**IMPLEMENTATION OF MULTIHOP PROTOCOL WITH COST FUNCTION FOR DECREASING ENERGY CONSUMPTION IN NODES**

**CHAPTER -1**

**ABSTRACT**

We present a routing protocol for Wireless sensor Networks that is reliable, power efficient, and has a high throughput (WSNs). To reduce energy consumption and increase network longevity, we employ a multi-hop topology. To identify the parent node or forwarder, we offer a cost function. The proposed cost function chooses a parent node with the highest residual energy and the shortest distance to the sink. The residual energy parameter balances energy consumption across sensor nodes, while the distance parameter guarantees packet delivery to the sink is successful.

Our suggested approach decreases the energy consumption of nodes which helps in maximizing the network lifetime.

**Keywords**-- Wireless Sensor Network, Cost Function, energy consumption

**CHAPTER-2**

**INTRODUCTION**

With the popularity of laptops, cell phones, PDAs, GPS devices, RFID, and intelligent electronics in the post-PC era, computing devices have become cheaper, more mobile, more distributed, and more pervasive in daily life. It is now possible to construct, from commercial off-the-shelf (COTS) components, a wallet size embedded system with the equivalent capability of a 90’s PC. Such embedded systems can be supported with scaled down Windows or Linux operating systems. From this perspective, the emergence of wireless sensor networks (WSNs) is essentially the latest trend of Moore’s Law toward the miniaturization and ubiquity of computing devices. Typically, a wireless sensor node (or simply sensor node) consists of sensing, computing, communication, actuation, and power components. These components are integrated on a single or multiple boards, and packaged in a few cubic inches. With state-of-the-art, low-power circuit and networking technologies, a sensor node powered by 2 AA batteries can last for up to three years with a 1% low duty cycle working mode. A WSN usually consists of tens to thousands of such nodes that communicate through wireless channels for information sharing and cooperative processing. WSNs can be deployed on a global scale for environmental monitoring and habitat study, over a battle field for military surveillance and reconnaissance, in emergent environments for search and rescue, in factories for condition based maintenance, in buildings for infrastructure health monitoring, in homes to realize smart homes, or even in bodies for patient monitoring After the initial deployment (typically ad hoc), sensor nodes are responsible for self-organizing an appropriate network infrastructure, often with multi-hop connections between sensor nodes.

The on board sensors then start collecting acoustic, seismic, infrared or magnetic information about the environment, using either continuous or event driven working modes. Location and positioning information can also be obtained through the global positioning system (GPS) or local positioning algorithms. This information can be gathered from across the network and appropriately processed to construct a global view of the monitoring phenomena or objects. The basic philosophy behind WSNs is that, while the capability of each individual sensor node is limited, the aggregate power of the entire network is sufficient for the required mission. In a typical scenario, users can retrieve information of interest from a WSN by injecting queries and gathering results from the so-called base stations (or sink nodes), which behave as an interface between users and the network. In this way, WSNs can be considered as a distributed database .It is also envisioned that sensor networks will ultimately be connected to the Internet, through which global information sharing becomes feasible.

The era of WSNs is highly anticipated in the near future. In September 1999, WSNs were identified by Business Week as one of the most important and impactive technologies for the 21st century Also, in January 2003, the MIT’s Technology Review stated that WSNs are one of the top ten emerging technologies .It is also estimated that WSNs generated less than $150 million in sales in 2004, but would top $7 billion by 2010 [133]. In December 2004, a WSN with more than 1000 nodes was launched in Florida by the ExScal team ,which is the largest deployed WSN to date.

The term wireless is normally used to refer to any type of electrical operation which is accomplished without the use of a "hard wired" connection. Wireless communication” is the transfer of information over a distance without the use of electrical conductors or "wires“ using some form of energy, e.g. radio frequency (RF), infrared light (IR), laser light, visible light, acoustic energy. A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument, e.g. thermocouple, strain gauge. In general, the term network can refer to any interconnected group or system. A network is any method of sharing information between two systems.

Latest technological advancement in the field of hardware has developed small size, low capacity sensors with limited embedded on board processing unit that is able to communicate wirelessly. However, a lot of sensor networks also obviously introduce an enormous amount of data in WSNs (wireless sensor networks), that can process receive and transmit signals/data [1]. When various sensor nodes that are independent to each other are employed inside the targeted area or in its vicinity, it is referred to as sensor network [2]. A WSN is a self-organizing network which is designed using spatially distributed and is used sensors for monitoring physical environmental. Since WSN is usually dynamic in nature, its topology will change frequently. This will cause adding a new node into the network due to loss of connectivity. In past, there were many conventional centralized algorithms which require knowing whole knowledge of the overall network and also needing to update the information of entire network. In order to avoid serious protocol failure, it is required to have error free transmission or critical node free of failure [3]. In order to avoid the failure caused by single node, clustering algorithms are used, as they execute locally within partial nodes.

Wireless Sensor Networks (WSNs) can be defined as a self-configured and infrastructure-less wireless networks to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location or sink where the data can be observed and analysed. A sink or base station acts like an interface between users and the network. One can retrieve required information from the network by injecting queries and gathering results from the sink. Typically a wireless sensor network contains hundreds of thousands of sensor nodes. The sensor nodes can communicate among themselves using radio signals. A wireless sensor node is equipped with sensing and computing devices, radio transceivers and power components. The individual nodes in a wireless sensor network (WSN) are inherently resource constrained: they have limited processing speed, storage capacity, and communication bandwidth. After the sensor nodes are deployed, they are responsible for self-organizing an appropriate network infrastructure often with multi-hop communication with them. Then the onboard sensors start collecting information of interest. Wireless sensor devices also respond to queries sent from a “control site” to perform specific instructions or provide sensing samples. The working mode of the sensor nodes may be either continuous or event driven. Global Positioning System (GPS) and local positioning algorithms can be used to obtain location and positioning information. Wireless sensor devices can be equipped with actuators to “act” upon certain conditions.

Wireless sensor networks (WSNs) enable new applications and require non-conventional paradigms for protocol design due to several constraints. Owing to the requirement for low device complexity together with low energy consumption (i.e. long network lifetime), a proper balance between communication and signal/data processing capabilities must be found. This motivates a huge effort in research activities, standardization process, and industrial investments on this field since the last decade ([Chiara et. al. 2009](https://www.intechopen.com/books/wireless-sensor-networks-technology-and-protocols/overview-of-wireless-sensor-network#B8)). At present time, most of the research on WSNs has concentrated on the design of energy- and computationally efficient algorithms and protocols, and the application domain has been restricted to simple data-oriented monitoring and reporting applications (Labrador et. al. 2009). The authors in ([Chen et al., 2011](https://www.intechopen.com/books/wireless-sensor-networks-technology-and-protocols/overview-of-wireless-sensor-network#B36)) propose a Cable Mode Transition (CMT) algorithm, which determines the minimal number of active sensors to maintain K-coverage of a terrain as well as K-connectivity of the network. Specifically, it allocates periods of inactivity for cable sensors without affecting the coverage and connectivity requirements of the network based only on local information. In (Cheng et al., 2011), a delay-aware data collection network structure for wireless sensor networks is proposed. 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. In ([Matin et al., 2011](https://www.intechopen.com/books/wireless-sensor-networks-technology-and-protocols/overview-of-wireless-sensor-network" \l "B25)), the authors have considered relay nodes to mitigate 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. Energy efficient communication has also been addressed in ([Paul et al., 2011](https://www.intechopen.com/books/wireless-sensor-networks-technology-and-protocols/overview-of-wireless-sensor-network#B4); [Fabbri et al. 2009](https://www.intechopen.com/books/wireless-sensor-networks-technology-and-protocols/overview-of-wireless-sensor-network" \l "B13)). In ([Paul et al., 2011](https://www.intechopen.com/books/wireless-sensor-networks-technology-and-protocols/overview-of-wireless-sensor-network#B4)), the authors proposed a geometrical solution for locating the optimum sink placement for maximizing the network lifetime. Most of the time, the research on wireless sensor networks have considered homogeneous sensor nodes. But nowadays researchers have focused on heterogeneous sensor networks where the sensor nodes are unlike to each other in terms of their energy. In ([Han et al., 2010](https://www.intechopen.com/books/wireless-sensor-networks-technology-and-protocols/overview-of-wireless-sensor-network#B37)), the authors addresses the problem of deploying relay nodes to provide fault tolerance with higher network connectivity in heterogeneous wireless sensor networks, where sensor nodes possess different transmission radii. New network architectures with heterogeneous devices and the recent advancement in this technology eliminate the current limitations and expand the spectrum of possible applications for WSNs considerably and all these are changing very rapidly.

On comparing with centralized algorithms, clustering algorithms are more robust and scalable. To obtain prolong life of the network, energy efficient protocols are designed according to the characteristics of WSN, by efficiently organizing the sensor nodes in clusters.

CHARACTERISTICS OF WSN:

It was observed that there were many similarly between sensor network and ad hoc networks, both are dynamic and on demand. Some other similar characteristics are mobility, switching and the limit capability of the battery power. WSN also has some distinct properties as listed below

A. Power Efficiency Sensor nodes are often facing problem of void and dumped due to battery power run down of sensor node. In addition, as per many researches the energy consumes by the nodes in sending data over the communication is more than the energy of the nodes in computing. Therefore, maximize wireless sensor network’s lifetime is a problem is exists.

