Computer Networks: Data Link Layer

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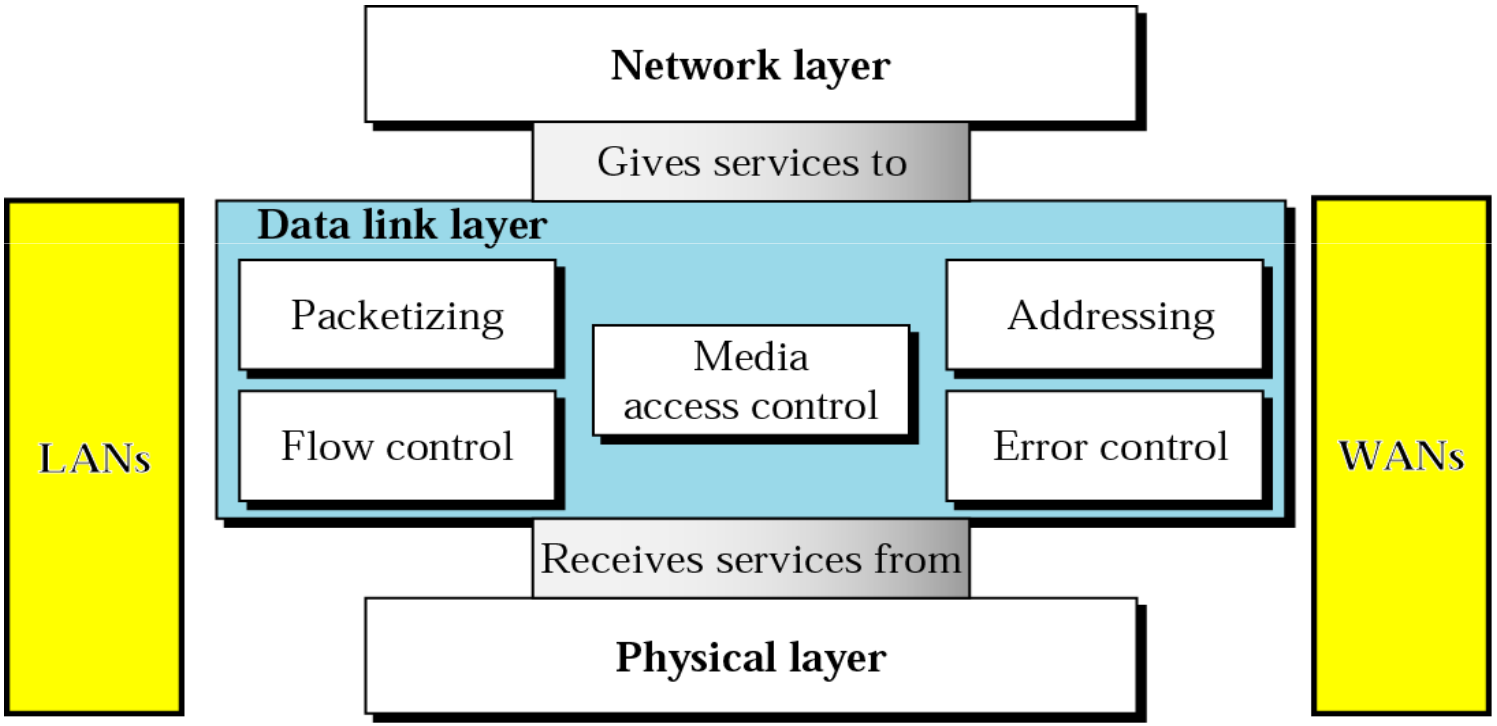
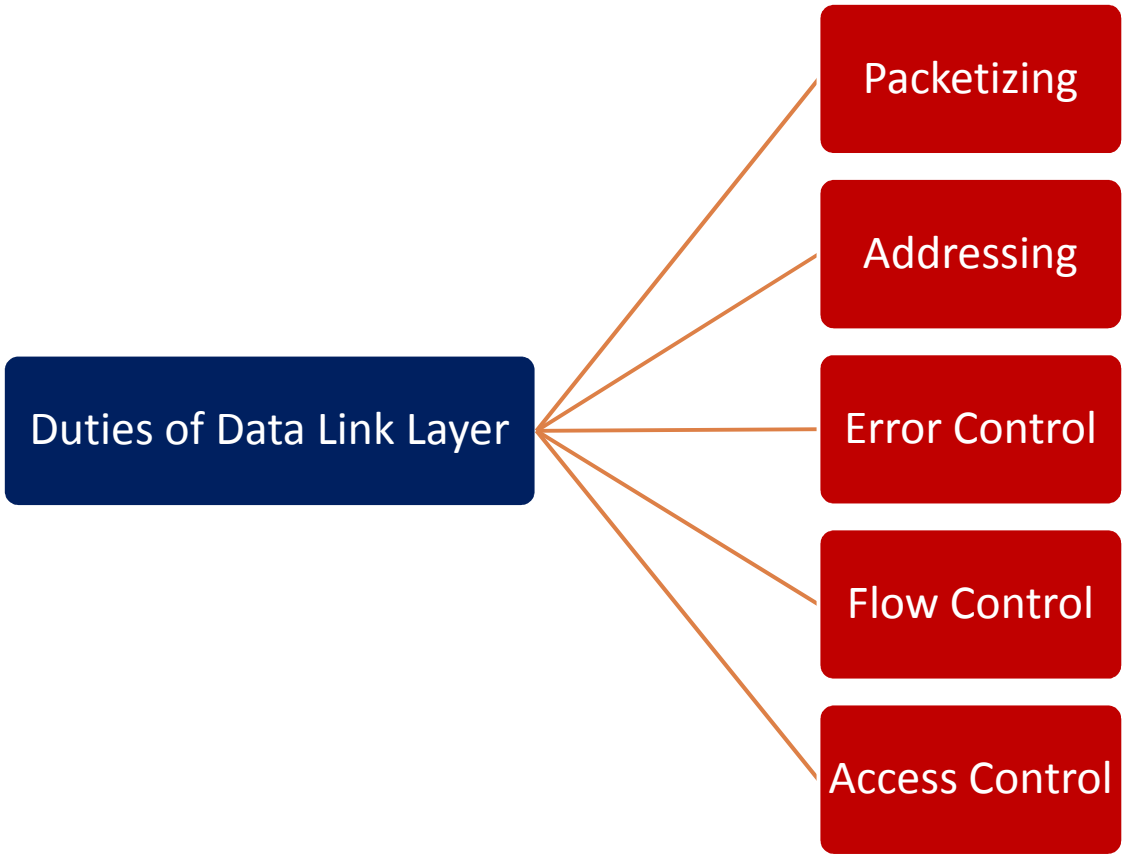
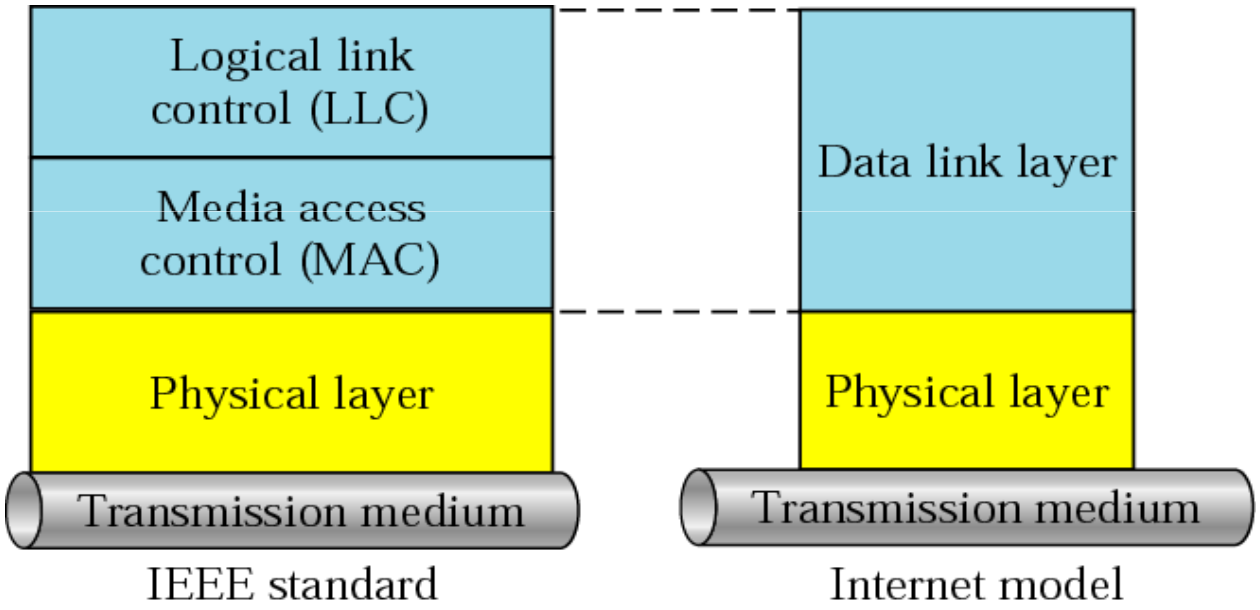
OSI Layers : Position of Data Link Layer



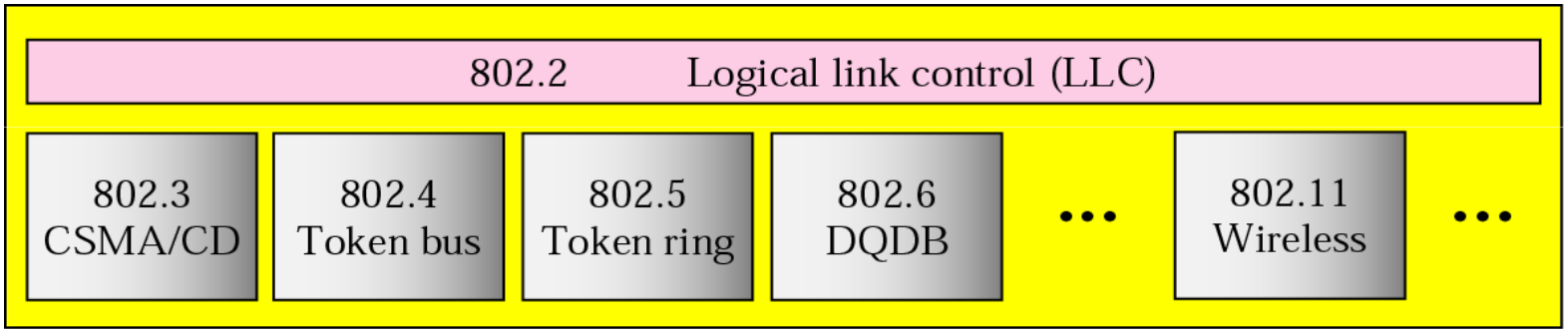
Data Link Layer : Duties ??



