

# Performance Analysis of Energy Efficient Error Control Codes for Wireless Sensor Networks

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**ABSTRACT:** Due to rapid growth of applications in wireless sensor networks, the data transmitted from the sensor nodes are susceptible to exploitation by errors induced by noisy channels and other factors. Hence it is essential to afford a suitable error control scheme to decrease the bit error rate (BER). In this paper, we cultivate an analytical energy efficiency model using adaptive error correction code (AECC) in wireless sensor networks in fading environments. To acclimatise energy efficiency of sensor node to channel variations, the packet length is tuned at the data link layer. In this model, we deliberate the error control of Bose-Chaudhuri-Hochquengh (BCH) coding for NC-FSK receiver node using AECC scheme and compare it to one of non-AECC. Depending on channel state variation via the ACK feedback, the sender can regulate the adequate BCH code required for the next transmission.

**KEYWORDS:** BCH Coding, Adaptive Coding, Energy Efficiency, Fading Channels, Wireless Sensor networks

## I. INTRODUCTION

The low-value, fast deployment, the capacity of self-organization and cooperative data-processing, have made wireless sensor networks a realistic solution for an extensive range of utility regions, such as military and place of home place security, health, environment, enterprise and commercial, and domestic [1]. The maximum considerable assignment in sensor networks is to overcome the energy constraints considering every sensor node have restrained energy to consume. Since data transmitted over the wireless media is liable to corruption by noise, error control schemes are necessary to hold the Bit Error Rate (BER) low. Due to the stringent energy constraint, it is not possible to boom the signal energy of the transmitted signal in wireless sensor networks. Hence an opportunity way is to use the error control codes to reduce the BER. The encoding and decoding circuitry for error control codes can also consume a sizable amount of energy. However the BER is shown to be directly proportional to the code rate and inversely proportional to energy per symbol noise ratio and transmitter power level [2]. This motivates us to take a look at energy-efficient error detection/correction codes.

A sensor node device generally employs a few optimization strategies to decrease energy consumption, like switching the transceiver unit to the sleeping mode, drastically decreasing the consumption with recognize to the energetic mode. As the radio transceiver is the most annoying energy module, a classical strategy is to minimize his energetic period of time, which conspicuously depends on transmission and reception traffic needs. A first method is to set off the transmitter simplest whilst there are data to be transmitted, however retaining the receiver wide awake for taking image information packets addressed to the node. Such solution sincerely is not efficient for energy conservation, because the receiver is lively even if there is no information to be received. A method to avoid this problem is to maintain also the receiver within the sleeping mode, activating it handiest for short-term durations of time to verify the channel interest and get hold of data, turning again to the sleeping mode if no signal is detected [3] Another technique to lessen consumption is to improve the network routing algorithms, dispensing the burden for forwarding the information to the destination node. It is likewise viable to use local data aggregation (cluster). In this situation, the data forwarding to the destination happens in multiple hops via concentration nodes (cluster heads). The cluster head nodes consume extra energy since they've a better lively duration and transmission power. Using periodic or random intervals,

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the cluster head function is switched to other nodes, aiming at higher distributing the energy consumption within the network [4].

## II. BACKGROUND WORK

However, the aforementioned solutions are at risk of channel impairments, because any radio signal is affected by random noise and channel fading [5], [6]. If a node gets a corrupted data packet, the data can be discarded and the node maintains anticipating a brand new transmission or the node employs an Automatic Repeat request (ARQ) system (a retransmission system). However, in both cases, there may be a waste of energy within the network. A mainly undesirable situation occurs when the channel circumstance is terrible, causing successive retransmissions. Another approach to growth the strength conservation in WSN is to apply forward error correction (FEC) strategies, lowering the frame error rate and therefore the number of retransmissions. Basically, there are training of error control codes: block codes and convolutional codes. The convolutional encoding technique is a method broadly utilized in wireless communication environments like sensor networks given that they commonly present an easier implementation for the equal performance of a competitor block code [7]. The difficulty of making use of error control codes to WSNs is the topic for some of the preceding works in which the overall performance of block codes and Viterbi decoded convolutional codes is investigated [9]-[11]. Also, the iterative deciphering algorithm justifies the capacity of faster codes in solving the hot-spot trouble and increase the network lifetime [12]. Error control coding (ECC) is a traditional approach used to growth hyperlink reliability and lower the desired transmitted strength. However, lowered power at the transmitter comes on the price of more energy intake because of the decoder on the receiver. Stronger codes provide higher performance with lower power requirements however have extra complex decoders with higher strength intake than less complicated error control codes. If the greater strength consumption at the decoder outweighs the transmitted energy savings because of using ECC, the ECC could not be power-efficient compared with an uncoded device.

