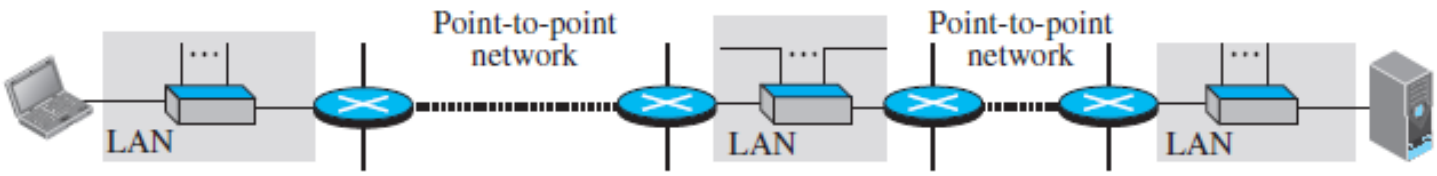
DATA LINK LAYER

DATA LINK LAYER

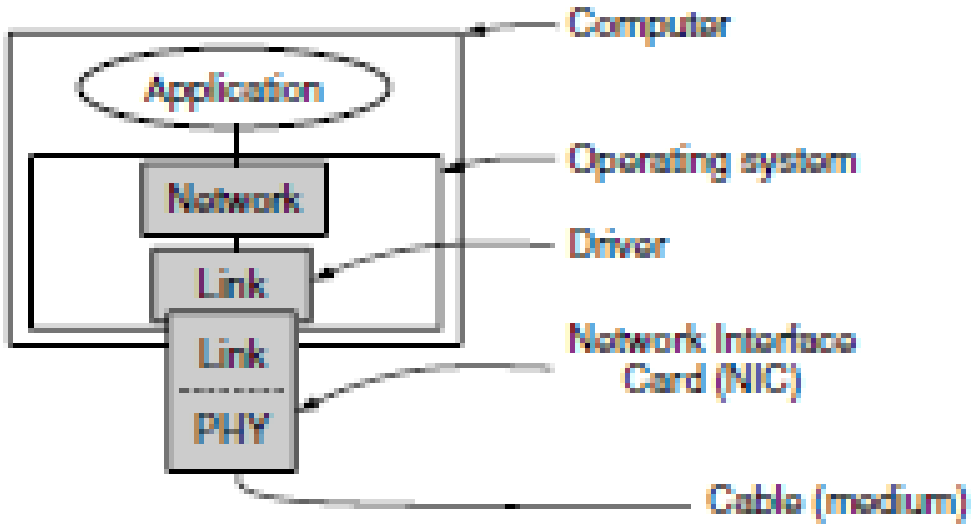


a. A small part of the Internet

b. Nodes and links

DATA LINK LAYER

- The physical layer process and some of the data link layer process run on dedicate hardware called a **NIC** (**Network Interface Card**)
- The rest of the link layer process and the network layer process run on the main CPU as part of the operating system, with the software for the link layer process often taking the form of a **device driver**.



DATA LINK LAYER

Services to Network Layer

- Unacknowledged Connectionless Service
- Acknowledged Connectionless Service
- Acknowledged Connection Oriented Service

DATA LINK LAYER

Framing

- Byte Count
- Byte Stuffing (flag Byte- start and end)
- Bit Stuffing(5 ones- Flag 01111110)
- Physical Layer coding Schemes

