ENHANCED RABIN ALGORITHM BASED ERROR CONTROL MECHANISM FOR WIRELESS SENSOR NETWORKS

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Abstract

In wireless sensor nodes, the data transmitted from the sensor nodes are prune to corruption by induced errors by noisy channels and other relevant parameters. Hence it is always vital to provide an effective and efficient error control methodology to minimize the bit error rate (BER).Due to the presence of scarce energy available in the sensor networks, it is important to use a high throughput, low end to end delay and energy aware error control scheme. In this paper, the performance analysis of three error control codes namely Enhanced Rabin Algorithm Based HARQ (ERABHARQ), Enhanced linear feedback shift register based mechanism (ELFSRM) and Hadamard code are analyzed based on the performance metrics namely Throughput, BER, End to End Delay and energy utilization by varying the sensor nodes. To elaborate the error control schemes with different situational parameters are simulated using ns-2. The Enhanced Rabin Algorithm Based HARQ code is the improved methodology when compared to Automatic Repeat Request, because the retransmission of the packets do not takes place automatically rather than it takes place based on the success or failure of the Enhanced Rabin's Algorithm. In this paper, three different error control codes are compared and it is concluded that Enhanced Rabin Algorithm Based HARQ performs better and it is well suited for wireless sensor networks

***Keywords*: Error control, ERABHARQ, Energy, WSN**

1. Introduction

In the recent days, the development of micro electrical and mechanical systems has enabled the development of wireless sensor nodes in WSN [11]. These responsible nodes posses the capabilities like, sensing, processing and communicating with each other [1, 2]. Due to the limited battery power of the sensor nodes, there is a need for strict energy consumption constrains, whose main objective is to increase the lifetime of the network. For accomplishing these demands of the sensor node adequate amount of energy is required for data communication. The reliability is considered to be the primary requirement for sensor communication. The extent of reliability required for data communication in WSN depends major on the two factors, first the application where it is required. Second one based on the requirements.

Some of the optimization schemes for minimizing the energy consumption in the sensor node were discussed in the literature. One such approach is like maintaining two modes for a sensor node, sleeping mode and active mode and switching from one mode to the other mode based on the demand of the transmission and reception traffic of the node. In this approach, the problem of receiver always kept on to receive the packets, is solved by tuning the receiver in the active mode by verifying the channel activity [3].

The next approach in optimizing the energy consumption based on network routing algorithms. In this approach, the load of the destination node has been distributed to a particular (head node) node in a formed cluster. The head distributes the load information to all other nodes in the cluster. Since head node consumes more energy during the periodic intervals, the head node functionality is given to another node in the cluster [4].

The above mentioned approaches have some disadvantages in minimizing the energy consumption, since those techniques are vulnerable to channel destruction. When the channel has been destructed the radio signals will be affected and as results the corrupted data packets will be sent to the receiver. The receiver discards the packets, waiting for new transmission in the active mode or it will send ARQ in the active mode. In both cases the energy consumption will be more. For this reason there are some methodologies to improve the energy preservation by reducing the packet error rate and minimizing the retransmissions to a considerable number. One such approach, which applies the Forward error correction strategies based on convolution coding scheme [5]. The performance of block codes such as Viterbi decoder, convolution codes, Hadamard code and ELFRSM code are investigated [6, 7]. Also the life time of the network can be enhanced by solving a problem called hot spot using iterative decoding algorithm [8].

Error control coding is a traditional approach used for increasing the link reliability by minimizing the required transmitted power. Moreover, the minimization power at the transmitter comes at the expense of extra power consumption due to the decoder at the receiver. Optimal codes always provide better performance with low power requirements, whereas most complex decoder comes with high power consumption [9, 10].

The set of the paper is organized as follows; section 2 discusses the various available error control codes in WSN. Section 3 proposes and explains the Enhanced Rabin Based Error control Mechanism.

2. Methodology

In this paper, a new error control technique called the ERABHARQ code and compares it with the Hadamard codes and ELFSRM Code. Hence, the three codes are simulated and implemented using the ns-2 simulator and compute their degree of control in propagation of errors during the transmission. All the comparison is based on the assumption of the same error control performance which is evaluated by the BER test.

