# AN ANALYSIS OF VARIOUS PARAMETERS IN WIRELESS SENSOR NETWORKS USING ADAPTIVE FEC TECHNIQUE

M.R.Ebenezar jebarani[1] and T.Jayanthy[2]

[1]Research Scholar, Sathyabama University, Chennai
jebaranimalgam_2007@rediff.com

[2]Principal, Panimalar Institute of Technology, Chennai
,jayanthymd@rediffmail.com

## ABSTRACT

*In Wireless sensor network, since the media is wireless there will be burst errors which leads to high bit error rate that affect the throughput. Wireless sensor networks drop the packets due to propagation errors that lead to retransmission traffic. This paper evaluates the effect of adaptive FEC in Wireless sensor networks. Adaptive FEC technique improves the throughput by dynamically tuning FEC depending upon the wireless channel loss. The main aim is to achieve desire throughput with less energy consumption. If the retransmission traffic decreases, that is error correction performed using adaptive FEC which maximize the throughput. The other related parameters packet delivery ratio, packet loss, delay, error rate are also being analyzed. The algorithm reduces the retransmission traffic by using Adaptive FEC technique thus improving the throughput and reduces the error rate.*

## KEYWORDS:

*Throughput, adaptive FEC, wireless channel, Bit error rate,* ARQ

## 1. INTRODUCTION

Wireless environment are unreliable, with error rate high that introduces burst errors. WSN should have error correction technique to tackle these problems. Error control acknowledges the fact that all transmission media and in particular wireless media introduce distortions into transmitted waveforms, which may render transmitted packets useless. With error-control mechanism the error shall be compensated. The efficiency and energy consumption of the different error control mechanisms depends on the error patterns on the link. The error control can be characterized in terms of following attributes [8], such as Error free, in-sequence, duplicate free and loss free. In error-free, the information that the receiving node delivers to its user should contain no errors that is the transmitted bits are reproduced exactly [8]. If the user of transmitter hand over two pieces of information it should be delivered in sequence. The receiver should receive the same piece of information at most once that is duplicate free delivery. In loss-free, the receiver should get any piece of information at least once.

The three most important error control techniques are ARQ, FEC and Hybrid ARQ/FEC[1,4,8]. ARQ protocols address all desired service attributes (errors free, in-sequence, Duplicate-free, loss-free) FEC methods are focused on achieving error-free transmission [13]. ARQ protocol is the simple error control technique. If there is no error there is no overhead. On receiving the negative acknowledgement, sender retransmits the erroneous packet. The retransmission leads to huge delay and energy consumption more. Therefore the retransmitting

DOI : 10.5121/ijasuc.2010.1303

traffic should be reduced [4, 14]. In FEC technique the erroneous packets are corrected with the help of redundant information. The disadvantage in this scheme is that there will be fixed overhead even though there are no errors. There may be packet loss if the error cannot be corrected [3, 15]. The combination of ARQ and FEC technique is Hybrid ARQ/FEC technique, in this technique if the error packet can be corrected with the help of redundant information (FEC) it will be corrected or else if the FEC cannot deal the errors, then receivers sends negative acknowledgement where the sender retransmit the error packet( ARQ)[7].

In this paper the adaptive FEC algorithm is introduced to reduce the retransmission traffic thus improving the throughput, packet delivery ratio, delay, packet loss, error rate.

## 2. EFFECT OF WAVE PROPAGATION IN WSN

FEC algorithm is adopted in application or data link layer for reproducing the damaged or lost packets [10]. Application layer restores the packet during congestion. Data link layer correct packets contaminated by propagation errors [5]. The waveforms transmitted over wireless channels are subject to several physical phenomena that all distort the originally transmitted waveform at the receiver [6]. The distortion introduces uncertainty at the receiver about the originally encoded and modulated data, resulting in bit errors. The basic wave propagation phenomena are reflection, Diffraction, Scattering, Doppler fading. Reflection means, when a waveform propagating the medium A, hits the boundary to another medium B, the boundary layer between them is smooth, one part of the waveform is reflected back into medium A, another one transmitted into medium B and the rest is absorbed. The amount of reflected/transmitted/absorbed energy depends on the material and the frequencies involved [8]. Diffraction is that by Huygen's principle, all points on a wave front can be considered as source of a new wave front. If a waveform hits a sharp edge, it can be propagated. Scattering is that, when a waveform hits a rough surface it can be reflected multiple times and diffused into many directions. When a transmitter and receiver move relative to each other the waveform experience a shift in frequency, according to Doppler Effect, this is Doppler fading.

