 ISSN : 0976-8491 (Online) | ISSN : 2229-4333 (Print)

EEMD: Energy Efficient Modified Deflate for Data Compression in Wireless Sensor Network

[1]Chetna Bharat Mudgule, [2]Prof. Uma Nagaraj, [3]Prof. Pramod D. Ganjewar
[1,2,3]Dept. of Computer Engineering, MIT Academy of Engineering, Pune, Maharashtra, India

Abstract
Wireless Sensor Networks (WSNs) has enhanced capabilities and huge applicability in many fields like military, environmental studies, medical and many more. WSN comprises of sensor nodes distributed spatially to accumulate and transmit measurements from environment through radio communication. It utilizes energy for all its functionality (sensing, processing, and transmission) but energy utilization in case of transmission activity is more. So, it opens a door towards the research which are done in concern of reducing the energy consumption of WSN by using different approaches. Data compression can work effectively in this regards and it deals with reducing the amount of data to be transmitted before transmission to the sink in WSN. Here proposed compression algorithm i.e. Energy Efficient Modified Deflate (EEMD) along with fuzzy logic works effectively to save the energy of WSN.

Keywords
Wireless Sensor Networks, Radio Communication, Energy Consumption, Transmission, Data Compression, Energy Efficient Modified Deflate, Fuzzy Logic

I. Introduction
Wireless sensor networks are gaining lots of lots of attention with advancements in the technology. WSN is a network of many self-organized sensor nodes those are small and perform the functions of sensing, measuring and gathering the information from the environment or purpose for which they are arranged. For performing the functionality of sensing, processing and transmission, it is provided with battery resource. But generally the more energy is utilized in transmission i.e. while taking the communication between sensor odes to sink and thus its need to be conserved or minimized [1].

Now a days the issue of energy conservation in WSN has taken a verge, many solutions are suggested. Data-driven approaches are one of them. Data compression comes under this category of energy saving and it can be defined as the process of reducing the data by encoding it and presenting it in encrypted form which can be easily recovered by the process of decompression i.e. decryption of data. As after compression lesser bits are required for representing the value, it is found to be effective in applying on sensor node, i.e. compressing the data before sending to sink [2-3].

Deflate is lossless compression algorithm which utilizes the capabilities of LZ77 and Huffman encoding for performing compression. The algorithm Energy Efficient Modified Deflate (EEMD) is proposed for improving the lifetime of network by minimizing the energy consumption, packet delay and enriching the compression ratios and throughput of network. Comparative results shows that EEMD works effective than Huffman and Deflate. EEMD works on the same principle of Deflate but it contains the addition of fuzzy rules to improve the energy efficiency.

II. Related Work
Jonathan et al. [5] proposes a fast and efficient lossless adaptive compression scheme (FELACS) for wireless sensor networks. This algorithm is fast by taking the idea of generating the coding in very less time, utilizes low memory, it has low complexity and very effective in case of packet losses

Tommy Szalapski and Sanjay Madria [6] presents Tinypack compression algorithm which is a set of energy-efficient methods. These methods are mend for achieving high compression ratios, for reducing the latency, storage and bandwidth usability. Here the compression method utilizes the concept of compression in Huffman way which in turn helps in consumption of bandwidth in more precise way. It is simulated on simulation as well as on hardware platform and found to be energy efficient. It also focus on the error estimation and recovery methods for more reliable WSNs.

Mohamed Abdelaal and Oliver Theel [7] introduces the innovative and adaptive data compression technique which uses Fuzzy transform for decreasing the bandwidth, memory used and energy utilized. It works extremely well and almost 90% of power consumed can be conserved with good compression ratio.

Emad et al. [8] gives the implementation of data oriented approach for minimizing the power consumption spend when the communication takes place between sensor nodes and sink node. They referred it as “Model-based Clustering” approach which works of the principles stated by mixture-model based clustering. In case of resource limited sensor network also it shows appreciable amount of energy saving.

According to Xi Deng and Yuanyuan yang [9] suggestions compression is not always capable of performing the task of reducing packet delay in wireless sensor network rather it is a combination of both network and hardware conformations. Thus taking this aspect they had proposed the adaptive approach towards it by compressing the data whenever it is required based on online decisions. It also helps in maximizing the benefits of compression and effectiveness of adaptive step taken towards it.

