# Image Transmission Model with Quality of Service and Energy Economy in Wireless Multimedia Sensor Network

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***Abstract*—The objective of this article is to present the efficiency of image compression in the Wireless Multimedia Sensor Network (WMSN), the method used in this work is based on the lifting scheme coupled with the SPIHT coding to wavelet biorthogonal CDF 9/7. The effectiveness of this technique results in combining two advantages. First it allows saving energy to prolong the life of the network; second, it improves the Quality of Service (QoS) in terms of average throughput, the number of dropped packets, and End-to-End average delay. The authors examined two scenarios of the same network model in NS2 simulator, according to the above critical points of the energy economy and quality of service, the first scenario transmits an original image, and the second sends the compressed image with the used method. The simulation results presented show that the proposed system allows to extend the life of the network and minimizes the consumption of energy; and it can transmit the image in comfortable conditions for QoS of network, reduce the End-to-End average delay, no dropped packet, best average throughput and satisfied for bandwidth.**

***Keywords*—*Wireless Multimedia Sensor Network; Multimedia; Compression; Routing; Energy Consumption; QoS; Energy Economy***

## I. INTRODUCTION

The emergence of Multimedia Sensor Networks Wireless and embedded computing systems opens the way for the deployment of new applications for surveillance, monitoring, and control of large systems, including those that extend over vast areas that require geographical and instrumentation scale [1].

WMSN are useful for many applications such as surveillance and monitoring, military, storage of potentially relevant activities, sport, medical and other fields. These applications bring new scientific and technological challenges that caught the attention of a large number of researchers in recent years.

The character and the specification of the multimedia data such as image cause problems in the transmission of data over the network and in the node itself. Among these constraints, the energy consumption and the quality of service represented average throughput, the number of dropped packets, and End-to-End average delay, knowing that the electronic transmission module take the largest share of energy consumption [2].

Image compression is the optimal solution to solve these problems simultaneously [3-6] while it saving a lot of energy, by sending a small amount of information (compressed image) in the circumstances of the comfortable Qos of the network in terms of flow of information, and no dropped packets in optimal time. The previous scenario is better than the second, which involves sending a very large amount of information (original image), which consumes more energy in unsatisfactory network conditions due to large information flows occupying bandwidth and dropping a high number of packets in a long time.

The paper comprises five sections followed by a conclusion. In the second section titled “energy consumption in wireless multimedia sensor network”, show the importance of image compression, and its importance in energy consumption in WMSN, as review some related work in this area. In the section entitled "QoS evaluation WMSN", show the importance of QoS in WMSNs, e.g. to help make decisions promptly, and explain some of the QoS criteria in WMSNs. In the next section titled "Radio Model (energy consumption)", mathematically illustrate power consumption in the radio equipment for the transmitter and receiver, and how to dissipate energy. The other sections include positioning of our work and our contributions in detail.

## II. ENERGY CONSUMPTION IN WIRELESS MULTIMEDIA SENSOR NETWORK

The energy consumption is very important criterion of performance in WMSNs. The large volume of media (eg image) requires bandwidth that consumes more energy. [5] The economy of energy for the transmission is necessary for nodes which allow extending the life of the network.

Data compression or source coding can be lossy or lossless. In WMSN, the lossy compression is often preferred for low-speed transmissions; it loses details in the image but within acceptable limits. Using this type of compression to data transmission in WMSN [10-12] allow energy saving visible, which leads to prolong the lifetime of the network, in contrast, the transmission the natural image that consumes seven times the energy, energy consumption are the additive value [23]. As prove it in this article.

Several research studies related to image compression in wireless multimedia sensor networks in the literatures [5] and [24-26].

In [5], ZainEldin H et al. discussed various compression techniques to WMSN a comparison between them and the factors that affect compression performance. Image quality, compression ratio, speed compression and energy consumption are the most important indicators discussed for compression performance.