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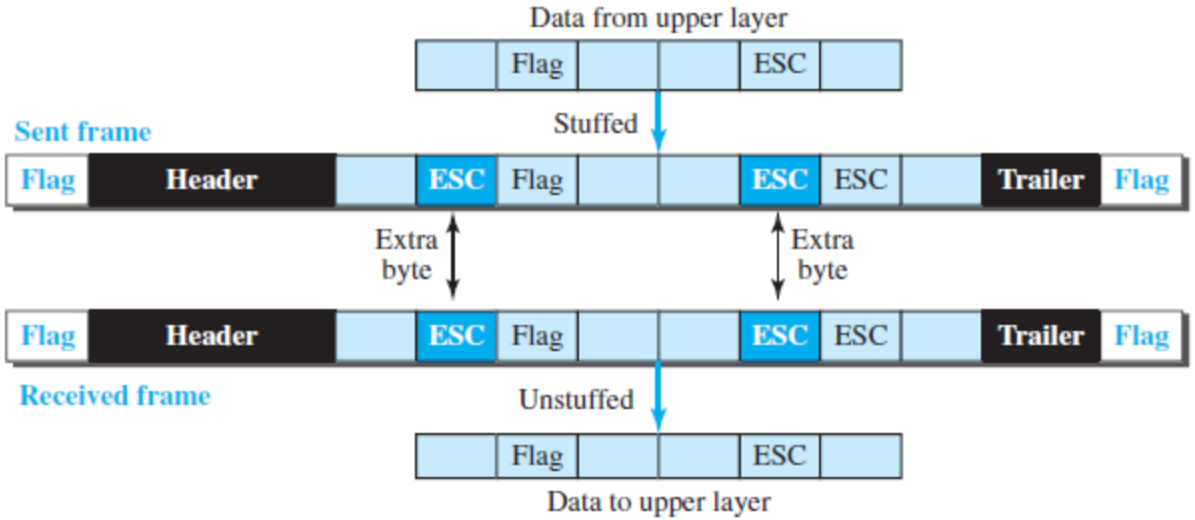
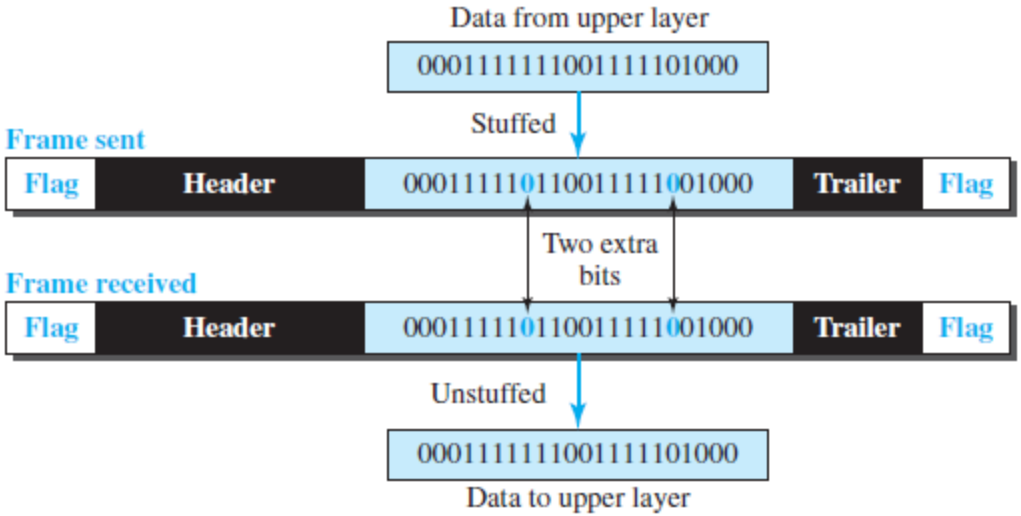


DATA LINK LAYER

Framing-Bit Stuffing



DATA LINK LAYER

Flow Control

- Feedback based flow control
- Rate based flow control

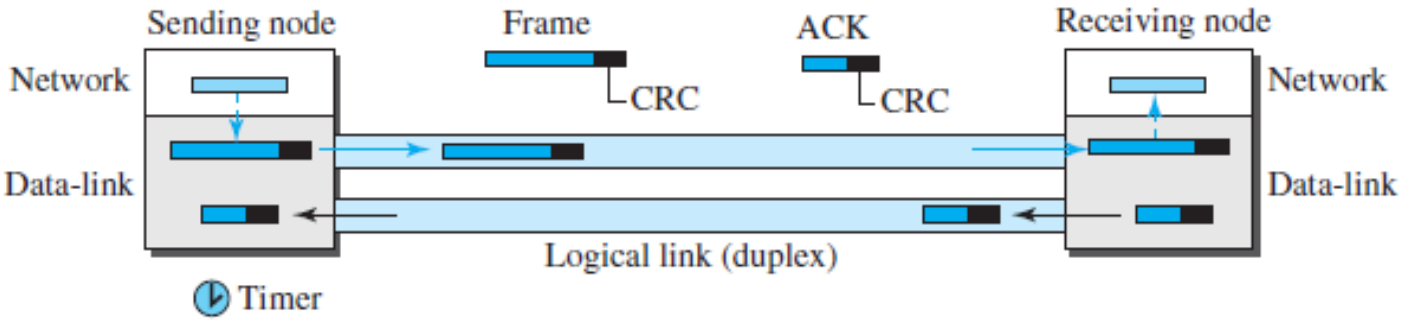
DATA LINK LAYER

Utopian Simplex Protocol

- Data transmission in unidirectional only
- Always network ready for sending and receiving
- Processing time not considering
- Infinite buffer space
- No lost or damaged frame

