18ECC303J – Computer Communication Networks

Course Credit : 4

Theory : 9 Hours

1. Behrouz A. Fehrouzan, “Data communication & Networking”, Mc-Graw Hill, 5th Edition Reprint, 2014.

2. Andrew S. Tanenbaum, “Computer Networks”, Pearson Education India, 5th Edition, 2013.

3. William Stallings, “Data & Computer Communication”, Pearson Education India, 10th Edition, 2014.

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Unit-2 : OSI Lower Layers

- OSI Network models
- Layered Architecture
- Data Link Layer - Introduction
- Link Layer Addressing
- Error detection and Correction
- Data Link control – LLC
- Data Link control – MAC
- Flow and Error Control Protocol
- ARQ Schemes
- HDLC protocol

Unit 2 –Week 5

Session 13

LLC (Flow Control)

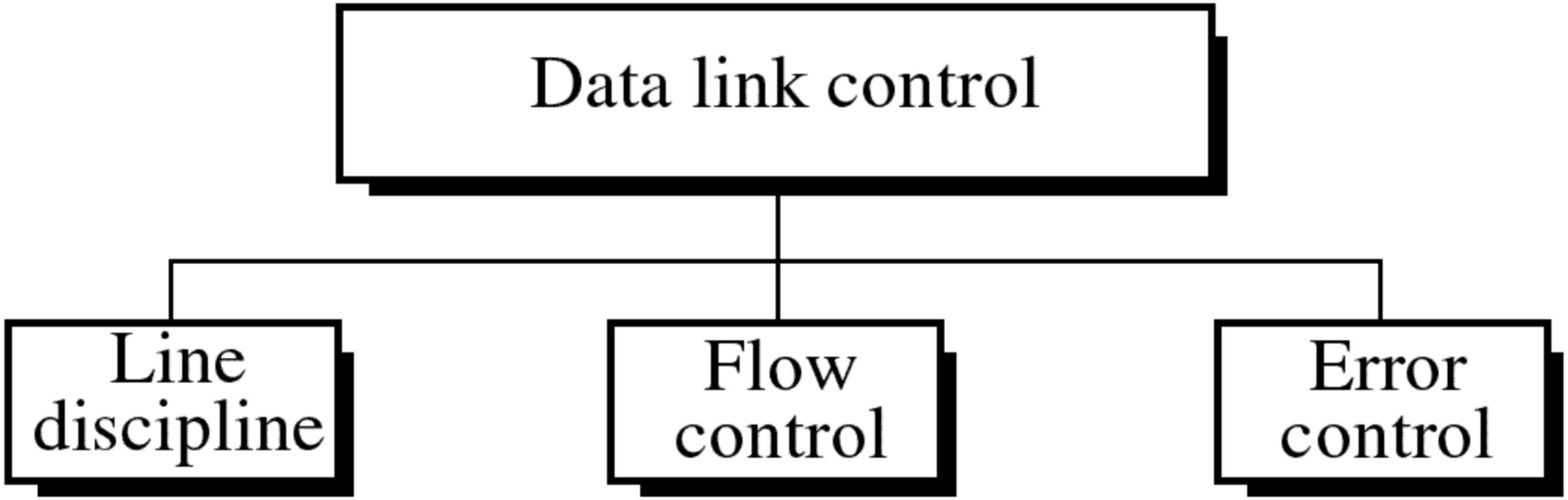
Session 14

LLC (Error Control)

Session 15

MAC Protocols

Data Link Control

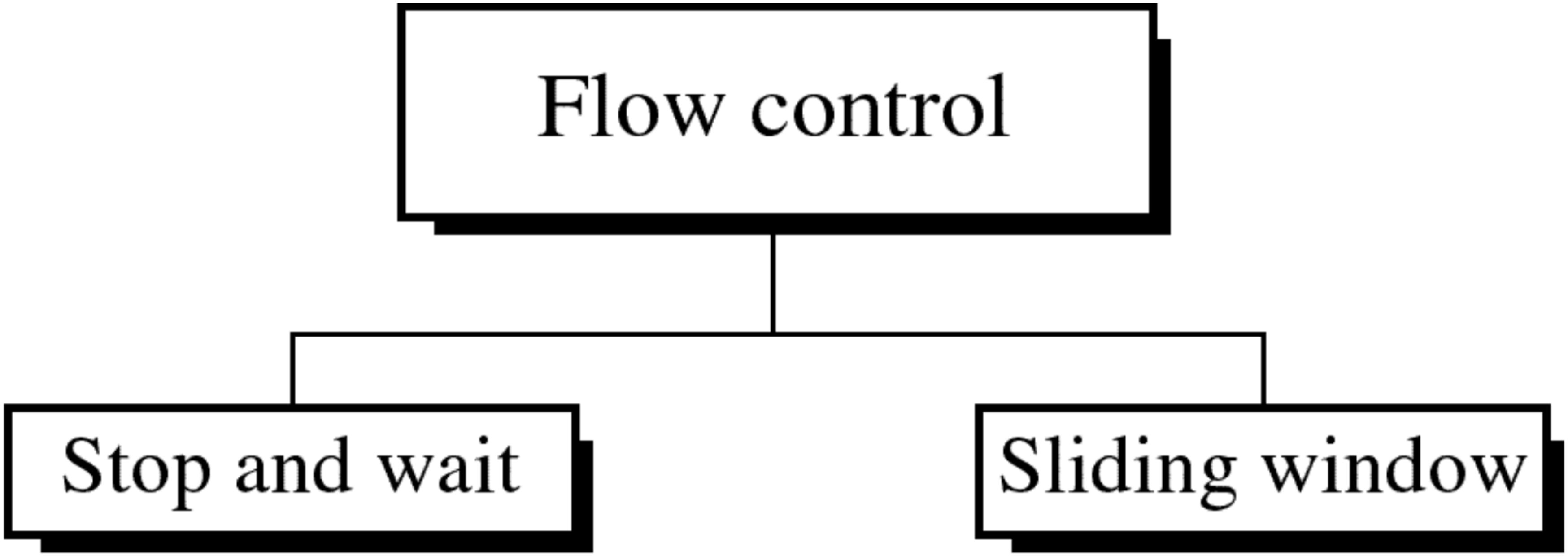


Who should send now?

How much data may be sent?

How can errors be corrected?

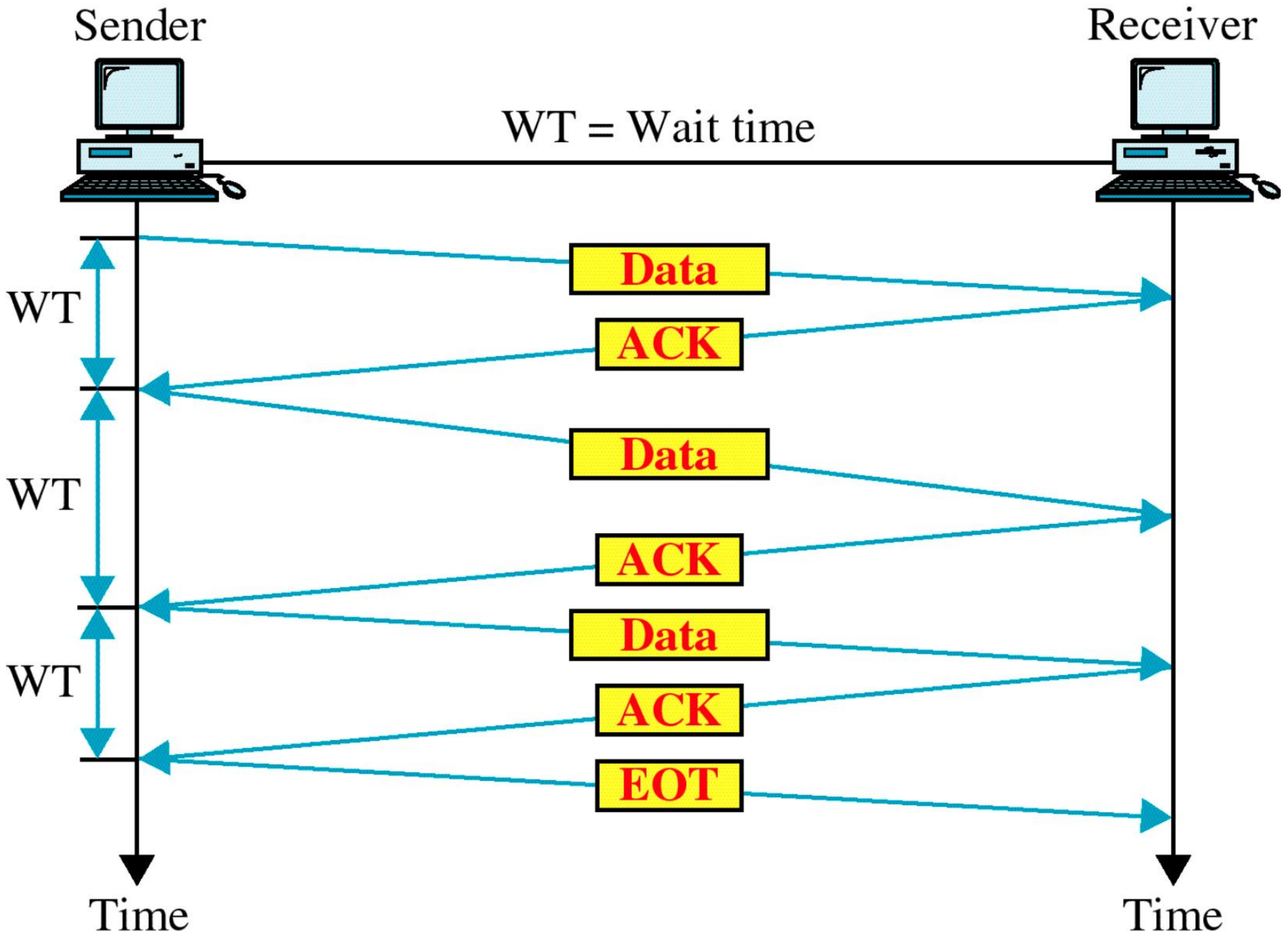
- **Flow Control**
- **Error Control**



Send one frame at a time

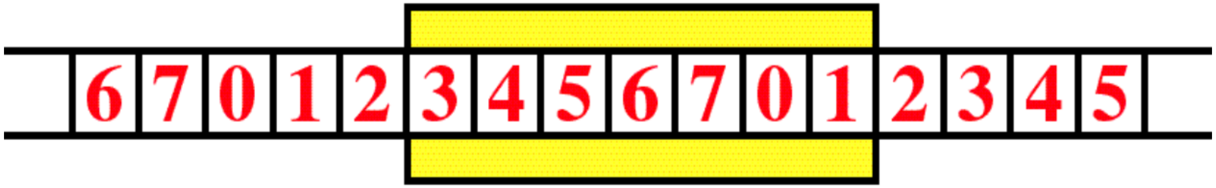
Send several frames at a time

Stop and Wait



Sliding Window

- Sliding window protocols are data link layer protocols for reliable and sequential delivery of data frames.
- The sliding window is also used in Transmission Control Protocol (TCP).
- In this protocol, multiple frames can be sent by a sender at a time before receiving an acknowledgment from the receiver.
- The term sliding window refers to the imaginary boxes to hold frames.
- Sliding window method is also known as windowing



- In these protocols, the **sender has a buffer** called the **sending window** and the **receiver has buffer** called the **receiving window**.

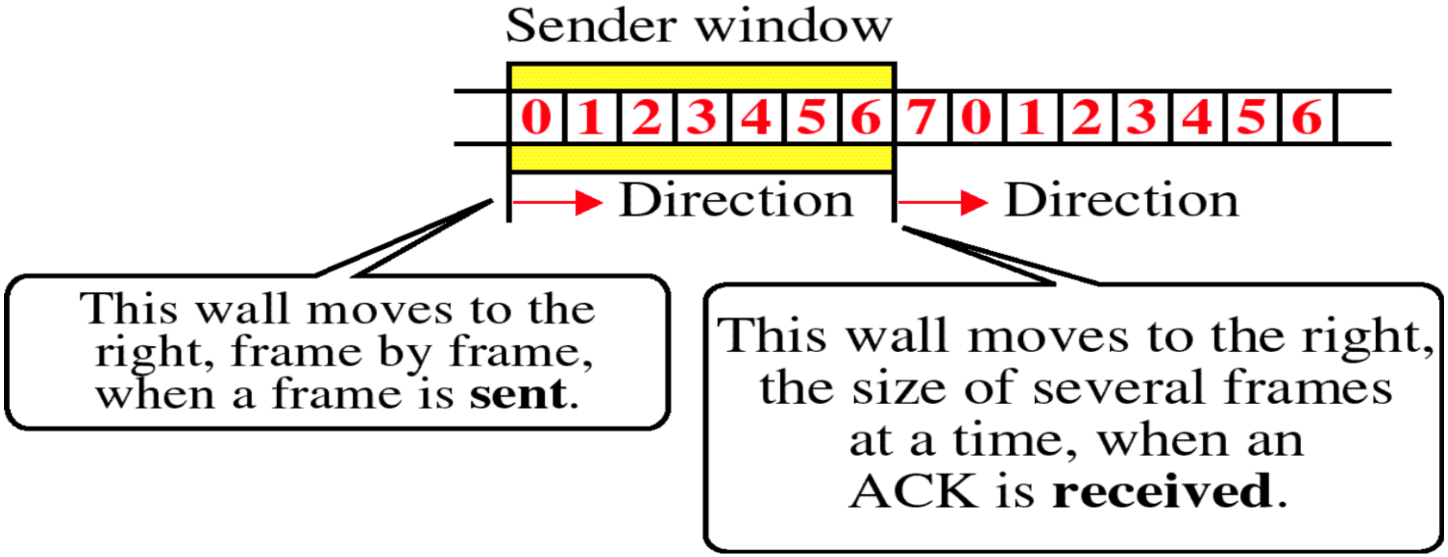
Sender Sliding Window

The size of the sending window determines the sequence number of the outbound frames.