In [24], Kumar v et al analyzes of all the obtained experimental results demonstrates that the incorporation of SVD and BTC in image compression along with OCT in an adaptive manner enhances the compression performance significantly. They proposed technique performs the best technique in terms of PSNR and MSE. But it requires slightly longer time that makes it suitable for large bandwidth. This compression technique depends on the parameter (x) that based on the observation of the standard deviation ( $\sigma$ ) to decide what compression technique can be used as following: if ( $\sigma$ < x) use DCT, else if ( $\sigma$ > x) use SVD, else if $(35 \leq \sigma \leq 45)$ use BTC

In [25], Ghorbel et al compare two image compression methods, Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) and test the ability of each method on wireless sensor networks (WSN) to. And they implement these methods on a real platform of sensor networks with TelosB sensor type. And they are running the performance evaluation and compare the two methods in terms of image quality, execution and transmission time, and lost packet and memory usage and energy consumption

Ma et al. [26] present the multimedia compression techniques and multimedia transmission techniques and provided an analysis of energy efficiency when applied to limited resources platform. For the image compression they discussed three important technical JPEG2000, JPEG (DCT) (EBCOT) and SPIHT. They analyzed in their working efficiency in compression terms, the memory requirement and computational complexity. They concluded that SPIHT is the best choice for compression methods lower power consumption due to its ability to provide higher compression ratio with low complexity. JPEG2000 (EBCOT) hit a high compression ratio, which means better quality than SPHIT, but the burden of higher computation and power consumption for resource-limited systems, due to the complexity of operations EBCOT Tier-1 and Tier-2 caused intensive complex coding.

## III. The QoS Evaluation in WMSN

Because of the critical and urgent nature of certain information from multimedia sensors such as in football, detection systems errors arbitration as technology on the goal line (goal-line technology or goal decision system) is an electronic device and / or video assistance to arbitration, used to determine for certain whether a ball has crossed fully or not the goal line in a very short time, it is necessary to provide QoS support for these applications.

These applications require that the data received must reach the base station during a limited time to the data is useful and acceptable [13]. WMSN with QoS reflects the delay requirements, bandwidth and residual energy. It also optimizes energy management.

In general, a criterion is a system or standard of measurement defined as a parameter for quantitatively assessing a method, event, and entity by using special procedures to perform measurements [14].

Among the QoS evaluation objective criteria in WSN:

*Average energy consumption:* [15] the average energy consumed by all nodes in the network, and lifetime: [16, 17] Time until the first sensor node or group of sensor nodes in the network runs out of energy.

*End-to-end delay:* the average time taken by a data packet to arrive in the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations that counted. The delay of end to end and is the additive value [15, 23].

End-to-end Average delay = ∑ (arrive time – send time) / ∑ Number of connections.

*Throughput:* [15] the average time from the first bit until the last bit of data packets has left the transmitting node to destination a certain node, excluding protocol overhead, and excluding retransmitted data packets, which generally is lower than network access connection speed (the channel capacity or bandwidth).

Throughput = ∑ number of packet send / ∑ send time.

*Packet Delivery Ratio:* [15, 18] is measured as a percentage of receive packets with respect to Generated Packets (packets sent), Packet Delivery Ratio is the multiplicative value [23]. The main parameters that monitored are usually bandwidth, latency, dropped packet and request response time.

Packet Delivery Ratio = ∑ number of packet receive / ∑ Number of packet send

*Dropped Packets:* the total number of dropped packets during the transmission

Dropped Packet = number of packet send – number of packet received.

## IV. Radio Model (Energy Consumption)

Model of the energy consumption of the radio equipment for transmitter and receiver dissipate energy, to operate the electronic radio, as shown in Figure 1. The formula for the transmission of energy consumption and reception data of K-bit from two sensors at a distance *d* is as follows [20, 21]:

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d) \qquad d > 1$$

$$E_{Tx}(k,d) = E_{elec} * (k) + \in_{amp} * k * d^{2} \qquad (1)$$

And receive data, radio spending:

$$E_{Rx}(k) = E_{Rx-elec}(k)$$

$$E_{Rx}(k) = E_{elec} * k \quad (2)$$

Total consumed energy of each node

$$= \Sigma E_{Rx} + \Sigma E_{Tx} \quad (3)$$

= Total consumed energy of data receiving + total consumed energy of data transmitting [22].