## 3. RELATED WORK

The existing algorithm, adjusts the FEC code size based on the channel status indicated by acknowledgement packets arrival. It ascends to the higher level FEC level at a packet loss otherwise descending to the lower level FEC in a multiplicative increase additive decrease (MIAD) way. The existing algorithm works with Type I or Type II, which determine the strength of FEC code or the amount of FEC code, send in next transmission [2, 12].

Type I is not that much efficient due to waste of bandwidth by resending the data again. Type II will not be that much efficient if data packet or some previous transmitted data not reached the receiver. Adaptive FEC code control algorithm increases the FEC code level multiplicatively and decrease the code additively to test whether the channel become noises free. Adaptive FEC code control algorithm tunes the FEC code size without any explicit information such as SNR and packet loss rate. The waveform is analyzed with the parameter of performance ratio, mostly with respect to distance, time interval, error rate etc [2]. In this paper we had analyzed the different parameters such as throughput, packet delivery ratio, packet loss, delay, error rate by varying the number of packets sent.

Adaptive FEC code control algorithm use the higher FEC level after detecting packet loss. The transmitting overhead for FEC level is less than that of entire data packet. Adding more FEC is to improve the performance instead of dropping packet [2]. There are two methods to model bit level propagation errors in packet level simulators, that is large scale fading and small scale fading [12]. Adaptive FEC code control matches the FEC code size to the low frequency wireless channel BER, which is evaluated by acknowledgement packet arrival [2]. Initially in this algorithm for short distance the FEC size is 2 bytes and for long distance it is increased to 10 bytes. When distance increases there will be more erroneous bits, so the FEC code size is varied from 2 bytes to 10 bytes. If the distance increases, say 13 m then the sender should add 36 byte code to correct the 18 damaged bytes. Reed Solomon code needs 2 byte error correction code for 1 byte error. With static FEC algorithm it leads to 24 byte waste as the distance is less than 11 m the error bytes will be less than 6 (it needs 12 bytes to correct the error and remaining 24 bytes are unnecessarily transmitted and it leads to wastage of bandwidth). In this paper the distance and bandwidth waste ratio was also analyzed [8].

## 4. Analyzing Various Parameters Using Adaptive FEC Technique

The algorithm is developed to analyze various parameters with respect to number of packets sent, by varying the FEC code size with the help of acknowledgement packet arrived.The algorithm reduces the FEC code if positive acknowledgement is received and increases the FEC code if packet loss occurs [12]. The algorithm identifies the channel behavior by reducing the FEC code size. The **throughput** is the most important parameter to analyze the performance of the network, to get better throughput the error should be corrected, instead of retransmitting the packet. If the error is corrected there is no need of retransmitting the packet. If the retransmission traffic is reduced the congestion will not occur. If there is no congestion there is no packet loss that is error. If more number of packets in the network the performance of the network degrades which leads to congestion, which leads to packet loss. If there is an error correction technique which corrects the error instead of going for retransmission it improves throughput. **Packet delivery ratio** is the ratio of no of packets received to no of packets generated. The throughput is usually measured in bits per second (bit/s or bps).

The error rate is corrected by varying the FEC code size. Erroneous packets are corrected to improve the throughput [16]. In this algorithm the parameter analyzed is throughput with respect to the number of packets sent from source to destination [9]. The error rate decreases which leads to the improvement in throughput. Throughput is the ratio of number of packets (bytes) sent to the number of packets (in bytes) received. The data packet is of variable size and the FEC code size is also variable in data packet frame.

**Packet loss** occurs when one or more packets of data travelling across a network fail to reach their destination. Packet loss is distinguished as one of the three main error types encountered in digital communications; the other two being bit error and spurious packets caused due to noise. Packet loss can be caused by a number of factors, including signal degradation over the network medium due to multi-path fading, packet drop because of channel congestion, corrupted packets rejected in-transit, faulty networking hardware, faulty network drivers or normal routing routines.In addition to this, packet loss probability is also affected by Signal-to-noise ratio and distance between the transmitter and receiver. In this algorithm the packet loss is analyzed with respect to number of packet sent .

