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DOF: Duplicate Detectable Opportunistic Forwarding In Energy Consumption Duty Cycled Wireless Sensor Network

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***Abstract*— In this paper Forward Error correction Techniques have been analysed and investigated. It is used to enhance the efficiency and accuracy of information transmitted over a channel. The principle this method is to add some redundancy to the data to be transmitted over a channel. Amongst so many technique of FEC coding, Turbo codes are more commonly used now a days due to its compatibility. Turbo Codes have been licensed on a worldwide basis to ST Microelectronics. The investigation of applications of turbo codes has produced new concept for spatial transmission with greater efficiency. this paper aims at getting efficient and reliable communication.**

***Index Terms*— Turbo Codes, Spatial transmission, FEC**

I. INTRODUCTION

In a communication transmission system, data is transferred from a transmitter to a receiver across a physical medium of transmission or wireless channel [1]. The channel wired or wireless is generally affected by noise or fading, which introduces errors in the data being transferred from sender to receiver [2]. The transmission of data over a specific channel has to be pre defined with specific bandwidth and data rate for evaluation of channel [3]. During transmission of data over a channel, errors are obvious having depth as per prevailing conditions instantaneously [4]. For correcting the errors, we have to use error control strategies. There are two main error control strategies adopted in communication systems:

1. Error correcting techniques
2. ARQ technique

II. ERROR CORRECTING TECHNIQUES

In communication systems, the introduction of errors while data is over a channel is big issue to be considered for efficient and reliable system. To overcome such errors in data, forward error correction coding is used to enhance the efficiency and accuracy of information transmitted. If 'n' number of bits is to be sent, a FEC system will add 'k' redundancy bits, therefore total n+k bits are sent through the transmission channel [5]. Such a redundancy will help the receiver to detect any error inside received data and, depending on the FEC algorithm, receiver can correct data without querying the sender for more information, this is why it is called Forward Error Correction technique. There are many Forward Error Correction techniques amongst them turbo codes are more commonly used nowadays due to their compatibility and simplicity [6].

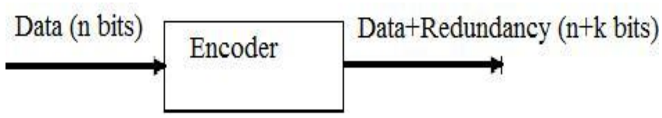

Fig.1 Forward Error Correction technique

A Turbo code is basically a composition of several FEC components, often placed in parallel but sometimes in other schemes, for example in serial or mixed [7]. The idea is to have several FEC encoders that take the same data pool as input but with bits ordered differently inside this data pool. To be more precise, it is a bit like if each FEC encoder had a different view angle of the data, therefore producing a

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different redundancy. At the opposite, the decoding part uses the same number and types of FEC components, placed identically. As each decoder has its own view angle and redundancy of the data, one decoder may correct some errors that other decoders won't be able to correct and vice versa. For example this case is often encountered with burst errors. The key point of turbo code architecture is that each decoder sends its corrections to next decoder. The last decoder sends its corrections to the first one, involving an incremental and recursive correction process [8]

A. The Limit To Capacity

At which data could be transmitted over a channel perturbed by additive white Gaussian noise (AWGN) with an arbitrarily low bit error rate [10]. This maximum data rate, the capacity of the channel, was shown to be a function of the average received signal power, the average noise power N, and the bandwidth of the system W. This standard function is known as the Shannon-Hartley Capacity [8], which can be stated as.

$$C \;\; W \log_2 (1 \;\; {}_N^S)$$

If W is in Hz, then the capacity, C, is in bits/s. Shannon stated that it is theoretically possible to transmit data over such a channel at any rate $R \;\; C$ with an arbitrarily small error probability by use of a sufficiently complicated coding scheme. Rather than using S/N, We often use information bit energy per bit to noise power spectral density ratio Eb/No, to allow systems with different coding or modulation schemes to be compared on an equal basis [11]. The two quantities are related by

$$^{S\,E}b\,^{R}\,N\,N_o$$

Shannon theory also states that there is a limiting value of Eb/No below which there can be no error free transmission at *any* data rate. Using the identity

$$\lim\,(1\;x)^{1/x}\;e\;x\;0$$

We can calculate this limiting value of Eb/No_ by letting

$${}_x{}^{E}b\,^{C}\,N_o\,W$$

Actually, the term turbo code is given for this iterative decoder scheme with reference to the turbo engine principle. The first decoder will decode the sequence and then pass the hard decision together with a reliability estimate of this decision to the next decoder.

