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A Smart Multi-Attribute Decision Making Approach for Improving the Performance of Sensor Networks

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Abstract : *This study used a multi-attribute decision-making model to enhance wireless sensor network performance. An unwanted side effect of the increased demand for new services and ubiquitous connectivity in communication technologies is rising energy usage. The primary element of wireless infrastructure and the primary source of energy consumption in wireless sensor networks are the wireless network nodes. To properly service consumers and prevent frequent shutdowns, a well-designed and planned infrastructure is therefore required. In order to improve wireless sensor network energy savings, this work created a Multi-Attribute Decision Making Model and created a MATLAB Model for simulation and analysis of wireless sensor network energy savings. This Proposed Technique lasted until an estimated value of 330 rounds of simulation (82.5% energy efficient), whereas the Conventional Technique (Non-hierarchical) has a functional capability that lasted 120 rounds of simulation (30% energy efficient). The packet delivery ratio variation between the cluster-based Routing Technique active and deactivated states that the Proposed Model achieved a 96% packet delivery ratio compared to 64% for the Conventional (current) Model. In comparison to the Conventional Technique, the Proposed Technique's Sensor Network lifespan increased by 52.5%, indicating improved network performance.*

Keywords – *Wireless Sensor Network, Wireless Network Node, Micro Electromechanical Systems, Mobile Ad-hoc Networks, Received Signal Strength Indicator.*

I. INTRODUCTION

Many people believe that one of the most significant technological advancements of the twenty-first century will be wireless sensor networks, or WLANs [1]. Tiny, inexpensive, and intelligent sensors deployed in a physical area and networked through wireless links and the internet offer unprecedented opportunities for a variety of civilian and military applications, such as environmental monitoring, pipeline monitoring, battle field surveillance, and industrial process control [2]. These applications are made possible by recent advancements in micro electromechanical systems (MEMS) and wireless communication technologies. When sensor nodes are built properly, they can measure temperature, humidity, luminosity, and other parameters on their own. A sink node that has been set up for data collecting receives sensing data from sensor nodes. Future sensors will be widely available and more affordable, making user location-dependent services and sensor placement crucial. WSNs are distinct from traditional wireless communication networks, such as cellular systems and mobile ad-hoc networks (MANETs), due to their unique features, which include severe energy, computing, and storage constraints, a higher degree of node deployment density, and higher unreliability of sensor nodes [3]. These challenges create a number of new ones for the development and use of WSNs. A WSN is usually made up of several multifunctional, low-cost, low-power sensor nodes that are placed throughout an area of interest [4]. Despite their small size, these sensor nodes are packed with radio transceivers, embedded microprocessors, and sensors, giving them the ability to analyze and communicate data in addition to being sensory. They work together to complete a shared job while communicating over a short distance using a wireless means. In an energy-efficient test-bed, wireless sensor nodes which make up the majority of wireless infrastructure and are major sources of energy consumption for wireless sensor networks are used to reduce the negative effects of rising energy consumption and when infrastructure is well-planned, designed with a symmetric cryptographic technique that is lightweight and created to encrypt and decrypt data that is transferred, it also helps users avoid frequent collisions, attacks, and shutdowns [5], [6]. Additionally, sensor locations are crucial since, in environmental sensing applications like pipeline monitoring, sensing data are useless if the location of the sensors is unknown. High accuracy can be achieved with methods utilizing ultrasound or lasers, but each device increases the amount of space, money, and energy needed. These factors make these techniques inappropriate for use with sensor networks. A low-cost, reconfiguration-required RF-based method has been investigated [7, 8]. These experiments demonstrated that while fading and shadowing might induce delirious effects, the received signal strength indicator (RSSI) has more variance. Therefore, in order to obtain higher accuracy, an RSSI-based strategy requires more data than previous methods [9]. Although virtual private network services have always been offered in a range of formats, the Internet Protocol (IP), frame-relay, MPLS, and ATM networking communities have recently shown a great deal of interest in them [10]. Also, in order to enhance traffic management, a data network traffic model, a Poisson Process Algorithm, and a Discrete Time Markov Modulated Poisson Process usually were created to meet Quality of Service (QoS) standards for effective capacity and effective bandwidth [11]. But because our approach was implemented in the tpr2420 ca sensor node, it will be used for the studies in this study. Berkeley, California's University of California (UC) invented this technology. A number of elements that affect radio signal transmission also contribute to the signal's deterioration. When it comes to low-power radios, which are commonly used in Wireless Sensor Networks (WSNs), the consequences of these elements are even more pronounced. As such, radio connectivity in wireless sensor networks is frequently erratic. As a matter of fact, their connectivity is usually asymmetric and their quality varies with time and space [12]. Three factors—the environment, which can cause multi-path propagation effects and background noise, interference from concurrent transmissions within a wireless network or between coexisting wireless networks and other electromagnetic sources, and hardware transceivers, which can distort sent and received signals due to internal noise—are now well-known to cause link unreliability.

Because the Base Transceiver Stations (BTS or BS) in WSNs broadcast a low-power signal, radiated transmissions are more vulnerable to multi-path distortion, noise, and interference.

