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Effective Energy Preservation Technique to Enhance the Intra-Clustering Communication for WSN

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ABSTRACT
Individual nodes in wireless sensor networks are divided into several virtual groups called cluster. Each cluster will be formed of a cluster head (CH) and cluster members. Clustering techniques are an energy efficient process that prolong the network lifetime. Intra-cluster communication is the major factor that influencing energy in clustering protocols. The dissipated energy in intra-cluster will primary depends on the communication between member nodes and its belonging cluster head. Sensor node which equipped with camera for intruder detection in a monitoring area, need to transfer the captured image to cluster head directly. The improvement of powerful compression method is much needed to minimize the requirement of communication bandwidth; minimize the redundancy of data packets and to overcome the energy limitation of wireless sensor. The proposed improved technique has extra benefit to enhance the saving energy and to eliminate the consumption energy to prolong the entire network lifetime, by present a significant data reduction for the tested images.
The experimental results present that the proposed hybrid image compression scheme which uses distinct image coding scheme based on wavelet transform that combined effective types of compression algorithms for further compression. EZW and SPIHT algorithms are types of significant compression techniques that obtainable for lossy image compression algorithms. This hybrid technique will have improved the efficiency of compression ratio between 8.1to 31.4%, and will present a promising preservation energy technique in intra-clustering communication by the ratio between 17.8 to 36.7% (depends on the specifications of the tested image), which prolong the entire network lifetime. From the results obtained, it became clear to us that the image with high color variation has high compression ratio, lead to get high gain in energy for processing and transmission the compressed data.

Key words: Dual compression, image compression, intra-clustering, energy consumption.

I. INTRODUCTION

The nodes commander for each cluster in wireless sensor network, will receive sensing data that collected from monitoring area by active sensor node. The process of transferring the sensed data from active node in the monitoring area within cluster, to the CH is called intra-cluster. The intra-clustering communication is the prime factor that effects on the efficiency of the depletion energy in clustering protocols [Pal 2012] [Meng 2016].

The sensor nodes which deployed over a geographical area will communicate wirelessly through wireless links [Thenmozhi 2016]. The main task of the associated sensors is to monitoring physical phenomena like seismic events, vibrations, temperature, humidity, and more another number of applications like border surveillance or any other military applications and health related applications [[Vlab 2019]]. Since nodes in wireless sensor networks are generally small size and equipped with limited energy, and because of sensor nodes commonly operate in harsh environment with small capacity of energy source. The process of changing or replacing the sensor battery is difficult if not impossible; nodes may be deployed in unfriendly or unpractical environment. [Thenmozhi 2016] [Vlab 2019].

Energy exhaustion enhancement is a vital issue in prolonging the network lifetime, the goal of draining minimum quantity of energy is to remain the network from failure. In wireless sensor network data transferring and reception is the most energy constraint task. The lifetime of whole component in network should be long enough to achieve the application requirements. In the past two decades there are numerous papers which

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offered different ways to extend the wireless network life time. Data compression by active nodes before transmit to CH in intra-clustering, is one of important way to reduce the transmitting data.

Figure 1, shows a monitoring area equipped with homogenous nodes that provide with camera to capture image for any event driven. Data compression by active node before sends to its associated cluster head will reduce the energy dissipation for transmitting data in intra-clustering communication. Energy conservation is a critical matter in wireless sensor networks system design.

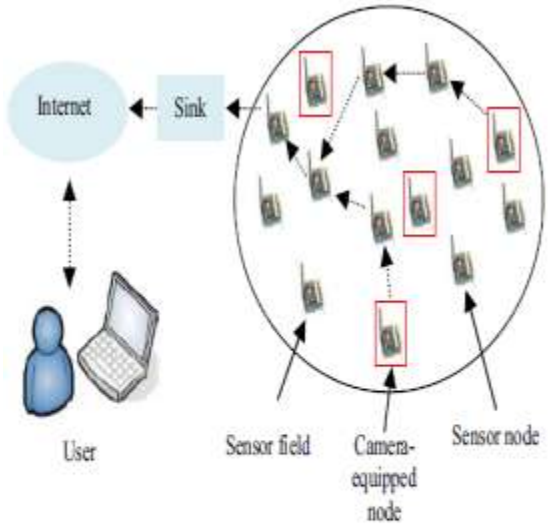

Figure 1: Monitoring area [Nasri 2015]

In intra-clustering the communication processes is done through three steps:

- Active sensor node will transmit the collected data after processing to its belonging cluster head (CH).
- CH aggregate the collectd data send by its associated sensor node members.
- CH then transmits data to the sink node by one hop or relay sensed data to other CH in multi-hop routing.

