A New Selective Retransmitted ARQ System

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Abstract: In this paper, a partly repeated ARQ error control system of combining continuous transmission pattern with SW ARQ pattern is considered. The system transmits data by means of a half—duplex channel. It can save frequency—band or a channel comparing with GBN ARQ strategy, while its throughput is much higher than that of SW ARQ strategy and approximates to a throughput of GBN ARQ strategy. Analysis in this paper will show that the system has excellent performance and practical values.

Keyword: Throughput, SW—ARQ, GBN—ARQ, the Probability of bit error, Half—duplex channel, Error control.

1. Introduction

ARQ error control system is an effective form for retransmission error control in the data communication. It has three basic types and many other varieties. The stop—and—wait (SW ARQ) use a half duplex channel and can be easily realized. But when the loop delay becomes longer, the system throughput will quickly decrease. Both the Go—Back—N ARQ(GBN ARQ) and the selective retransmission ARQ increase the throughput by means of continuous transmission. However, they need a full duplex channel and they are more difficult to be realized. Considering the above problems, we will present a new ARQ system which uses an half duplex channel. Through analysing the non — error perid (non—error sequence) of information and its distribution, this system operates by alternating between the continuous transmission and the SW — ARQ. The continuous transmission will increase the system throughput while the SW ARQ will make the data transmission be highly accurate. Because of using the half duplex channel, this system can save the band source of the communication system. For the existing fixed band system, using this system can increase the band width of information which is transmitted forward, increase the transmission speed, and can improve the communication capacity of the whole system.

2. The system structure.

Fig. 1 shows the operation processes of the partly selected retransmission ARQ system presented in this paper. This system uses an half duplex channel, and transmits the information words by alternating between the continuous transmission and the SW—ARQ, Different from the traditional ARQ, the receiver needn't transmit an ACK or NAK answer back to the sender for every received word. The receiver just transmitsthe code number to the sender for the code tested to be wrong. When a group of continuous transmitted codes are all received through request transmission, the receiver will send an answer CACK which means that this group has been totally received.

In the system design, two problems must be solved. One is how to divide and number the code groups. Before the sender begining to transmit, the codes are devided into several certain length groups (assuming the length be M, here). Each code in the groups is numbered form 1 to M. When the sender send the codes to the receiver, it need not send the number. Both the receiver and the sender determine the number by the sequence postition of sending and receiving. The other one is that both the sender and receiver need a data buffer to store M code words and the receiver need a buffer to store the number of the error codes to make the system work normally.

Now, in the following, we discuss how to determine the code length M.

In the communication system, error sequences are caused by random factors. It is a random sequence or a random process, which obeys a certain distribution rule. So based on the analysis on non—error period (non—error sequence) and its distribution, the length of the continuous transmission group in the sender can be chosen to make the whole system more effective and reasonable.

Provided that the input sequence in the code channel is $C=(c_0,\ c_1\ \cdots)\ c_i \in GF(q)$. In a binary system, $q=2$, $C_i \in GF(2)$, C is a sequence made up of symbol 0 and 1. let $R=(r_0,\ r_1\ \cdots)$ be the output sequence of the channel, $r_i \in GF(2)$. Because there are interference in the channel, C is not equal to R. their relationship are:

$$R=C+E+(c_0+e_0,\ c_1+e_1\ \cdots)$$
$$E=R-C=(e_0,\ e_1\ \cdots)$$

E is the difference set between input sequence and output sequence. It is obviously a random sequence and totally determined by the interference in the channel. Here, we call it the error sequence of the code channel. The symbol "0" in E means the code on this position is right, "1" means that is wrong.

Definition: In error sequence E, if the number of non — error code bits (0) between two neighhouring error code bits (1) is K—1, then this non—error code bits sequence is called a non — error period or non — error sequence whose length is K, simplified as K period.

let G_K show the K period. then probability of G_K occured is:

$$P(G_K)=P(0^{K-1}1\ /\ 1)$$

obviously, $\sum_{K=1}^{\infty} P(G_K)=\sum_{K=1}^{\infty} P(0^{K-1}1\ /\ 1)=1$

If the mathematical expectation of period length (average value) E(K) exists, then

