International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 2, January-February 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Optimizing Energy Efficiency in Wireless Sensor Networks: A Review of Cluster Head Selection Techniques

Suraj Patel

Automotive IT Infrastructure, Detroit, USA

ABSTRACT

A wireless sensor network (WSN) in its simplest form can be defined as a network of (possibly low-size and less complex) devices which are denoted as nodes that can sense the environment and communicate the information gathered from the monitored field through wireless channel or link. In the data is forwarded, possibly via multiple hops relaying, in sink network that can use it locally, or connected to other networks. The idea of development of wireless sensor networks was initially motivated by military applications. Wireless sensor network provides a reliable, low power method for making measurements in applications where cabled sensors are impractical or otherwise undesirable, low maintenance. In the nodes are connected in senor, wireless sensor network (WSN) is a large network of resource-constrained sensor nodes with multiple preset functions used, sensing and processing, to fulfill different applications. In this paper we study of introduced wireless sensor network, Sensor Network, Energy Consumption, Cluster Head, and literature review.

KEYWORDS: *WSN, Energy Consumption, Cluster Head*

How to cite this paper: Suraj Patel "Optimizing Energy Efficiency in Wireless Sensor Networks: A Review of Cluster Head Selection Techniques" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-2, February 2022, pp.1584-1589, URL: www.ijtsrd.com/papers/ijtsrd49226.pdf

IJTSRD49226

1. INTRODUCTION

Wireless Sensor Networks (WSNs) consist of numerous spatially distributed sensors that monitor and record physical conditions of the environment and pass this data to a central location for analysis. Energy efficiency is one of the most crucial factors in WSNs, as sensor nodes are typically battery-powered and deployed in hard-to-reach locations where replacing or recharging batteries may not be feasible [1-2].

One effective method of optimizing energy consumption in WSNs is through the cluster head (CH) selection mechanism, which reduces the overall energy spent on communication. In a clustered WSN, nodes are grouped into clusters, each with a CH that gathers data from its cluster members and transmits it to the base station [3]. This review focuses on energy consumption in WSNs, with an emphasis on the role of cluster head selection techniques in optimizing energy efficiency. The wireless sensor networks are interesting network to study due to the fact that large number of applications are being developed using these networks system [4-7]. A wireless sensor network of the type investigated here refers to a collection of sensors, and nodes that are linked by a medium which is wireless in nature system [1]. Network to a main location or sink where the data can be observed and analyzed. One can be retrieve required information from the network by injecting queries and gathering results from the sink. The sensor nodes can communicate among themselves using radio signals. For typically a wireless sensor network contains hundreds of thousands of sensor nodes. It have individual nodes in a wireless sensor network (WSN) are inherently resource constrained: they have limited processing speed, communication bandwidth and storage capacity. After the sensor nodes are responsible for self-organizing an appropriate network infrastructure often with multi-hop communication. Wireless sensor devices in respond to queries sent from a “control site” to perform specific instructions or provide sensing [2]. The working mode of the sensor nodes may be either continuous or event driven. Wireless sensor devices can be equipped with actuators to “act” upon certain conditions. It is wireless network sometimes more specifically referred as Wireless Sensor and Actuator

Networks as described in a Wireless sensor networks (WSNs) enable new applications and require non-conventional paradigms for protocol design due to several constraints [8]. Wireless sensor network are using Global Positioning System (GPS) and local positioning algorithms can be used to positioning information and obtain location. The requirement for low device complexity together with low energy consumption, a proper balance between communication and signal/data processing capabilities must be found [9-12].

2. MOTIVATION OF WSN

This is motivates a huge effort in research activities, industrial investments and standardization process on this field since the last decade. At present time, most of the research on WSNs has concentrated on the design of energy- and computationally efficient algorithms and protocols; the application domain has been restricted to simple data-oriented monitoring and reporting applications [3, 13, 14]. Specifically, it is allocates periods of inactivity for cable sensors without affecting the coverage and connectivity requirements of the network based only on local information schemes. In a delay-aware data collection network structure for wireless sensor networks is proposed in the objective of the proposed network structure is to minimize delays in the data collection processes of wireless sensor networks which extends the lifetime of the network. The network geometric deficiencies and used Particle Swarm Optimization (PSO) based algorithms to locate the optimal sink location with respect to those relay nodes to overcome the lifetime challenge Sensor-actuator networks can provide the ability to continuously monitor the integrity of structures in real-time, and detect damage at an early stage, and provide robustness in case of catastrophic failures [4, 15-17].