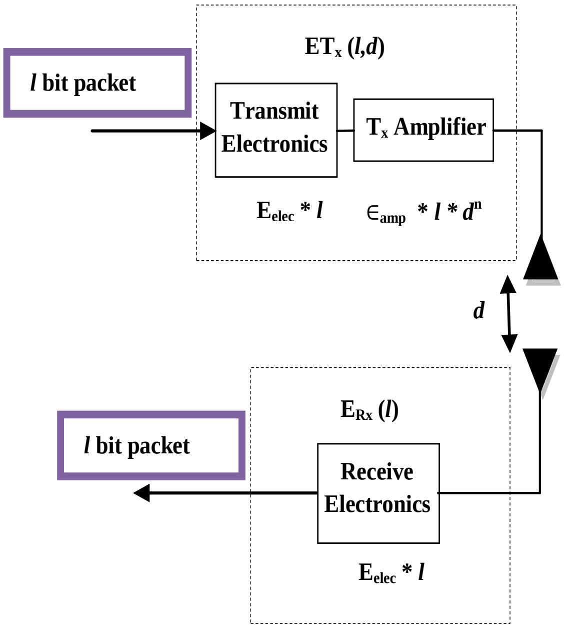


Fig. 1. Radio Model (energy consumption)

## V. Network Model and Simulation

The proposed work is implemented using NS2 version 2.35 and Matlab R2014a. The simulation is carried out on personal computer with Intel(R), Pentium (R) CPU P6200, processors rated at 2.13 GHz, main memory of 4 GB and 64 bit Microsoft Windows 7 operating system and in Ubuntu 14.04.

### *A. The compression method*

The Biorthogonal CDF 9/7 Wavelet Based on Lifting Scheme and SPIHT Coding is a Discrete Wavelet Transform (DWT). The wavelet transform that uses functions located both in real space [7,8]. This method is detailed in [9] Beladgam.M et al have used a grayscale image to prove the effectiveness of this method in terms of image evaluation criteria objectives such as the compression ratio , PSNR and MSSIM, where they are compared against other methods. For these reasons, take decision to use this method to transmit a color image in WMSN. In the MATLAB simulation program, the color image compression flowchart 512x512 Lena to be transmitted is described in Figure 2. In a first step, each pixel of the original image color is multiplied by the bitrate 0.75 pixels per second (bpp). Then, convert the color space of the image from RGB to YCbCr. Third, apply Wavelet Decomposition (CDF9 / 7 + lifting) Each layer is Independently and apply SPIHT Encoding Each layer is Independently For Each matrix Y, Cb and Cr. Eventually image size is obtained compressed to be transmitted (Bit Streams) to generate packets that are saved in a CSV file; the algorithm to generate these packets is as follows:

**Algorithm 1**

```
image_compressed_size = bit Streams/8      /* image compressed size by bytes */
Initialize the packet size (packet_seize)      /* in bytes */
Packet_number1 = image_compressed_size/packet_seize
Packet_number2= rounding the (Packet_number1)
if  (Packet_number1 > Packet_number2)
{
   packet_number = Packet_number2 +1
else
    packet_number = Packet_number1
}
/* creating a matrix contains the number of packets and the size of each packet * /
s=0
for (i=1 ;i<= packet_number; i++)
 {
if  (packet_seize < (image_compressed_size - s))
{
T[i]= packet_seize;
s=s+ packet_seize;
 else
  T[i]= image_compressed_size -s;
}
}
    /* Then, Write the content of the matrix T [packet_number] that contains the size of each packet in a CSV type file, then uses this file in the image transmission model in NS2 simulator  * /
```

### *B. Wireless Multimedia Sensor Network*

In this experiment, using the NS-2 simulator, is particularly well suited to packet switched networks [19], using the reference image Lena color. Two scenarios are realized, the first is to transmit the original image and calculate the energy consumed for each node of the network and overall energy, and also calculates the average of the network and the rate of dropped packets, and calculated the same for the second scenario, which will send a compressed image.

