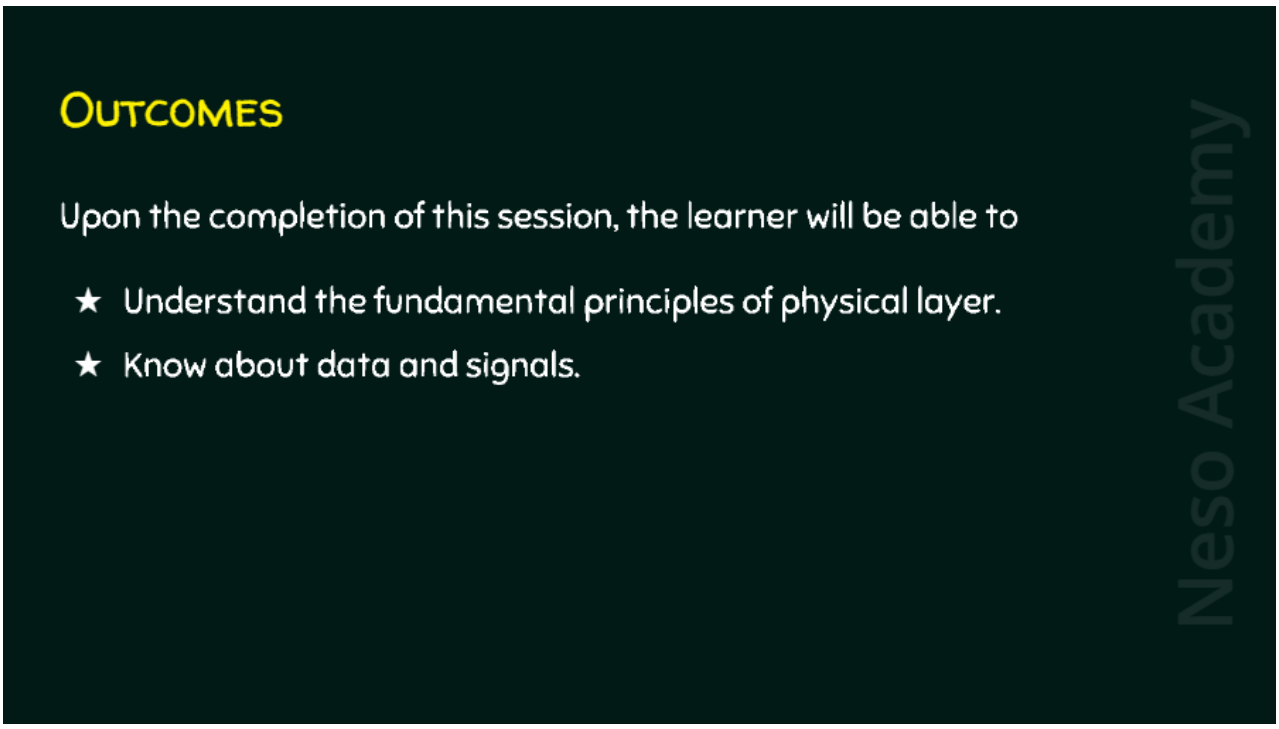
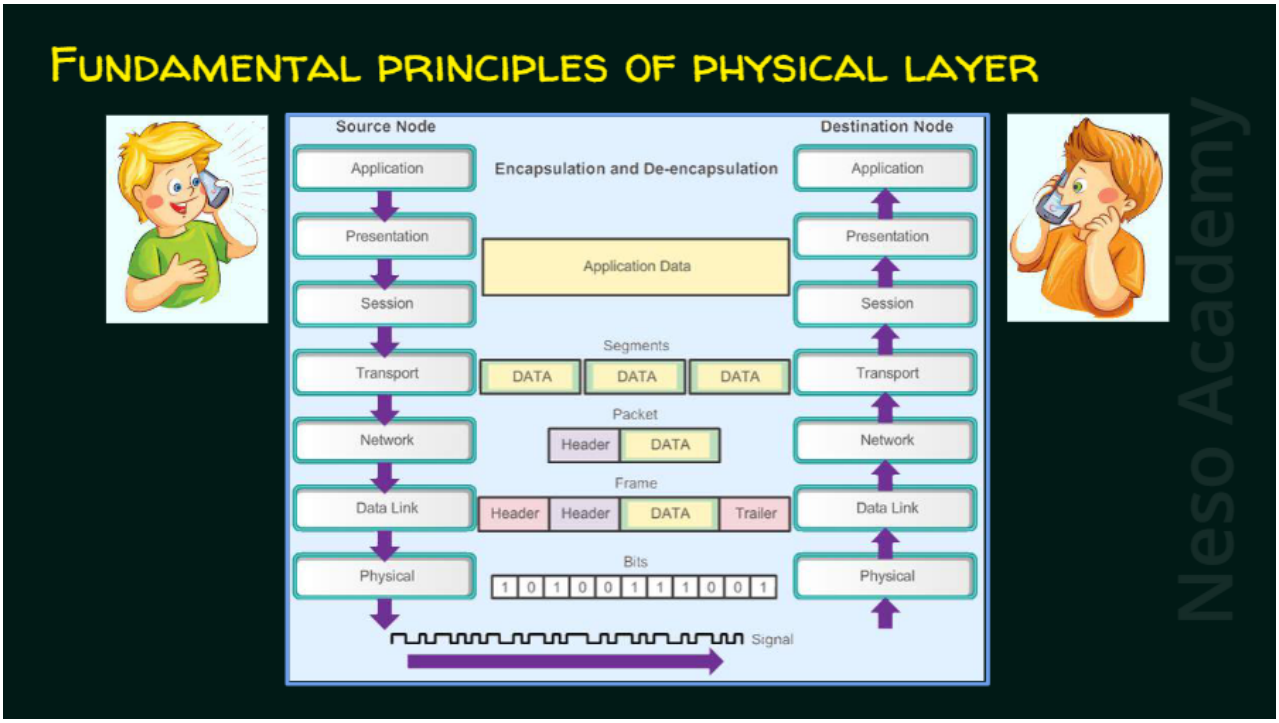
Data Link Layer | Neso Academy

nesoacademy.org/cs/06-computer-networks/ppts/02-datalinklayer

Data LinkLayerNeso AcademyCHAPTER - 2

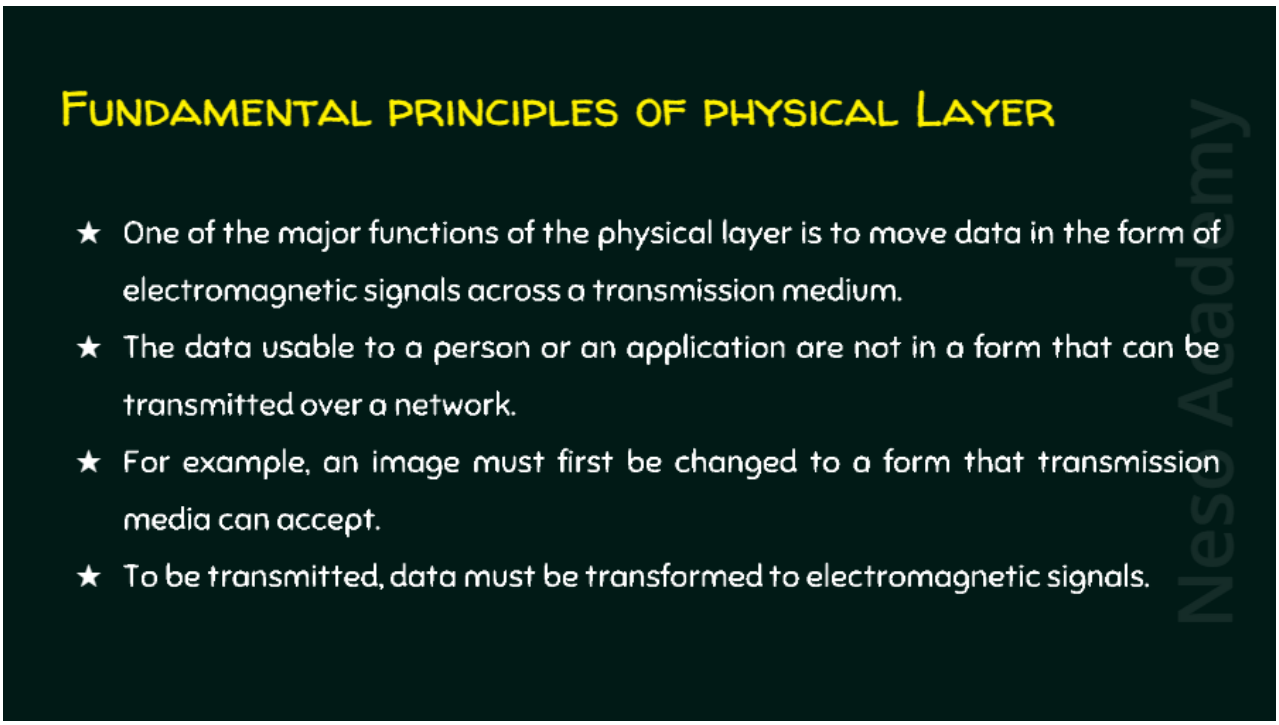


Outcomes★★Neso Academy

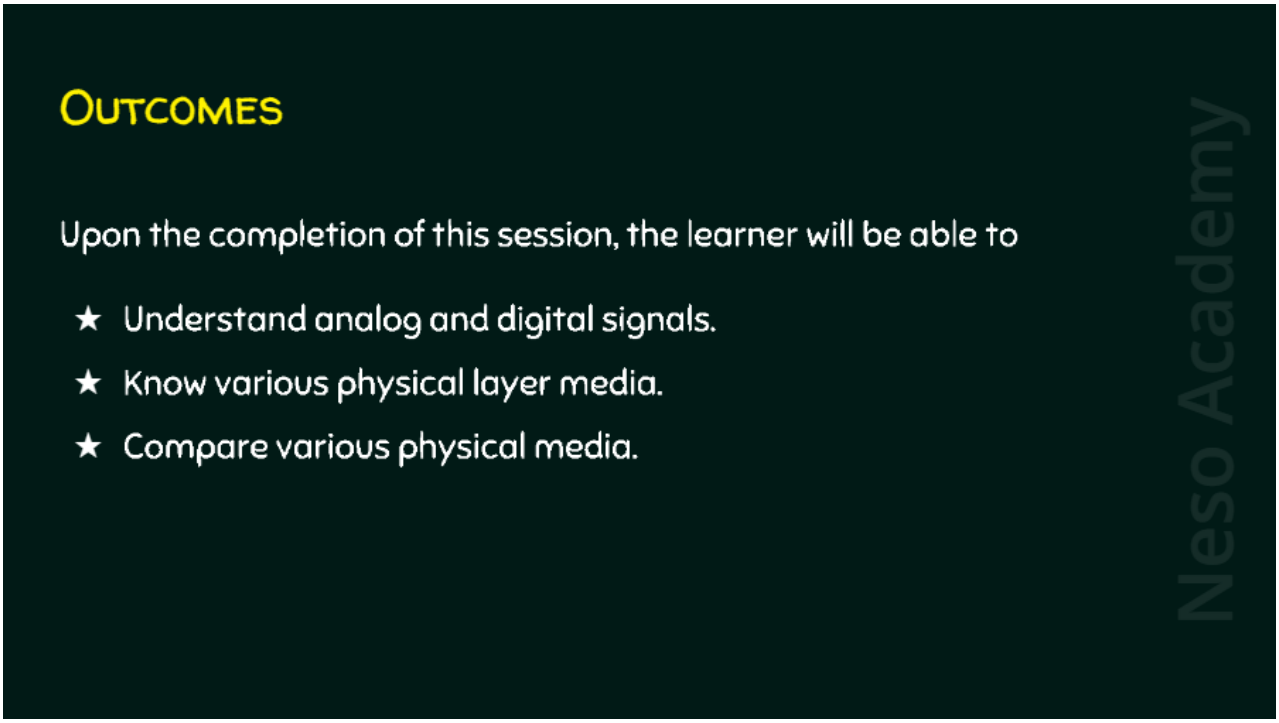


Fundamental principles of physical layerNeso Academy

Physical layer -Data and SignalsNeso Academy



Fundamental principles of physical Layer★★★★Neso Academy



Outcomes★★★Neso Academy

Signal

- ★ It is a function that represents the variation of a physical quantity with respect to time.
- ★ Example: Variation in temperature of a city in one day i.e. 24 hours.
- ★ Analog Signal and Digital Signal.

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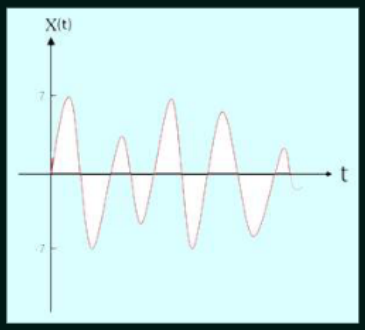
Signal★★★Neso Academy

Analog signal

- ★ It is the signal that can take any value in the defined range.
- ★ All real-life signals are analog in nature.



The signal x(t) can take any value between −7 to +7.

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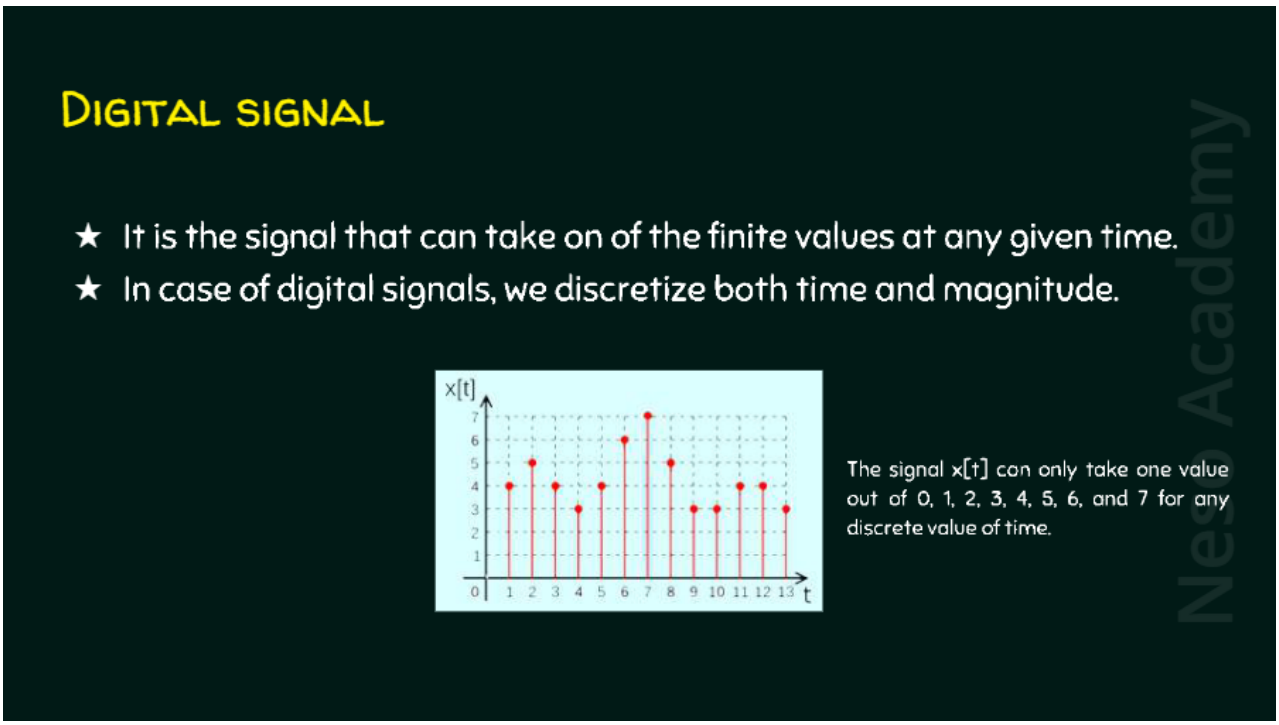
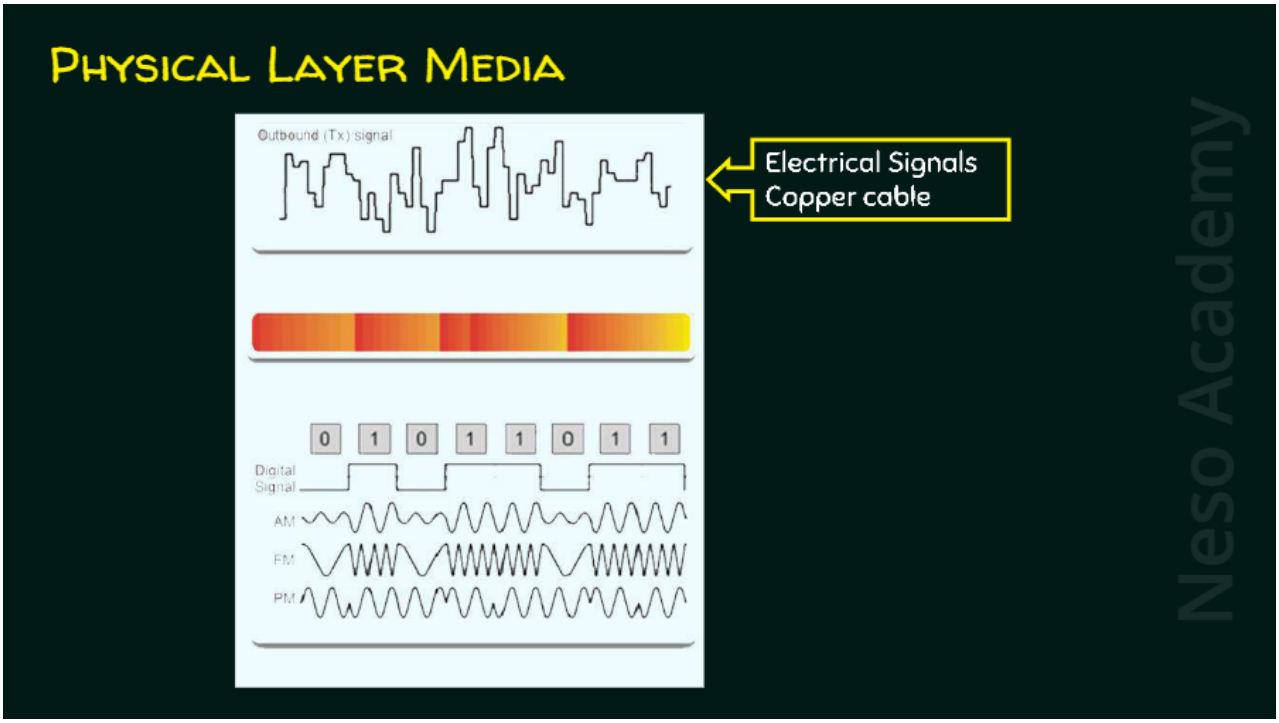
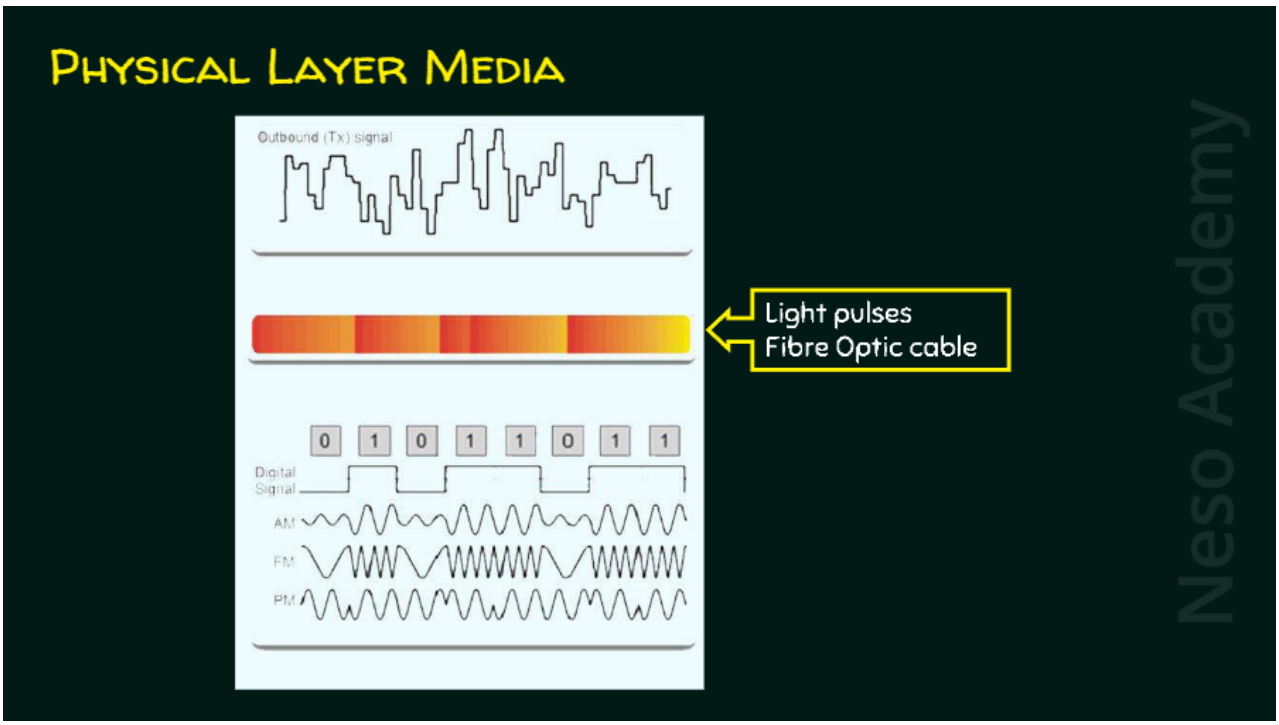
Analog signal★★Neso Academy



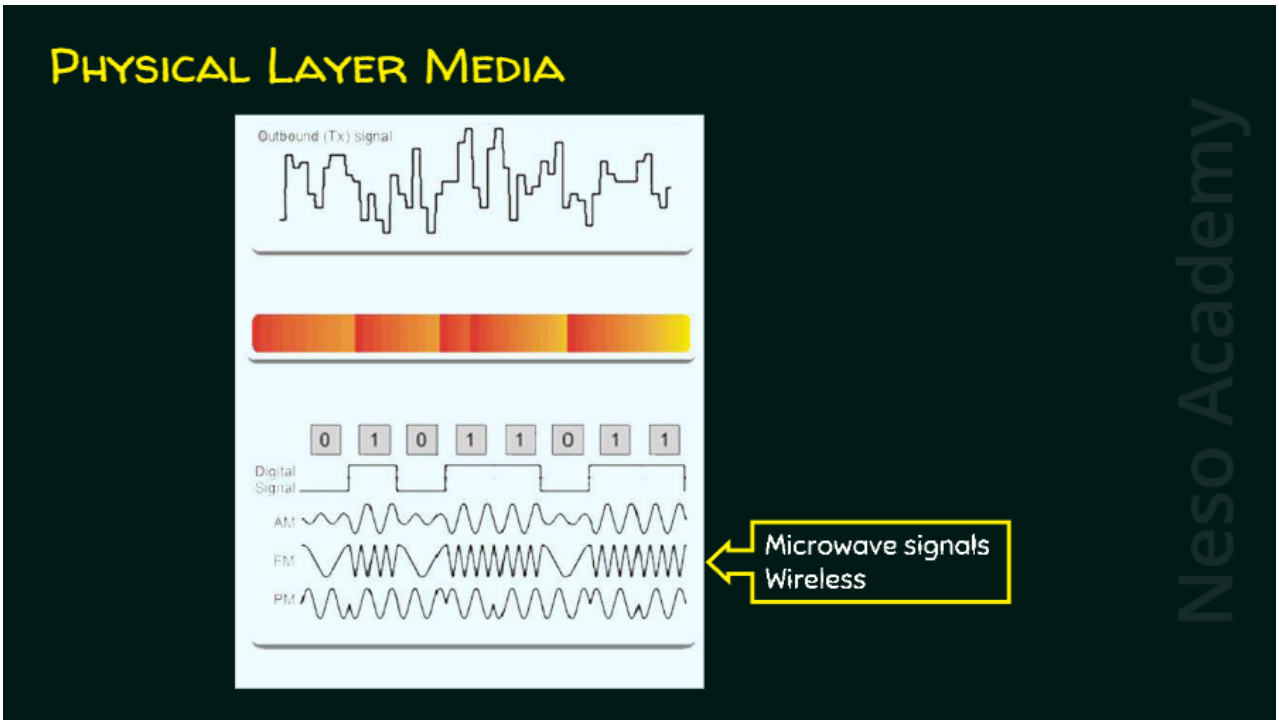
Digital signal★★Neso Academy



Physical Layer MediaNeso Academy



Physical Layer MediaNeso Academy



Physical Layer MediaNeso Academy

Comparison of various physical media

Media	Physical Components	Signal
Copper Cable (Wired)	·UTP/STP ·Coaxial ·Connectors ·NICs ·Ports/·Interfaces	Electromagnetic Signal
Fiber Optic Cable (Wired)	·Single-mode Fiber ·Multimode Fiber ·Connectors ·NICs and Interfaces ·Lasers and LEDs	·A light pulse equals 1. ·No light pulse is 0.
Wireless Media	·Access Points ·NICs ·Radio ·Antennae	·Radio waves

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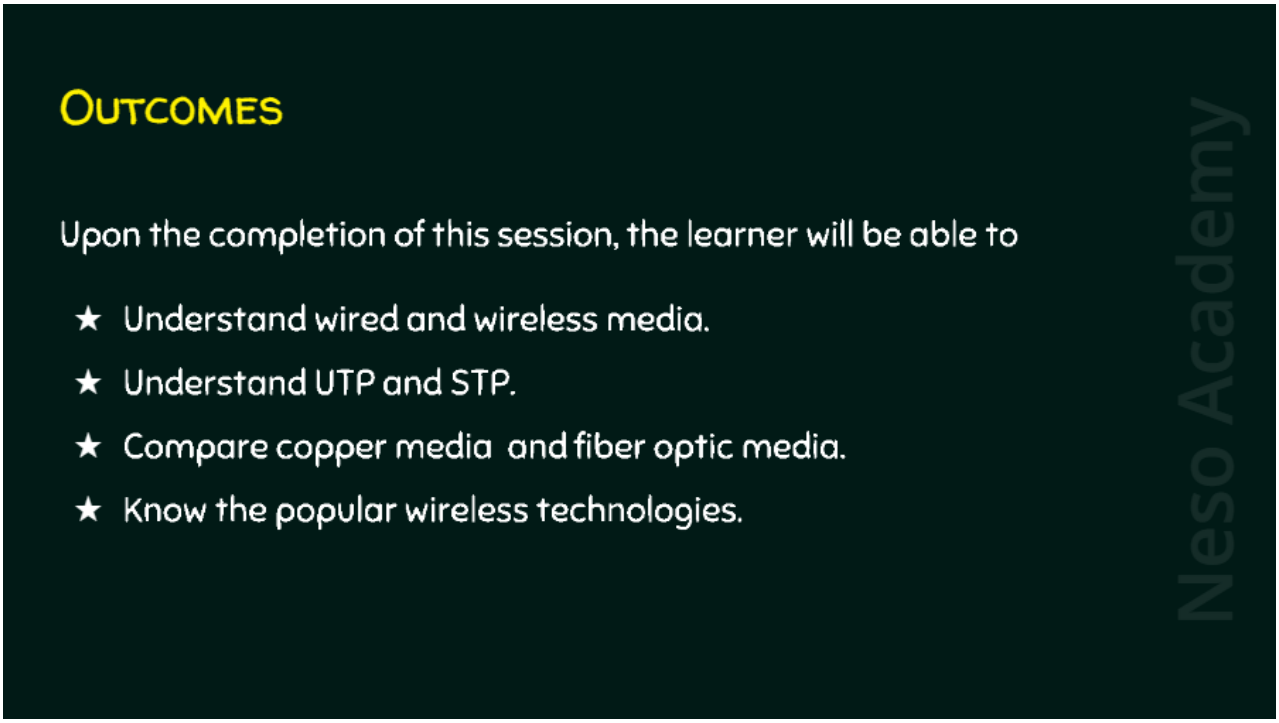
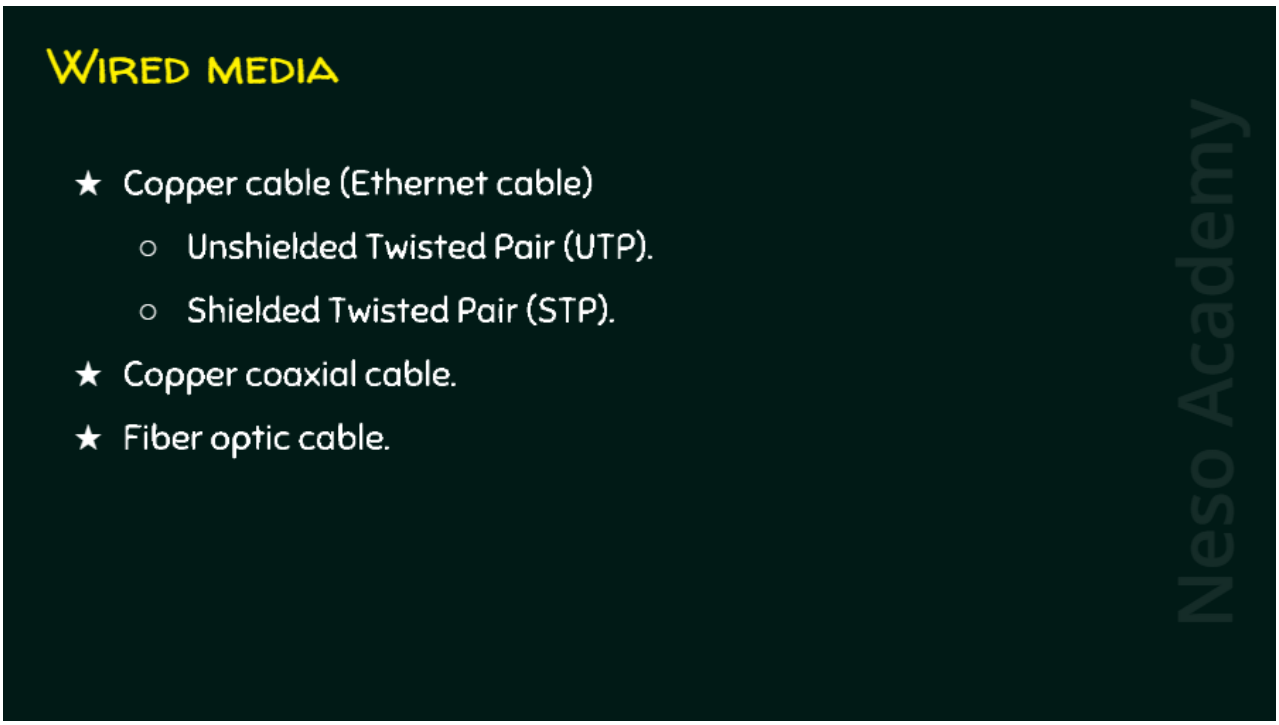
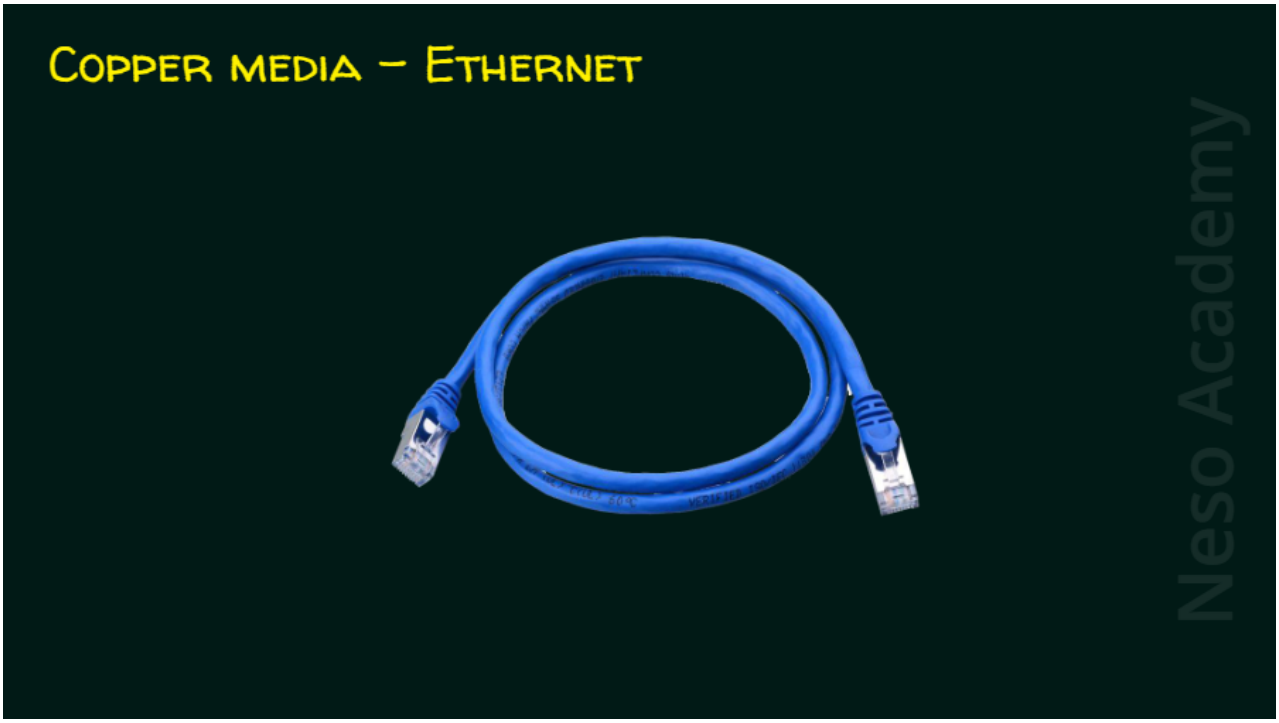


Outcomes★★★★Neso Academy

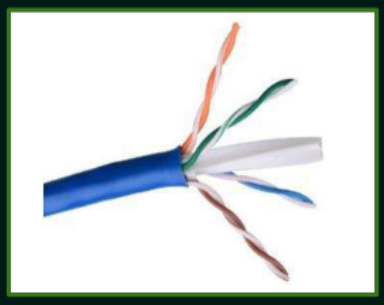


Wired media★○○★★Neso Academy

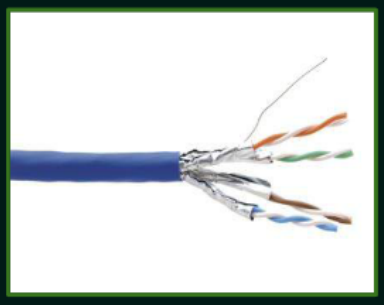


Copper media -EthernetNeso Academy

Copper media – Ethernet



Unshielded Twisted Pair (UTP)
Ethernet Cable



Shielded Twisted Pair (STP)
Ethernet cable

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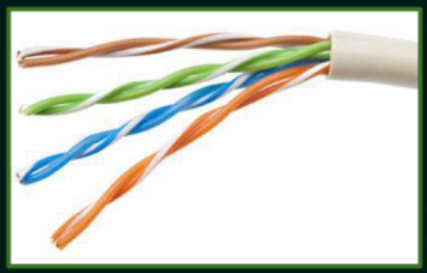
Copper media -EthernetNeso Academy

Crosstalk

★ UTP cable does not use shielding to counter the effects of EMI and RFI.

★ The negative effect of crosstalk can be limited by varying the number of twists per wire pair.



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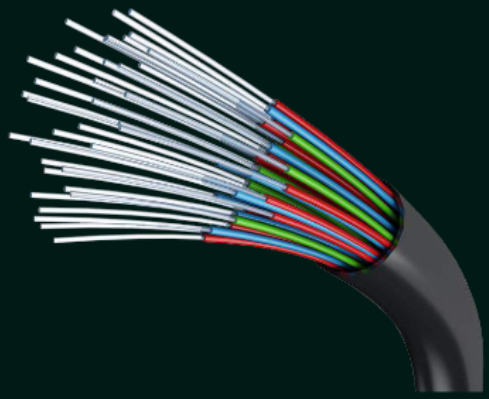
Crosstalk★★Neso Academy

Fiber optic media

- ★ Light waves.
- ★ High Speed transmission.



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Fiber optic media★★Neso Academy

Copper Vs Fiber Optic media

Implementation Points	Copper	Fiber Optic
Bandwidth Supported	10 Mbps – 10 Gbps	10 Mbps – 100 Gbps
Range	Relatively short (upto 100 meters)	Relatively High (upto 100,000 meters)
Immunity To EMI And RFI	Low	High (Completely immune)
Immunity To Electrical Hazards	Low	High (Completely immune)
Media And Connector Costs	Lowest	Highest
Installation Skills Required	Lowest	Highest
Safety	Lowest	Highest

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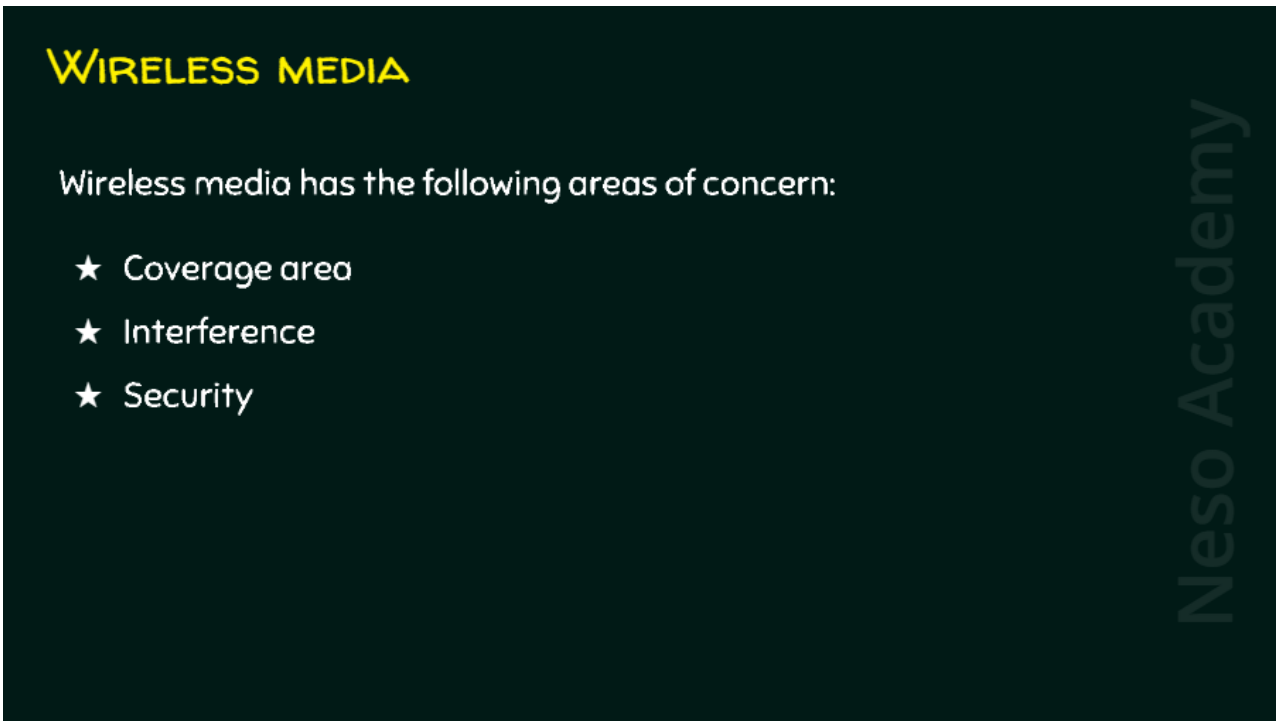
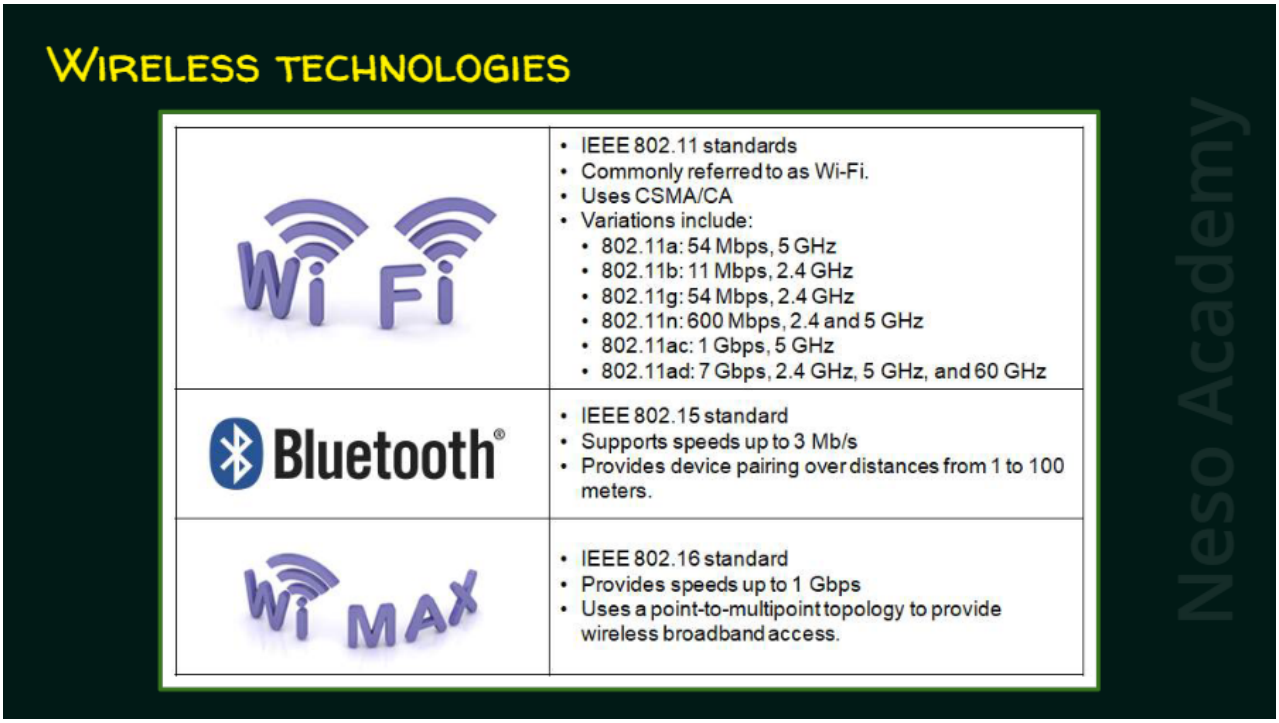
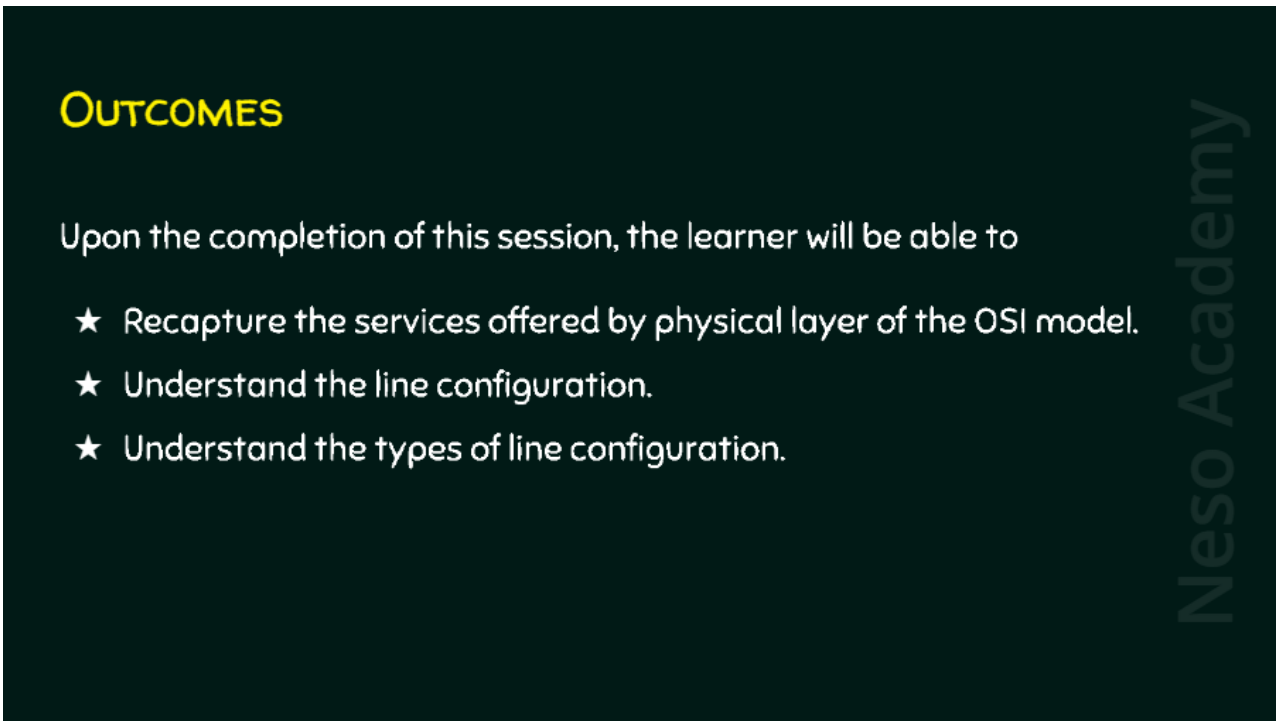
Copper Vs Fiber Optic mediaNeso Academy



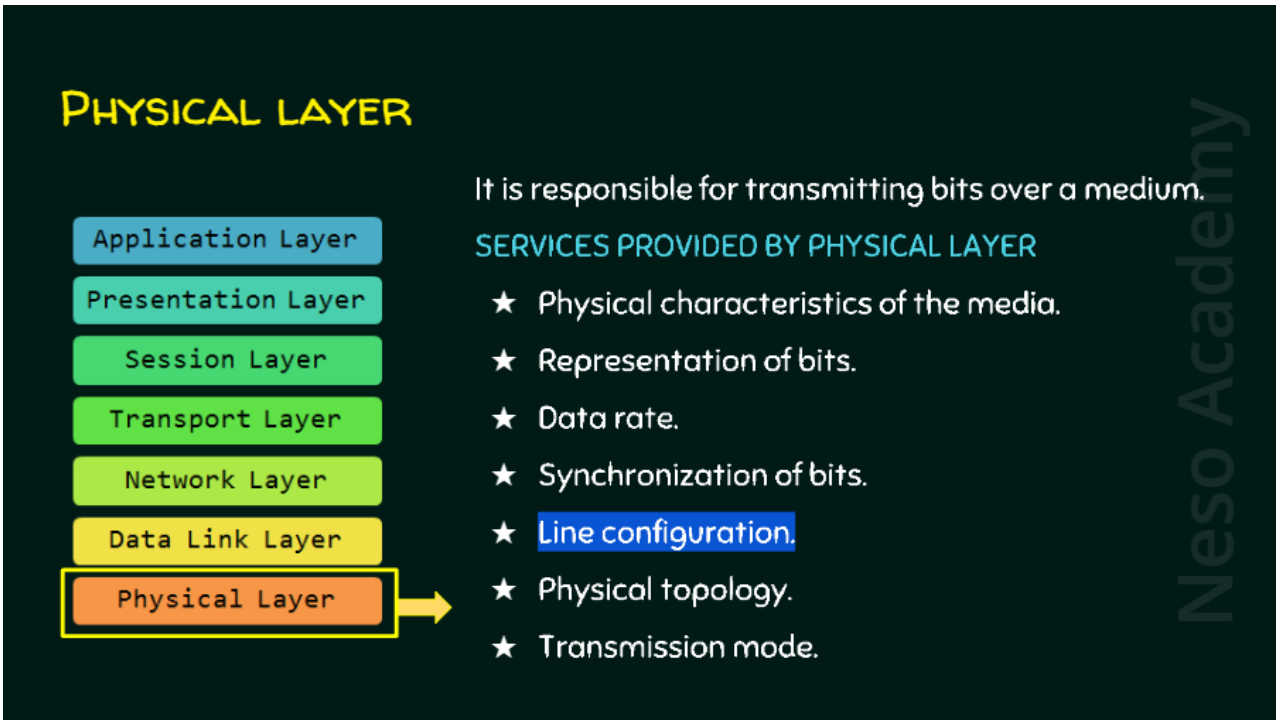
Wireless media★★★Neso Academy



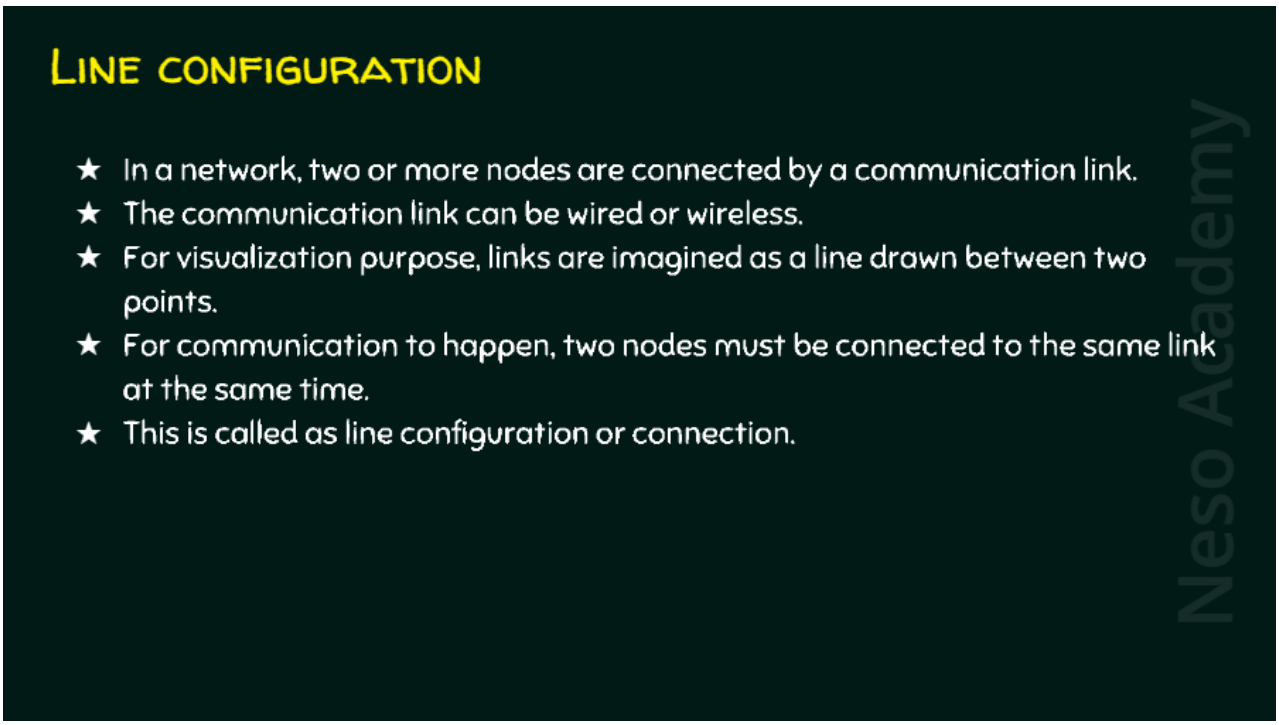
Wireless technologiesNeso Academy



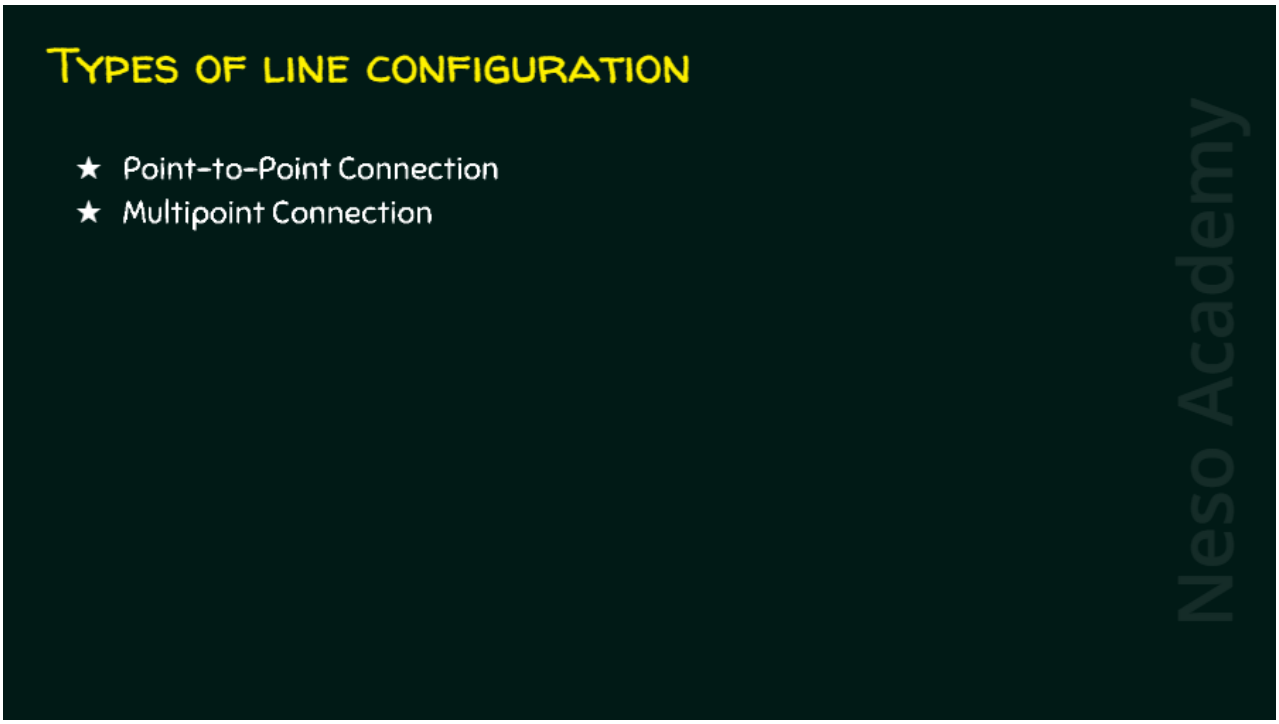
Outcomes★★★Neso Academy



Physical layer★★★★★★★Neso Academy



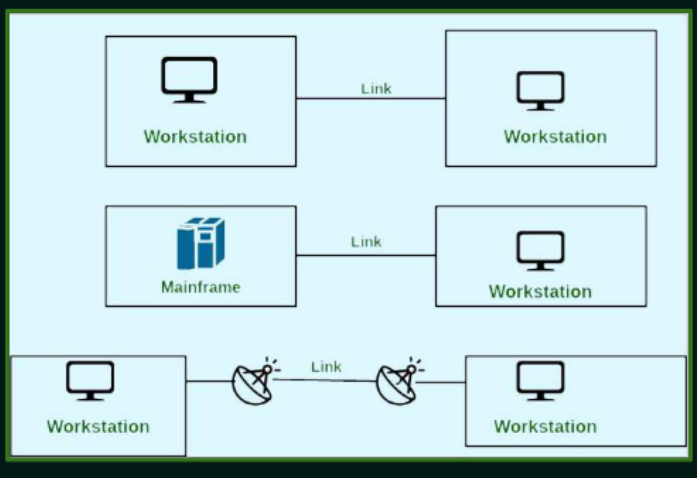
★★★★★Line configurationNeso Academy



★★Types of line configurationNeso Academy

Point-to-point connection

- ★ A point-to-point connection provides a dedicated link between two devices.
- ★ The entire capacity of the link is reserved for transmission between those two devices.



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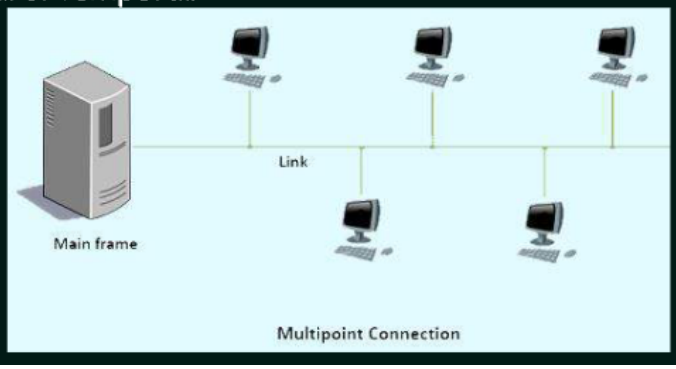
Point-to-point connection★★Neso Academy

Multipoint connection

- ★ It is also called Multidrop configuration or Broadcast connection.
- ★ In this connection, two or more devices share a single link.
- ★ Since more than two devices share the link, the capacity of the channel is shared now.
- ★ It can be spatial or temporal.



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Multipoint connection★★★★Neso Academy

Outcomes

Upon the completion of this session, the learner will be able to

- ★ Know the various services offered by data link layer.
- ★ Understand the services offered by data link layer.

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Outcomes★★Neso Academy

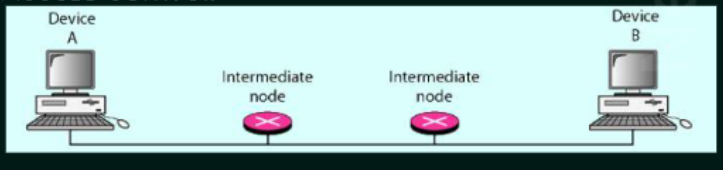
Data Link Layer

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

It is responsible for moving data(frames) from one node to another node.

SERVICES PROVIDED BY DATA LINK LAYER

- ★ Framing.
- ★ Physical Addressing.
- ★ Flow Control.
- ★ Error Control.
- ★ Access Control.



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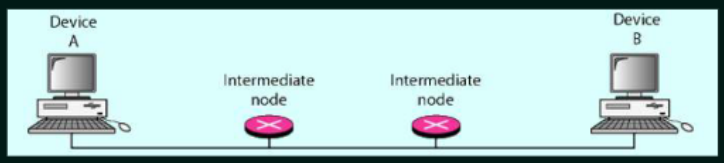
Data Link Layer★★★★★Neso Academy

Framing

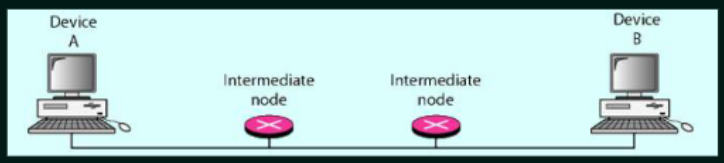
- ★ The data link layer needs to pack bits into frames, so that each frame is distinguishable from another.
- ★ Our postal system practices a type of framing.
- ★ The simple act of inserting a letter into an envelope separates one piece of information from another; the envelope serves as the delimiter.



Framing★★★Neso Academy

Physical Addressing

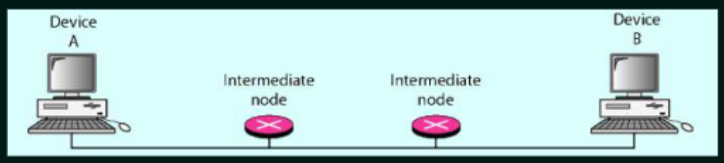
- ★ A Frame is the encapsulation of the header and trailer information with the packet.
- ★ In the header, the source and the destination MAC address are dealt.



Physical Addressing★★Neso Academy

Flow control

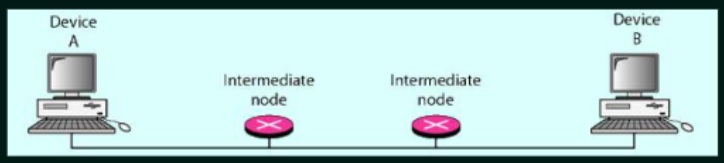
- ★ Flow Control is one of the duties of data link control sublayer.
- ★ The flow control in data link layer is end to end flow control.
- ★ Speed matching mechanism.
- ★ Flow control coordinates the amount of data that can be sent before receiving an acknowledgment.



Flow control★★★★Neso Academy

Access control

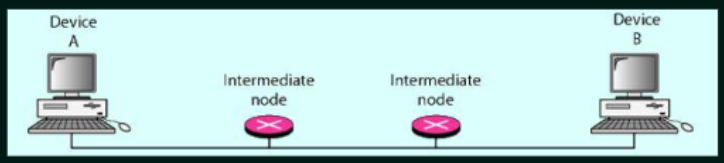
- ★ Media Access control.



Access control★Neso Academy

Error control

- ★ Error Detection.
- ★ Error Correction.



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Error control★★Neso Academy

Outcomes

Upon the completion of this session, the learner will be able to

- ★ Understand the sublayers of data link layer.
- ★ Know the responsibilities of LLC or DLC.
- ★ Know the responsibilities of MAC sublayer.

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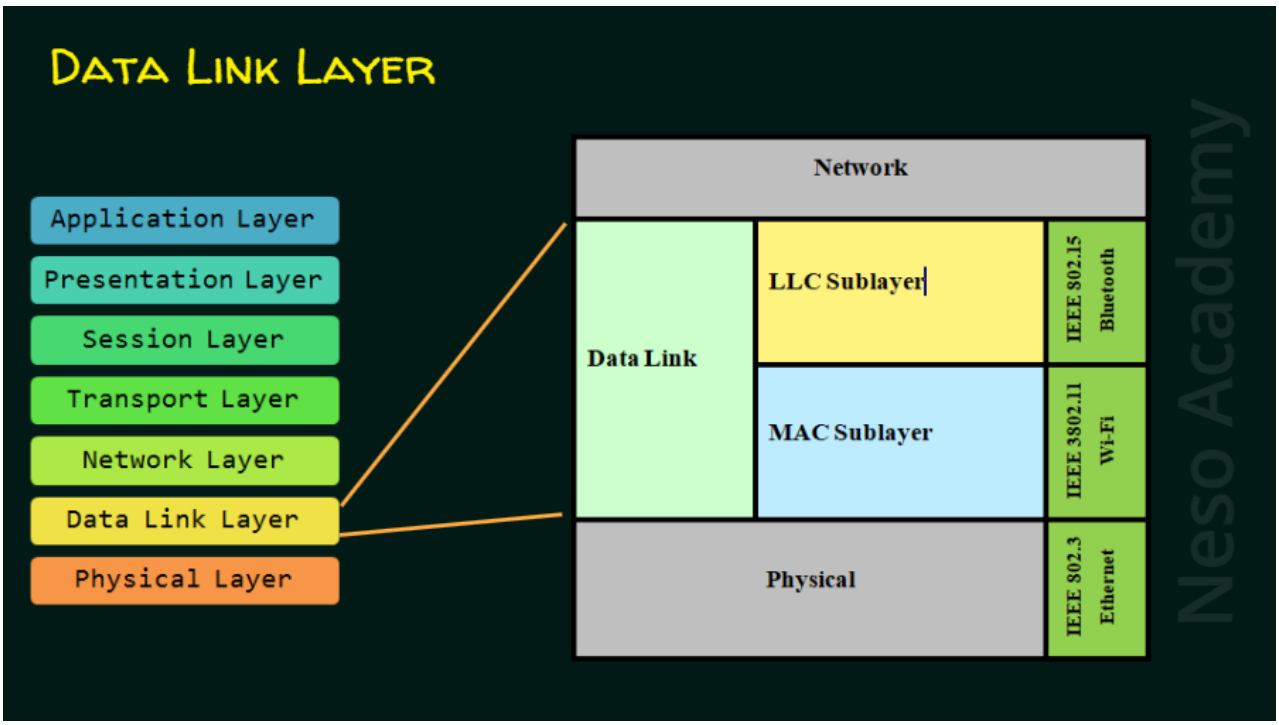
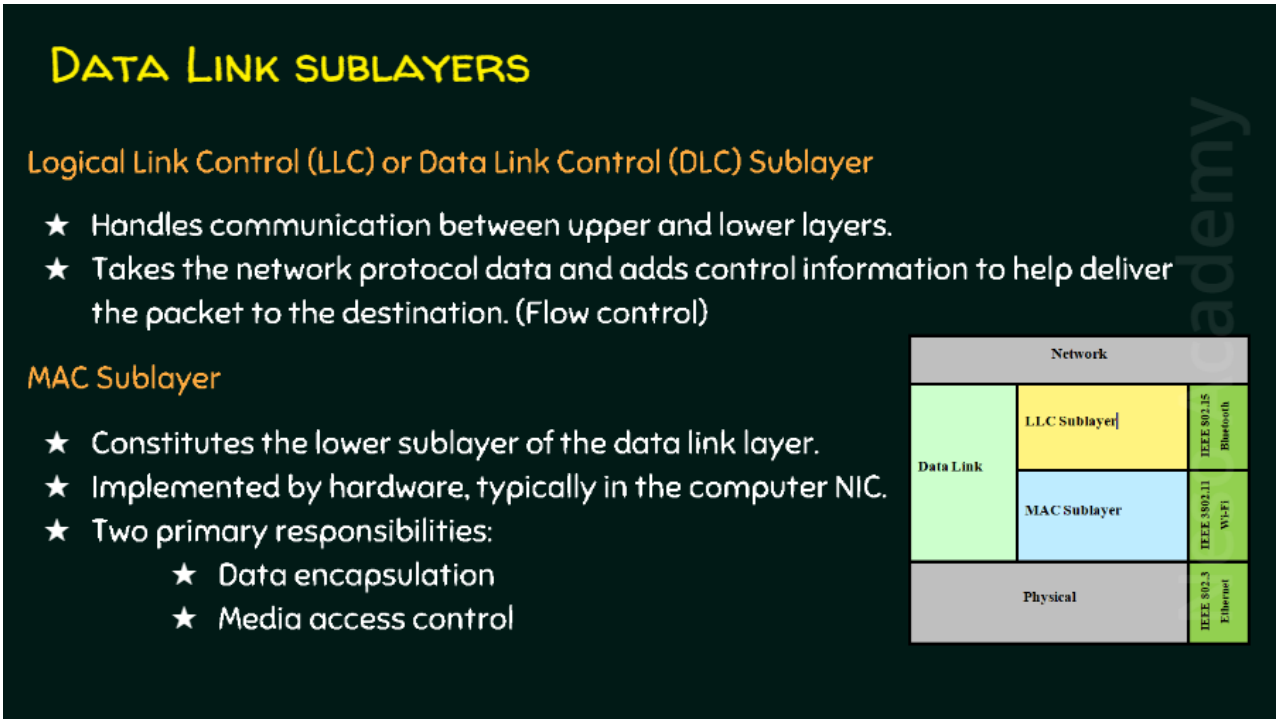
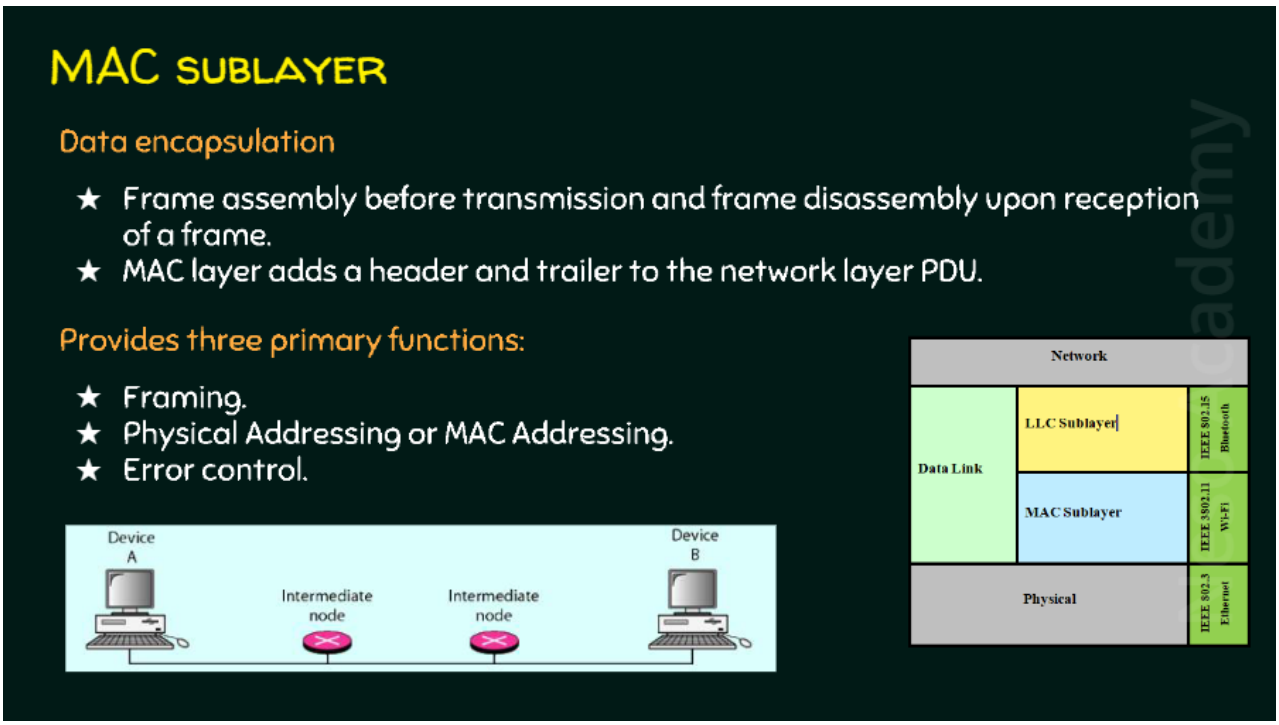
Outcomes★★★Neso Academy



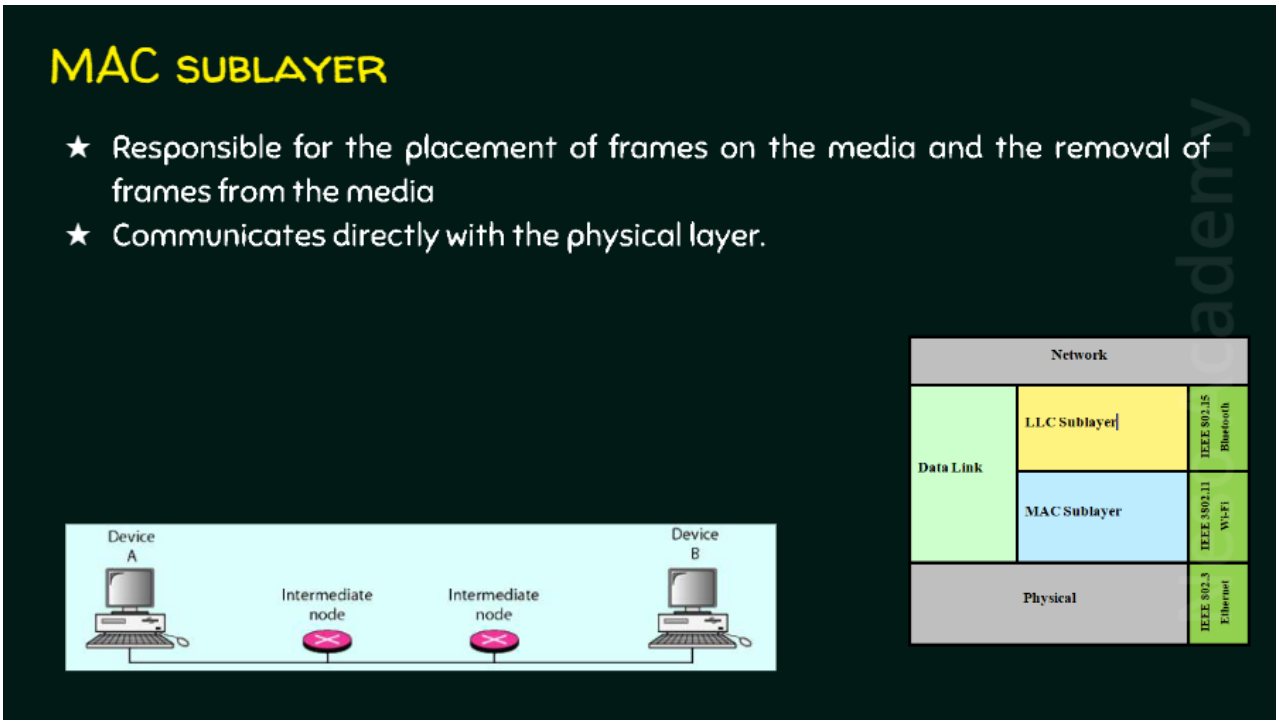
Data Link LayerNeso Academy



Data Link sublayers★★★★★★★Neso Academy



MAC sublayer★★★★★Neso Academy



MAC sublayer★★Neso Academy

Activity Time

Mention the sublayer that is responsible for the service shown in the table.

Service	Sublayer
Flow Control	LLC or DLC
Framing	MAC
Physical Addressing	
Error Control	
Access Control	

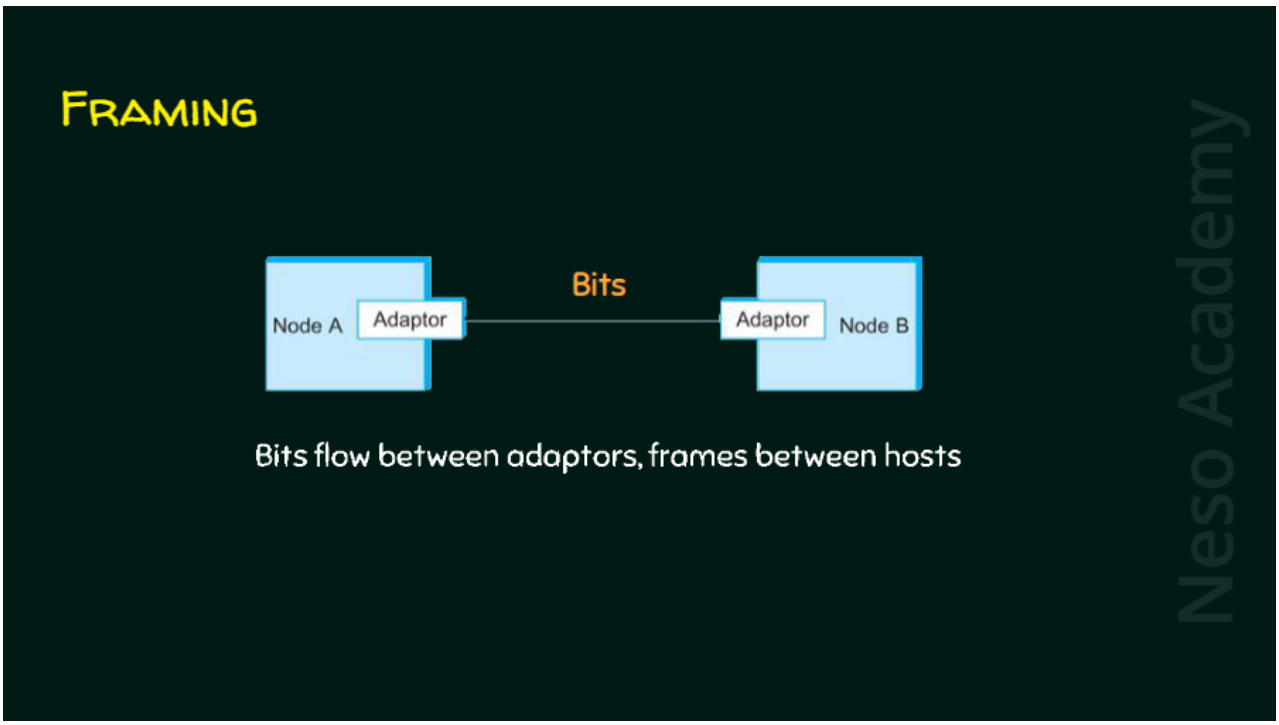
Activity TimeNeso Academy

Outcomes

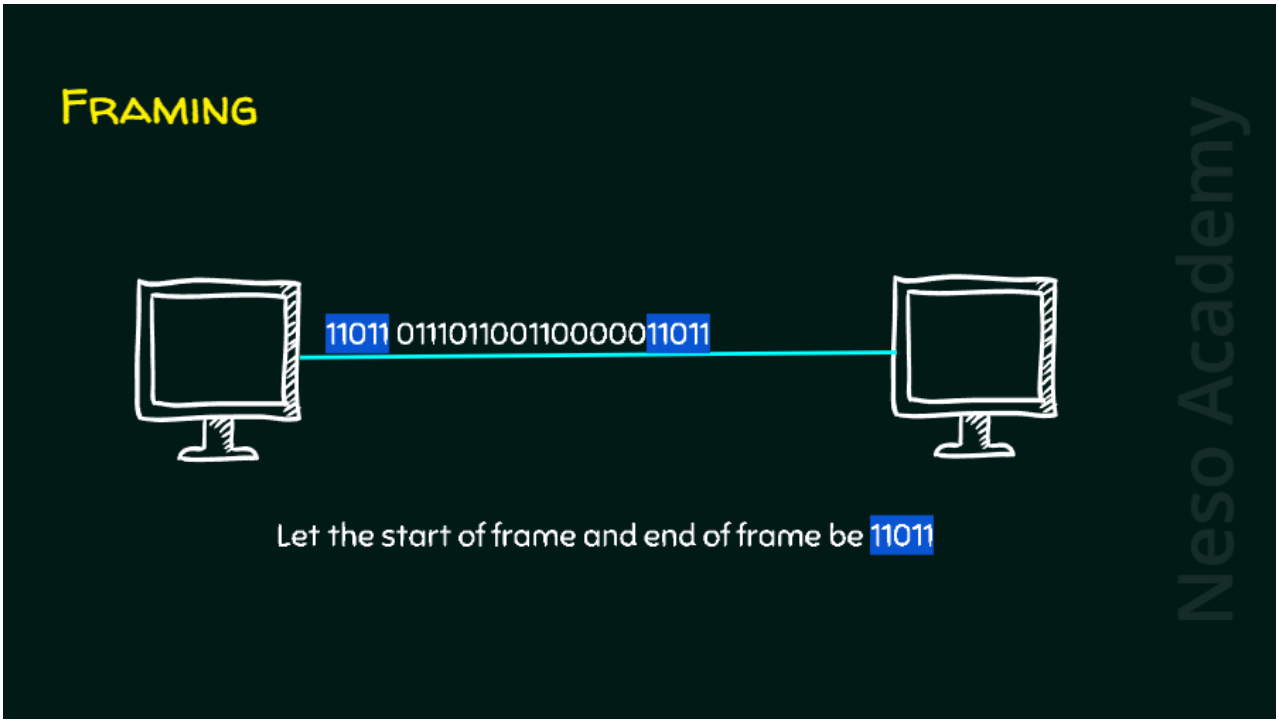
Upon the completion of this session, the learner will be able to

- ★ Understand framing.
- ★ Understand framing errors.

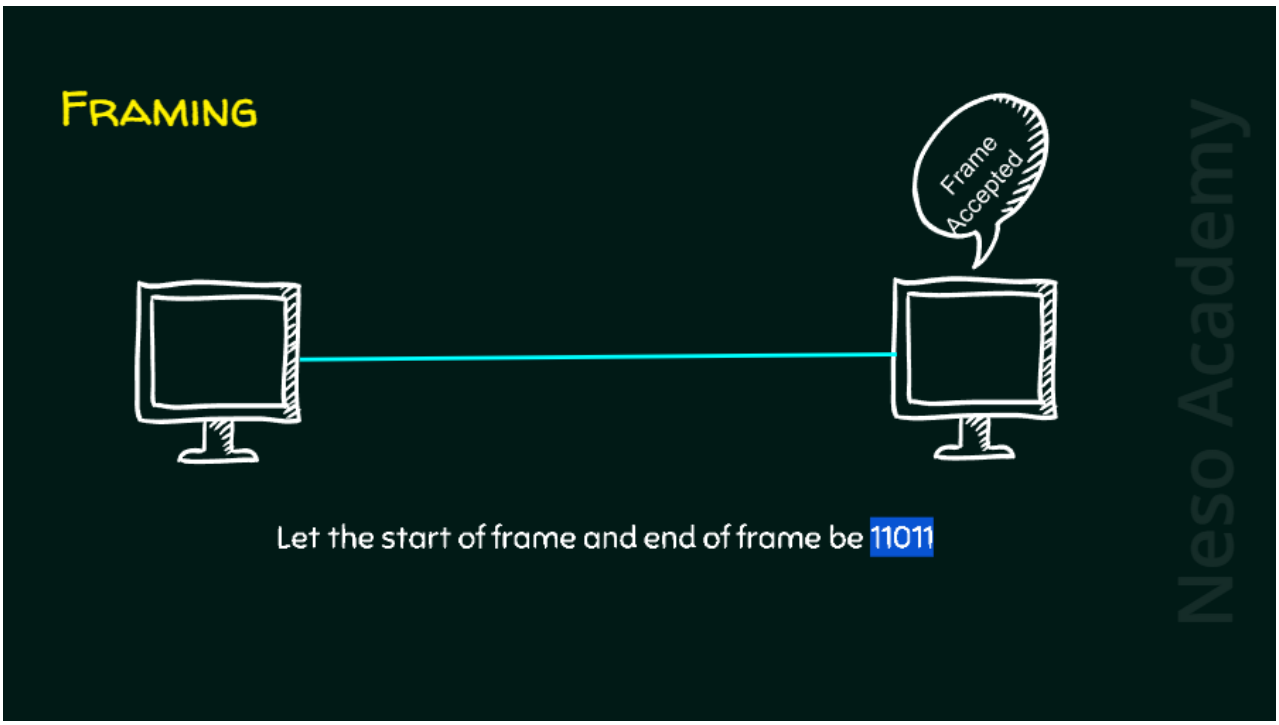
Outcomes★★Neso Academy



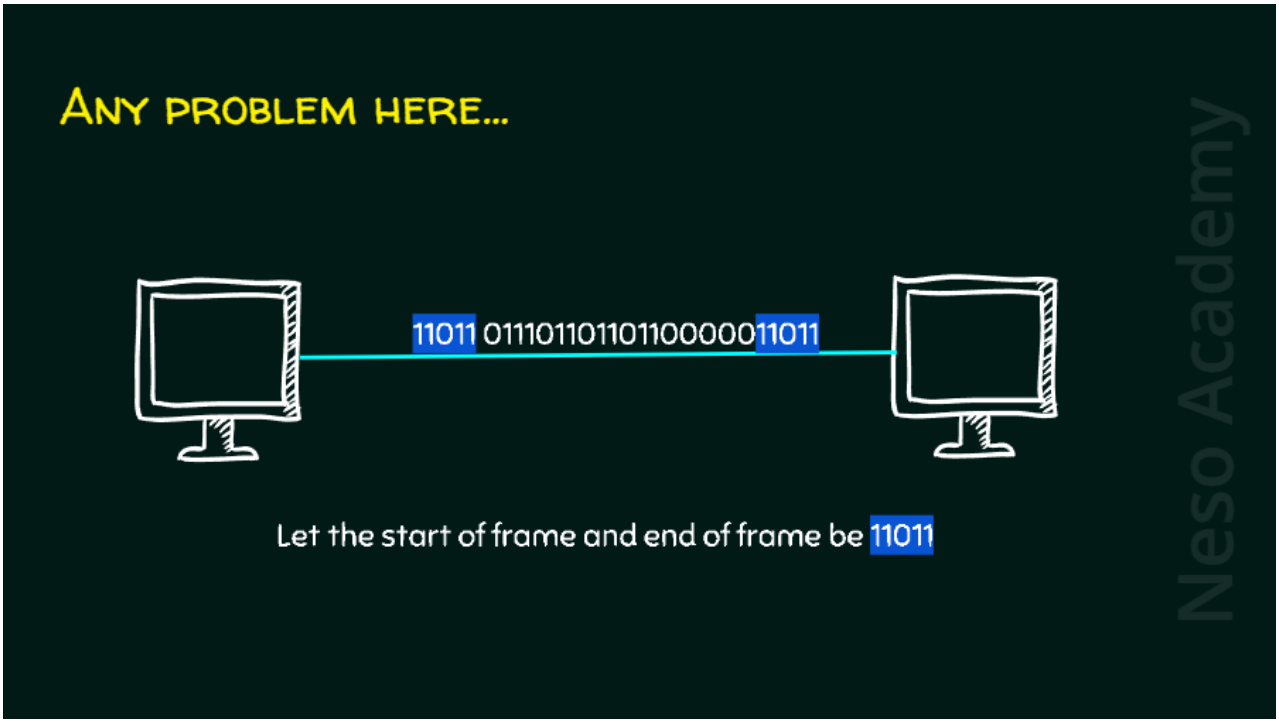
FramingNeso Academy



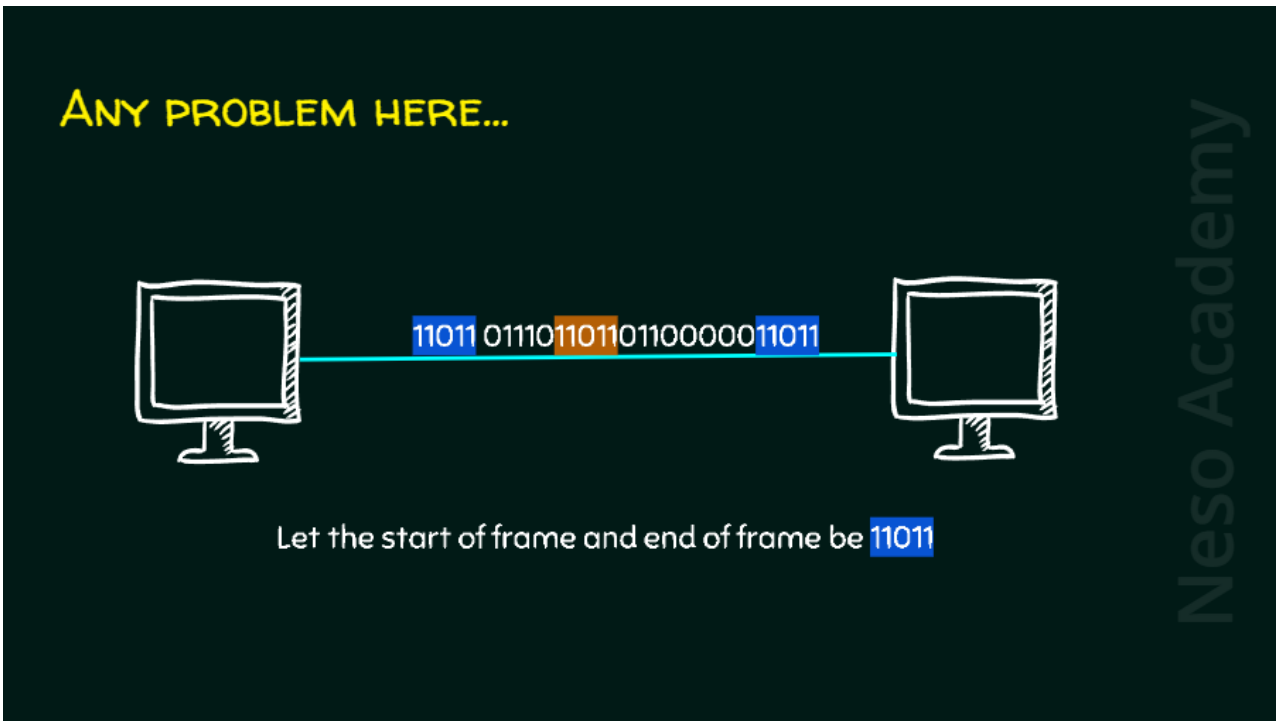
FramingNeso Academy



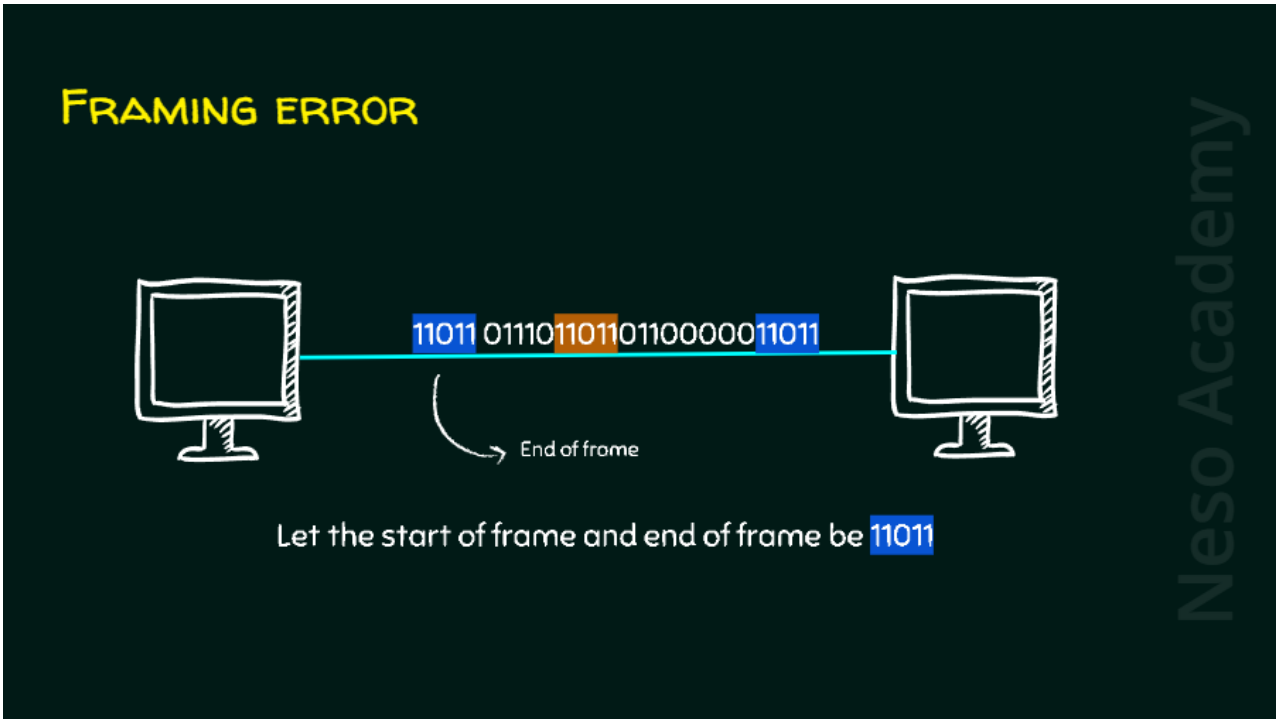
FramingNeso Academy



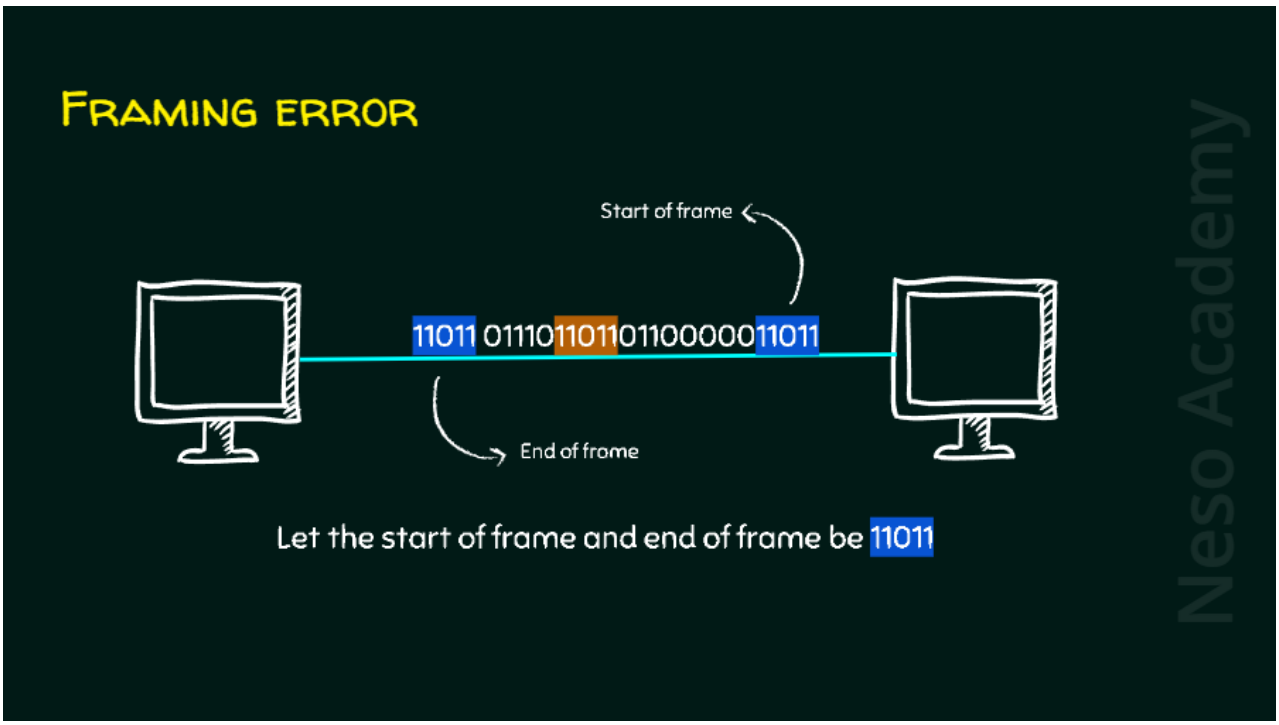
Any problem here...Neso Academy



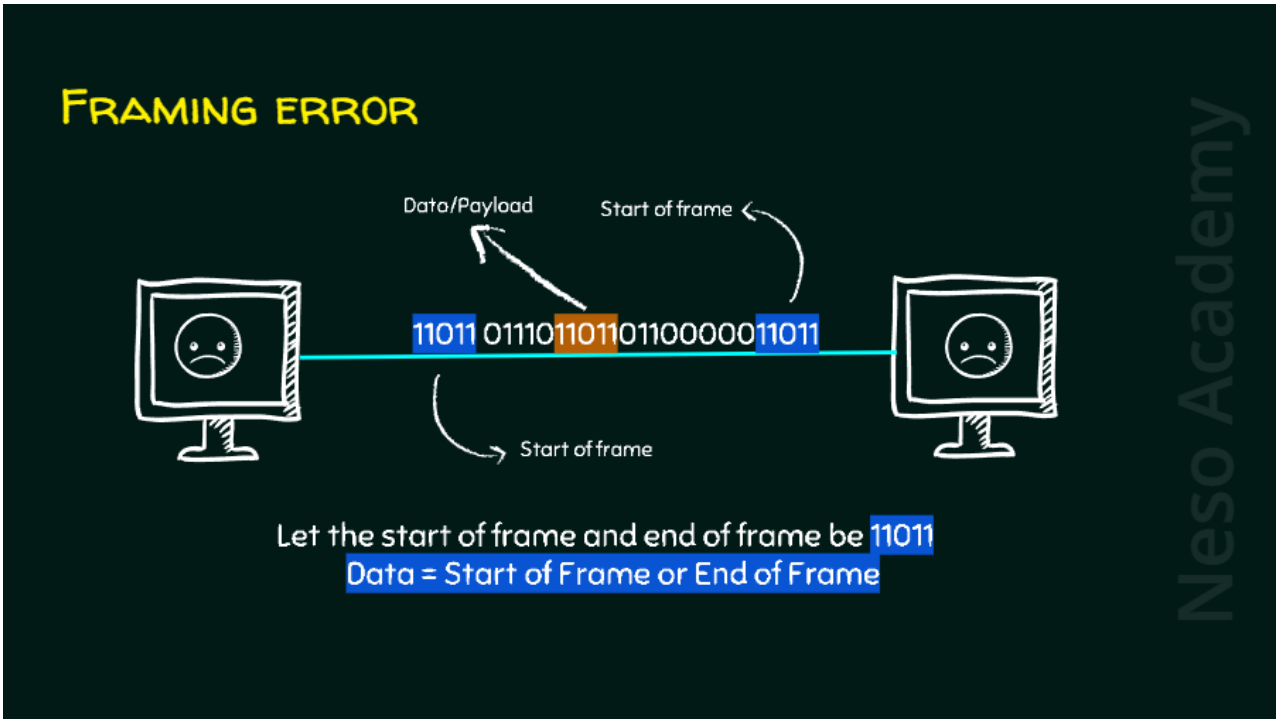
Any problem here...Neso Academy



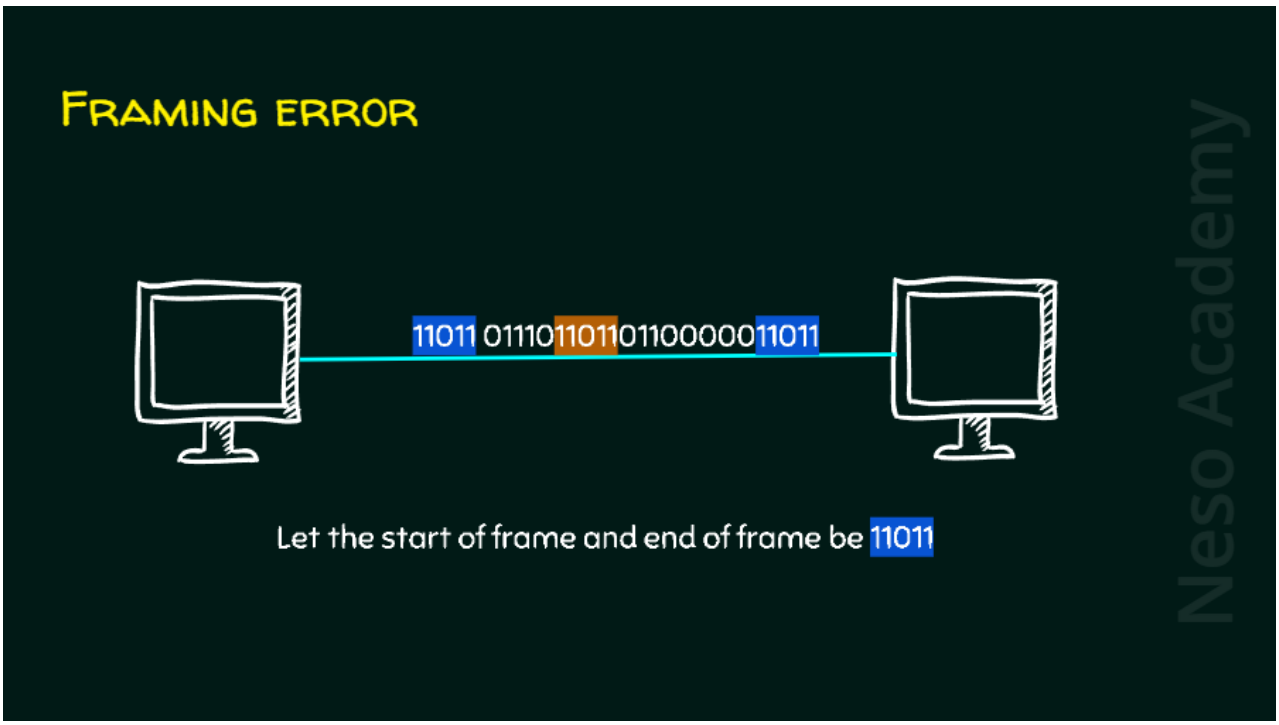
Framing errorNeso Academy



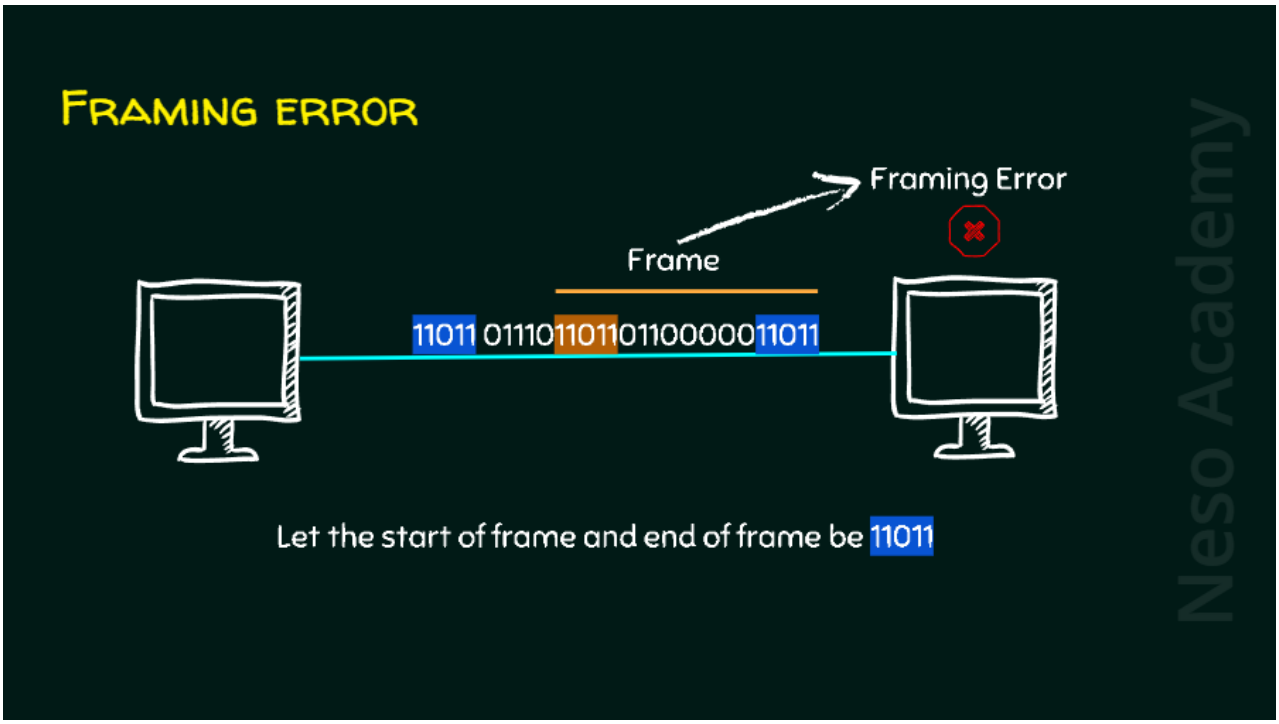
Framing errorNeso Academy



Framing errorNeso Academy



Framing errorNeso Academy



Framing errorNeso Academy

Outcomes

Upon the completion of this session, the learner will be able to

- ★ Understand the basics of framing.
- ★ Understand the types of framing.
- ★ Know various framing approaches.