Data Link Layer : Sub Layers

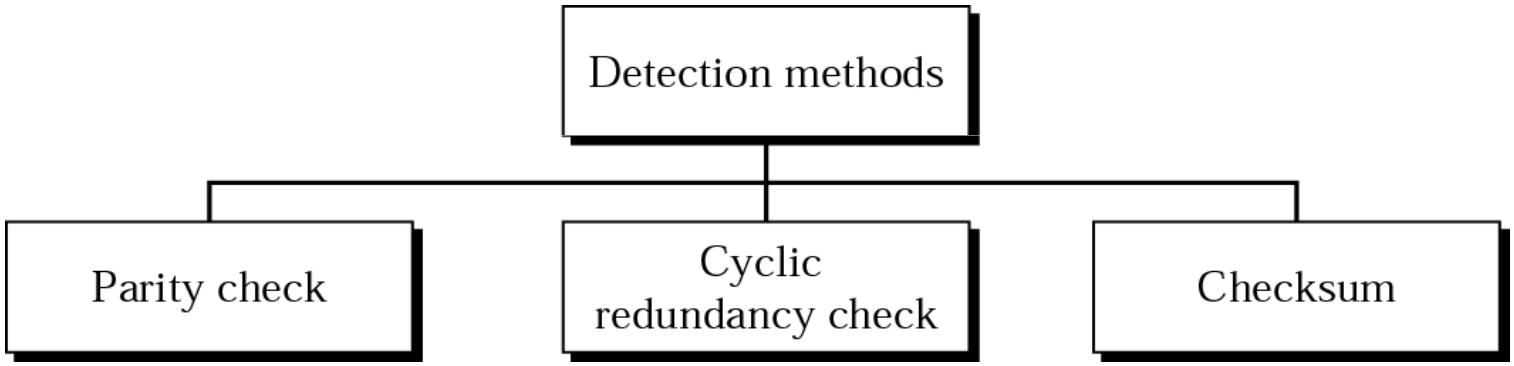


Data Link Layer : IEEE Standards For LANs

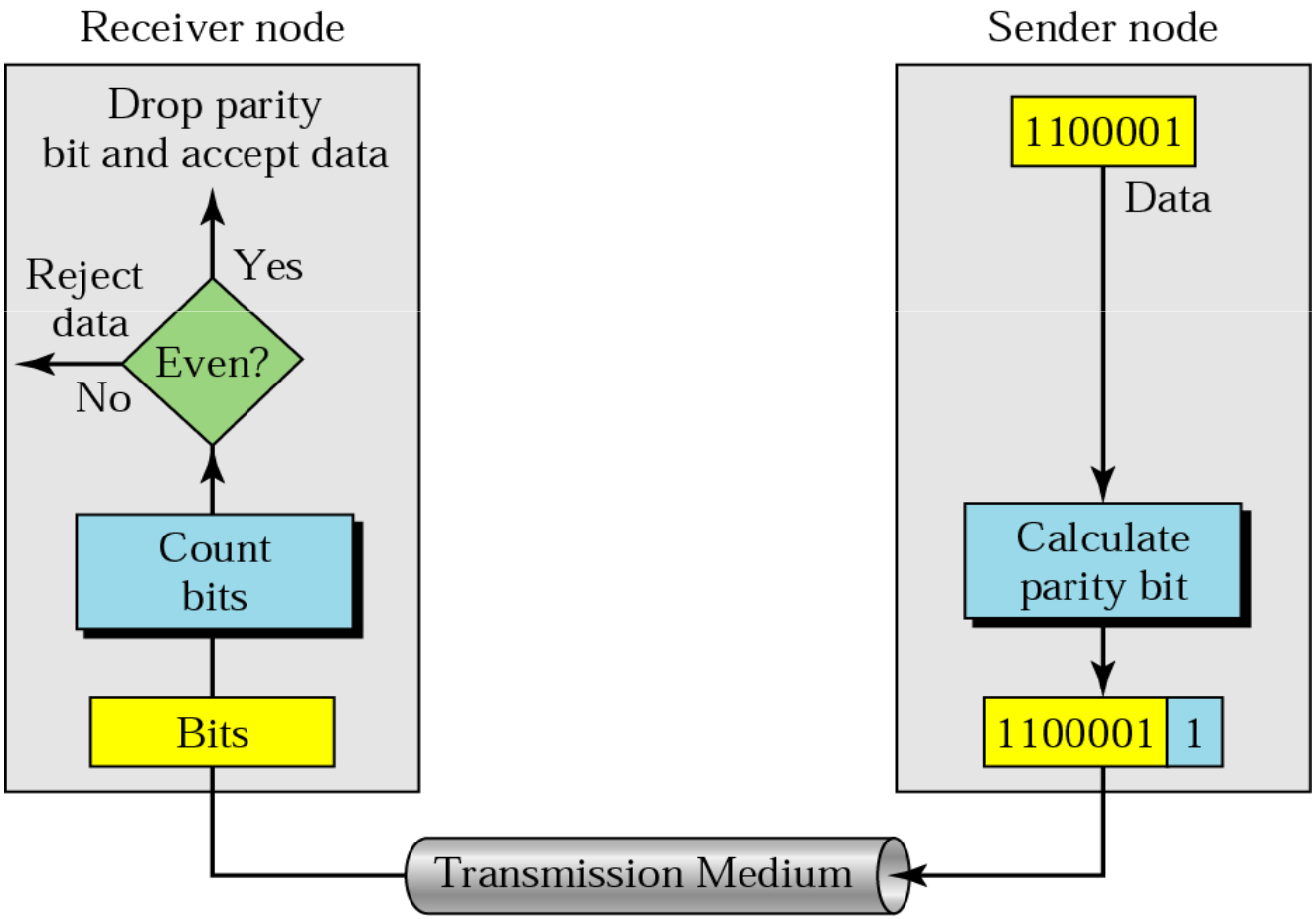


Project 802

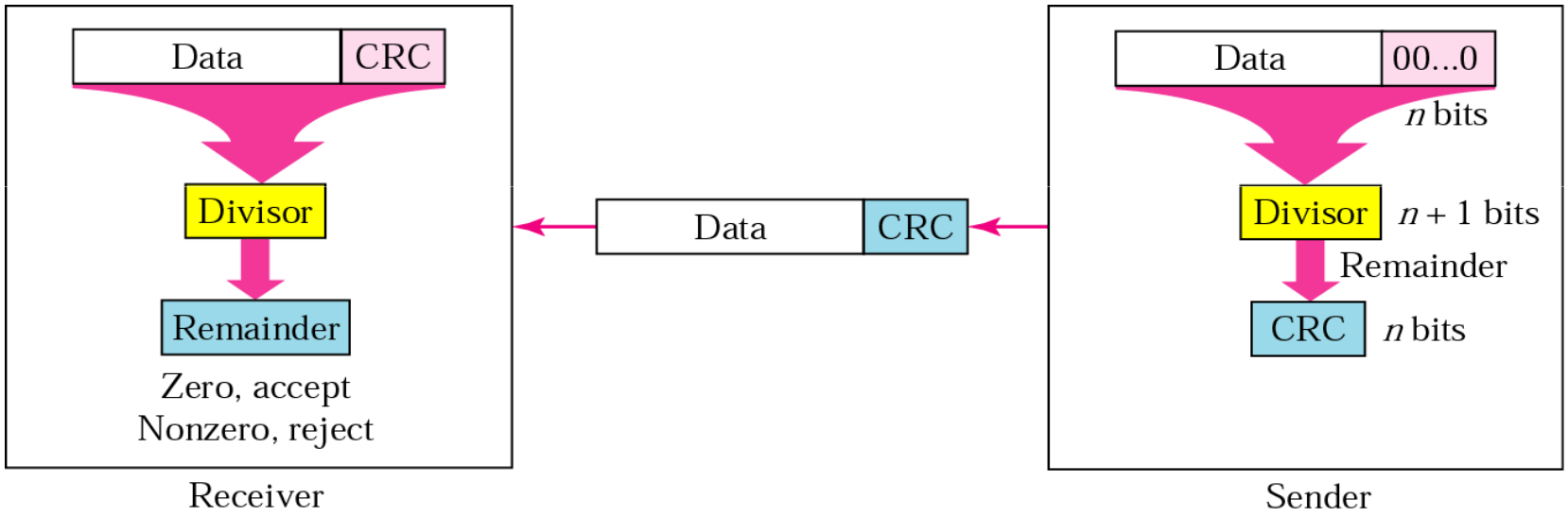
Data Link Layer : Error Detection



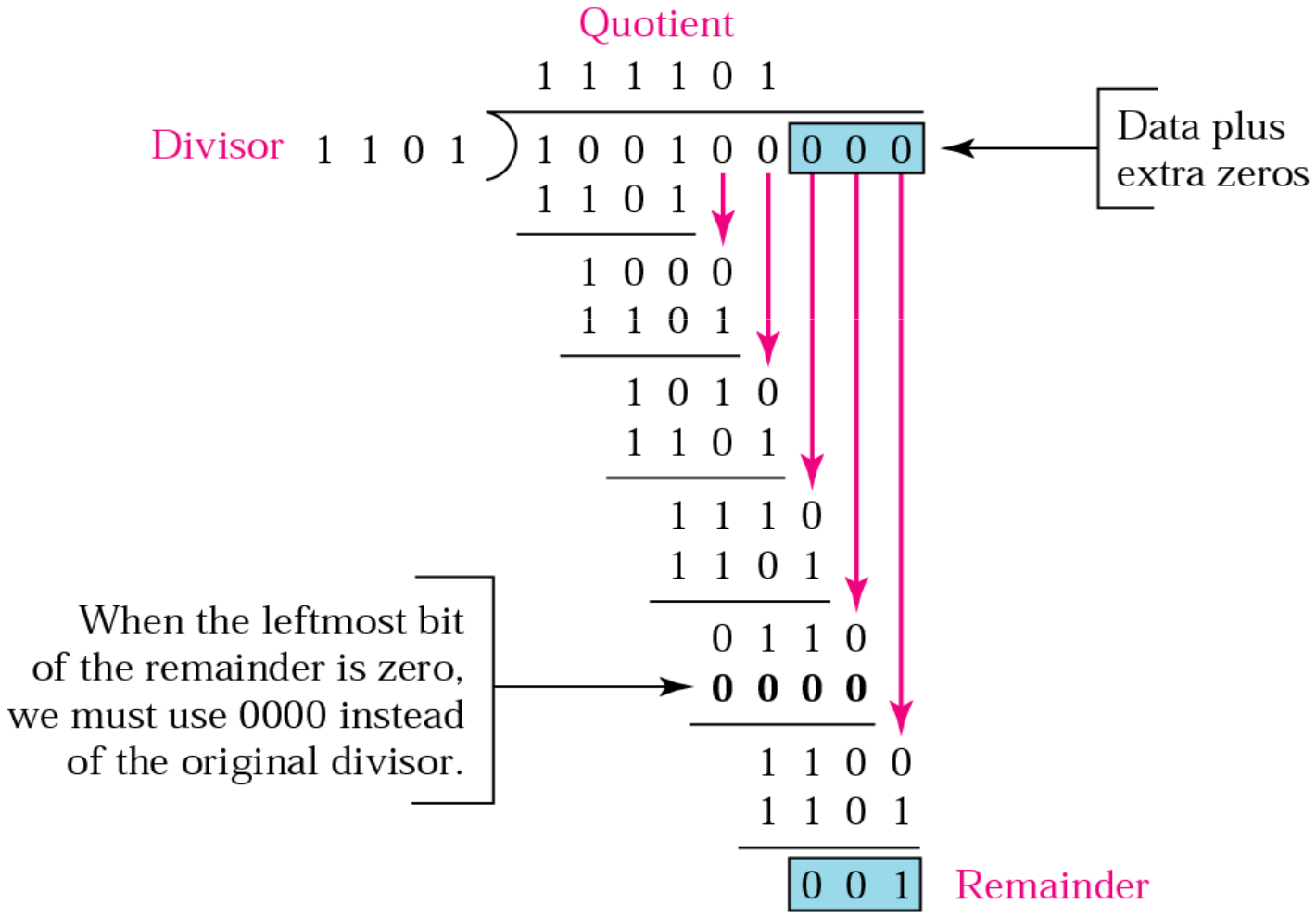
Parity Check : Even Parity Concept



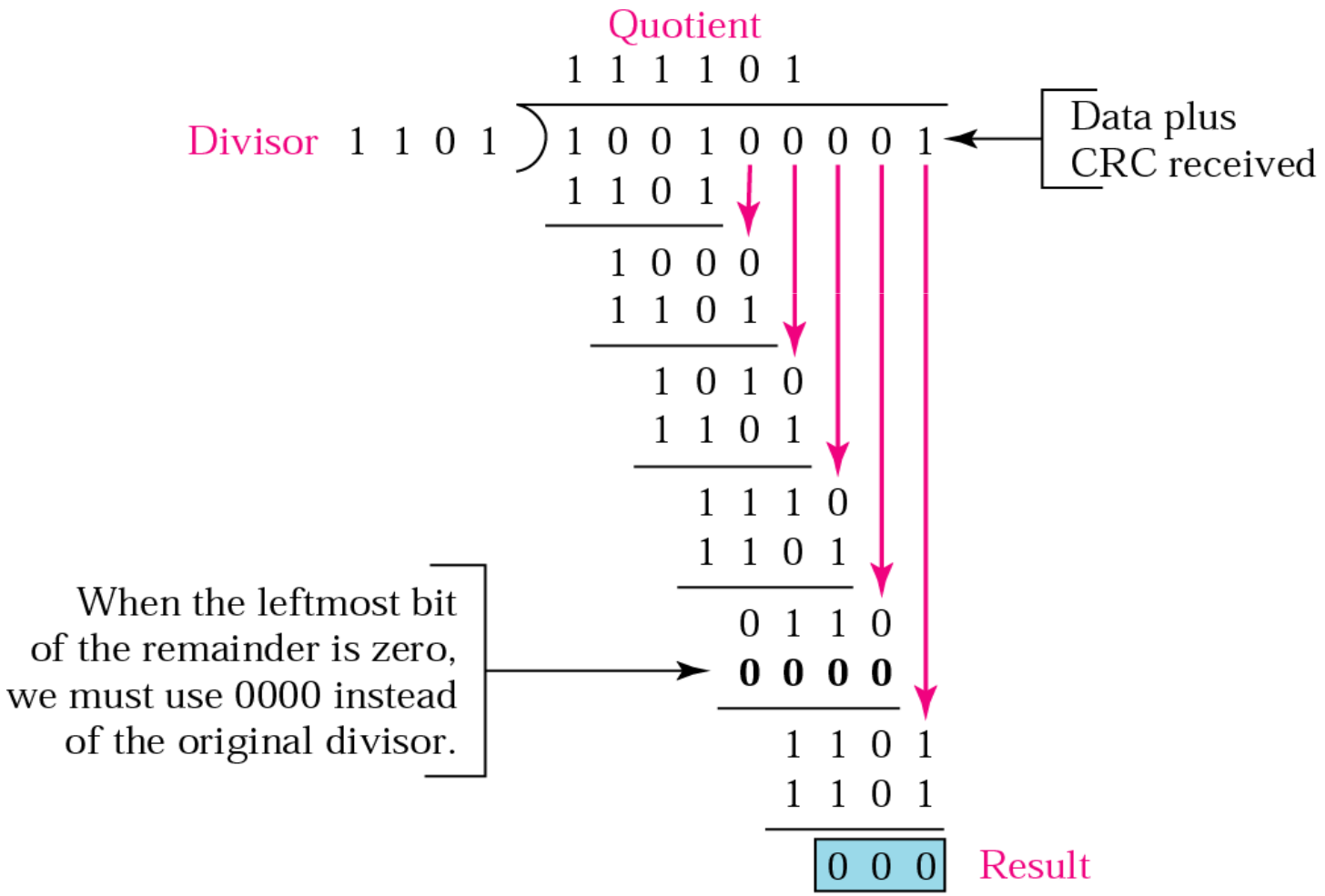
CRC：Generator and Checker



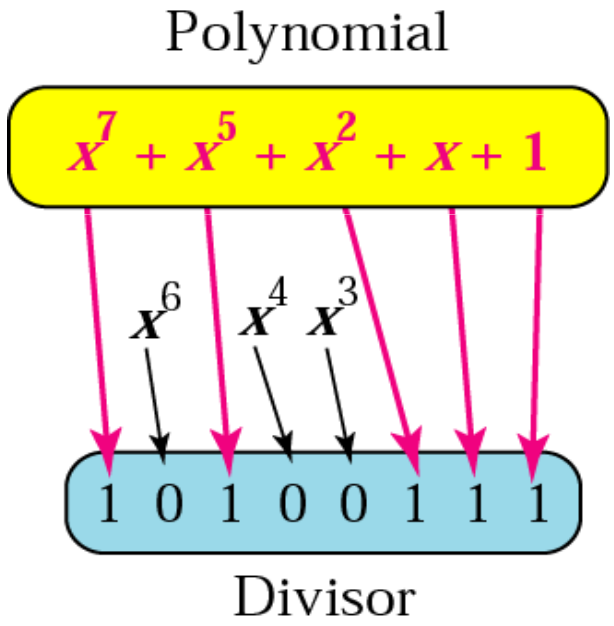
CRC Generation : Sender Side



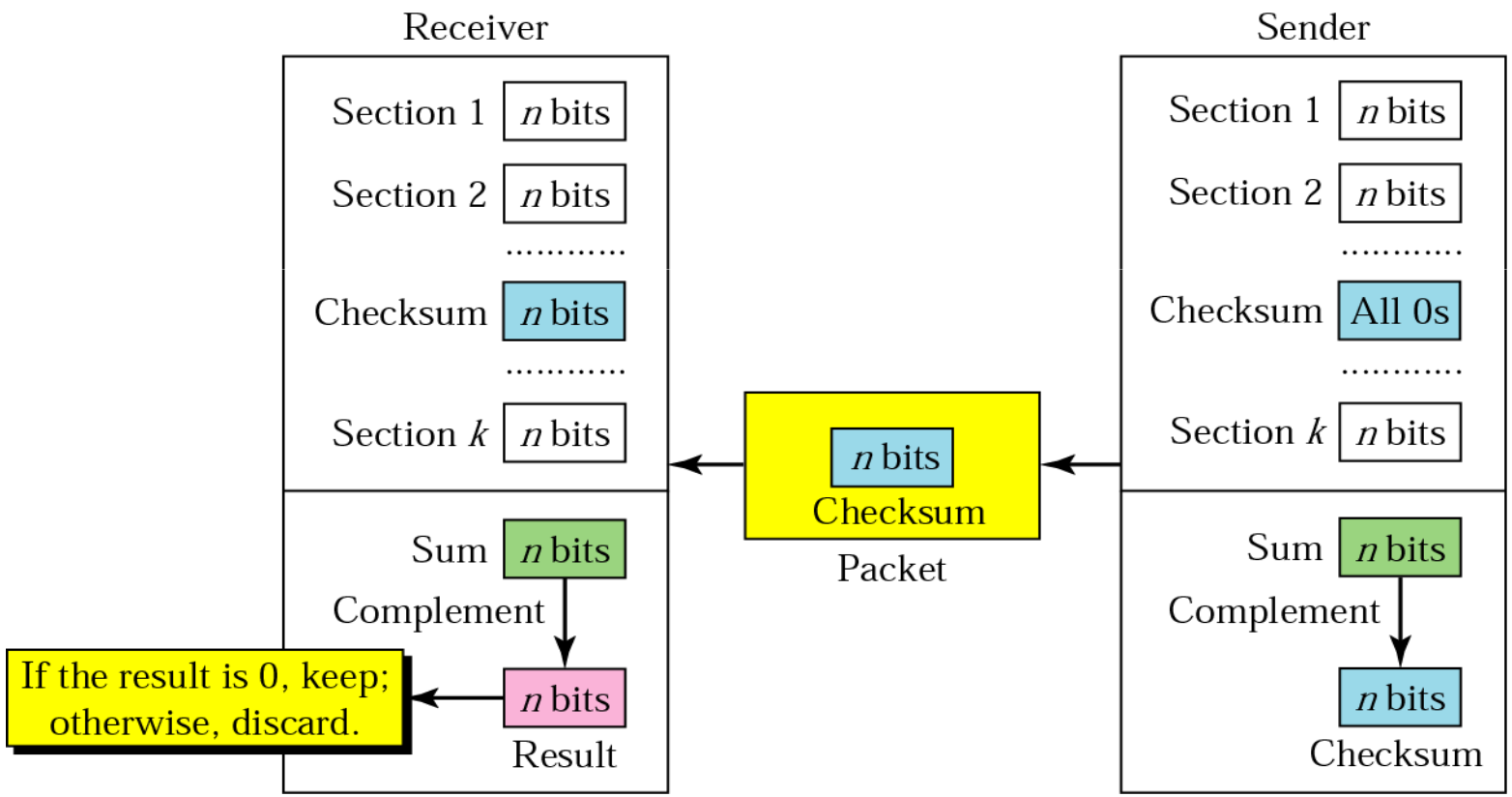
CRC Check : Receiver Side



CRC Polynomial



Checksum


Receiver
Sender
Section 1
n bits
Section 2
n bits
Checksum
n bits
Section k
n bits
All 0s
Sum
Complement
Result
Checksum
Packet
If the result is 0, keep;
otherwise, discard.

Checksum Example: Sender Side

- Suppose the block of 16 bits is to be sent using a checksum of 8 bits. [10101001 00111001]
- Two 8 Bit Numbers are added.

  10101001 + 00111001 = 11100010
- One's Complement of 11100010 = 00011101
- The Pattern Sent is

  10101001 00111001 00011101

Checksum Example: Receiver Side

- The Received data along with checksum is added

  10101001

  00111001

  00011101

  11111111

- Compute One's Complement of 11111111 = 00000000

- No Error in Transmission.

Error Correction

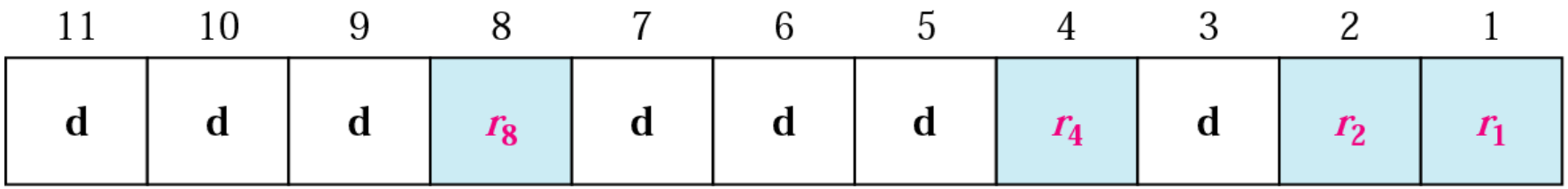
- Error Correction By Retransmission
  - ✓ Stop AND Wait ARQ
  - ✓ Go-Back-N ARQ
  - ✓ Selective Repeat ARQ
- ARQ => Automatic Repeat Request
- Error Correction By Forward Error Control
  - ✓ Hamming Code

Hamming Code: Data and Redundancy Bits

Number of Data Bits (m)	Number of Redundancy Bits (r)	Total Bits (m + r)
1	2	3
2	3	5
3	3	6
4	3	7
5	4	9
6	4	10
7	4	11

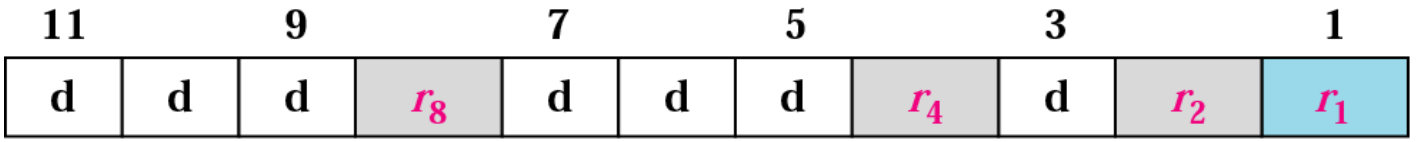
$$2^r \geq m+r+1$$

Hamming Code: Position of Redundancy Bits

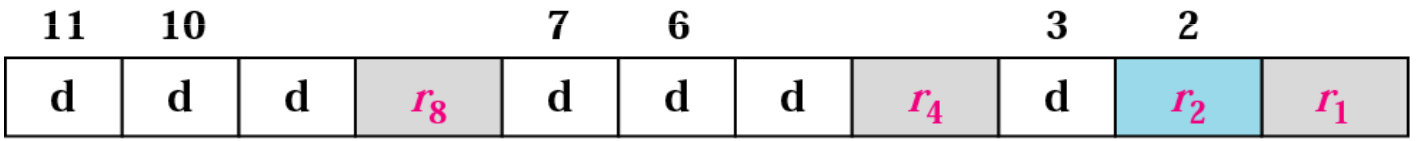


Hamming Code: Redundancy Bits

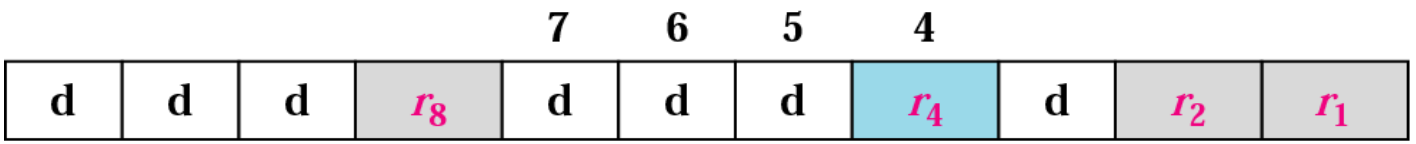
r_1 will take care of these bits.