B. Fault Tolerance The wireless sensor nodes have ability of organizing itself in the network as nodes have deployed in random fashion remote location and unreceptive environment. For preventing from fault sensor nodes have worked in collaboration to reorganize itself and used distributed algorithm to form network automatically

C. Mobility of Nodes As it knows that wireless sensor network is collection sensor network in which some nodes are movable and some are static. We say that nature of WSN is dynamic. Due to limited resources nodes can failed for battery fatigue or some other conditions, communication channel may be disrupted. Topology is also affected by adding of node or failure of node. Thus, the WSN nodes have developed the function of self-governing and self-management

D. Heterogeneity of Nodes Heterogeneous means different nature of nodes, which are different from each other by the communication range, mobility, sensing parameters and work at different protocols etc. Heterogeneous WSN are collection of various different types of sensor nodes with have different features, follow different protocol, different computation capacity and different sensing and monitoring range. Deployment of heterogeneous sensor network more typical than homogeneous wireless sensor network

E. Scalability of Node In WSNs sensor nodes are able to collecting, processing, arranging, aggregating and sending data to sink node or base station. As number of nodes increases sensor network become very large. In the large network sensor nodes are able to communicate with faraway nodes but also produce traffic problem, difficult to manage and coordinate

F. Responsiveness WSN has ability to quickly adapt itself the changes in the topology. It has considered its responsiveness. To get highly responsiveness in the network. It needs to compromise with latency of network and as well as scalability

G. Communication Failures Wireless sensor networks work in free style fashion as ad hoc in nature. Sensor device has very low communication bandwidth and low communication distance range. And also it has some mobility degree of freedom. Sensor network will also be affected by the impact of natural disaster such as mountains slid, buildings damage and storms and cyclones, heavy rain falls and thunder lighting, the remote location obstacles, weather, and many more. That’s why; it is very difficult to manage and maintain WSN run smoothly. This is an important impact of research direction in the future

COMPONENTS OF WSN

A. Gateway: Gateways work as system network administrators to interface with node to Personal Computers (PCs) and Personal Digital Assistants (PDAs). Gateway may classify into various states:

1. Active

2. Passive

3. Hybrid Active gateway (sensor node) sends its message asynchronously to the server gateway. Passive gateway has worked in different way from active gateway. First it has sent a request packet to nodes and then has sent its own data. As the name suggest Hybrid gateway works as both active and passive gateway, which can operate in both of the states

B. Sensor/Actuator :

Without sensor we can image wireless sensor network. Sensors device collects data from their surrounding and convert environmental attribute/property just like sound, temperature, color, smoke, light, vibration and many more physical properties etc. into analog signals

C. Sensor Node:

Basically sensor nodes are three types

1. Temperature sensor node

2. Vibration sensor node

3. Moisture Sensor Node

But some other nodes can have more advantage that have taken capture pictures, motion detection, pressure monitor, intensity of light, etc

The sensor nodes are transceivers usually scattered in a sensor field where each of them has the capability to collect data and route data back to the sink/gateway and the end-users by a multi-hop infrastructureless architecture through the sink. They use their processing capabilities to locally carry out simple computations and transmit only the required and partially processed data. The sink may communicate with the task manager/end-user via the Internet or satellite or any type of wireless network (like WiFi, mesh networks, cellular systems, WiMAX, etc.), making Internet of Things possible. However, in many cases the sink can be directly connected to the end-users. Note that there may be multiple sinks/gateways and multiple end-users in the architecture, each sensor node is consisting of five main components; a microcontroller unit, a transceiver unit, a memory unit, a power unit and a sensor unit. Each one of these components is determinant in designing a WSN for deployment. The microcontroller unit is in charge of the different tasks, data processing and the control of the other components in the node. It is the main controller of the wireless sensor node, through which every other component is managed. The controller unit may consist of an on-board memory or may be associated with a small storage unit integrated into the embedded board. It manages the procedures that enable the sensor node to perform sensing operations, run associated algorithms, and collaborate with the other nodes through wireless communication. Through the transceiver unit a sensor node performs its communication with other nodes and other parts of the WSN. It is the most power consumption unit. The memory unit is for temporal storage of the sensed data and can be RAM, ROM and their other memory types (SDRAM, SRAM, EPROM, etc.), flash or even external storage devices such as USB. The power unit, which is one of the critical components, is for node energy supply. Power can be stored in batteries (most common) rechargeable or not or in capacitors. For extra power supply and recharge, there can be used natural sources such as solar power in forms of photovoltaic panels and cells, wind power with turbines, kinetic energy from water, etc. Last but not least is the sensor unit, which is the main component of a wireless sensor node that distinguishes it from any other embedded system with communication capabilities. It may generally include several sensor units, which provide information gathering capabilities from the physical world. Each sensor unit is responsible for gathering information of a certain type, such as temperature, humidity, or light, and is usually composed of two subunits: a sensor and an analog-to-digital converter (ADC). The analog signals produced by the sensor based on the observed phenomenon are converted to digital signals by the ADC, and then fed into the processing unit. In WSNs, the sensor nodes have the dual functionality of being both data originators and data routers. Hence, communication is performed for two reasons: Source function: Each sensor node’s primary role is to gather data from the environment through the various sensors. The data generated from sensing the environment need to be processed and transmitted to nearby sensor nodes for multi-hop delivery to the sink. • Router function: In addition to originating data, each sensor node is responsible for relaying the information transmitted by its neighbours. The low-power communication techniques in WSNs limit the communication range of a node. In a large network, multi-hop communication is required so that nodes relay the information sent by their neighbours to the data collector, i.e., the sink. Accordingly, the sensor node is responsible for receiving the data sent by its neighbours and forwarding these data to one of its neighbours according to the routing decisions. Except for their transmit/receive operation state, transceivers can be put into an idle state (ready to receive, but not doing so) where some functions in hardware can be switched off, reducing energy consumption, a transceiver expends a similar amount of energy for transmitting and receiving, as well as when it is idle. Moreover, a significant amount of energy can be saved by turning off the transceiver to a sleep state whenever the sensor node does not need to transmit or receive any data. In this state, significant parts of the transceiver are switched off and the nodes are not able to immediately receive something. Thus, recovery time and start up energy to leave sleep state can be significant design parameters. When the transmission ranges of the radios of all sensor nodes are large enough and the sensors can transmit their data directly to the centralized base station, they can form a star topology. In this topology, each sensor node communicates directly with the base station using a single hop. However, sensor networks often cover large geographic areas and radio transmission power should be kept at a minimum in order to conserve energy; consequently, multi-hop communication is the more common case for sensor networks .In this mesh topology, sensor nodes must not only capture and disseminate their own data, but also serve as relays for other sensor nodes, that is, they must collaborate to propagate sensor data towards the base station. This routing problem, that is, the task of finding a multi-hop path from a sensor node to the base station, is one of the most important challenges and has received large attention from the research community. When a node serves as a relay for multiple routes, it often has the opportunity to analyze and pre-process sensor data in the network, which can lead to the elimination of redundant information or aggregation of data that may be smaller than the original data.

**ARCHITECTURE OF SENSOR NODE :**

This section discusses major components and other dependants components of wireless sensor network.

A. Main Components 1) Sensing Unit All sensor devices are equipped with sensing units. It is usually are divided into two sub units: sensors part and analog-to-digital. In sensor part which contains cameras, video, sound, and/or scalar sensors and analog-to-digital converters. Analog signals generated by sensor nodes and converted into digital signals with help of software and send to processing unit 2) Power Unit Power unit provides power to sensor node and sensor uses energy for many areas as sensing environment, data processing which come from sensor nodes and communicated to other sensor nodes. From many researches it is found that more energy is consume than any other processes. Basic source of power of sensor node is electrochemical material such as NiMH, NiZn, and lithium ion cells 3) Communication Unit . A communication unit is subsystem, stabilize interface between the device and the network and a make possible transmission and receiver with the help of communication software 4) Processing Unit After getting information or data from sensor nodes/devices then processing unit starts its execution in the system software as coordinating sensing. It is interacted with storage unit and communication tasks.

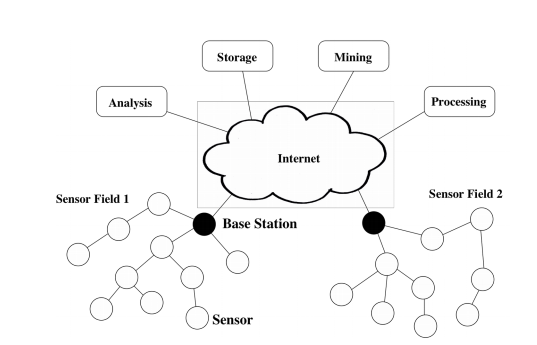


Figure: General System Model of a WSN

WSN Network Topologies:

For radio communication networks, the structure of a WSN includes various topologies like the ones given below:

#### Star Topologies:

Star topology is a communication topology, where each node connects directly to a gateway. A single gateway can send or receive a message to several remote nodes. In instar topologies, the nodes are not permitted to send messages to each other. This allows low-latency communications between the remote node and the gateway (base station).

Due to its dependency on a single node to manage the network, the gateway must be within the radio transmission range of all the individual nodes. The advantage includes the ability to keep the remote nodes’ power consumption to a minimum and simply under control. The size of the network depends on the number of connections made to the hub.

#### Tree Topologies:

Tree topology is also called as a cascaded star topology. In tree topologies, each node connects to a node that is placed higher in the tree, and then to the gateway. The main advantage of the tree topology is that the expansion of a network can be easily possible, and also error detection becomes easy. The disadvantage with this network is that it relies heavily on the bus cable; if it breaks, all the network will collapse.