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Outcomes★★★Neso Academy

Framing

- ★ Framing in the data link layer separates a frame distinguishable from another frame.
- ★ Frame = Header + Network Layer PDU + Trailer.
- ★ In packet switched networks, the block of data called frames are exchanged between nodes, not bits streams.

Bits flow between adaptors, frames between hosts

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Framing★★★Neso Academy

Framing

- ★ When node A wishes to transmit a frame to node B, it tells its adaptor to transmit a frame from the node's memory.
- ★ This results in a sequence of bits being sent over the link.
- ★ The adaptor on node B then collects together the sequence of bits arriving on the link and deposits the corresponding frame in B's memory.
- ★ Challenge: What set of bits constitute a frame?

Bits flow between adaptors, frames between hosts

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Framing★★★★Neso Academy

Types of framing

1. Fixed-size framing.

- ★ Here the size of the frame is fixed and so the frame length acts as delimiter of the frame.
- ★ Consequently, it does not require additional boundary bits to identify the start and end of the frame.

2. Variable-size framing.

- ★ Here, the size of each frame to be transmitted may be different.
- ★ So additional mechanisms are kept to mark the end of one frame and the beginning of the next frame.

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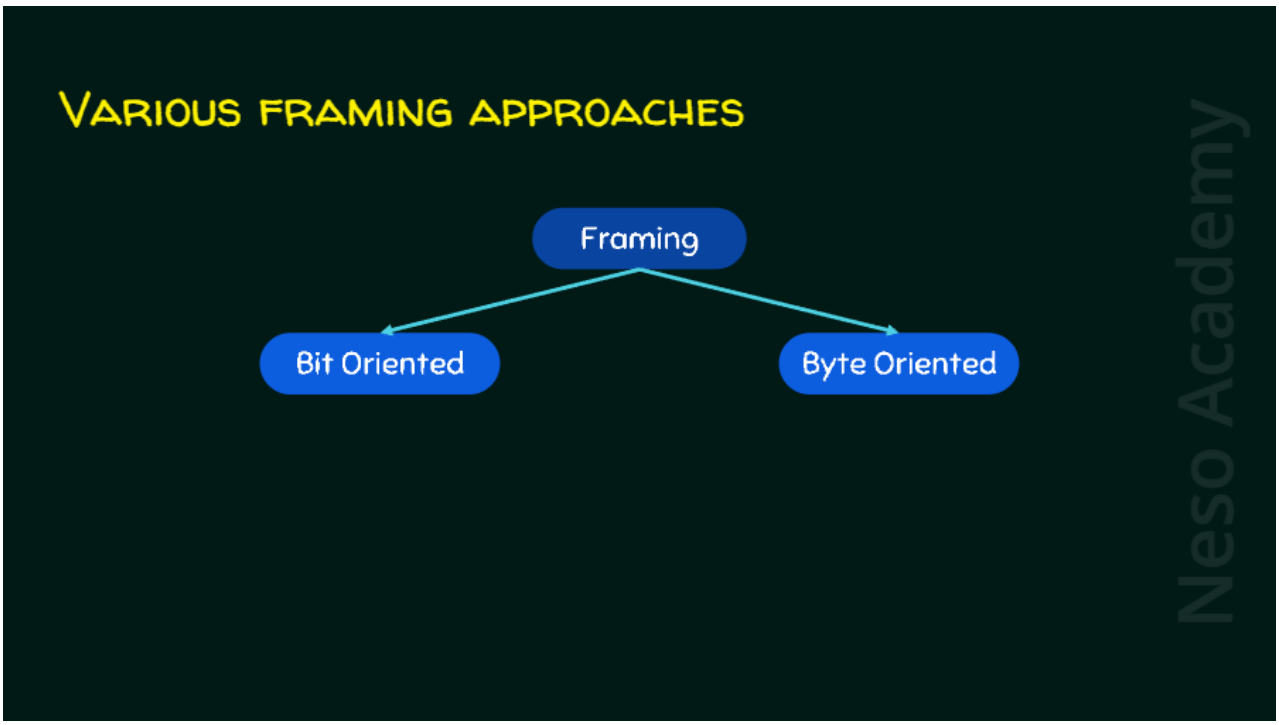
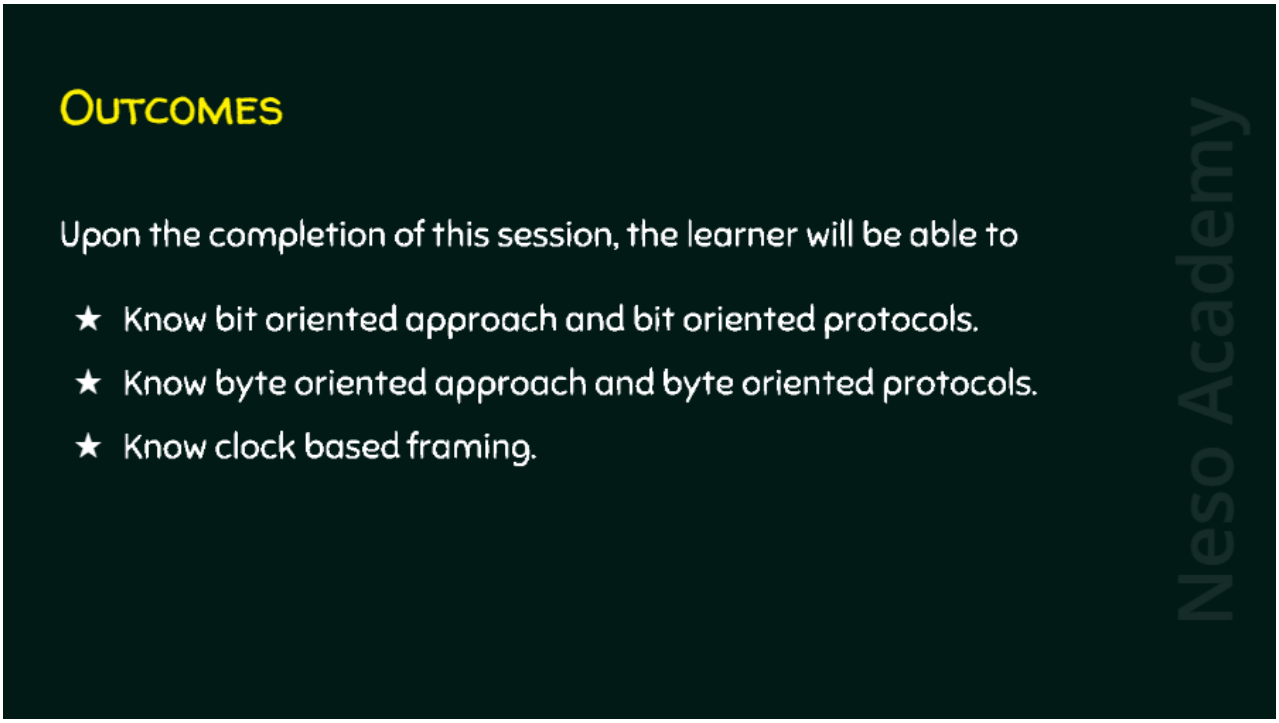
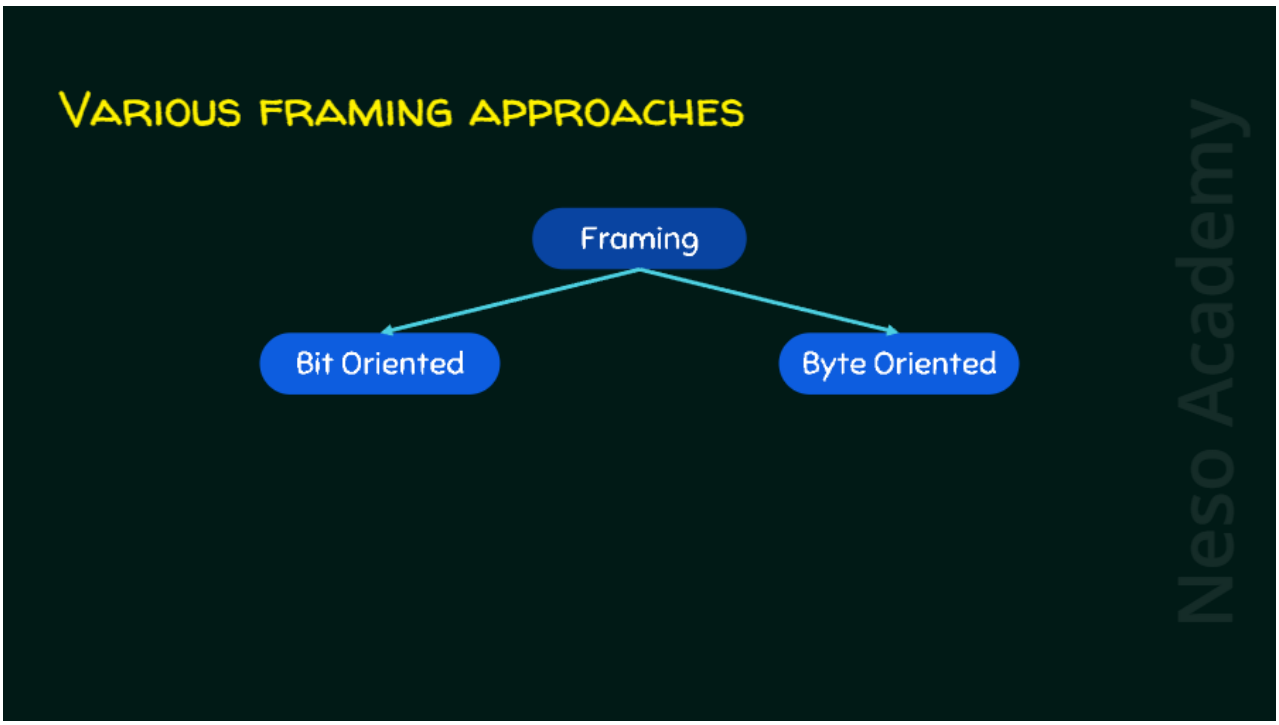
Types of framing★★★★Neso Academy



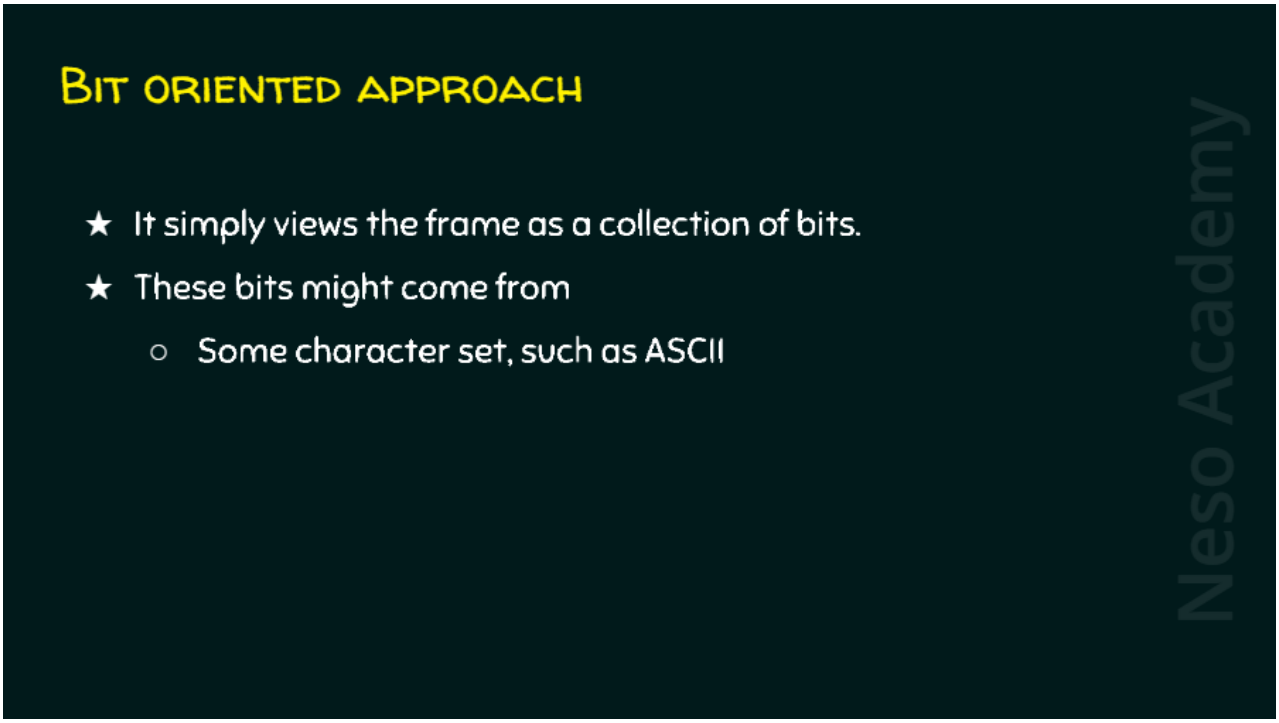
Various framing approachesNeso Academy



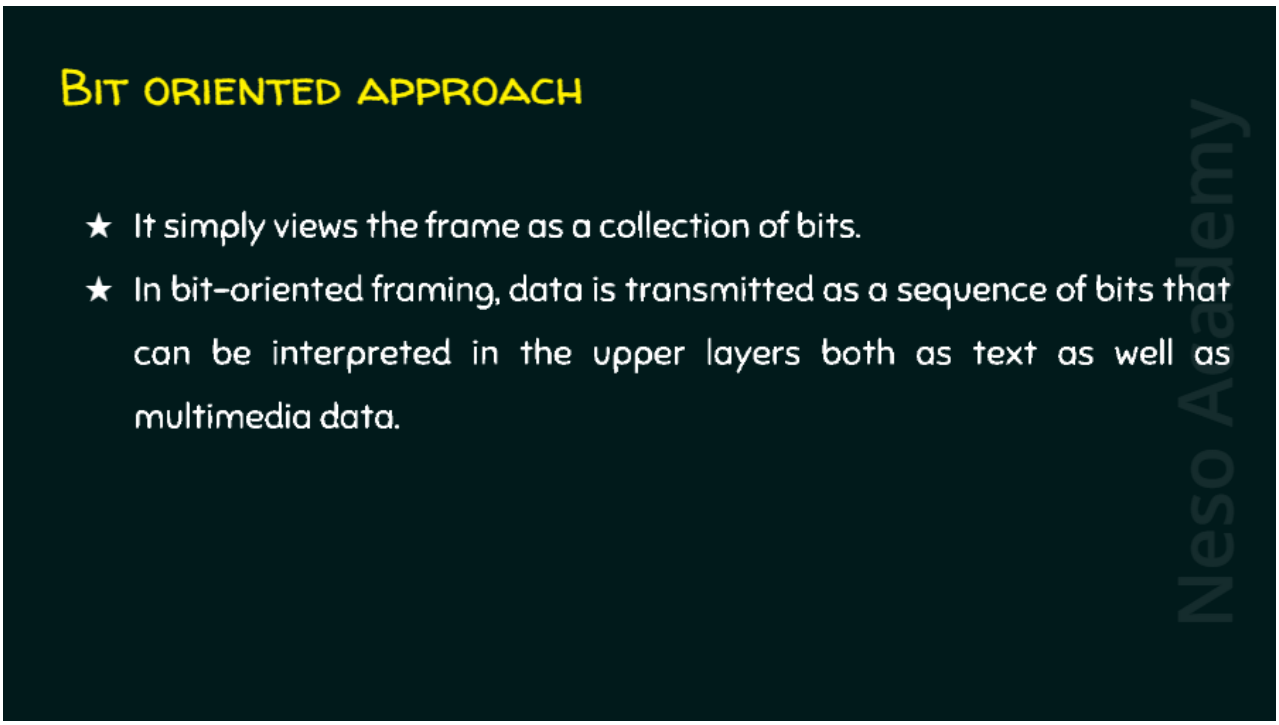
Outcomes★★★Neso Academy



Various framing approachesNeso Academy

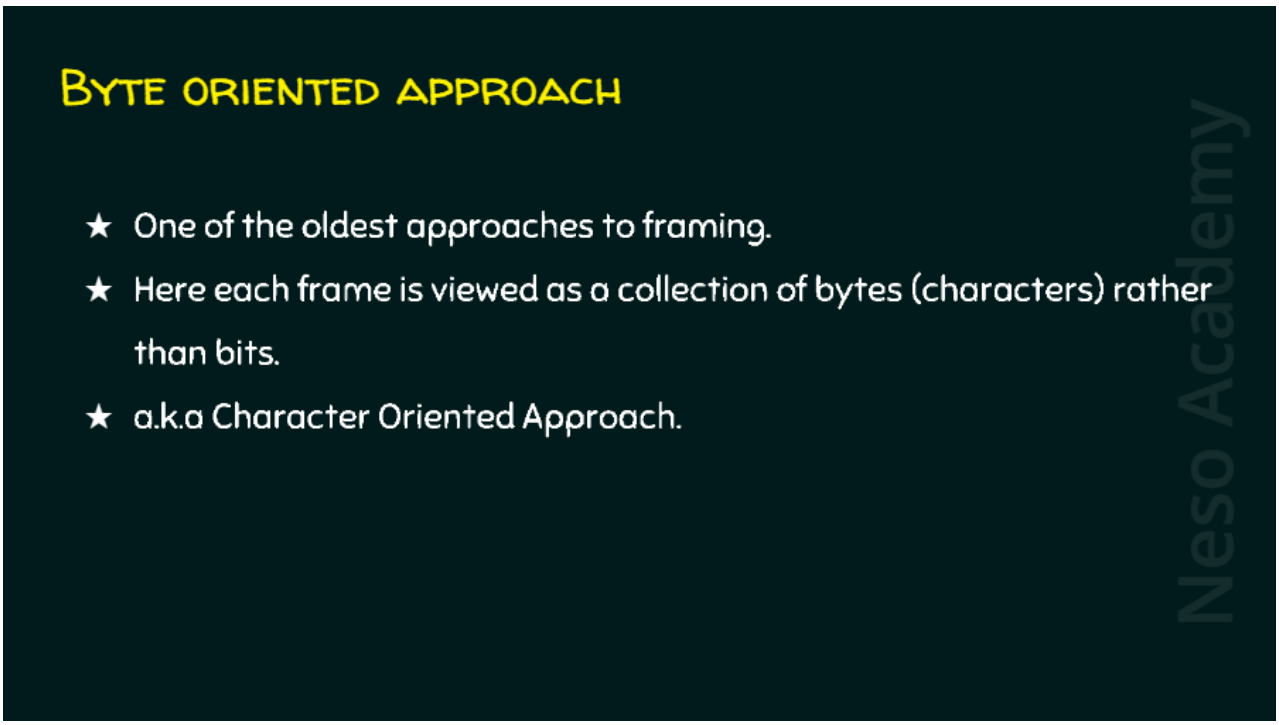


Bit oriented approach★★○Neso Academy

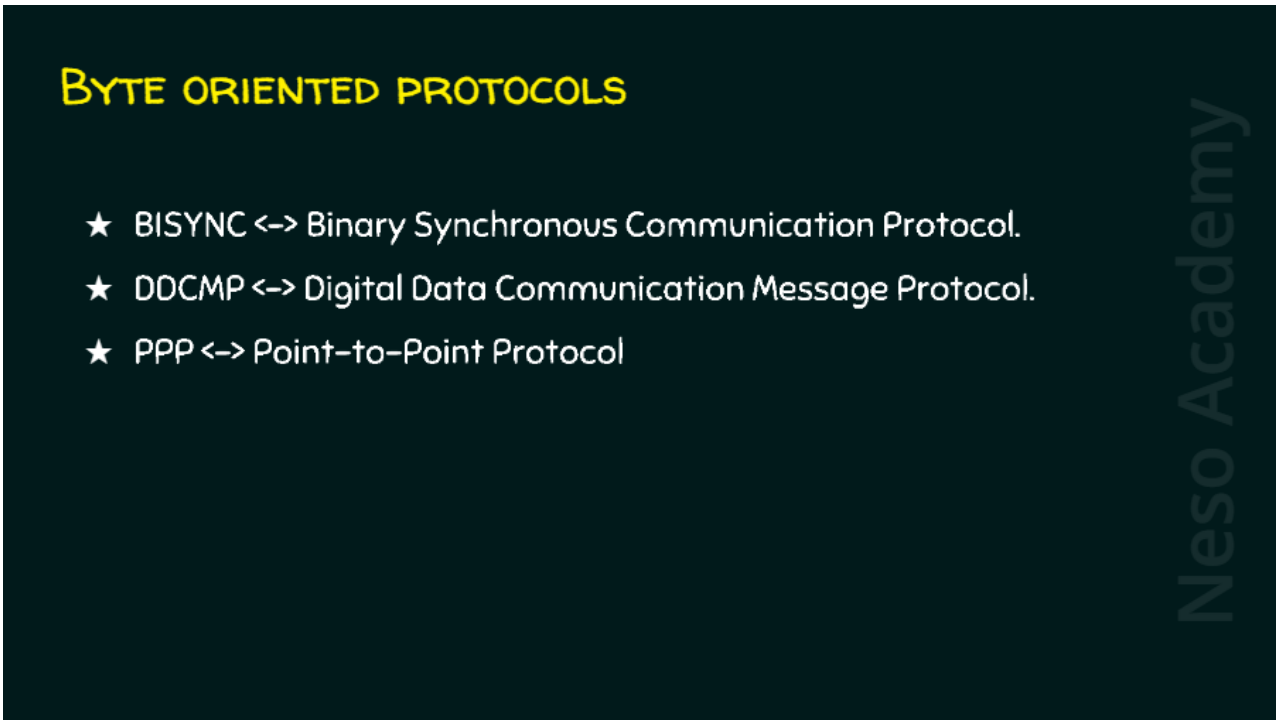


Bit oriented approach★★Neso Academy

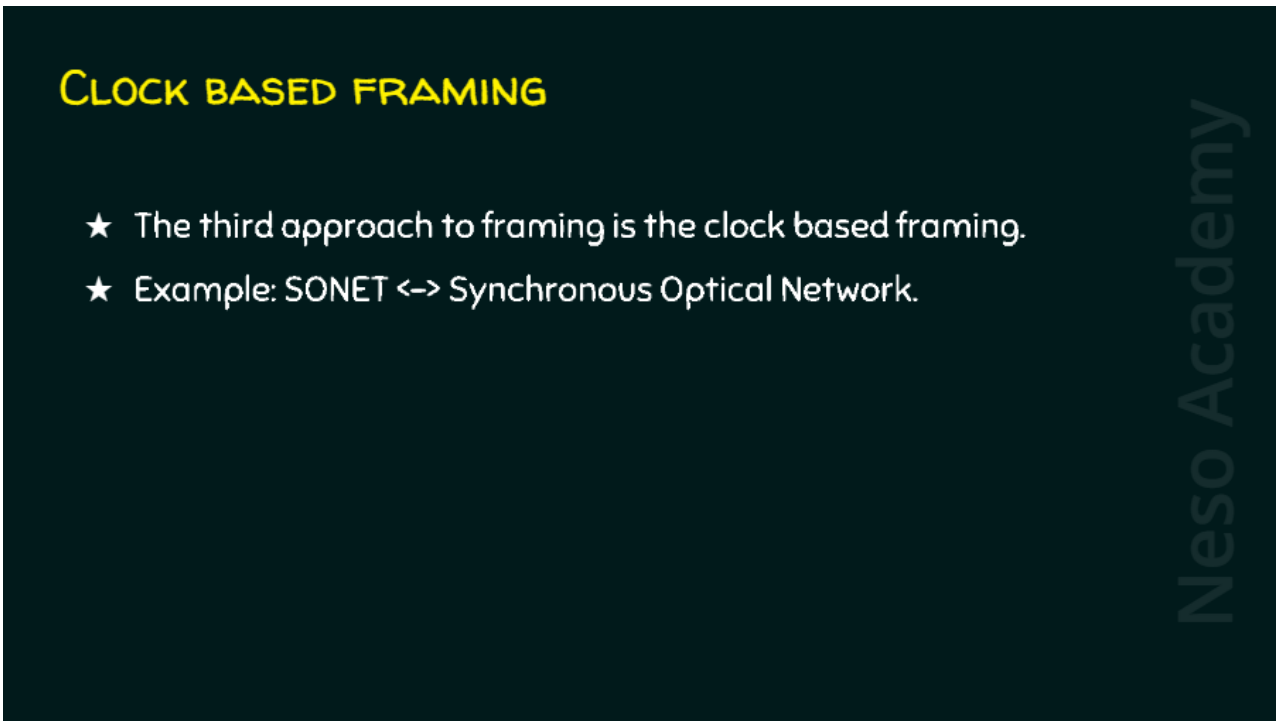
Bit oriented protocol★Neso Academy



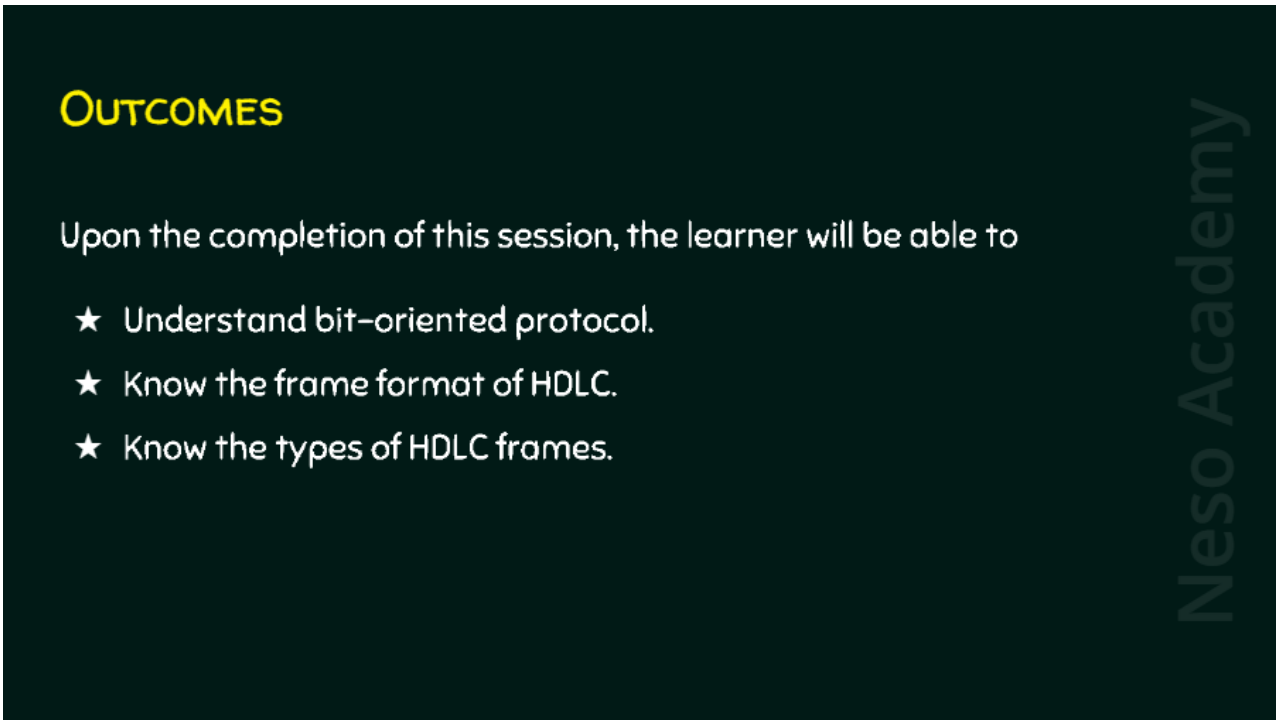
Byte oriented approach★★★Neso Academy



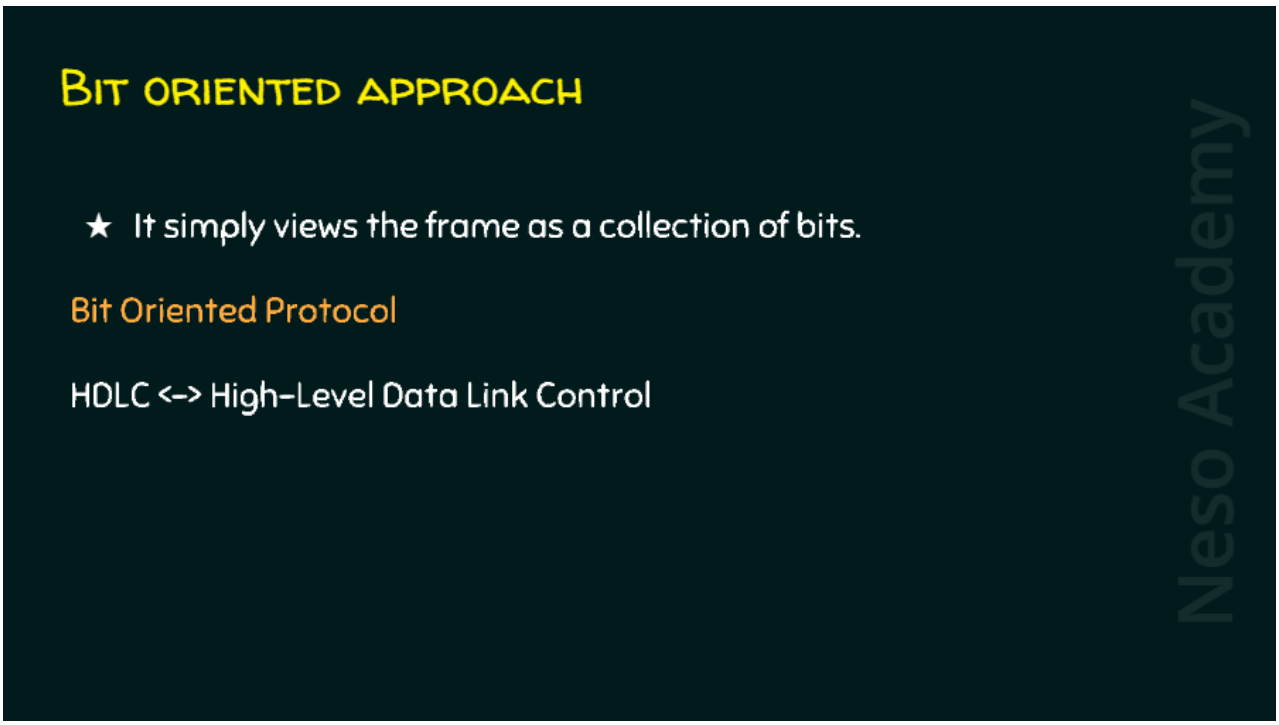
Byte oriented protocols★★★Neso Academy



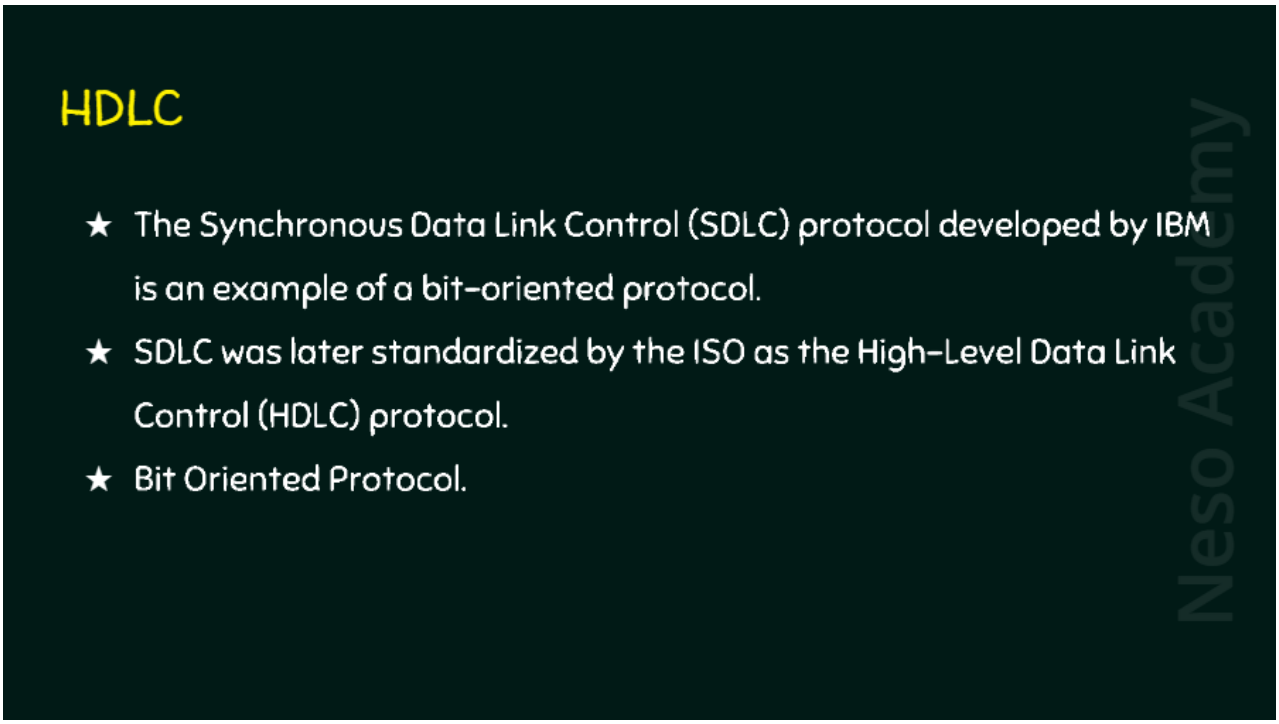
Clock based framing ★★Neso Academy



Outcomes★★★Neso Academy



Bit oriented approach★Neso Academy



HDLC★★★Neso Academy

HDLC – Frame format

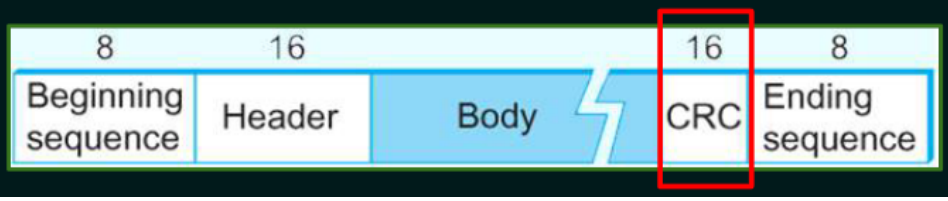
Beginning and Ending Sequences: 01111110

This sequence is also transmitted during any times that the link is idle so that the sender and receiver can keep their clocks synchronized.

Header: Address and Control Field.

Body: Payload (Variable size)

CRC: Cyclic Redundancy check – Error Detection



HDLC -Frame formatNeso Academy

Types of HDLC Frames

The type of frame is determined by the control field.

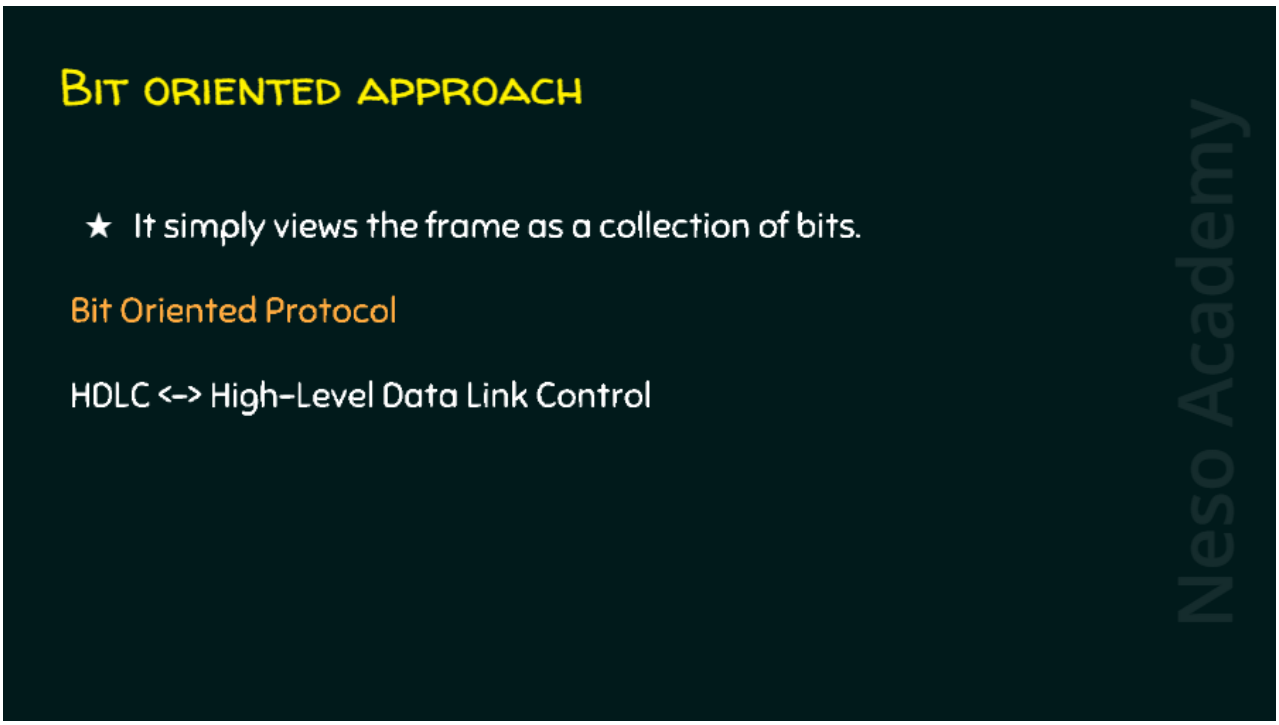
I-Frame: Information Frame.

S-Frame: Supervisory Frame.

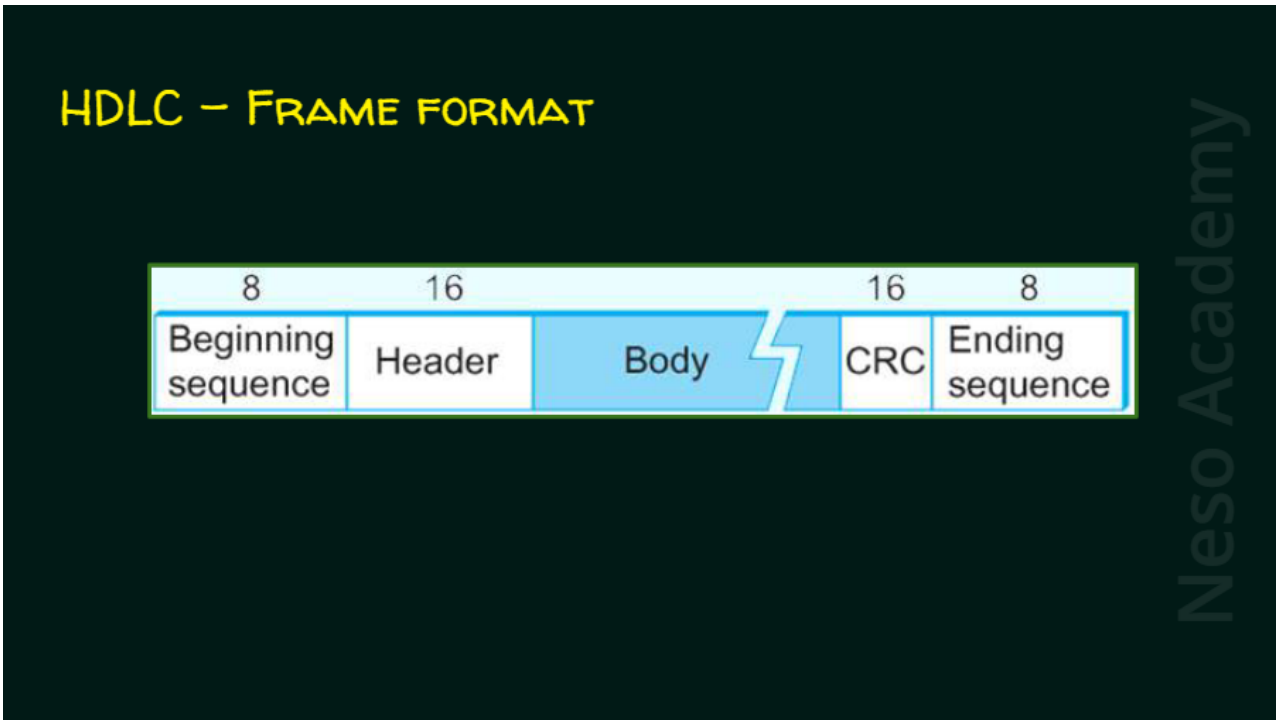
U-Frame: Un-numbered Frame.

I-Frame	1st bit is 0
S-Frame	1st two bits is 10
U-Frame	1st two bits is 11

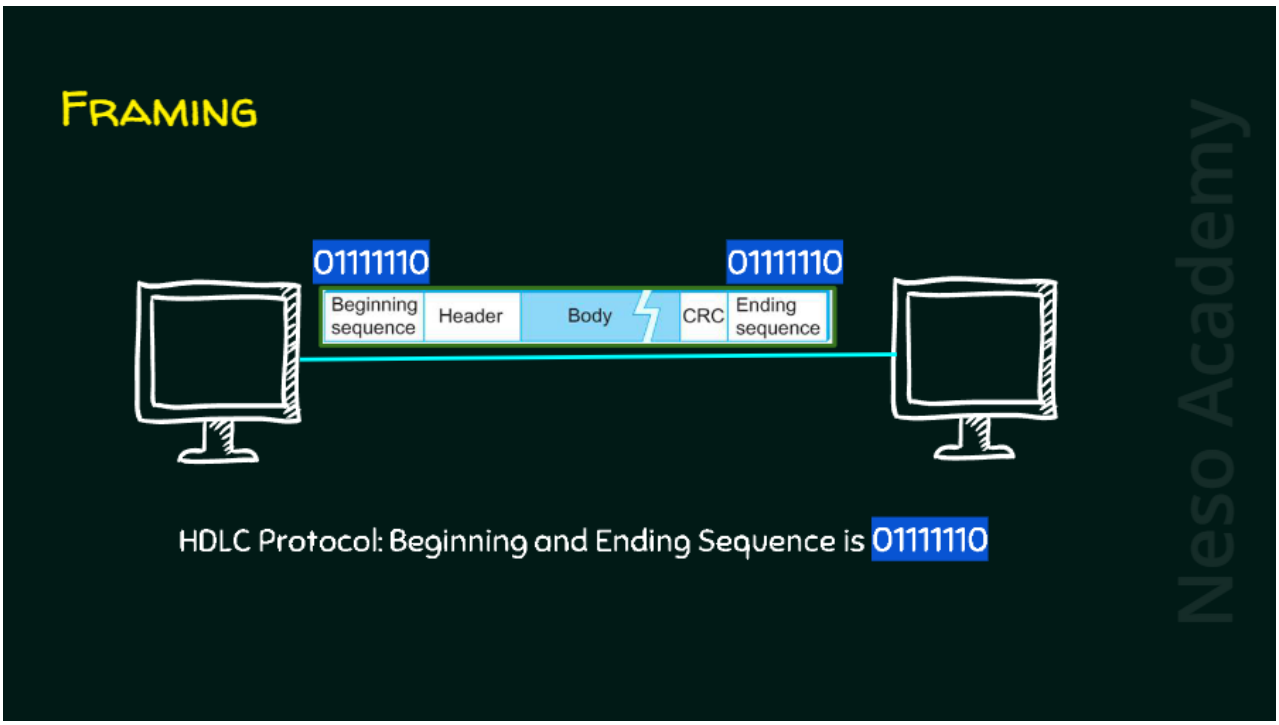
Types of HDLC FramesNeso Academy



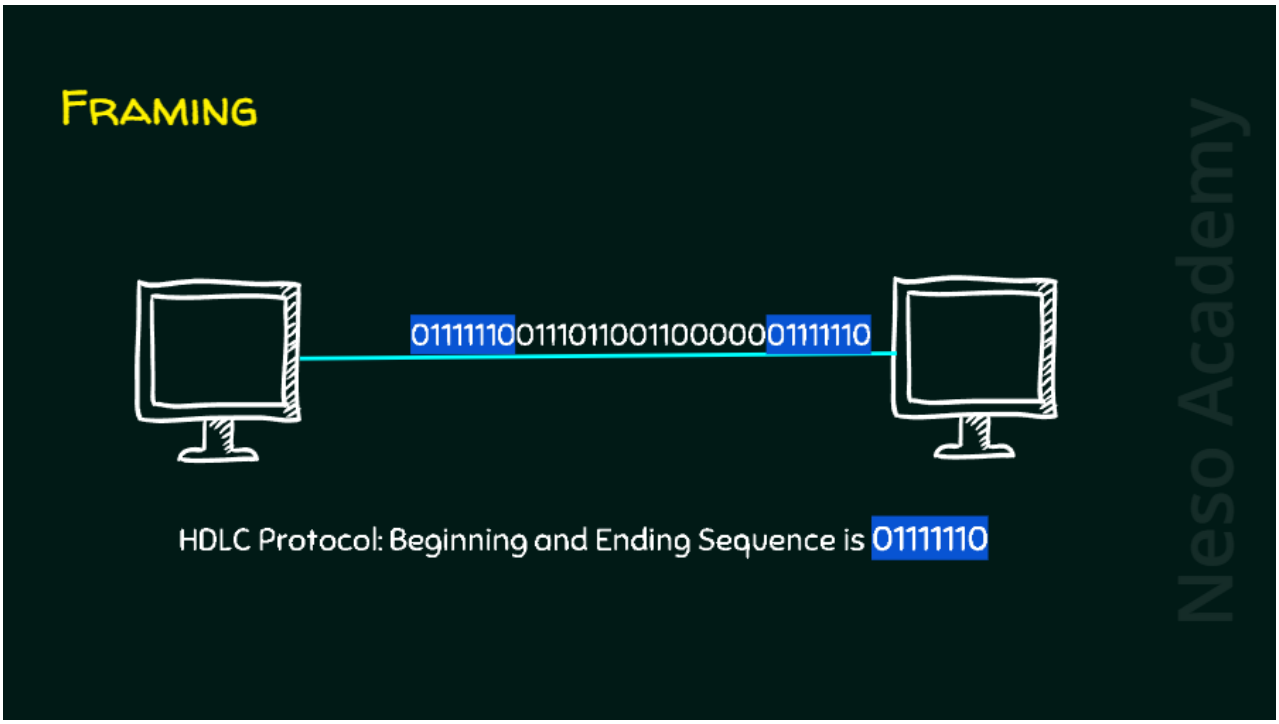
Bit oriented approach★Neso Academy



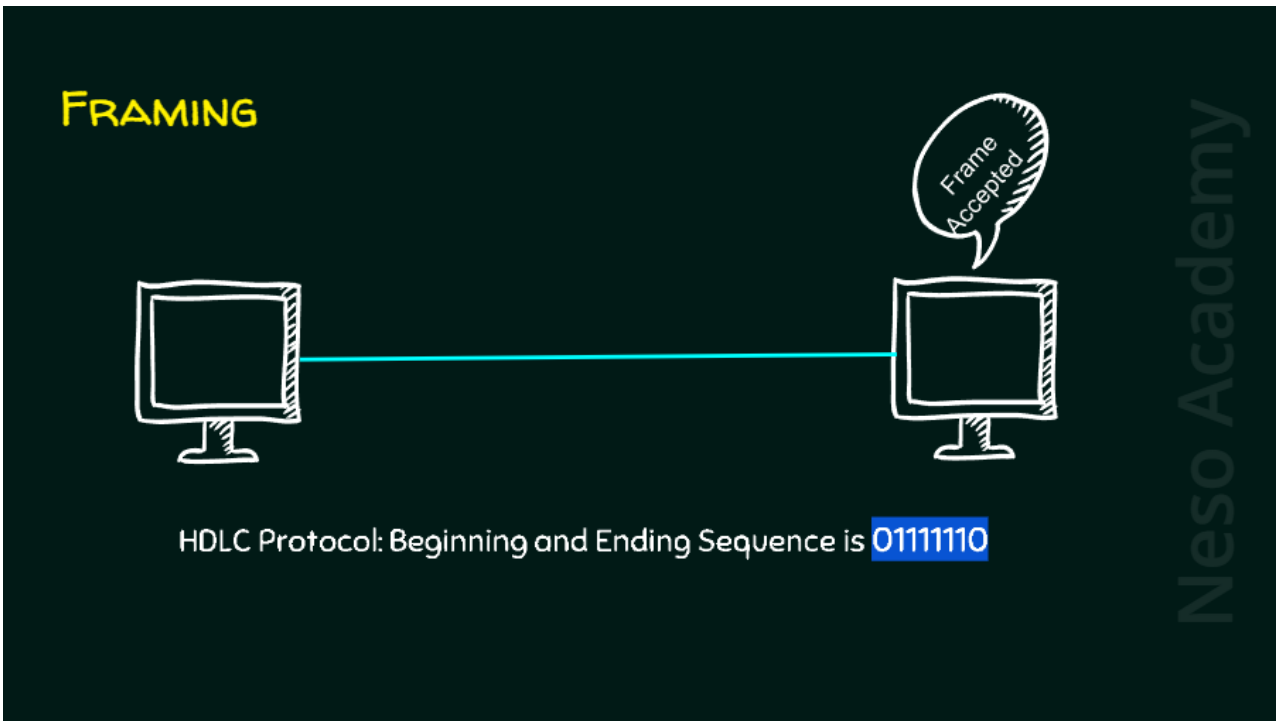
HDLC -Frame formatNeso Academy



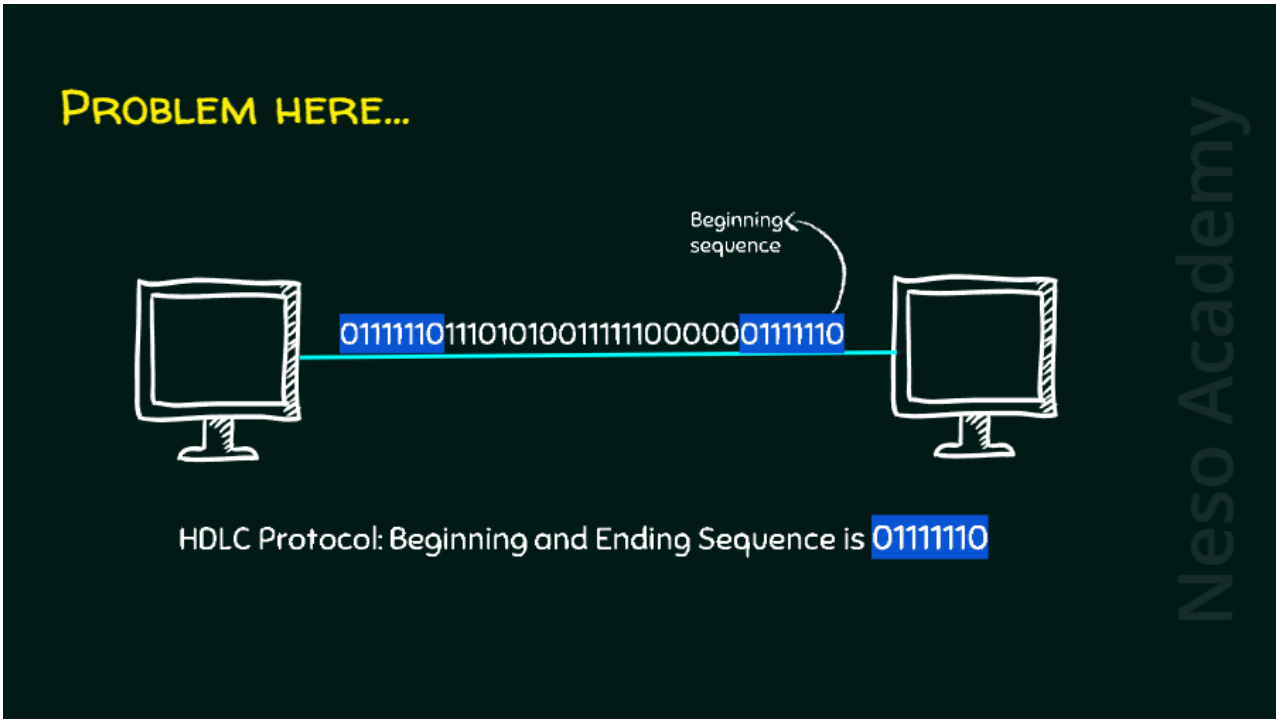
FramingNeso Academy



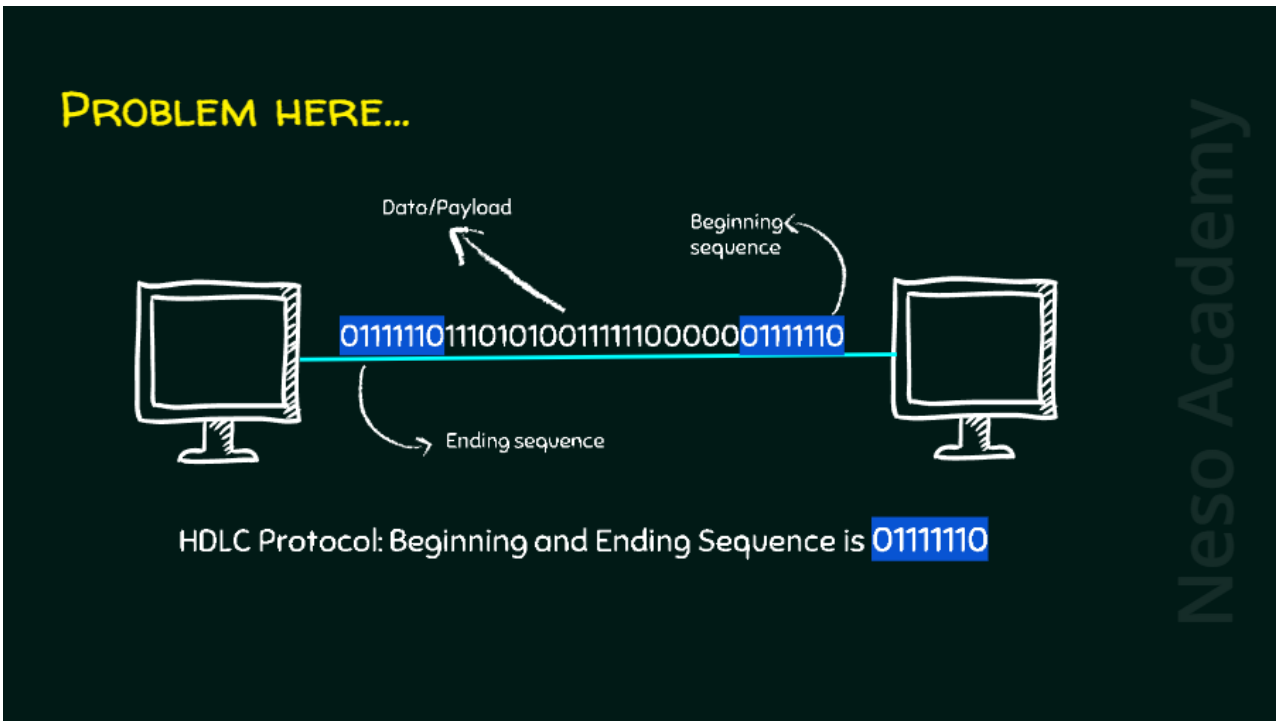
FramingNeso Academy



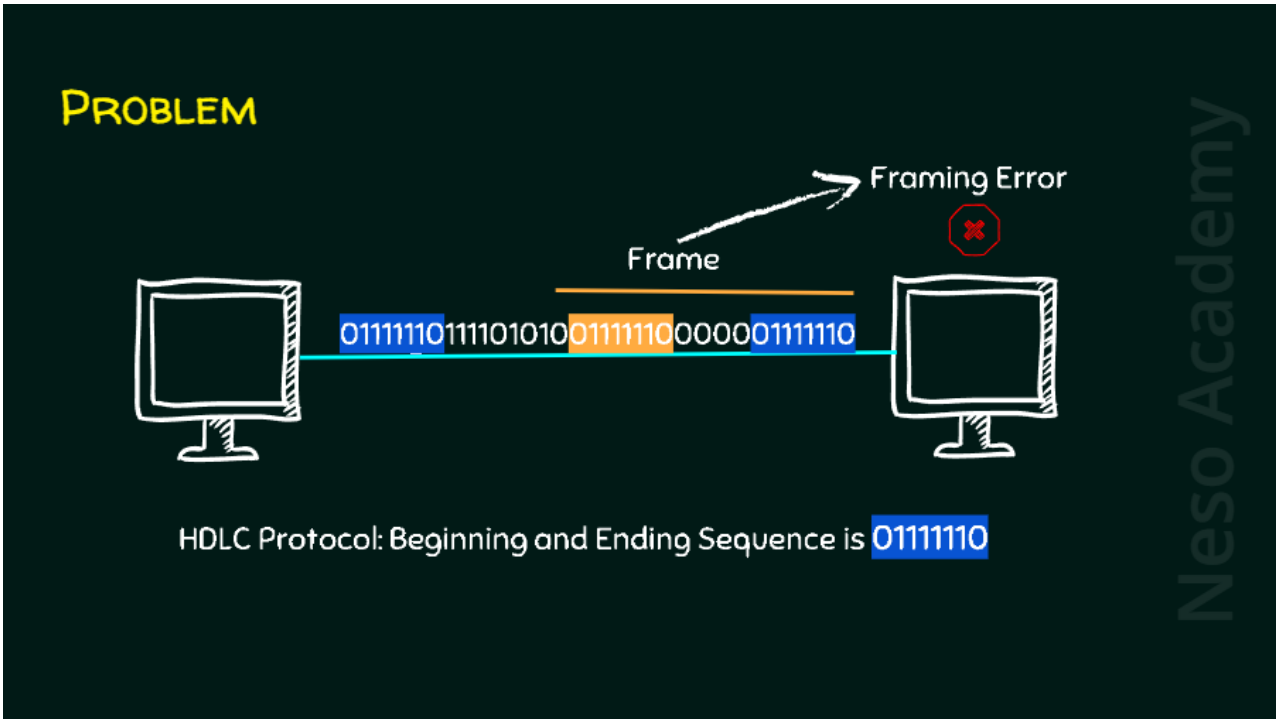
FramingNeso Academy



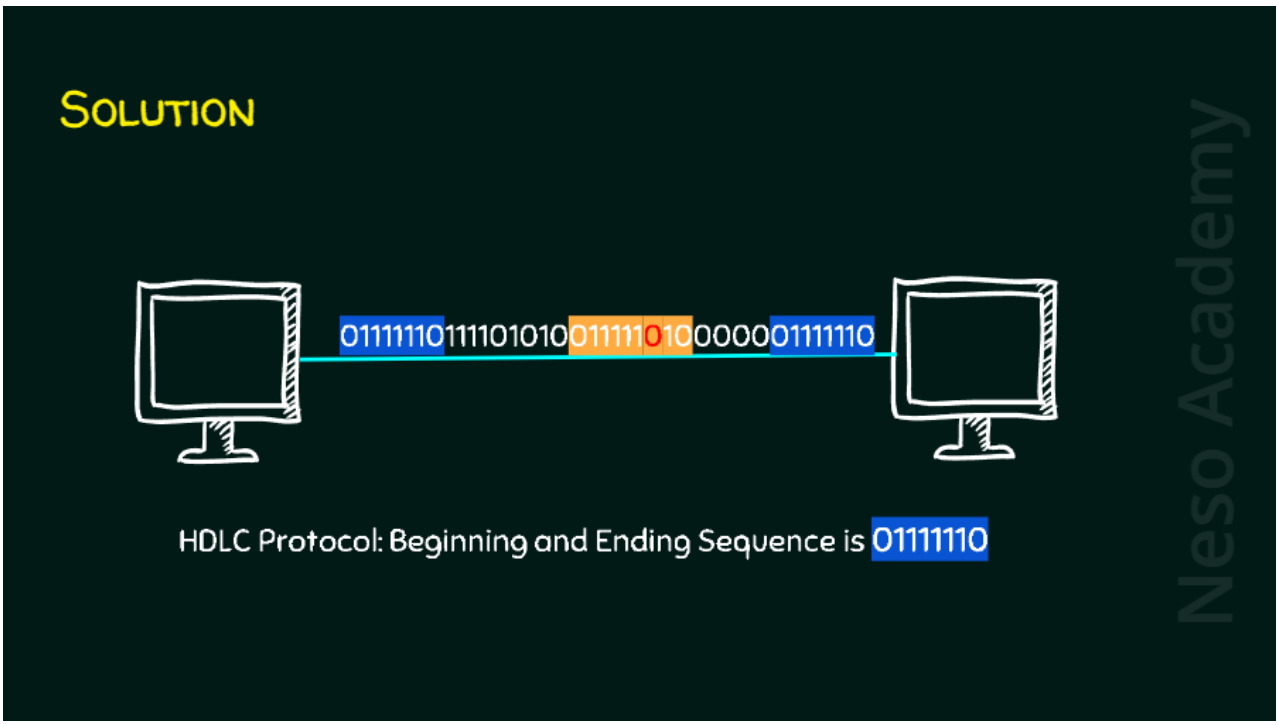
Problem here...Neso Academy



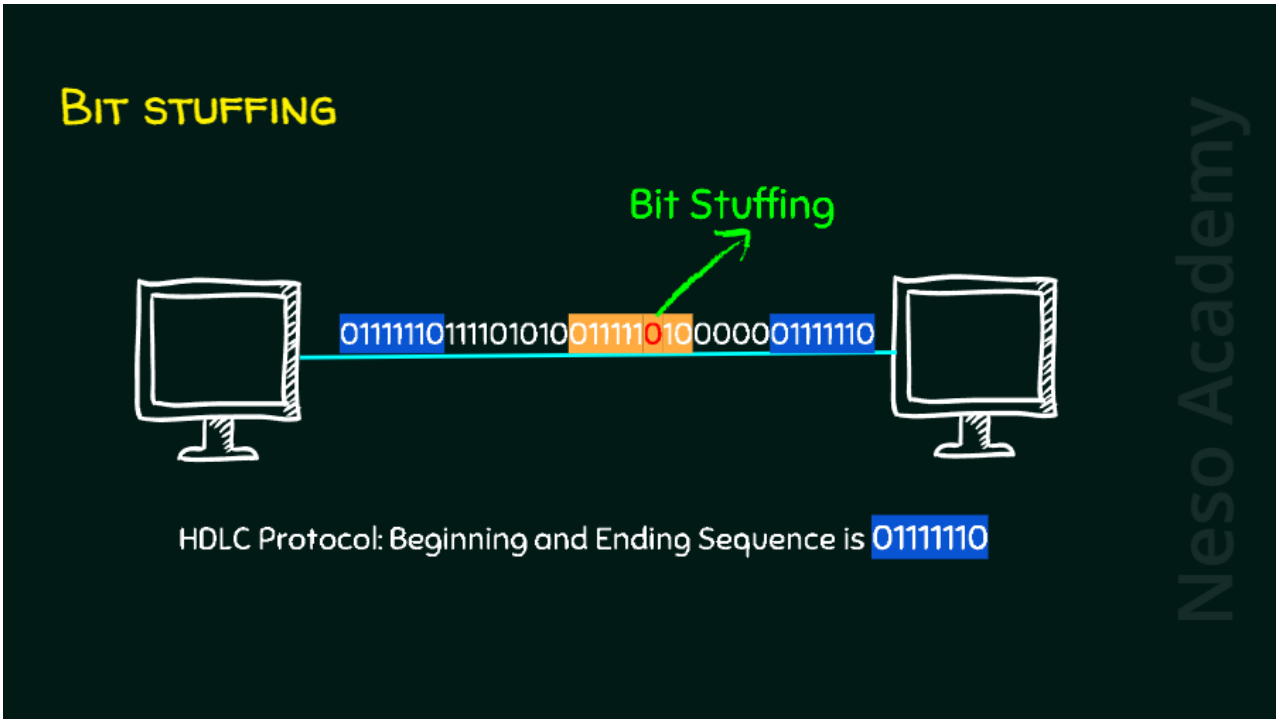
Problem here...Neso Academy



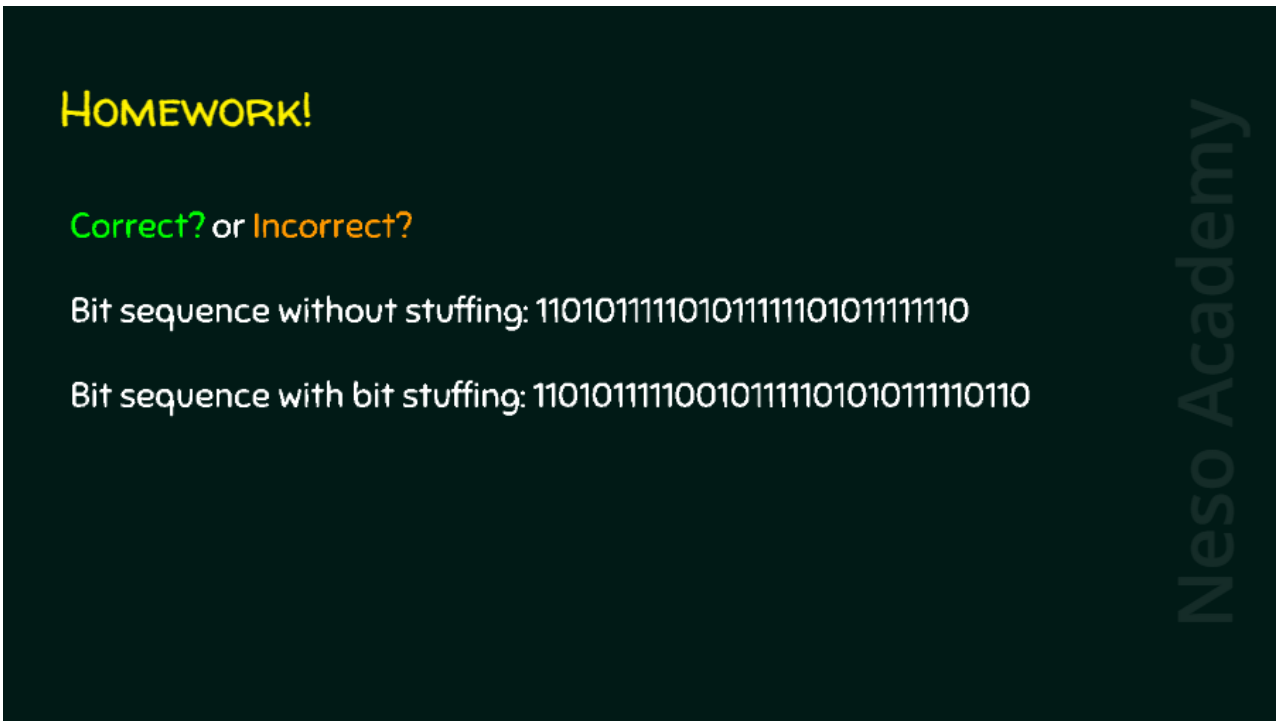
ProblemNeso Academy



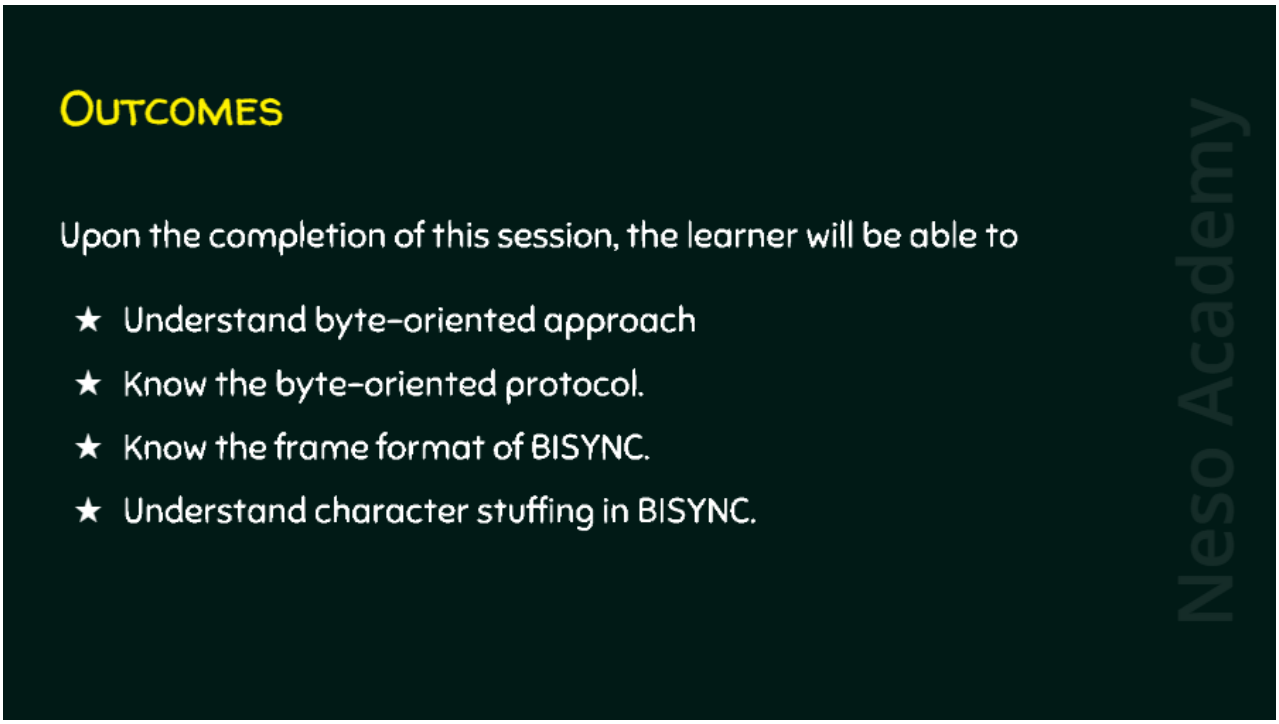
SolutionNeso Academy



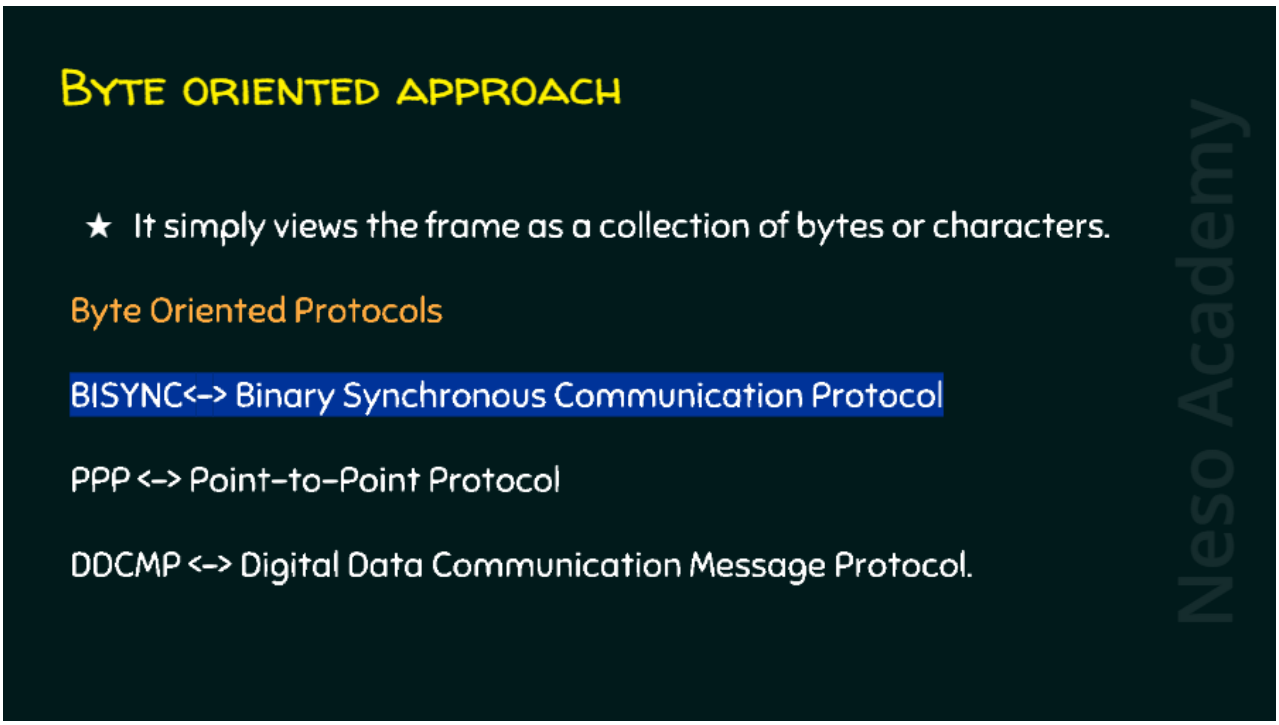
Bit stuffingNeso Academy



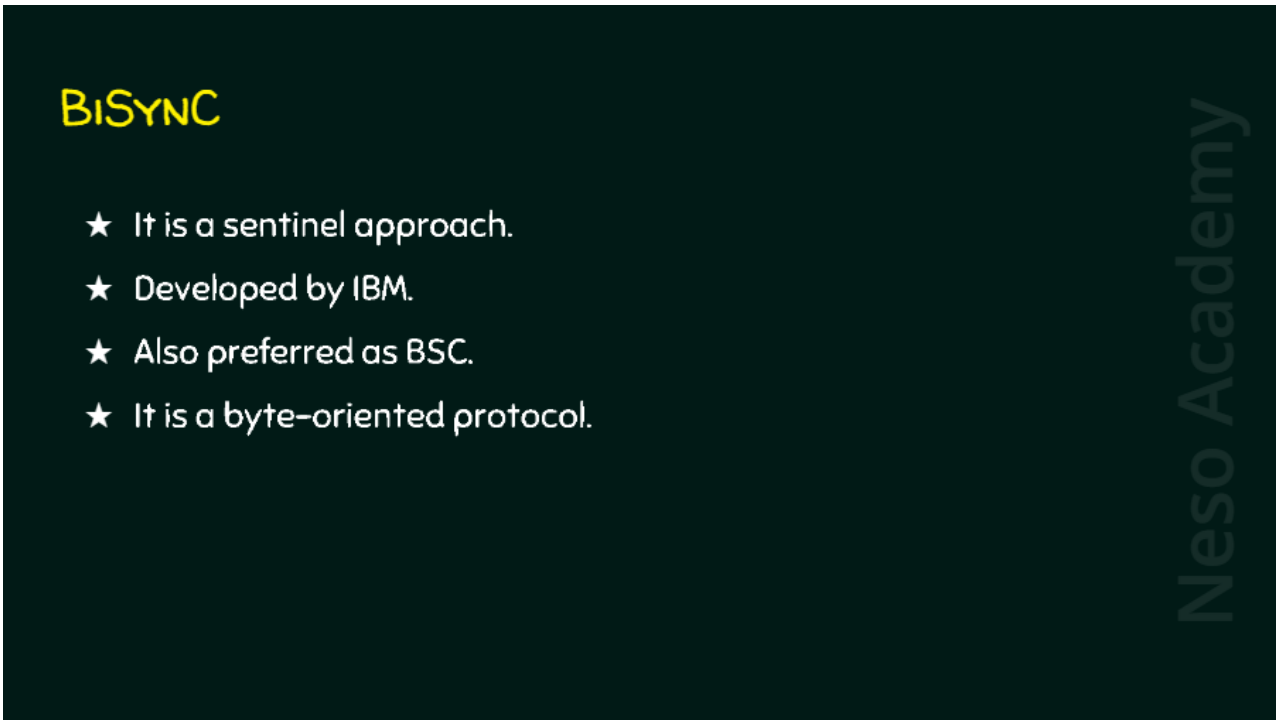
Homework!Neso Academy



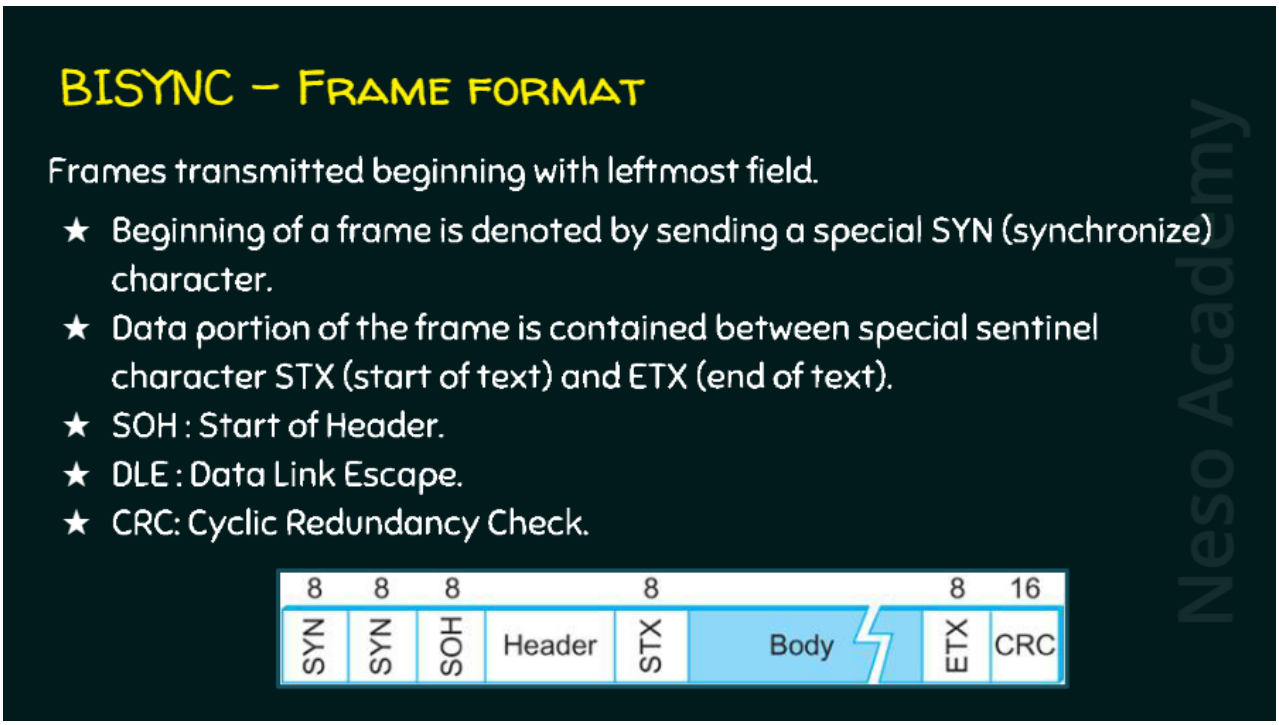
Outcomes★★★★Neso Academy



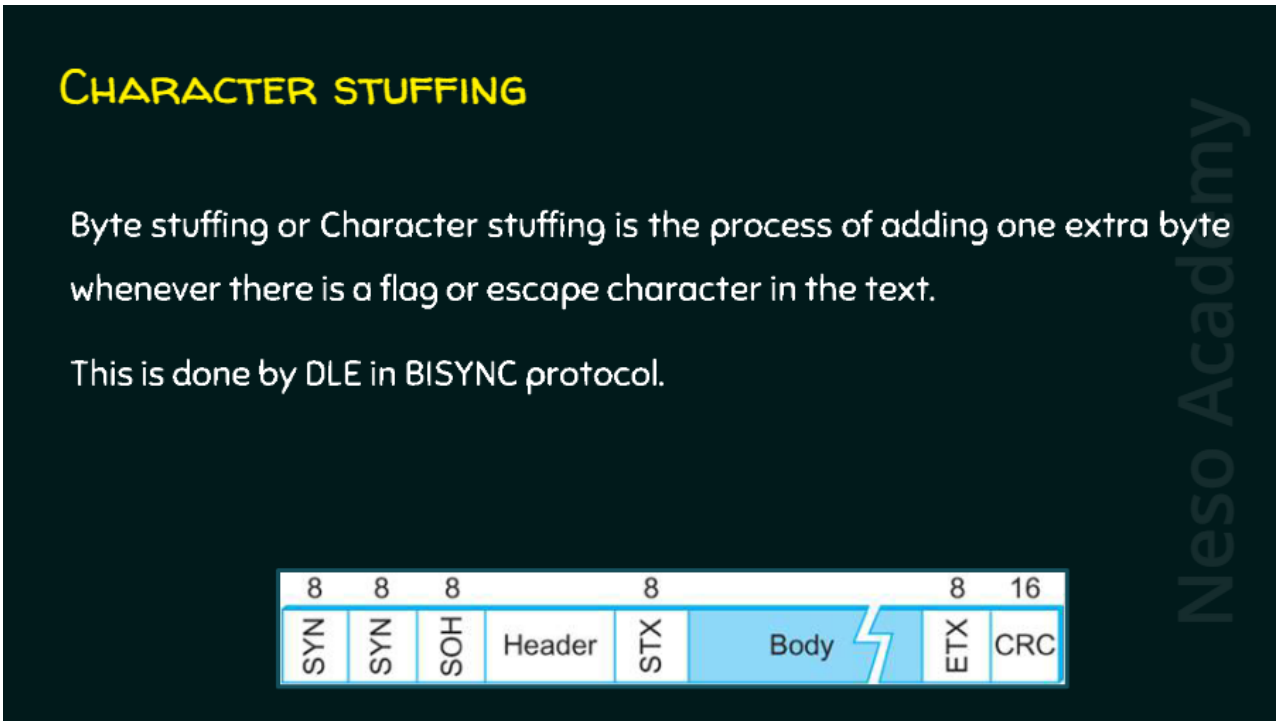
Byte oriented approach★Neso Academy



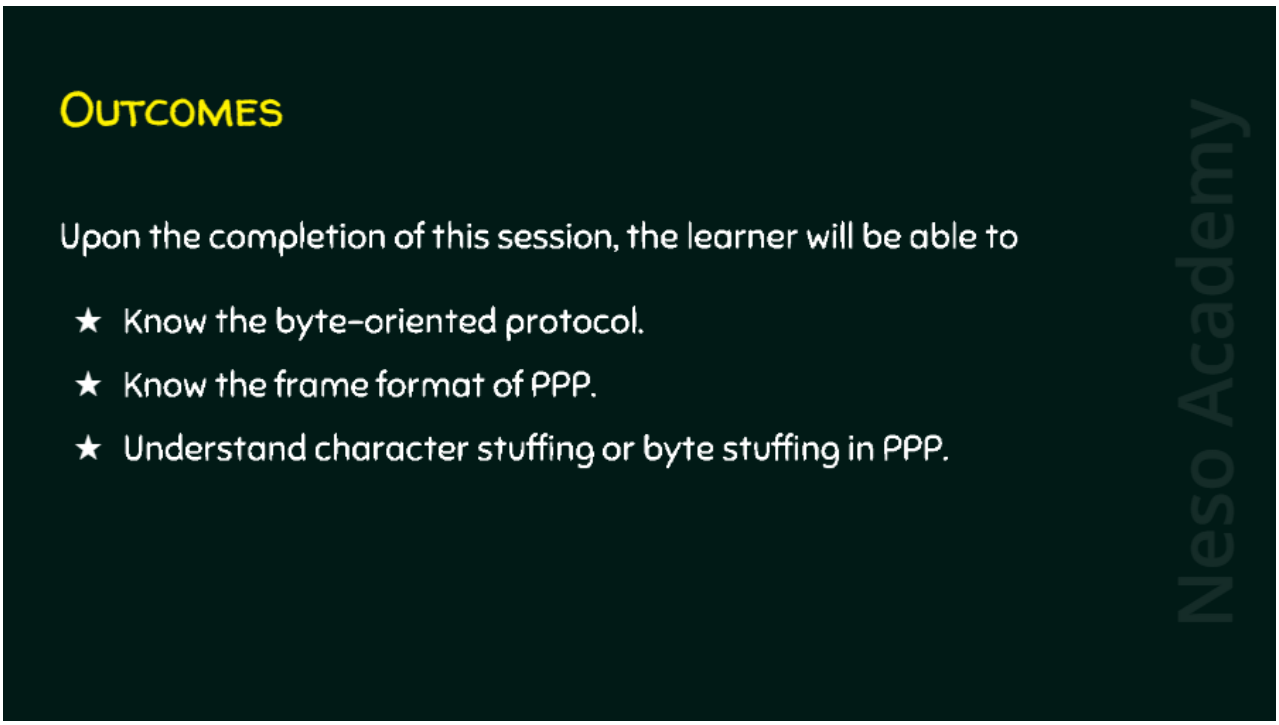
BiSynC★★★★Neso Academy



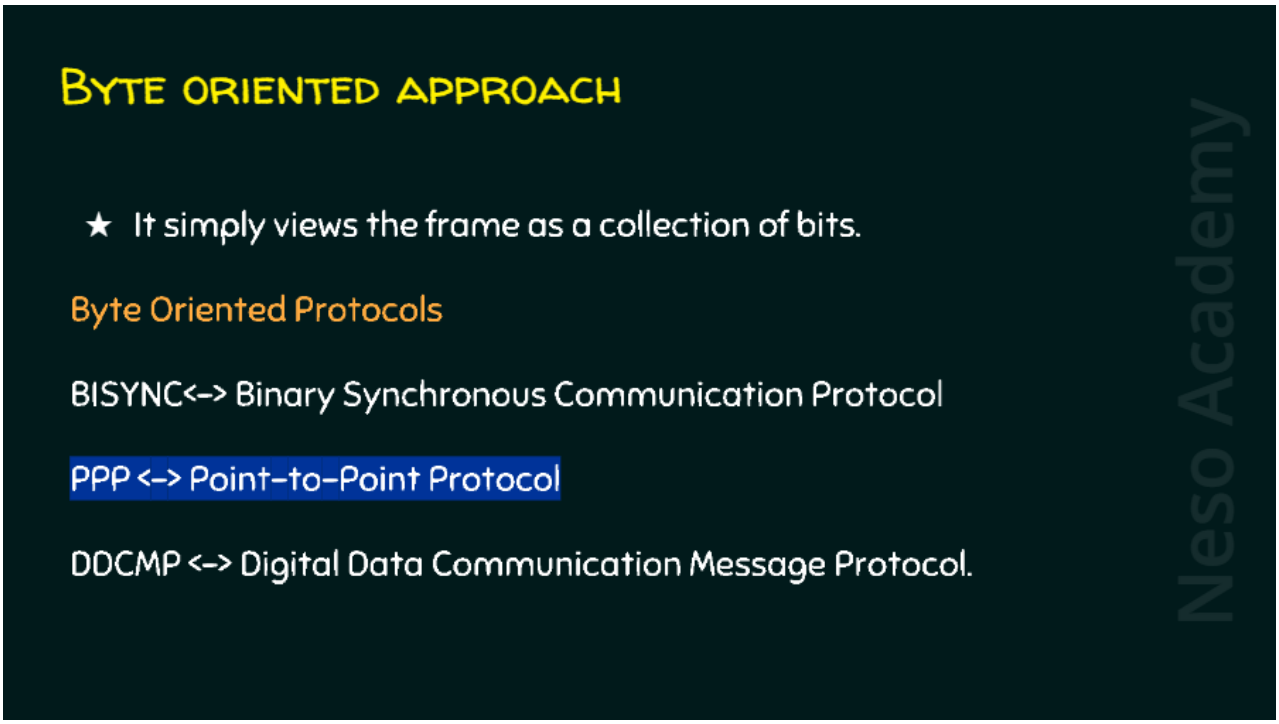
BISYNC -Frame format★★★★★Neso Academy



Character stuffingNeso Academy



Outcomes★★★Neso Academy



Byte oriented approach★Neso Academy

PPP

- ★ PPP is a data link layer protocol.
- ★ PPP is a WAN protocol and which is commonly run over Internet links.
- ★ It is widely used in broadband communications having heavy loads and high speeds.
- ★ It is used to transmit multiprotocol data between two directly connected (point-to-point) computers.

PPP★★★★Neso Academy

PPP – Frame format

- ★ Flag – 1 byte that marks the beginning and the end of the frame. The bit pattern of the flag is 01111110.
- ★ Address – 1 byte which is set to 11111111 in case of broadcast.
- ★ Control – 1 byte set to a constant value of 11000000.
- ★ Protocol – 1 or 2 bytes that define the type of data contained in the payload field.
- ★ Payload – This carries the data from the network layer. The maximum length of the payload field is 1500 bytes. However, this may be negotiated between the endpoints of communication.
- ★ Checksum – Error detection.

PPP -Frame format★★★★★★Neso Academy

Character stuffing

Byte stuffing or Character stuffing is the process of adding one extra byte whenever there is a flag sequence appear in the payload.

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Character stuffingNeso Academy

Outcomes

Upon the completion of this session, the learner will be able to

- ★ Understand DDCMP frame format.
- ★ Understand the framing error in DDCMP.

