INTERFACING AND DATA LINK CONTROL - 07.03.2006

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DTE/DCE Pair Interfacing

An Interface has four important characteristics

- Mechanical:
  The mechanical characteristics pertain to the actual physical connection of the DTE to the DCE.

- Electrical:
  The electrical characteristics have to do with the voltage levels and timing of voltage changes.Both DTE and DCE must use the same code (e.g., NRZ-L), must use the same voltage levels to mean the same things, and must use the same duration of signal elements.

- Functional:
  Functional characteristics specify the functions that are performed by assign- ing meanings to each of the interchange circuits. Functions can be classified into the broad categories of data, control, timing, and electrical ground.

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- Procedural:
  Procedural characteristics specify the sequence of events for transmitting data , based on the functional characteristics of the interface. The examples that follow should clarify this point.

EIA-232. specification

- Mechanical Specification:
  The DTE and DCEmust present plugs of opposite genders at one end of the cable, effecting the physical connection.

- Electrical specification:
  Digital signaling is used on all interchange circuits. Depending on the function of the interchange circuit, the electrical values are interpreted either as binary or as control signals.

- Functional Specification:

  - Data signals:

    There are four data signals .There is one data circuit in each direction, so full-duplex operation is possible.In addition there are two secondary data circuits that are useful when the device operates in a half-duplex fashion.
  - Control signals:

    * There are fifteen control circuits. Ten of them relate to the transmission of data over the primary channel.
      For asynchronous transmission, six of these following circuits are used

      - DTE READY
      - DCE READY
      - CLEAR TO SEND
      - READY TO SEND
      - RING INDICATOR
      - LINE SIGNAL DETECTOR

* Three other control circuits are used in synchronous transmission

    · SIGNAL QUALITY DETECTOR
    · DATA SIGNAL RATE SELECTOR(TWO)

* The three other control circuits (Secondary request to send,Secondary clear to send,Secondary received line signal detector) are used to control the use of the secondary channel, which may be used as a reverse channel or for some other auxiliary purpose.

* Another group of control signals relate to loopback testing. These circuits allow the DTE to cause the DCE to perform a loopback test.

    · Local loopback :

      In the local loopback function, the transmitter output of the modem is connected to the receiver input, disconnecting the modem from the trans- mission line. A stream of data generated by the user device is sent to the modem and looped back to the user device.

    · Remote loopback :

      For remote loopback, the local modem is connected to the transmission facility in the usual fashion, and the receiver output of the remote modem is connected to the modem's transmitter input

    · Loopback control is a useful fault-isolation tool.

    · Local loopback checks the functioning of the local interface and the local DCE. Remote loopback tests the operation of the transmission channel and the remote DCE.

– Timing signals:

  The timing signals provide clock pulses for synchronous transmission.

– Ground:

  The signal ground/common return serves as the return circuit for all data leads.

- Procedural Specification:
  The procedural specification defines the sequence in various circuits are for a particular application.

Data Link Control Processes

- Frame synchronisation:
  Data are sent in blocks called frames. The beginning and end of each frame must be recognizable.

- Flow Control
  The sending station must not send frames at a rate faster then the receiving station can absorb them.

- Error Control
  Any bit errors introduced by the transmission system must be corrected.

- Addressing
  On a multipoint line, such as a local area network (LAN), the identity of the two stations involved in a transmission must be specified.

- Control and Data on same link
  It is usually not desirable to have a physically separate communications path for control information. Accordingly, the receiver must be able to distinguish control information from the data being transmitted.

- Link Management
  The initiation, maintenance, and termination of a sustained data exchange requires a fair amount of coordination and cooperation among stations. Procedures for the management of this exchange are required.