#### Mesh Topologies:

## The Mesh topologies allow transmission of data from one node to another, which is within its radio transmission range. If a node wants to send a message to another node, which is out of the radio communication range, it needs an intermediate node to [forward the message](https://www.elprocus.com/wireless-pc-communication-system-using-transceiver/) to the desired node. The advantage of this mesh topology includes easy isolation and detection of faults in the network. The disadvantage is that the network is large and requires huge investment.

## Types of Wireless Sensor Networks

Depending on the environment, the [types of networks](https://www.elprocus.com/important-of-network-in-embedded-systems-for-beginners/) are decided so that those can be deployed underwater, underground, on land, and so on. Different types of WSNs include:

1. Terrestrial WSNs
2. Underground WSNs
3. Underwater WSNs
4. Multimedia WSNs
5. Mobile WSNs

#### Terrestrial WSNs

Terrestrial WSNs are capable of communicating base stations efficiently, and consist of hundreds to thousands of wireless sensor nodes deployed either in an unstructured (ad hoc) or structured (Pre-planned) manner. In an unstructured mode, the sensor nodes are randomly distributed within the target area that is dropped from a fixed plane. The pre planned or structured mode considers optimal placement, grid placement, and 2D, 3D placement models.

In this WSN, the [battery power](https://www.elprocus.com/battery-charger-timer-tips/)is limited; however, the battery is equipped with solar cells as a secondary power source. The Energy conservation of these WSNs is achieved by using low duty cycle operations, minimizing delays, and optimal routing, and so on.

#### Underground WSNs

The underground wireless sensor networks are more expensive than the terrestrial WSNs in terms of deployment, maintenance, and equipment cost considerations and careful planning. The WSNs networks consist of several sensor nodes that are hidden in the ground to monitor underground conditions. To relay information from the sensor nodes to the base station, additional sink nodes are located above the ground.

The underground wireless sensor networks deployed into the ground are difficult to recharge. The sensor battery nodes equipped with limited battery power are difficult to recharge. In addition to this, the underground environment makes wireless communication a challenge due to the high level of attenuation and signal loss.

More than 70% of the earth is occupied with water. These networks consist of several sensor nodes and vehicles deployed underwater. Autonomous underwater vehicles are used for gathering data from these sensor nodes. A challenge of underwater communication is a long propagation delay, and bandwidth and sensor failures .Underwater, WSNs are equipped with a limited battery that cannot be recharged or replaced. The issue of energy conservation for underwater WSNs involves the development of underwater communication and networking techniques. Multimedia wireless sensor networks have been proposed to enable tracking and monitoring of events in the form of multimedia, such as imaging, video, and audio. These networks consist of low-cost sensor nodes equipped with microphones and cameras. These nodes are interconnected with each other over a wireless connection for data compression, data retrieval, and correlation

The challenges with the multimedia WSN include high energy consumption, high bandwidth requirements, data processing, and compressing techniques. In addition to this, multimedia contents require high bandwidth for the content to be delivered properly and easily. These networks consist of a collection of sensor nodes that can be moved on their own and can be interacted with the physical environment. The mobile nodes can compute sense and communicate. Mobile wireless sensor networks are much more versatile than static sensor networks. The advantages of MWSN over static wireless sensor networks include better and improved coverage, better energy efficiency, superior channel capacity, and so on.

Internet of Things (IoT) is a significant source of technological solutions in several applications. The IoT is pillared by a wireless sensor network (WSN) which decreases the cost of the new technology. Literature verifies that this technology integration will reduce costs and ensure convenience in daily

life through smart sensor node networks whereby the nodes have access to internet

WSN, an inexpensive legacy system, has been applied in several fields, such as industrial control, environmental monitoring, military surveillance, and intelligent transportation systems providing large-scale physical data that can be further utilized. Thus, by integrating the IoT and WSN

applications, no massive paradigm shift is needed WSN-based IoT is advantageous for its convenient deployment and low cost. Furthermore, it can function independently in harsh or high-risk places where human presence is not possible. However, WSNs have defects that need to be addressed. The network lifetime problem is the main challenge in WSN. The sensor's lifetime is only related to its batteries, which are difficult or impossible to replace or recharge due to the

rugged environments where they are operating This problem undermines the integration of the WSN into IoT, elevating the costs of new technology. Accordingly, prolonged network lifetime is considered as a major challenge in the WSN- based IoT. Consequently, to prolong the network's life- time and improve energy consumption, a clustering approach is used in the WSN. The clustering protocol, where the sensor nodes are divided into small clusters, is an effective technique to reduce energy consumption and prolong network lifetime by avoiding long-distance communication .Each cluster employs one node as a cluster head (CH) that has duties more than member nodes (MNs). Practically, each MN in the cluster transmits its sensing data to its CH, and then the CH transmits these data to BS via a single-hop or multi-hop manner.

IoT is a significant regional arrangement that is related to the typical features of a conventional system that can communicate and trade data with one another. The system method can include any equipment, programming or sensors. IoT provides data management and security management. IoT connects individuals and objects from anywhere .IoT can use in a combination of uses such as vehicle response to vehicles, smart buildings, acute stress, quick medical services, smart cities .The internet is currently a series of system associations where the number of related devices is overgrowing. At present, the internet is being used to access process and order ongoing parameters from remote locations. A large number of sensors are used to control electrical machines for a long time in the past few days for domestic automation. However, it is not appropriately implemented, then cost-effectiveness and efficiency will not improve .For home automation, a large number of sensors have been used for a long time to control electrical equipment. This is not cost effective because of the many sensors used. Each device requires its sensor, so the cost and power consumed will increase as the number of devices increases. In modern IoT systems, a large number of sensors can replace by a small number of sensors, IoT can be placed on one platform and thus consume power and energy. The context recognition system is designed to operate IoT effectively. Even in the most potent scenarios, wireless sensor networks that play an essential role in various monitoring applications are ideal application . The emergence of a smarter grid increases the reliability of the system by taking pro-active steps when the power crisis and natural disasters occur. Increased emissions make it easier for consumers to reduce their dependence on the grid which involves greenhouse gas emissions from burning fossil fuels. Distributed generation using electronic converters and inverters, it is possible to overcome distributed problems by activating grid and island mode failures to cause power plants to turn off .Detecting and control framework has three primary stages in particular: sensing stage, data response stage, and control stage. The sensing unit must generally operate by using a wireless sensor node (WSN) .It is estimated that the WSN is exceptional and not suitable for a variety of topologies, is a versatile and promising innovation, allowing proper inspection and enhancement of power system .Data correspondence can realize with the ultra-low power RF (radio frequency) signal used by the WSN receiver module. The control framework can appreciate with an electronic power converter that used as a substitute to send the generated control to the network.

**CHAPTER-3**

**LITERATURE REVIEW**

**[1] T. Shah, N. Javaid, T. N. Qureshi :** This paper presents Wireless Sensor Networks (WSNs), with growing applications in the environment which are not within human reach have been addressed tremendously in the recent past. For optimized working of network many routing algorithms have been proposed, mainly focusing energy efficiency, network life-time, clustering processes. Considering homogeneity of network, we proposed Energy Efficient Sleep Awake Aware (EESAA) intelligent routing protocol for WSNs. In our proposed technique we evaluate and enhance certain issues like network stability, network lifetime and cluster head selection process. Utilizing the concept of characteristical pairing among sensor nodes energy utilization is optimized. Simulation results show that our proposed protocol significantly improved the network parameters and can be a useful approach for WSN

**Summary**: Studied about a homogeneity of network, Energy Efficient Sleep Awake Aware (EESAA) intelligent routing protocol for WSNs.

**[2] Heinzelman, Wendi Rabiner, Anantha Chandrakasan, and Hari Balakrishnan:** Wireless distributed microsensor systems will enable the reliable monitoring of a variety of environments for both civil and military applications. In this paper, we look at communication protocols, which can have significant impact on the overall energy dissipation of these networks. Based on our findings that the conventional protocols of direct transmission, minimum-transmission-energy, multi-hop routing, and static clustering may not be optimal for sensor networks, we propose LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilizes randomized rotation of local cluster based station (cluster-heads) to evenly distribute the energy load among the sensors in the network. LEACH uses localized coordination to enable scalability and robustness for dynamic networks, and incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to the base station. Simulations show the LEACH can achieve as much as a factor of 8 reduction in energy dissipation compared with conventional outing protocols. In addition, LEACH is able to distribute energy dissipation evenly throughout the sensors, doubling the useful system lifetime for the networks we simulated.

**Summary:** Studied about LEACH (Low-Energy Adaptive Clustering Hierarchy).

**[3] Y. Ebrahimi and M. Younis:** In wireless sensor networks, nodes probe ambient conditions in their surrounding and report back to the base-station via multi-hop routing. In a hostile environment the network may be subject to adversary attacks. Given the role that the base-station plays, it can be targeted in order to inflict the most damage to the network. Although stealth design and other physical precautionary measures may be pursued to hide the base-station, the fact that the base-station acts as a sink of all data transmission enables an adversary to employ traffic analysis techniques and identify the location of the base-station. This paper presents a novel approach for countering such traffic analysis and boosting the anonymity of the base-station. Sensors in low activity areas will send out deceptive packets among each other in order to distract the attention of the adversary and make the traffic analysis inconclusive. Simulation results show the effectiveness of the approach.

**Summary:** Studied about novel approach for countering such traffic analysis and boosting the anonymity of the base-station

**[4] aring, Alan, et al:** We provide an in-depth study of applying wireless sensor networks to real-world habitat monitoring. A set of system design requirements are developed that cover the hardware design of the nodes, the design of the sensor network, and the capabilities for remote data access and management. A system architecture is proposed to address these requirements for habitat monitoring in general, and an instance of the architecture for monitoring seabird nesting environment and behavior is presented. The currently deployed network consists of 32 nodes on a small island off the coast of Maine streaming useful live data onto the web. The application-driven design exercise serves to identify important areas of further work in data sampling, communications, network retasking, and health monitoring.

