

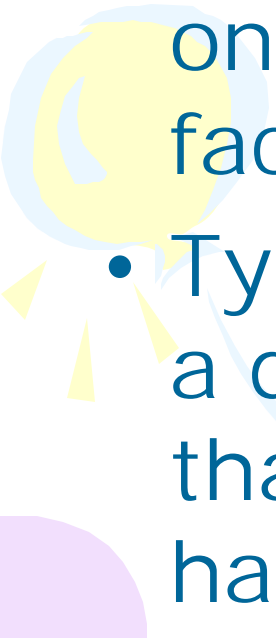

The background features several large, overlapping, semi-transparent swirls in shades of purple, green, and blue. Scattered throughout are numerous small, yellow, triangular shapes that resemble sun rays or decorative elements.

Data Link Layer

Jaringan Komputer
Minggu ke-8



What is Data Link Layer

- The layer that regulates and formats transmission of data from software on a node to the network cabling facilities.
 - Typically implemented on a node as a device driver (software component that is specific to both a piece of hardware)
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A decorative graphic on the left side of the slide features three balloons: a yellow one at the top, a yellow one in the middle, and a purple one at the bottom. Each balloon has a string and several small yellow triangular shapes representing streamers or light rays. The balloons are partially overlapping and have a soft, glowing effect.

Data Link Services

- Framing, which involves partitioning data into frames and exchanging these frames over the link
- Frame sequencing, involves maintaining the correct ordering of frame as they are being exchanged

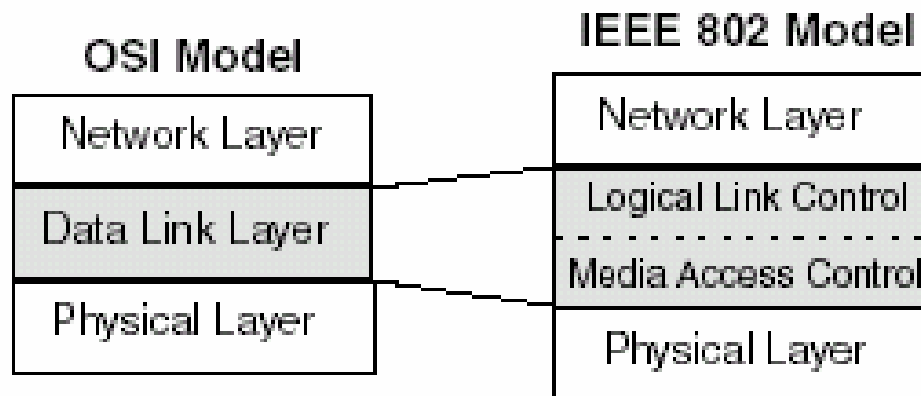


Data Link Services

- Establishing and maintaining an acceptable level of flow control as frames are being exchanged across a link
 - Detecting/correcting errors in the physical layer, includes error notification when errors are detected but not corrected
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LLC & MAC

- IEEE divides OSI's data link layer into two parts :
 - Logical Link Control Sublayer (LLC)
 - Media Access Control Sublayer (MAC)





LLC - Framing

- Framing refers to the process of partitioning a bit stream into discrete units or blocks of data called frames
- Framing enables sending and receiving machines to synchronize the transmission and reception of data because frames have detectable boundaries.
- Framing also facilitates error detection and correction.



LLC - Framing

- One common framing procedure involves inserting flag characters before and after the transmitted data message.
- The data set has been “framed” by distinct boundaries consisting of start-stop flags(bits) known as bit-stuffing.



LLC – Bit Stuffing

Data set to be transmitted: 1111110011111011

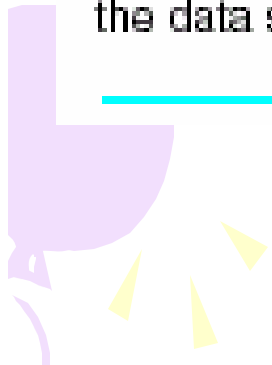
Data set after bit-stuffing: 111110100111110011

Data set after bit-stuffing and start–stop bits have been inserted: 0111111011111010011111001101111110

Thus, the frame to be transmitted is:

01111110 111110100111110011 01111110
Start of Frame User Data with Bit-Stuffing End of Frame

The data link layer on the receiving machine removes the start and stop bits and unstuffs the data set by removing the 0-bits that follow each set of five consecutive 1-bits.





