International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 9, Issue 1, January 2020 ISSN 2319 - 4847

Interleaver Scheme for Channel Coding Technique – A review

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Abstract

The Interleaver is an important component of concatenated coding scheme and has a strong impact on its error correcting performance. This Concatenated codes are error-correcting codes that are constructed from two or more simpler codes in order to achieve good performance with reasonable complexity. Originally introduced by Forney in 1965 to address a theoretical issue, they became widely used in space communications in the 1970s. Turbo codes and other modern capacity- approaching codes may be regarded as elaborations of this approach. Although there are several existing interleavers which meet some of these criteria, the interleaver design efficiency still can be improved.

1. INTRODUCTION

In recent years there has been an increasing trend towards personal computers and workstations becoming portable. Desire to maintain connectivity of these portable computers to the existing installation of Local Area Networks (LANs), Metropolitan Area Networks (MANs), and Wide Area Networks (WANs), in a manner analogous to present day computers, is fueling an already growing interest in wireless networks. Wireless networks will be needed to provide voice, video and data communication capability between mobile terminals and also to permit such terminals to have access to wire line networks. However, before wireless networks can be employed for packet voice, video, data, and other applications, it is important that appropriate communication protocols suited for the wireless environment are developed. Specific interest are “physical”, “link” and “network” layer protocols that take into account the characteristics of the underlying communication channel. Wireless channels provide error rates that are typically around 10^{-2}. Such high error rates result due to multipath fading which characterize mobile radio channels. However, many applications such as video and data transmissions require that the error rates be significantly smaller. In addition to the poor channel quality, the design of wireless communication systems is complicated by the rapidly changing quality of the radio channel.

2. DEADLINE DEPENDENT CODING

Within the context of a probabilistic view of real-time constraints, this digital communication problem also has an elegant probabilistic formulation due to Shannon. A fundamental result was formulated is known as Shannon's channel capacity. The channel capacity incorporates the effects of channel parameters such as thermal noise, constrained bandwidth, and limited signal power into one composite parameter. The channel capacity is a fundamental limit for the achievable data rate over channels described by these parameters. Considering a wireless radio channel in terms of these simple parameters, bandwidth is limited since the radio spectrum is a limited natural resource. The radio spectrum is assigned according to strictly enforced rules and thus, a fully utilized frequency band cannot easily be complemented by additional resources. Furthermore, wireless devices are often battery-driven and therefore the transmitted signal power should be limited to prolong battery life. The significance of channel capacity is that as long as the communication rate is kept below the channel capacity, an arbitrarily low error rate can in principle be obtained using infinitely long signals. In real-time communications however, we have a time-limited channel, implying that we cannot make the signals arbitrarily long. We also know that most codes are good provided they are sufficiently long. However, decoding complexity may prohibit the use of codes beyond a certain length. When a real-time communication system is used, we are not only concerned with decoding complexity but also transmission time.
The question is how well we can perform when complexity requirements in terms of time to decode and time to transmit have to be considered.

To increase the apparent quality of a communication channel there exist the following two distinct approaches:
 Forward Error Correction (FEC)
 FEC employs error correcting codes to combat bit errors (due to channel imperfections) by adding redundancy (henceforth parity bits) to information packets before they are transmitted. This redundancy is used by the receiver to detect and correct errors.
 Automatic Repeat Request (ARQ)
Where in only error detection capability is provided and no attempt to correct any packets received in error is made; instead it is requested that the packets received in error be retransmitted.
In order to overcome their individual drawbacks, the combination of these two basic classes of error control schemes, called hybrid ARQ schemes, have been developed. Specifically, this paper discusses the alternatives available for providing a reliable end-to-end communication channel in communication networks through the concept of Interleaver.

3. INTERLEAVER

An alternative to choosing long codes to combat the effect of burst errors is interleaving. Interleaving simply involves interleaving symbols from two or more code words before transmission on the channel. The number of code words that are interleaved is referred to as the depth of the Interleaver, m. Figure 1 shows an Interleaver with an interleaving depth of m and a codeword length of N. The data is written row-by-row into an m _ N matrix and read out column-by-column by the Interleaver before sending it over the channel. The reverse process is performed at the de-interleaver. Therefore, between successive symbols of any given codeword there are m − 1 symbols that belong to the m − 1 other code words being interleaved. If the Interleaver has sufficient depth the fading processes that affect successive symbols belonging to the same codeword will be uncorrelated.
Therefore, from the perspective of any single codeword, interleaving makes a burst error channel appear as one which has only random errors.
Note that interleaving does not decrease the long-term bit error rate but it is successful in decreasing the number of errors in each codeword, therefore the codeword should have enough capability to correct the erroneous symbols in it after de-interleaving.