**Summary:** Studied about requirements for habitat monitoring.

**[5] N. Javaid, U. Qasim, Z. A. Khan, M. A. Khan, K. Latif and A. Javaid**

In Wireless Multi-hop Networks (WMhNs), routing protocols with energy efficient and delay reduction techniques are needed to fulfill users' demands. In this paper, we present Linear Programming models (LP\_models) to assess and enhance reactive routing protocols. To practically examine constraints of respective LP\_models over reactive protocols, we select AODV, DSR and DYMO. It is deduced from analytical simulations of LP models in MATLAB that quick route repair reduces routing latency and optimizations of retransmission attempts results efficient energy utilization. To provide quick repair, we enhance AODV and DSR. To practically examine the efficiency of enhanced protocols in different scenarios of WMhNs, we conduct simulations using NS-2. From simulation results, enhanced DSR and AODV achieve efficient output by optimizing routing latencies and routing load in terms of retransmission attempts.

**Summary:** Studied about the NS2 tool, Linear Programming models (LP\_models) to assess and enhance reactive routing protocols.

**CHAPTER-4**

**EXISTING METHOD**

An improved energy-efficient clustering protocol (IEECP) to prolong the lifetime of the WSN-based IoT which consists of three parts: Firstly, a modified mathematical model is proposed based on the analysis of the energy consumption model for multi-hop communications and overlapping clusters in order to determine the optimal number of clusters. Secondly, a modified fuzzy C-means algorithm (M-FCM) is proposed in order to produce balanced cluster. Thirdly, a new algorithm is proposed known as CH selection and rotation algorithm (CHSRA) that integrates the back-off timer mechanism for

CH selection, with a new rotation mechanism for CH rotation among members of the cluster.

The main contribution by the proposed protocol is the prolonging of the WSN-based IoT lifetime that depends on the node's battery, which extensively increases the applications' range of the WSN-based IoT. This major contribution can be achieved through the following tasks:

1) Selecting the optimal number of clusters based on the modified mathematical model by considering the overlapping case among clusters and multi-hop communications,

2) Forming balanced clusters that reduce the cost in the intra-distance based on modified fuzzy C-means algorithm (M-FCM) that result from a combination of the FCM algorithm with a centralized mechanism,

3) Reducing the energy overhead that results from the CH selection process in each round by a new integration of the back-off timer mechanism for CH selection with rotation mechanism in one algorithm known as CH selection and rotation model (CHSRA),

4) Balancing the communication distance among the CHs in the network based on a new objective function for the back-off mechanism, and

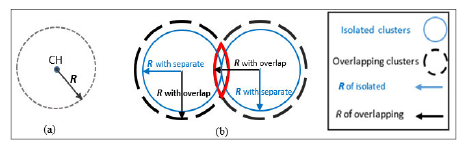
5) Balancing the life of the selected CHs in the cluster based on a new dynamic threshold.

This section clarifies the proposed protocol which consists of three parts: determination of the optimal number of clusters based on a modified mathematical model, formation of balanced clusters based on a modified fuzzy C-means (M-FCM) and selection and rotation of the CH for clusters based on the CH selection-rotation algorithm (CHSRA).The clustering protocol should consider four aspects: 1) the optimal number of clusters, 2) the formation of balanced and static clusters, 3) the evenly distribution of the selected CHs in the monitoring area with low overhead in the selection process, and finally, 4) the CH rotation process that relies on a threshold value. However, these factors have not been addressed in depth by the existing studies, hence, affecting the clustering protocol performance.

A. DETERMINATION OF THE OPTIMAL NUMBER FOR CLUSTERS

The mathematical model is popularly used in the domain to ascertain the number of clusters. This method is less time-consuming in finding the number of clusters, where the number of clusters is defined prior to the execution of the deployment process for nodes. Accordingly, it is suitable for all types of applications, especially for real-time applications, hence, drawing many studies to utilize this method to determine the optimal number of clusters. This method is often executed by the BS.

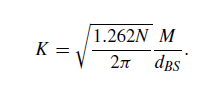
The mathematical model relies on a disk model to represent the distance to the CH. The disk model [7] is often utilized for studying the WSN communication, taking into account the coverage area for the transmission and entailing a disk of the plane with radius R, as shown in Figure 5.1(a). This value represents the distance to the CH in the mathematical model. The estimated value of radius (R) has a significant effect on the final result of the number of clusters, as proven later in this paper. Although other studies consider the distance to CH is the same whether the clusters are overlapping or isolated, in reality, the value of the radius is greater in the overlapping clusters, as shown in Figure 5.2(b).We assume that N nodes are deployed randomly in a square sensing area (M2). If K clusters exist, then the means number of the total nodes for each cluster is N/K (one CH and N/K -1 of MNs). Every cluster head consumes an amount of energy when receiving data from MNs, aggregating them from MNs, and transmitting the aggregate data to the BS. As the BS is located outside the sensing area, the multi-hop communication is used to transmit the sensing data to BS.



**Figure: disk model, and difference in radius between**

**overlapping clusters and separate clusters.**

The optimum number of clusters can be obtained and given by:

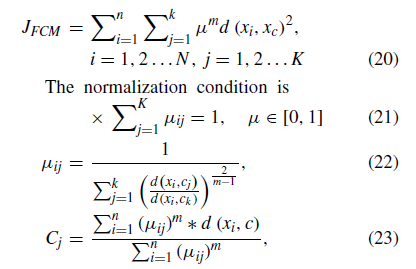


B. FORMATION OF BALANCED CLUSTERS

For the formation of balanced clusters, a modified fuzzy C-means algorithm (M-FCM) is proposed in this study by combining the FCM with a centralized mechanism. Before discussing the proposed algorithm to form balanced clusters, the conventional FCM algorithm is illustrated in the next section to provide a general idea.

1) FCM ALGORITHM OVERVIEW

The FCM algorithm has been widely used in the clustering processes for WSN cluster formation. This algorithm was originally presented by Dunn [31]. The goal of FCM is to form better clusters by reducing the summation of distances between the objects (N) and the cluster centers (C) by using the objective function. In WSN, the objects refer to nodes that are already distributed in the sensing area. The FCM objective function for organizing nodes into clusters in the WSN can be formulated as follows



where K refers to the number of clusters, N refers to the number of nodes, µ refers to the membership of node (i) to cluster (j), Cj refers to cluster centroid; d refers to the distance between a node (i) and centroid (cj), commonly described by Euclidean distance; and m is the value of the fuzzifier that is chosen as a real number greater than 1 (m 2 [1;1)). m approaches to 1 clustering tend to become crisp (same as K-means algorithm) but when it reaches to the infinity, clustering becomes fuzzified (unreliable) [32]. Therefore, the value of fuzzifier is usually chosen as 2 in most of the applications [33], [34]. To terminate the algorithm, we use the condition where t is the current iteration, and  is a very small number close to zero (e.g., 0.001). On certain occasions, FCM produces unbalanced clusters because of the nature of the random deployment of sensor nodes in the monitoring area ,This situation leads to unbalanced energy consumption for nodes, which adversely affects the network lifetime . Some of the studies sought to overcome this problem by rearranging the degrees of belonging for nodes to produce balanced clusters.However, relying on the degrees of belonging is inefficient because of a normalization condition in the membership function, leading to an increase in the intra-distance for the clusters. Consequently, this condition increases the energy consumption of nodes .

To address this issue, a modified clustering algorithm has been proposed in this study to form balanced clusters with minimal intra-cluster distance by relying on the actual distance from centroids rather than the degrees of belonging for nodes.

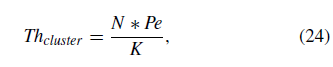
2) MODIFIED FCM (M-FCM)

The proposed clustering algorithm is executed at the BS and consists of two phases: 1) initial cluster formation, which is based on the FCM, and 2) balanced cluster formation, which is based on the CM. In the initial cluster formation, the FCM is applied to form the clusters as shown in the algorithm, and then the process shifts to the second phase. The balanced cluster formation phase consists of two sub phases. The first sub phase consists of the following steps:

1) The cluster threshold (Thcluster ) is determined based on below equation

2) Clusters are sorted based on size. Minimum cluster size is compared with that of the Thcluster .

If the size is greater than the Thcluster , then the FCM creates balanced clusters. Otherwise, the process shifts to the second subphase.



where Pe is the permittivity value equals to 0.85 [25], and K signifies the number of clusters.

In the second sub phase, CM considers the final centroids of the clusters that were produced from the previous phase (FCM phase) as initial points to form balanced clusters. Steps of the CM are as follows:

1. The distance between the initial points and nodes is determined.

2. Nodes are arranged based on their distance from the initial points.

3. The initial points select the nearest number of nodes that are equal to the threshold of the cluster value to join it.

4. The remaining nodes that are still non-jointed join the nearest initial point to construct the final clusters.

5. Each cluster determines the new centroid based on the means for node locations.

This procedure ensures that the minimum cluster size is equal to or greater than the threshold cluster range with lower intra- cluster distance.

**CH SELECTION AND ROTATION ALGORITHM:**

The CH selection and rotation issues have gained a great interest in researchers. Furthermore, in this study, a new algorithm has been proposed by integrating the back-off timer mechanism for CH selection with a rotation mechanism called CHSRA. In this algorithm, the CH is selected accurately by using a new objective function. Furthermore, the CH function is rotated among the members of the cluster based on a new rotation mechanism, where it is executed without any contribution to the BS.

