RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #3

ACTION ITEM 2-10

Clarification of Conservative Error Correction

Vincent Orlando

SUMMARY

At the Melbourne meeting, a question was raised on how to implement the conservative error correction technique. The specific issue was whether the process could stop when a correctable pattern was found, or must the processes continue to determine if the correctable pattern was unique.

The answer to the question is that there is at most one correctable error correction pattern possible with the conservative error technique. Therefore the process can stop if this unique solution is found.

This working paper provides a brief overview of conservative error correction in order to support the above conclusion.

1.0 Introduction

At the Melbourne meeting, Ian Levitt raised a question on how to implement the conservative error correction technique. The specific issue was whether the process could stop when a correctable pattern was found, or must the processes continue to determine if the correctable pattern was unique.

The answer to the question is that there is at most one correctable error correction pattern possible with the conservative error technique. Therefore the process can stop if this unique solution is found. I have talked to Ian and he agrees with this conclusion. He recommends that a more detailed definition of this technique be included in the MOPS.

This working paper provides a brief overview of conservative error correction in order to support the above conclusion.

2.0 Mode S Error Correction

2.1 Overview

A Mode S 1090 MHz transmission is equipped with an error detection/error correction code technique based on the use of a cyclical polynomial technique.

The sender of a transmission executes the polynomial technique to generate a parity field that is the last 24-bits of the transmission (the PI field). The message receiver executes a complementary polynomial decoding process.

If the message is received error free, the result of the decoding process will be a field of all zeros in the last 24 bits (referred to as the error syndrome). If the error syndrome is non-zero, it indicates that one or more bit errors exist in the decoded message.

2.2 Message Reception

When the message is being received, the processor declares a value (one or zero) for each of the message bits. In addition, the processor makes an estimate (high or low) on the declared bit.

The principal basis for declaring bit confidence makes use of the 1090 encoding technique known as pulse position modulation (PPM). Each one-microsecond bit position can have a chip in the leading half of the bit (a one) or in the trailing half (a zero).

In the absence of interference there should be received energy in only one of the chip positions. Significant energy in both chips (in addition to other considerations) will lead to the declaration of low confidence for that bit.

Bit confidence is very important to error correction since it identifies which of the received bits may be subject to modification to achieve error correction.

2.3 The Sliding Window Technique

The form of error correction in use by ground stations and some TCAS units is known as the "sliding window" technique. Using this technique, a 24-bit widow is defined for the last 24 message bits. If the error syndrome is non zero, each bit in the syndrome relates to the corresponding bit in the window.

In order to achieve a successful error correction, each message bit in the window corresponding to a one in the error syndrome must have its value complemented (i.e., a one is changed to a zero and a zero is changed to a one). This complementing can only be done if each of the bits is declared to be low confidence. If so, each of the bits is complemented and the message is declared to be error corrected. If not, the window is shifted one bit, a transformed syndrome is computed and the process repeats. The process ends when a correctable error pattern has been found, or the sliding window reaches the beginning of the message.

In order to control undetected errors, correction is not attempted if there are more than 12 low confidence bits in the window.

2.4 The Conservative Technique

The sliding window technique is suitable for the low fruit environments of a rotating beam antenna (long range, narrow beam) or a TCAS (omni directional, short range). However, the fruit environment for the long-range air-air application (which uses omni-directional antennas) is very severe and it is not appropriate to use the sliding window technique due to undetected error considerations.

For the very severe fruit environment, a simpler approach, know as the conservative technique is used. Using this technique, error correction is only attempted if the low confidence bits are all within a 24-bit window, and there are no more than 12 low confidence bits. This is a conservative approach in that the conditions for attempting error correction are much more restrictive than with sliding window.

If these conditions are met, the error syndrome is generated for the window position and (as above) a check is made to see if the ones in the error syndrome correspond to low confidence bits in the window. If so, error correction is accomplished, if not the process is terminated.

Note that if the low confidence spans less than 24-bits, more than one window could be defined to span them. This will not effect the error correction action, since regardless of the 24-bit window selected to span the low confidence bits, the ones in the error syndrome will identify the same message bits. That is, if the window is moved one bit, the error syndrome will shift by one bit.

3.0 Unique Solution for the Conservative Technique

Note that in the above description, there is only one possible successful error correction possibility. Regardless of the specific 24-bit window position, the same message bits are identified. All of the bits corresponding to a one in the error syndrome must be complemented. This can only happen if they are all low confidence.

There is at most, one correctable error pattern that can be achieved with the conservative error correction technique.