One of appropriate methods that eliminate the use of energy and improve the network lifetime in clustering communication is data compression before transmission [Thenmozhi 2016] [Kadhim 2019]. Data gathering techniques in clustering algorithms decrease the collected data by cluster head to the degree that eliminate the utilized consumed energy, cluster head also responsible to send the collected data to the sink or base station directly in one-hop routing, or relay sensed data to next hop cluster head in hierarchal routing protocol [Abbasi 2007] [Chinh 2012].

In this paper, a hopeful dual combined compression method for sensing data is present which has additional benefit to improve power saving and to eliminate the consumption energy in the entire network, by submit a significant data reduction method for the tested capturing images. As a result, this technique will reduce the intra-cluster communication which improves the energy efficiency of the proposed cluster.

The experimental results present that the utilizing of dual combined image compression scheme which uses distinct image coding methods based on wavelet transform, that combined effective types of compression algorithms for further compression. Has an important enhancement on the entire network lifetime when utilizing in intra-clustering communication. The following two image compression methods, which are EZW and SPIHT were chosen to achieve high compression for the transferred images in order to achieve the desired goal. EZW and SPIHT algorithms are types of significant compression techniques that obtainable for lossy image compression algorithms.

The major components of ordinary sensor node architecture will be presented in Figure 2. The sensing unit for data gathering from the physical environment, a microcontroller for processing the data locally, a transceiver which is a wireless communication unit that transmit and receive signals to and from other nodes, power source (a battery) for supply energy needed by the device to perform the required task, analog to digital convertor ADC and memory unit for store data locally. The sensing unit holds the information from the physical environment of network area; the sensor will activate the camera unit to capture the image of event driven and then relay the data to ADC unit to obtain digitized information. The processor unit will get the data for processing and then either transfer it to transceiver unit which contains both transmitter as well as receiver, or will transfer the process data to memory for storing. All physical components of sensor architecture based on power supply for working, this power must provide from batteries [Govindasamy 2018].

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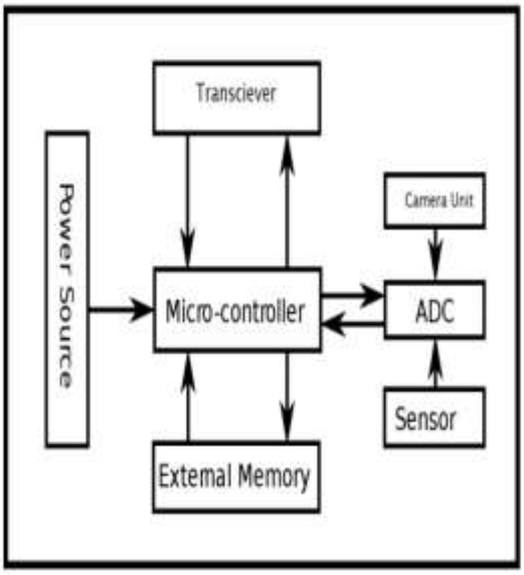

Figure 2: Architecture of sensing node [Govindasamy 2018]

The rest of the paper are arranging as follows. Section II will present the related work. Section III will describe the Improvement of Intra-Clustering Communication. Section IV Proposed Model. Experimental results are shown in Section V. Section VI concludes the paper.

II. RELATED WORK

The compression of data is one of the significant field of studies the resource constraint for sensor networks. Many various research studies are seeking for powerful way to decrease sensing data by utilizing compression techniques, in order to reduce the consumed energy due to computation, processing and transmitting of sensing data of each node, which at the end will extend the entire network lifetime and also reduce the demand bandwidth for transmitting and receiving data [Mudgule 2014].