If the sequence number of the frames is an n-bit field in the protocol, then the range of sequence numbers that can be assigned is 0 to 2^n-1.

Thus, the size of the sending window is 2^n-1.

The sequence numbers are numbered as modulo-n.

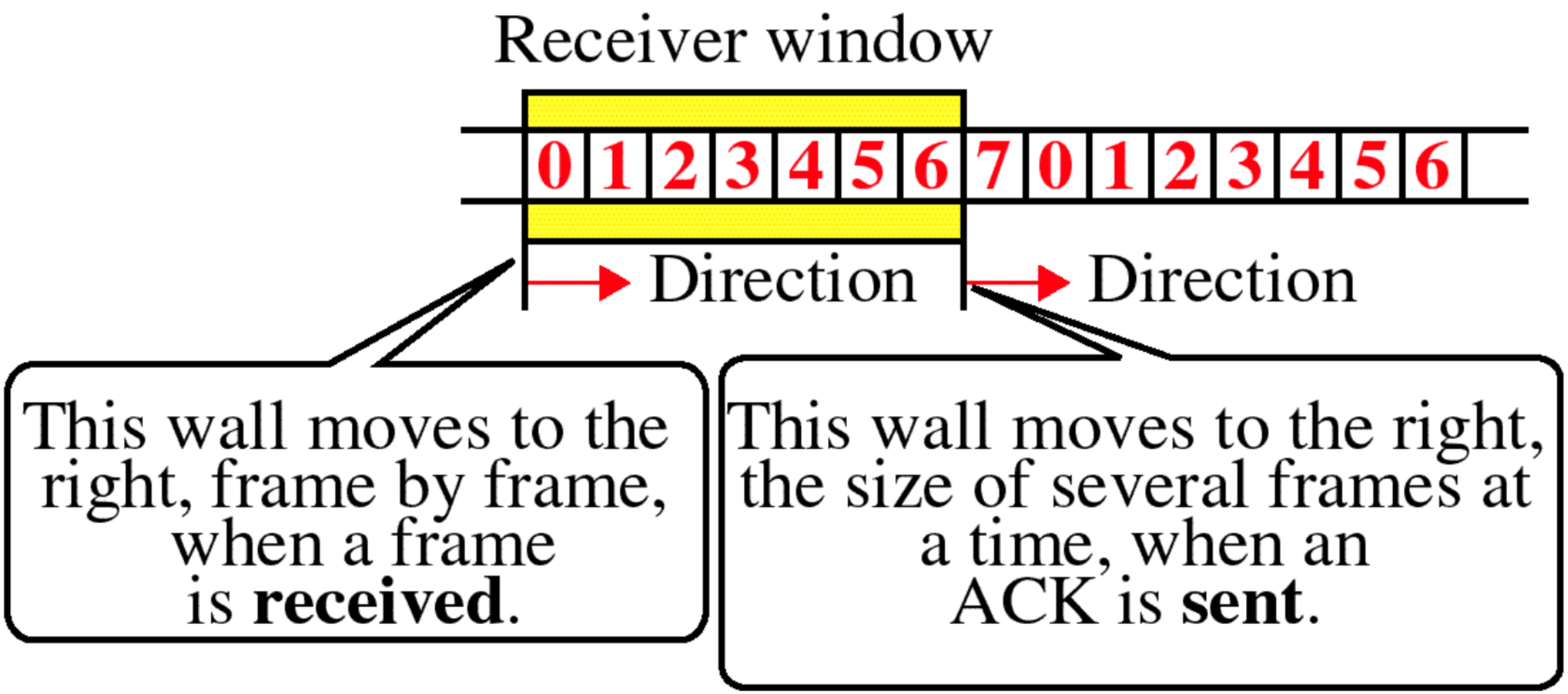


For example, if the sending window size is 8, then the sequence numbers will be 0, 1, 2, 3, 4, 5, 6, 7, 0, 1, 2, 3, 4, 5, 6, 7, 0, 1, and so on. The number of bits in the sequence number is 3 to generate the binary sequence 000, 001, 010, 011,100,100,101,110,111

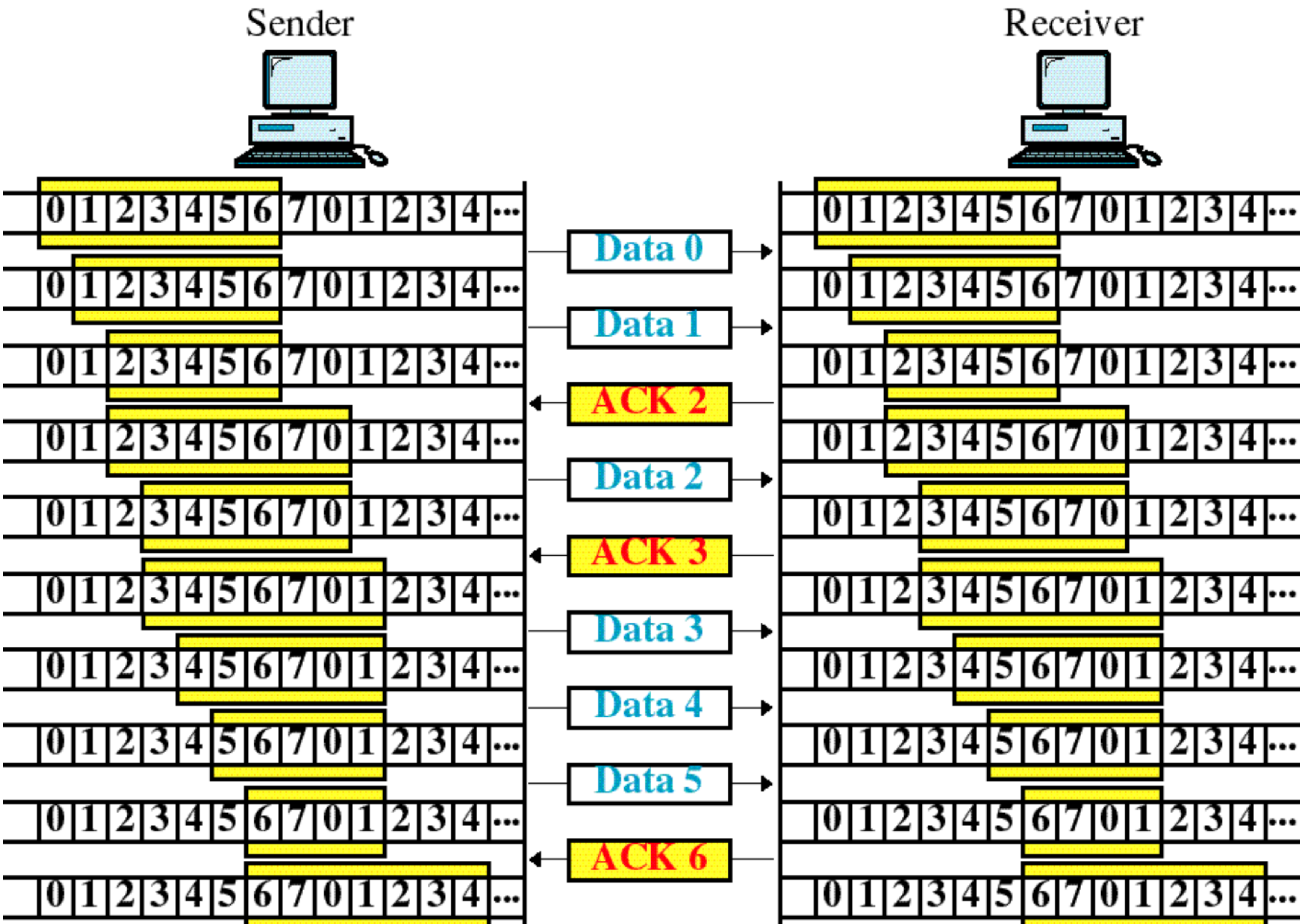
Receiver Sliding Window

The **size of the receiving window is the maximum number of frames that the receiver can accept at a time**.

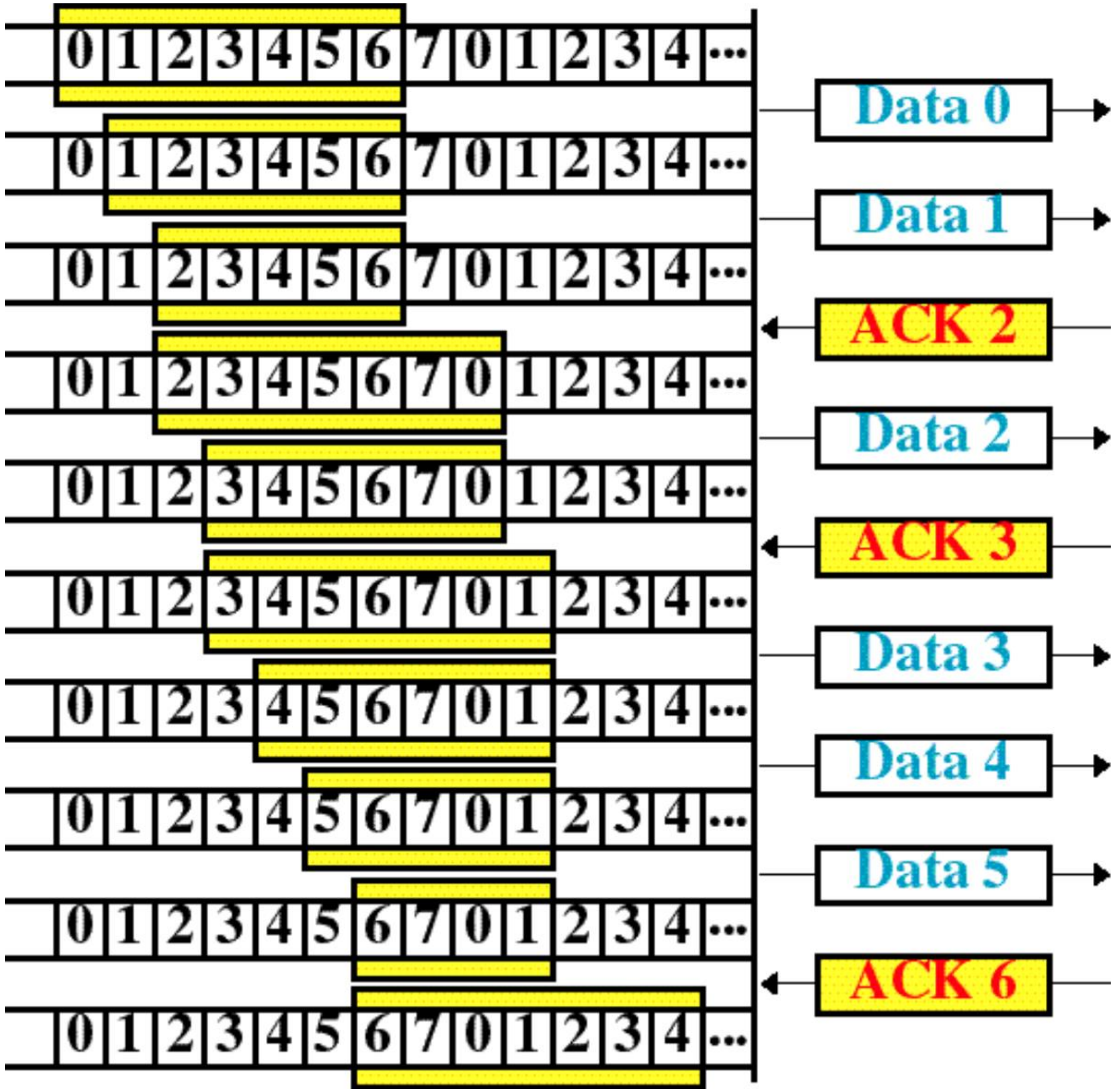
It determines the maximum number of frames that the sender can send before receiving acknowledgment.



