International Journal of Advanced and Innovative Research (2278-844)/

Volume 7 Issue 11

Enhancement of Energy-Efficiency in Wireless Sensor Network

Chitra Saini[1], Jyotsna Rathee[2], Harkesh Sehrawat[3]

Department of Computer Science and Engineering,
University Institute of Engineering and Technology,
Rohtak, India
[1]chitrasaini13@gmail.com
[2]jyotsnarathe@gmail.com
[3]sehrawat_harkesh@yahoo.com

Abstract— **A Wireless Sensor Network (WSN) is made up of hundreds or thousands, spatially disseminated self-organizing interconnected sensors, to surveil physical and environment conditions like Humidity, Movement, Temperature, etc. and to interactively pass collected data to a main location using the network. Energy-Efficiency is an important topic in sensor nodes as they are powered by batteries with limited capacity and it is difficult to replace and recharge them. Energy-Efficiency is a noteworthy issue as the lifetime of the whole WSN depends on the sensors with limited energy resource. In this dissertation such a scheme is presented to have a WSN with little long life time by using energy of sensor nodes efficiently working different parameters of AODV (Ad hoc On Demand Distance Vector) Routing protocol. All the work is done to reduce the number of RREQs packets over the network to reduce overall load on network. For this purpose, work is done on parameters of AODV and a better Modified AODV M (AODV) is introduced.**

Keywords— **WSN, AODV, MAODV, RREQ, RREP, RRER, TTL.**

I. Introduction

A Wireless Sensor Network (WSN) is made up of hundreds or thousands, spatially disseminated, self-organizing, interconnected sensors, to surveil physical and environment conditions like Humidity, Movement, Temperature, etc. and to interactively pass collected data to a main location using the network. It has many application areas such as Area Monitoring, Environmental/Earth sensing, Tracking, Traffic Control, Healthcare Monitoring and Industrial monitoring etc.

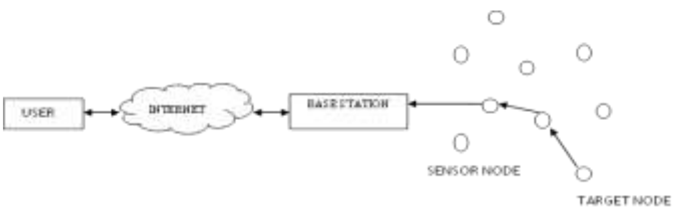


Fig. 1: Wireless Sensor Network.

Sensor Node: A sensor node is a low-power, low-cost and either fixed or mobile nodes. Each node is made up of several parts: a radio transceiver with an internal antenna or connection to an external antenna, a CPU, an energy source usually a battery, a microcontroller and an electronic circuit for interfacing with sensor nodes [1]. A sensor node can also be implemented with Global Positioning System (GPS), if required. Size of a sensor nodes vary from size of a grain of dust to size of a shoe box. And similarly, depending on complexity of a sensor node, cost of a sensor node also varies. Resources of a sensor node such as energy, memory, communication bandwidth and processing speed are also limited due to the constraint of size and cost. Life time of a sensor node is also limited as it runs on an energy source, battery.

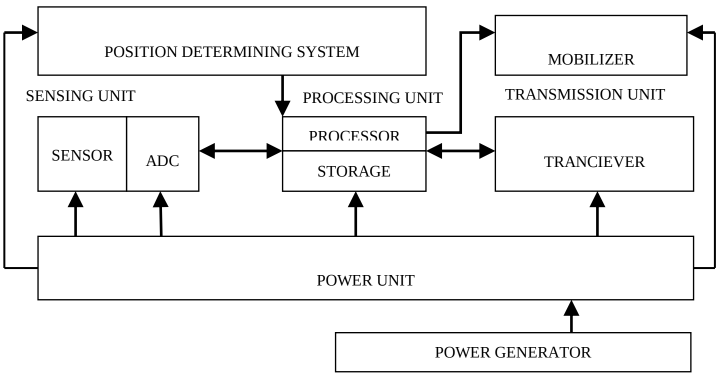


Fig. 2: Components of a Sensor node

Characteristics: The main characteristics of WSN are as follows:

- Nodes can be either fixed or mobile.
- No infrastructure and self-organizing.

