A study based on Performance Analysis of Energy efficient cross layer Load Balancing in Tactical Multi-gateway Wireless Sensor Network

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Abstract— In a recent time owing to the expansion in Micro-Electro-Mechanical-System (MEMS) technology, the popularity of wireless sensor network has enhanced enormously. A tactical wireless sensor network (WSN) is a distributed network that collects data from the sensor among the region of interest. Since the sensor nodes are battery operated device, as a result of which it impact the service lifetime of the network. Power saving is a sensitive issue in WSNs as the sensor nodes are deployed with limited battery life. In multi-gateway communication, choice of nodes and account for node movement and communication within the network is extremely necessary that indirectly decides the lifetime of network. To boost the lifetime of the network, load balancing technique using efficient routing mechanism in such a way that traffic is distributed between sensor nodes and gateway. In our analysis we are majorly focusing on compression algorithm i.e. RLE (Run Length Encoding) for reducing the network delay, which can facilitate the system to communicate data from the source to the destination in a very less time and thus improve the speed and throughput of the network. .

***Index Terms*— Huffman coding, Huffman Algorithm, Run Length Encoding (RLE), Tactical wireless sensor network .**

• 1) INTRODUCTION

A sensor network is an architecture that is comprised of sensing (measuring), computing and communication elements that provides an administrator (handler)the power to instrument, observe and react to events and phenomena in a particular environment. The WSNs are often utilized in a very variety of applications like home mnagement, building automation, industrial automation and environment observation. As a result of the enhanced use of WSNs in our day today life, it is finding its popularity in department of defense in specific area to surveillance & intelligence operation. WSNs technology that is employed in defense application will be made-to-order, sensor laden, networked nodes and both mobile & internet hosted user interfaces. The WSNs can replace single high cost sensor assets with large arrays of distributed sensors both in surveillance and security application. WSNs can be utilized to separately monitor deployed system and alarm at a command & control site when certain events occur. Each sensor nodes in the WSNs must be able to sense the physical quantity accurately and must be able to act as a communicating device that can exchange information with nearby nodes. It is vital that data collected from every node is communicated to a desired destination outside the network. A typical WSN and its associated supporting elements are shown in fig. 1. Each individual sensor node capture data using limited battery life. Nodes then use their peers to pass this data to a gateway node and then through supporting infrastructure to command and control site for further processing.

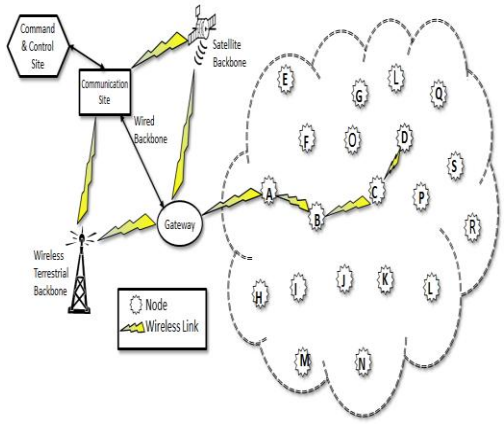

Fig. 1. Operational view of 20 nodes WSN with supporting elements. Sensor D is shown transmitting its data to the gateway through node C, B, and A.

In this paper we will develop the tactical WSNs. These tactical WSNs will be placed in the potentially danger area with gateway nodes placed on the outskirt of these potentially dangerous area. In the absence of the human observation, the network must operate reliably and with full efficiency, covering larger area. The key challenge in the development

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of tactical WSNs is the limited battery life, which affects the performance and lifespan of the network. So to improve the life span of the network, we will use compression algorithm i.e. Run Length Encoding (RLE) in each cluster along with load balancing technique using effective routing mechanism. This will reduce delay in the network and will increase energy efficiency such that traffic is distributed between sensor nodes and gateways. Since there will be maximum number of sensors covering vast geographical region, the main focus will be on how to select nodes and account for node movement and communication in the network. Here we will majorly focusing on compression algorithm i.e. Run Length Encoding (RLE) which will reduce the network delay and help the system to communicate information from source to destination in less amount of time and hence improve the speed, efficiency and throughput of the network.

