International Journal of Technology Research and Management
ISSN (Online): 2348-9006
Vol 5 Issue 12 December 2018

Implementation, Enhancing Lifetime of Wireless Sensor Network by Implementing Energy Efficient Routing

Saraswati Sharma[1], Prof. Namrata Sharma [2]
Pursuing M.Tech, Computer Science Department, Sushila Devi Bansal College of Engineering, Indore[1]
Assistant Professor, Computer Science Department, Sushila Devi Bansal College of Engineering, Indore[2]
saraswatisharma35@gmail.com[1]

Abstract: *Wireless Sensor Networks consist of small wireless nodes which are capable of sensing, computation, and wireless communication capabilities. The main constraint associated with wireless sensor network design is that sensor nodes operate with limited energy budget. The efficient utilization of energy source in a sensor node is very important criteria to elongate the life-time of WSN. Wireless sensor networks have explored to many protocols specifically designed for sensor networks where energy consideration is very crucial. There are several energy efficient reactive routing protocols among this, AODV is a protocol. This thesis is intended to introduce energy-efficient routing protocol, known as MAODV, which is extended version of AODV to enhance energy-efficiency, lifetime in WSN. We have simulated AODV and MAODV in Network simulator-2 (NS2) and analyzed performance in terms of residual energy, throughput and network life time.*

Keywords: *Wireless Sensor Networks, Energy-Efficiency, Network Simulator-2, AODV, MAODV.*

1. INTRODUCTION

A Wireless Sensor Network [1] is a network of many sensor nodes, having wireless channel to communicate with each other. Sensor nodes in WSNs are small sized and are capable of sensing, gathering and processing data while communicating with other connected nodes in the network, via radio frequency (RF) channel. All nodes are capable to act as a source or sink node at the same time. The development of low-cost, a multifunctional sensor has received increasing attention from various industries.

WSNs nodes are battery powered which are deployed to perform a specific task for a long period of time, even years. If WSNs nodes are more powerful or mains-powered devices [2] in the vicinity, it is beneficial to utilize their computation and communication resources for complex algorithms and as gateways to other networks. New network architectures with heterogeneous devices and expected advances in technology are eliminating current limitations and expanding the spectrum of possible applications for WSNs considerably. Wireless sensor networks have their own unique characteristics which create new challenges for the design of routing protocols for these networks. Sensors are very limited in transmission power, computational capacities, storage capacity and most of all, in energy. The design [3] of a sensor network routing protocol changes with application requirements. Data traffic in WSN has significant redundancy since data is probably collected by many sensors based on a common phenomenon. Such redundancy needs to be exploited by the routing protocols to improve energy and bandwidth utilization. Due to such different characteristics, many new protocols have been proposed to solve the routing problems in WSN. In the following sections, introduce to current research on routing protocols have been presented.

In the recent past, lot of research had been done to produce different mechanism that can use for energy improvement and enhancement of energy parameters. This proposed research mainly focuses developing a new routing protocol based on existing routing protocol which will enhance the energy-efficiency, network life-time & will improve performance parameters like PDR, Throughput, Residual Energy and End to End Delay.

1.1 Wireless sensor Node architecture

The basic block diagram of a wireless sensor network is presented in Figure1.1. It is made up of four basic components:

- a sensing unit
- a processing unit
- a transceiver unit
- a power unit

There can be application dependent additional components such as a location finding system, a power generator.

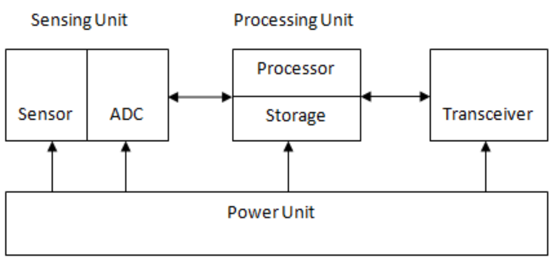


Figure 1.1: Architecture of a Wireless Sensor Node

Sensing Unit: Sensing units are usually composed of two sub units: sensor and analog to digital converters (ADCs). Sensor is a device which is used to translate physical phenomena to electrical signals.

Processing Unit: The processing unit mainly provides intelligence to the sensor node. It consists of a microprocessor, which is responsible for control of the sensors, execution of communication protocols and signal processing algorithms on the gathered sensor data.