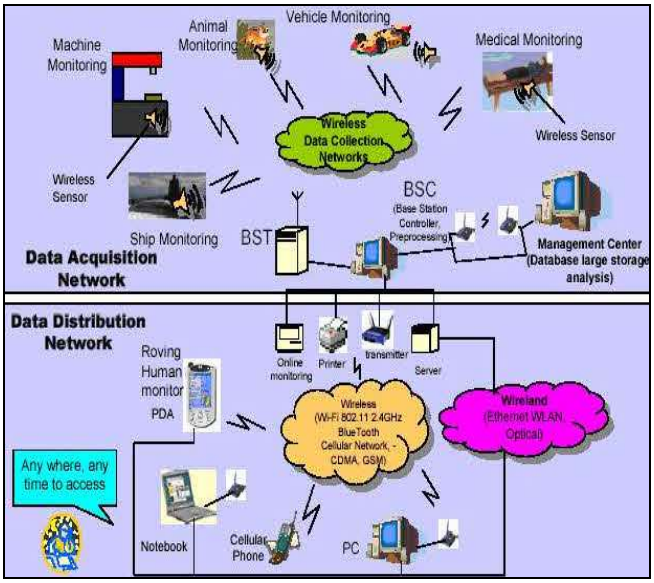

Fig.1: Wireless Sensor Networks (WSN)

3. SENSOR NETWORK

A Sensor is a device that responds and detects some type of input from both the physical or environmental conditions, such as heat, light, pressure etc. The output of the sensor is generally an electrical signal that is transmitted to a controller for further processing. A wireless sensor network consists of autonomous sensors scattered in an environment where they monitor conditions such as temperature, sound, and pressure. Because of the huge size of this forest, changes in the forest affect not only the local environment but also global climate by altering wind and ocean current patterns [5, 18].

WSN projects include wireless sensor networks applications such as wireless, Zigbee, home automation, SCADA transformer health monitoring system and so on [1, 19-22].

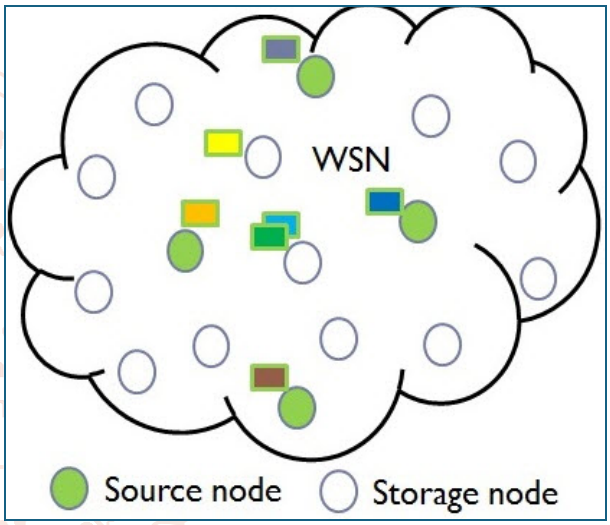

Fig. 2: Sensor Network (Source and Storage Node)

In the localization for outdoor wireless sensor networks (WSNs) is a fundamental middle-ware service for many wireless sensor networks applications [23-24]. For example, in military surveillance location information of each node is essential to determine a target's position. The Sensor networks are shown in figure 2.

A. Types of WSNs (Wireless Sensor Networks)

Depending on the environment, the types of networks are decided so that those can be deployed underwater, underground, on land, and so on. Different types of WSNs include. Terrestrial WSNs, Underground WSNs, Underwater WSNs, Multimedia WSNs and Mobile WSNs.

4. ENERGY CONSUMPTION IN WSN

Energy consumption in WSNs can be categorized into three primary activities:

Sensing: The energy required to measure physical quantities, such as temperature, humidity, or motion.

Processing: Energy consumed by the microcontroller or other onboard processors to process and filter sensed data.

Communication: The most energy-intensive activity, especially for nodes transmitting data over long distances. It includes both intra-cluster communication and communication between the cluster head and the base station.

To minimize energy consumption, WSN protocols aim to reduce the communication overhead and balance energy consumption among all sensor nodes.