Flow Control

- There are two flow control Strategies:
  - Stop-and-Wait Flow Control Protocol
  - Sliding Window Control Protocol

Stop-and-wait Control Flow

- Overview
  - A source entity transmits a frame. After reception, the destination entity indicates its willingness to accept another frame by sending back an acknowledg- ment to the frame just received. The source must wait until it receives the acknowl- edgment before sending the next frame. The destination can thus stop the flow of data by simply withholding acknowledgment.This is done for the following reasons:
    - The buffer size of the receiver may be limited.
    - The longer the transmission, the more likely that there will be an error, neces- sitating retransmission of the entire frame. With smaller frames, errors are detected sooner, and a smaller amount of data needs to be retransmitted.
    - On a shared medium, such as a LAN, it is usually desirable not to permit one station to occupy the medium for an extended period, as this causes long delays at the other sending stations.
  - Refer to figure
    transmission time (the time it takes for a station to transmit a frame) is normalized to 1.
    propagation delay (the time it takes for a bit to travel from sender to receiver) is expressed as the variable a.
    - Case I .(a>1)
      The propagation time is greater than the transmission time. The sender completes transmission of the entire frame before the leading bits of that frame arrive at the receiver. The line is always underutilized.
    - Case II .(a<1)
      The propagation time is less than the transmission time.The

frame is sufficiently long that the first bits of the frame have arrived at the destination before the source has completed the transmission of the frame.The line is inefficiently utilized.

Thus for very high data rates, or for very long distances between sender and receiver, stop- and-wait flow control provides inefficient line utilization.

- Utilization of Stop-and-wait Flow Control Protocol:
  - The total time to send the data. T, can be expressed as T = nT_F, Where T_F is the time to send one frame and receive an acknowledgment.

    We can express T_F as follows:
    $T_F = t_{prop} + t_{frame} + t_{proc} + t_{prop} + t_{ack} + t_{proc}$

    where
    t_{prop} = propagation time from S1 to S2
    t_{frame} = time to transmit a frame
    (time for the transmitter to send out all of the bits of the frame)
    t_{proc} = processing time at each station to react to an incoming event
    t_{ack} = time to transmit an acknowledgment

    Let us assume that the processing time is relatively negligible, and that the acknowledgment frame is very small compared to a data frame, both of which are reasonable assumptions.

    Then we can express the total time to send the data as
    $T = n\,(2t_{prop} + t_{frame})$
    Of that time, only n X t_{frame} is actually spent transmitting data and the rest is overhead.

    The utilization, or efficiency, of the line is
    $U = n * t_{frame} / (\, n\, (\, 2\, t_{prop} + t_{frame}\,))$
    $= t_{frame} / (\, 2\, t_{prop} + t_{frame})$

    Defining parameter a = t_{prop} / t_{frame}, then
    $U = 1/\,(1 + 2a)$
    This is the maximum possible utilization of the link.

    The frame contains overhead bits, actual utilization is lower.
    $a = (d/V)/(L/R) = Rd/VL$
    where ,
    V= velocity(in m/s)
    d= distance (in meter)
    L= Frame length in bits
    R = Data rate(in bps)

Sliding Window Control Flow

- Overview
  - For two stations, A and B, connected via a full-duplex link. Station B allocates buffer space for n frames. Thus, B can accept n frames, and A is allowed to send n frames without waiting for any acknowledgments. To keep track of which frames have been acknowledged, each is labeled with a sequence number. B acknowledges a frame by sending an acknowledgment that includes the sequence number of the next frame expected. This acknowledgment also implicitly announces that B is prepared to receive the next n frames, beginning with the number specified.

    For a k-bit field the range of sequence numbers is 0 through 2k - 1, and frames are numbered modulo 2k.

    An example is shown in Figure. The example assumes a 3-bit sequence number field and a maximum window size of seven frames. Initially, A and B have windows indicating that A may transmit seven frames, beginning with frame 0 (FO).

    After transmitting three frames (FO, F1, F2) without acknowledgment, A has shrunk its window to four frames. The window indicates that A may transmit four frames, beginning with frame number 3. B then transmits an RR (receive-ready) 3, which means: "I have received all frames up through frame number 2 and am ready to receive frame number 3; in fact, I am prepared to receive seven frames, beginning with frame number 3." With this acknowledgment, A is back up to permission to transmit seven frames, still beginning with frame 3. A proceeds to transmit frames 3, 4, 5 , and 6. B returns an RR 4, which allows A to send up to and including frame F2.

  - Sliding-window flow control is potentially much more efficient than stop-and-wait flow control. The reason is that, with sliding-window flow control, the transmission link is treated as a pipeline that may be filled with frames in transit. In contrast, with stop-and-wait flow control, only one frame may be in the pipe at a time.