Sliding Window Example

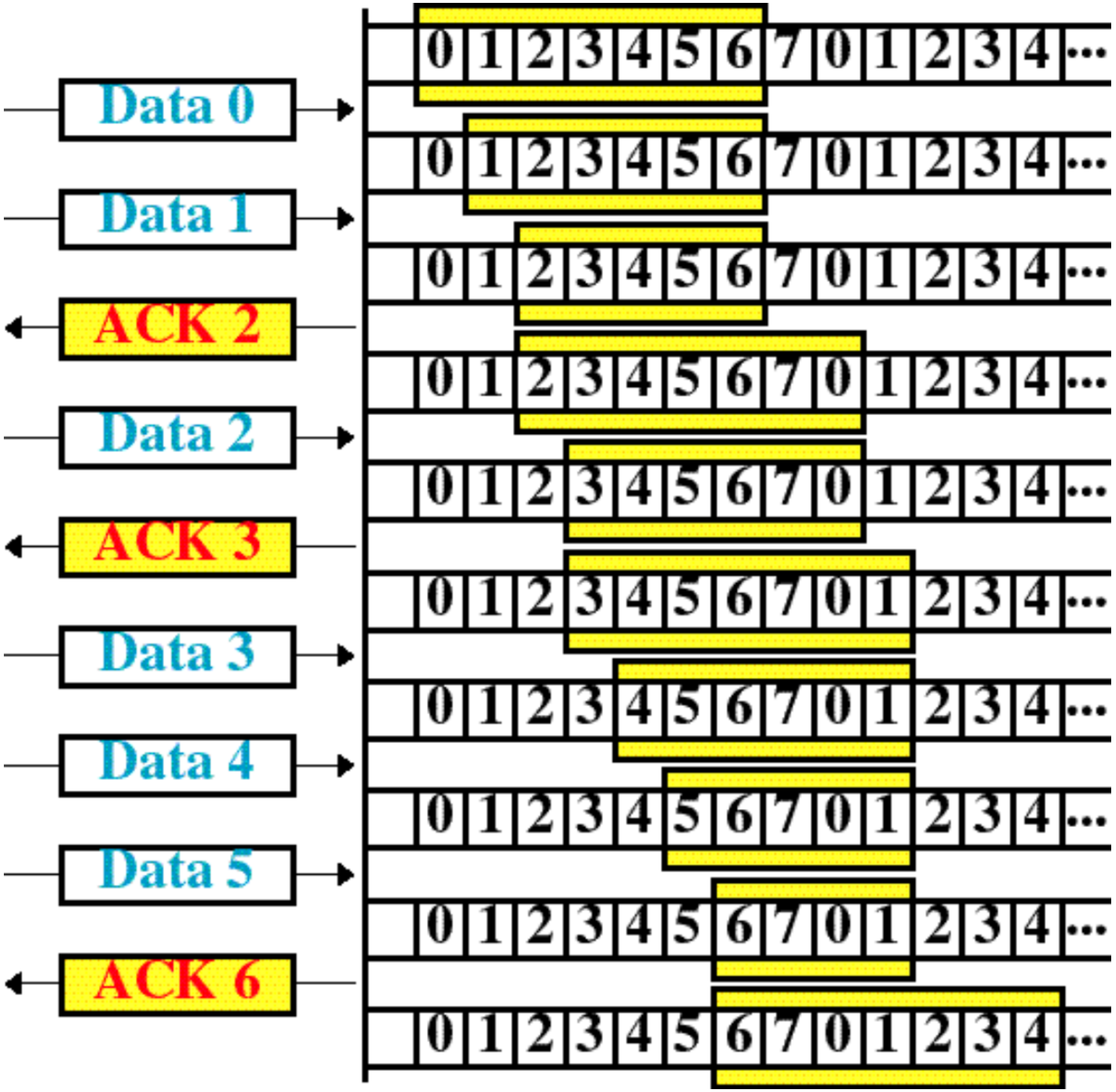


Sender



0 1 2 3 4 5 6 7 0 1 2 3 4 ...
Data 0
Data 1
ACK 2
Data 2
ACK 3
Data 3
Data 4
Data 5
ACK 6

Receiver



Data 0
Data 1
ACK 2
Data 2
ACK 3
Data 3
Data 4
Data 5
ACK 6
0 1 2 3 4 5 6 7 0 1 2 3 4 ...

Difference between Stop and Wait and Sliding Window Protocol

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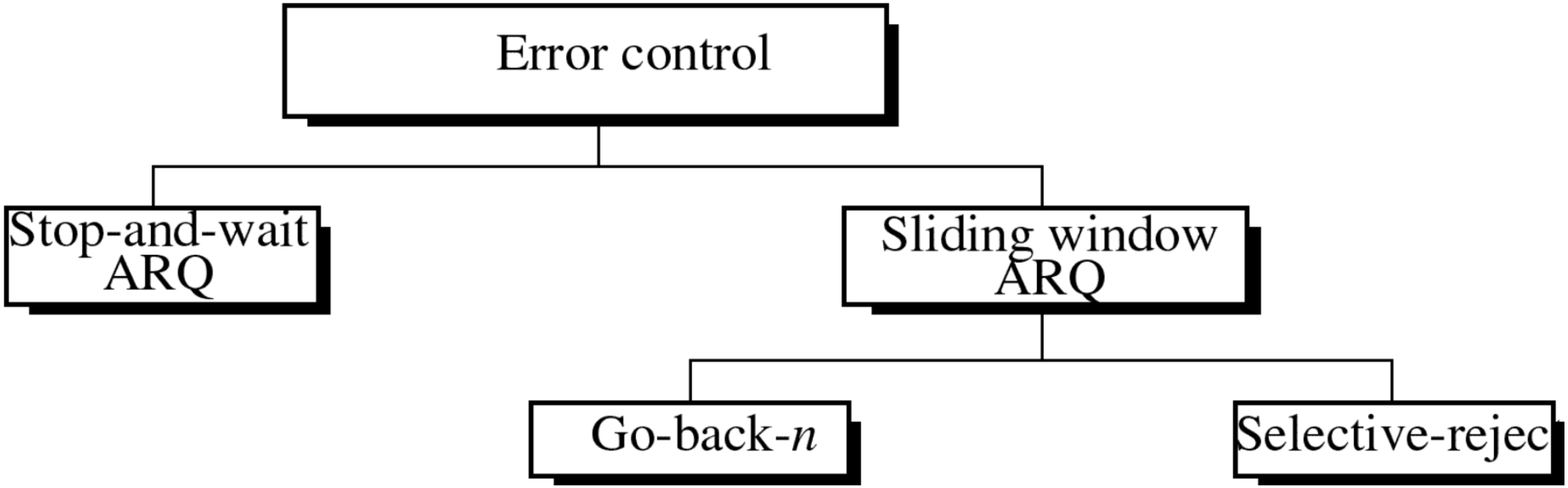
Parameter	Stop and Wait Protocol	Sliding Window
Mechanism	In Stop and Wait protocol, the sender sends a single frame and waits for an acknowledgment from the receiver.	In Sliding window protocol, the sender sends multiple frames at a time and retransmits the damaged frames.
Window Size	1	Varies from 1 to n, where n is the number of bits allotted in the protocol to represent the sequence number
Sorting	Sorting of frames is not needed.	Sorting of frames helps to increase the efficiency of the protocol.
Efficiency	Stop and Wait protocol efficiency is formulated as 1/(1+2a) where a is a ratio of propagation delay to the transmission delay.	Sliding Window protocol efficiency is formulated as N/(1+2a) where N is no. of window frames and a is a ratio of propagation delay to the transmission delay.
Duplex	Stop and Wait protocol is half-duplex in nature.	Sliding Window protocol is full-duplex in nature.

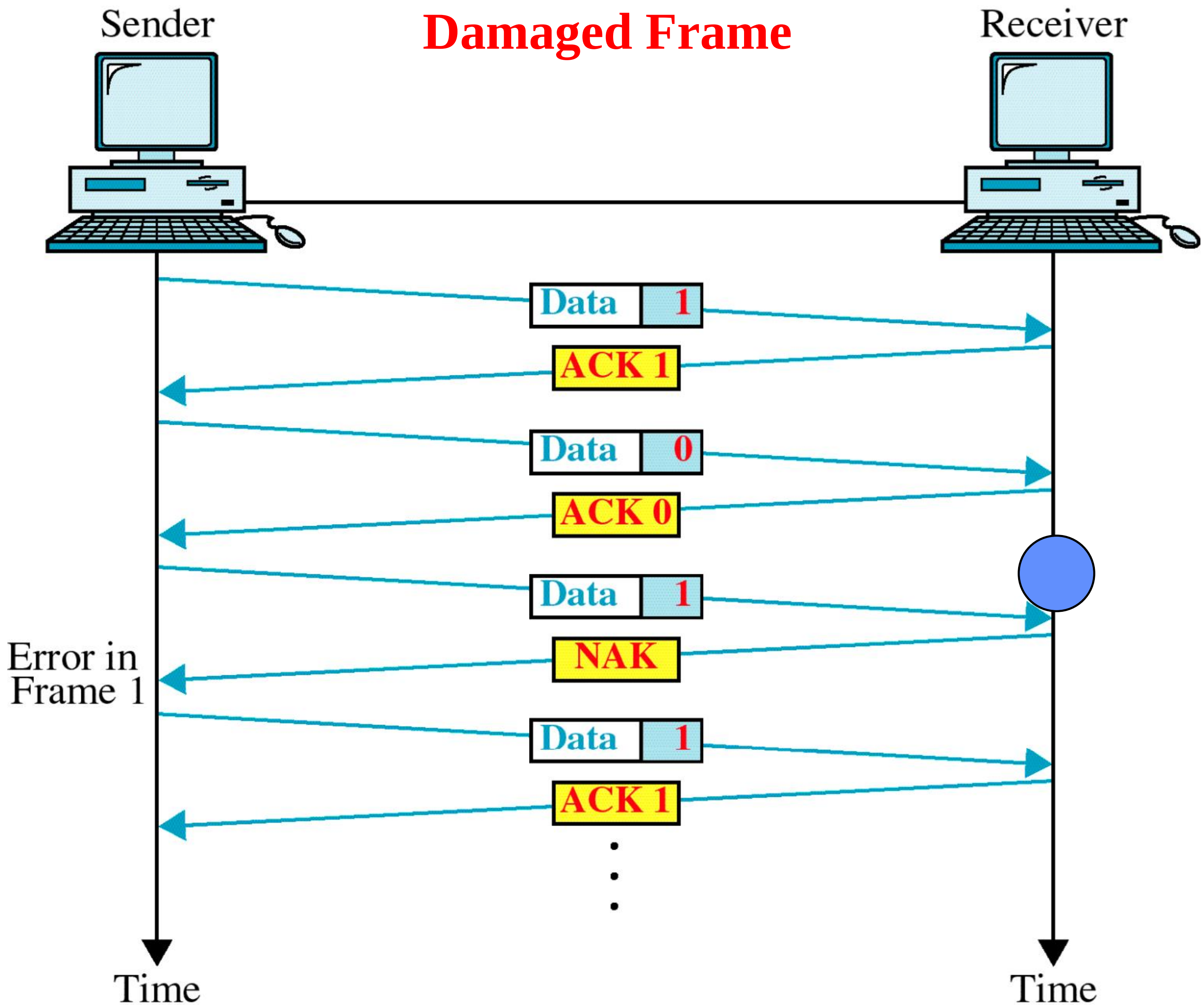
Review Questions

1. Communication at the data-link layer is ____________________________
2. ________________________and ____________________ is needed at each intermediate node
3. First service provided by the data-link layer is__________________
4. LAN and WAN are connected by ________________________
5. A link-layer address is sometimes called _______________________________sometimes a ___________________________, and sometimes a _____________________.
6. Sliding window method is also known as_____________________
7. Size of the sending window is __________
8. Size of the receiving window is the maximum number of frames that the _______________________can accept at a time
9. In Stop and Wait Protocol, the window size is __________________
10. _____________________ is half duplex in nature and ________________________ is full duplex in nature.
11. In Stop wait protocol, sorting of frames is required. (YES/NO)
12. _______________________and ___________________________define the two ends but cannot define which links the datagram should pass through.