A. Requirements for a Wireless Sensor Network

Initial research into wireless network sensors was mainly motivated by military applications, with the Defiance Advanced Research Projects Agency (DARPA), continuing to fund a number of prominent research projects (e.g., Smart Dust, Network of Embedded systems (NEST)).The type of applications considered by these projects led to a de facto definition of a wireless sensor network as a large-scale (thousands of nodes, covering large geographical areas), wireless, ad-hoc, multi-hop, un-partitioned network of homogenous, tiny (hardly noticeable), mostly immobile (once deployed), sensor nodes that would be randomly deployed in the area of interest, (Kay Romer et al. 2004). Further applications and projects do not always fit these requirements, but these are the basic constraints assumed by most developers. To summarize the aims that a node and a network of this nature have to achieve, these are ideally the main characteristics: Low power consumption, Low cost nodes that use cheap and commonly available batteries, Small physical size to facilitate deployment, Compliance to standards and regulations, Single design for international markets, Ability to maintain time synchronization with other nodes and hopping messages to destination, Operate over wide temperature ranges especially for military applications or high temperature scenarios (i.e. a desert zones) and Fault tolerant [7].

5. LITERATURE REVIEW

[1] Shiv Prasad Kori et al. **"Performance Comparison in Terms of Communication Overhead for Wireless Sensor Network Based on Clustering Technique"** International Journal of Electronics Communication and Computer Engineering, Vol. 4(3), 2013. The present work, the comparative evaluation of communication overhead for the wireless sensor network based of on clustering technique is carried out. It has been be observed that overhead in cluster based protocol is not much dependent upon update time. Simulation a result indicates that cluster based protocol has low communication overheads compared with the BBM based protocol when sink mobility is high [5].

[2] Anshul Shrotriya et al. **"Energy Efficient Modeling of Wireless Sensor Networks Based on Different Modulation Schemes Using QualNet"** International Journal of Scientific Engineering and Technology, Vol. 1(3), 2013. I have study in the paper that it account for the analysis of energy consumption in existing energy models of Wireless Sensor Network (WSN) based upon different modulation. There are two main energy models preferred in Wireless Sensor Network, MOTES and MICAZ [1].

[3] Amrinder Kaur et al. **"Simulation of Low Energy Adaptive Clustering Hierarchy Protocol for Wireless Sensor Network"** International Journal of Scientific Engineering Vol. 3(7), July 2013. Recent advances in wireless sensor networks have settled into an important part of one's everyday life and gained attention from both the research community and actual users. In wireless sensor networks energy alertness is an essential consideration & it explored to many new protocols specifically designed for sensor networks. Most of rank, given to hierarchical routing protocols based on clustering because of scalability .In this paper analyze the routing challenges & design issues involved in the wireless sensor networks and present the overall working of LEACH protocol and its SIMULATION [2].

[4] Arivanantham Thangavelu et al. **"Clustering Techniques to Analyze Communication Overhead in Wireless Sensor Network"** International Journal of Computational Engineering Research, Vol. 4(5), May – 2014. The major problem with wireless sensor network is their limited source of energy, the courage constraint and high traffic load. In this paper we introduce various clustering techniques which are to be used to reduce communication overhead and increase network's lifetime [16].

[5] Labisha R.V et al. **"Energy Efficient Clustering Algorithms in Wireless Sensor Networks-An Analytical View"** International journal Vol. 9(3), May 2014 Wireless sensor network refers to a group of spatially distributed and dedicated sensors for monitoring and recording the physical conditions of environment like temperature, humidity, sound, pollution levels, and wind speed with direction and pressure. Sensors are self powered nodes which also possess limited processing capabilities and the nodes communicate wirelessly through a gateway. In these applications a large number of sensors are expected and requiring careful architecture and management of the network. Significant attention has been paid to clustering strategies and algorithms yielding a large

number of publications. In this paper, we demonstrated that cluster based protocol leads to less communication overheads [6].

[6] Sandeep Gupta et al.. **"Comparison of Energy Consumption in Wireless Sensor Networks with Different Clustering Technique"** International Journal of Engineering Science & Management, 5(4), (2015). The wireless sensor network consists of the sensor nodes. The idea of development of wireless sensor networks was initially motivated by military applications. A WSN provides a reliable, low maintenance, low power method for making measurements in applications where cabled sensors are impractical or otherwise undesirable. In this paper Comparison of Communication overhead for 50 nodes and 100 nodes of three clustering technique SOM, K-Means and Fuzzy clustering and result analysis in between Communication overhead versus velocity in m/s [17].