A powerful solution to the problems that related for image data transmission in wireless sensor applications is presented in [Nasri 2015]. Performance estimation present that the proposed technique will reduced the communication process consumed energy by reducing the bits transmitted and therefore extends the entire network lifetime. A novel algorithm that utilize for lossless compression to respectably improve the performance in data compression for several applications and data collections in WSNs is submit in [LI 2016], also present article that widespread predictive coding framework for merged two technique of data compression (lossless and lossy). Also in [Kishk 2014] proposed new schema which called hybrid 2-D DWT-Zonal DCT, which give better enhancement on the compression ratio and PSNR. Beside that offered in his paper, that the sharing of data compression between sensors nodes will reduced network consumed energy. [Nasri 2013] Present energy efficient technique for image compression that depends on Discrete Wavelet Transform (DWT) by utilizing lifting scheme. The experimental test shows that the proposed method will present a significant reduction in consumed energy needed, with little distortion in image quality. Compression methods for providing enhancement in using limited constraint of WSNs are presented in [Malleswari 2017]. In this comparative study has been analyzed the characteristics of all proposed compression techniques and found that some of them will providing better compression rates and will save energy consumption. In [Ciancio 2014] suggests in his work that there are three elements of power consumption, (i) computational cost (ii) communication cost (intra-clustering) between sensor nodes and cluster head (iii) communication cost (inter-clustering) between sensor node and base station. The computation cost of wavelet coefficient with lifting scheme is very low as matching with other components of energy consumption. Therefore, this system will achieve a perfect power saving.

An image compression and transmission method is proposed in [Ciancio 2014], which based on non-negative matrix factorization (NMF). Simulation results present that the proposed method has a higher recovered images quality and lower whole node power consumption as compared with other compression schemes like JPEG2000 and singular value decomposition (SVD). The gained advantages are the reduction in energy consumption and prolong the entire network lifetime, which has great important for practical implementation of wireless sensor networks. An image compression method through utilizing dual compression algorithms which based on many wavelet methods, is present in [Shikang 2017]. From the results obtained the metrics of compression image for two stages, are as follows: the gained compression ratio is equal to 2.3%, which means that we can store the compressed image by using 2.3% of the data size for original image. While the BPP metric is equal to 0.575, which perform the number of bit that utilized to save individual pixel for color image.

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III. IMPROVEMENT OF INTRA-CLUSTERING COMMUNICATION

Clustering is approach that divide wireless sensor networks into many virtual groups; each group is contain a number of sensor nodes. The cluster is consisting of a leader called a cluster head and members of sensor nodes. Figure 3, present the cluster structure [Pal 2012].

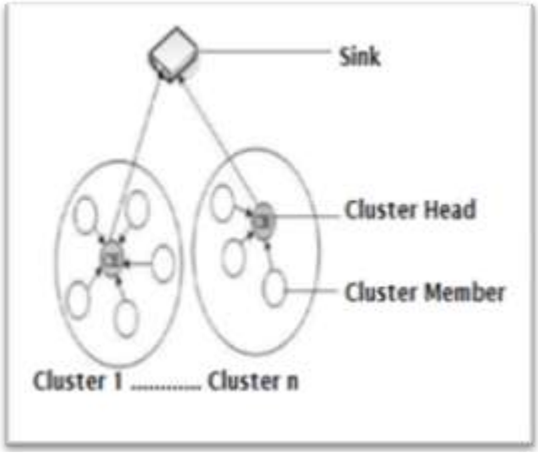

Figure 3: Cluster structure [Shikang 2017]

Clustering scheme is used to minimize the consumed energy in wireless sensor networks. The process of clustering will prolong network lifetime by balancing sensor energy level. The cluster head (CH) is a node with distinctive characteristics, the responsibility of CH is (i) communications with all nodes in the cluster and (ii) collect data that send from sensor members and forwarding data to other CH or to base station or sink node [Qi 2011] [Vlab 2019]. The selection of CH is an important issue in wireless sensor network, the improper selection of CH wills dramatically effects on the consumed energy in clustering scheme. For this reason, the selection of CH is vital issue to minimize intra-cluster communication [Pal 2012]. CHs election is based primary on two parameters: Firstly is the residual energy of node, therefore, high residual energy node has high probability of selection as a CH. Secondly is communication cost of intra-cluster, which is a function of the following metrics: (i) cluster features, like cluster size; (ii) the consumed energy from node, each node wants to connect to its CH, must utilize minimum power level or must use the same power level for all intra-cluster communication [Vlab 2019].

For simplify, the intra-clustering communication between active nodes and CHs is done directly or through the hierarchical scheme [Meng 2016]. On the other hand, inter-cluster communication is established when the connection between CH and base station or between two CHs, which is one of CHs responsibility [Stemm 2007]. Moreover, CH will manage the communication process through: (i) collect the transmitting data from active nodes, sends the aggregate data to the CH in next hop in multi-hop routing. (ii) A CH will forward the receive data from another CH to next hop [Yu 2002] [Meng 2016].