Transceiver Unit: This is responsible for connecting the sensor to the WSN by controlling the transmission and reception operations.

Battery: The battery supplies power to the complete sensor node. It plays a vital role in determining sensor node lifetime. The amount of power drawn from a battery should be carefully monitored. Sensor nodes are generally small, light and cheap, the size of the battery is limited.

2. LITERATURE REVIEW

In general, routing in WSNs can be divided [4] into flat-based routing, hierarchical-based routing, and location-based routing depending on the network structure. In flat-based routing, all nodes are typically assigned equal roles or functionality. In hierarchical-based routing, however, nodes will play different roles in the network. In location-based routing, sensor nodes' positions are exploited to route data in the network.

Furthermore, these protocols can be classified into multipath-based, query-based, negotiation-based, QoS-based (Al-Karaki & Kamal, 2004), (Vidhyapriya & Vanathi, 2007), and (Akkaya & Younis, 2005)., or routing techniques depending on the protocol operation. In addition to the above, routing protocols can be classified into three categories, namely, proactive, reactive, and hybrid protocols depending on how the source sends a route to the destination. When sensor nodes are static, it is preferable to have table driven routing protocols rather than using reactive protocols. A significant amount of energy is used in route discovery and setup of reactive protocols.

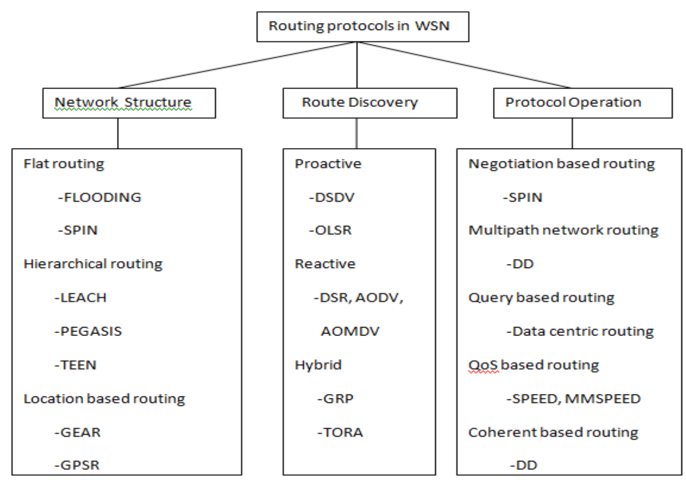


Figure 2: Classification of routing protocols

Flat routing: In these protocols, all nodes have assigned equal roles in the network (AI-Karaki & Kamal, 2004). E.g. FLOODING, SPIN (Sensor Protocol for Information via Negotiation).

Hierarchical routing (Al-Karaki & Kamal, 2004), and (Jolly & Latifi, 2006). The main concept of this protocol depends on dividing the job among wireless sensor nodes into more than one level. Most such protocols consist of two routing layers, the first one is responsible for selecting the cluster-heads, and the second is related to routing decisions. E.g. LEACH (Low Energy Adaptive Clustering Hierarchy), PEGASIS (Power-Efficient Gathering in Sensor Information

System), TEEN (Threshold sensitive energy efficient sensor network protocol).

Location based routing: In this routing the nodes have capability to locate their present location using various localization protocols. Location information helps in improving the routing procedure and also enables sensor networks to provide some extra service. E.g. GEAR (Geographical and Energy Aware Routing) and GPSR (Greedy Perimeter Stateless Routing), are introduced.

Proactive routing: Proactive routing protocols can also be seen as table driven protocols means every node or a device continuously updates the table containing routing information about every other node of the network. Here latency delay is very less as the route from source to destination is updated and available in routing table before the actual communication requirement. It performs better in slow speed of mobile nodes. E.g. DSDV (Destination Sequenced Distance Vector) and OLSR (Optimized link source routing).

Reactive Routing: Reactive routing protocols can also be seen as on demand protocols. Here latency delay is high. It performs better in highly dynamic movement of mobile nodes of the network. E.g. AODV (Ad-hoc on Demand Distance Vector)[5], AOMDV (Ad-hoc on Demand Multipath Distance Vector), and DSR (Dynamic Source Routing).

Hybrid Routing: It is called as hybrid because this protocol is consolidation of above described two types of routing protocol along with a location identification routing algorithm and gives the advantage of both of it. E.g. Temporally Ordered Routing Algorithm (TORA), and Gathering Routing Protocol (GRP).