In data transmission, the **bit error rate** or **bit error ratio** (BER) is the number of received bits that have been altered due to noise, interference and distortion, divided by the total number of transferred bits during a particular time interval. The bit error rate is more the error correcting code should be more, if the BER is less the error correcting code is small enough to correct the erroneous packet.

BER can also be defined in terms of the probability of error (POE),

$$POE = \frac{1}{2}(1 - erf)\sqrt{E_b / N_o}$$

Where *erf is* the error function, $E_b$ is the energy in one bit and $N_o$ is the noise power spectral Density (noise power in a 1 Hz bandwidth).The error function is different for the each of the various modulation methods.**Delay** is another parameter where it is very important in case of real time data transfer. In audio and video it doesn't matter much as it is soft real time, but in case of hard real time where the little delay leads to dangerous situation, delay plays an important role. So depending upon the requirement delay parameters are analyzed.**Energy consumption** is also a parameter to be analyzed in case of wireless sensor networks as the sensors gather information througout the day the power saving is very important, if more number of retransmission the power consumption will be more which is not fair in case of tiny sensor nodes.The battery used is to charge through environment, so solar cells are mostly used in these sensors. The energy saving is also an important parameter where mostly the sensors are deployed in remote areas.**Distance** between the transmitter and receiver is another parameter, which introduces more errors. In wireless environment there is more number of errors introduced due to distance travelled.

**octets**

| 2 | 2 | 6 | 6 | 6 | 2 | 1 | variable | |
|---|---|---|---|---|---|---|---|---|
| **Frame Control** | **Duration** | **Destination address** | **Source address** | **BSSID** | **Sequence Control** | **FEC Strength** | **Data** | **FEC** |

**a. Data Packet Frame**

**octets**

| 2 | 2 | 6 | 6 | 4 |
|---|---|---|---|---|
| **Frame Control** | **Duration** | **Destination address** | **Source address** | **FEC** |

**b. RTS Frame**

**octets**

| 2 | 2 | 6 | 4 |
|---|---|---|---|
| **Frame Control** | **Duration** | **Destination address** | **FEC** |

**c. CTS Frame**

**octets**

| 2 | 2 | 6 | 4 |
|---|---|---|---|
| **Frame Control** | **Duration** | **Destination address** | **FEC** |

**d. ACK Frame**

Figure 1: Data packet frame, RTS frame, CTS frame and ACK frame

There are four frames shown in figure 1. They are Data packet frame, RTS (request to send) frame, CTS (clear to send) frame and ACK frames. The FEC code sent for data packet frame is variable because the data packet frame is lengthy, so Adaptive FEC code is needed to correct errors[2].The static FEC code sent for other frames are enough to decode the errors and correct the errors [17, 18]. The algorithm is analyzed to improve the throughput and also to compare the throughput with respect to error rate. Adaptive FEC set 11 FEC level each of which corrects 2,5,8,12,16,21,26,33,40 and 45 corrupted bytes[8]. FEC level maintain in the particular level if there is no packet loss. The FEC level should be adapted to fast changing BER. Instead of increasing FEC other parameters can also be adjusted. But in this algorithm the FEC is varied, varying the FEC code is better improvement in throughput, packet delivery ratio, packet loss, delay and also BER reduces. The performance of this algorithm counts the number of packets that are received successfully or recovered with FEC code. The various parameters analyzed in this algorithm are throughput, packet delivery ratio, packet loss, and delay and error rate. There are so many other parameters to be discussed in wireless environment.

## 5. SIMULATION RESULTS

The algorithm is to improve the throughput and also reduces the BER [20]. Network simulator is used for simulation. The fig 2 shows the sample screenshot (Network animator - NAM) while running the program in NS2 [11]. The NAM window shows the delivery of data from source to destination. The version used is NS-2.31. Simulation is done using 50 nodes in the network. Simulation is performed in wireless environment. The fig 3-8 is drawn with the help of trace file in NS2. The readings are taken by observing the network behavior by varying the number of packets sent.