Massimo et al. [10] presents the two adaptation schemes for the lossless compression algorithm i.e. Lossless Entropy Compression (LEC) by applying the concept for rotating the prefix–free tables. It is observed that the adaptive schemes perform better than the LEC by analyzing them based on different statistical tests.

Mohammad et al. [11] describes the second mode of Deflate algorithm which is appropriate for real-time applications and thus the improvement is done in this mode by adding the advantage of modifying the table adaptively depending on the input provided. It improves the coding enactment but needs some improvements in terms of hardware and throughput.

Danny Harnik et al. [12] provides the implementation of deflate by making it fast by utilizing the fast version of LZ77 (LZ4 package) and Huffman (zlib). It is observed that it outperforms in terms of improving the speed of Deflate.

Wu Weimin et al. [13] has worked on the drawbacks arises in Deflate i.e. memory overflow and thus it presents the solution to this by exchanging or replacing the Huffman encoding with Marchov chain instead of changing with the static and dynamic Huffman. It is found the mentioned improved version of deflate is efficient than earlier.

III. Proposed Work

Depending on the purpose of application, a WSN is deployed for it helps in performing the sensing activity by sensors. These sensed values are transmitted by sensor nodes to the sink by spending some amount of energy and this energy utilization is more as compare to the energy utilized for sensing and processing. According to researches done, to transmit a single bit of it requires 0.4μJ of energy. The transmission in WSN is quite costly in terms of energy. Data compression can be used as one of the major to reduce the energy consumption while transmission. It will helps in reducing the size of data to be transmitted making the less energy usage for sending the compressed data.

Proposed work includes the compression algorithm and fuzzy logic applied after compression. Performance and analysis is done by calculating energy consumption (in Joules), compression ratio, end-to-end delay (in seconds) and throughput (in kbps).

A. Performance Metrics in Consideration

1. Energy Consumption

Energy Consumption is measured as the percent of energy consumed by a node with respect to its initial energy. The initial energy and the final energy left in the node, at the end of the simulation run are measured. The percent energy consumed by a node is calculated as the energy consumed to the initial energy. And finally the percent energy consumed by all the nodes in a scenario is calculated as the average of their individual energy consumption of the nodes.

Percent Energy Consumed = (Initial Energy – Final Energy) / Initial Energy *100

Average Energy Consumed=Sum of percent energy consumed by all nodes / Number of nodes

2. Compression Ratio

The performance of a compression algorithm is computed by the compression ratio formula defined as:

Compression ratio= 1- (compress size – original size) x 100

3. End to End Packet Delay

It is used to calculate the time between packet origination time at source and packet reaching time at the destination if transmission is successful. The delay occurs for finding of route, queuing, in case of failure, packet retransmission etc.

Packet delay = Receive time at destination – Transmit time at source

4. Throughput

Throughput is calculated as the total number of packets delivered per second, means the total number of messages which are delivered per second.

Throughput of node = (Total data bits received) / (Simulation runtime)

B. Experimental Setup

The simulation of wireless sensor network is computed by using the network simulator NS-3.

Table 1: Simulation Parameters

S.No.	Parameter	Value
1.	Topological Area	1000 x1000m
2.	Number of nodes	30 to 100
3.	Topology	Random
4.	Network type	Multihop
5.	Routing protocol	AODV
6.	Packet size	64k bit
7.	Initial energy of node	10 J
8.	Initial voltage supply	3.0 Volts
9.	Low battery threshold	0.10(fraction of initial energy)
10.	High battery threshold	0.15(fraction of initial energy)
11.	Time between two consecutive periodic energy updates	1.0 second