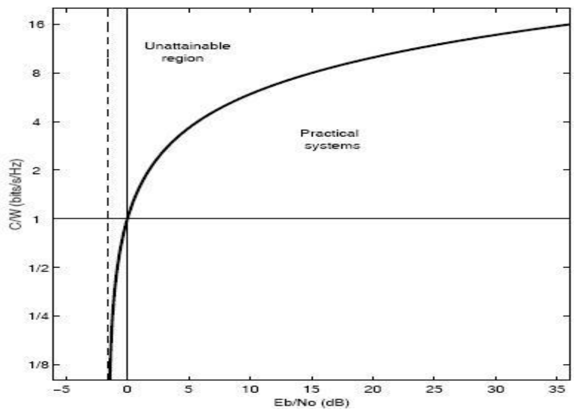

Fig.2 Block Diagram of a Turbo Decoder

This value expressed in dB is Eb/No = -1.59 dB, representing the Shannon bound on Eb/No. It is not possible in practice to reach this limit, because this would require codes so long, and of such complexity, that it would be impracticable to decode them. Shannon's work initiated a search for codes that could approach the bounds shown in Fig.1 and yet have realizable decoding complexity. By the late 1980's, performance within a few dBs of the Shannon bound had been demonstrated using powerful serially-concatenated codes. These codes tended to comprise a Reed-Solomon outer code in series with a long constraint length convolution inner code. However, Viterbi decoding of such convolutional codes is slow and memory intensive [2]. Then, in 1993, Claude Berrou and his colleagues at ENST, France, announced a new type of powerful error control code. Berrou and his colleagues showed that a rate 1/2 turbo code, Frame size 65536 and 18 decoding iterations could achieve BER = 10^{5} at $Eb \,/\, No$ = 0.7 dB with QPSK transmission over the AWGN channel. At this spectral efficiency ($C\,/W$ = 1 bit/s/Hz), "Turbo" means exchanging soft output iteratively. In practice the number of iterations does not exceed 18, and in many cases 6 iterations can provide satisfactory performance [15]. Actually, the term turbo code is given for this iterative decoder scheme with reference to the turbo engine principle. The first decoder will decode the sequence and then pass the hard decision together with a reliability estimate of this decision to the next decoder. Now, the second decoder will have extra information for the

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decoding; a priori value together with the sequence [13]. Additional coding gain can be achieved by sharing information between the two decoders in an iterative fashion. This is achieved by allowing the output of one decoder to be used as a priori information by the other decoder. Each decoder estimates the a posteriori probability (APP) of each data bit, which is used as a priori information by the other decoder. Decoding continues for a set number of iterations. Performance generally improves till the threshold level.

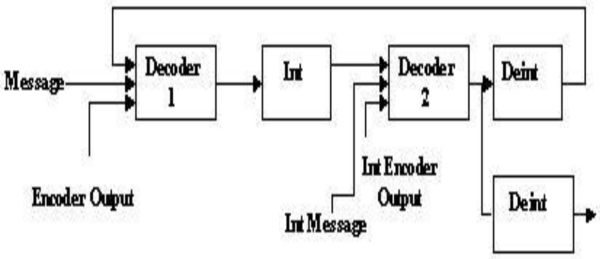

Fig.3 Block Diagram of a Turbo Decoder

The interleave in-between is responsible for making the two decisions uncorrelated and the channel between the two decoders will seem to be memory less due to interleaving. There are two well-known soft-input / soft-output decoding methods, namely, MAP (Maximum A Posteriori) decoding algorithm and SOVA (Soft Output Viterbi Algorithm)

III. SIMULATION RESULTS

In this experiment the simulated results available. The plot is between BER with respect to SNR for different frame sizes. It shows that increase in the frame size for decoding iteration 8, BER is improved for higher SNR. Higher frame size and SNR gives better result i.e. reduced BER. Increase in the frame size results to increase in latency. Hence this type of reconfiguration may be suitable for delay insensitive applications e.g. data transfer.

The effect of puncturing on BER. It is obvious that code rate is increased by puncturing the encoder output. This way bandwidth requirement is reduced for transferring the same amount of information. But Puncturing results to the increased BER. Hence this type of reconfiguration may be suitable where bandwidth requirement is low and QoS is not that important e.g. video telephony. Figure-6 shows the result of BER with respect to SNR for different number of decoding iterations and fixed frame size. It shows that increase in decoding iterations results to higher decoding time and latency. By increasing the number of decoding iterations, BER is improved until threshold is reached. Figure-6 also shows that number of decoding iterations required is lesser for higher SNR till the threshold level. Table-1 shows the result of the simulation for AWGN (additive white Gaussian noise) channel.

In this simulation different frame sizes and different code rate are used. The table shows the performance of the turbo coded system with unpunctured code rate 1/3 and punctured code rate of ½ for constraint length 3 and decoding iteration 8. The result shows that an acceptable BER's (10^{-4}) can be obtained in AWGN channel by having the Eb/No (ratio of energy per bit to the noise power spectral) to approximately 1.5 dB with a code rate of 1/3 and. Similarly an acceptable BER's (10^{-4}) was obtained in AWGN channel with the code rate 1/2 and Eb/No=2.0 dB at frame size 1024 and can be further reduced by increasing frame size. The 4096 bit frame has a BER of order 10^{-5} and longer latency. Hence this is appropriate for playback of compressed video. Hence this is appropriate for data and file transfer. the turbo code for constraint length 3. This shows that turbo code can achieve different level of BER with the same network infrastructure.