- Ability to handle node failure, link failure.
- Communication is done either directly or via multi-hop routing.
- Heterogeneity of nodes.
- Scalable according to increasing requirements.
- Ability to withstand harsh environmental conditions.
- Power consumption constrained.

Challenges: Challenges and limitations of wireless sensor networks include, but are not limited to, the following:

- Limited functional capabilities, including problems of size
- Power factors
- Environmental factors
- Transmission channel factors
- Topology management complexity and node distribution
- Standards versus proprietary solutions
- Scalability concerns
- Power Consumption
- Energy and delay trade-off
- Bandwidth limitation

II. Literature Review

In this section, we study a number of different Energy-Efficient Routing Protocols which are proposed in the literature. Various Protocols are available for WSN. All routing protocols have their own advantages, disadvantages and scope for further research.

Energy efficient mobility support to LEACH (LEACH-M) protocol method is proposed by *Lan Tien Nguyen, Xavier Defago and Razvan Beuran* [2]. Their algorithm offered significant improvement in performance and also energy efficient in case of mobile nodes.Aggregate packet stream and more uniform resource utilization introduces DCE (Data Combining Entities) method is proposed by *Curt Schurgers and Mani B. Srivastava* [3]. *K.Padmanabhan, Dr.P.Kamalakkannan* [4] explained the recent developments in sensor networks have made the researchers to find the energy efficient routing protocols. They proposed Energy Efficient Dynamic Clustering Protocol (EEDCP) that distributes the energy consumption evenly among all nodes to increase the life time of network overall. *Gurpreet Singh, Amandeep Kaur in 2013* explained saving energy for sensors in WSN by bringing the concept of clustered AODV (Ad hoc On demand Distance Vector routing protocol). *Fahed Awad, Eyad Taqieddin, Asmaa Seyam* [5] elaborates the concept of Energy efficiency and sensing coverage are essential metrics for enhancing the life time and the utilization of WSN. Their proposed framework is based upon applying the principles of Virtual Field Force on each cluster in order to move the sensor nodes towards proper locations that maximize the sensing coverage and minimizing the transmitted energy. Two types of virtual forces are used: an attractive force that moves the nodes towards the cluster head in order to reduce the energy used for communication and a repulsive force that moves the overlapping nodes away from each other so that their sensing coverage is maximized. The proposed scheme is applied on LEACH clustering algorithm. The simulation results a considerable improvement in performance of LEACH protocol in terms of achieved sensing coverage and network lifetime. EE-AODV, Energy Efficient Ad hoc ON demand Distance Vector routing protocol was proposed by *Reena Singh and Shilpa Gupta* [6]. The algorithm adopted by EEAODV has enhanced the RREQ and RREP handling process to save the energy in mobile devices. It considers some level of energy as threshold value which should be available in node to be used as an intermediary node. *V Bharathi* [7] performed a work, “A Performance Enhancement of an Optimized Power Reactive Routing based on AODV Protocol for Mobile ad-hoc network”. In this paper author described that an optimized power reactive routing based AODV protocol by using concept of cognitive function. It ensures that data packets are transferred in the shortest and most reliable mode. In order to improve the scalability of the network management and provide a way of transmission with an energy efficient manner in the path of every node, author proposed a novel way of transmission with stability using a technique called Optimized Power Reactive Routing (OPRR).