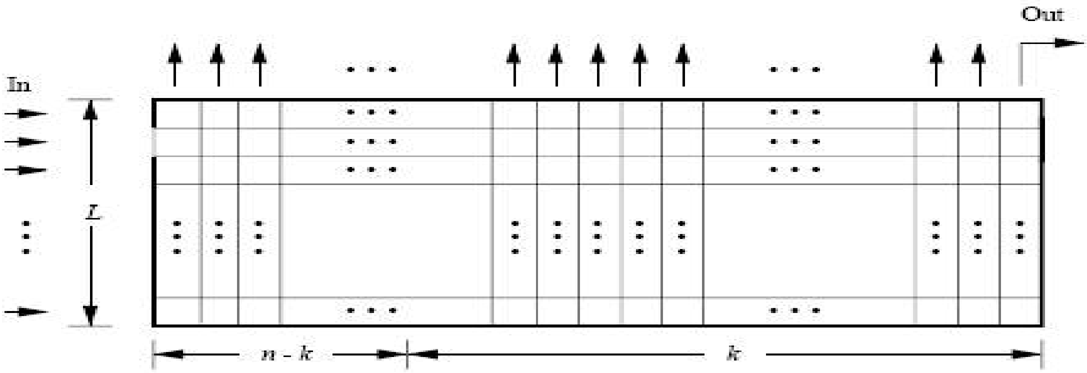

Figure 1 Interleaver

So the interleaver bursts to "spread out" the errors so that they appear random to the decoder. There are two types of Interleaver commonly in use today, Block interleaver and Convolutional Interleaver. Figure 1 illustrates the operation of a block Interleaver.
The block Interleaver is loaded row by row with L code words, each of length n bits. These L Code words are then transmitted column by column until the Interleaver is emptied. Then the Interleaver is loaded again and the cycle repeats. At the receiver, the code words are de-interleaved before they are decoded. A burst of length L bits or less will cause no more than 1 bit error in any one codeword. The random error decoder is much more likely to correct this single error than the entire burst.

Classification of Interleaver can be done as –
1. Series Interleaver
2. Parallel Interleaver

In this case however, an Interleaver, Π, is used as an integrated part of the code to create longer, more powerful codes. Previously, if an Interleaver was used it was mainly as a way of randomizing the errors from the inner decoder.
Figure 3 Parallel Interleaver Encoder structure for parallel concatenation. Π is an Interleaver.

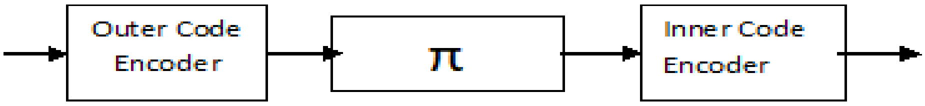

Figure 2 Series Interleaver

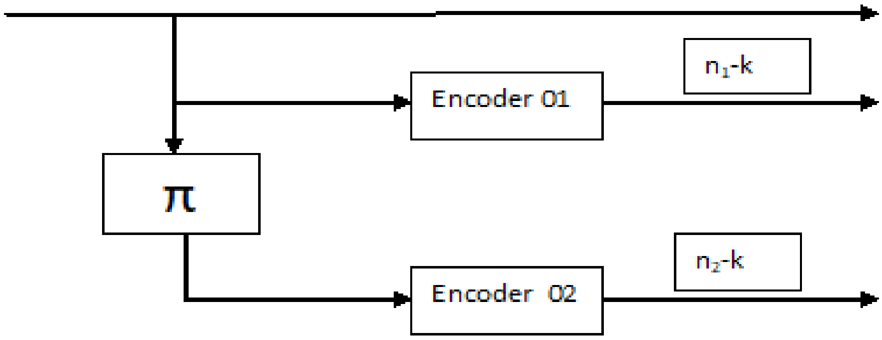

Figure 3 Parallel Interleaver

4. CONCATENATED CODING SCHEME

[1] The field of channel coding is concerned with sending a stream of data at as high a rate as possible over a given communications channel, and then decoding the original data reliably at the receiver, using encoding and decoding algorithms that are feasible to implement in a given technology. Shannon's channel coding theorem (Shannon, 1948) shows that over many common channels there exist channel coding schemes that are able to transmit data reliably at all rates less than a certain threshold called the channel capacity of the given channel. In fact, the probability of decoding error can be made to decrease exponentially as the block length of the coding scheme goes to infinity. However, the complexity of an optimum decoding scheme that simply computes the likelihood of every possible transmitted codeword increases exponentially with so such an optimum decoder rapidly becomes infeasible.