Moreover, they depend on antennas that have less-than-ideal radiation patterns. The following are elements of a wireless sensor network:

i. Sensor Field: The target region where sensor nodes are positioned to carry out a specific function is called a sensor field.

ii. Sensor nodes: Consisting of four parts (a sensor, a CPU, a radio transceiver, and a power supply/battery), sensor nodes (SNs) gather data and relay the information back to BS.

iii. Base Station (BS): BS gathers data from the network. It might serve as a storage facility or a gateway to other networks. BS could be a workstation or a laptop.

Sensor nodes use wireless communication technologies such radio waves, infrared, or Bluetooth to communicate with base station, other sensor nodes, or both. Single-hop or multi-hop transmission is used by sensor nodes. Every sensor node transmits its perceived data straight to the base station (BS) in a single hop. It is simple to create single hop transmission. Sensor nodes use intermediate nodes to send their detected data to the base station (BS) via a multi-hop transmission. Sensor nodes run on a finite amount of power. The battery of sensor nodes cannot be changed. When carrying out different tasks like gathering local data, interacting with other nodes, and sending local data to the base station, sensor nodes need more energy. Among the difficulties with wireless sensor networks are:

i. Wireless ad hoc nature: WSNs lack an established infrastructure for communication. They deal with issues of asymmetric and unstable connectivity since shared wireless media transmission between nodes is restricted [13].

ii. Topology changes and mobility: Mobility causes frequent route modifications, which impact packet delivery [14]. Both new and existing nodes have the ability to enter and leave the network. Nodes could cease to operate. Applications for WSNs need to be resilient to node failures and changing topology.

iii. Energy constraints: At first, the sensor nodes are given a restricted quantity of energy to carry out different tasks like sensing, interacting, and sending data to the base station. The main focus of study in wireless sensor networks is energy consumption.

iv. Physical distribution: In wireless sensor networks (WSNs), sensor nodes are independent devices that send messages to other nodes in order to exchange sensed data, which is then sent to the base station (BS) at a high communication cost.

v. Location discovery: In order to connect sensed data with the object under inquiry, many applications need to know the precise or approximate physical location of a sensor node.

vi. Security: Sensor nodes in wireless sensor networks may be physically taken over, compromising their security. The main problem that needs to be solved is security.

II. OVERVIEW OF WIRELESS SENSOR NETWORK

As with practically any technology, WSNs have demonstrated an unparalleled capacity to monitor and control the physical environment in recent years. Nevertheless, the advantages of WSNs come with a high risk of misuse. So how can a user trust the data that the sensor network provides, one might wonder?

Small in size, sensor nodes have the capacity to process data, sense events, and communicate with one another in order to provide interested consumers with information. As seen in [15], Figure 1 below depicts a typical sensor node (mote) created by UC Berkeley researchers and named Mica2. A sensor node typically has four subsystems [16].

- Processor and memory in the computing subsystem: these are in charge of managing the sensors and carrying out communication protocols.
- Transceiver: a communication subsystem used to exchange data with nearby nodes and external entities.
- Sensor subsystem: connect the node to the external environment.
- The battery-powered power supply subsystem provides the node with power.

WSNs are made up of a group of transient, self-organizing sensor nodes. There is no centralized network administration system or predefined network infrastructure. Wireless nodes use radio links to interact with one another. Because of their short transmission range, nodes that want to connect with other nodes use a multi-hop communication technique, in which each node serves as both a host and a router at the same time.

Figure 1: Sensor Node Example (mica2) [11]

Note that there are restrictions on the amount of bandwidth that can be used to communicate between wireless nodes. This is because, in comparison to fixed-line data networks, wireless networks have a far lower data transmission capacity. Moreover, battery-powered wireless nodes have a restricted power source since they quickly run out of power. Finally, a very dynamic network architecture is produced by wireless nodes, which can join or exit a network at any time and regularly move around inside it.

WSNs are made up of many sensor nodes—tens of thousands as opposed to tens or hundreds—deployed in vast numbers, each with limited computing and communication capabilities. The same difficulties that any other Mobile Ad-hoc network (MANET) has—mobility, unreliability of connectivity, and lack of infrastructure—are present, but the computing constraint makes solution design considerably more difficult. In addition, WSNs perform a function beyond that of MANETs, which is event monitoring, data collection and processing, and sensing information transmission to interested parties. The basis of this new research to model confidence in WSNs is this observed discrepancy. The development of wireless sensor networks (WSNs) in recent years has drawn more attention to this relatively new and developing field of study. Furthermore, the requirement for minuscule and inexpensive nodes to be placed in large quantities and challenging settings, like war zones, prompted researchers to concentrate more on WSNs. All facets of daily life currently employ wireless communication, yet WSNs have not progressed past the experimental phase. The implementation of WSNs in various applications is very desirable, and a substantial amount of research is being done in this area.

Small, inexpensive sensor nodes that can gather and relay environmental data are now available because to remarkable technological advancements in communications and electronics [12]. These nodes can be installed in a variety of settings and possess sensing, processing, and short-range communication capabilities.

III. METHODOLOGY

1) Adopted Design

In WSNs, decision fusion is a crucial problem, and fuzzy set (FS) is a cutting-edge technique for handling ambiguous data. Based on FS, we provide a Multi-Attribute Decision Making Model with two components: The Category Similarity Weight-Based Fuzzy Set Decision Algorithm (CSWB-FS) and the Data Distribution-Based FS Construction Algorithm (DDBFCA).

