Implementation of Modified Huffman Coding in Wireless Sensor Networks

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ABSTRACT
WSNs are composed of many autonomous devices using sensors that are capable of interacting, processing information, and communicating wirelessly with their neighbors. Though there are many constraints in design of WSNs, the main limitation is the energy consumption. For most applications, the WSN is inaccessible or it is unfeasible to replace the batteries of the sensor nodes makes the network power inefficient. Because of this, the lifetime of the network which has maximum operational time is also reduces. To make the network power efficient, different power saving/reduction algorithms are proposed by different authors. Some of the authors have achieved the low power consumption by modifying like encryption & decryption algorithms, Routing algorithms, Energy Efficient Algorithms, Compression and decompression algorithms, minimizing control packets, and many other different power reduction algorithms. Among many algorithms, we have chosen data compression techniques aiming different targets like memory, power & bandwidth reduction. To achieve our objectives, we have worked on Huffman coding - compression algorithm and updated the algorithm by including one's complement, XOR operations and finally named as Modified Huffman Coding. The performance of the proposed model is analyzed and it is observed that, information is maximum compressed which consumes less computational power, thereby increasing the battery life.

Keywords
WSN, Power Consumption, Security, Huffman Compression, Decompression.

1. INTRODUCTION
A sensor network is an infrastructure comprised of sensing (measuring), computing and communication elements that gives an administrator the ability to instrument, observe and react to events and phenomena in a specified environment. The administrator typically is a civil, governmental, commercial or industrial entity. Sensors are typically deployed in a high-density manner and in large quantities. WSNs typically transmit information to collecting (monitoring) stations that aggregate some or all of the information. WSNs have unique characteristics, such as, power constraints and limited battery life, redundant data acquisition, low duty cycle, security and many-to-one flows. In some cases it is challenging to collect data from WSNs because of irregular connectivity due to a low-battery status. Low power consumption is a key factor in ensuring long operating horizons for non-power-fed systems. To make WSN power efficient, different solutions have been proposed by many authors and some of them are listed below.

- Data compression & decompression algorithms.
- Minimization of control packets by reducing link failures, results low power consumption.
- Specially designed power control techniques
- By modifying encryption & decryption algorithms

Among many techniques/proposals, the authors Ruxanayasmin, et al, proposed LZW compression technique to minimize the power consumption [1]. Lempel-Ziv-Welch (LZW) compression algorithm is fast, simple to apply and works best for files containing lots of repetitive data. LZW algorithm is efficient because the output resembles numerical data and also it doesn't need to pass the string table to the decompression code. Due to compression, the number of bits can be reduced to maximum extend so that the need of memory and bandwidth are very less. Also, the compressed text resembles a scramble message and an attacker in middle cannot able to understand. Therefore, the data compression not only reduces the size of the original text, but also gives data security.

Section-II describes the related work on power consumption techniques proposed by different authors and description of the Huffman Coding in Section-III. Section IV describes the Problem statement and Overview of proposed algorithm. Implementation and simulation results are observed in section-V and section-VI concludes the work with future enhancement.

2. RELATED WORK
The authors Shahina Sheikh, Ms. Hemlata Dakhore proposed Data Compression Techniques for Wireless Sensor Networks. They proposed modified Huffman Coding for Wireless Sensor Networks which does not require the statistics of the sensed data and it encodes the difference of the current and the previous value of the sensed data. By this algorithm, a good compression ratio for both highly correlated and medially correlated sensor node data is achieved [2].

The authors Karl Skretting, et al, proposed Improved Huffman Coding Using Recursive Splitting. The proposed scheme takes an advantage of some dependencies in the symbol sequence and exploits this in the Huffman coding procedure. They splitted the original symbol sequence into two sequences in such a way that the symbol statistics are, hopefully, different for the two sequences. Individual Huffman coding for each of these sequences will reduce the average bit rate. This split is

done recursively for each sub-sequence until the cost associated with the split is larger than the gain [3].

The authors Swati C.Pakhale, et al, proposed Data Compression Technique Using Huffman Code for Wireless Sensor Network. The objective of their proposed work is to minimize the total number of bits required to be transmitted from the sensor node to reduce the energy consumed by the sensor node. The proposed algorithm does not require the statistics of the sensed data though however encodes the difference of the current and the previous value of the sensed data [4].

