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LECTURE NOTES-Computer Network
BCA-IVth Semester

Lecture 5
Data Link Layer Design Issues

Data Link Layer Design Issues

The Data Link Layer

- This layer deals with the algorithms for achieving reliable, efficient communication between two adjacent (i.e. physically connected by a communication channel like a wire) machines just above the physical layer.

- Data transfer data rate and error correction are the major concerns of the data link layer.

- Circuit errors, finite data rate and propagation delay have important implications for the efficiency of the data transfer. The protocols used for communications must take all these factors into consideration.

Data Link Layer Design Issues

Functions of the data link layer:

1. Providing a well-defined service interface to the network layer
2. Determining how the bits of the physical layer are grouped into frames
3. Dealing with transmission errors
4. Regulating the flow of frames so that slow receivers are not swamped by fast senders.

Services Provided to the Network Layer

- The function of the data link layer is to provide service to the network layer.

- The principal service is transferring data from the network layer on the source machine to the network layer on the destination machine.

- The network layer hands some bits to the data link layer for transmission to the destination, the job of the data link layer is to transmit the bits to the destination machine, so they can be handed over to the network layer on the destination machine.

- The data link layer can be designed to offer various services. Three possibilities that are commonly provided are:

1. **Unacknowledged connectionless service.**
2. **Acknowledged connectionless service.**
3. **Acknowledged connection-oriented service.**

- **Unacknowledged connectionless service** consists of having the source machine send independent frames to the destination machine without having the destination machine acknowledge them. No connection is established beforehand or released afterward. Good channels with low eror rates, for real-time traffic, such as speech.

- **Acknowledged connectionless service.** When this service is offered, there are still no connections used, but each frame sent is individually acknowledged. This way, the sender knows whether or not a frame has arrived safely. Good for unreliable channels, such as wireless.

- **Connection-oriented service.** With this service, the source and destination machines establish a connection before any data are transferred. Each frame sent over the connection is numbered, and the data link layer guarantees that each frame sent is received. Furthermore, it guarantees that each frame is received exactly once and that all frames are received in the right order.

- When connection-oriented service is used, transfers have three distinct phases.

1. In the first phase the connection is established by having both sides initialize variable and counter need to keep track of which frames have been received and which ones have not.
2. In the second phase, one or more frames are actually transmitted.
3. In the third phase, the connection is released, freeing up the variables, buffers, and other resources used to maintain the connection.

Framing

- In order to provide service to the network layer, the data link layer must use the service provided to it by the physical layer.

- What the physical layer does is accept raw bit stream and attempt to deliver it to the destination. This bit stream is not guaranteed to be error free.

- It is up to the data link layer to detect, and if necessary, correct errors.

- The usual approach is for the data link layer to break the bit stream up into discrete frames and compute the checksum for each frame. When the frames arrive at the destination , the checksum is re-computed.

- There are four methods of breaking up the bit stream

1. **Character count.**
2. **Starting and ending character stuffing.**
3. **Starting and ending flags, with bit stuffing.**
4. **Physical layer coding violations.**

- The first framing method, **Character count**, uses a field in the header to specify the number of characters in the frame. when the data link layer at the destination sees the character count, it knows how many characters follow. **Problem:** count can possible be misrepresented by a transmission error. This method is rarely used anymore.

- The second framing method, **Starting and ending character stuffing**, gets around the problem of resynchronization after an error by having each frame start with the ASCII character sequence DLE STX and end with the sequence DLE ETX. (DLE is Data Link Escape, STX is Start of Text, and ETX is End of Text). **Problem:** a serious problem occurs with this method when binary data, such as object programs or floating-point numbers, are being transmitted it is possible that the DLE, STX, and ETX characters can occur, which will interfere with the framing. One way to solve this problem is to have the sender's data link layer insert and DLE character just before each "accidental" DLE and the data link layer on the other machine removes them before it gives the data to the network layer, this is called **Character stuffing**.

