ERROR CONTROL FOR DIGITAL SATELLITE

Dr. Marwah Ahmed

Networks and Communication Department
Outlines

- Satellite signal coding
- Error Control for digital satellite
- Error Control Coding
- Implementation of Error Detection on Satellite Links
Signal Coding

- In the popular since, coding is used to describe the rearrangement of information to prevent unauthorized use. This process is known technically as encryption. It is widely used on both analog and digital signals that are sent by cable and radio links.

- Coding is also a name applied to many processes that change data from one form to another. For example, pulse code modulation (PCM) change analog data into binary words for transmission over a digital link.

- Throughout this chapter we shall use the term coding to refer to error detection or error correction. This implies that additional (redundant) bits are added to the data stream to form an error-detecting or error-correcting code.
The transmission of information over a satellite communication system always results in some degradation in the quality of the information.

In digital links we measure degradation of the information content of a signal in terms of bit error rate (BER). By using phase shift keying, usually coherent QPSK, we can trade bandwidth for signal power and achieve good BER with low C/N.

A fundamental difference between analog and digital signals is that we can improve the quality of a digital signal by the use of error correction techniques.
In a digital system, we can add extra redundant bits to our data stream, which can tell us when an error occurs in the data and can also point to the particular bit or bits that have been corrupted.

Systems that can only detect errors use error detection. Systems which have only error detection must make a decision about what action to take when an error is detected.
- Ignore the error,
- Flag the error,
- Send a block of information again,
- Estimate the error and replace the corrupted data.

Systems that can detect correct errors use forward error correction (FEC).
Collectively, these techniques are known as error control. Error control may be implemented at the earth station as a permanent part of the satellite communication link, or it may be applied by the end user.

In practice, there is a trade-off between the number of redundant bits added to the information data bits and the rate at which information is sent over the link.

The efficiency of a coding scheme is a measure of the number of redundant bits that must be added to detect or correct a given number of errors.
In some FEC systems the number of redundant bits is equal to the number of data bits, resulting in halving of the data rate for a given channel transmission rate. This is called half rate FEC.

The loss of communication capacity is traded for a guaranteed low error rate. This technique is widely used in VSAT system where the links to and from the small antenna terminal have low C/N ratios.

Consequently, all satellite terminals which tend to have low C/N ratios (VSAT, satellite telephones, DBS-TV terminals) make use of forward error correction to improve the bit error rate on the links to and from the small terminal.
Error Control Coding

- Error detection coding is a technique for adding redundant bits to a data stream in such a way that one or more errors in the data stream can be detected.

- One redundant bit is added for every $N$ data bits; this allows a single error within that block of $N$ bits to be detected.
**Figure 7.3 (p. 277)**

(a) Example of even and odd parity for a 7-bit ASCII word. (b) Example of error detection in a 7-bit ASCII word with even parity. Error bits are underlined.

<table>
<thead>
<tr>
<th>Data bits</th>
<th>Parity bit</th>
<th>Sum (Modulo-2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Even parity</td>
<td>0101101</td>
<td>0</td>
</tr>
<tr>
<td>Odd parity</td>
<td>0101101</td>
<td>1</td>
</tr>
</tbody>
</table>

(a)

<table>
<thead>
<tr>
<th>Received codeword</th>
<th>Sum of bits</th>
<th>Error detected?</th>
</tr>
</thead>
<tbody>
<tr>
<td>One error</td>
<td>01010010</td>
<td>Yes</td>
</tr>
<tr>
<td>Two errors</td>
<td>01010110</td>
<td>No</td>
</tr>
<tr>
<td>Three errors</td>
<td>11010110</td>
<td>Yes</td>
</tr>
</tbody>
</table>

(b)
When an error-detection code or CRC is used and the error must be corrected, a transmission of the block of data containing the error must be made so that the correct data are acquired at the receiver terminal. If an error is detected in the block, a not acknowledge (NAK) signal is sent back to the transmit end of the link, which triggers a retransmission of the erroneous block of data.

This is called an automatic repeat request (ARQ) system.

There are three basic techniques for retransmission requests, depending on the type of link used:

- One-way, simplex link
- Stop-and-wait system
- Continuous transmission system
One-way, simplex link

- The ACK or NAK signals must travel on the same path as the data, so the transmitter must stop after each block and wait for the receiver to send back an NAK or ACK before it retransmits the last data block or sends the next one.

- The data rate of such a system will be very low and it is suitable only for links in which data are generated slowly.

- Satellite links usually establish **two-way communication** (duplex channel) by the use of SCPC-FDM, or TDM.

- The ACK and NAK signals can be sent on the return channel while data are sent on the go channel, however, if the data rate is high, the acknowledgment will arrive long after the block to which it relates was transmitted.
Stop-and-wait system

- The transmitting end sends a block of data and waits for the acknowledgment to arrive on the return channel.

- The delay is the same as in the simplex case, but implementation is simpler.

- Figure 7.7 shows an example of a stop-and-wait sequence.
Figure 7.7 (p. 286)
Stop-and-wait ARQ system.
Continuous transmission system

- Continuous transmission system using the go-back-N technique, data are sent in blocks continuously and held in a buffer at the receive end of the link.

- Each data block is checked for errors as it arrives, and the appropriate ACK or NAK is sent back to the transmitting end, with the block number appended.

- When a NAK(N) is received, the transmit end goes back to block N and retransmits all subsequent blocks, as illustrated in figure 7.8.

- If sufficient buffering is provided at both ends of the link, only the corrupted block need be retransmitted. This system is called selective repeat ARQ.
Figure 7.8 (p. 286)
Example of a go-back-$N$-blocks ARQ system. $N$ is three blocks in this example.
The purpose of the interleaving is to spread out the errors that occurred in a burst and thus to make it easier for an error correction system to recover the original data.

The interleavers used in satellite transmission of digital video signals are generally short, typically 12 * 7. Figure 7.11 shows the coding and decoding structure of a typical DBS-TV signal.

(a)

(b) Networks and Communication Department
Figure 7.11 (p. 290)
Coding and decoding structure for data in a DBS-TV system.
Research Work

- Find more about Turbo codes