The goal of CHSRA is to reduce the overhead by selecting the CH within members of the cluster only. Furthermore, it balances the distance among CHs in adjacent clusters by adopting the routing information in the CH selection process that leads to balanced energy consumption for CHs. Besides,the CHSRA ensures the balance in energy consumption for the successive CHs of the cluster. The CHSRA comprises two phases:

1) CH selection phase implemented by the back-off timer mechanism, and

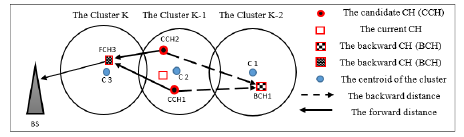
2) CH rotation phase implemented by the dynamic thresh- old mechanism.

**1) CH SELECTION PHASE**

The back-off timer mechanism is used to select the CH, which is a distributed mechanism. This mechanism is widely used in the literature because it reduces the overhead for nodes and has the least delay in the selection process. In this mechanism, each node in the cluster sets its timer. The node is set as either CH or CM according to its timer (Tb) and the advertisement (ADV) message is received before the timer terminates. If the node received the ADV message from another node in the cluster, then it will cancel its timer and become CM. However, if the timer expires and the node does not receive any message, it broadcasts the ADV message and becomes a CH [37]. The timer value is set based on an objective function (F) of the node, where the timer value is the converse of the objective function as follows



This is presumably, the first time that the back-off timer mechanism is applied to select the CH within members of the cluster. In the current study, this mechanism is applied to the CH selection in all network nodes, thus, increasing time and energy consumption. Another significant contribution con cerning the CH selection is to propose a new objective function for this mechanism that provides efficient distribution for the selected CHs in the network through selecting them in the optimal location. In this new objective function, the distance between a specific node to the forward CH (FCH) and the backward CH (BCH) is adopted along with the adjustment of coefficient for distances (ACD), in order to show the balance of distance between FCH and BCH and the residual energy of the node as the selection parameters for the CH selection process. This procedure ensures that the selected CH is in an optimal location according to the adjacent CHs of the other clusters. The proposed objective function relies on the a fore mentioned parameters rather than the residual energy of the node only [3]or the residual energy of the node and distance to the BS [24], as they do not guarantee the efficient distribution of the CHs in the network. Figure shows the effect of distances on the CH selection.

****

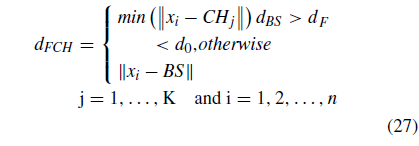
**Figure:** CH selection mechanism using backward and forward distance.

Consequently, each node in certain clusters computes the following parameters to define the objective function F, which are: residual energy Er to prevent selecting CH with low energy. The current value of energy in a node after receiving or transmitting routing packets is the residual energy

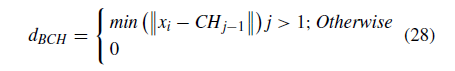


where Eini refers to the initial energy and Econ refers to the consumption energy of the node.

1) Euclidean distance from the nearest forward CH(dFCH ) to reduce the energy consumption for the candidate CH (j)



2) Euclidean distance from the nearest backward CH (dBCH ) to reduce energy consumption for backward CH (j-1)



3) ACD for the node; this coefficient is responsible for showing the balance of distance between FCH and BCH.



According to these parameters, the objective function F for CH selection is



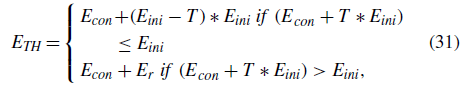
The selected CH based on this proposed algorithm over- comes the following two issues:

1) The energy overhead (additional energy cost) in the CH selection process is minimized by using the back-off time mechanism with members of the cluster rather than using all nodes in the network as in the current studies.

2) The CH is selected optimally because the required criteria for a balanced energy consumption in the selection are considered.

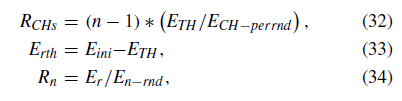
2) CH ROTATION PHASE

To solve the problem of unbalanced energy consumption for the successive CHs in the cluster, we set a dynamic threshold value for the CH rotation mechanism rather than the fixed value as in the other studies, where this value gradually increases with each process of the CH reselection. In this proposed mechanism, the energy consumed and the ratio from the initial energy (T) are used to estimate the threshold value. The first action taken by the selected CH directly after selection is calculating the value of its threshold for rotation (ETH) based on Eq. 31.



where Econ is the consumption energy of the node, Eini is the initial energy of the node, Er is the residual energy of the node, and T is a constant value of initial energy but may differ from one cluster to another subjects to the number of members in the cluster. The T value is estimated only once

for the cluster throughout the network lifetime. The T value can be calculated as follows



where RCHs refers to the rounds of all CHs in the cluster at the ETH , with Erth as the residual energy of the node at the ETH value, Rn represents the rounds of the member nodes in the cluster at the ETH , is the energy consumption per round for the CH, is the energy consumption per round for the nodes; and ETH is the threshold value within the range from 0.1 to 0.9 of the initial energy values for the node.



The appropriate value of T represents the intersection point of the curve of all CH rounds with the curve of members' rounds. At the end of each round, the CH in the cluster compares its energy with the threshold value that is computed based on Eq. 32. If the residual energy of the current CH is equal to or less than the threshold value, then the current CH changes. Otherwise, the CH continues its function. Finally, the preceding algorithms are combined in the IEECP framework that represents the main objective of this study, .For data transmission, members of the cluster directly transmit the sensing data to their selected CH. Then, the CH transmits this data to the BS by using a multi-hop manner. This manner is considered an advantageous option used to reduce energy consumption in case of relatively long-distance transmission [28]. In this manner, we adopt the same mechanism as portrayed in the [25]; the chosen CH checks if its transmission distance to BS is less than d0; it transmits the data directly to BS. Otherwise, it selects the nearest forward CH (towards BS) to reduce the energy consumption for CHs. Although this mechanism will lead to some delay in data

arrival at BS, it can bypass the long transmission distance for the selected CH, leading to energy saving for CHs.

the execution of the IEECP protocol processes occurs in two different places. The first place is the BS, where the number of clusters is computed initially based on the modified mathematical model, and then the balanced clusters are formed based on the M-FCM. The second place is the node, where the CH selection and rotation are processed based on the CHSRA algorithm. The determination of the number of clusters does not con- tribute to any time complexity, hence, it is deemed suitable for real-time applications. For the M-FCM, the time complexity is O((NK^2 x IFCM)+NK). The time complexity for FCM is O(NK^2 x IFCM) as reported by [20], where Nis the number of sensor nodes of the network, K is the required number of clusters, and IFCM is the number of FCM iterations. In M-FCM, the time complexity has been increased by NK rather than in FCM. However,

due to the one-time execution of this procedure through the BS prior to the network operation, there is no contribution to the time complexity related to M-FCM at the network operation. Moreover, since the BS does not have constraints related to the memory as found in the sensors, the space complexity of the M-FCM algorithm does not constitute any obstacle at the formation of clusters. Therefore, the parts of the IEECP protocol executed at the BS do not perform any time and space complexity with regard to the network operation. Since CHSRA is a distributed algorithm which is being applied within the cluster (it is not applied for the whole network), the member of the cluster updates its information

at each round. The CH re-selection phase occurs when the energy consumption of the current CH is more than the threshold; members of the cluster (n) need to update their information to select the next CH for the cluster by relying on CHs for other clusters (K-1). Thus, the analysis of the time complexity is based on the equations given in (30). Therefore,the time complexity is O (nxIround CK-1), where I\_round is the number of rounds for the node until it dies. Consequently, the time complexity for the CHSRA is identical for the linear function, which is a small contribution for time complexity in terms of CH selection and rotation processes [38]. Further-more, the space complexity of the CHSRA is O (K^2+50), where it is an acceptable contribution of the space complexity for processes of the CH selection and rotation. As for the overload complexity, the nodes do not suffer from overhead during the formation of clusters due to the fact that this process occurs only once in the network, executed by the BS, getting the benefit of forming static clusters through a centralized approach. Likewise, for CHSRA, the overload for the CH selection is reduced to the maximum possible extent, as during the selection process only the node that will be the CH broadcasts ADV message to the rest of the cluster members for joining it. Similarly, for the re-selection process, only the CH broadcasts the message to the rest of the cluster members for the re-election. Therefore, the overhead complexity of the CHSRA is dependent upon the number of CH in the network, which equal to the number of clusters K. The overhead complexity of the CHSRA is constant and identical to an O(1) because K is a predefined fixed value. In other words, the overhead complexity is independent of the network size.

**DISADVANTAGES:**

1. Complexity.

2. More energy consumption.

**CHAPTER-5**

**PROPOSED METHOD**

Technology advancements have created a numerous chances for resource efficiency in critical environments. In this context, Wireless Sensor Networks (WSNs) have ushered in a revolution. With the development of this technology, it became possible to collect and distribute useful information to the desired location. These schemes can be used to monitor applications such as battlefield surveillance, smart offices, traffic monitoring, and so on.

A wireless sensor network (WSN) is often made up of a collection of sensors that probe their physical surroundings for data and send their findings to a central controller nearby. The controller collects all of the data from the sensor nodes and connects the WSN to distant users who use it to plan specific actions. WSNs are ad hoc networks in which sensor nodes are dispersed across a region of interest for real-time data extraction. Sensor nodes perform both sensing and routing functions. To transport data from the first source node to the destination node, multiple sensor nodes may be employed (i.e., multi-hop communication).