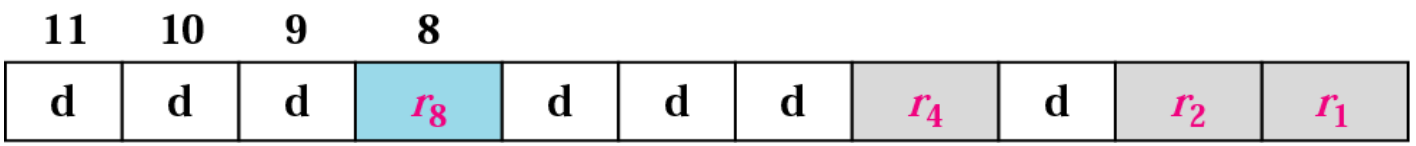
r_2 will take care of these bits.



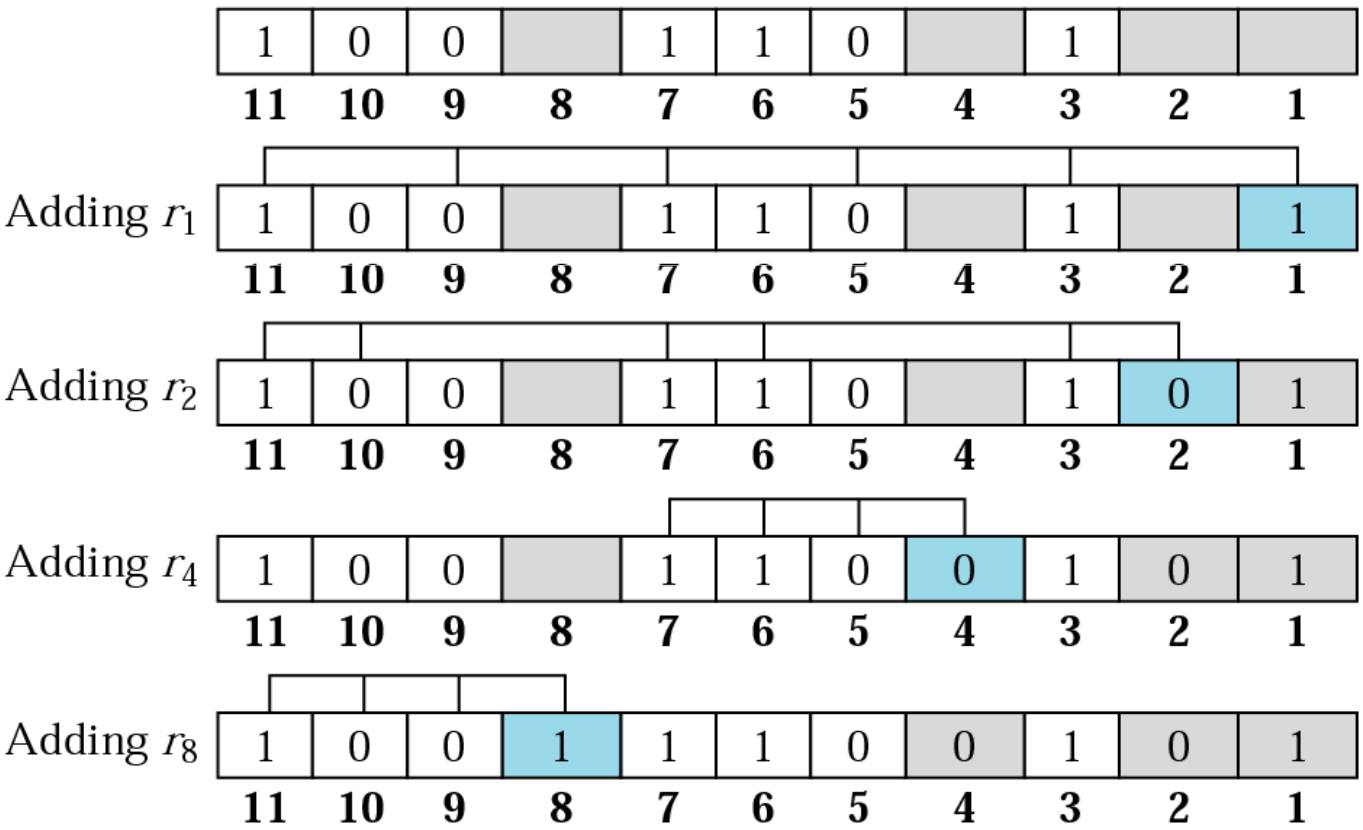
r_4 will take care of these bits.



r_8 will take care of these bits.



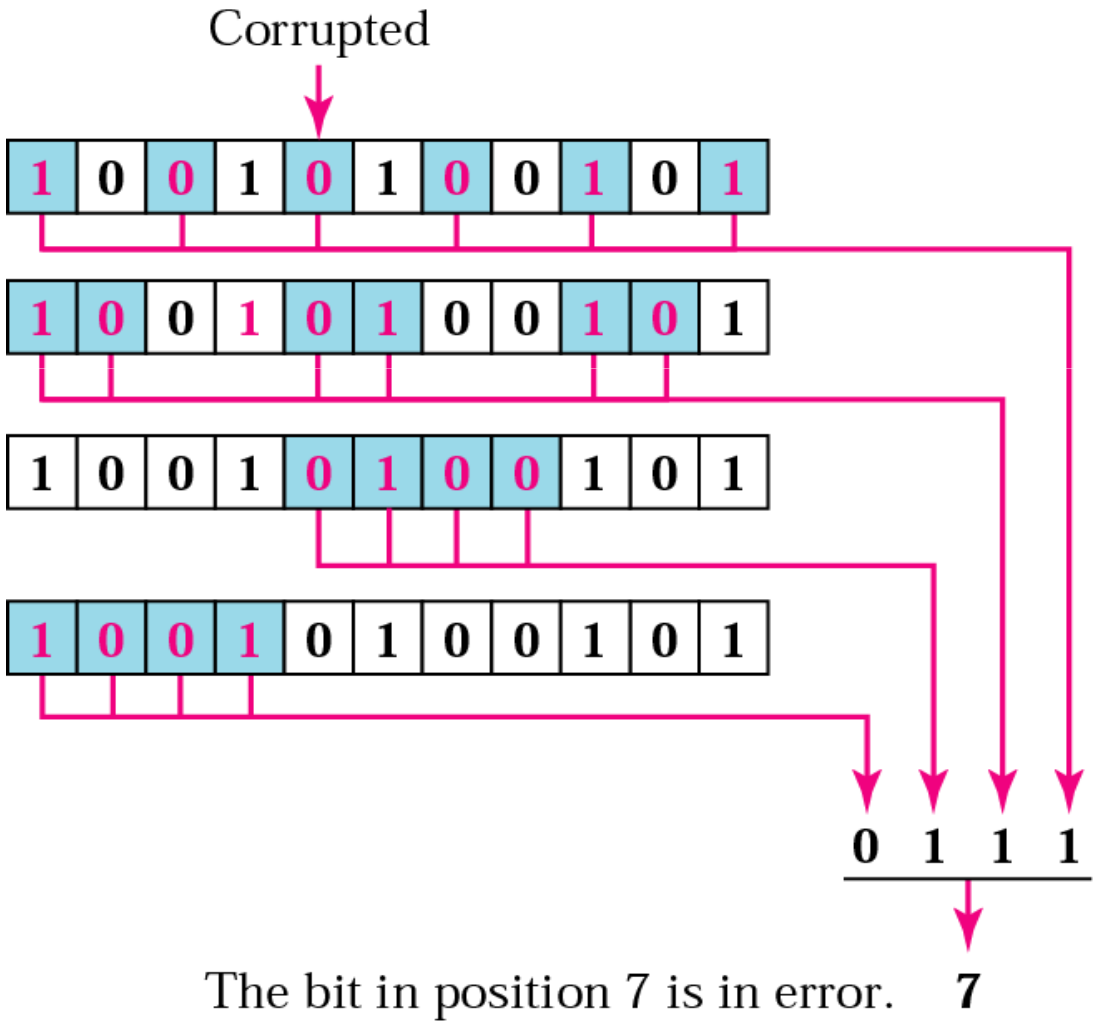
Hamming Code: Example of Redundancy Bit Calculation