Error Control

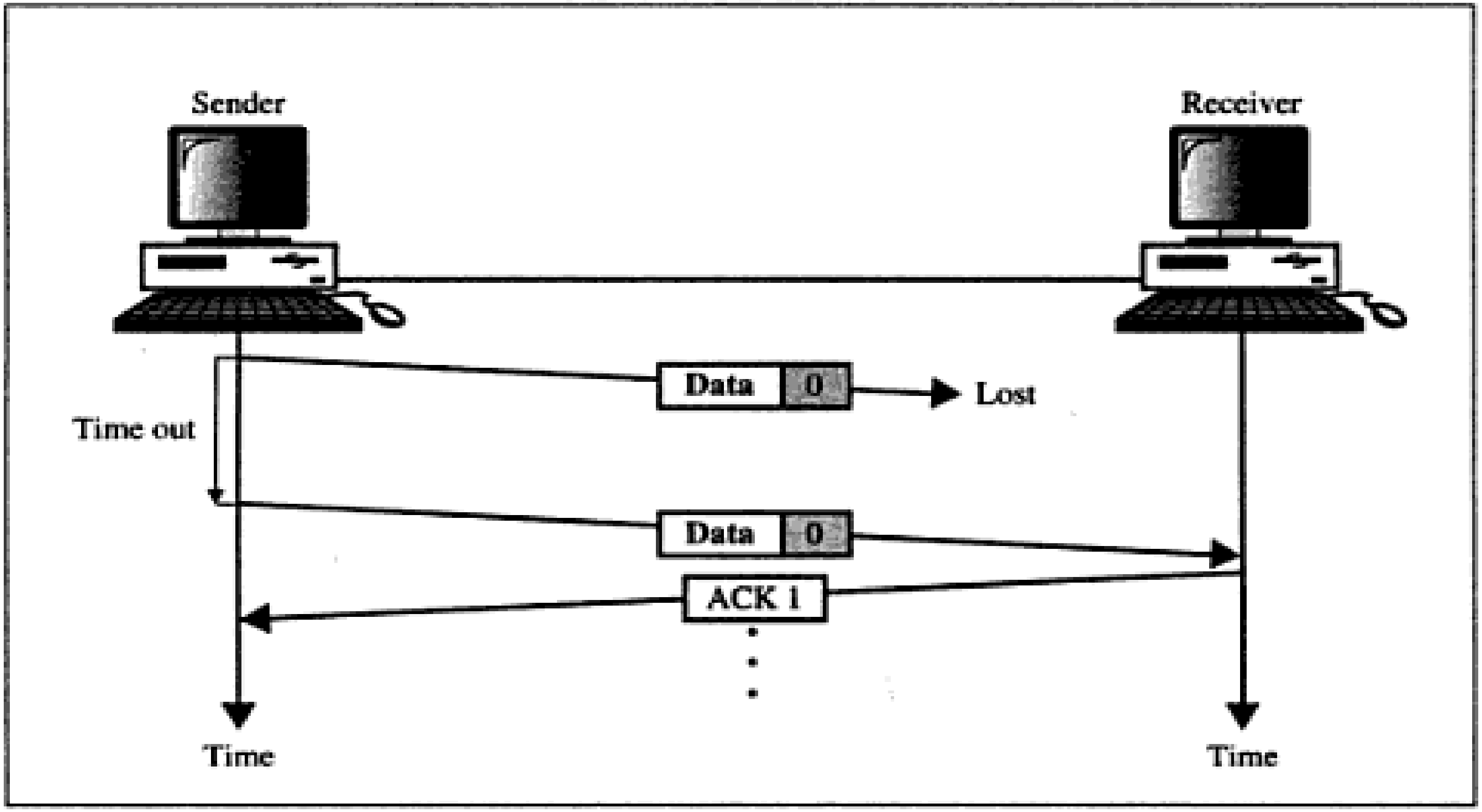


Stop and Wait Error Control Mechanism

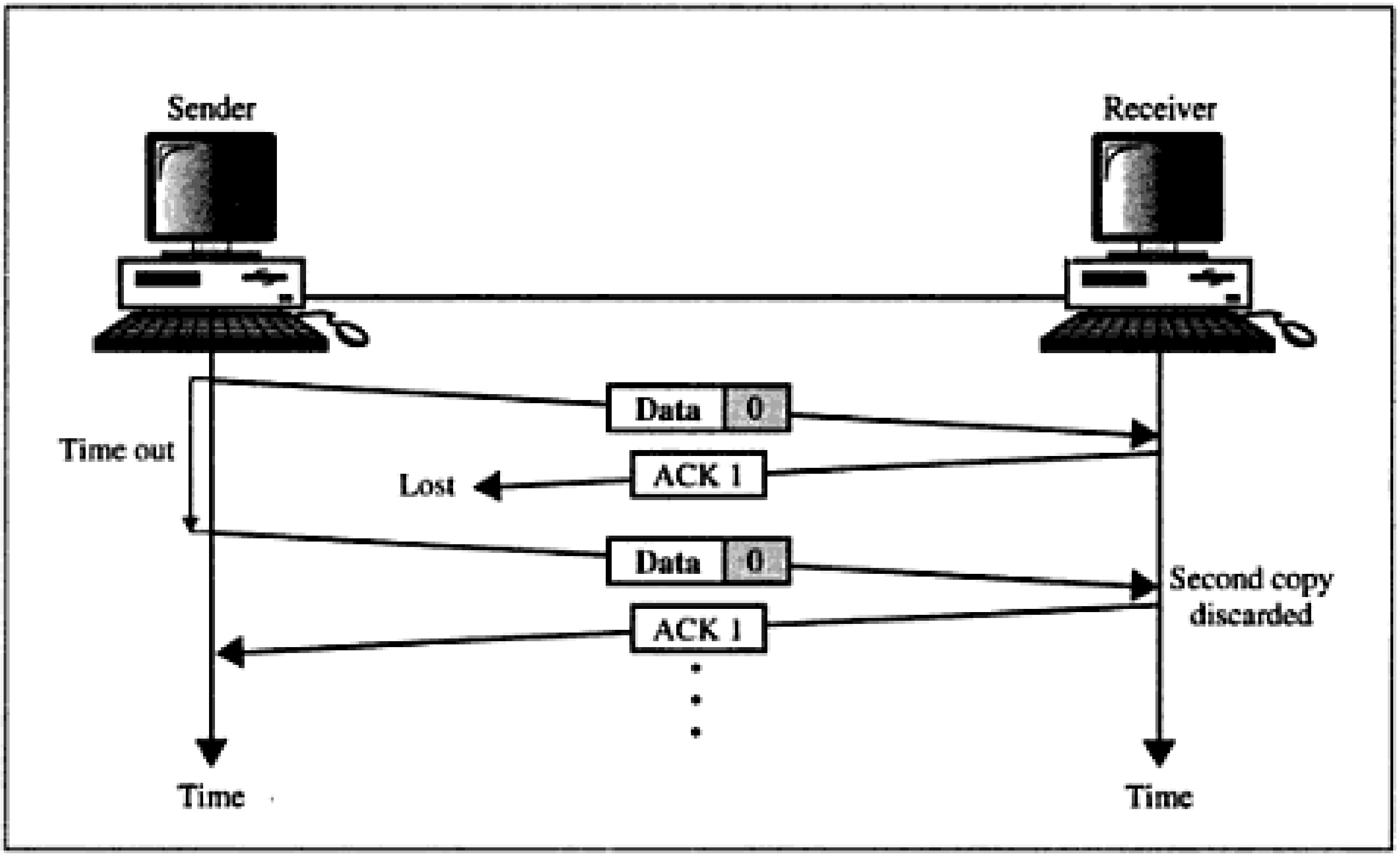


Stop and Wait Error Control Mechanism

Lost Frame

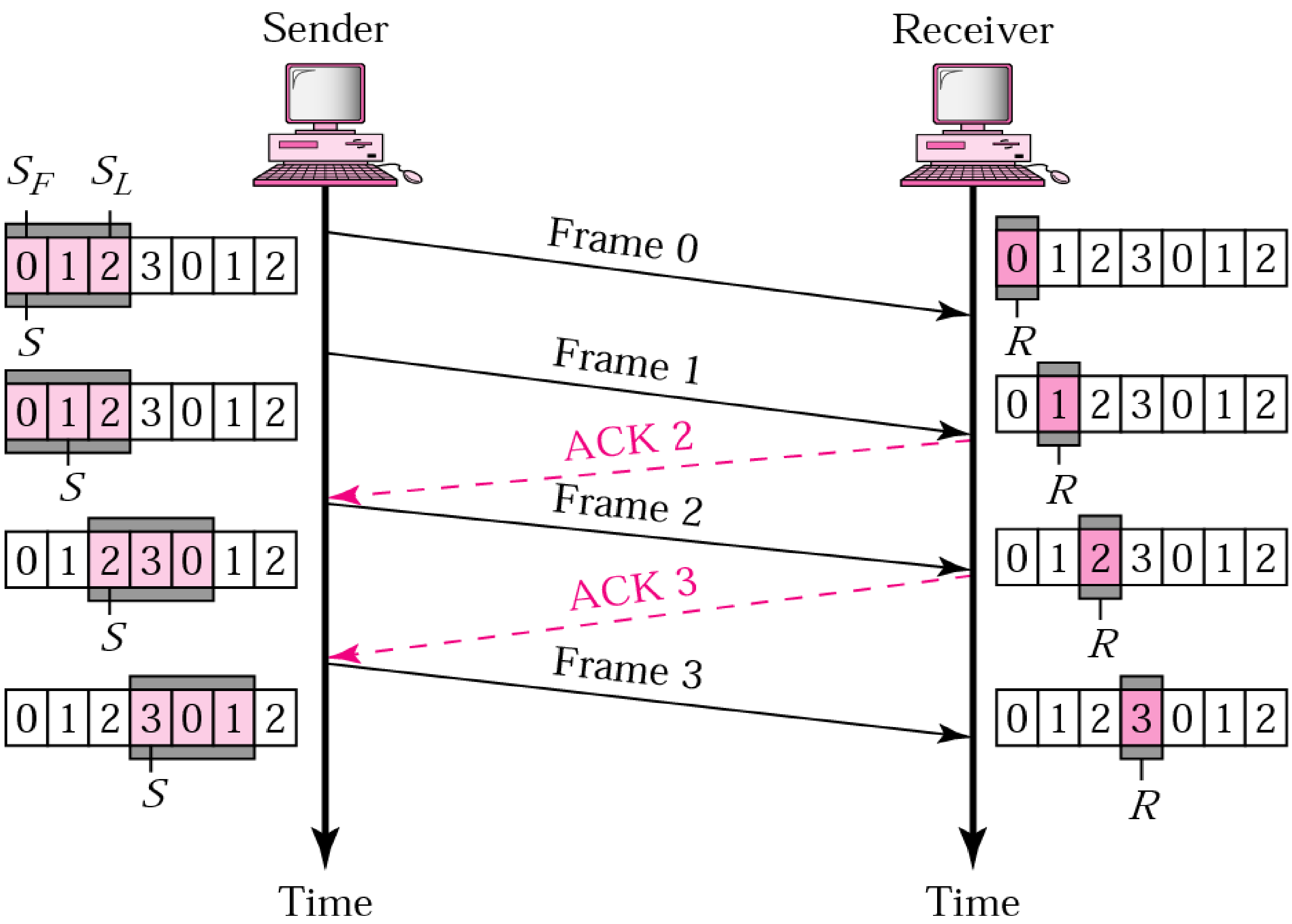


Lost ACK


Sender
Receiver
Data 0
Time out
ACK 1
Lost
Data 0
Second copy discarded
ACK 1
Time
Time

