tier Data Dissemination Protocol (TTDD)

When a source generates data [10], it would start the data dissemination by building grid structures. The source itself acts as one crossing point of the grid and it would send data announcement message to each of its four adjacent crossing points. Each data announcement message finally stops on a sensor node that is closest to the crossing point specified in the message. The node stores the source information and forwards the message to its adjacent crossing point except to the one from which it received the message. This process repeats until the sensors that are closest to the crossing locations become the dissemination node of the given source.

Once a grid has been built, the sink can then flood the query message within the local grid to receive the data. The query will be then received by nearest dissemination node, which would then propagate the query upstream to other dissemination nodes towards the source. The requested data would then flow in the reverse path to the sink.

### 6. SEAD

SEAD which is a Scalable Energy-efficient Asynchronous Dissemination protocol is a distributed self-organizing protocol, that would reduce the communication energy. SEAD usually builds an optimal dissemination tree. A stationary sensor node takes the place of the mobile sink for building the dissemination tree. Data dissemination paths to these stationary terminals are selected to minimize energy cost. As sink moves away from the terminals, the forwarding delay to the sink increases. Here power consumption is reduced. The SEAD protocol consists of four phases: *subscription query, gate replica search, replica placement and d-tree management.* At the subscription phase, the sink directs a join query to the source via its access node. At the gate replica search phase, a gate replica is determined, which serve as the grafting point from which a branch to the new access point is extended. The replica placement phase locally readjusts the tree in the neighborhood of the gate replica to further reduce communication energy.

### 7. MADD Protocol

The Mobile Agent-based Directed Diffusion Protocol (MADD) consider the mobile agents in the absence of the cluster head. In MADD, the sink initially floods an interest packet to locate the source that sends the packet. There is a target region and if the sources in that region receive the interest packet, they flood the exploratory data to the sink individually. The sink will then receive the exploratory packets from various sources and would decide the list of sources that will be visited by the Mobile Agent. When the target source receives the corresponding interest, they would sent exploratory data, along multiple paths towards the sink.

### 8. Mobi-Route Protocol

Mobi Route is another routing technique towards the mobile sink for improving the lifetime of the sensor network. Mobi Route applies beacon mechanism for tracing the mobility of the sink. The sink usually broadcasts beacon messages periodically. Once a node receives the s-beacon, it would set(reset) its detecting timer. If the timer has timed out, then it would indicate a link breakage and hence a new parent should be chosen. The Mobi Route is based on Berkeley MintRoute routing protocol. The route messages are periodically exchanged among neighbor nodes. The exchanged route messages help to evaluate the distance from the sink.

### 9. LPTD

LPTD is a rendezvous point based solution for updating the location of the mobile sink. It is also called Line Proxy Target Detection Protocol. LPTD is based on the assumption that all sensor nodes are time synchronized and achieve the same temporal based hash function. Here the network is divided into cells (square areas). All cells in the same row or column become the rendezvous points (line proxies), depending on the temporal based hash function. The rendezvous points are alternated over time for network load balance. When a sink wants to query some event, it first calculates the rendezvous points by the same temporal-based hash function and sends an interest registration message to the rendezvous points. The interest registration message is then flooded to all sensors within the same row or column. When a source detects some event, it sends a target registration message to the same rendezvous points by the same hash function. The cell where the interest registration message and target registration message are overlapped, forwards the data packet to the sink. The sink may directly send a message to ask the source for continuous reporting. If the sink moves too far away from its previous location, it achieves the same process as mentioned above.

### 10. ELASTIC ROUTING

Elastic Routing[1], is a geographic routing technique which make use of greedy forwarding mechanism for updating the location of the mobile sink. Initially, the location of the sink will be known using some location service. The event detected by the source will be routed to the sink hop by hop, using greedy forwarding technique, where the node selects the neighbor node that is closest to the sink as the next hop.

As the sink moves outside the radio range of last hop forwarding node A, the new location of the sink becomes unknown to node A. Besides sending periodic beacon messages to neighbor nodes, a sink also informs its current location to the node from which it received the last data packet by greedy forwarding. The new location of the sink will be updated to node A by greedy forwarding mechanism.

Now node A resets the sink location information in the data packet to the new sink location and selects the node B as the next hop forwarding node to forward the subsequent data packets. Now node B becomes the last hop forwarding node to the sink. Thus the mobility of the mobile sink can be traced in this way. The function of the mobile sink is as shown below:

- Send beacon messages to announce its current location to neighbor sensor nodes.
- Checks whether it has moved out range of the last hop forwarding node; if so, informs its current location to the last hop forwarding node by uni-casting

The function of the sensor nodes for location propagation of the mobile sinks is summarized as follows:

- Checks whether the sink is located in its radio range; if so, record the sink ID and location.