- The third method, Starting and ending flags with bit stuffing, allows data frames to contain and arbitrary number of bits and allows character codes with an arbitrary number of bits per character. Each frame begins and ends with a special bit pattern, 01111110, called a **flag** byte. Whenever the sender's data link layer encounters five consecutive ones in the data, it automatically stuffs a 0 bit into the outgoing bit stream, which is called **bit stuffing.** The receiving machine destuffs the 0 bit.

- The fourth method, **Physical coding violations**, is only applicable to networks in which the encoding on the physical medium contains some redundancy. For example, some LANs encode 1 bit of data by using 2 physical bits.

Error Control

- The next problem to deal with is, who to make sure all frames are eventually delivered to the network layer at the destination, and in proper order.

- The usual way to ensure reliable delivery is to provide the sender with some feedback about what is happening at he other end of the line.

- One complication with this is that the frame may vanish completely, in which case, the receiver will not react at all, since it has no reason to react.

- This possibility is dealt with by introducing timers into the data link layer. When the sender transmits a frame, it generally also starts a timer. The timer is set to go off after an interval long enough for the frame to reach the destination machine. If the frame or acknowledgment is lost the timer will go off. The obvious solution is to transmit the frame again. This creates the problem of possible sending frames multiple times. To prevent this from happening, it is generally necessary to assign sequence numbers to outgoing frames, so that the receiver can distinguish retransmission from originals.

- The whole issue of managing the timers and sequence numbers so as to ensure that each frame is ultimately passed to the network layer at the destination exactly one, no more no less, is an important part of the data link layer's duties.

Flow Control

- Another important design issue that occurs in the data link layer (and higher layers as well) is what to do with a sender that systematically wants to transmit frames faster than a receiver can accept them.

- This situation can easily occur when the sender is running on a fast computer and the receiver is running on a slow machine.

- The usual solution is to introduce **flow control** to throttle the sender into sending no faster than the receiver can handle the traffic.

- Various flow control schemes are known, but most of them use the same basic principle.

The protocol contains well-defined rules about when a sender may transmit the next frame.

HDLC - High Level Data Link Control

Protocol Overall Description:

Layer 2 of the OSI model is the data link layer. One of the most common layer 2 protocols is the HDLC protocol. In fact, many other common layer 2 protocols are heavily based on HDLC, particularly its framing structure: namely, SDLC, SS#7, LAPB ,LAPD and ADCCP. The basic framing structure of the HDLC protocol is shown below:
HDLC uses zero insertion/deletion process (commonly known as bit stuffing) to ensure that the bit pattern of the delimiter flag does not occur in the fields between flags. The HDLC frame is synchronous and therefore relies on the physical layer to provide method of clocking and synchronizing the transmission and reception of frames.
The HDLC protocol is defined by ISO for use on both point-to-point and multipoint (multidrop) data links. It supports full duplex transparent-mode operation and is now extensively used in both multipoint and computer networks.

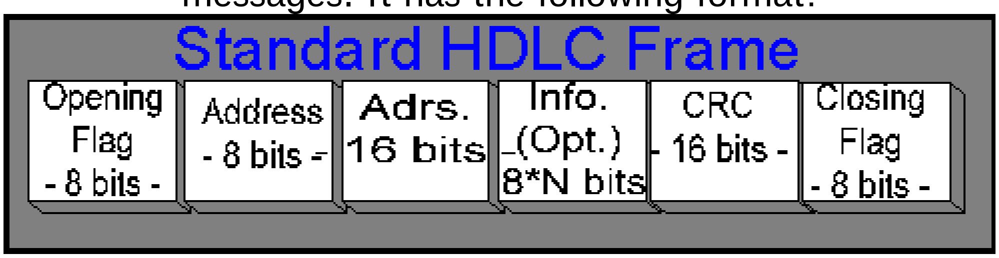
HDLC Operation Modes:

HDLC has three operational modes:

1. Normal Response Mode (NRM)
2. Asynchronous Response Mode (ARM)
3. Asynchronous Balanced Mode (ABM)

Frame Formats:

The standard frame of the HDLC protocol handles both data and control messages. It has the following format:



The length of the address field is commonly 0,8 or 16 bits, depending on the data link layer protocol.
For instance the SDLC use only 8 bit address, while SS#7 has no address field at all because it is always used in point to point links.