The authors Chetna Bharat Mudgule, et al, surveyed different compression techniques in Wireless Sensor Network. In their analysis, Predictive coding is very helpful in reducing the data communication but needs to have a knowledge of statistics of data and thus in case of dynamic environment it can be highly expensive and complex. Distributed Source Coding (DSC) techniques provides high compression ratios but again it requires the correlation knowledge of data, it is quite expensive in that terms [5].

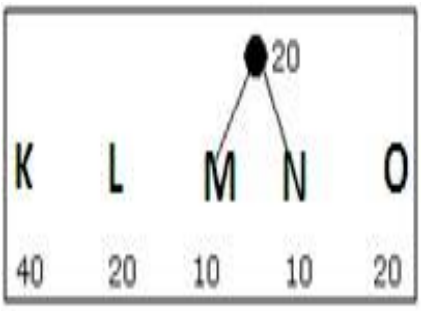
The authors Peng Jiang and Sheng-Qiang Li, proposed Data Compression Algorithm for Wireless Sensor Networks Based on an Optimal Order Estimation Model and Distributed Coding. They proposed a data compression algorithm for wireless sensor networks based on optimal order estimation and distributed coding. Sinks can obtain correlation parameters based on optimal order estimation by exploring time and space redundancy included in data which is obtained by sensors. Then the sink restores all data based on time and space correlation parameters and only a little necessary data needs to be transmitted by nodes. Because of the decrease of redundancy, the average energy cost per node is reduced and the life of the wireless sensor network is obviously be extended as a result [6].

Among different compression techniques, here we have modified existing Huffman Coding to increase its efficiency and also to obtain data security.

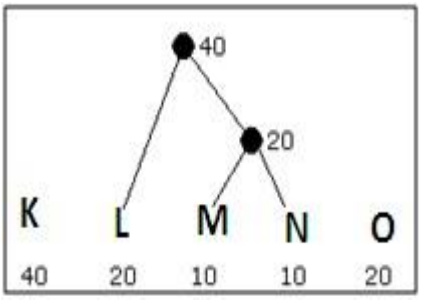
3. DESCRIPTION OF HUFFMAN CODING

The concept of Huffman Coding is obtained from binary trees which are used for data compression. Huffman Coding is a statistical data compression technique used for standard text documents. The algorithm gives the reduction in the average code length used to represent the symbols of an alphabet. It produces variable length codes that are an integral length of bits and it is a method for the construction of Minimum-Redundancy Codes [7]. The Huffman coding comes under Source coding in which less number of bits are assigned for the characters with highest probability of occurrence and vice-versa. This is also known as variable length coding. The important property is that coding is constructed in such a way that no two constructed codes are prefixes of each other and it is much helpful in deciphering the code. The algorithm is explained with an example.

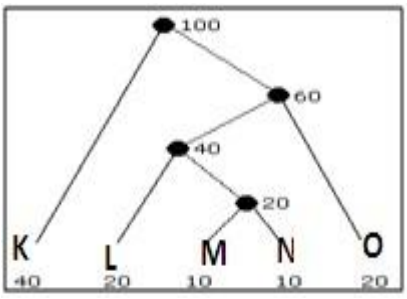
- Assume five different symbols with relative frequencies are:
  - **K**: 40
  - **L**: 20
  - **M**: 10
  - **N**: 10
  - **O**: 20
- The Huffman tree is constructed by considering the symbols with less frequency. Here the symbols M and **N** have frequency 10 and 10, so combine those two frequencies.



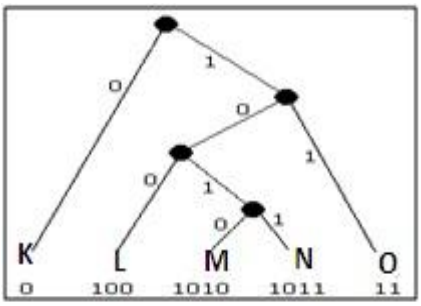
- **M** and **N** have already been used, and the new node is placed above them (named as **M**+**N**) has value 20.
- The smallest values are **L**, **M**+**N**, and **O**, all of which have value 20.
- Connect any two of these frequencies.