The energy dissipation of CHs in multi-hop routing algorithms is divided into two types (i) intra-cluster energy dissipation and (ii) inter-cluster energy dissipation. But in one-hop communication clustering algorithms only inter-cluster energy dissipation between CHs and sink [Meng 2016]. One of the most important jobs in our consideration is the computation of consumed energy in intra-clustering communication in order to extend the network lifetime as long as possible. Briefly, the main task of this paper is how to prolong entire network lifetime through reducing the intra-clustering communication energy, via compression the transmitting data from active node to its cluster head. Figure 4 shows the structure of intra-clustering data gathering scheme.

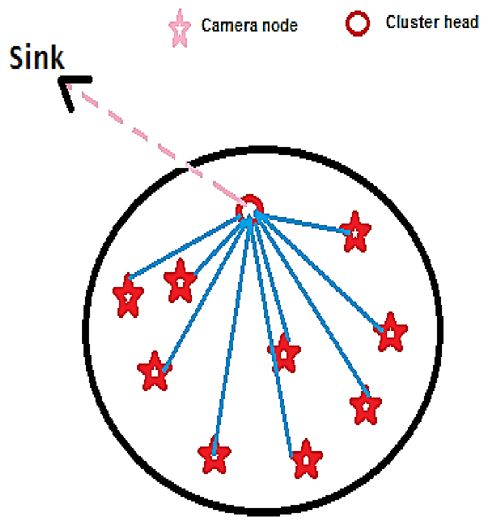

Figure 4: The intra-clustering data gathering scheme

IV. PROPOSED MODEL

The proposed model architecture is consisting of sink node and a number of homogenous nodes. Each cluster contains sensor member nodes and an elected cluster head, the cluster head will collect the sensing data from member nodes and forward the sensed data to sink

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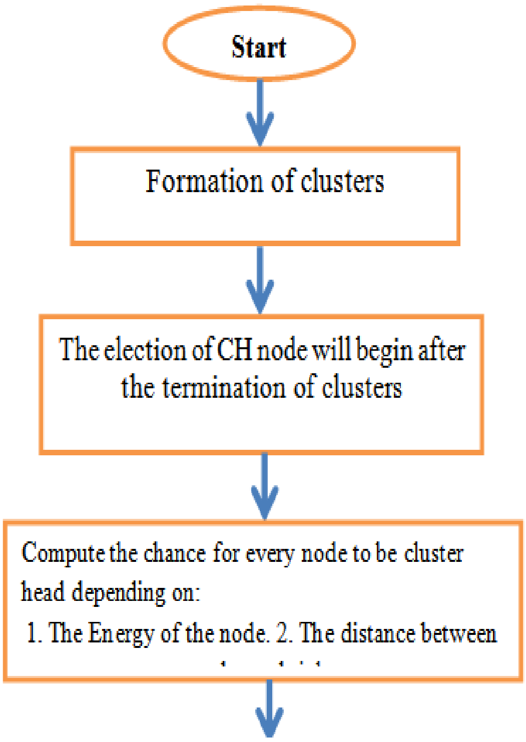
directly or by multi-hop. Figure 5 present the flow chart of the proposed model.
In our proposed system the following presumption must be considered:

1- All nodes in WSN are homogenous.
2- All nodes position is fixed when deployed in observation area.
3- Sensor nodes are randomly distributed.
4- Each node has an ID number.
5- Single sink node which positioned out of the scope field.
6- All active sensors nodes in the field may have data to be transmitted.
7- Each individual cluster consists of a member of nodes.
8- Node with high energy and closet distance to base station is select as cluster head.
9- The initialized energy is same for all sensors.
10- Intra-clustering links are symmetric.
11- Sensor node equipped with camera that sense the monitoring area.
12- Each send packet has same size which equal to 4000 bits.
13- The node is considered to die only when their energy is exhausted.