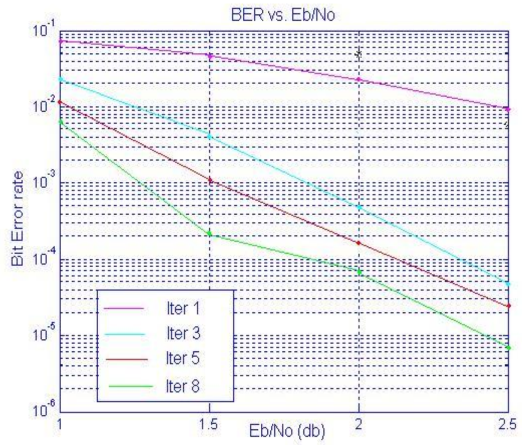

Fig.4 BER with number of iterations

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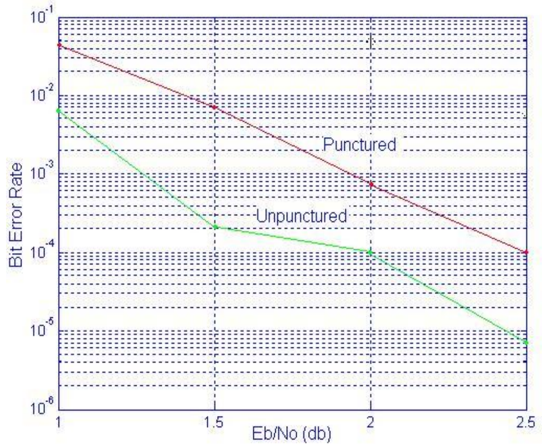

Fig. 5: Effect of puncturing on BER

Turbo code in terms of frame size, puncturing and decoding iterations. We find out that, the desired BER is achievable with reconfiguration of the turbo code. Hence depending on the BER, power, speed and other requirements, parameters of the turbo code can be reconfigured dynamically.

IV. ADVANTAGES OF FEC CODES OR TURBO CODES

As turbo codes are a very recent technique, the application fields are growing. Today, they are mainly used for spatial transmissions, like at the European Spatial Agency and at the NASA. There are also some considerations on it for the new mobile phone generation, called UMTS. Unlike QPSK, Turbo Code allows for two HDTV stream channels to be broadcast on a 27-MHz transponder. Furthermore, it increases the maximum number of standard TV channels from five to eight. If the system is used with the same data rate as QPSK with Viterbi-RS coding, the area size of its antenna may be reduced by 30%.

V. LIMITATION OF FORWARD ERROR CORRECTING CODES

Error correcting codes, sometimes referred to as forward error correcting (FEC) codes or channel codes, have become an invaluable tool in 'closing' the link budget of wireless-based digital communications systems. That is, by allowing a system to operate at a lower signal to noise ratio than would otherwise be the case, a desired quality of service over a link can be achieved within the transmit power or antenna gain constraints of the system. This property of error correcting codes is often referred to as 'power efficiency'. The channel encoder adds code bits to the transmission bit stream, based on the data bits at its input. These extra bits are used by the channel decoder at the receiver to correct errors introduced into the transmission stream by a noisy or fading channel.

VI. THE DISADVANTAGES OF ERROR CORRECTINGCODES ARE TWO-FOLD

Firstly, the injection of extra bits into the transmission stream has the effect that, if the original rate of transmission of 'useful' data bits is to remain the same, the symbol rate over the channel must be increased, thus increasing the bandwidth needed to transmit the signal.

VII. CONCLUSIONS

With performance results of the turbo code, we find that different BER can be achieved by reconfiguring the turbo code parameters. Hence dynamic turbo code reconfiguration based on the resource constraint in the communication network is an effective method.

For example if there is a power constraint then the turbo code can be reconfigured with help of more iteration, frame size, unpuncturing and other parameters to achieve the same BER. If the information is delay sensitive then turbo code may be configured with reduced frame size, higher code rate and lower iterations.

This way there are varieties of reconfigurations possible based on the available network infrastructure and Quos requirements. The result shows that turbo code can be reconfigured in terms of frame size and code rate based on the channel model and SNR to suit the BER and latency requirements for real time voice, real time video, playback of compressed video, data and file transfer applications.

In similar way turbo code parameters can be configured to suit the different QoS classes i.e. conversation class, streaming class, interactive class and background class. This way we find that turbo codes are very helpful in future generation mobile communication from the reconfigurability as well as QoS requirement aspect. The turbo code can be reconfigured with help of more iteration, frame size,

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unpuncturing and other parameters to achieve the same BER. If the information is delay sensitive then turbo code may be configured with reduced frame size, higher code rate and lower iterations. Turbo codes are more commonly used now a days due to its compatibility. Turbo Codes have been licensed on a worldwide basis to ST Microelectronics. The investigation of applications of turbo codes has produced new concept for spatial transmission with greater efficiency.

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