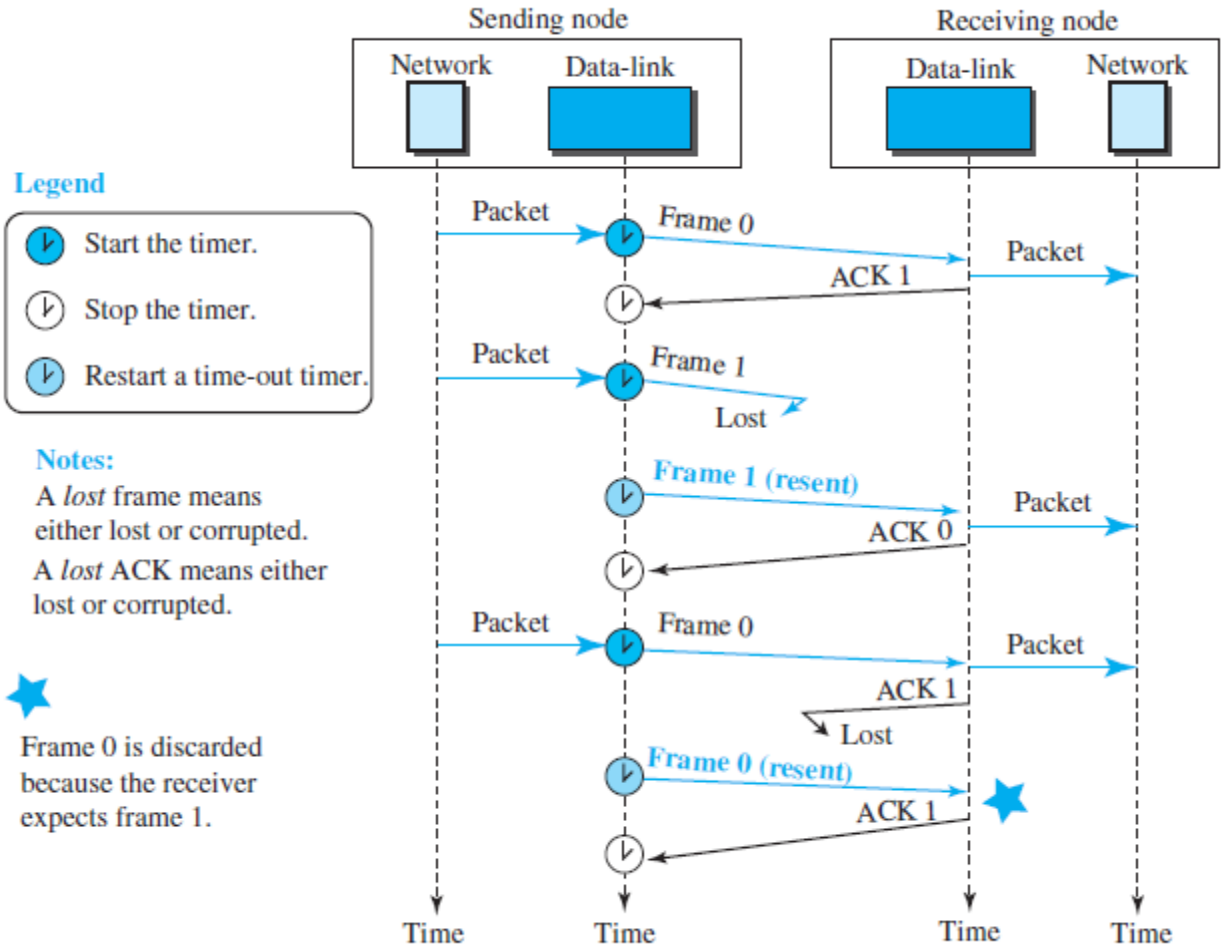
DATA LINK LAYER

Simplex Stop-and-Wait Protocol for noisy channel



DATA LINK LAYER

Stop-and-Wait Protocol without piggybacking



DATA LINK LAYER

ARQ protocols

- Protocols in which the sender waits for a positive acknowledgement before advancing to the next data item are often called **ARQ** (**Automatic Repeat reQuest**) or **PAR** (**Positive Acknowledgement with Retransmission**).

Transmission of a frame-Only three possibilities exist:

- an acknowledgement frame arrives undamaged
- a damaged acknowledgement frame staggers in
- the timer expires

Sender triggers ,

- If a valid acknowledgement comes in, the sender fetches the next packet from its network layer and puts it in the buffer, overwriting the previous packet
- If a damaged frame arrives or the timer expires, neither the buffer nor the sequence number is changed so that a duplicate can be sent

The technique of temporarily delaying outgoing acknowledgements so that they can be hooked onto the next outgoing data frame is known as **piggybacking**

DATA LINK LAYER

Sliding Window Protocols

- All sliding window protocols, each outbound frame contains a sequence number, ranging from 0 up to some maximum
- The maximum is usually $2^n - 1$ so the sequence number fits exactly in an n-bit field
- The stop-and-wait sliding window protocol uses $n = 1$, restricting the sequence numbers to 0 and 1