[7] Vineet Mishra et al. (2015). "**Performance Analysis Of Cluster Formation In Wireless Sensor Networks**", Global Journal of Advance Engineering Technologies and Sciences, 2(11). The energy consumption is the principal concern in WSN. It system is built on an IEEE 802.15.4 wireless mesh network. Wireless Sensor Networking is a network of wireless sensor nodes deployed in an area. The wireless sensor network consists of the sensor nodes. The idea of development of wireless sensor networks was initially motivated by military applications [18].

6. TYPES OF CLUSTERING TECHNIQUES

Two well-known clustering algorithms are used in association with a visualization interface to simulate the possible cluster network with optimized energy Consumption. Clustering algorithms Subtractive clustering assumes each node as a potential cluster head and calculate the measure of' the likelihood that each node defines the cluster head, based on the density of surrounding nodes.

1. The algorithm has the following features: Selects the node with the highest potential to be the first cluster head.
2. Removes all nodes near to the fust cluster head, in order to determine the next node cluster and its head location.

Fuzzy C-mean (FCM) algorithm was introduced by Bezdek. The FCM based algorithm is a data clustering technique wherein each data point belongs to a cluster to some degree that is specified by a membership grade. K- Means: - Clustering K-means was first used by Mac-Queen in 1967 is one of the simplest clustering method comes under unsupervised learning algorithms used to solve the well-known clustering problem. It follows a simple and easy way to classify a given data set through a certain number of clusters (i.e. k clusters) fixed a priori. K- Means clustering comes under the category of partitioning method in which a partition of a database D of n objects is done into a set of k clusters. Given a k, the main task is of finding a partition of k clusters that optimizes the chosen partitioning criterion. That's why we have preferred k-means clustering for this work.

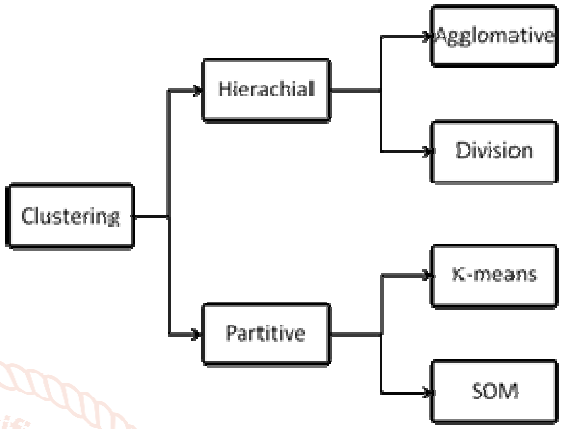

Fig: 3. Types of Clustering Techniques

7. ENERGY CONSUMPTION

Wireless Sensor Network (WSN) plays an extremely significant role in usual lives. Wireless Networks in provisions of constraints of their resources [14]. The energy consumption is the principal concern in Wireless Sensor Network (WSN). Therefore, a numerous researchers focused on energy efficient algorithms in WSNs for extending the life time of sensors. These differ depending on the deployment of node, the network design, the characteristics of the cluster head nodes and the network operation. Energy is proficient of save by grouping nodes as clusters. There are three types of activities that take up the majority of the power in a sensor node: sensing, computation, and radio operations such as receiving and transmitting. Of these three activities radio operations take up the majority of the power, so an energy efficient scheme should focus on reducing the amount of time spent on receiving and transmitting [4]. Nodes tend to take up more power consumption in receiving than in transmitting. Listening idly to the channel and overhearing packets consume the most of a nodes power [4].

8. CLUSTER HEAD

Clustering is used in order to advance the scalability of network performance. Clustering is useful in several sensor network applications such as inter cluster communication, node localization and so on. Clustering algorithms have extensive applications in the precedent years and common clustering algorithms have been proposed for energy consumption in recent years in all of these algorithms,

and nodes are structured as clusters, superior energy nodes are called as Cluster Head (CH) and other nodes are called as normal sensor nodes [15]. In the cluster based model, the network is divided into clusters comprising of number amount of nodes. Cluster head, which is master node, within each respective cluster is responsible for routing the information to other cluster head the figure 4 of cluster based model.

