Forward Error Correction for the Ground Communications Facility?

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Using the recently developed five-state Markov model for the GCF, we have calculated the tradeoffs between block error correction efficiency and block overhead for several forward error correction schemes. The results indicate that this particular kind of error control is not suitable for the GCF.

I. Introduction

It has been determined by both DSN and flight project studies that the errors made in transferring deep space telemetry from the various tracking stations to the Network Operations Control Center (NOCC) are frequently more serious to flight project data systems than the errors caused by the space channel itself. Since at present Ground Communications Facility (GCF) errors must be corrected by later retransmission, any reduction in these errors will result in improved real-time deep space telemetry.

One method of error control which has found wide application in other situations is *block coding*. In a block coding scheme certain parity-checks are added to the source data prior to transmission. If the transmission channel causes some of the data to be received in error, the pattern of parity-check failures can be used to correct the errors, provided the noise is not too severe. There is a large amount of literature dealing with the selection of the appropriate parity checks and error-correction algorithms which can be drawn upon. We now describe one possible application to the GCF.

Let us suppose that a certain fraction α, $0 < \alpha < 1$, of the 1200-bit NASA Communications (NASCOM) data block is available for parity-check information. At present the 33 error-detecting parity checks represent $\alpha = 0.03$. In general α should be kept as small as possible and in any case could never exceed 0.2. In the next section we shall study the tradeoff between α and block error probability for two classes of block codes.

II. Block Coding Study

It is well known that the bit errors in the GCF are not independent but tend to occur in bursts. Thus the block coding techniques we studied were designed to cope with bursts of errors. We first describe the burst error correcting codes. In general, these codes are designed to correct any burst of length $\leq b$ in a block of n bits. (The errors occurring in a block are said to occupy a burst of length b

if the distance between the first and last bits in error is b). For our application, $n = 1200$, and the value of b is determined by the fraction α of the 1200 bits which are parity checks. The smallest possible α for a given value of $\beta = b/1200$ was obtained from Table 11.6 of Ref. 1:

Using Table 1 we simulated the performance of burst error correcting codes for the GCF, using Adeyemi's model (Ref. 2) for generating error events. We obtained the following graphical tradeoff between α, the fraction of the GCF block used for error correction, and γ, the fraction of GCF blocks received in error which could be corrected (see Fig. 1).

The designations "green," "amber," and "red" refer to the classification made by McClure (Ref. 3) of the GCF transmission quality, green being the best state and red the worst. It is seen that when the channel is in its red condition, even 20% redundancy would allow the correction of only 35% of the blocks received in error.

The second type of block coding employed was *symbol* error correcting, whereby the 1200-bit block was divided into n s-bit symbols, where $1200 = ns$. The code employed could then correct a certain number of symbol errors. The best choice of s turned out to be $s = 8$, so $n = 150$. The relation between α, the redundant fraction, and β, the fraction of the 150 symbols which could be corrected, using a Reed-Solomon code, is given in Table 2.

Again using Adeyemi's model we obtained the graph shown in Fig. 2.

It is seen from Figs. 1 and 2 that symbol error correcting codes give performance superior to burst-error correcting codes, but the improvement is not dramatic. We conclude that block error correction in 1200-bit blocks is not appropriate for the GCF. However, it is possible that encoding in blocks (much) longer than 1200 bits could be more attractive. We hope to devote a future article to that subject.

References

1. Lucky, R. W., et al., *Principles of Data Communication*, McGraw-Hill, New York, 1968.
2. Adeyemi, O. H., *Error Control on the GCF: An Information-Theoretic Model for Error Analysis and Coding*, Technical Memorandum 33-699, Jet Propulsion Laboratory, Pasadena, Calif. (in press).
3. McClure, J. P., "4800-bps High Speed Data Error Statistics," Interoffice Memorandom, Jet Propulsion Laboratory, Pasadena, Calif., Jan. 5, 1973 (an internal document).

Table 1. Tradeoff between α and β for burst error correcting codes

α	β
0.01	0.004
0.02	0.008
0.04	0.017
0.07	0.025
0.08	0.035
0.09	0.038
0.12	0.047
0.13	0.048
0.15	0.068
0.19	0.090

Table 2. Tradeoff between α and β for symbol error correcting codes

α	β
0.05	0.027
0.10	0.05
0.15	0.073
0.20	0.10

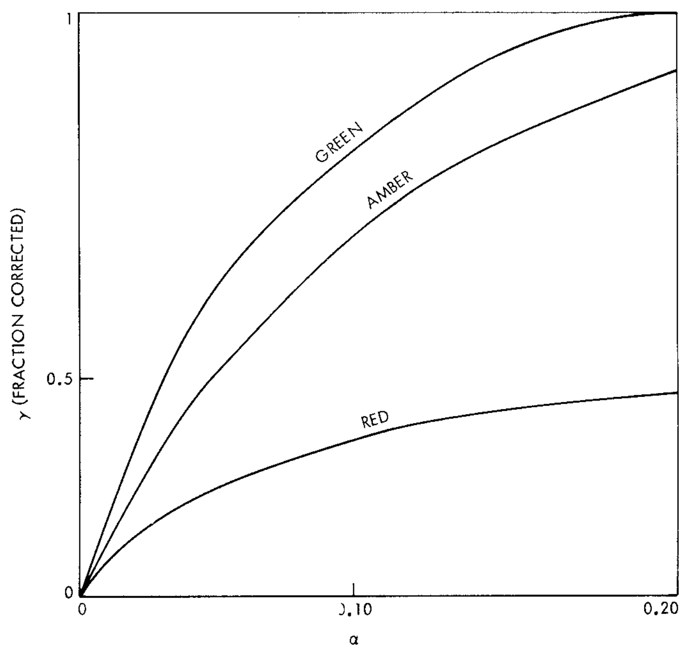

Fig. 1. Relation of α and γ for burst error correcting codes

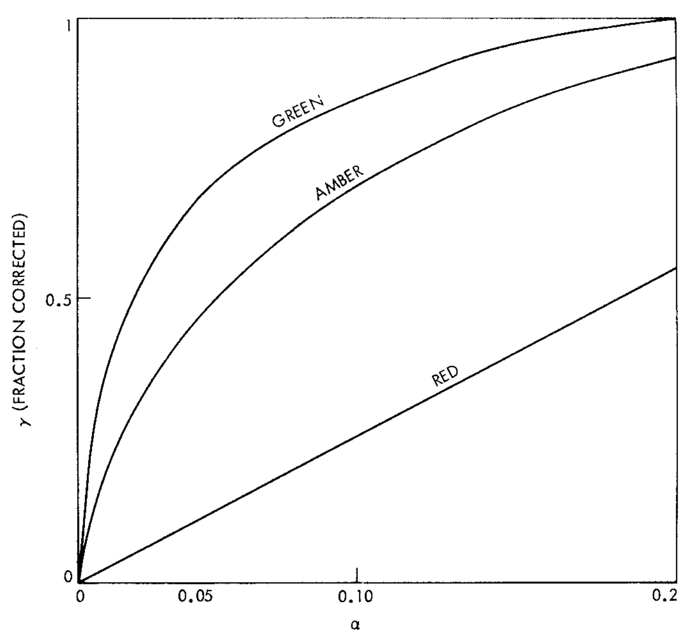

Fig. 2. Relation of α and γ for symbol error correcting codes