LLC – IEEE 802.3 Frame

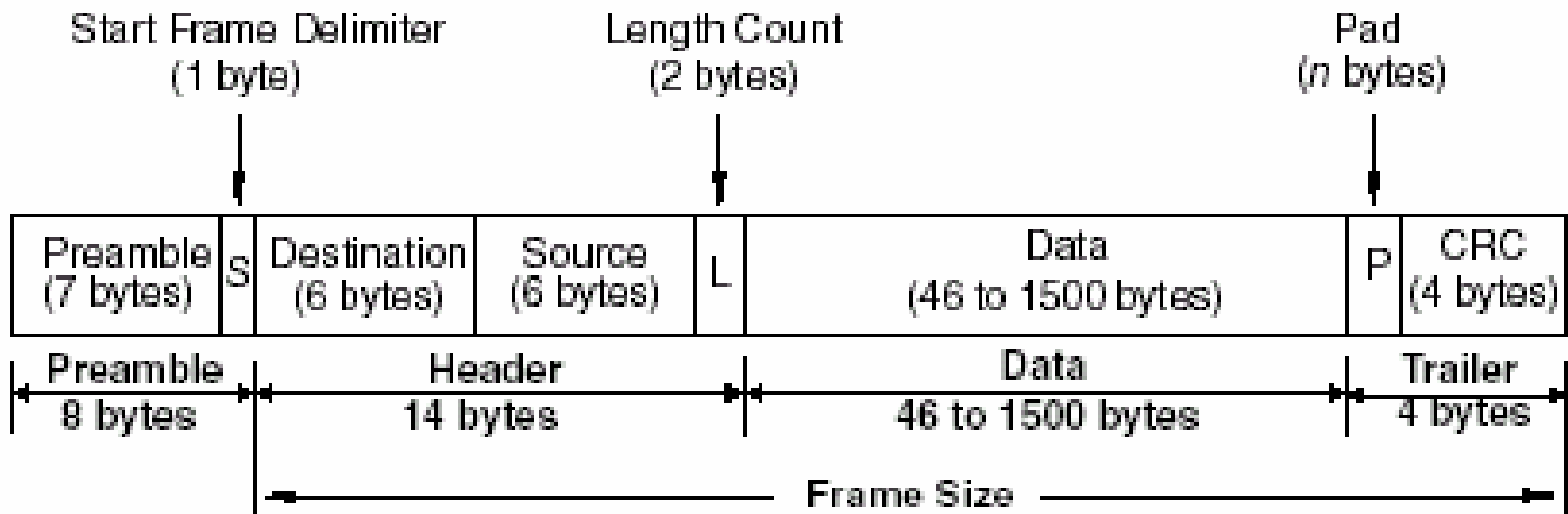
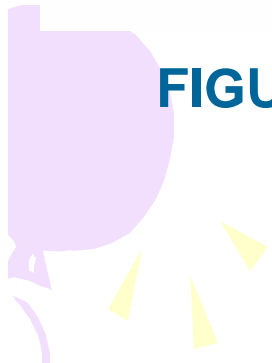


FIGURE 5.3 The contents and structure of an IEEE 802.3 frame.





LLC – Flow Control

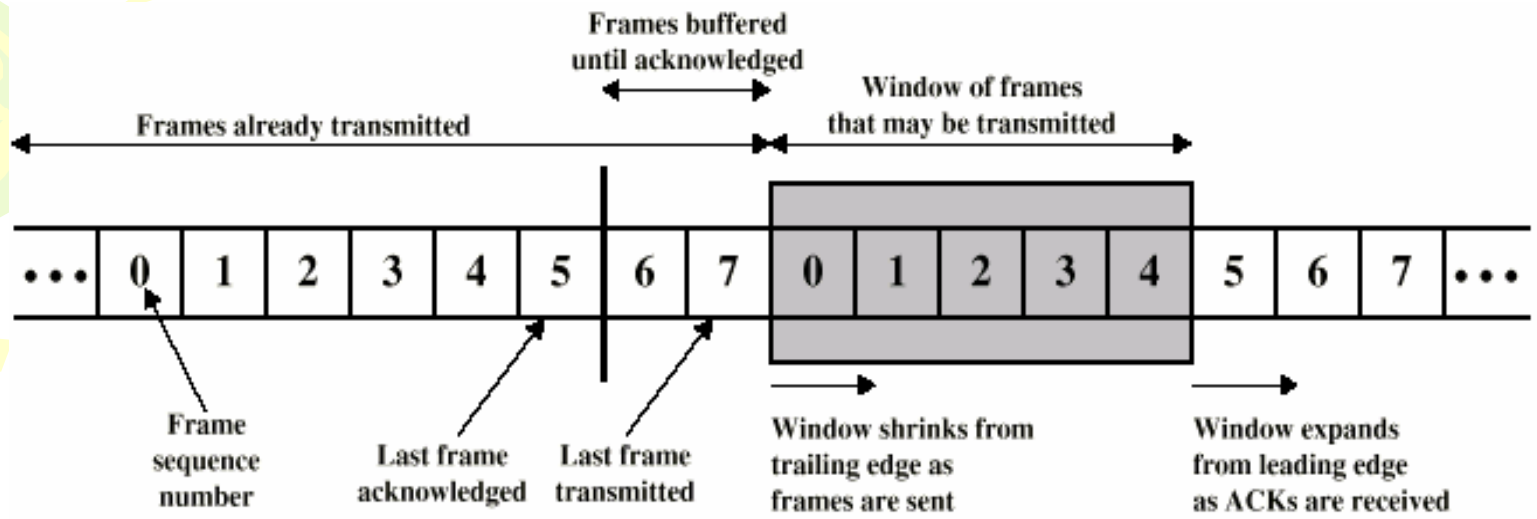
- Flow Control refers to a process that controls the rate at which data are exchanged between two nodes.
- Flow control involves a feedback mechanism that informs the source machine of the destination machine's ability to keep up with current flow of data transmission.
- Usually, a source node may not transmit frames until it receives permission from the destination machine.



