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A SURVEY ON ENERGY EFFICIENT MODULATION AND CODING TECHNIQUES FOR WIRELESS SENSOR NETWORKS

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Abstract: A standard Wireless Sensor Network comprises of a huge number of sensor nodes with data processing and communication capabilities. The sensor nodes pass the gathered data using radio transmitter, to a sink either straightforwardly or through other nodes in a multi-hop approach. Wireless sensor network is a power consuming system, since nodes perform on restricted power batteries which decreases its lifetime. Optimally selected modulation and coding is extremely vital technique in wireless sensor networks. This paper surveys the performance of differentmodulation schemes and error control codes used in sensor networks. The survey also analyzes the role of modulation and coding techniquesto improve the energy efficiency, bandwidth efficiency and lifetime of the sensor nodes.

Keywords: Sensor Network, Modulation, Energy Efficiency, Coding

INTRODUCTION

Recently there has been a tremendous improvement in the growth and development of Wireless Sensor Networks (WSN). WSN has been used in several application areas consist of environmental, medical, armed forces transportation, entertainment, and smart spaces [25]. Modulation and coding provide the important link between the user and the wireless channel, and determine the performance of the system and its use of the resources of bandwidth and signal power. The modulation and coding process played an important role to improve the energy efficiency and bandwidth efficiency of wireless networks. Especially ina sensor network, its lifetime depends on the energy consumption of transceivers. This paper surveys the role of modulation and coding as they apply to wireless sensor networks

RELATED WORK

M.Sheik Dawood et al. (2012) analyzed the modulation schemes such as BPSK, MSK and QAM and transmission approach to improve bandwidth and energy efficiency in fault tolerant wireless sensor networks for landslide area monitoring. The total energy consumption includes both the transmitted energy and the circuit energy consumption. The modulation schemes are compared based on their energy consumptions at their transceiver node. The authors also analyzed the appropriatehomogenous and heterogeneous modulation schemes to improve the energy efficiency and bandwidth efficiency in a wireless sensor network.[1]

RajendranValli et al. (2012) analyzed a game theoretic model with pricing for power control in a sensor network considering ECC for random, square, triangular and hexagonal deployment schemes where the performance of the proposed power control scheme with RS (Reed Solomon) and MIDRS (Multivariate Interpolation Decoding RS) code for WSN was evaluated in terms of utility, and energy consumption and the result showed that for hexagonal deployment scheme, with the inclusion of ECC, the transmitting nodes power of the was reduced thereby saving energy and increasing the network lifetime. The maximum utility was obtained at minimal transmission power for the hexagonal deployment scheme with MIDRS coding.[2]

Himanshu Sharma et al. (2012) analyzed the energy consumption of a practical Wireless Sensor Network scenario which was modeled at the bottom three layers of the traditional networking stack—the physical layer, data link layer and the MAC layer, where the optimization of energy consumption of WSN nodes was achieved using different modulation schemes to maximize the network lifetime. And also describes the design and simulation of a wireless sensor network scenario consisting of 12 nodes in 500x500 m area and the optimized energy consumption (radio energy + circuit energy) of each node using suitable modulation techniques, where the Energy Consumption was reduced up to 80% in a home automation scenario.[3]

Yongsheng Wu et al. (2012) described the GBF (Grouped Bit-flipping) decoding algorithm based on PPM signal has a better coding performance compared with the standard BF (Bit-flipping) decoding algorithm with the same decoding complexity. When the value of M is 16, the GBF decoding algorithm got more than 2 dB coding gain at the BER level about 10^{-5}, and got more coding gain as the increasing of the modulation number. Also provided the guarantee for the high order number of PPM, and achieved both high energy efficiency and better error control. Although the simulation was based on the simplified AWGN channel, the performance of the system was improved when the block length of LDPC code is large.[4]

Sanjeev Kumar et al. (2011) investigated the performance of Reed-Solomon code used to encode the data stream in digital communication. The performances were evaluated by applying to binary phase shift keying modulation scheme in symmetric Additive White Gaussian Noise (AWGN) channel. And concluded that the BER performance is improved as the code rate is decreased and the simulations also showed that the BER performance is also improved for large block lengths.[5]