- ❑ Sending Window- permitted to send
- ❑ Receiving Window- permitted to receive

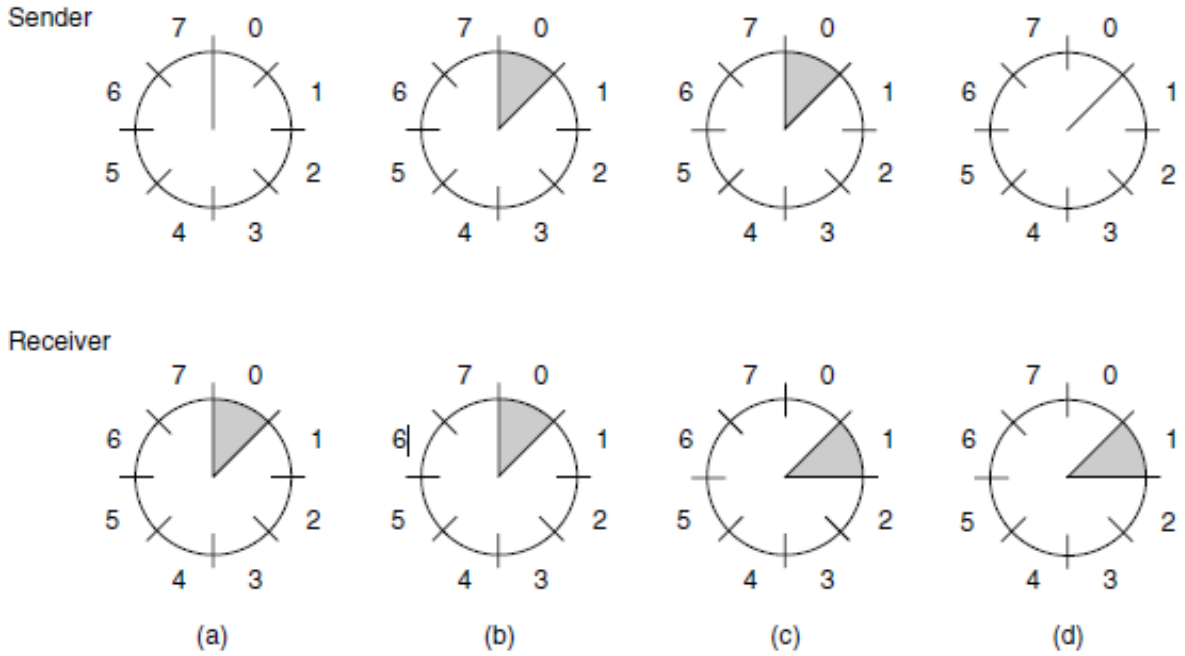
DATA LINK LAYER

Sliding Window Protocols

- The sender's window and the receiver's window need not have the same lower and upper limits or even have the same size
- If the maximum window size is *n*, the sender needs *n* buffers to hold the unacknowledged frames
- The receiving data link layer's window corresponds to the frames it may accept
- Any frame falling within the window is put in the receiver's buffer
- When a frame whose sequence number is equal to the lower edge of the window is received, it is passed to the network layer and the window is rotated by one.
- Any frame falling outside the window is discarded

DATA LINK LAYER

Sliding Window Protocols



sliding window of size 1, with a 3-bit sequence number.
(a) Initially (b) After the first frame has been sent (c) After the first frame has been received
(d) After the first acknowledgement has been received.

DATA LINK LAYER

Pipelining

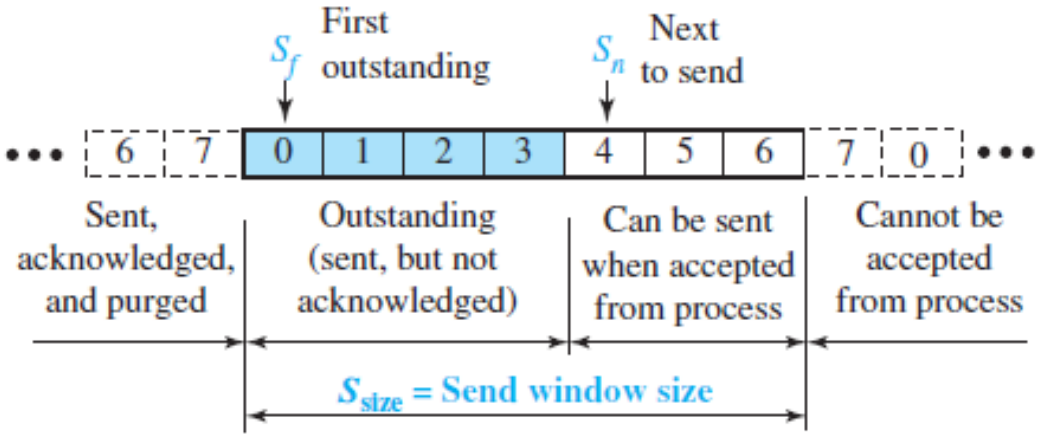
- Efficiency of the link can be increased by pipelining
- Several packets can be sent before a sender receives feedback about the previous packets.
- Pipelining improves the efficiency of the transmission if the number of bits in transition is large with respect to the bandwidth-delay product.