The error control techniques employed in the wireless sensor networks to control errors were mainly based on the FEC or the ARQ techniques. But, even though the basic ARQ protocols possess the capability of error control they have several drawbacks, in order to eliminate these types of drawbacks the hybrid error control methodology was first evolved which consists of the properties of ARQ and FEC error control codes. The FEC based system increases the system throughput by detecting and correcting almost frequently occurring error patterns in the code words that are transmitted. But when a detectable and uncorrectable error pattern is obtained ARQ retransmission has to be performed to increase the reliability.

Hybrid ARQ scheme can be classified into type1 and type2. The type1 scheme is always used for error detection and error correction. When a code word is received the receiver sensor node tries to correct the error. These error corrections is done through this proposed methodology called ERABHARQ.

The HARQ is still classified into the chase code combining and incremental redundancy combining. Chase code combining is a technique used to combine repeated data packets at the receiver. The successive retransmitted data packets are identical copies of original transmission having same code rate but have different weights associated to each of them. Chase combining can be considered as additional repetition coding and therefore has no coding gain. Here the second technique called the chase code combining is employed for retransmission. This retransmission has to be done after applying ERABHARQ algorithm. The ERABHARQ code and algorithm is as follows

2.1. *ERABHARQ code*

1. Raw Data is transmitted as a stream of integers ranging from 0…..2^{m-1}.
2. The raw data length is divided into k-partitions each of length'n.'
3. Each'k' partitions each of length 'n'are arranged into 'k' columns.
4. During relay, each piece of data are multiplied with pseudo random vectors.
5. Now new message = (A-Original message)*(B-array of pseudo random vectors)
6. The next node, after receiving computes W^T and A^T from the information got from periodic refreshment.
7. The message is reconstructed as B.

Here when the information travels from one node to the other node, the communication channel is prune to errors .the errors that are detected can be corrected by using an the information dispersal scheme called the Rabin's algorithm which acts in essence as an erasure code. It is achieved by adding a limited redundancy to the data to allow recovery from a number of faults. Here the transmitted data and the redundancy are divided into a number of pieces so that even a partial reception can lead to the successful reconstruction of the message at the receiver. This could be accomplished with the help of a factor called the redundancy factor.

2.2 ERABHARQ Algorithm:

1. A Source sensor node sends packet to all possible paths in the sensor network.
2. A Source node along with the packet information it also sends, the 'code word' calculated for the packet.
3. Each and every static sensor node receives the packet, along with the 'code word'.
4. In the receiver side, the calculation of 'code word' is done based on the received packet.
5. Variation between the calculated code word and received code is calculated. The Hamming distance between

the calculated and received value is calculated to be a certain value for a particular packet.

6. If the value obtained in the static node within the certain value (n/2) , then call ERABHARQ( ).
7. If the value obtained in the static node is beyond the certain value (n/2), then it is inferred that more number of bits are changed.
8. Hence, Retransmission of Packets (ARQ).

A source node sends the packet to all the other nodes by dividing the entire information into linear block of codes. When the sensor nodes receive the blocks of data, they manipulate the checksum of the pair formed by the blocks of code. From the checksum, the hamming distance is calculated. If the hamming distance (i.e) value obtained in the static node within the certain value (n/2) , then call ERABHARQ( ) and If the value obtained in the static node is beyond the certain value (n/2), then it is inferred that more number of bits are changed. This is accomplished through the neighbors in a hop to hop transmission mechanism present distributed in the static nodes of the sensor networks

3. Simulation and Results

Network Simulator-2 is used for simulation. 50 mobile nodes are randomly placed in a rectangular area 1000 m×1000 m. The wireless channel capacity is 2 Mb/s. Each simulation can run for 50 seconds. A Constant Bit Rate (CBR) source is used as the data source for each node. Each source node transmits packets at a certain rate. The random way point model is used. The maximum allowed speed for a node is 10 meters per second. The following performance metrics are used to compare the different error control codes are BER, Energy consumption, end to end delay and throughput by varying the no of nodes..