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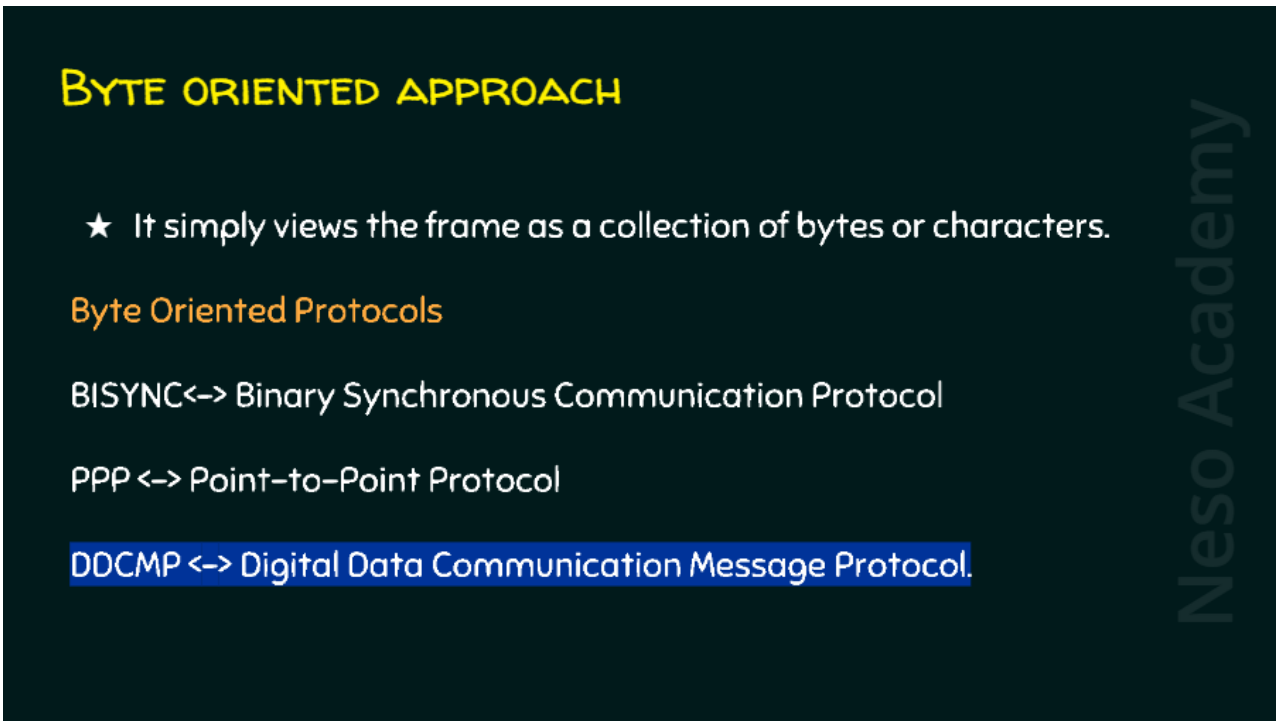
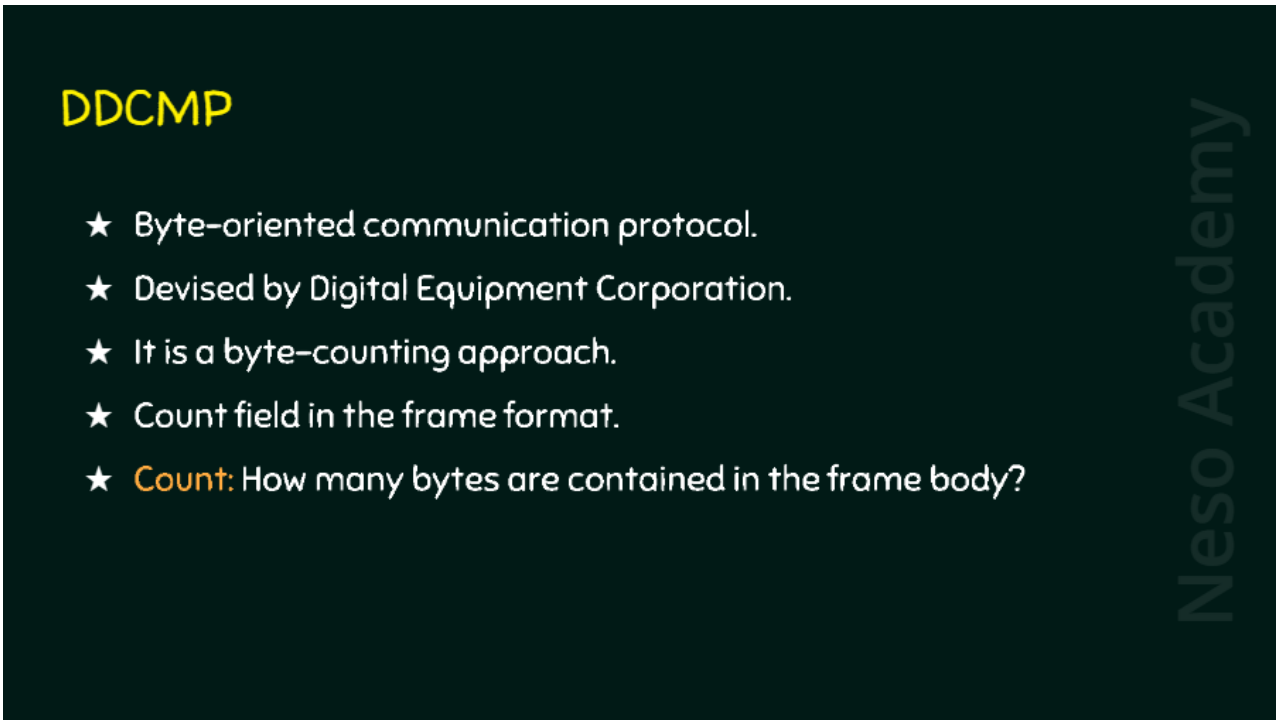
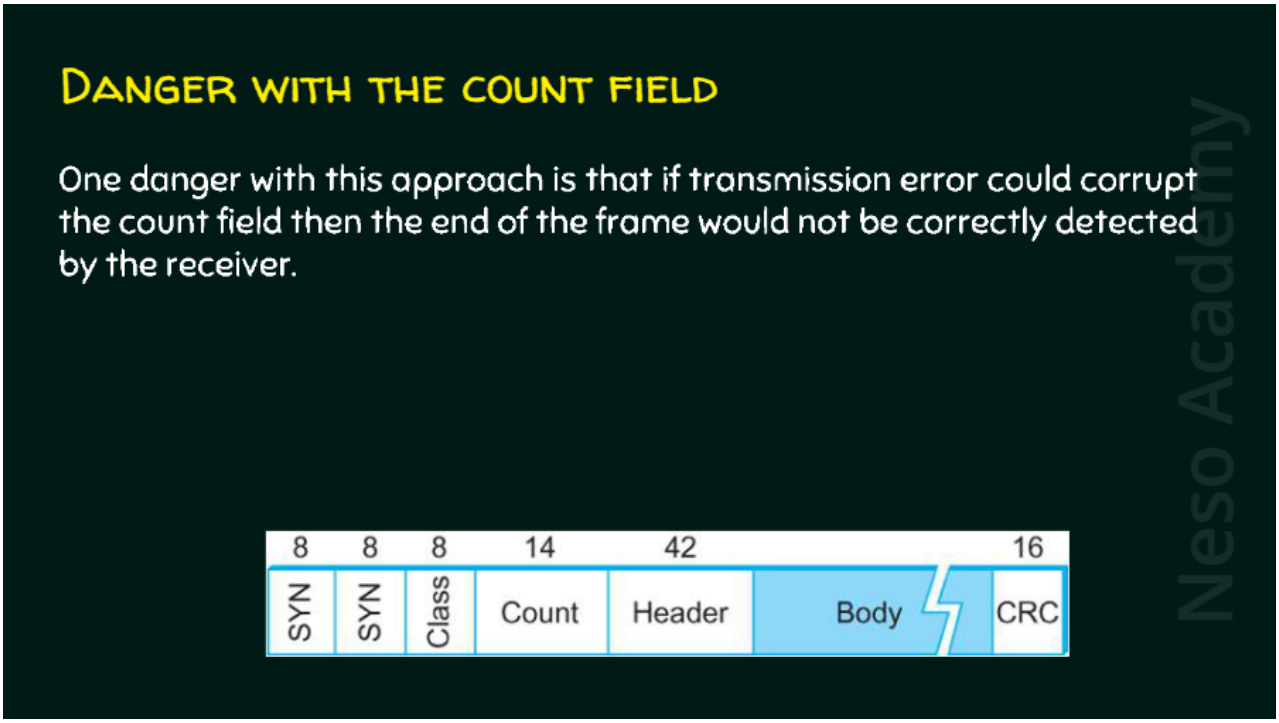
Outcomes★★Neso Academy



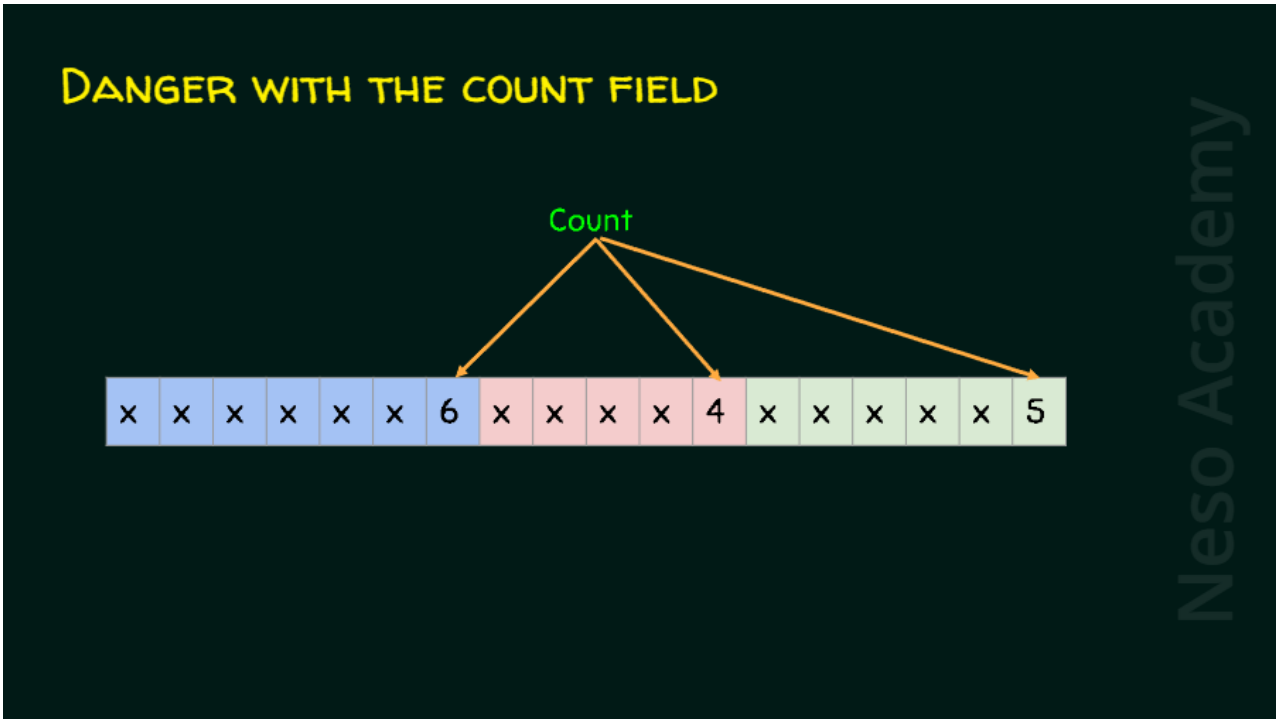
Byte oriented approach★Neso Academy



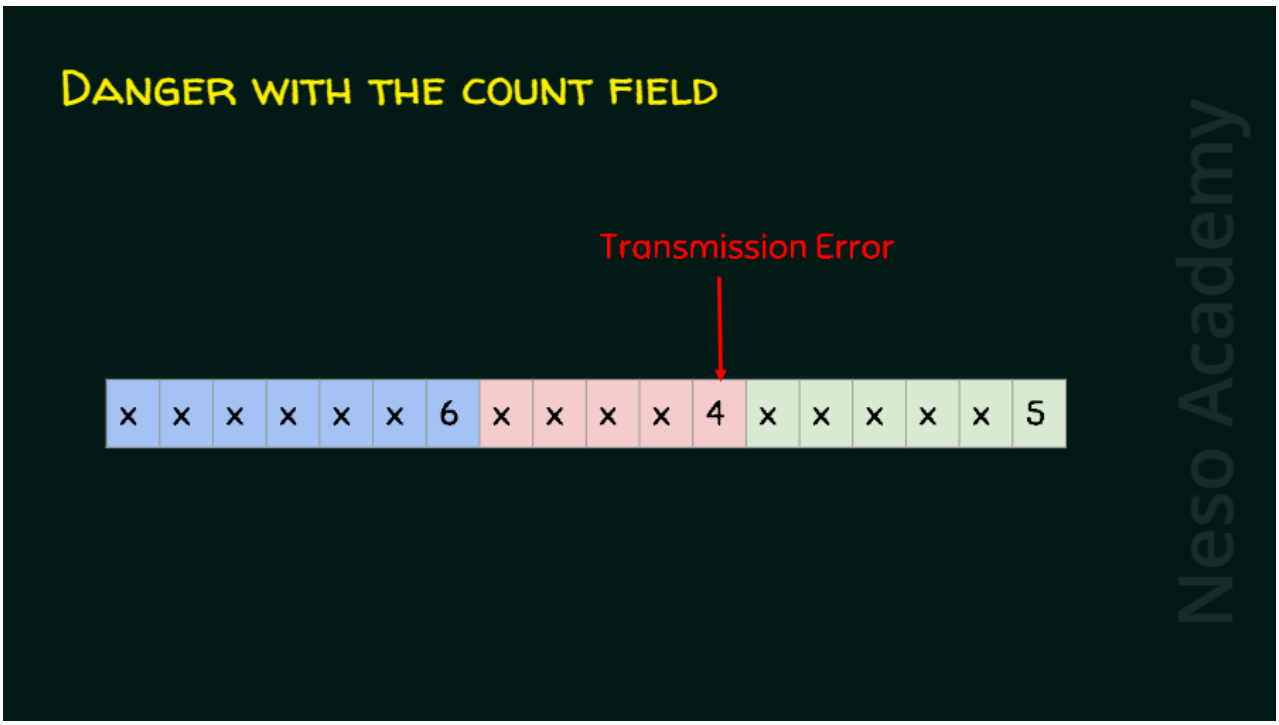
DDCMP★★★★★Neso Academy



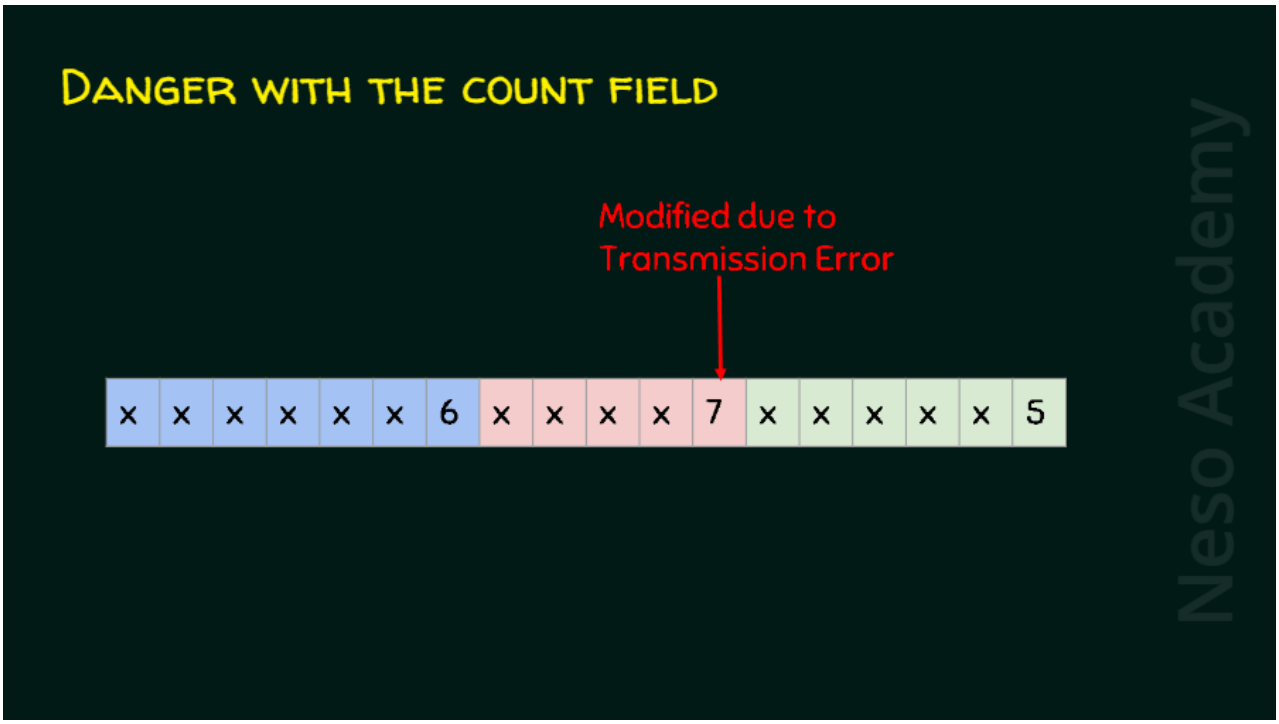
Danger with the count fieldNeso Academy



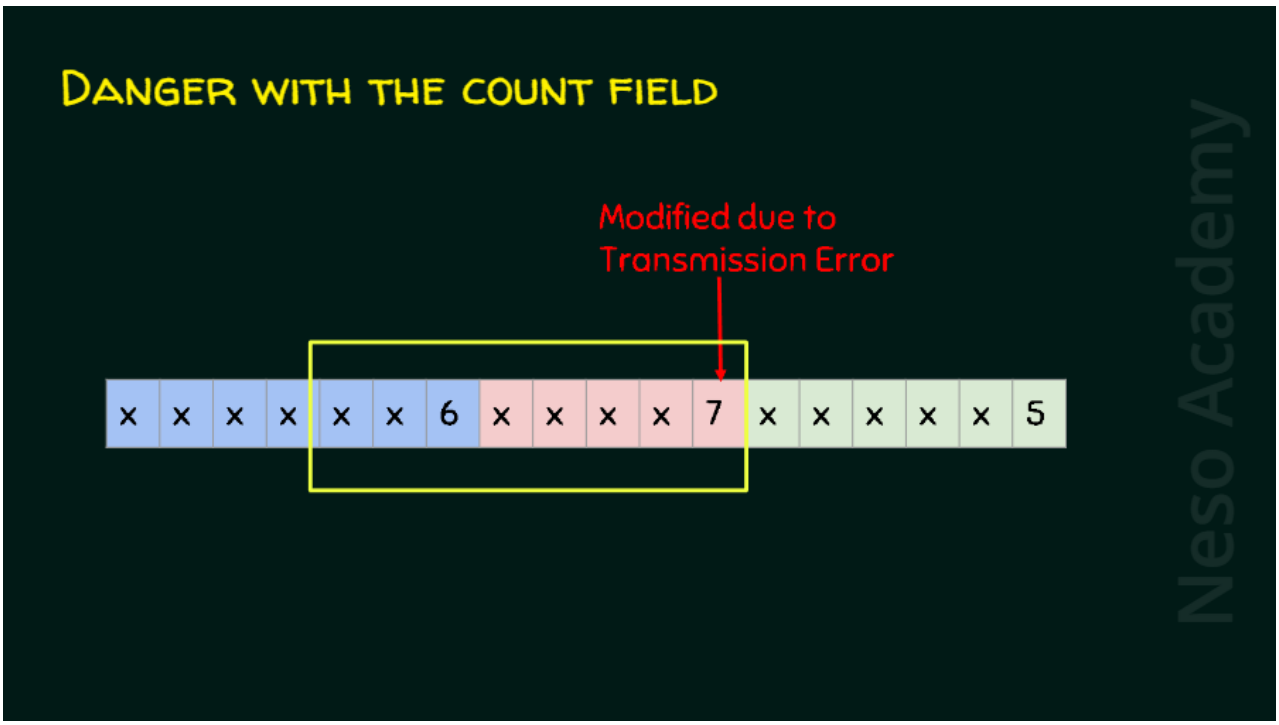
Danger with the count fieldNeso Academy



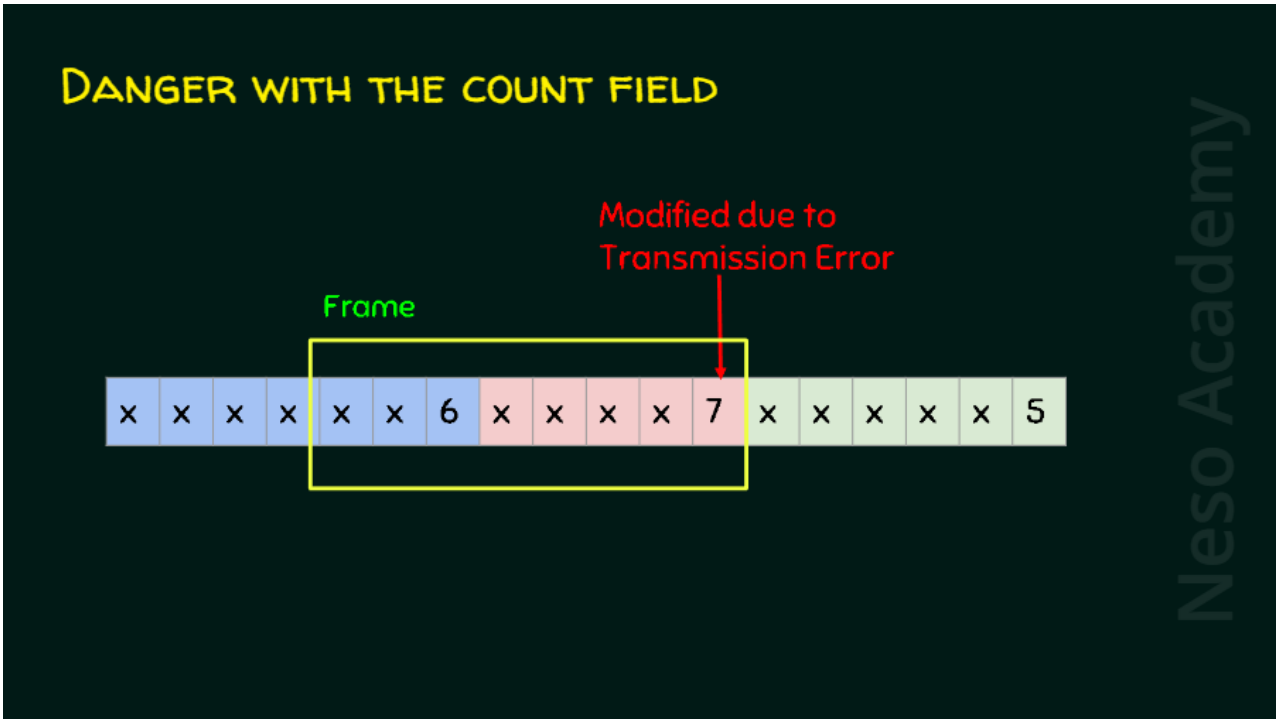
Danger with the count fieldNeso Academy



Danger with the count fieldNeso Academy



Danger with the count fieldNeso Academy



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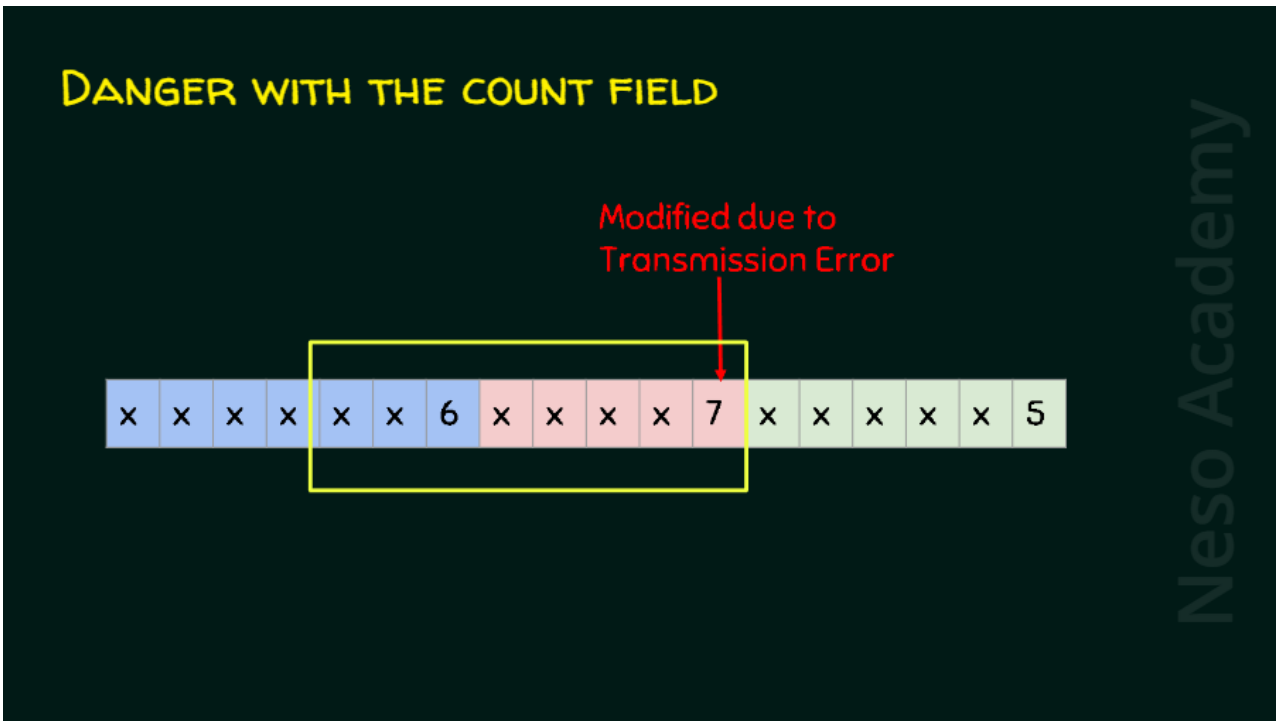
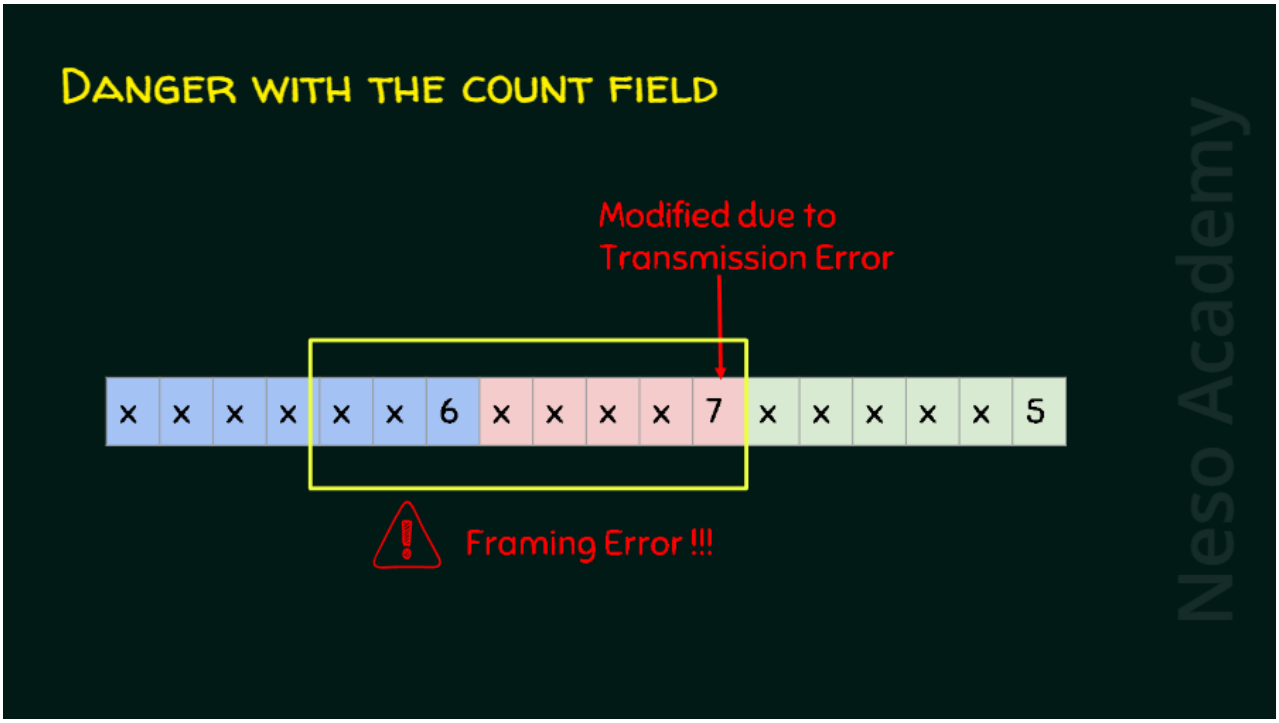
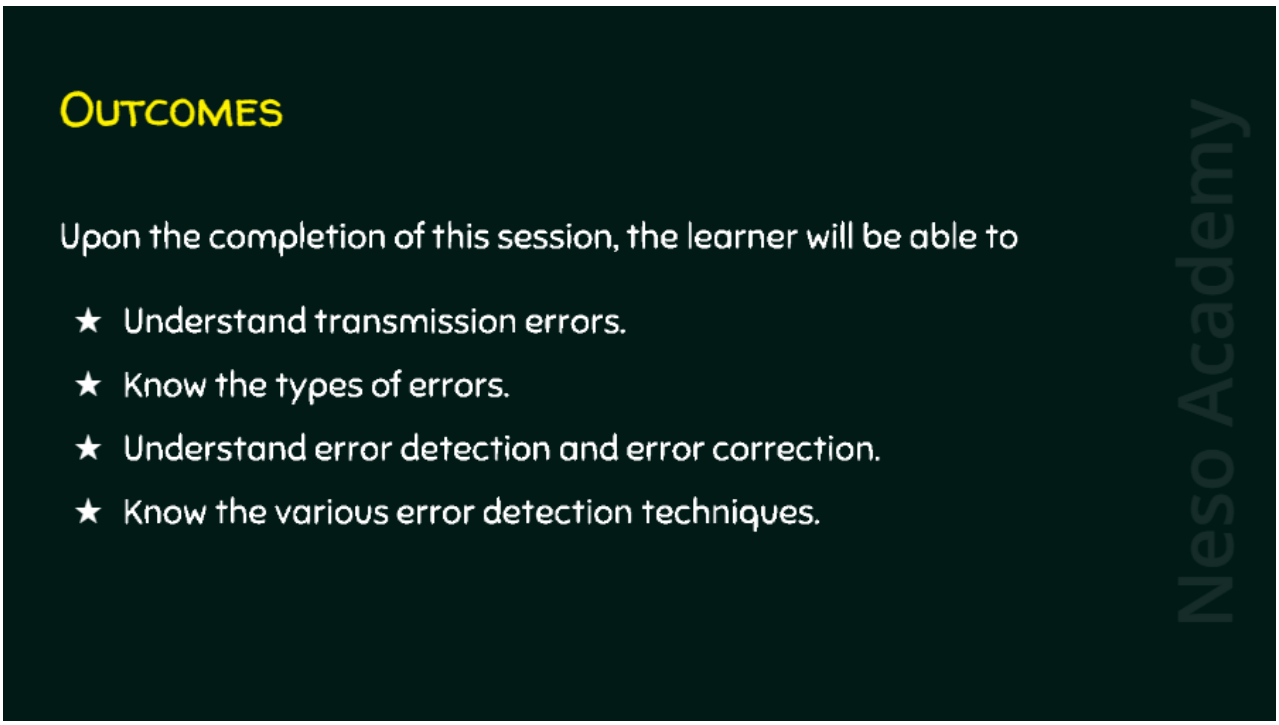


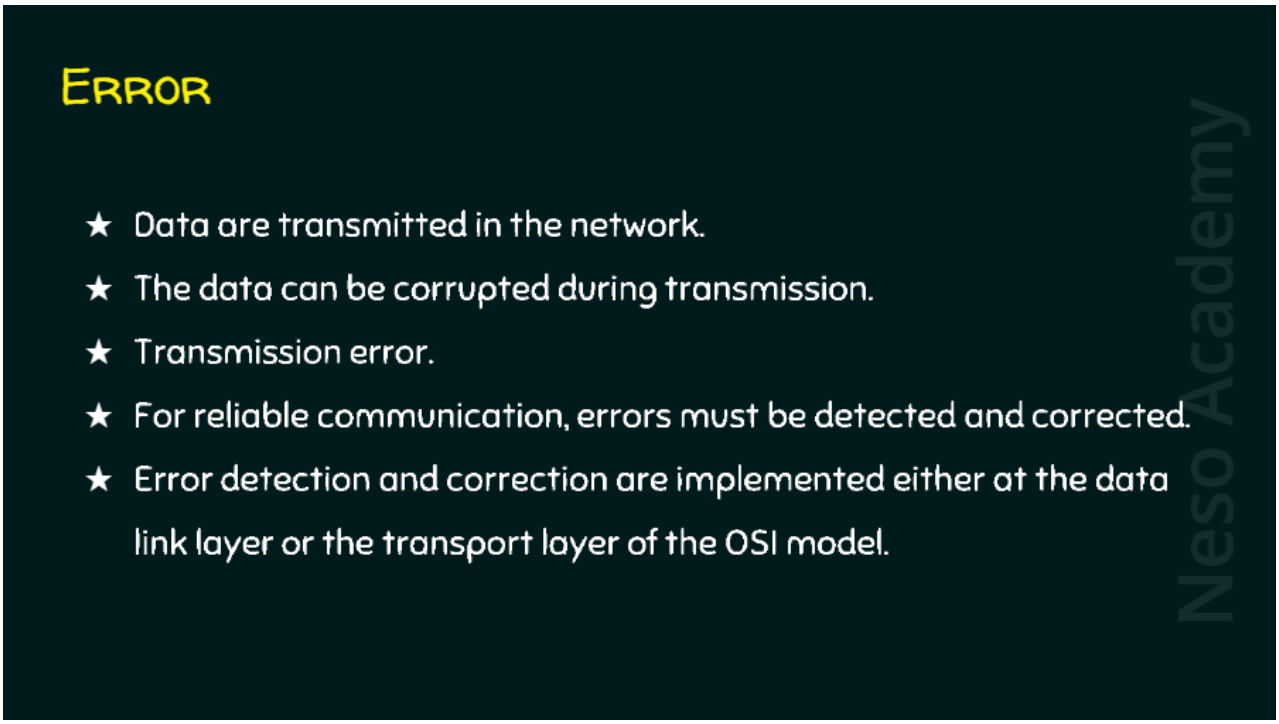
Danger with the count fieldNeso Academy



Danger with the count fieldNeso Academy



Outcomes★★★★Neso Academy



Error★★★★★Neso Academy

Types of error

1. Bit Error.
2. Burst Error.

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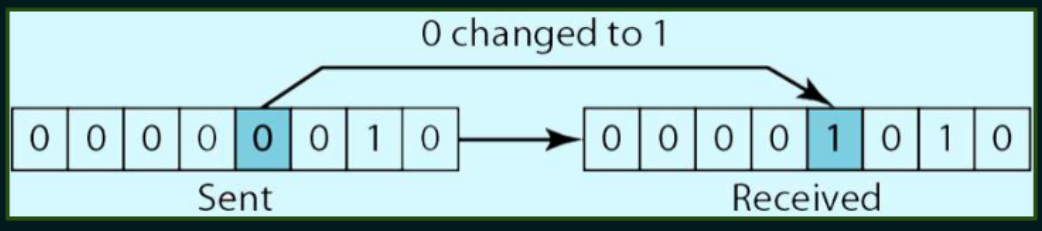
Types of errorNeso Academy

Bit error

★ a.k.a single bit error.

★ In a single bit error, only 1 bit in the data unit has been changed.



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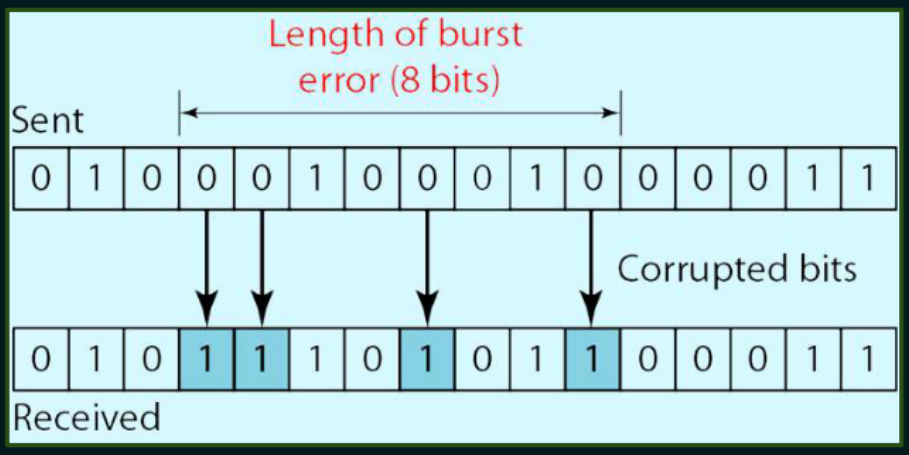
★★Bit errorNeso Academy

Burst error

★ In burst error, 2 or more bits in the data unit have changed.



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★Burst errorNeso Academy

How to detect the errors?

★ Error detection means to decide whether the received data is correct or not without having a copy of the original message.

★ To detect or correct errors, we need to send some extra bits with the data.

★ The extra bits are called as redundant bits.

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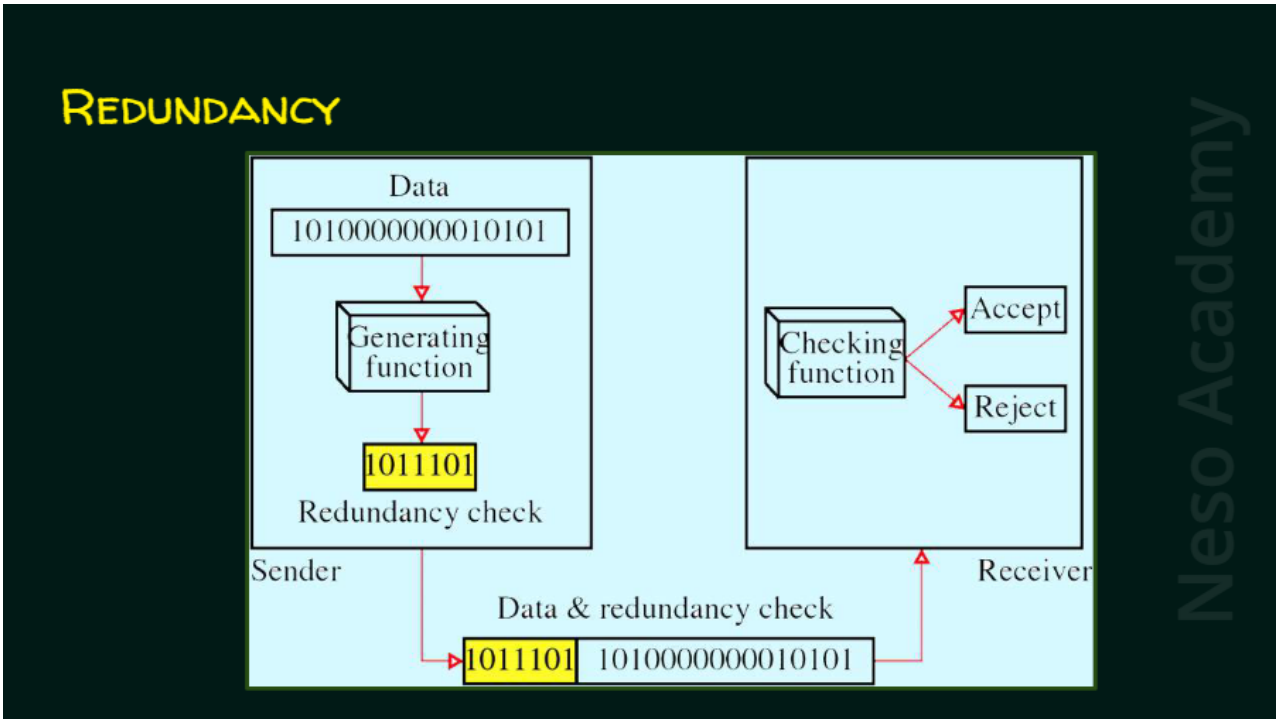
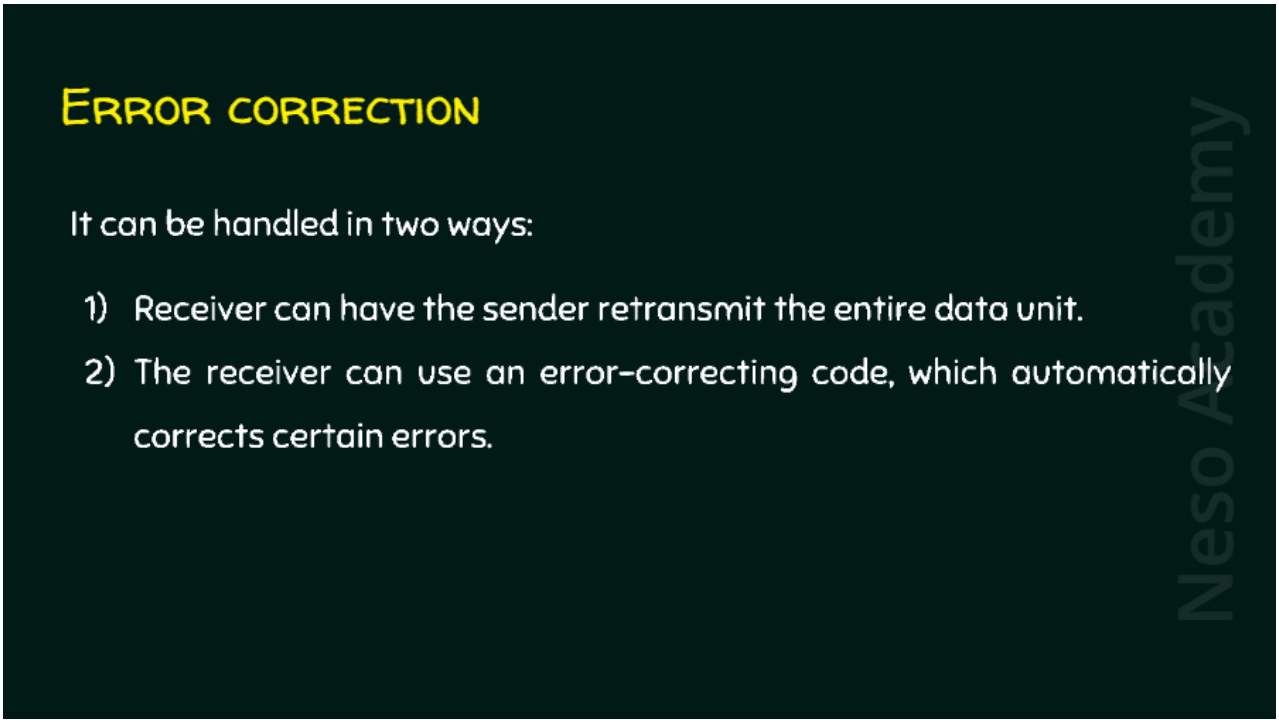
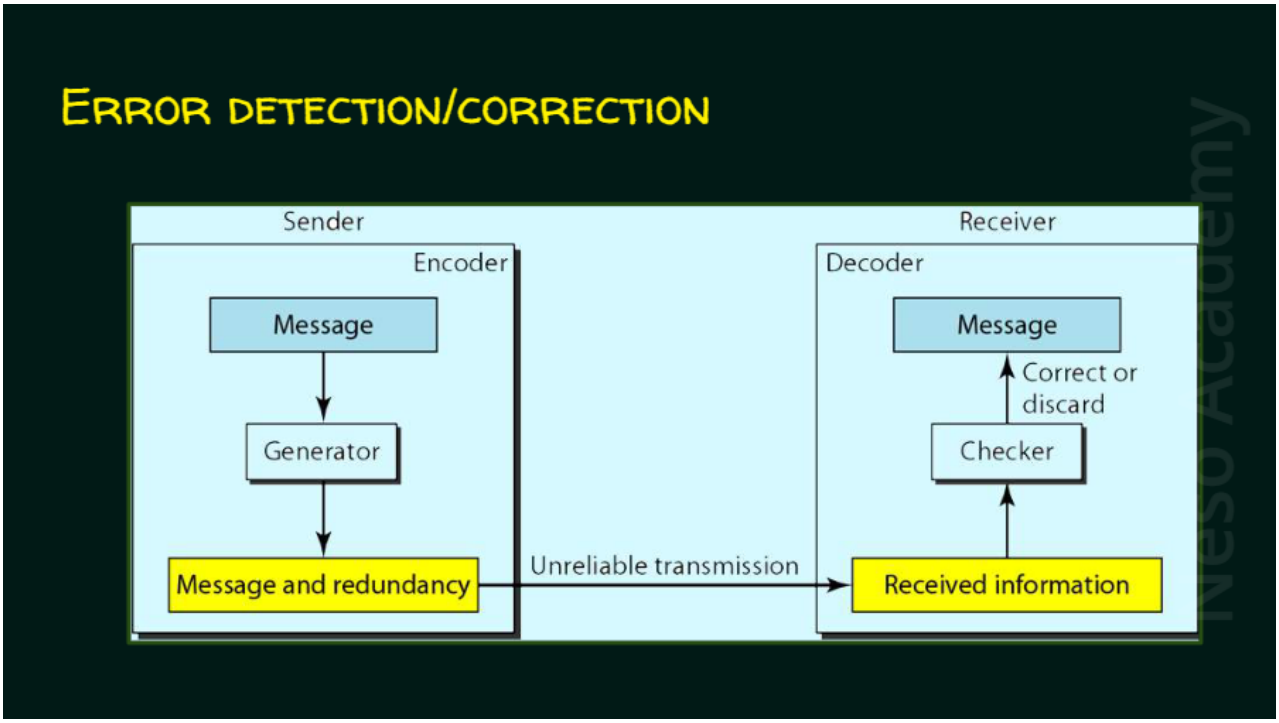
How to detect the errors?★★★Neso Academy



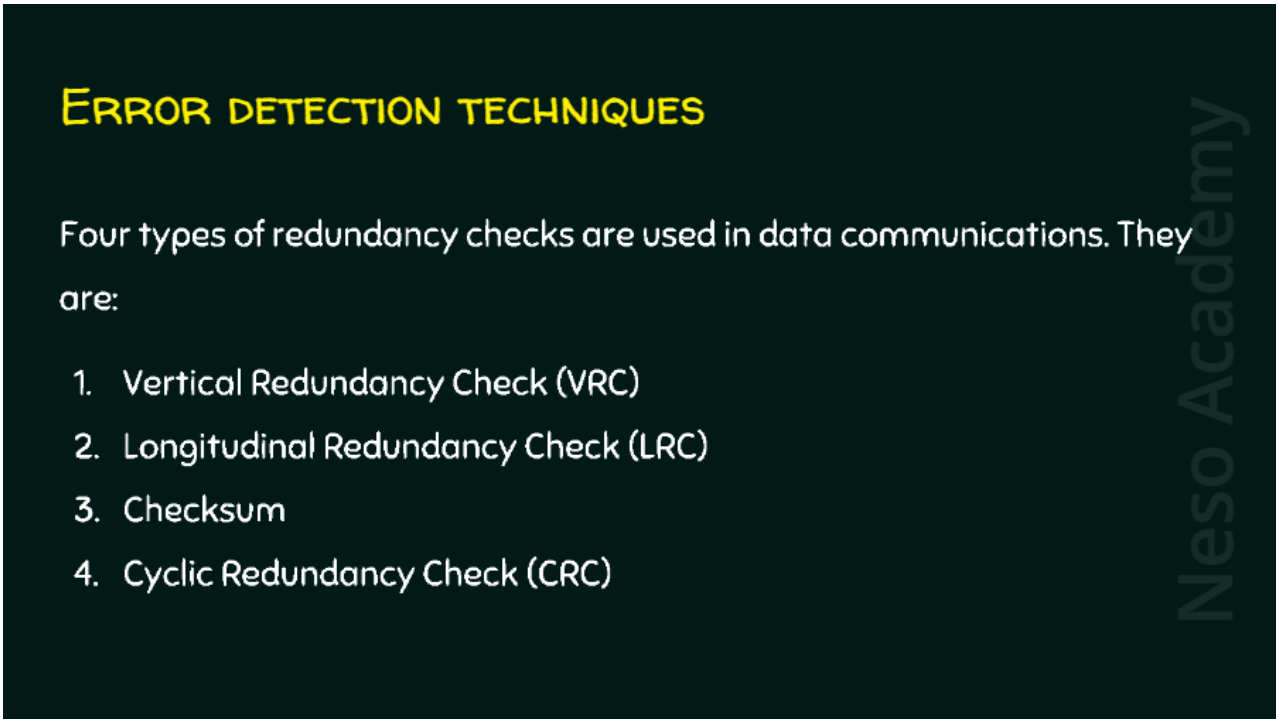
RedundancyNeso Academy



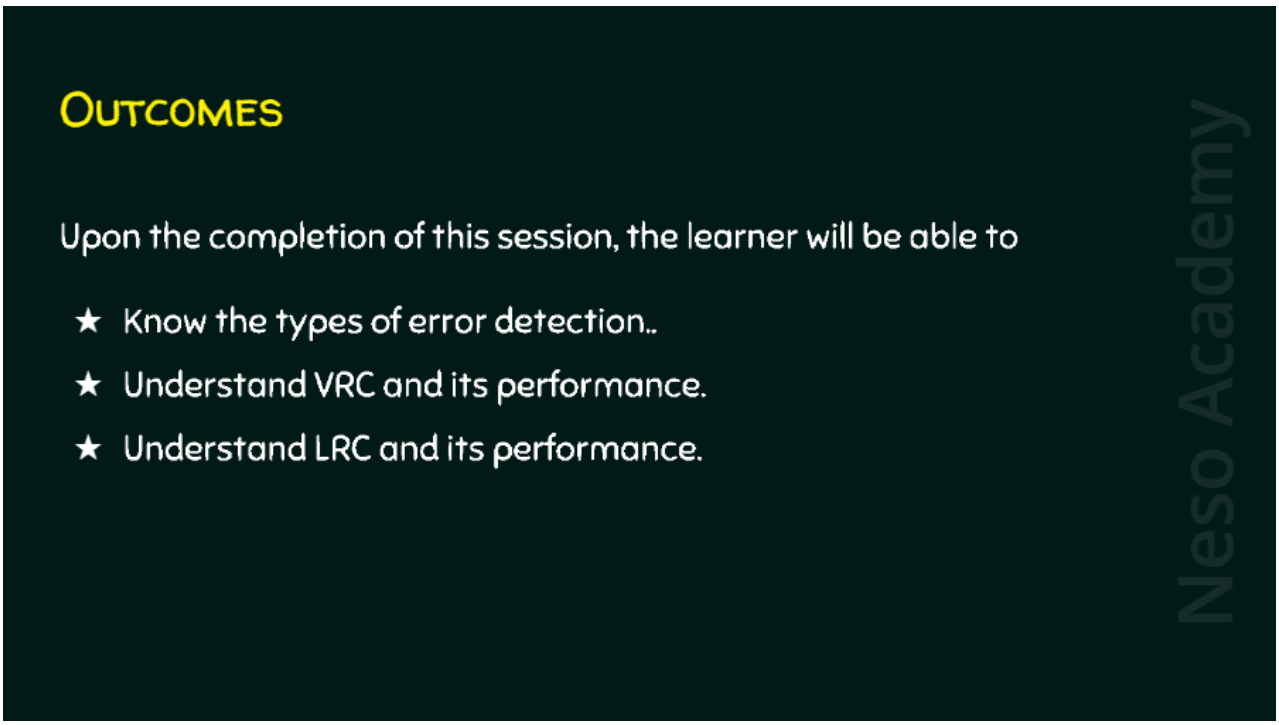
Error correctionNeso Academy



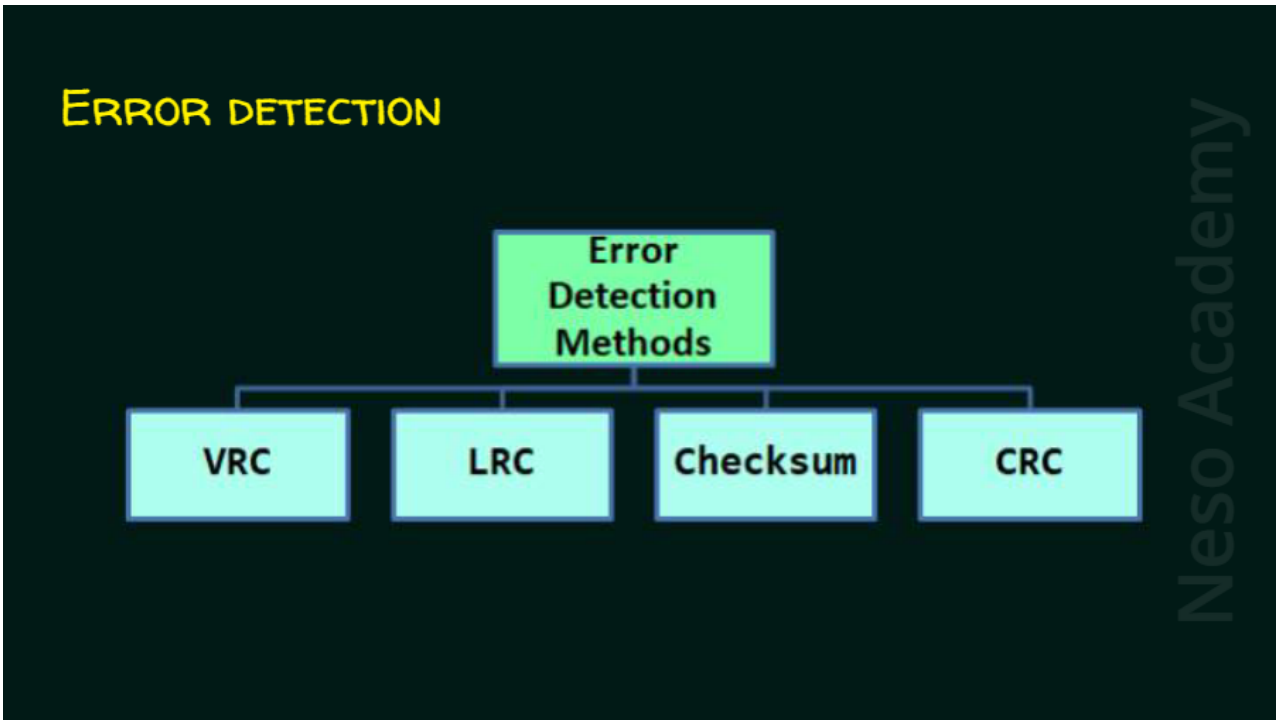
Error detection/correctionNeso Academy



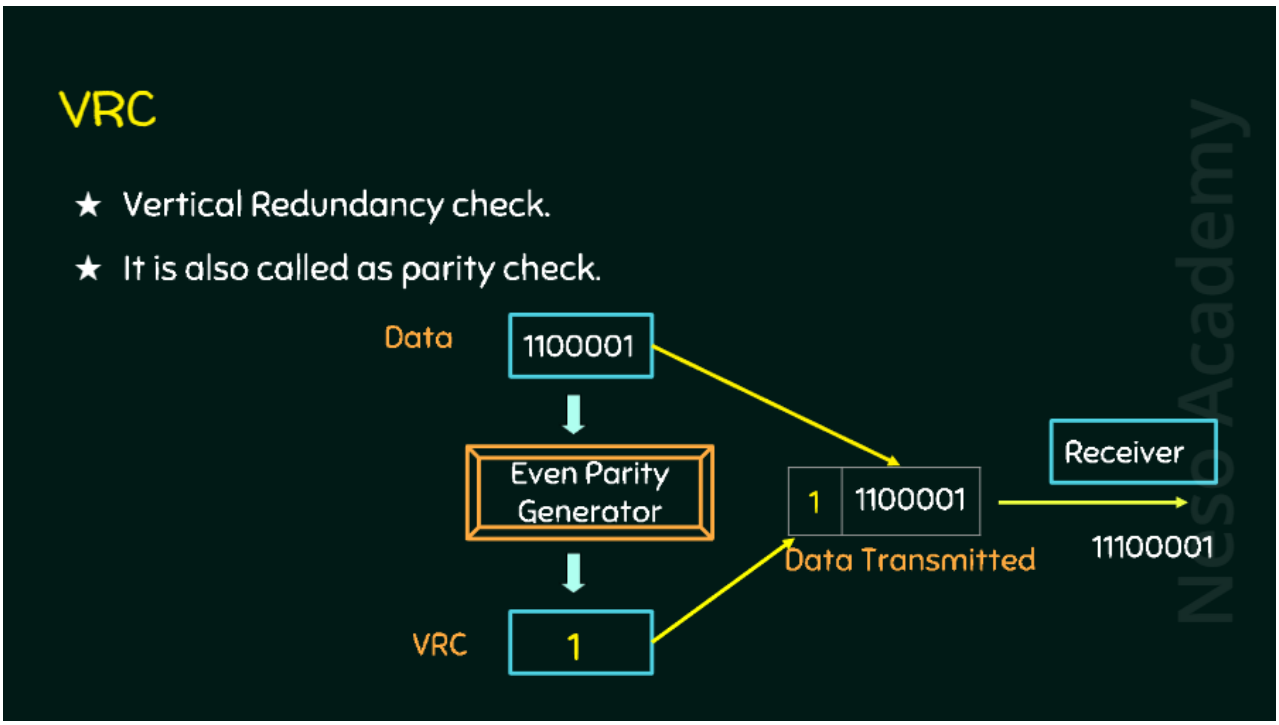
Error detection techniquesNeso Academy



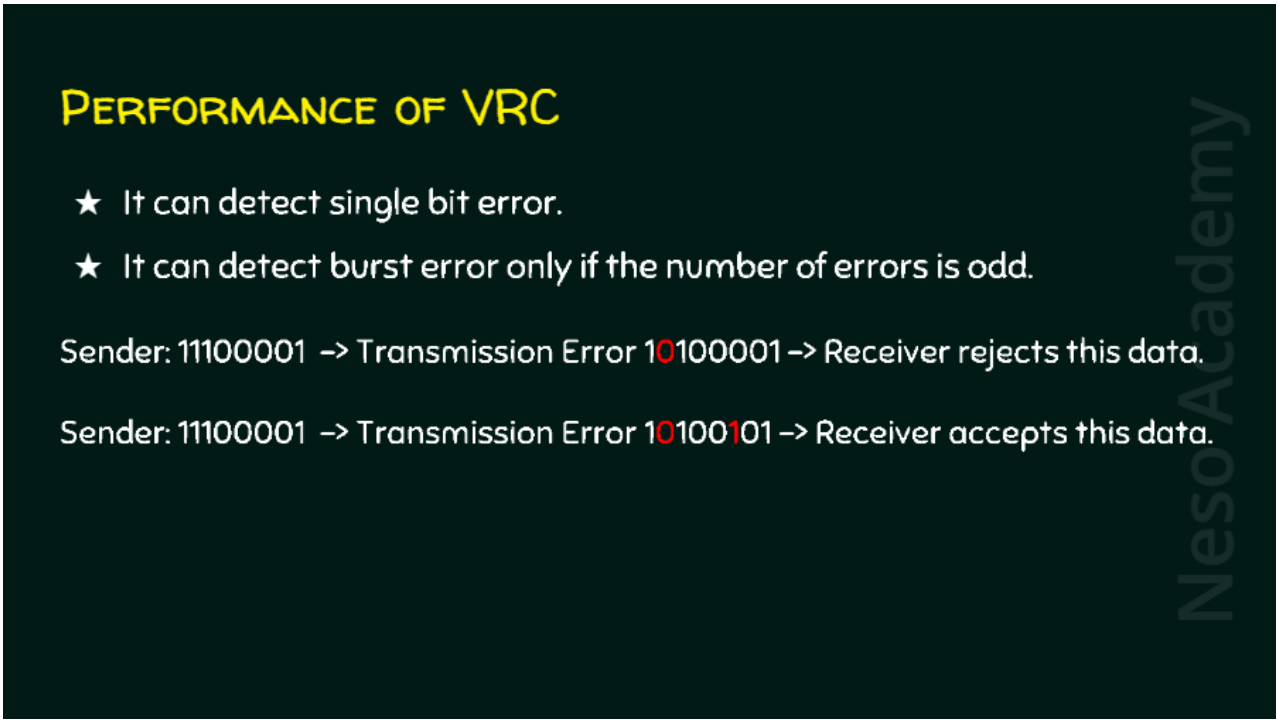
Outcomes★★★Neso Academy



Error detectionNeso Academy



VRC★★Neso Academy



Performance of VRC★★Neso Academy

LRC

- ★ Longitudinal Redundancy Check.
- ★ A block of bits is organized in rows and columns.
- ★ a.k.a Two Dimensional parity.
- ★ The parity bit is calculated for each column and sent along with the data.
- ★ The block of parity acts as the redundant bits.

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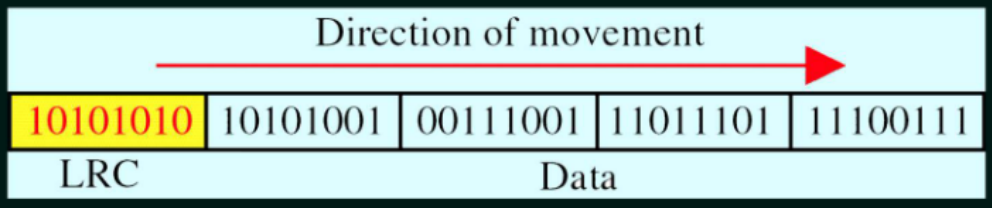
LRC★★★★★Neso Academy

LRC

1	1	1	0	0	1	1	1
1	1	0	1	1	1	0	1
0	0	1	1	1	0	0	1
1	0	1	0	1	0	0	1
1	0	1	0	1	0	1	0

LRC →



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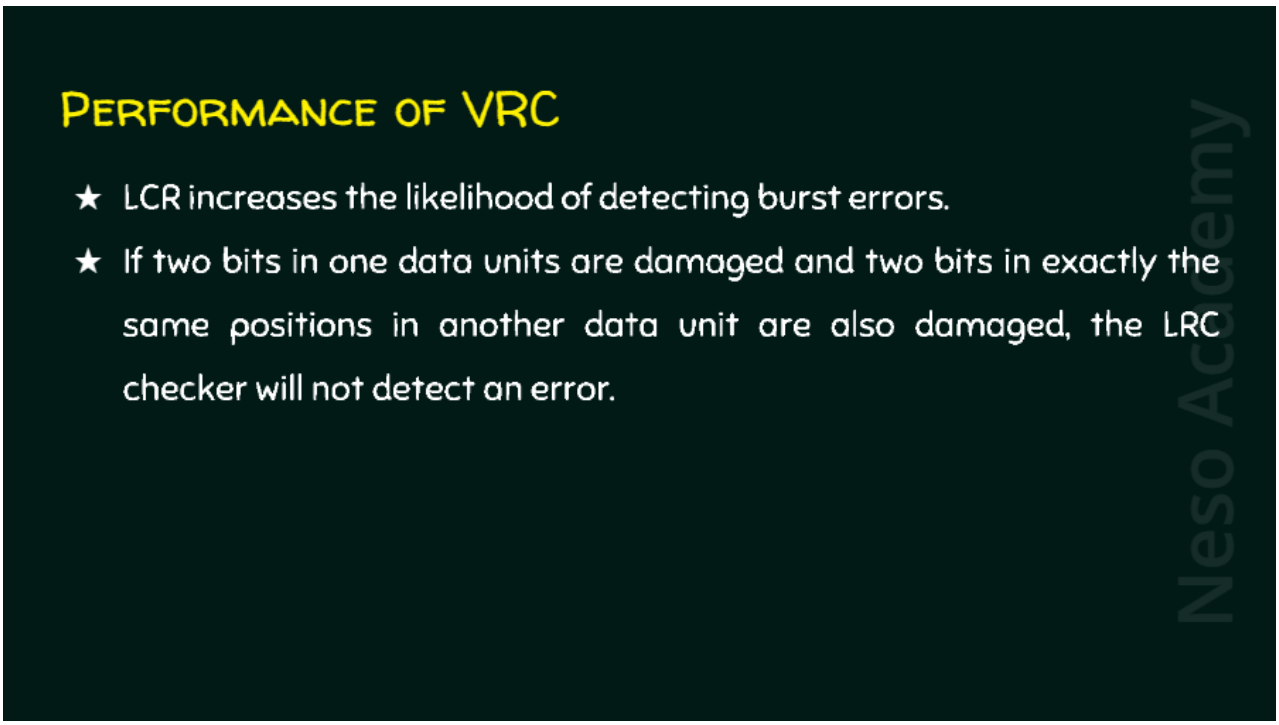
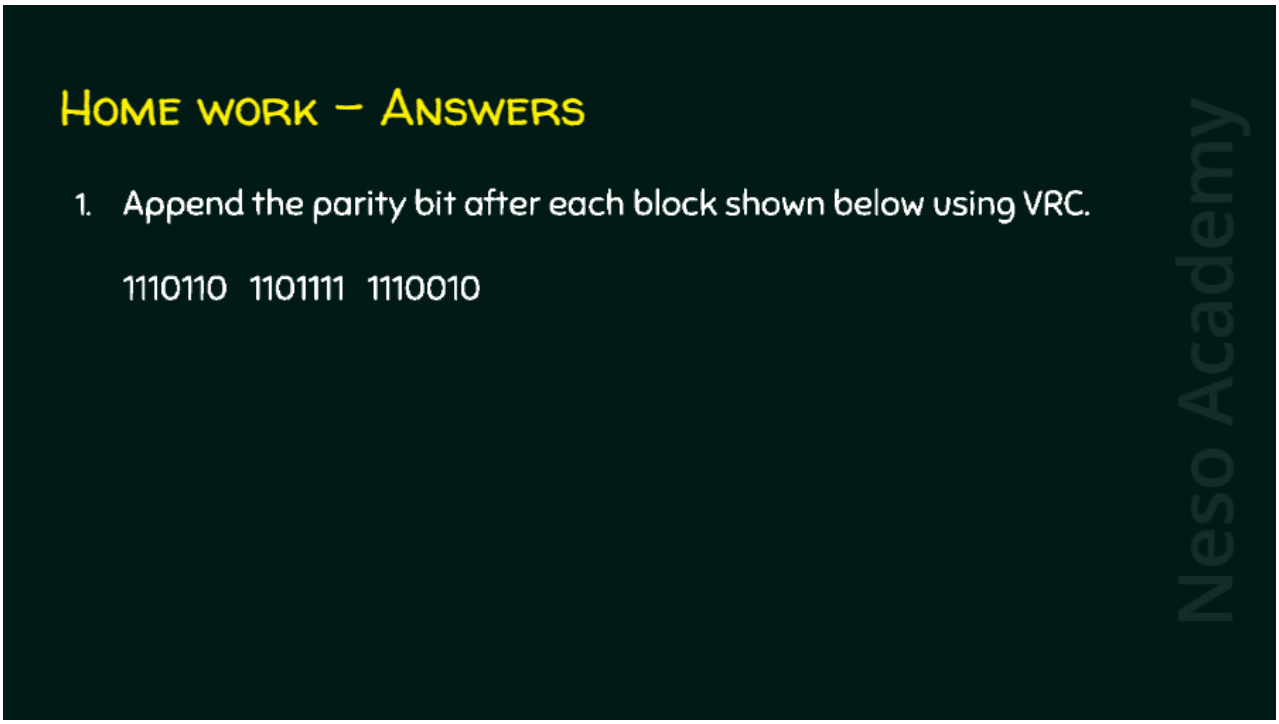
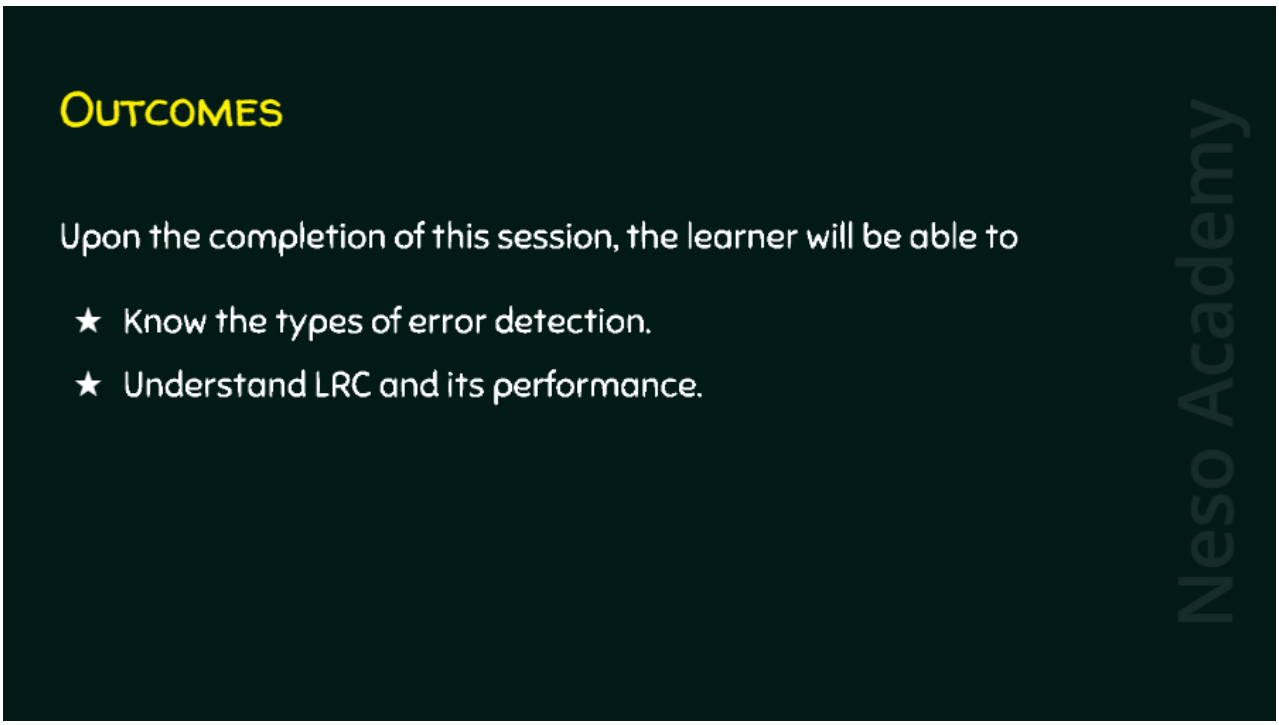
LRCNeso Academy



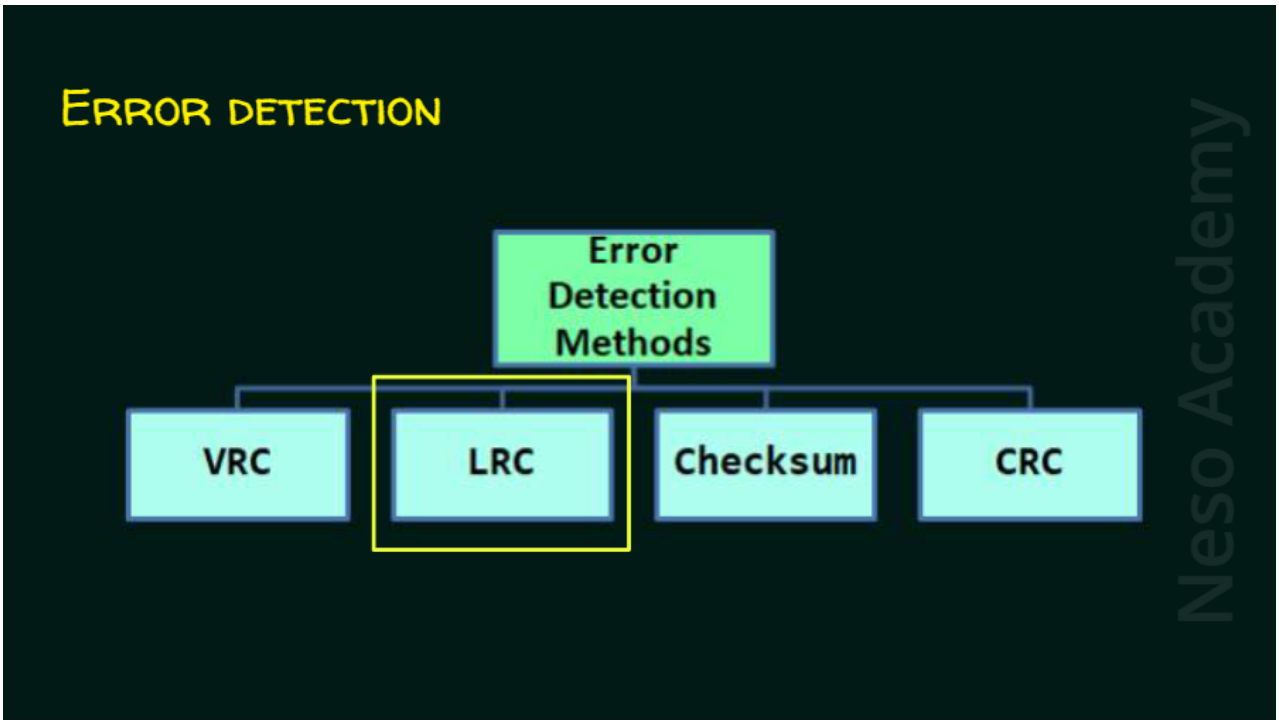
Performance of VRC★★Neso Academy



Home work -AnswersNeso Academy



Outcomes★★Neso Academy



Error detectionNeso Academy

LRC

- ★ Longitudinal Redundancy Check.
- ★ In LRC, a block of bits is organized in rows and columns.
- ★ a.k.a Two Dimensional parity.
- ★ The parity bit is calculated for each column and sent along with the data.
- ★ The block of parity acts as the redundant bits.

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LRC★★★★★Neso Academy

LRC – Example

Find the LRC for the data blocks 11100111 11011101 00111001 10101001 and determine the data that is transmitted?

Odd no. of 1's	1
Even no. of 1's	0

	1	1	1	0	0	1	1	1
	1	1	0	1	1	1	0	1
	0	0	1	1	1	0	0	1
	1	0	1	0	1	0	0	1
LRC →	1	0	1	0	1	0	1	0

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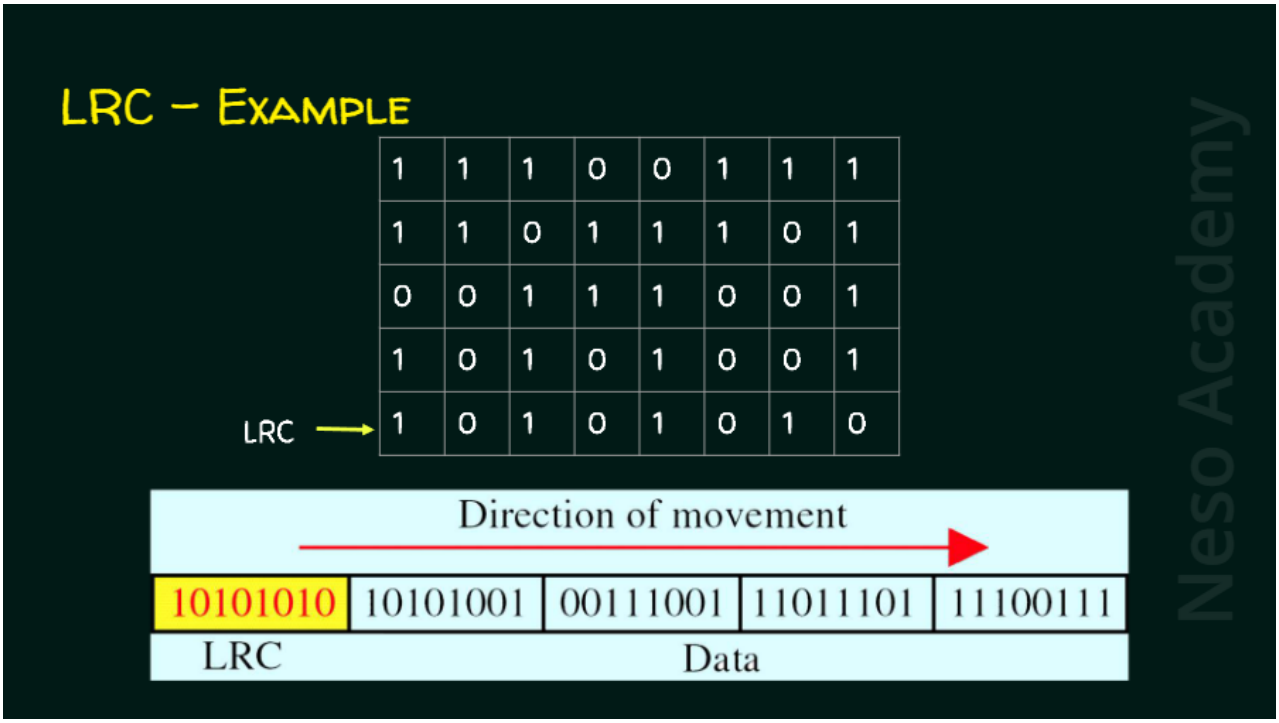
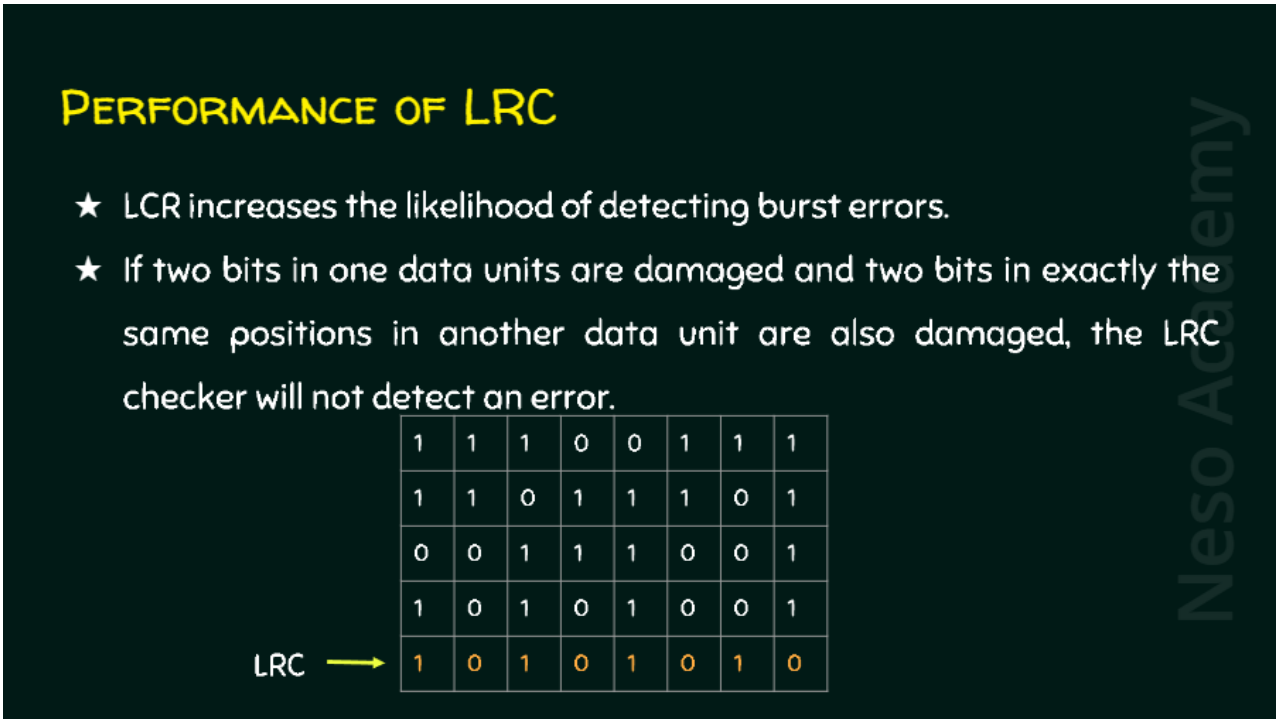
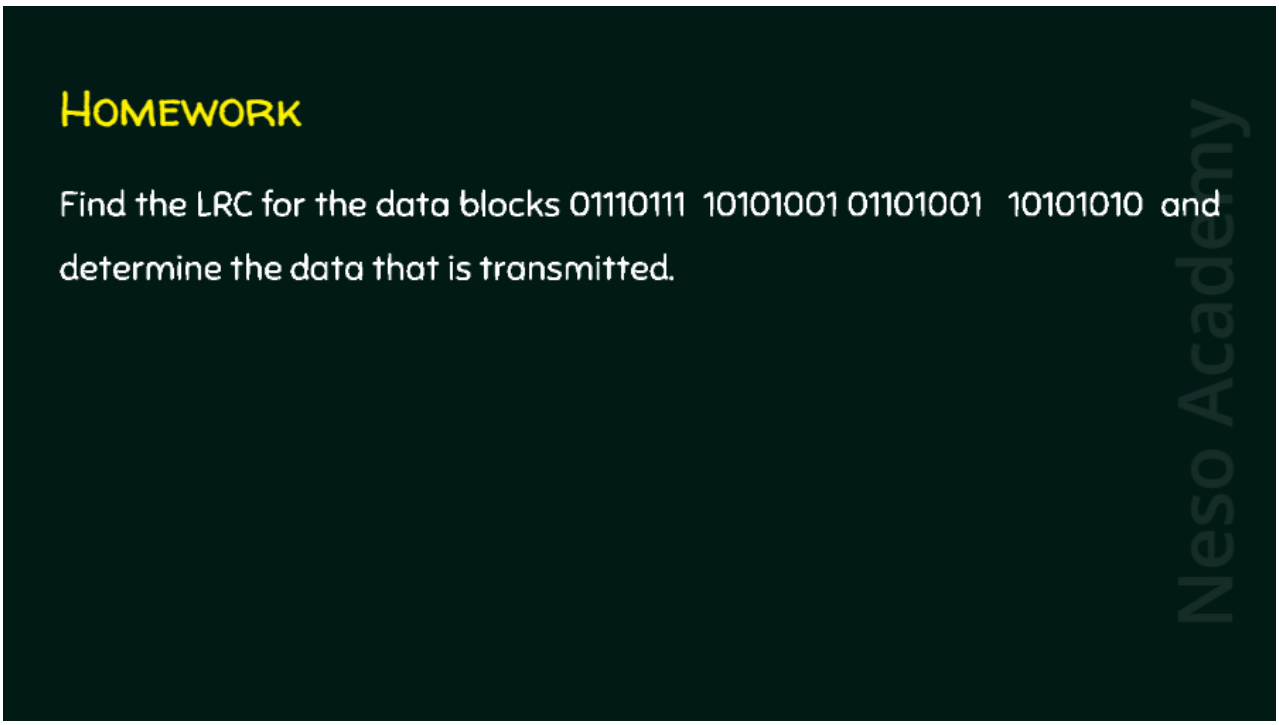
LRC -ExampleNeso Academy



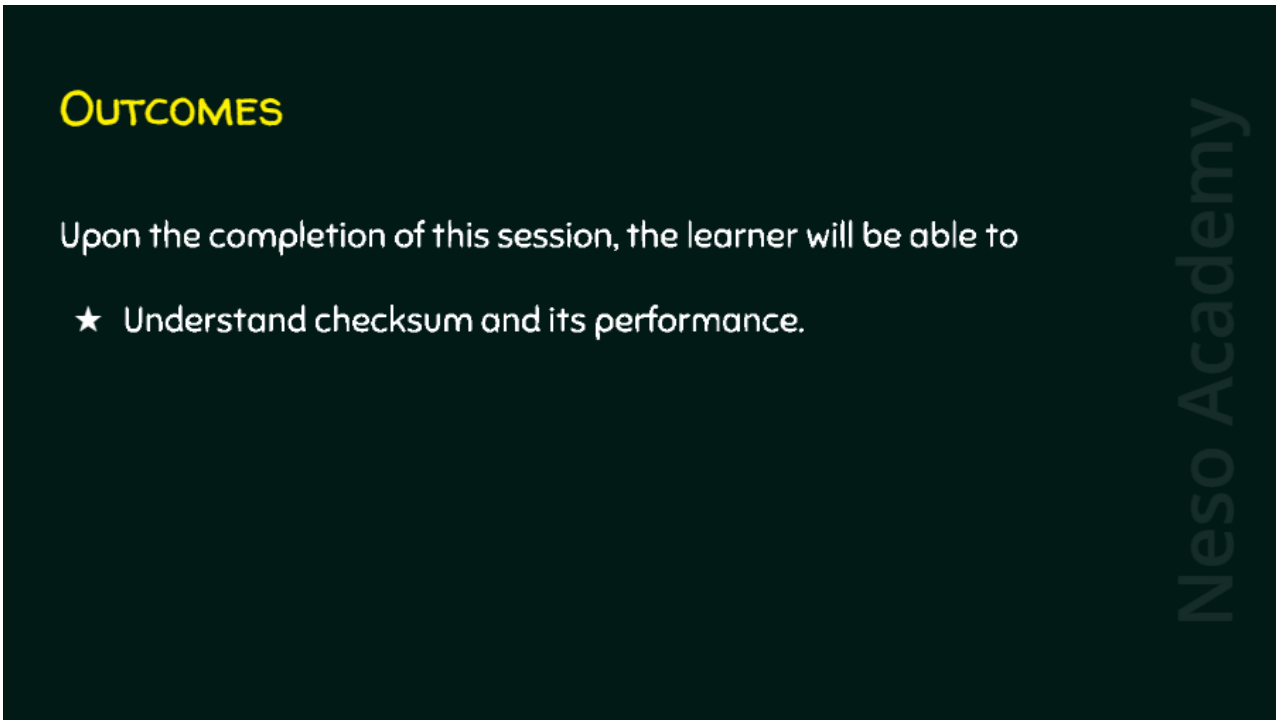
LRC -ExampleNeso Academy



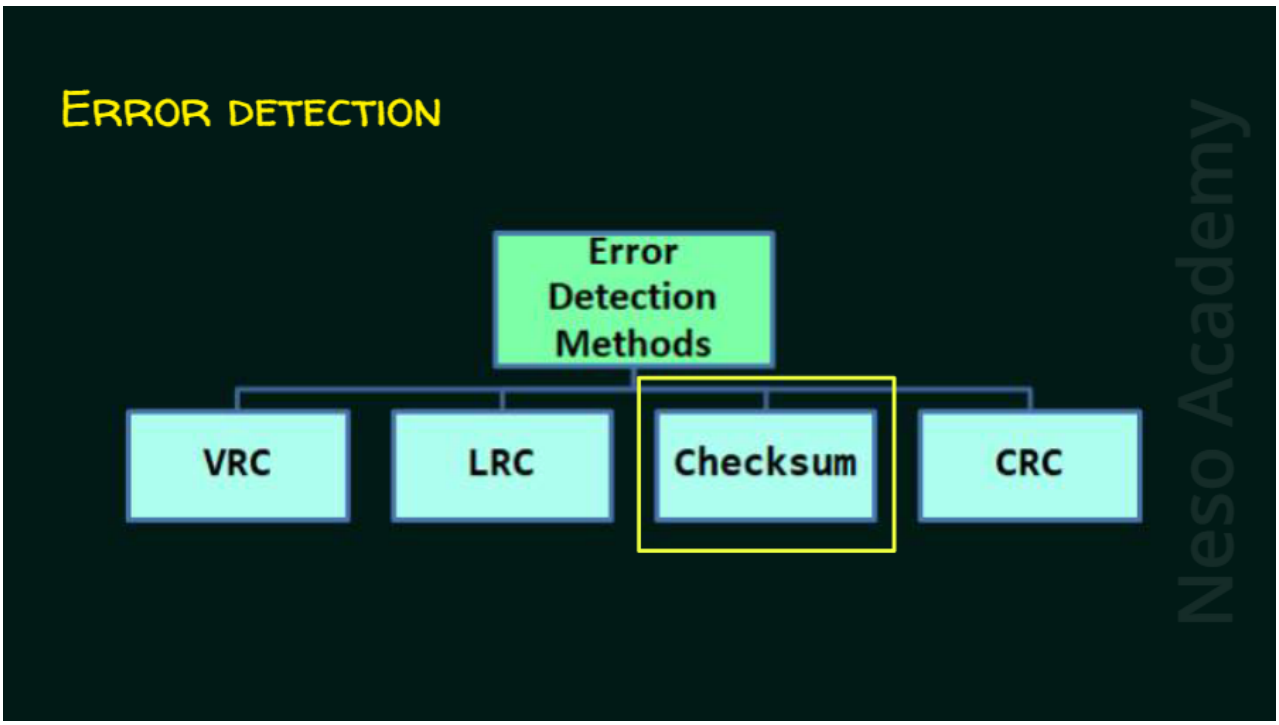
Performance of LRC★★Neso Academy



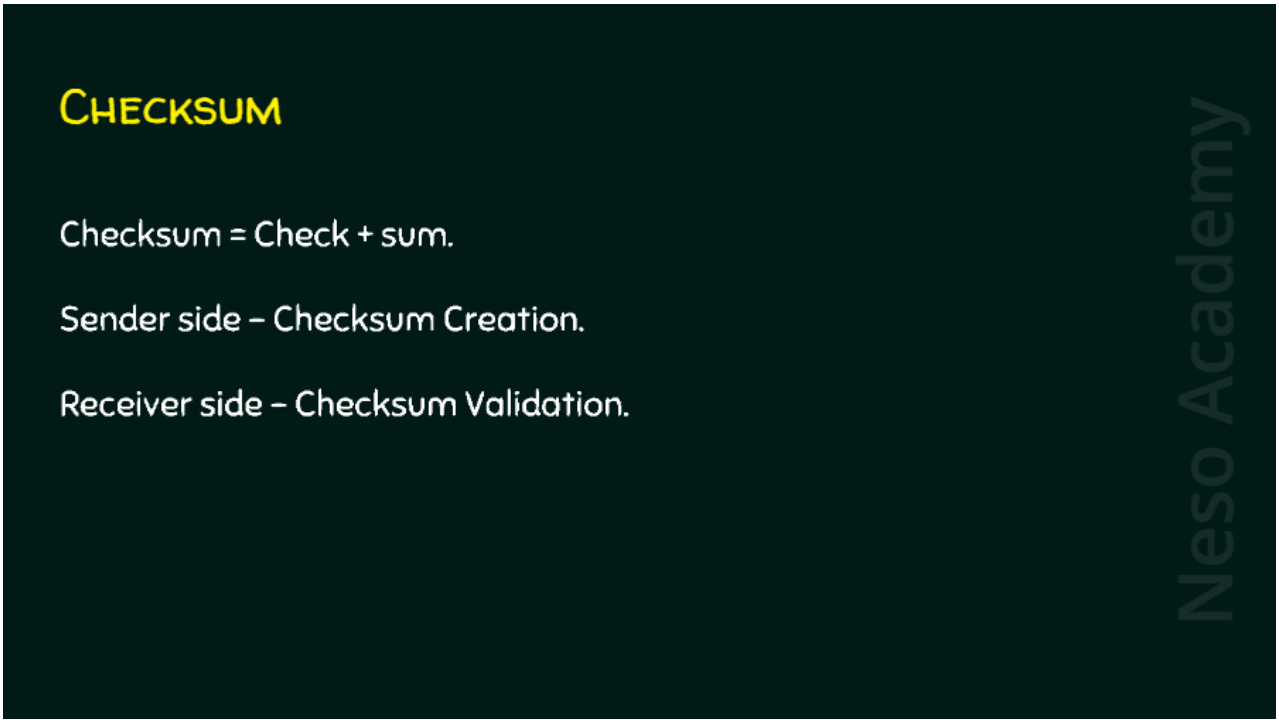
HomeworkNeso Academy



Outcomes★Neso Academy



Error detectionNeso Academy



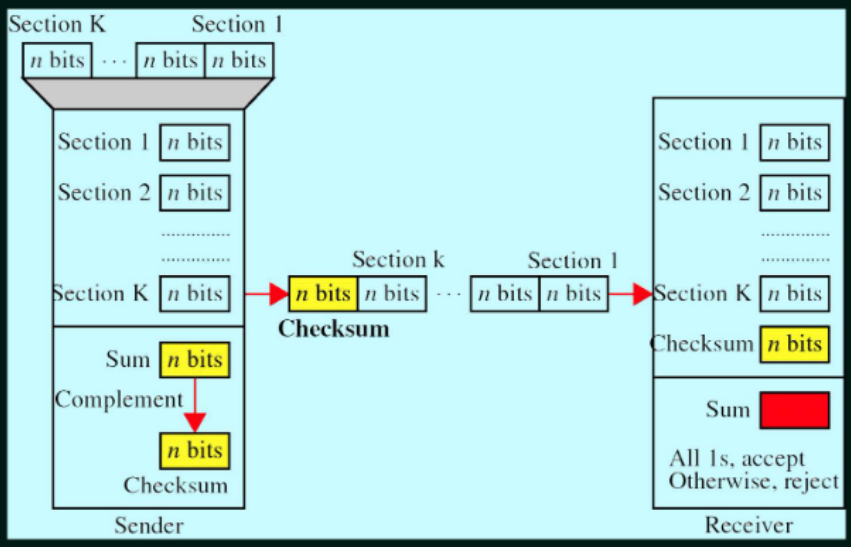
ChecksumNeso Academy

Checksum – Operation at sender side

1. Break the original message in to 'k' number of blocks with 'n' bits in each block.
2. Sum all the 'k' data blocks.
3. Add the carry to the sum, if any.
4. Do 1's complement to the sum = Checksum.