DATA LINK LAYER

Go-Back-*N* Protocol (GBN)

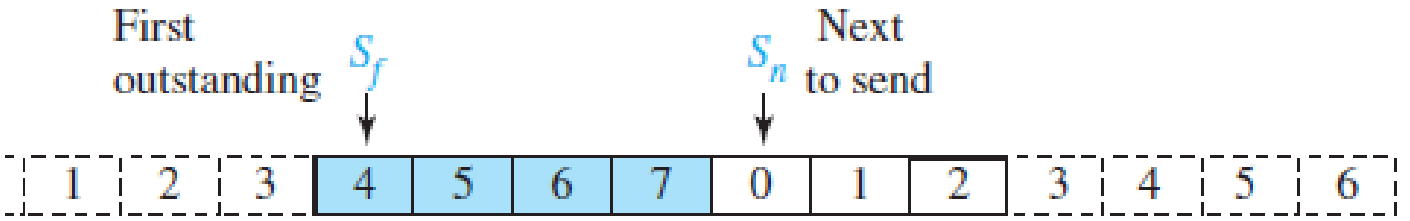
- More than one packet be outstanding to keep the channel busy while the sender is waiting for acknowledgment
- In the Go-Back-N protocol, the acknowledgment number is cumulative and defines the sequence number of the next packet expected to arrive.
- The maximum size of the window is $2^m - 1$, where m is the size of the sequence number field in bits.

Send window for Go-Back-N

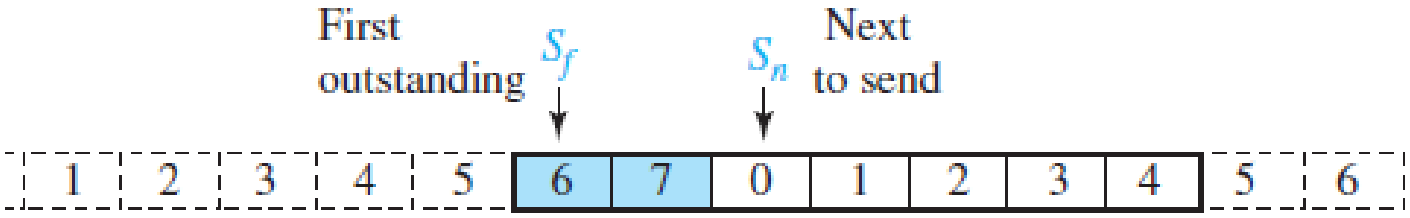


Go-Back-*N* Protocol (GBN)

Sliding the send window



a. Window before sliding



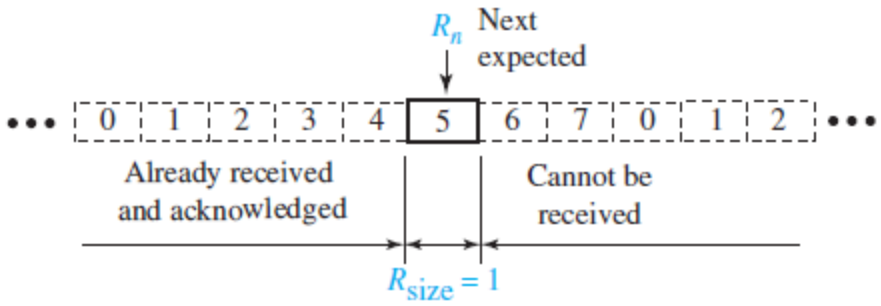
b. Window after sliding (an ACK with ackNo = 6 has arrived)

DATA LINK LAYER

Go-Back-*N* Protocol (GBN)