- The smallest value is **O**, while **K** and **L**+**M**+**N** all have value 40
- Connect the symbol **O** to either of the others.
- Connect the final two nodes



- Assign 0 to left branches, 1 to right branches
- Each encoding is a path from the root



- The bits assigned for the given symbols are
- **K** = 0

L = 100
M = 1010
N = 1011
O = 11

- Each path terminates at a leaf.

4. PROBLEM STATEMENT AND OVERVIEW OF PROPOSED ALGORITHM

The main objective of this work is to implement a novel scheme to eliminate the redundant hardware as well as the redundant transformed data which reduces system complexity, memory, bandwidth and power. Also, a secure communication among nodes is necessary to allow the integrity of the delivered packets. To achieve this, we proposed a novel technique which is simple and easy to implement is shown in the Fig.1.

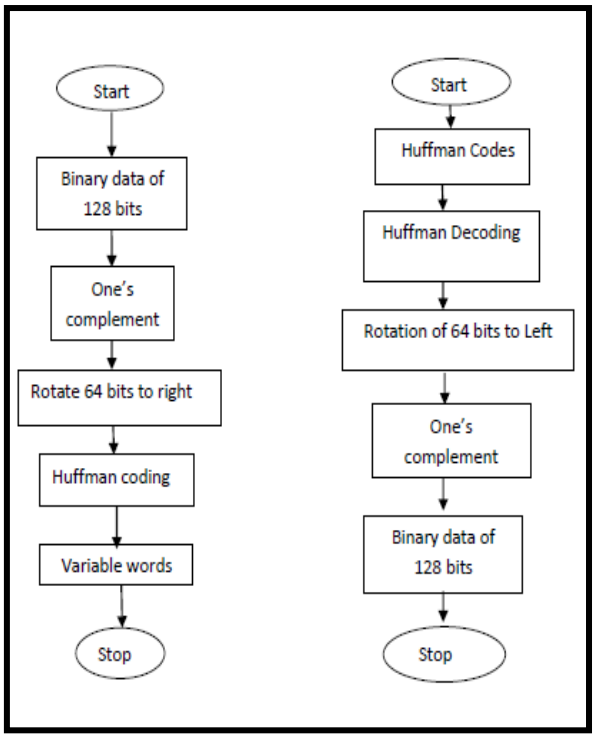


Figure 1: Flow Chart of Proposed Algorithm

The proposed work is the combination of one's complement, rotations and Huffman Coding algorithm, named as Modified Huffman Coding Algorithm. In the first stage, the incoming bit stream is divided into packets of size 128 bits each, and performs one's complement on the bits. The one's complemented data is shifted 64 bits right and compressed using Huffman Coding algorithm and transmitted. At receiver, the reverse operation is performed to get back the original data. By implementing this algorithm,

- The information can protect from attackers.
- The transmission bandwidth and memory requirement can minimize.
- Transmitting less number of bits consumes less power

The proposed algorithm is explained with a simple example. Consider the text "ABCD".

At Transmitter

Step1: Let the original text : ABCD

Step2: Binary Conversion of Original text – 10000011000010100000111000100. In this example each character is assigned with 7 bits. Total 28 bits.

Step3: One's Complement of step 2 – 0111110 0111101 0111100 0111011

Step4: Rotate 14 bits to right – 0111100 0111011 0111110 0111101

Step5: binary to decimal conversion: 60 59 62 61

Step6: Output of Huffman Coder: 00101100011000100011. The output sequence of Huffman Coder is transmitted.

At Receiver

Step1: Let the received data is 00101100011000100011

Step2: The received data is decompressed using Huffman Decompression
0111100 0111011 0111110 0111101

Step3: Rotate 14 bits to left 0111110 01111010111100 0111011

Step4: One's Complement of Step3: 10000011000010100000111000100
Step5: Binary to String Conversion: ABCD

5. IMPLEMENTATION AND SIMULATION RESULTS

The proposed work is implemented in Glomosim (Global Mobile Information System Simulation) and the performance is evaluated. It is a scalable simulation environment for large wireless network systems are uses a parallel discrete event simulation capability provided by C-based Parallel Simulation Environment for Complex System (PARSEC). The proposed method was simulated analyzed shown in table 1.