SaurabhMahajan et al. (2011) investigated the performance of Reed Solomon code that was examined in different point of view like Code Size, Redundancy, and Code Rate. In order to inspect the gap between theoretical and practical sides of communication system, the channel coding was applied to get enhanced system performance. Also observed that a properly chosen error correction coding scheme can significantly improve the BER performance.The BERperformance curve improves as the size of codeword (Code Size) (*n*) is increased at constant code rate. The BERperformance also improves as the size of codeword (*n*) is increased at the similar error correcting capability.The error performance is improved (error correcting codes become more efficient) as the redundancy is increased (lower code rate).[6]

RaghavendraPrabhu (2010) defined and motivated a metric called energy-per-goodbit (EPG), which represents the total energy cost to convey one bit of information without error at the receiver. Although the methods developed are quite general and can be extended to several communication scenarios of interest, it is convenient to classify the work into two main categories: a) scalar channel b) parallel channel. First, they consider a single-carrier QAM system (scalar channel), and find the optimum constellation size (spectral efficiency) and transmit power that minimizes the EPG. As a result, the energy efficiency viewpoint provides a convenient and unified perspective of the various water-filling solutions. Finally, they extend the parallel channel formulation to a MIMO-SVD system and MIMO-OFDM-SVD systems (parallel channel).[7]

Masud et al. (2010) considered the transmission from base station to mobile or downlink transmission using M-ary Quadrature Amplitude modulation (QAM) and
Quadrature phase shift keying (QPSK) modulation schemes in Wideband-Code Division Multiple Access (W-CDMA) system. And also analyzed the performance of these modulation techniques when the system is subjected to Additive White
Gaussian Noise (AWGN) and multipath Rayleigh fading in the channel.[8]

Felipe and Hideki (2010) explained three different modulation types (i.e. MQAM, MPSK, and MFSK) frequently employed in wireless communication and relation between channel capacity or cutoff rate and signal to noise ratio (SNR) to find the optimized parameters for minimizing the energy consumption per information bit in a point-to-point wireless link.[9]

Padmavathy and Chitra (2010) analyzed the hop distance estimation which is used to find the minimum number of hops required to relay a packet from one node to another node in a random network by statistical method. The energy consumption and latency are calculated from the minimum number of hops.[10]

Maryam Soltan et al. (2008) focused on improvement of life time of each cluster of sensors in hierarchical WSN using optimization techniques at the physical layer and how the location-aware selection of the modulation schemes for sensors can affect their energy efficiency. Also analyzed how the energy in the network can be distributed more evenly by proper selection of the modulation schemes for different sensors.[11]

Maryam Soltan et al. (2008) also analyzed on how certain physical layer attributes can affect both the lifetime and the end-to-end delay in a hierarchical WSN.A heterogeneous modulation scheme has been presented and reported its impact on the spatial distribution of energy dissipation and the resulting network lifetime. Moreover, the authors discussed how this heterogeneous modulation scheme affects the end-to-end delay due to inherent trade-offs in power efficiency and bandwidth efficiency of the different modulation schemes.[12]

Rehna Raj et al. (2008), analyzed a fault tolerant and energy efficient clustering
Approach which organizes the whole network into smaller cluster and sub cluster groups enabling a considerable reduction of communication and processing overhead. Sub cluster formation also gives the possibility to skillfully deal with sensor nodes, node leader, and cluster head failures. Also proposed a fault tolerant approach that uses a matrix based error approximation method for providing the approximate sensor data of the failed node.[13]

Yunxia Chen et al. (2005) derived a general formula for the lifetime of wireless sensor networks which holds the network model including network architecture and protocol, data collection initiation, lifetime definition, channel fading characteristics, and energy consumption model. And referred to as the max-min approach, this protocol maximizes the minimum residual energy across thenetwork in each data collection.[14]

Mhatre, V. P. et al. (2005) discussed a cost effective heterogeneous sensor network to minimize the overall cost of the network constraint in which lifetime is defined as the number of successful data gathering trips (or cycles) that are possible until connectivity and/or coverage are lost.[15]

