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A Comparative Study of Energy Efficient Schemes and Data Compression in Wireless Sensor Network

Narinder Singh, Research Scholar, Department of Computer Science, Desh Bhagat University,Mandi Gobindgarh, India ns_kalra@yahoo.co.in

Dr. Harmaninderjit Singh, Assistant Professor Desh Bhagat University, Mandi Gobindgarh, India, jeetsinder@gmail.com

ABSTRACT - In this paper a survey is done on different energy efficient schemes and data compression techniques in wireless sensor network. Data compression reduces the number of bits used to store or transmit information. Sensor nodes are powered by batteries which cannot generally change or recharged, so energy saving in wireless sensor networks a critical issue. Various algorithms and programs have developed to address problem of energy efficiency in WSN. In this paper comparative study of Data compression algorithms focus on various algorithms for better energy efficiency in WSN.

Keywords: WSN, Data compression, ALDC, RLE, K-RLE, S-LZW

I. INTRODUCTION

WSN has limited impact on full scale systems due to the issue of power constraints. Energy is an important parameter constraint in the design of sensor networks. Due to the limitation of energy and transmission capacity, the transmitted packet must be small. One way to overcome this is to increase the amount of energy of the nodes. However, this is not practical option as the nodes are battery energized. The other solution is to reduce the consumed energy by the nodes. So, to reduce the size of the transmitted packet is one of the crucial activities in WSN Compression is a technique which is generally used to shrink data. Compression process saves execution time and memory space. Data compression is primarily used in communication as is aids devices to store or transmit the same amount of data but in less number of bits. Generally compression techniques can be classified in to two groups: Lossy compression and lossless compression. Lossy compression is a technique which is generally applied for image and video files whereas, lossless compression is applied for text files:

Data Compression in wireless sensor network

Data compression is known as the branch of resource utilization studies for sensor networks. Many researchers are looking forward to find the best way of data compression .It helps in reducing the energy due to processing and transmitting data in each node, which in returns will extend the life of sensor network and also less bandwidth will be required for sending and receiving data. Data compression is one of the effective methods of utilizing limited resources of WSNs. By using the compression algorithm to compress data before transmission, which in turn can reduce the overall power consumption but in many cases it is observed that it may increase the power consumption due to the access of memory for execution of compression algorithm. Thus it is preferred to apply the data compression before transmitting data and selection of data compression algorithm which will take less memory access for execution, to effectively reduce the amount of energy consumption .

II. LITERATURE SURVEY

Qing Ling and Zhi Tian,*(2010)* investigates the problem of monitoring sparse phenomena using a large-scale and distributed sleeping wireless sensor network. Random node sleeping strategies are adopted for energy conservation, which effect compression during the measurement collection process. A decentralized sparse signal recovery algorithm is developed based on regularized least squares and consensus optimization. Each active sensor not only optimizes for itself, but also optimizes for its inactive neighbors. Through iterative one-hop information exchange, active sensors are able to reach consensus for inactive sensors. As a result, a phenomenon, no matter whether it occurs at an active sensor point or inactive sensor point, can be detected and quantified. It is theoretically proved that sensors eventually reach globally optimal decisions for their local regions, at scalable computation and communication costs with respect to the network size. Benefiting from the decentralized optimization scheme, the sleeping strategy, and most of all, the recognition of signal sparsity, the proposed decentralized sparse signal recovery algorithm improves the scalability and robustness of large networks, preserves energy of wireless sensors, and at the same time guarantees high spatial resolution for monitoring [1].

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Alexandre Ciancio and Antonio Ortega (2004) have proposed a distributed wavelet compression algorithm for wireless sensor networks to allows a flexible way of exploiting trade-off points between processing and communication costs, to achive energy savings while maximizing the network performance for given specifications[2].