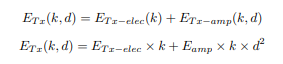
Each sensor has a limited quantity of energy when a WSN is deployed. Sensors are fueled by the power subsystem, and every action a sensor takes has an energy cost that depletes the sensor's power over time. Some tasks, like as communication, necessitate a significant amount of power, but others, such as data processing and sensing, necessitate very little. When a sensor loses power, it loses the ability to sense data, communicate with other nodes, and route data. The loss of a single node has little impact on the WSN, but as more nodes die out, the network's performance degrades and becomes unreliable. Small and affordable devices come with a tradeoff: the network is resource constrained and has a finite lifespan.

WSNs are used to monitor certain parameters in a variety of applications, including environment monitoring, habitation monitoring, [3] war field, agriculture field monitoring, and smart homes. To monitor the field, these wireless sensors are scattered throughout the detecting region.

Sensor nodes in WSNs are powered by a finite amount of energy. Data transmission from sensor nodes to sink must use the least amount of power possible. Battery recharge is one of the most difficult challenges in WSN. To address the problem of battery recharging, an efficient routing protocol is necessary. WSN technology [4], proposes a number of energy-efficient routing methods.

For WSN, we present a routing protocol that is high throughput, reliable, and stable. In a given area, we set up sensor nodes. Near the sink, sensors are positioned. Because sensors carry data and require low attenuation, great reliability, and extended life, they always send data directly to the sink. Other sensors track their parent node and send data to the sink via the forwarder node. It conserves node energy and allows the network to operate for longer.

Many radio models are proposed in literature. We use first order radio model proposed in [18]. This radio model consider d, the separation between transmitter and receiver and d2 , the loss of energy due to transmission channel. First order radio model equations are given as.





where ET x is the energy consumed in transmission, ERx is the energy consumed by receiver, ET x−elec and ERx−elec are the energies required to run the electronic circuit of transmitter and receiver, respectively. Eamp is the energy required for amplifier circuit, while k is the packet size., the communication medium which contributes attenuation to radio signal. Therefore, we add path loss coefficient parameter n in radio model, Above Equation of transmitter can be rewritten as.



A new technique to reduce energy use while increasing throughput.

Our contribution consists of the following:

The stability period of our proposed scheme is longer. Nodes are able to stay alive for longer periods of time while using the least amount of energy possible.

High throughput is aided by a long stability period and low node energy consumption.

A.Proposed Protocol:

We deploy numerous nodes in a region under this scheme. The power and compute capability of all sensor nodes are identical.

Two nodes are chosen, and these two nodes will transport data directly to the sink.

a) First phase:

During this phase, the sink sends out a brief data packet containing the sink's location in the area. Each sensor node stores the location of sink after receiving this control message. Each sensor node sends out a data packet that includes the node's ID, position in the area, and energy status. All sensor nodes are updated with the location of their neighbours and sink in this manner.

b) Forwarder Node Selection:

We designed a multi-hop approach for WSN in order to save energy and increase network throughput. The conditions for a node to become a parent node or forwarder are presented in this section. Proposed protocol elects a new forwarder in each round in order to balance energy consumption across sensor nodes and reduce network energy usage.

The ID, distance, and remaining energy status of the nodes are all known to the sink node. Sink calculates all nodes' cost functions and sends them to all nodes.

Every node determines whether or not to become a forwarder node based on this cost function. If n is the number of nodes, the following is the cost function for n nodes:

C.F (n)=

The distance between node n and sink is denoted by d (n) and R.E (n) is the residual energy of node n, determined by subtracting the current energy of node from the initial total energy. As a forwarder, it is preferable to use a node with a low cost function. All of the neighboring nodes join forces with the forwarder node and send data to it.

Data is gathered and sent to the sink via the forwarder node.Because the forwarder node has the most residual energy and travels the shortest distance to the sink, it uses the least amount of energy to send data there. Two chosen nodes interact directly with the sink and are not involved in data transmission.

c) Scheduling:

The forwarder node provides time slots to its progeny nodes using Time Division Multiple Access (TDMA) in this phase. Every child node sends its detected data to the forwarder node at a predetermined time. A node enters idle mode when it has no data to send. Only during transmission time do nodes wake up. The energy dissipation of individual sensor nodes is minimized when sensor nodes are scheduled. Performance metric of the proposed method is Energy consumption of nodes, here we use the residual energy parameter to study network energy consumption in order to investigate the energy consumption of nodes every round.

Deployment of sensor nodes in an area

Initial Phase

Forwarder Node Selection

Selection

Cost function calculation

Scheduling

**Block diagram of proposed method**

**CHAPTER-6**

**ADVANTAGES AND APPLICATIONS**

**Advantages:**

1.Less Complexity

2.Less energy consumption.

**Applications:**

1.industrial control

2.environmental monitoring,

3. military surveillance,

4.intelligent transportation systems and medical field.

5.Furthermore, it can function independently in harsh or high-risk places where human presence is not possible

6.Disaster relief operations.

7.Biodiversity mapping

8.monitoring of temperature, pressure, and humidity

**CHAPTER-7**

**MATLAB**

**7.1 INTRODUCTION TO MATLAB**

**What Is MATLAB?**

MATLAB is an elite dialect for specialized registering. It incorporates calculation, representation, and programming in an easy to-utilize condition wherein issues and preparations are communicated in herbal numerical documentation. Run of the mill utilizes comprise

• Math and calculation

• Algorithm advancement

• Data obtaining

• Modeling, re-enactment, and prototyping

• Data examination, investigation, and representation

• Scientific and designing illustrations

• Application advancement, including graphical UI building

MATLAB is an intuitive framework whose important statistics aspect is an show off that does not require dimensioning. This allows you to tackle several specialized processing issues, particularly those with framework and vector info, in a small quantity of the time it'd take to compose a program in a scalar non intuitive dialect, as an instance, C or FORTRAN.

The call MATLAB stays for grid studies facility. MATLAB changed into first of all composed to present easy access to framework programming created by way of the LINPACK and EISPACK ventures. Today, MATLAB motors fuse the LAPACK and BLAS libraries, inserting the cutting side in programming for network calculation.

MATLAB has advanced over a time of years with contribution from several customers. In university situations, it's far the usual academic apparatus for early on and propelled guides in mathematics, designing, and science. In enterprise, MATLAB is the tool of choice for excessive-profitability studies, advancement, and exam.

MATLAB highlights a collection of more utility-specific arrangements known as tool booths. Important to most clients of MATLAB, device kits permit you to learnandapply particular innovation. Tool compartments are exhaustive accumulations of MATLAB capacities (M-records) that reach out the MATLAB condition to take care of precise training of problems. Territories in which tool stash are reachable include flag coping with, manipulate frameworks, neural structures, fluffy reason, wavelets, pastime, and severa others.

**The MATLAB System:**

The MATLAB system consists of five main parts.

**Development Environment:**

 This is the set of tools and centres that help you operate MATLAB features and files. Many of that gear are graphical person interfaces. It includes the MATLAB desktop and Command Window, a command history, an editor and debugger, and browsers for viewing assist, the workspace, files, and the hunt direction.

**The MATLAB Mathematical Function:**

This is a great collection of computational algorithms ranging from standard capabilities like sum, sine, cosine, and complex arithmetic, to extra sophisticated features like matrix inverse, matrix eigen values, Bessel functions, and speedy Fourier transforms.

**The MATLAB Language:**

This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs.

**Graphics:**

MATLAB has considerable centres for displaying vectors and matrices as graphs, as well as annotating and printing those graphs. It consists of high-stage functions for 2-dimensional and 3-dimensional records visualization, photograph processing, animation, and presentation graphics. It also consists of low-stage capabilities that will let you absolutely customise the appearance of graphics as well as to construct complete graphical person interfaces for your MATLAB programs.

**The MATLAB Application Program Interface (API):**

This is a library that allows you to put in writing C and Fortran applications that have interaction with MATLAB. It consists of facilities for calling workouts from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for studying and writing MAT-documents.

**7.2 MATLAB WORKING ENVIRONMENT:**

## MATLAB DESKTOP:

Matlab Desktop is the principle Matlab application window. The desktop consists of five sub windows, the summon window, the workspace program, the existing catalog window, the order records window, and at the least one figure home windows, which can be proven simply while the consumer suggests a sensible.

The order window is the area the customer sorts MATLAB orders and expressions at the initiate (>>) and wherein the yield of these fees is shown. MATLAB characterizes the workspace because the association of factors that the customer makes in a work session. The workspace software demonstrates these elements and some statistics approximately them. Double tapping on a variable within the workspace application dispatches the Array Editor, which may be applied to get data and salary instances modify sure homes of the variable.

The present Directory tab over the workspace tab demonstrates the substance of the existing registry, whose way is seemed within the present index window. 1For case, within the windows running framework the manner may be as consistent with the subsequent: C:MATLABWork, demonstrating that registry "paintings" is a subdirectory of the primary catalog "MATLAB", which is delivered in pressure C. Tapping on the bolt inside the present index window demonstrates a rundown of as of past due utilized approaches. Tapping at the seize to one aspect of the window enables the client to exchange the existing catalog.

MATLAB utilizes an inquiry way to discover M-data and different MATLAB related documents, which might be sort out in catalogs within the PC file framework. Any file keep strolling in MATLAB must dwell inside the ebb and go with the flow registry or in an index that is on are trying to find manner. Of direction, the statistics supplied with MATLAB and math works device kits are included into the inquiry way. The least stressful method to look which indexes are at the inquiry manner. The handiest method to peer which catalogs are soon the quest way, or to encompass or regulate an inquiry manner, is to pick set manner from the File menu the computer, and after that utilization the set way exchange container. It is exquisite exercise to add any typically utilized catalogs to the pursuit way to hold a strategic distance from again and again having the exchange the existing index.