• 2) LITERATURE SURVEY

Nodes are battery powered which is limited resource and inseparable, whose energy is slowly drained away while sensing the physical quantity thereby also reduces the network life. The communication between two nodes in the WSN takes place in the form of layers. The general network layer consist of five layers: physical, medium access control (MAC), network, transport and application layer. In research paper, Energy Efficient Cross Layer Load Balancing in Tactical Multi-gateway Wireless Sensor Network, the authors [1] has explored a cross layer solution for the load balancing problem. Authors [1] have studied load balancing from cross layer point of view; specifically considering energy efficiency. They have investigated the impact of deploying single and multiple gateways on the subsequent established energy aware load balancing routing techniques: minimum transmission energy, Direct routing, low energy adaptive cluster head routing & zone clustering. To improve the life span of network cross layer load balancing technique is used, which reduces energy consumption by each nodes (Specifically for load balancing and energy efficiency, network layer is access to physical layer for battery parameters and distance between nodes for performance of energy-efficient routing strategies). Authors have developed energy efficient zone clustering algorithm called EZone, which is stimulated in MATLAB software showing that the EZone algorithm maximizes network lifetime and service area coverage.

In energy efficient routing protocol for WSNs which has been proposed in [2]. The authors in [2] have concluded that a substantial amount of energy can CH be conserved by lowering the overhead in election process. Energy consumption reduction via reduction in the volume of transmitted data and outside the cluster region is facilitated by time series prediction based data reduction scheme. In order to balance the load in WSN, a Multipath routing protocol is presented in T.Ming.Hao [4] and A survey on energy efficient, secure routing protocol for wireless sensor network [3]. A load balancing algorithm is designed to balance the network over the established paths [4], [3]. The data packets are distributed over more number of sensor network (SN) and help in energy optimization [4], [3]. The stimulation was performed and compared the result with various routing protocols. The mechanism brings the energy optimization in WSNs [4].

In Multi-Hop clustering protocol using gateway nodes in WSNs [5], the authors [5] have proposed a multi hop cluster based routing protocol which is more energy efficient then single hop protocol. They have come to the conclusion that energy consumed for single hop transmission is more than multi-hop transmission for long distance. They have presented a new multi-hop routing protocol for the homogeneous WSN and increase the lifetime of sensor network.

In [7], to design the wordbook (dictionary), the statistics of the data are needed, unlike in real time; statistics of the data will modify depending on the event. Therefore the objective of the study is to design a simple method to compress sensor data which does not require prior knowledge of the statistics of sensor data. In [6], the author have used RLE, while have very less encoding time while in Huffman algorithm take more time for encoding.

3) *Huffman coding: Basically divided into two categories.*

- Static Huffman coding
- Adaptive/ dynamic Huffman coding

The uncompressed need have some knowledge of the probabilities of the symbol in the compressed files, due to this fact static Huffman coding suffers. This requires more number of bits to encode the file. The compressing of the file requires two passes if this information is unavailable. FIRST PASS finds the frequency of every symbol and constructs the Huffman tree. SECOND PASS is employed to compress the file. The Author [6], have already use the concept of static Huffman coding. Faller, Gallager, first conceived adaptive Huffman coding independently. Knuth contributed enhancement to the initial algorithm and also the ensuing algorithm is referred to as algorithm FGK [7]. These are the word schemes that confirm the mapping from source (origin) messages to code words on the basis of a running estimate of the source (origin) message probabilities. The code is adaptational that stay optimum.

4) *Huffman Algorithm:*

Huffman coding requires prior knowledge of the probabilities of the source sequence. If this knowledge is not available, Huffman coding becomes a two pass procedure: the statistics are collected in the first go (pass) and the source is encoded in the second go (pass) [6]. In the Adaptive Huffman coding procedure, neither transmitter nor receiver is aware of something concerning the statistics of the source (origin) sequence at the beginning of transmission. The tree at each the transmitter and also the receiver consists of a one (single) node that corresponds to all or any symbols Not Nevertheless Transmitted (NNT) and contains a weight of 0. As transmission progresses, nodes akin to symbols transmitted will be added to the tree and also the tree is reconfigured using an update methodology. Considering an easy 4 bit ADC illustration for every data, then before the start of transmission, a set 4 or 5 bit code relying whether the symbol is positive or negative is allowed between the

transmitter and receiver [6, 8]. The particular code consists of 2 parts: The prefix akin to the code obtained by traversing the tree and also the suffix akin to four or five bit binary illustration akin to positive or negative data respectively [6]. In the process of coding, the probability for the incoming source sequence is assigned (allocated) as the elements get in to the tree formed [6]. This gives rise to a problem where the elements which come in the initial stages of tree formation having lesser probability keep smaller codes [6]. Thereby, the compression ratio obtained is lesser [6].