3.1. Performance Measures

The decoder is a code combiner based on maximum likelihood estimation of transmitted information. The soft decisions statistics of previously received data packets are combined so as to obtain the best estimate of the transmitted information packet and thus improve the SNR of the received signal .In the incremental redundancy scheme of soft decision combining, each of the retransmitted data packets has different coded bits and different code rates for the same set of information bits. They have a coding gain since several different codes are combined to form a lower rate code with stronger error correction capabilities

Bit-Error-Rate (BER) **–** Bit error rate (BER) is defined as the percentage of bits that have errors relative to the total number of bits received in a transmission, usually expressed as ten to a negative power. it may be also defined as the probability of bit error. We want to keep this number small, naturally less than 10^{-4}. Bit-error rate is termed as an indicator of system performance on an independent error channel.

End-to-end delay- it refers to the time taken for a packet to be transmitted across a network from source to destination.

Throughput: It is referred as the average rate of message delivery over the communication channel. It is always expressed in bps.

Energy Consumption: It is the total sum of energy needed by a node for error control in an hop to hop manner.

3.2. Performance Evaluation of Enhanced Rabin algorithm based hybrid ARQ error control Mechanism

3.2.1. Bit Error Rate (BER)

Fig. 1 shows the comparison between Variation in Number of nodes and the three error correcting code scenarios namely with Hadamard code and with ELFSRM Code and ERABHARQ. From the figure, it is clear that BER is low in ERABHARQ when compared to the other error correcting codes like HADAMARD and ELFSRM Code.

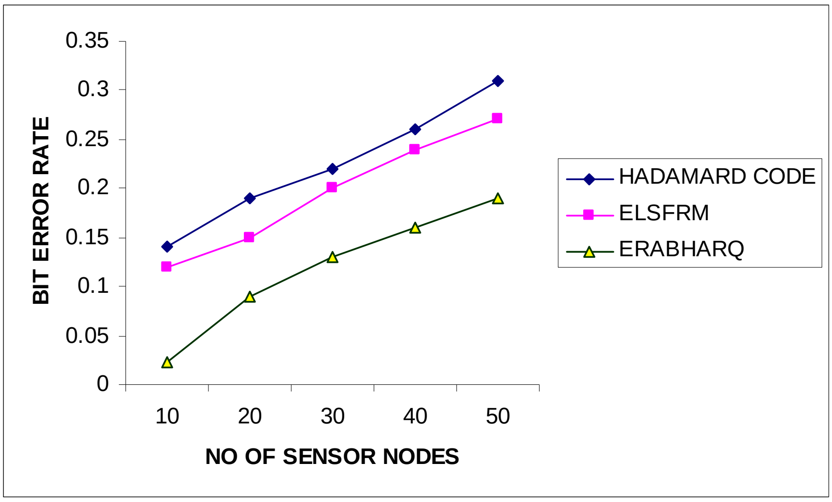

Fig. 1. BER comparison between hadamard, elfsrm code and ERABHARQ by varying the sensor nodes

Fig.1. depicts that the BER gets nearly 17 % lowered with the ERABHARQ code. For an efficient error control code the BER rate should be minimum and hence the BER obtained after proposed code is better compared to other two codes.

3.2.2 Throughput

Figure 2 shows the comparison between Number of Nodes and throughput of three error correcting code scenarios namely with Hadamard code, ELFSRM Code and ERABHARQ. From the figure, it is clear that throughput is relatively high with reference to two error correcting code scenarios namely with Hadamard code, ELFSRM Code when compared with ERABHARQ Code.