Checksum -Operation at sender sideNeso Academy

Checksum



ChecksumNeso Academy

Checksum – Example

Consider the data unit to be transmitted is:

10011001111000100010010010000100

10011001	11100010	00100100	10000100

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Checksum -ExampleNeso Academy

Checksum – Example

10011001		11100010		00100100		10000100		
Carry	1	1	1	1	1			
	1	0	0	0	0	1	0	0
	0	0	1	0	0	1	0	0
	1	1	1	0	0	0	1	0
	1	0	0	1	1	0	0	1
	0	0	1	0	0	0	1	1
							1	0
	0	0	1	0	0	1	0	1
1's Complement	1	1	0	1	1	0	1	0

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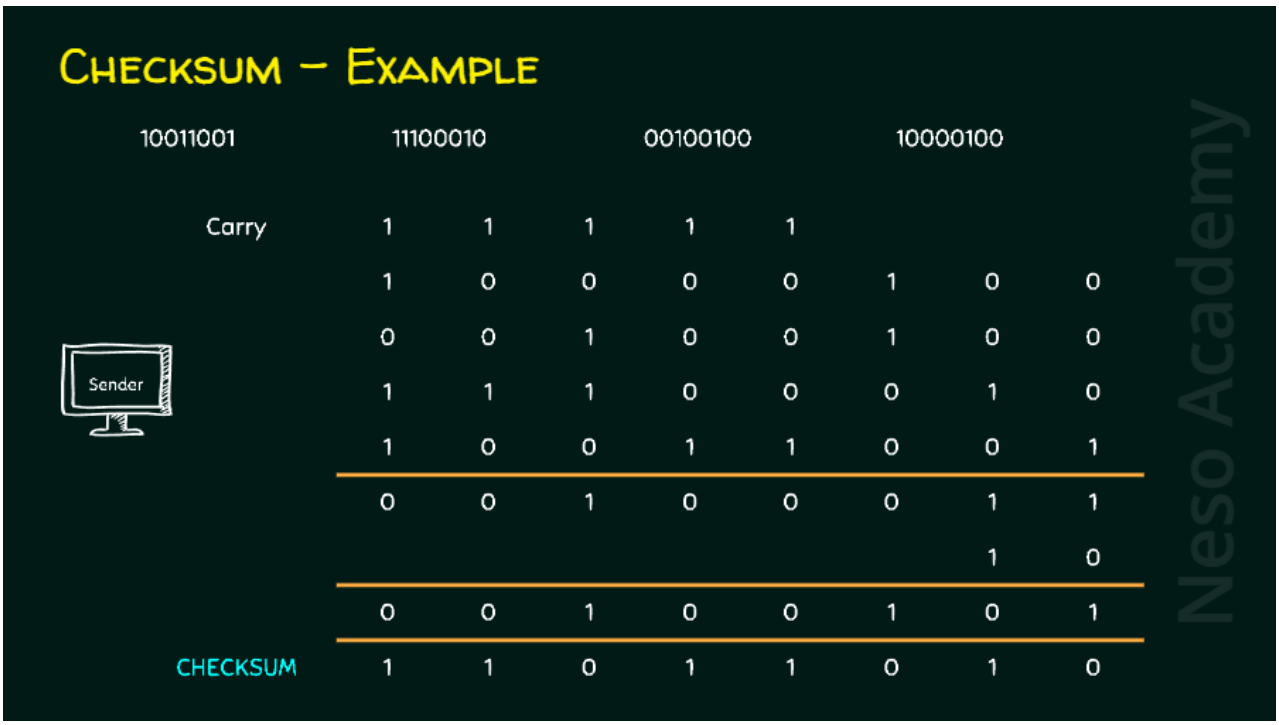
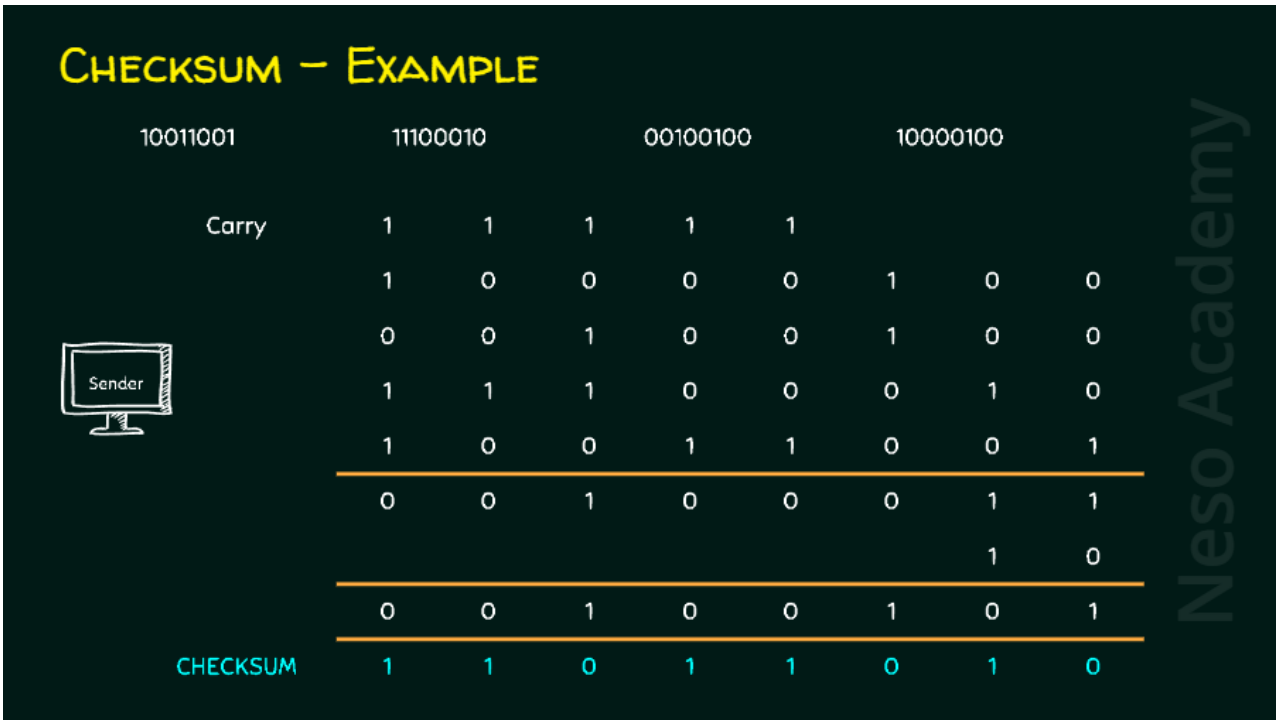
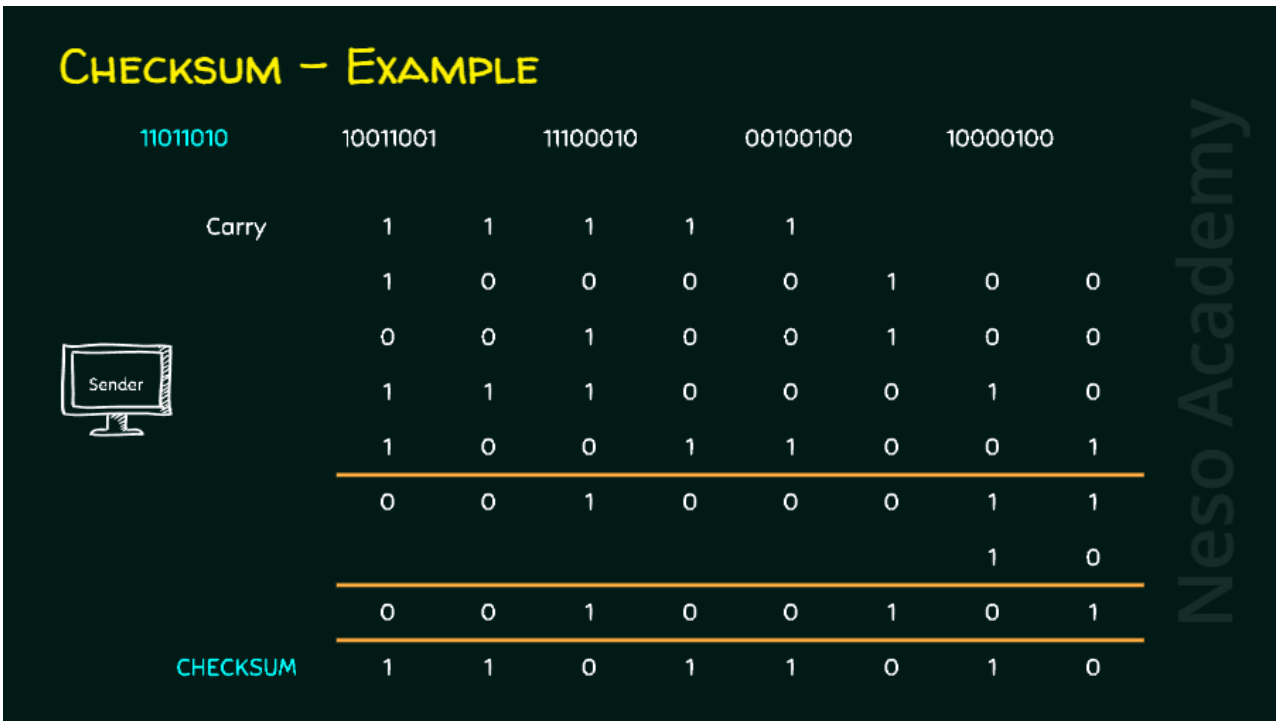
Checksum -ExampleNeso Academy



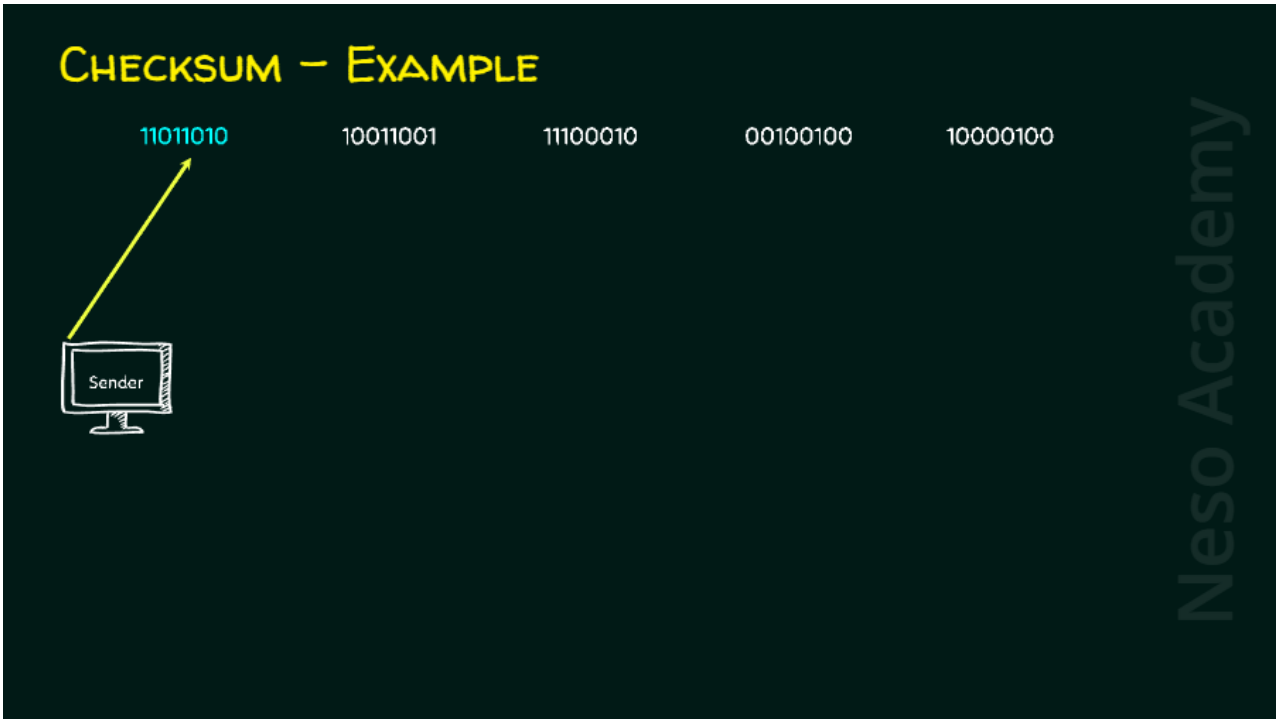
Checksum -ExampleNeso Academy



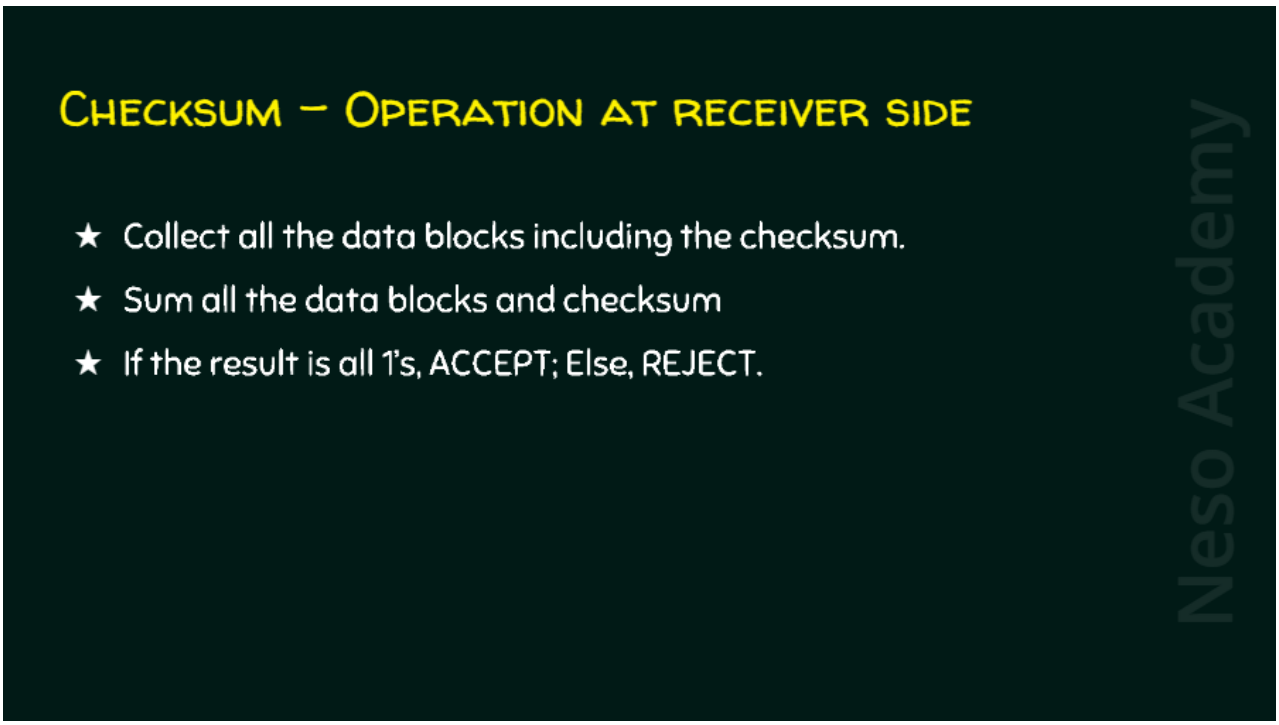
Checksum -ExampleNeso Academy



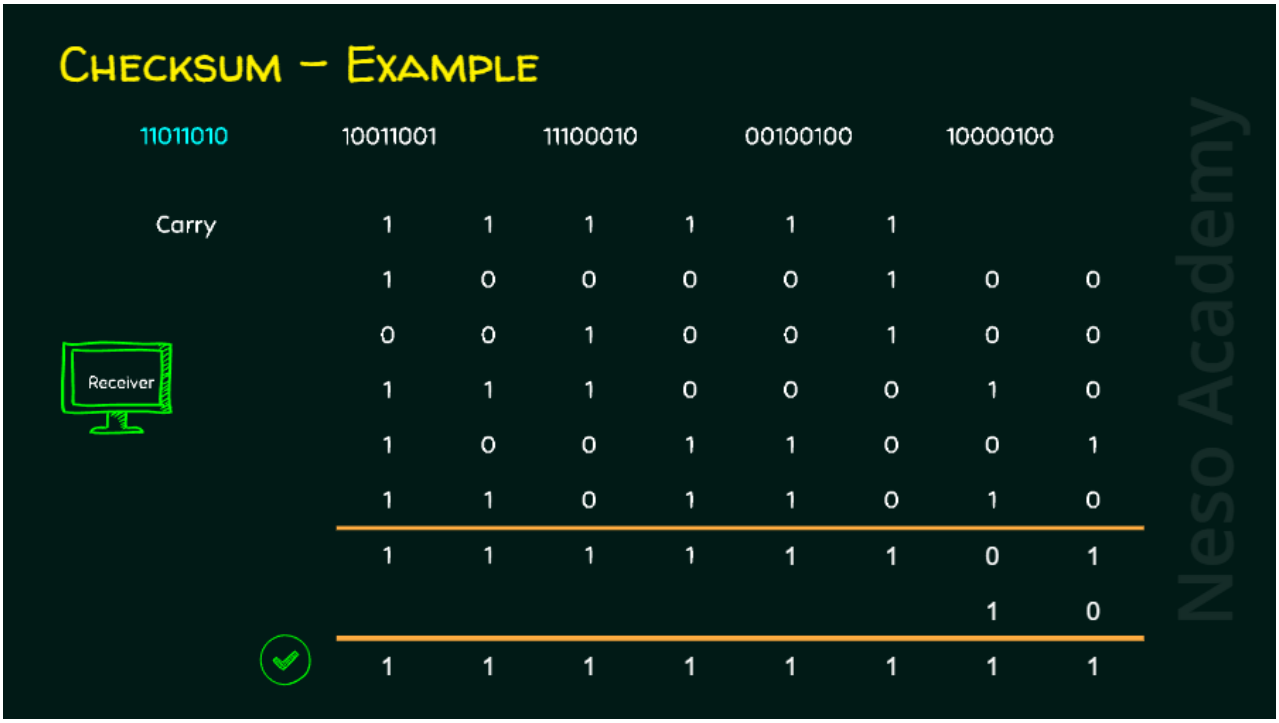
Checksum -ExampleNeso Academy



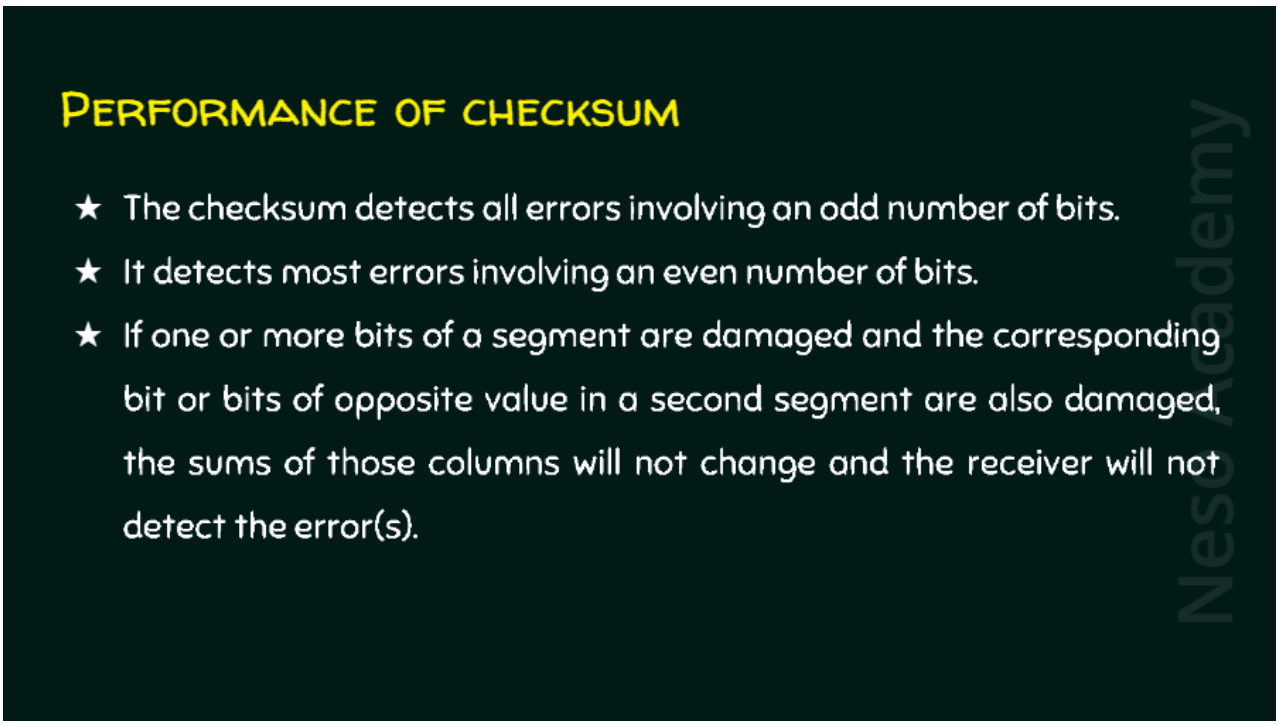
Checksum -ExampleNeso Academy



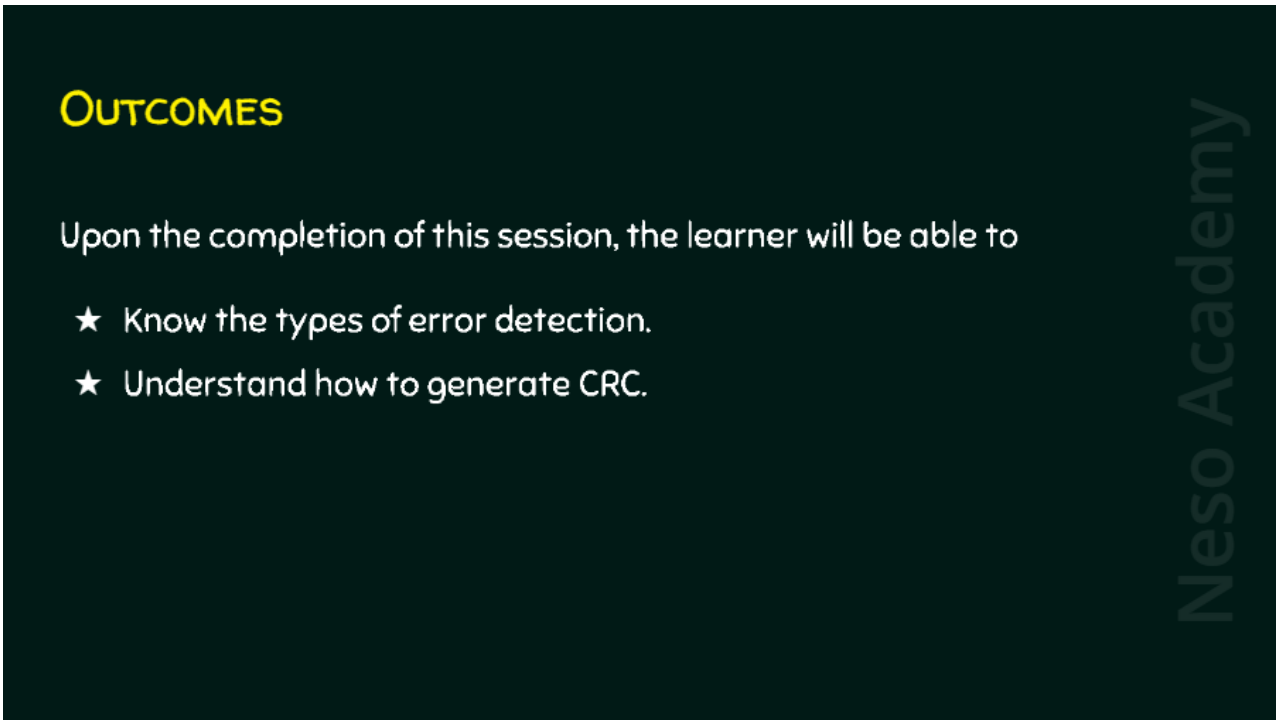
Checksum -Operation at receiver side★★★Neso Academy



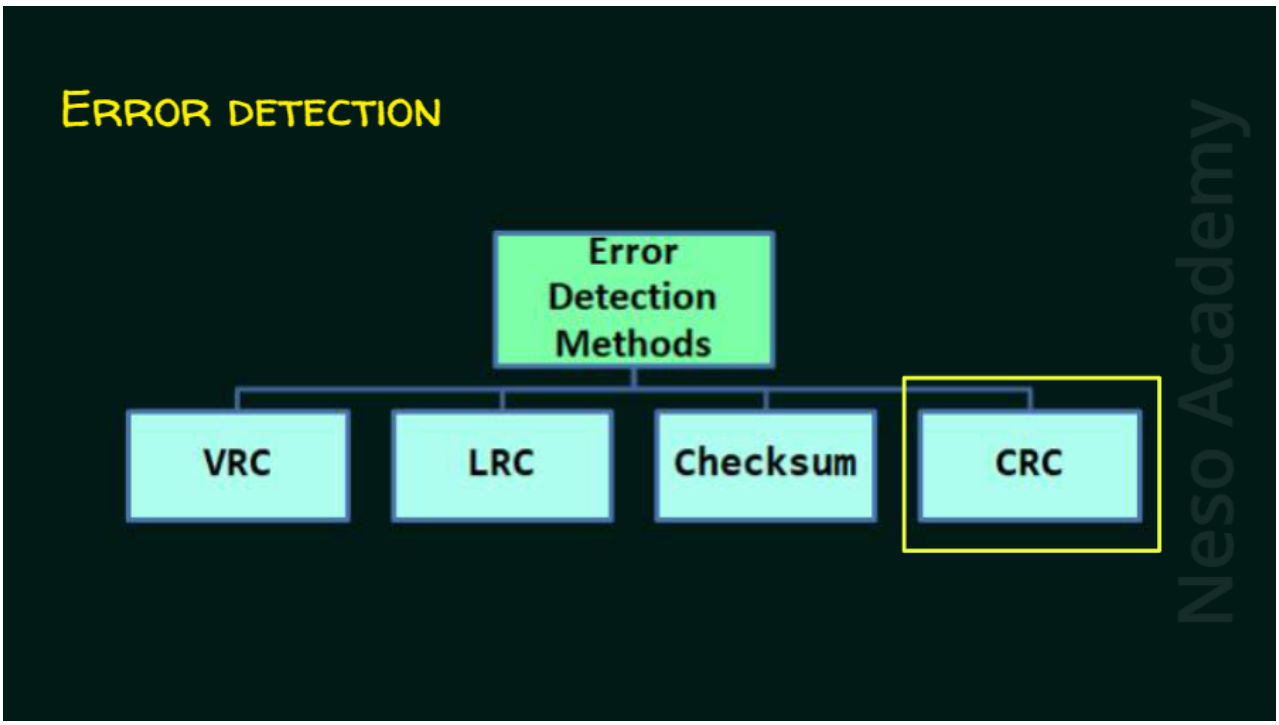
Checksum -Example11011011111111Neso Academy



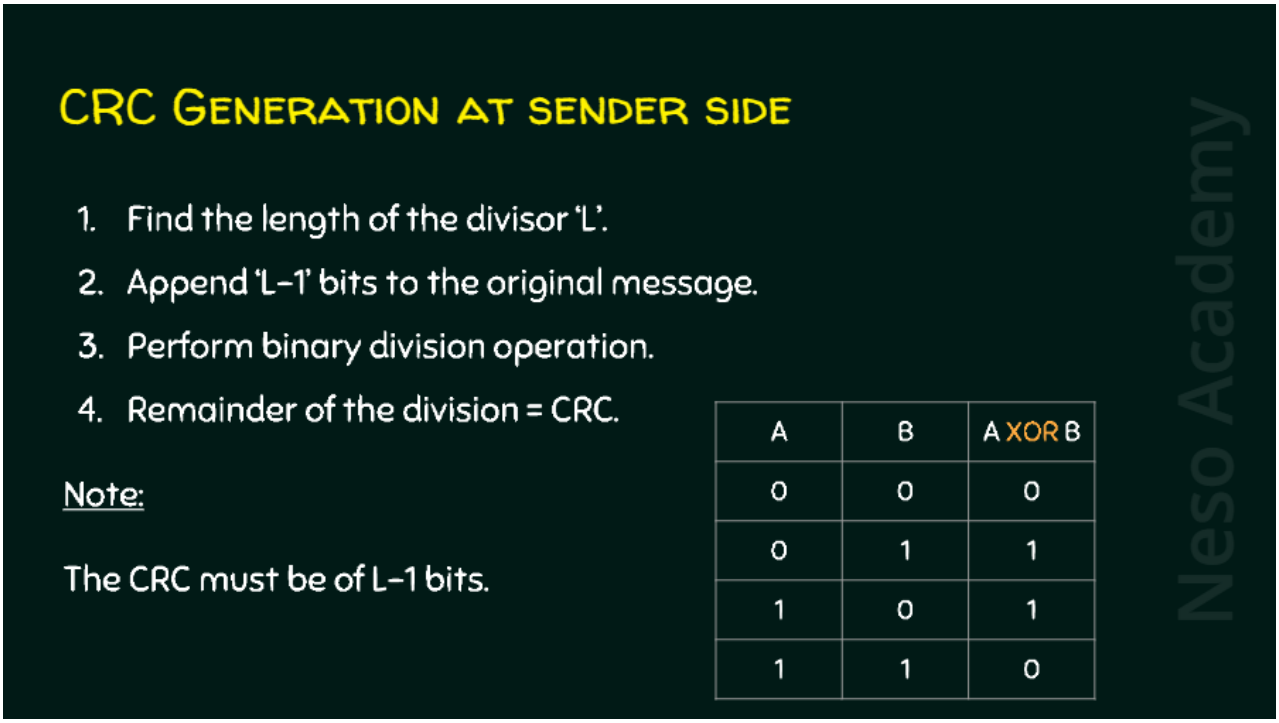
Performance of checksum★★★Neso Academy



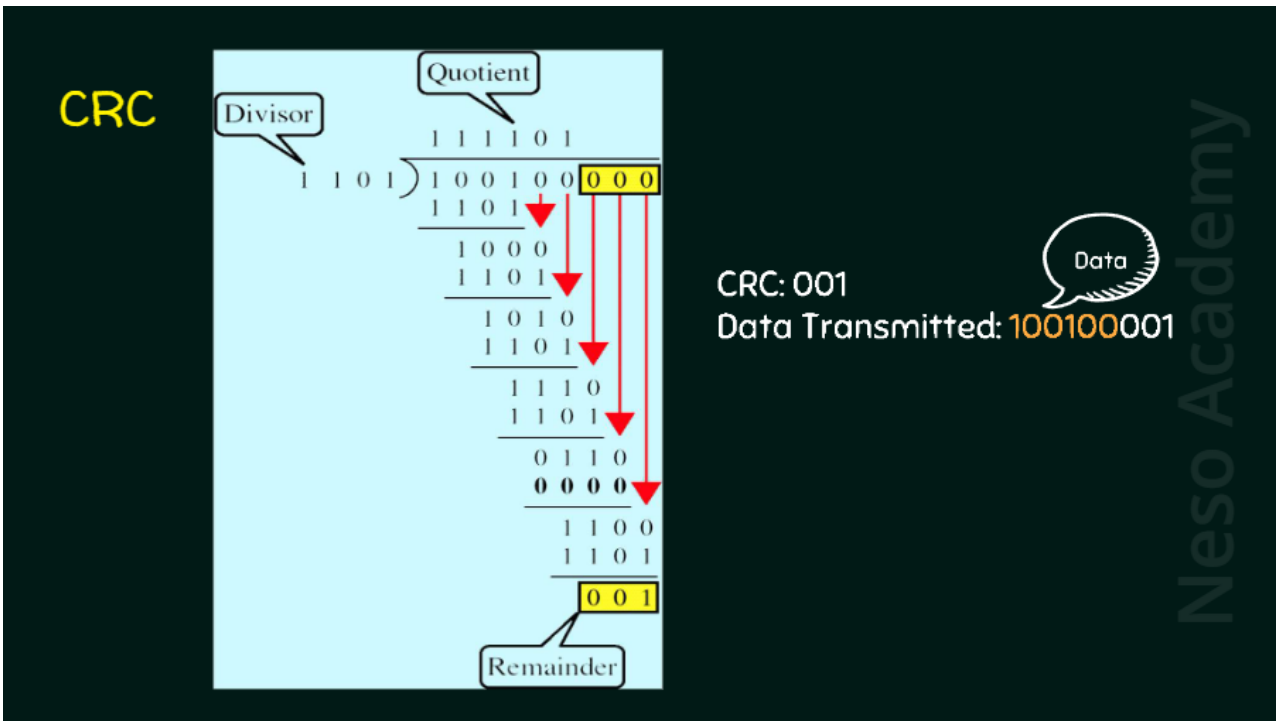
★★OutcomesNeso Academy



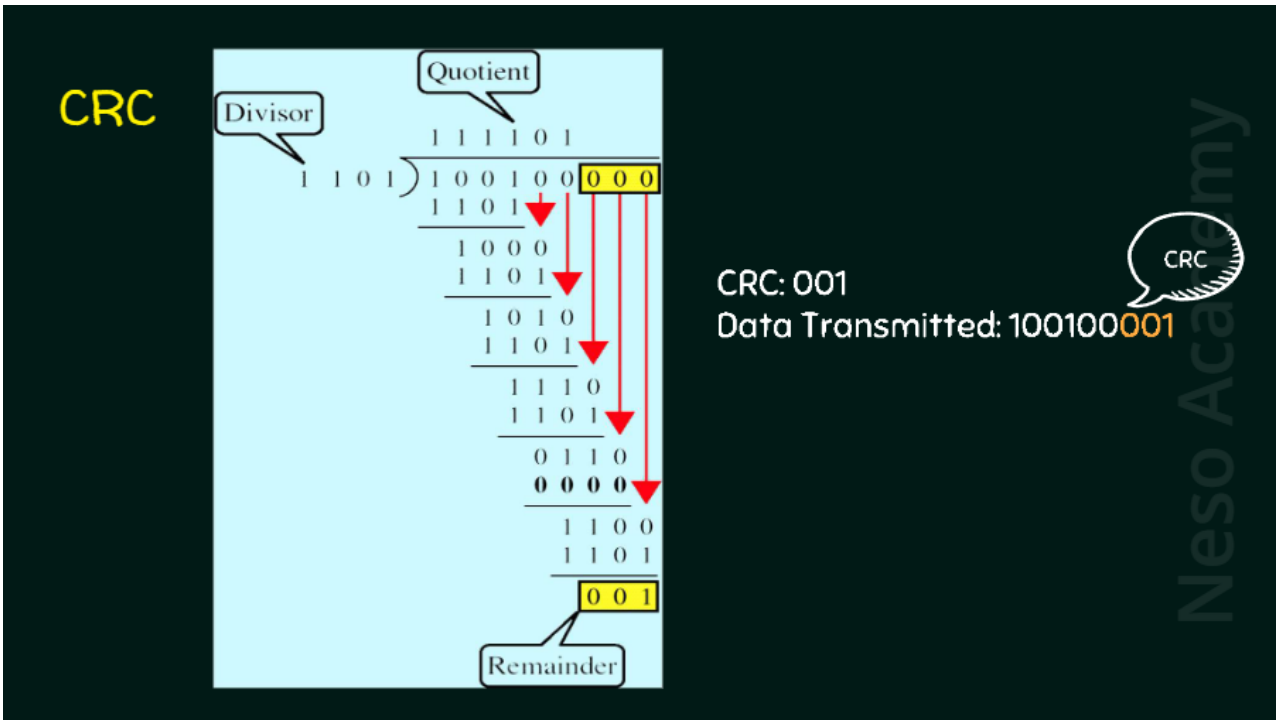
Error detectionNeso Academy



CRC Generation at sender sideNeso Academy



CRCNeso Academy



CRCNeso Academy

HOMEWORK

Find the CRC for 1110010101 with the divisor x^3+x^2+1?

Hint:

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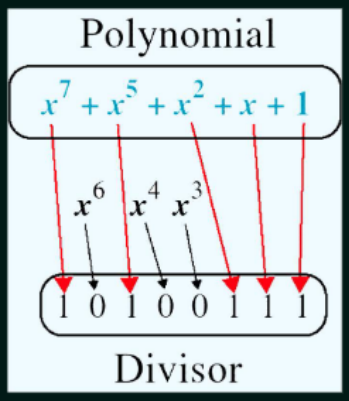
HomeworkNeso Academy

HOMEWORK

Find the CRC for 1110010101 with the divisor x^3+x^2+1?

Hint:



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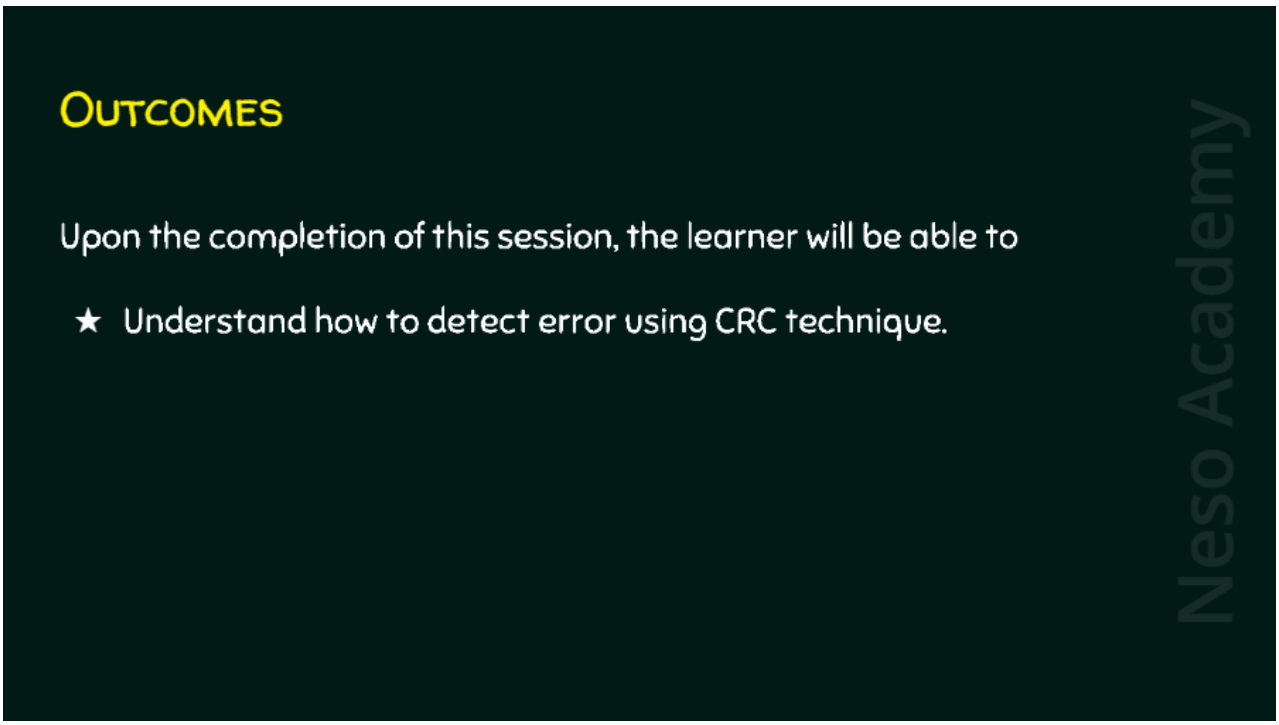
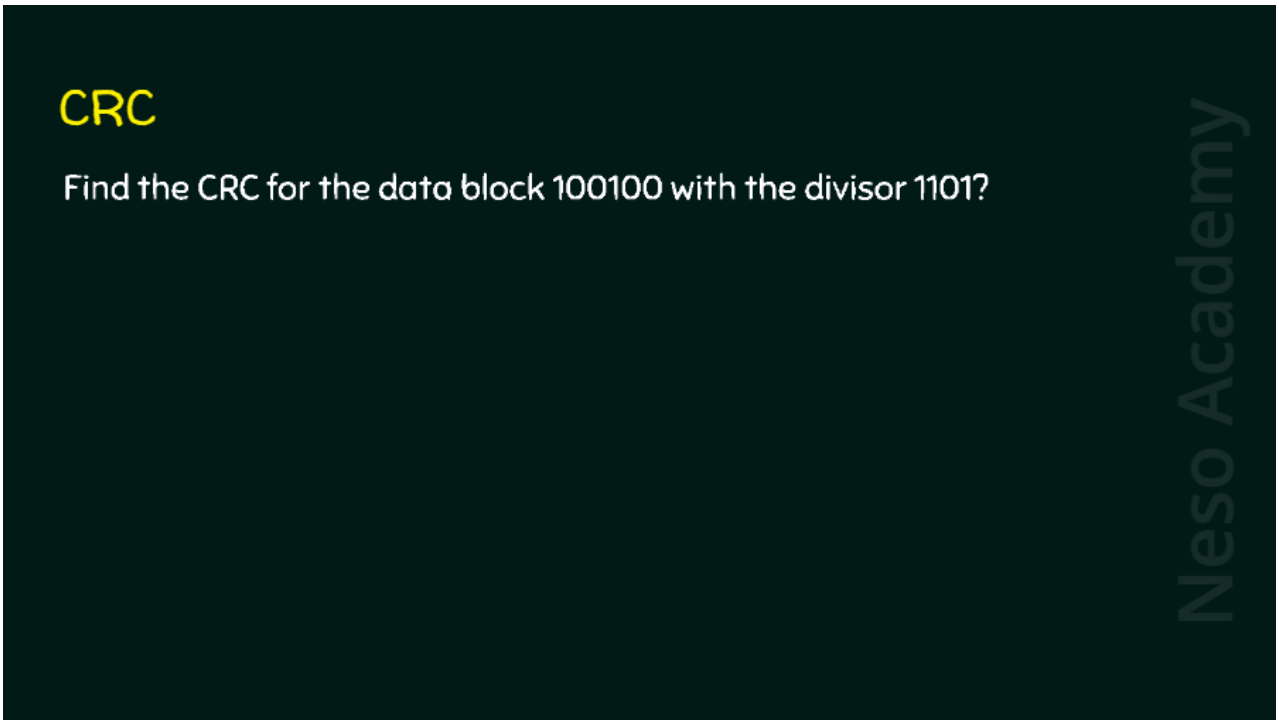
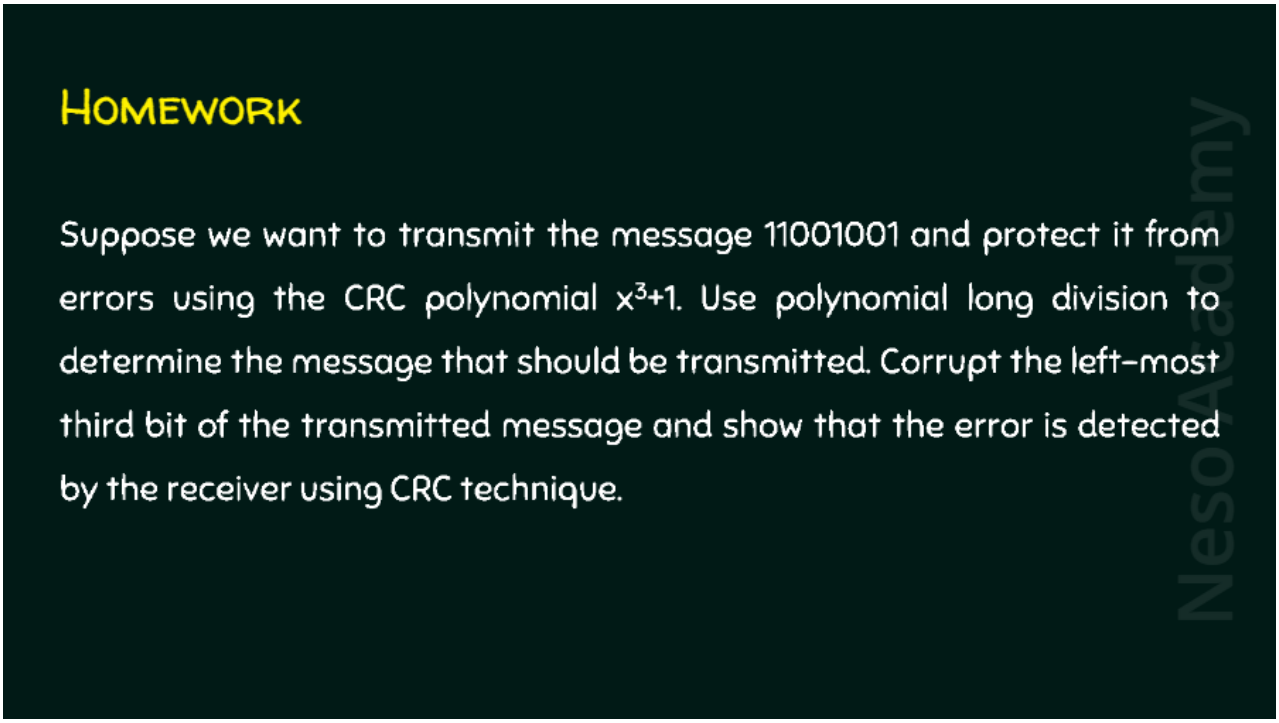


★OutcomesNeso Academy

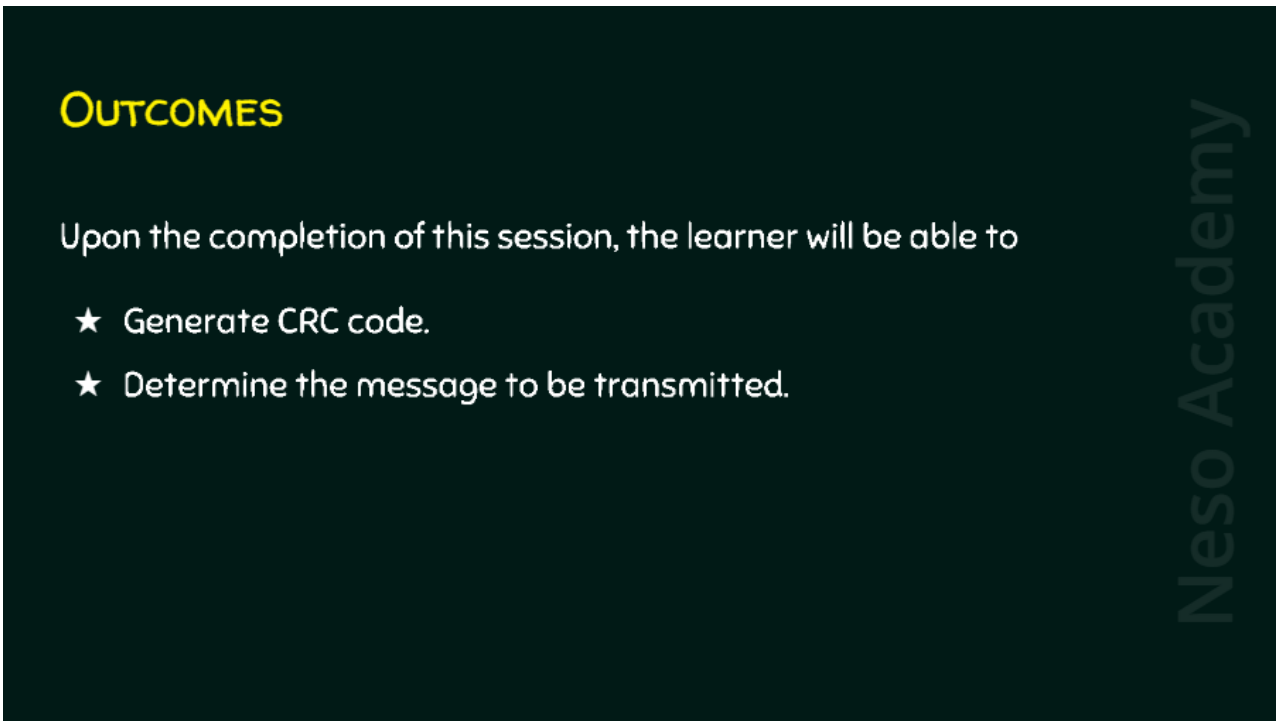


CRCNeso Academy

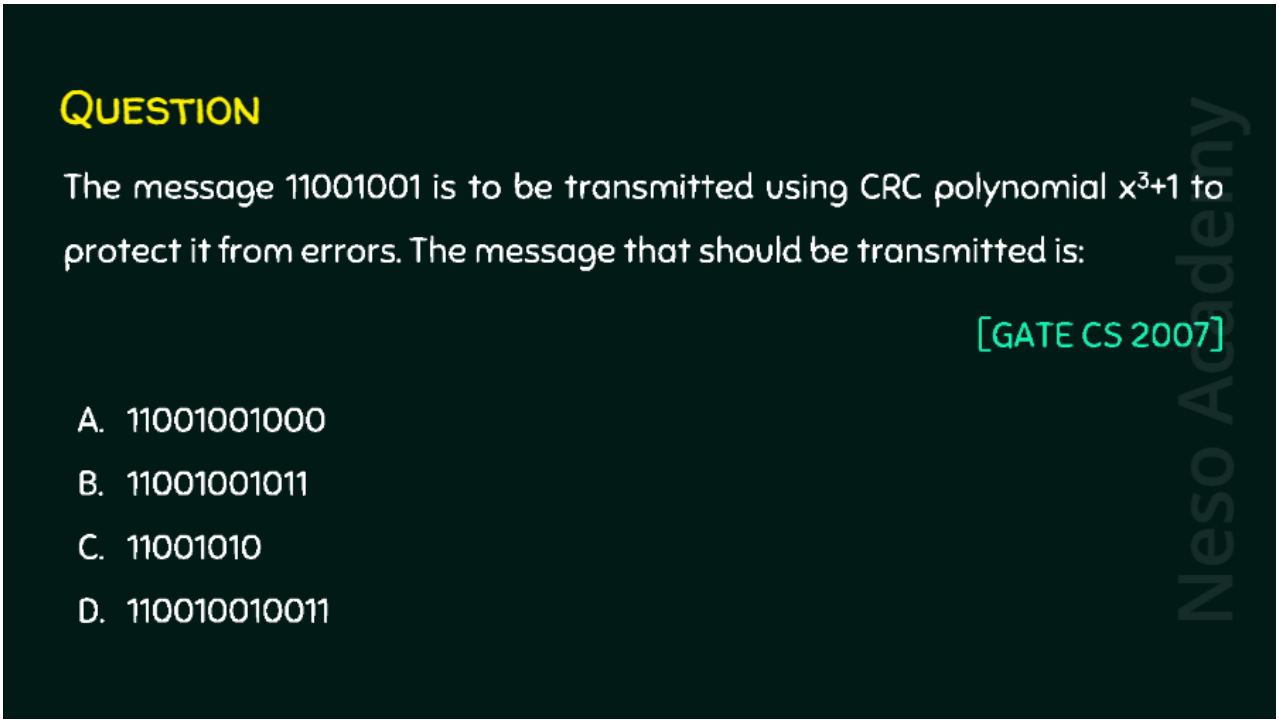
CRCNeso Academy



HomeworkNeso Academy



★★OutcomesNeso Academy



QuestionNeso Academy

CRC Generation at sender side

1. Find the length of the divisor 'L'.
2. Append 'L-1' bits to the original message.
3. Perform binary division operation.
4. Remainder of the division = CRC.
5. Message to be transmitted = Message + CRC

Note:

The CRC must be of L-1 bits.

A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

CRC Generation at sender sideNeso Academy

CRC Generation at sender side

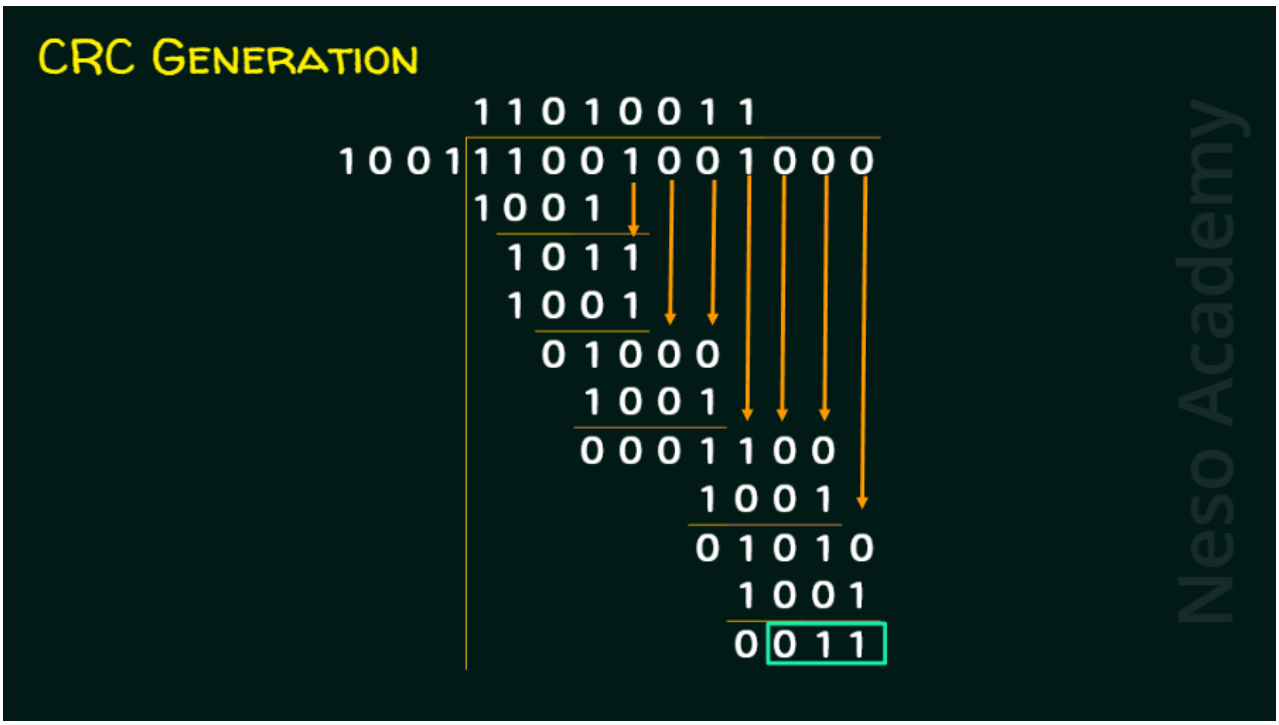
1. The length of the divisor is 4. $(x^3+1 = 1x^3+0x^2+0x^1+1) = 1001$
2. Append '4-1' bits to the original message. (3 bits are appended)
3. Perform binary division operation.
4. Remainder of the division = CRC.
5. Message to be transmitted = Message + CRC

Note:

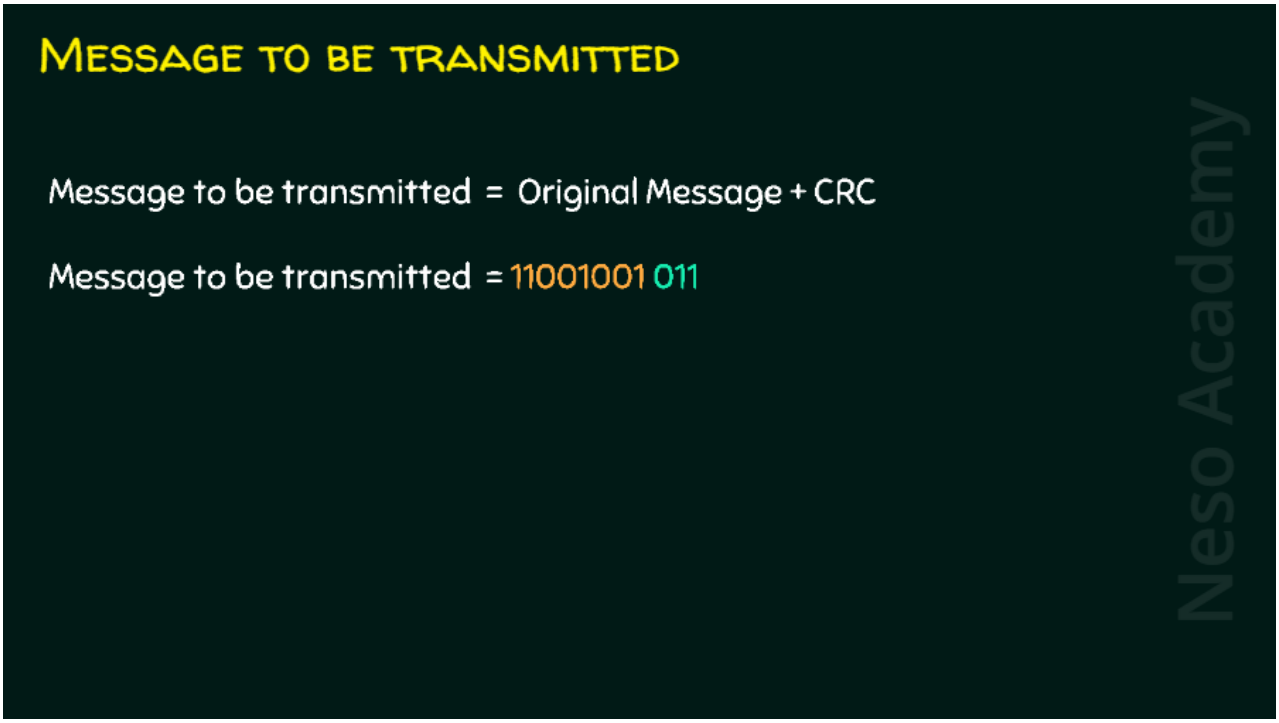
The CRC must be of L-1 i.e 4-1 =3 bits.

A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

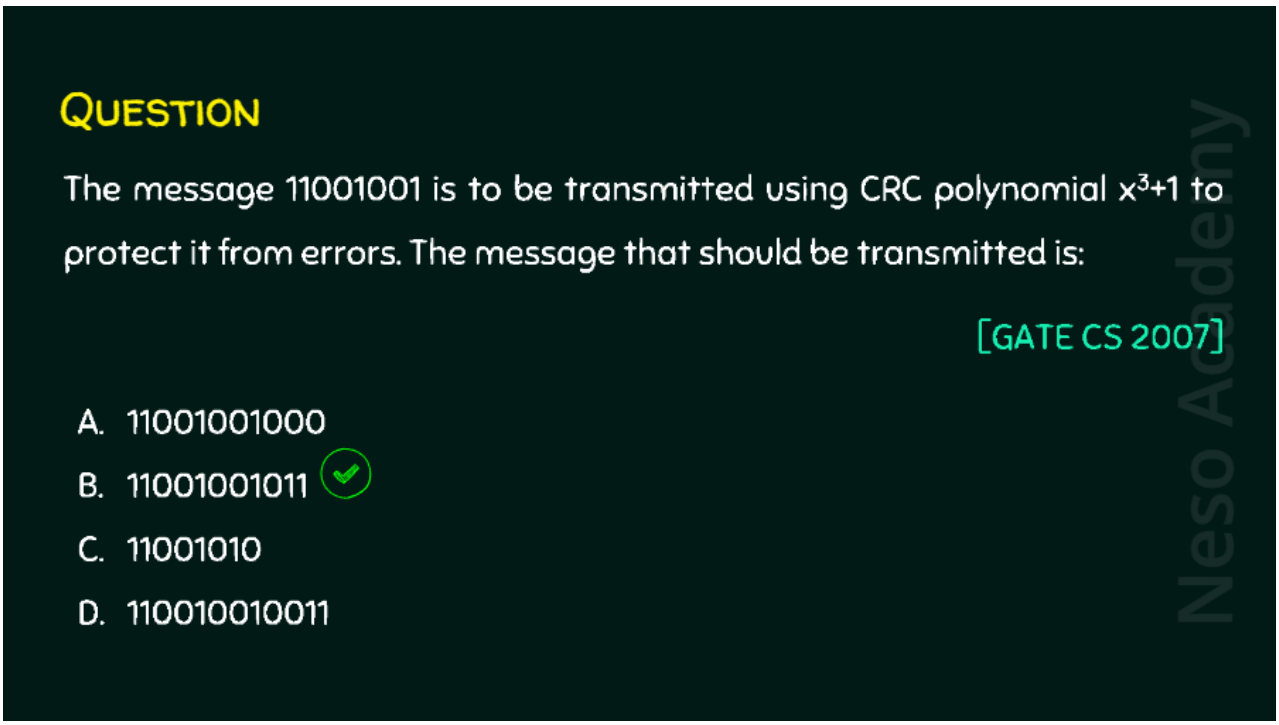
CRC Generation at sender sideNeso Academy



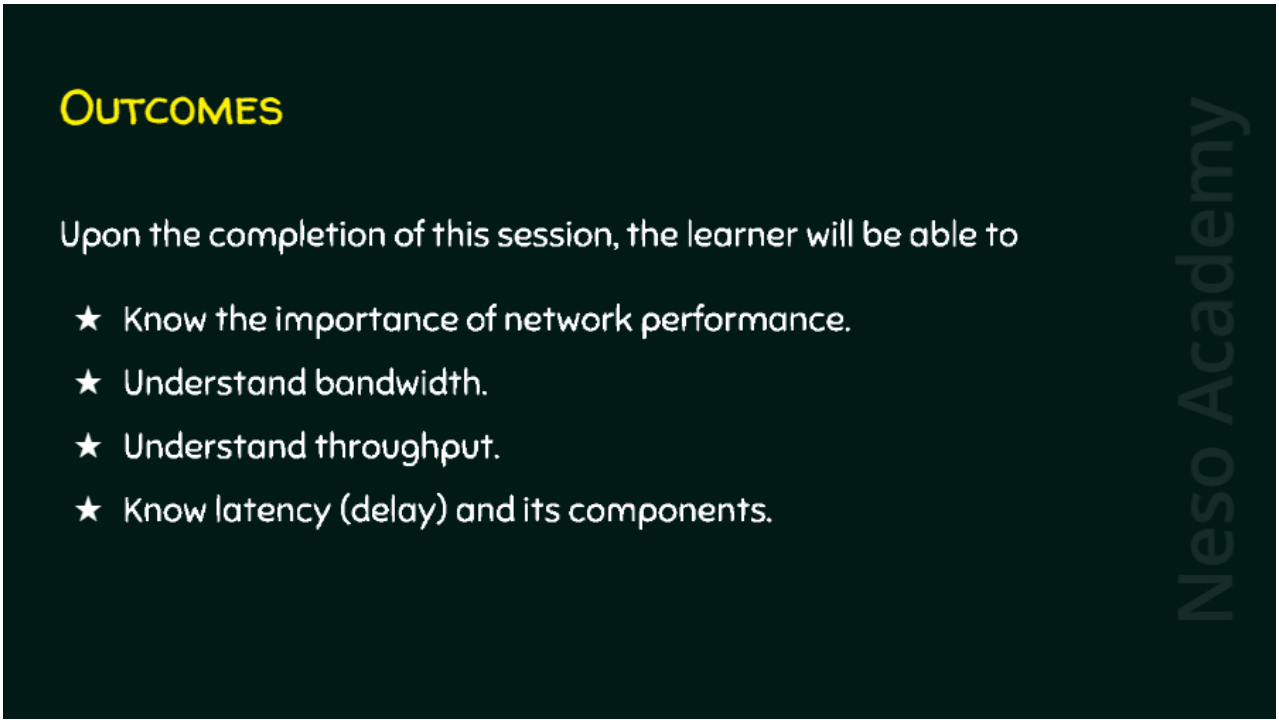
CRC GenerationNeso Academy



Message to be transmittedNeso Academy



QuestionNeso Academy



Outcomes★★★★Neso Academy

Network Performance

One important issue in networking is the performance of the network – how good is it?

Network performance is measured in following fundamental ways

- ★ Bandwidth
- ★ Throughput
- ★ Latency (Delay)

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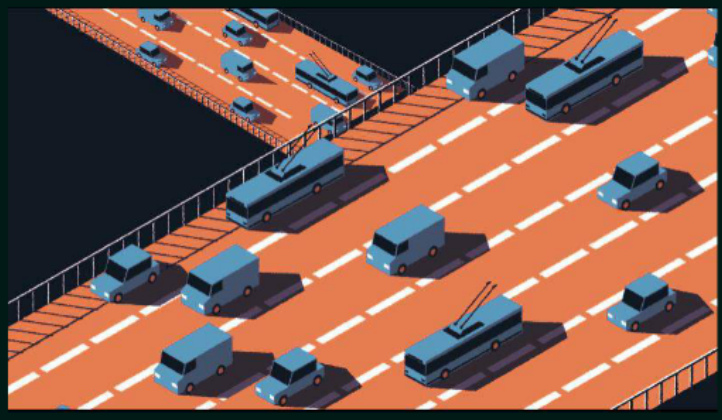
Network Performance★★★Neso Academy

Bandwidth and Throughput – Analogy



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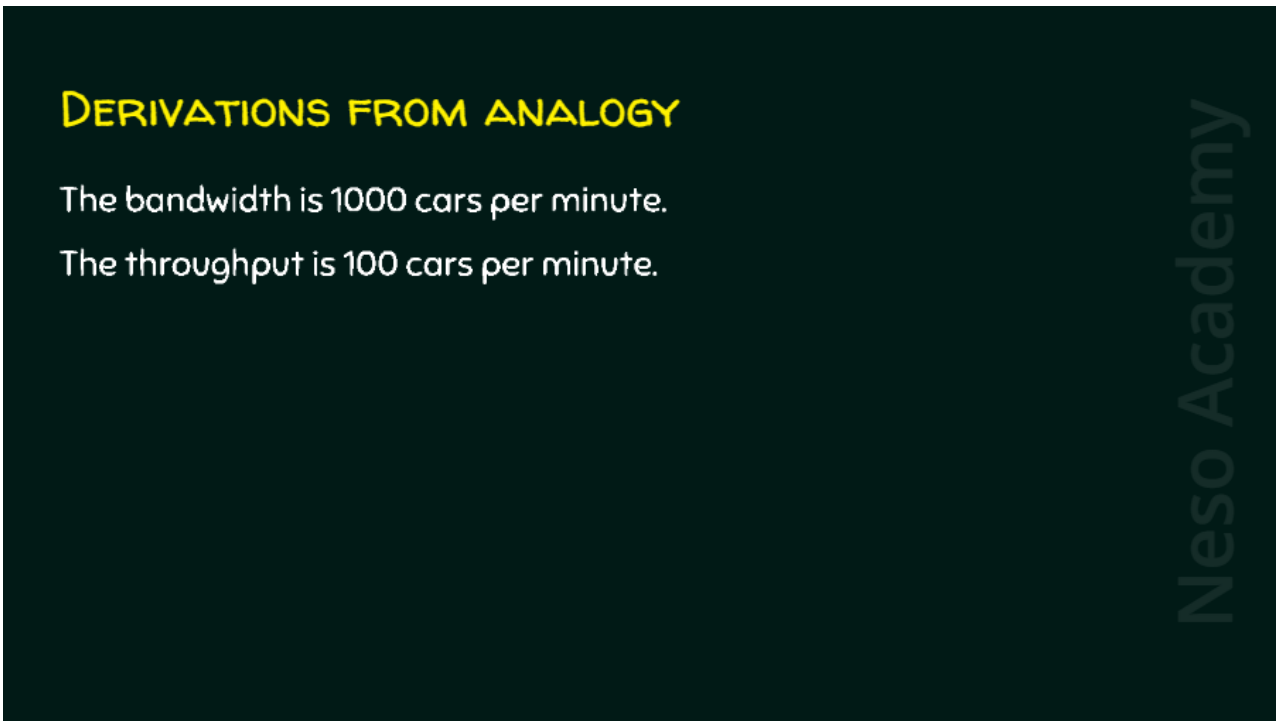
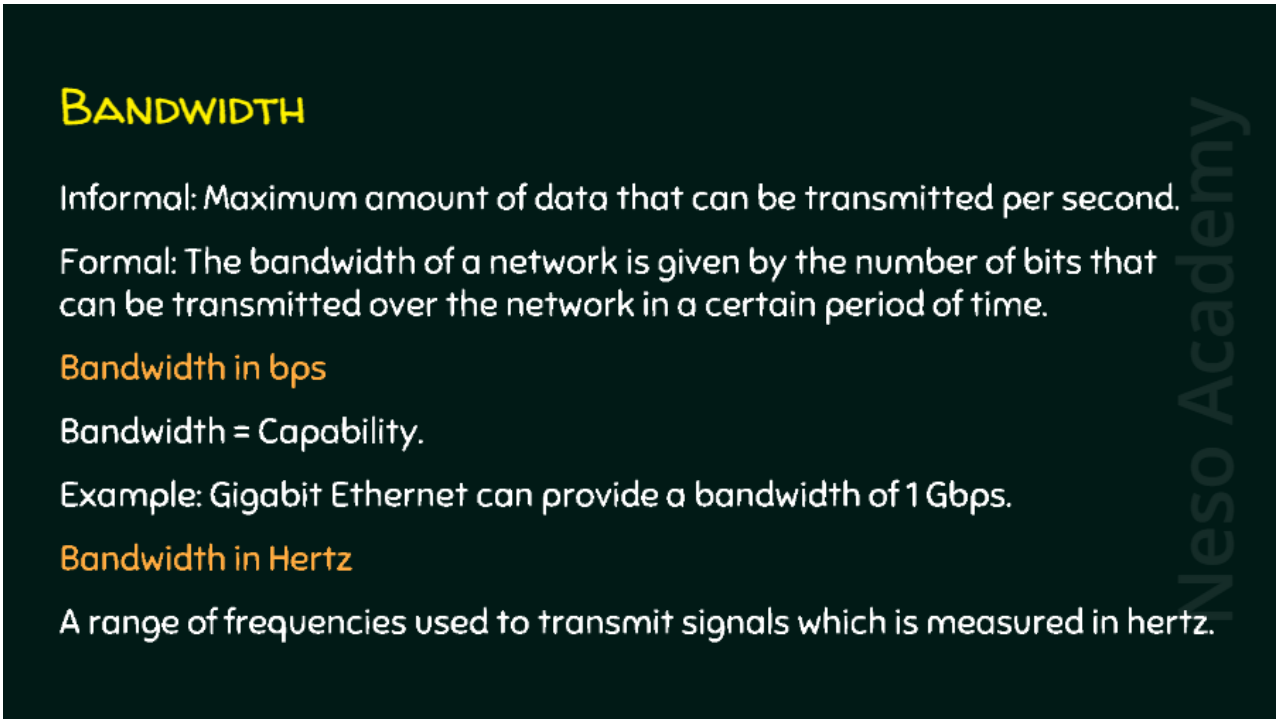
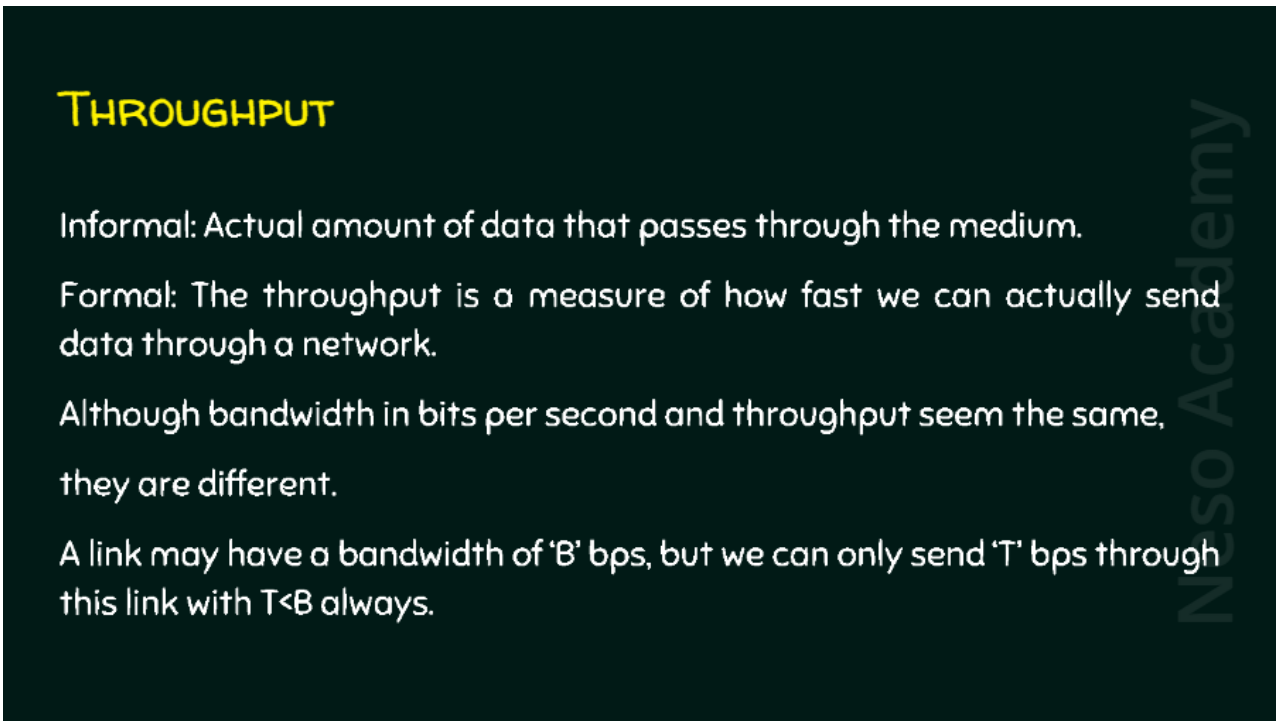
Bandwidth and Throughput -AnalogyNeso Academy



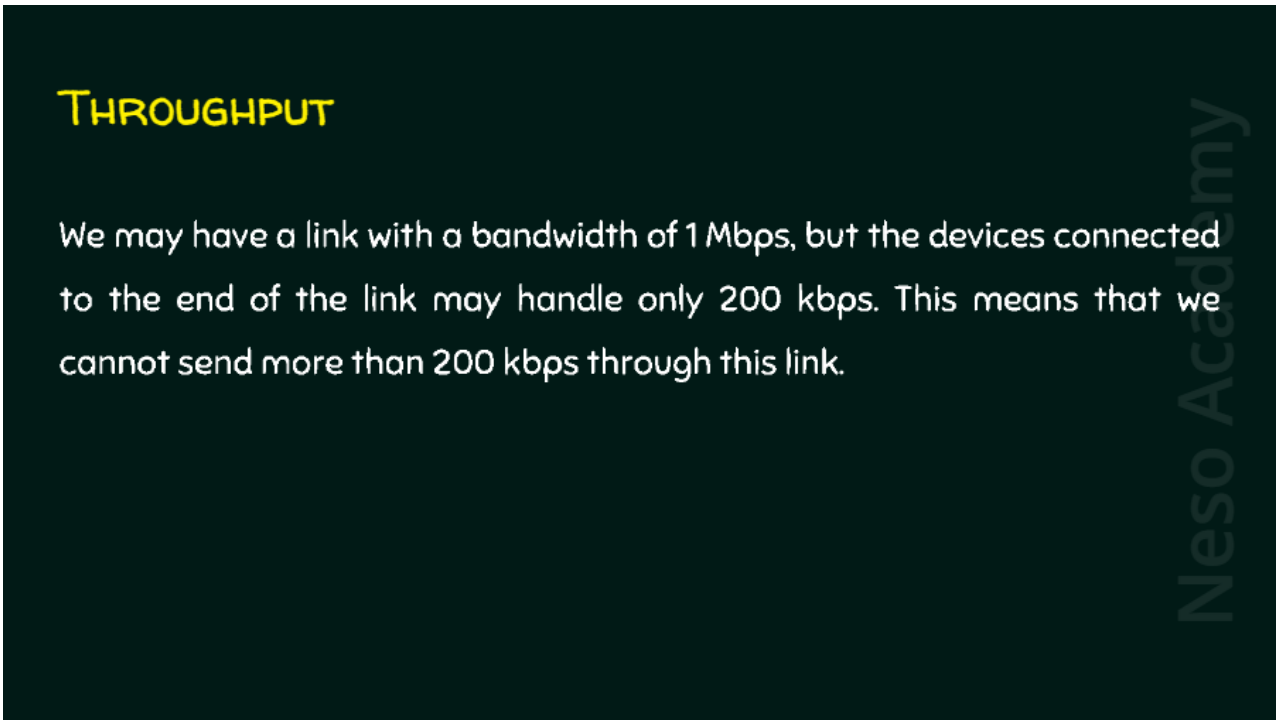
Derivations from analogyNeso Academy



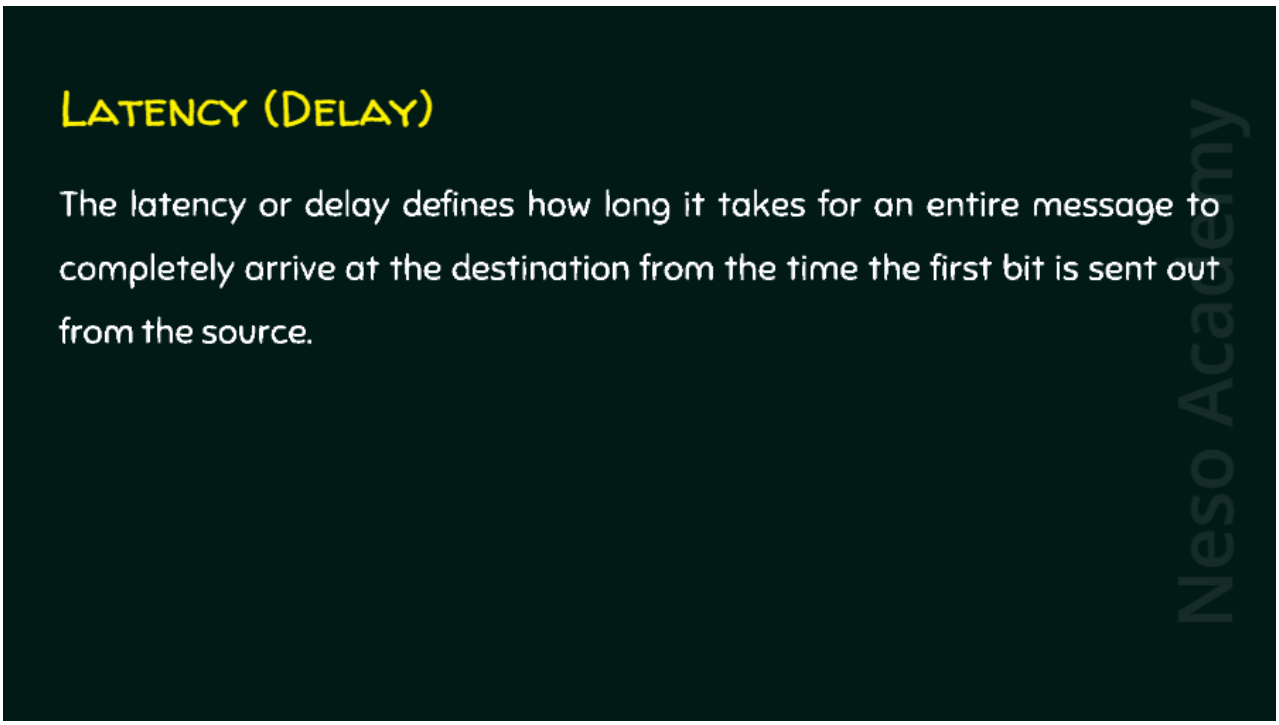
BandwidthNeso Academy



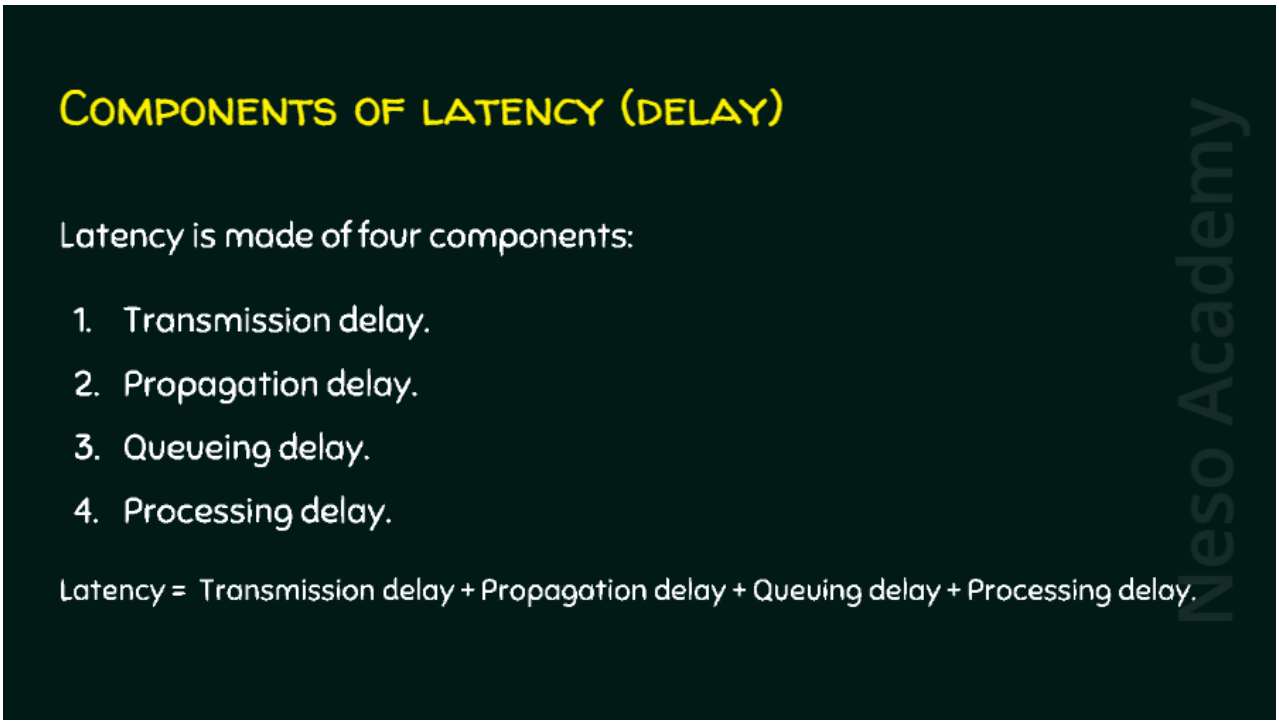
ThroughputNeso Academy



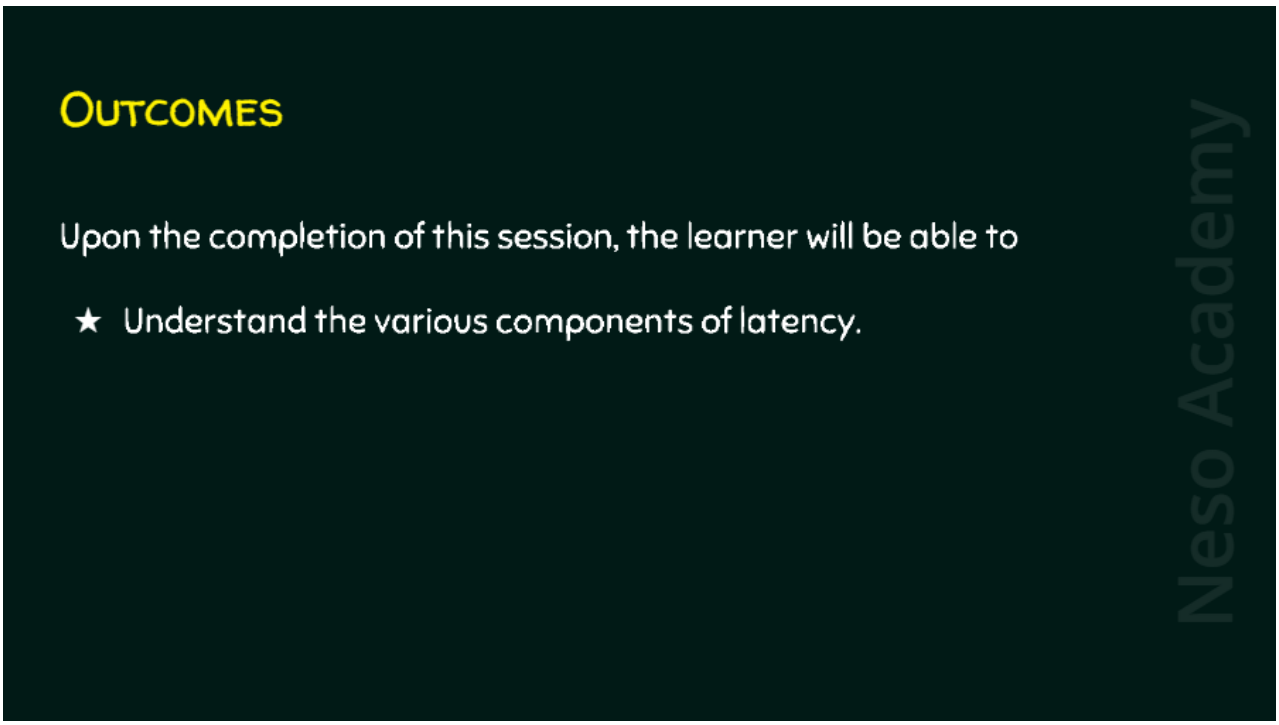
ThroughputNeso Academy



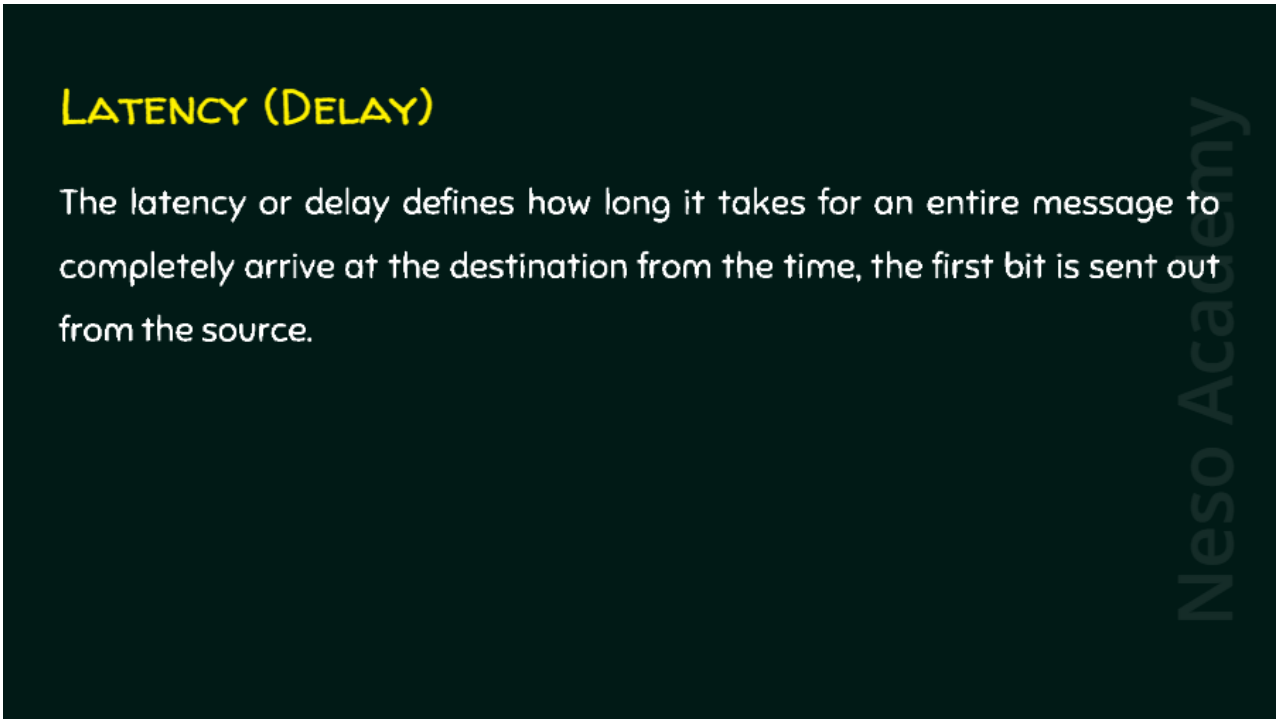
Latency (Delay)Neso Academy



Components of latency (delay)Neso Academy



Outcomes★Neso Academy



Latency (Delay)Neso Academy

Components of latency (delay)

Latency is made of four components:

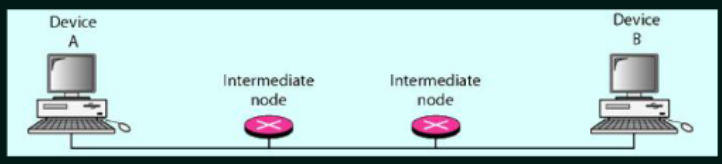
1. Transmission delay.
2. Propagation delay.
3. Queuing delay.
4. Processing delay.

Latency = Transmission delay+Propagation delay+Queuing delay+Processing delay.

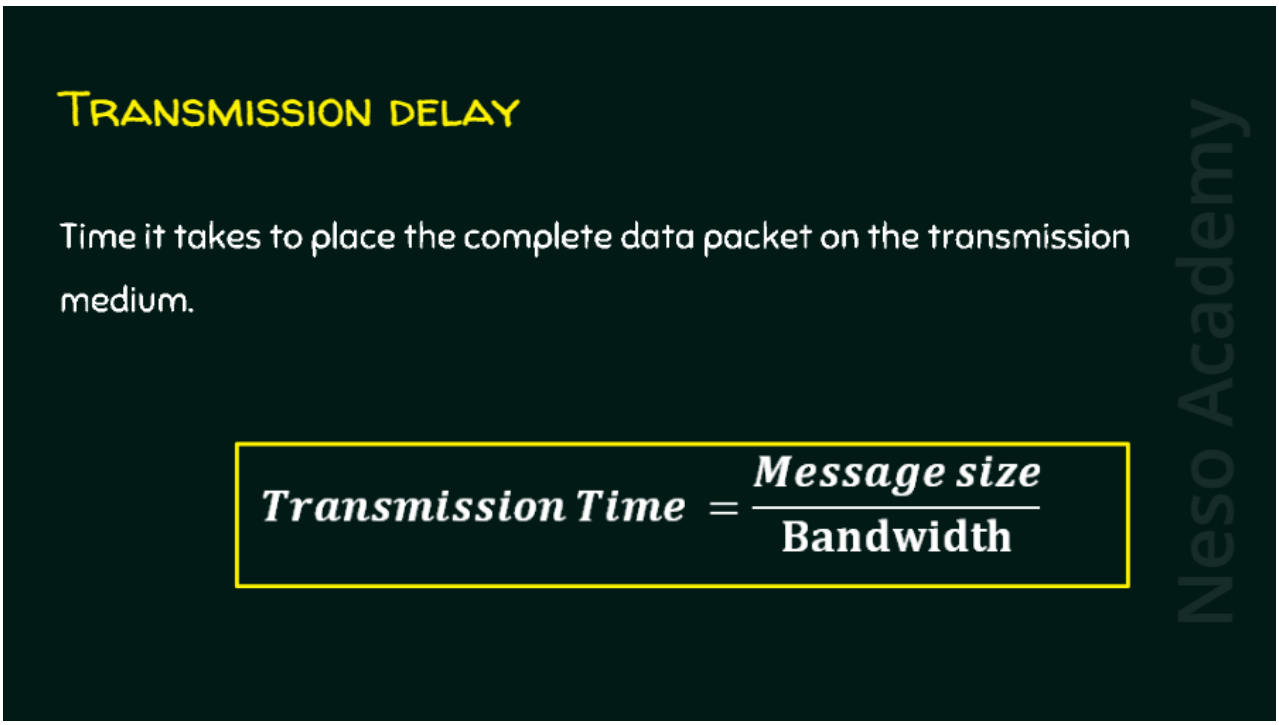
Components of latency (delay)Neso Academy

Transmission delay

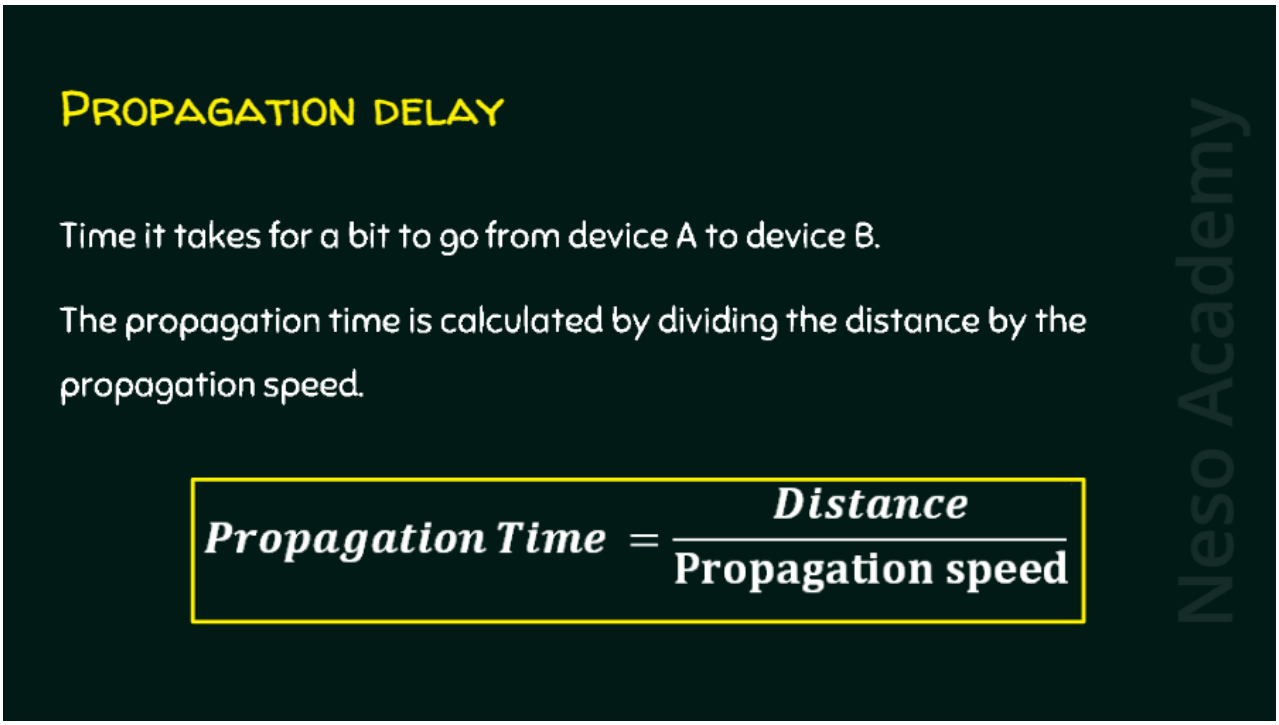
Time it takes to place the complete data packet on the transmission medium.



Transmission delayNeso Academy



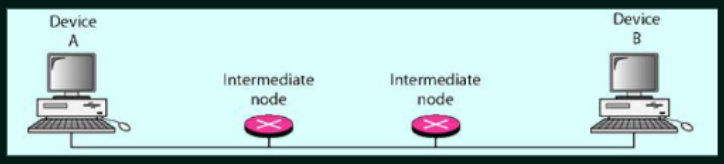
Transmission delayNeso Academy



Propagation delayNeso Academy

Queuing delay

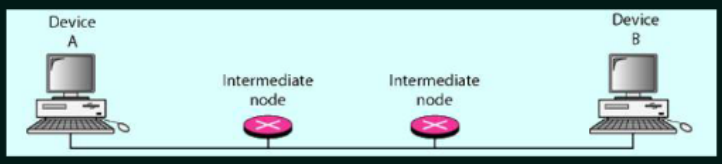
- ★ The third component in latency is the queuing time, the time needed for each intermediate or end device to hold the message before it can be processed.
- ★ The queuing time is not a fixed factor; it changes with the load imposed on the network.
- ★ When there is heavy traffic on the network, the queuing time increases.



Queuing delay★★★Neso Academy

Processing Delay

- ★ How much time the node takes to process the message?



Processing Delay★Neso Academy

Outcomes

Upon the completion of this session, the learner will be able to

★ Understand bandwidth-delay product.

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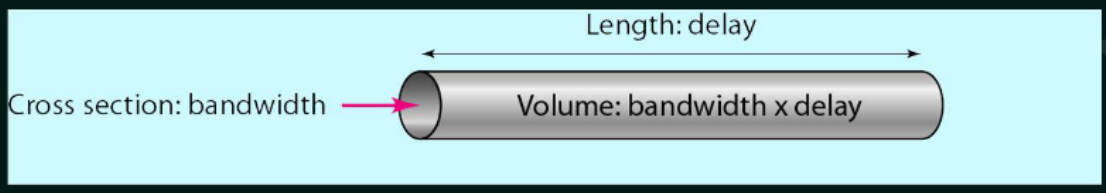
Outcomes★Neso Academy

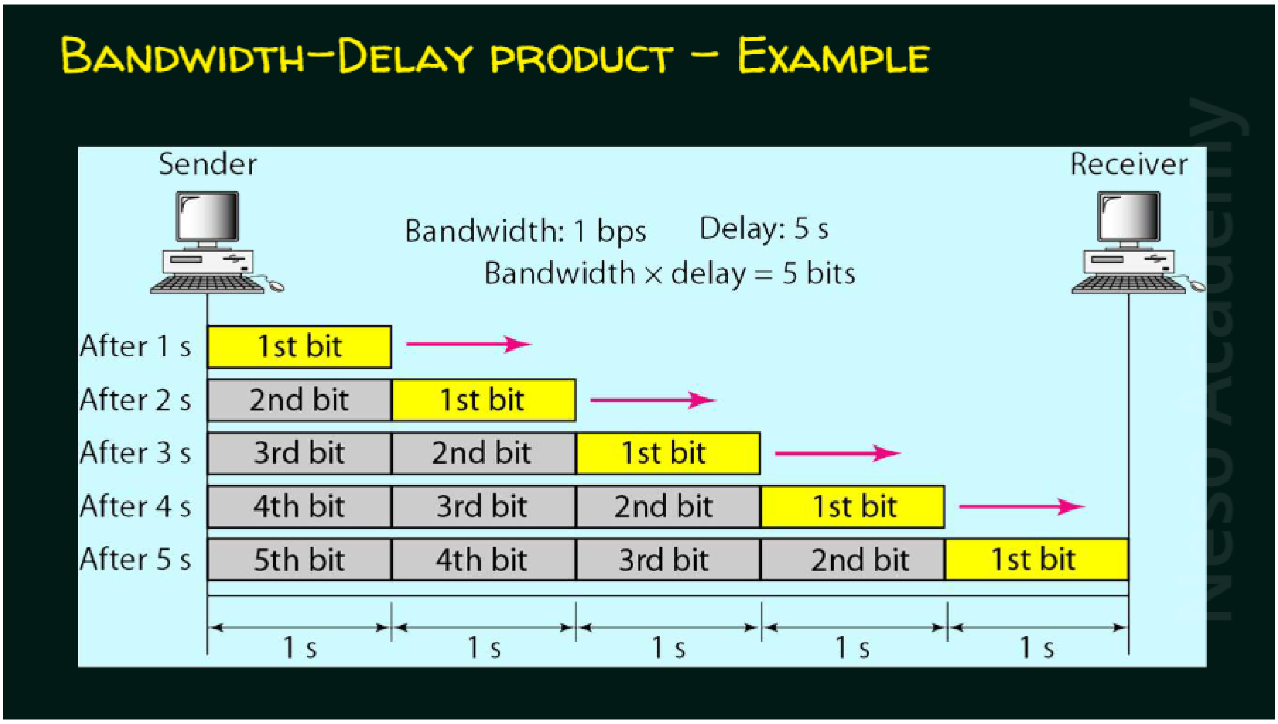
Bandwidth-Delay product

The bandwidth-delay product defines the number of bits that can fill the link.