Xiaobing Wu, Guihai Chen (2008) have explored the theoretical aspects of the non-uniform node distribution strategy that addresses the energy hole problem in WSNs. The author showed that with the proposed non-uniform node distribution strategy, the network can achieve very high energy efficiency. The author presented a new routing algorithm called q-Switch Routing that is tailored for the proposed non-uniform node distribution strategy. Extensive simulations are performed to validate their analysis. In all simulations, the network achieves high energy efficiency, and less than 15 percent energy is wasted. Simulation results also show that the proposed non-uniform node distribution strategy has advantages over its two counterparts in terms of the network lifetime [3].

Mohammad Hossein Anisi, Abdul Hanan Abdullah, Shukor Abd Razak (2011) have proposed an energy-efficient data collection approach in wireless sensor networks which uses an efficient strategy to forward data toward the best route. In their algorithm, there are three factors which enable the nodes to choose an appropriate parent in term of energy. These factors are distance, residual energy and data correlation. With the suggested mechanism, the remaining energy of the nodes will be increased and the life time of the whole network will be increased, too.

Bulent Tavli, Ibrahim E. Bagci, and Onur Ceylan (2010). In this paper he investigated the lifetime improvements that can be achieved by jointly optimizing data compression and flow balancing in wireless sensor networks. Its result show that by using dynamic compression it is possible to extend the system lifetime significantly beyond the lifetime achievable by pure strategies. They also proposed a heuristic strategy and showed that its performance level approaches the performance of the optimal strategy [5].

Jonathan Gana Kolo,1 S. Anandan Shanmugam,1 DavidWee Gin Lim,1 Li-Minn Ang,2 and Kah Phooi Seng3 (2012) have presented a light weight adaptive lossless data compression algorithm for wireless sensor networks. Their proposed ALDC algorithm is efficient and simple, and is particularly suitable for wireless sensor nodes. This ALDC compression scheme allows compression to dynamically adjust to a changing source. The proposed algorithm reduce the data amount for transmission which contributes to the energy saving. Additionally, Their proposed algorithm can be used in monitoring systems that have different types of data and still provide satisfactory compression ratios.[6].

Carlo Caione(2012) addresses the problem to minimize the power consumption when a large-scale ZigBee-based deployment is considered. The author proposed a new mixed algorithm has been introduced to save on communication power and prolong the network lifetime. The simulations performed, carefully calibrated on values for power consumption extracted from real sensor nodes, have shown that one of the main source of energy expenditure is the compression phase. According to this consideration, a modified version of the algorithm has been presented stressing how optimal parameters do exist able to obtain a better overall behavior. This study has shown that CS can be a powerful tool for energy saving in WSN as long as network size and compression work are both taken into account in network design. The proposed modified algorithm is able to prolong the lifetime of the network achieving a trade-off between traffic in the network and energy spent in compression[7]

Tarik Arici, Bugra Gedik, Yucel Altunbasak, Ling Liu(2003) proposed Data collection schemes for wireless sensor networks that push the requested query into the network and process the raw data using an aggregation function. In this paper, They have shown that in-network compression enables energy-efficient full-data collection applications. Their in-network compression scheme trades higher latency for lower energy consumption. With the presented PINCO scheme for single-valued data, it is possible to recompress data groups to reduce redundancies that are available in different stages of routing through the network. The author discussed the framework for handling energy and full data collection applications and helping us to discover tradeoffs when tweaking in-network compression schemes for different degrees of performance requirements [8].

Yanjun Yao, Qing Cao(2015) proposed EDAL, an Energy-efficient Delay- Aware Lifetime-balancing protocol for data collection in wireless sensor networks, which is inspired by recent techniques developed for open vehicle routing problems with time deadlines (OVRP-TD) in operational research. The goal of EDAL is to generate routes that connect all source nodes with minimal total path cost, under the constraints of packet delay requirements and load balancing needs. They develop a centralized heuristic to reduce its computational complexity. The author compared to baseline protocols, EDAL achieves a significant increase on network lifetime without violating the packet delay constraints. Finally, They demonstrate that by integrating compressive sensing with EDAL, additional lifetime gains can be achieved.[9]