In this article, adopt a WMSN formed by fifteen nodes multimedia randomly denoted by N= {n1, n2, ..., n15}, deployed sensors in area of 600*600 $M^2$, of the different distances *d* between tow nodes and only one sink node. All sensing nodes are used for data collection in the surveillance zone and do not move after deployment, in these 15 nodes three nodes multimedia (n2, n9 and n13) transmit data at the same time to the sink node, as shown in Figure 3. The main distinguishing features of the system are as the followings:

- The sink node has highest ability of communication and computation, and has not the energy problem.
- All the multimedia sensor nodes have the same initial energy and the capacity of communication and computing.

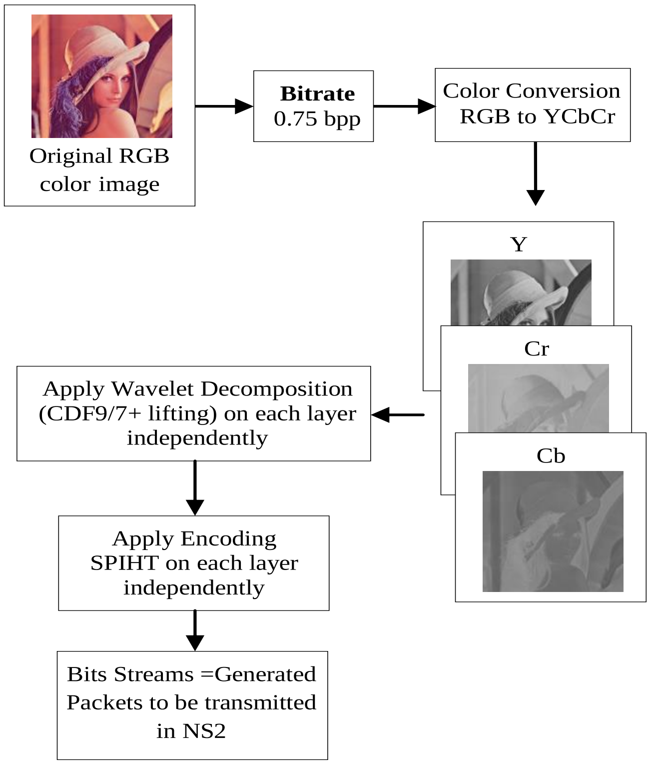


Fig. 2. The image compression flowchart

Only focus on overall energy consumption by the entire network as a single unit, the energy consumed by each sensor, Packet Delivery Ratio, Average End-to-End Delay and Average Throughput, while communications between node and sink devices outside the network are outside the scope of this article.

The simulation parameters are shown in Table I.

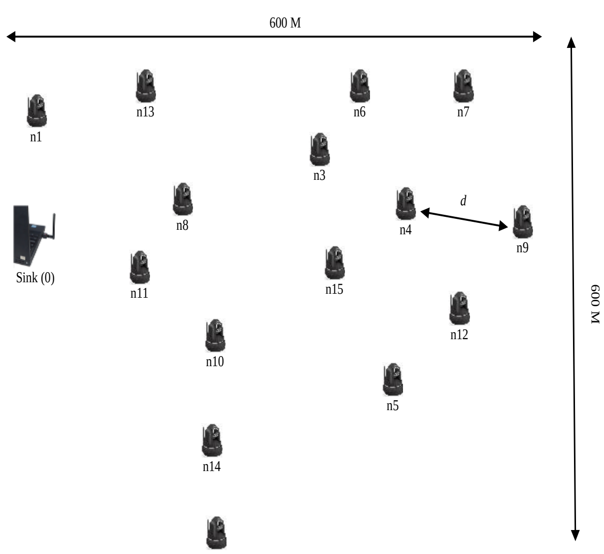


Fig. 3. Network model

TABLE I. NS2 SIMULATION PARAMETERS

| **Parameter** | **Value** |
|---|---|
| **Network** | Static |
| **Simulation area** | 600 m* 600 m |
| **Network sizes (node number)** | 15 |
| **Routing protocols** | AODV |
| **Traffic source** | Constant Bit Rate (CBR) |
| **Initial energy (J)** | 100 |
| $E_{Tx}$ | 0.6 nJ/bit |
| $E_{Rx}$ | 0.3 nJ/bit |
| **Antenna model** | Antenna/omniantenna |
| **Interface queue type** | Queue/Drop tail/priqueue |
| **Link layer type** | LL |
| **Min packet in ifq** | 50 |