The Command History Window contains a record of the orders a client has entered in the charge window, including both present and past MATLAB sessions. Already entered MATLAB orders can be chosen and re-executed from the charge history window by right

tapping on a summon or arrangement of orders. This activity dispatches a menu from which to choose different choices notwithstanding executing the orders. This is helpful to choose different choices notwithstanding executing the summons. This is a valuable component while trying different things with different orders in a work session

**Using the MATLAB Editor to create M-Files:**

The MATLAB manager is both a word processor unique for making M-statistics and a graphical MATLAB debugger. The proofreader can display up in a window without everybody else, or it could be a sub window in the laptop. M-facts are intended by means of the expansion .M, as in pixelup.M. The MATLAB editorial manager window has various draw down menus for errands, for instance, sparing, seeing, and troubleshooting documents. Since it plays out a few basic checks and furthermore utilizes shading to separate between exclusive additives of code, this content device is suggested as the equipment of selection for composing and changing M-capacities. To open the proofreader, sort regulate at the incite opens the M-report filename.M in a supervisor window, organized for altering. As referred to before, the record has to be inside the momentum catalog, or in an index within the pursuit manner.

**Getting Help:**

The important technique to get help on line is to utilize the MATLAB assist application, opened as a exclusive window both via tapping at the query mark image at the computing device toolbar, or by using writing help program on the provoke within the order window. The help Browser is an internet application coordinated into the MATLAB computing device that shows a Hypertext Markup Language (HTML) statistics. The Help Browser contains of two sheets, the assistance pilot sheet, used to find out data, and the show sheet, used to look the statistics. Clear as crystal tabs aside from pilot sheet are applied to play out a pursuit. Second, within the motion pictures taken via transferring camera setup, the state of affairs becomes extra complex because the heritage may additionally exchange by using shifting shot, we cannot tune item motion exactly inside the sum of distinction map. Therefore, in this situation, the purpose is executed through reusing the previous seam and applying it to the cutting-edge body. In order to discover the seams, we use the preceding seam from previous body to look the modern-day seam in contemporary frame. our method is using a seam computed in frame1 (in crimson) to go looking a comparable seam in frame2. For the pixels close by the area of previous seam, we decide how a lot the selected pixel might vary from the pixel of preceding seam. We use difference of the 2 pixels as the degree of temporal coherence. If the distinction value of first seam pixel is over the threshold, we can keep to go looking the next seam pixel on three feasible pixels (in yellow, blue and brown) in subsequent row, until we discover 5 consecutive pixels that also exceed the threshold.

When we can't search the matching seam, we recalculate the energy for a new seam. We assume a seam 𝑆l-1 has been calculated inside the previous body, and a seam must be calculated for the contemporary frame. For preserving the temporal coherence, we want to make a new seam close to the previous seam with the identical index. We use the distinction among preceding seam and all pixels at the current body as the measure

Thus we upload temporal coherence price Tc(i,j) to the strength map earlier than calculating a seam 𝑆L. The price Tc is zero while the body pixels have the equal fee as previous seam pixels. Using our temporal coherence price, we will calculate the seam which has least electricity and is more close to the preceding seam in previous frame. Consequently, we will decrease the jittery artifacts inside the films.

**COMMUNICATION:**

Communications System Toolbox™ offers algorithms and gear for the layout, simulation, and analysis of communications systems. These capabilities are furnished as MATLAB ® features, MATLAB System gadgets™, and Simulink ® blocks. The machine toolbox includes algorithms for source coding, channel coding, interleaving, modulation, equalization, synchronization, and channel modeling. Tools are supplied for bit blunders charge evaluation, producing eye and constellation diagrams, and visualizing channel characteristics. The machine toolbox additionally provides adaptive algorithms that allow you to version dynamic communications structures that use OFDM, OFDMA, and MIMO techniques. Algorithms support fixed-point facts arithmetic and C or HDL code era.

**Key Features**

▪ Algorithms for designing the physical layer of communications systems, which includes supply coding, channel coding, interleaving, modulation, channel fashions, MIMO, equalization, and synchronization

▪ GPU-enabled System objects for computationally intensive algorithms together with Turbo, LDPC, and Viterbi decoders

▪ Interactive visualization equipment, consisting of eye diagrams, constellations, and channel scattering capabilities

▪ Graphical tool for evaluating the simulated bit mistakes rate of a machine with analytical outcomes

▪ Channel models, consisting of AWGN, Multipath Rayleigh Fading, Rician Fading, MIMO Multipath Fading, and

LTE MIMO Multipath Fading

▪ Basic RF impairments, along with nonlinearity, section noise, thermal noise, and section and frequency offsets

▪ Algorithms available as MATLAB features, MATLAB System objects, and Simulink blocks

▪ Support for fixed-point modeling and C and HDL code technology

**System Design, Characterization, and Visualization:**

The layout and simulation of a communications gadget requires analyzing its reaction to the noise and interference inherent in real-world environments, reading its behavior the usage of graphical and quantitative manner, and determining whether the resulting overall performance meets requirements of acceptability. Communications System Toolbox implements a selection of obligations for communications machine layout and simulation. Many of the functions, System objects™, and blocks inside the device toolbox perform computations associated with a specific thing of a communications gadget, consisting of a demodulator or equalizer. Other talents are designed for visualization or evaluation.

**System Characterization**

The system toolbox offers several standard methods for quantitatively characterizing system performance:

▪ Bit error rate (BER) computations

▪ Adjacent channel power ratio (ACPR) measurements

▪ Error vector magnitude (EVM) measurements

▪ Modulation error ratio (MER) measurements

Because BER computations are fundamental to the characterization of any communications system, the system toolbox provides the following tools and capabilities for configuring BER test scenarios and accelerating BER simulations:

**BER tool**— A graphical user interface that enables you to analyze BER performance of communications systems. You can analyze performance via a simulation-based, semi analytic, or theoretical approach.

**Error Rate Test Console** — A MATLAB object that runs simulations for communications systems to measure error rate performance. It supports user-specified test points and generation of parametric performance plots and surfaces. Accelerated performance can be realized when running on a multi core computing platform.

**Multi core and GPU acceleration** — A capability provided by Parallel Computing Toolbox™ that enables you to accelerate simulation performance using multi core and GPU hardware within your computer.

**Distributed computing and cloud computing support** — Capabilities provided by Parallel Computing Toolbox and MATLAB Distributed Computing Server™ that enable you to leverage the computing power of your server farms and the Amazon EC2 Web service. Performance Visualization. The system toolbox provides the following capabilities for visualizing system performance:

**Channel visualization tool** — For visualizing the characteristics of a fading channel

**Eye diagrams and signal constellation scatter plots** — for a qualitative, visual understanding of system behavior that enables you to make initial design decisions

**Signal trajectory plots** — for a continuous picture of the signal’s trajectory between decision points

**BER plots** — for visualizing quantitative BER performance of a design candidate, parameterized by metrics such as SNR and fixed-point word size

**Analog and Digital Modulation**

Analog and digital modulation strategies encode the facts circulation into a sign this is appropriate for transmission. Communications System Toolbox presents some of modulation and corresponding demodulation abilities. These talents are available as MATLAB features and gadgets, MATLAB System Modulation sorts provided by the toolbox are:

**Source and Channel Coding**

Communications System Toolbox affords source and channel coding talents that can help you develop and compare communications architectures fast, enabling you to discover what-if eventualities and avoid the need to create coding competencies from scratch.

**Source Coding**

Source coding, also referred to as quantization or signal formatting, is a manner of processing facts a good way to lessen redundancy or prepare it for later processing. The system toolbox offers a diffusion of styles of algorithms for imposing source coding and interpreting, inclusive of:

▪ Quantizing

▪ Companding (*µ*-law and A-law)

▪ Differential pulse code modulation (DPCM)

▪ Huffman coding

▪ Arithmetic coding

**Channel Coding**

▪ orthogonal area-time block code (OSTBC) (encoder and decoder for MIMO channels)

▪ Turbo encoder and decoder examples

The gadget toolbox offers application functions for developing your personal channel coding. You can create generator polynomials and coefficients and syndrome deciphering tables, in addition to product parity-take a look at and generator matrices.

The system toolbox additionally presents block and convolutional interleaving and deinters leaving functions to reduce facts errors as a result of burst mistakes in a conversation machine:

**Block,** including General block interleaver, algebraic interleaver, helical scan interleaver, matrix interleaver, and random interleaver.

**Convolutional,** including General multiplexed interleaver, convolutional interleaver, and helical interleaver

**Channel Modeling and RF Impairments**

Channel Modeling

Communications System Toolbox provides algorithms and tools for modeling noise, fading, interference, and different distortions which might be commonly found in communications channels. The system toolbox supports the subsequent styles of channels:

▪ Additive white Gaussian noise (AWGN)

▪ Multiple-enter multiple-output (MIMO) fading

▪ Single-enter single-output (SISO), Rayleigh, and Rician fading

▪ Binary symmetric

A MATLAB channel object provides a concise, configurable implementation of channel models, enabling you to

specify parameters such as:

▪ Path delays

▪ Average path gains

▪ Maximum Doppler shifts

▪ K-Factor for Rician fading channels

▪ Doppler spectrum parameters

For MIMO systems, the MATLAB MIMO channel object expands these parameters to also include:

▪ Number of transmit antennas (up to 8)

▪ Number of receive antennas (up to 8)

▪ Transmit correlation matrix

▪ Receive correlation matrix

To combat the effects noise and channel corruption, the system toolbox provides block and convolutional coding and decoding techniques to implement error detection and correction. For simple error detection with no inherent correction, a cyclic redundancy check capability is also available. Channel coding capabilities provided by the system toolbox include:

▪ BCH encoder and decoder

▪ Reed-Solomon encoder and decoder

▪ LDPC encoder and decoder

▪ Convolutional encoder and Viterbi decoder

****

**RF Impairments**

To model the effects of a non-ideal RF front end, you can introduce the following impairments into your communications system, enabling you to explore and characterize performance with real-world effects:

▪ Memory less nonlinearity

▪ Phase and frequency offset

▪ Phase noise

▪ Thermal noise

You can include more complex RF impairments and RF circuit models in your design using SimRF™.

