Types of Error Control

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1. 6.2 TYPES OF ERROR CONTROL

Before we discuss the details of structured redundancy, let us describe the two basic ways such redundancy is used for controlling errors. The first, error detection and retransmission, utilizes parity bits (redundant bits added to the data) to detect that an error has been made. The receiving terminal does not attempt to correct the error; it simply requests that the transmitter retransmit the data. Notice that a two-way link is required for such dialogue between the transmitter and receiver. The second type of error control, forward error correction (FEC), requires a oneway link only, since in this case the parity bits are designed for both the detection and correction of errors. We shall see that not all error patterns can be corrected; error-correcting codes are classified according to their error-correcting capabilities.

2. 6.2.1 Terminal Connectivity

Communication terminals are often classified according to their connectivity with other terminals. The possible connections, shown in Figure 6.6, are termed simplex (not to be confused with the simplex or transorthogonal codes), half-duplex, and full-duplex. The simplex connection in Figure 6.6a is a one-way link. Transmissions are made from terminal A to terminal B only, never in the reverse direction. The half-duplex connection in Figure 6.6b is a link whereby transmissions may be made in either direction but not simultaneously. Finally, the full-duplex connection in Figure 6.6c is a two-way link, where transmissions may proceed in both directions simultaneously.

Figure 6.6 Terminal connectivity classifications. (a) Simplex. (b) Halfduplex. (c) Full-duplex.

3. 6.2.2 Automatic Repeat Request

When the error control consists of error detection only, the communication system generally needs to provide a means of alerting the transmitter that an error has been detected and that a retransmission is necessary. Such error control procedures are known as automatic repeat request or automatic retransmission query (ARQ) methods. Figure 6.7 illustrates three of the most popular ARQ procedures. In each of the diagrams, time is advancing from left to right. The first procedure, called stop-and-wait ARQ, is shown in Figure 6.7a. It requires a half-duplex connection only, since the transmitter waits for an acknowledgment (ACK) of each transmission before it proceeds with the next transmission. In the figure, the third transmission block is received in error; therefore, the receiver responds with a negative acknowledgment (NAK), and the transmitter retransmits this third message block before transmitting the next in the sequence. The second ARQ procedure, called continuous ARQ with pullback, is shown in Figure 6.7b. Here a full-duplex connection is necessary. Both terminals are transmitting simultaneously; the transmitter is sending message data and the receiver is sending acknowledgment data. Notice that a sequence number has to be assigned to each block of data. Also, the ACKs and NAKs need to reference such numbers, or else there needs to be a priori knowledge of the propagation delays, so that the transmitter knows which messages are associated with which acknowledgments. In the example of Figure 6.7b, there is a fixed separation of four blocks between the message being transmitted and the acknowledgment being simultaneously received. For example, when message 8 is being sent, a NAK corresponding to the corrupted message 4 is being received. In the ARQ procedure, the transmitter “pulls back” to the message in error and retransmits all message data, starting with the corrupted message. The final method, called continuous ARQ with selective repeat, is shown in Figure 6.7c. Here, as with the second ARQ procedure, a full-duplex connection is needed. In this procedure, however, only the corrupted message is repeated; then, the transmitter continues the transmission sequence where it had left off instead of repeating any subsequent correctly received messages.

Figure 6.7 Automatic repeat request (ARQ). (a) Stop-and-wait ARQ (halfduplex). (b) Continuous ARQ with pullback (full-duplex). (c) Continuous ARQ with selective repeat (full-duplex).

The choice of which ARQ procedure to choose is a trade-off between the requirements for efficient utilization of the communications resource and the need to provide full-duplex connectivity. The half-duplex connectivity required in Figure 6.7a is less costly than ful-duplex; the associated inefficiency can be measured by the blank time slots. The more efficient utilization illustrated in Figures 6.7b and c requires the more costly full-duplex connectivity.

The major advantage of ARQ over forward error correction (FEC) is that error detection requires much simpler decoding equipment and much less redundancy than does error correction. Also, ARQ is adaptive in the sense that information is retransmitted only when errors occur. On the other hand, FEC may be desirable in place of, or in addition to, error detection, for any of the following reasons:

1. A reverse channel is not available or the delay with ARQ would be excessive.

2. The retransmission strategy is not conveniently implemented.

3. The expected number of errors, without corrections, would require excessive retransmissions.

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