Digital information transfer systems an overview

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Abstract:- **Digital information transfer systems are used techniques based either on Automatic Repeat Request (ARQ) or Forward Error Correction (FEC) method. ARQ systems constitute a simple and efficient method for providing highly reliable transfer of messages from the source to the user over a variety of transmission channels. ARQ systems are therefore widely used in data communication systems that are highly sensitive to errors.**

Key words: **FEC, ARQ, HARQ .**

I. INTRODUCTION

Apart from high speed, the modern requirements to digital information transfer systems include high reliability of the information transferred. Reliability is of vital importance in the theory of encoding, particularly in terms of using codes capable of detecting and correcting errors which have occurred in the process of information transfer along the communication channel.

II. A CODE AND ENCODING

Nowadays the problem of enhancing information reliability is of particular relevance and its solution is accomplished by means of diverse methods and means. Theory of encoding is part of the engineering sciences and mathematics which study the reliability of data transfer as well as data storage. Encoding is a method for converting information by implementing an algorithm in such a way that it has nothing to do with the original and no one else can read it. In the theory of encoding attention is focused on finding optimal codes for a certain purpose. For fast information transfer codes of less length are required. For the transfer of a greater number of messages the required codes should have a greater number of words. The encoding algorithms should provide the opportunity for retrieving the initial information required. By implementing codes additional information is added to the initial data in such a way that the receiving party alone finds and corrects the likely errors.

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III. METHODS OF ERROR CONTROL

Several methods for control of the errors in data transfer systems are known.

Forward Error Correction (FEC)

The methods for channel coding are also called methods for error correction in forward direction FEC. All FEC methods are based on the principle of data encoding prior to their transfer by introducing a certain excess of information. Based on this excess the receiver, finding out this excessive information, manages to decode, and in many cases, to correct the errors introduced to the data during their transfer along the channel. The purpose of the channel coding is to process the information sequence in such a way, that the receiving part is capable of detecting the transfer errors and possibly of correcting some of them thus improving the quality of the received signal.[1]

The simplest FEC method is data retransmission upon error detection, which in turn unnecessarily prolongs the transfer time and therefore channel work load. Modern mobile radio networks use FEC methods based on the implementation of channel codes. The latter being capable of only detecting errors are referred to as detecting codes, whereas codes which can not only detect errors but also correct them are known as correcting codes.[1]

There are two basic groups of detecting and correcting codes – block codes and convolution codes.

- Block codes are FEC codes which provide the opportunity to detect and correct a limited number of errors without data retransmission. Special bits are introduced into them (called bits for odd-even check) to the blocks of data bits by means of which the so called code words, or code blocks, are created.[2]
- In the block encoder is done encoding *k* information bits into *n* code bits. Fig. 1.

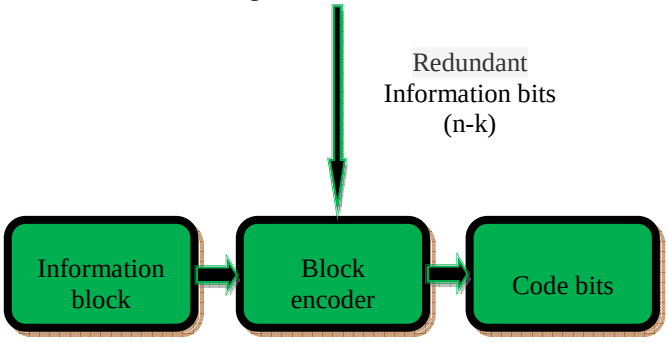

Fig.1 Block coding

➢ With convolution codes the information sequence is immediately converted coordinately into a certain code sequence without being divided into blocks or being encoded. The convolution encoder receives at its input *k* bits, the output is *n* bits, and the proportion *k/n* is called an encoding level. Convolution encoding is non-linear. Memory for data processing is required. Each output bit c_n depends not only on the input bit b_n, but also on several previous bits. The number of the input bits required for obtaining the encoded output is called code restriction. Encoding is accomplished by using the following equations (1,2):

$$c_{2k} = b_k \oplus b_{k-3} \oplus b_{k-4} \quad (1)$$

$$c_{2k+1} = b_k \oplus b_{k-1} \oplus b_{k-3} \oplus b_{k-4} \quad (2)$$

Where ⊕ is the sum module 2, k ∈{0, 1, 2, ……, 189} and b_k=0 for -∞ ≤κ <0.

By using a shifting register the scheme has the structure shown in fig. 2.

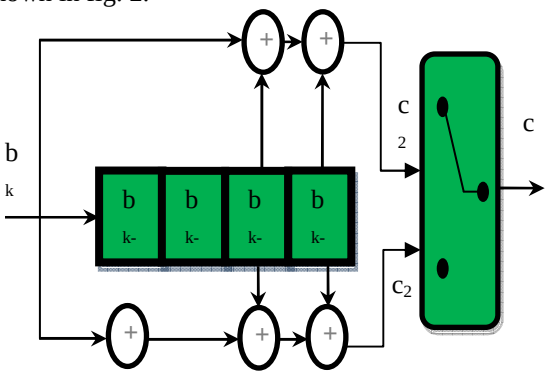

Fig 2. Scheme of coding

It is worth mentioning that the frequency of the output sequence is twice as high as that of the input. Convolution codes are used mainly in digital networks as part of the so called Concatenated Coding.