III. AODV Routing protocol

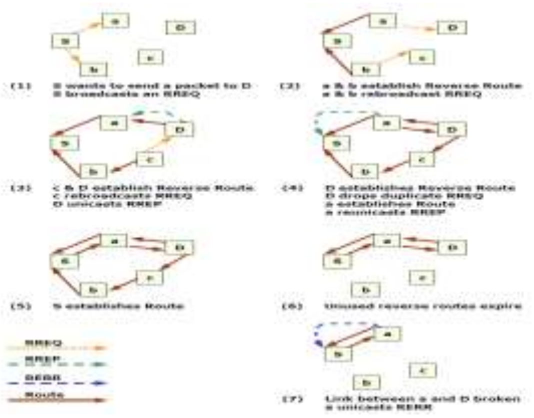
In November 2001 the MANET (Mobile Ad-hoc Networks) working group of routing of IEFT community has published the first version of the AODV (*Ad-hoc On Demand Distance Vector*) Routing Protocol. [8] It was jointly developed on July 2003 in Nokia Research enter, University of California, Santa Barbara and University of Cincinnati by C. Perkins, E. Belding-Royer and S. Das. [9] AODV is the routing protocol used in ZigBee. There are various implementations of AODV such as MAD-HOC, Kernel-AODV, AODV-UU, AODV-UCSB and AODV-UIUC. [10]

AODV enables “dynamic, self-starting, multi-hop routing between mobile nodes wishing to establish and maintain an ad hoc network”.[11] AODV is an on demand routing protocol with small delay, it means that routes are only established when needed, to reduce traffic overhead, maintenance of routing table etc. Being a reactive routing protocol AODV uses traditional routing tables, one entry per destination and sequence numbers are used to determine whether routing information is up-to-date and to prevent routing loops. It supports broadcasting, Multicasting and unicasting. [12] The operation of AODV is loop-free, and by avoiding the Bellman-Ford "Count-To-Infinity" problem offers quick convergence when the ad hoc network topology changes (typically, when a node moves in the network). Link breakages can locally be repaired efficiently.

A. Control Messages

- *Route REQuest Message (RREQ):* If a node wants to send a packet to a node for which no route is available it broadcasts a RREQ to find the route. A RREQ includes a unique identifier (RREQ ID), Destination IP address, Destination sequence no, Source IP address, Source sequence no, Hop Count initialized to 0 and some flags. When a node receives a RREQ, it matches the RREQ ID, and if it is not received previously i.e. a new RREQ, then it sets up a reverse route to the sender. It checks its routing table if it knows the route to the destination with a higher sequence number then it creates a RREP and unicast to the source using reverse routes. If it doesn't know the route it simply increases the hop count and rebroadcast the updated RREQ. Any intermediated node which contains the route to the destination can also generate RREP.

- *Route REPly Message (RREP):* If a node is the destination, or has a valid route to the destination, it unicasts a RREP back to the source. The reason one can unicast RREP back is that every node forwarding a RREQ message caches a route back to the source node.



- *Route ERRor Message (RERR):* When a link break in an active route is detected, a RERR message is used to notify other nodes that the loss of that link has occurred. The RERR message indicates those destinations which are no longer reachable because of link breakage.

- *Route REPly-ACKnowledgement Messages (RREP-ACK):* RREP-ACK is another message type that must be sent in response to a RREP message. This is typically done when there is danger of unidirectional links preventing the completion of a Route Discovery cycle.

- *Hello Messages:* If a node doesn't receives any message from its neighbours for a long time it broadcasts periodically a hello message to check if the route is still active and no link breakages are assumed by its neighbours. If a link breakage is found it tries to repair the route locally. For local repairing, the node increments the sequence no for the destination and then broadcasts a RREQ for that destination. Local repair attempts will be invisible to the originating node. The Hello Messages will never be forwarded because they are broadcasted with TTL (Time to Live) is set 1.

Fig. 3: Aodv Message types

Merits & Demerits

- No central administrative system to control the routing process.
- AODV reacts relatively fast to the topological changes in the network and updates only the nodes affected by these changes.
- The Hello messages supporting the routes maintenance and local link breakage are range limited, so they don't cause unnecessary overhead in the network.
- Saves energy and storage space.
- Count-To-Infinity problem is solved.
- Determining reasonable expiry time is difficult
- AODV rely on a route discovery flood, which carry significant network overhead, which may cause so-called broadcast storm problem.
- Not suitable for long paths as overhead is increased directly proportional to length of path.
- Security measurements are not implemented.
- AODV protocol can be used in networks with limited resources: bandwidth, energy, computational power, and with a limited number of nodes too.