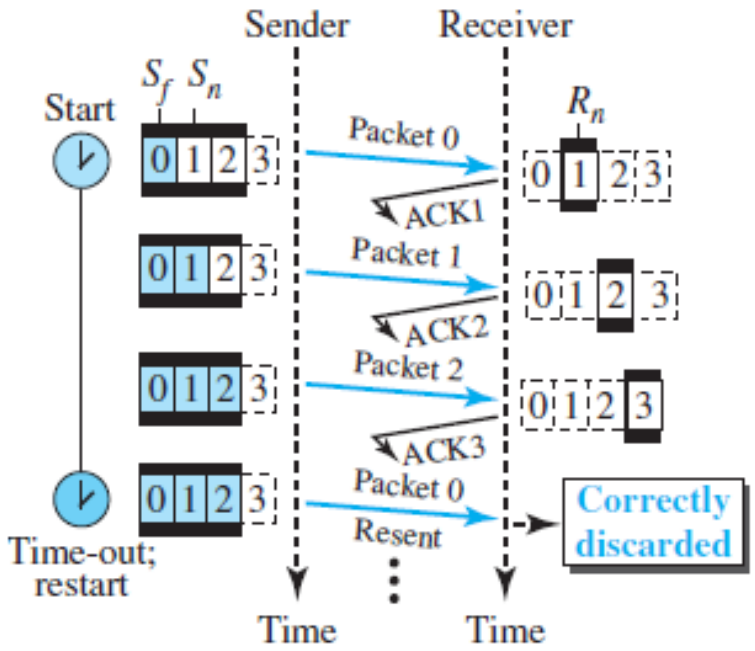
Receive Window

- The receive window makes sure that the correct data packets are received and that the correct acknowledgments are sent.
- In Go-Back-*N*, the size of the receive window is always 1.
- The receiver is always looking for the arrival of a specific packet.
- Any packet arriving out of order is discarded and needs to be resent
- When a correct packet is received, the window slides, $R_n = (R_n + 1)$ modulo $2m$.

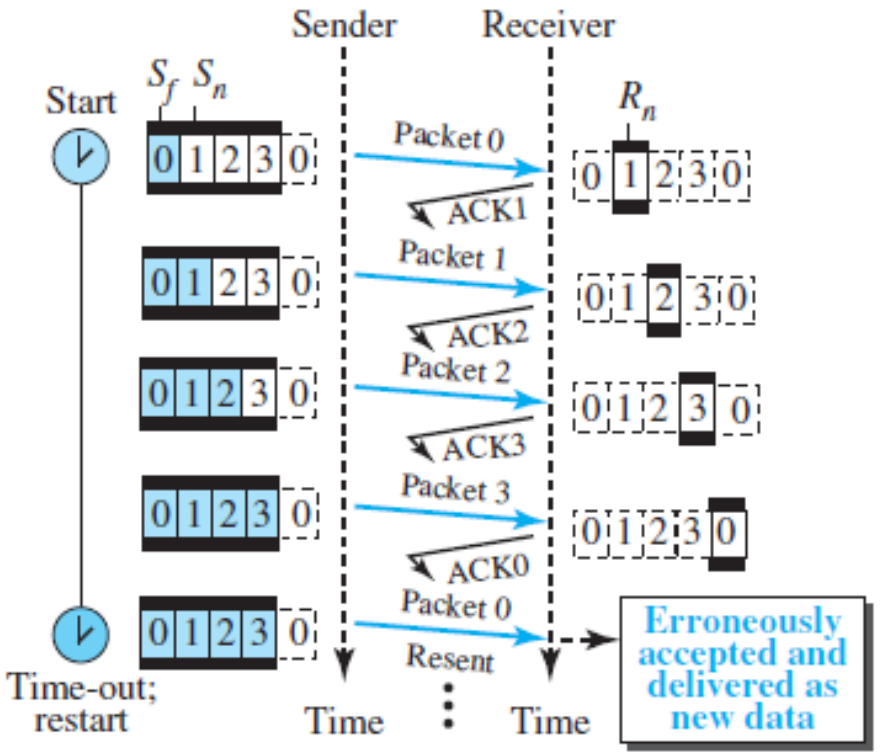


DATA LINK LAYER

Go-Back-*N* Protocol (GBN)