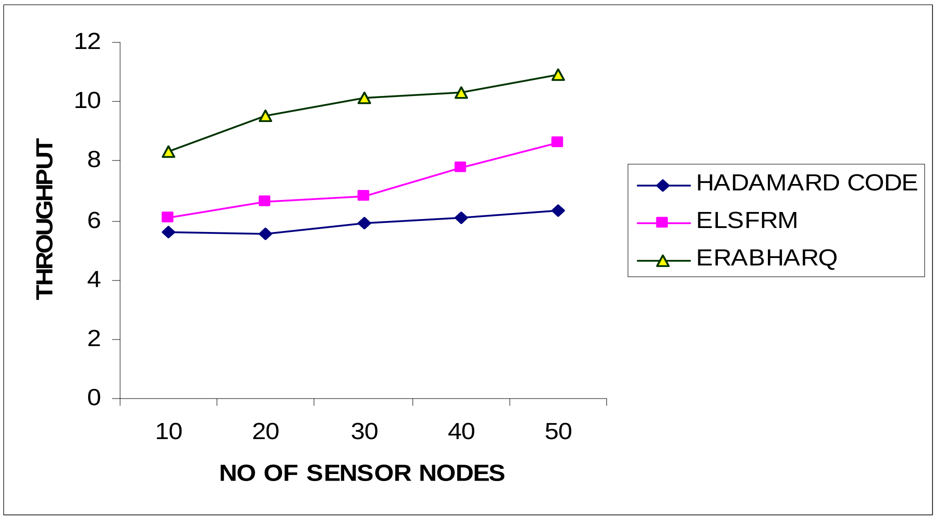

Fig. 2 Throughput comparison between hadamard, elfsrm code and ERABHARQ by varying the sensor nodes

Fig 2. Depicts that the throughput gets nearly 25% increased with the ERABHARQ code. For an efficient error control code the throughput should be maximum and hence the throughput obtained after proposed code is better compared to other two error correcting codes.

3.2.3. Energy Consumption

Fig.3. shows the comparison between Number of Nodes and Energy Consumption of three error correcting code scenarios namely with Hadamard code, ELFSRM Code and ERABHARQ, it is clear that energy consumption is relatively high in Hadamard code and ELFSRM code when compared to ERABHARQ.

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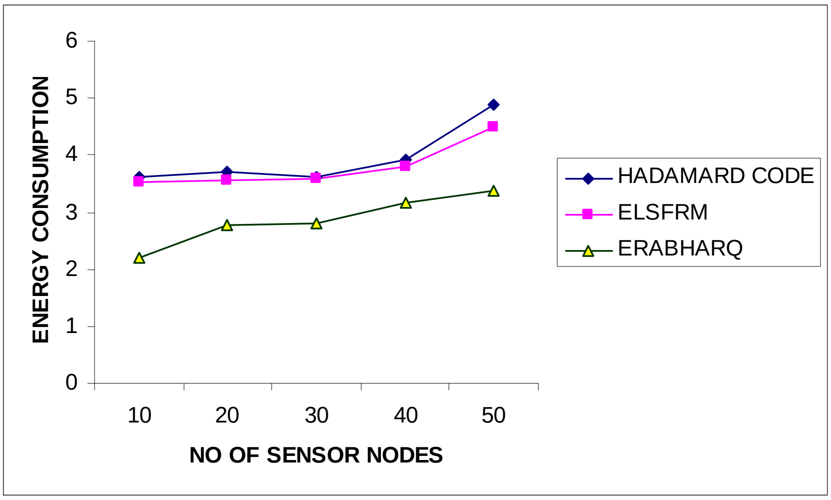

Fig 3. Energy consumption comparison between hadamard, elfsrm code and ERABHARQ by varying the sensor nodes

Fig.3. depicts that the energy consumption gets nearly 19% lowered with the ERABHARQ code. For an efficient error control code the energy consumption should be minimum and hence the energy consumption obtained after proposed code is better compared to other two error correcting codes

3.2.4. End to end delay

Figure 4 shows the comparison between number of nodes and delay of three error correcting code scenarios namely with Hadamard code, ELFSRM Code and ERABHARQ.. From the figure, it is clear that delay is relatively high in Hadamard code and ELFSRM code when compared to ERABHARQ.