Negotiation based routing: In these types of protocols to keep the redundant data transmission level at minimum, the sensor nodes negotiate with the other nodes and share their information with the neighboring nodes about the resources available and data transmission decisions are made after the negotiation process. (Al-Karaki & Kamal, 2004) E.g. SPIN (Sensor Protocol for Information via Negotiation).

Multipath network routing: These routing protocols provide multiple paths for data to reach the destination providing load balancing, low delay and improved network performance as a result. The multiple routing protocol also provide alternate path in case of failure of any path. Dense networks are more interested in multiple path networks. To keep the paths alive, some sort of periodic messages have to be sent after some periodic intervals. Hence, multiple path routing is not much energy efficient. E.g. DD (Directed Diffusion).

Query based routing: These type of routing protocols are mostly receiver-initiated. The sensor nodes will only send data in response to queries generated by the destination node. The destination node sends query of interest for receiving some information through the network and the target node sense the information and send back to the node that has initiated the request. E.g. Data centric routing.

QoS based routing: QoS is the performance level of service offered by a network to the user. To get good Quality of Service, these protocols are used. QoS aware protocols [6] try to discover path from source to sink that satisfies the level of metrics related to good QoS like throughput, data delivery, energy and delay, but also making the optimum use of the network resources. E.g. SEED, MMSPEED (Multipath and Multi SPEED).

Coherent based routing: In coherent based routing protocol, the nodes perform minimum processing (time, stamping, data compression etc..) on the data before transmitting it towards the other sensor nodes or aggregators. Aggregators perform aggregation of data from different nodes and then pass to the sink node. E.g. DD (Directed Diffusion).

3. AODV (AD-HOC ON DEMAND DISTANCE VECTOR) ROUTING

It is engineered for Mobile infrastructure-less networks. It employs on-demand routing methodology for formation of route among network nodes. Path is established solitary when source node wants to direct packs of data and preset route is maintained as long as the source node needs, that is why we call it as on-demand. AODV satisfies unicast, multicast and broadcast routing. It directs packets among mobile nodes of wireless ad-hoc network. It also permits mobile nodes to pass data packets to necessary destination node via nodes of neighbor that are unable to connect link openly. The material of routing tables is switched intermittently among neighbor nodes and prepared for sudden updates.

AODV chooses shortest but round free path from routing table to transmit packets. Suppose if errors or variations come in nominated path, then AODV is intelligent enough to make a fresh new route for rest of communication.

3.1 Working of AODV routing protocol with diagram:

AODV is an on-demand (reactive) routing protocol. It is one of the standard routing algorithms in MANET and build on the principle of discovering routes only on demand. AODV has distinct capability such as memory overhead, low processing, low network utilization and better performance in high mobility environment. AODV routing algorithm is super method for building path between the networks. Continuously change in topology of a network, requests is generated only on demand. It works by maintaining a routing table over time. There are two phases in AODV routing phases as described below:

- Route Discovery Phase
- Route Maintenance

When a node S wants to send a packet to destination D, the route to destination D is obtained by route discovery mechanism. In this mechanism the source node S broadcasts a ROUTE REQUEST packet which in a controlled manner is flooded through the network and answered in the form of ROUTE REPLY packet by the destination node or from the node which has the route to destination. The routes are kept in Route Cache, which to the same destination can store multiple routes. The nodes check their route cache for a route that could answer the request before repropagation of ROUTE REQUEST. The routes that are not currently used for communication the nodes do not expend effort on obtaining or maintaining them i.e. the route discovery is initiated only on-demand.

The routing table helps by providing information about next hop to destination. It utilizes a sequence number, which is received route request message (RREQ) to its neighbor node. An intermediate node can update the routing table if it holds an RREQ Packet. For reverse route (ie.from destination to source) source and intermediate node receives RREP (route reply message), which update valid route to destination node. The other mechanism is the route maintenance by which source node S detects if the topology of the network has changed so that it can no longer use its route to destination. If the two nodes that were listed as neighbors on the route moved out of the range of each other and the link becomes broken, the source node S is notified with a ROUTE ERROR packet. The source node S can use any other known routes to the destination D or the process of route discovery is invoked again to find a new route to the destination.