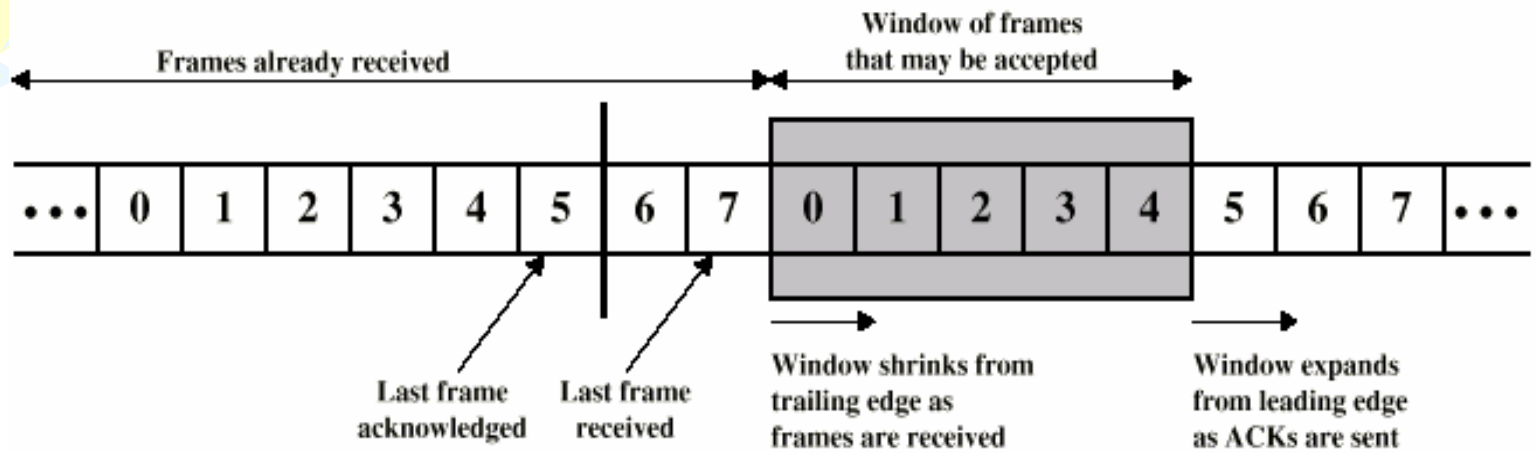
LLC – Flow Control

- Stop & Wait Flow Control
- Sliding Window Flow Control

SLIDING WINDOW

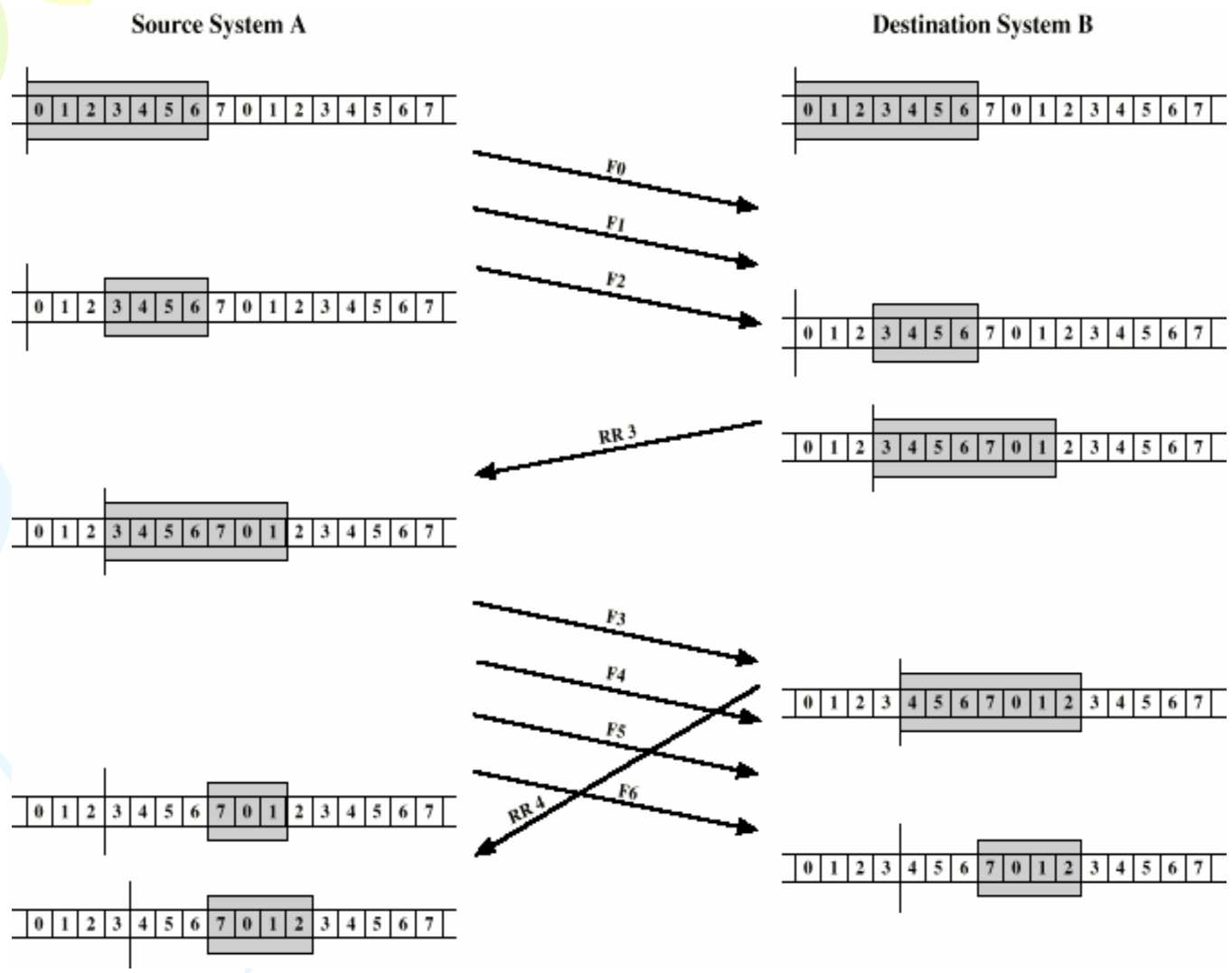


(a) Sender's perspective

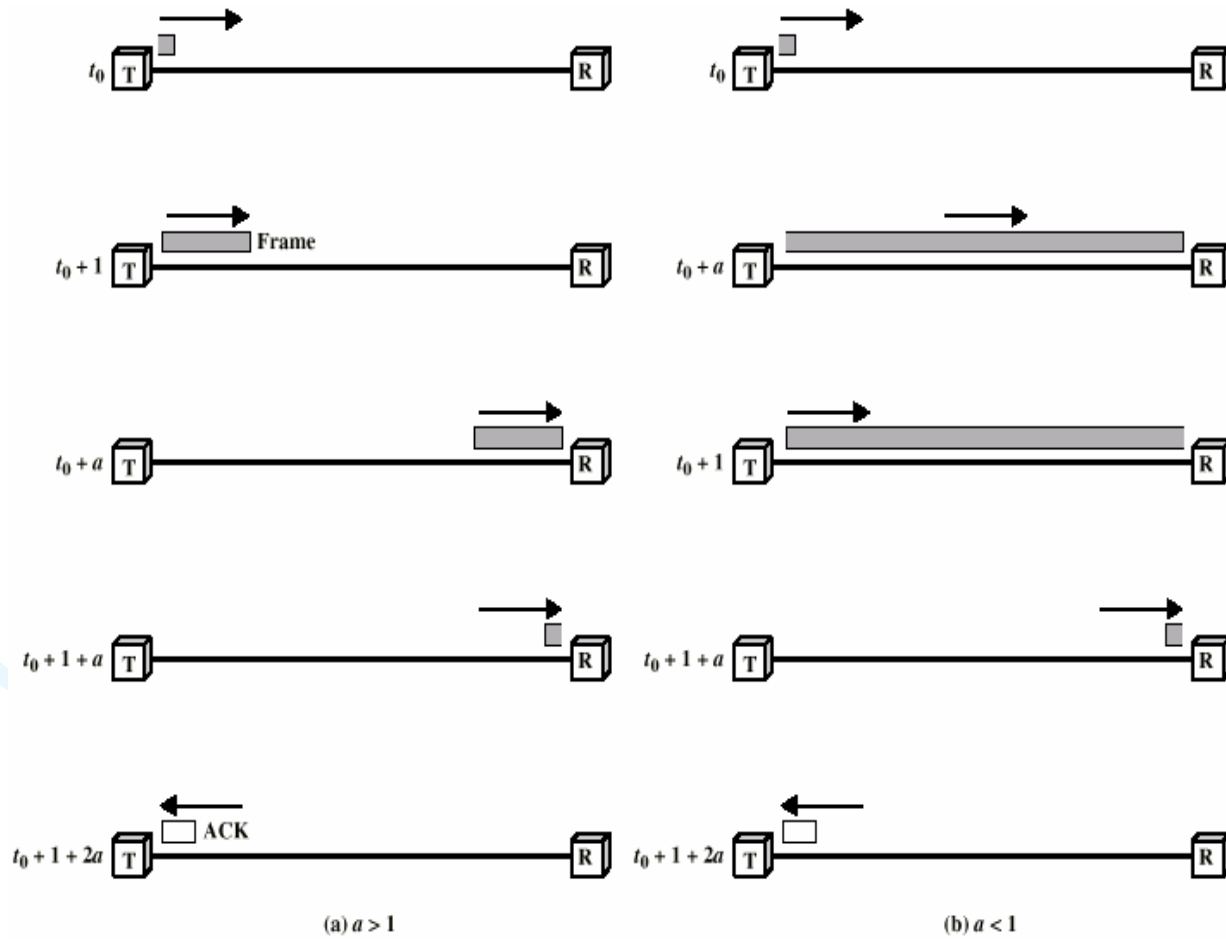


(b) Receiver's perspective

SLIDING WINDOW



Stop & Wait Flow Control





Error Control

- Error Control refers to the process of guaranteeing reliable data delivery
- Error Detection method
 - Parity Bits
 - CRC (Cyclic Redundancy Check)



Parity Bits

- Bit string of "A": 1 0 0 0 0 0 1
 - For even parity, parity bit is 0:
(even number of 1-bits) 1 0 0 0 0 0 1 0
 - For odd parity, parity bit is 1:
(odd number of 1-bits) 1 0 0 0 0 0 1 1
-