If more number of packets sent, usually the throughput will be less due to number retransmission, Fig 3 shows the improvement of throughput with respect to more number of packets sent. As the number of packet sent increases the throughput also increases with Adaptive FEC algorithm. If more number of packets sent there will be more delay to deliver that packet, due to more number of packets in the network. But Fig 4 shows the Decrease in delay with respect to increase number of packets sent. Fig 5 shows the graph between throughput and error rate. Error rate decreases the throughput increases. The decrease in error rate increases the throughput, the error rate is decreased with the help of varying the FEC code size so that the erroneous packets are corrected instead of going for retransmission which improves the throughput. In figure 6, the error rate decreases even though more number of packets sent. With the low FEC code bytes the error rate is more but by applying Adaptive FEC technique the error rate decreases, thus reducing retransmission traffic. In figure 7, it shows that the packet delivery ratio increases as the number of packet sent increases. The performance of the network is better even though the packets sent are more, so that the Adaptive FEC improves the packet delivery ratio. In figure 8, it shows that the packet loss is reduced. If more number of packets sent there will be more number of packet losses due to errors. But the fig 7 shows by the adaptive FEC algorithm the packet loss is reduced. If more number of packets transmitted without loss then the throughput, packet delivery ratio automatically increases.

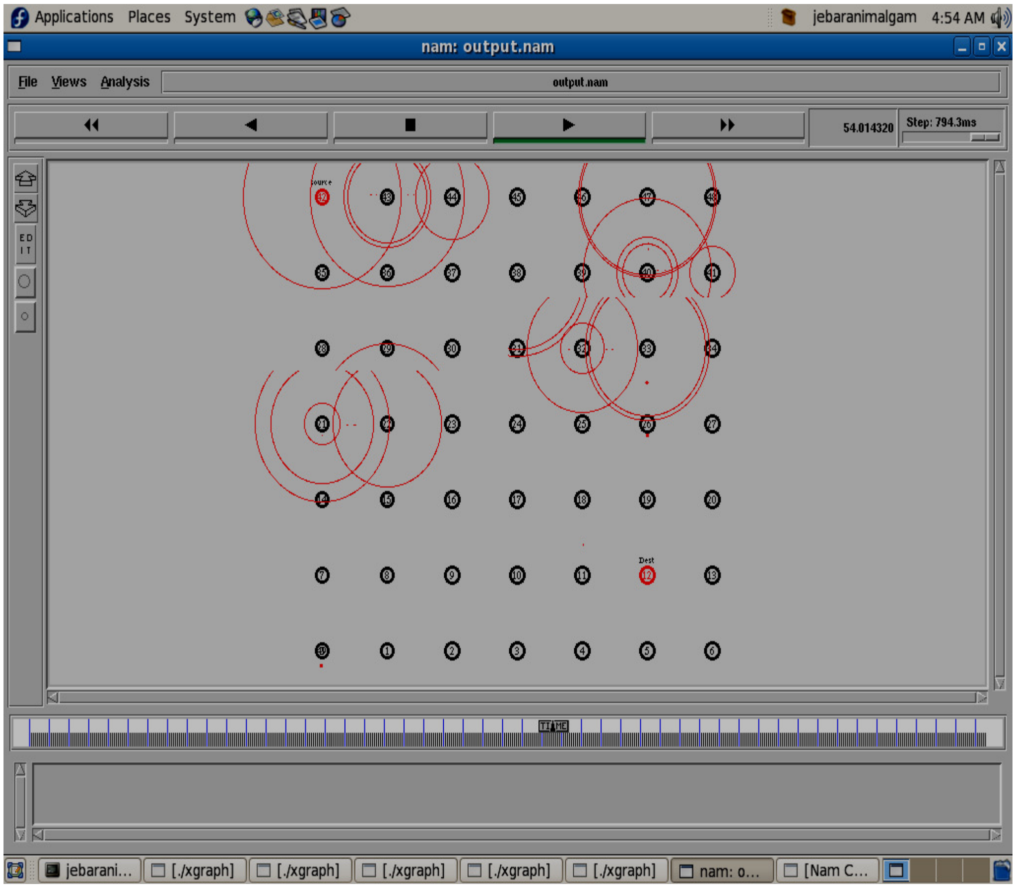


Figure 2: Sample screen shot of NAM in NS2.