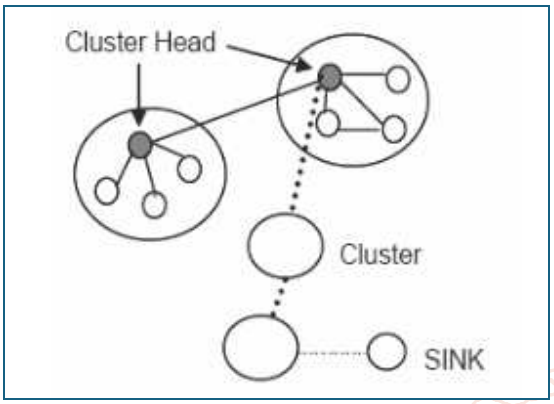

Fig. 4: Cluster based model

9. CHALLENGES AND FUTURE DIRECTIONS

Heterogeneity in WSNs: Many real-world WSNs have nodes with different energy levels, sensing capabilities, and communication ranges. Clustering algorithms should be designed to handle such heterogeneity effectively to ensure balanced energy consumption and network longevity.

Mobility of Nodes: In some applications, sensor nodes are mobile, which introduces additional challenges for clustering algorithms, such as frequent CH re-election and managing dynamic communication links. Mobility-aware clustering algorithms need to be developed to ensure efficient data transmission.

Energy Harvesting: Future WSNs may use energy-harvesting technologies, where nodes can recharge their batteries using environmental energy sources, such as solar power. Clustering algorithms will need to adapt to these new paradigms by dynamically selecting CHs based on not just residual energy but also harvested energy.

Security Considerations: Cluster heads are critical points in the network, and their compromise can significantly disrupt network operations. Future clustering algorithms should incorporate security mechanisms to ensure the integrity of data transmission and CH selection.

10. CONCLUSION

Energy consumption is a critical concern in the design and operation of WSNs. Cluster head selection plays a pivotal role in optimizing energy usage by reducing communication costs and balancing the energy load among nodes. Efforts have been made to minimize the energy consumption of wireless sensor networks and lengthen their useful lifetime at different levels and approaches. Some approaches aim to minimize the energy consumption of sensor itself at its operating level, some aim at minimizing the energy spent in the input/output operations at data transmission levels and others target the formulation of sensor networks in terms of their topology and related routing mechanisms. Advances in wireless communication technology are enabling the deployment of networks of small sensors. These sensor networks have applications in military monitoring, health, industrial control, weather monitoring, commodity tracking, home control etc.

REFERENCES

[1] Anshul Shrotriya, Dhiraj Nitnawwre, "Energy Efficient Modeling of Wireless Sensor Networks Based on Different Modulation Schemes Using QualNet" International Journal of Scientific Engineering and Technology, Vol.1, Issue No.3, pg : 171-174, 2012, ISSN : 2277-1581

[2] Amrinder Kaur, "Simulation of Low Energy Adaptive Clustering Hierarchy Protocol for Wireless Sensor Network", Vol. 3, Issue 7, July 2013, ISSN: 2277 128X

[3] Amitabh Basu , Jie Gao, Joseph S. B. Mitchell, Girishkumar Sabhnani , "Distributed localization using noisy distance and angle information" 7th AC Minternational symposium on Mobile ad hoc networking and computing, 2006,pp. 262 – 273.

[4] S. Kami Makki et. al., "Energy Consumptionin Wireless Sensor Networks using data fusion assurance" International Journal of Wireless & Mobile Networks (IJWMN) Vol. 5, No. 2, 2013.

[5] Shiv Prasad Kori, "Performance Comparison in Terms of Communication Overhead for Wireless Sensor Network Based on Clustering Technique", Vol. 4, Issue 3, ISSN (Online): 2249–071X,.

[6] Labisha R.V, 2Baburaj E, "Energy Efficient Clustering Algorithms in Wireless Sensor Networks-An Analytical View", Vol. 9, Number3, 2014.

[7] Abdul Sattar Malik, Jingming Kuang, Jiakang Liu, Wang Chong, Performance Analysis of Cluster-based Wireless Sensor Networks with

Application Constraints, I.J. Computer Network and Information Security, Vol. 1, pp. 16-23, 2013.