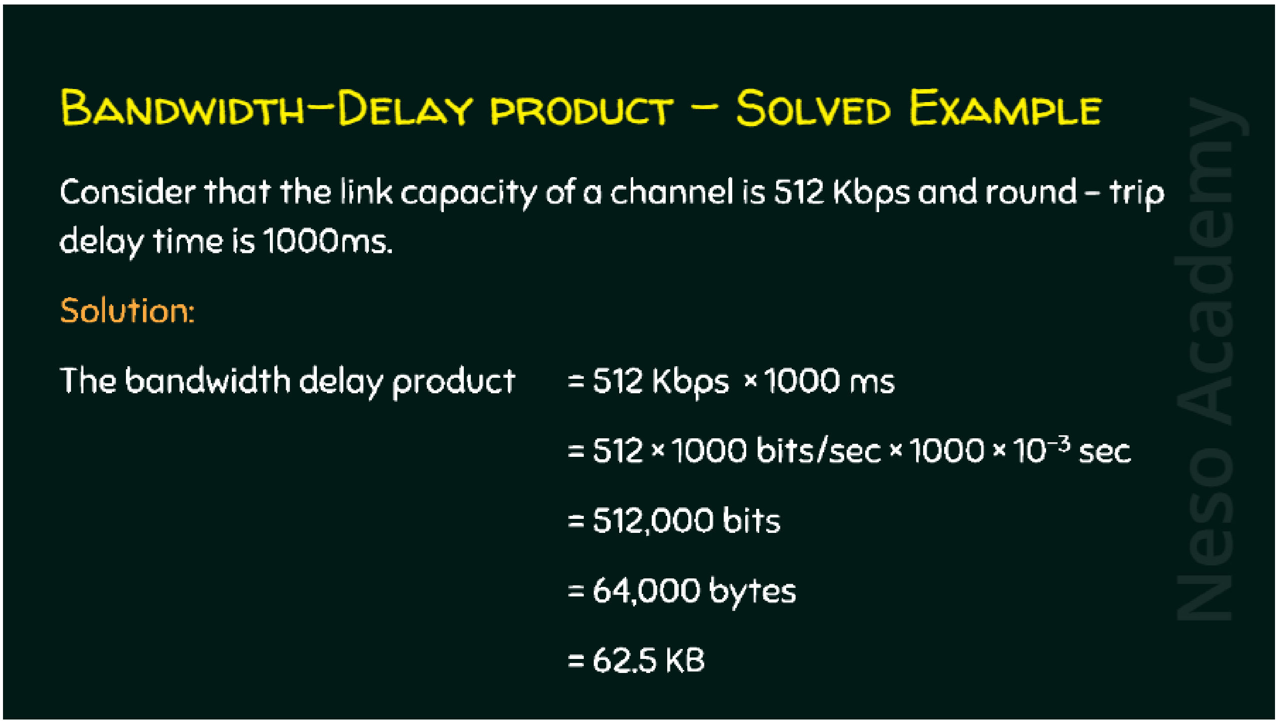


Neso Academy

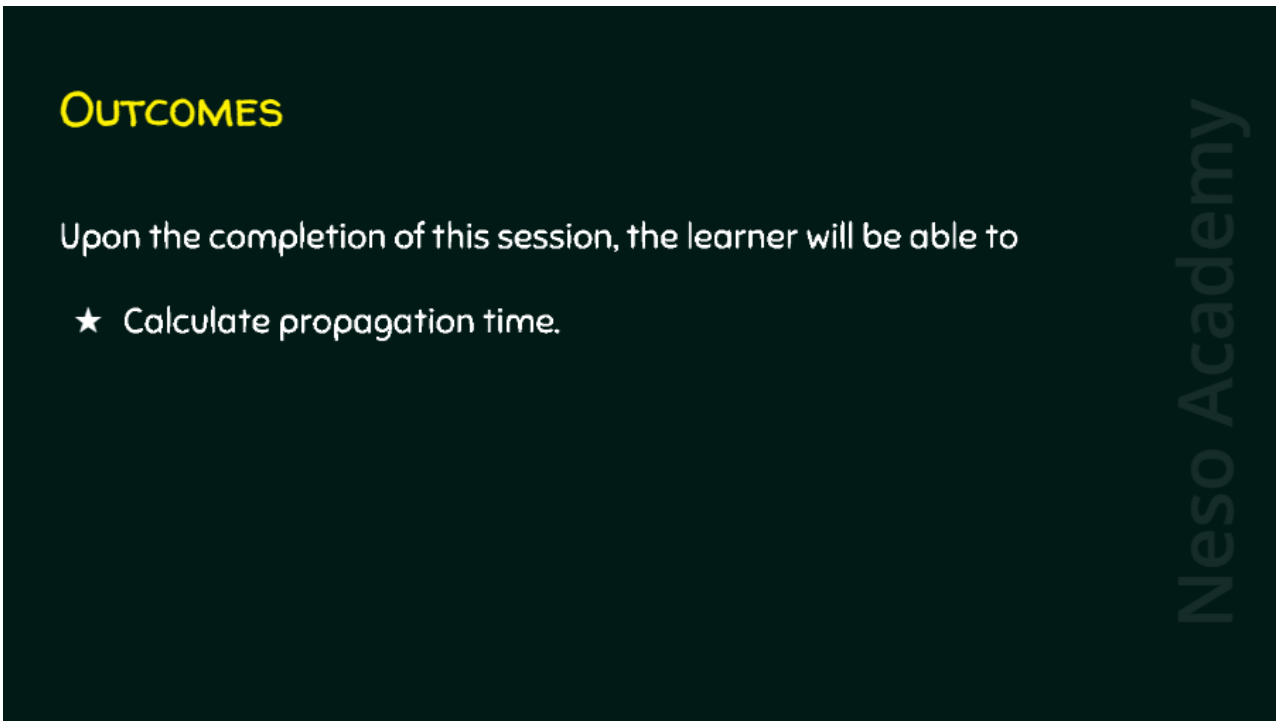
Bandwidth-Delay productNeso Academy



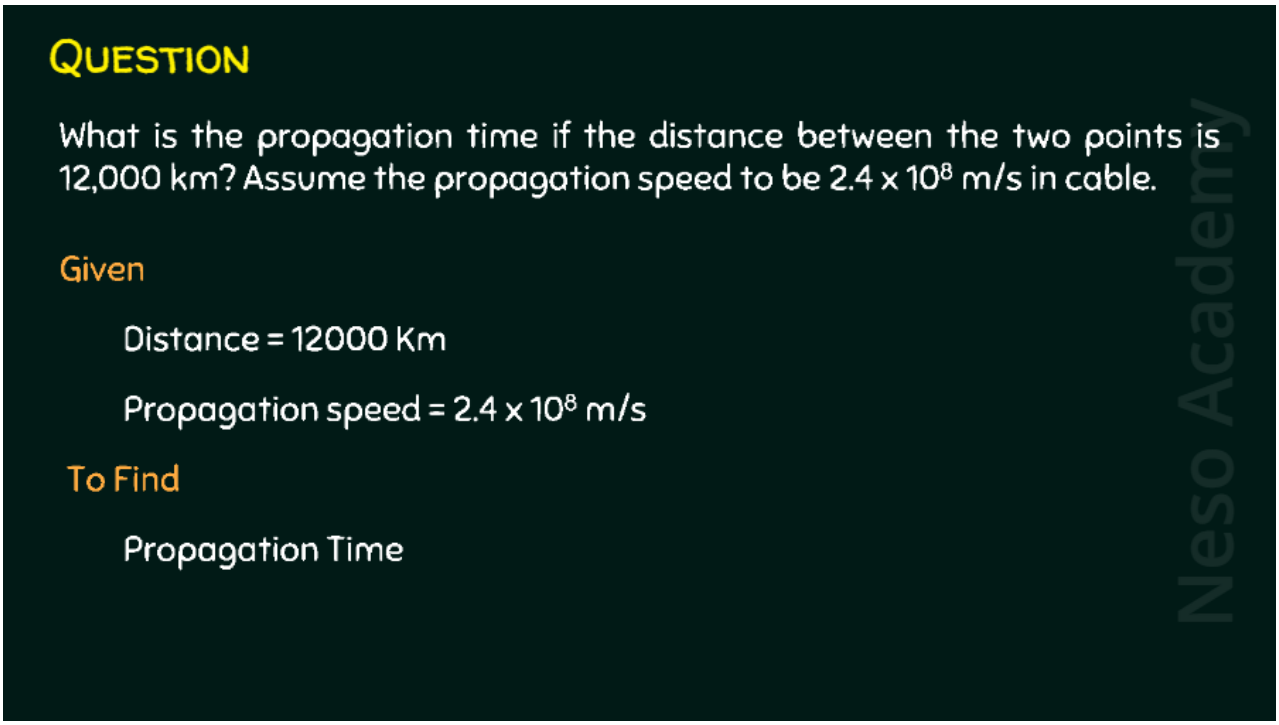
Bandwidth-Delay product -ExampleNeso Academy



Bandwidth-Delay product -Solved ExampleNeso Academy



Outcomes★Neso Academy



QuestionNeso Academy

Solution

$$\text{Propagation Time} = \frac{\text{Distance}}{\text{Propagation speed}}$$

$$\text{Propagation Time} = \frac{12000 \times 1000}{2.4 \times 10^8} \text{sec}$$

$$\text{Propagation Time} = \frac{5000 \times 1000}{10^8} \text{ sec}$$

$$\text{Propagation Time} = \frac{5000 \times 1000}{10^8} \times \frac{10^{-3}}{10^{-3}} \text{ sec}$$

$$\text{Propagation Time} = \frac{5000 \times 1000}{10^8} \times \frac{1}{10^{-3}} \text{ millisec}$$

$$\text{Propagation Time} = \frac{5000 \times 1000}{10^8} \times \frac{10^3}{1} \text{ millisec}$$

$$\text{Propagation Time} = \frac{50 \times 100 \times 1000}{10^8} \times \frac{10^3}{1} \text{ millisec}$$

Propagation Time = 50 millisec OR 50 ms

SolutionNeso Academy

Outcomes

Upon the completion of this session, the learner will be able to

★ Recall propagation time.

★ Understand RTT.

★ Calculate RTT.

Outcomes★★★Neso Academy

Round Trip Time (RTT)

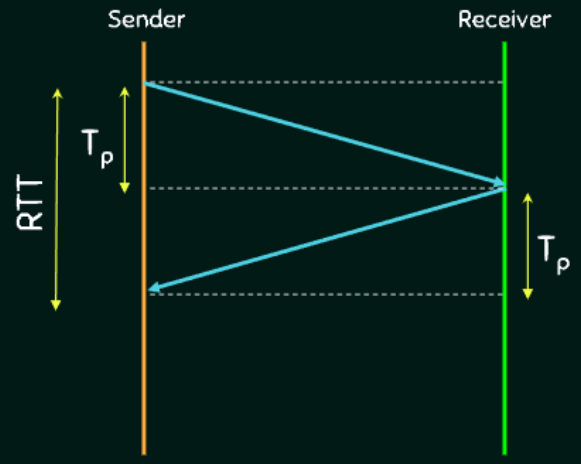
- ★ a.k.a Round Trip Delay Time (RTD).
- ★ It is the length of time it takes for a signal to be sent plus the length of time it takes for an acknowledgement of that signal to be received.
- ★ This time therefore consists of the propagation times between the two point of signal.
- ★ If T_p is the Propagation time, then

$$RTT = 2 \times T_p$$

Neso Academy

Round Trip Time (RTT)★★★★Neso Academy

Round Trip Time (RTT)



$$RTT = T_p + T_p$$

$$RTT \cong 2 \times T_p$$

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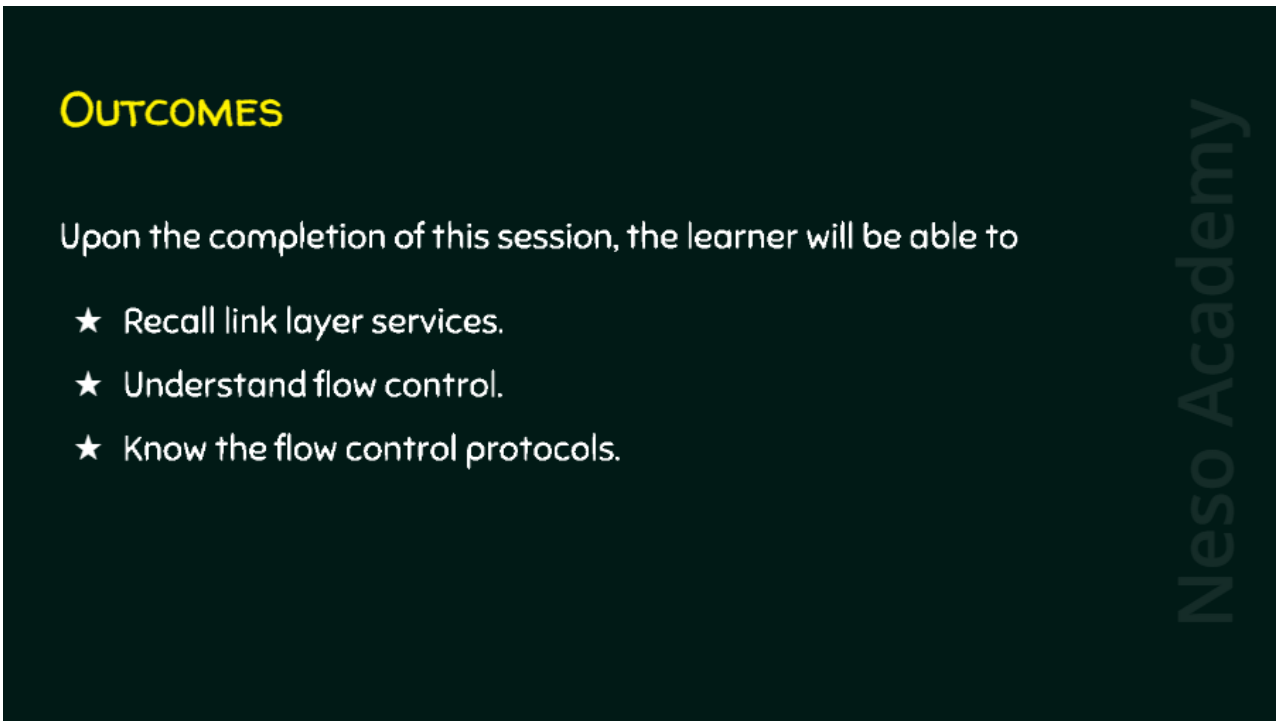
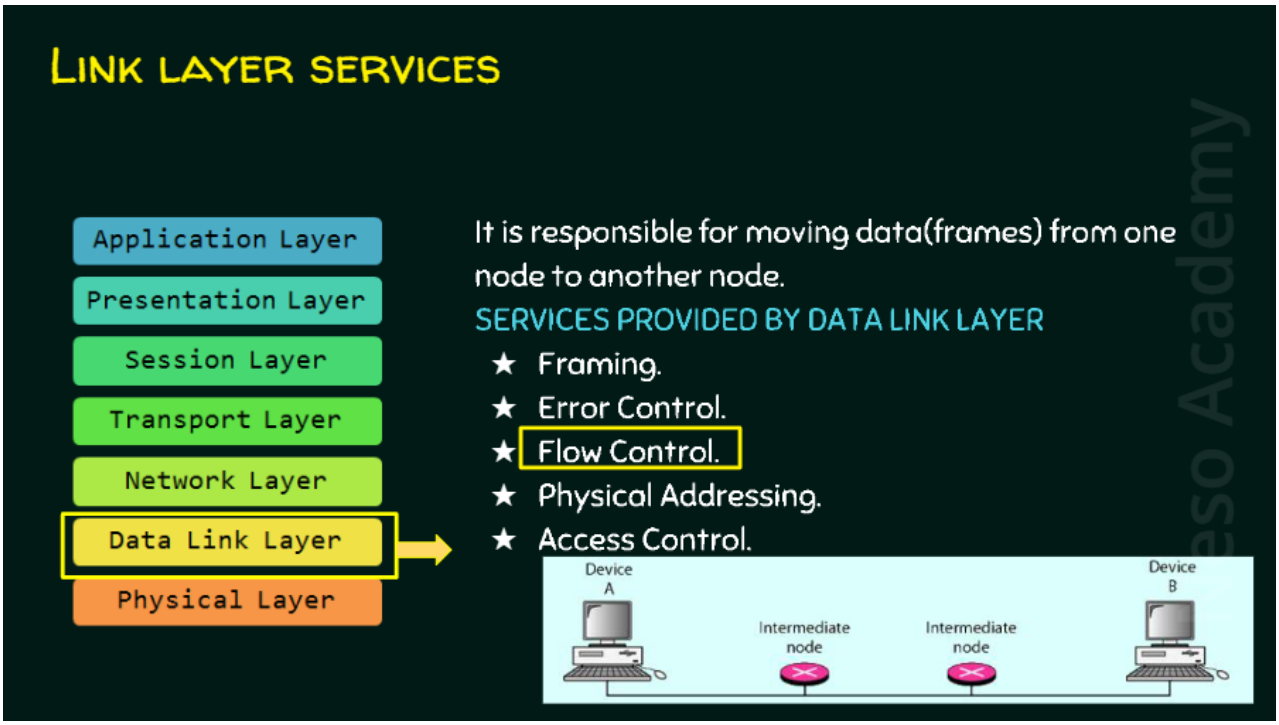
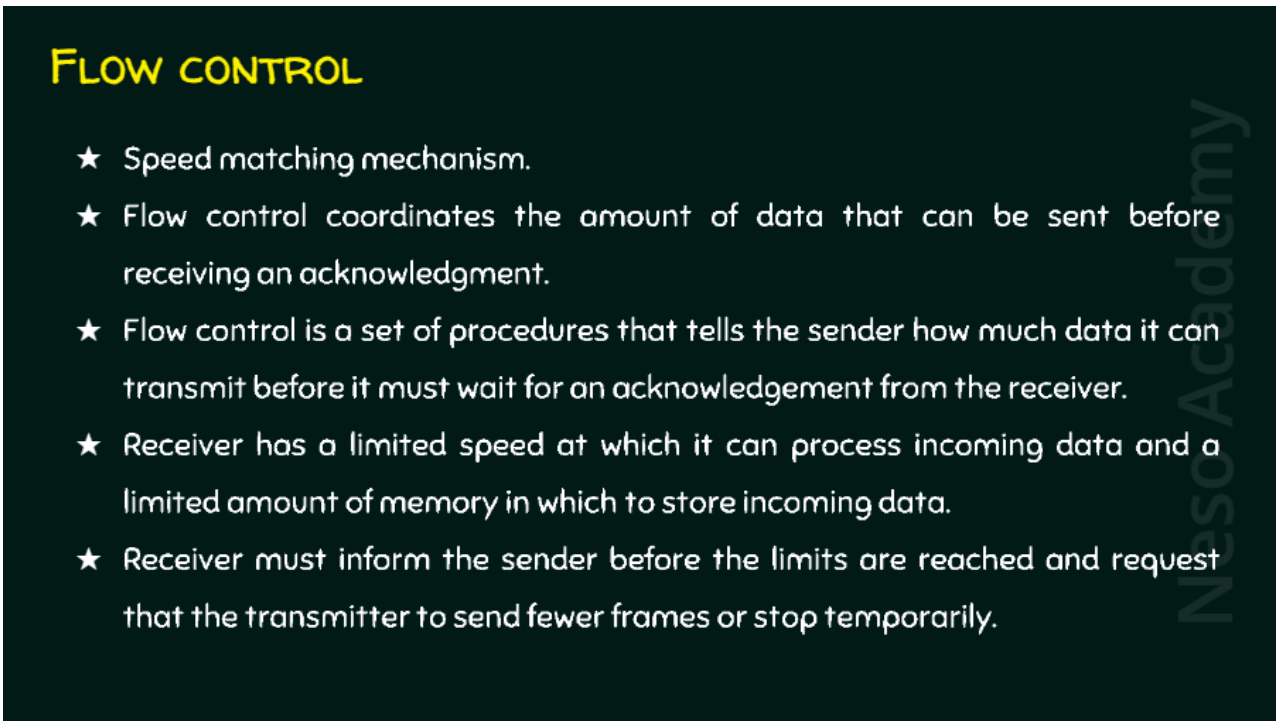
Round Trip Time (RTT)≅Neso Academy



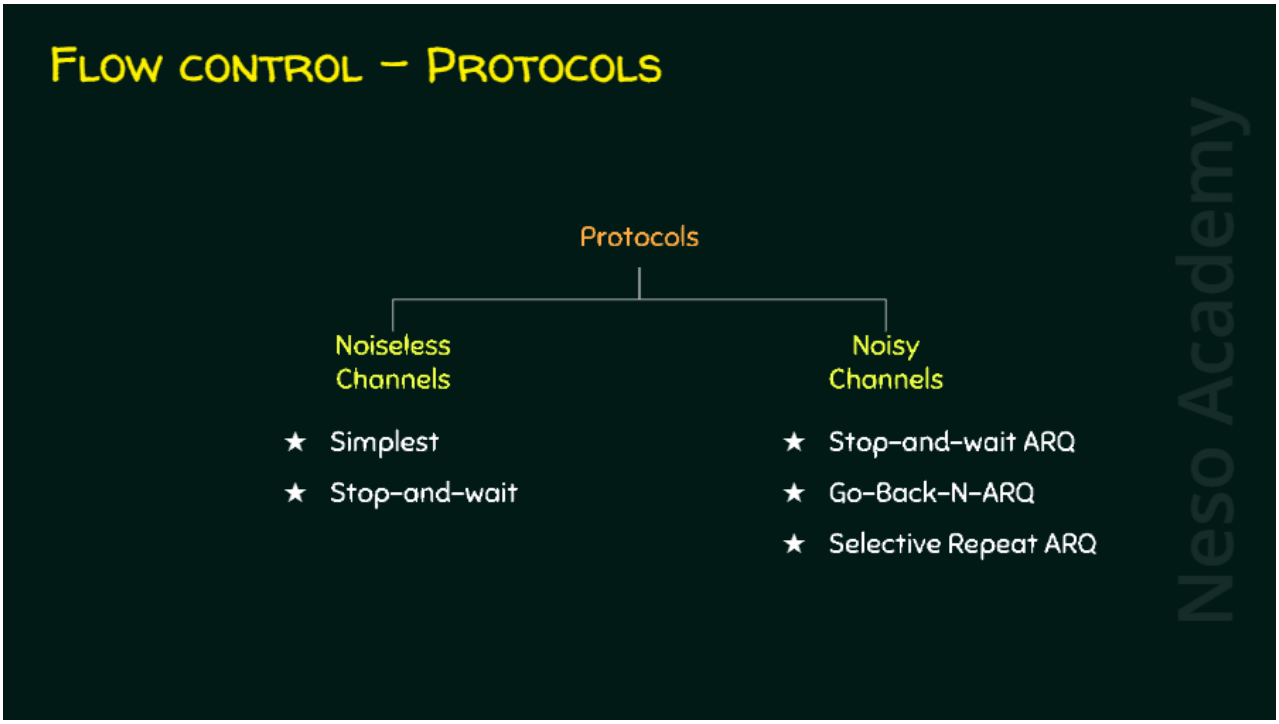
Outcomes★★★Neso Academy



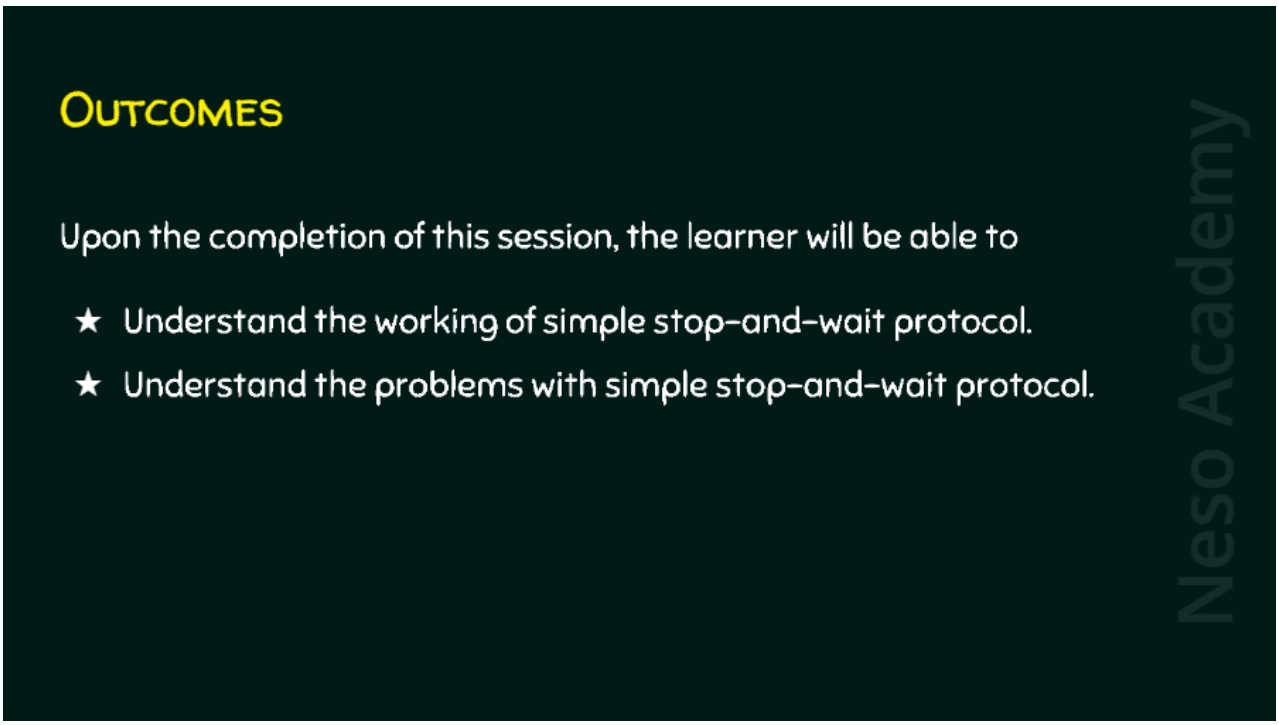
Link layer services★★★★★Neso Academy



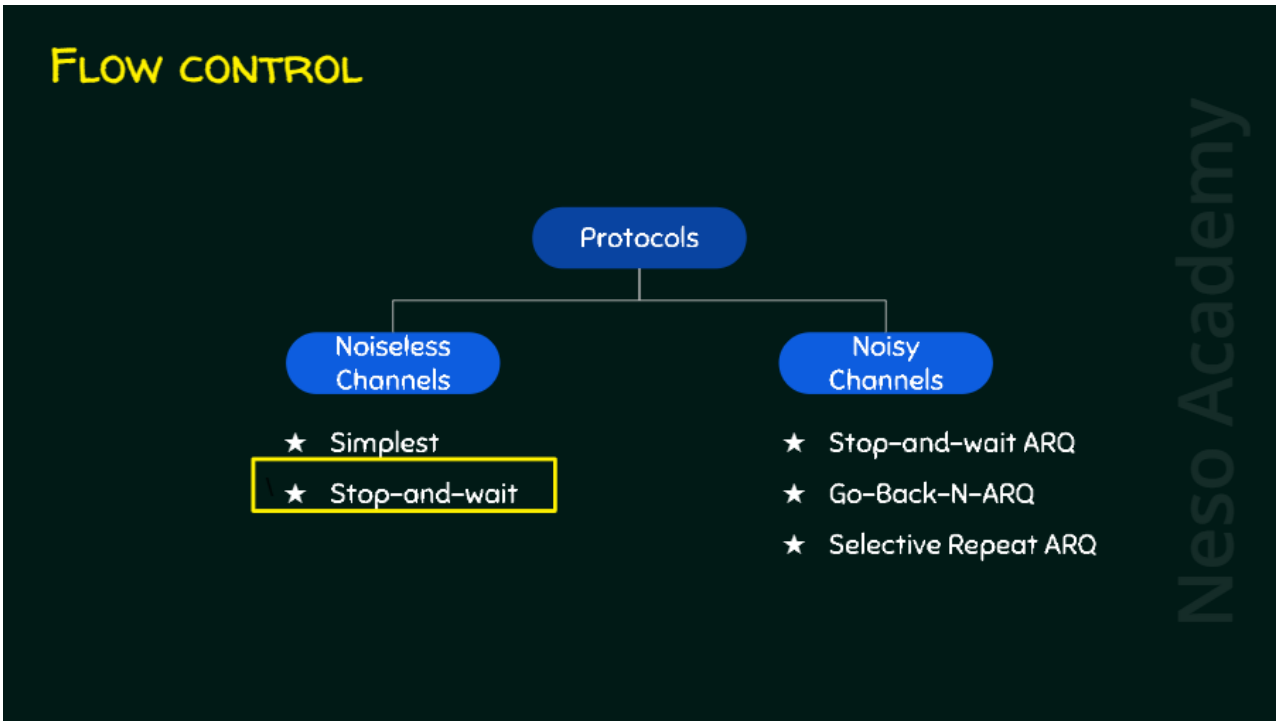
Flow control★★★★★Neso Academy



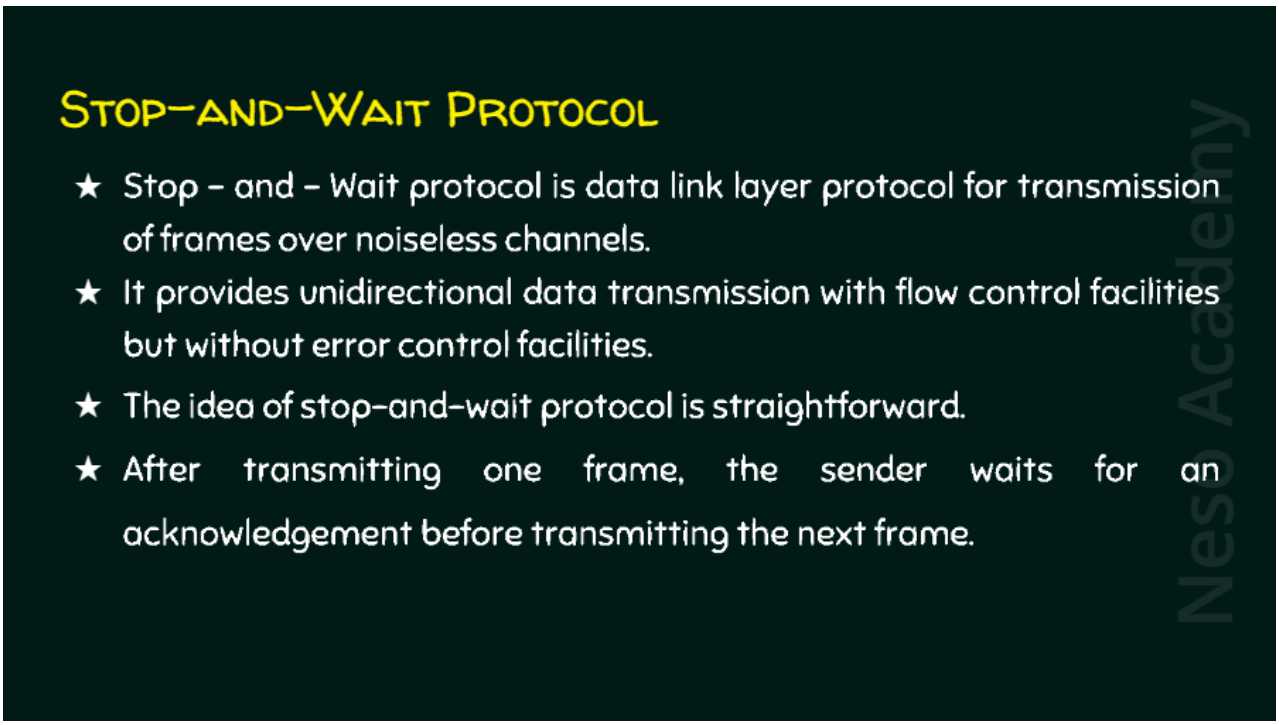
Flow control -Protocols★★★★★Neso Academy



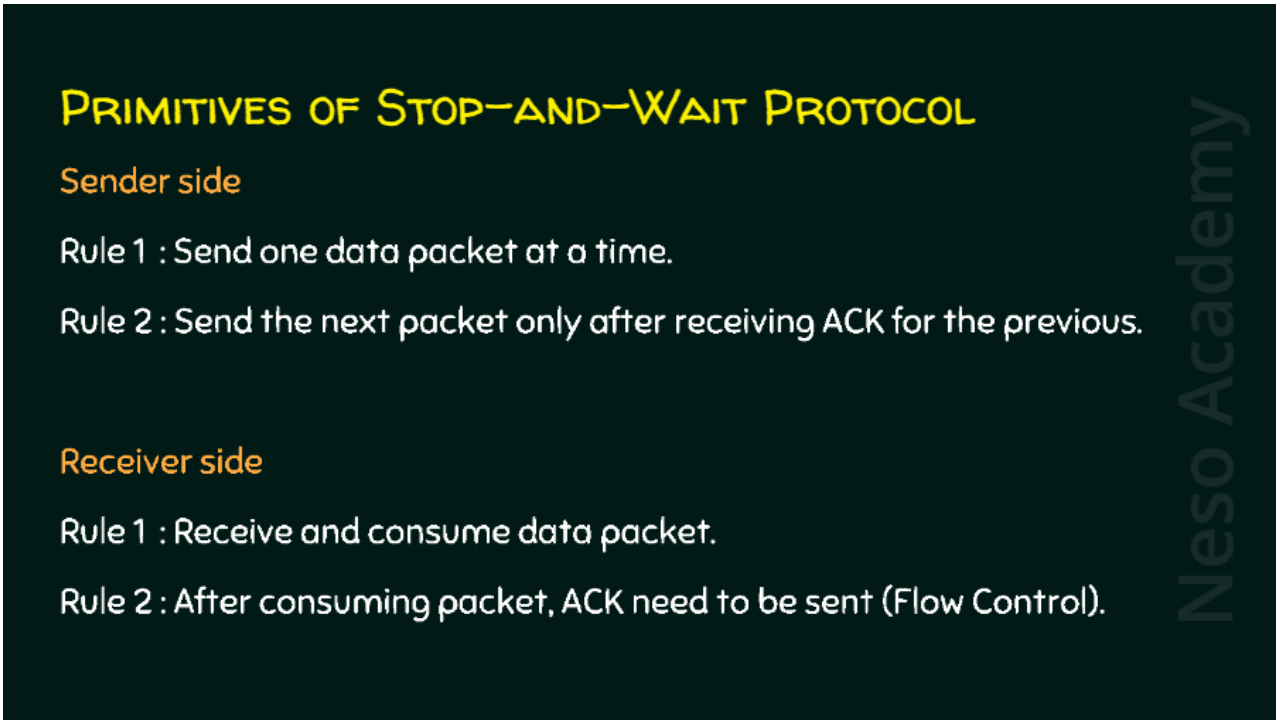
Outcomes★★Neso Academy



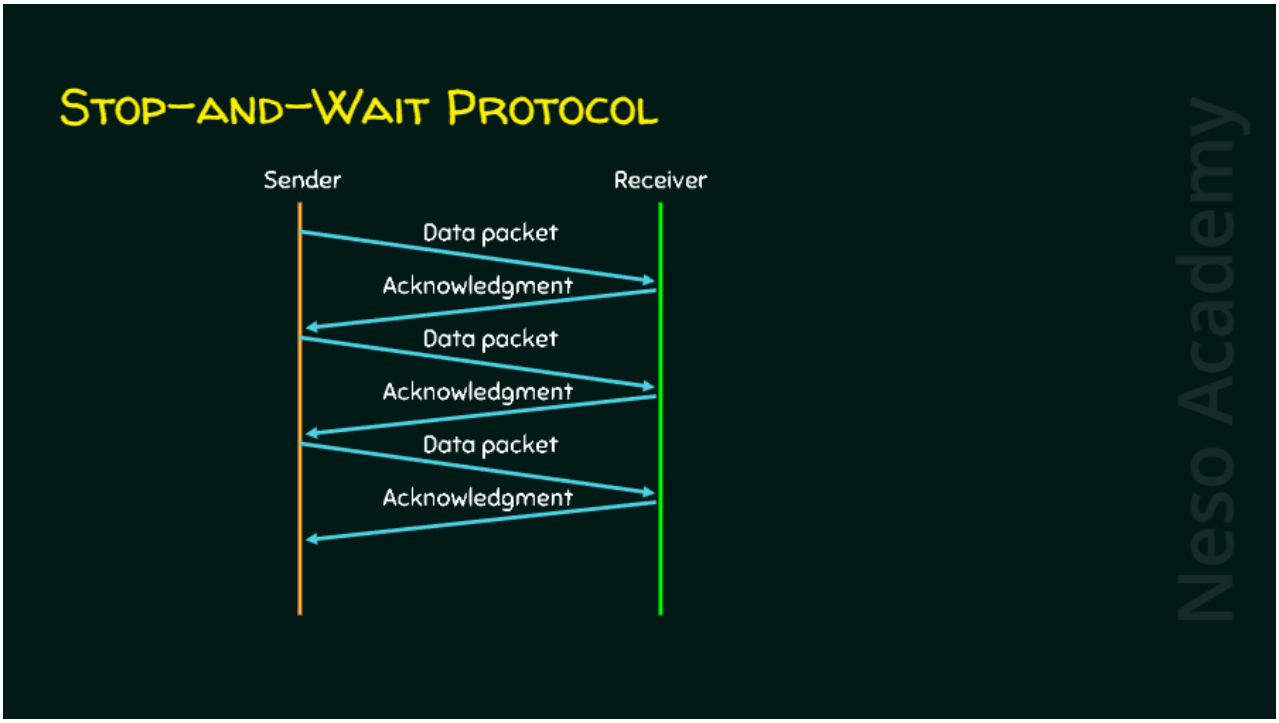
Flow control★★★★★\Neso Academy



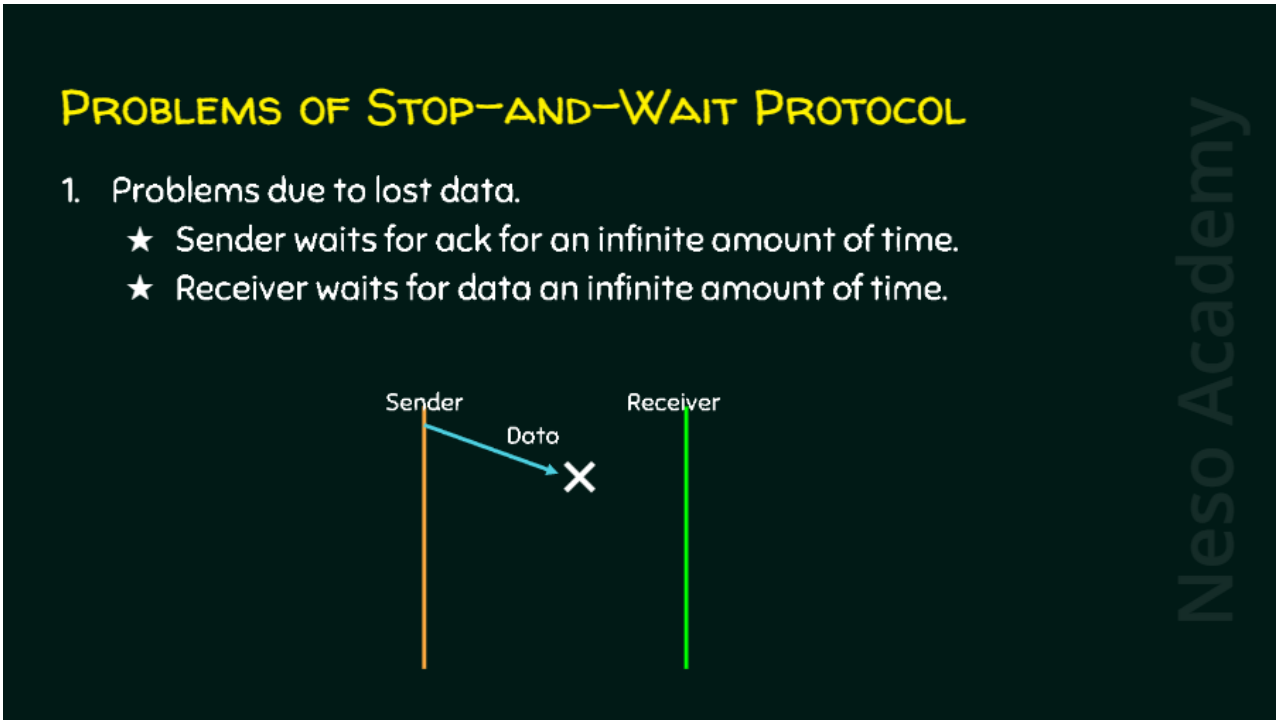
Stop-and-Wait Protocol★★★★Neso Academy



Primitives of Stop-and-Wait ProtocolNeso Academy



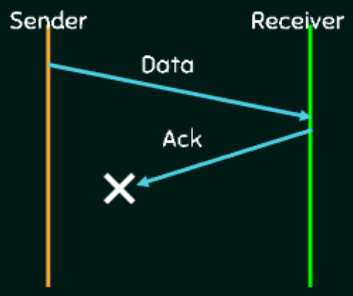
Stop-and-Wait ProtocolNeso Academy



Problems of Stop-and-Wait Protocol ❌ ★★Neso Academy

Problems of Stop-and-Wait Protocol

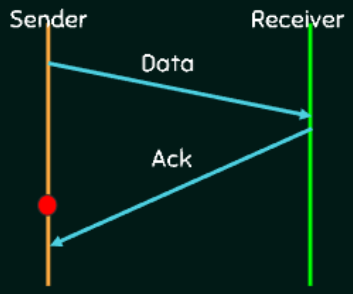
2. Problems due to lost ACK.
   - ★ Sender waits for an infinite amount of time for ack.



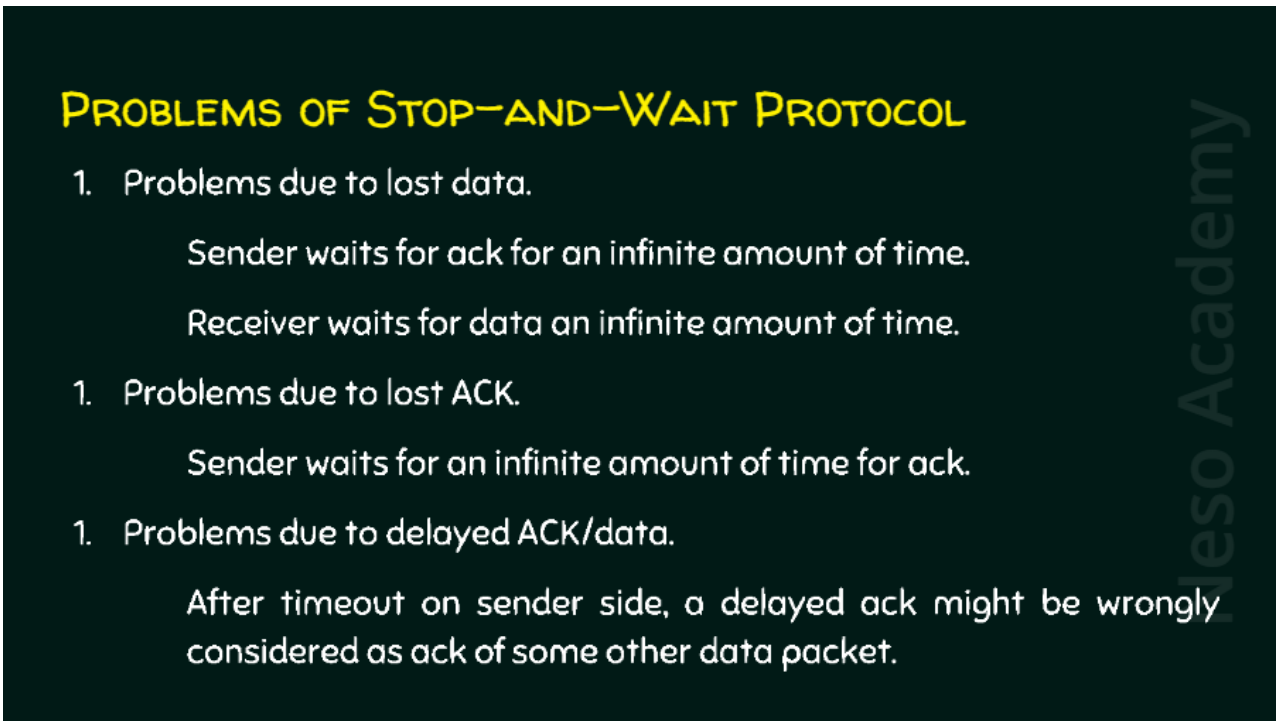
Problems of Stop-and-Wait Protocol ❌ ★Neso Academy

Problems of Stop-and-Wait Protocol

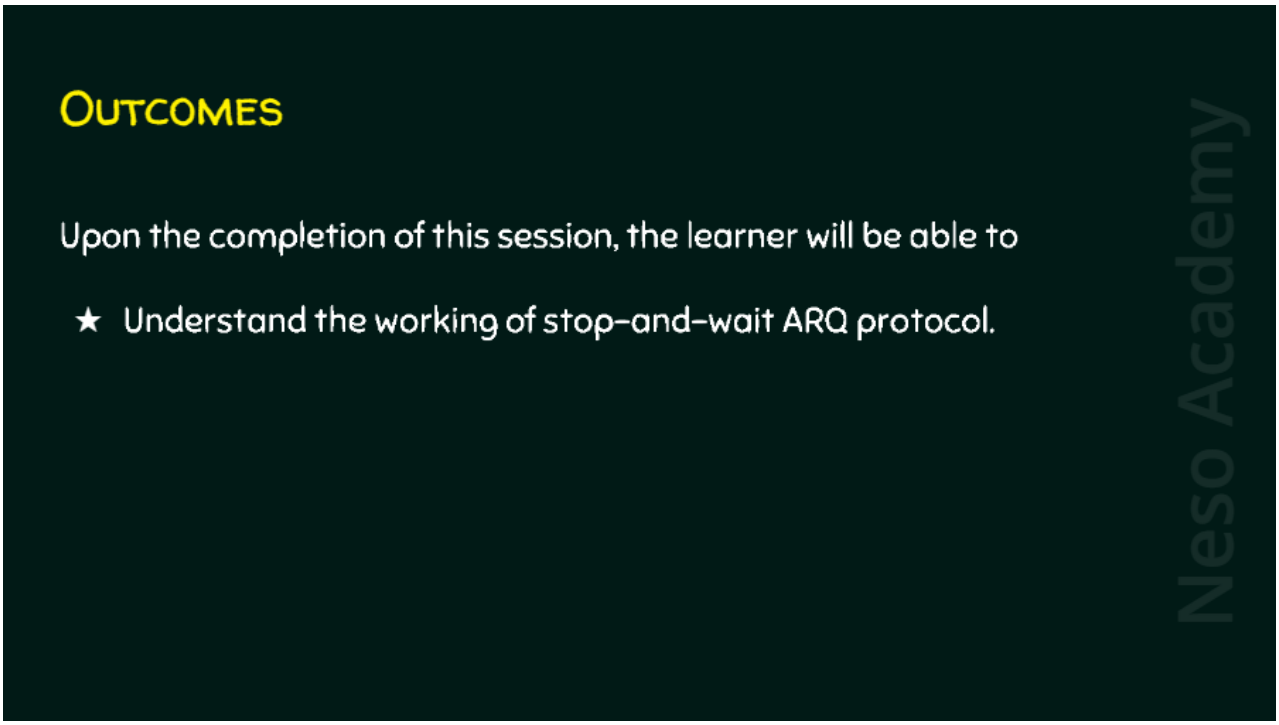
3. Problems due to delayed ACK/data.
   - ★ After timeout on sender side, a delayed ack might be wrongly considered as ack of some other data packet.



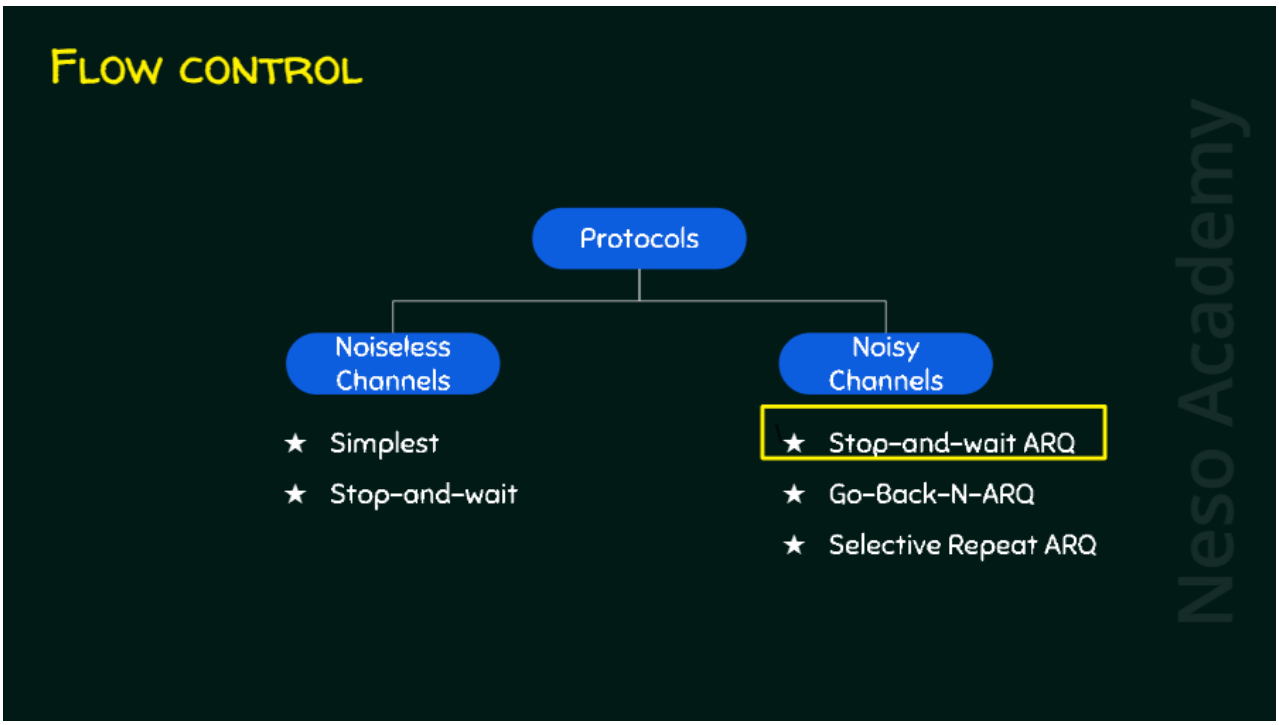
Problems of Stop-and-Wait Protocol★Neso Academy



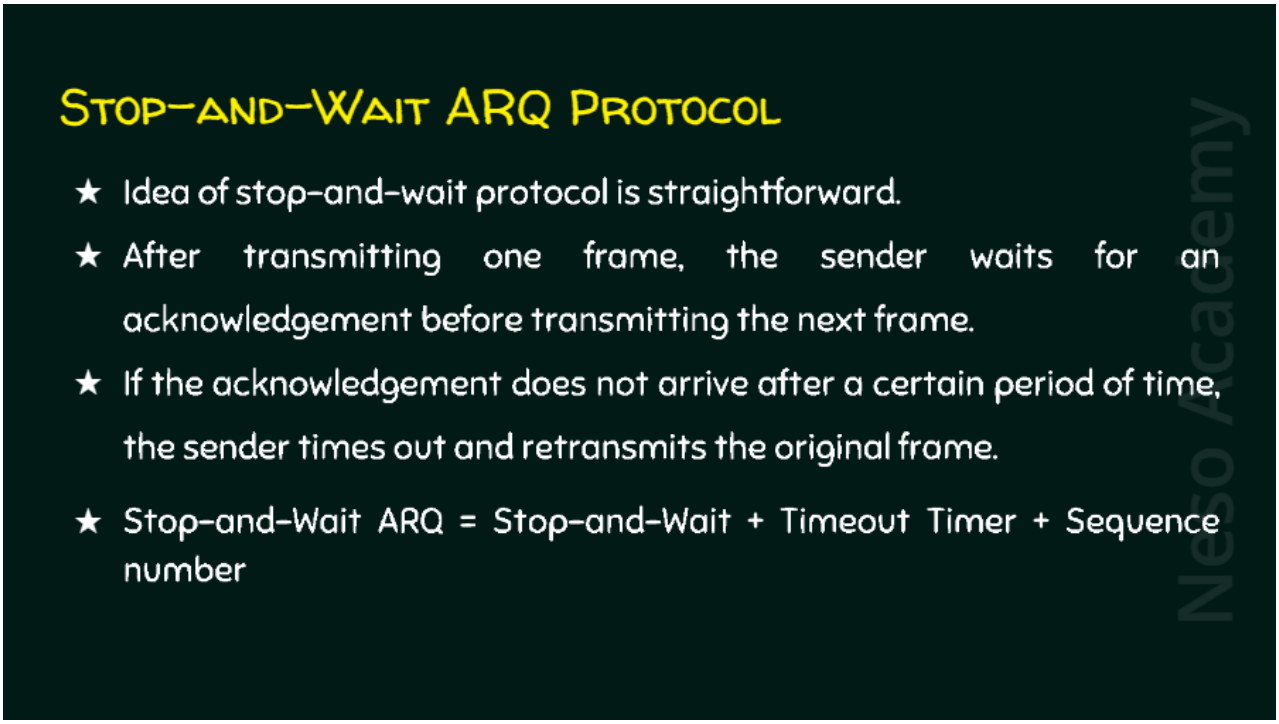
Problems of Stop-and-Wait ProtocolNeso Academy



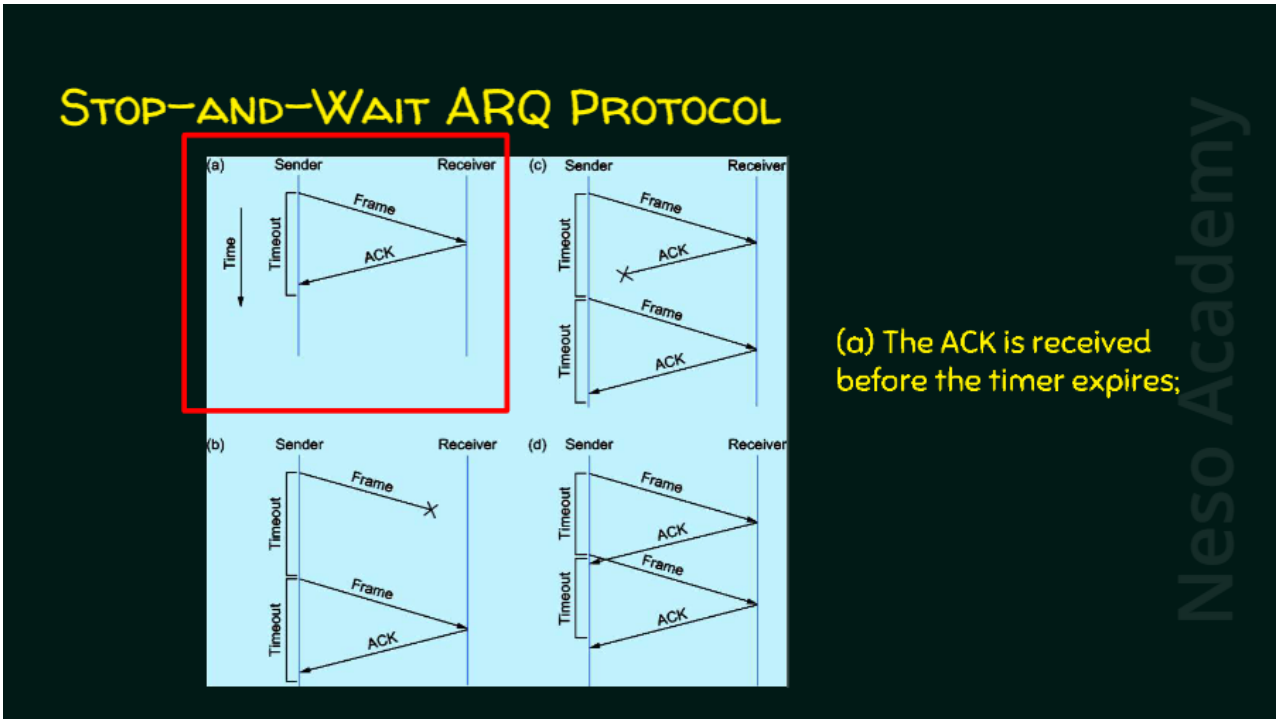
Outcomes★Neso Academy



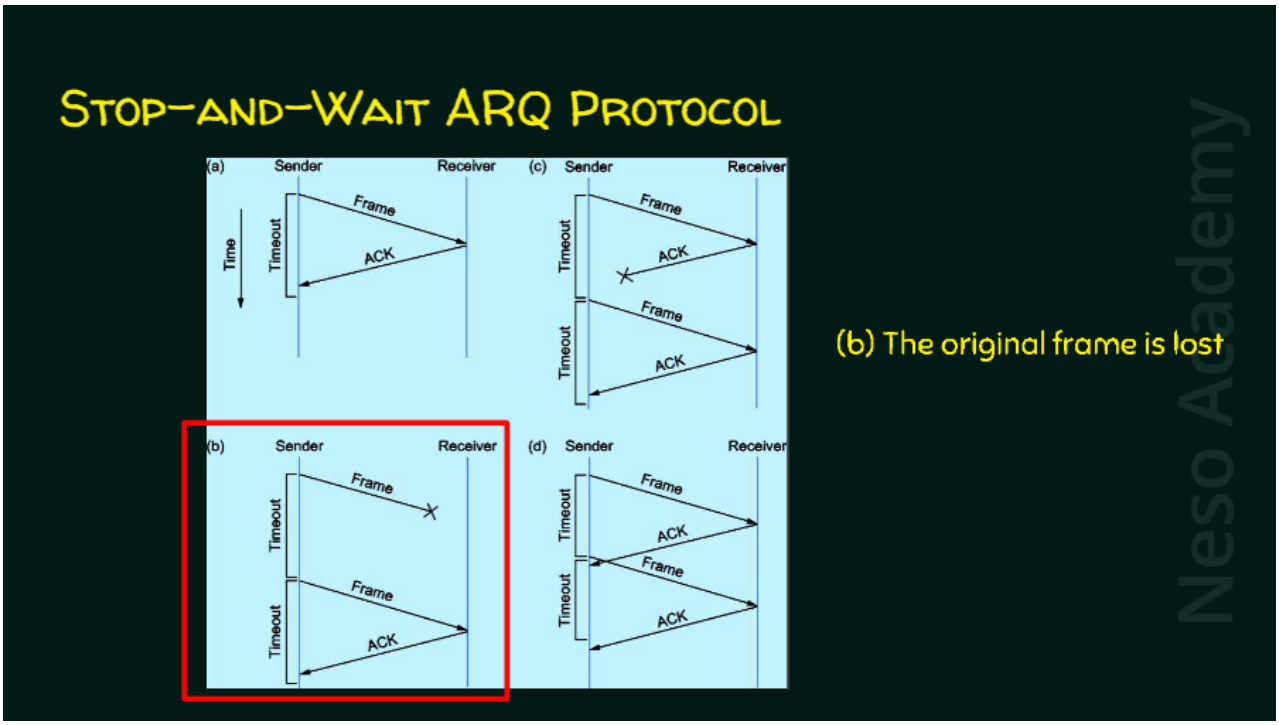
Flow control★★★★★\Neso Academy



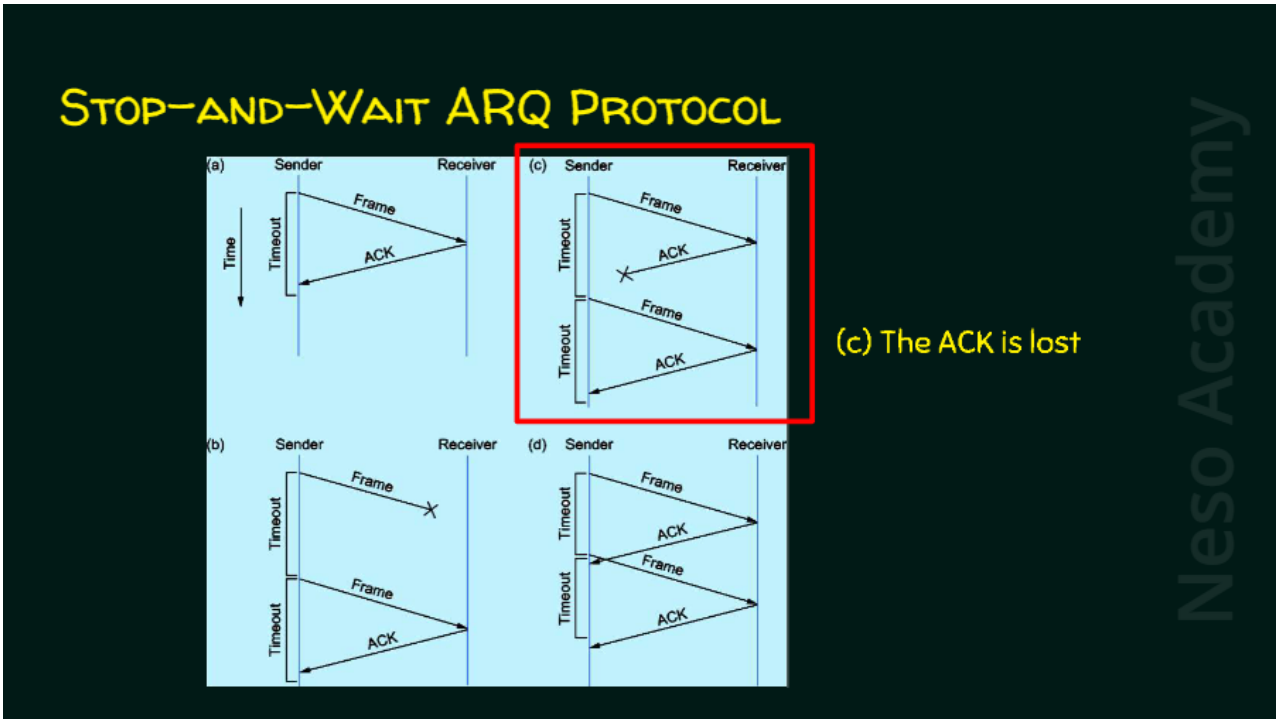
Stop-and-Wait ARQ Protocol★★★★Neso Academy



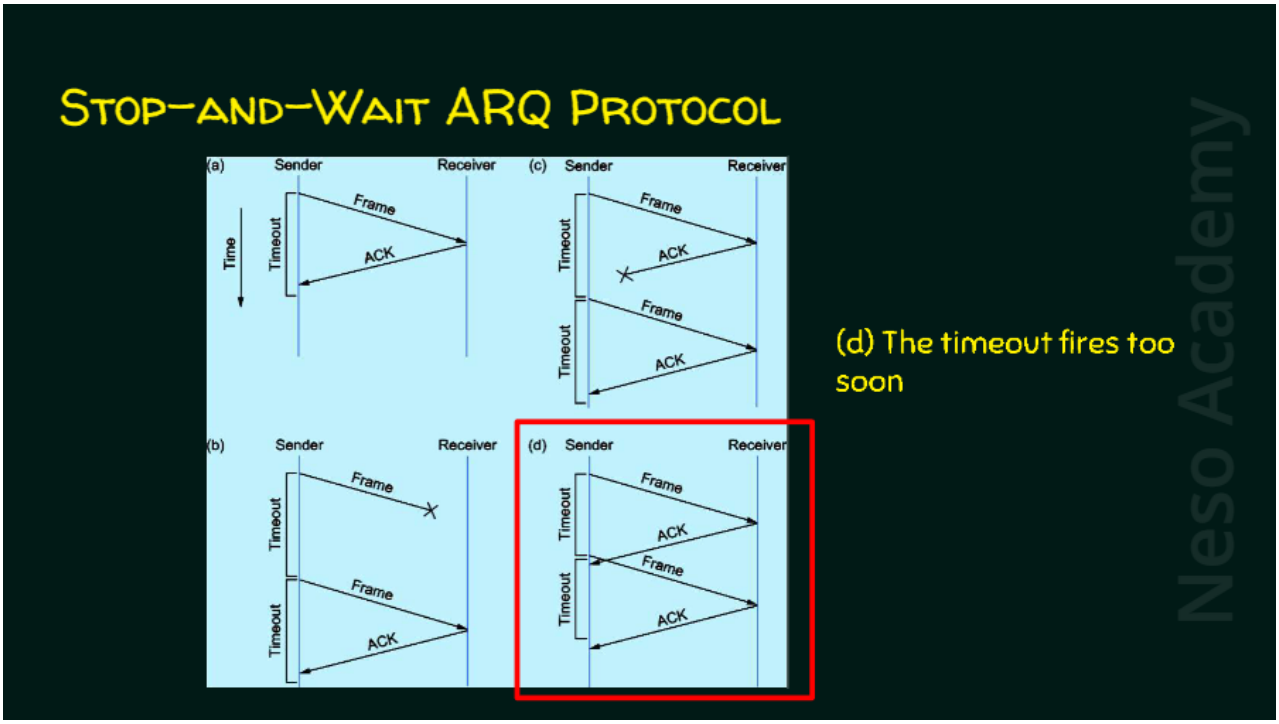
Stop-and-Wait ARQ ProtocolNeso Academy



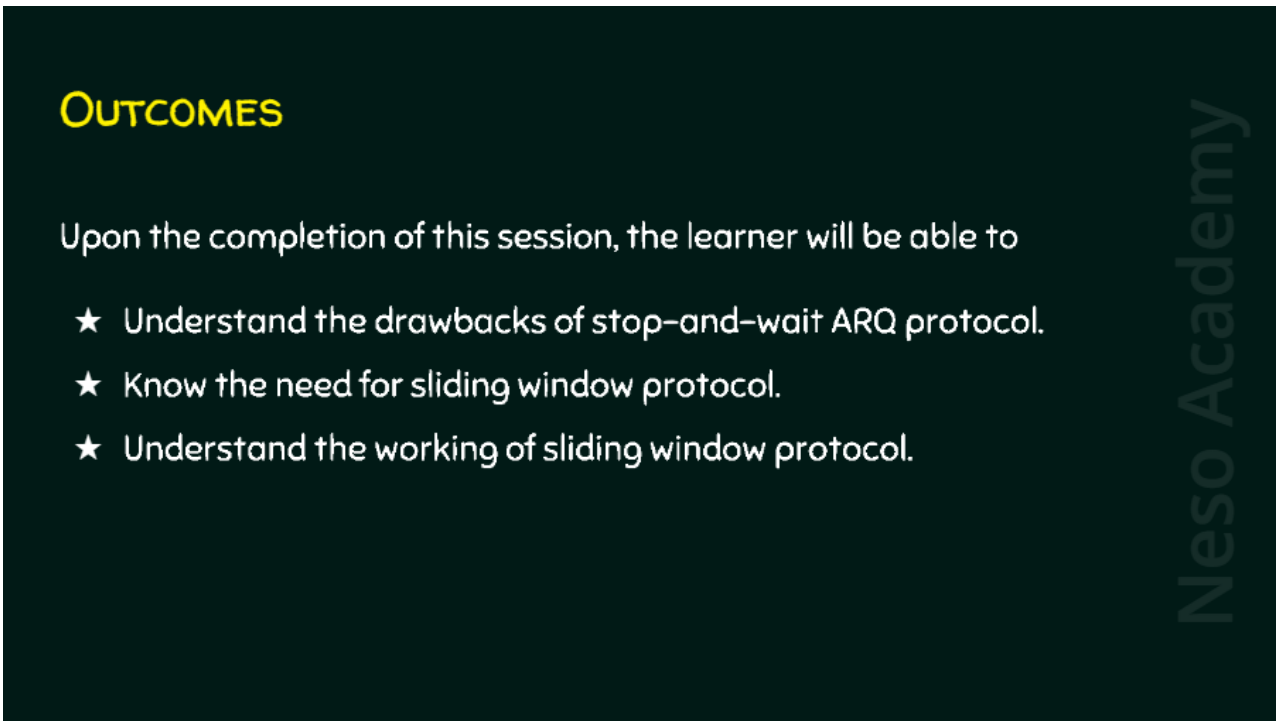
Stop-and-Wait ARQ ProtocolNeso Academy



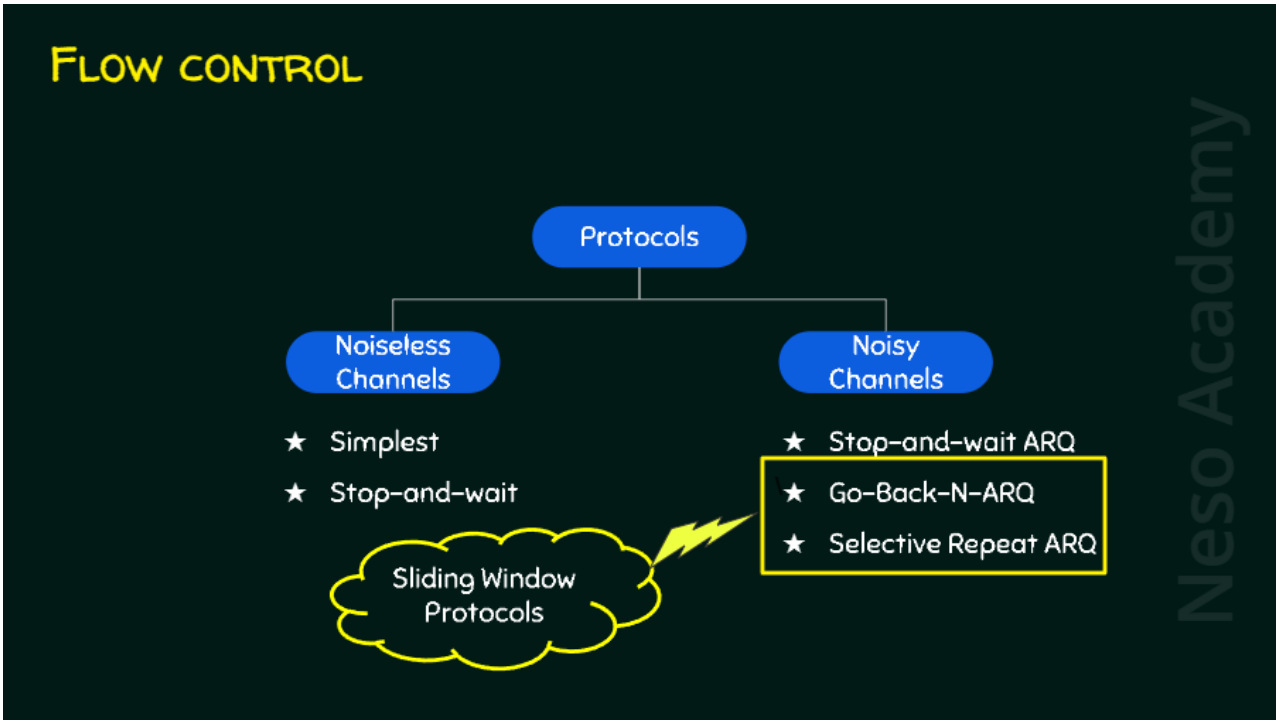
Stop-and-Wait ARQ ProtocolNeso Academy



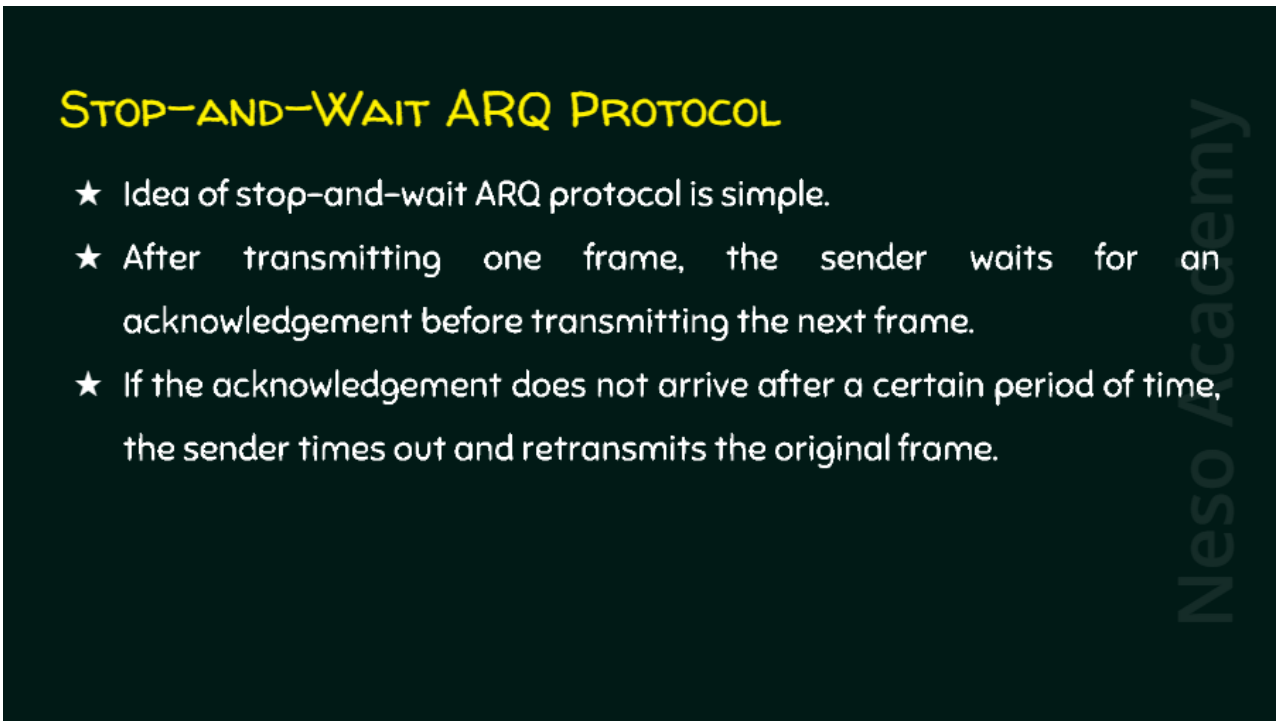
Stop-and-Wait ARQ ProtocolNeso Academy



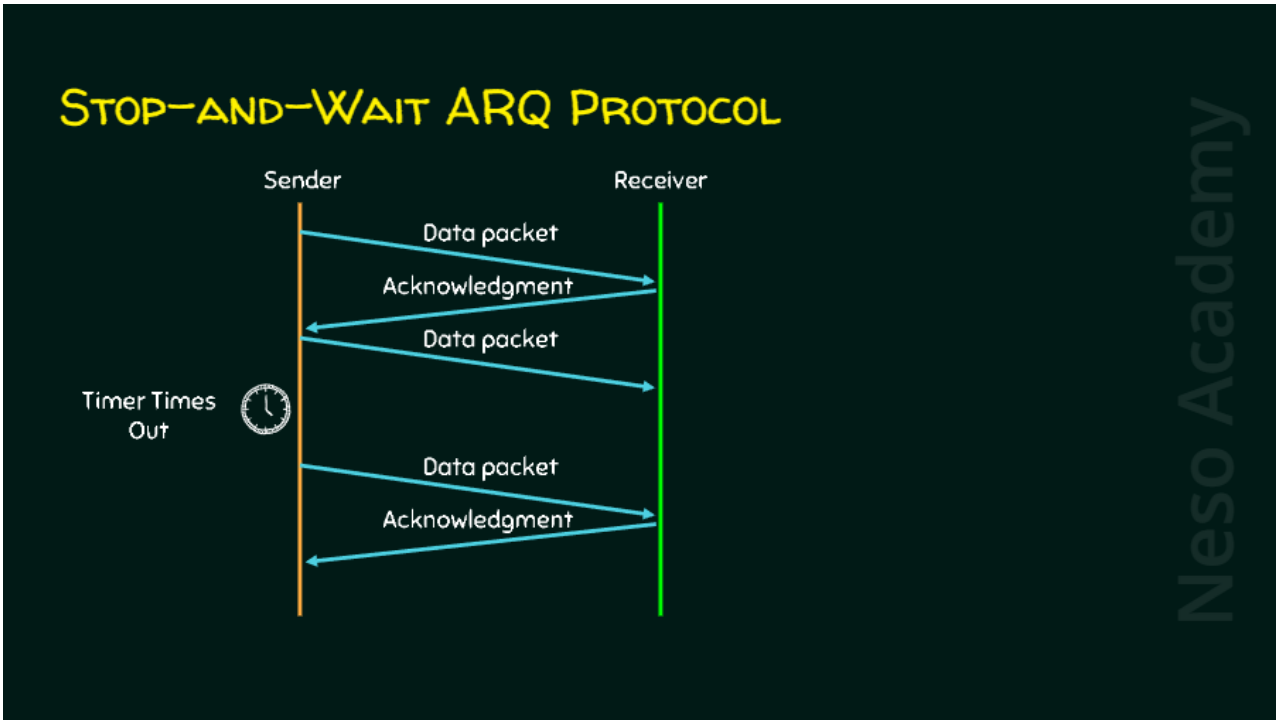
Outcomes★★★Neso Academy



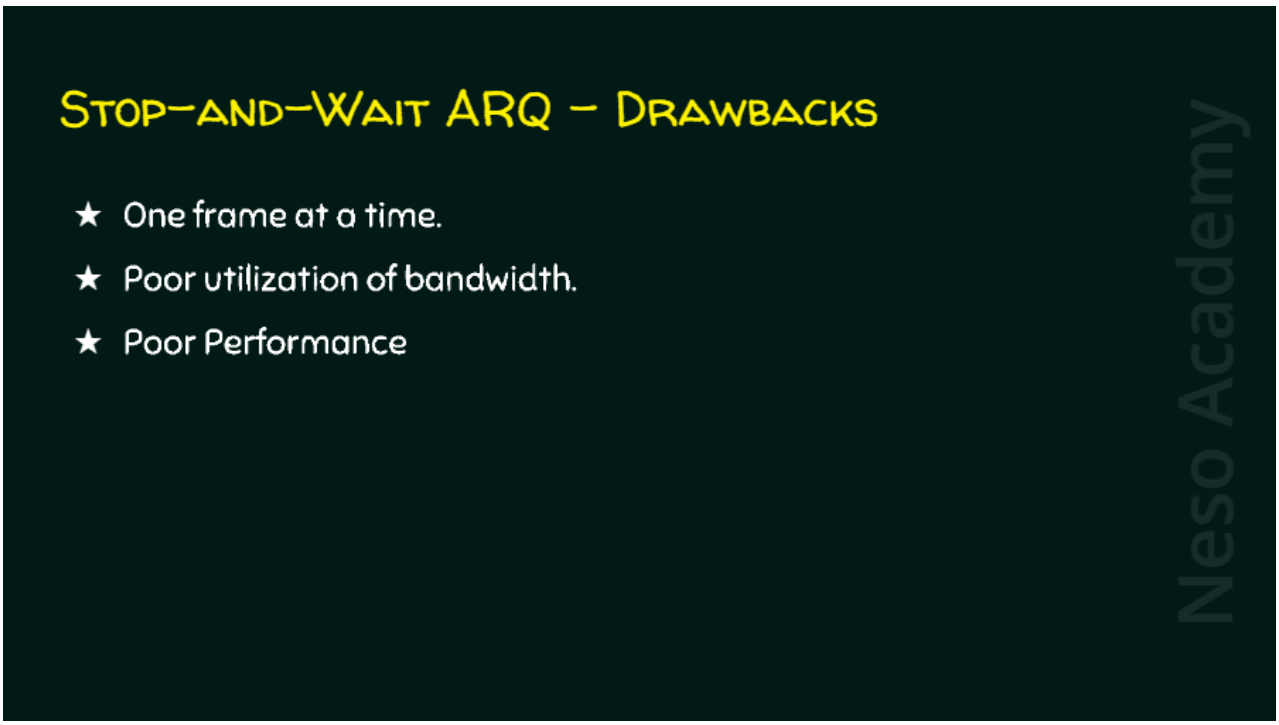
Flow control★★★★★\Neso Academy



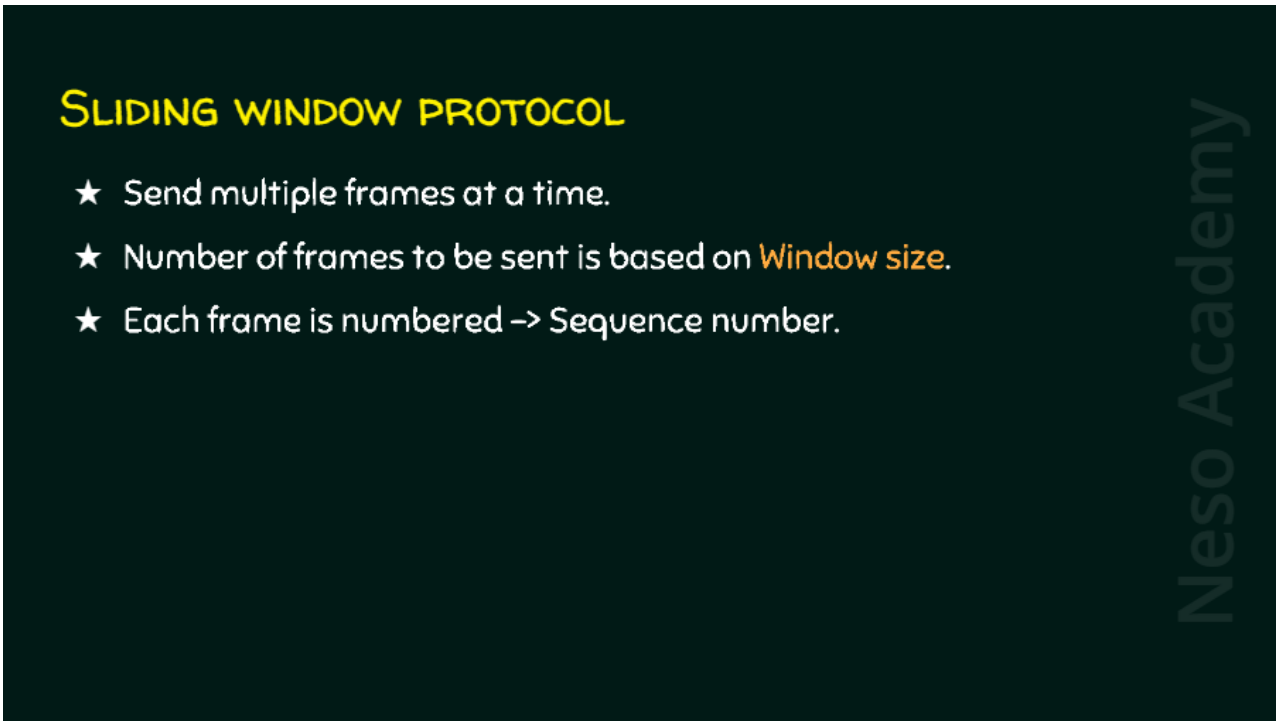
Stop-and-Wait ARQ Protocol★★★Neso Academy



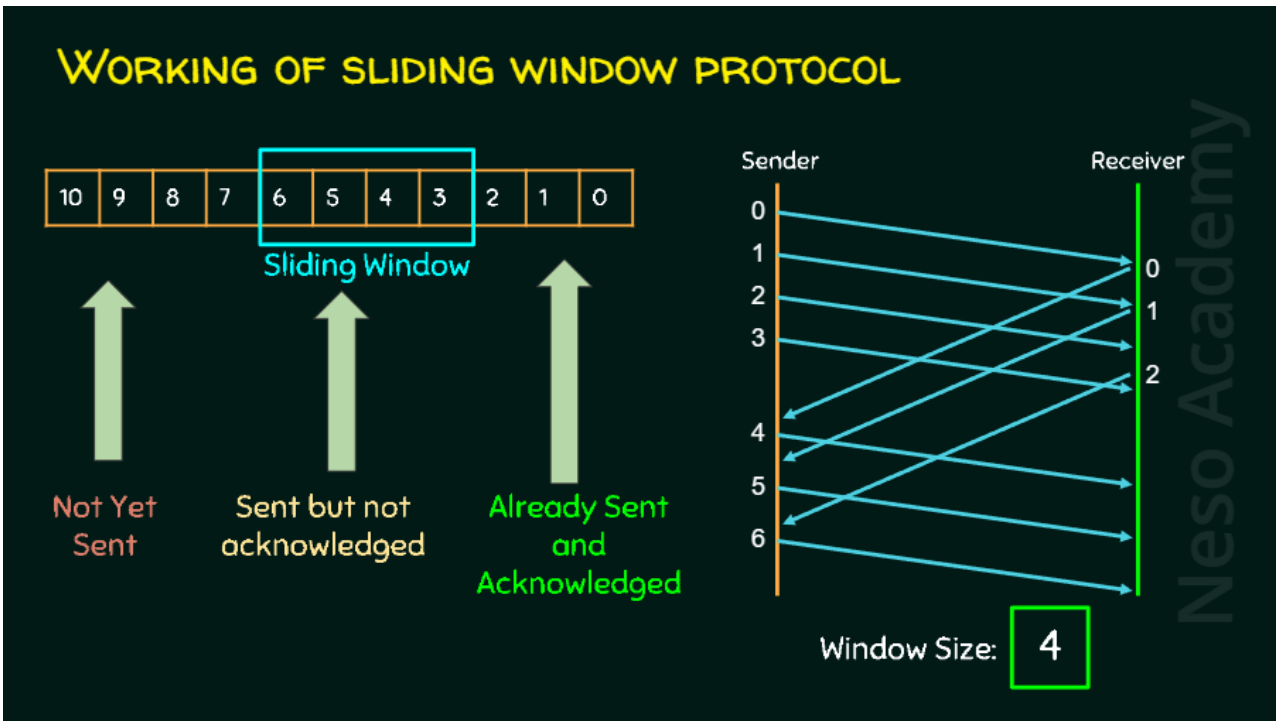
Stop-and-Wait ARQ ProtocolNeso Academy



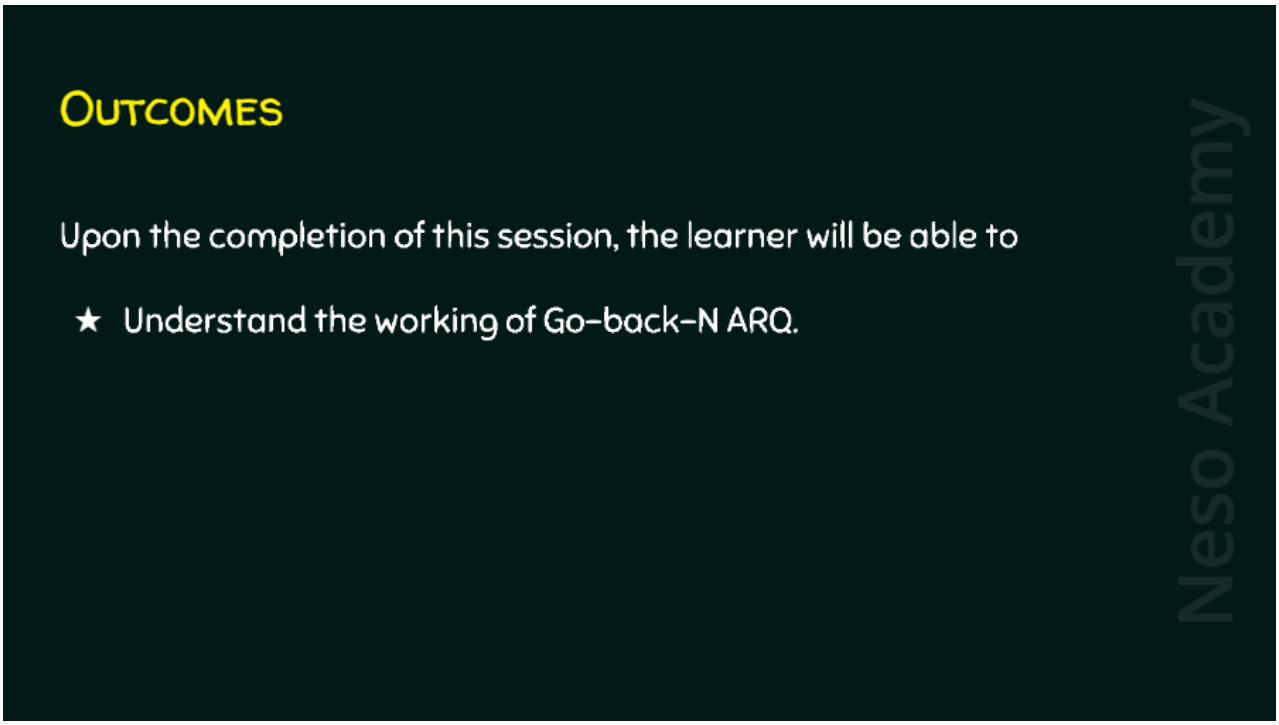
Stop-and-Wait ARQ -Drawbacks★★★Neso Academy



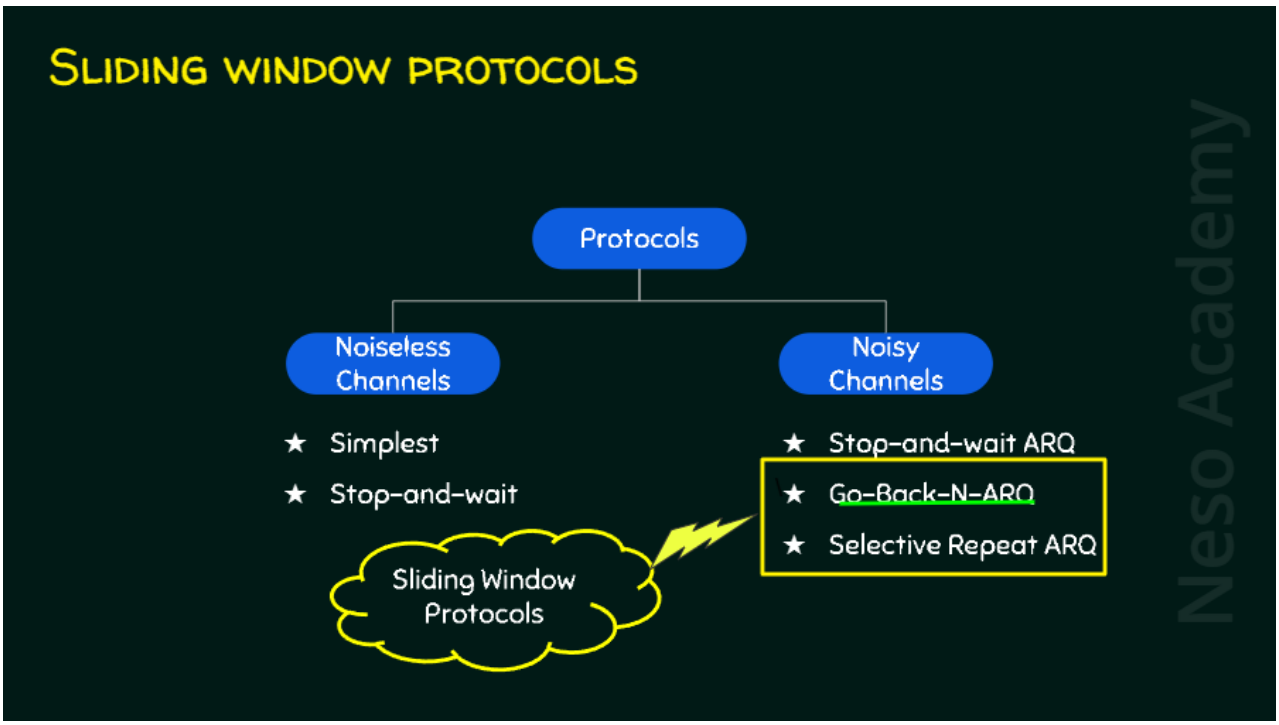
Sliding window protocol★★★Neso Academy



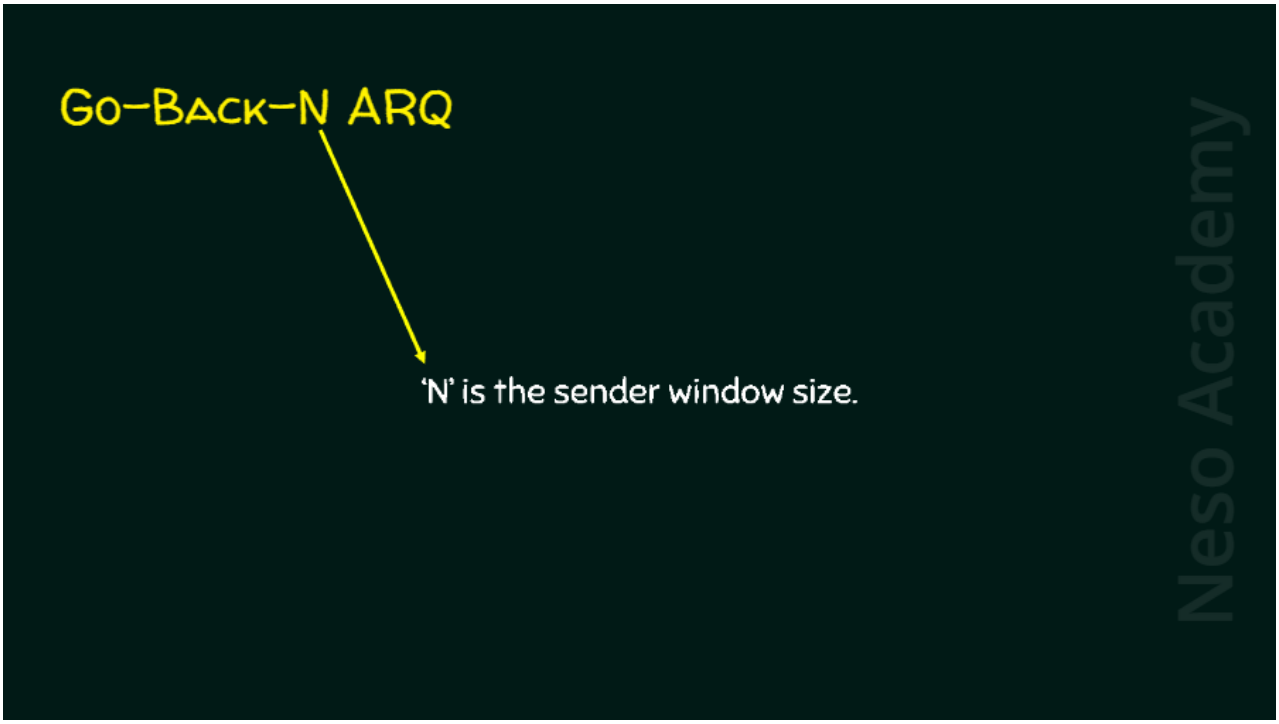
Working of sliding window protocol0132041526Neso Academy