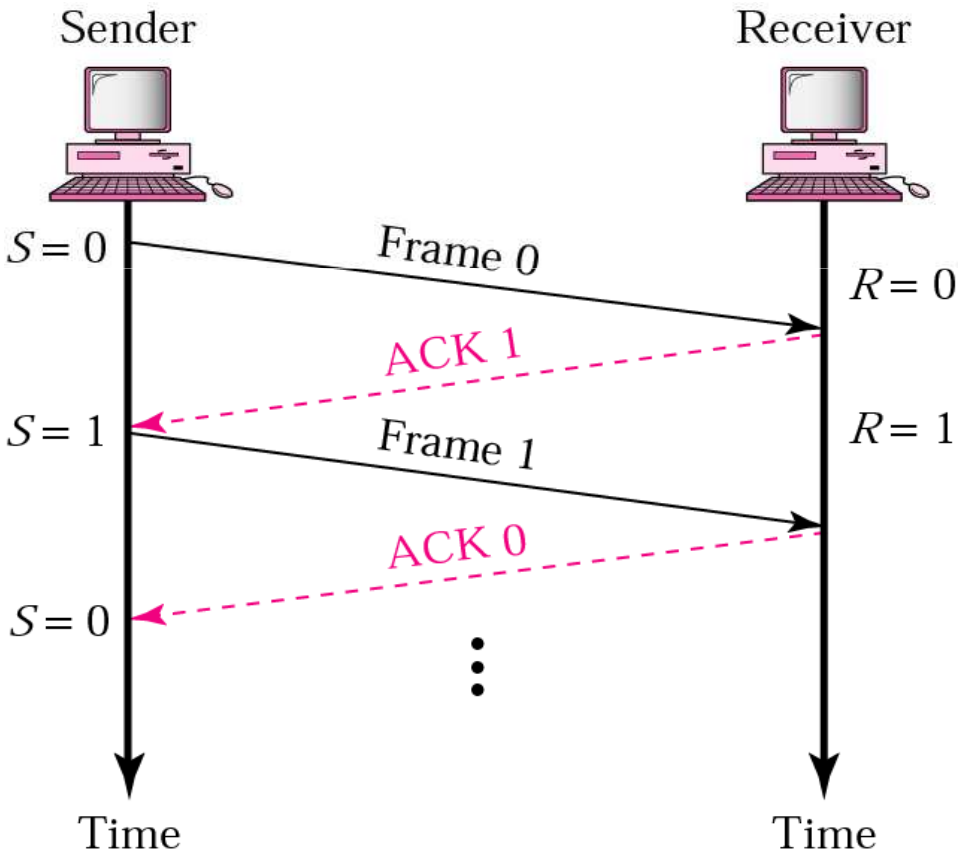
Data:
1 0 0 1 1 0 1

Code:
1 0 0 1 1 1 0 0 1 0 1

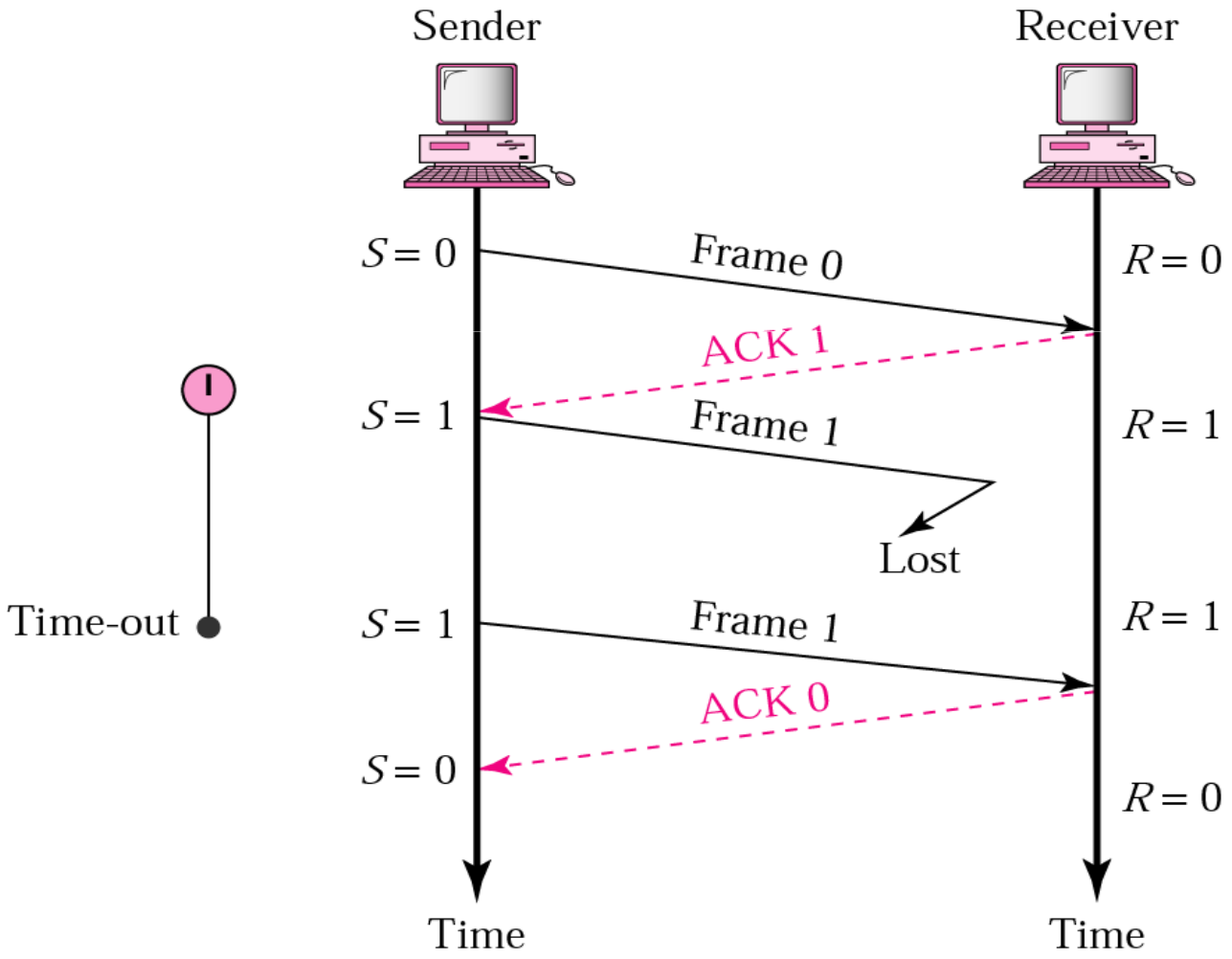
Hamming Code: Error Detection



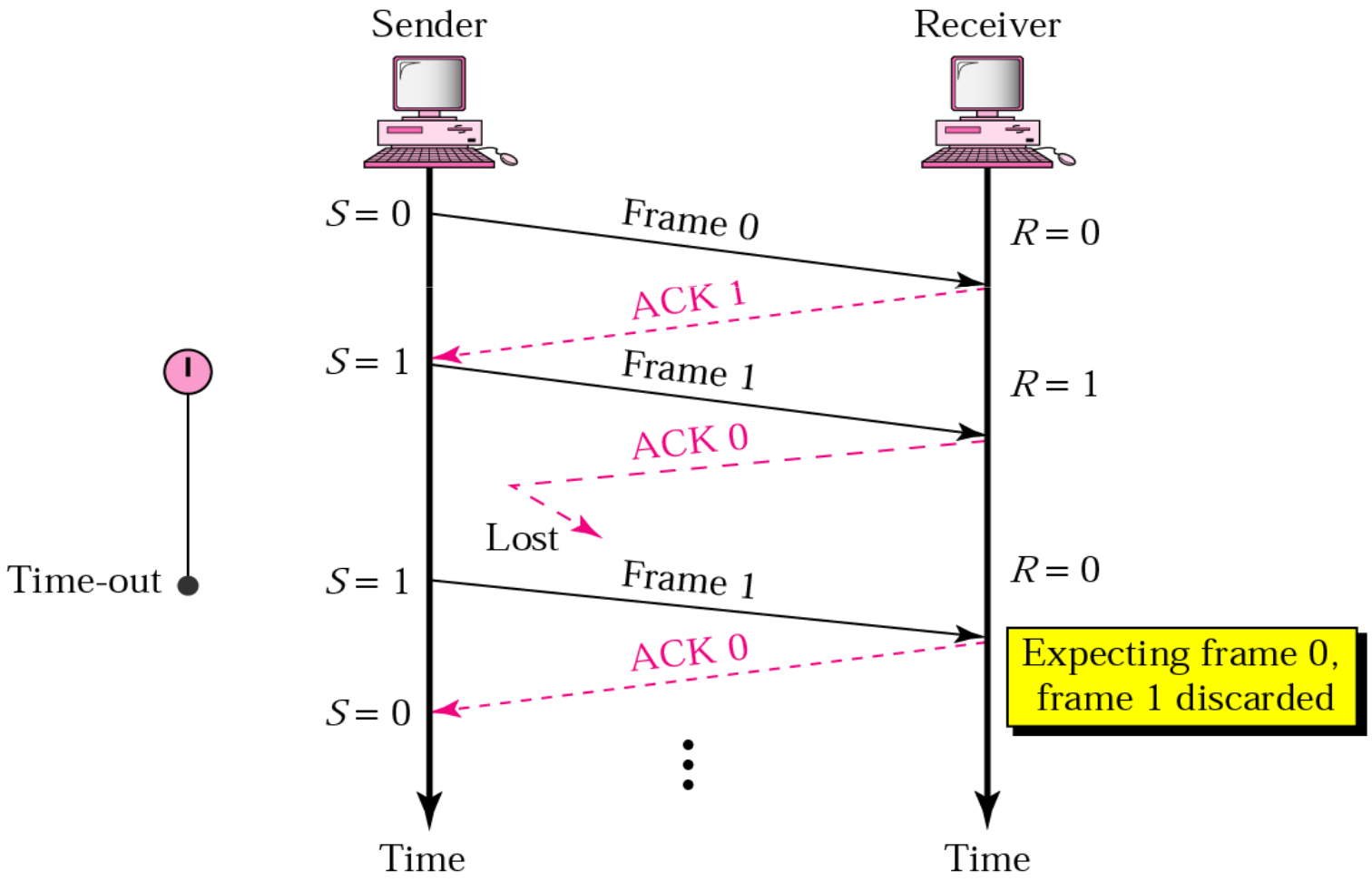
Stop and Wait ARQ : Normal Operation



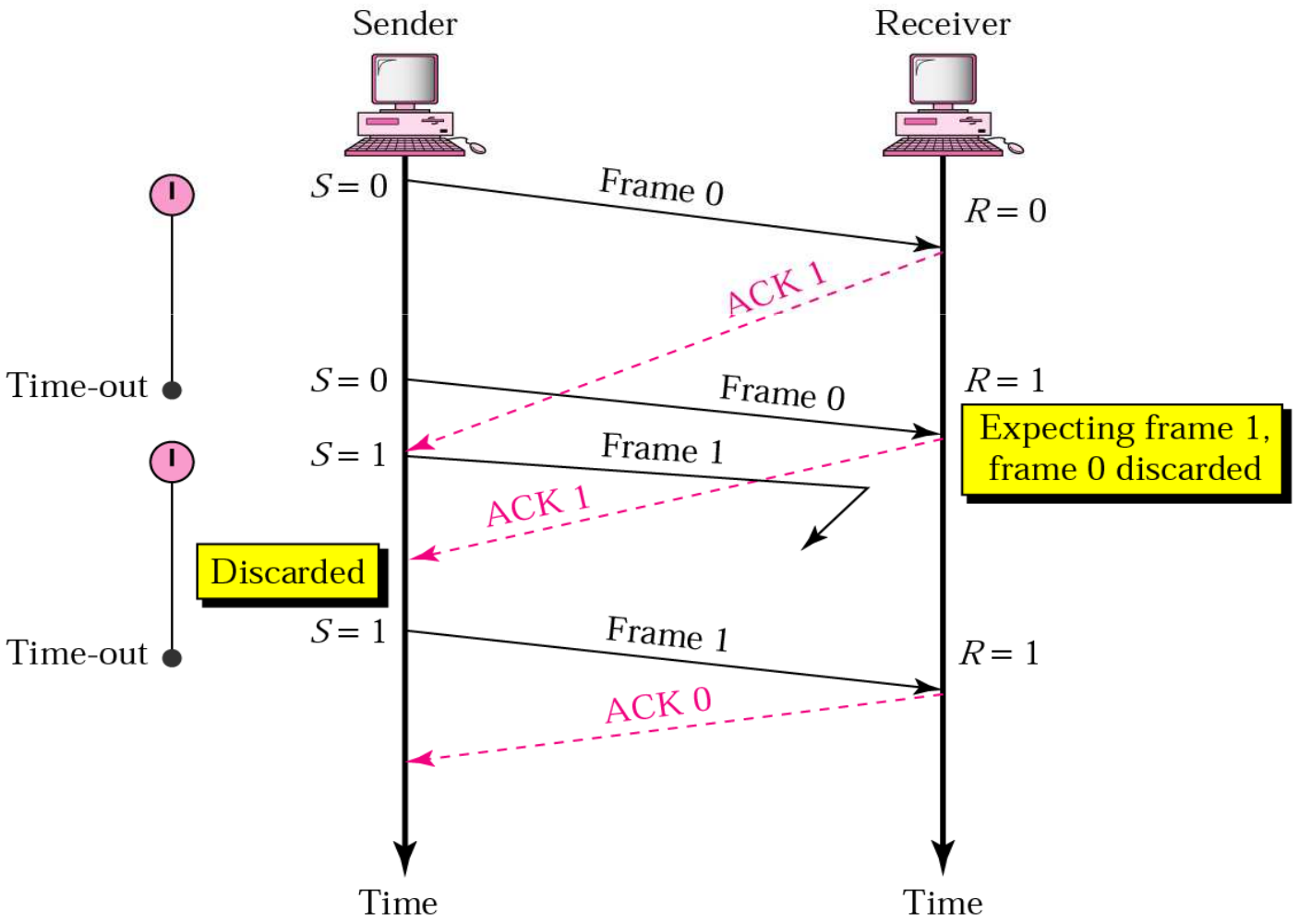
Stop and Wait ARQ : Lost Frame



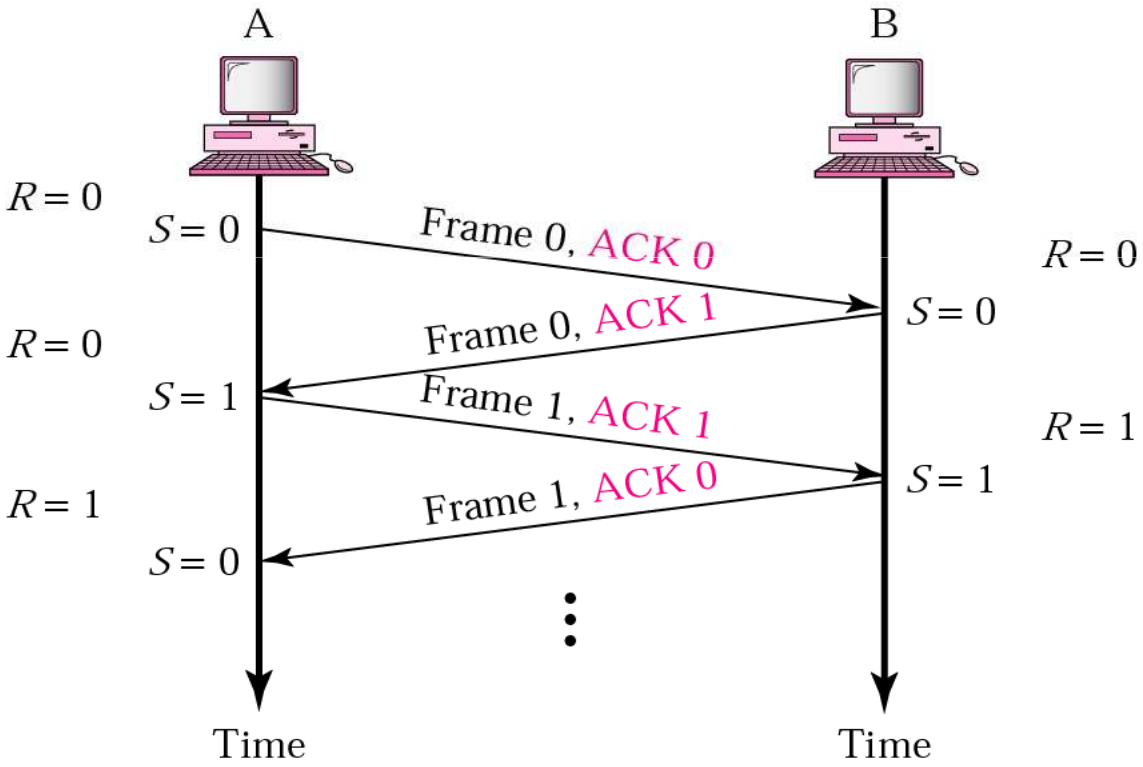
Stop and Wait ARQ : Lost ACK



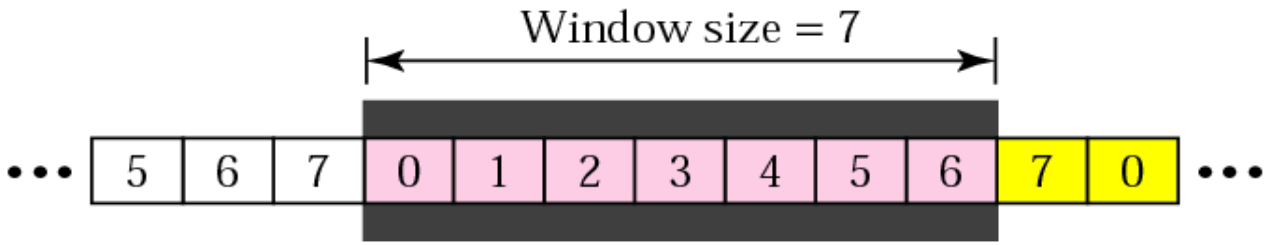
Stop and Wait ARQ : Delayed ACK



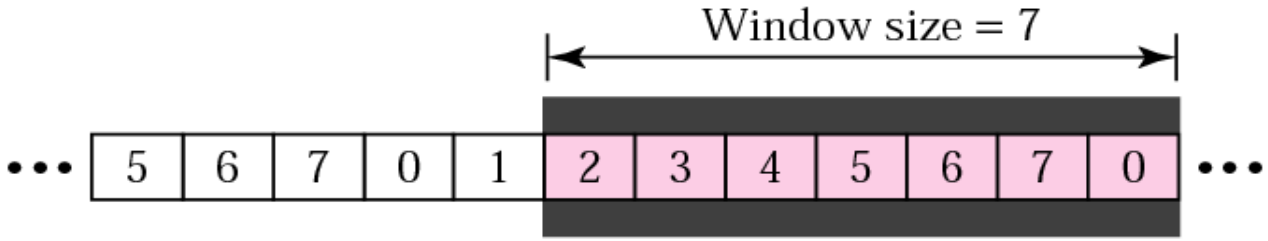
Piggybacking : Bidirectional Transmission (Frame +ACK)