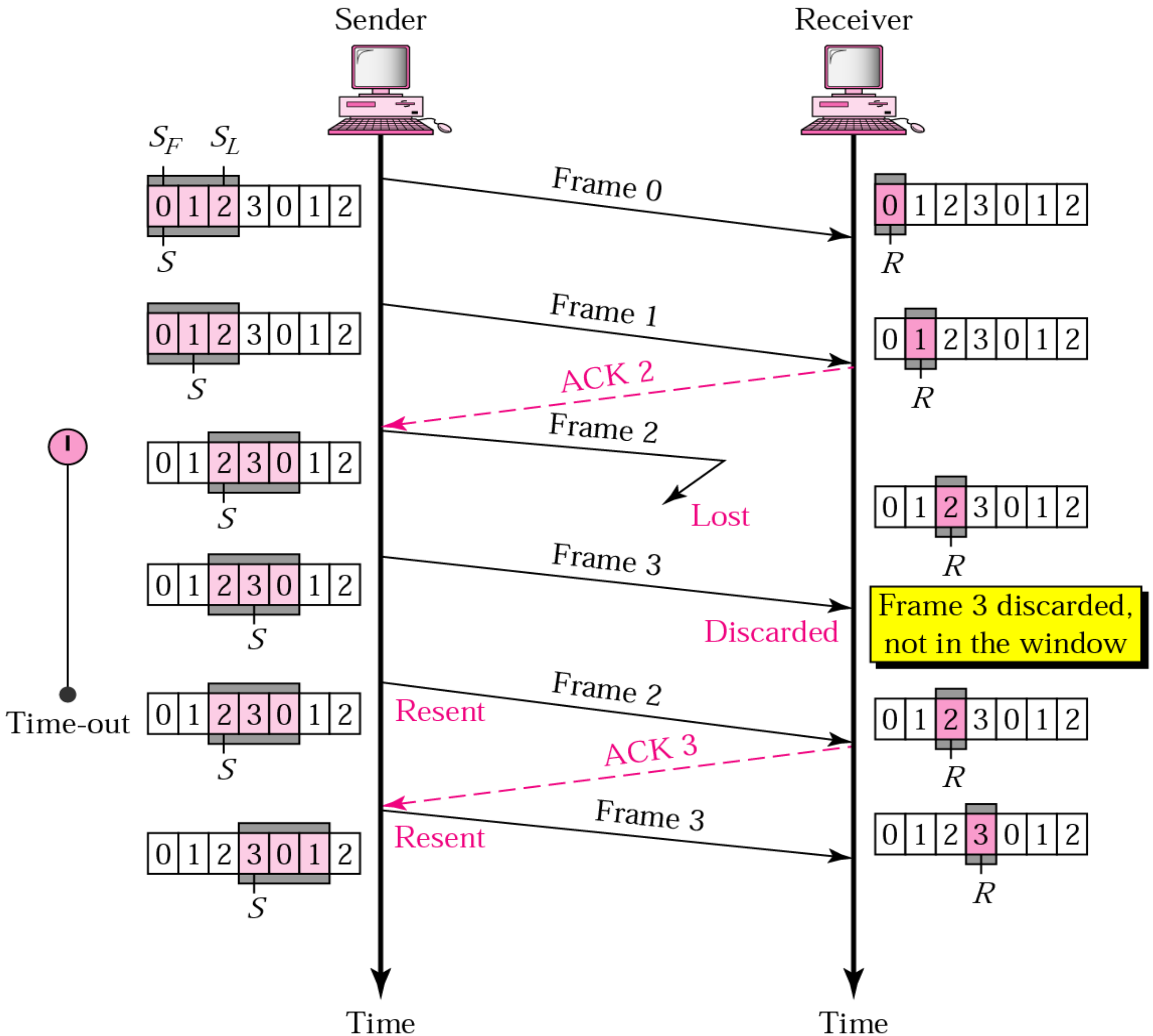
Go-Back-n Error Control Mechanism

Normal Operation

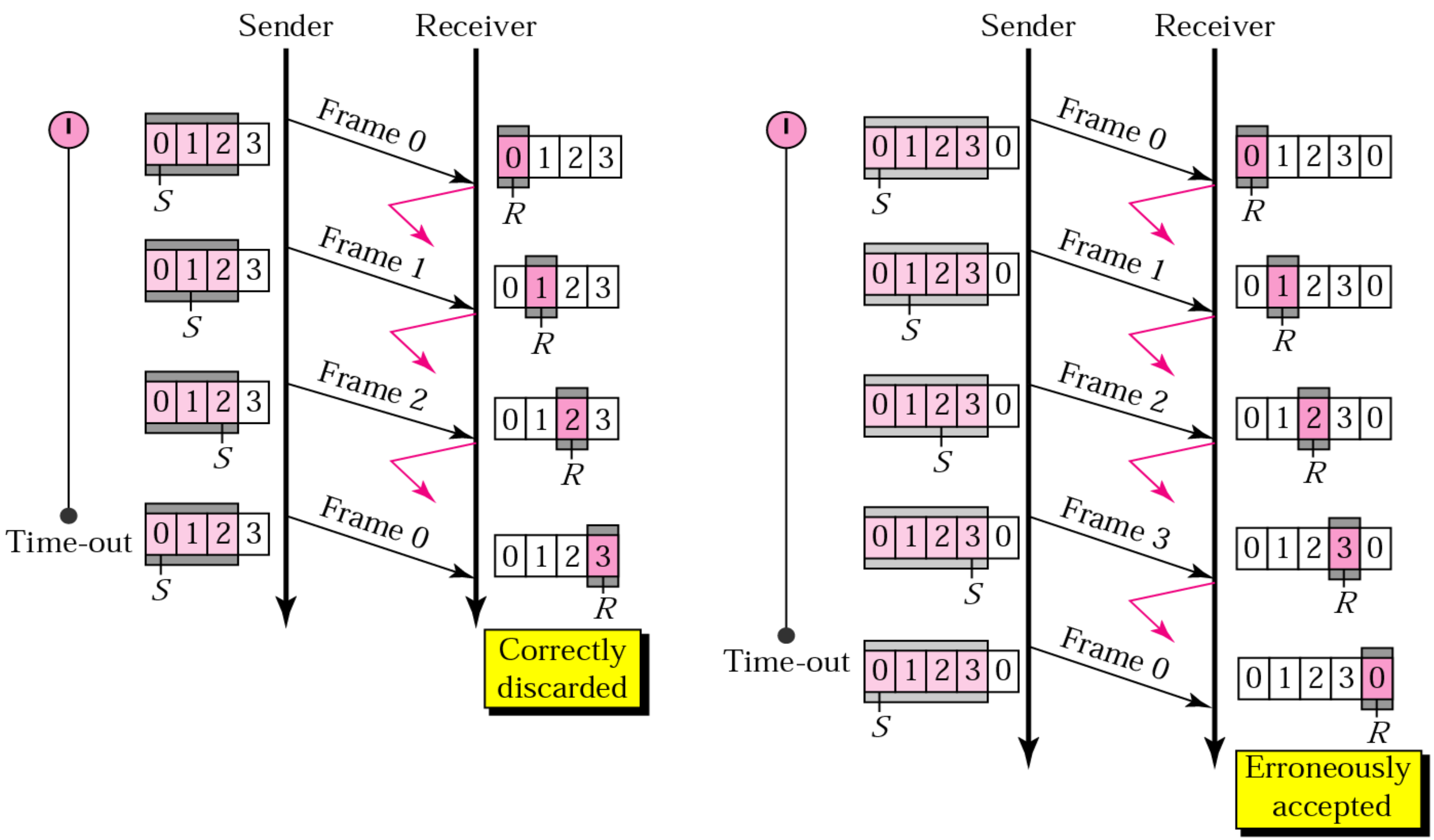


Go-Back-n Error Control Mechanism

Lost Frame



Go-Back-n - Sender window size

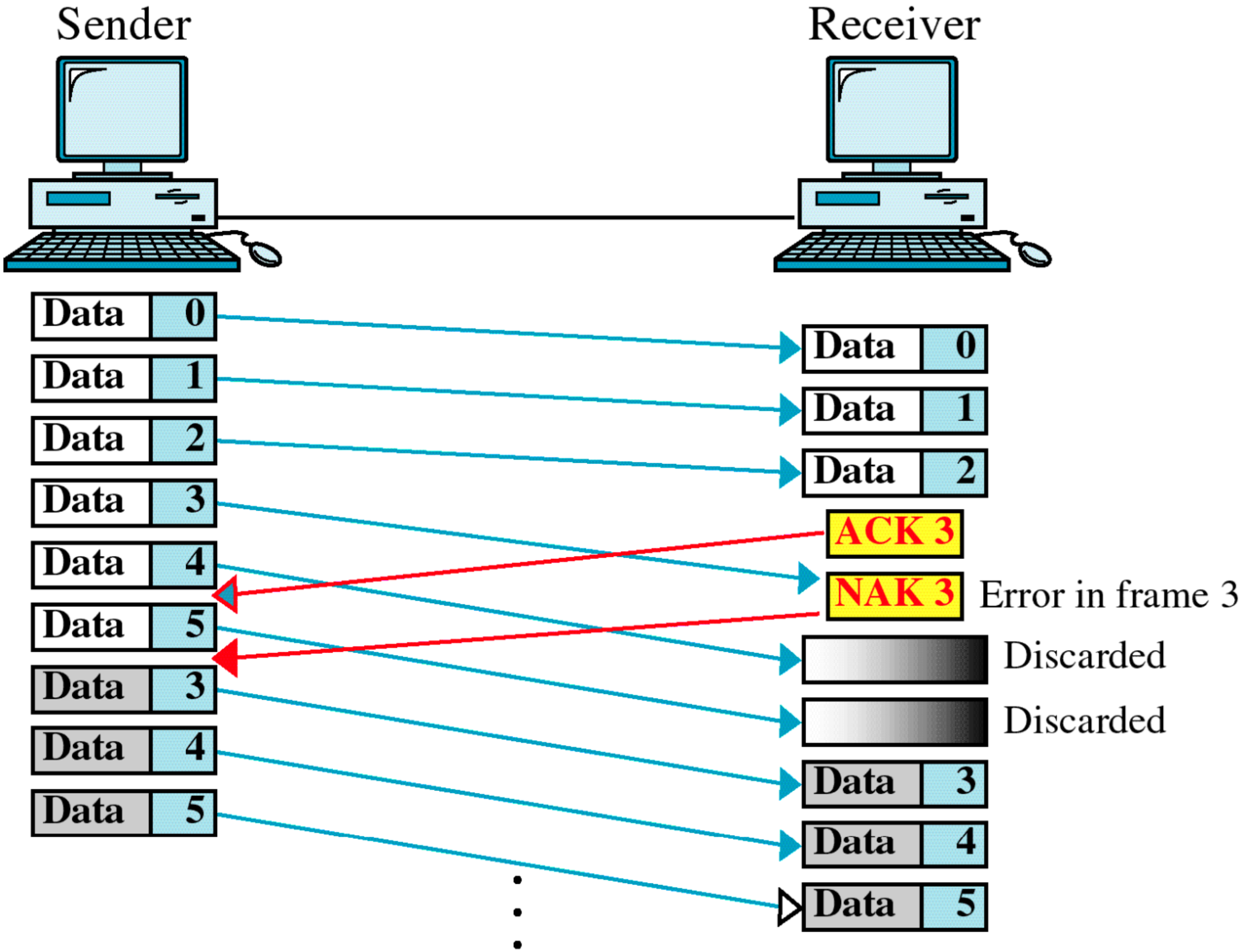


a. Window size < 2^m

b. Window size = 2^m

Go-Back-n Error Control Mechanism

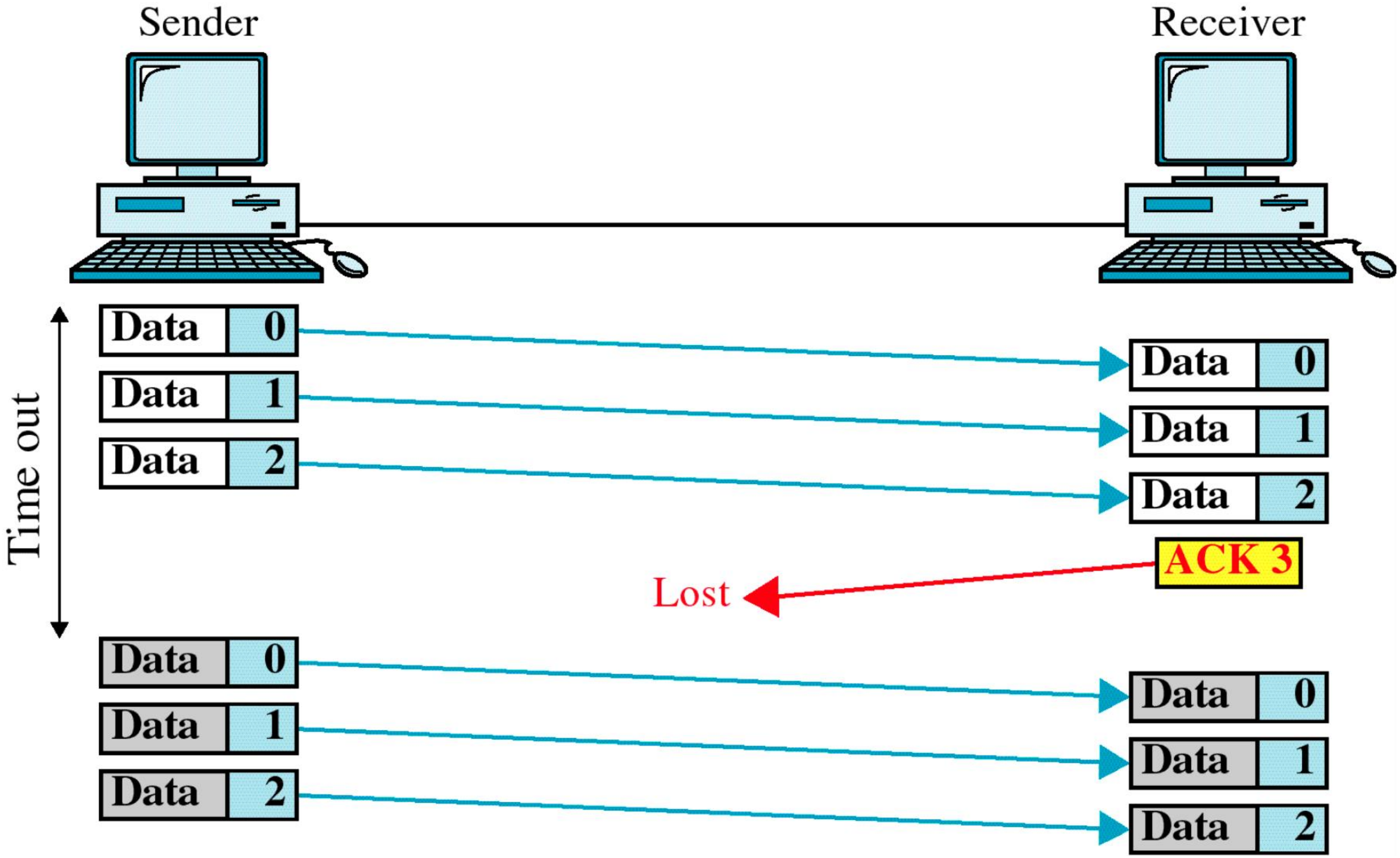
Damaged Frame



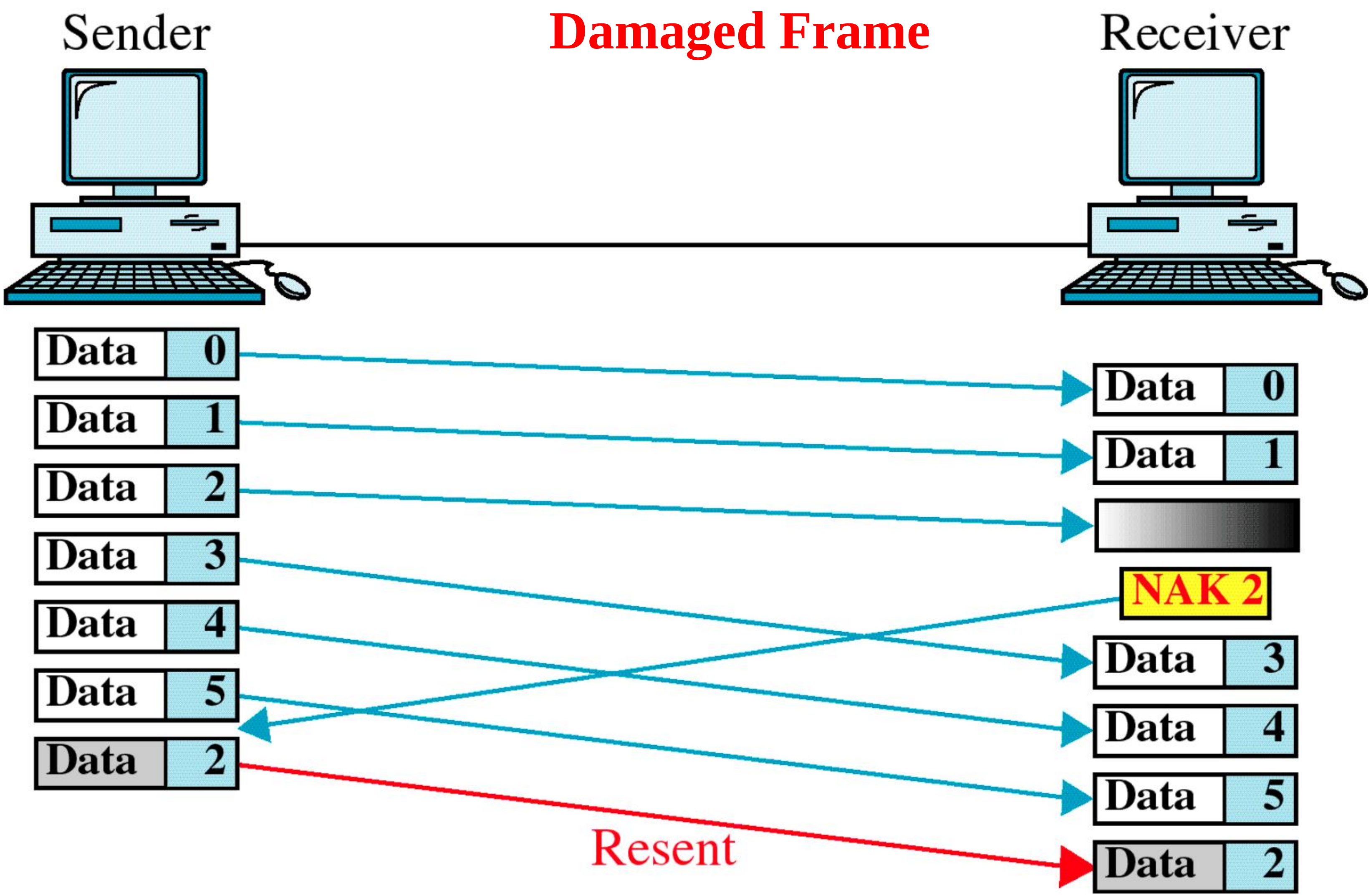
The size of the receiving window is 1.