Previous research the use of ECC in wireless sensor networks targeted more often than not on long-time enterprise-standard codes such as Reed-Solomon and convolutional codes. A hybrid scheme deciding on the most energy-efficient of ECC and ARQ is considered in [13], the usage of checksums, CRCs, Reed-Solomon and convolutional codes. A predictive error correction set of rules is supplied in [14] which uses data correlation, but is not an error control code, as there is no encoding. Power-conscious, machine-stage strategies consisting of modulation and MAC protocols, in addition to differing cost and constraint period convolutional coding, are considered in [15] to reduce device power consumption in wi-fi microsensor networks. Depending on the specified bit error rate (BER), a higher rate convolutional code, or no coding in any respect, can be the maximum energy-efficient method. In this paper, an appropriate error correction code is selected from a list of present codes for wireless sensor network.

## III. ADAPTIVE ERROR CORRECTION CODING SYSTEM

In this paper, we consider the sender of wireless sensor with adaptive error correction capability as shown in Fig.1. At the sender, the optimum error correction capability ( $t$ ) chooses from Look-up Table depending on the packet size and the distance between neighbouring sensors to achieve the best energy efficiency. Where the packet size varies based on BER in an inverse relationship. ARQ controller and BCH controller of HARQ are both considered to provide error protection on the transmitted data. BCH controller is responsible for adding channel coding to packet at the physical layer; and if the BCH decoder at the receiver fails in correcting the bit errors in the packet then ARQ controller retransmits the entire packet after timeout expired, if  $t=0$  then only ARQ subsystem of HARQ system is to be activated; otherwise HARQ is activated. Received signal strength indicator (RSSI) is a measurement of the power present in a received radio signal. At the sender, when ACK packet is received, the value of RSSI feedback is used to estimate the distance between neighbouring sensors. At the first transmission, initially minimum packet size (511 bits) is sent with error correction bits ( $t$ ) equals 2 bits. For more illustration, Fig.2 explains the events sequence between the sender and receiver.

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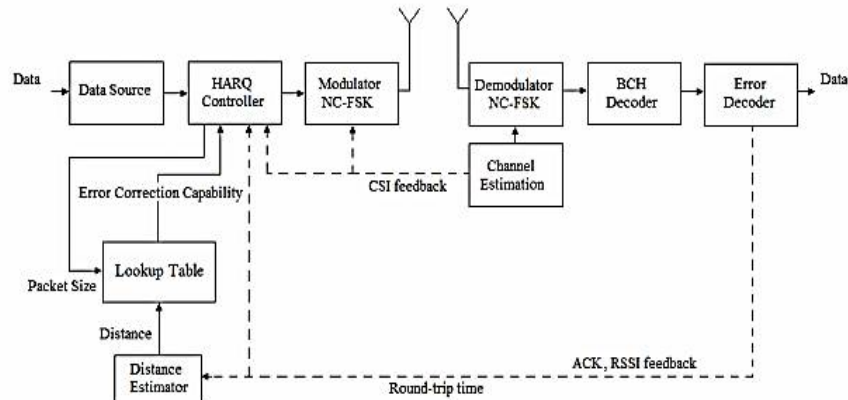


Fig. 1 Adaptive Error Correction Coding System in Wireless Sensor Network

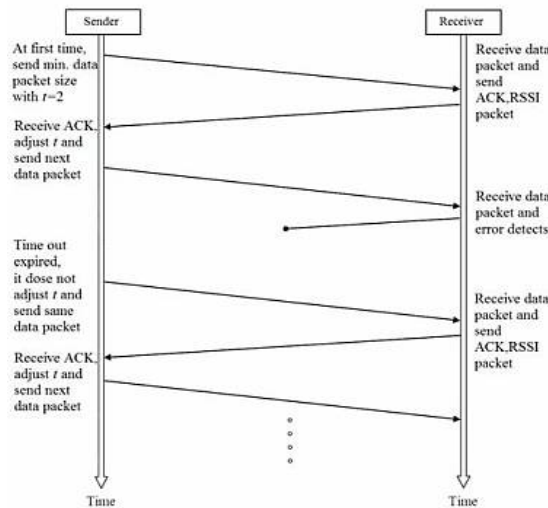


Fig. 2 Timing Diagram

Figure 3 summarizes the details of the mechanism based on the ACK feedback to adapt the required error correction to the next packet transmission. This feedback refers to RSSI indicator.