C. Proposed Architecture

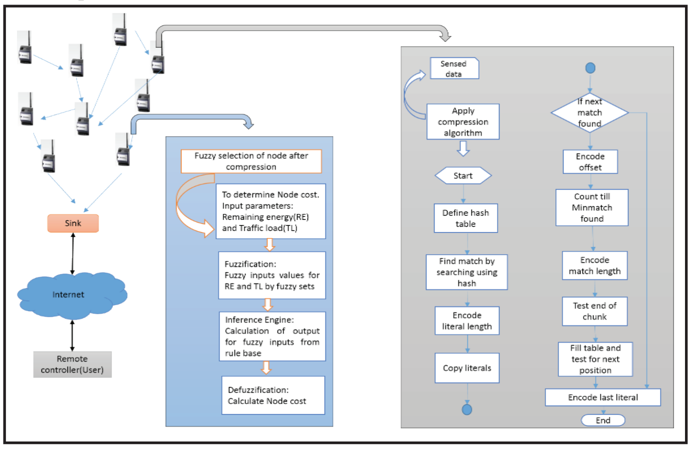

Fig. 1: Proposed Architecture

Fast Deflate is proposed using the fast version of LZ77 i.e. lz4 and has capability of performing the compression at very high speed [12]. But it is widely used for machine level, here it is used for compressing sensor data which is generally more repetitive as compare text data and introducing the ability of this fast deflate version for WSN. EEMD works by dividing the data to be compressed into blocks with specified size and finding the matching in the block compression takes place by maintaining the hashing function. But it gives rise to two important outcomes which can be improved. Firstly it should specify the bound limit for compression and secondly it should effectively work for the remaining data to be compress. To solve both EEMD is designed for WSN. EEMD is more efficient than Huffman and also addition of fuzzy logic concept [14] for achieving the less power consumption on the compressed data. The forwarding the compressed data only to the node which are capable of it which is

ISSN : 0976-8491 (Online) | ISSN : 2229-4333 (Print)

determined by calculating the node cost of node which are coming in the path of source to destination nodes. The detailed working of fuzzy logic is explained as further.

Steps of algorithm:
1. Defining Hash table
2. Finding match by searching using hash
3. Encode literal length
4. Copy literals
5. If nextmatch is found then
- Encode offset
- Start counting till Minmatch verified
- Encode Matchlength
- Test end of chunk
6. Fill table
7. Test next position
8. Perform encoding for last literal
9. End

D. Fuzzy Selection of Node for Data Transmission After Compression

The goal of the fuzzy part of the proposed algorithm is to determine the optimal value of the node cost of node that depends on the remaining energy and the traffic load of node in order to achieve less power consumption on compressed data. Fig. 2 shows the fuzzy approach with two input variables i.e. remaining energy(RE) and traffic load(TL), and an output node cost, with universal of discourse [0…5], [0…10], and [0…1], respectively. It uses five membership functions for each input and an output variable. For the fuzzy approach, the fuzzified values are processed by the inference engine, which consists of a rule base and various methods to inference the rules. The rule base is simply a series of IF-THEN rules that relate the input fuzzy variables and the output variable using linguistic variables each of which is described by fuzzy set and fuzzy implication operator AND.

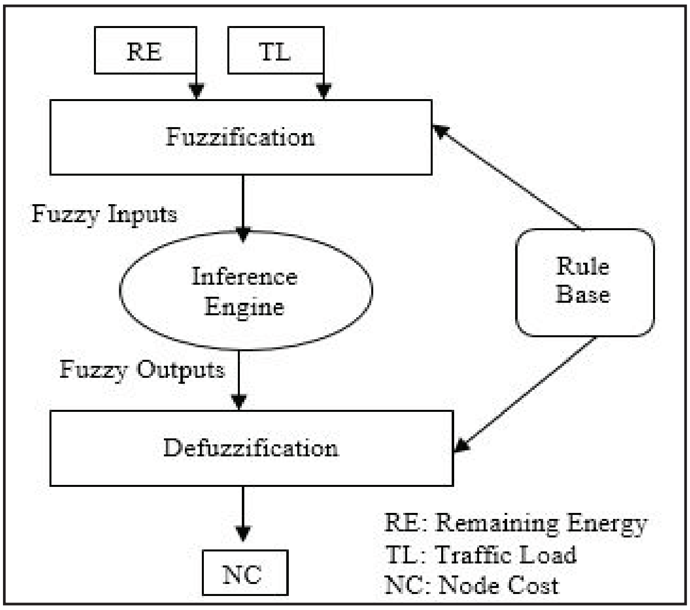

Fig. 2: Fuzzy Structure With Two Inputs of Compressed Data Communication (Remaining Energy and Traffic Load) and One Output (Node Cost).

E. Working of Fuzzy logic

As transmission takes place by considering the path which includes many nodes (as network is multihop), it is more energy saving again after compression to send data to node with maximum energy so to avoid packet drops. And thus it can be reliably known by determining the node cost of each node in considered flow. To calculate node cost by using fuzzy phase as follows:

1. Consider remaining energy and Traffic load as two input parameters for determining Node cost of for the particular flow.
2. Perform Fuzzification. Determine input values of fuzzy inputs values for remaining energy and Traffic load by representing them with fuzzy sets.
3. Calculating the outputs for fuzzy inputs from the rule base i.e. through Inference engine.
4. Defuzzification includes the calculation of Node cost by using the output of rule base and center of output member function.

