Previously

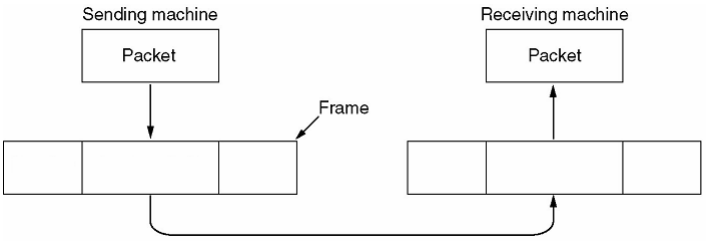
- Error Correction
  - Forward Error Correction
- Error Detection
  - Cyclic Redundancy Check

Data Link Layer Design Issues

- Introduction
  - Functionality
  - Services
- Framing
  - Stuffing
- Error Control
- Flow Control

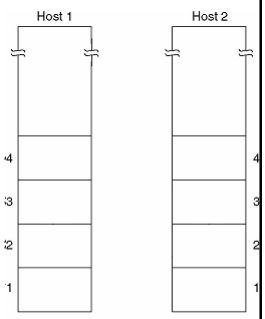
Functionality

- Provide a well defined service interface to the network layer,
- Deal with transmission errors
- Regulate the flow – Receivers do not get swamped by a fast sender,
- Manage frames – prepend headers and append trailers



Services

- Virtual communication
  - To the network layer it seems as though it sends packets to and receives from the data link layer.
  - However the actual path goes through the physical layer and the physical medium
- The data link layer provides different service levels as follows:
  - Connectionless
    - Unacknowledged
    - Acknowledged
  - Connection-oriented

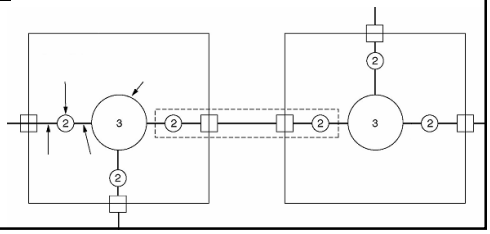


1. Unacknowledged connectionless service

- All frames are independent,
- No frames are acknowledged,
- No logical connection is established between the sender and receiver
- In the case of a lost frame…
  - Detection: We don't try and detect lost frames,
  - Recovery: Definitely don't try and recover from it.
- This type of service is appropriate where the error rate is extremely low and hence error recovery can be left to higher layers. Also appropriate for real-time traffic.

2. Acknowledged connectionless service

- All frames are acknowledged,
- No logical connection between sender and receiver,
- In the case of a lost frame…
  - Detection: Timeouts are used to detect lost frames,
  - Recovery: It is achieved by simple retransmission,
- This type of service is appropriate when the error rate is somewhat higher and/or the packet size is significant with respect to the frame size.



3. Acknowledged connection–oriented service

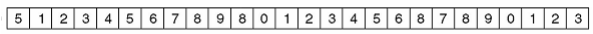
- All frames are numbered and acknowledged,
- A logical connection is established between source-destination
- Frames are guaranteed to arrive only once,
- Frames are guaranteed to arrive in order,
- Three phases
  - Connection: Both sides initialise variables and counters necessary to keep track of frames.
  - Transmission: Frames are transmitted in both directions.
  - Release: Connection is released and resources are freed.
- This type of service is appropriate when QoS requirements are of primary importance.

Transmitting Frames

- To transmit frames the data link layer must use the physical layer.
  - This provide an unreliable bit transmission scheme, where bits are Lost and/or Corrupted.
- The data link layer takes packets and breaks them into discrete frames for transmission by the physical layer.
- Framing the data is done using various methods:
  1. Character count
  2. Byte stuffing
  3. Bit stuffing
  4. Coding violations

1. Character Count

- Use a header field to specify the number of characters in the frame. This way we know how long the frame is.
- However if the header is corrupted how can we find where the next frame begins?



- This is a common mechanism that is used together with the mechanisms which follow.

2. Flag bytes, byte stuffing

- Use a FLAG byte at the start and end of each frame.
  - If the FLAG FLAG appears this should mean the end of one frame and the start of a consecutive frame,
  - If FLAG occurs in the data we replace FLAG by ESC FLAG and strip off the ESC bytes when receiving the data stream. This is byte stuffing.
  - If ESC appears in the data we insert a 2nd ESC so that we can safely strip off the 1st ESC character

3. Flags, bit stuffing

- It is more efficient to work with bits rather than

With fixed character size. Not all data is comprised of 8 bit characters.

- So instead transmit Frames of bits
  - Flag specified as 01111110: Frames preceded and followed by the flag,
  - If 111111 occur in the data then it is taken to indicate the start/end of a frame. Use bit stuffing. If 6 1s appear in a row, a 0 bit is inserted in the bit stream after the 5th 1.
  - If 1111101 appear in the received data stream then strip/remove the zero.

0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0

4. Coding violations

- Some physical layer coding scheme use more than 1-physical bit to represent 1-data bit, (e.g. 4B5B as used on 100Base-TX fast ethernet wiring)
- It is possible to use the invalid codes as flags for delineating frames

Error Control

- To identify errors in a received from
  - Use a checksum
  - Then send a Negative Acknowledgement
  - The sender should retransmit the frame
- If a frame goes missing, what then?
  - Data frame
    - Sender needs a timer to ensure retransmission,
  - ACK frame
    - Receiver needs to be able to cope with new frames as duplicates
  - NAK
    - Sender needs to again retransmit the frame.

Flow Control

- Swamping
  - It is possible that a receiver may not be able to cope with continuous data from a sender
  - E.g. a router which has many transmission lines all of which are being routed to the same location – or just a slow machine receiving from a fast machine.
- To overcome this:
  - Use Feedback based flow control where – based on permission – only so many frames can be sent until permission is given to send more
  - Use Rate based flow control which used no feedback from receiver. This is never used in the data link layer.