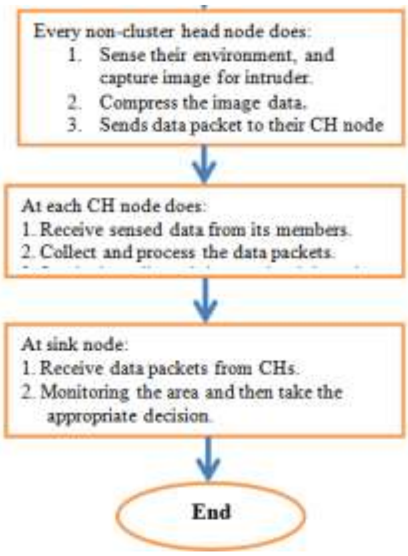


Figure 5: The flow chart of the proposed model

4.1 Energy Model

Generally, sensor nodes in WSNs are distributed randomly. The energy is exhausted mainly within communication in WSN as it depends mainly on the distance between each dual node [Pal 2012]. The energy consumption model can be seen in Figure 6.
The calculation of consumed energy by transceiver unit and the entire consumed energy for intra-clustering communication by radio unit are as follow:

1- The sensor member consumed energy through data processing and then transmission by its radio electronics.
2- The amplifier circuitry of sensors also dissipates a considered energy.
3- The cluster head receiver consumed energy through data receiving by its radio electronics.
4- Data gathering and processing in cluster head consumed considering energy.
5- The transmission and amplification energy by radio electronics of cluster head node to sink.

The processing unit of node member will compress the capture image directly by utilizing an improvement compression technique consists of EZW and SPIHT algorithms which are types of vital compression techniques that used for lossy image compression algorithms. The EZW coding is a worthwhile and simple efficient algorithm. SPIHT is a most powerful technique that used for image compression depends on the concept of coding set of wavelet coefficients as zero trees [Kadhim 2019]. The compressed data will transmit to cluster head which collect data from active nodes

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and forward it to sink node immediately or by multi-hop.

According to proposed energy model, the total consumed energy in transmission case is compute by collect the consumed energy from camera node and cluster head node. The consumed energy in receiving case is determined by the consumed energy from cluster head to collect data.

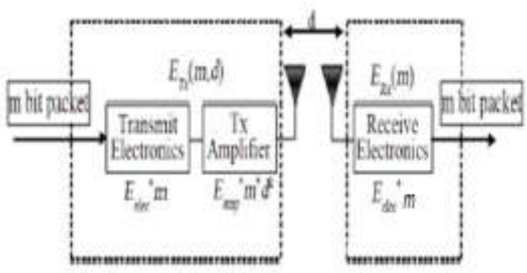

Figure 6: Radio energy dissipation model [Pal 2012]

4.2 Energy Computation

The radio circuitry of member node will spend energy (E_{elec}) through data transmission, and (E_{amp}) energy for radio amplifier. Therefore, the gross energy for transmission m-bits packet data from member node to cluster head node with distance equal to d is given by:

E_{Tx} (m,d) = mE_{elec} + mE_{amp} × d^2……………………………………………………………(1)

Where E_{elec} is the consumed energy per bit to run the transceiver circuit, E_{amp} is energy dissipated by amplifier to transmit single bit. d^2 is the distance between ordinary node and commander node, for free space model (less than the crossover distance).

The dissipate energy by cluster head receiver circuitry for receiving m-bit message from associated node is:

E_{Rx} (m,d) = E_{elec} × m………………………………..……………………………………..(2)

The cluster consists of N nodes distributed in area of M ×M. Each dissipate energy for cluster head will comes from two ways, by aggregation data from active nodes and by forwarding the collected data to the sink node. Thus, the energy consumed by cluster head is calculated by:

E_{ch} = N × E_{Rx}(m,d) + N × E_{dc} + E_{Rx} (m,d)…………………..……………..(3)

Where E_{dc} is the data collecting energy. For multi path model the distance from CH to sink node is greater than the radio distance of coverage area in each cluster. Therefore, the distance for multi path power loss is d^4. The overall energy dissipated by the CH is given by:

E_{ch} = N × E_{Rx}(m,d) + N × E_{dc} + mE_{elec} + mE_{tran} × d^4……………………..(4)

Where E_{tran} is the transmitter amplifier energy for multi path model.

4.3 The Proposition of Energy Values

1- Initial energy supplied to each node (unit in Joules):
Eo=0.5
2- Energy required to run circuitry (both for transmitter and receiver), $E_{elec}=E_{Tx}=E_{Rx}$ (in nJoules/bit):
E_{elec}=50*10^(-9) (units in nJoules/bit)
E_{Tx}=50*10^(-9) is the transmitter energy per node (units in nJoules/bit)
E_{Rx}=50*10^(-9) is the receiver energy per node (units in nJoules/bit)
3- Energy spent by the amplifier to transmit one bit is:
E_{amp}=100*10^(-12) units in (nJoules/bit/m^2)
The amplification energy in (nJ/bit/m^2), when d is less than d_0 (threshold distance) for free space is:
E_{fs}=10*0.000000000001
The amplification energy in (pJ/bit/m^4), when d is greater than d_0 in multi path channel is:
E_{mp}= 0.0013*0.000000000001
Distance between cluster head and base station:
d_o= sqrt(E_{fs}/E_{mp})= 87.7m
4- Data collecting energy from cluster head node
E_{dc}=5*10^(-9) (units in nJoules/bit)

