Hybrid Automatic Repeat Request (HARQ) Overview

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Abstract:- **This article mainly investigates the combining schemes for hybrid automatic retransmission request (HARQ) protocols in communication systems. Based on of HARQ combining, we classify the HARQ combining schemes into three types. We are discussed advantages and disadvantages of HARQ systems.**

Key words: **ARQ, HARQ I, HARQ II, HARQ III, RB-HARQ.**

I. INTRODUCTION:

The combination between ARQ and FEC schemes is known as a hybrid automatic repeat request (HARQ).

HARQ systems are used to enhance system efficacy and efficiency and are employed in modern data communication systems.

In FEC schemes, by means of the attempts to correct, the behavior of the corrected word is evaluated and if the code word is found valid, then it is assumed as such. If errors have been found in the corrected word, then most likely there has been a greater number of errors in it than a FEC is capable of correcting. ARQ is used for verification of retransmission. HARQ systems provide higher reliability than FEC systems and feature higher efficiency than ARQ systems [1]. Depending on the schematic realization, the following types of HARQ systems are available – HARQ Type I, HARQ Type II, HARQ Type III and RBHARQ.

II. TYPE I HARQ SYSTEM

Fig. 1 shows Type I HARQ system. It is used for simultaneous error detection and correction [2, 3].

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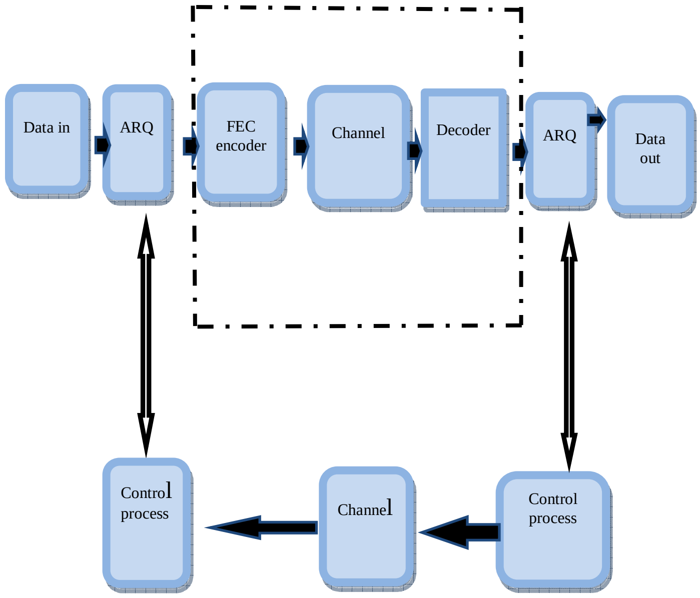

Fig. 1 Block scheme Type I HARQ system.

A code is used for error detection and a different one for correction. When receiving a packet containing errors, the receiver first tries to correct them. If correction is unsuccessful, the packet is rejected and a retransmission is required. The code speed of this system is fixed. This shortcoming may be overcome by optimizing channel conditions.

Type I HARQ is appropriate for systems with constant noise level and with interferences present in the channel.

Advantages:

- Type I HARQ provides higher throughput than an ARQ scheme.

Disadvantages:

- With noise in the channel the correcting ability of the code may appear to be insufficient.
- The number of retransmissions increases but the HARQ system throughput decreases.

III. TYPE II HARQ SYSTEM

Fig. 2 illustrates a scheme of Type II HARQ system. In this case a buffer with memory is required. Two basic systems of Type II are known [3,4]:

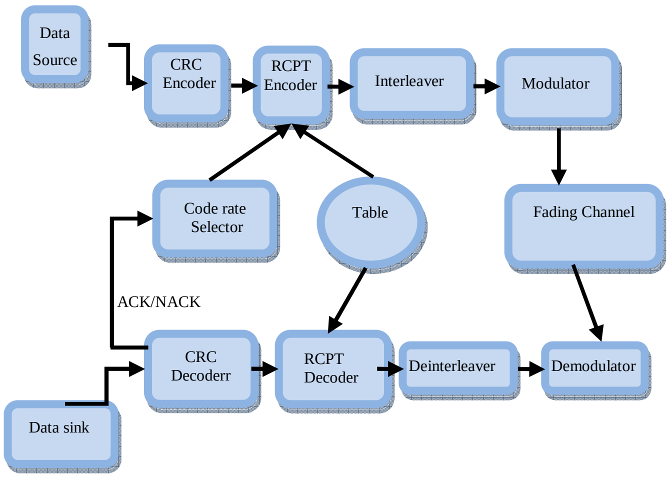

Fig. 2 Block scheme Type II HARQ system.

- Chase combining
- A system with excess adding

The main idea of the Chase combining is in sending numbers of a certain packet with the quotations in each packet of encoded data. It is possible for the decoder to accomplish decoding by measuring the signal/noise proportion from a previous decoding.

Type II HARQ system with excess adding is characterized by the following:
If there is an error, the word received is stored in a buffer and NACK is sent to the transmitter. The latter sends a block of bits for initial message verification and makes an attempt for error correction.