Go-Back-N ARQ : Sender Sliding Window

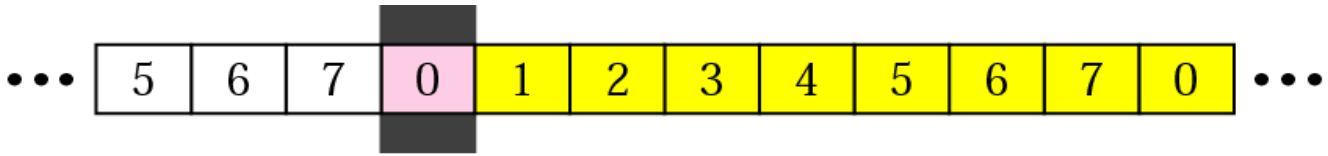


a. Before sliding

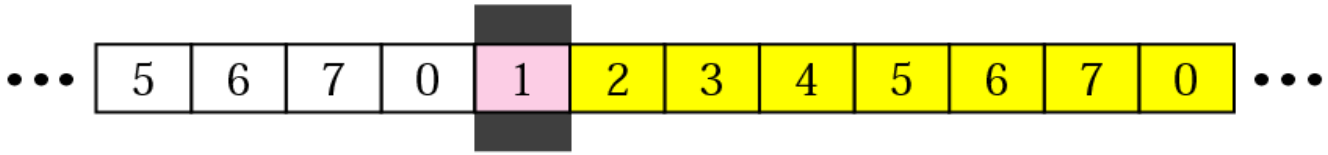


b. After sliding two frames

Go-Back-N ARQ : Receiver Sliding Window

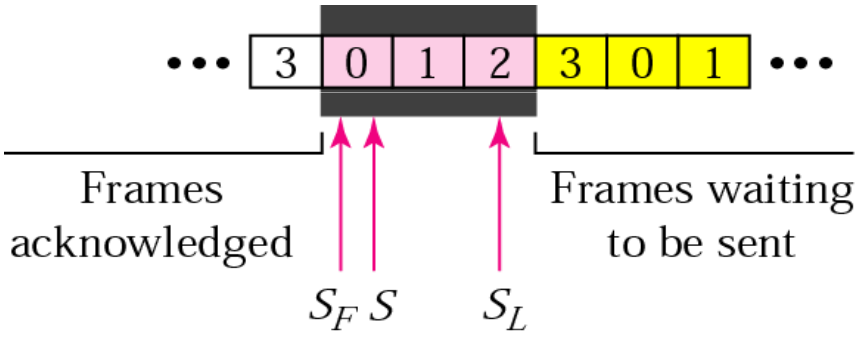


a. Before sliding

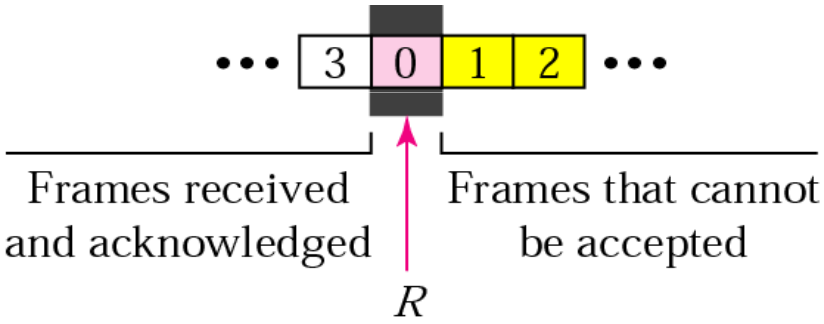


b. After sliding

Go-Back-N ARQ : Control Variables

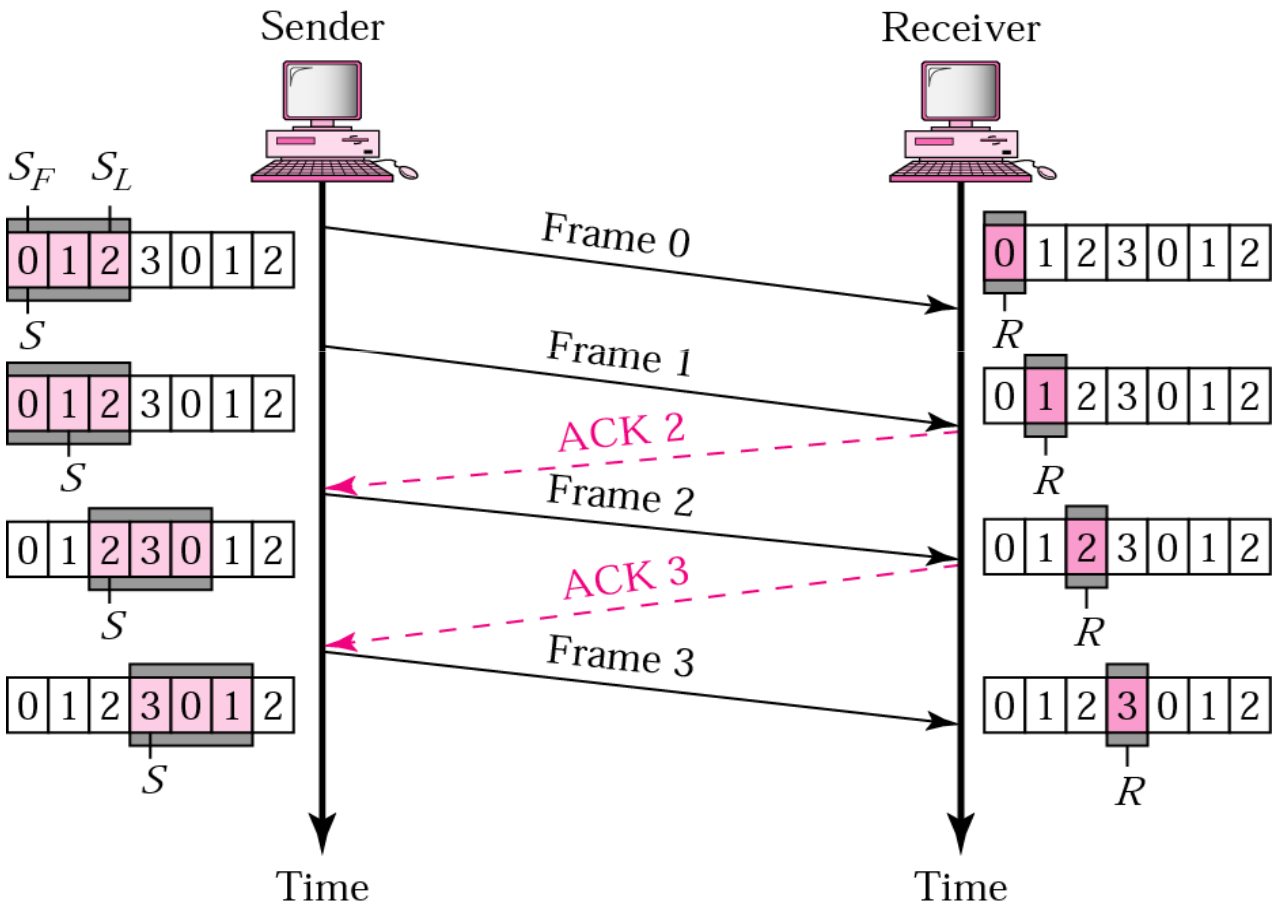


a. Sender window

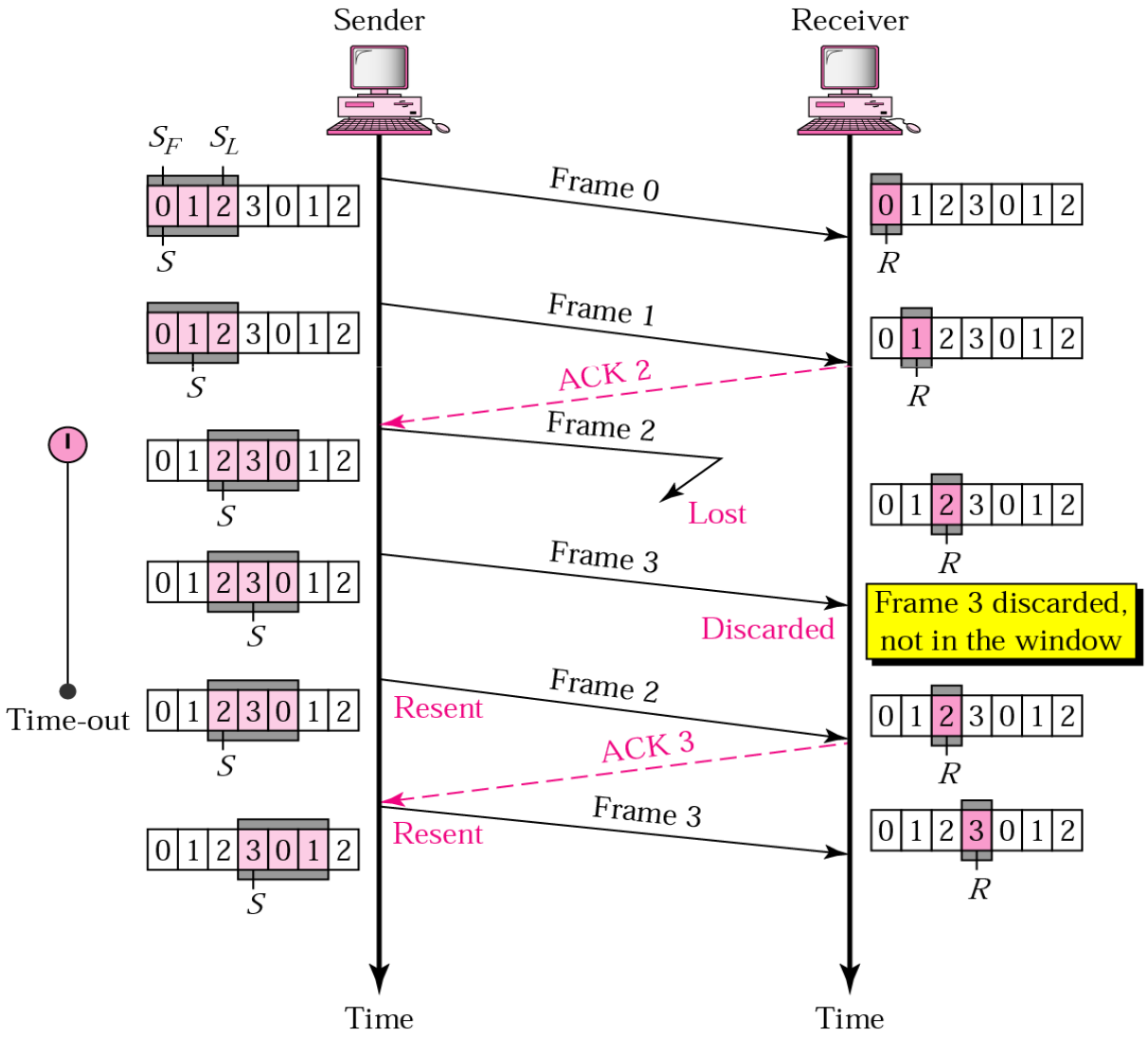


b. Receiver window

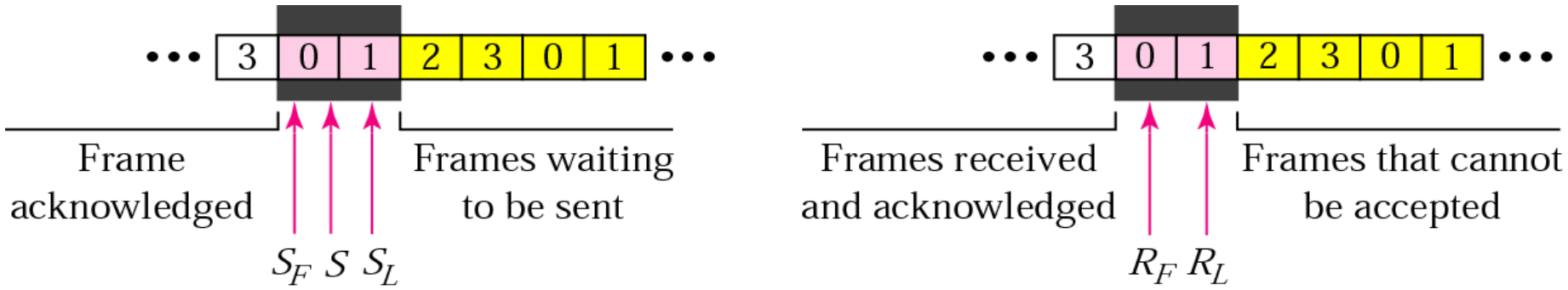
Go-Back-N ARQ : Normal Operation



Go-Back-N ARQ : Lost Frame



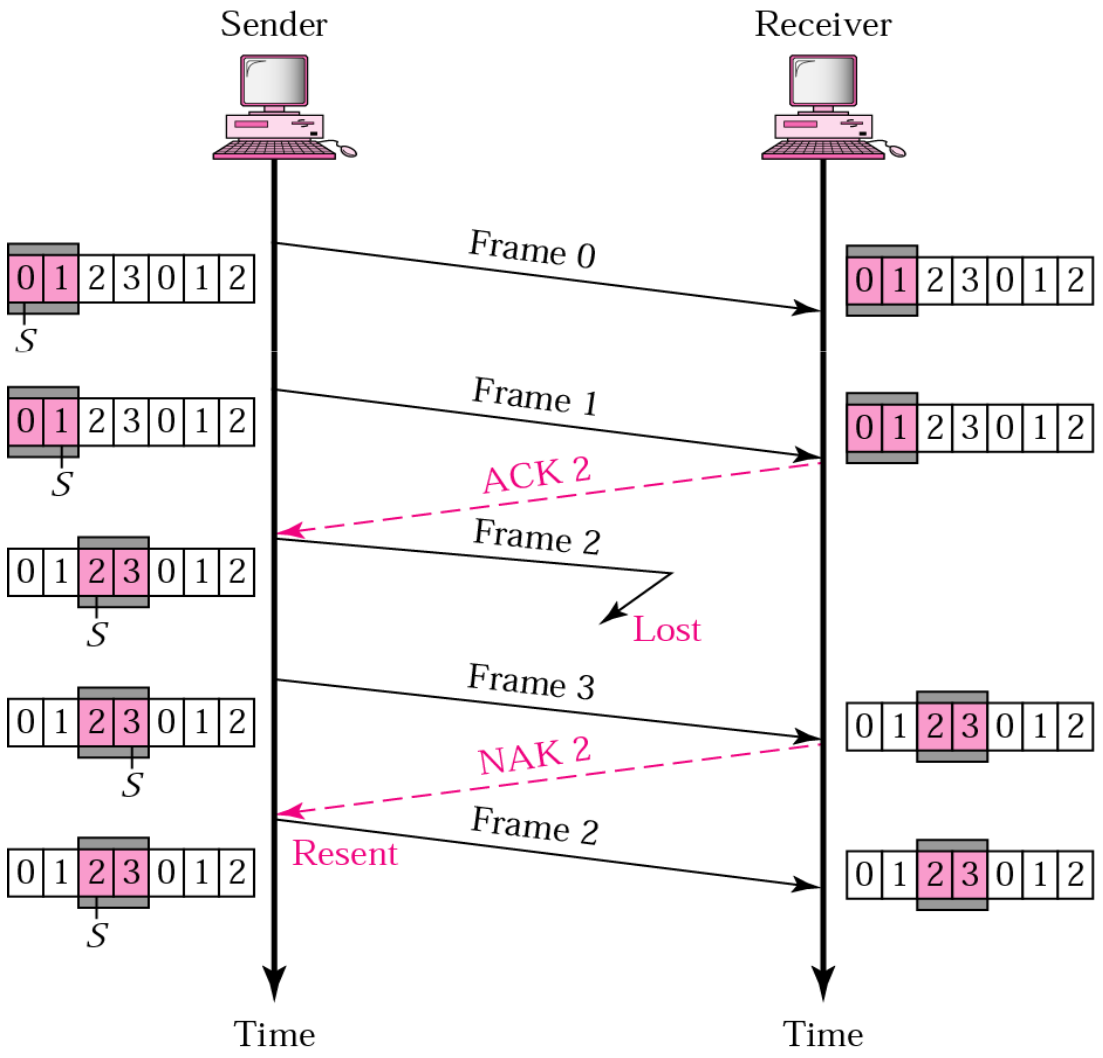
Selective Repeat ARQ : Sender and Receiving Windows



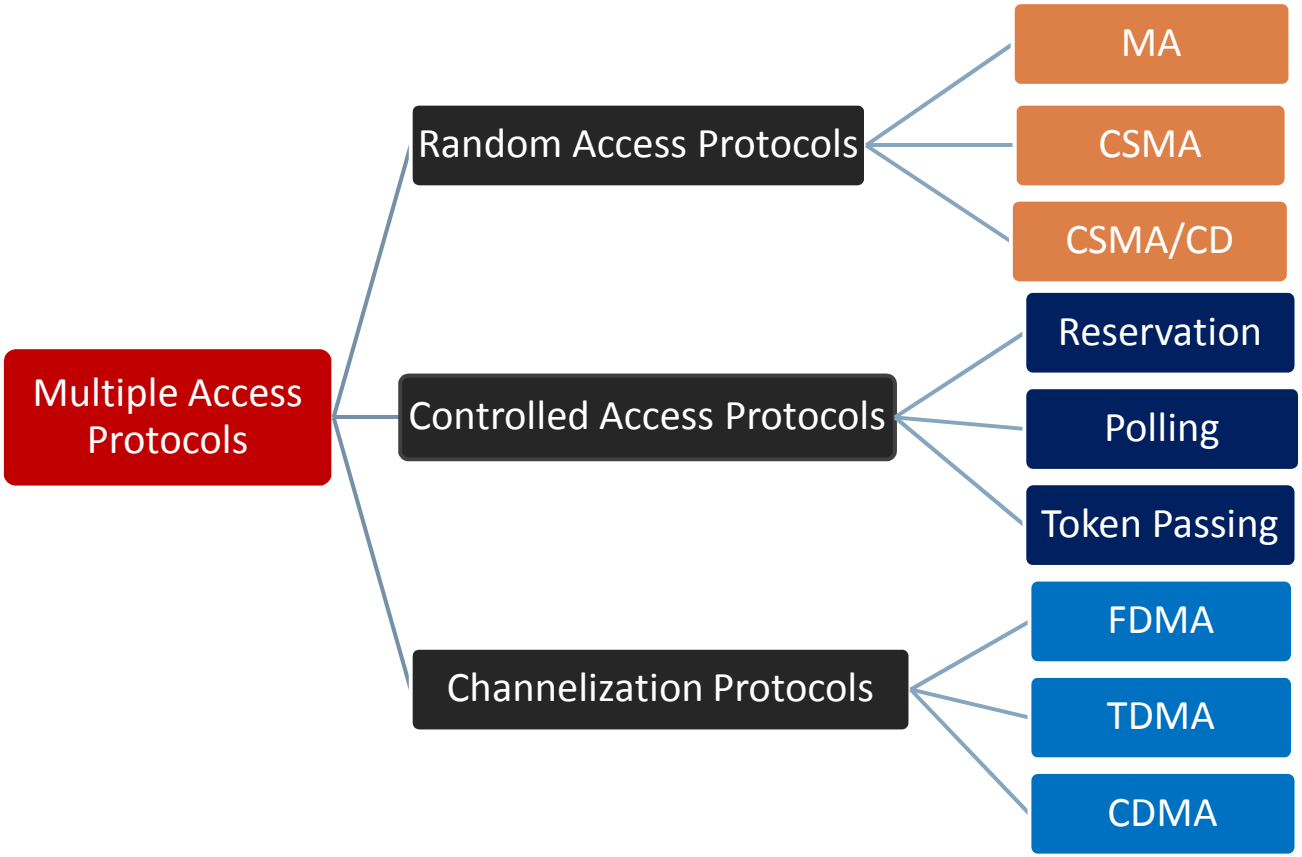
a. Sender window

b. Receiver window

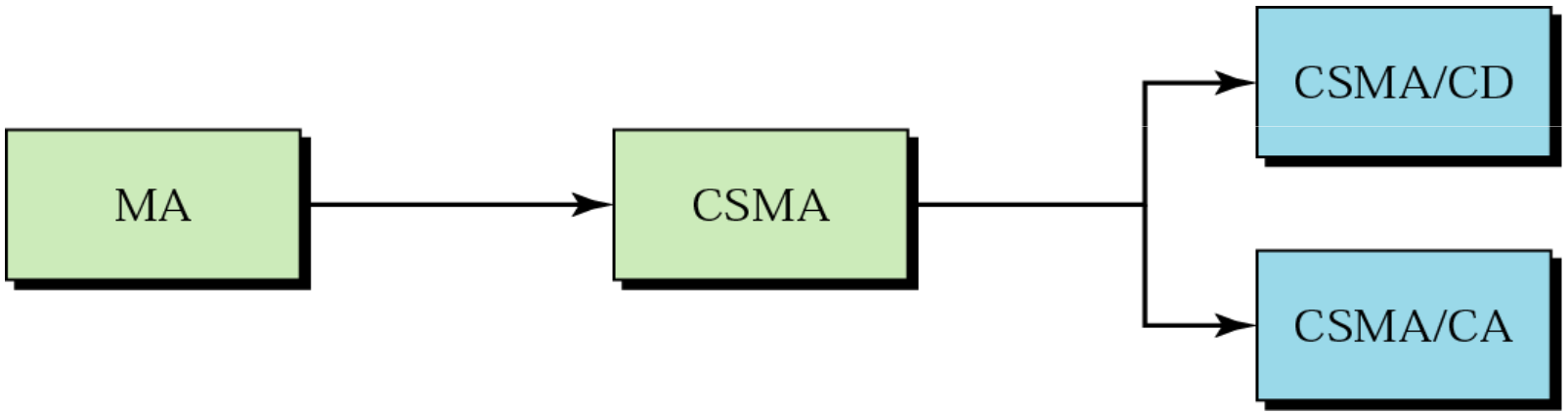
Selective Repeat ARQ : Lost Frame



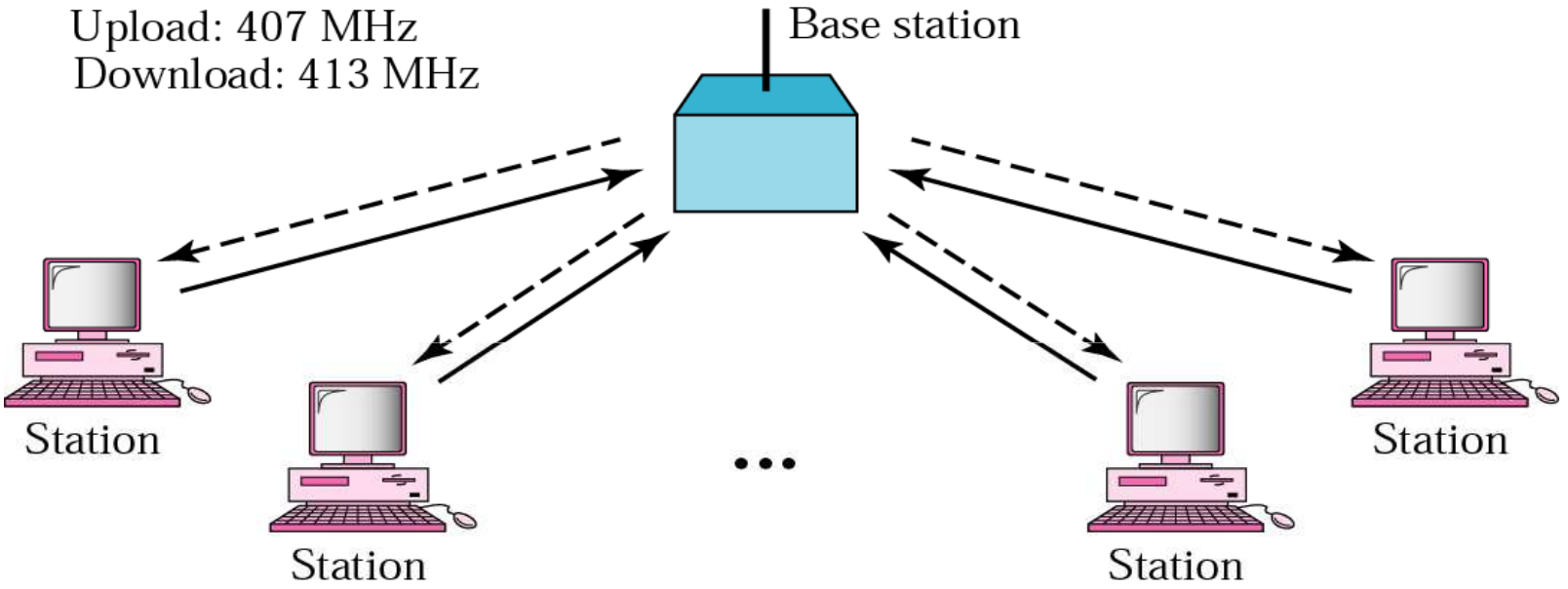
Multiple Access Protocols



Evolution of Random Access Protocols



Multiple Access : ALOHA



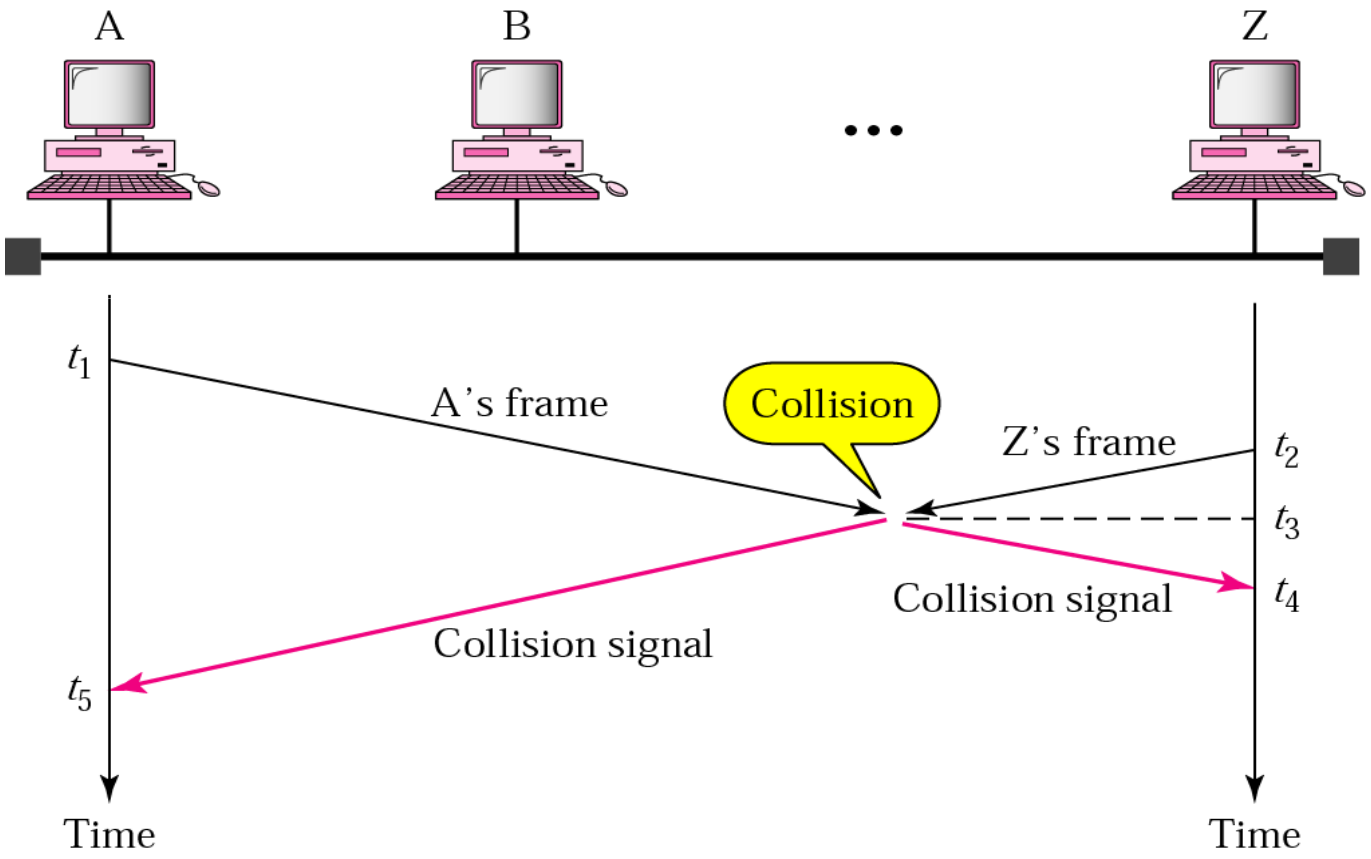
1. Pure ALOHA

If you have data to send, send the data. If message collides with other transmission try resending later.