Iranli et al. (2005) investigated the energy-efficient strategies for deployment of wireless sensor networks (WSN) for the purpose of monitoring some phenomenon of interest in a coverage region. In which, a two-level WSN structure where the sensors in the lower level monitor their surrounding environment and the micro servers in the top level provide connectivity between the sensors and a base station.[16]

Soltan and Pedram (2007) analyzed a hierarchical wireless sensor network with mobile overlays, along with a mobility-aware multi-hop routing scheme, in order to optimize the network lifetime, delay, and local storage size.[17]

Manish Bhardwaj et al. (2002) achieved the fundamental limits of energy-efficient collaborative data-gathering by deriving upper bounds on the lifetime of increasingly sophisticated sensor networks.[18]

JamshidAbouei et al. (2009) analyzed the energy efficiency of LT codes with Non Coherent M-ary Frequency Shift Keying (NC-MFSK), known as green modulation in a proactive Wireless Sensor Network (WSN) over Rayleigh flat-fading channels with path-loss.In addition, although uncoded NC-MFSK outperforms coded schemes for d <dT, the energy gap between LT coded and uncoded NC-MFSK is negligible for d<dT compared to the other coded schemes. They proved LT codes are beneficial in practical low-power WSNs with dynamic position sensor nodes.[19]

BenignoZurita Ares et al. (2007) analyzed the bit error rate and average energy consumption for two coding schemes proposed in the literature: Minimum Energy coding (ME), and Modified Minimum Energy coding (MME). Furthermore, a detailed model of the energy consumption is described as a function of the coding schemes, the radio transmits powers, the characteristics of the transceivers, and the dynamics of the wireless channel. A distributed radio power minimization algorithm is also addressed. Numerical results show that ME and MME coding schemes exhibit similar bit error probabilities, whereas MME outperforms ME only in the case of low data rate and large coding codewords. [20]

Jaeweon Kim et al. (2005)analyzed a direct sequence code division multiple access (DS-CDMA) system combined with modified minimum energy (MME) coding. The results show that the proposed system clearly outperforms DS-CDMA systems with or without ME coding in terms of energy consumption and bit error rate. This indicates that combining MME coding and DS-CDMA is an attractive choice for wireless sensor networks. [21]

Jinyun Zhang et al. (2009) discussed various techniques and tradeoffs in UWB systems and indicate that time-hopping and frequency hopping impulse radio physical layers combined with a simple multiple-access techniques like ALOHA are suitable designs. They also described the IEEE 802.15.4a standard, an importantSystem that adopts UWB impulse radio to ensure robust data communications and precision ranging. In order to accommodate heterogeneous networks, they used specific modulation, coding, and ranging waveforms that can be detected well byboth coherent and noncoherent receivers. [22]

Qingwen Liu et al. (2005) analyzed the joint effects of finite-length queuing and
AMC for transmissions over wireless links and also presented a general analytical procedure, and derived the packet loss rate, the average throughput, and the average spectral efficiency (ASE) of AMC. Furthermore, they introduced a cross-layer design, which optimizes the target packet error rate of AMC at the physical layer, to minimize the packet loss rate and maximize the average throughput, when combined with a finite-length queue at the data link layer. [23]

GopinathBalakrishnan et al. (2007) focused the performance analysis of various error control codes in terms of their BER performance and power consumption on different platforms. And also evaluated the error control performance of these codes in terms of Bit Error Rate (BER) by transmitting randomly generated data through a Gaussian channel. Based on the study and comparison of the three different error control codes such as binary-BCH codes, non-binary BCH codes and convolutional codes, that was identified that binary-BCH codes with ASIC implementation was best suitable for wireless sensor networks. [24]

CONCLUSION

Wireless sensor networking is a rapidlygrowing subfield in the field of wirelessnetworking. It is very vital technology for theupcoming future. In this paper the performance of different modulation schemes and error control codes is reviewed based on parameters like energy efficiency , bandwidth efficiency and lifetime of the sensor nodes in a wireless sensor network. This survey paper covers up all these open research issues as well as their explanations and point out and represents the energy efficient modulation and coding.

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