Control messages used for the discovery and breakage of route are as follows:

- Route Request Message (RREQ)
- Route Reply Message (RREP)
- Route Error Message (RERR)
- HELLO Message

Route Request Message (RREQ): A route request packet is flooded through the network when a route is not available for the destination from source. The RREQ has various fields such as-

Source Address	Request ID	Source Sequence Number	Destination Address	Destination Sequence Number	Hop Count

Route Reply Message (RREP): On having a valid route to the destination or if the node is destination, a RREP message is sent to the source by the node. The following parameters are contained in the route reply message Route Error Message (RERR): The neighborhood nodes are monitored. When a route that is active is lost, the neighborhood nodes are notified by route error message (RERR) on both sides of link.

Source Address	Destination Address	Destination Sequence Number	Hop Count	Life Time

HELLO Message: The HELLO messages are broadcasted in order to know neighborhood nodes. The neighborhood nodes are directly communicated. In AODV, HELLO messages are broadcasted in order to inform the neighbors about the activation of the link. These messages are not broadcasted because of short time to live (TTL) with a value equal to one.

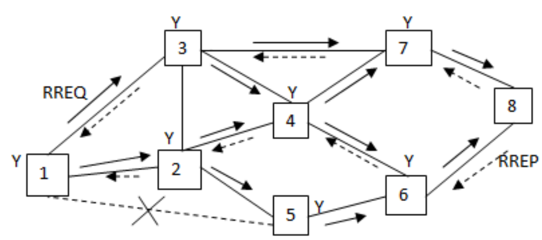


Figure 3.1: AODV Communication signaling from node 1 to 8

Figure, shows the process of signals with AODV from node 1 (source node) to node 8 (destination node). To establish a connection, source node 1 searches in its table for a valid route to destination node 8. RREQ reaches the destination for the first time through path 1-2-4-6-8. The destination then issues a RREP packet to the source. After a while, the destination receives another RREQ, this time through path 1-3-7-8. The destination evaluates this path, and finds that path 1-3-7-8 is better, and then issues a new RREP packet, telling the source to discard the other reply.

4. PROPOSED PROTOCOL

MAODV Protocol: Multicast protocol is a key technique to the group team application, which benefits in the significant reduction of network loads when packets need to be transmitted to a group of nodes. Multicast protocol must guarantee the performance requirements: adaptable to the dynamic change of network topology, timeliness, minimizing routing overhead and efficiency etc. Multicast is a communication approach for groups on information source using the single source address to send data to hosts with same group address. MAODV topology is based on multicast tree adopting broadcast routing discovery mechanism to search multicast routing, which sends data packets to each group nodes from data source.

- **Route Discovery**

MAODV use route request (RREQ) and route reply (RREP) which already exist in AODV. If a node wants to join in or send messages to a multicast group while there is no path to the multicast group, it will broadcast a RREQ, any multicast group member will respond to the request message if necessary. If RREQ is not a Join Request, any node with updated (serial number is greater than RREQs) routing path can respond directly. If non-multicast node receives RREQ request, or the node is not available to the target group, it will forward RREQ directly

- **Route Maintenance**

a) Multicast Tree Maintenance: Group leader main- trains the multicast groups' serial number by broadcasting Group Hello periodically. Group Hello is extended from the Hello message in AODV, which is consisted of multicast address, multicast serial number, hop count and TTL (Time to live).

b) Node Leave: If the node is not a tree leaf, it still can act as a router only by setting multicast address 0, else it will send Add and Prune (P marked MACT) to prune itself. When its upstream node receives P-marked MACT, it will delete this node from its multicast routing table. If the node is a multicast member or not a tree leaf, the prune process ends, else send the P-Marked MACT to its upstream node continuously.

c) Disconnection Repair: When the link is disconnected due to node mobility or other reasons, it will broadcast RREQ to re-join in the multicast group, only the member with latest serial number and its hop less than multicast group hop can respond. If the upstream node which has lost its node is not a multicast group member, and becomes the tree leaf, then it will set the timer to rebuild and if in certain period, it is still not be activated, the Add and Prune will be sent to prune the node itself. If the network is divided due to the repair failure, the divided network needs new group leader. If the nodes initiating repair is a multicast group member, then it will become the group leader, or the new group leader will be selected by sending G-Marked MACT.

d) Tree Merge: When the node receives Hello message, if it is a multicast group member and contains group members of the lower address group leader, it will initiate tree-rebuild process.