To maximize the number of clusters and cluster heads, three factors are taken into account: residual energy, the distance between nodes and the BTS, and the number of neighboring nodes. Due to their advantages—low computational complexity and low energy consumption, for example—the algorithms can be used in WSNs with limited energy resources. First, a number of presumptions are made in order to make the research easier:

1) The target has many attributes, and each Sensor Node is made up of different modules to monitor different attributes;

2) Each Node receives its position from its GPS module and sends it to the fusion center for decision aggregation; 3) The Proposed Multiple Attributes Decision Fusion Algorithm is used to obtain the classification result.

4) Sensor Nodes are uniformly and randomly deployed over a flat area, with no obstacles.

Numerous sensors are keeping an eye on the target. Following the data collecting process, each Sensor Node converts each attribute value into a set of fuzzy values representing the target's membership degree for each attribute's potential categories, in accordance with the Proposed DDBFCA algorithm. Next, using the CSWB-FS Algorithm, each Node combines the fuzzy values into a single classification conclusion. The FC receives the combined choices after that. By using fusion rules, the FC combines the local decisions it has received to arrive at a final outcome.

2) Materials Used

The following tools were employed for the drive test, one of which was a car for mobility.

1. DC power supplies Tektronix PS280
2. Prototyping boards and measurement tools, such as Hewlett Packard 54600A oscilloscopes and Fluke 8050A digital multimeters
3. Vector signal and spectrum analyzer, Agilent 89600.
4. A personal computer (PC) or laptop
5. ROM Memory

MATLAB SIMULINK was used to model the outcome.

3) Field Work Experimental Measurement

a. Characterization of the Conventional Wireless Sensor Network and determination of Energy Consumption

The amount of time that passes before all of the devices' batteries run out or before the WSN becomes unusable and can no longer produce an appropriate event detection ratio is how long a WSN lasts. There was one sink and six nodes in the network that was put into use for this project. A Crossbow Mica2 mote Figure 2 with rechargeable AA batteries powered each node. Energizer Accumulator Rechargeable 1200mAH at 1.2 V NiMH batteries were used in the initial testing. Mercury Rechargeable NiMH batteries with 1.2 V and 2500mAh were utilized in further trials. There was only one kind of battery used for each run. The Mica2 sensor board draws 0.7 mA, the CPU draws 8.0 mA when it is in the active state, and the radio draws anywhere from 3.7 to 21.5 mA. The experiments in this work did not employ the sensor board because their purpose was to measure the power consumption of communications protocols and because the sensing electronics have a modest power consumption.

The nodes were placed so that three of them were directly connected to the sink and the other three were unable to communicate with it directly. This created the network topology. 22 potential locations were used in the initial coverage area test. Figure 3 displays the connectivity pattern, test motes, and chosen sites.

Figure 2; Crossbow Mica2 mote [11]

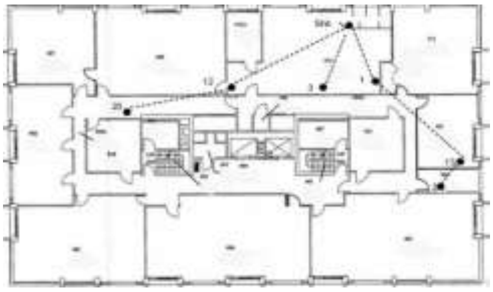


Figure 3: Node Location and Connectivity. Source – Researcher

Nodes 0 (sink), 1, 3 and 12 are located in the Wireless Laboratory. The rest are located as follows: Node 2 in room 1, Node 13 in room 2, Node 20 in room 3. Nodes 1, 3 and 12 communicate directly with the sink. Nodes 2, 13 and 20 should reach the sink through some of the other Nodes.

Table 1: Distances from the Nodes to the Sink

Node	d (m)
1	5.32
2	15.22
3	4.19
20	16.31
12	16.31
13	13.44

All messages are received by the Sink, which uses a serial port to transmit them to a computer. Every packet that is received is tracked along with the time and date of receipt.

The Nodes were configured to use Binary FSK with Manchester coding at 19.2 kbps and to transmit in the 903 MHz band at the maximum power of 5dBm.

Crossbow's default MAC Protocol (CSMA/CA) was used in the experiments. The mote listens to the medium at the start of the CSMA/CA version. The protocol waits during a back-off time if the medium is idle. The node broadcasts if, after the back-off time, the medium is still free. The node waits throughout a congestion back-off time to feel the medium once more if it is not free. Sequence numbers, acknowledgements, and collision detections are absent. After a transmission failure, the MAC Protocol will not attempt to send another frame. When there is still a message being sent, failures happen. Given that the buffer cannot be changed in this situation, the new message will be dropped. An upper layer receives a signal indicating the outcome of the process (success delivering a frame or transmission failure), and it decides what to do next.

The connection layer frame structure is depicted in Figure 4. It should be noted that the packet (network layer entity) format and the frame format are the same because GSP does not add any further overhead to the link layer.

Bytes

8	2	2	1	1	1	2	2	2
Pream	Sync	DA	Type	Group	Length	Counter	SA	CRC

Figure 4: Frame Structure

- The preamble consists of eight bytes, or pream. The eight bytes are 0xAA (10101010) or 0x55 (01010101) repeats.
- Synch is a synchronization of two bytes. 0x33CC are these.
- The destination address is DA. The broadcast address (FFFF) was the only one utilized in this field during the testing.