Table 1: Analysis of Existing & Proposed Model

S.No	Original Huffman coding				Proposed Model / Modified Huffman coding			
	Original bits	Compressed bits	Efficiency (%)	Time(S)	Original bits	Compressed bits	Efficiency (%)	Time(S)
1.	2310	1664	27.96	0.1514	2310	1664	28.80	0.1824
2.	9464	3021	68.07	0.1913	9464	3021	69.78	0.2391
3.	15918	5256	66.98	0.2887	15918	5256	66.01	0.3126
4.	22736	7444	67.25	0.3800	22736	7444	68.25	0.4316

From the table 1, it is observed that the efficiency of existing and modified Huffman Coding is almost same. Huffman Coding has good efficiency if the incoming text is large. The execution time of modified Huffman coding is little bit high and this is due to one's complement and rotations. The main advantage of proposed work is reduction of battery consumption, thereby increasing battery life along with information security.

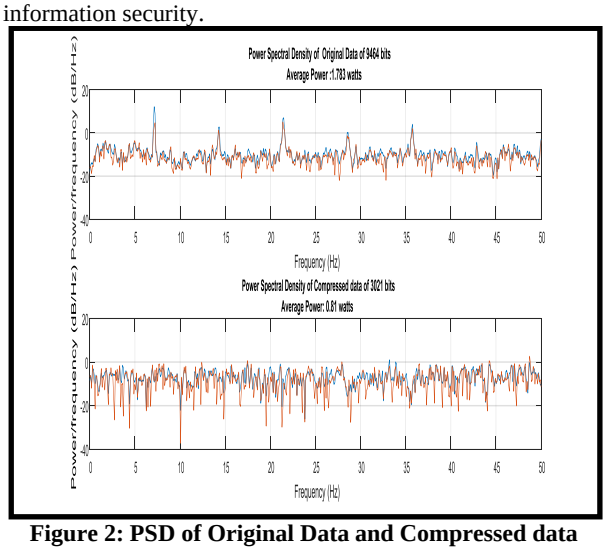


Figure 2: PSD of Original Data and Compressed data

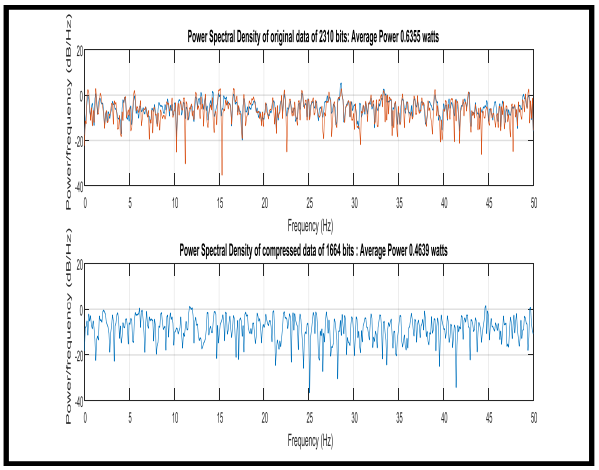


Figure 3: PSD of Original Data and Compressed data

The figures 2 & 3 show the Power Spectral Density of the incoming data and compressed data. It is clear that the power required for the compressed data is less than the original message. Thus by implementation of our proposed work, it is observed that the delay and power consumption is reduced, there by requirement of Bandwidth reduces.

6. CONCLUSION AND FUTURE WORK

In this paper, Modified Huffman Coding which is an efficient algorithm for compression with data security implemented successfully. Using this compression technique, any text or document file can be compressed more than 50% of its original size without any loss of data and the performance of the algorithm is analyzed before and after compression. In this, we have considered the data compression to improve the battery life by transmitting compressed data to consume low power. In future, other attributes in this limited battery life can be addressed, so that the Quality of service in Wireless Sensor Networks can be improved. In the future, the other compression techniques are needed to implement and compare their performance.

7. REFERENCES

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