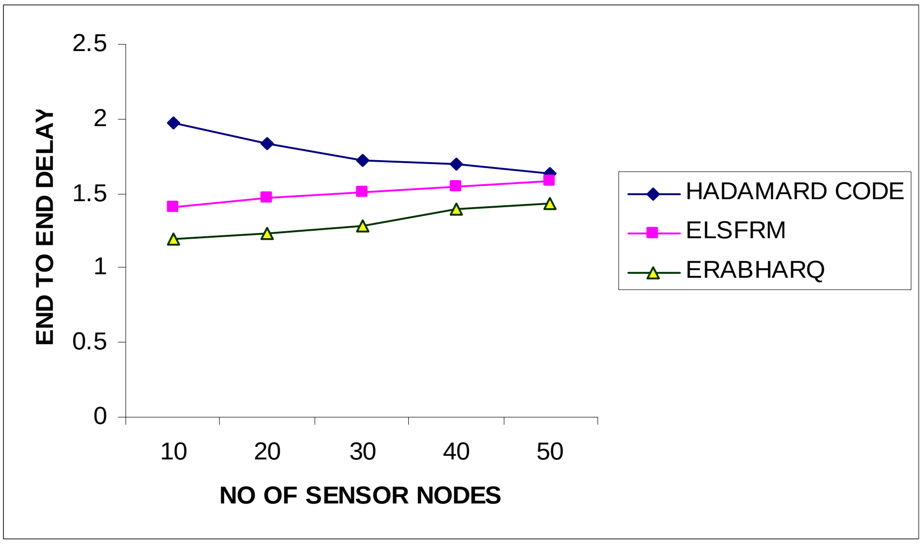

Fig.4 Delay comparison between hadamard, elfsrm CODE AND ERABHARQ by varying the sensor nodes

Fig 4.depicts that the end to end gets nearly 23% lowered with the ERABHARQ code. For an efficient error control code the end to end delay should be minimum and hence the end to end delay obtained after proposed code is better compared to other two error correcting codes.

Fig.5. shows the Nam Screen shot of WSN simulation that implements the ERABHARQ code Mechanism with 30 receivers and packet size 256 and the Terrain is 1000x1000in an random way point model.

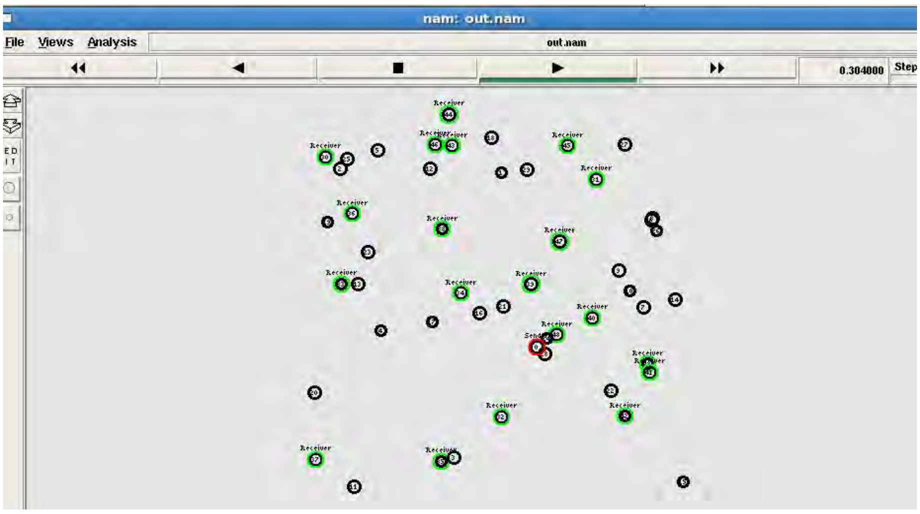

Fig.5. NS 2- NAM Window for ERABHARQ code.

4. Conclusion

In this paper, Enhanced Rabin Algorithm based Error control mechanism was proposed, which performs better compared to the other two error correcting codes, namely Hadamard code and Enhanced linear shift register based error control mechanism. The wireless sensor network environment is simulated using NS 2 network simulator tool and various parameters are analyzed by varying the sensor nodes. The various parameters discussed are throughput, BER, end to end delay and Energy consumption. The performance evaluation clearly depicts and it is proved through simulation that the proposed Enhanced Rabin algorithm based Error control mechanism performs better compared to Hadamard code and ELFSRM. In future it can be extended for real time test bed and also can be analyzed with various real time environments.

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