Go-Back-n Error Control Mechanism

Lost ACK

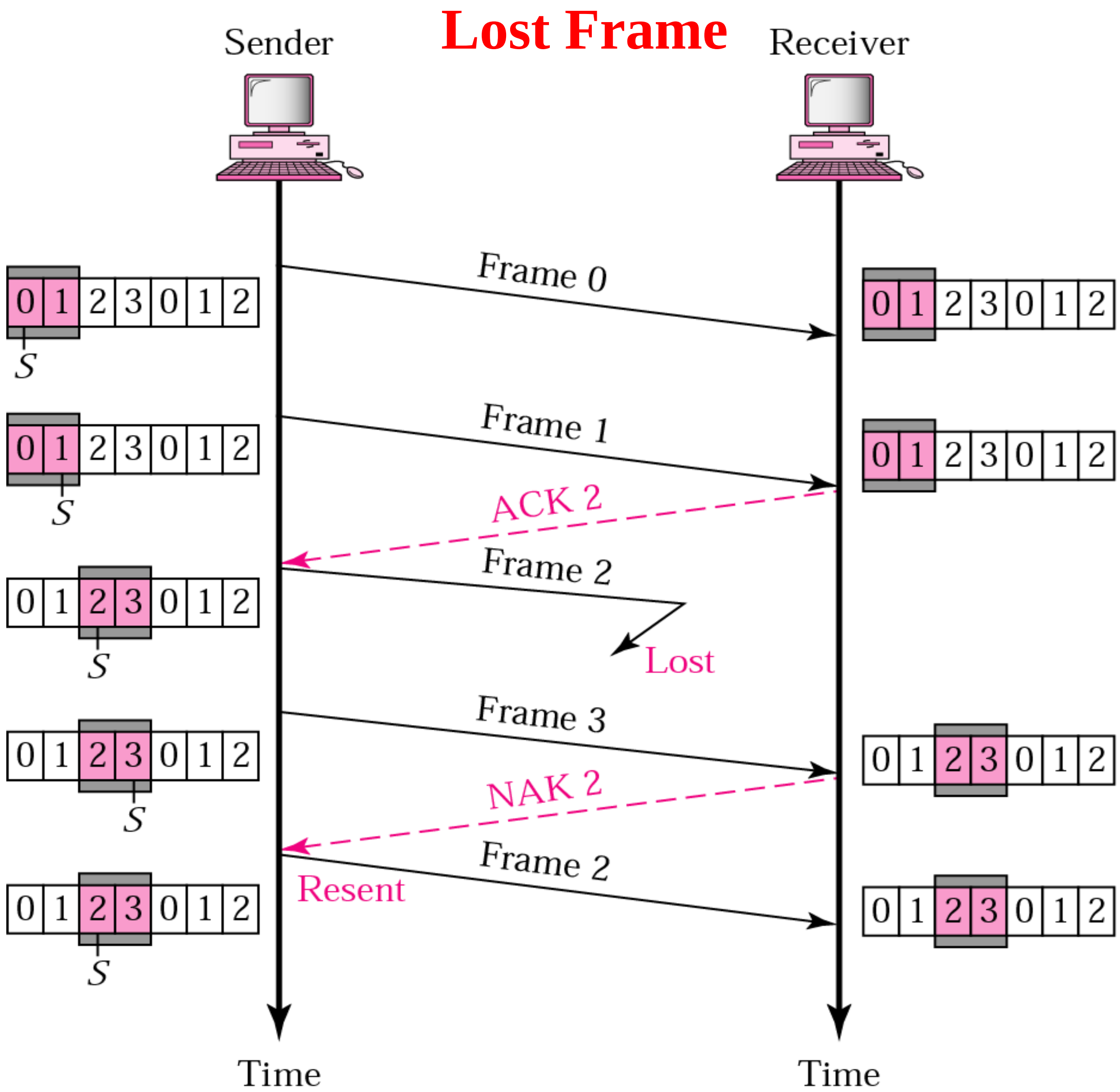


Selective Reject Error Control Mechanism



The size of the receiving window is < 2^n-1.

Selective Reject Error Control Mechanism



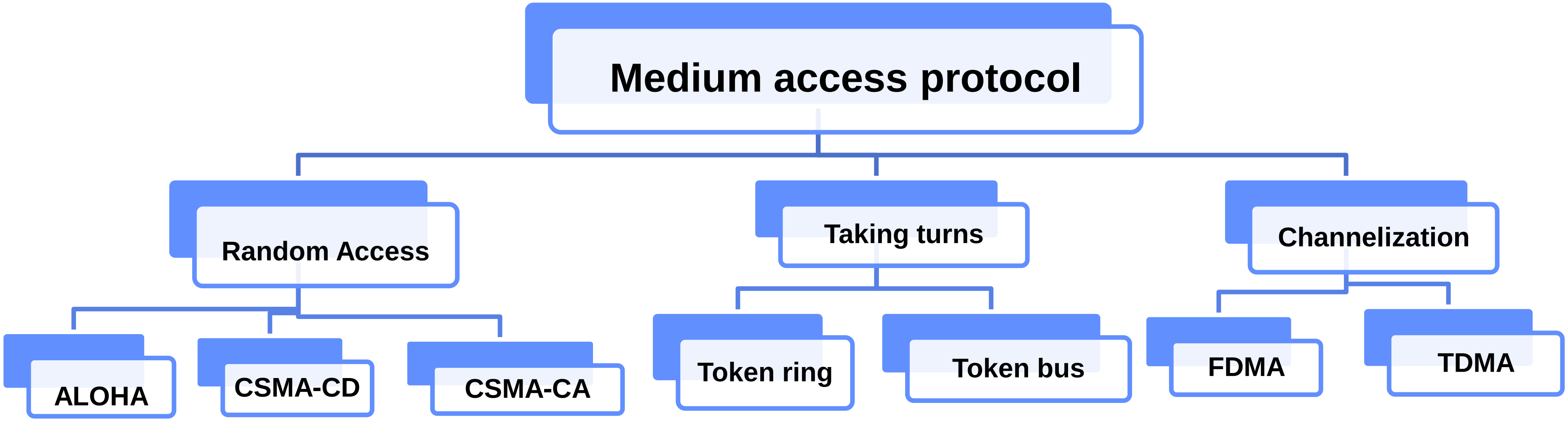
Difference between Stop and Wait, Go-Back-n and Selective Reject

Parameter	Stop and Wait	Go-Back-n	Selective Reject
Sender window size	Sender window size is 1.	Sender window size is less than $2^n - 1$.	Sender window size is equal to $2^n - 1$.
Receiver Window size	Receiver window size is 1	Receiver window size is 1.	Receiver window size is n.
Acknowledgement Type	Individual	Cumulative	Individual
Supported Order	no specific order is needed at receiver end	In-order delivery only are accepted at receiver end	Out-of-order deliveries also can be accepted at receiver end.
Re-transmission	in case of packet drop, number of re-transmission is 1	in case of packet drop, numbers of re-transmissions are N	in case of packet drop, number of re-transmission is 1

MAC Sub layer

Medium access protocols are distributed algorithm that determines how nodes share a channel. Ideally,

- When only one node wants to transmit, it can send at the maximum channel rate R.
- When M nodes want to transmit, each can send at an average rate R/M