- On overhearing a transmission, for instance, node M overhears a transmission from node N, elastic routing is implemented.

**Table -1:** Comparison on mobile sink based Routing protocols

| Routing Protocol | Network Structure | Path Establishment | Protocol Operation | Power Usage |
|---|---|---|---|---|
| EAR | Flat | Reactive/Proactive | Query | Limited |
| TTDD | Hierarchical | Proactive | Query | Limited |
| SPAN | Location | Proactive | | Limited |
| Mobi-Route | Flat | Proactive | Query | Limited |
| LBDD | Location | Proactive | | Limited |
| GAF | Location | Proactive | | |
| GEAR | Location | Proactive | | Limited |
| GRAB | Flat | Proactive | | Limited |
| Elastic | Location | Proactive | Query | Limited |

## 4. CONCLUSIONS

In this paper, various routing protocols for randomly deployed mobile sink based WSNs were discussed. The mobility of the sinks in WSN drastically reduces energy consumption of the network and thereby increases the network lifetime. The data packets destined to the sink must be efficiently routed without delay and much overhead. Based on the survey of various routing protocols available, Elastic Routing is considered to be an efficient routing protocol for updating the location of the mobile sink and finally propagating the packet to the destination. It uses a novel geographic routing technique, which make use of the overhearing feature of wireless transmission. Other protocols like TTDD, LPTD, GRAB etc., are also efficient, but they incur high overhead due to excessive energy consumption and higher collision.

## REFERENCES

[1] F. Yu, S. Park, E. Lee, and S.H.Kim, "Elastic routing: a novel geographic routing for mobile sinks in wireless sensor networks," *IET Communications,* vol. 4, no.6, pp, 716-727,2010

[2] G. S. Sara and D. Sridharan, "Routing in mobile wireless sensor network: a survey," Telecommunication Systems, vol. 57, no. 1, pp. 51–79, 2014.

[3] J. Yick, B. Mukherjee, and D. Ghosal, "Wireless sensor network survey," Computer networks, vol. 52, no. 12, pp. 2292–2330, 2008.

[4] A. A. Taleb, T. Alhmiedat, O. A.-h. Hassan, and N. M. Turab, "A survey of sink mobility models for wireless sensor networks," Journal of Emerging Trends in Computing and Information Sciences, vol. 4, no. 9, 2013.

[5] E. Ekici, Y. Gu, and D. Bozdag, "Mobility-based communication in wireless sensor networks," IEEE Communications Magazine, vol. 44, no. 7, p. 56, 2006.

[6] I. Stojmenovic, D. Liu, and X. Jia, "A scalable quorum-based location service in ad hoc and sensor networks," International Journal of Com-munication Networks and Distributed Systems, vol. 1, no. 1, pp. 71–94, 2008.

[7] T. He, C. Huang, B. M. Blum, J. A. Stankovic, and T. Abdelzaher, "Range-free localization schemes for large scale sensor networks," in Proceedings of the 9th annual international conference on Mobile computing and networking, pp. 81–95, ACM, 2003.

[8] F. Ye, G. Zhong, S. Lu, and L. Zhang, "Gradient broadcast: A robust data delivery protocol for large scale sensor networks," Wireless Networks, vol. 11, no. 3, pp. 285–298, 2005.

[9] K. Kweon, H. Ghim, J. Hong, and H. Yoon, "Grid-based energy-efficient routing from multiple sources to multiple mobile sinks in wireless sensor networks," in Wireless Pervasive Computing, 2009. ISWPC 2009. 4thInternational Symposium on, pp. 1–5, IEEE, 2009.

[10] F. Ye, H. Luo, J. Cheng, S. Lu, and L. Zhang, "A two-tier data dissemination model for large-scale wireless sensor networks," in Proceedings of the 8th annual international conference on Mobile computing andnetworking, pp. 148–159, ACM, 2002.

[11] H. S. Kim, T. F. Abdelzaher, and W. H. Kwon, "Minimum-energy asychronous dissemination to mobile sinks in wireless sensor networks," in Proceedings of the 1st international conference on Embedded networked sensor systems, pp. 193–204, ACM, 2003.

[12] C. Fu, Z. Jiang, W. Wei, and A. WEI, "An energy balanced algorithm of leach protocol in wsn," IJCSI International Journal of Computer Science Issues, vol. 10, no. 1, pp. 354–359, 2013.

[13] G. Wang, T. Wang, W. Jia, M. Guo, and J. Li, "Adaptive location updates for mobile sinks in wireless sensor

networks," The Journal of Supercomputing, vol. 47, no. 2, pp. 127–145, 2009.
[14] J. Lee, W. Yu, and X. Fu, "Energy-efficient target detection in sensor networks using line proxies," International Journal of Communication Systems, vol. 21, no. 3, pp. 251–275, 2008.