IV. Conclusion

The proposed Energy Efficient Modified Deflate (EEMD) compression of sensor data will definitely be more efficient as compare to the fast version of Deflate and Huffman. As compression helps in reducing the size of data to be transmitted in WSN, by applying the EEMD algorithm the data will get reduced which in turn helps in reducing the energy consumed for transmission. Along with energy conserved, we are also focusing on the compression ratios, end-to-end delay, and throughput of the wireless sensor networks which are varying on the size. This transmission energy saved will in turn help in prolonging the lifetime of whole network.

References

[1] Jennifer Yick, Biswanath Mukheerjee, Dipak Ghosal, "Wireless Sensor Network Survey", Elsevier, Computer Networks, 2008, pp. 2292-2330.

[2] M.A. Razzaque, Chris Bleakley, Simon Dobson, "Compression in Wireless Sensor Networks: A Survey and Comparative Evaluation", ACM Transactions on Sensor Networks, Vol. 10, No. 1, 2013.

[3] Tossaporn Srisooksai, Kamol Keamarungsi, Poonlap Lamsrichan, Kiyomichi Araki,"Practical data compression in wireless sensor networks: A survey", Elsevier, Journal of Network and Computer Applications, 35, pp. 37–59, 2012.

[4] Sebastian Puthenpurayil, Ruirui Gu, Shuvra S Bhattacharyya,"Energy-Aware Data Compression for Wireless Sensor Networks", ICASSP 2007.

[5] Jonathan Gana Kolo, S.Anandan Shanmugan, David Wee Gin Lim, Li-Minn Ang,"Fast and Efficient Lossless Adaptive Compression Scheme for Wireless Sensor Networks", Elsevier, Computer and Electrical Engineering, June 2014.

[6] Tommy Szalapski, Sanjay Madria,"On compressing data in wireless sensor networks for energy efficiency and real time delivery", Springer, Distrib Parallel Databases 31, pp. 151–182, 2013.

[7] Mohamed Abdelaal, Oliver Theel,"An Efficient and Adaptive Data Compression Technique for Energy Conservation in Wireless Sensor Networks", IEEE Conference on Wireless Sensors,December 2013.

[8] Emad M. Abdelmoghith, Hussein T. Mouftah,"A Data Mining Approach to Energy Efficiency in Wireless Sensor Networks", IEEE 24th International Symposium on Personal, Indoor and Mobile Radio Communications: Mobile and Wireless Networks, 2013.

[9] Xi Deng, Yuanyuan Yang," Online Adaptive Compression in Delay Sensitive Wireless Sensor Networks", IEEE Transaction on Computers, Vol. 61, No. 10, October 2012.

[10] Massimo Vecchio, Raffaele Giaffreda, Francesco Marcelloni,"Adaptive Lossless Entropy Compressors for Tiny IoT Devices", IEEE Transcationd on Wireless Communications, Vol. 13, No. 2, Februrary 2014.

[11] Mohammad Tahghighi, Mahsa Mousavi, Pejman Khadivi, "Hardware Implementation of Novel Adaptive Version of Deflate Compression Algorithm", Proceedings of ICEE 2010, May 11-13, 2010.

[12] Danny Harnik, Ety Khaitzin, Dmitry Sotnikov, Shai Taharlev,"Fast Implementation of Deflate", IEEE Data Compression Conference, IEEE Computer Society, 2014.

[13] Wu Weimin, Guo Huijiang, Hu Yi, Fan Jingbao, Wang Huan,"Improvable Deflate Algorithm", 2008 IEEE.

[14] Imad S. AlShawi, Lianshan Yan, Wei Pan,"Lifetime Enhancement in Wireless Sensor Networks Using Fuzzy Approach and A-Star Algorithm", IEEE Sensor Journal, Vol. 12, No. 10, October 2012.

[15] Ranganathan Vidhyapriya, Ponnusamy Vanathi,"Energy Efficient Data Compression in Wireless Sensor Networks", International Arab Journal of Information Technology, Vol. 6, No. 3, July 2009.