- Utilization of Sliding Window Protocol

  – For sliding-window flow control, the efficiency of the line depends on both the window size, N, and the value of a.

    * Case 1: $N > 2a + 1$
      The acknowledgment for frame 1 reaches A before A has exhausted its window. Thus, A can transmit continuously with no pause, and utilization is 1.0.

    * Case 2: $N < 2a + 1$
      A exhausts its window at to + Nand cannot send additional frames until to + 2a + 1. Thus, line utilization is N time units out of a period of (2a + 1) time units.

  therefore, U = 1 if N>= 2a+1
  = N/(2a+1) N < 2a+1

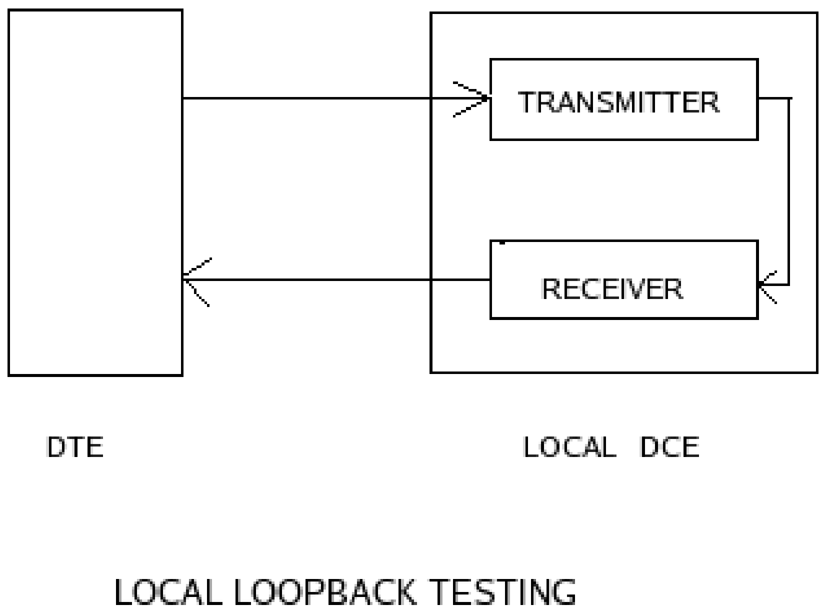

Figure 1: Local LoopBack Testing

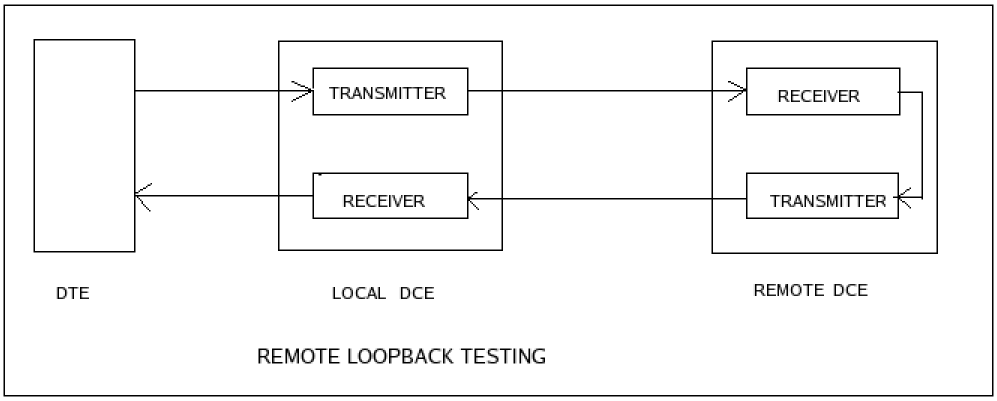