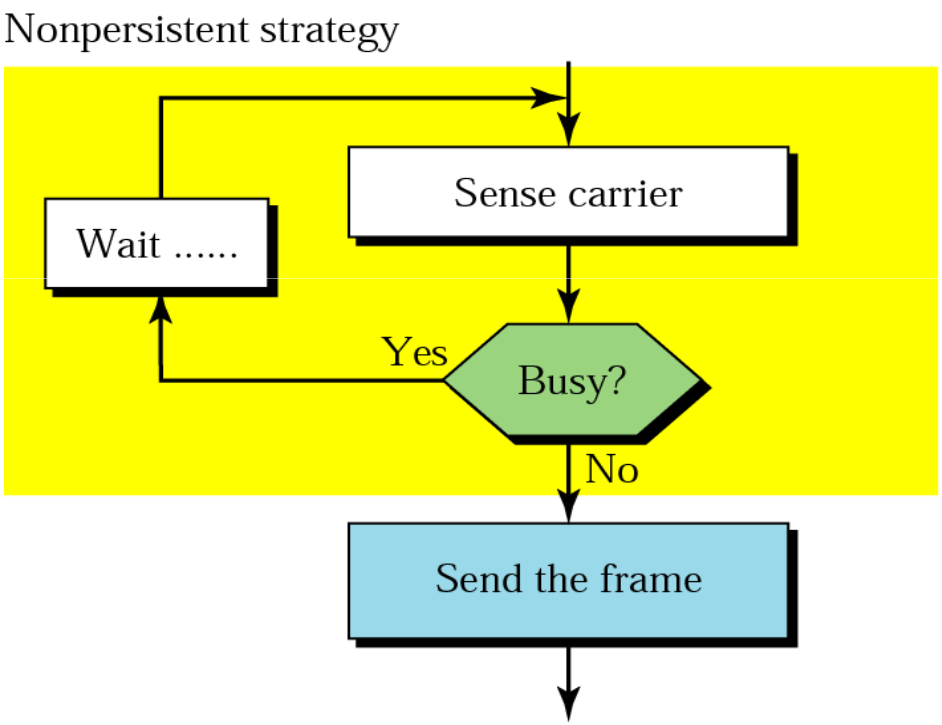
2. Slotted ALOHA

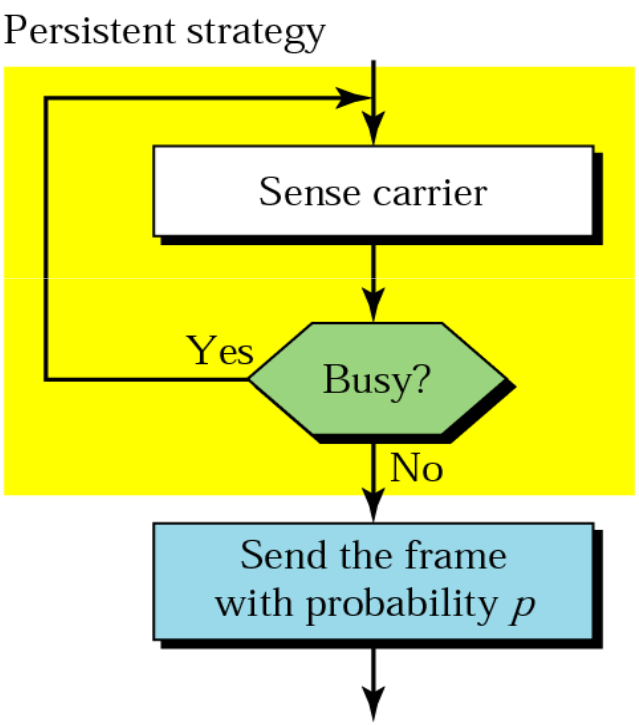
Introduced discrete timeslots and increased the maximum throughput.

Collision in CSMA

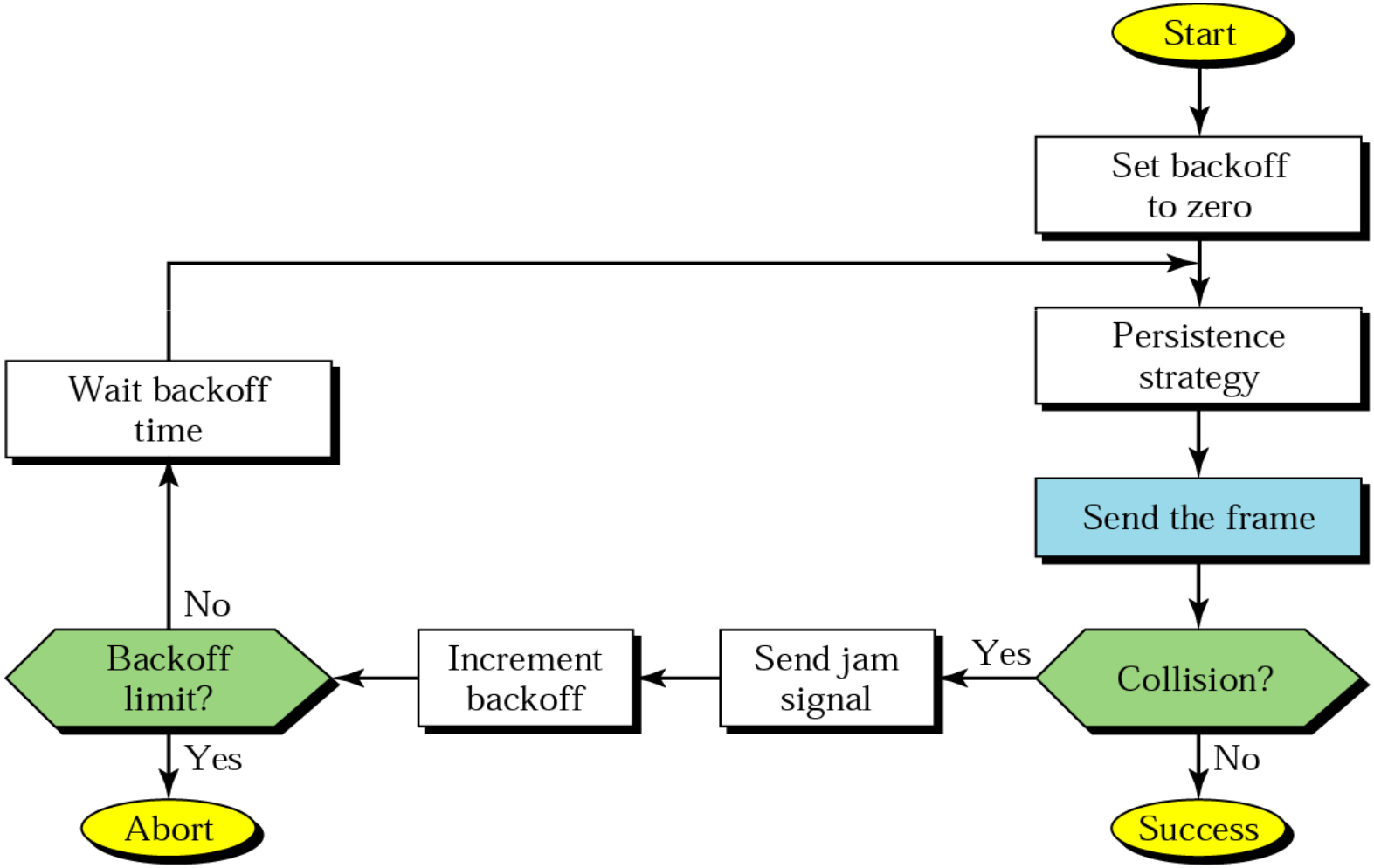


Carrier Sense: Strategies

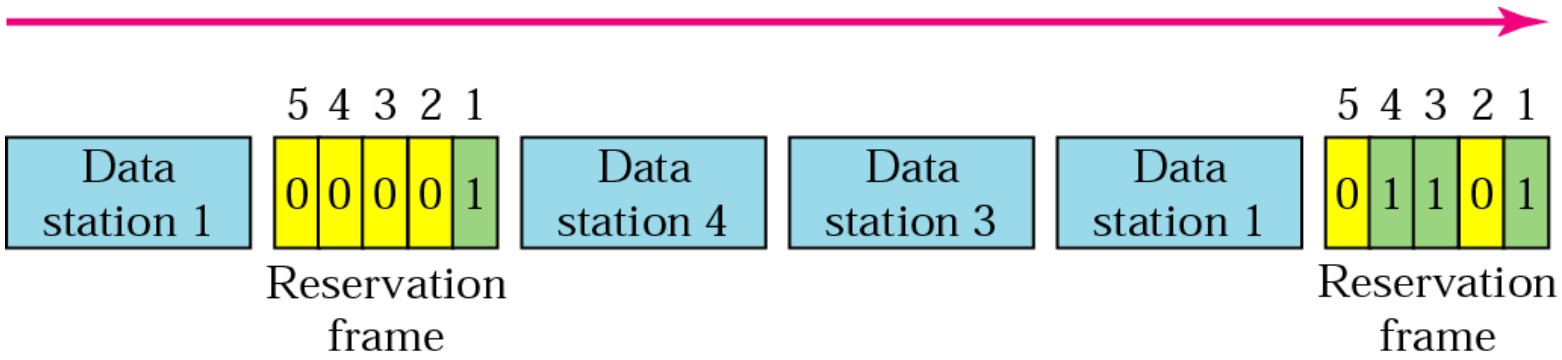




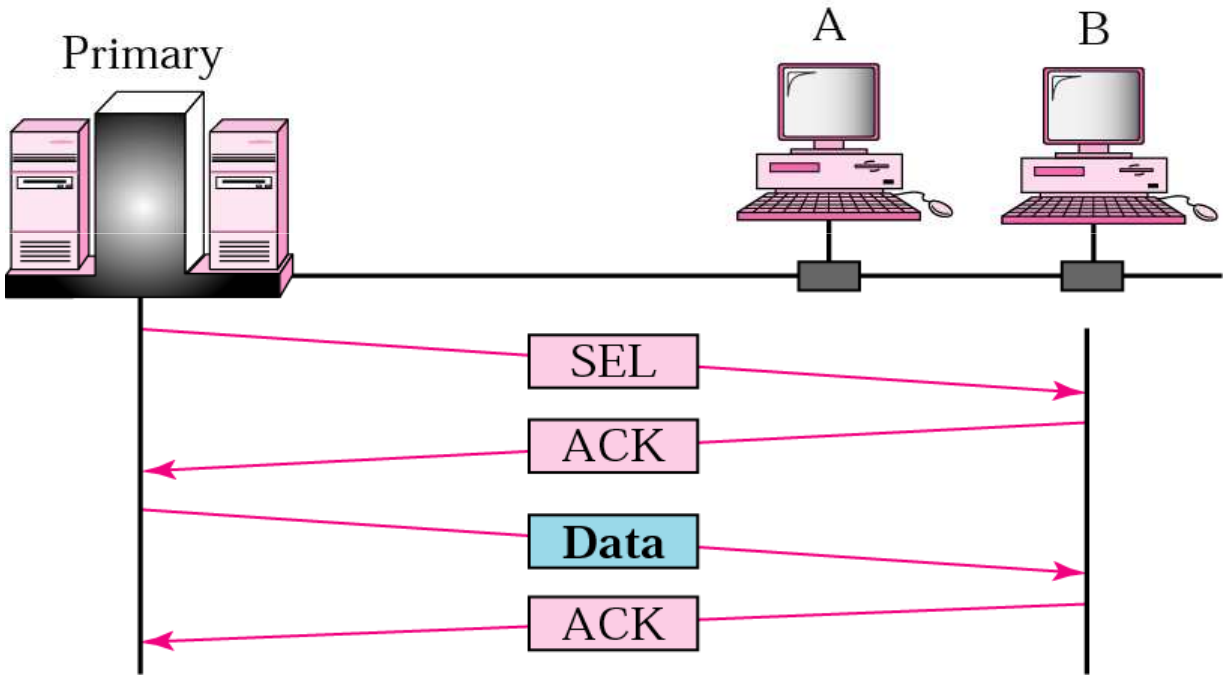
CSMA/CD: Algorithm



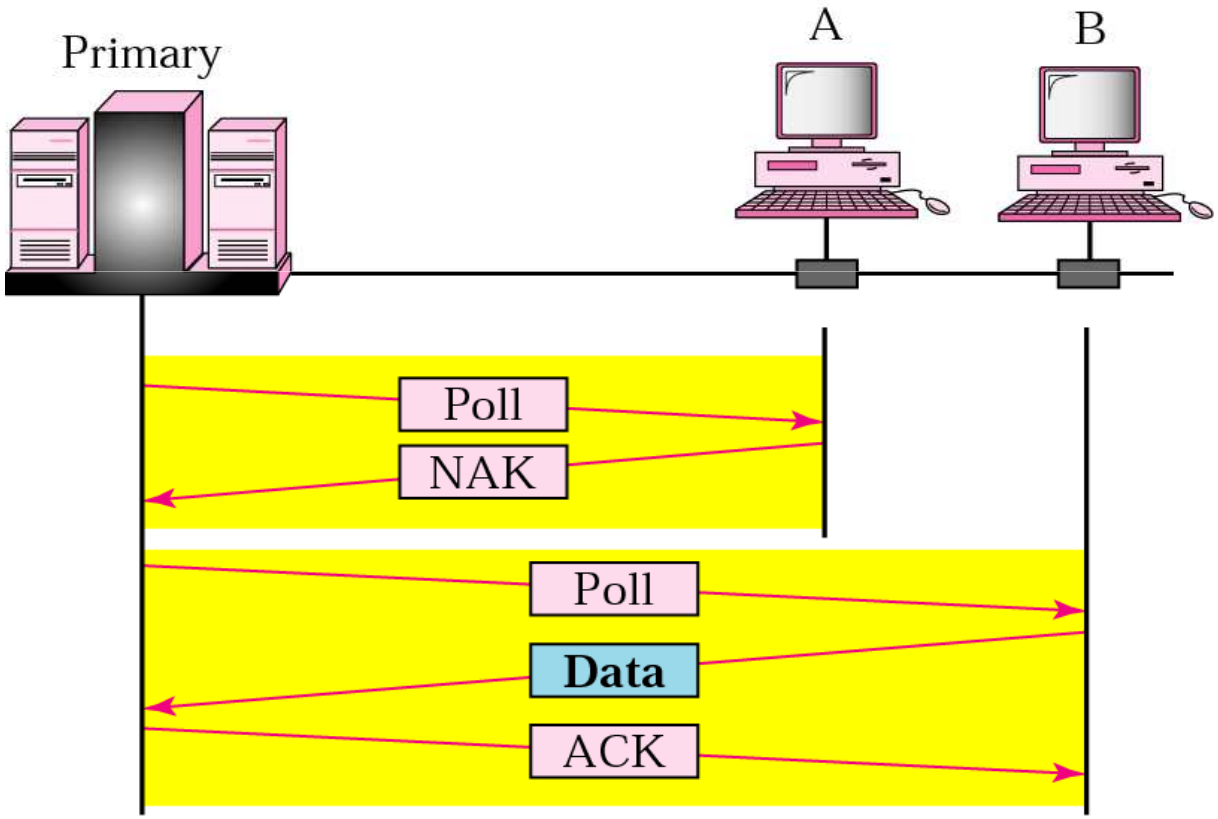
Controlled Access: Reservation Access Method