C R C

- CRC-12

$$- X^{12} + X^{11} + X^3 + X^2 + X + 1$$

- CRC-16

$$- X^{16} + X^{15} + X^2 + 1$$

- CRC-CCITT

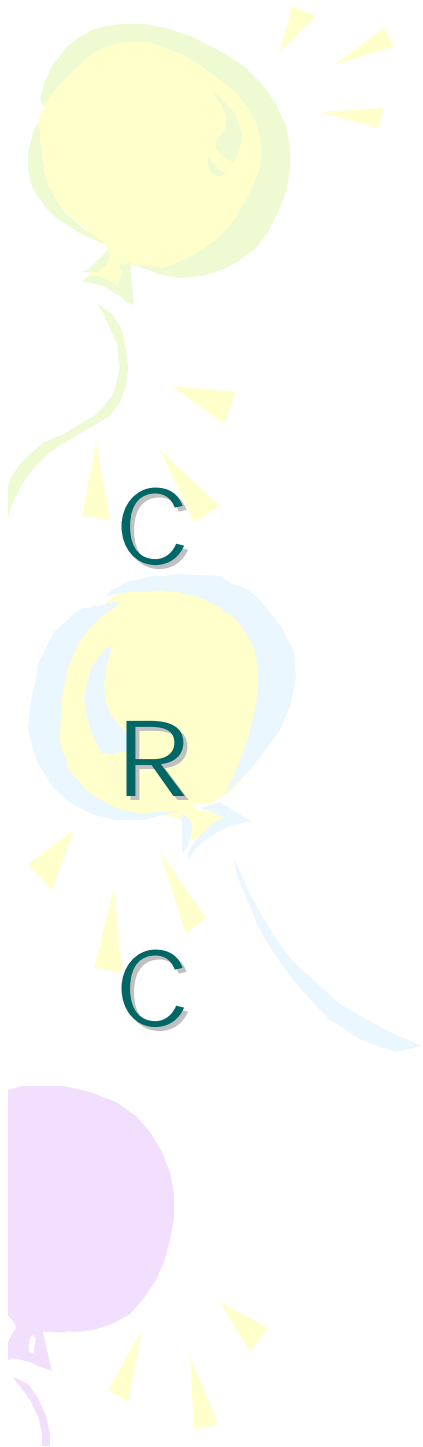
$$- X^{16} + X^{15} + X^5 + 1$$

- CRC-32

$$- X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10}$$

$$- X^8 + X^7 + X^5 + X^4 + X^2 + X + 1$$

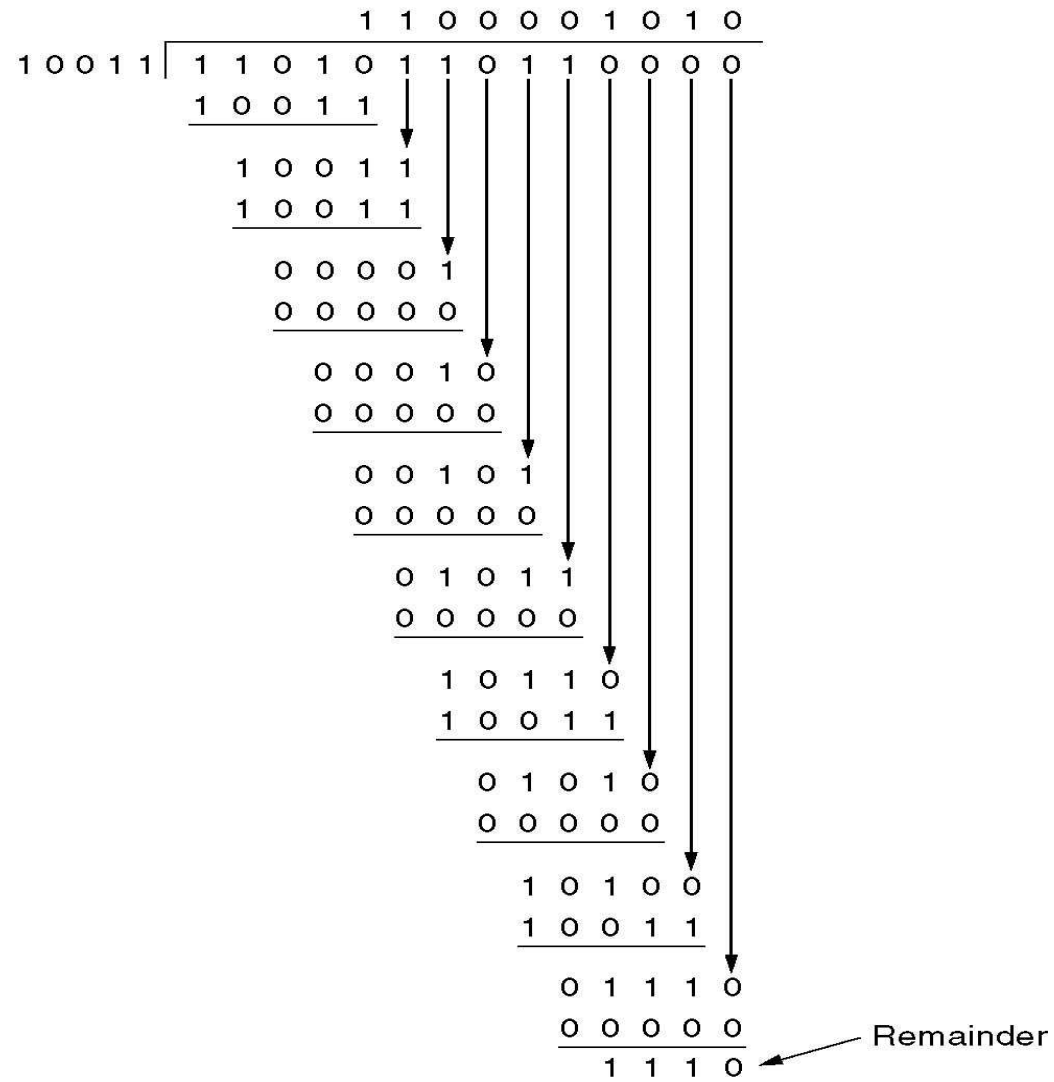
- CRC's Are Implemented in Shift registers



Frame : 1 1 0 1 0 1 1 0 1 1

Generator: 1 0 0 1 1

Message after 4 zero bits are appended: 1 1 0 1 0 1 1 0 1 1 0 0 0 0



Transmitted frame: 1 1 0 1 0 1 1 0 1 1 1 1 1 0



Error Control

- Detection and correction of errors
- Lost frames
- Damaged frames
- Automatic repeat request
 - Error detection
 - Positive acknowledgment
 - Retransmission after timeout
 - Negative acknowledgement and retransmission



Automatic Repeat Request (ARQ)