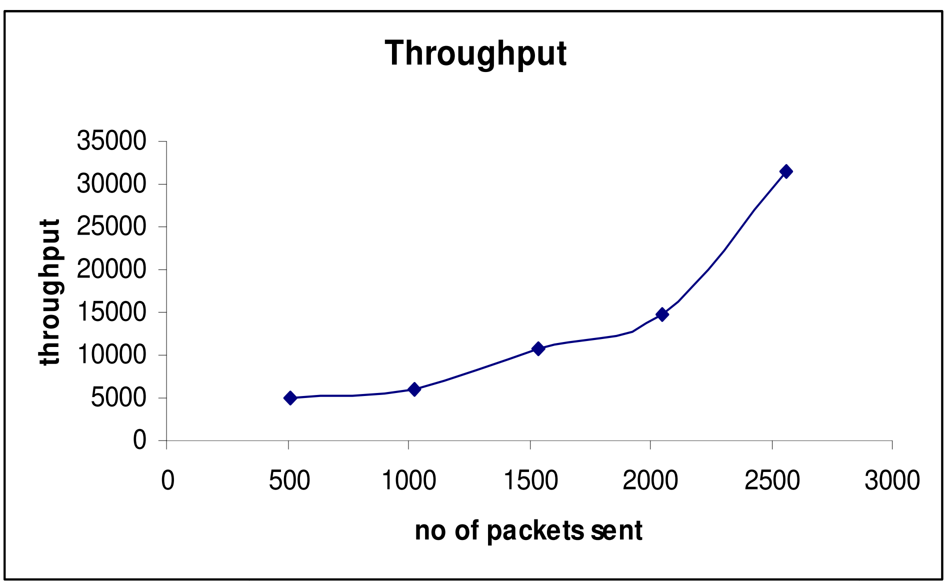


Figure 3: Throughput vs. No of packets sent

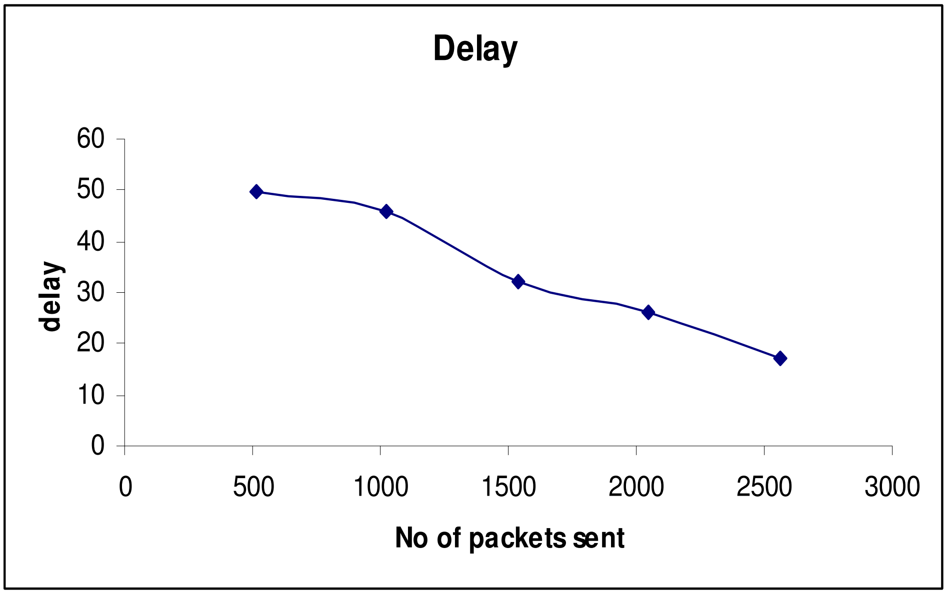


Figure 4: Delay Vs No of packets sent

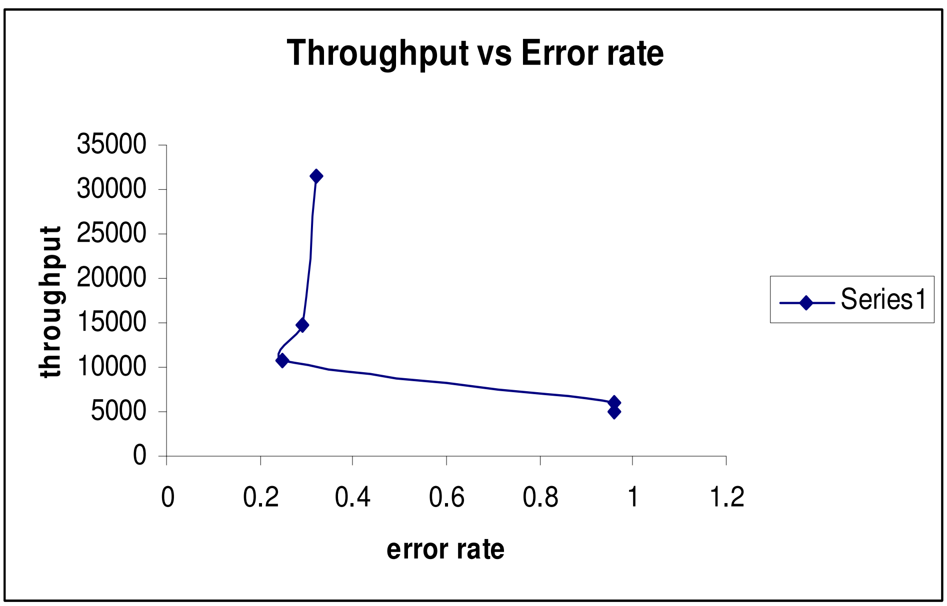


Figure 5: Throughput vs Error rate

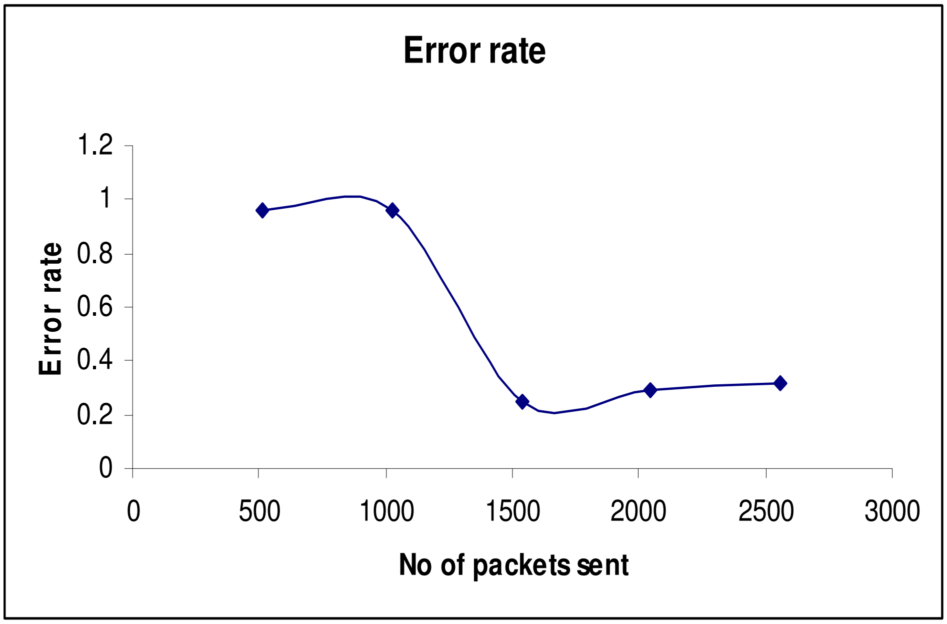


Figure 6: Error Rate vs Number of packet sent

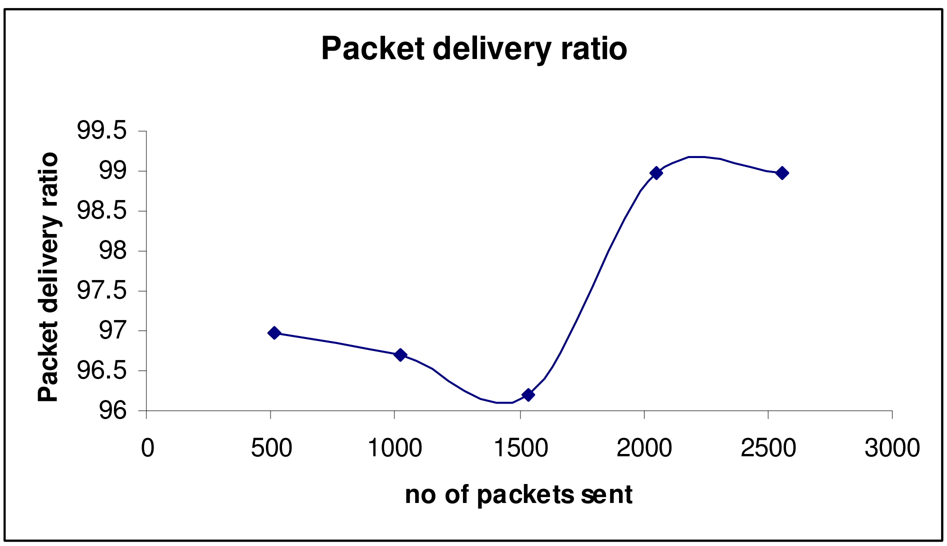


Figure 7: Packet delivery ratio vs no of packet sent

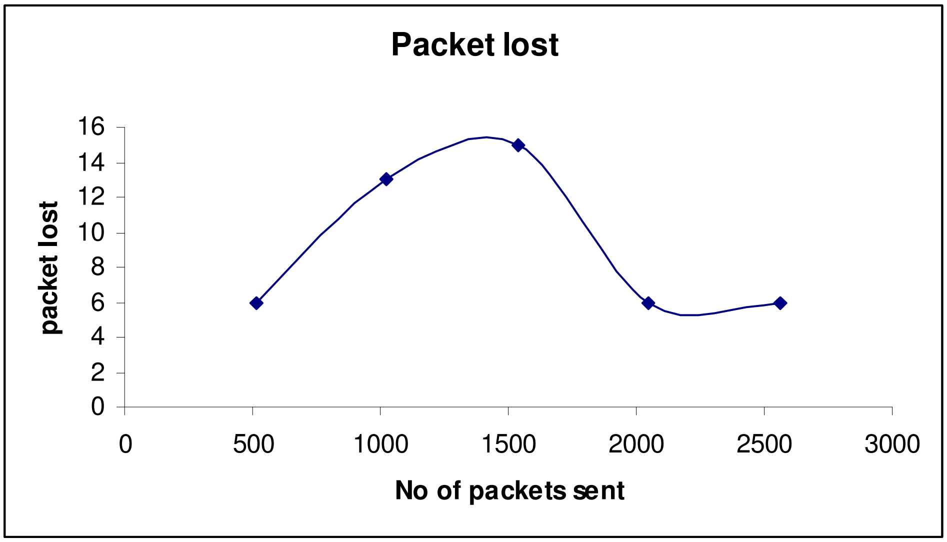


Figure 8: Packet Lost vs. no of packet sent

Table 1 shows various parameters that are analyzed with respect to no of packets sent. Usually the throughput degrades as the number of packets sent increases due to congestion, error packets retransmission etc, but using this adaptive FEC technique the throughput increases, even though more number of packets sent. In wireless media the error probability is more, but using this algorithm as the number of packets sent increases, the error rate decreases. The delay to transmit a packet will also become more due to so many packets in the network, but this algorithm