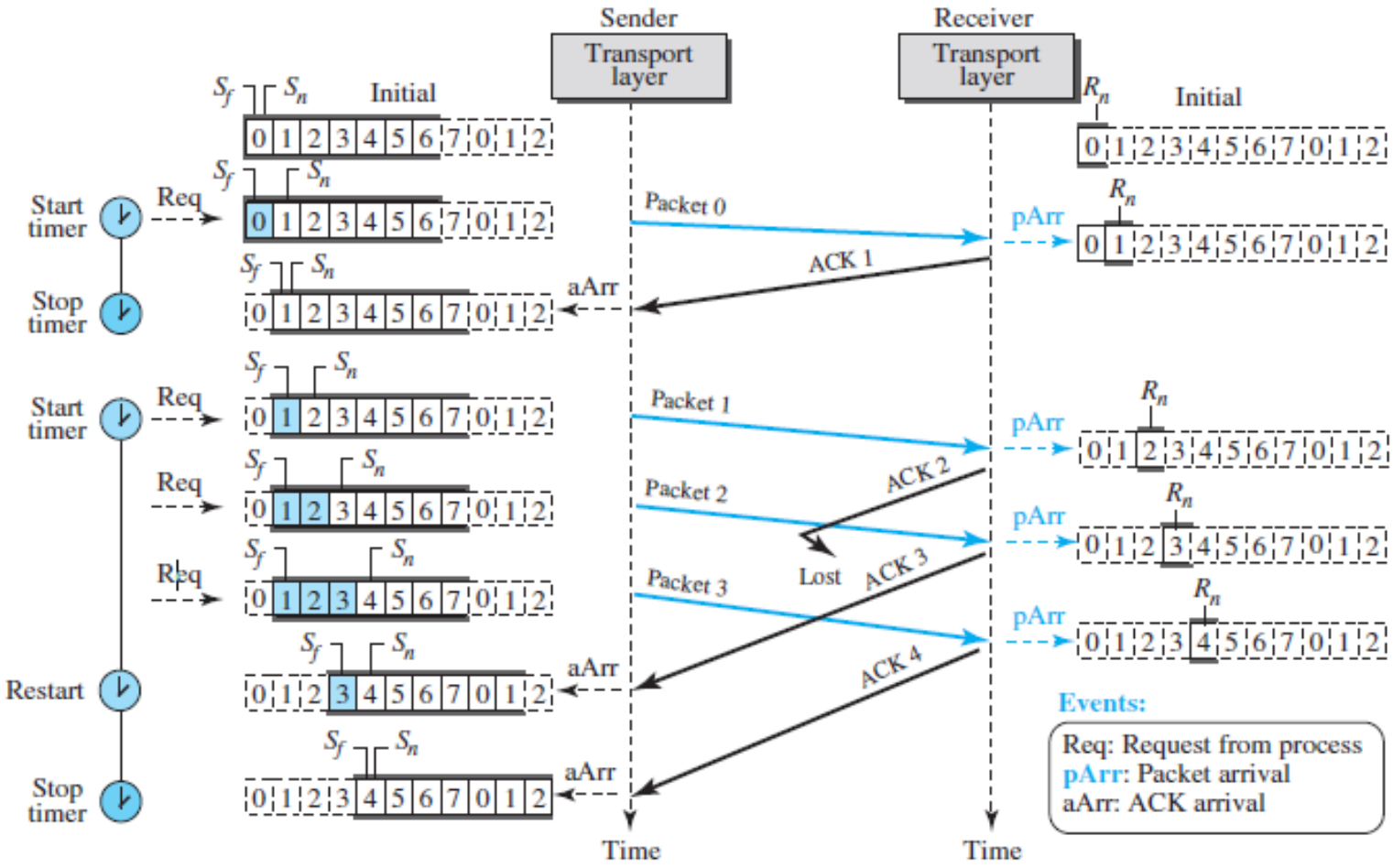
a. Send window of size $< 2^m$



b. Send window of size $= 2^m$

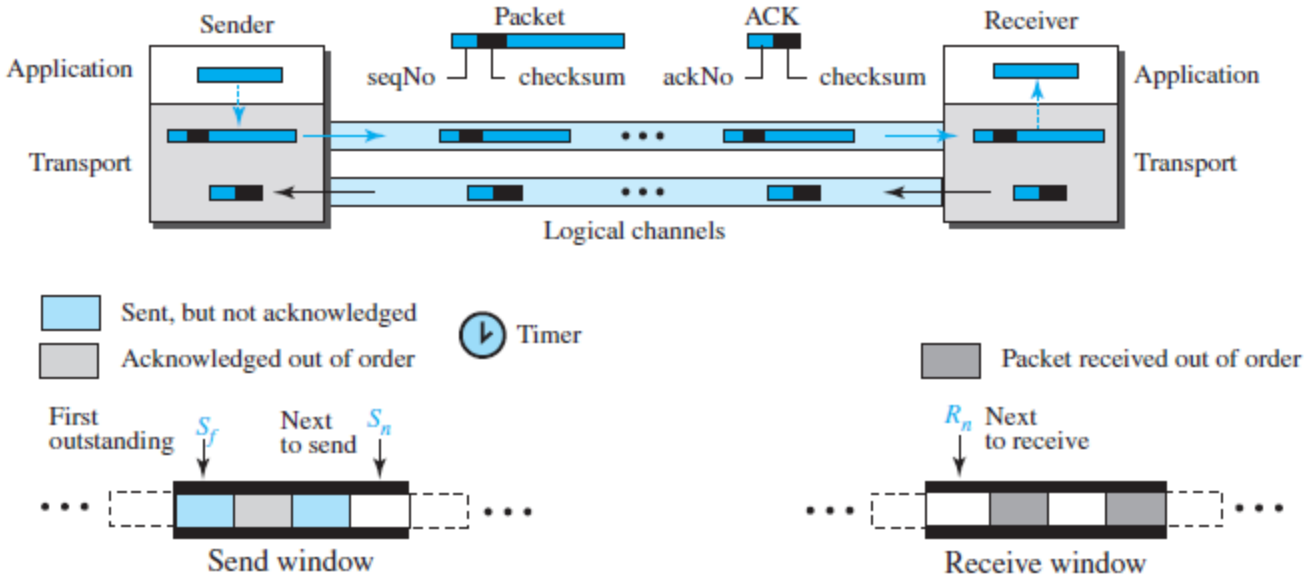
DATA LINK LAYER

Go-Back-*N* Protocol (GBN)