****

**Equalization and Synchronization**

Communications System Toolbox lets you discover equalization and synchronization strategies. These techniques are usually adaptive in nature and tough to design and symbolize. The machine toolbox affords algorithms and tools that will let you swiftly select the proper approach on your communications machine. Equalization To compare one-of-a-kind techniques to equalization, the device toolbox offers you with adaptive algorithms which include:

▪ LMS

▪ Normalized LMS

▪ Variable step LMS

▪ Signed LMS

▪ MLSE (Viterbi)

▪ RLS

▪ CMA

These adaptive equalizers are available as nonlinear decision feedback equalizer (DFE) implementations and as

Linear (symbol or fractionally spaced) equalizer implementations.

**Synchronization**

The device toolbox provides algorithms for each service segment synchronization and timing phase synchronization. For timing section synchronization, the machine toolbox presents a MATLAB Timing Phase Synchronizer object that offers the following implementation techniques:

▪ Early-late gate timing method

▪ Gardner’s method

▪ Fourth-order nonlinearity method

**Stream Processing in MATLAB and Simulink**

Most verbal exchange structures cope with streaming and frame-primarily based statistics using a aggregate of temporal processing and simultaneous multi frequency and multichannel processing. This form of streaming multidimensional processing can be visible in superior communication architectures consisting of OFDM and MIMO. Communications System Toolbox enables the simulation of advanced communications structures via helping move processing and frame-based simulation in MATLAB and Simulink. In MATLAB, circulate processing is enabled by way of System items™, which use MATLAB objects to symbolize time-based and facts-driven algorithms, sources, and sinks. System objects implicitly manipulate many information of flow processing, including information indexing, buffering, and management of set of rules state. You can mix System gadgets with fashionable MATLAB functions and operators. Most System items have a corresponding Simulink block with the identical abilities. Simulink handles circulation processing implicitly with the aid of coping with the float of information thru the blocks that make up a Simulink model. Simulink is an interactive graphical environment for modeling and simulating dynamic systems that uses hierarchical diagrams to symbolize a machine version. It includes a library of widespread-reason, predefined blocks to represent algorithms, resources, sinks, and device hierarchy.

**Implementing a Communications System**

Fixed-Point Modeling Many communications systems use hardware that requires a fixed-point representation of your design.

Communications System Toolbox supports fixed-point modeling in all relevant blocks and System objects™ with tools that help you configure fixed-point attributes.

Fixed-point support in the system toolbox includes:

▪ Word sizes from 1 to 128 bits

▪ Arbitrary binary-point placement

▪ Overflow handling methods (wrap or saturation)

▪ Rounding methods: ceiling, convergent, floor, nearest, round, simplest, and zero

Fixed-Point Tool in Simulink Fixed Point™ facilitates the conversion of floating-point data types to fixed point. For configuration of fixed-point properties, the tool tracks overflows and maxima and minima.

**Code Generation**

Once you've got advanced your set of rules or communications device, you can robotically generate C code from it for verification, rapid prototyping, and implementation. Most System gadgets, functions, and blocks in Communications System Toolbox can generate ANSI/ISO C code the use of MATLAB Coder™, Simulink Coder™, or Embedded Coder™. A subset of System gadgets and Simulink blocks also can generate HDL code. To leverage present highbrow belongings, you can choose optimizations for specific processor architectures and integrate legacy C code with the generated code.

You can also generate C code for both floating-point and fixed-point data types.

DSP Proto typing DSPs are used in communication system implementation for verification, rapid prototyping, or final hardware implementation. Using the processor-in-the-loop (PIL) simulation capability found in Embedded Coder, you can verify generated source code and compiled code by running your algorithm’s implementation code on a target processor. FPGA Prototyping

FPGAs are used in communication systems for implementing high-speed signal processing algorithms. Using the FPGA-in-the-loop (FIL) capability found in HDL Verifier™, you can test RTL code in real hardware for any existing HDL code, either manually written or automatically generated HDL code.

**CHAPTER -8**

**HARDWARE & SOFTWARE REQUIREMENTS:**

**Software:**

• Matlab R2018a.

**Hardware:**

**Operating Systems:**

• Windows 10

• Windows 7 Service Pack 1

• Windows Server 2019

• Windows Server 2016

**Processors:**

Minimum: Any Intel or AMD x86-64 processor

Recommended: Any Intel or AMD x86-64 processor with four logical cores and AVX2 instruction set support

**Disk:**

Minimum: 2.9 GB of HDD space for MATLAB only, 5-8 GB for a typical installation

Recommended: An SSD is recommended a full installation of all Math Works products may take up to 29 GB of disk space

**RAM:**

Minimum: 4 GB

Recommended: 8

**CHAPTER-9**

**RESULTS**

We used MATLAB R2018a to run for testing the proposed approach. We compared the proposed protocol's performance to that of the existing IEECP protocol.

The suggested model employs a multi hop architecture, in which the data from each distant node is sent through a forwarder node to the sink. The cost function is used to select the forwarder node. In each round, choosing the right forwarder helps you save energy. Our multi hop design uses a separate forwarder node in each cycle to transport packets to the sink, preventing overloading of a single node.

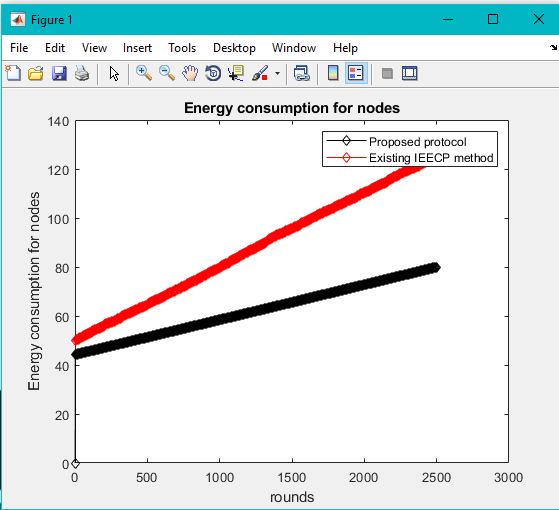


Figure : Energy consumption for effective network

**CHAPTER-10**

**CONCLUSION**

We propose a data routing mechanism in WSNs in this research. To choose an appropriate route to sink, the suggested scheme uses a cost function. The cost function is determined by the nodes' leftover energy and their distance from the sink. The parent node is chosen by the nodes with the lowest cost function value. Other nodes join the parent node as children and send their data to it. Due to their proximity to the sink, two nodes forward their data directly to it; yet, these two nodes cannot be elected as parent nodes because both sensor nodes contain crucial and important data. It is not necessary for these two nodes to expend energy forwarding data from other nodes.

**CHAPTER-11**

**REFERENCES**

[1] T. Shah, N. Javaid, T. N. Qureshi, "Energy Efficient Sleep Awake Aware (EESAA) Intelligent Sensor Network Routing Protocol," [2012 15th International Multitopic Conference (INMIC)](https://ieeexplore.ieee.org/xpl/conhome/6507006/proceeding).

[2] Y. Ebrahimi and M. Younis, “Using deceptive packets to increase base station anonymity in Wireless Sensor Network,” in Proc. Wireless Communications and Mobile Computing Conference, 2011, pp. 842–847.

[3] aring, Alan, et al. “Wireless sensor networks for habitat monitoring.” Proceedings of the 1st ACM international workshop on Wireless sensor networks and applications. ACM, 2002

[4] N. Javaid, U. Qasim, Z. A. Khan, M. A. Khan, K. Latif and A. Javaid, “On Energy Efficiency and Delay Minimization in Reactive Protocols in Wireless Multi-hop Network”, 2nd IEEE Saudi International Electronics, Communications and Photonics Conference (SIECPC 13), 2013, Riyadh, Saudi Arabia.

[5]Heinzelman, Wendi Rabiner, Anantha Chandrakasan, and Hari Balakrishnan. “Energy-efficient communication protocol for wireless microsensor networks.” System Sciences, 2000. Proceedings of the 33rd Annual Hawaii International Conference on. IEEE, 2000.

[6] D. Malan, T. Fulford-Jones, M. Welsh, and S. Moulton, "CodeBlue: An Ad Hoc Sensor Network Infrastructure for Emergency Medical Care," International Workshop on Wearable and Implantable Body Sensor Networks, 2004.

[7] Latré, B., P.D. Mil, I. Moerman, B. Dhoedt, P. Demeester and N.V. Dierdonck, 2006. Throughput and delay analysis of unslotted IEEE 802.15.4. J. NetWork., 1(1): 20-28.

[8]Liu, A., Ren, J., Li, X., Chen, Z., & Shen, X. (Sherman). (2012). Design principles and improvement of cost function based energy aware routing algorithms for wireless sensor networks. Computer Networks, 56(7), 1951–1967