**Channel Estimation:** We first estimate the raw channel bit error rate (BER) for typical wireless sensor networks. The probability of bit error is evaluated under a non-coherent FSK modulated Rayleigh fading channel model in wireless sensor networks, is defined as follows [16]:

$$P_{b,NC-FS} = \frac{1}{2+SNR} \dots\dots\dots (1)$$

$$SNR(dB) = 77 - 10\beta \log(d) \dots\dots\dots (2)$$

where  $\beta$  is the path loss exponent. (Assume a typical  $\beta = 3.5$ ).

According to the receiver implementation, signal-to-noise ratio (SNR) depends on the neighbor distance  $d$  between sensor nodes. The path loss is the average propagation loss as a function of the distance  $d$  on the order of  $\beta$ .

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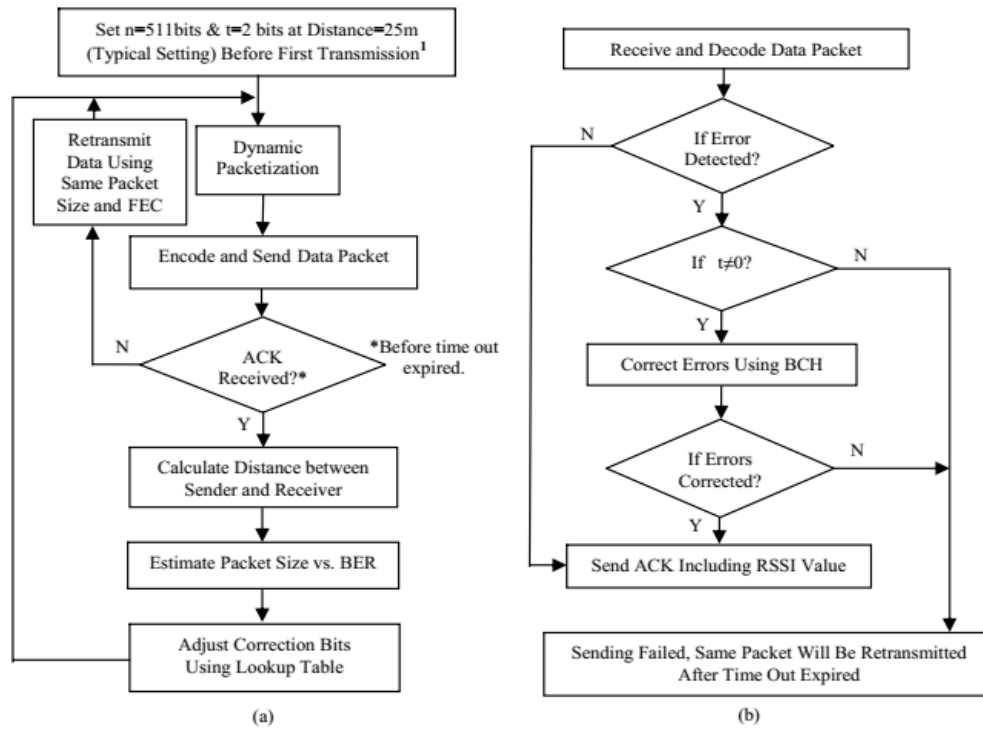


Fig. 3 Proposed Adaptive Error Coding System in Wireless Sensor Network (a) Sender node (b) Receiver node

**Optimization Metric:** The energy efficiency  $\eta$  is a suitable metric that captures the energy and reliability constraints, which is defined as [4]:

$$\eta = \eta_e \cdot R = \frac{E_{eff}}{E_{total}} (1 - PER) \dots \dots \dots (3)$$

where  $\eta_e$  is the energy throughput,  $R = (1 - PER)$  is the packet acceptance rate, which accounts for data reliability, and  $E_{eff} / E_{total}$  denotes the energy throughput. Therefore, the energy efficiency  $\eta$  represents the useful fraction of the total energy expenditure in a communication link between neighbouring sensors.

In this section, the AECC scheme was associated with one of non-AECC, in terms of energy efficiency based on different communication distances and data packet size using HARQ error control over Rayleigh fading channel. The interval of the distances in simulation is 5 meter because of the location error in WSNs. The energy efficiency of two types of error control scheme is all sharply reducing with increasing of communication distance. Energy efficiency of AECC scheme decreases to some degree, but the performance of this scheme is maintained relatively well with increasing of communication distance for various packet size.

## IV. CONCLUSION

The usage of error correcting code (ECC) can allow a system to operate at expressively, but the choice of ECC is a very important for a wireless sensor network. In this paper, energy efficiency of error control schemes in wireless sensor networks is deliberated. The maximal energy efficiency of HARQ technique can be accomplished by adaptation of error correction capability for a target communication distance and packet size. Additionally, AECC is associated with non-AECC scheme in terms of energy efficiency based on different communication distances and packet lengths.

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