shows that the delay decreases as more number of packet sent. The packet delivery ratio also increases as more number of packets sent. The loss of packet also decreases, the more packets leads to packet loss as the receiver may not able to receive as fast as transmitter, but by this algorithm it shows that the packet loss is less. The algorithm reveals that there is an improvement while analyzing throughput, packet delivery ratio, packet lost, delay and error rate parameters.

Table 1: Comparison of Various Parameters with respect to No of Packets Sent

| No of packets sent | Throughput | Error Rate | Delay | Packet Delivery Ratio | Packet Lost |
|---|---|---|---|---|---|
| 512 | 4994.05 | 0.96 | 49.71 | 96.97 | 6 |
| 1024 | 5930.25 | 0.96 | 45.76 | 96.70 | 13 |
| 1536 | 10764.13 | 0.25 | 31.98 | 96.21 | 15 |
| 2048 | 14636.18 | 0.29 | 26.33 | 98.97 | 6 |
| 2560 | 31408.85 | 0.32 | 17.12 | 98.97 | 6 |

## 6. CONCLUSION & FUTURE WORK

Since wireless sensor network transmit the information in wireless environment, the error probability is more. Error rate affects the throughput and also it increases the delay. The delay is an important parameter in case of real time traffic. The delay should be reduced or else it leads to dangerous situation in case hard real time systems. When the packet transmitted, if there is error the entire packet should be retransmitted, which is wastage of bandwidth. In this algorithm only the FEC code size are transmitted, that is lesser than data packet and the bandwidth is utilized efficiently. In this paper we had analyzed the throughput, packet delay, packet delivery ratio, packet loss and the comparison with respect to throughput and error rate is performed. The draw back in FEC is that if there is no error there is non zero overhead which is not necessary.

In future it should be compared with the static FEC code such as Reed Solomon codes[19] and also conventional dynamic FEC. The parameter energy consumption and bandwidth also to be analyzed. The error rate decreases will also reduce the energy consumption. The performance of the network to be analyzed by increasing the number of nodes in the network.

