Module-4

- **Data link control**
  DLC services
  Data link layer protocols
  Point to Point protocol (Framing, Transition phases only).
- **Media Access control**
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DATA LINK CONTROL

DLC SERVICES

• The data link control (DLC) deals with procedures for communication between two adjacent nodes i.e. node-to-node communication.
• Data link control functions include
  1) Framing
  2) Flow control
  3) Error control.

Framing

• A frame is a group of bits.
• Framing means organizing the bits into a frame that are carried by the physical layer.
• The data-link-layer needs to form frames, so that each frame is distinguishable from another.
• Framing separates a message from other messages by adding sender-address & destination-address.
• The destination-address defines where the packet is to go.
  The sender-address helps the recipient acknowledge the receipt.
• Q: Why the whole message is not packed in one frame?

Ans: Large frame makes flow and error-control very inefficient.
  Even a single-bit error requires the re-transmission of the whole message.
  When a message is divided into smaller frames, a single-bit error affects only that small frame.

(Our postal system practices a type of framing. The simple act of inserting a letter into an envelope separates one piece of information from another; the envelope serves as the delimiter. In addition, each envelope defines the sender and receiver addresses since the postal system is a many-to-many carrier facility).

Frame Size

• Two types of frames:

Fixed Size Framing

- There is no need for defining boundaries of frames; the size itself can be used as a delimiter.
- For example: ATM WAN uses frames of fixed size called cells.

Variable Size Framing

- We need to define the end of the frame and the beginning of the next frame.
- Two approaches are used: (1) Character-oriented approach
  (2) Bit-oriented approach.

Character Oriented Framing

• Data to be carried are 8-bit characters from a coding system such as ASCII (Figure 11.1).

• The header and the trailer are also multiples of 8 bits.

1) Header carries the source and destination-addresses and other control information.
2) Trailer carries error-detection or error-correction redundant bits.

• To separate one frame from the next frame, an 8- bit (I-byte) flag is added at the beginning and the end of a frame.

• The flag is composed of protocol-dependent special characters.

• The flag signals the start or end of a frame.

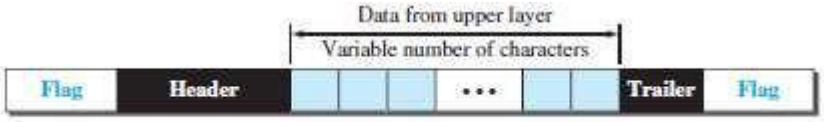

Figure 11.1 *A frame in a character-oriented protocol*

• Problem:

- Character-oriented framing is suitable when only text is exchanged by the data-link-layers.
- However, if we send other type of information (say audio/video), then any pattern used for the flag can also be part of the information.
- If the flag-pattern appears in the data-section, the receiver might think that it has reached the end of the frame.

Solution: A byte-stuffing is used. (Byte stuffing character stuffing)

• In byte stuffing, a special byte is added to the data-section of the frame when there is a character with the same pattern as the flag.

• The data-section is stuffed with an extra byte. This byte is called the escape character (ESC), which has a predefined bit pattern.

• When a receiver encounters the ESC character, the receiver
→ removes ESC character from the data-section and
→ treats the next character as data, not a delimiting flag.

• Problem:

- What happens if the text contains one or more escape characters followed by a flag?
- The receiver removes the escape character, but keeps the flag, which is incorrectly interpreted as the end of the frame.

Solution:

- Escape characters part of the text must also be marked by another escape character (Fig 11.2).

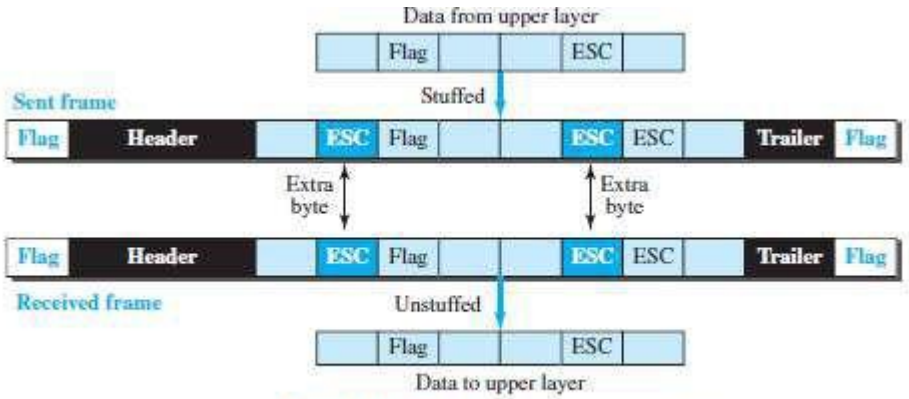

Figure 11.2 *Byte stuffing and unstuffing*

• In short, byte stuffing is the process of adding one extra byte whenever there is a flag or escape character in the text.

Bit Oriented Framing

• The data-section of a frame is a sequence of bits to be interpreted by the upper layer as text, audio, video, and so on.

• However, in addition to headers and trailers, we need a delimiter to separate one frame from the other.

• Most protocols use a special 8-bit pattern flag 01111110 as the delimiter to define the beginning and the end of the frame (Figure 11.3).

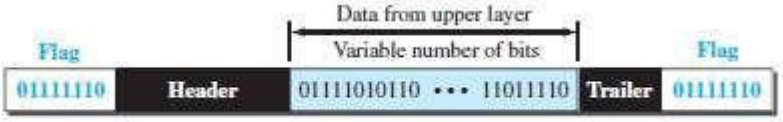

Figure 11.3 *A frame in a bit-oriented protocol*

• Problem:

- If the flag-pattern appears in the data-section, the receiver might think that it has reached the end of the frame.