Figure 2: Remote Loopback Testing

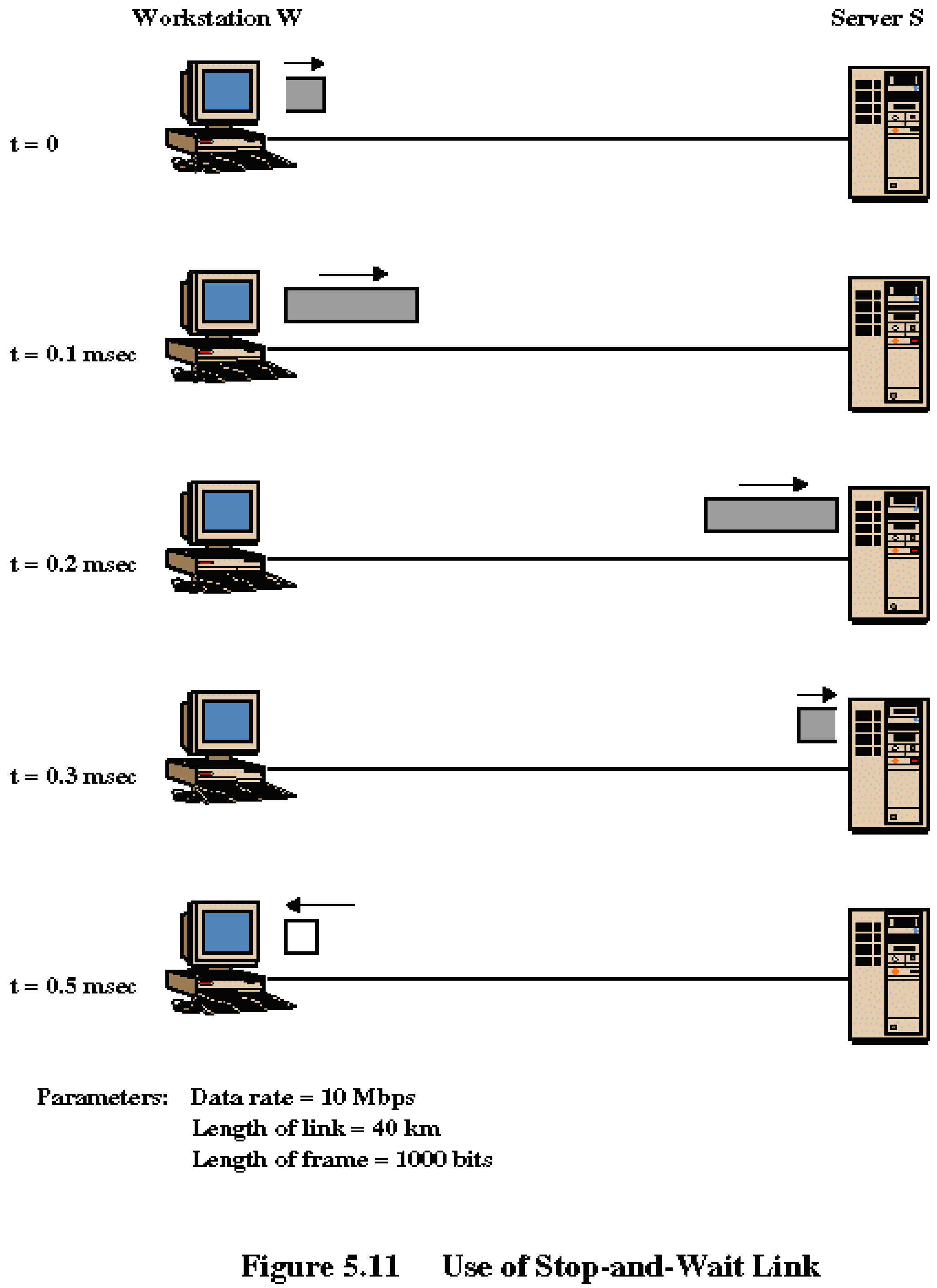

Figure 3: Use of Stop and Wait Link

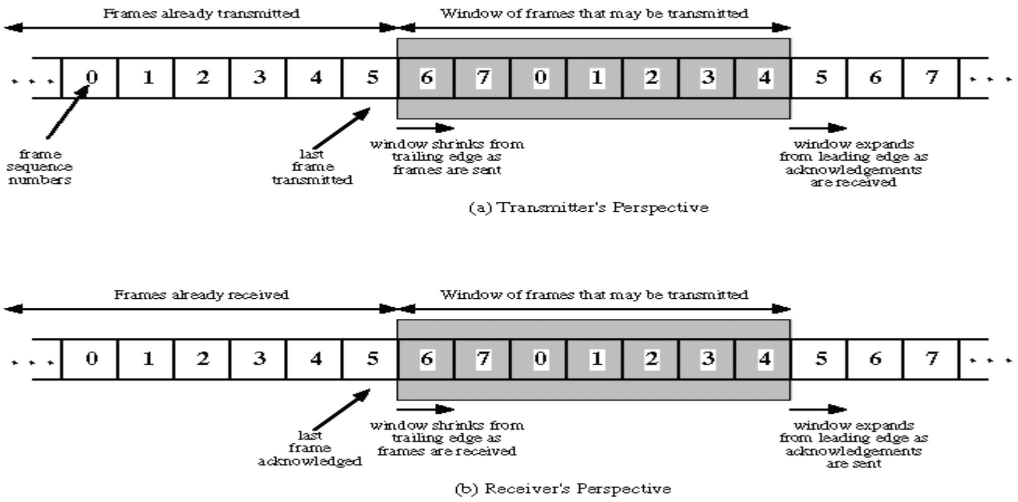

Figure 5.12 Sliding-Window Depiction

Figure 4: Sliding window depiction

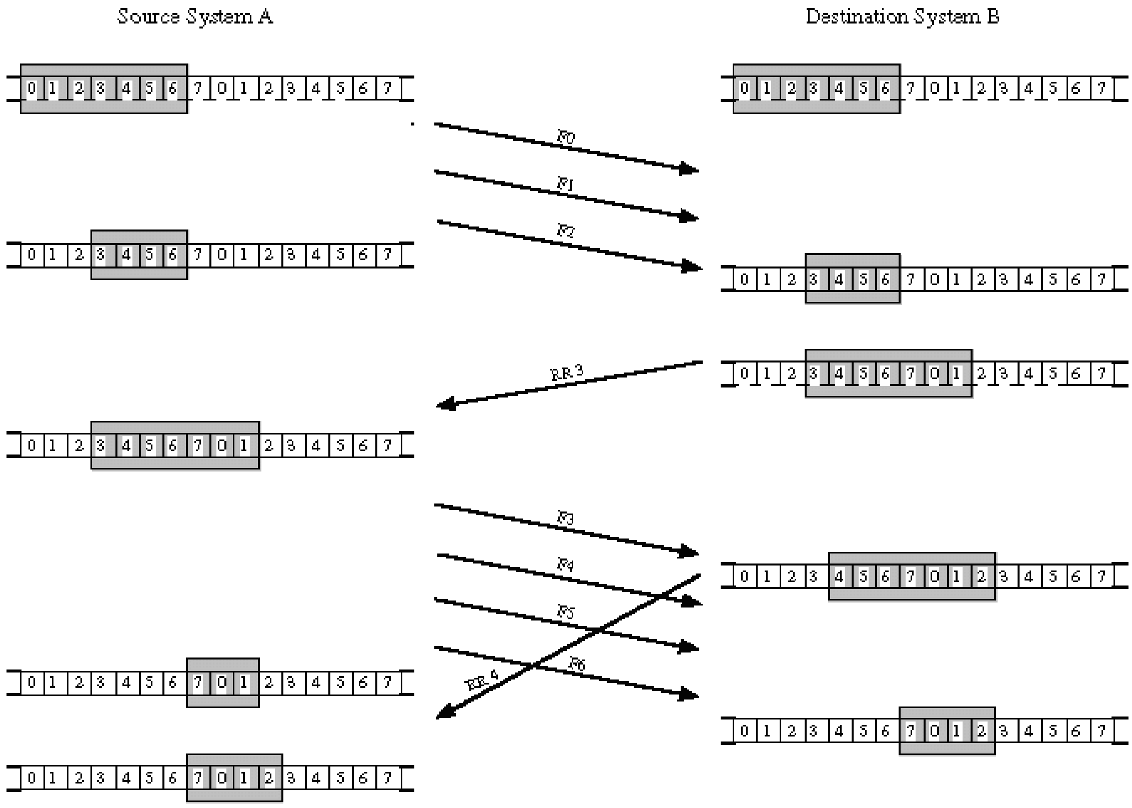

Figure 5.13 Example of a sliding-window protocol

Figure 5: Example of Sliding Window Protocol