V. EXPERIMENTAL RESULT

The computation of energy dissipation in intra-clustering communication for transmission of data images before and after utilizing a dual combined compression technique is presented in this paper. Reducing the quantity of transmitting data is considered as a means to improve energy exhausting in order to prolong the entire network lifetime. The proposed images in this work are elected from a dataset of web JPEG images.

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1- The elected dataset color images are shown in Figure 7.
2- Table 1 presents the image size in byte for dataset images before and after compression.
3- Figure 8 shows bar chart of energy dissipation from sensor node before and after utilizing the proposed technique, by using the elected dataset test images.
4- Figure 9 shows bar chart of energy dissipation from cluster head node before and after utilizing the proposed technique.
5- Figure 10 shows bar chart of gained energy in sensor node and cluster head by utilizing the proposed technique.

Figure 7: The proposed dataset color images.

Table 1: The image size in byte before and after compression

Image title	File size in byte	File size after 1st compression	File size after 2nd compression
Guard	17177	12134	11308
Border Patrol	13977	11783	11131
Air Plane	9935	7231	6737
Sniper	15933	12196	11566
Battle	17329	13935	12461
Patrol	11559	9249	7986

Figure 8: Show bar chart of energy dissipation from sensor node before and after utilizing the proposed technique for the elected dataset test images.

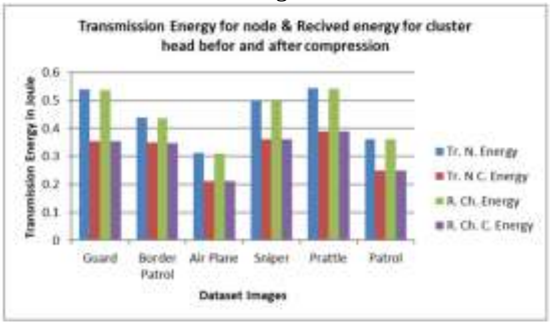

Figure 9: Show bar chart of energy dissipation from active node and cluster head before and after utilizing the proposed technique.

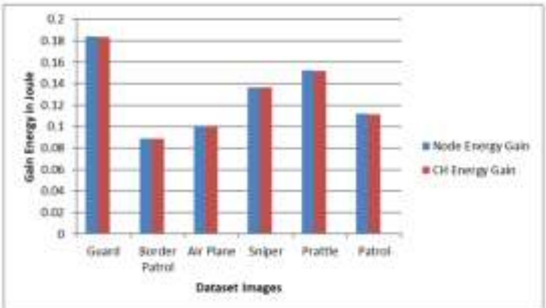

Figure 10: Shows bar chart of gained energy in sensor node and cluster head by utilizing the proposed technique.

VI. CONCLUSION

In WSN the enhancement of energy dissipation will promote, by utilizing a dual compression technique for images transmission. The improvement of promise compression technique for efficient energy dissipation is present and examine. In order to overcome the limitation of energy resources for individual nodes in intra-clustering communication, the consumed energy and image quality must be considered. The proposed technique has extra advantage in improving the decreasing of energy dissipation to prolong the entire network lifetime, by present a significant data reduction for the elected dataset images.

There have been several attempts by researchers who preceded us in this field and their results were promising, but using this method of image compression has reduced the volume of data transferred and will improved the amount of dissipated energy from the wireless sensors. A distinction was made in this study through taking many types of compression techniques, based on selected wavelet methods, and informed the influences of these methods at the parameters of image compression. Henceforth, the better couple of these methods has been identified.

The practical results show that the proposed image compression combining techniques will enhance the efficiency of compression ratio between 8.1 to 31.4%, and will present a promising preservation energy technique in intra-clustering communication by the ratio between 17.8 to 36.7% (depends on the specifications of the tested image). Which have a positive effect on WSN exhausting energy, that will prolong the network lifetime.

From the results obtained, it became clear to us that the image with high color variation has high compression ratio, lead to get high gain in energy to compress the elected image and to transmit the image data by active node. In the future, image compression methods can be used that do not significantly affect the quality of the transmitted data images.

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