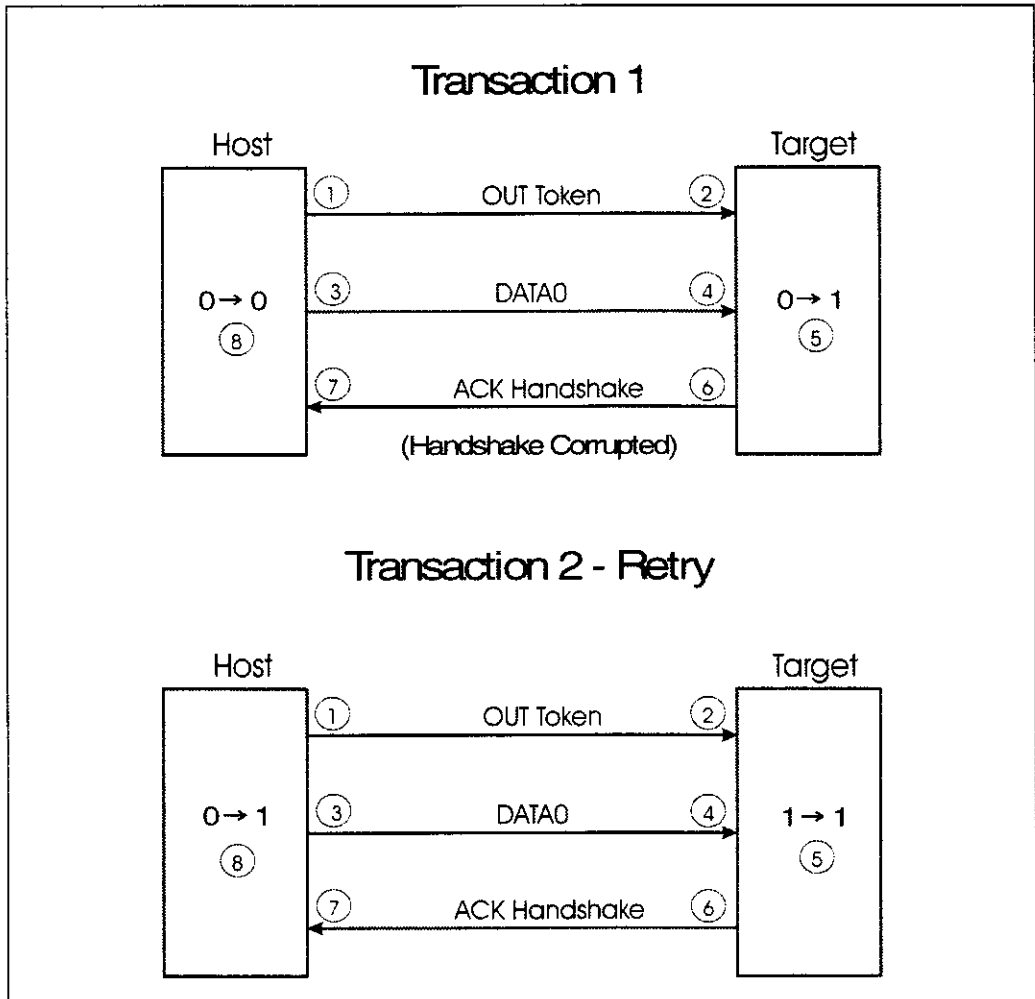


USB System Architecture

Data Toggle and Handshake Errors — OUT Transactions

Figure 8-7 on page 184 illustrates an OUT transaction that fails due to an ACK packet error.

Figure 8-7: OUT Transaction With Data Toggle and Handshake Errors



Chapter 8: Error Recovery

The sequence of events that occur in detecting and recovering from the error is enumerated below:

Transaction 1

1. The host transmits an OUT token to the target device.
2. The target device receives the token without any packet errors.
3. The host then transmits a DATA0 packet (consistent with its toggle bit) to the target device.
4. The target receives data packet zero, which matches the toggle bit.
5. Having successfully received the DATA0 packet, the toggle bit transitions to one.
6. The target transmits an ACK handshake packet to inform the host that data was received without error.
7. The host receives the ACK packet with errors.
8. Since errors are detected by the host, it cannot verify that the target has successfully received the data. Thus, the host leaves the toggle bit unchanged (zero). The host presumes that the target did not receive the data and therefore initiates a retry.

Transaction 2 — the retry

1. The host transmits the OUT token to the target.
2. The target device receives the packet without errors.
3. The host retransmits the DATA0 packet (consistent with the state of its toggle bit).
4. The target receives the packet without error, but DATA0 does not match the state of its toggle bit.
5. The target recognizes that it is out of sync with the host and therefore discards the data and leaves the toggle bit unchanged (one).
6. The target transmits an ACK handshake packet to inform the host that data was received without error. This is because the host apparently did not receive the previous ACK handshake.
7. The host receives the ACK packet without error.
8. Having successfully received the ACK packet, the host transitions the toggle bit to a one. The host and target are now ready to proceed to the next transaction.

The host and target temporarily disagreed on whether the data had actually been completed. However, the data toggle mechanism ensures that the de-synchronization is detected and permits re-synchronization.