Advantages:
- The system adapts itself to the channel characteristics so that jamming can be overcome.
- At high speed, the system with excess adding is better than the one with Chase.

It enhances permeability in comparison with Type I.

Disadvantages:
- The amount of information increases due to the added code symbols sent along with the packet.
- The format retransmission depends on the applied strategy and on the error recovery code.
- A buffer with greater memory is required resulting in increase in the price of the system.
- Greater complexity of decoding in comparison with Type I HARQ.

IV. Type III HARQ system

Fig. 3 shows a scheme of a Type III HARQ system. It is based on independent decoding. The system is of adaptable structure and determines the amount of the additional information. Under good channel conditions FEC code is used [6].

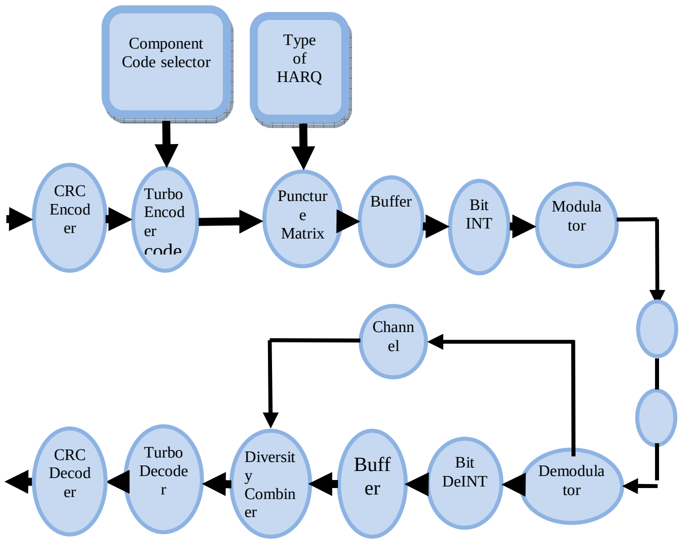

Fig. 3 Block scheme Type III HARQ system.

According to the type of excess these schemes are divided into two groups:
- with one variant of excess;
- with several variants of excess.

Advantages:

- In comparison with Type I permeability is improved;
- In comparison with Type II efficiency is enhanced [7];
- Type III HARQ system is of adaptable structure, i.e. the number of abbreviations is decreased to the minimum.

Disadvantages:
- with noisy channels the amount of excess information increases;
- complex algorithms for encoding and decoding are applied;
- under good channel conditions Type III HARQ system has got lower permeability in comparison with Type II HARQ system.

V. Reliability Based Hybrid ARQ (RBHARQ)

With the RBHARQ, bits are retranslated arbitrary to the receiver by using the calculated bit of reliability [7].

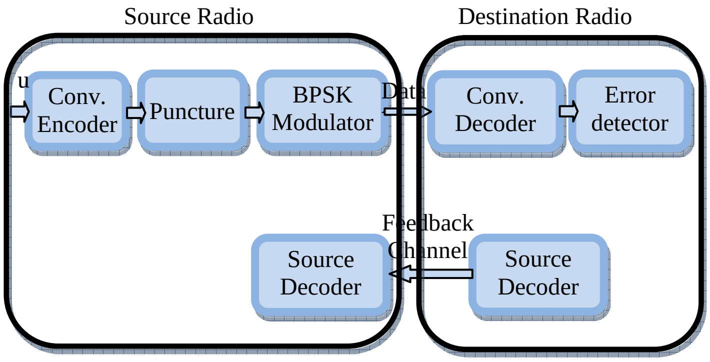

Fig. 4 Block scheme RBHARQ system.

One of the possible algorithms is the MAP algorithm [8] where for each bit of information the logarithm of a posteriori probability is calculated by formula (1) in which y is the received code word with noise [6].

$$L(u_k) = \log\left(\frac{P(u_k = +1 \mid y)}{P(u_k = -1 \mid y)}\right), \qquad (1)$$

There are three techniques for reliability assessment [8,9]:

- logarithmic likelihood ratio;
- determination of erroneous bit probability;
- error assessment by using reliable information.

Advantages

- The employment of reliable information enhances network permeability;
- Network general usefulness for choosing functions is increased.

Disadvantages:

- This type of systems requires greater memory necessary to support the combining of the transferred packets
- Under bad channel conditions and with the use of convolution codes the time for analysis increases [7].

VI. CONCLUSION

With digital signal receiving and decoding it is possible that an error in certain bits or groups of bits may occur. Each error distorts the message; thus the greater the number of errors, the more unusable the received information becomes.

Error likelihood increases with the decrease of the signal/ noise proportion at the input of the input device. There are many factors leading to errors in digital signal decoding. To decrease the possibility of errors in the digital signal, protection against errors is applied by using certain algorithms. The protection against errors is realized by forming a digital flow by the multiplexer. So far various solutions to this problem have been suggested but with the advances of computer technologies this issue is becoming more and more serious.

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