- Type, which indicates the kind of frame being transmitted, is comparable to a TCP/UDP port in that it specifies the application to whom the frame needs to be delivered.
- Group serves as a unique group of motes' identifiers. This address corresponds to each set of nodes that may be present when using Crossbow motes. There was just one group utilized in the experimental test-bed, which was group 0x7D, or 125 in decimal.
- Length is the total message length that is being transmitted. Four bytes in length were employed in the experiment, and they were split up as follows: The counter is the first two bytes. The address of the mote that sent the message in the first place, or the Source Address, is contained in the next two bytes.
- The final two bytes are a CRC check, which aids the mote in determining whether or not the frame was received successfully. Packets with a flawed CRC are not dropped by the MAC layer. Upper layers will decide if they are discarded or not.

There are 21 bytes in every frame. The mote backs off and then enters transmission mode. It takes 250 microseconds to switch. The mote returns to reception mode after transmitting the packet. It requires an additional 250 microseconds. Thus, it is important to take into account the "Time frame" shown in Figure 5.

Time (msecs)

6	0.25	9	0.25
Backoff timer	SwtoTX	Message	SwtoRx

Figure 5: “Time frame”

Since the actual figure relates to the time it takes to send between 1 and 32 bytes, the number displayed in the back-off timer is an approximation. The times are spread out along the range [0.416, 13.312] milliseconds. After performing the initial back-off, a second timer termed Congestion Back-off begins if the node detects a busy medium. The times are dispersed in the interval [0.416, 6.656] msec since the timer selects a random value between 1 and 16 bytes. Figure 5's time window only applies when one node transmits.

A straightforward program was made, with one counter on each node that is updated and transmitted to the network every 80 milliseconds. The application will resend the same counter if the MAC layer reports a transmission error; it won't attempt to send the next value of the counter until it receives a success signal from the MAC layer. The transmission of one bit at 19.2 kbps takes 52 seconds. With the 8MHz crystal enabling up to 8 MIPS processing speed, the mote microcontroller can process up to 416 instructions in the time it takes to transmit a single bit.

b. Transmitted and Received Power

By positioning a receiving antenna close to the sending node, the Agilent 89600 Vector Signal Analyzer was used to monitor the output transmit power.

The setup is shown in Figure 6.

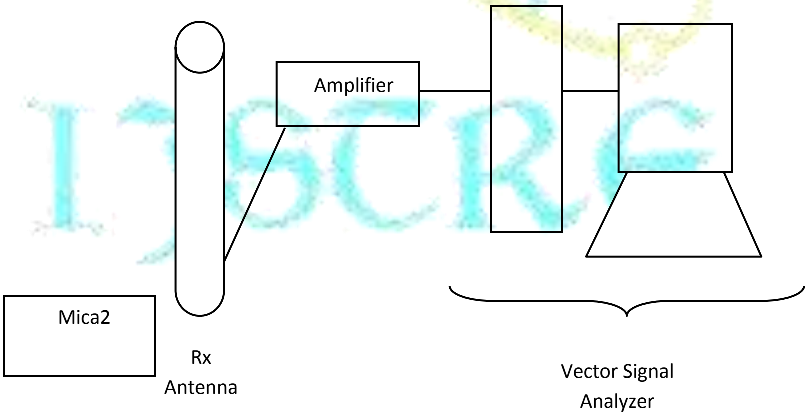


Figure 6: Equipment setting for measuring transmitted Power

This time, the receiving antenna was put in close proximity to the sink, but the same equipment was utilized to confirm received power. The waveforms that the antenna receives in the time and frequency domains are displayed by the Vector Signal Analyzer program. When none of the nodes were broadcasting, the noise was measured using the same configuration.

This study employed a radio model in which the energy utilized by a transmit amplifier is proportional to d^2, where d is the distance, for shorter transmissions, such as direct data transfers from sensor node to cluster head.

$E_T = E_e + E_L d^4$ 3.1

Where;

E_T = Energy consumed to transmit

E_e = Energy consumed in the electronics circuit to transmit or receive the signal

E_L = Energy consumed by the amplifier to transmit at a longer distance

d^4 = long distance

Similarly, the energy needed to send a 1-bit message over a shorter distance is determined by:

$E_T = E_e + E_S d^2$ 3.2

Where;

E_T = Energy consumed to transmit

E_e = Energy consumed in the electronics circuit to transmit or receive the signal

E_S = Energy consumed by the amplifier to transmit at a shorter distance

d^2 = short distance

Additionally, the following represents the energy used to receive a 1-bit message:

$E_R = E_e + E_{BF}$ 3.3

Where;

E_R = Energy consumed to receive

E_e = Energy consumed in the electronics circuit to transmit or receive the signal

E_{BF} = Energy consumed for Beam Forming

(The beam forming approach reduces energy consumption).