5) *Modified Adaptive Algorithm:*

In [9] Adaptive Huffman algorithm, though the probabilities are allocated dynamically, as a result of the augmented range of data offered within the source sequence, the quantity of levels and therefore the quantity of bits transmitted will increases and is found to be effective just for terribly opt and initial occurring data. Moreover, the binary tree construction is predicted on the order of arrival of incoming information. Hence, each static and adaptive Huffman algorithms are discovered to own some drawbacks. The Modified Adaptive Huffman algorithm overcomes the disadvantages of each static and dynamic Huffman algorithm by combining the benefits of the two algorithms and ultimately increasing the compression ratio (magnitude relation).

6) *Binary Tree Construction***:** Binary Tree is constructed where each node consists of set of elements.

7) *Compression Ratio*: Compression ratio is calculated as defined in [8]. The formula used for compression ratio analysis is given as follows: Compression ratio = 100 (compressed size/original size).

8) *Run Length Coding*: Run length coding replaces sequences of the same data values within a file by a count number and a single value. Run Length Encoding is a very simple form of lossless data compression in which sequences of the same data value occurs in many consecutive data elements and are stored as a single data value and count, rather than as the original run. Example
WWWWWWWWWWWWBWWWWWWWWWWWWB
BBWWWWWWWWWWWWWWWWWWWWWWW
BWWWWWWWWWWWWW

> With a run-length encoding (RLE) data compression algorithm we can give one example as it can be rendered as follows:
>
> 12W1B12W3B24W1B14W
>
> This can be interpreted as a sequence of twelve Ws, one B, twelve Ws, three Bs, etc.

*9) Over-all Analysis of Literature Survey***:**

Run-Length-Encoding, which is a simple form of lossless data compression technique is preferred over other encoding technique such as Huffman coding (Static Huffman coding & Adaptive/ dynamic Huffman coding) and Arithmetic Coding. Huffman coding algorithm uses static table of data but doesn't produce efficient compression ratio. The Modified Adaptive algorithm doesn't need prior knowledge of the statistics of sensor data & perform adaptively by tree formation of the sensor data. The Modified Adaptive algorithm provides effective compression by reducing the number of levels in the binary tree. Arithmetic coding is generated based on their intervals. The intervals range is [0, 1]. The range should be greater than 0 and should be lesser than 1. Arithmetic algorithm can provide high compression ratio, but has lower compression speed. Arithmetic algorithm also has complex calculation. The step involved in Arithmetic algorithm is lengthy. Data transmission in Arithmetic algorithm can begin only after the entire data is compressed.

10**)** *Proposed Methodology***:**

Proposed work can be divided into the following modules,

1. Creation of network: we will create tactical network using NS2 software.
2. Deployment of nodes with gateway selection
3. Development of load balancing communication in the network
4. Development of compression algorithm for reducing network delay: we will use Run Length Encoding in the network layer. The advantage of using RLE is it has better compression ratio as compared with Huffman algorithm which slower and difficult to decode data as Huffman algorithm is based on variable length code(it is difficult to find missing data and corrupt data).
5. Performance analysis and comparison: we will analyze performance with respect to single and multiple gateways established energy aware load balancing routing techniques given above. Those parameters are delay, throughput efficiency, packet delivery ratio, routing load, spectral efficiency and throughput fairness.

• CONCLUSION

In all previous work, the researchers have solved the issue of multi-gateway communication effectively specifically considering the energy efficiency. Here in this paper we will use compression technique i.e. Run Length Encoding (RLE) so as to reduce data packet size & reducing delay in the tactical multi-gateway WSNs. We will also analyze performance parameter such as delay, throughput efficiency, packet delivery ratio, routing load, spectral efficiency and throughput fairness. We can implement the system in real time in order to get the real time performance of the system on hardware.

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