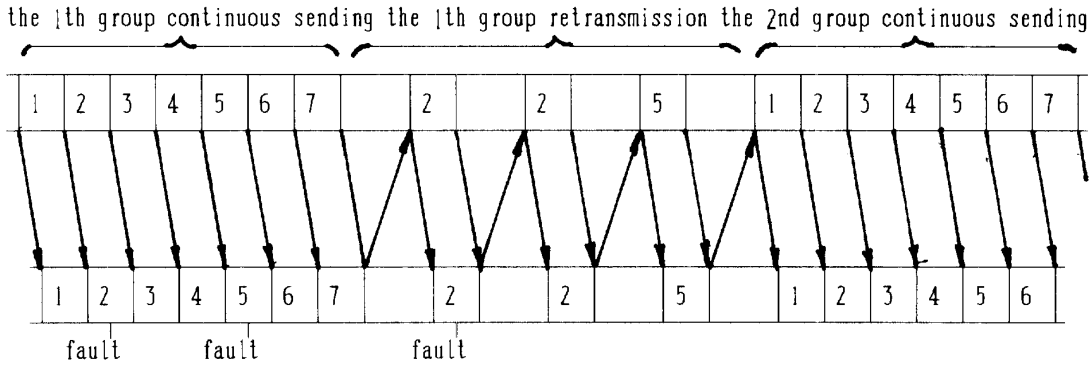

Fig.1 The sketch map of operation process

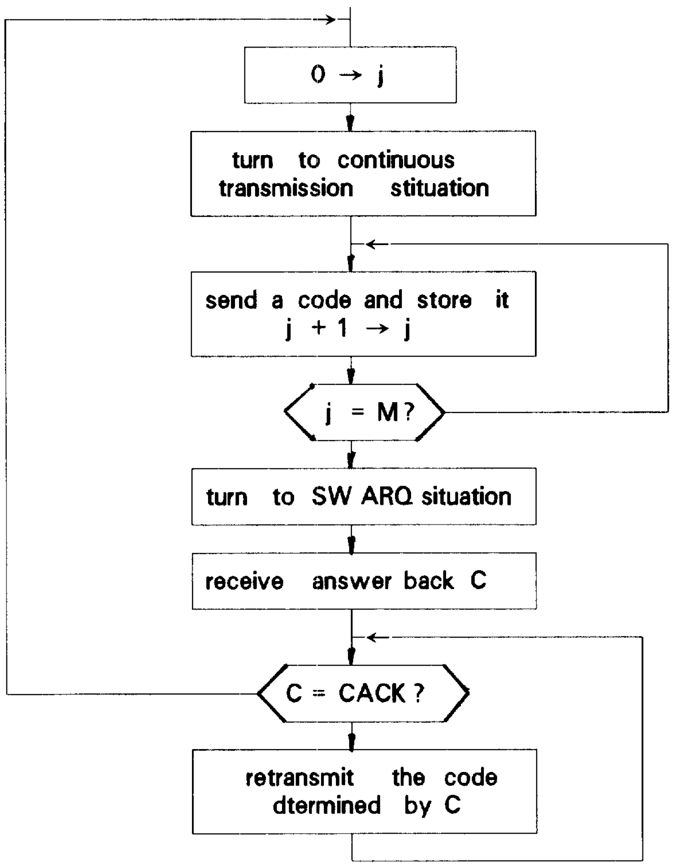

Fig.2 The operation frame of sender

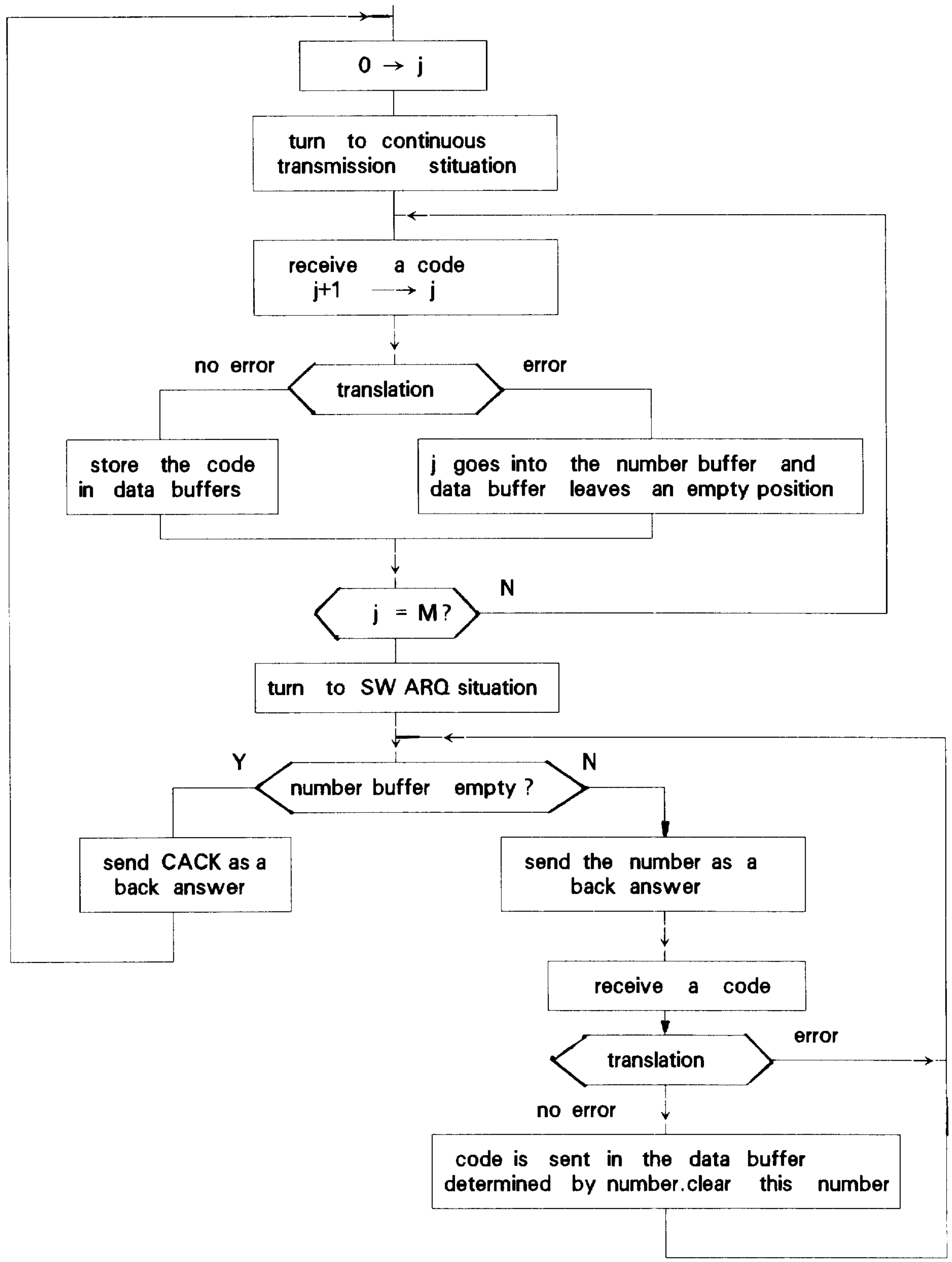

Fig.3 The operation frame of receiver

$$E\{K\}=\sum_{j=1}^{\infty}(j+1)P(0^{j}\quad 1/1)$$

In the above formula, P(i/j) means the conditional probability of j which occurs after i.

If the length N of the error sequence E is too long, then we can get the average length of the period according to the following formula:

$$E\{K\}=\sum_{K=0}^{\infty}(K+1)\times\frac{\text{the number of periods whose length equals to }(K+1)}{\text{the total period numbers}}$$

Because the period numbers are equal to the numbers of symbol "1" in the sequence, so we can rewrite the above formula as:

$$E\{K\}=\frac{\sum_{K=0}^{\infty}(K+1)\times\text{ the number of periods whose length equals to }(K+1)}{\frac{\text{the number of symbol 1 in the sequence}}{N}\times N}$$

The sum of the numerator in the above formula equals N, so

$$E\{K\}=\frac{1}{\frac{\text{the number of symbol 1 in the sequence}}{N}}=\frac{1}{p}$$

Here p is the probability of the bit error in the channel. This means that the average length of non—error period is equal to the reversion of the probability of the bit error. This can be easily understand from the angle of physics.

In our ARQ system, we take the average length of the non— error sequence to be the continuous transmission length. This makes the codes continuously pass in a non—error period. Therefore it can increase the communication efficiency.

In the following, we will describe the system operation process in detail.

(1). The continuous transmission code situation.