Table 2: Energy Consumption with respect to Number of Clusters on the Network

Number of Clusters	**Energy Consumption (J) Cluster head-set size is 1**	**Energy Consumption (J) Cluster head-set size is 3**
1	5.2391	1.7462
2	2.4620	0.8205
3	1.6072	0.5356
4	1.1931	0.3976
5	0.9490	0.3162
6	0.7881	0.2626
7	0.6741	0.2246
8	0.5891	0.1962
9	0.5233	0.1743
10	0.4709	0.1569
11	0.4282	0.1426
12	0.3927	0.1308
13	0.3628	0.1208
14	0.3372	0.1123
15	0.3151	0.1049
16	0.2958	0.0985
17	0.2788	0.0928
18	0.2637	0.0878
19	0.2503	0.0833
20	0.2382	0.0793

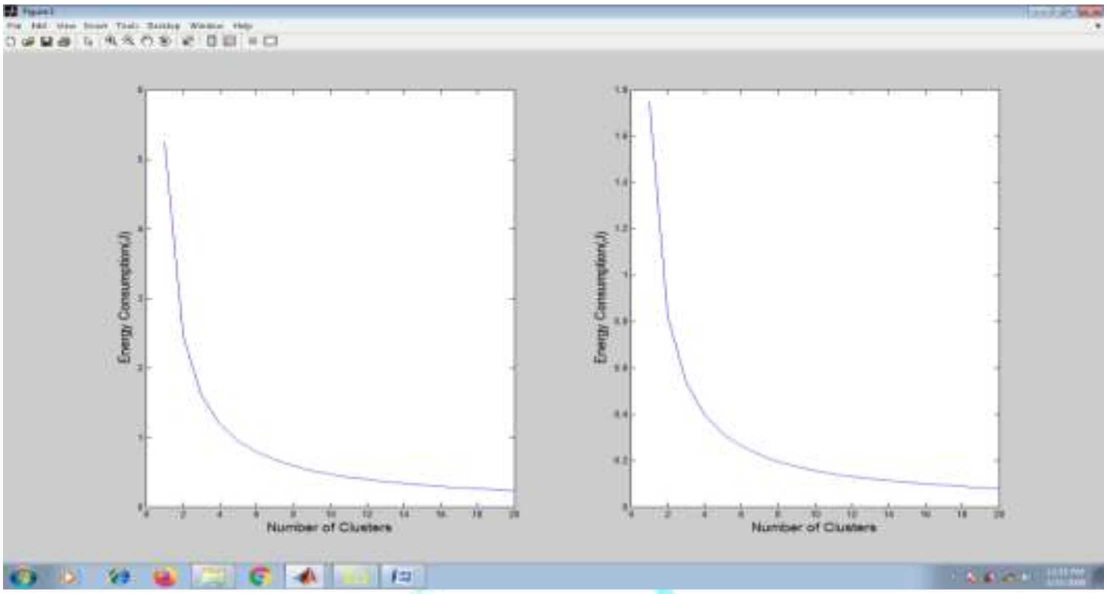


Figure 7: (a) (b)

Number of Clusters Versus Energy Consumption for various Cluster head-set sizes

The energy usage vs the number of clusters for different cluster head-set sizes is shown in Figures 7a and 7b. As the number of clusters rises, Figure 7a shows that the energy consumption decreases. When the cluster head-set size is 1, the ideal variance in the energy consumption falls between 0 and 6 (Joules).

According to Figure 7b, when the number of clusters rises, the energy consumption decreases. When the cluster head-set size is three, the ideal fluctuation in the energy consumption falls between 0 and 1.8 (Joules). As a result, when comparing the two graphs, Figure 7b's energy usage when the cluster head-set size is three is less than Figure 7a's when the cluster head-set size is 1.

Consequently, the lower the energy usage during transmission, and vice versa, the larger the cluster head-set size. This is because a lower energy consumption in the network would result in a longer network lifetime and the ability to carry out more transmissions.