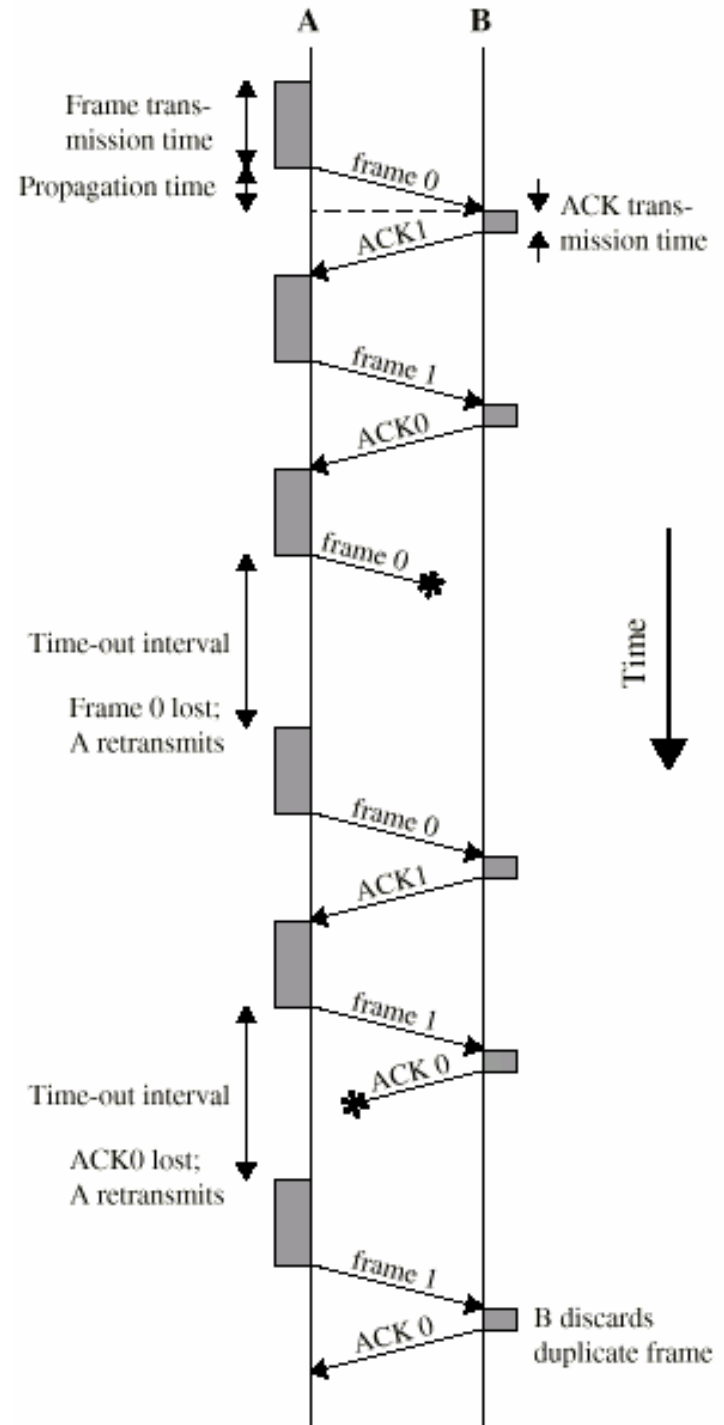
- Stop and wait
- Go back N
- Selective reject (selective retransmission)



Stop and Wait

- Source transmits single frame
- Wait for ACK
 - If received frame damaged, discard it
 - Transmitter has timeout
 - If no ACK within timeout, retransmit
 - If ACK damaged, transmitter will not recognize it
 - Transmitter will retransmit
 - Receiver gets two copies of frame
 - Use ACK0 and ACK1

Stop and Wait - Diagram





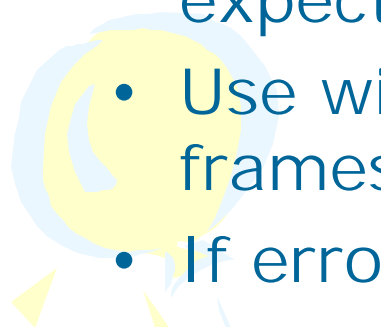

Stop and Wait – Pros and Cons

- Simple
- Inefficient





Go Back N (1)

- Based on sliding window
 - If no error, ACK as usual with next frame expected
 - Use window to control number of outstanding frames
 - If error, reply with rejection
 - Discard that frame and all future frames until error frame received correctly
 - Transmitter must go back and retransmit that frame and all subsequent frames
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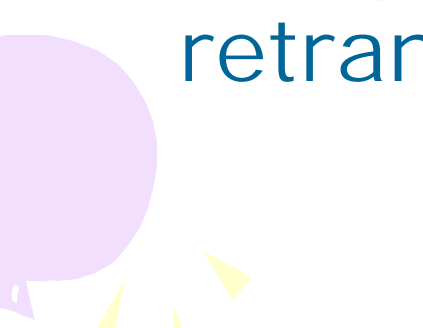