Channel coding introduces excess to the information transferred. Increase in the speed of transfer along the channel and consequent increase in the bandwidth are required.

Automatic Requirement Request (ARQ)

With errors present in the vector received, the functions of the receiver are connected with location and correction of the former. The improvement of the communication channel characteristics of FEC systems is achieved by means of additional information to the data transferred. The application of ARQ is connected with enhancement of the efficiency of permeability of the physical channels. The purpose is to decrease the losses from official information transfer.[3]

Hybrid Automatic Repeat Request (HARQ)

The combination of both FEC and ARQ techniques is known as Hybrid Automatic Repeat Request (HARQ) which is used in modern data communication systems. Depending on the conditions of operation there are three basic types of HARQ systems:

- "Stop and Wait"
- "Go back – N"
- "Selective Repeat"

"Stop and Wait" HARQ system

It is mandatory for this mode of operation that the system requires a positive acknowledge (ACK) or a negative acknowledge (NACK) when transmitting a block or a codeword. No word is transmitted unless the previous one is received correctly. In this case packet buffering is required.

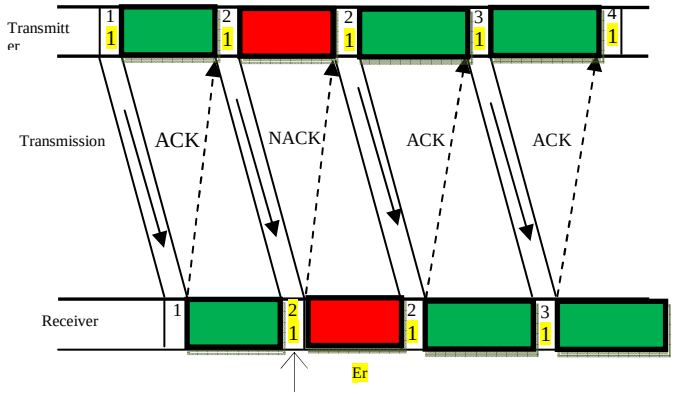

Fig.3 Stop and Wait scheme

"Go back – N" HARQ system

The system is connected with the buffering of more than one packet. In the cases of NACK reply all packets that follow are ignored. The process continues until a correct packet is received. Fig.4

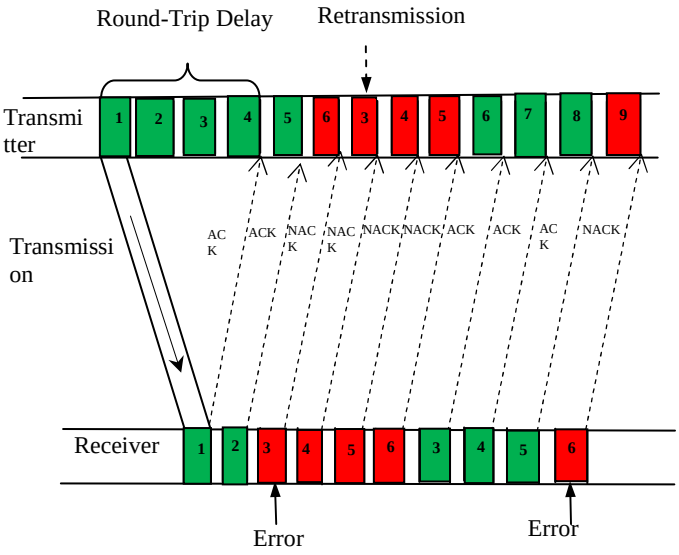

Fig.4 Go back –N scheme

"Selective Repeat" HARQ system

This system features transmission of the missing packets only. Fig. 5

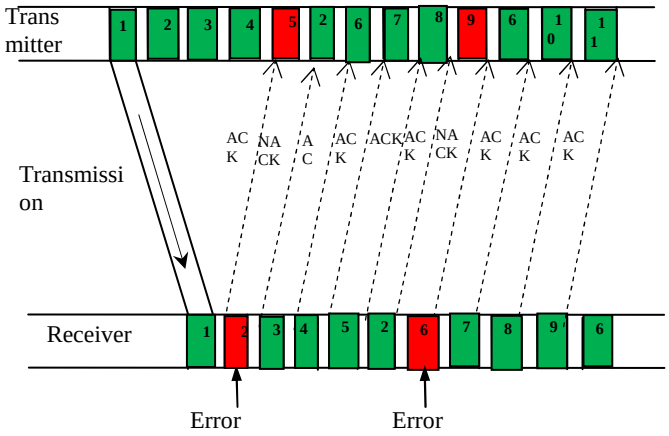

Fig. 5 Selective repeat scheme

To increase the efficacy and the efficiency of the system HARQ systems are used. They provide higher reliability in comparison with a FEC system and feature higher efficiency than an ARQ one.

IV. Conclusion

A great part of the theory of binary codes is based on the assumption that each of the symbols is distorted by the noise independently and therefore the errors of a particular combination depend on the number of errors in the latter. There is a certain limit for the efficiency of the systems in which only error detection is used. However, in practice, there are always accidental errors. The purpose of the codes is to make errors detectable and to correct them if possible.

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