## List and briefly define some of the requirements for effective communications over a data link.

**Frame synchronization:** The beginning and end of each frame must be recognizable. **Flow control:** The sending station must not send frames at a rate faster than the receiving station can absorb them. **Error control:** Bit errors introduced by the transmission system should 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:** 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 require a fair amount of coordination and cooperation among stations. Procedures for the management of this exchange are required.

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## Define *flow control*.

The function performed by a receiving entity to limit the amount or rate of data that is sent by a transmitting entity.

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## Describe stop-and-wait flow control.

A flow control protocol in which the sender transmits a block of data and then awaits an acknowledgment before transmitting the next block.

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## What are reasons for breaking a long data transmission up into a number of frames?

**(1)** The buffer size of the receiver may be limited. **(2)** The longer the transmission, the more likely that there will be an error, necessitating retransmission of the entire frame. With smaller frames, errors are detected sooner, and a smaller amount of data needs to be retransmitted. **(3)** 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, thus causing long delays at the other sending stations.

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## Describe sliding-window flow control.

A method of flow control in which a transmitting station may send numbered packets within a window of numbers. The window changes dynamically to allow additional packets to be sent.

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## What is the advantage of sliding-window flow control compared to stop-and-wait flow control?

The stop-and-wait approach requires acknowledgments after each frame. The sliding window flow control technique can send multiple frames before waiting for an acknowledgment. Efficiency can be greatly improved by allowing multiple frames to be in transit at the same time.

## What is piggybacking?

The inclusion of an acknowledgment to a previously received packet in an outgoing data packet.

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## Define *error control.*

Error control refers to mechanisms to detect and correct errors that occur in the transmission of frames.

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## List common ingredients for error control for a link control protocol.

Error detection; positive acknowledgment; retransmission after timeout; negative acknowledgment.

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## Describe automatic repeat request (ARQ).

A feature that automatically initiates a request for retransmission when an error in transmission is detected.

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## List and briefly define three versions of ARQ.

**Stop-and-wait ARQ:** Based on stop-and-wait flow control. A station retransmits on receipt of a duplicate acknowledgment or as a result of a timeout. **Go-back-N ARQ:** Based on sliding-window flow control. When an error is detected, the frame in question is retransmitted, as well as all subsequent frames that have been previously transmitted. **Selective-reject ARQ.** Based on sliding-window flow control. When an error is detected, only the frame in question is retransmitted.

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## Why is it useful to have more than one possible path through a network for each pair of stations?

It is advantageous to have more than one possible path through a network for each pair of stations to enhance reliability in case a particular path fails.

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## What are the four generic architectural components of a public communications network?Define each term.

**Subscribers:** the devices that attach to the network, such as telephones and modems. **Subscriber line:** the link between the subscriber and the network. **Exchanges:** the switching centers in the network. **Trunks:** the branches between exchanges. Trunks carry multiple voice-frequency circuits using either FDM or synchronous TDM.

## What is the principal application that has driven the design of circuit-switching networks?

Telephone communications.

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## What are the advantages of packet switching compared to circuit switching?

**(1)** Line efficiency is greater, because a single node-to-node link can be dynamically shared by many packets over time. **(2)** A packet-switching network can perform data-rate conversion. Two stations of different data rates can exchange packets because each connects to its node at its proper data rate. **(3)** When traffic becomes heavy on a circuit-switching network, some calls are blocked; that is, the network refuses to accept additional connection requests until the load on the network decreases. On a packet-switching network, packets are still accepted, but delivery delay increases. **(4)** Priorities can be used. Thus, if a node has a number of packets queued for transmission, it can transmit the higherpriority packets first. These packets will therefore experience less delay than lower-priority packets.

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## Explain the difference between datagram and virtual circuit operation.

In the **datagram** approach, each packet is treated independently, with no reference to packets that have gone before. In the **virtual circuit** approach, a preplanned route is established before any packets are sent. Once the route is established, all the packets between a pair of communicating parties follow this same route through the network.

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## What is the significance of packet size in a packet-switching network?

There is a significant relationship between packet size and transmission time. As a smaller packet size is used, there is a more efficient "pipelining" effect, as shown in Figure 10.14. However, if the packet size becomes too small, then the transmission is less efficient, as shown in Figure 10.14d.

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## What types of delay are significant in assessing the performance of a packet-switching network?

Transmission, processing, and queuing delays.