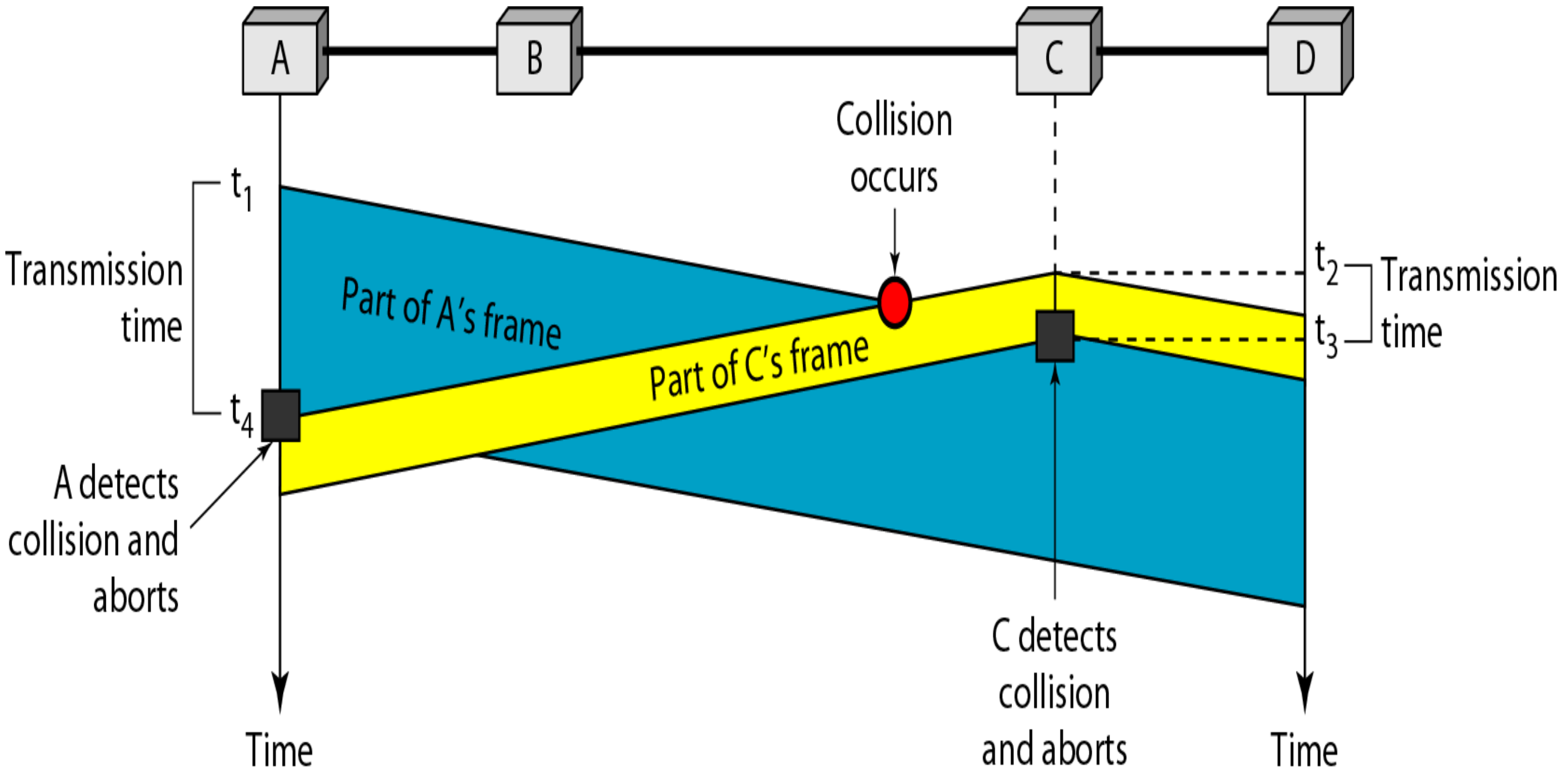


Random Access Methods
CSMA

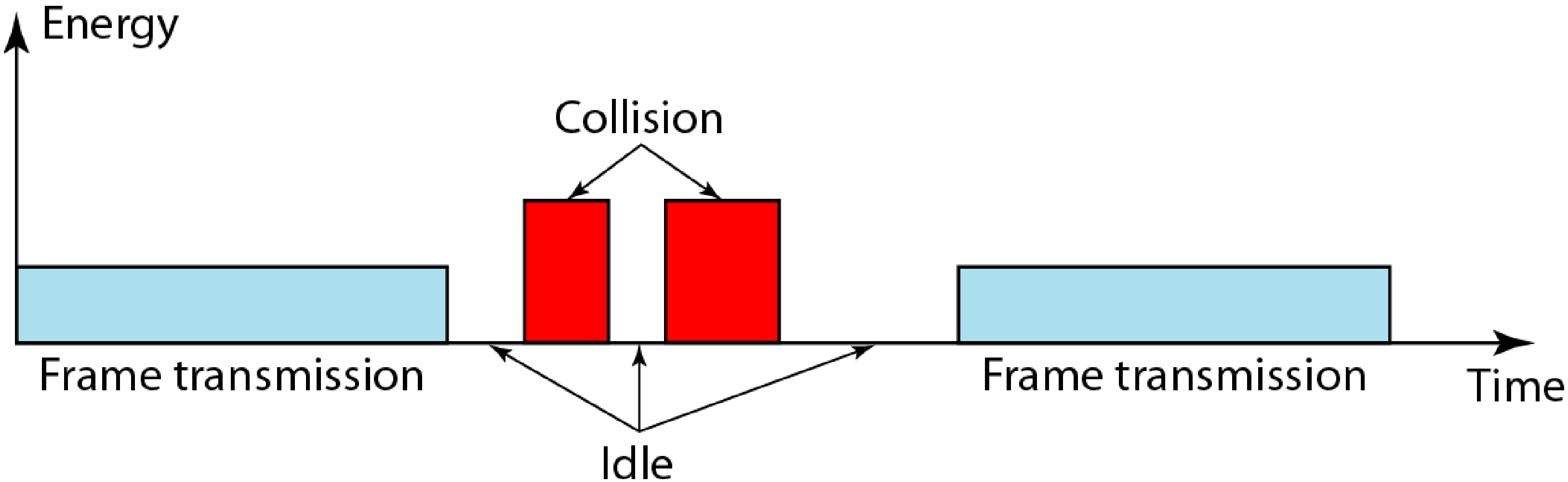
- Carrier Sense Multiple Access (CSMA) requires that each station check the state of the medium before sending.
- CSMA to reduce the possibility of collision
- Possibility of collision may still exists because of propagation delay
- Station may sense the medium and find it idle, because the first bit sent by another station has not yet been received.
- At time t1, station B senses the medium and finds it idle, so it sends a frame. At time t2 (t2 > t1), station C senses the medium and finds it idle because, at this time, the first bits from station B have not reached station C. Station C also sends a frame. The two signals collide and both frames are destroyed.

CSMA-CD

- In CSMA, a station monitors the medium after it sends a frame to see if the transmission was successful.
- If there is a collision, the frame is sent again.
- Each station continues to send bits in the frame until it detects the collision

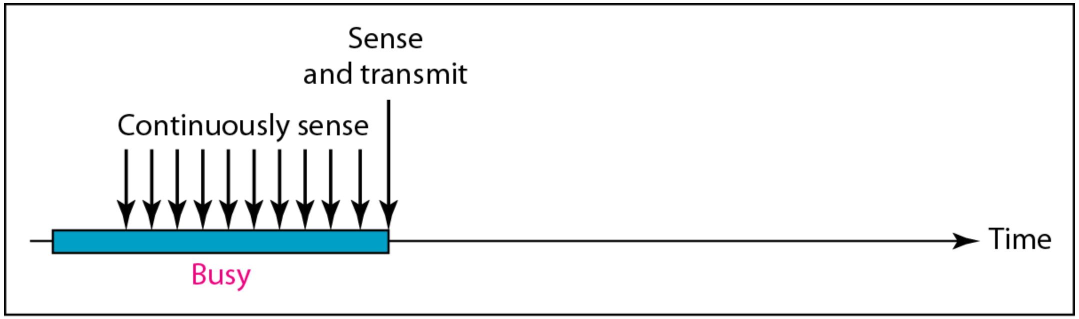


CSMA-CD

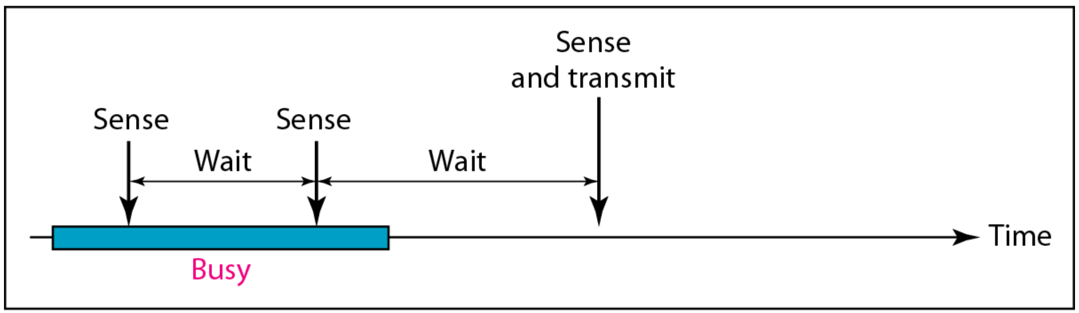


- We can say that the level of energy in a channel can have three values: zero, normal, and abnormal.
- At the zero level, the channel is idle. At the normal level, a station has successfully captured the channel and is sending its frame.
- At the abnormal level, there is a collision and the level of the energy is twice the normal level.
- A station that has a frame to send or is sending a frame needs to monitor the energy level to determine if the channel is idle, busy, or in collision mode

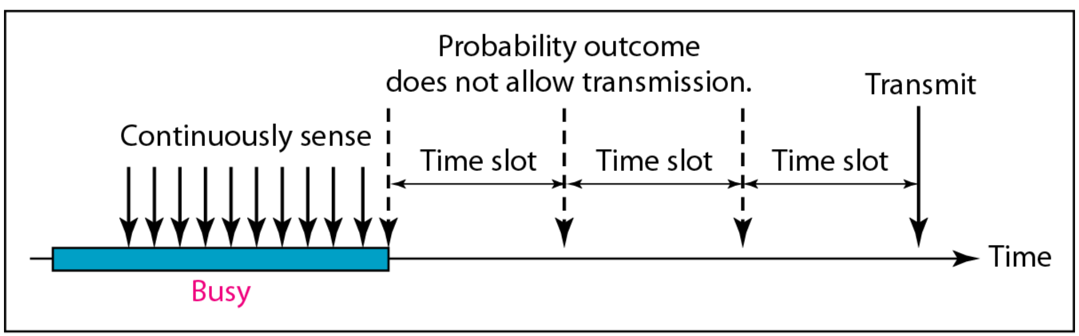
Behavior of three persistence methods



a. 1-persistent



b. Nonpersistent



c. p-persistent

Behavior of three persistence methods

1- Persistent

- In this method, after the station finds the line idle, it sends its frame immediately (with probability 1).
- This method has the highest chance of collision because two or more stations may find the line idle and send their frames immediately.

Non persistent

- In this method, a station that has a frame to send senses the line, If the line is idle, it sends immediately. If the line is not idle, it waits a random amount of time and then senses the line again.
- The nonpersistent approach reduces the chance of collision because it is unlikely that two or more stations will wait the same amount of time and retry to send simultaneously.
- However, this method reduces the efficiency of the network because the medium remains idle when there may be stations with frames to send.

Behavior of three persistence methods

p- Persistent

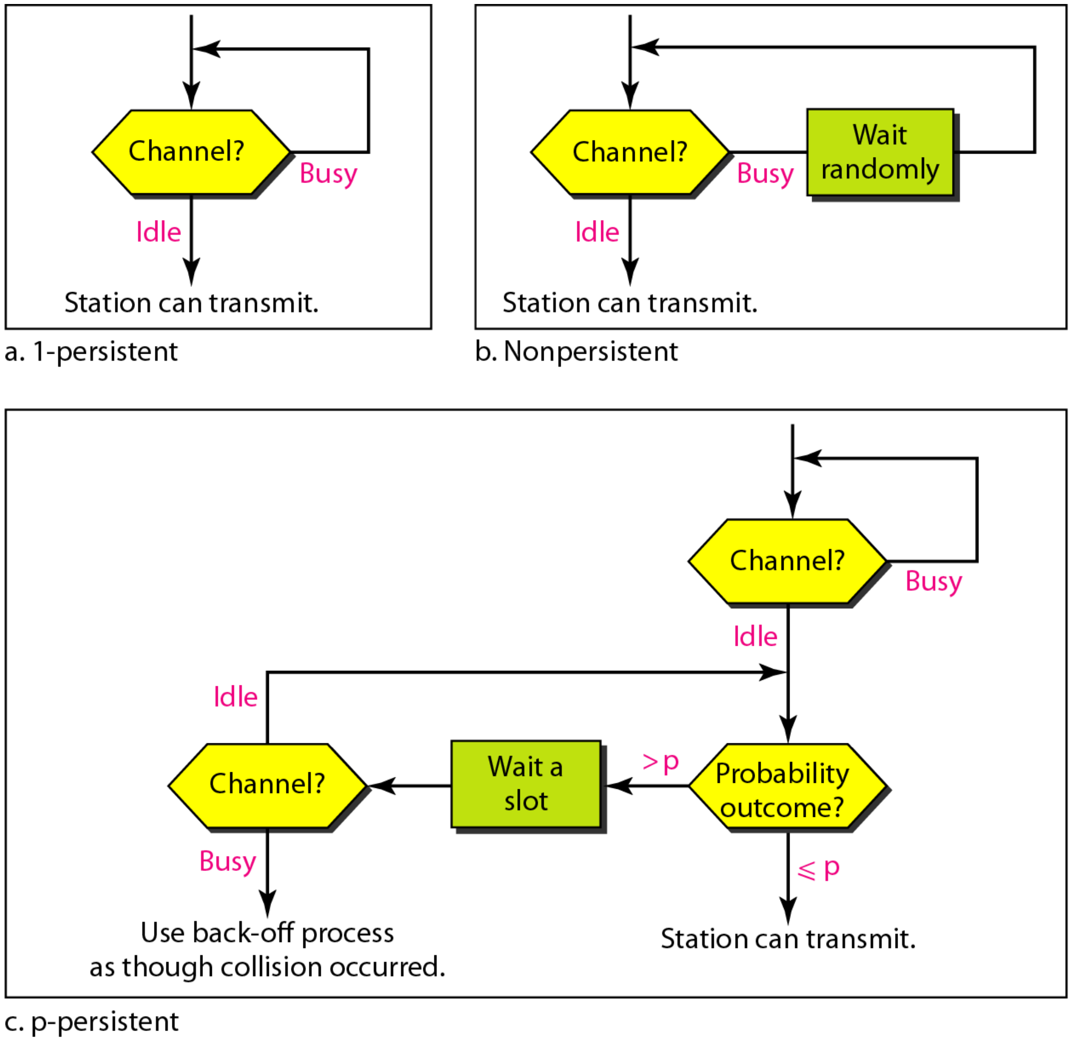
- The p-persistent method is used if the channel has time slots with a slot duration equal to or greater than the maximum propagation time.
- The p-persistent approach combines the advantages of the other two strategies.
- It reduces the chance of collision and improves efficiency. In this method, after the station finds the line idle it follows these steps:

With probability p, the station sends its frame.
With probability $q = 1 - p$, the station waits for the beginning of the next time slot and checks the line again.

a. If the line is idle, it goes to step 1.

b. If the line is busy, it acts as though a collision has occurred and uses the back-off procedure.

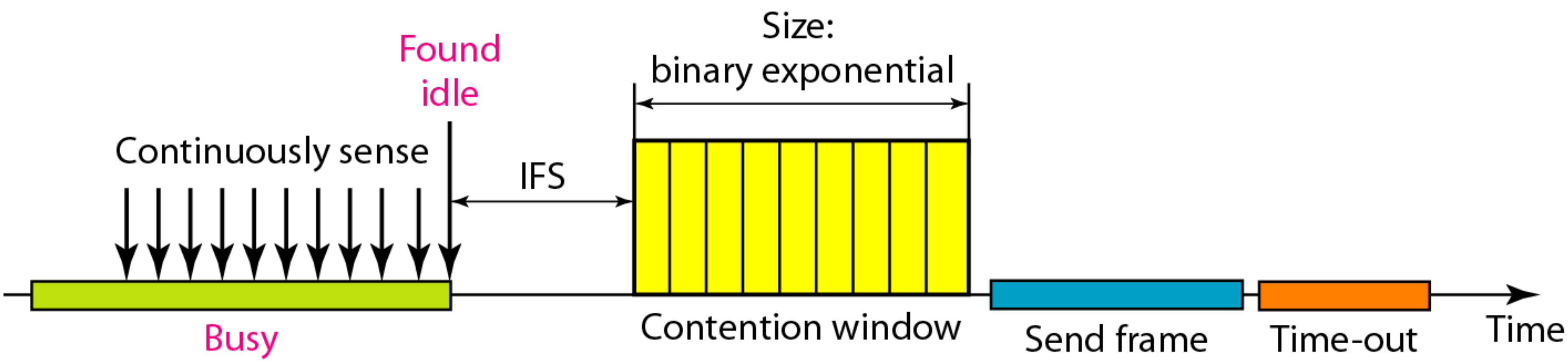
Flow diagram for three persistence methods



CSMA / CA

- Carrier sense multiple access with collision avoidance (CSMA/CA) was invented for wireless networks.
- Collisions are avoided through the use of three strategies:
  - Interframe space (IFS)
  - Contention window
  - Acknowledgments
- When an idle channel is found, the station does not send immediately. It waits for a period of time called IFS.
- The IFS time allows the front of the transmitted signal by the distant station to reach this station.
- After waiting an IFS time, if the channel is still idle, the station can send, but it still needs to wait a time equal to the contention window
- The contention window is an amount of time divided into slots. A station that is ready to send chooses a random number of slots as its wait time. The number of slots in the window changes according to the binary exponential back-off strategy.
- One interesting point about the contention window is that the station needs to sense the channel after each time slot.
- However, if the station finds the channel busy, it does not restart the process; it just stops the timer and restarts it when the channel is sensed as idle.