Solution: A bit-stuffing is used.

• In bit stuffing, if a 0 and five consecutive 1 bits are encountered, an extra 0 is added. This extra stuffed bit is eventually removed from the data by the receiver. (Figure 11.4).

• This guarantees that the flag field sequence does not inadvertently appear in the frame.

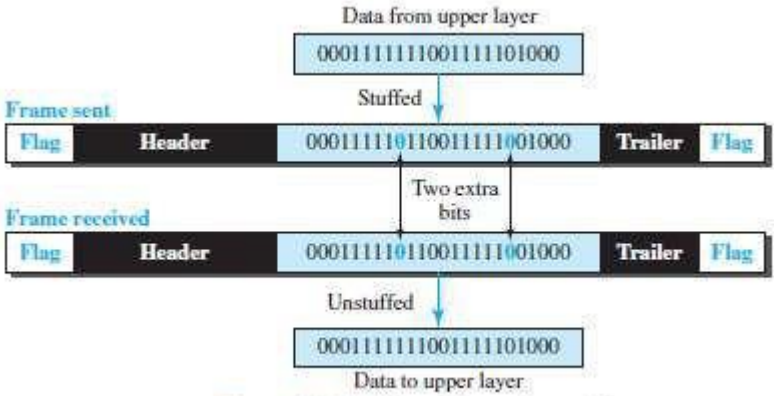

Figure 11.4 *Bit stuffing and unstuffing*

• In short, bit stuffing is the process of adding one extra 0 whenever five consecutive 1s follow a 0 in the data, so that the receiver does not mistake the pattern 0111110 for a flag.

Flow Control and Error Control

• One of the responsibilities of the DLC sublayer is flow and error control at the data-link layer.

Flow Control

• Whenever an entity produces items and another entity consumes them, there should be a balance between production and consumption rates.

• If the items are produced faster than they can be consumed, the consumer can be overwhelmed and may need to discard some items.

• We need to prevent losing the data items at the consumer site.

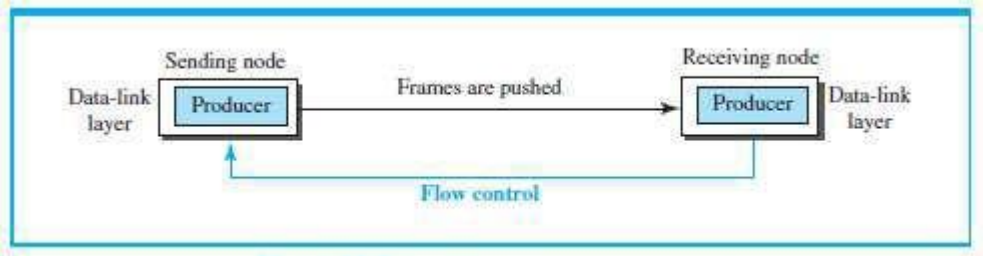

Figure 11.5 *Flow control at the data-link layer*

• At the sending node, the data-link layer tries to push frames toward the data-link layer at the receiving node (Figure 11.5).

• If the receiving node cannot process and deliver the packet to its network at the same rate that the frames arrive, it becomes overwhelmed with frames.

• Here, flow control can be feedback from the receiving node to the sending node to stop or slow down pushing frames.

Buffers

• Flow control can be implemented by using buffer.

• A buffer is a set of memory locations that can hold packets at the sender and receiver.

• Normally, two buffers can be used.

1) First buffer at the sender.
2) Second buffer at the receiver.

• The flow control communication can occur by sending signals from the consumer to the producer.

• When the buffer of the receiver is full, it informs the sender to stop pushing frames.

Error Control

• Error-control includes both error-detection and error-correction.

• Error-control allows the receiver to inform the sender of any frames lost/damaged in transmission.

• A CRC is

→ added to the frame header by the sender and
→ checked by the receiver.

• At the data-link layer, error control is normally implemented using one of the following two methods.

3) First method: If the frame is corrupted, it is discarded;
If the frame is not corrupted, the packet is delivered to the network layer.
This method is used mostly in wired LANs such as Ethernet.
4) Second method: If the frame is corrupted, it is discarded;
If the frame is not corrupted, an acknowledgment is sent to the sender.
Acknowledgment is used for the purpose of both flow and error control.

Combination of Flow and Error Control

• Flow and error control can be combined.

• The acknowledgment that is sent for flow control can also be used for error control to tell the sender the packet has arrived uncorrupted.

• The lack of acknowledgment means that there is a problem in the sent frame.

• A frame that carries an acknowledgment is normally called an ACK to distinguish it from the data frame.

Connectionless and Connection-Oriented

• A DLC protocol can be either connectionless or connection-oriented.

Connectionless Protocol

- Frames are sent from one node to the next without any relationship between the frames; each frame is independent.
- The term connectionless does not mean that there is no physical connection (transmission medium) between the nodes; it means that there is no connection between frames.
- The frames are not numbered and there is no sense of ordering.
- Most of the data-link protocols for LANs are connectionless protocols.

Connection Oriented Protocol

- A logical connection should first be established between the two nodes (setup phase).
- After all frames that are somehow related to each other are transmitted (transfer phase), the logical connection is terminated (teardown phase).
- The frames are numbered and sent in order.
- If the frames are not received in order, the receiver needs to wait until all frames belonging to the same set are received and then deliver them in order to the network layer.
- Connection oriented protocols are rare in wired LANs, but we can see them in some point-to-point protocols, some wireless LANs, and some WANs