When the system begins to operate, it is in the continuous transmission situation. To the sender, data form the information resource are transmitted to the receiver after the channel coder outputs the anti — interference codes. At the same time, this code is also transimitted to be stored in the data buffer so as to appropriately retransimit the error code according to the answer from the receiver. The above process is repeated until all M codes have been sent. After that the sender will turn to the SW ARQ situation. To the receiver, codes from the channel are translated by channel translator. If there are no error, the codes are sent to be stored in the data buffer. If there are errors, then the number of this code (determined by the receiving sequence) are transmitted to the number buffer. In the meantime, the system leaves a position in the data buffer which it should occupy to store the error code. The process of receiving the codes in the receiver is continuous. When the receiver receives all M codes, it also turns to the SW ARQ.

(2). The SW ARQ situation.

In this situation, the receiver operation depends on whether or not the number buffer has the number. If there are numbers in it, the first of them will be sent back to the sender. After receiving this code, the sender will search the error code which the number designates in the data buffer and retransmites the original code again. In the receiver, it receives this code and translates it. If there is an error, it will requst the sender to retransimt again. Otherwise, this code will be sent to the proper position designated by the number. All the above process will be continued untill the total error in the M continuous transmission codes have been corrected. When the number buffer becomes empty, the receiver will send an answer CACK back to tell the sender that the whole M codes have been sucessfully received and then turns to the continuous transmission situation. When the sender receives the CACK answer, it also turn to the continuous transmission situation.

The system repeats the above process untill the total codes which need to be transmitted have been sucessfully transmitted. The diagram of the above process is shown in Fig. 2 and Fig. 3. All these can be realized either by a hardware alone or can also be realized by a combination of hardware and software.

3. Analysis of the throughput.

The througput is an important item to describe the feature of the feedbake error control system. It is defined as the proportion of the average information number which the receiver translator receives and sends to the user, to the average number of data sent by the sender per unit time. In the following, we will discuss the throughput of our system and compare it to that of the SW ARQ system.

At first, we will seek out the average sending times of M codes in a continuous transmission group. We assume that n is the code length, K is the information bits length, R is the transmission speed and T is the loop delay time in the SW ARQ situation.

If we suppose that the probability of bit error is p, then the probability of the receiver recevies correctly P_c is:

$$P_c=(1-p)^n$$

The probability of the code error occuring is:

$$P_B=1-P_c=1-(1-p)^n$$

So the average transmission time N is:

$$N=M+MP_B+MP_B^2+\cdots\cdots$$

$$=M\times\sum_{i=1}^{\infty}P_B^i=\frac{M}{1-P_B}$$

During the N times transmission of M codes, there are M time in the continuous transmission situation, N−M times in the SW ARQ situation. Therefore, the time spent on the N times transmission can be converted to bit quantities: $N\times n+(N-M+1)\times R\times T$, where the transmitted information bits are $M\times K$. So the system throughput is:

$$\eta=\frac{MK}{N\times n+(N-M+1)\times RT}$$

According to the previous analysis, M is taken to be the average non—error period length. As the information are transmitted with bytes, so the value of M is 1/8p. Then the above equation can be written as:

$$\eta=\frac{K\times(1-p)^n}{n+RT[1-(1-p)^n(1-8p)]}$$

As we have known, the throughput of SW ARQ is:

$$\eta_{SW}=\frac{K\times(1-p)^n}{n+RT}$$

Because $p\ll 1$, we can see easily that the throughput of our system is more higher than that of SW ARQ.

4. Conclusion.

In the communication system, the design of the transmission protocol shoud be considered either the realization cost of the device, or the accuracy and the efficiency of the transmission. Through reforming the traditional ARQ system, and based on the analysis on the non — error period of the information and its distribution, the system presented in this paper operates by alternating between the continuous transmission and the SW ARQ. The analysis show that this system is realized easily, but throughput is more higher than that of the SW ARQ. It has a nice function and practical values.

Reference

[1] Towsley D. ,The Stutter Go—Back—N ARQ Protocol, IEEE COM. 1979; 27,PP. 869—875.

[2] Wang Yuming, A Modified Selective Repeat Type — II Hybrid ARQ Systemand Its Performance, IEEE COM. 1983;31,pp. 593—607.

[3] E. J. Weldon, An Improved Selective — repeat ARQ Strategy, IEEE Ttrans. Commun. ,1982,30,pp. 480—486.

[4] M. J.. Miiller and S.. Lin, The Analysis of Some Selective—repeat ARQSchemes with Finite Receiver Buffer, IEEE Trans. Commun. , 1981, 29, pp. 1307—1315.

[5] G. fayolle, E. Gelenbe, An Analytic Evaluation of the 'Send and Wait' Protocol, IEEE Trans. Commun. , 1978,26,pp. 313—319.