- **Link Repair Mechanism of MAODV:**

In MAODV, when a link breakage is detected, the downstream node is responsible for initiating the repair procedure. In order to repair the tree, downstream node broadcasts RREQ-J message with multicast group leader extension included. The multicast group hop count field in multicast group leader extension is set equal to node's current distance to multicast group leader, only nodes no further to the group leader can respond. A node receiving the RREQ-J respond by unicasting a RREP-J only if it satisfy the following constraints: It is a member of the multicast tree, its record of the multicast group sequence number is at least as great as that contained in RREQ-J and its hop count to the multicast group leader is less than or equal to the contained in the multicast group hop count extension field. After waiting for RREP-J wait time, the source node selects the best path from the RREP-J messages received and subsequent route activation is performed by a MACT-J message. Once the repair is finished, it is likely that the node which initiated the repair is now at a different distance to the group leader. In this case, it must inform its downstream nodes about their new distance to the group leader. The node performs this task by broadcasting a MACT-J message with the new hop count to leader contained. When a downstream node receives the MACT-J message and determines that this packet arrived from its upstream node, it increments the hop count value contained in the MACT-J and updates its distance to the group leader. The problem associated with this link repair mechanism is that the shortest path to the group leader is not ensured and it can lead to tree partitioning.

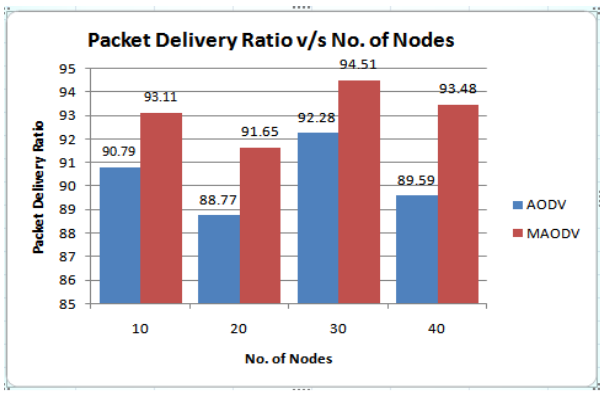
5. RESULT

This section describes the various results that are obtained after the complete execution of the project.

Simulation results by using various performance parameters (PDR, End to End Delay, Residual Energy, and Throughput) have been observed. After comparison between traditional routing protocols (AODV) and proposed routing protocol (MAODV) has been shown below:

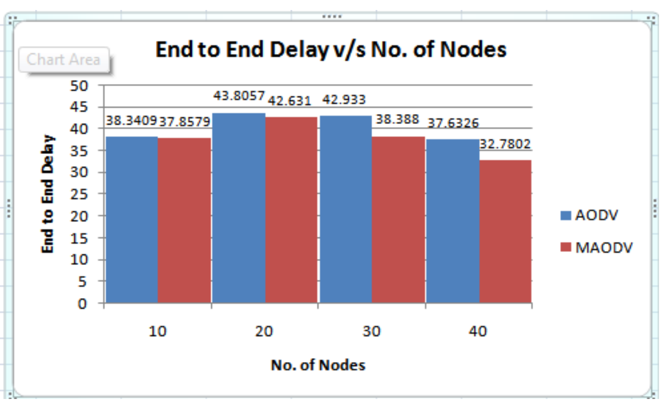
- **Packet Delivery Ratio:** PDR is a ratio of those data packets which is delivered to destination nodes. It also measures efficiency of network. When PDR is high means performance of network is better. It's unit is "Kbps"

$$\text{PDR} = \frac{\text{Total no of packets received}}{\text{Total no of packets sent}} * 100$$



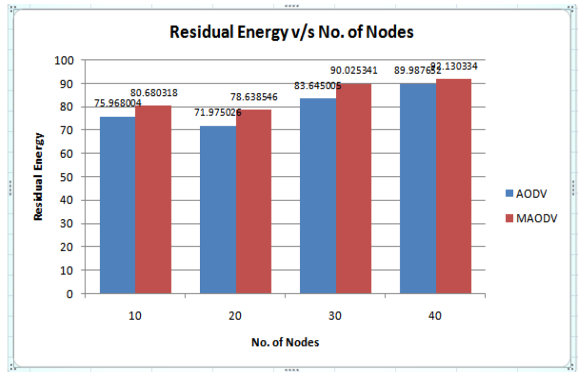
- **End to end Delay:** It is defined as the amount of time taken by packet to go from source to destination node. When end to end delay decreases, it will increase the performance of the network. Its unit is "ms".