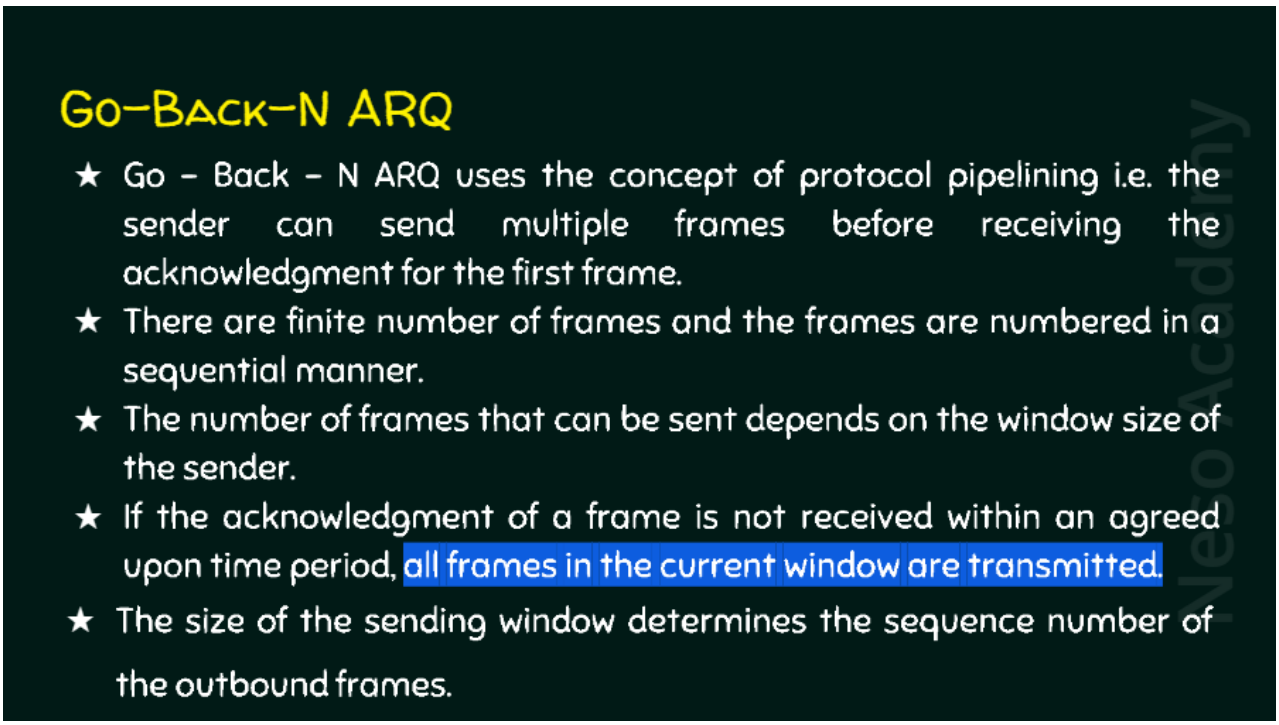
Outcomes★Neso Academy



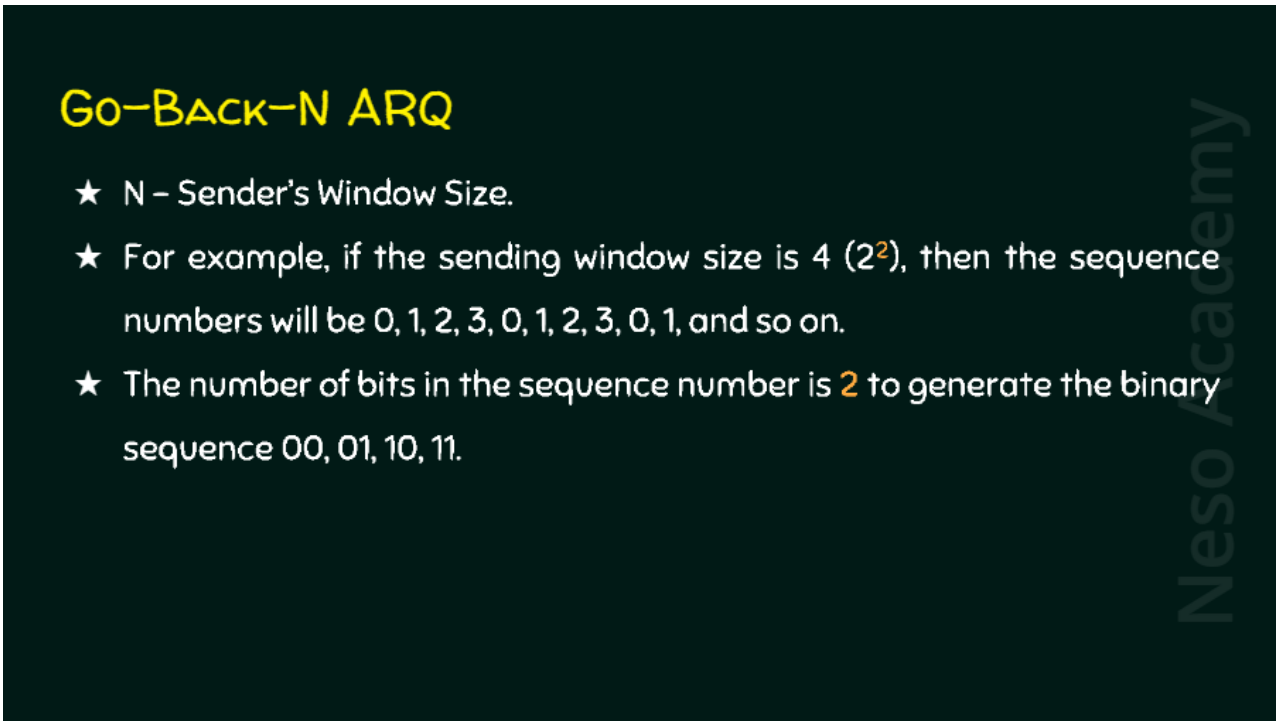
Sliding window protocols★★★★★\Neso Academy



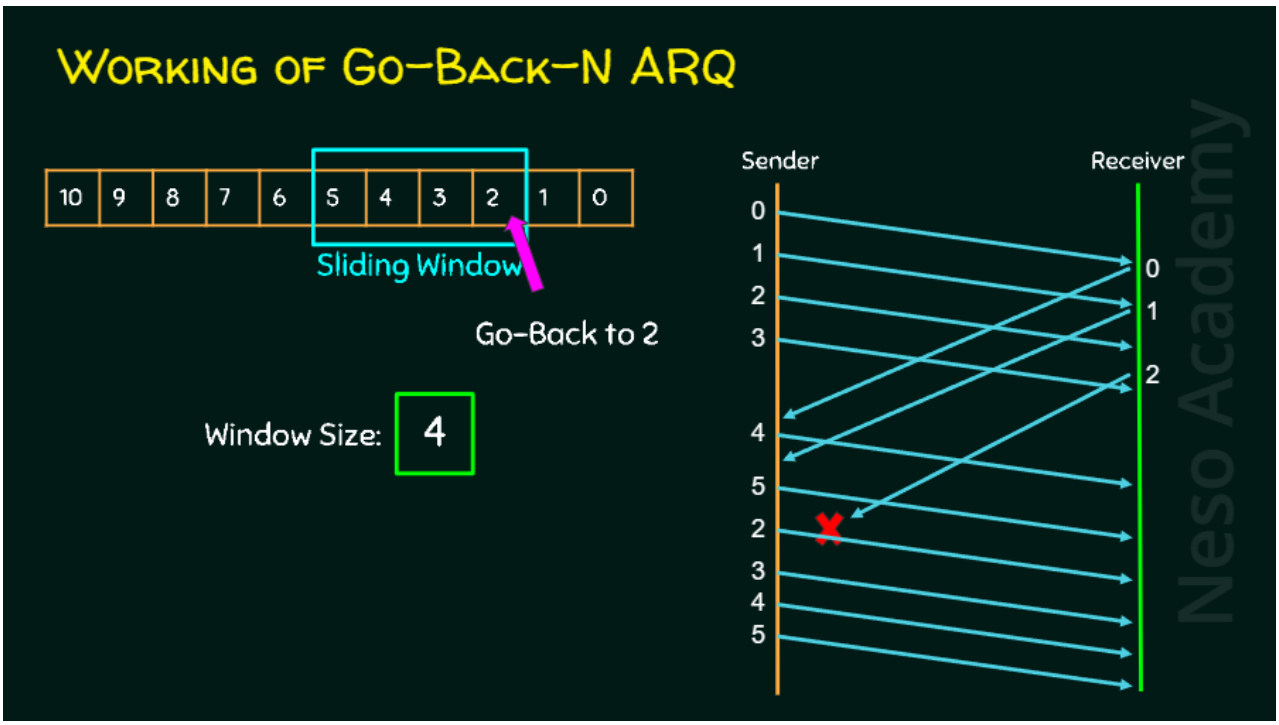
Go-Back-N ARQNeso Academy



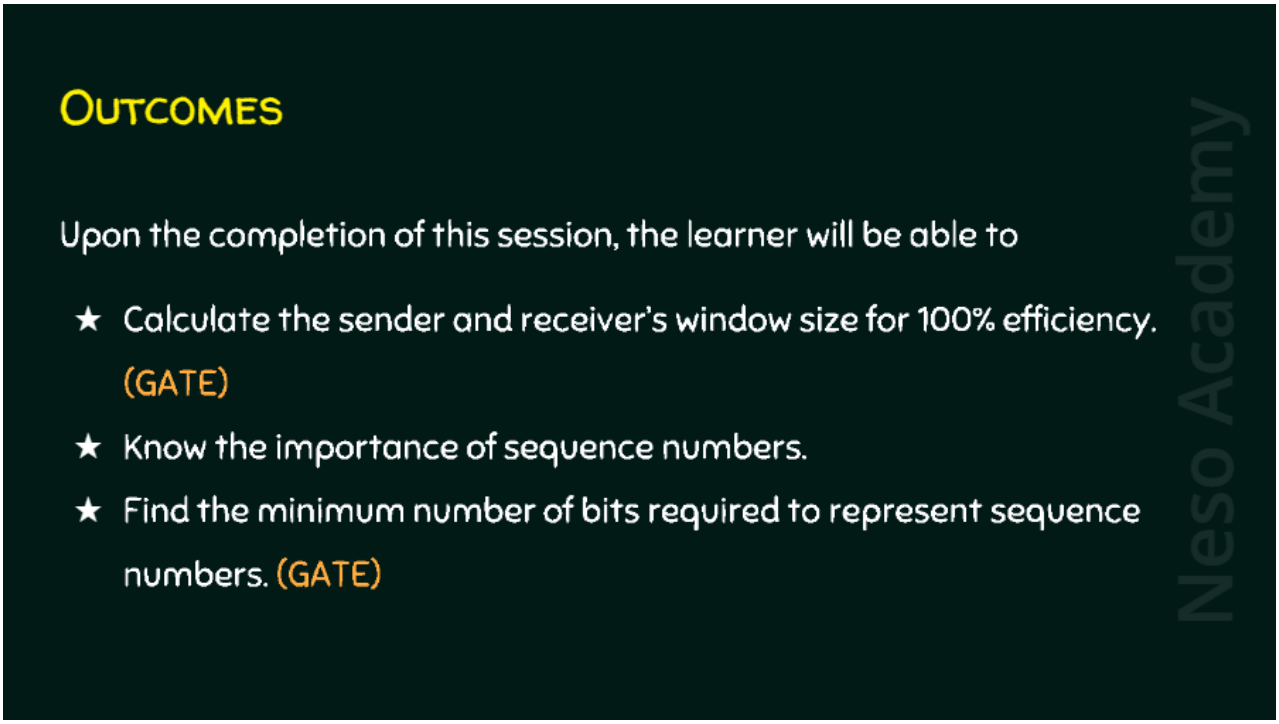
Go-Back-N ARQ★★★★★Neso Academy



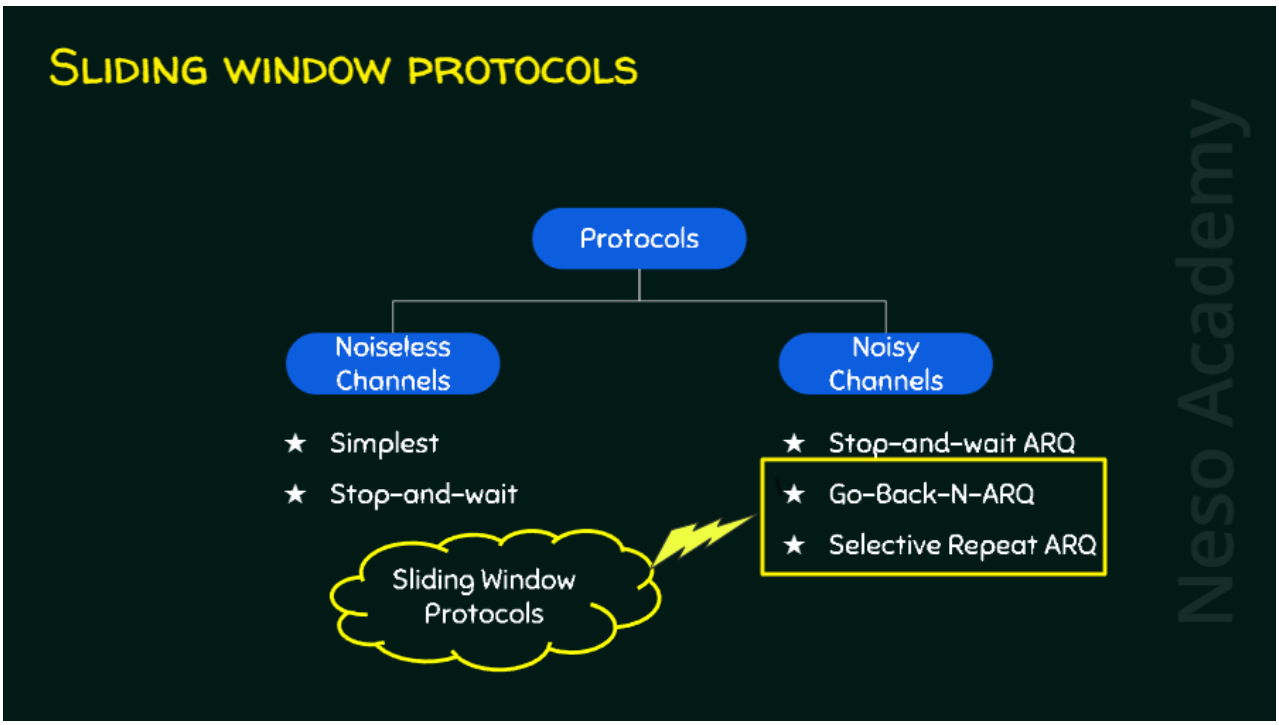
Go-Back-N ARQ★★★Neso Academy



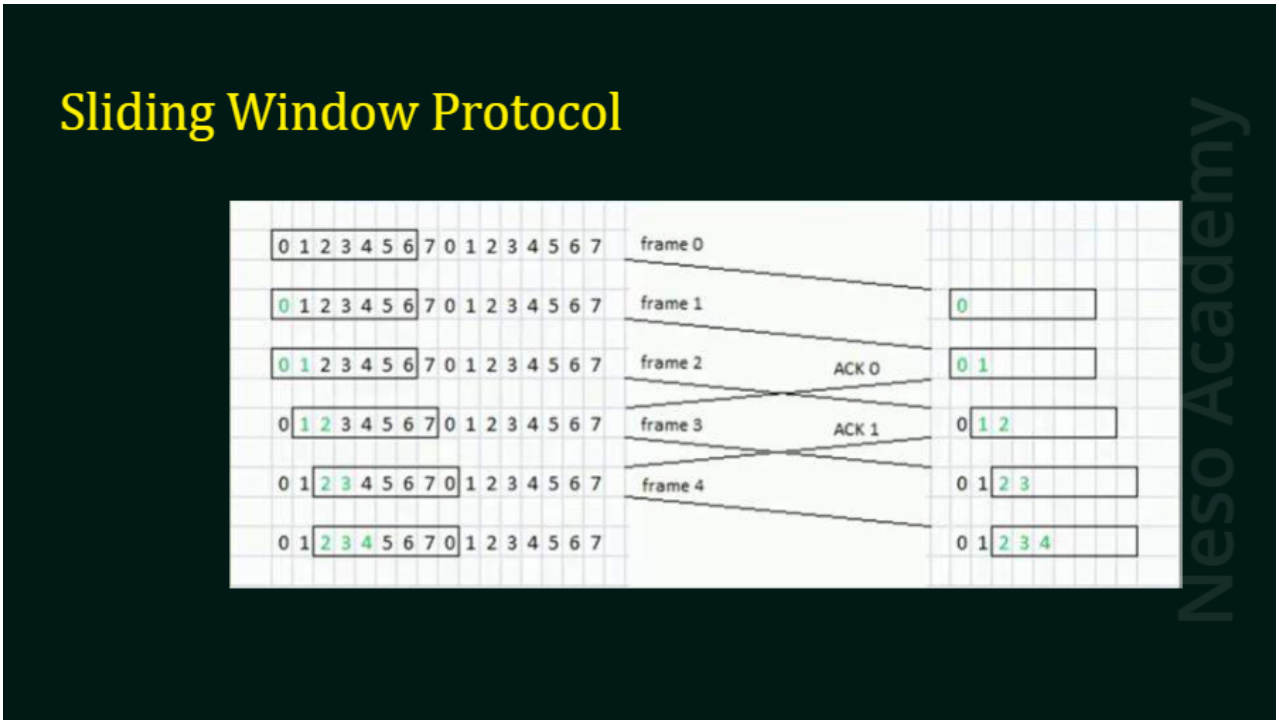
Working of Go-Back-N ARQ0132041523245Neso Academy



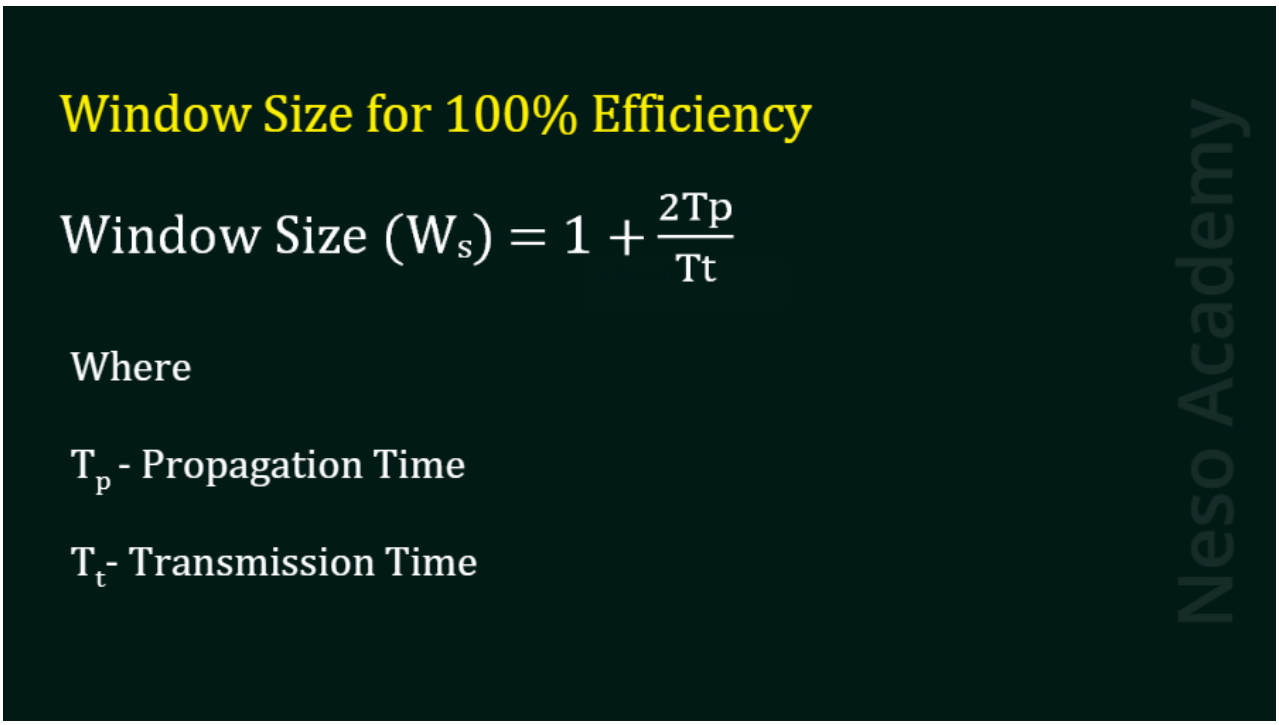
Outcomes★★★Neso Academy



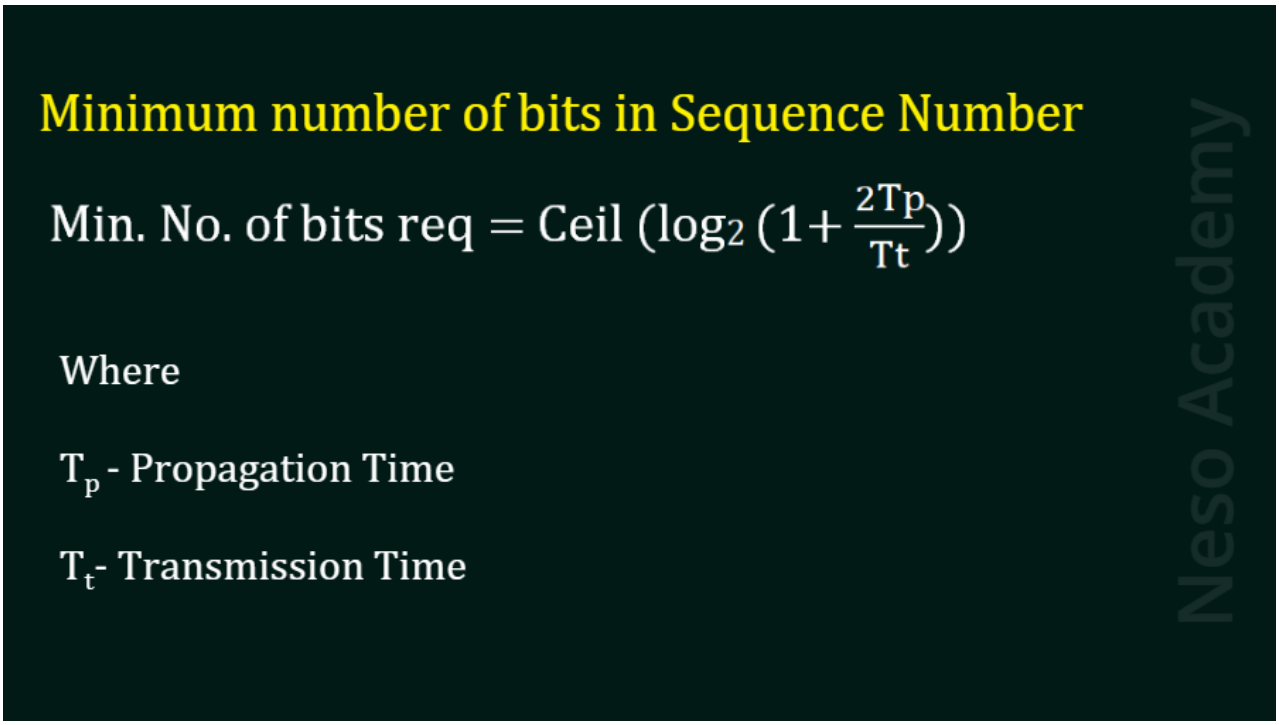
Sliding window protocols★★★★★\Neso Academy



Sliding Window ProtocolNeso Academy



Window Size for 100% EfficiencyWhereTp-PropagationTimeTt-TransmissionTimeNeso Academy



Minimum number of bits in Sequence NumberWhereTp-PropagationTimeTt-TransmissionTimeNeso Academy

Outcomes

Upon the completion of this session, the learner will be able to

★ Understand the working of Go-back-N ARQ by solving a problem asked in GATE CS 2006.

Outcomes★Neso Academy

Question

Station A needs to send a message consisting of 9 packets to station B using a sliding window (window size 3) and go-back-n error control strategy. All packets are ready and immediately available for transmission. If every 5th packet that A transmits gets lost (but no ACKs from B ever get lost), then what is the number of packets that A will transmit for sending the message to B? [GATE CS 2006]

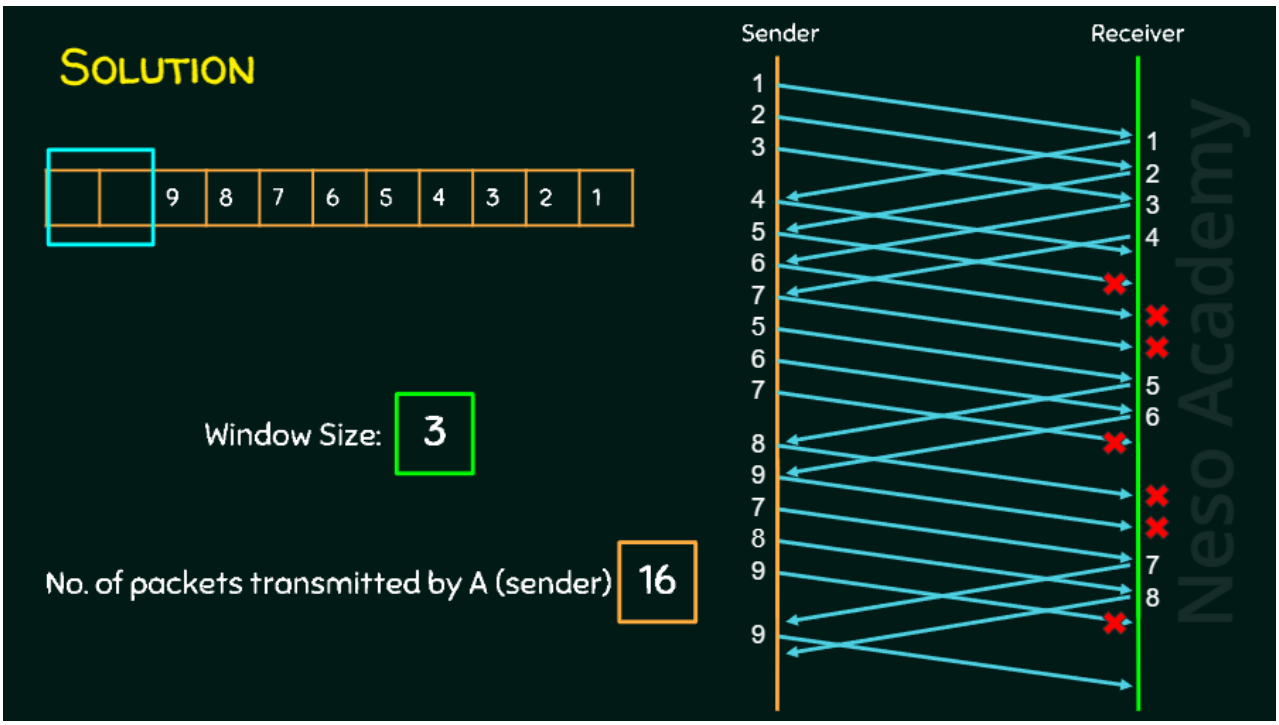
(A) 12

(B) 14

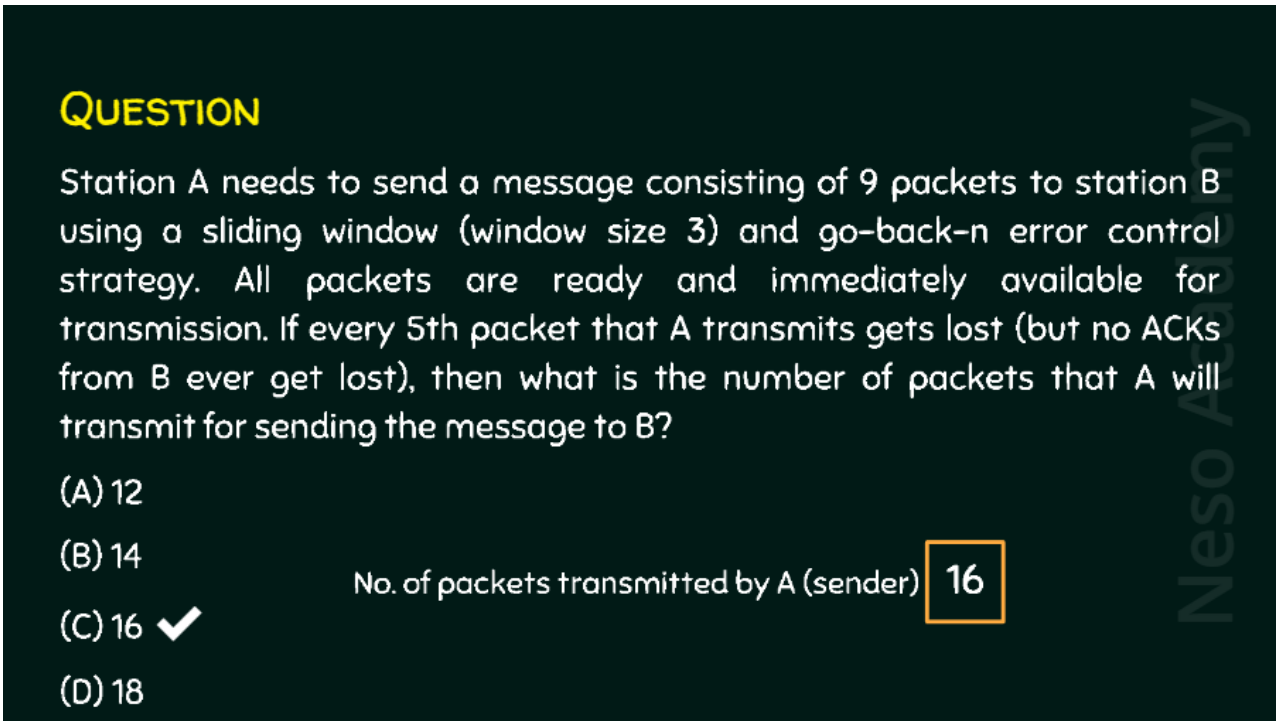
(C) 16

(D) 18

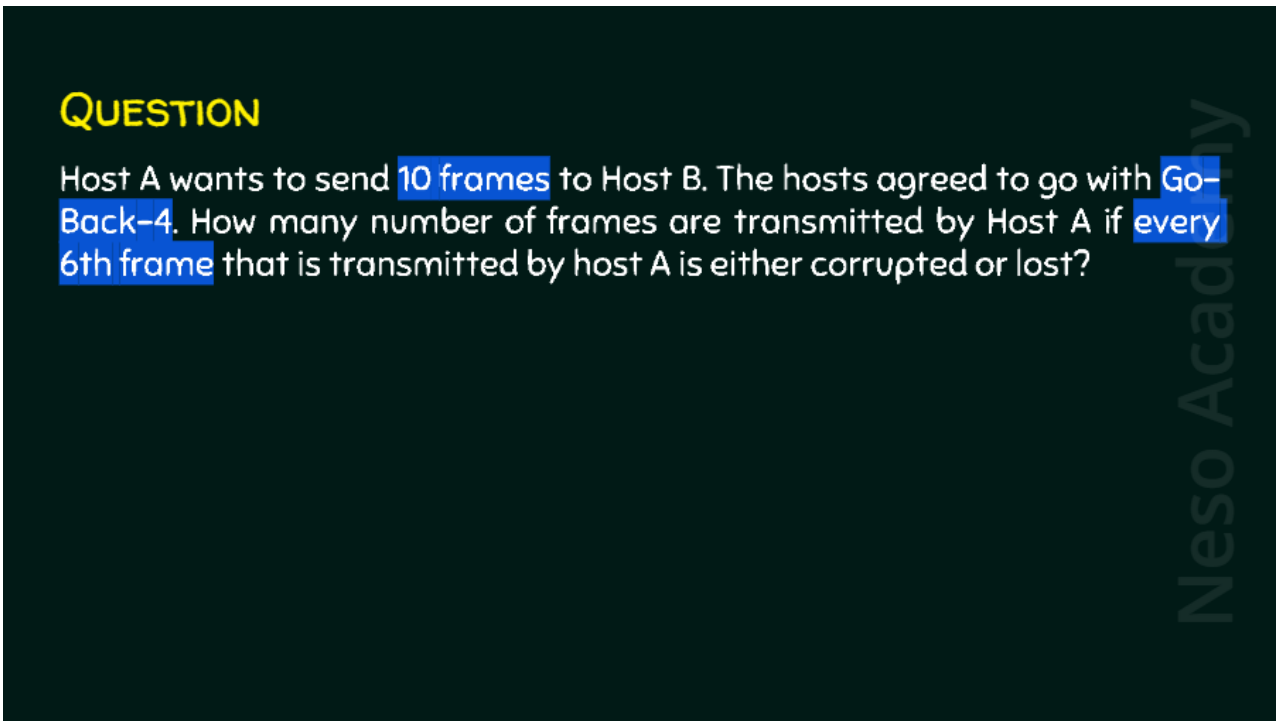
QuestionNeso Academy



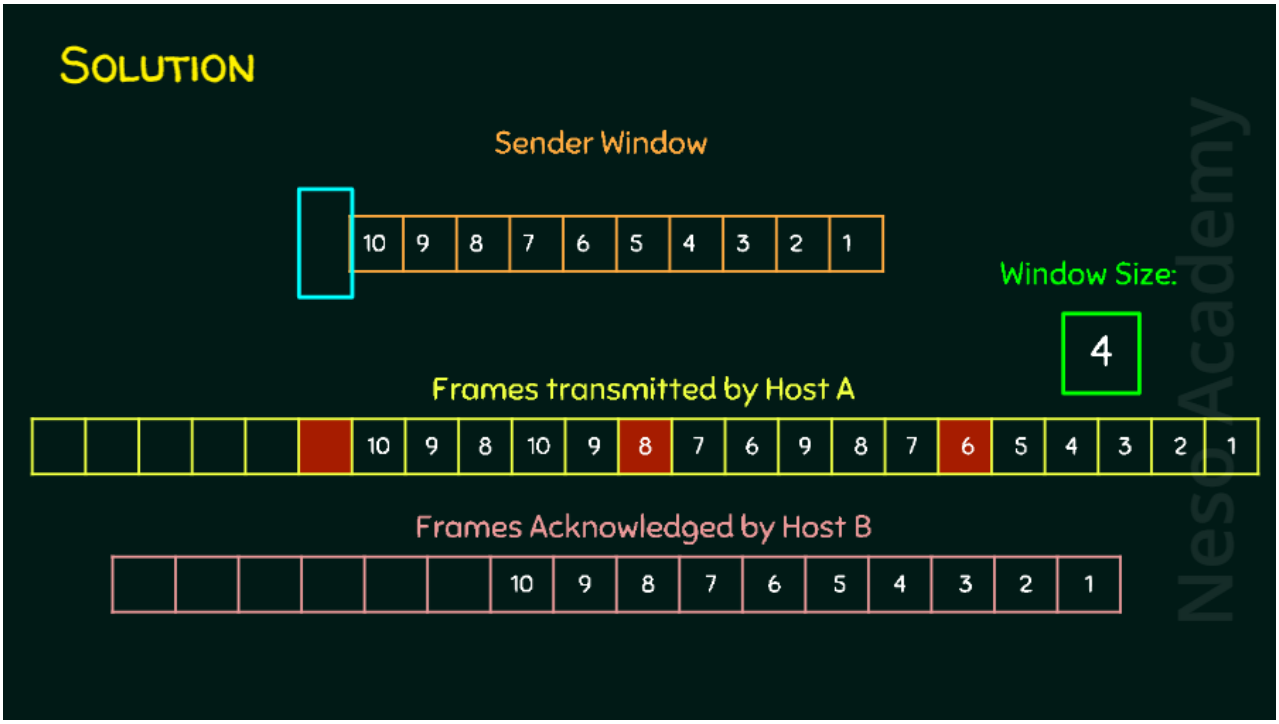
123142536475765869789789SolutionNeso Academy



Question ✔ Neso Academy



QuestionNeso Academy



SolutionNeso Academy

Question

Host A wants to send 10 frames to Host B. The hosts agreed to go with Go-Back-4. How many number of frames are transmitted by Host A if every 6th frame that is transmitted by host A is either corrupted or lost?

Answer

Number of frames transmitted by Host A: 17

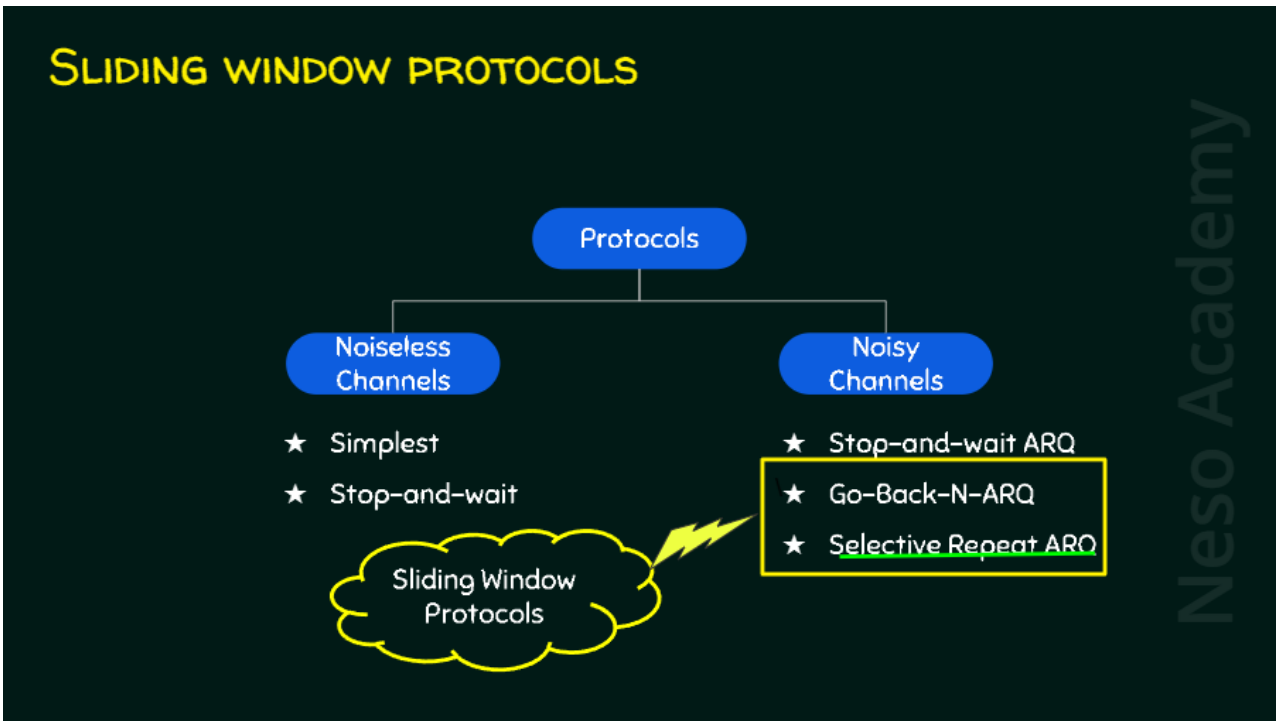
QuestionAnswer Neso Academy

Outcomes

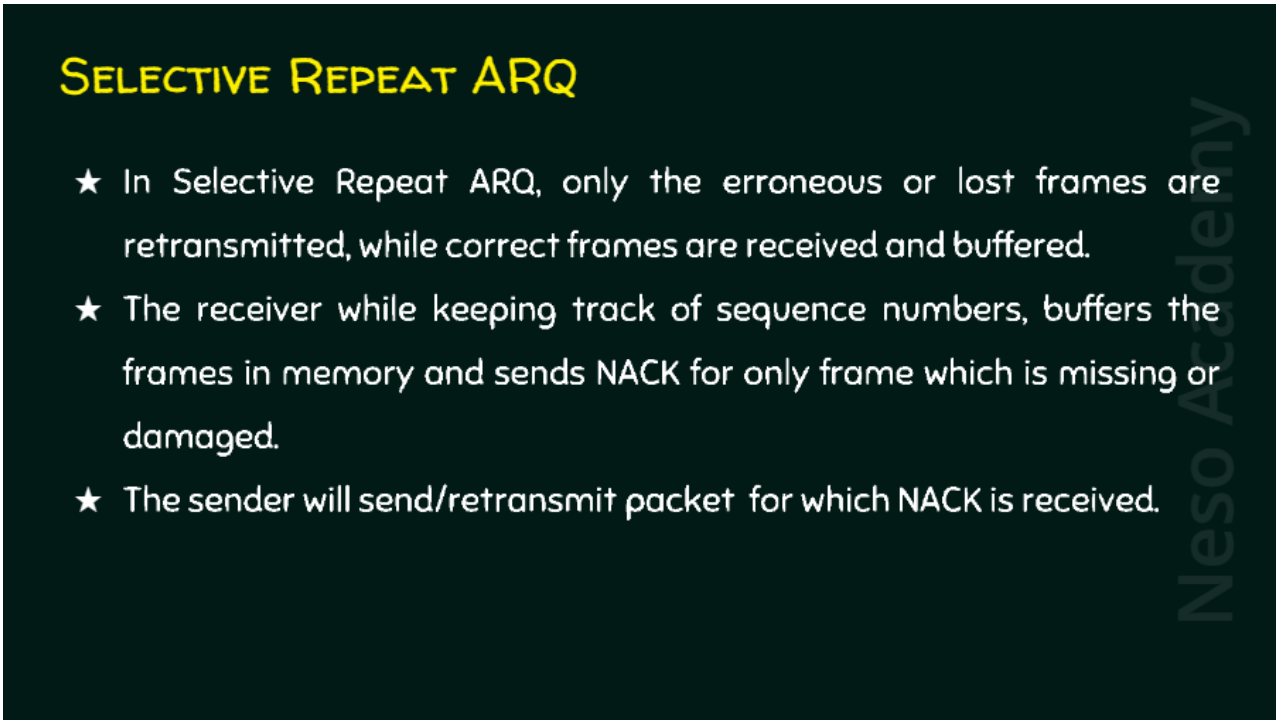
Upon the completion of this session, the learner will be able to

★ Understand the working of Selective Repeat ARQ.

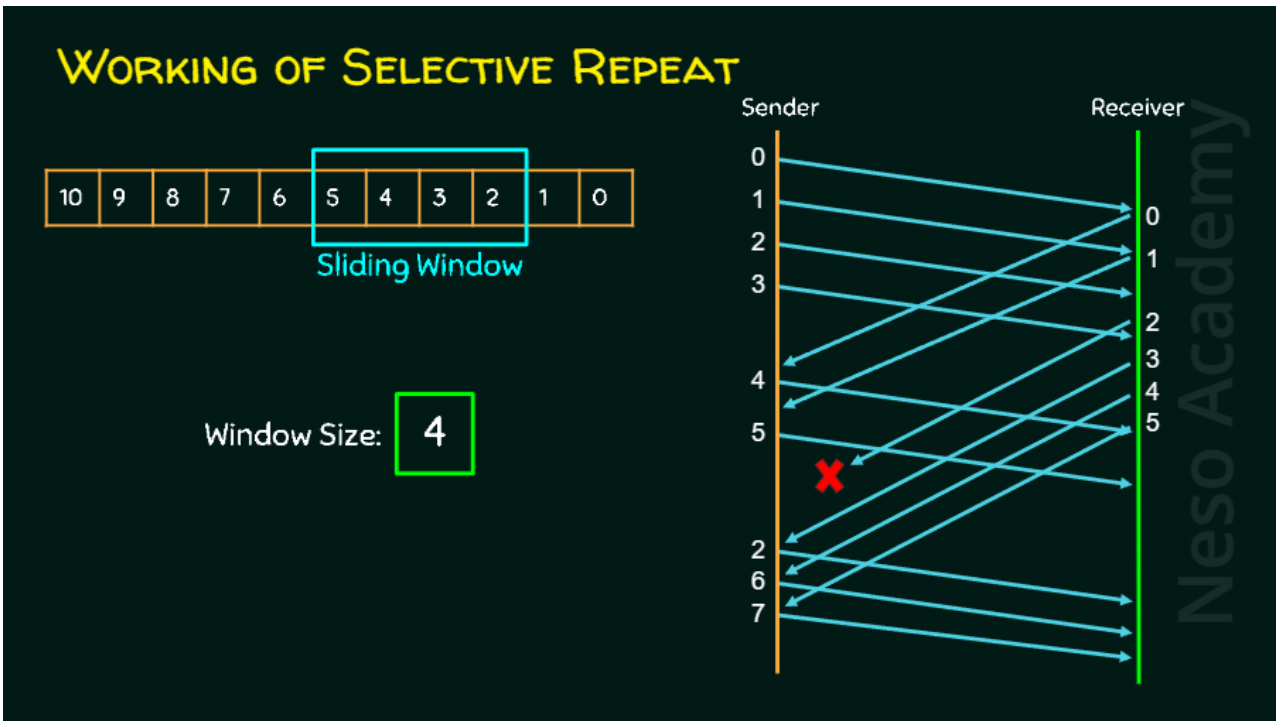
Outcomes★Neso Academy



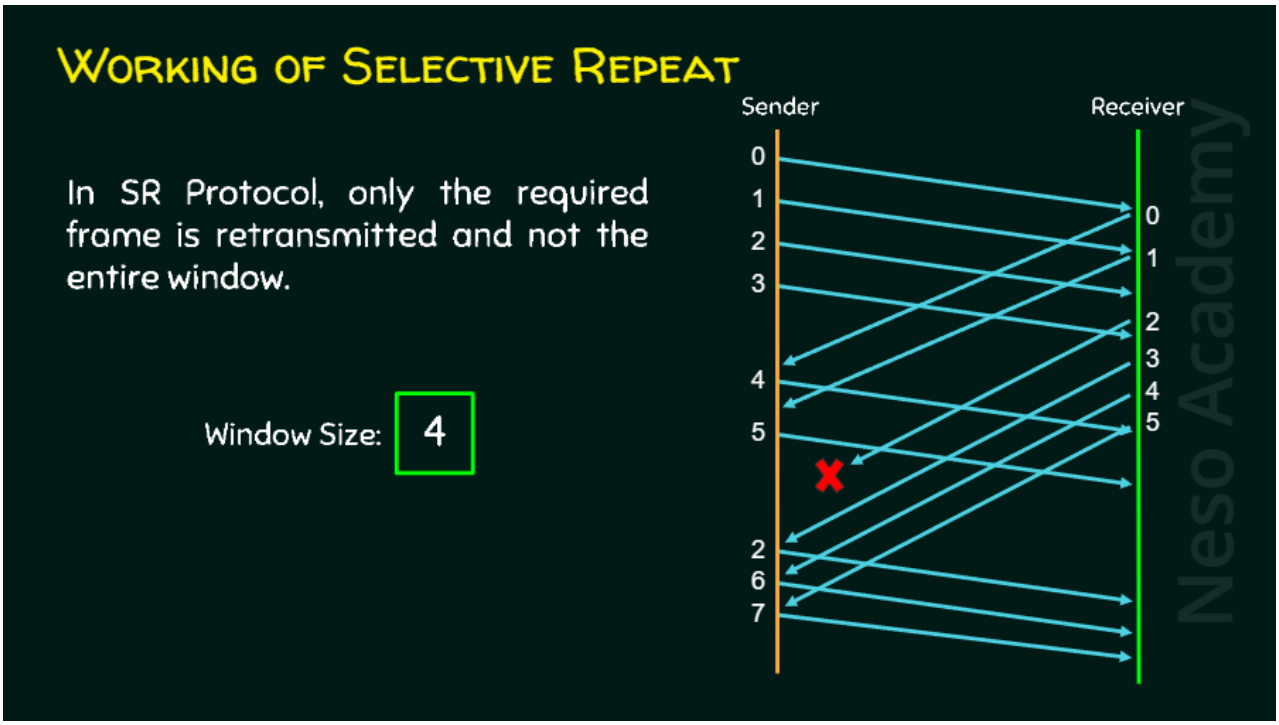
Sliding window protocols★★★★★\Neso Academy



Selective Repeat ARQ★★★Neso Academy



Working of Selective Repeat01320415232647 5Neso Academy



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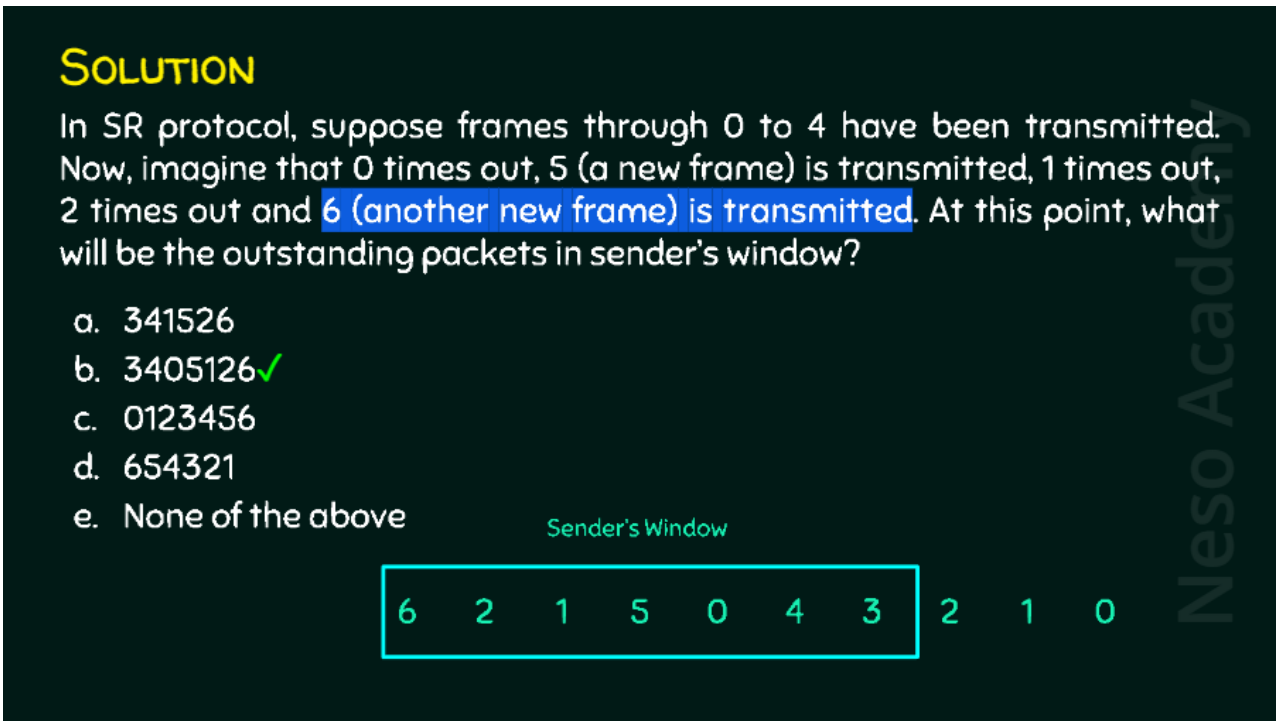
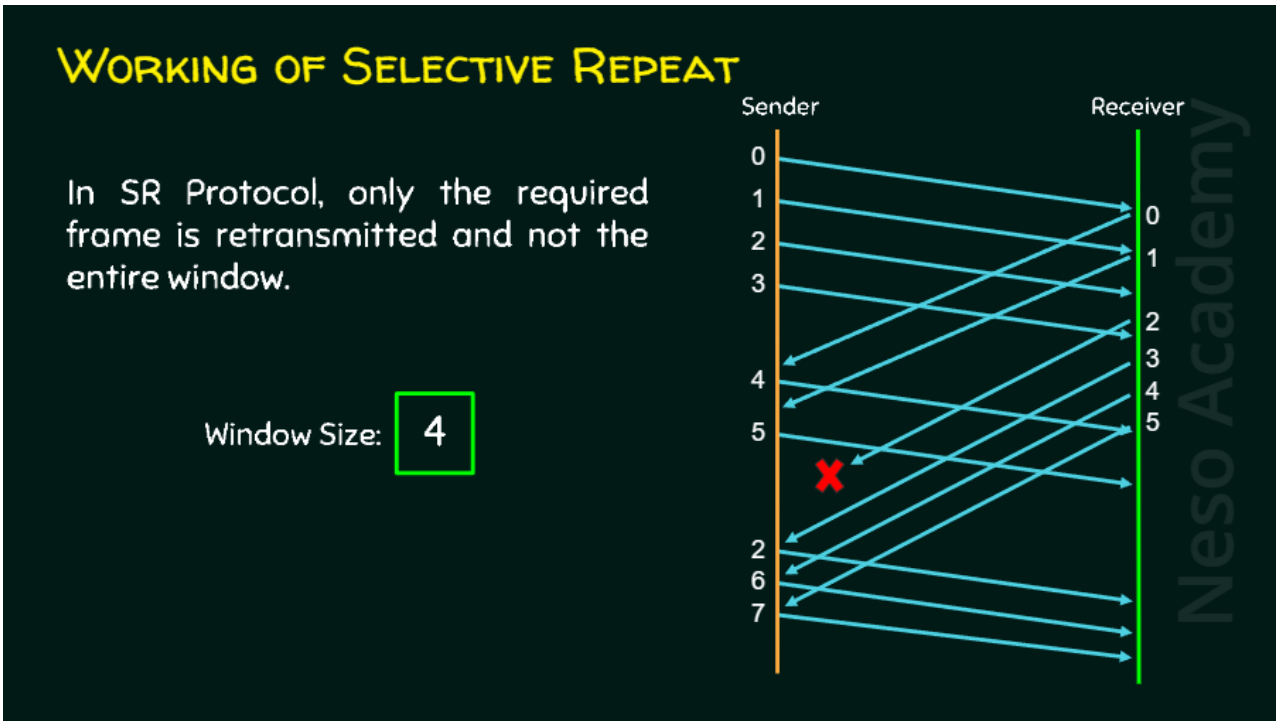
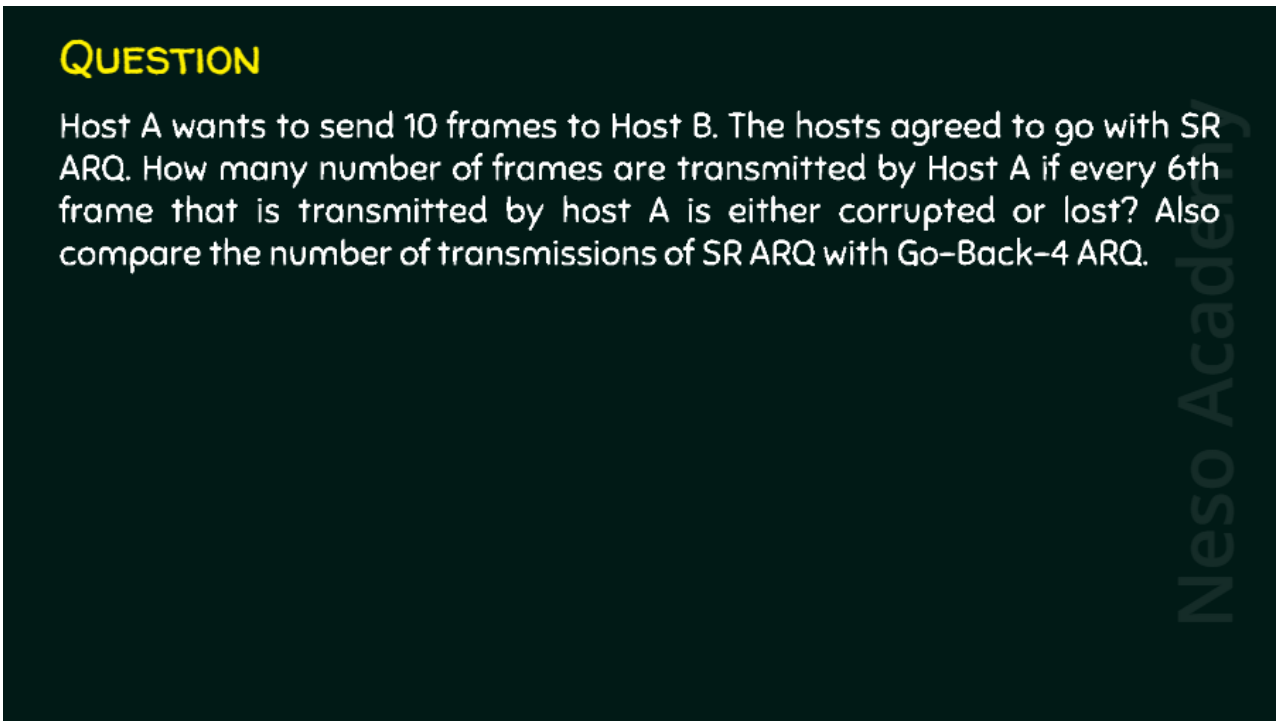


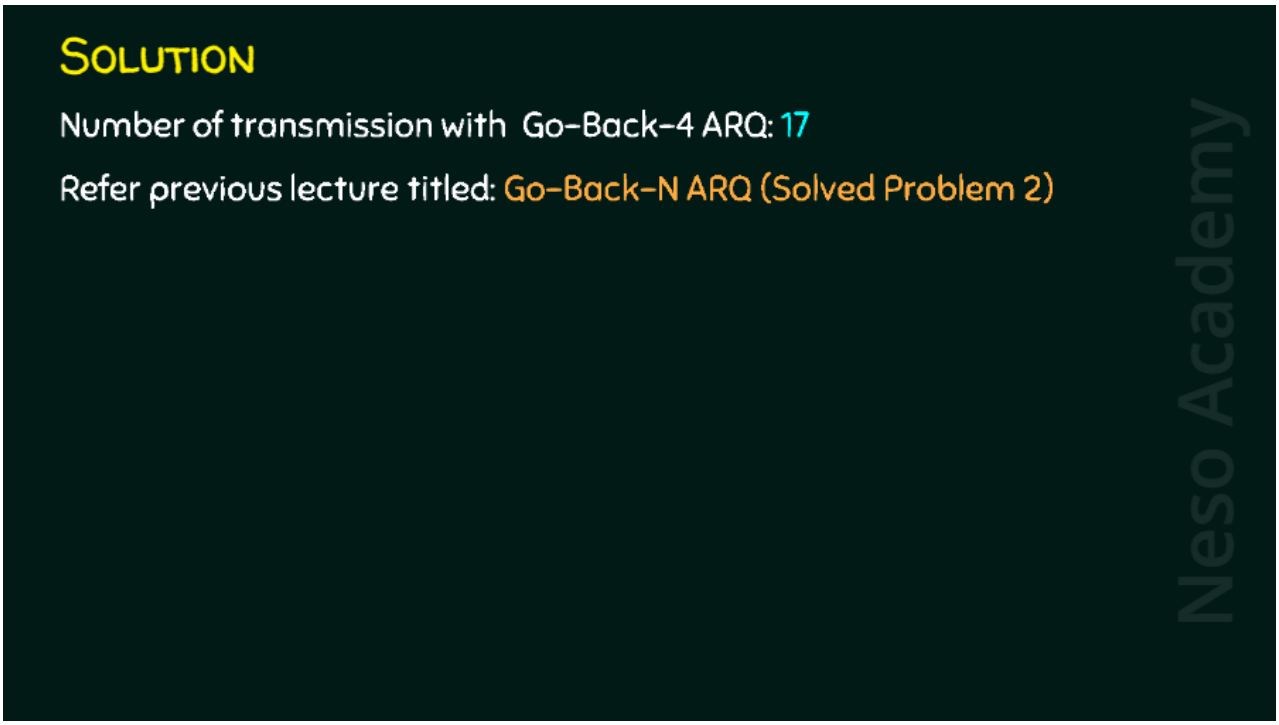
Solution✓Neso Academy



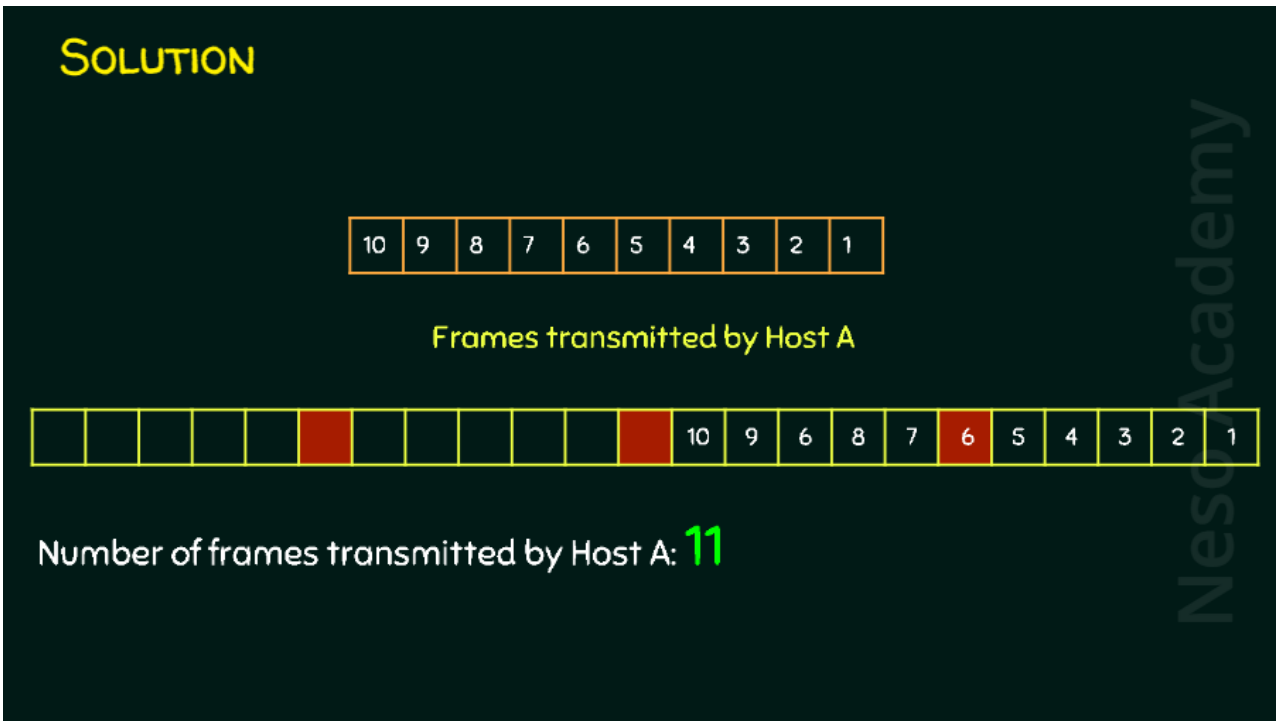
Working of Selective Repeat013204152326475Neso Academy



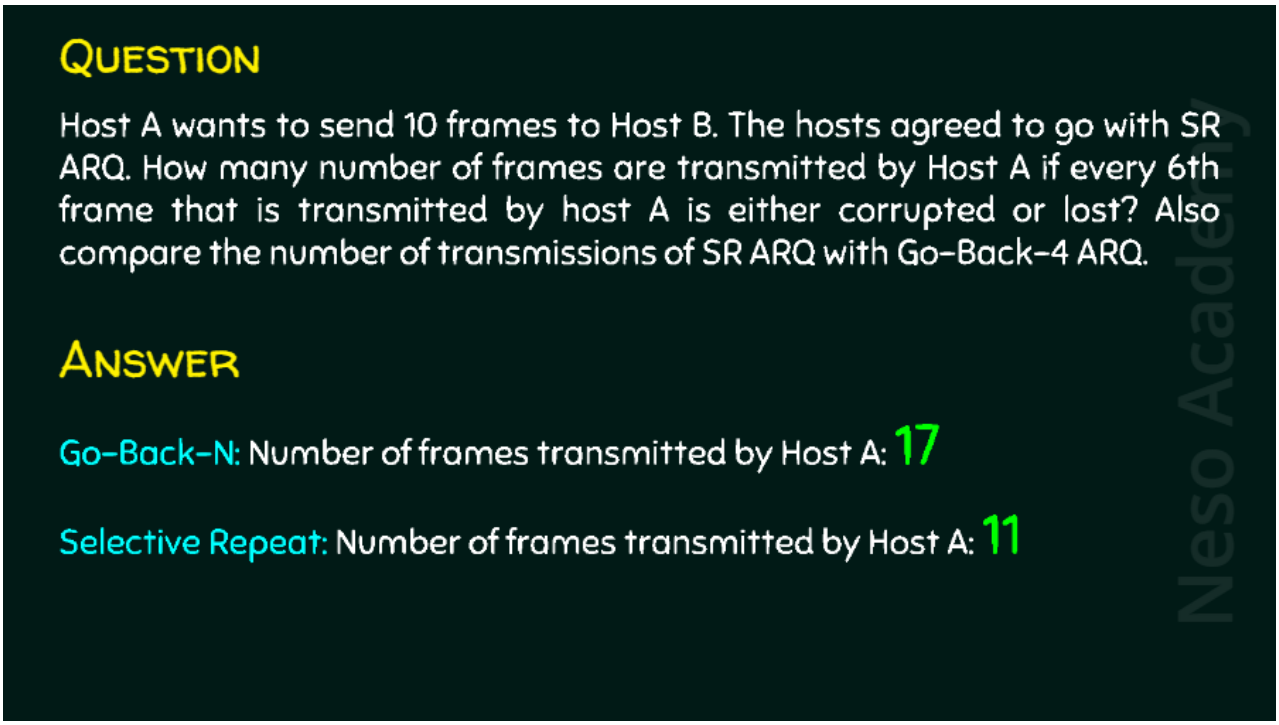
QuestionNeso Academy



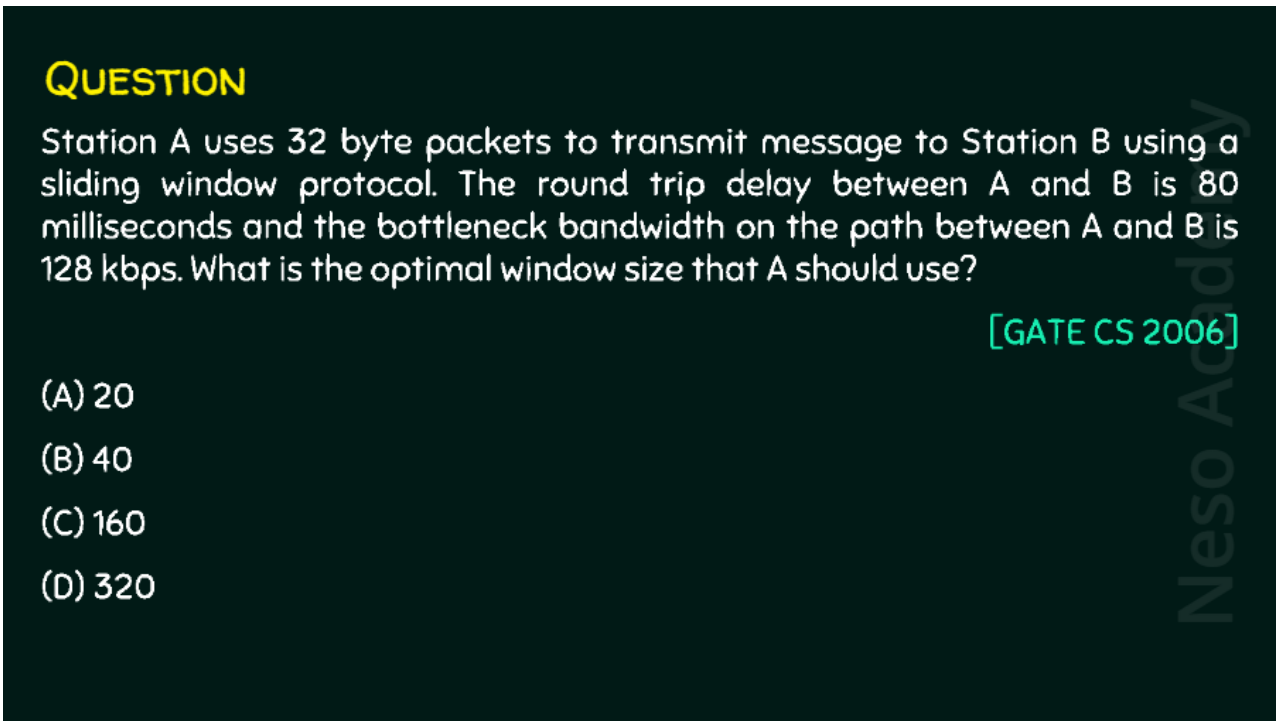
SolutionNeso Academy



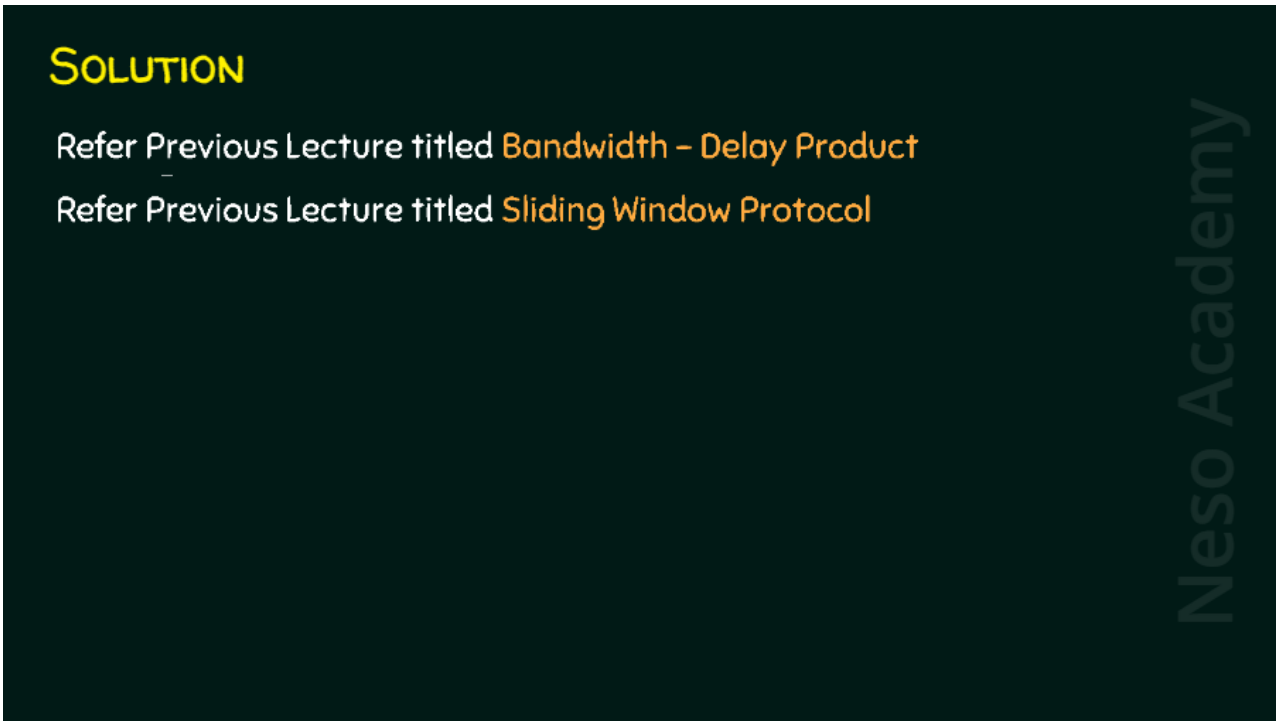
SolutionNeso Academy



QuestionAnswer Neso Academy



QuestionNeso Academy



SolutionNeso Academy

Solution

Station A uses 32 byte packets to transmit message to Station B using a sliding window protocol. The round trip delay between A and B is 80 milliseconds and the bottleneck bandwidth on the path between A and B is 128 kbps. What is the optimal window size that A should use?

Given Data

Delay = 80 milliseconds

Bandwidth = 128 kbps

Packet Size = 32 bytes

SolutionNeso Academy

Solution

Bandwidth – Delay Product = Bandwidth x Delay

Bandwidth – Delay Product = 128 kbps x 80 milliseconds

Bandwidth – Delay Product = 128 x 1024 x 80 milliseconds

Bandwidth – Delay Product = $128 \times 1024 \times 80 \times 10^{-3}$ bits

$$\text{Bandwidth – Delay Product} = \frac{128 \times 1024 \times 80 \times 10^{-3}}{8} \text{ bytes}$$

$$\text{Optimal Window Size} = \frac{128 \times 1024 \times 80 \times 10^{-3}}{8 \times 32} \text{ bytes}$$

Optimal Window Size = 40

SolutionNeso Academy

SOLUTION

Station A uses 32 byte packets to transmit message to Station B using a sliding window protocol. The round trip delay between A and B is 80 milliseconds and the bottleneck bandwidth on the path between A and B is 128 kbps. What is the optimal window size that A should use?

(A) 20

(B) 40 ✔

(C) 160

(D) 320

Solution ✔ Neso Academy

QUESTION

The distance between two stations M and N is *L kilometres*. All frames are *K bits* long. The propagation time per kilometer is *t seconds*. Let *R bits/second* be the channel capacity. Assuming the processing delay is negligible, the minimum number of bits for the sequence number field in a frame for maximum utilization, when the sliding window protocol is used, is:

[GATE CS 2007]

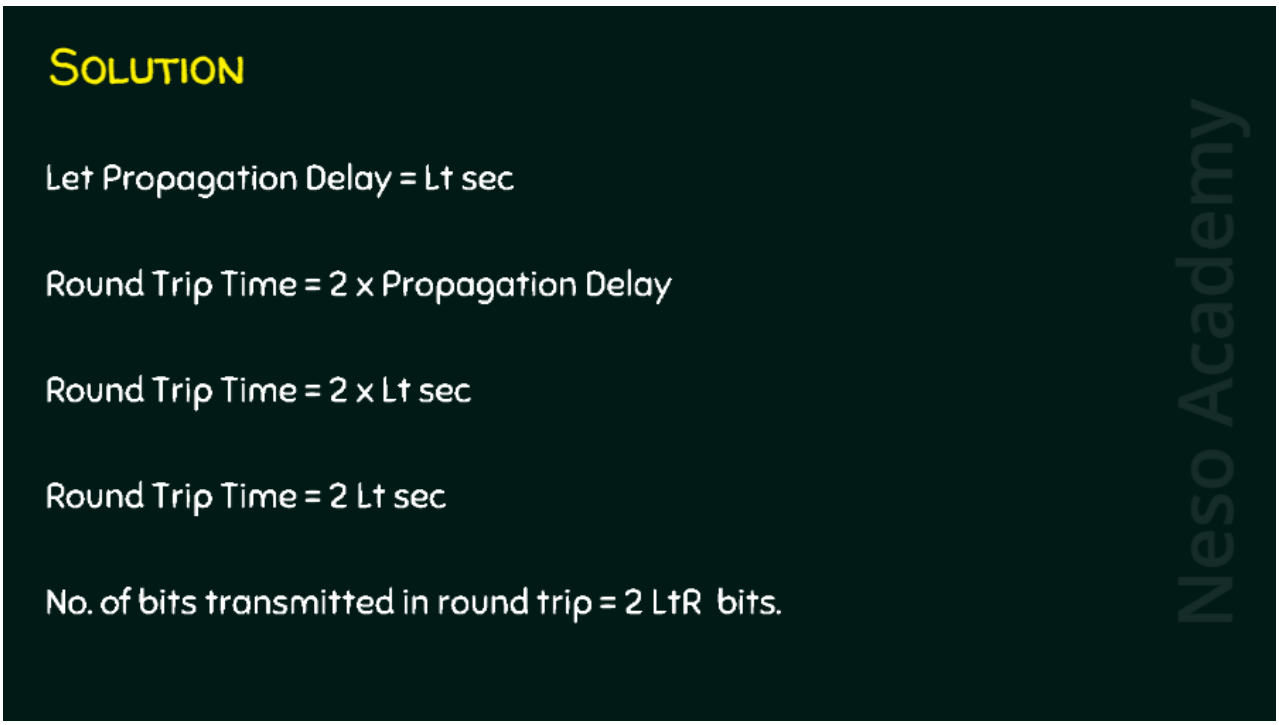
A. $\log_2\left(\frac{2LtR+2K}{K}\right)$

B. $\log_2\left(\frac{2LtR}{K}\right)$

C. $\log_2\left(\frac{2LtR+K}{K}\right)$

D. $\log_2\left(\frac{2LtR+K}{2K}\right)$

QuestionNeso Academy



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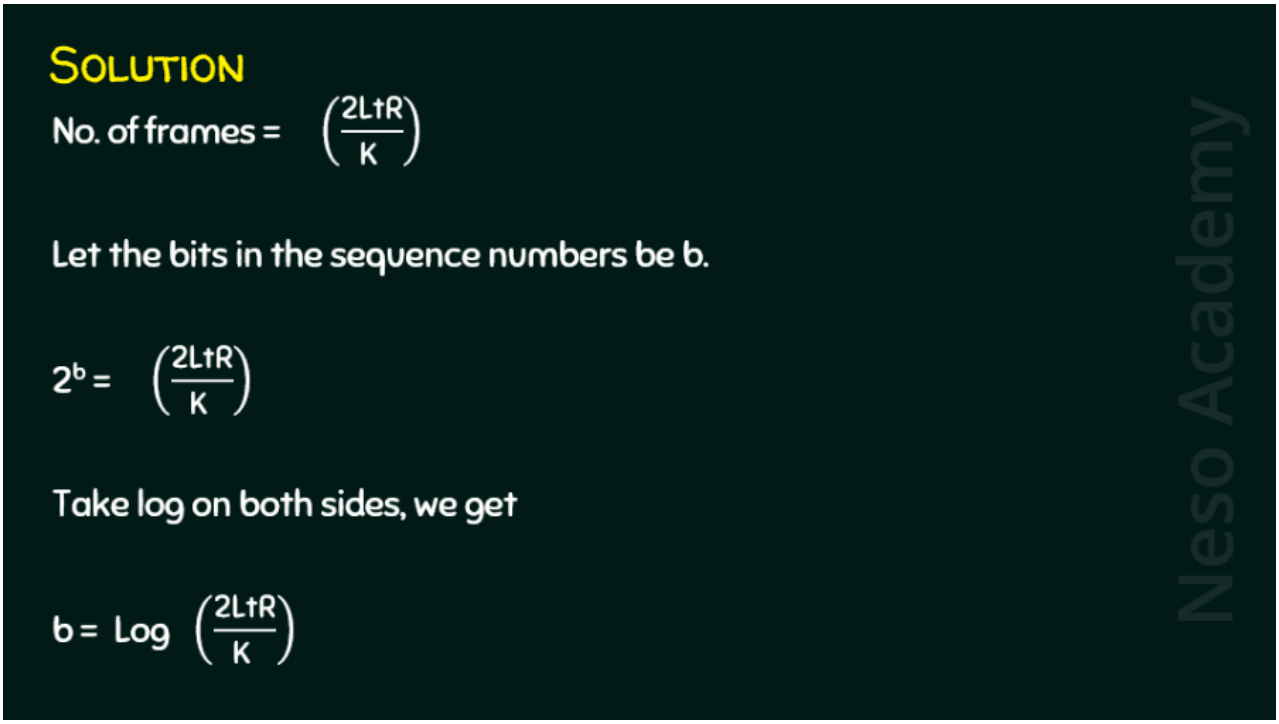


SolutionNeso Academy

QUESTION

The distance between two stations M and N is *L kilometres*. All frames are *K bits* long. The propagation time per kilometer is *t seconds*. Let *R bits/second* be the channel capacity. Assuming the processing delay is negligible, the minimum number of bits for the sequence number field in a frame for maximum utilization, when the sliding window protocol is used, is:

[GATE CS 2007]

A. $\log_2\left(\frac{2LtR+2K}{K}\right)$

C. $\log_2\left(\frac{2LtR+K}{K}\right)$

B. $\log_2\left(\frac{2LtR}{K}\right)$ ✓

D. $\log_2\left(\frac{2LtR+K}{2K}\right)$

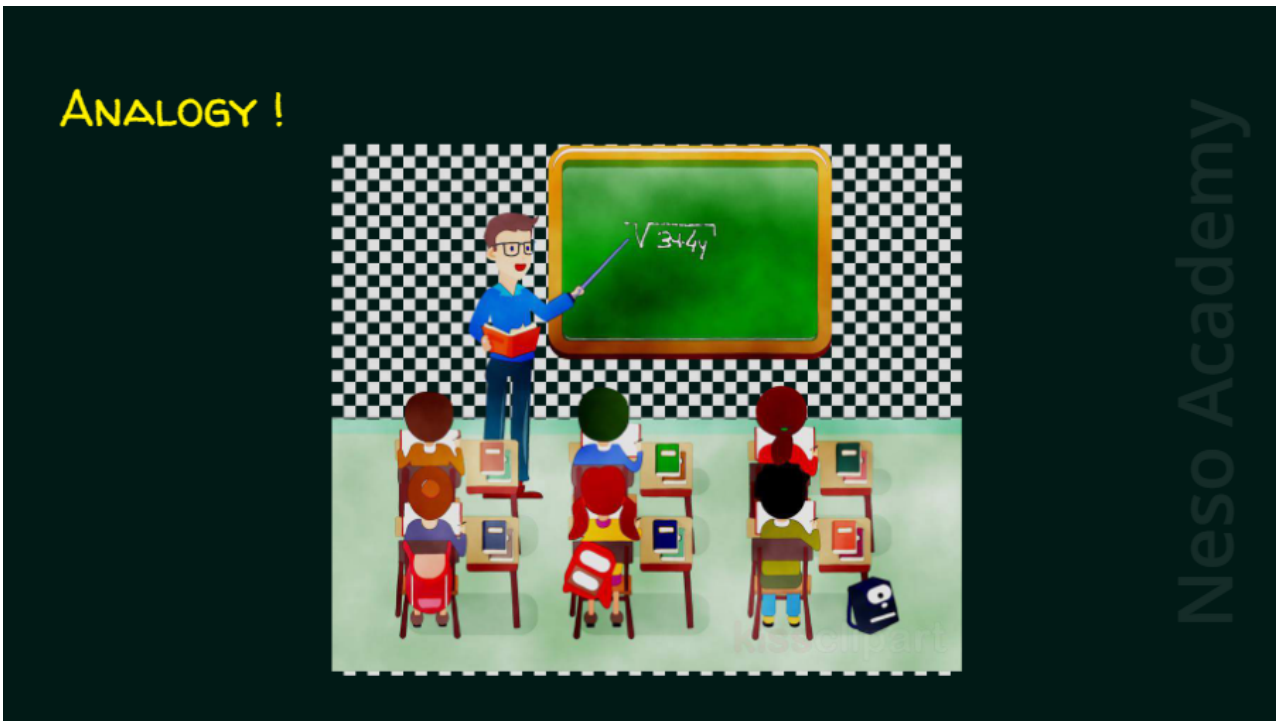
Question✓Neso Academy

OUTCOMES

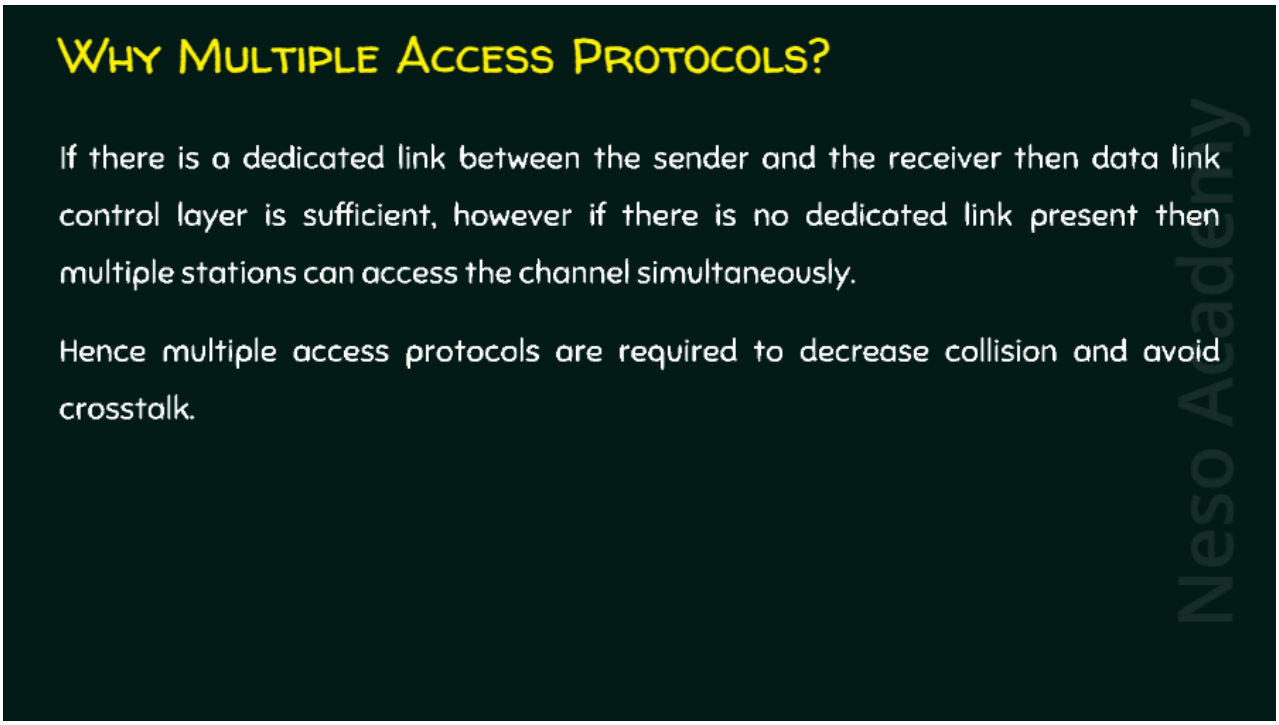
Upon the completion of this session, the learner will be able to

★ Know the various multiple access protocols.