The 8 or 16 bit control field provides a flow control number and defines the frame type (control or data). The exact use and structure of this field depends upon the protocol using the frame.

Data is transmitted in the data field , which can vary in length depending upon the protocol using the frame. Layer 3 frames are carried in the data field.

Error Control is implemented by appending a cyclic redundancy check (CRC) to the frame, which is 16 bits long in most protocols.

Frame Classes:

In the HDLC protocol , three classes of frames are used :

1. Unnumbered frames - are used for link management.

Unnumbered frames are used for link management, for example they are used to set up the logical link between the primary station and a secondary station, and to inform the secondary station about the mode of operation which is used

2. Information frames - are used to carry the actual data.

Information frames are those who carry the actual data. The Information frames can be used to piggyback acknowledgment information relating to the flow of Information frames in the reverse direction when the link is being operated in ABM or ARM.

3. Supervisory frames - are used for error and flow control.

Supervisory frames are use for error and flow control. They contain, send and receive sequence numbers.

Frame types: Three classes of frames are used in HDLC. Some of the different types of frame in each class are described below. Unnumbered frames are used for link management. SNRM and SABM frames , for example, are used both to set up logical link between the primary and the secondary station and to inform the secondary station of the mode of operation to be used. A logical link is subsequently cleared by the primary station sending a DISC frame. The UA frame is used as an acknowledgment to the other frames in this class.

There are four types of supervisory frames but only RR and RNR are used in both NRM and ABM These frames are used both to indicate the willingness or otherwise of a secondary station to receive an information frame from the primary station, and for acknowledgment purposes. REJ and SREJ frames are used only in ABM which permits simultaneous two-way communication across a point to point link. The two frames are used to indicate to the other station that a sequence error has occurred, that is an information frame containing an out of sequence N(s) has been received. the SREJ frame is used with a selective repeat transmission procedure, whereas the REJ frame is used with a go back N procedure.

Protocol operation

The two basic functions in the protocol are link management and data transfer (which includes error and flow control).

Link management

. Prior to any kind of transmission (either between two stations connected by a point to point link or between a primary and secondary station a multidrop link) a logical connection between the two communication parties must be established.

Data transfer

NRM all data (information frames) if transferred under the control of the primary station. The unnumbered poll frame with the P bit set to 1 is normally used by the primary to poll a secondary. If the secondary has no data to transmit, it returns an RNR frame with the F bit set. If data is waiting, it transmits the data, typically as a sequence of information frames.

The two most important aspects associated with the data transfer phase are error control and flow control. Essentially, error control uses a continues RQ procedure with either a selective repeat or a go back N transmission strategy, while flow controls based on a window mechanism. For more information Email To: ofirp@eng.tau.ac.il This Document Was written by: 1. Ziegler Alon 2. Kirshenberg Gilad 3. Paz Ofir This Document was based on the following books: 1. Data Communications , Computer Networks and Open Systems, by Fred Halsall 2. Data Communication ICs, High-Level Serial Communications, by Siemens

Synchronous Data Link Control(SDLC)

SDLC is same as HDLC . The only difference is in the format. In this case the size of the information field is variable whereas in case of HDLC it is multiple of byte.

SLIP(Serial **L**ine **I**nternet **P**rotocol)

Short for, a protocol for connection to the Internet via a dial-up connection. Developed in the 80s when modem communications typically were limited to 2400 bps, it was designed for simple communication over serial lines. SLIP can be used on RS-232 serial ports and supports asynchronous links.

PPP(Point-to-Point Protocol)

A more common protocol is PPP (Point-to-Point Protocol) because it is faster and more reliable and supports functions that SLIP does not, such as error detection, dynamic assignment of IP addresses and data compression. **P**oint-to-**P**oint **P**rotocol, a method of connecting a computer to the Internet. PPP is more stable than the older SLIP protocol and provides error checking features. Working in the data link layer of the OSI model, PPP sends the computer's TCP/IP packets to a server that puts them onto the Internet.

In general, Internet service providers offer only one protocol although some support both protocols.