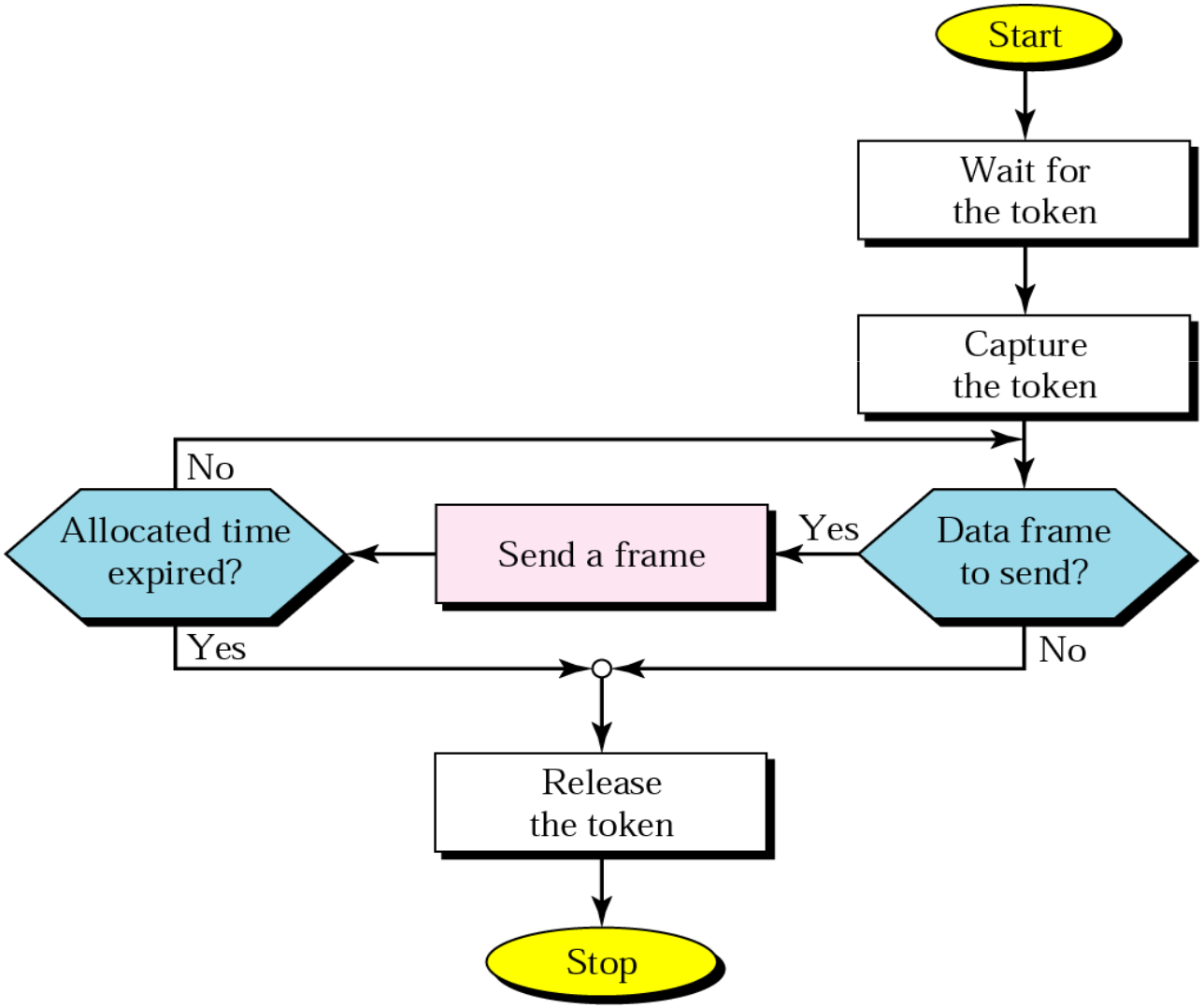
Controlled Access: Select (Primary intended to Send)



Controlled Access: Poll (Primary Intended to Receive)



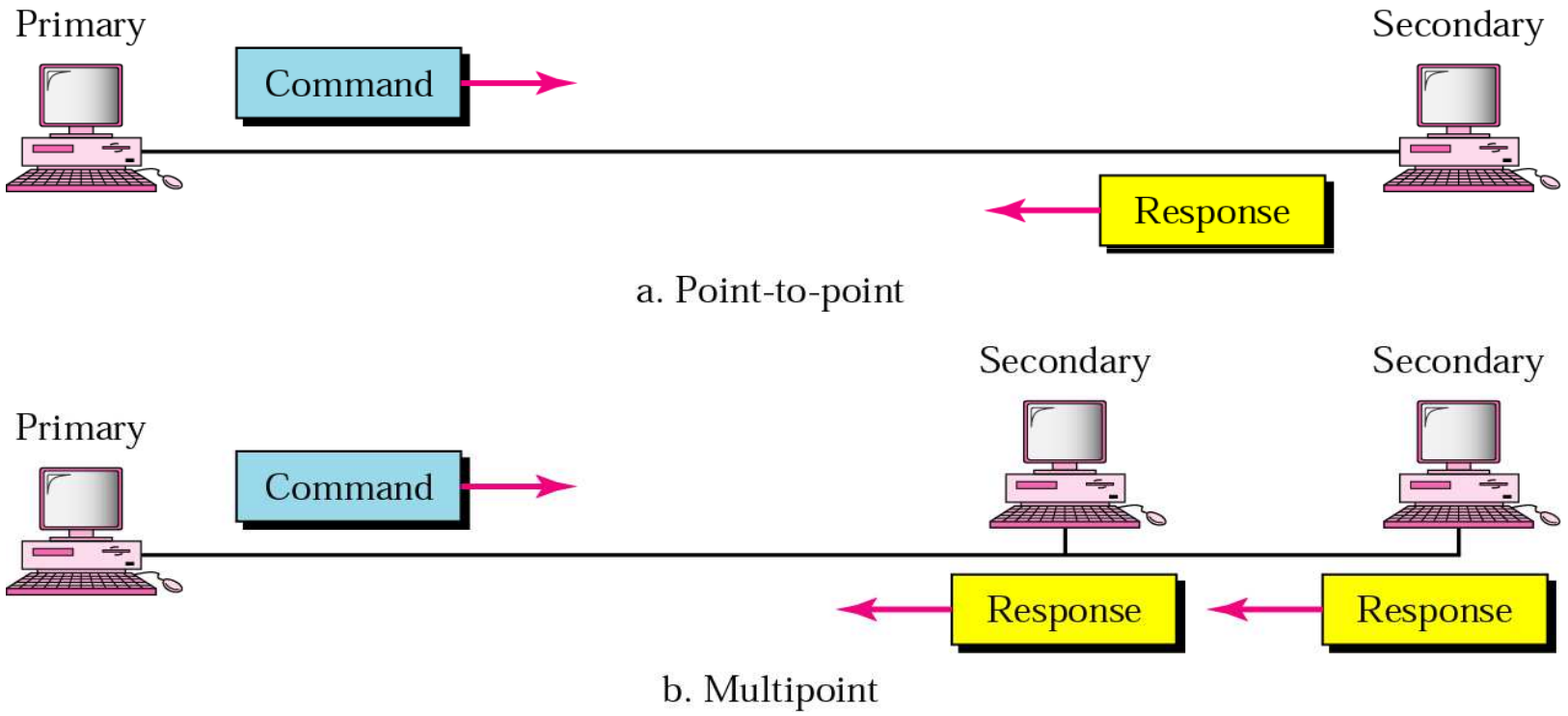
Controlled Access: Token Passing



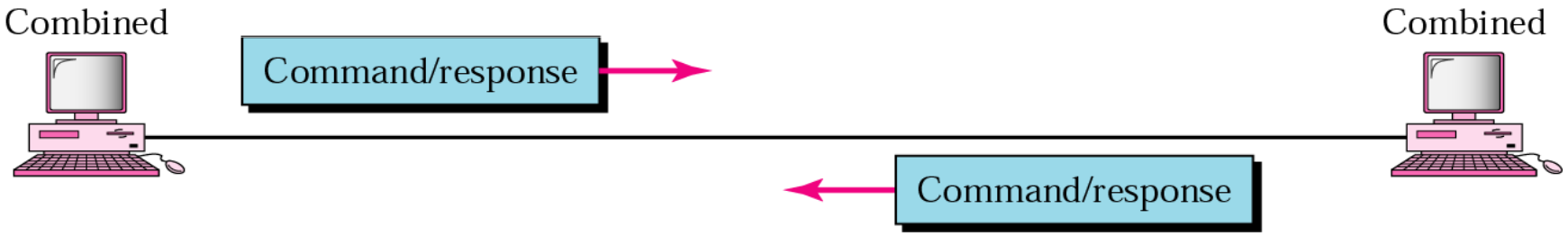
Data Link Protocols: HDLC

- High Level Data Link Control Protocol.
- Designed to support Half Duplex and Full Duplex Communication.
- It can be used over Point to Point and Multipoint Links.
- HDLC Provides two common modes of transmission
  - ✓ NRM (Normal Response Mode)
  - ✓ ABM (Asynchronous Balanced Mode)

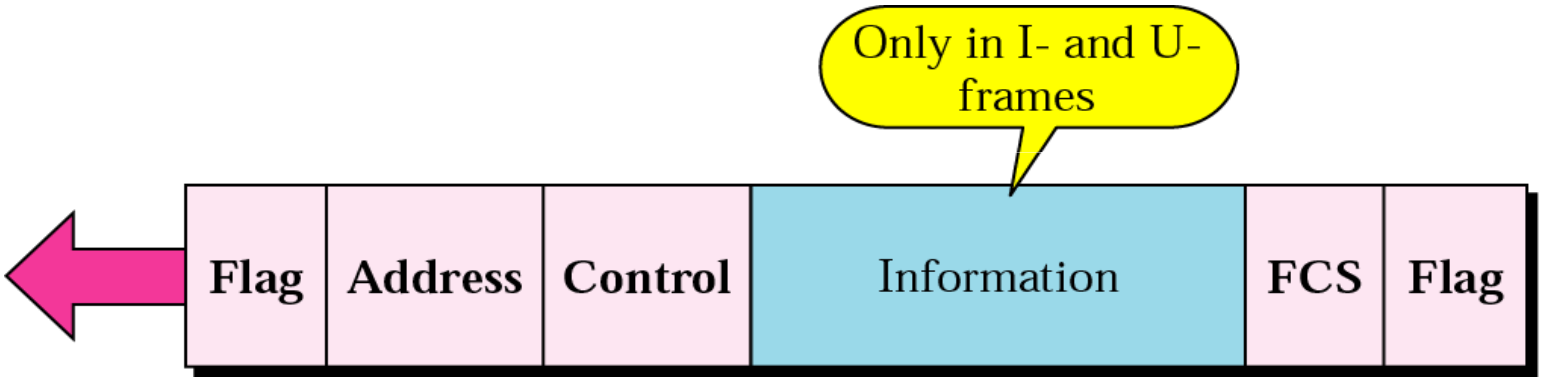
Normal Response Mode: NRM



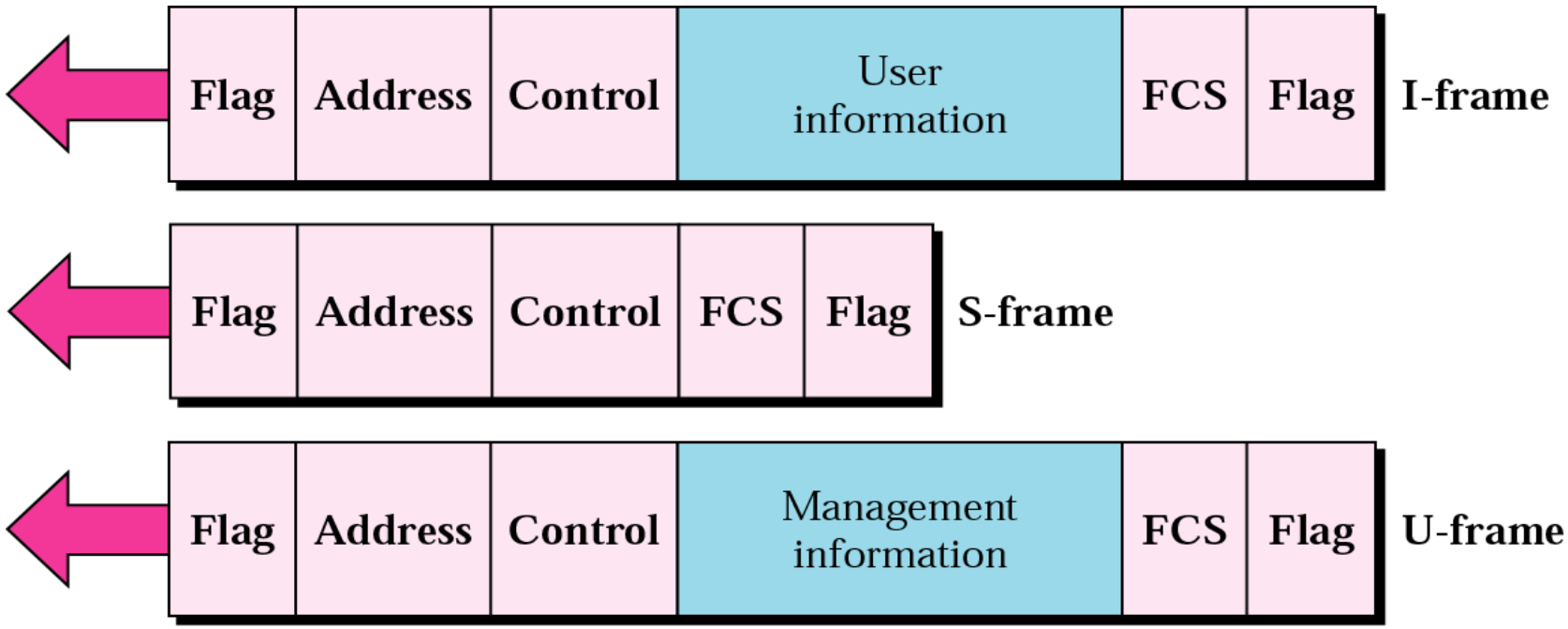
Asynchronous Balanced Mode: ABM



HDLC : Frame Format



HDLC : Frame Types



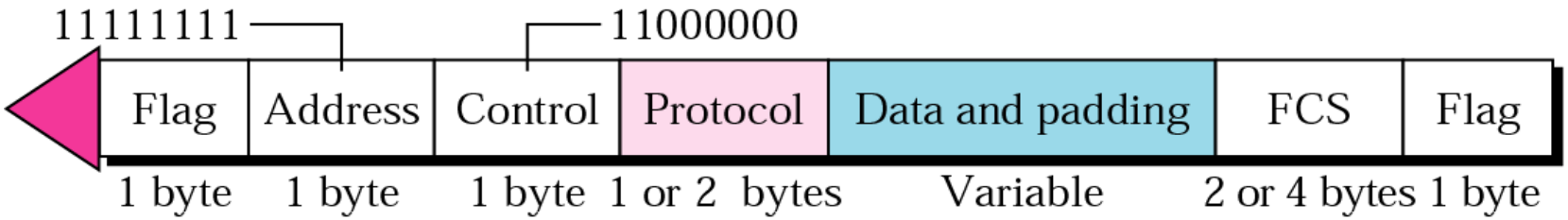
HDLC Frame Format: Discussions

- I-Frames => Information Frames
- I-Frames are used to transport User data and Control Information.

- S-Frames => Supervisory Frames
- S-Frames are used only to transport control information.

- U-Frames => Unnumbered Frames
- U-Frames are reserved for system management.
- It is intended for managing the link itself.

PPP: Frame Format



- Most Common Protocol For Point to Point Access.
- PPP Employs the version of HDLC.

PPP: Frame Format Discussions

- Flag Field : Identify the Boundaries of PPP. Value is 01111110
- Address Field : Uses Broadcast Address of 11111111.
- Control Field : It Contains 11000000 to show that Frame does not contain any Sequence Numbers and there is no Flow and Error Control.
- Protocol Field : Specifies what is carried in the data field.
- Data Field : Carries Either User data or other Information.
- FCS : Contains 2 byte or 4 byte CRC.

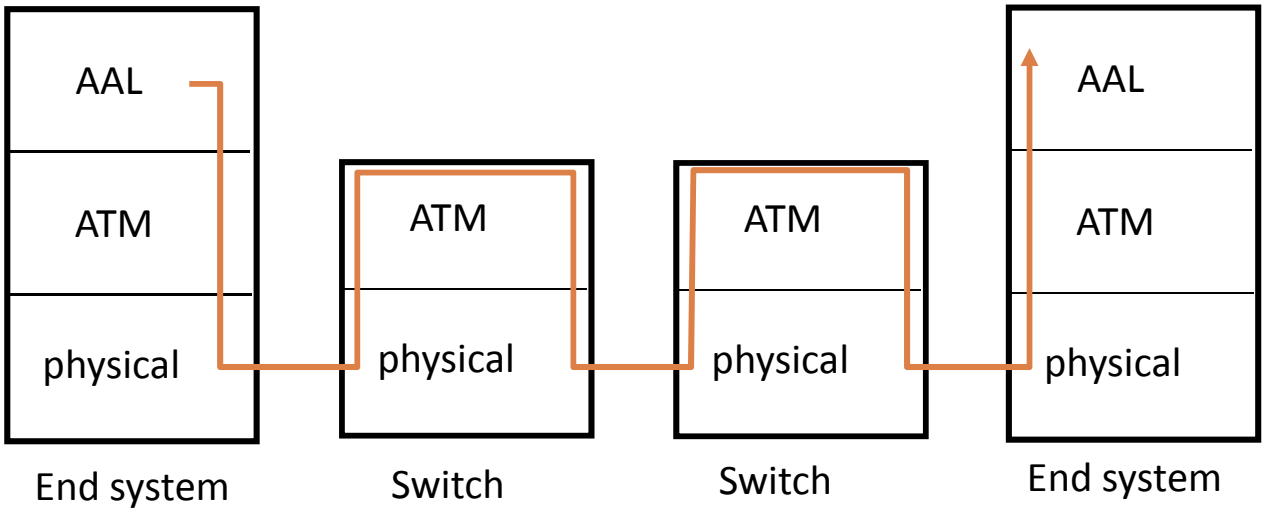
SLIP: Serial Line Internet Protocol

- Older Protocol Used by PCs to Connect to Internet Via Modem.
- Data Link Layer Protocol that Provides Connectivity Across Telephone Line and No Error Correction.
- Relies on Hardware For Error Checking and Correction.
- Supports only on TCP/IP.
- Not Used Much in Today's Environment.

ATM : Asynchronous Transfer Mode

- 1990s Standard for High Speed for Broadband Integrated Service Digital Network Architecture.
- Data Rate => 155 Mbps to 622 Mbps and Higher.
- Goal => Integrated Voice, Video and Data Transport.
- Provide QoS Requirements for Integrated Traffic.
- Root of Next Generation Telephony.
- Fixed Length Packets => Cells (Uses Virtual Circuit Approach).

ATM : Architecture ??



ATM : Protocol Architecture

AAL (ATM Adaptation Layer)

- Used only at edge of ATM Network.
- Data Segmentation Reassembly.
- Analogous to Internet Transport Layer.