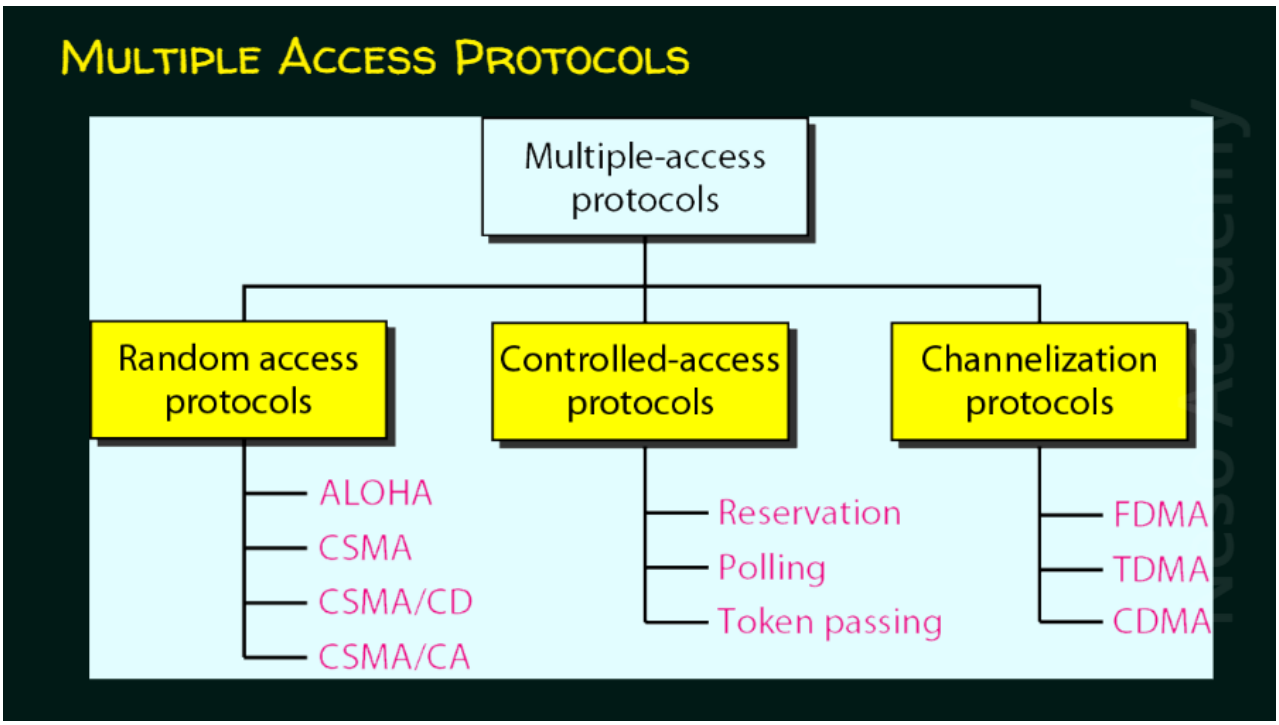
Outcomes★Neso Academy



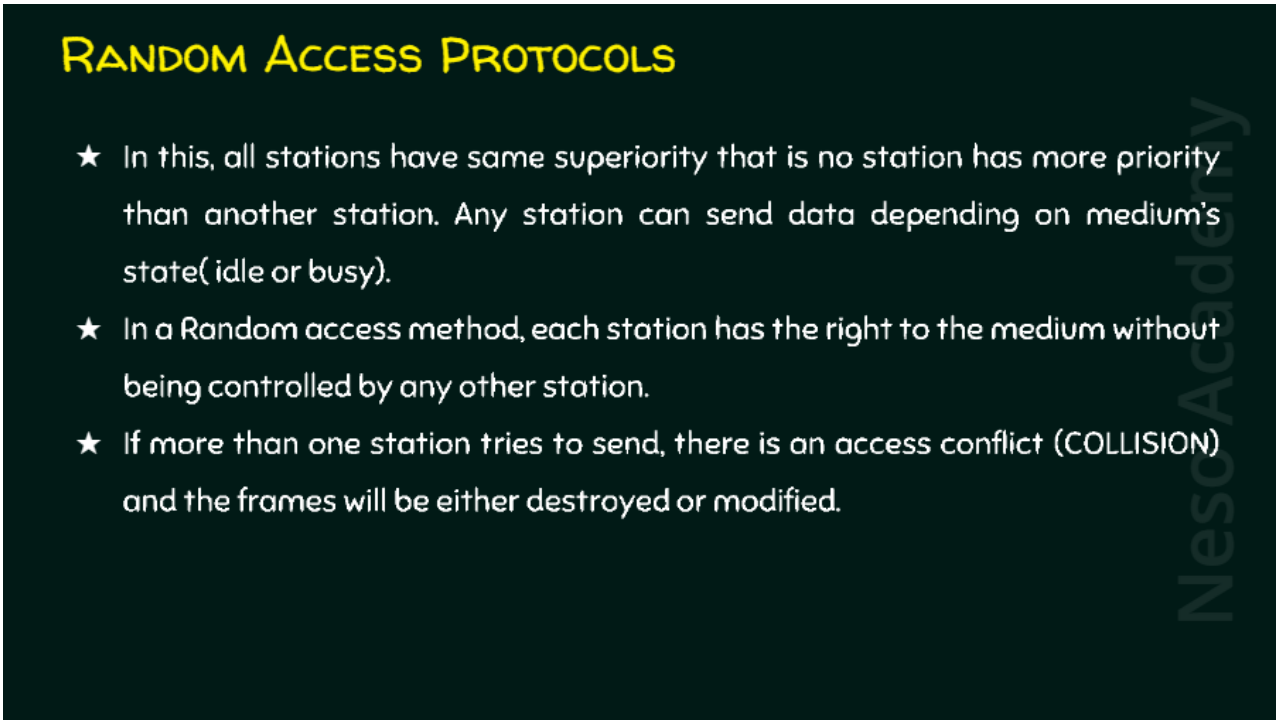
Analogy !Neso Academy



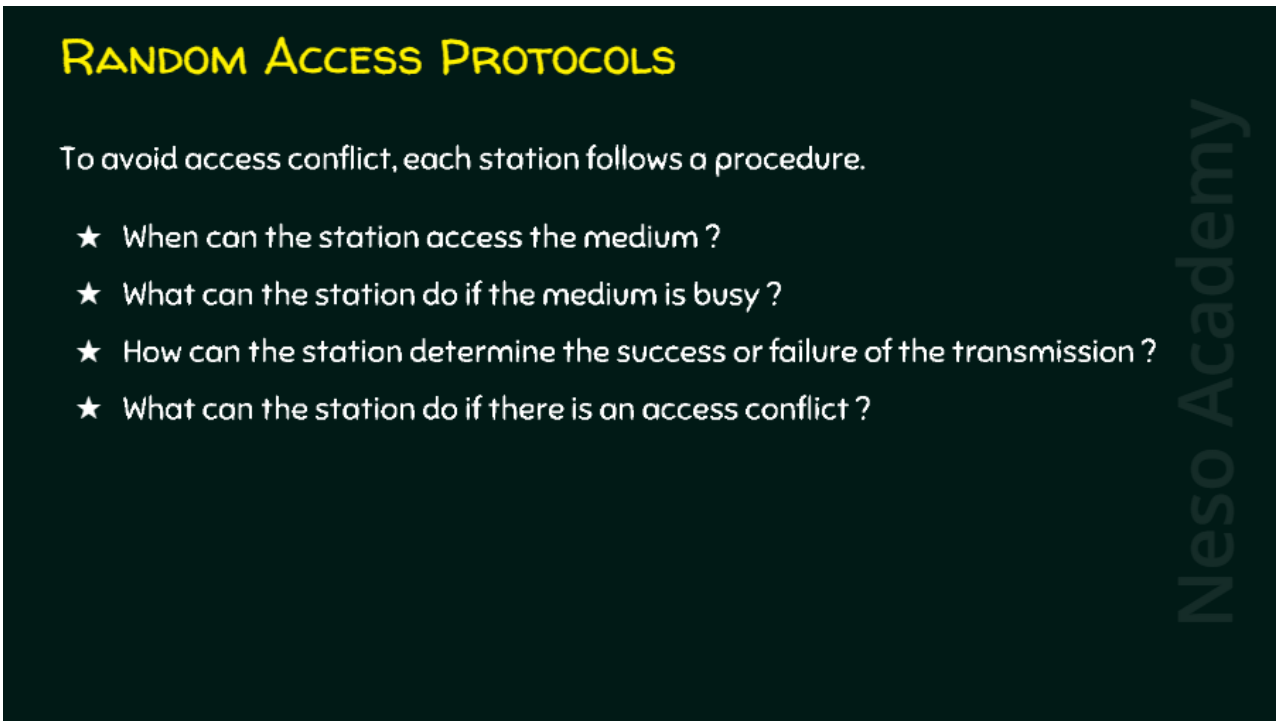
Why Multiple Access Protocols?Neso Academy



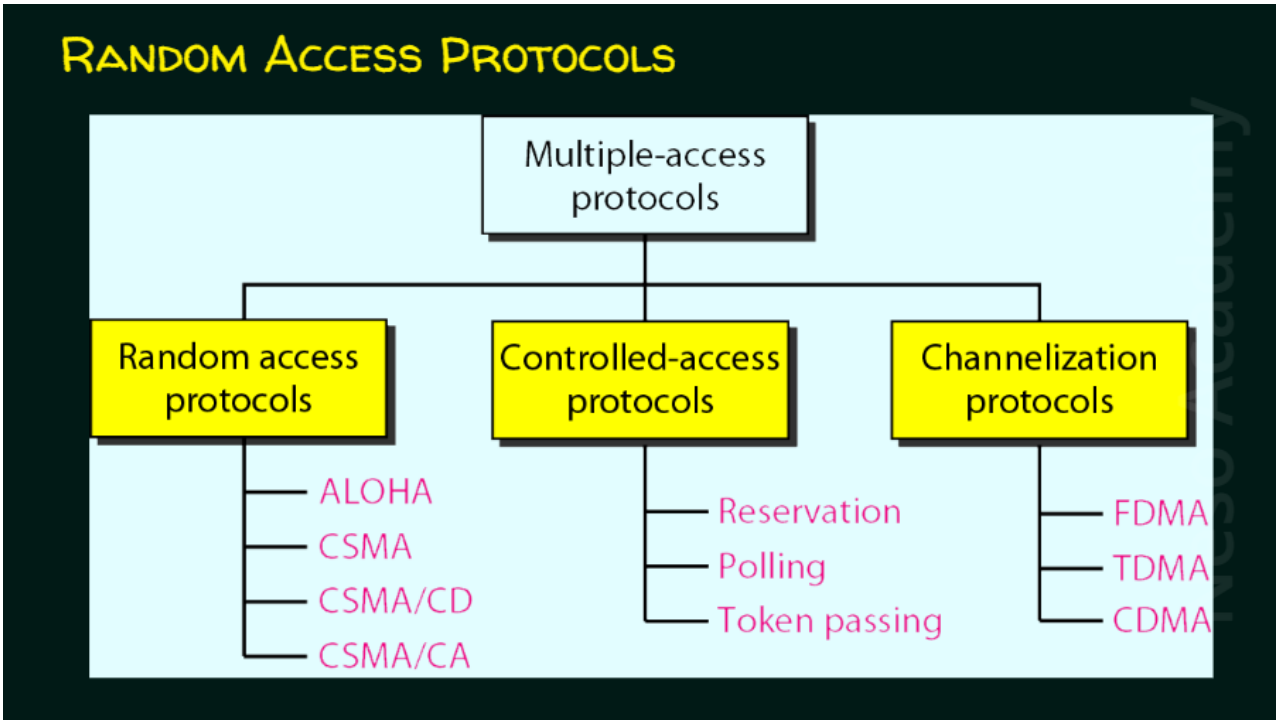
Multiple Access ProtocolsNeso Academy



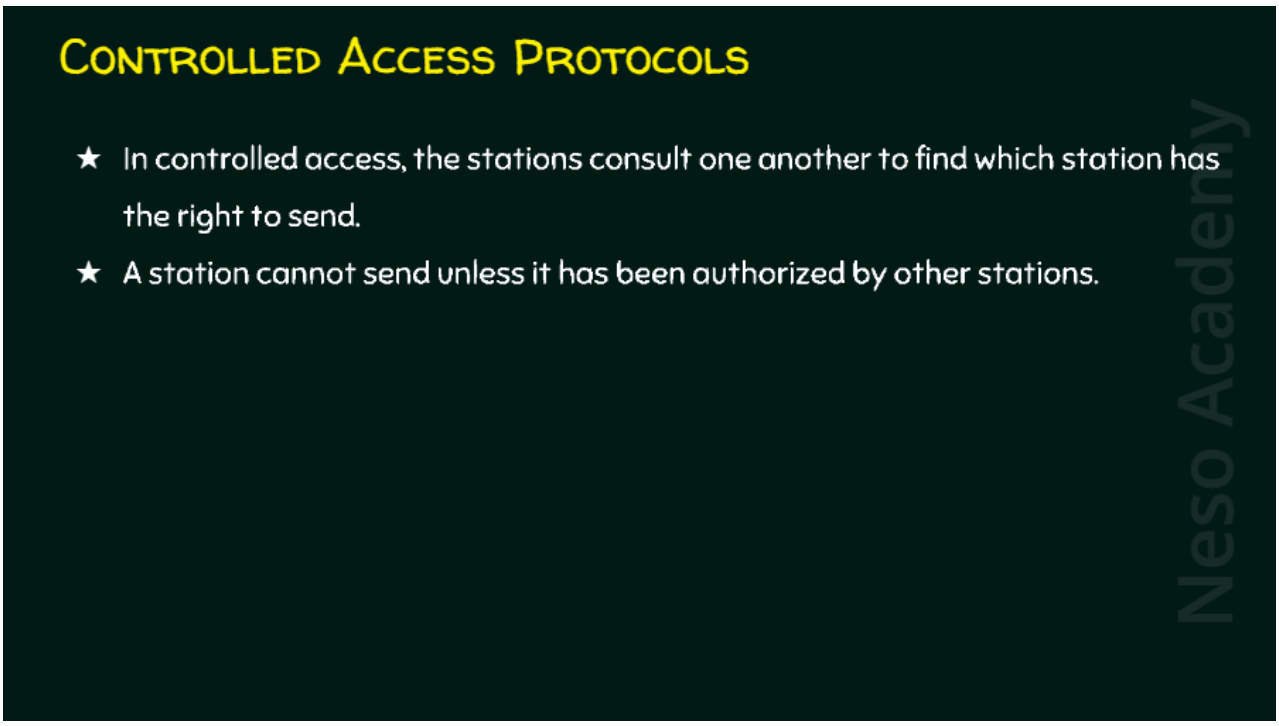
Random Access Protocols★★★Neso Academy



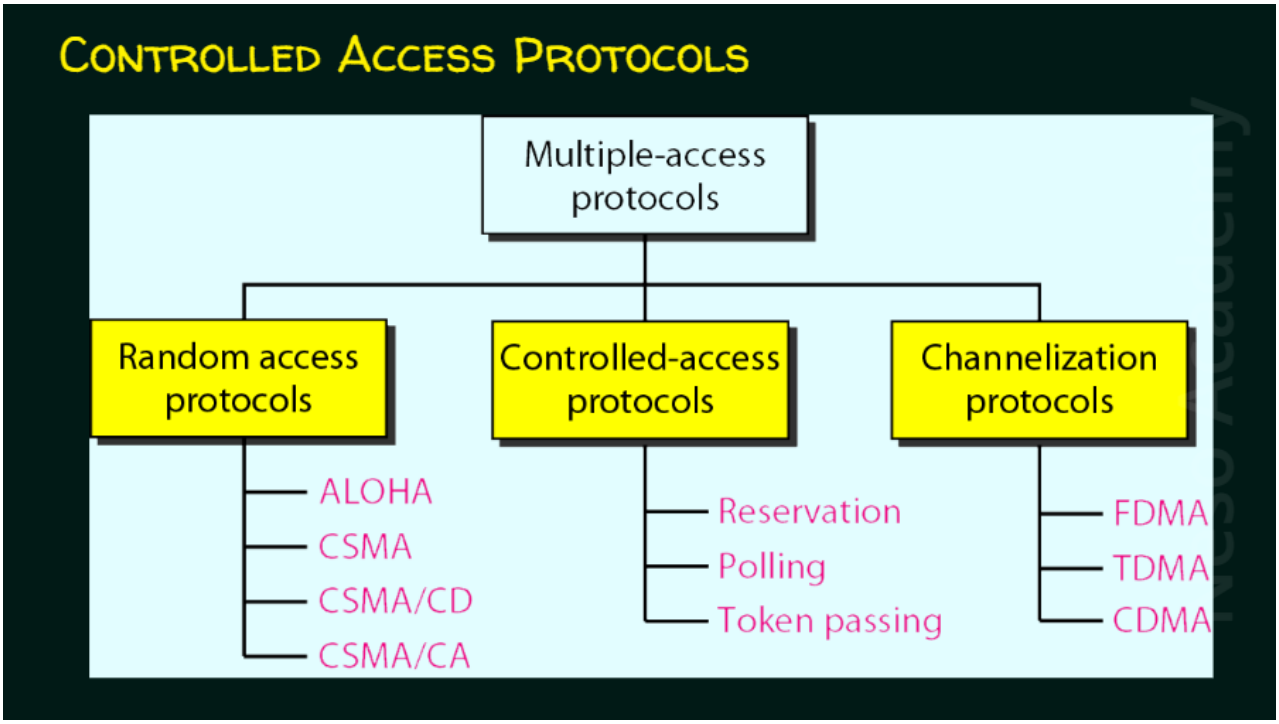
Random Access Protocols★★★★Neso Academy



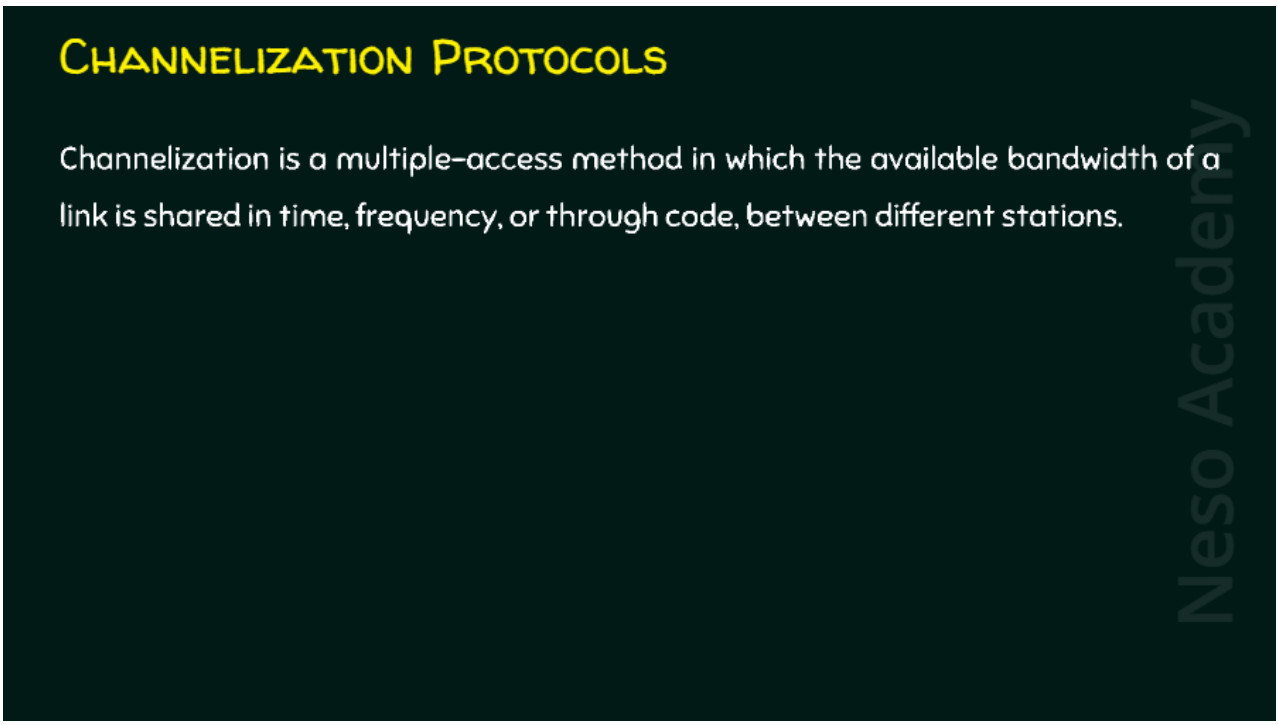
Random Access ProtocolsNeso Academy



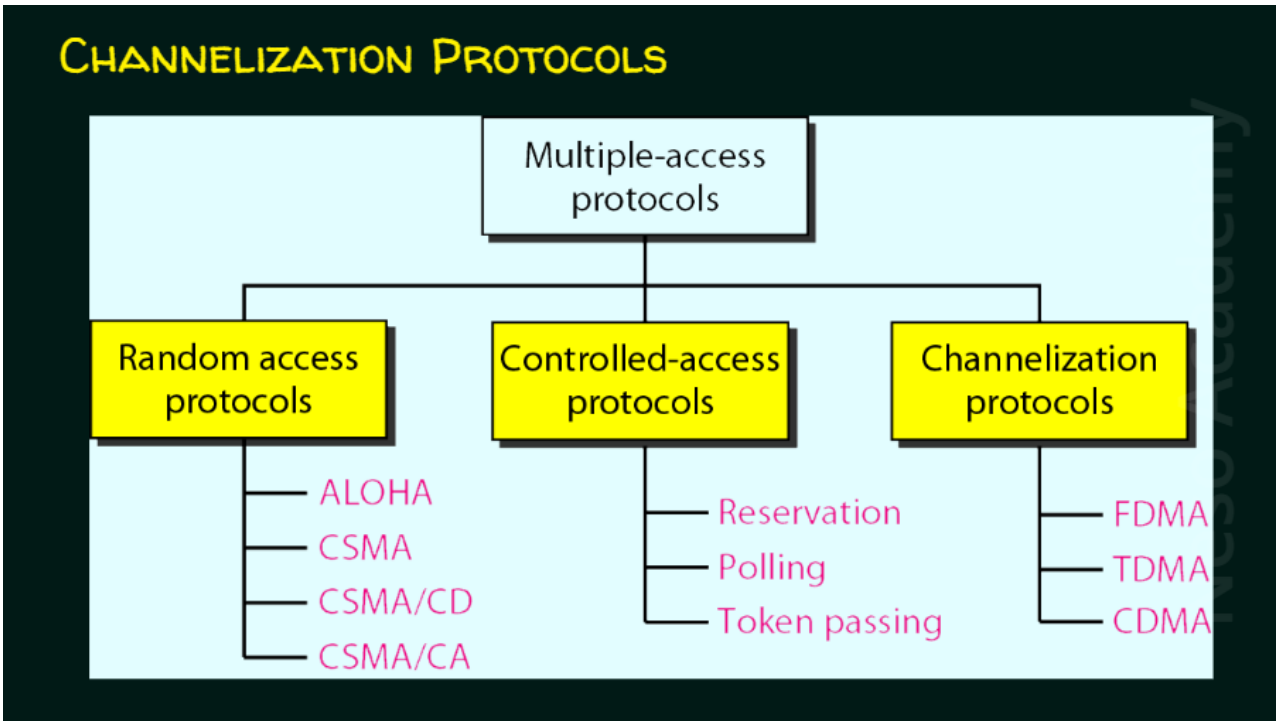
Controlled Access Protocols★★Neso Academy



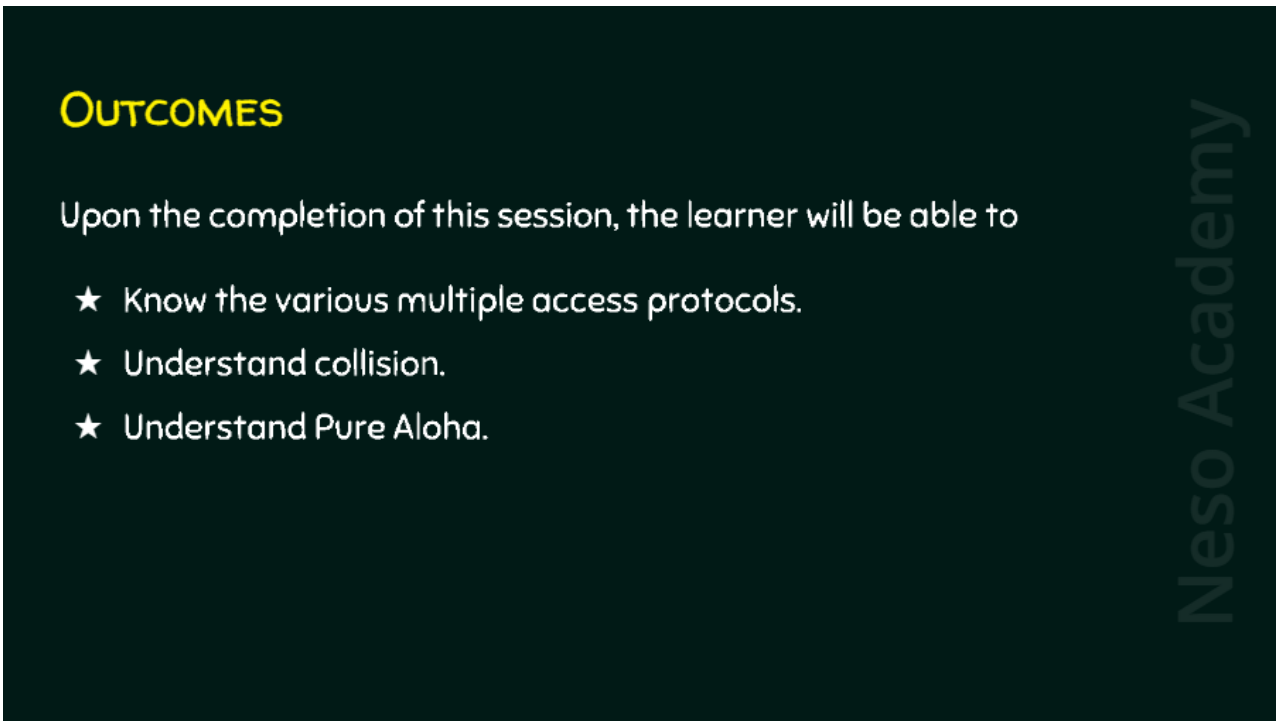
Controlled Access ProtocolsNeso Academy



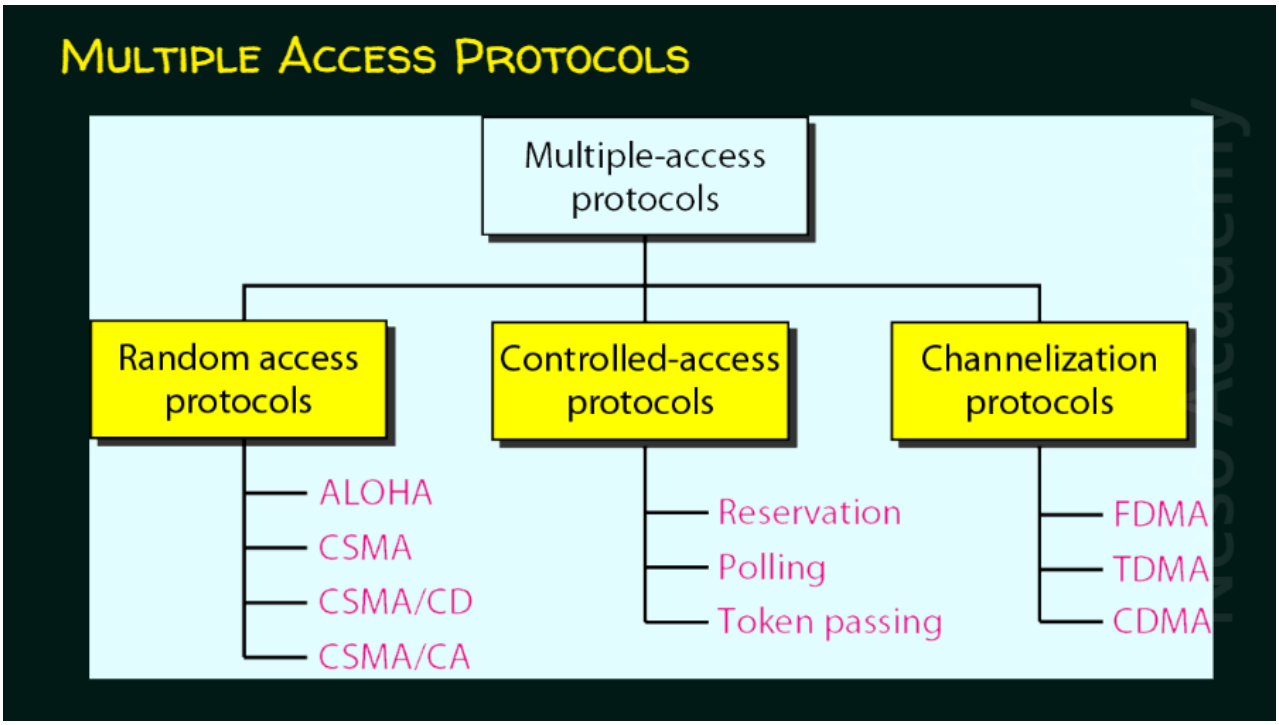
Channelization ProtocolsNeso Academy



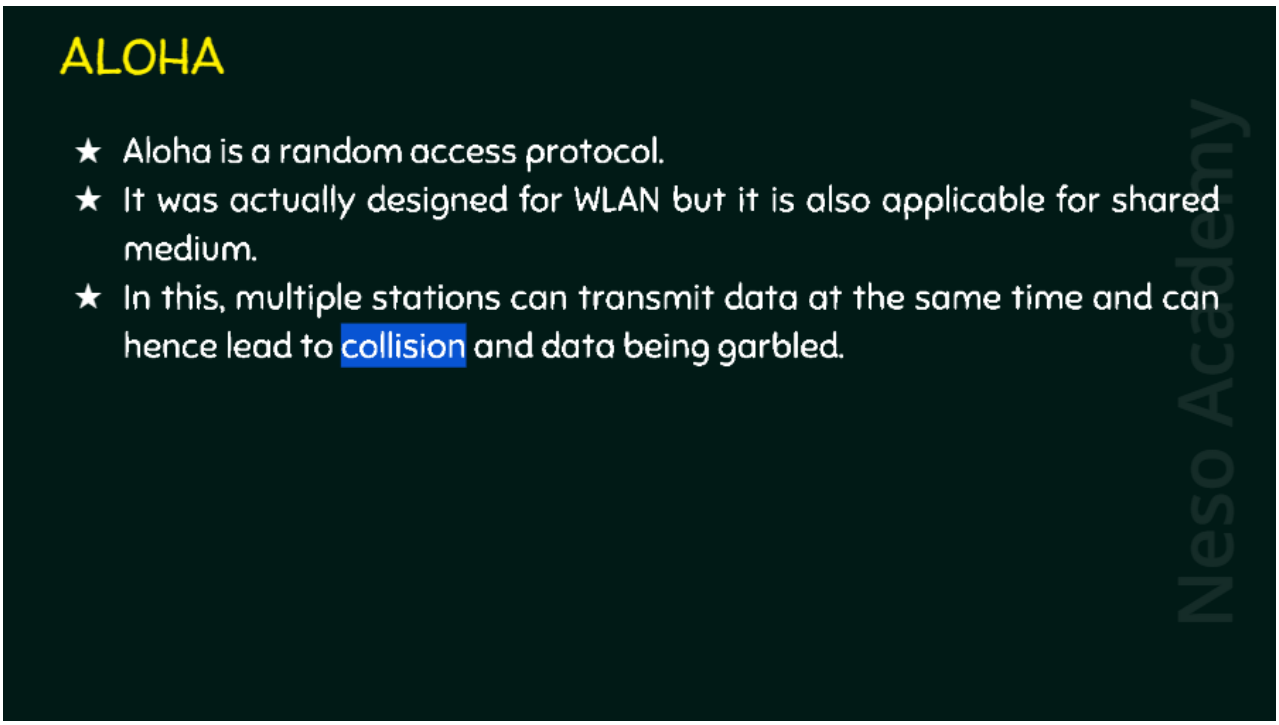
Channelization ProtocolsNeso Academy



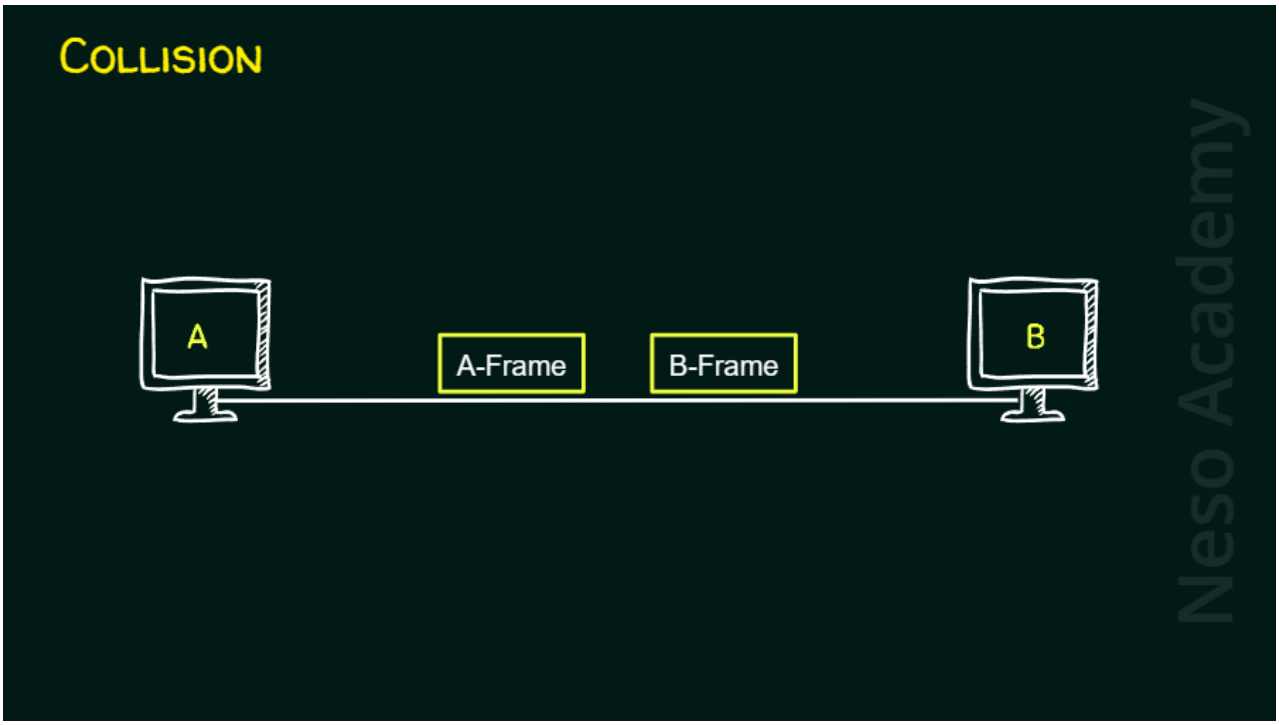
Outcomes★★★Neso Academy



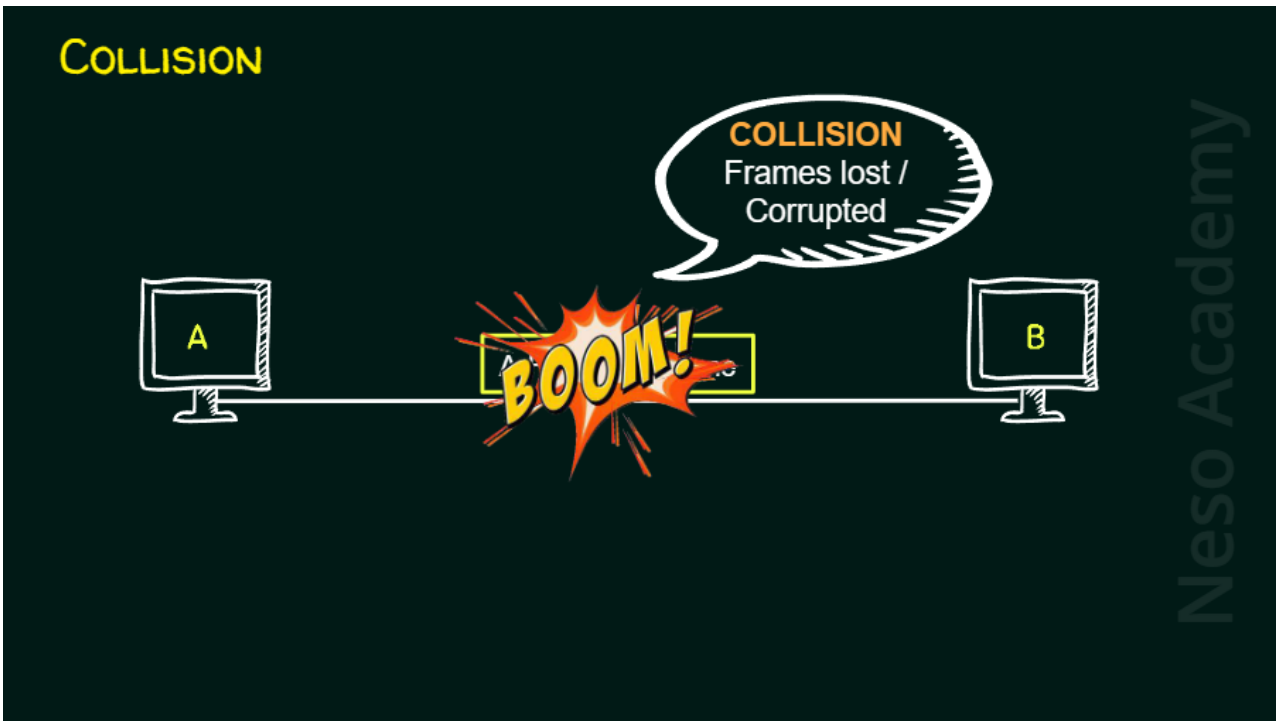
Multiple Access ProtocolsNeso Academy



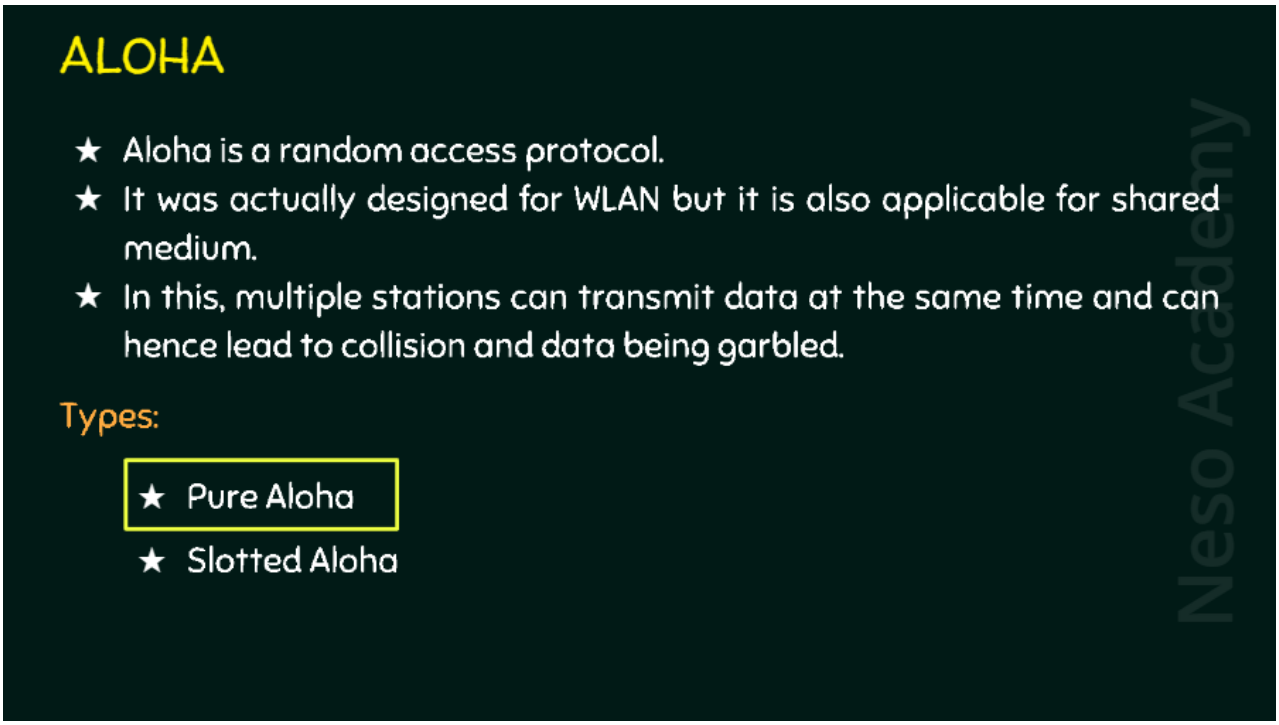
ALOHA★★★Neso Academy



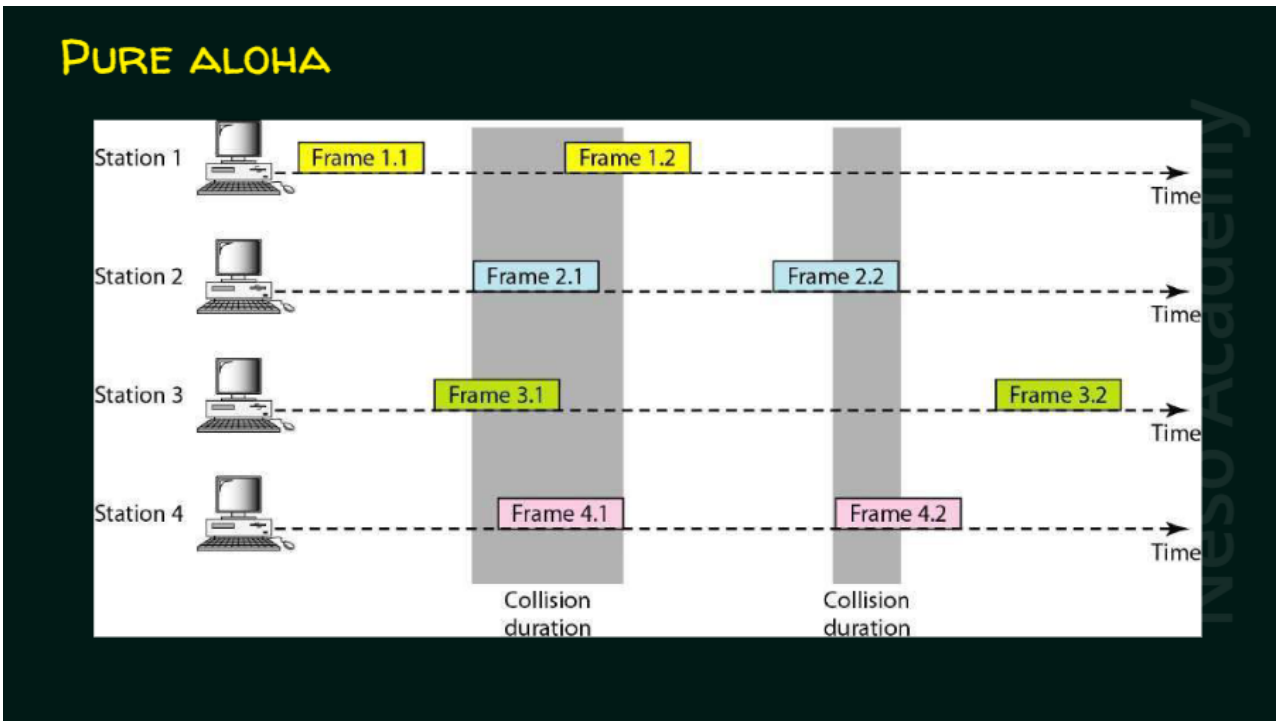
CollisionA-FrameB-FrameNeso Academy



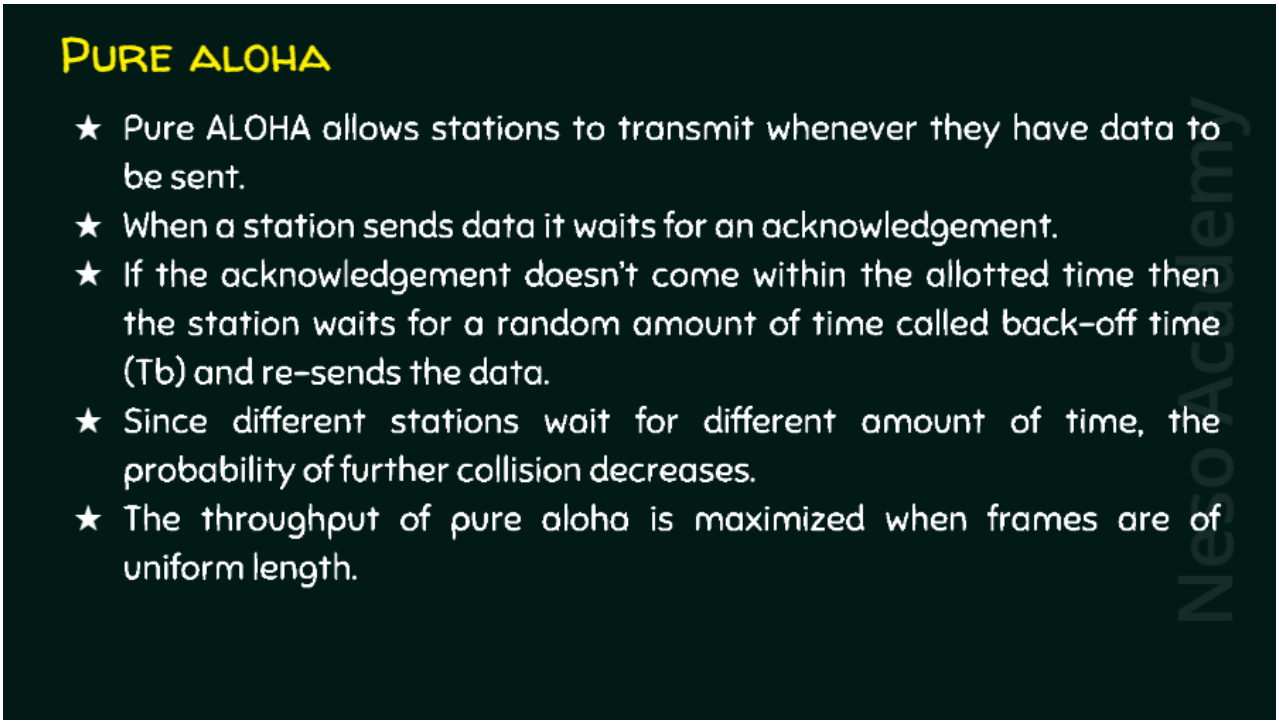
CollisionA-FrameB-FrameCOLLISIONFrames lost / CorruptedNeso Academy



ALOHA★★★★★Neso Academy



Pure alohaNeso Academy



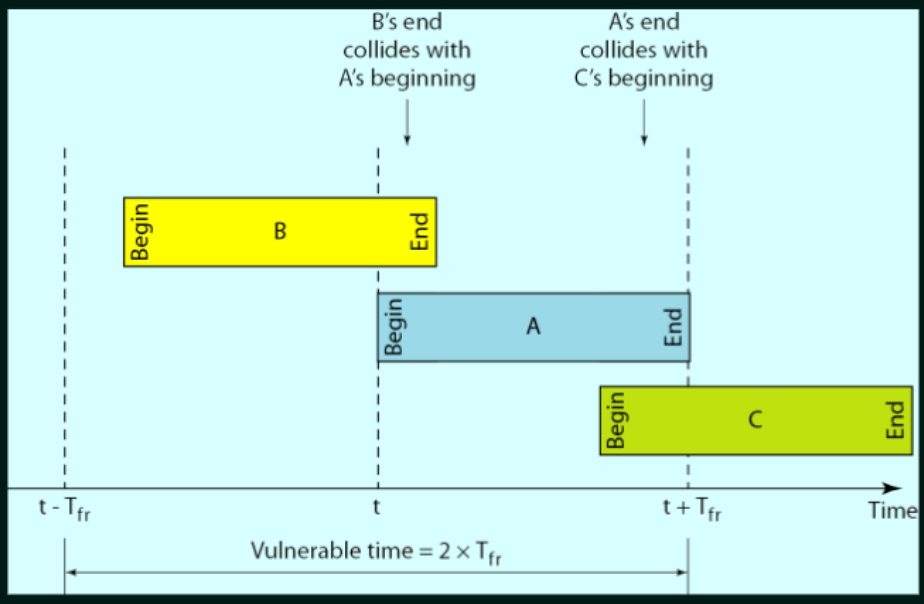
Pure aloha★★★★★Neso Academy

Pure aloha

- ★ Whenever two frames try to occupy the channel at the same time, there will be a collision and both will be garbled.
- ★ If the first bit of a new frame overlaps with just the last bit of a frame almost finished, both frames will be totally destroyed and both will have to be retransmitted later.

Pure aloha★★Neso Academy

Pure aloha



Pure alohaNeso Academy

PURE ALOHA

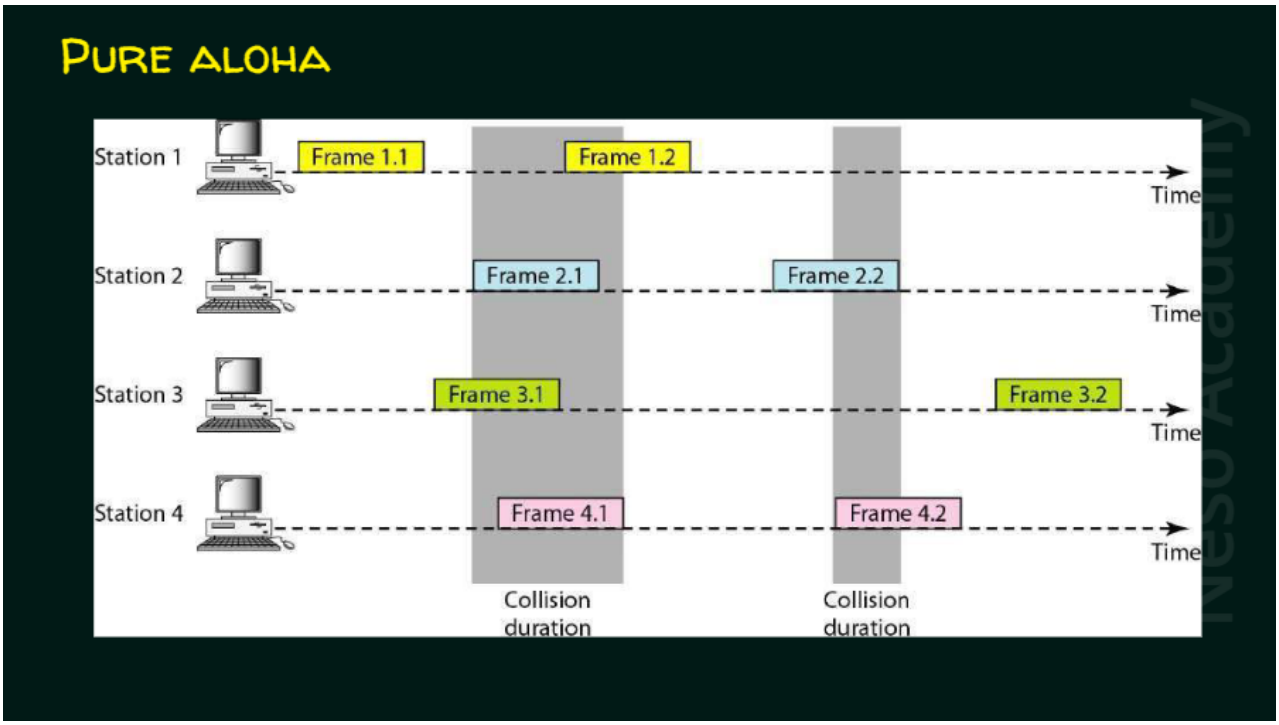
- ★ Whenever two frames try to occupy the channel at the same time, there will be a collision and both will be garbled.
- ★ If the first bit of a new frame overlaps with just the last bit of a frame almost finished, both frames will be totally destroyed and both will have to be retransmitted later.

Vulnerable Time = $2*T_{fr}$

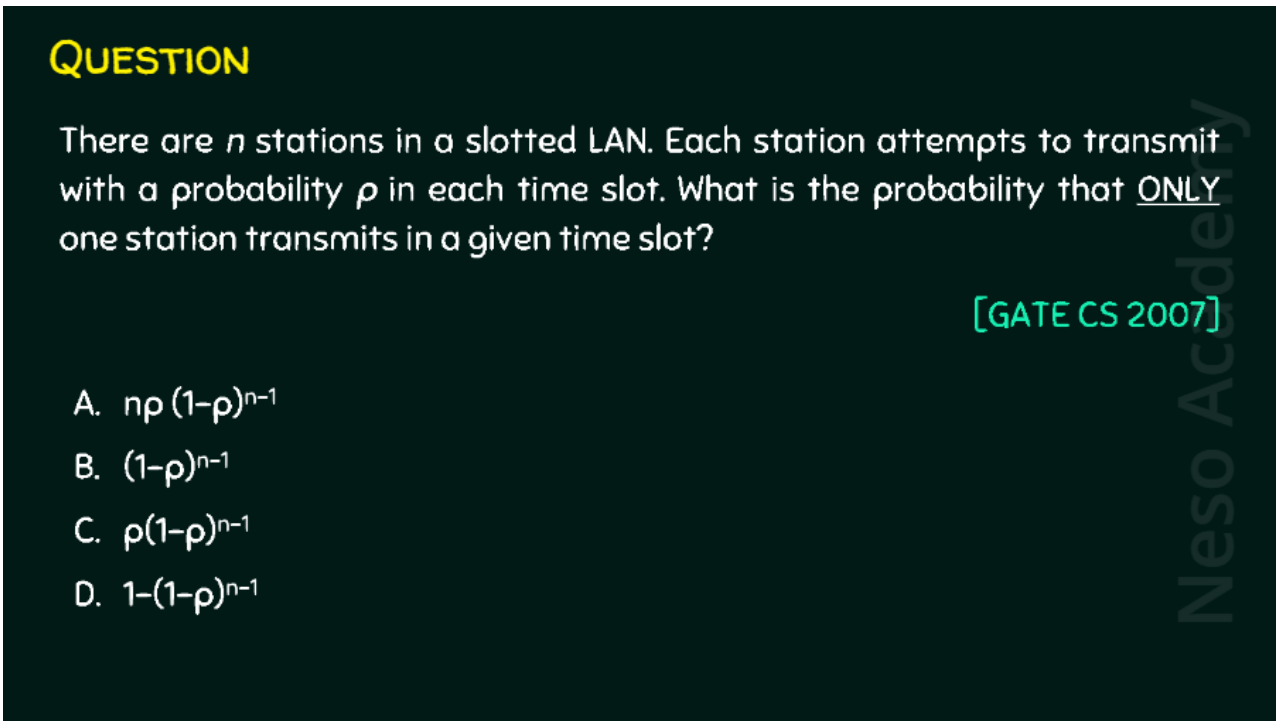
Throughput = $G \times e^{-2G}$; Where G is the number of stations wish to transmit in the same time.

Maximum throughput = 0.184 for G=0.5 (1/2)

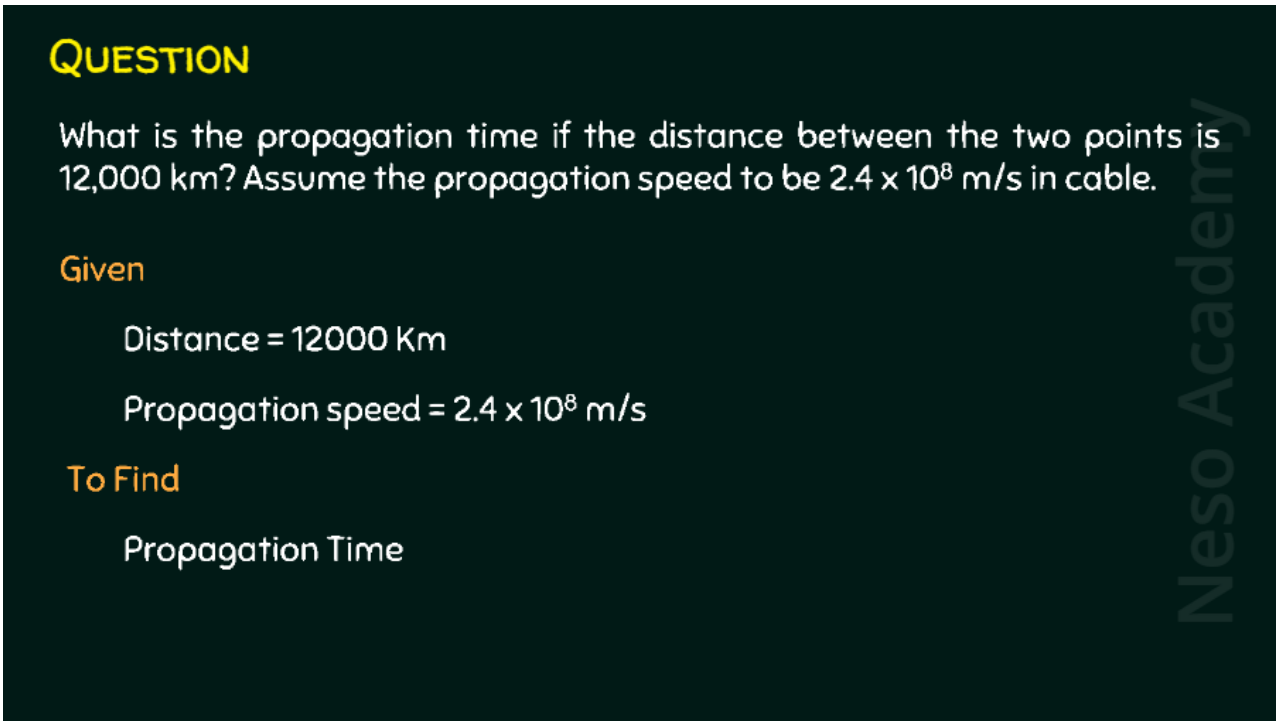
Pure aloha★★Neso Academy



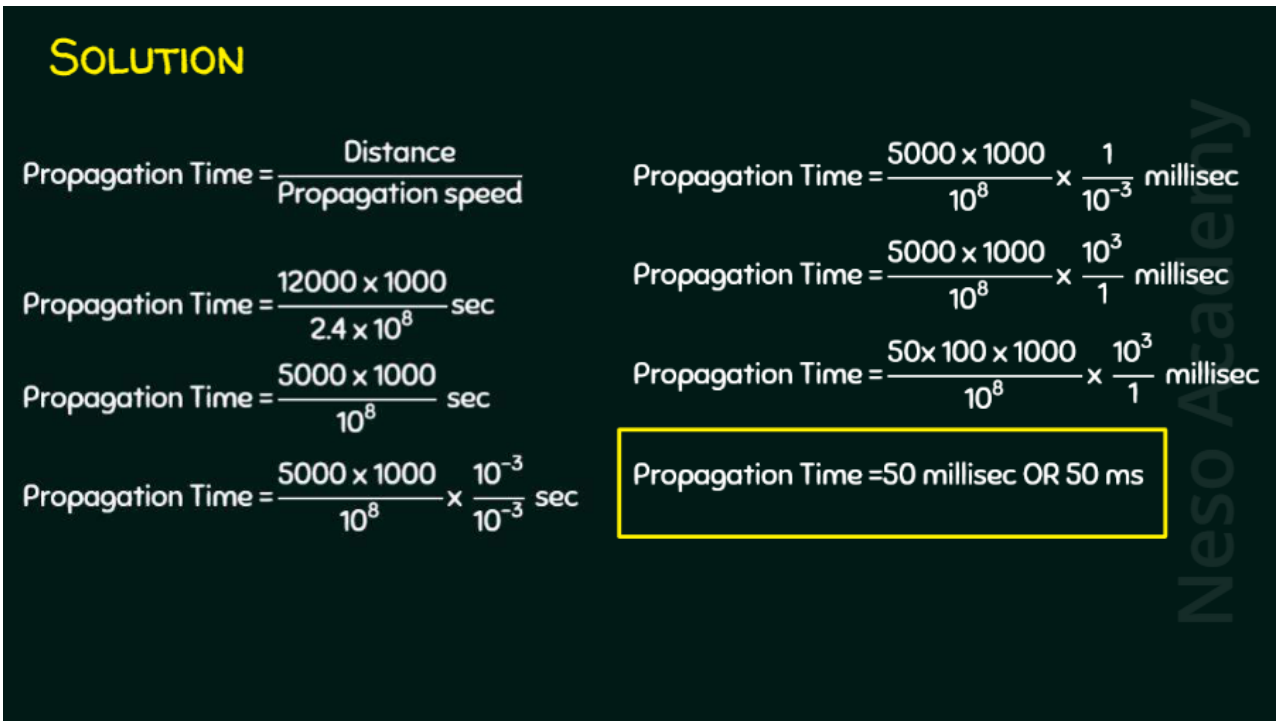
Pure alohaNeso Academy



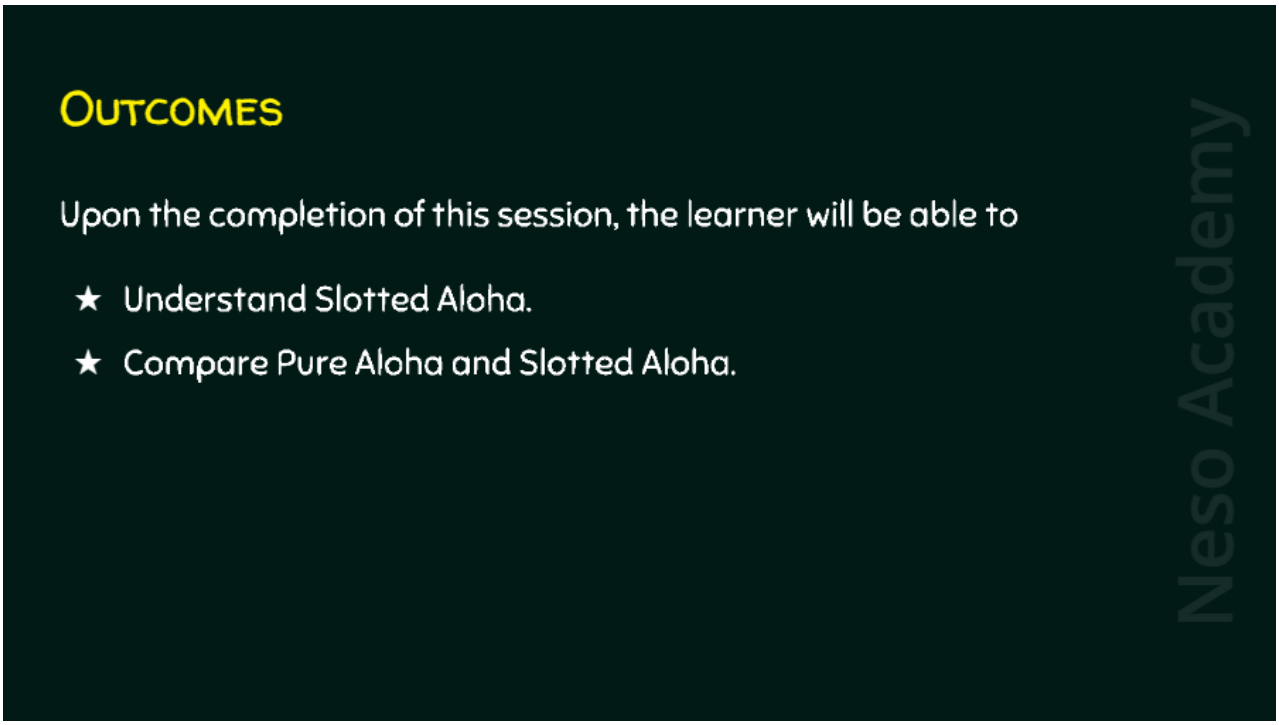
QuestionNeso Academy



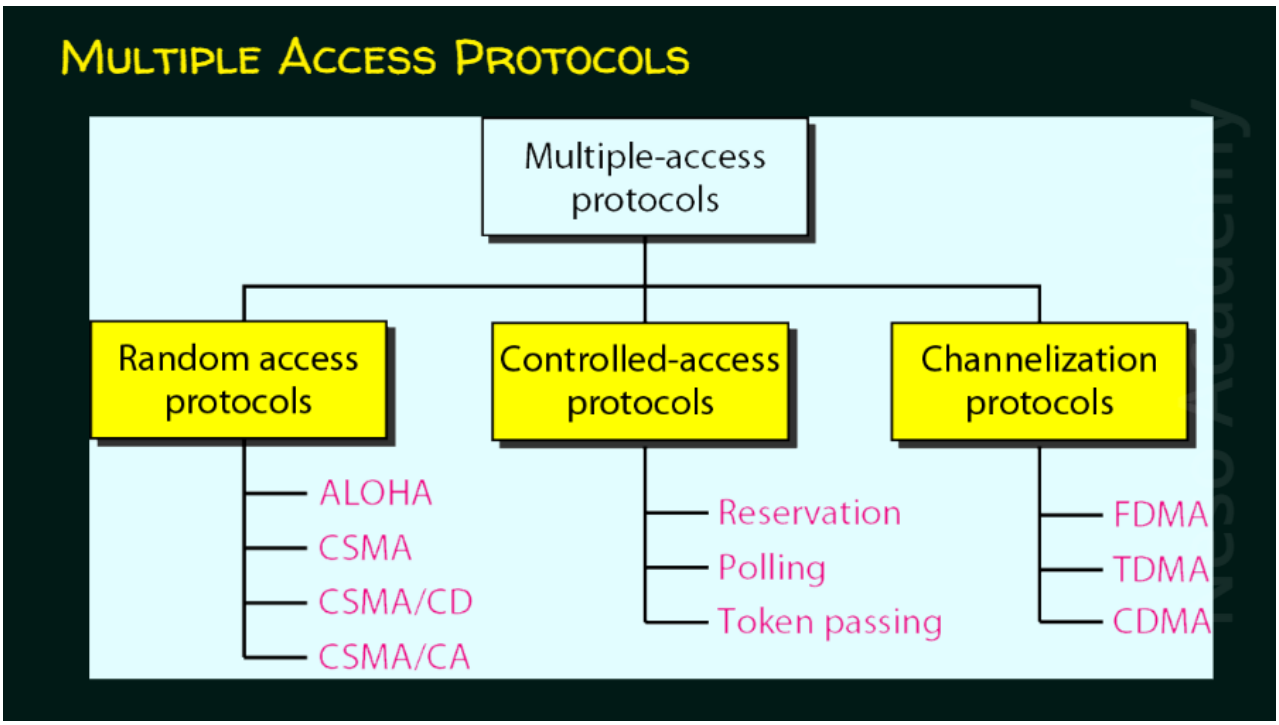
QuestionNeso Academy



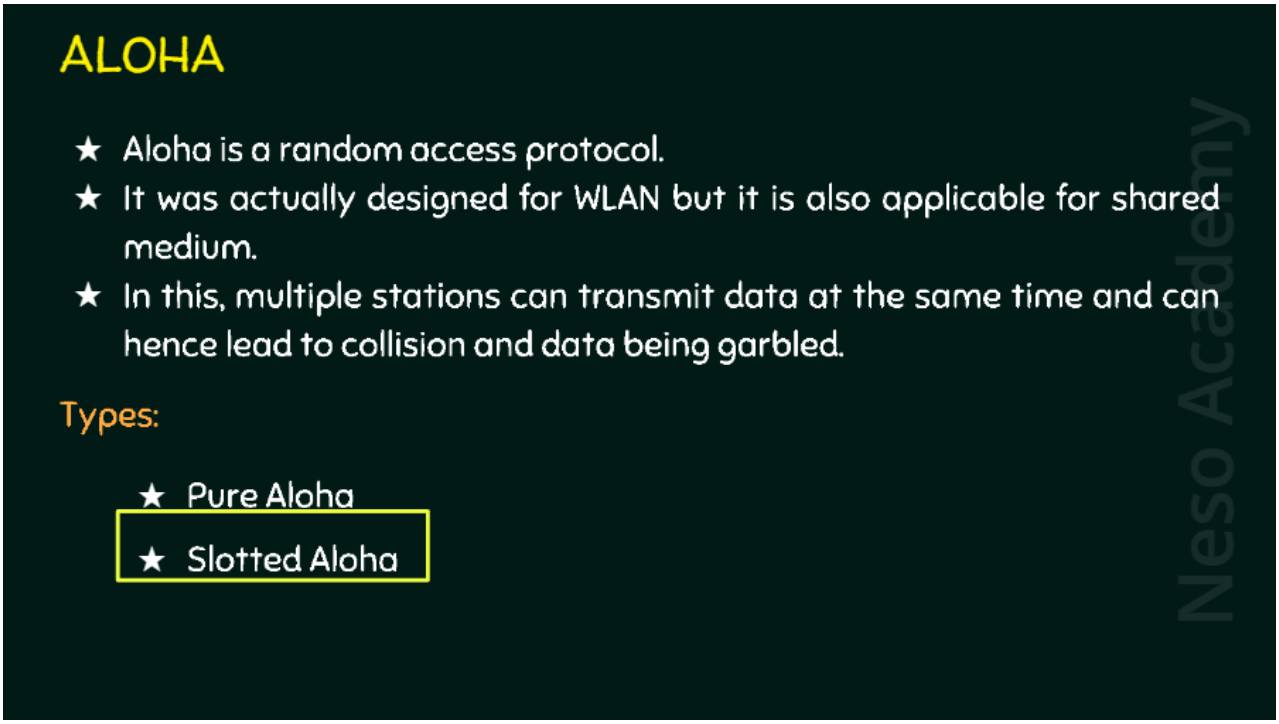
SolutionNeso Academy



★★OutcomesNeso Academy



Multiple Access ProtocolsNeso Academy



ALOHA★★★★★Neso Academy

SLOTTED ALOHA

- ★ It was developed just to improve the efficiency of pure aloha as the chances for collision in pure aloha are high.
- ★ The time of the shared channel is divided into discrete time intervals called slots.
- ★ Sending of data is allowed only at the beginning of these slots.

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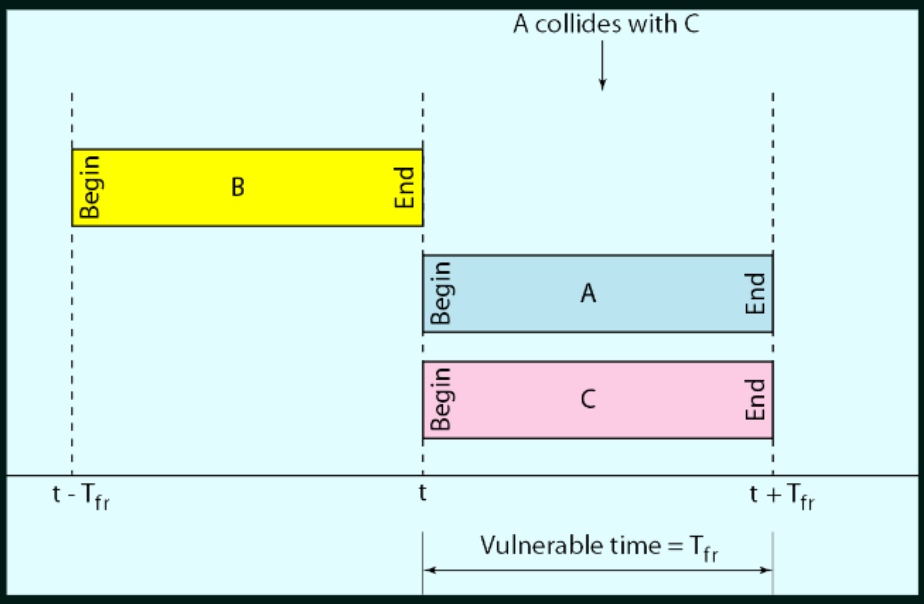
Slotted aloha★★★Neso Academy

SLOTTED ALOHA



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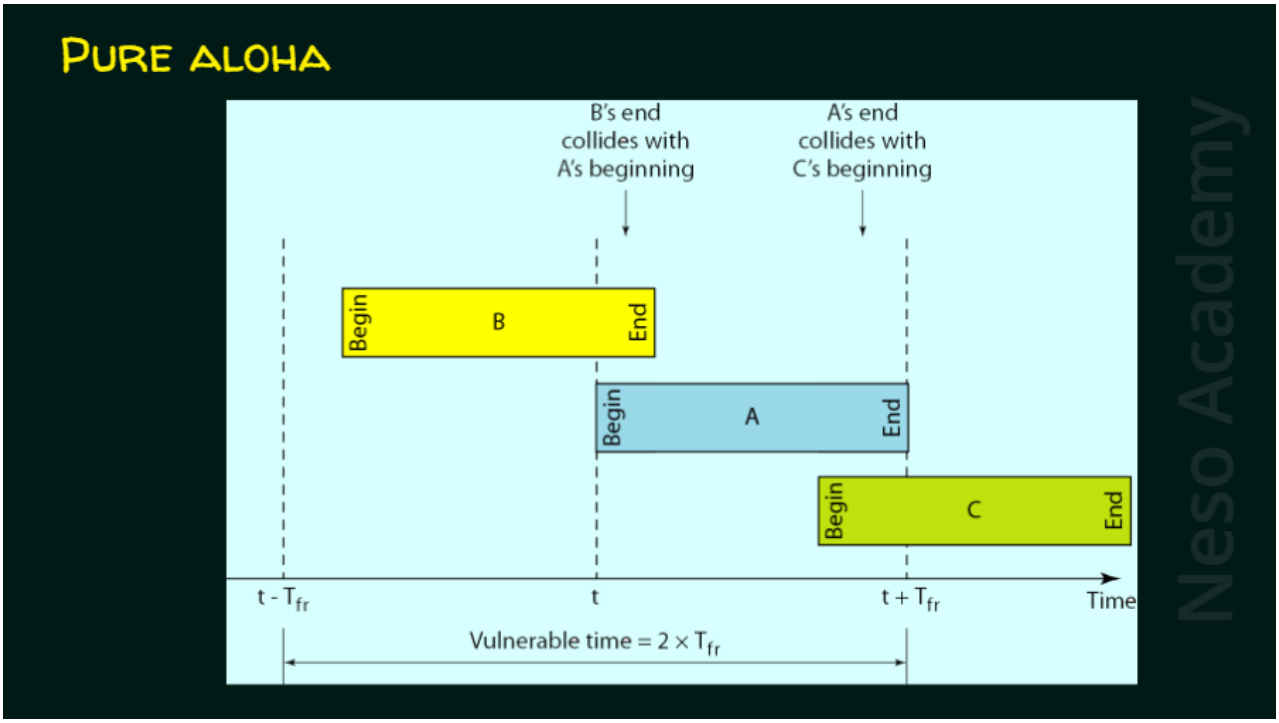
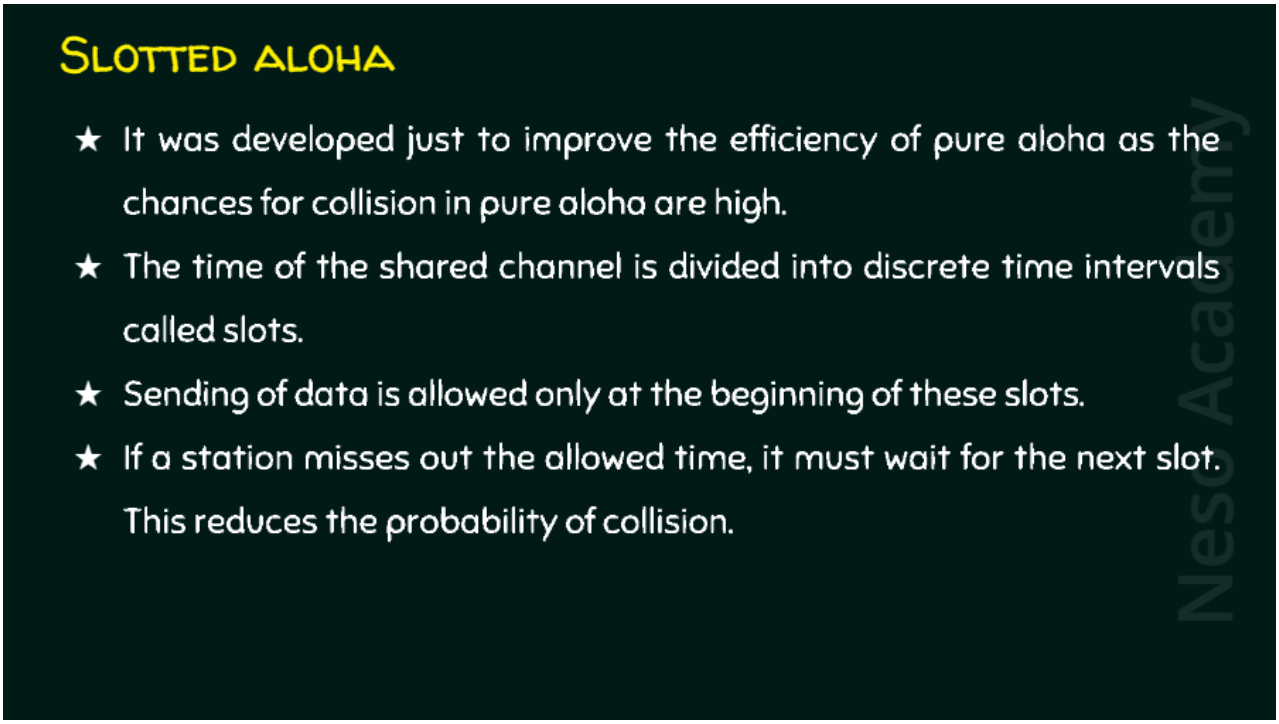
Slotted alohaNeso Academy



Pure alohaNeso Academy



Slotted aloha★★★★Neso Academy

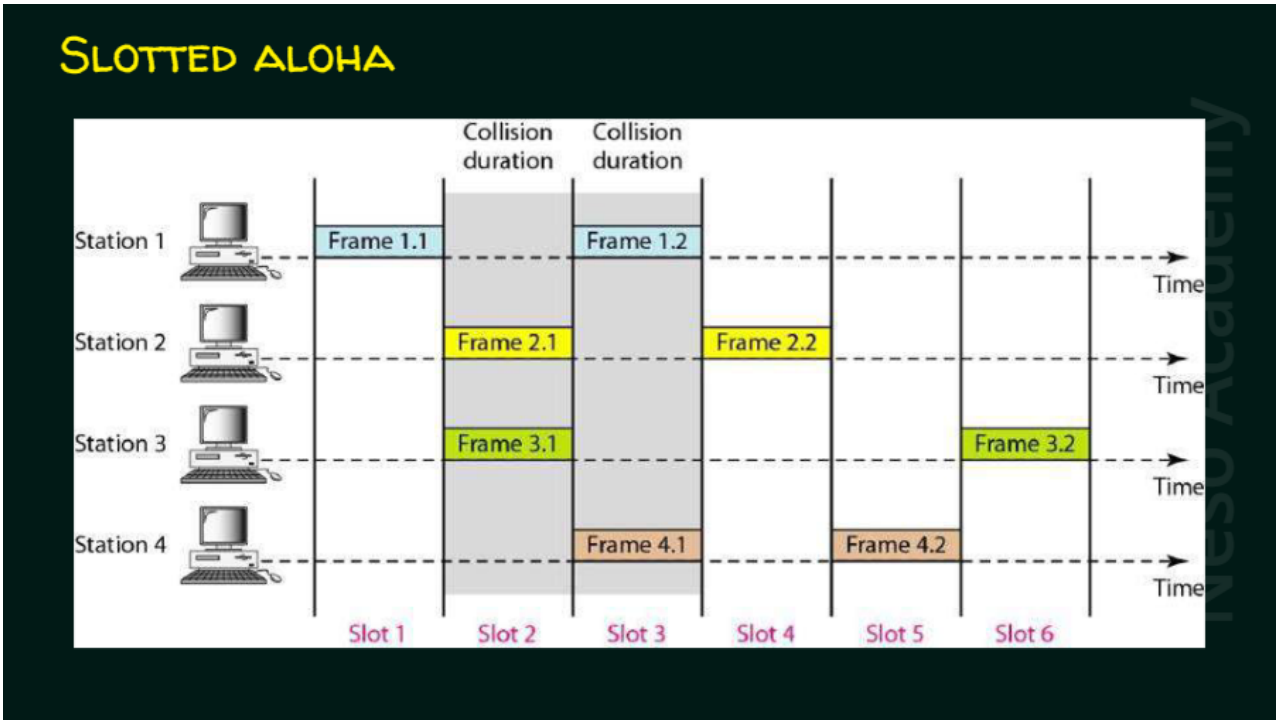
Slotted ALOHA

Vulnerable Time = Frame Transmission Time.

Throughput = $G \times e^{-G}$; Where G is the number of stations wish to transmit in the same time.

Maximum throughput = 0.368 for G=1.

Slotted alohaNeso Academy



Slotted alohaNeso Academy

Pure aloha vs Slotted aloha

Pure Aloha	Slotted Aloha
Any station can transmit the data at any time.	Any station can transmit the data at the beginning of any time slot.
The time is continuous and not globally synchronized.	The time is discrete and globally synchronized.
Vulnerable time in which collision may occur = $2 \times T_{Fr}$	Vulnerable time in which collision may occur = T_{Fr}
Probability of successful transmission of data packet= $G \times e^{-2G}$	Probability of successful transmission of data packet= $G \times e^{-G}$
Maximum efficiency = 18.4% (Occurs at G = 1/2)	Maximum efficiency = 36.8% (Occurs at G = 1)
Main advantage: Simplicity in implementation.	Main advantage: It reduces the number of collisions to half and doubles the efficiency of pure aloha.

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Pure aloha vs Slotted alohaNeso Academy

Outcomes

Upon the completion of this session, the learner will be able to

- ★ Know the various multiple access protocols.
- ★ Understand CSMA protocol.
- ★ Types of CSMA.
- ★ Understand the behaviour of three persistent methods.

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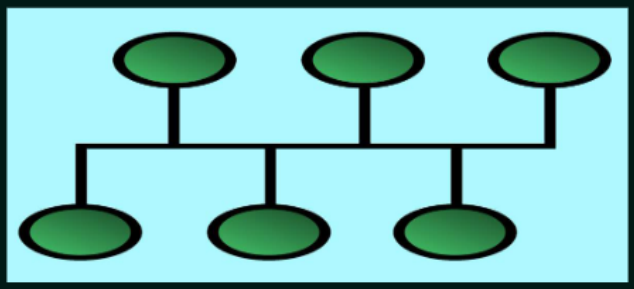
Outcomes★★★★Neso Academy

CSMA PROTOCOL

- ★ Carrier Sense Protocol.
- ★ To minimize the chance of collision and, therefore, increase the performance, the CSMA method was developed.
- ★ Principle of CSMA: "sense before transmit" or "listen before talk."

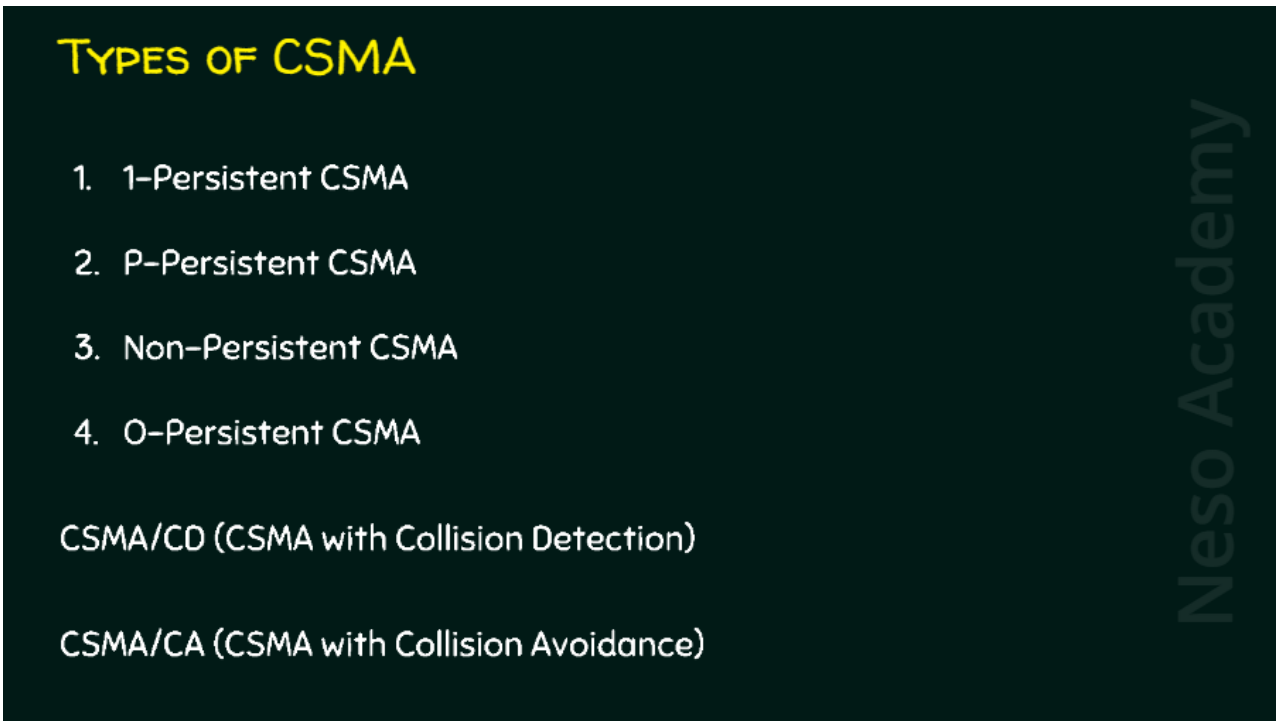


CSMA protocol★★★Neso Academy

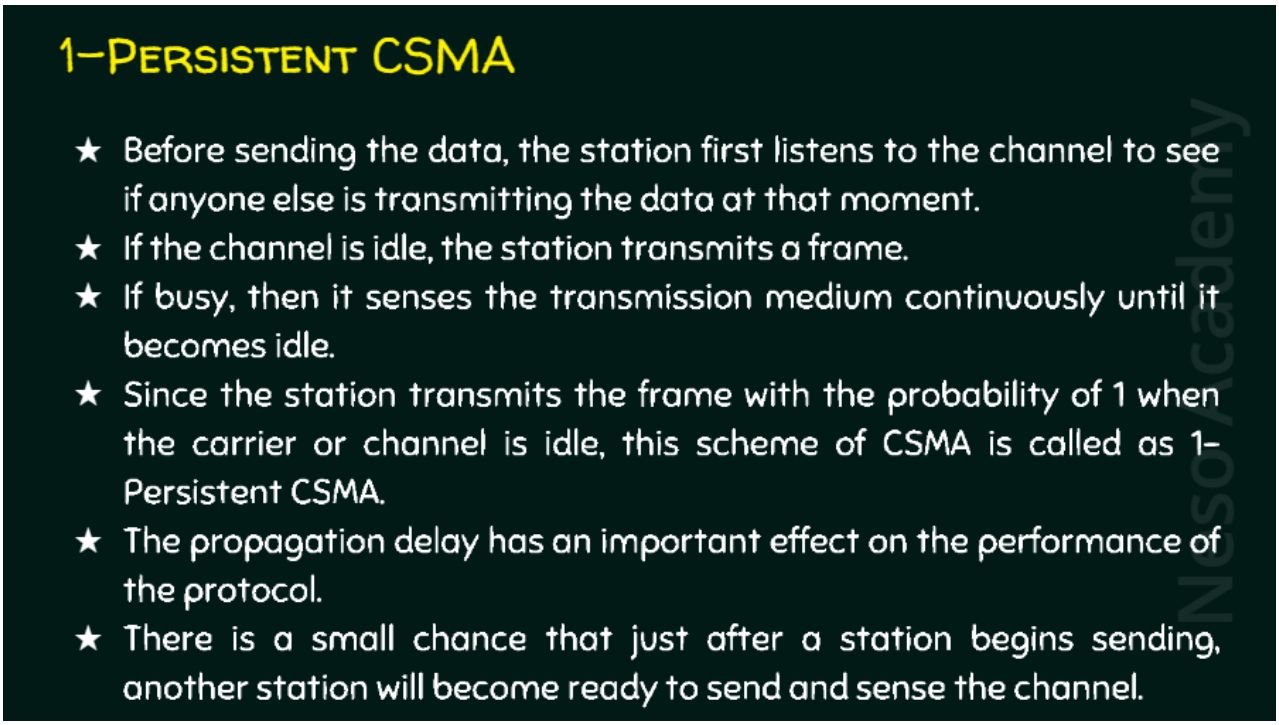
CSMA PROTOCOL

- ★ Carrier Sense Protocol.
- ★ To minimize the chance of collision and, therefore, increase the performance, the CSMA method was developed.
- ★ Principle of CSMA: "sense before transmit" or "listen before talk."
- ★ Carrier busy = Transmission is taking place.
- ★ Carrier idle = No transmission currently taking place.
- ★ The possibility of collision still exists because of propagation delay; a station may sense the medium and find it idle, only because the first bit sent by another station has not yet been received.

CSMA protocol★★★★★★Neso Academy



Types of CSMANeso Academy

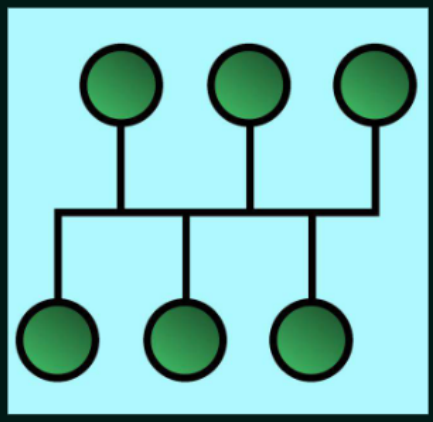


1-Persistent CSMA★★★★★★Neso Academy

1-Persistent CSMA

★ The longer the propagation delay, the more important this effect becomes, and the worse the performance of the protocol.

★ Even if the propagation delay is zero, there will still be collisions.



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1-Persistent CSMA★★Neso Academy

Non-Persistent CSMA

★ Before sending, a station senses the channel. If no one else is sending, the station begins doing so itself.

★ However, if the channel is already in use, the station does not continually sense it for the purpose of seizing it immediately upon detecting the end of the previous transmission.

★ Instead, it waits a random period of time and then repeats the algorithm. Consequently, this algorithm leads to better channel utilization but longer delays than 1-persistent CSMA.

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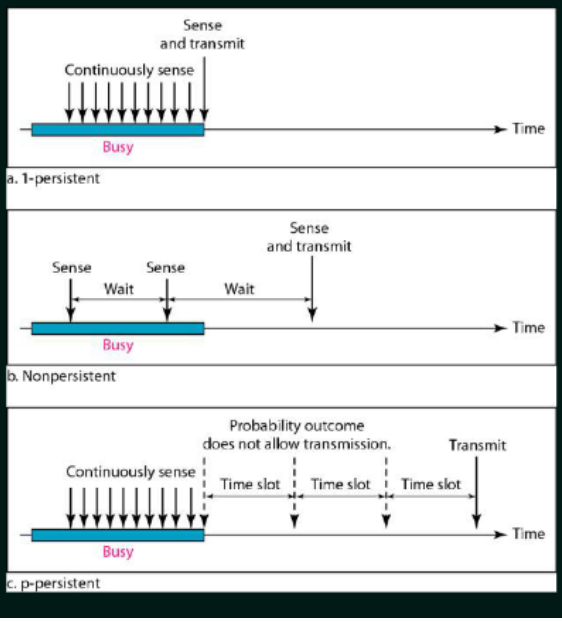
Non-Persistent CSMA★★★Neso Academy

P-Persistent CSMA

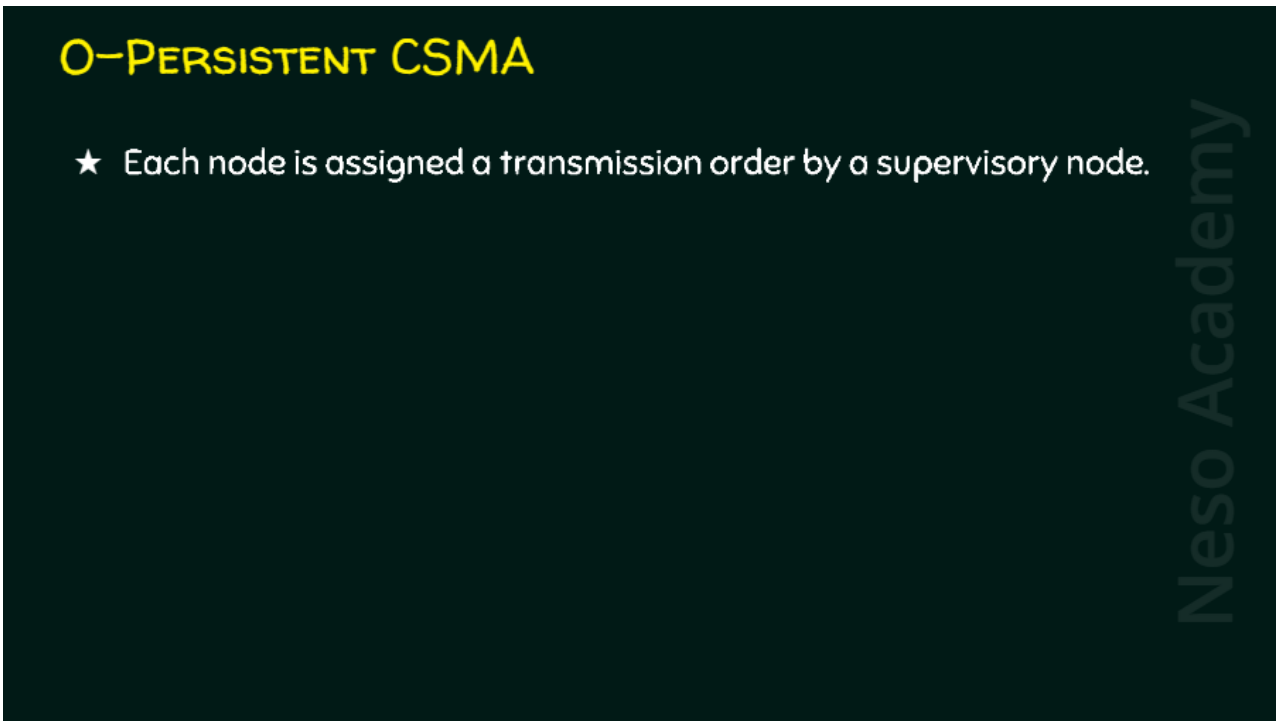
- ★ It applies to slotted channels.
- ★ When a station becomes ready to send, it senses the channel.
- ★ If it is idle, it transmits with a probability P.
- ★ With a probability Q=1-P, it defers until the next slot.
- ★ If that slot is also idle, it either transmits or defers again, with probabilities P and Q.
- ★ This process is repeated until either the frame has been transmitted or another station has begun transmitting.
- ★ In the latter case, the unlucky station acts as if there had been a collision (i.e., it waits a random time and starts again).
- ★ If the station initially senses the channel busy, it waits until the next slot and applies the above algorithm.

P-Persistent CSMA★★★★★★★★Neso Academy

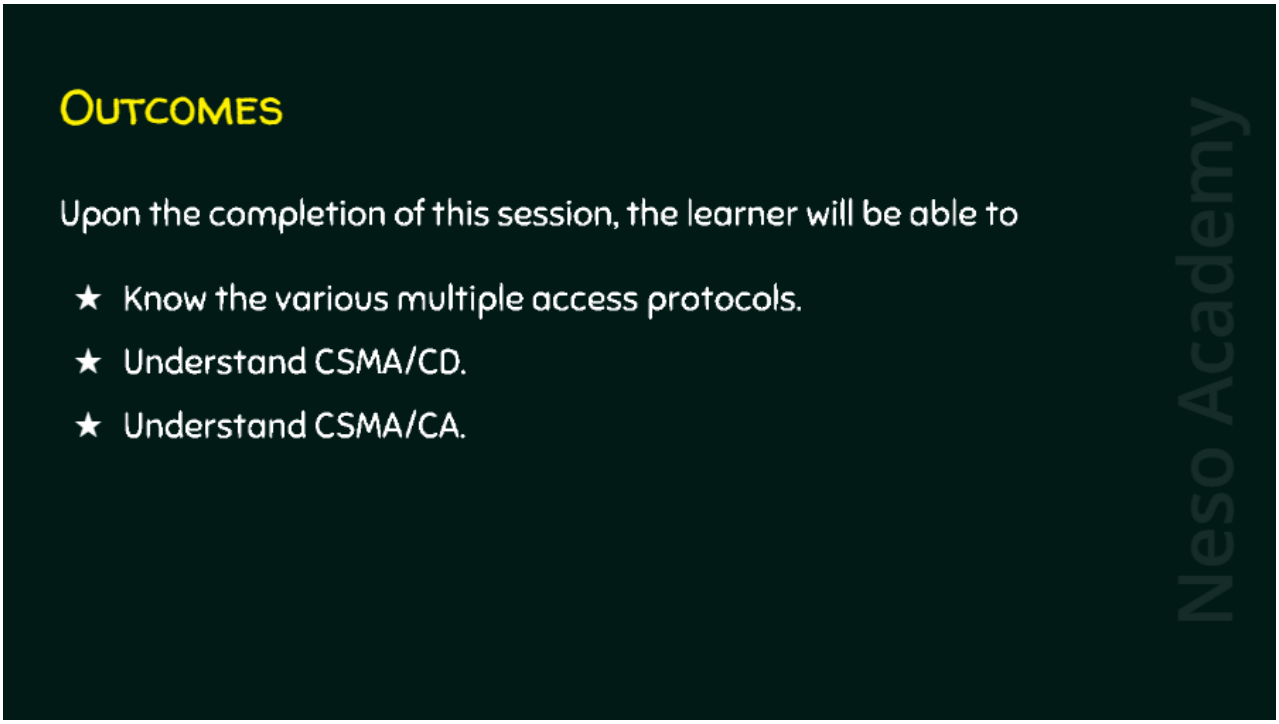
Behaviour of three persistent methods



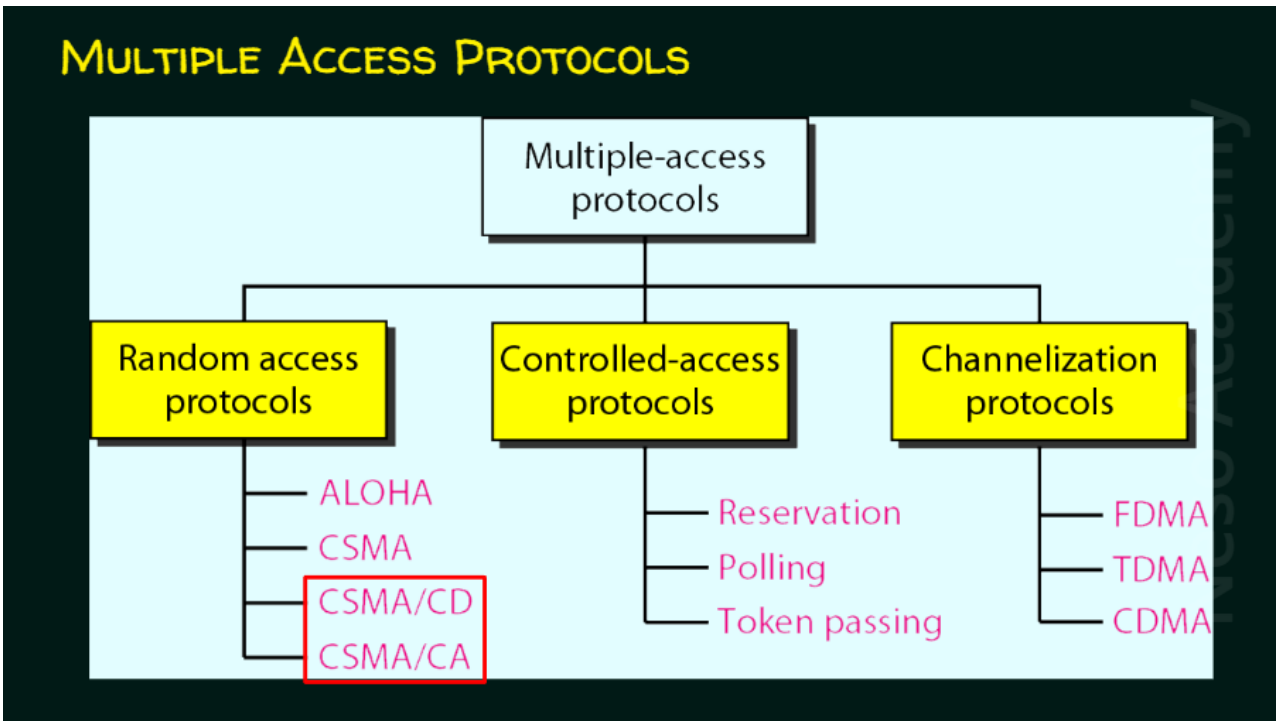
Behaviour of three persistent methodsNeso Academy



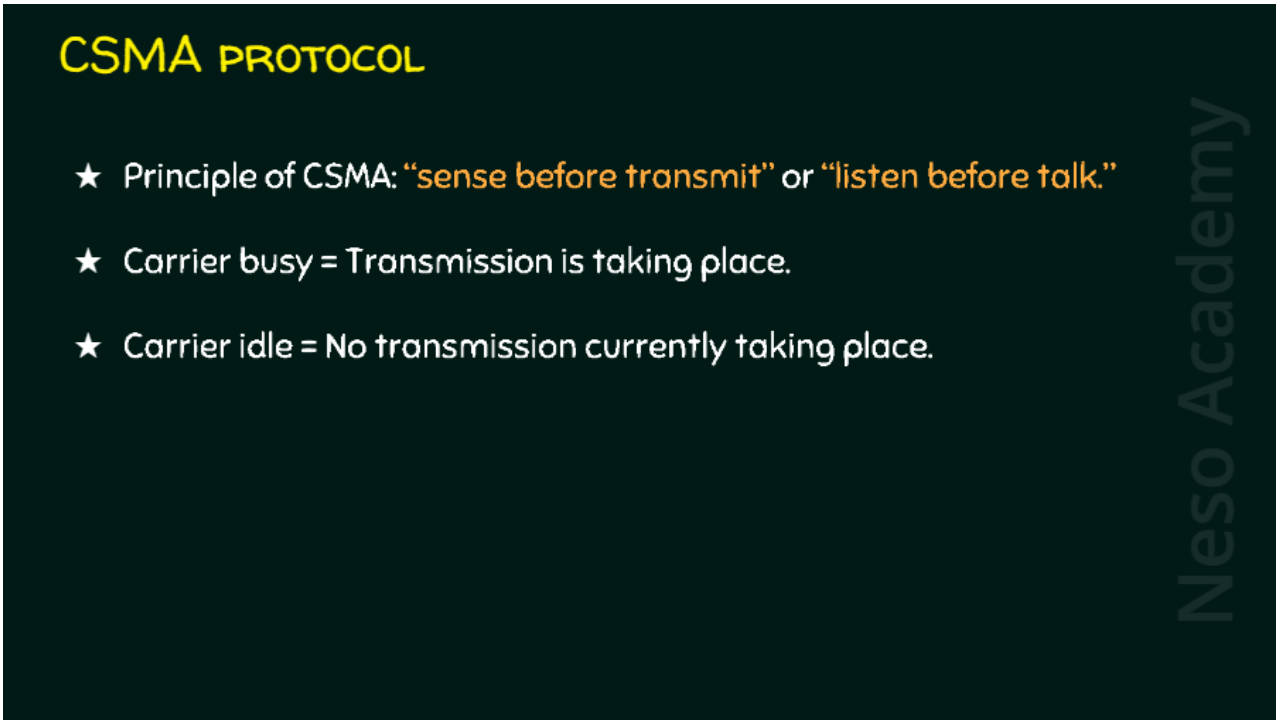
O-Persistent CSMA★Neso Academy



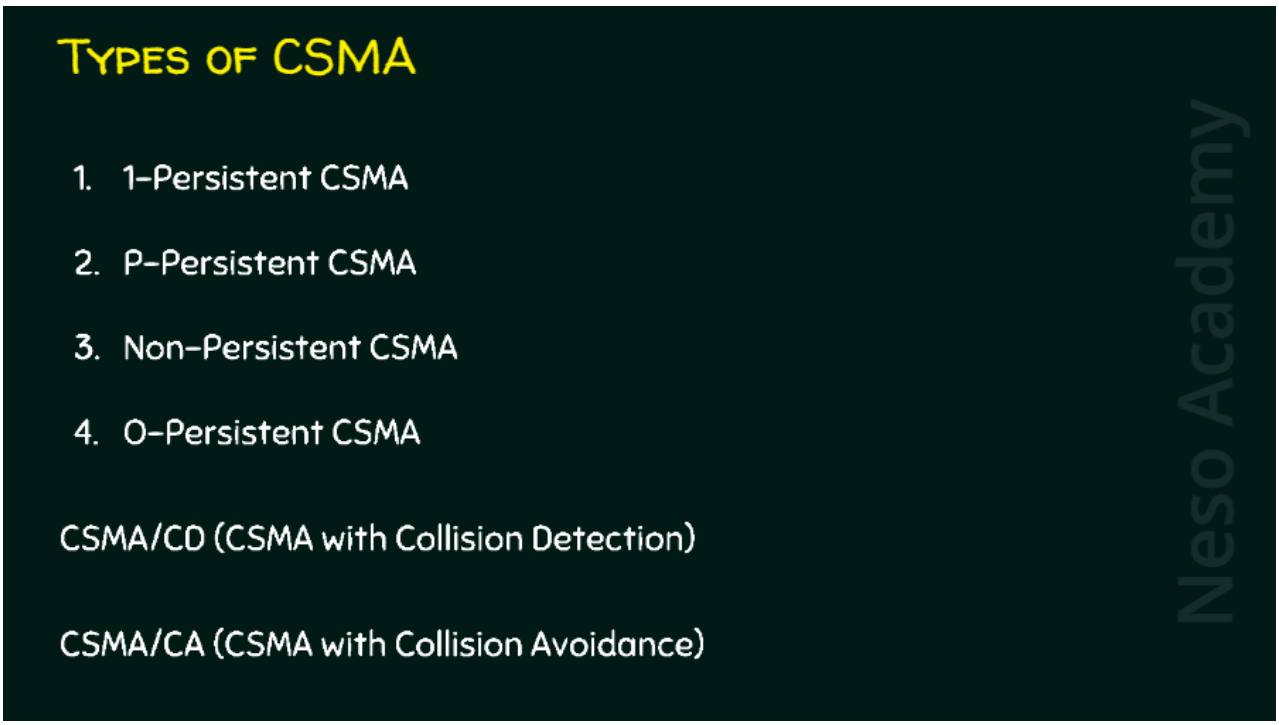
Outcomes★★★Neso Academy



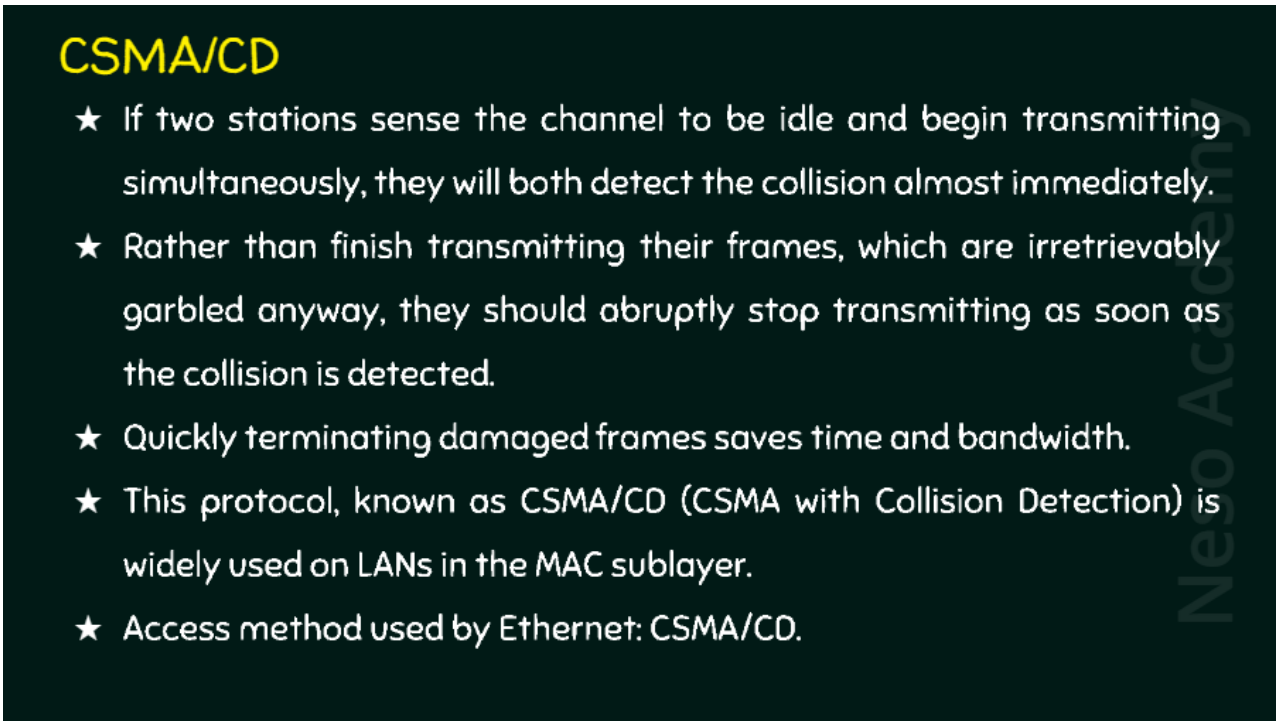
Multiple Access ProtocolsNeso Academy



CSMA protocol★★★Neso Academy



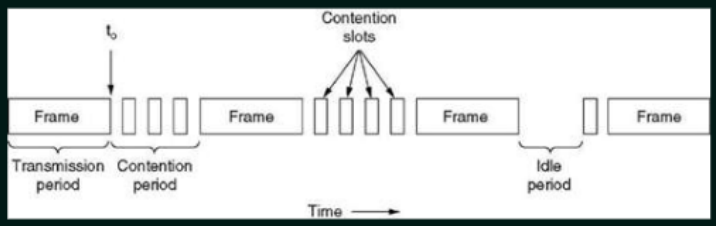
Types of CSMANeso Academy



CSMA/CD★★★★★Neso Academy

CSMA/CD

★ At the point marked t_0, a station has finished transmitting its frame.