Timing in CSMA/CA



Acknowledgment.

- With all these precautions, there still may be a collision resulting in destroyed data.
- In addition, the data may be corrupted during the transmission.
- The positive acknowledgment and the time-out timer can help guarantee that the receiver has received the frame.

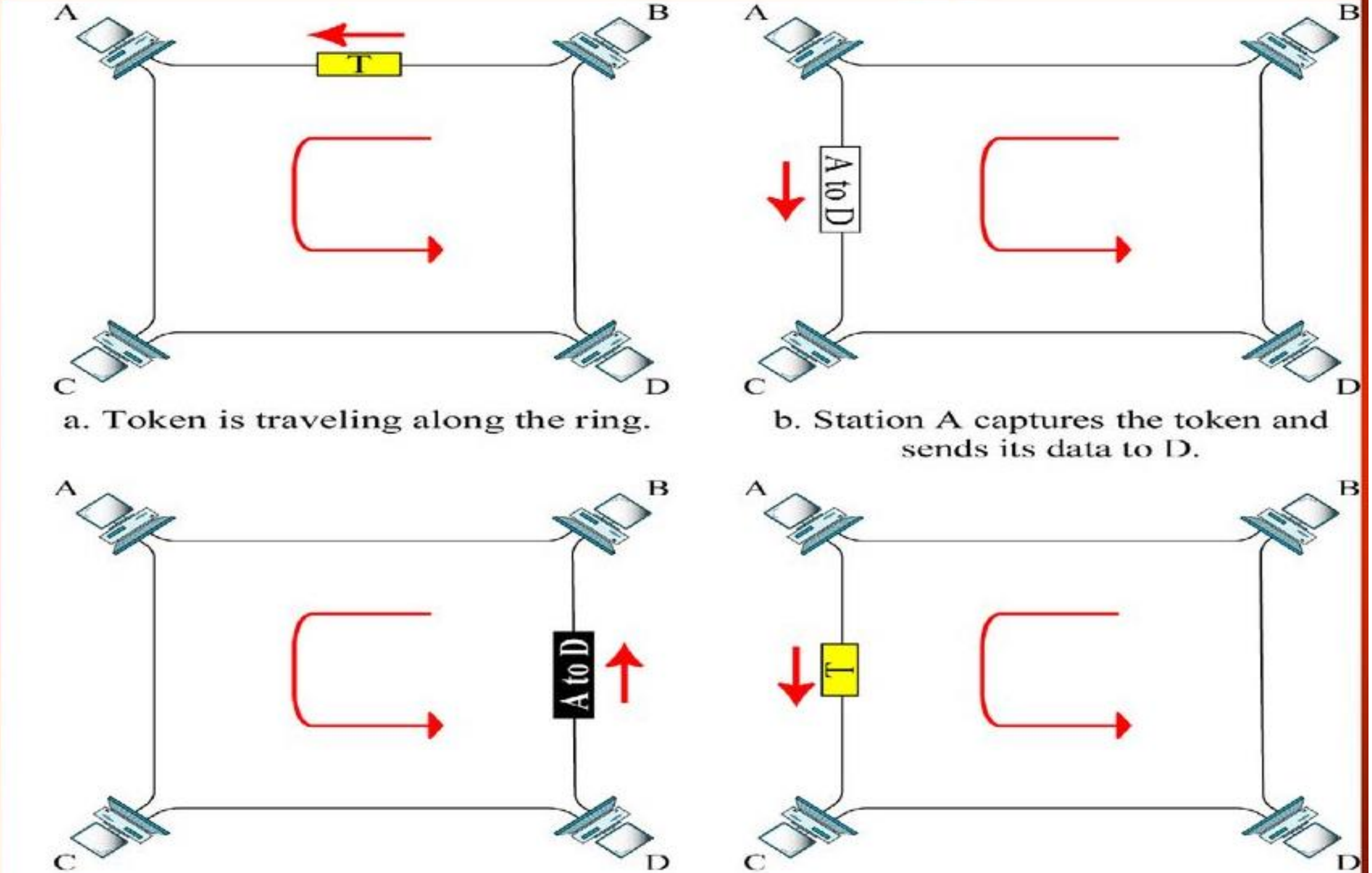
Difference between CSMA-CD & CSMA-CA

CSMA-CD	CSMA-CA
Effective after a collision.	Effective before a collision
It only reduces the recovery time	CSMA-CA minimizes the possibility of collision
Used in **wired networks**	Used in **wireless networks**
CSMA-CD resend the data frame whenever a conflict occurs.	CSMA / CA will first transmit the intent to send for data transmission.
CSMA-CD is used in **IEEE 802.3 standard**	CSMA / CA is used in **IEEE 802.11 standard.**

Token ring

- Token ring is used in IEEE 802.5 standard
- 4 and 16 Mbps is the supported data rate
- Twisted pair cabling with Differential Manchester Line coding
- Channel access method is Token passing
- Each station take turns in sending data and can transmit only during its turn
- May send only one frame during each turn
- Whenever a station wishes to send a frame, it first waits for the token. When the station gets the token, it start sending frame
- The intended recipient retains a copy of the frame and indicates by setting the response bits at the tail of the frame

Token Ring



a. Token is traveling along the ring.

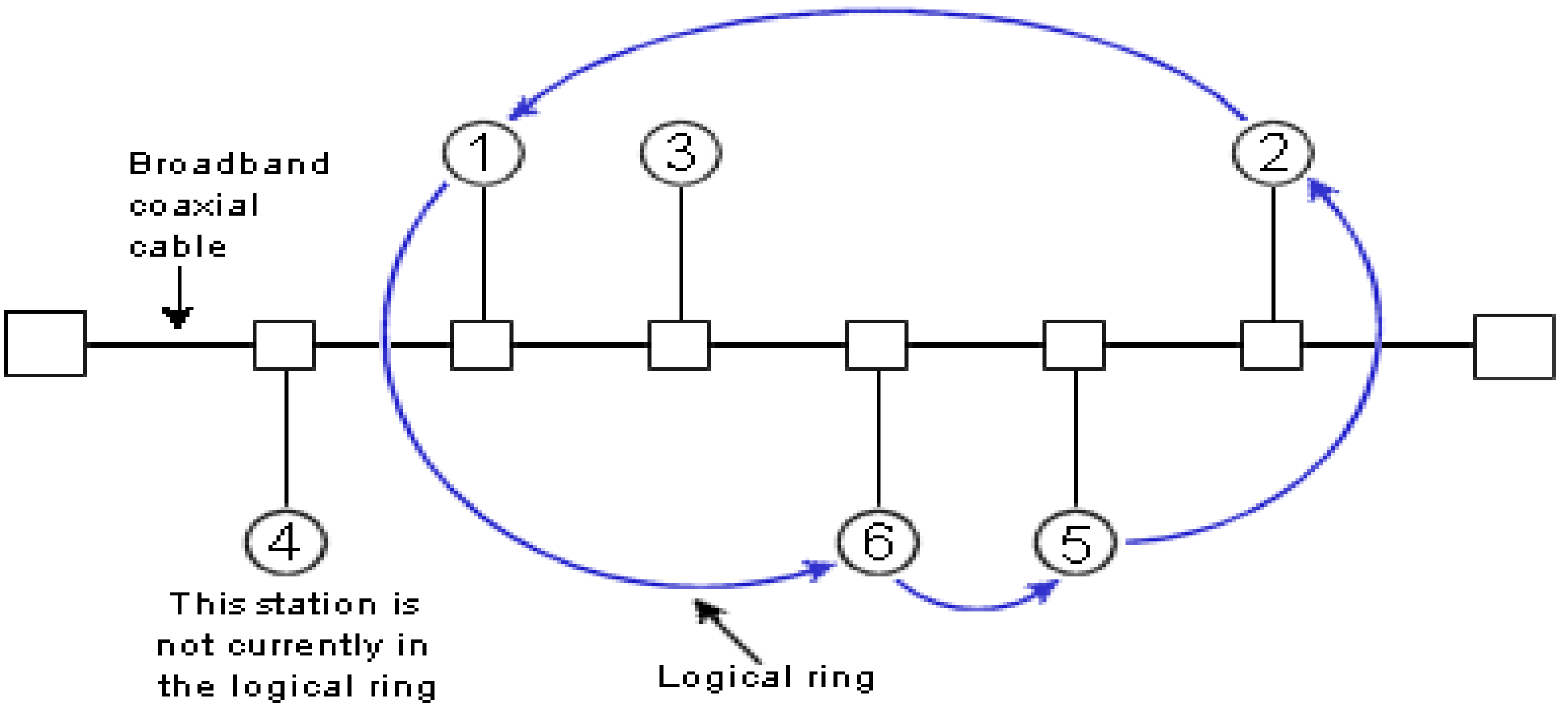
b. Station A captures the token and sends its data to D.

c. Station D copies the frame and sends the data back to the ring.

d. Station A receives the frame and releases the token.

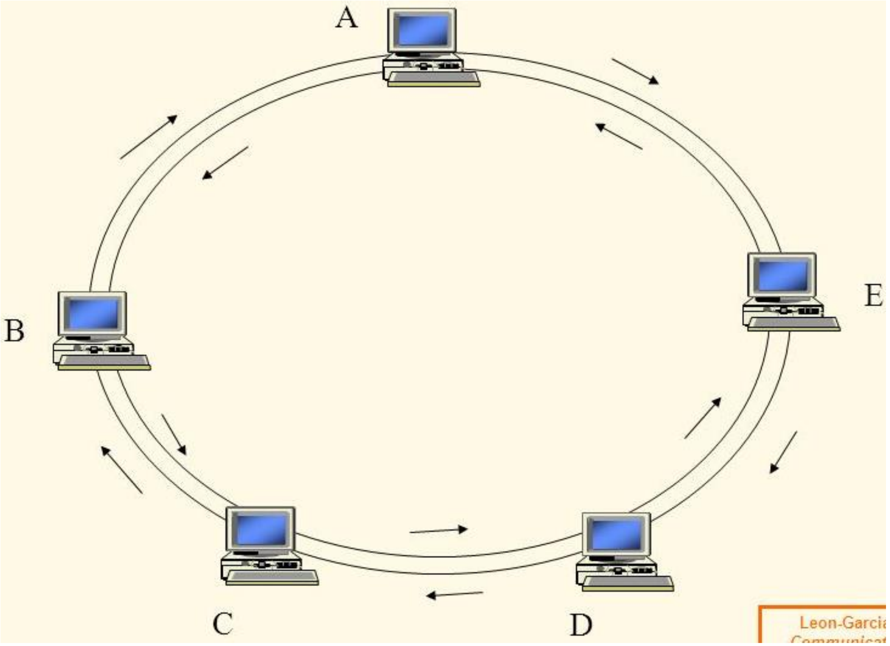
Token Bus

- Token Bus is used in **IEEE 802.4 standard**
- Channel access method is **Token passing**
- Token bus is a logical ring on a physical bus topology
- The network is physically a bus topology and logically arranged as a ring with respect to passing the token from node to node



FDDI

- Fiber Distributed Data Interface (FDDI) standardized by **ANSI and ITU-T**
- It uses Dual ring, one act as primary and the other as secondary
- Normally secondary ring is idle and used for redundancy for auto repairing
- Supported data rate is **100 Mbps**
- Access method: **Token passing**
- Permits up to **500 stations and spans up to 200 Km**
- Uses 4B/5B encoder
- Uses 1300 nm wavelength light source



FDDI- Time registers

FDDI defines 3 time registers to control the circulation of the token and to distribute link access opportunities equally to all the nodes in the n/w. The 3 registers are

- Synchronous Allocation (SA)
- Target Token Rotation Time (TTRT)
- Absolute Maximum Time (AMT)

Values of these registers are set when the ring is initialized and do not vary in the course of operation

Synchronous Allocation- Time allowed for each station to send synchronous data. This value is different for each station and its negotiated during initialization of the ring

TTRT- Average time required for a token to circulate around the ring once.

AMT- Its value is twice the TTRT . It’s the maximum time a token take to complete one rotation, beyond which the token is reinitialized

FDDI -Timers

Each station contains a set of timers that compare the actual timings with the values in the time registers. FDDI uses 2 timers and they are

- Token Rotation Timer (TRT)
- Token Holding Timer (THT)

TRT: Runs continuously and measures the actual time taken by the token to complete one rotation. We use an incrementing TRT.

THT: Begins running as soon ass the token is received and it shows how much time remains for sending asynchronous frames, once synchronous frames have been sent. We use decrementing THT

Station Procedure

When a token arrives, each station follows this procedure

1. THT is set to TTRT – TRT
2. TRT is set to 0
3. Station sends its synchronous data first
4. Station sends asynchronous data as long as THT is positive