Go Back N - Damaged Frame

- Receiver detects error in frame i
- Receiver sends rejection- i
- Transmitter gets rejection- i
- Transmitter retransmits frame i and all subsequent



Go Back N - Lost Frame (1)

- Frame i lost
 - Transmitter sends $i+1$
 - Receiver gets frame $i+1$ out of sequence
 - Receiver send reject i
 - Transmitter goes back to frame i and retransmits
- 
- 



Go Back N - Lost Frame (2)

- Frame i lost and no additional frame sent
- Receiver gets nothing and returns neither acknowledgement nor rejection
- Transmitter times out and sends acknowledgement frame with P bit set to 1
- Receiver interprets this as command which it acknowledges with the number of the next frame it expects (frame i)
- Transmitter then retransmits frame i



Go Back N - Damaged Acknowledgement

- Receiver gets frame i and send acknowledgement ($i+n$) which is lost
- Acknowledgements are cumulative, so next acknowledgement ($i+n$) may arrive before transmitter times out on frame i
- If transmitter times out, it sends acknowledgement with P bit set as before
- This can be repeated a number of times before a reset procedure is initiated

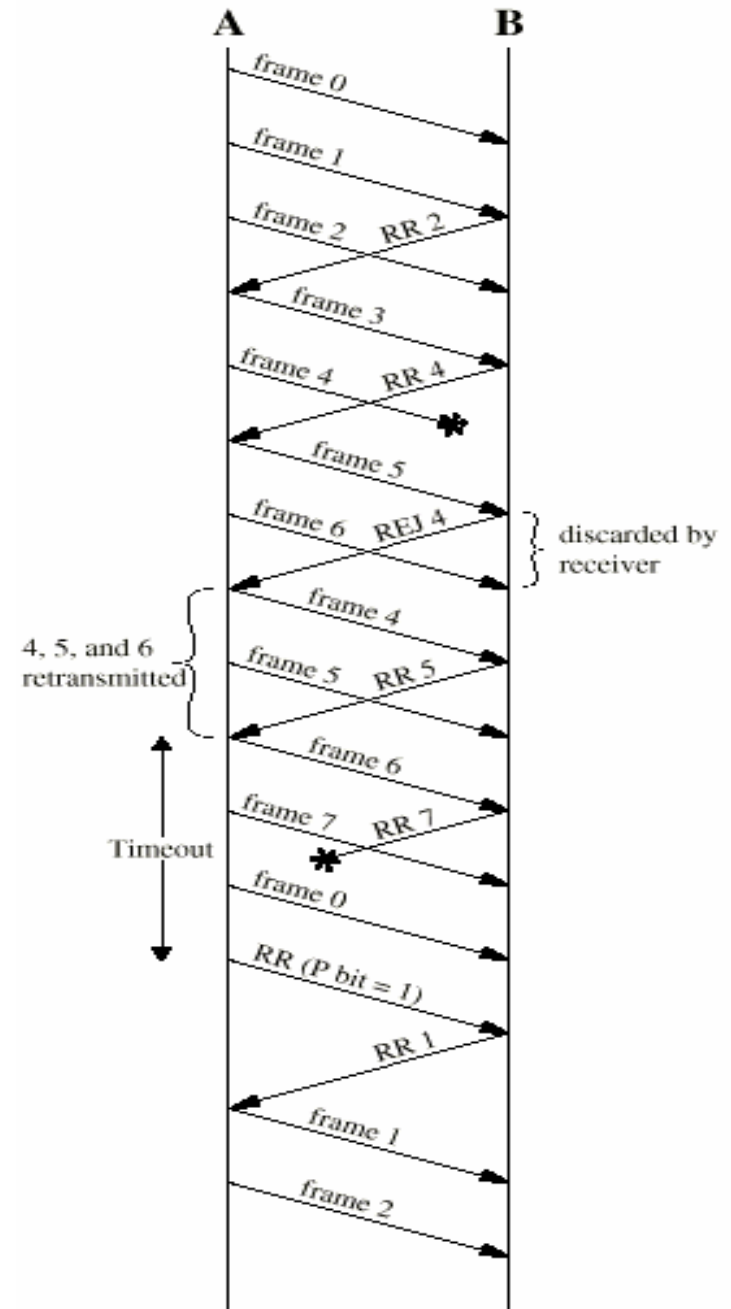


Go Back N - Damaged Rejection

- As for lost frame (2)



Go Back N - Diagram





Selective Reject

- Also called selective retransmission
- Only rejected frames are retransmitted
- Subsequent frames are accepted by the receiver and buffered
- Minimizes retransmission
- Receiver must maintain large enough buffer
- More complex logic in transmitter

Selective Reject - Diagram