## REFERENCES


[1]. Hang Liu, Hairuo Ma, Magda EI Zarki and sanjay gupta,"Error Control schemes for networks: An overview". Mobile networks and applications 2(1997)167-182

[2]. Jong-Suk Ahn, Seung-Wook Hong, and John Heidemann, An Adaptive FEC Code Control Algorithm for Mobile Wireless Sensor Networks, journal of communications and networks, vol. 7, no. 4, December 2005.

[3]. Jong-Suk Ahn, Young-su lee, Jong Hyuk Yoon and Kang woo Lee, "Analyzing the effect of a Block FEC algorithm's symbol Size on energy consumption in wireless sensor networks,UCS 2006, LNCS 4239,pp 440-453 2006.

[4]. Prajit Paul, Subhabrata Barman, ARQ protocols on mobile Communication and Networks, International Journal of Computer and Electrical Engineering, Vol. 1, No. 2, June 2009, Pp.1793-8163.

[5]. O. Akan and I. Akyildiz, "Event-to-Sink Reliable Transport in Wireless Sensor Networks," *IEEE/ACM Transactions on Networking*, vol. 13, no.5, pp. 1003–1016, Oct. 2005.

[6]. Wessam Ajib, David Haccoun and Jean Francois Frigon, "MIMO Link Layer Transmission Techniques Based on Cross Layer Design", Journal Of Communications, Vol. 2, No. 7, December 2007 pp.28-35.

[7]. Shoubhik Mukhopadhyay, Debashis Panigrahi, Sujit Dey,Data aware, Low cost Error correction for Wireless Sensor Networks, WCNC 2004/ IEEE Communications Society

[8]. Holger Karl, Andreas willig, "Protocols and architectures for Wireless sensor networks, 1970.

[9]. Andreas Kpke, Andreas Willig, Holger Karl, "Chaotic Maps as Parsimonious Bit Error Models of Wireless Channels", Proceedings of the IEEE Infocom, vol.22, no. 1, pp.513-523, March 2003.

[10]. J. Hagenauer, “Rate Compatible Punctured Convolutional Codes (RCPC Codes) and Their Applications”, IEEE Trans. Communications, vol. 36, no 4, pp. 389-400, April 1988.

[11]. L.F.Akyildiz W.Su.Y.Sankarasubramaniam and E.Cayirei, “Wireless sensor Networks,A survey”, computer networks(Elsevier) Journal , Vol38,No4.PP.393-422,March 2002

[12]. J. C. Bolot, S. Fosse-Parisis, and D. Towsley, Adaptive FEC-Based Error Control for Internet Telephony, Infocom’99, Pp.1453-1460, April 1999

[13]. Parise, R.,Hogie, K.,Criscuolo, E. (Computer Sciences Corp),Schnurr, R. (Nasa Goddard Space Flight Cen-Ter),Wesdock, J.,Burns, M. (ITT industries) : A Standard Link-Layer Protocol for Space mission Communications,2002.

[14]. KOˇS´UT, P. : Analysis of throughput in adaptive Go-back-N schemes PhD thesis, KTL FEI STU, Bratislava, 2001. (in Slovak).

[15]. M.Lalam,K.Amis and D.Leroux, Iterative Decoding of space time error correcting codes in Proc IEEE 18th International symposium on personal indoor and mobile radio communications, PIMRC’07,pp1-5,sept 2007

[16]. M.Zorzi and R.R.Rao, Capture and Retransmission control in mobile Radio,IEEE journal on Selected Areas in Communication, 12(8):1289-1298,1994

[17]. M.Busse, T.Haenselmann, T.King and W.Effelsberg, “The impact of Forward error correction on Wireless sensor networks performance, proc.of ACM workshop on real world wireless sensor networks, 2006.

[18]. J.Jeong and C.T. Ee, “Forward error correction in Sensor networks, Technical reports, University of California Berkeley, 2003.

[19]. Y.Xu and T.Zhang, A VLSI Design for Universal Reed-Solomon Erasure decoder. Proc, IEEE Intl. conference on signal processing, 2002, pp 398-401.

[20]. X.Qiu and J.C.Chuang, “Link adaptation in wireless data networks for throughput maximization under retransmissions,” Proc IEEE ICC Vancouver, Canada, June 1999, pp1272-1277.