Francesco Marcelloni (2008) in this paper the author proposed a simple lossless compression algorithm. They have evaluated the algorithm by compressing temperature and relative humidity data collected by a real WSN. They

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have obtained compression ratios of 66.99% and 67.33% for temperature and relative humidity datasets, respectivel. And compared this algorithm with S-LZW, a lossless compression algorithm .They have shown that result of their algorithm can achieve higher compression ratios than S-LZW. [10]

Nandini. S. Patil, Prof. P. R. Patil (2010) the author proposed two most important parts of data communication in sensor networks- query processing, data aggregation and realized how communication in sensor networks is different from other wireless networks. Wireless sensor networks are energy constrained network. Efficient data aggregations not only provide energy conservation but also remove redundancy data and hence provide useful data only. The simulation result of a simulator shows that when the data from source node is send to sink through neighbors nodes in a multihop fashion by reducing transmission and receiving power, the energy consumption is low as compared to that of sending data directly to sink that is aggregation reduces the data transmission then the without aggregation. They have showed how aggregate queries are efficiently executed in wireless sensor networks.[11]

Eug`ene Pamba Capo-Chichi, Herv´e Guyennet, Jean-Michel Friedt(2009) have evaluated several data compression algorithms on a ultra-low power microcontroller from Texas Instrument known as MSP430. Authors have compared a famous dictionary-based data compression algorithm using real temperature datasets for WSN named S-LZW with RLE. A new algorithm inspired from RLE named K-RLE has introduced which increases the ratio compression compared to RLE and S-LZW. For K equal to 2, this compression algorithm increases the ratio by 40% compared to RLE. A study shows that while 2-RLE offers good compression ratio, it consumes a lot of energy compared to RLE and S-LZW. [12]

ANNA SCAGLIONE and SERGIO SERVETTO (2005) proposed a work on the transport capacity of large-scale wireless networks, it has been established that the per-node throughput of these networks vanishes as the number of nodes becomes large. This result poses a serious challenge for the design of such networks; some have even argued that large networks are *not* feasible, precisely because of this reason [22]. Previous work, however, pointed out that, in the context of sensor networks, the amount of information generated by each node is not a constant, but instead decays as the density of sensing nodes increases – this was illustrated with an example based on the transmission of samples of a Brownian process, with arbitrarily low distortion (even with vanishing per-node throughput), by means of using distributed source coding techniques [23].In this work They have shown an alternative approach to work around the vanishing per-node throughput constraints of [22]. This new approach is not based on distributed coding techniques, but instead is based on the use of classical source codes combined with suitable routing algorithms and re-encoding of data at intermediate relay nodes [13].

S.jancy, dr . C. Jaya kumar(2015) proposed Packet level data compression algorithm. Using this algorithm a better compression ratio has been achieved when compared to the previously proposed algorithm. This paper also discusses various standard compression Algorithms. (Delta encoding, Huffman coding, Run length encoding and Arithmetic coding).[15]

Y.-C. Wang(2012) observed that Sensor nodes are usually battery-powered and thus conservation of energy is a primary concern in WSNs. In network data compression can help reduce the amount of sensing data that sensor nodes have to regularly report to the sink(s) and therefore significantly reduce their energy consumption. This paper provides a comprehensive survey of recent research on the data compression techniques in WSNs.[16]

Rajinder Kaur Mrs. Monica Goyal talked about a need of data compression, and situations in which these lossless methods are useful. The algorithms used for lossless compression are described in brief. A special, Run-length coding, statistical encoding and dictionary based algorithm like LZW, are provided to the concerns of this family compression methods. In the Statistical compression techniques, Arithmetic coding technique performs with an improvement over Huffman coding, over Shannon-Fano coding and over Run Length Encoding technique[17].