  end to end delay= total delay



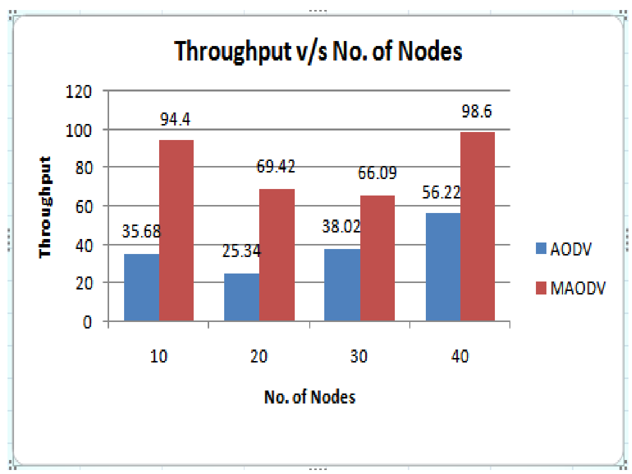
- **Residual Energy:** It is defined as how much energy is remaining which differentiate between total energy and energy used in the network. It's unit is in "%" or "Joule"

  Residual energy= Total energy-Consumed energy



- **Throughput:** It is defined as total number of data packets received by the destination node. It is used for measuring efficiency and effectiveness of the system. It is measured in "kbps"

$$\text{Throughput} = \frac{\text{Total no of packets received successfully}}{\text{Total simulation time}}$$



6. CONCLUSION

Wireless sensor network is highly emerging area for industrial control and monitoring applications. In some typical application like, disaster management or environmental control, the delay in data transmission is not acceptable. In these applications, the selection of appropriate routing protocol is extremely crucial. In this article, we have implemented an extended version of AODV routing protocol named as MAODV which uses multicast routing to improve the energy efficiency in WSN. From the all the graphical results, which are explored using NS2 simulator, it is observed that, MAODV protocol show better results in terms of Residual Energy, PDR, End-to-End Delay and Throughput.

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “A survey on sensor networks,” Communication Magazine, IEEE, vol. 40, pp.102-114, 2002.

[2] I.F.Akyildiz, W.Su, Y. Sankarasubramaniam and E. Cayirci, “Wireless sensor network: a survey,” Computer Networks, Elsevier, vol.38, pp. 393-422, 2002.

[3] Jennifer Yick, Biswanath Mukherjee, Dipak Ghosal, “Wireless sensor network survey,” Computer Networks, Elsevier, vol.52, pp. 2292-2330, 2008.

[4] Jian Yin, Sanjay Madria, “A Hierarchical Secure Routing Protocol against Black Hole”, IEEE SUTC 2006 Taiwan, 5-7 June 2006.

[5] Xiaoyan Hong, Kaixin Xu, and Mario Gerla, “Scalable Routing Protocols for Mobile Ad hoc Networks,” IEEE Network Vol. 16(4) pp11-21, July/August 2002.

[6] Al-karaki J. N., andK amal A. E., 2004," Routing Techniques in Wireless Sensor Networks: A Survey", IEEE Wireless Communications, Vol 11, Issue6 , pp. 6-28, December2 004.

[7] Jolly, V., and Latifi, S., 2006, "Comprehensive Study of Routing Management in Wireless Sensor Networks Part 1", Proceeding of the 2006 international conference on wireless networks, pp. 37-44, Las Vegas, USA, 26-29 June 2006.

[8] L. Li, J. Y Halpern, "Minimum energy mobile wireless networks revisited," in Proceedings of IEEE International Conference on Communications, vol. 1, Helsinki, Finland, June 2001, pp. 278-283.

[9] C. F. Wang, J. D. Shih, B. H. Pan, and T. Y. Wu, “A Network Lifetime Enhancement Method for Sink Relocation and Its Analysis in Wireless Sensor Networks”, IEEE Sensors Journal, vol. 14, no. 6, Jun 2014.

[10] P. K. K. Loh, H. W. Jing, and Y. Pan, “Y Performance evaluation of efficient and reliable routing protocols for fixed-power sensor networks”, IEEE Transaction Wireless Communication, vol. 8, no. 5, pp. 2328-2335, 2009.