IV. Proposed Work

For enhancing the energy-efficiency in AODV different parameters are considered on which work is performed, explained as follows:

- **Time-To-Live** (TTL): AODV RREQ routing table consist of this parameter, which determines the life time of the packet over the network. Default value is set to 1. TTL consists of 3 types:

1) TTL Start
2) TTL Increment
3) TTL Threshold

By setting High Starting TTL, High Increment & High Threshold value, RREQ flooding can be reduced and network load will be decreased. By setting TTL Start to 2, incrementing it by a value 4 and having a high threshold as 14(double of default), we can enlarge the circle of a RREQ packet life time over the network. It will reduce the RREQ flooding packets by a factor of 2.

- **Hello Interval:** These are special type of messages generated during local link breakage and maintenance. Each node generates a hello message and sends it to its neighbours periodically to check whether then link is still working or broken. This checks the route validity during data transmission. Better performance can be increased by reducing hello interval but it increases the network load by a factor. Default value is 1s or 1000 ms. By increasing the Hello Interval value, we can reduce the number of hello messages generated for local route maintenance. This reduction leads to decrease in load on network or node for maintenance. For our work, we are increasing it to 1500 ms.

- **Allowed Hello Loss:** It is maximum time to wait for reply of hello message from its neighbour to determine whether link is still alive or dead. As nodes are mobile in nature, so delay in reply of Hello message is possible. Due to this delay, a valid route is also considered as invalid. So by increasing this interval, RRER is delayed by a factor and network load is reduced. Default value is 2 and we have increased it by 1.

*Max. Reaction Time = Hello Interval * Allowed Hello Loss*

Maximum reaction time means that any node will wait of tis interval before generating a RRER message to the neighbours. Increase in Allowed Hello Loss leads to high Maximum Reaction Time Interval.

- **Node traversal Time**: It is a conservative estimate of the average one hop traversal time for packets and should include queuing delays, interrupt processing time and transfer time. It effects Net Traversal time.

*NET_TRAVERSAL_TIME = 2 * NODE_TRAVERSAL_TIME * NET_DIAMATER*

An increase in Node traversal Time leads to increase in Net traversal Time, which gives a node more time to deal with a packet and a packet can bear network generated delays. In our work, we have proposed to double its default value and setting it to 80 ms.

- **RREQ Retries**: It determines that how much times for a route RREQ must be generated. If this threshold is reached, destination is declared unreachable and packets destined for it should be dropped. Decreasing it, we can reduce no of retries and also decrease the load on network. In our work, it is reduced by one from default value.

V. Simulation Environment

QualNet is a commercial version of GloMoSim used by Scalable Network Technologies (SNT) for their defense projects namely JTRS Network Emulator, BCNIS and Stratcom Cyber. It is a state-of-the-art simulator for large, heterogeneous networks and the distributed applications that execute on those networks. It is commercial software that runs on all common platforms (Linux, Windows, Solaris, OS X) and is specialized in simulating all kind of wireless applications. It has a quite clear user interface compared to other solutions while also offering an easy to use command line interface. QualNet provides a comprehensive environment for designing protocols, creating and animating network scenarios, and analyzing their performance.

Qualnet Features: Qualnet enables users to:

- Robust set of wired and wireless network protocol and device models, useful for simulating diverse types of networks.
- Optimized for speed and scalability on one processor, Qualnet executes equivalent scenarios 5-10x times faster than commercial alternatives
- A robust graphical user interface covers all aspects of the simulation, from scenario creation and topology setup, integration of custom protocols, through real-time execution of network models from within the GUI, animation, to post-simulation statistical analysis.
- Design new protocol models.
- Optimize new and existing models.
- Design large wired and wireless networks using pre-configured or user-designed models.
- Analyze the performance of networks and perform what-if analysis to optimize them.