Mamta Rani and Vikram Singh have presented a review of LZW, Huffman coding and Shannon-Fano coding, Run Length Encoding, Burrows Wheeler Transform techniques of data compression on English words in terms of compression ratio and saving percentage and all the algorithms show different level of compression. After testing these algorithms, Huffman coding and Shannon Fano coding methodologies are very powerful over LZW. Huffman coding and Shannon Fano coding gives better results and reduces the size of the text.[18]

Gaurav Sethi , Sweta Shaw ,Vinutha K , Chandrani Chakravorty(2014) This paper provided overview of the data compression methods of general utility. This Algorithms evaluated in terms of the amount of compression they provide efficiency of algorithm and the susceptibility to error. Semantic dependent data compression techniques are special- purpose methods designed to exploit local redundancy or context information [19].

A.Alish Preethi1, Anjali Ramakrishnan observed that Sensor nodes are usually battery powered and thus how to conserve their energy is a primary concern in WSNs. In this paper the survey is based on data compression in wireless sensor network for minimize the energy consumption and for processing and transmission of data. The researchers

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keep on introducing their improvisation in this field and try to make them more efficient. [20].

III. COMAPARATATIVE STUDY

The different data compression algorithms which are compatible for wireless sensor network are proposed by various authors keeping in mind the various issues of communication in WSN like energy conservation, data compression ratio , transition time, but still there is need to develop more effective algorithms which helps to save energy in wireless sensor network . The following table depict the various proposed schemes and its advantages

S no	Title	Author	Proposed Energy Efficiency Scheme	Advantages
1	A distributed wavelet compression algorithm for wireless sensor Networks using lifting	Alexandre ciancio and antonio Ortega	A distributed wavelet compression algorithm for wireless sensor networks. Authors have used the lifting scheme to compute wavelet transforms as way of decor relate data.	The proposed algorithm allows a flexible way of exploiting trade-off points between processing and communication costs, so that energy savings can be achieved while maximizing the network performance.
2	Avoiding energy holes in wireless sensor Networks with non uniform node distribution	Xiaobing wu, guihai chen, member and sajal k. Das	Proposed non uniform node distribution strategy	Proposed non uniform node distribution strategy has advantages over its two counter parts in terms of the network lifetime, the residual energy ratio, and the data delivery ratio
3	Energy-efficient data collection in wireless sensor networks	Mohammad Hussein anisi, abdul hanan abdullah, Shukor abd razak	An energy-efficient data collection approach in wireless sensor networks which uses an efficient strategy to forward data toward the best route on basis of distance, residual energy and data correlation	With the suggested mechanism, the remaining energy of the nodes will be increased and the life time of the whole network will be increased.
4	Optimal data compression and forwarding in wireless sensor networks	Bulent tavli, Ibrahime. Bagci, and onur ceylan	In this survey investigation is done on lifetime of sensor network that can be achieved by jointly optimizing data compression and flow balancing in wireless sensor networks.	Increased energy efficiency by data compression and flow balancing in WSN.
5	An adaptive lossless data compression scheme for Wireless sensor networks	Jonathan gana kolo, s. Anandan Hanmugam,davidwee gin lim,Li-minn ang, and kah phooi seng	Presented a lightweight adaptive lossless data compression algorithm for wireless sensor networks. Proposed ALDC scheme performs compression loss Lesley using two code options.	Proposed algorithm reduce the data amount for transmission which contributes to the energy saving. Additionally, our proposed algorithm can be used in monitoring systems that have different types of data and still provide satisfactory compression ratios. Furthermore proposed ALDC algorithm took into account the different real-time requirements on data compression.
6	Distributed compressive sampling for lifetime Optimization in dense wireless sensor networks	Carlo caione, davide brunelli, and luca benini, fellow,	This paper addresses the problem to minimize the power consumption when a large-scale zigbee-based deployment is considered. A new mixed algorithm has been introduced to save on communication power and prolong the network lifetime.	This study has shown that compressive sampling can be a powerful tool for energy saving in WSN as long as network size and compression work are both taken into account in network design. The proposed modified algorithm is able to extend the lifetime of the network .
7	Pinco: a pipelined in-network compression scheme for data Collection in wireless sensor networks	Tarik arici, bugra gedik, yucel altunbasak, ling liu	This Survey, shown that in network compression enables energy-efficient full-data collection applications. In network compression scheme trades higher latency for lower energy consumption. With the presented pinco scheme for single-valued data, it is possible to recompress data groups to reduce redundancies that are available in different stages of routing through the network.	Pinco is a very useful in handling energy-efficient in-network compression schemes for different performance requirements.
8	Edal: an energy-efficient, delay-	Yanjun yao, qing cao, member, ieee, acm, and	An energy-efficient delay-aware lifetime-balancing protocol for data	Edal achieves a significant increase on network lifetime without