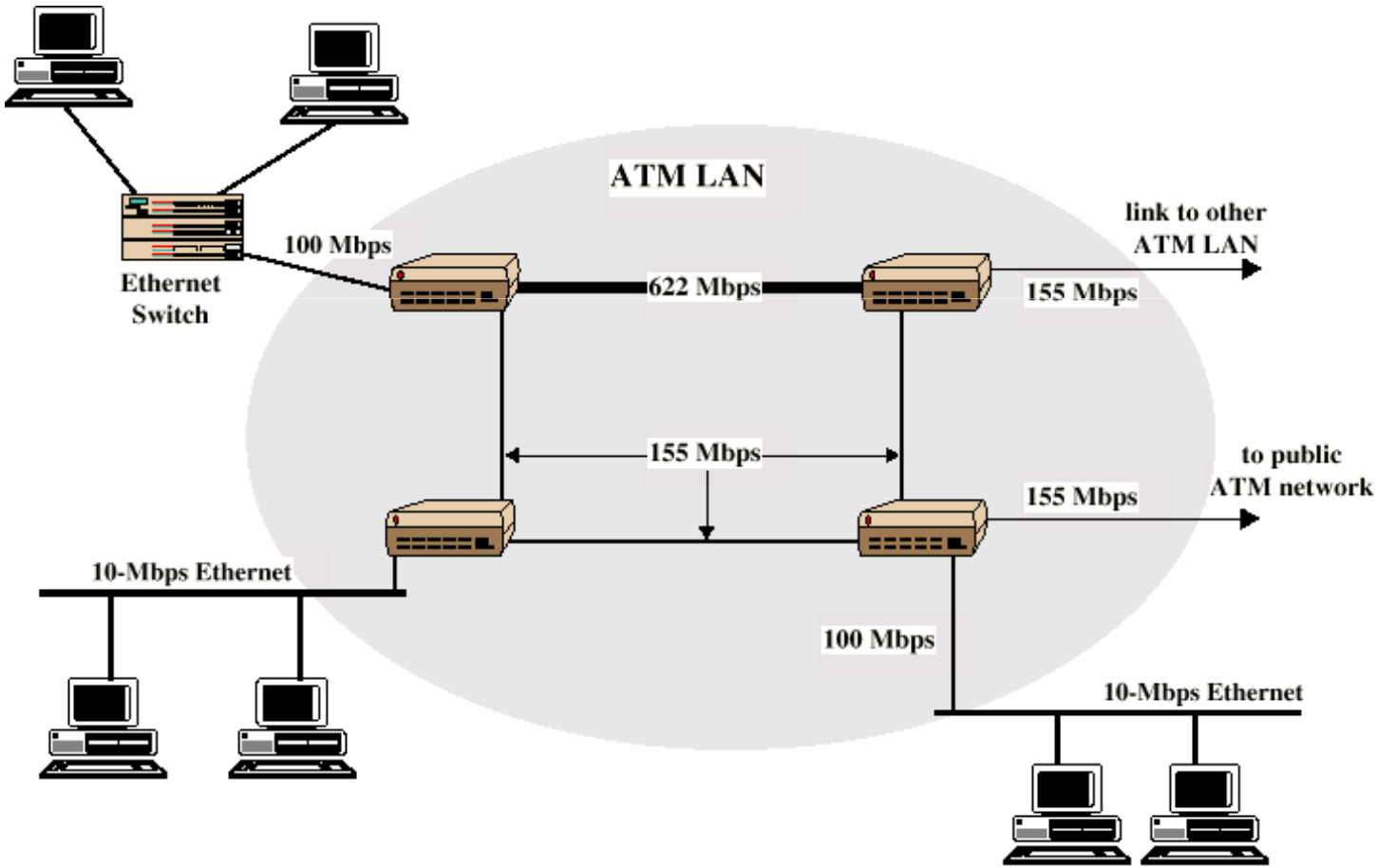
ATM Layer

- Analogous to Internet Network Layer.
- Cell Switching and Routing.

Physical Layer

- Analogous to Internet Physical Layer.

ATM : Example ATM LAN



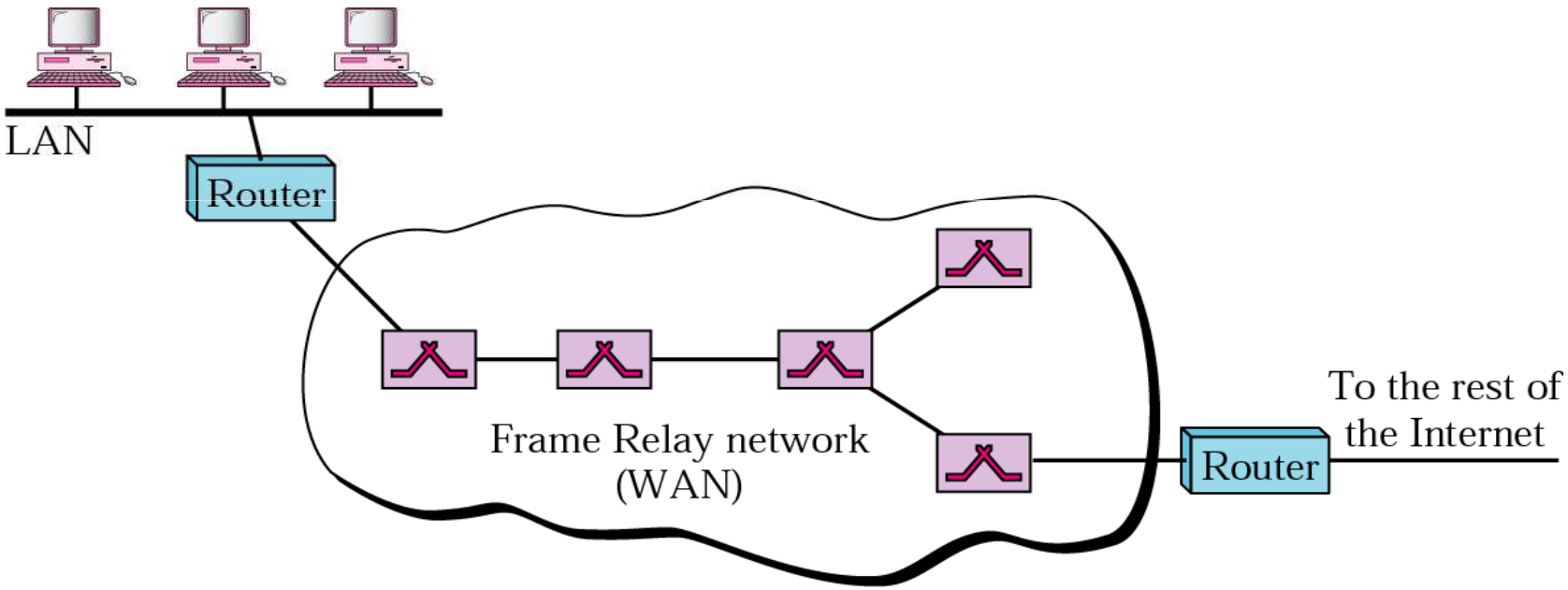
Frame Relay

- It is a Virtual Circuit Wide Area Networks.
- Designed to respond for new type of WAN in late 1980s.
- Prior to Frame Relay => X.25 were Used.

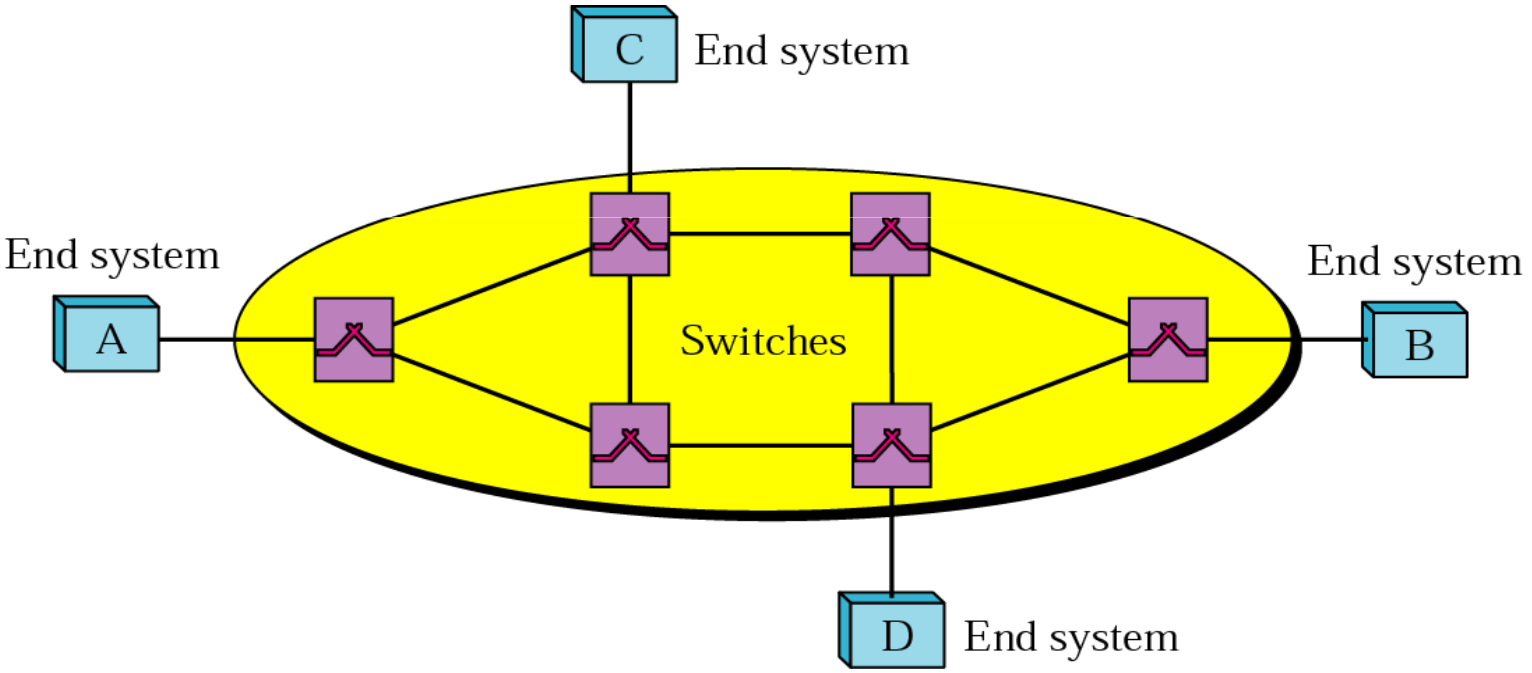
- Demerits of X.25
  - ✓ Low Data Rate (64 Kbps).
  - ✓ Flow and Error Control at Data Link Layer and Network Layer.
  - ✓ X.25 has its own Network Layer.

- Frame Relay Operates at Higher Speed (1.54 Mbps).
- It Operates in Physical and Data Link Layers.
- Can be easily used as a backbone Network.

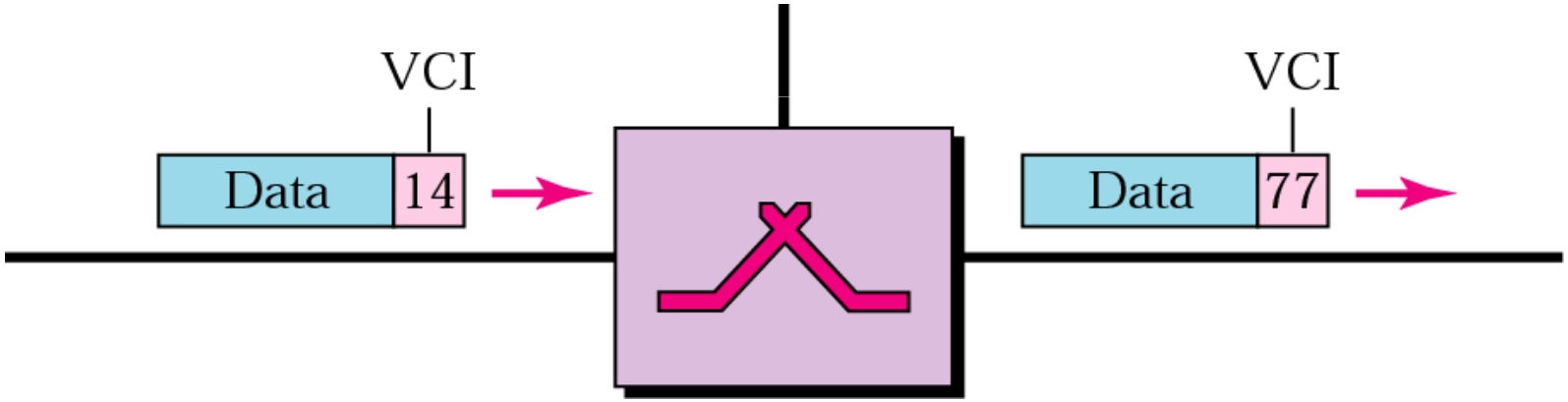
Frame Relay Networks



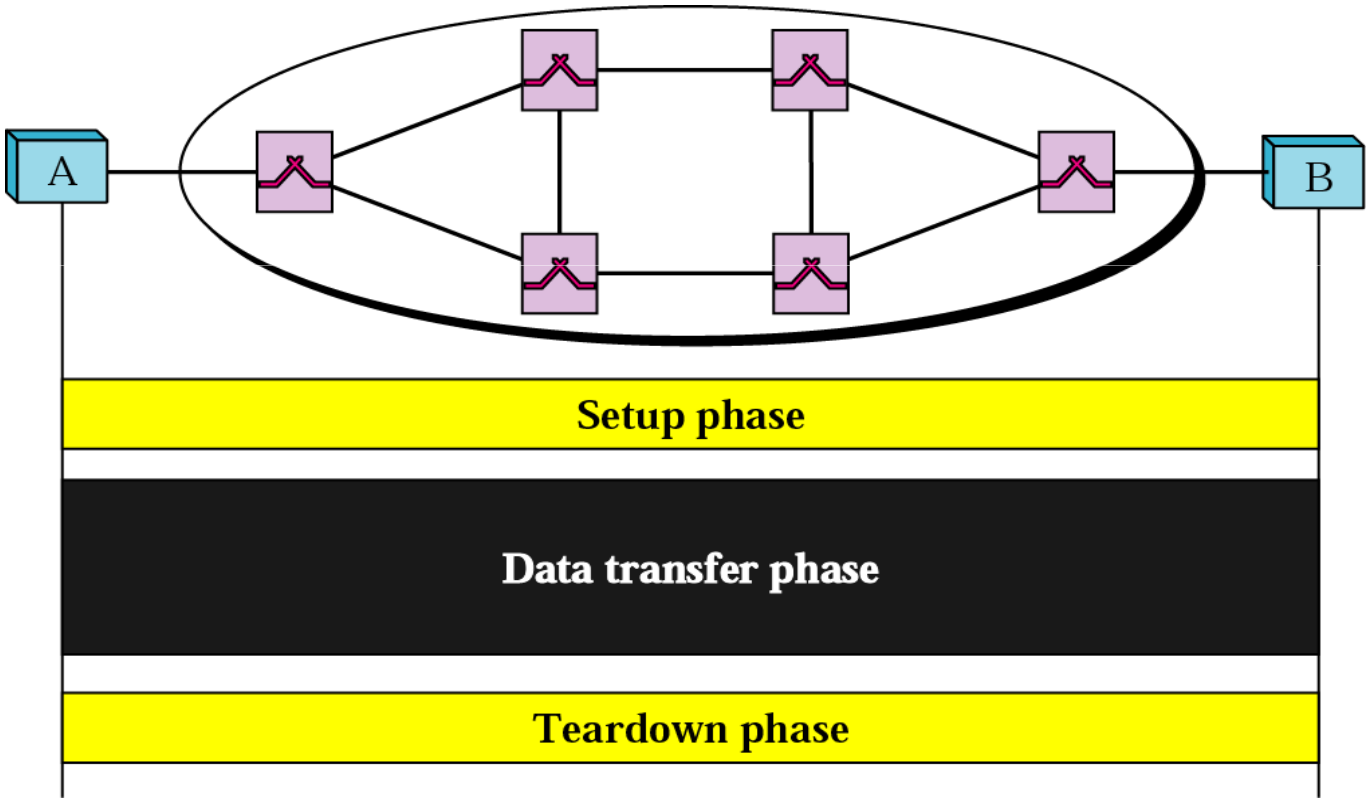
Frame Relay Networks: Virtual Circuit Wide Area Network



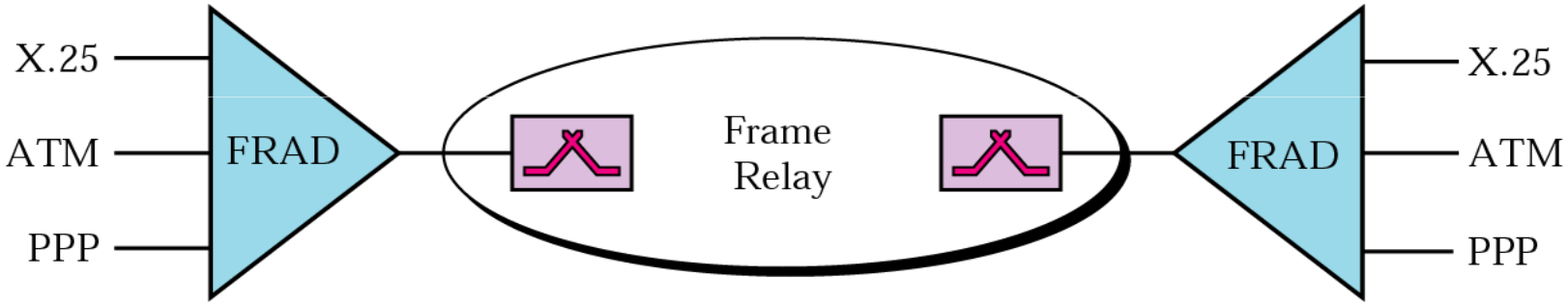
VCI: Virtual Connection Identifier



VCI Phases: Three Phases of VCI



FRAD: Frame Relay Assembler Disassembler



ISDN: Integrated Service Digital Network

- ITU Standard For global Digital Communication.
- It was Developed in 1984 to replace Analog Telephone System.
- Allow the Complete Integration of both Voice, Video and Data Within a Single System.
- Two Types of ISDN
  - ✓ Basic Rate ISDN => Provides 2B+D Channels.
  - ✓ B Channel of 64 Kbps and D Channel of 16 Kbps.
  - ✓ B Channel for Data and D channel for Control.
  - Primary Rate ISDN => Provides 23B+D Channels.
  - Provides Data Rate of 1.544 Mbps.

Thank You