[8] Performance evaluation of routing protocols for packet drop statistics for Meshed routing in IEEE 802.15.4 based WSNs

[9] A. Allirani, and M. Suganthi, An Energy Efficient Cluster Formation Protocol with Low Latency In Wireless Sensor Networks, Vol: 3, 2009.

[10] Eugene Shih, SeongHwan Cho, Nathan Ickes, Rex Min, Amit Sinha, Alice Wang, Anantha Chandrakasan," Physical layer driven protocol and algorithm design for energy efficient wireless sensor networks", Proc. MOBICOM, 2001, pp. 272–287.

[11] E. Ekici , S. Vural, J. McNair, D. Al-Abri "Secure probabilistic location verification in randomly deployed wireless sensor networks " Elsevier Science Publishers B. V ,pp.,195-209, 2006.

[12] Heinzelman, W.B. Chandrakasan, A.P. Balakrishnan, H. "An application-specific protocol architecture for wireless micro-sensor networks", IEEE Transactions on Wireless Communications, pp. 660- 670, 2002.

[13] N.B. Priyantha, H. Balakrishnan, E. D. Demaine, and S.Teller, "Mobile assist localization in wireless sensor networks, "in Proceedings of the 24th Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM'05), vol.1, pp. 172–183.

[14] Padmavathy, M.Chitra, "Performance Evaluation of Energy Efficient Modulation Scheme and Hop Distance Estimation for WSN" Vol. 2, No. 1, 2010

[15] Arivanantham Thangavelu et al. "Clustering Techniques to Analyze Communication Overhead in Wireless Sensor Network" International Journal of Computational Engineering Research, Vol. 04 Issue, 5, 2014.

[16] Shreyaskumar Patel. (2021). Enhancing Image Quality in Wireless Transmission through Compression and De-noising Filters. In International Journal of Trend in Scientific Research and Development (Vol. 5, Number 3, pp. 1318–1323). IJTSRD. https://doi.org/10.5281/zenodo.11195294

[17] Arpita Tiwari, Mukesh Patidar et al. Efficient designs of high-speed combinational circuits and optimal solutions using 45-degree cell orientation in QCA nanotechnology, Materials Today: Proceedings, Vol. 66(8), 2022, Pages 3465-3473. https://doi.org/10.1016/j.matpr.2022.06.174

[18] Sandeep Gupta et al. "Comparison of Energy Consumption in Wireless Sensor Networks with Different Clustering Technique" International Journal Of Engineering Science & Management, 5(4), 2015

[19] Vineet Mishra et al."Performance Analysis of Cluster Formation In Wireless Sensor Networks", Global Journal of Advance Engineering Technologies and Sciences, Vol. 2 (11), 2015.

[20] Shreyaskumar Patel "Performance Analysis of Acoustic Echo Cancellation using Adaptive Filter Algorithms with Rician Fading Channel" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456- 6470, Volume-6 | Issue-2, February 2022, pp.1541-1547, URL: www.ijtsrd.com/papers/ijtsrd49144.pdf

[21] Lalit P. Patil et al. Efficient algorithm for Speech Enhancement using Adaptive filter, International Journal of Electrical, Electronics and Computer Engineering Vol. 3(1), 98-103(2014).

[22] Patidar, M., Gupta, N. (2019). Efficient Design and Simulation of Novel Exclusive-OR Gate Based on Nanoelectronics Using Quantum-Dot Cellular Automata. In: Nath, V., Mandal, J. (eds) Proceeding of the Second International Conference on Microelectronics, Computing & Communication Systems (MCCS 2017). Lecture Notes in Electrical Engineering, vol 476. Springer, Singapore. https://doi.org/10.1007/978-981-10-8234-4_48

[23] P. Gupta, M. Patidar and P. Nema, "Performance analysis of speech enhancement using LMS, NLMS and UNANR algorithms," 2015 International Conference on Computer, Communication and Control (IC4), Indore, India, 2015, pp. 1-5, doi: 10.1109/IC4.2015.7375561.

[24] Ashish M Sitapara et al. Performance of WiMAX 802.16e MIMO OFDM system using 2×2 alamouti scheme. Global Journal of Advanced Engineering Technologies and Sciences, 2(8), 12-15. https://gjaets.com/index.php/gjaets/article/view/278