DATA LINK LAYER

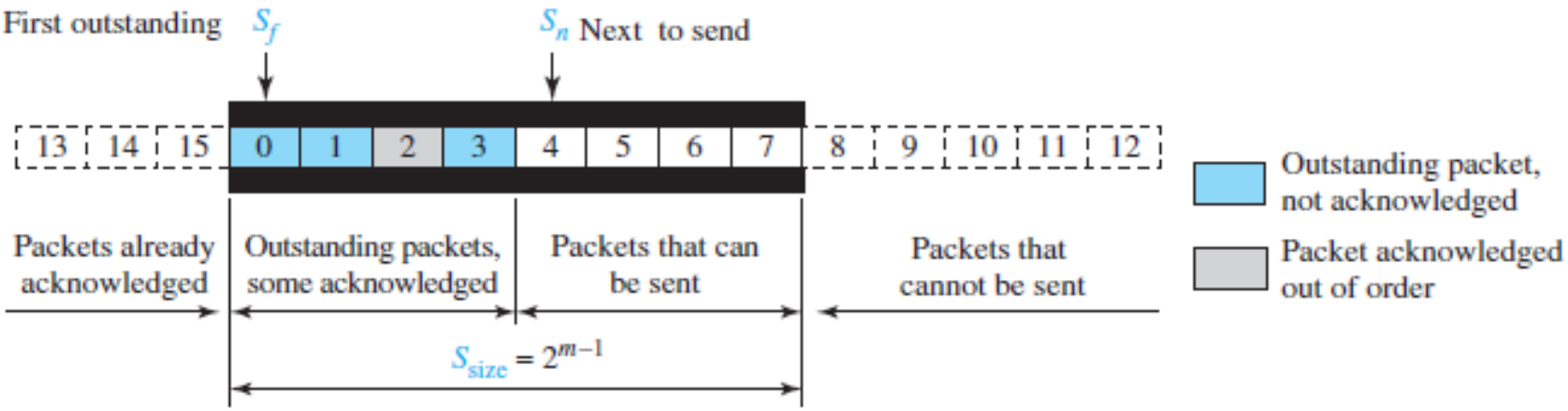
Selective-Repeat Protocol (SR)



DATA LINK LAYER

Selective-Repeat Protocol (SR)

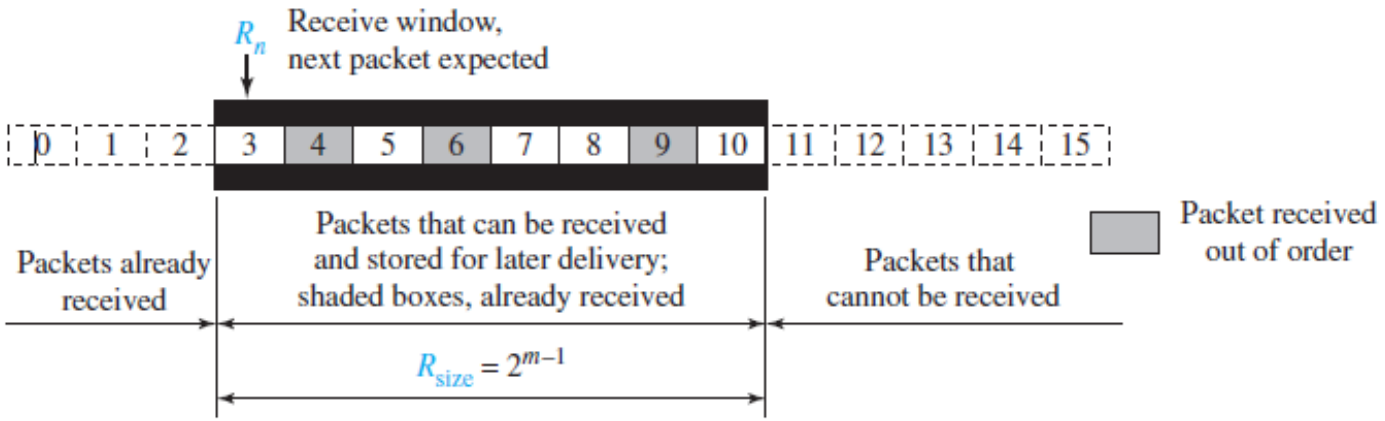
Send window



DATA LINK LAYER

Selective-Repeat Protocol (SR)

Receive window



DATA LINK LAYER

Selective-Repeat Protocol (SR)