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	aware, and Lifetime-balancing data collection protocol for heterogeneous wireless sensor networks	athanasios v. Vasilakos, senior member, ieee	collection in wireless sensor networks, which is inspired by recent techniques developed for open vehicle routing problems with time deadlines (OVRP-TD) in operational research.	violating the packet delay constraints.
9	A simple algorithm for data compression in wireless sensor networks	Francesco marcelloni, member, ieee, and massimo vecchio, member, ieee	A simple lossless compression algorithm mainly suitable to the reduced storage and computational resources of a WSN node ,and evaluated the algorithm by compressing temperature and relative humidity data collected by a real compared this algorithm with S-LZW we have shown that our algorithm can achieve higher compression ratios than S-LZW	
10	Data aggregation in wireless sensor network	Nandini. S. Patil, prof. P. R. Patil	This paper shows that in query processing, data aggregation, energy consumed for transmitting and receiving data, the process of data aggregation becomes an important issue and optimization is needed.	Efficient data aggregations not only provide energy conservation but also remove redundancy data and hence provide useful data only.
11	K-RLE : a new data compression algorithm for wireless sensor network	Eugene pamba capo-chichi, herve guyennet herve.,fcomte.frJean-michel friedt Femtost/lpmo	Introduced a new algorithm inspired from RLE named k-RLE which increases the ratio compression compared to RLE and S-LZW.	2-RLE offers good compression ratio, it conserve a lot of energy compared to RLE and S-LZW. In this article,. Since RLE does not have a great compression ratio, it uses less energy than 2-rle and S-LZW.
12	On the interdependence of routing and data compression In multi-hop sensor networks	Anna scaglione and sergio servetto	This new approach is not based on distributed coding techniques, but instead is based on the use of classical source codes combined with suitable routing algorithms and re-encoding of data at intermediate relay nodes.	a large-scale multi-hop sensor networks are perfectly feasible.
13	Packet level data compression techniques for Wireless sensor networks	s.jancy, dr. C. Jaya kumar	This paper proposed packet level data compression algorithm. Using this algorithm a better compression ratio has been achieved when compared to the previously proposed algorithm	In network data compression can help reduce the amount of sensing data that sensor nodes have to regularly report to the sink(s) and therefore significantly reduce their energy consumption.

IV. CONCLUSION AND FUTURE WORK

With increasing popularity and applicability of wireless sensor networks, the limitations which restrict the lifetime of network are also arising. It is observed in various researches that the energy utilized in transmission is more than processing the data in wireless sensor network. So, many approaches are proposed to tackle the problem of power consumption, used while transmission. One of the approaches includes the compression of data to be transmitted and recovery of it at sink node in wireless sensor network Though there are many efficient data compression algorithms, but there are mostly based on the sampling theorem. This theorem points out that sampling rate must be twice the highest frequency present in the signal of interest. And by using this theorem, some redundant data are collected firstly, However, existing compression algorithms are less applicable for sensor nodes because of their limited resource. Therefore, some of compression algorithms, which have been specifically designed for WSNs, are required, which will capable to minimize the energy consumption of the nodes and resulting in overcoming the other obstacles, need to be developed.

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