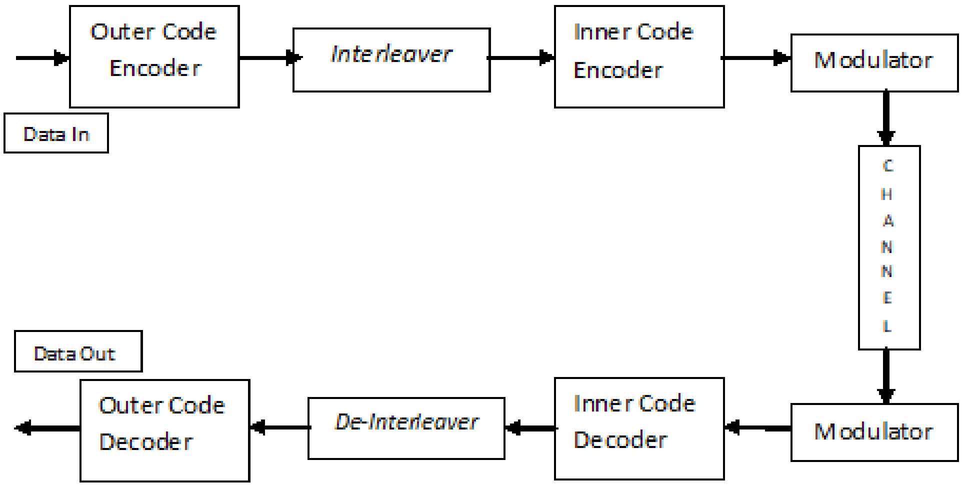

Figure 4 Concatenated coding scheme

The basic concatenated coding scheme considered by Forney is shown in Figure 4. The inner code is a short block code like that envisioned by Shannon, with rate close to block length and therefore code words. The inner decoder decodes optimally, so its complexity increases exponentially with for large enough to achieves a moderately low decoding error probability.

[2] The multiple access technology has progressed significantly during the past decade. The research of multiple access technology is concentrated on code division multiple access (CDMA). It has many advantages including diversity against fading and other-cell user interference problem. However, the performance of CDMA systems is limited by multiple access interference (MAI) and inter-symbol interference (ISI). A conventional random waveform CDMA (RW-CDMA) system involves separate coding and spreading operations. Thus the optimal multiple access channel (MAC) capacity cannot be achieved because the bandwidth is used for both coding and spreading. As a consequence, IDMA has been proposed which combing coding and spreading using low-rate codes [1- 5]. In this scheme, interleavers are employed to distinguish signals from different users. IDMA inherits the advantages of CDMA and maximizes the coding gain. Furthermore, it allows a very simple chip-by-chip iterative multi-user detection (MUD) strategy.

[3] In this paper, all input sequences may produce low-weight code words defined as Locally-bad are represented as “D-bad”. The effect of all Locally-bad are considered during mapping way selection. Considering the realistic problem of no effective algorithms to estimate the code words weight of common input sequences, an algorithm is proposed to estimate the parity weight low-bound of RSC at first. Based on this algorithm, the code words weight low-bound of Turbo codes is achieved. During mapping way selection, only the ways that can make the code words weight low-bound of Turbo codes satisfy the code words weight distribution condition will be judged as legal.

Compared with the traditional random interleaver or deterministic interleaver, code-matched interleaver designs always perform more excellent under the application of short frame turbo codes. To enhance the performance of short frame turbo codes, many code-matched interleaver designs have been proposed.

[4] Then interleaver is a key component of Turbo Codes (TCs). Its role is twofold. First, it has an important impact on the achievable minimum Hamming distance of the TC. Second, due to its scattering properties, it also acts on the correlation of exchanged extrinsic information during the iterative decoding process. In practical turbo coded systems, algebraic permutations are preferred to random-based permutations. In this case, permuted addresses can be computed via the application of a mathematical expression avoiding the use of storage elements or a look-up table. Therefore, they are easier to specify and implement the scheme.

5. CONCLUSIONS

Interleavers are the only means of user separation. Thus, the interleavers must be carefully designed. Good interleavers should meet three criteria including low memory requirement, easy generation and low correlation among interleavers. Although there are several existing interleavers which meet some of these criteria, the interleaver design efficiency still can be improved. The design of interleavers is one of the most core technologies for Concatenated Channel Coding systems because they are the only means of user separation. In channel coding systems that use randomly and independently generated interleavers is presented which provides good performance. For random interleavers, the entire interleaver matrix has to be transmitted to the receiver, which can be very costly. In order to minimize memory requirements and signaling overheads to store and exchange interleavers, alternate interleaver designs should be proposed.

References

[1.] Yan Di, “The Evaluation and Application of Forward Error Coding” 2011 International Conference on Computer Science and Network Technology.

[2.] HaiboPeng ; JianhuaJi ; Shouhao Wu, “A prime pair based interleaver design for IDMA systems” IET International Conference on Information Science and Control Engineering 2012 (ICISCE 2012).

[3.] Yu Dongfeng1 ,Zhang Wenqiang1, Lu Zhiling1, Xiao Yong1, “A Code-matched Interleaver Design based on the Parity-Check Weight Low-bound of Component Codes for Turbo Codes” 978-1-4244-7555-1/10/26.00©2010IEEE

[4.] Ching-Lung Chi,Chih-Hsiao Kuo, “Quadratic Permutation Polynomial Interleaver for LTE Turbo Coding” 978-1-4673-2588-2/12/31.00 ©2012 IEEE .

[5.] Ronald GarzónBohórquez, “On the Equivalence of Interleavers for Turbo Codes”, IEEE wireless communications letters, vol. 4, no. 1, february2015.