## VI. RESULTS AND DISCUSSION

The results of the simulation are shown in Table II, which shows:

All evaluation criteria: energy consumption average, the number of packets to be transmitted, Packet Delivery Ratio, Average End-to-End Delay and Average Throughput show that the results of scenario 2 (Compressed Image Transmission) are much better than the results of the first scenario.

Network lifetime: the simulation time of the second scenario is about 14.55% of the first scenario, which indicates that the length of life of network transmitting a compressed image with the method studied can extend this period almost seven times that the transmission of original image.

Figure 4 shows the simulation graph for the rate of energy consumption for each sensor node in both scenarios, and as see that the energy consumption in the second scenario is approximately equal to 14, 52% of Energy consumed in the first scenario.

TABLE II. SIMULATION RESULTS

| **Criteria** | **Scenario 1** | **Scenario 2** |
|---|---|---|
| **Simulation time (s)** | 31.108277 | 4.526776125 |
| **Average Energy Consumption (J)** | 9,561964533 | 1,388441 |
| **Generated Packets** | 2364 | 225 |
| **Received Packets** | 1702 | 225 |
| **Packet Delivery Ratio (%)** | 71.9966 | 100 |
| **Number of dropped data (packets)** | 660 | 00 |
| **Number of dropped data (bytes)** | 673200 | 00 |
| **Average End-to-End Delay (ms)** | 3353.02 | 970.678 |
| **Average Throughput [kbps]** | 436.74 | 390.83 |

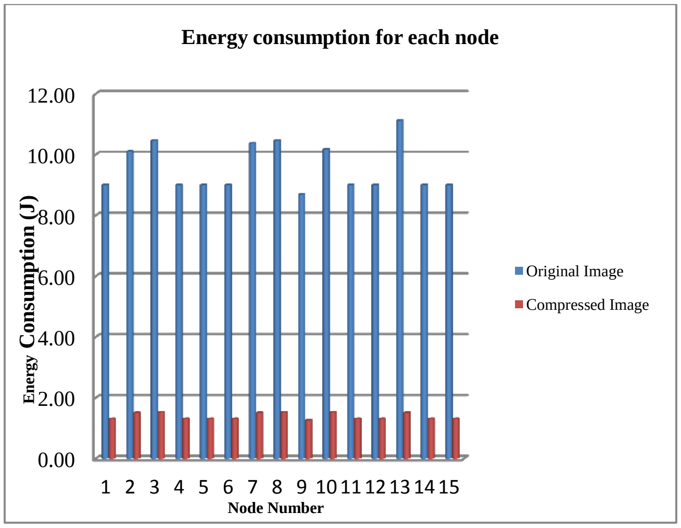


Fig. 4. Energy consumption for each node

## VII. Conclusion

In this article, the authors use an algorithm of Biorthogonal CDF 9/7 Wavelet Based on Lifting Scheme and SPIHT Coding in Wireless Multimedia Sensor Network.

This proposed scheme is shown to provide energy savings of about 14, 52% (that is to say seven times that the transmission of original image) at each network node, and can improve the overall energy economy, and also offer the best terms of Quality of Service, during the data transmission with a throughput without affecting bandwidth, without dropped packets (Packet Delivery Ratio = 0), and with an acceptable delay (Average End-to-End Delay).

From the foregoing, which confirms the effectiveness of the use of this method in all types of networks, whether large or small sizes, especially in networks that can monitor environments with unfavorable terrain such as volcanoes, mountains or forests.

## Acknowledgment

The authors would like to be grateful to the Editor and anonymous reviewers for their invaluable comments and suggestions, which have improved the quality of the paper.

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