4) Data Presentation and Analysis

a. Parameters for Simulation

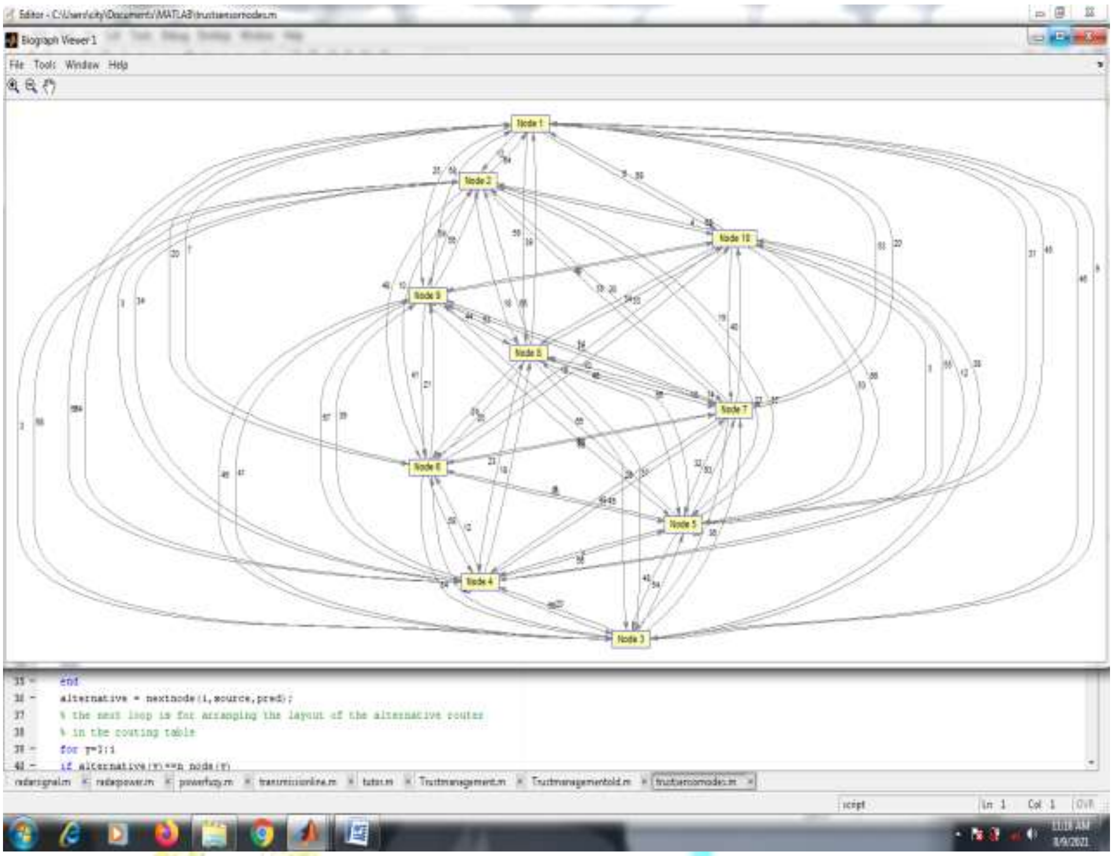
The suggested approach is extensively simulated using MATLAB. A 100 Sensor Node Heterogeneous WSN with random deployment between [0,0] and [100,100] in a 100*100 m square field is taken into consideration.

Table 3: Simulation parameter

Parameter	**Value**
RF power	–25 dBm~0 dBm
Power supply	0.1 V~3.6 V – (AA or AAA battery)
Range	~150 m (outdoor), 20~30 m (indoor)
Number of sensor nodes, n	10
Number of clusters	5
Number of cluster head	5
Network Field Dimensions	100 x 100m
Sink Location	50, 150
No of Packets sent	50

b. Simulation Results

Numerous outcomes were obtained from the MATLAB SIMULINK simulation. The connections between the Sensor Network Nodes and their distances are displayed in Figure 8.



```
end
alternative = nextnode(i,source,pred);
% the next loop is for arranging the layout of the alternative routes
% in the routing table
for y=2:i
if alternative(y)~=n_node(y)
```

Figure 8: The Routing Tree for the Ten Routers

All of the connections in the network are displayed in this tree (Figure 8), together with the summable distance between each link and a router.

Table 4: Cluster Head-Set Size Versus Number of Clusters

Cluster head-Set Size	Number of Clusters
1	7.2666
2	7.9959
3	9.0006
4	10.5134
5	13.1875
6	20.1902
7	0.0000 +34.4240i
8	0.0000 +15.5401i

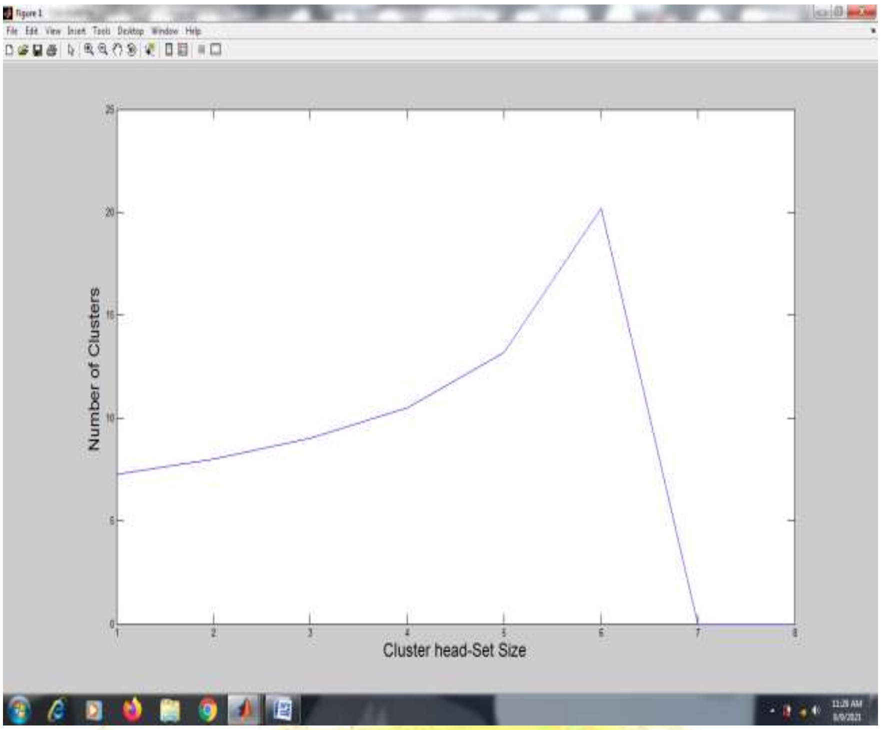


Figure 9: Cluster Head-Set Size versus Number of Clusters

The outcomes of the suggested cluster-based routing strategy are examined in this section. The ideal number of Clusters in relation to the Cluster Head-Set size is depicted in Figure 9. The graph indicates that there can be up to 20 clusters at most, with a cluster head-set size of 6. The graph illustrates how, after the number of Cluster Head-Set sizes surpasses six, the number of Clusters falls. There is a minimum of about 7 Clusters, and a minimum Cluster Head-Set size of 1. Consequently, the size of the Cluster Head-Set grows as the number of Clusters does. Because of this, larger cluster sizes may be managed by larger cluster numbers, whereas lower cluster sizes can be managed by smaller cluster numbers. This discovery is due to the fact that in a wireless sensor network, if the size of the cluster head-set is not carefully selected for the number of clusters involved, the cluster head-set nodes may experience packet drops during data transmission due to the increased load.