The key features of QualNet that enable creating a virtual network environment are:

- **Speed**
- **Scalability**
- **Model Fidelity**
- **Portability**
- **Extensibility**

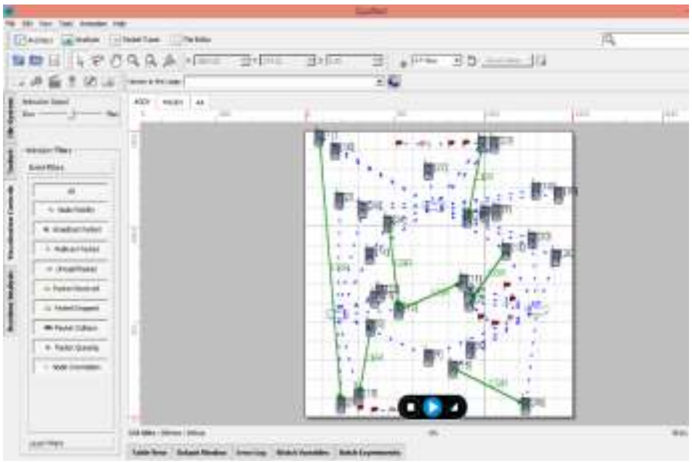


Fig. 4: Simulation Scenario

Parameters	Value
Number of nodes	30,40,50,55,65
Area	1500 * 1500 units square
Mobility Factor	Used
Link Type	Wireless links
Application used	CBR (Constant Bit Rate)
Simulation time	600 sec

Table 1: Simulation Scenario Parameters

VI. Result and Analysis

The Traditional AODV is compared with modified AODV with following parameters and results are shown below:

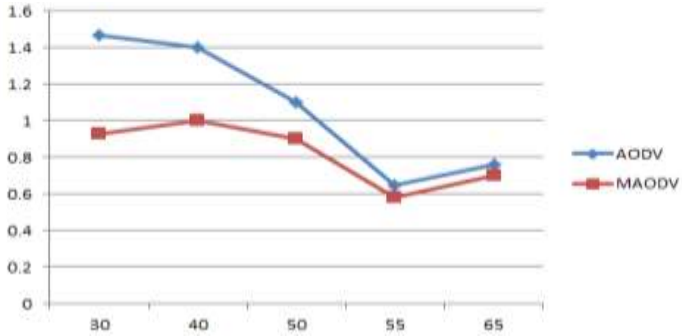


Fig. 5: Number of RREQs Initiated

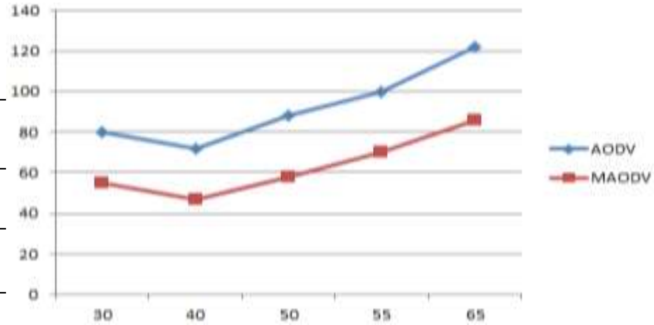


Fig. 6: Number of time Link Broken

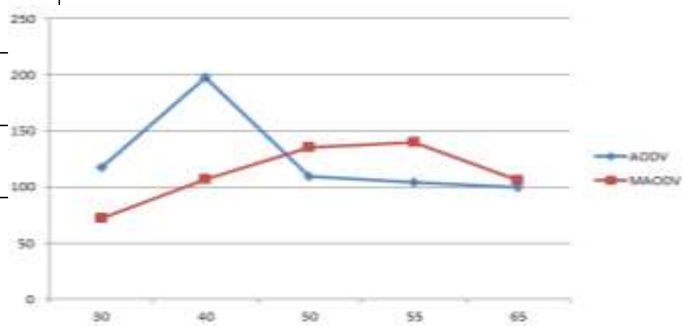


Fig. 7: End-To-End Delay

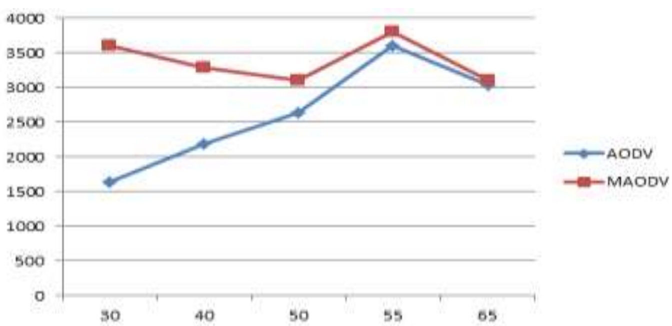


Fig. 8: Throughput (bits per sec)