Table 5: Distance versus Number Clusters

Distance	**No of Clusters**				
	Cluster head size 1	**Cluster head size 2**	**Cluster head size 3**	**Cluster head size 4**	**Cluster head size 5**
150	7.2666	7.9959	9.0006	10.5134	13.1875
160	6.3214	6.7841	7.3659	8.1288	9.1914
170	5.5584	5.8652	6.2291	6.6703	7.2210
180	4.9312	5.1416	5.3815	5.6584	5.9830
190	4.4078	4.5561	4.7206	4.9041	5.1110
200	3.9657	4.0727	4.1889	4.3156	4.4545
210	3.5884	3.6671	3.7512	3.8414	3.9383
220	3.2634	3.3223	3.3844	3.4502	3.5200
230	2.9814	3.0260	3.0728	3.1218	3.1731
240	2.7348	2.7692	2.8049	2.8420	2.8806
250	2.5180	2.5447	2.5723	2.6008	2.6303

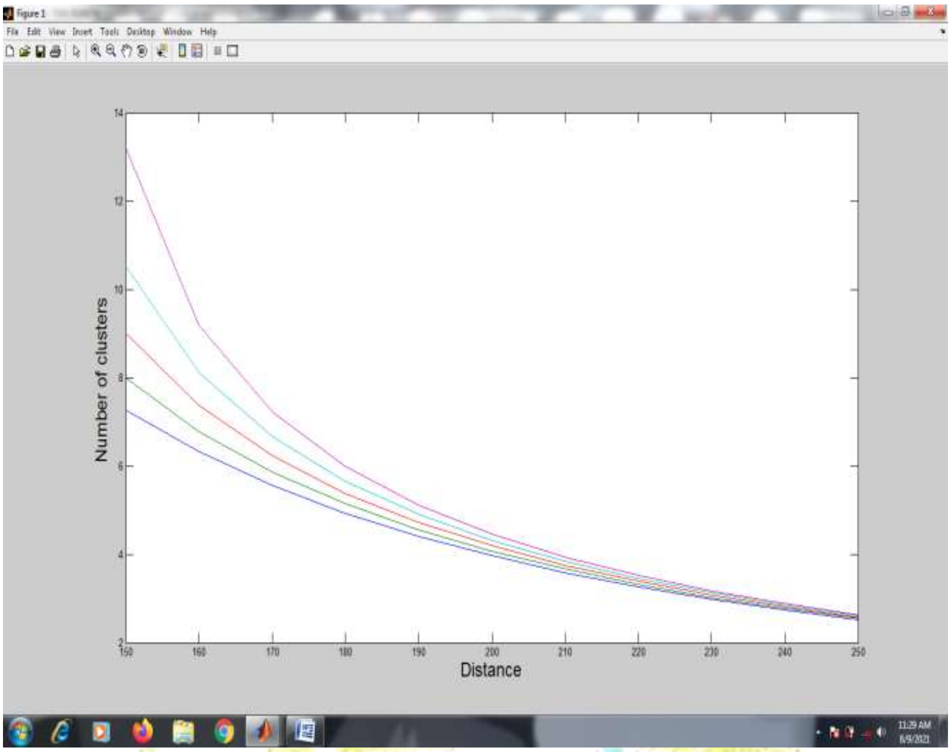


Figure 10: Distance versus Number of Clusters

Figure 10 illustrates how the number of clusters varies for different cluster head-set sizes in relation to their distance from the BTS. As the distance from the base station grows, the number of clusters in the graph decreases. For the different Cluster Head-Set sizes (i.e., from Cluster Head Set size 1 to Cluster Head Set size 5), this fluctuation is the same. This suggests that the number of Clusters, not the Cluster Head-Set size, varies with distance.

Table 6: Energy Consumption with Respect to Number of Clusters on the Network

Number of Clusters	**Energy Consumption (J)** cluster head-set size is 1	**Energy Consumption (J)** cluster head-set size is 3
1	5.2391	1.7462
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14	0.3372	0.1123
15	0.3151	0.1049
16	0.2958	0.0985
17	0.2788	0.0928
18	0.2637	0.0878
19	0.2503	0.0833
20	0.2382	0.0793

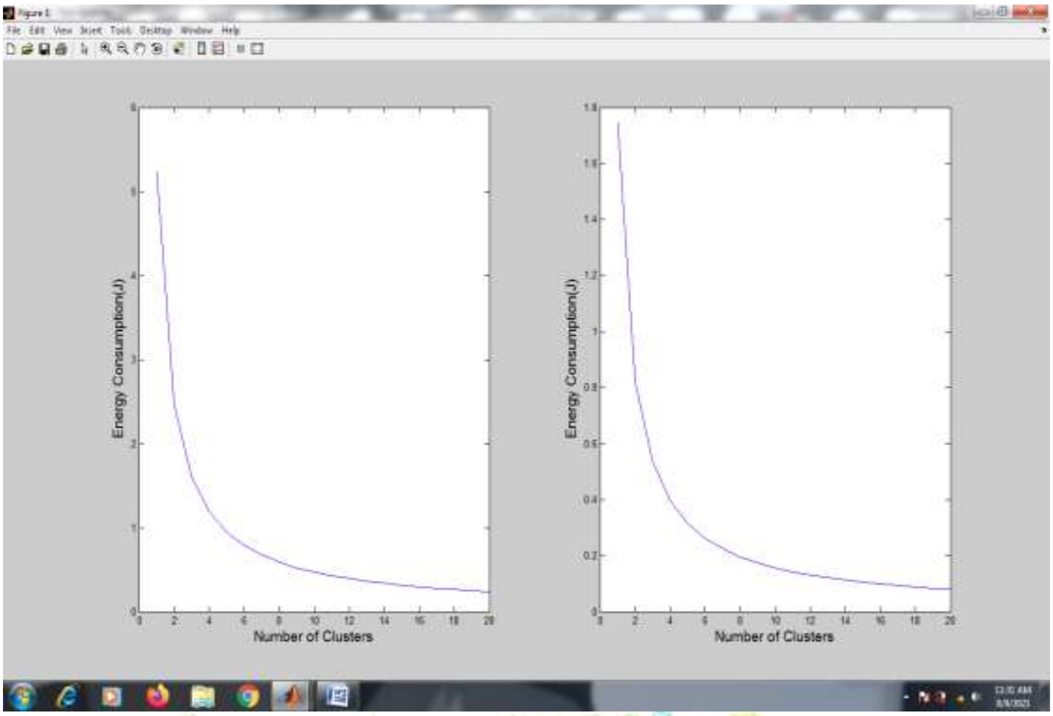

Figure 11: (a) (b)

Number of Clusters versus Energy Consumption for various Cluster Head-Set Sizes

The energy consumption is shown in Figures 11a and 11b for different Cluster Head-Set sizes. In Figure 11a, the energy consumption decreases as the number of Clusters increases, and the optimum variation in the energy consumption ranges from 0 (Joules) to 6 (Joules) when the Cluster Head-Set size is 1. In Figure 11b, on the other hand, the energy consumption decreases as the number of Clusters increases, and the optimum variation in the energy consumption ranges from 0 (Joules) to 1.8 (Joules) when the Cluster Head-Set size is 3. Thus, when comparing the two graphs, it can be observed that the energy consumption in Figure 11b is relatively lower when the Cluster Head-Set size is 3 than in Figure 11a when the Cluster Head-Set size is 1. When the cluster headset size is three, Figure 11b uses around three times less energy than Figure 11a, which has a cluster head-set size of one. Consequently, the lower the energy usage during transmission, and vice versa, the larger the cluster head-set size. The rationale behind this is that if the network's energy consumption is decreased, its lifespan will be extended and more transmissions will be possible.

c. Discussions

For both proposed and current systems, the ideal number of clusters was simulated and compared to the cluster head-set size. Larger clusters can handle larger Cluster Head-Set sizes, but smaller clusters can handle smaller Cluster Head-Set sizes, it has been observed. The maximum number of Clusters reduces as the distance from the BTS grows, according to a comparison of the Cluster size and distance from the BTS.

To increase the network's lifespan, care should be used when selecting the size of the cluster head-set and the total number of clusters. Additionally, more frames can be sent with larger Cluster Head-Set sizes. Stated differently, greater control and management of sensor nodes would result from larger Cluster Head-Set sizes. The simulation parameters that we employed in our tests are listed in Table 3. Clustering and data transfer phases make up each cycle. The ten Nodes are chosen during the clustering step and group together according to distance. Every cycle, a subset of nodes is chosen until every node has used up all of its energy. The distance between the BTS and the field is large. The number of cycles until each node in the network runs out of energy is used to calculate the lifetime of the network. The experiment's findings are displayed in Figure 8, wherein 100 × 100 m2 of sensor nodes are randomly placed and the number of nodes that remain alive throughout time in cycles is exhibited as a function of network lifetime.

5) Conclusion

This study demonstrates that when the Cluster Head-Set size is 6, the ideal number of Clusters in relation to the Cluster Head-Set is roughly 20. The number of Cluster Head-Sets rises with the number of Clusters (Figure 9). Once more, the size of the Cluster Head-Set varies solely in relation to the number of Clusters, not in relation to the distance to the BTS (Figure 10). When the Cluster Head-Set size is 3, the optimal variance in energy consumption is between 0 and 1.8 joules; in contrast, when the Cluster Head-Set size is 1, the optimal variation in energy consumption is between 0 and 6 joules. when a result, when the clusters grow, the energy consumption decreases (Figure 11a and 11b). An alternate Node will be used for the transmission if it has more energy when there is a low energy level and a lengthy distance to cover. This will enhance the wireless sensor network's performance by lowering packet transmission failure.

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