After the analysis of all the graphs, we analysed that proposed AODV is generating less number of RREQ's and it helps in reducing the load over the WSN which is caused due to RREQs'. There is a reduction in number of times the link breakage is possible in scenario. By Overall analysis, we observe that while maintaining fewer loads on network, i.e. less number of RREQs', less End-to-End delay and High throughput of the WSN is achieved by proposed work. This work is efficient for those networks which are consist of small number of nodes. RREQ's are reduced by 12% and it increases the throughput of the network by 23% overall. Less RREQ's will be handled by each node, in this way load on a node is also reduced by 17% and similarly less load leads to less energy consumption. Energy is consumed less as compared to original on bases of load and throughput with the help of proposed work.

VII. CONCLUSIONS

In this present work we have shown the improvement over AODV protocol to ensure Energy – Efficient WSN. For improving the energy efficiency of WSN, we have done work on AODV parameters. By varying the parameters, we have analysed our work. Here we have done some work on few parameters of AODV as TTL, Hello message, RREQ retries etc. and we conclude that an improvement is achieved over basic AODV. As we are working on parameters to reduce the number of RREQ packets generated in WSN. As less RREQ generated, less packets will be forwarded and processed by sensor nodes. By reducing processing factor, Energy of nodes can be saved by a little factor. Sensor Nodes are utilizing energy in saving mode, hence whole WSN leads to less consumption of energy and an energy – efficient WSN can be designed using basic AODV, just after modifying its few parameters. This proposed scheme has shown a good development over Energy–Efficient factor.

REFERENCES

[1]. *Dargie, W. and Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice", John Wiley and Sons. Pp. 168-183, 191-192.*

[2]. *T. Clouqueur et al., ''Sensor Deployment Strategy for Target Detection,'' Proceedings of the 1st Workshop on Sensor Networks and Applications (WSNA'02), Atlanta, GA, Sept. 2002.*

[3]. *I. F. Akyildiz et al., ''A Survey of Sensor Networks,'' IEEE Communications, Aug. 2002, pp. 102ff.*

[4]. *D. Estrin, D. Culler, K. Pister, ''Connecting the Physical World with Pervasive Networks,'' IEEE Pervasive Computing, Jan.–Mar. 2002.*

[5]. *E. Shih et al., ''Physical Layer Driven Protocol and Algorithm Design for Energy-Efficient Wireless Sensor Networks,'' Proceedings of the 7th ACM International Conference on Mobile Computing and Networking (MobiCom'01), Rome, Italy, July 2001, pp. 272–286.*

[6]. *W. Su et al., ''Communication Protocols for Sensor Networks,'' in Wireless Sensor Networks, C. S. Raghavendra, K. Sivalingam, and T. Znati, Eds., Kluwer Academic, New York, 2004.*

[7]. *Lan Tien Nguyen, Xavier Defago, Razvan Beuran, Yoichi Shinoda, "An Energy- Efficient Routing Scheme for Mobile Wireless Sensor Networks", Conference Paper, November 2008.*

[8]. *An Engineering Approach to Computer Network, S. Keshav, Addison Wesly / AT&T, 1997*

[9]. *Perkins, C.; Belding-Royer, E.; Das, S. (July 2003). Ad hoc On-Demand Distance Vector (AODV) Routing. IETF. RFC 3561. Retrieved 2010-06-18.*

[10]. *Jhaveri, R.H.; Patel, N.M. (2015). "Mobile Ad-hoc networking with AODV: A Review". International Journal of Next-Generation Computing* ***6*** *(3): 165–191.*

[11]. *Perkins, et. al. "Ad hoc On-Demand Distance Vector (AODV) Routing", RFC 3561, July 2003*

[12]. *Georgy Sklyarenko, "AODV Routing Protocol", Seminar Technische Informatik, http://cst.imp.fu-berlin.de.*