CSMA/CD★Neso Academy

CSMA/CD

★ At the point marked t_0, a station has finished transmitting its frame.

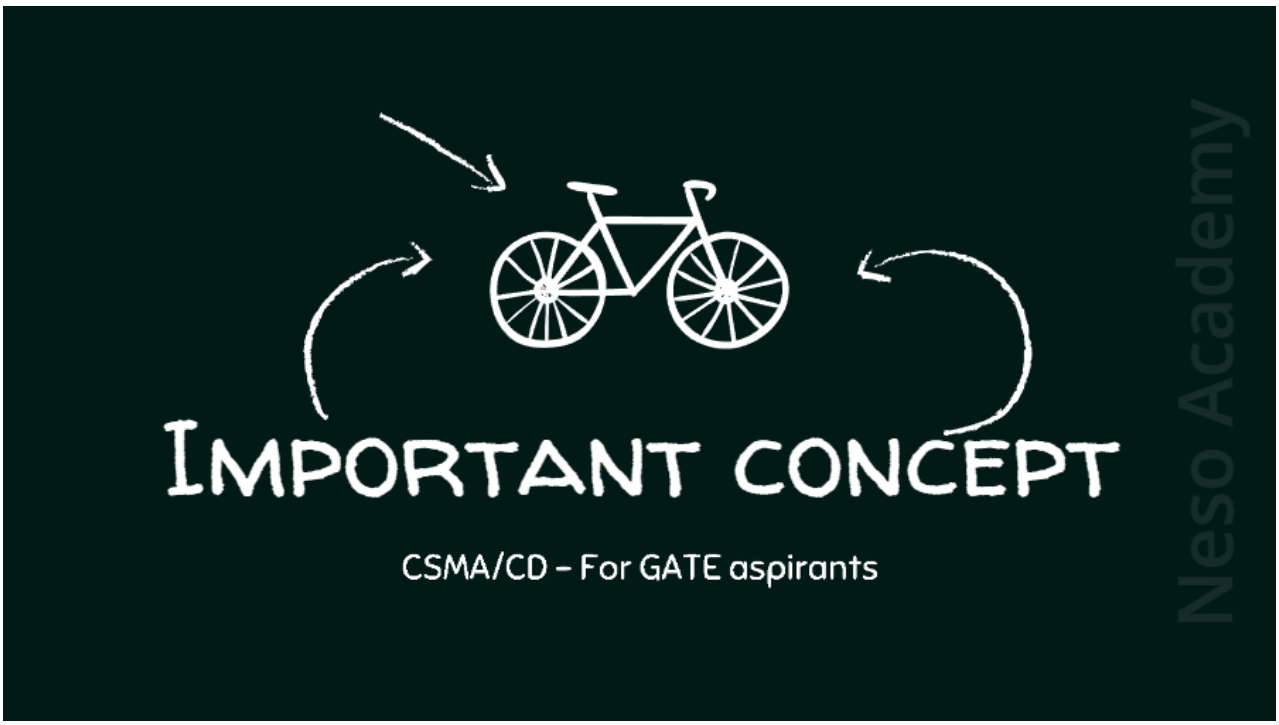
★ Any other station having a frame to send may now attempt to do so. If two or more stations decide to transmit simultaneously, there will be a collision.

★ Collisions can be detected by looking at the power or pulse width of the received signal and comparing it to the transmitted signal.

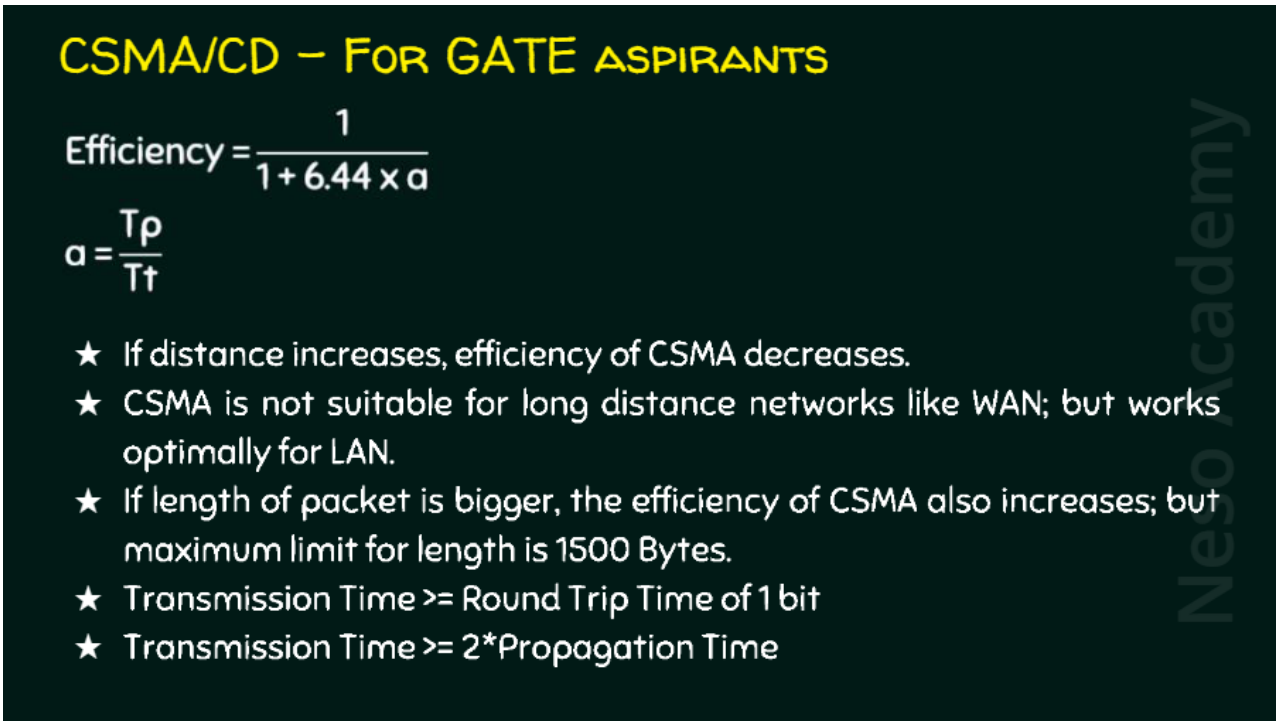
★ After a station detects a collision, it aborts its transmission, waits a random period of time, and then tries again, assuming that no other station has started transmitting in the meantime.

★ Therefore, model for CSMA/CD will consist of alternating contention and transmission periods, with idle periods occurring when all stations are quiet.

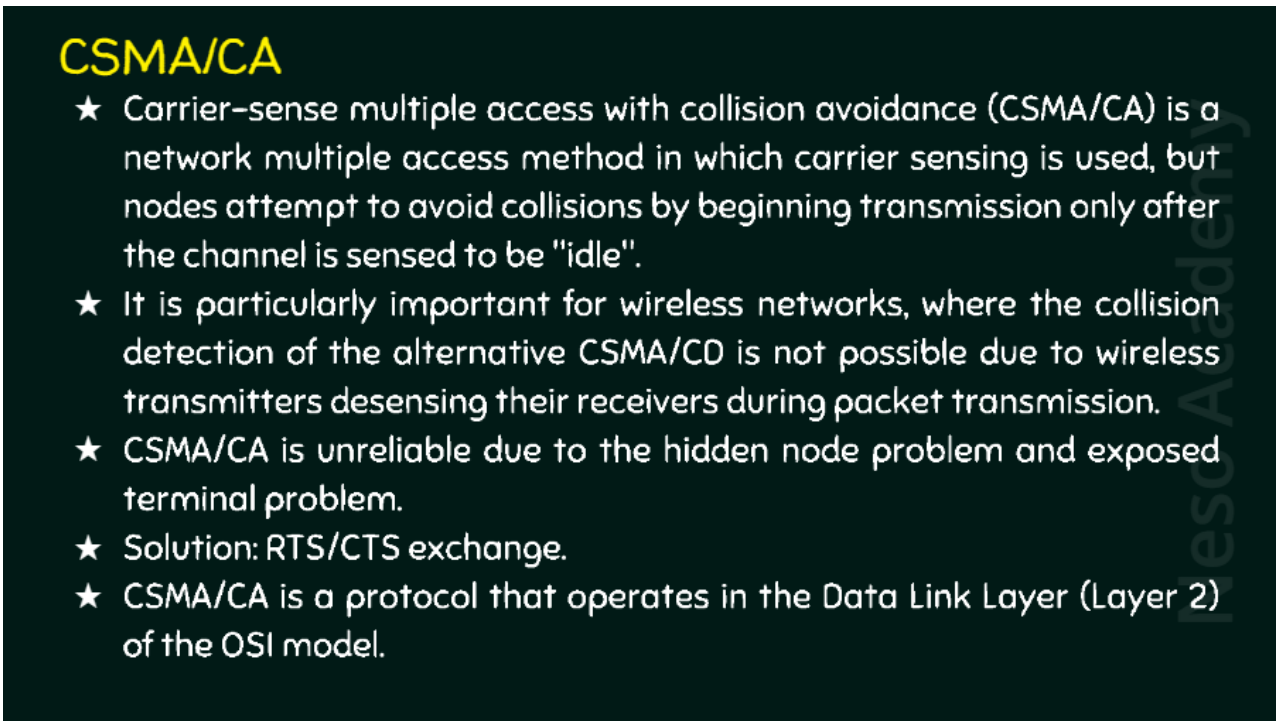
CSMA/CD★★★★★Neso Academy



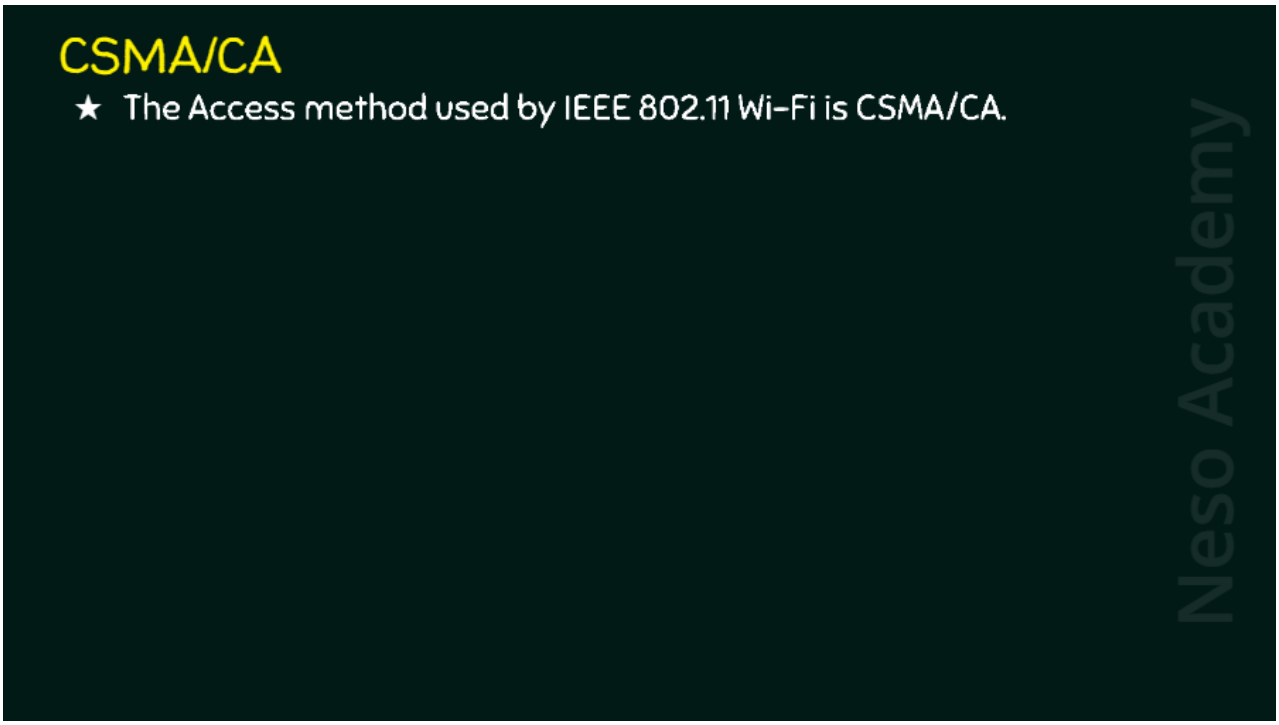
Important conceptNeso Academy



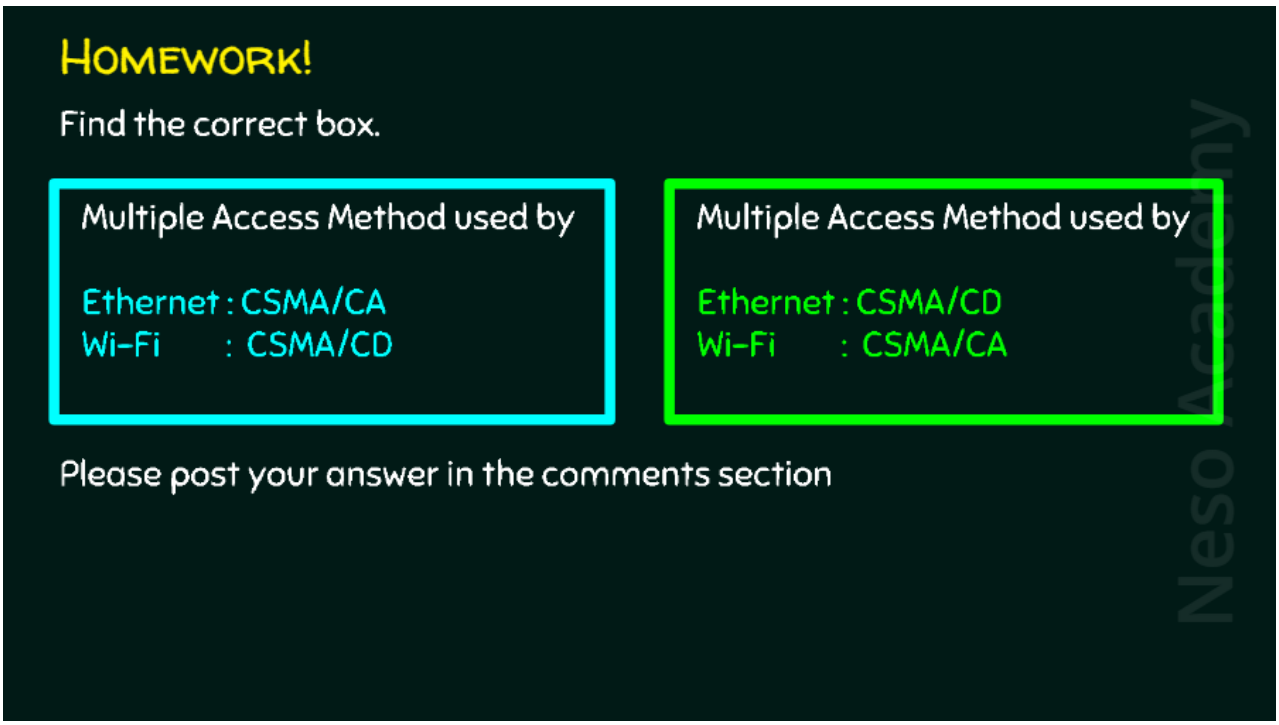
CSMA/CD -For GATE aspirants★★★★★Neso Academy



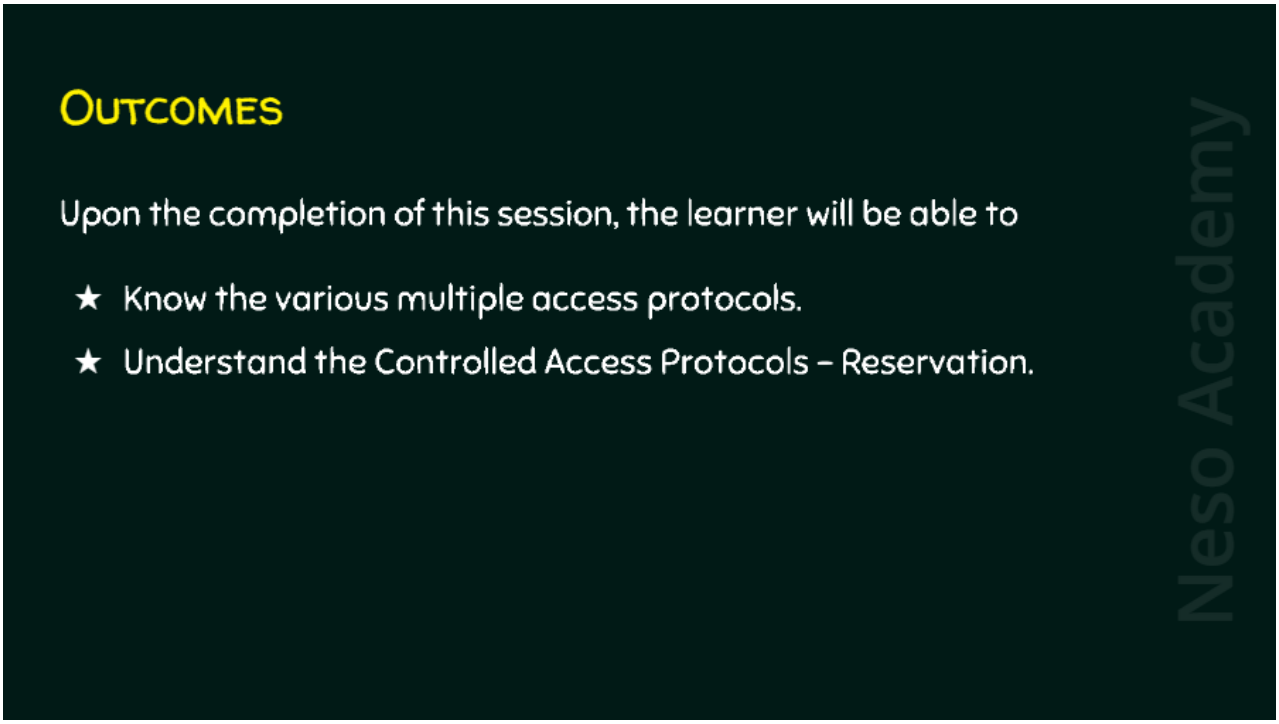
CSMA/CA★★★★★Neso Academy



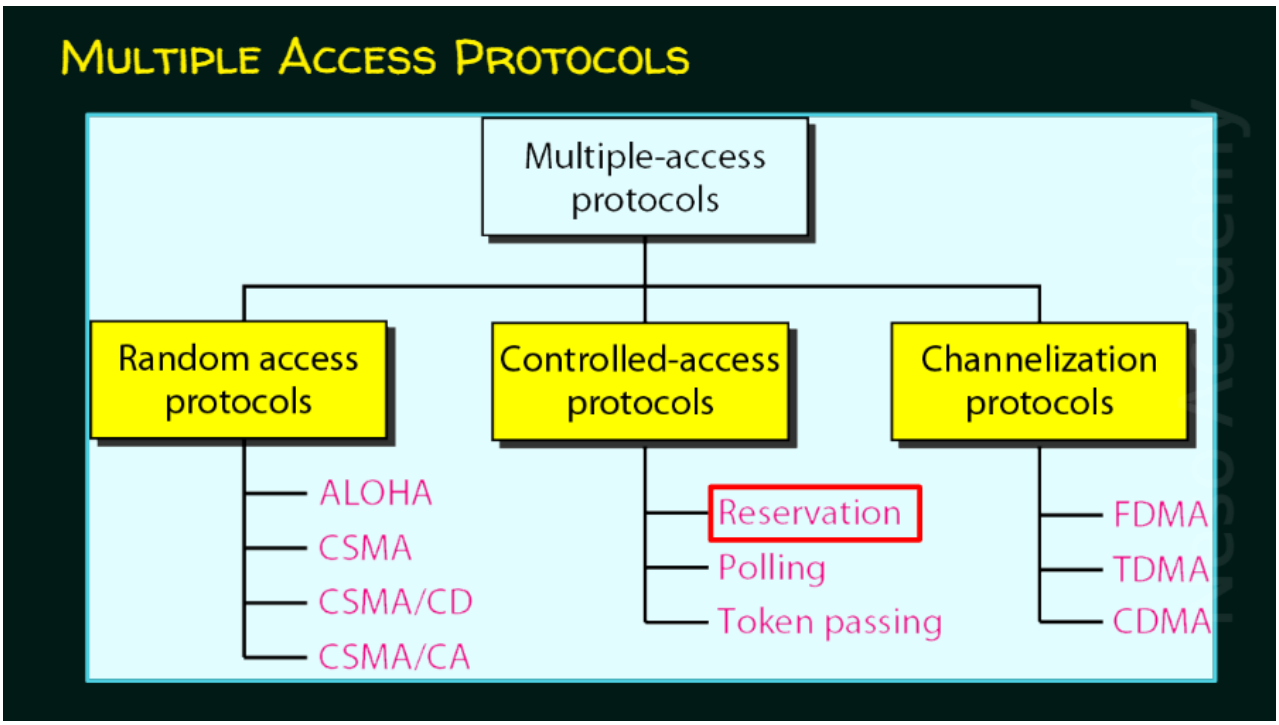
CSMA/CA★Neso Academy



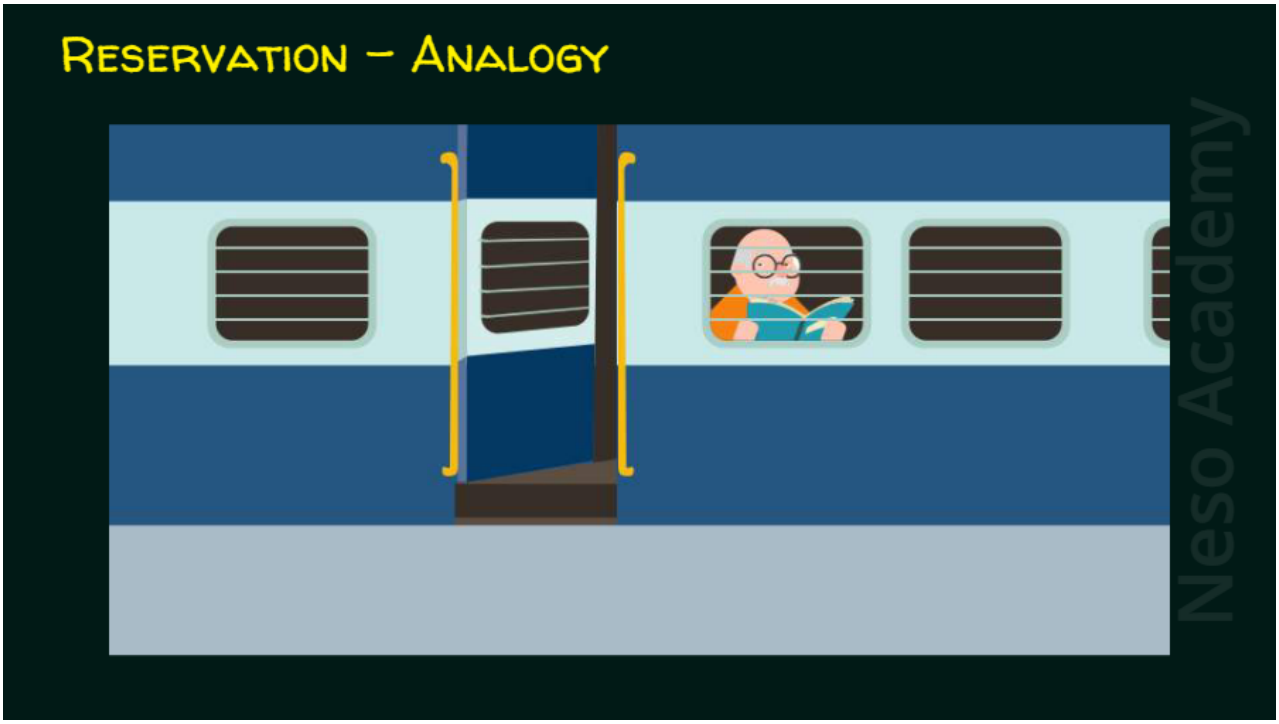
Homework!Neso Academy



Outcomes★★Neso Academy



Multiple Access ProtocolsNeso Academy



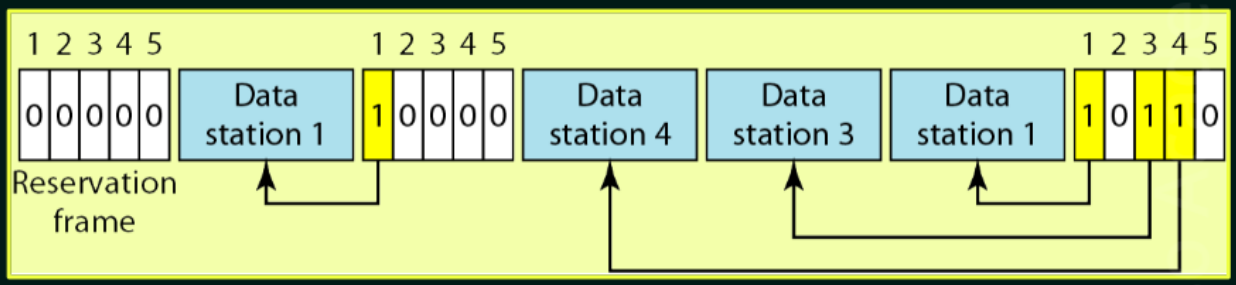
Reservation -AnalogyNeso Academy

Reservation

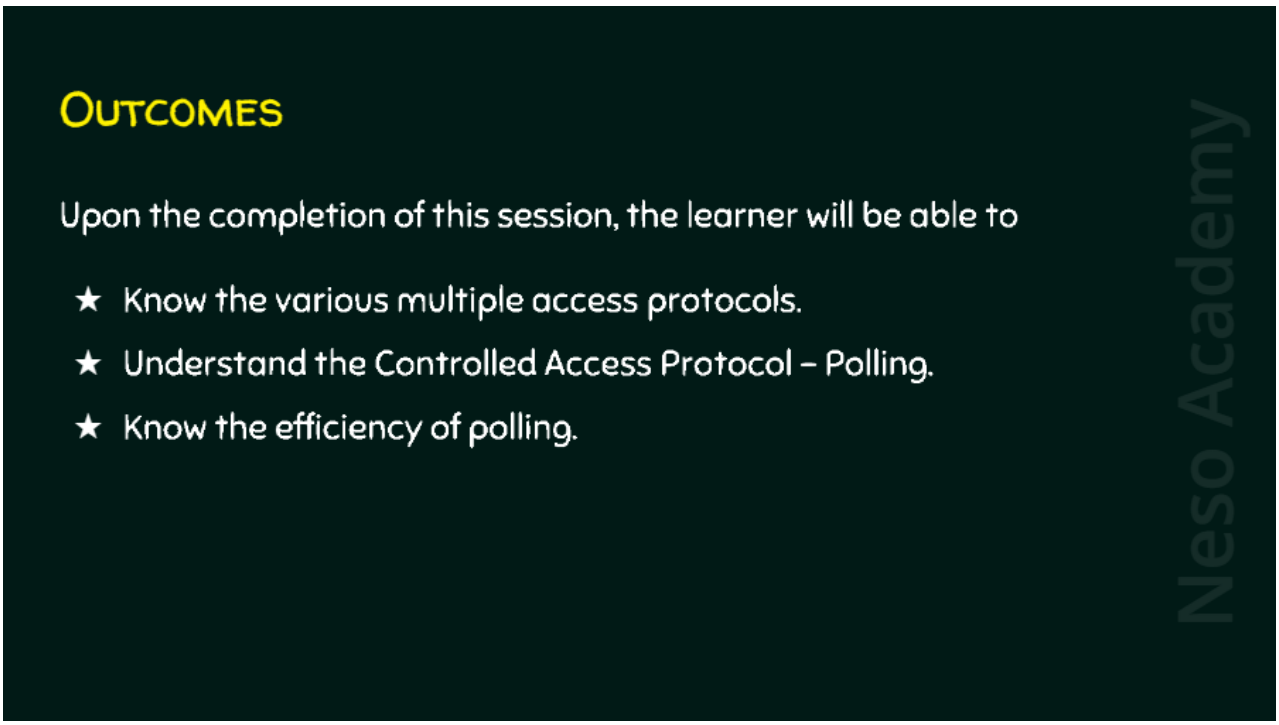
- ★ A station need to make a reservation before sending data.
- ★ In each interval, a reservation frame precedes the data frames sent in that interval.
- ★ If there are N stations in the system, there are exactly N reservation minislots in the reservation frame.
- ★ Each minislot belongs to a station.
- ★ When a station needs to send a data frame, it makes a reservation in its own minislot.
- ★ The stations that have made reservations can send their data frames after the reservation frame.

Reservation★★★★★★Neso Academy

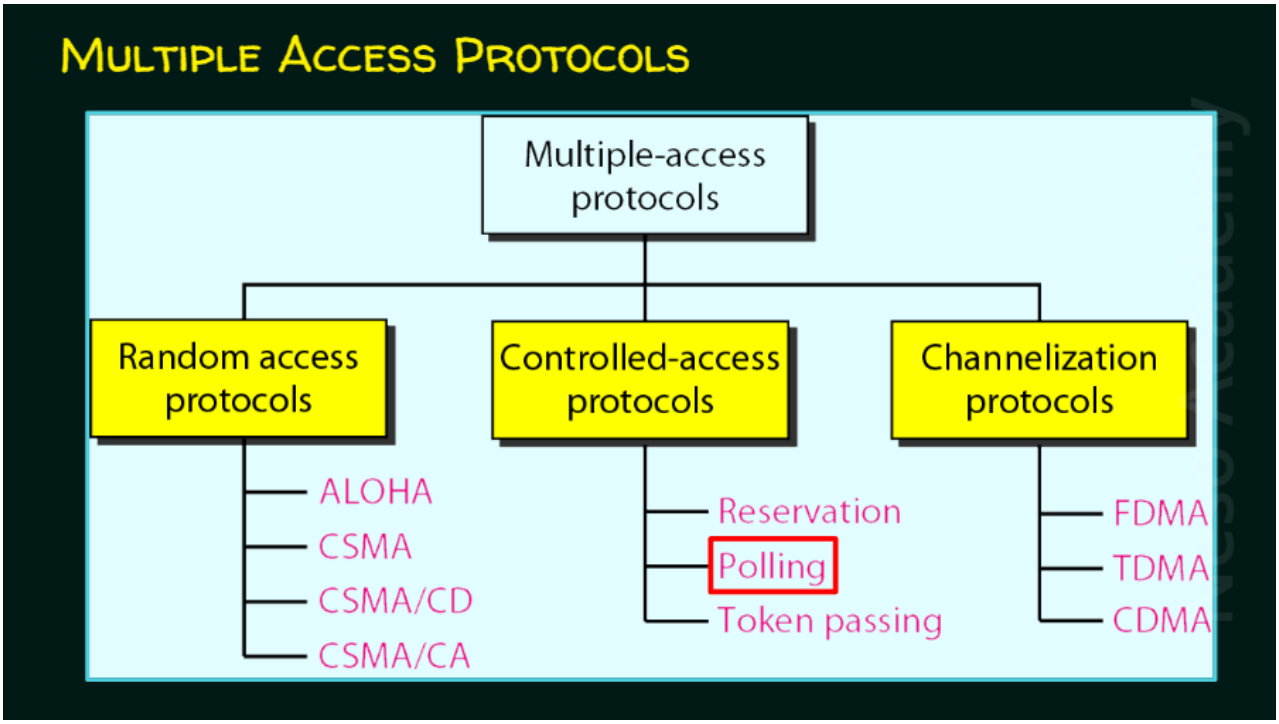
Reservation



ReservationNeso Academy



Outcomes★★★Neso Academy



Multiple Access ProtocolsNeso Academy

Polling –Analogy!

Neso Academy

Polling -Analogy! Neso Academy

Polling

- ★ The polling protocol requires one of the nodes to be designated as a Master node (Primary station).
- ★ The master node polls each of the nodes in a round-robin fashion.
- ★ In particular, the master node first sends a message to node 1, saying that it (node 1) can transmit up to some maximum number of frames.
- ★ After node 1 transmits some frames, the master node tells node 2 it (node 2) can transmit up to the maximum number of frames.
- ★ The master node can determine when a node has finished sending its frames by observing the lack of a signal on the channel.

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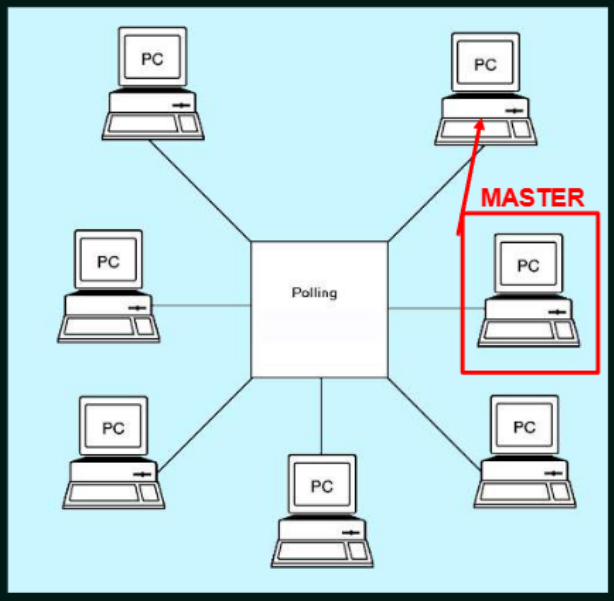
Polling★★★★★Neso Academy

POLLING

- ★ The procedure continues in this manner, with the master node polling each of the nodes in a cyclic manner.
- ★ The polling protocol eliminates the collision.
- ★ This allows polling to achieve a much higher efficiency.
- ★ The first drawback is that the protocol introduces a polling delay–the amount of time required to notify a node that it can transmit.
- ★ The second drawback, which is potentially more serious, is that if the master node fails, the entire channel becomes inoperative.

Polling★★★★★Neso Academy

POLLING



PollingMASTERNeso Academy

Polling – Functions

★ Poll function : If the primary wants to receive data, it asks the secondaries if they have anything to send.

★ Select function : If the primary wants to send data, it tells the secondary to get ready to receive.

Polling -Functions★★Neso Academy

Efficiency of Polling

Let T_{poll} be the time for polling and T_t be the time required for transmission of data. Then,

$$\text{Efficiency} = \frac{T_t}{T_t + T_{poll}}$$

Efficiency of PollingNeso Academy

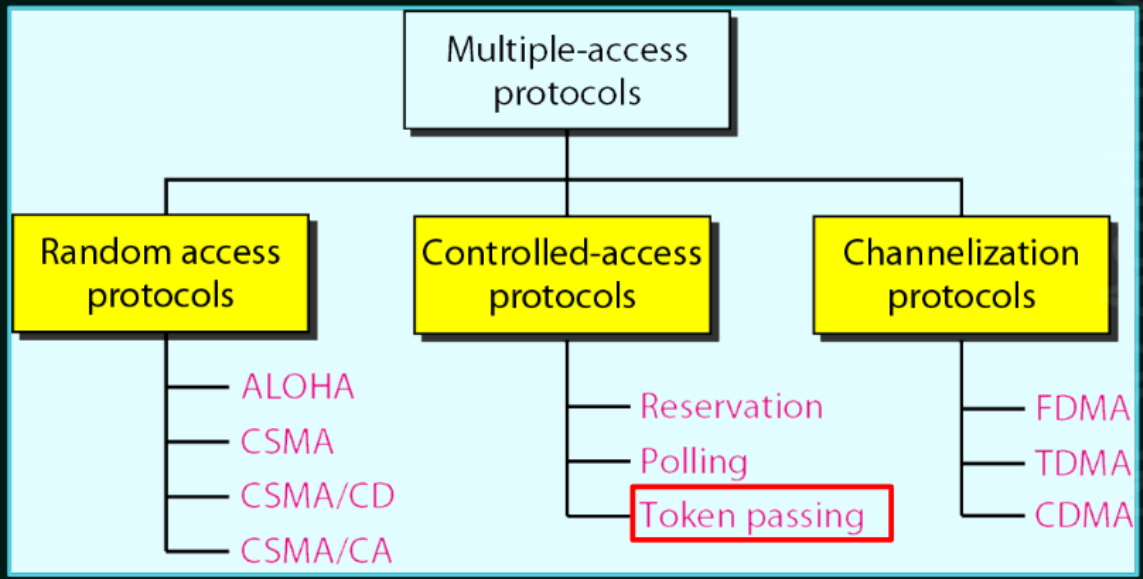
Outcomes

Upon the completion of this session, the learner will be able to

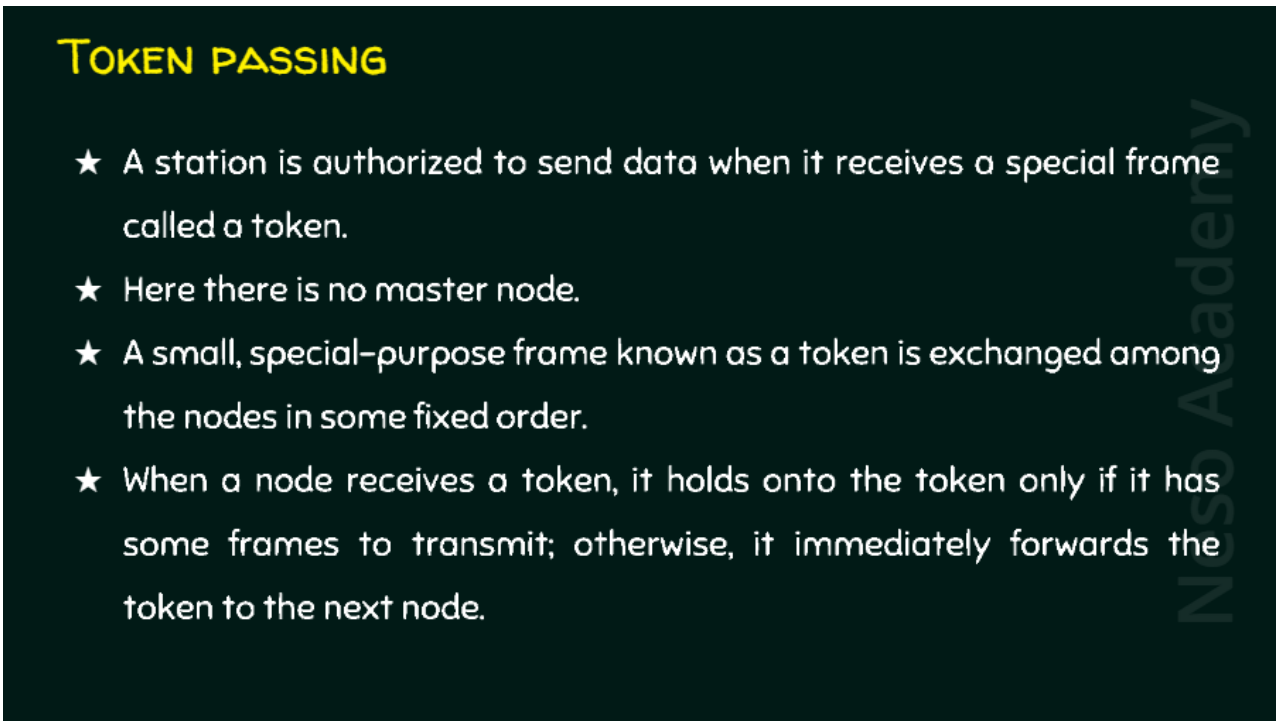
- ★ Know the various multiple access protocols.
- ★ Understand the Controlled Access Protocol – Token Passing.
- ★ Know the performance of Token Passing.

Outcomes★★★Neso Academy

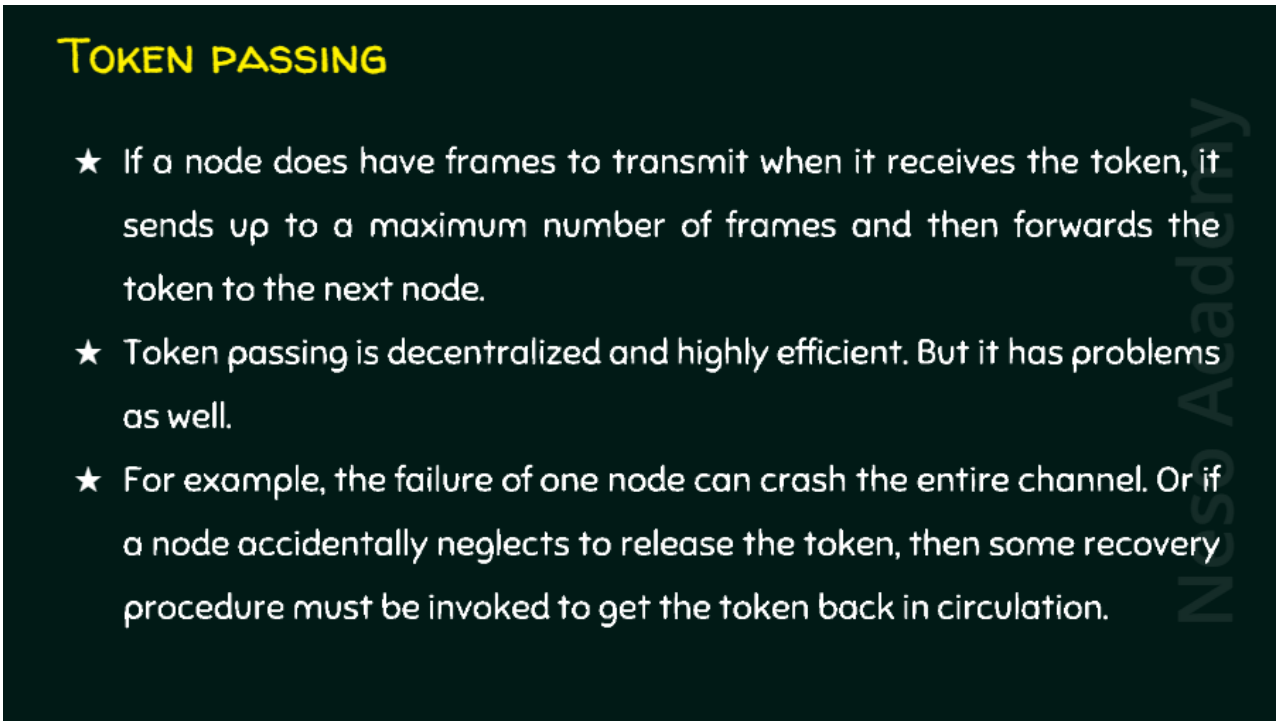
Multiple Access Protocols



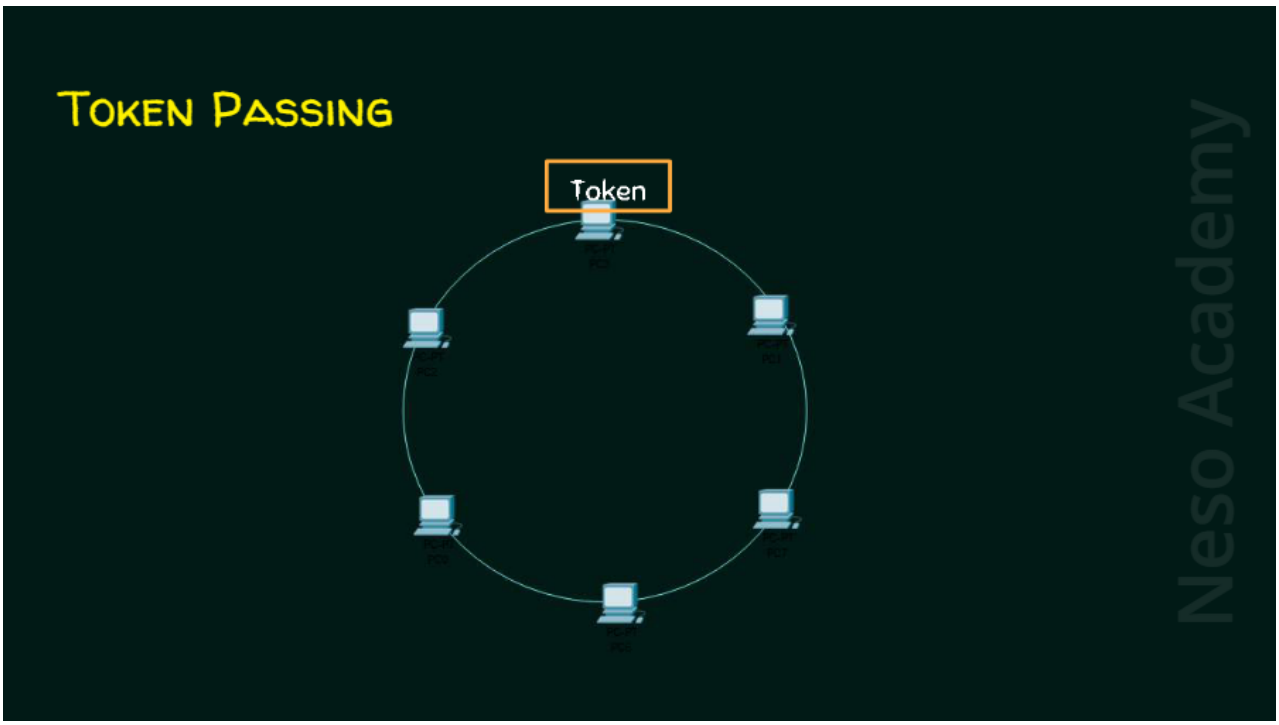
Multiple Access ProtocolsNeso Academy



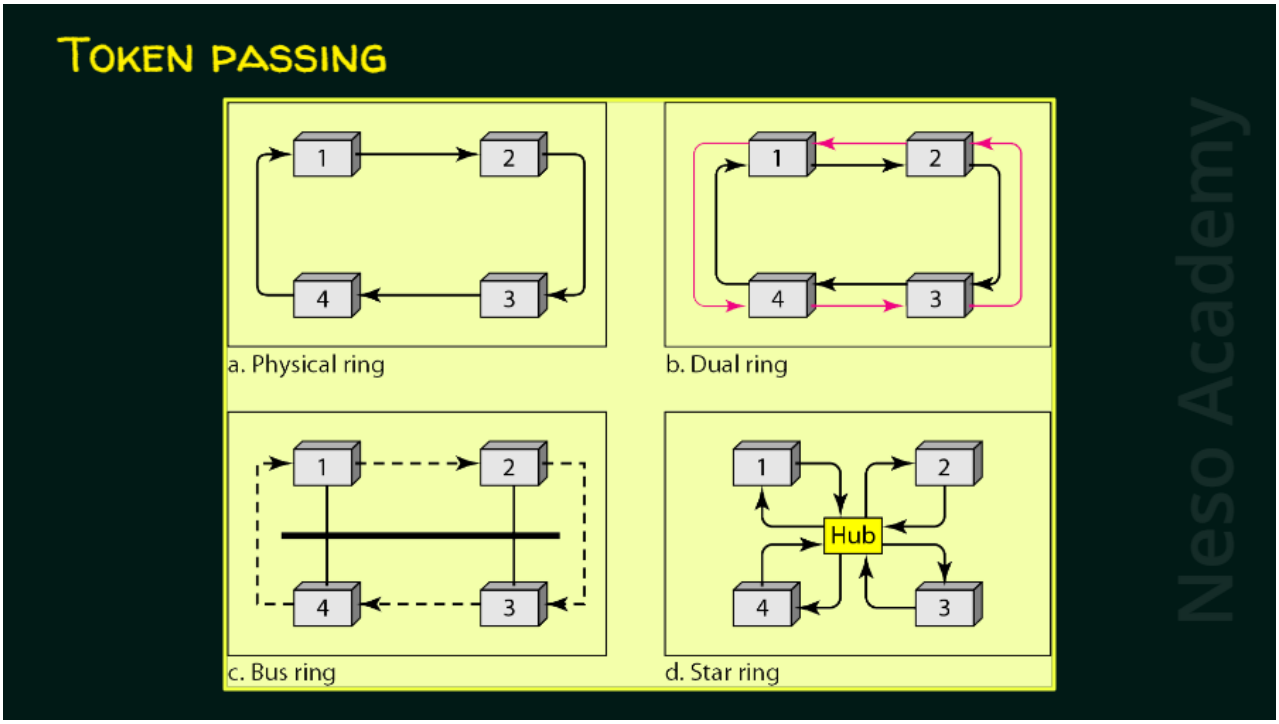
Token passing★★★★Neso Academy



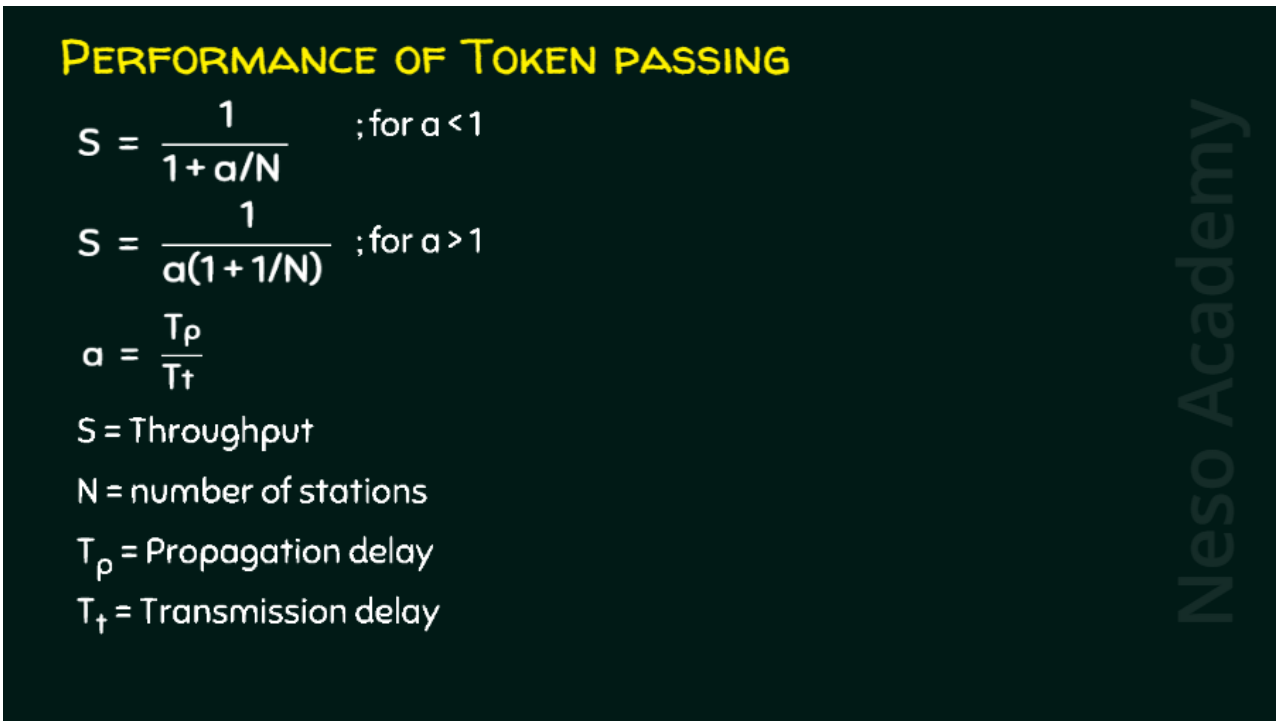
Token passing★★★Neso Academy



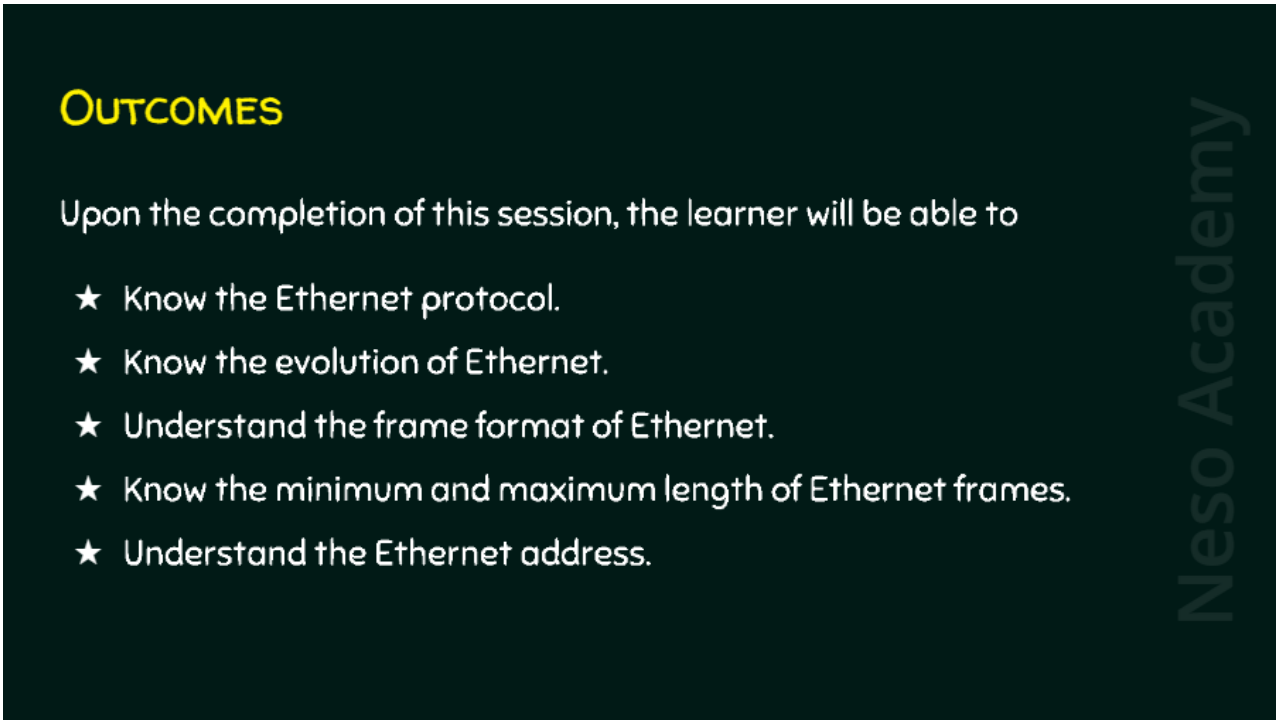
Token PassingNeso Academy



Token passingNeso Academy



Performance of Token passingNeso Academy



Outcomes★★★★★Neso Academy

ETHERNET

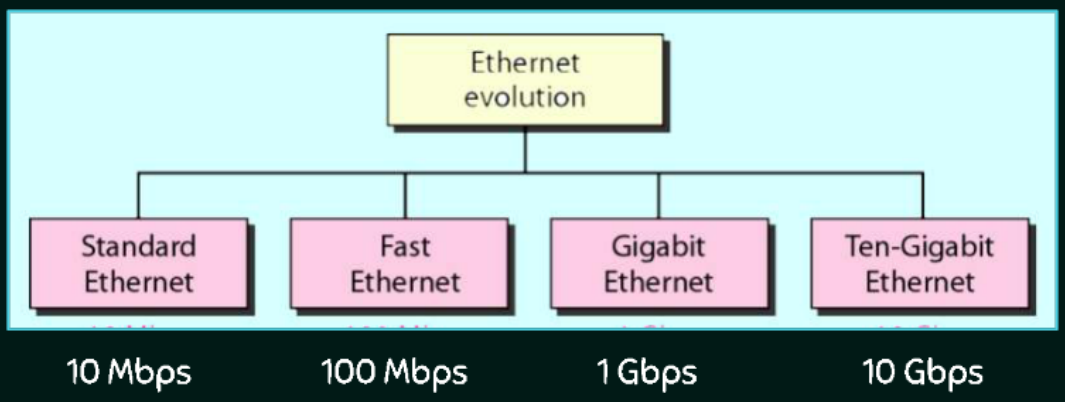
- ★ One of the most widely used Wired LAN technologies.
- ★ Operates in the data link layer and the physical layer.
- ★ Family of networking technologies that are defined in the IEEE 802.2 and 802.3 standards.
- ★ Supports data bandwidths of 10, 100, 1000, 10,000, 40,000, and 100,000 Mbps (100 Gbps).

Ethernet Standards

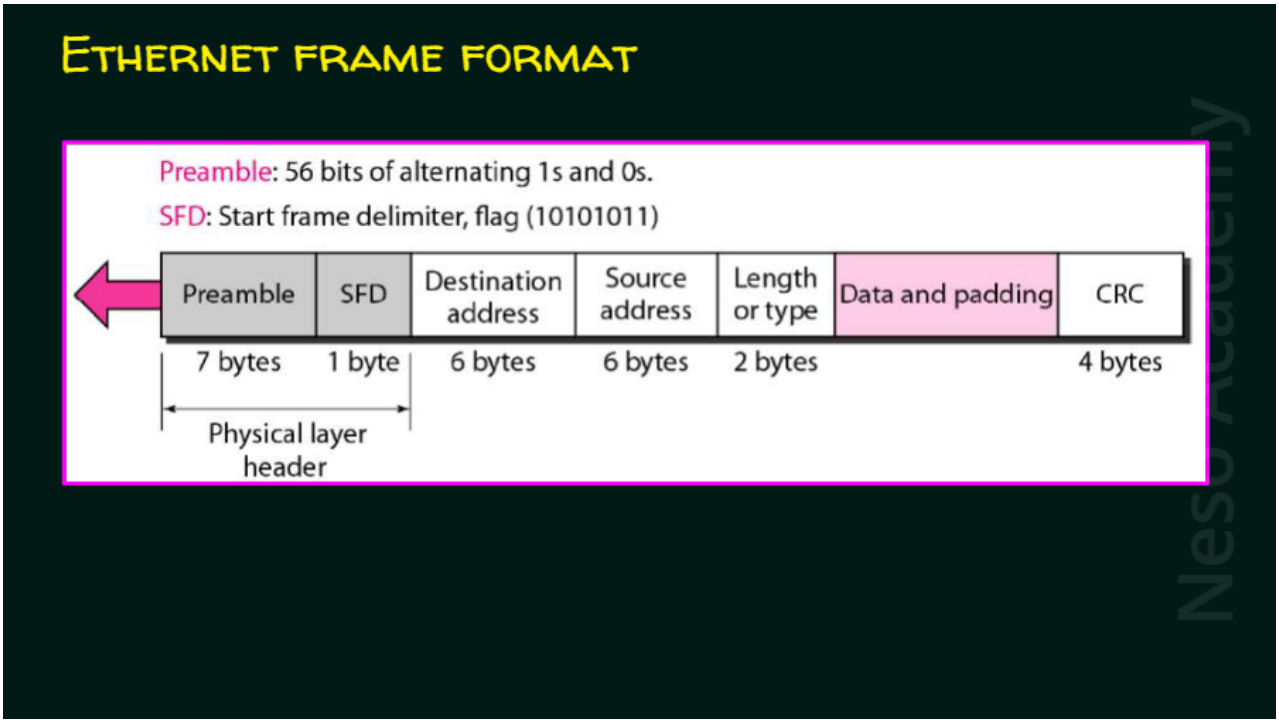
- ★ Define Layer 2 protocols and Layer 1 technologies
- ★ Two separate sublayers of the data link layer to operate – Logical link control (LLC) and the MAC sublayers.

Ethernet★★★★★★Neso Academy

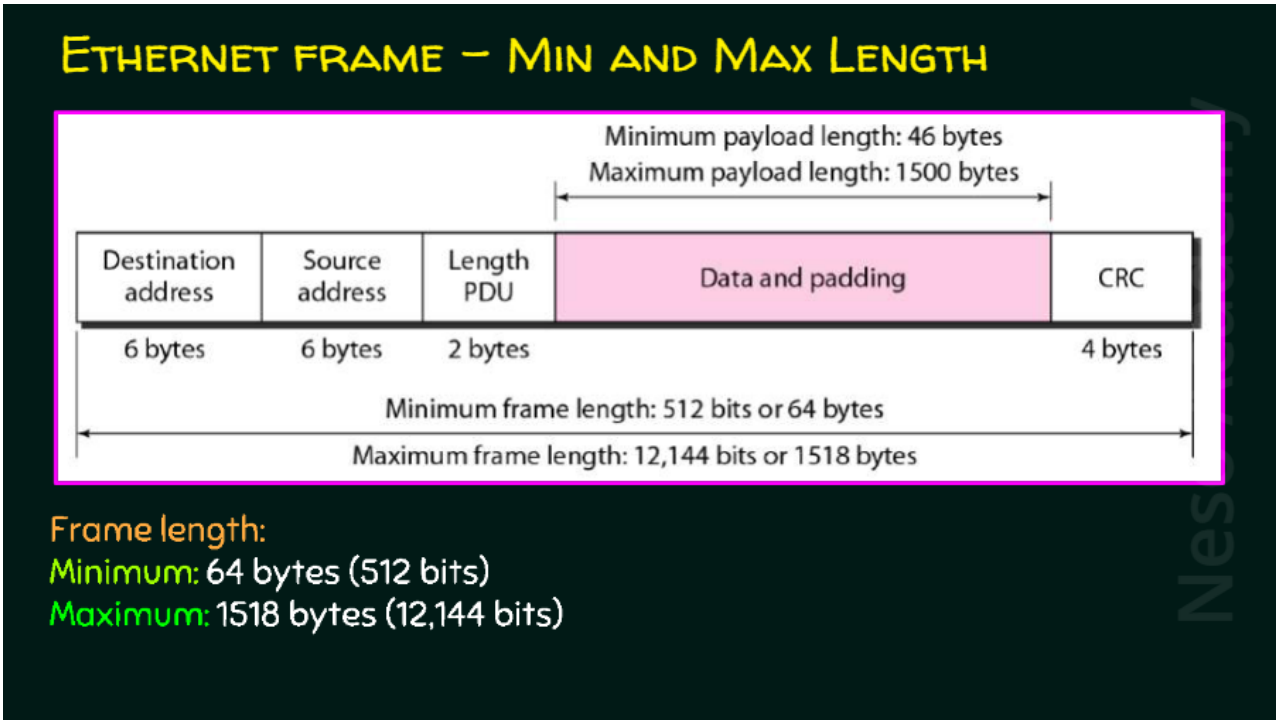
EVOLUTION OF ETHERNET



Evolution of ethernetNeso Academy



Ethernet frame formatNeso Academy

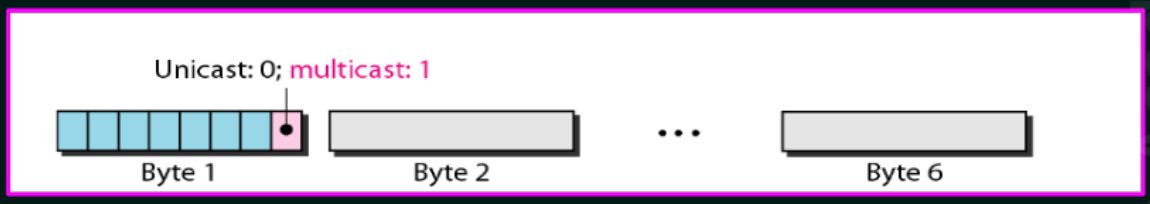


Ethernet frame -Min and Max LengthNeso Academy

Ethernet address

Example – 06:01:02:01:2C:4B

06:01:02:01:2C:4B <=> 6 bytes <=> 12 hex digits <=>48 bits



The least significant bit of the first byte defines the type of address.

If the bit is 0, the address is unicast; otherwise, it is multicast.

If all bits are 1, then it is broadcast address

Ethernet addressNeso Academy

Hexadecimal to Binary

1 Hexadecimal digit = 4 binary bits.

Hex: 0-9,A,B,C,D,E,F

Binary: 0,1

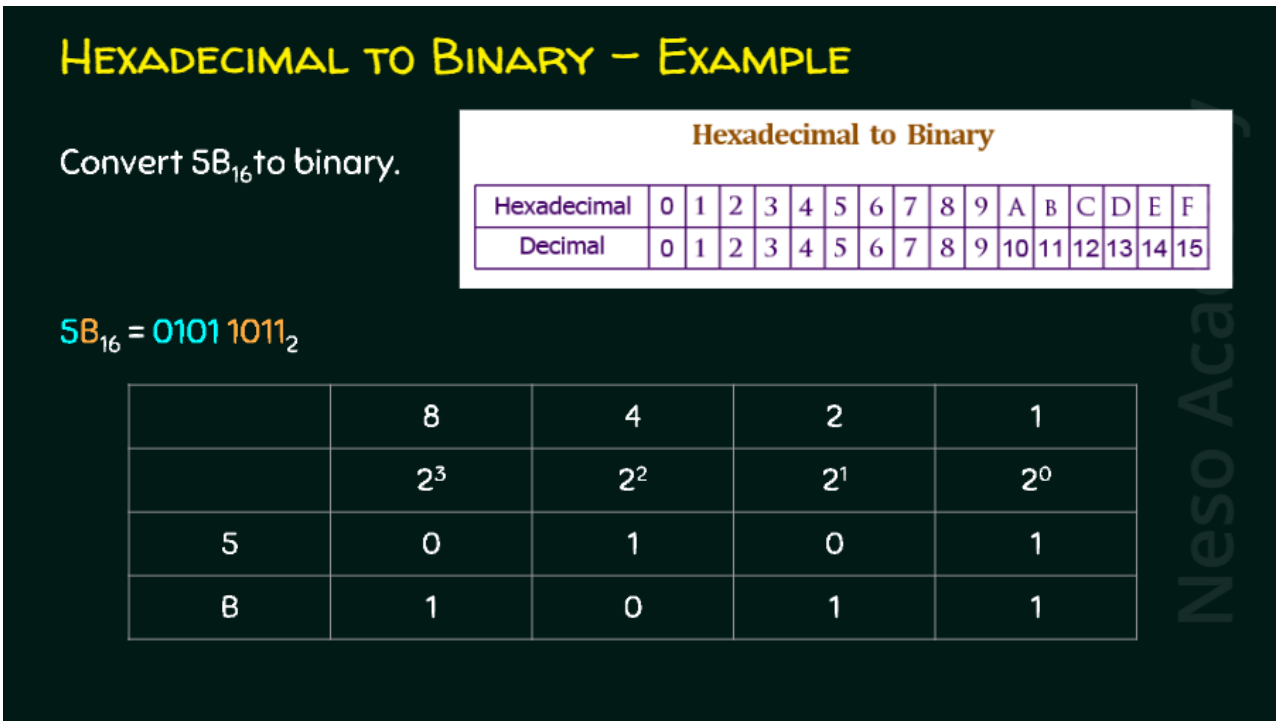
Hexadecimal to Binary

Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

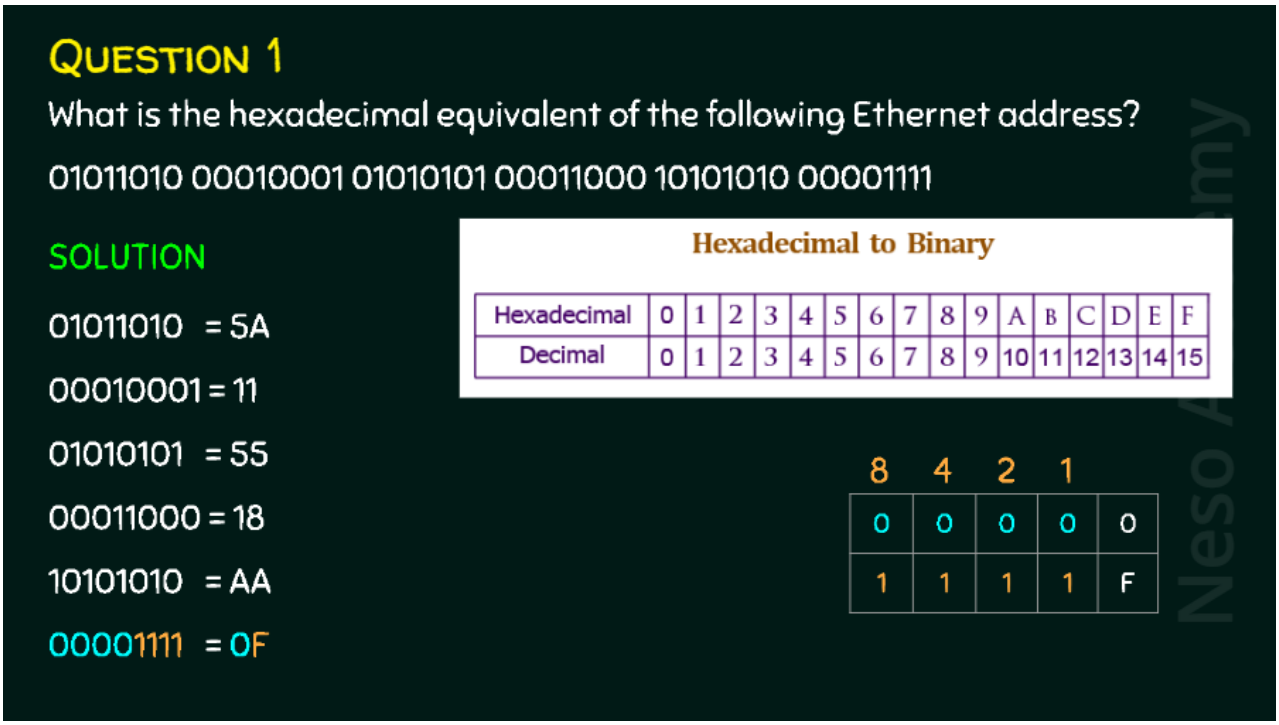
Conversion:

8	4	2	1
2^3	2^2	2^1	2^0

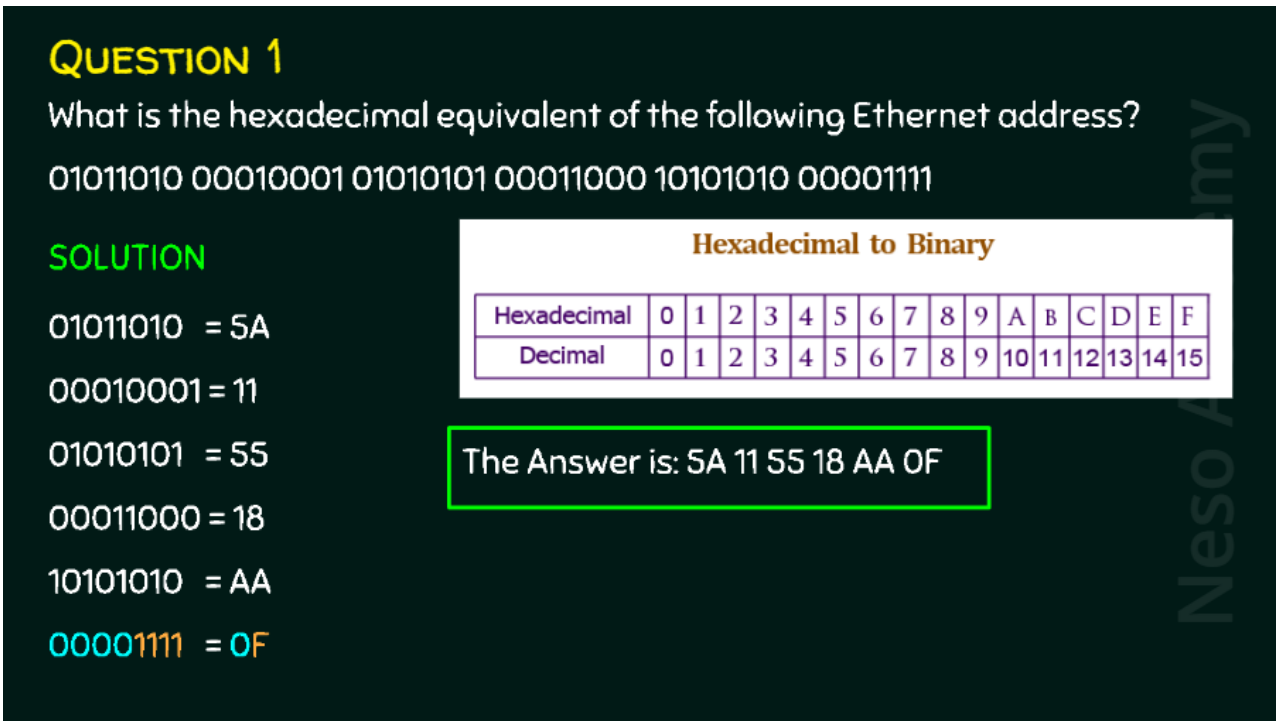
Hexadecimal to BinaryNeso Academy



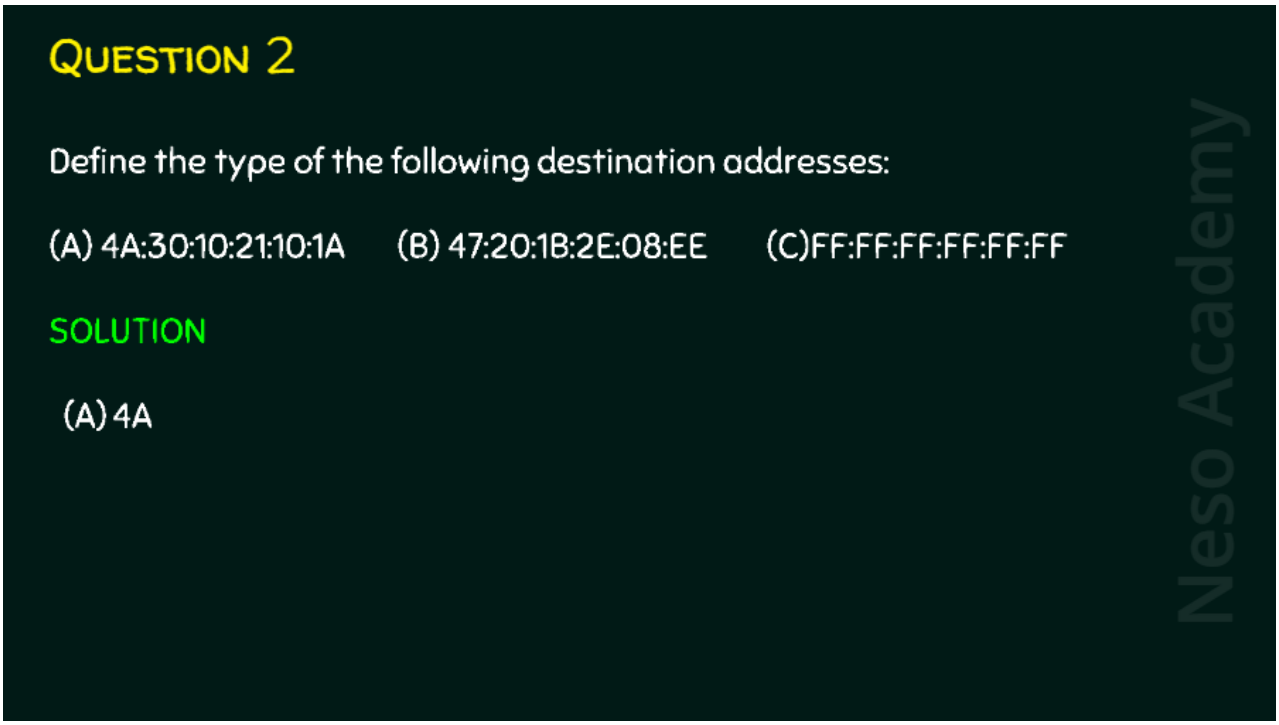
Hexadecimal to Binary -ExampleNeso Academy



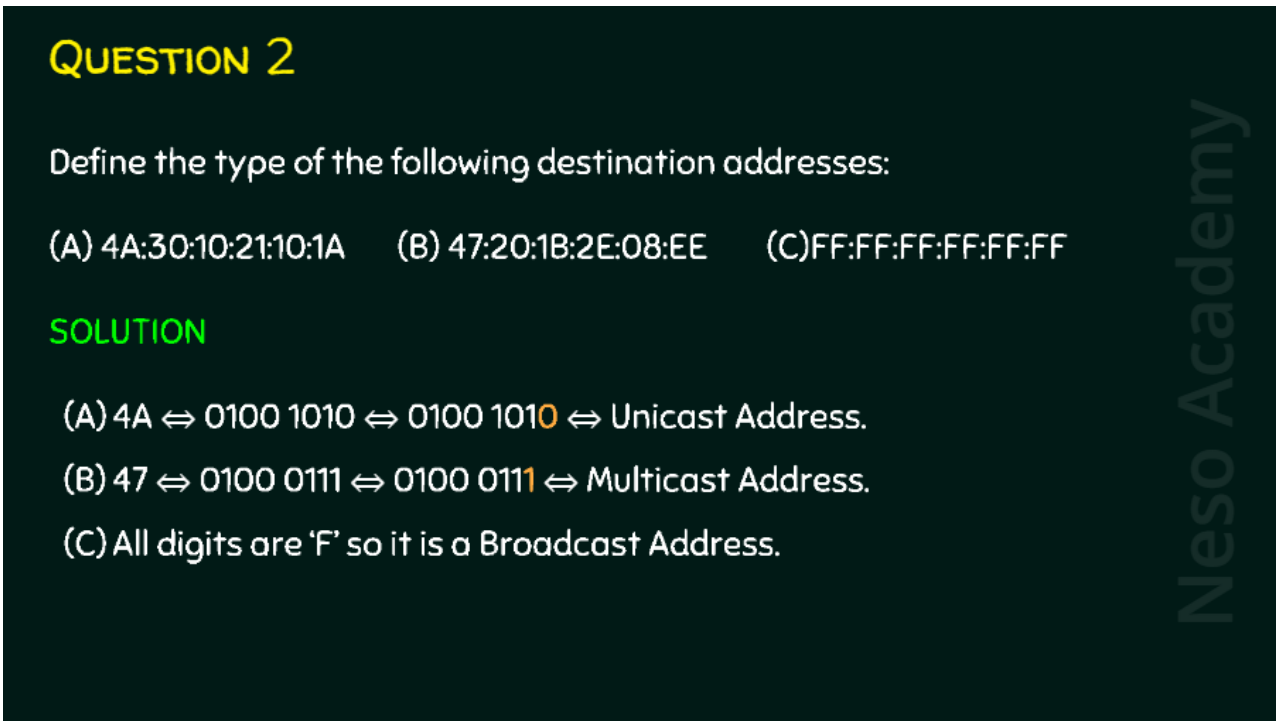
Question 1Neso Academy



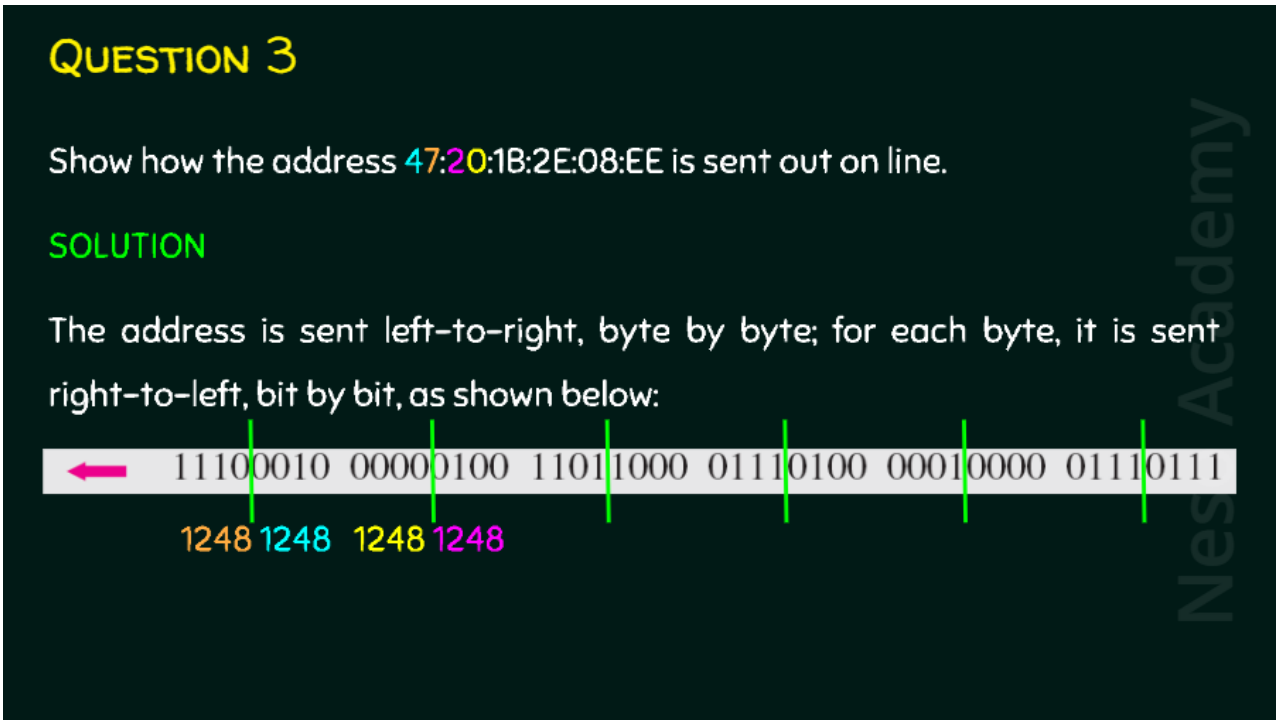
Question 1Neso Academy



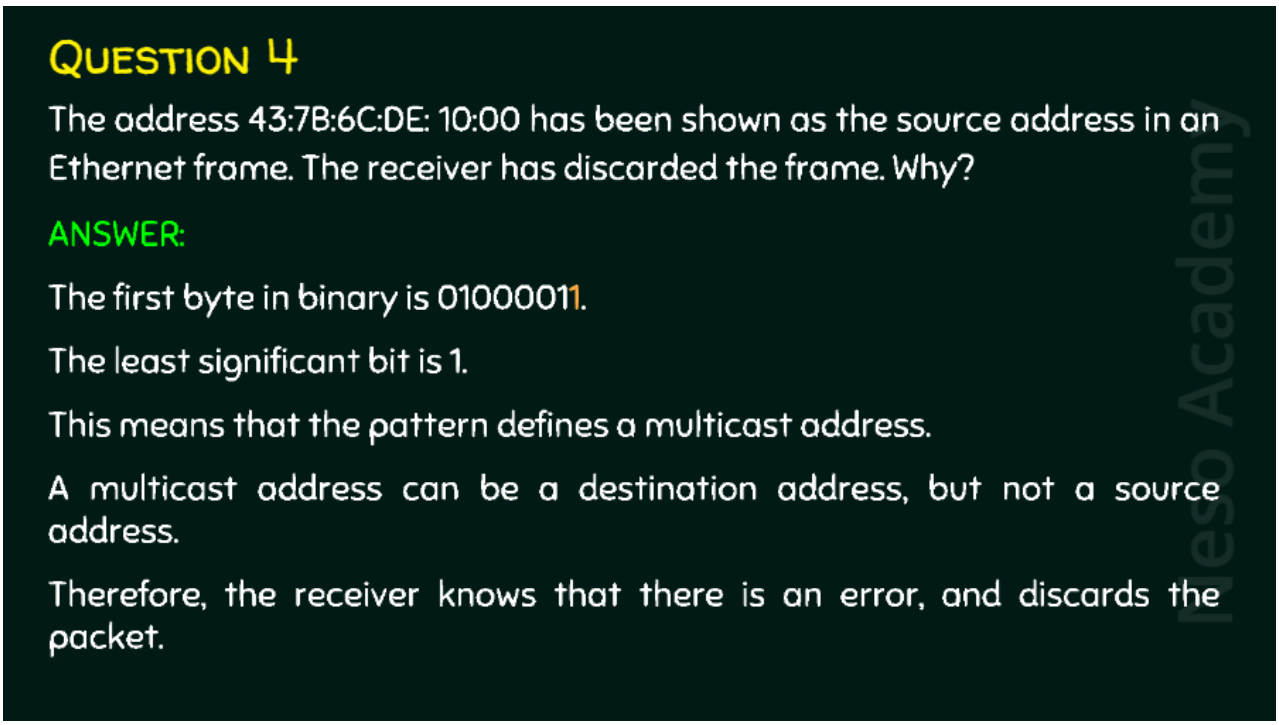
Question 2Neso Academy



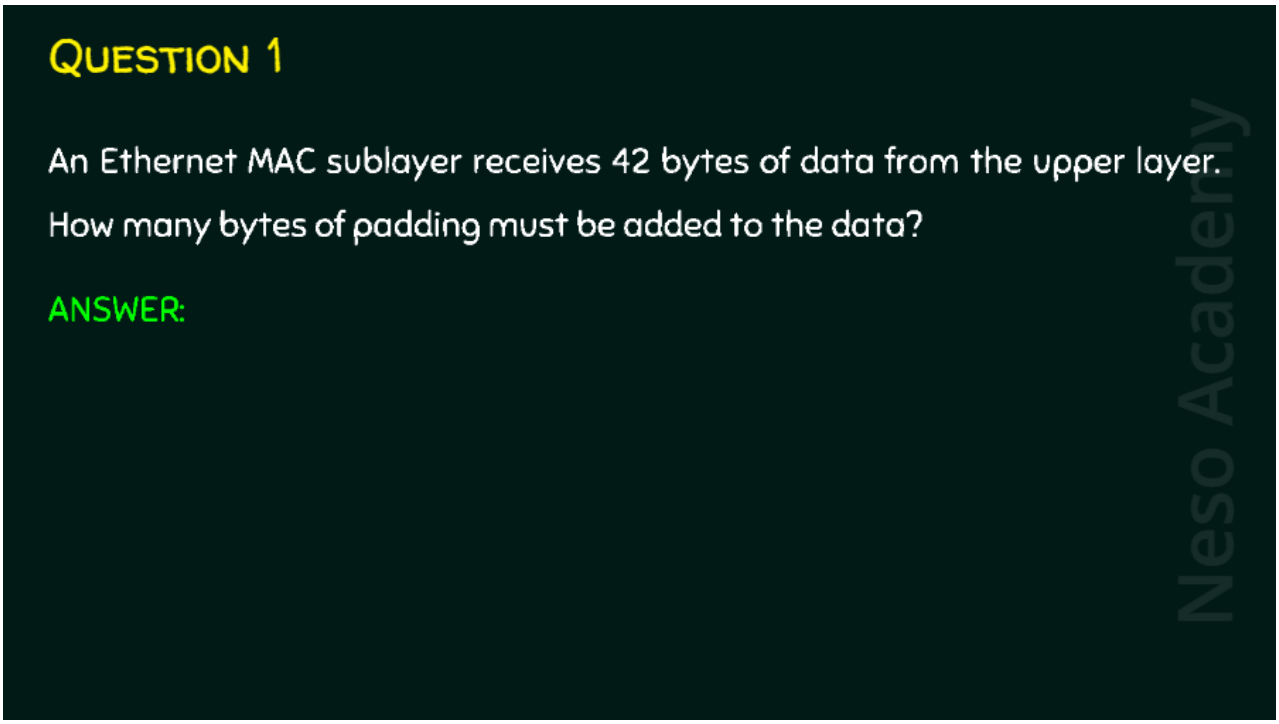
Question 2⇔⇔⇔⇔⇔⇔Neso Academy



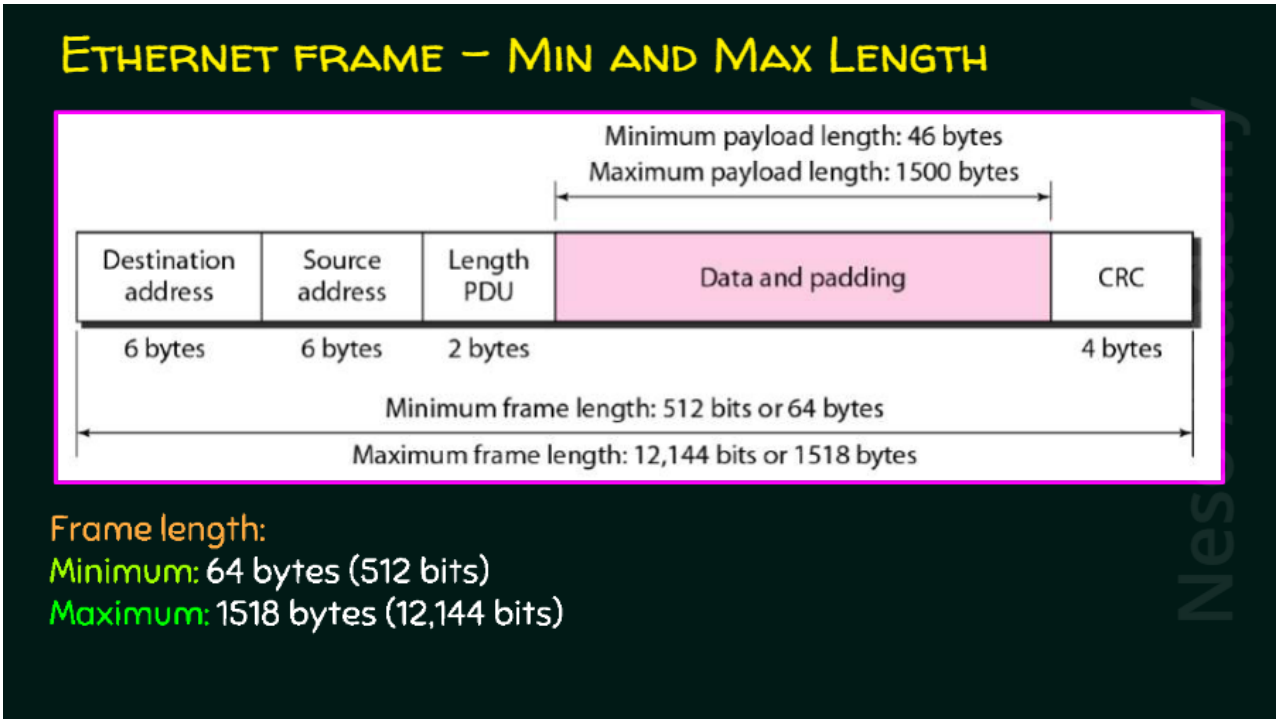
Question 3Neso Academy



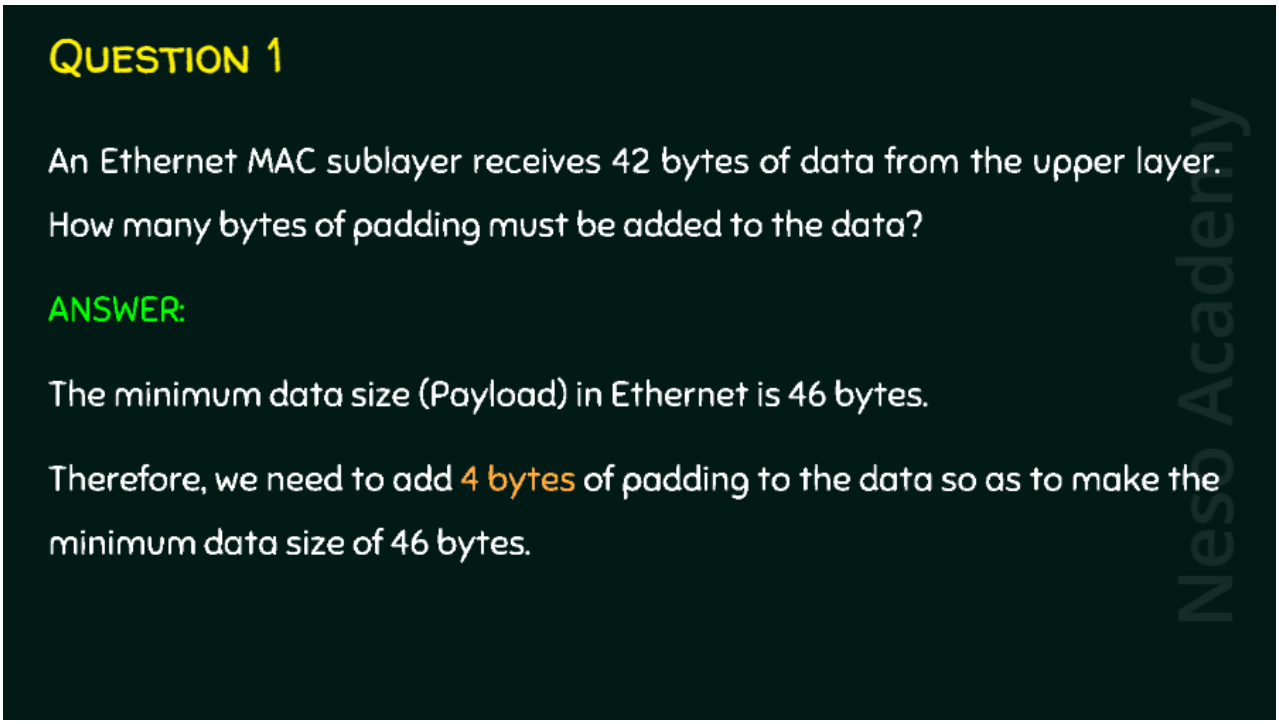
Question 4Neso Academy



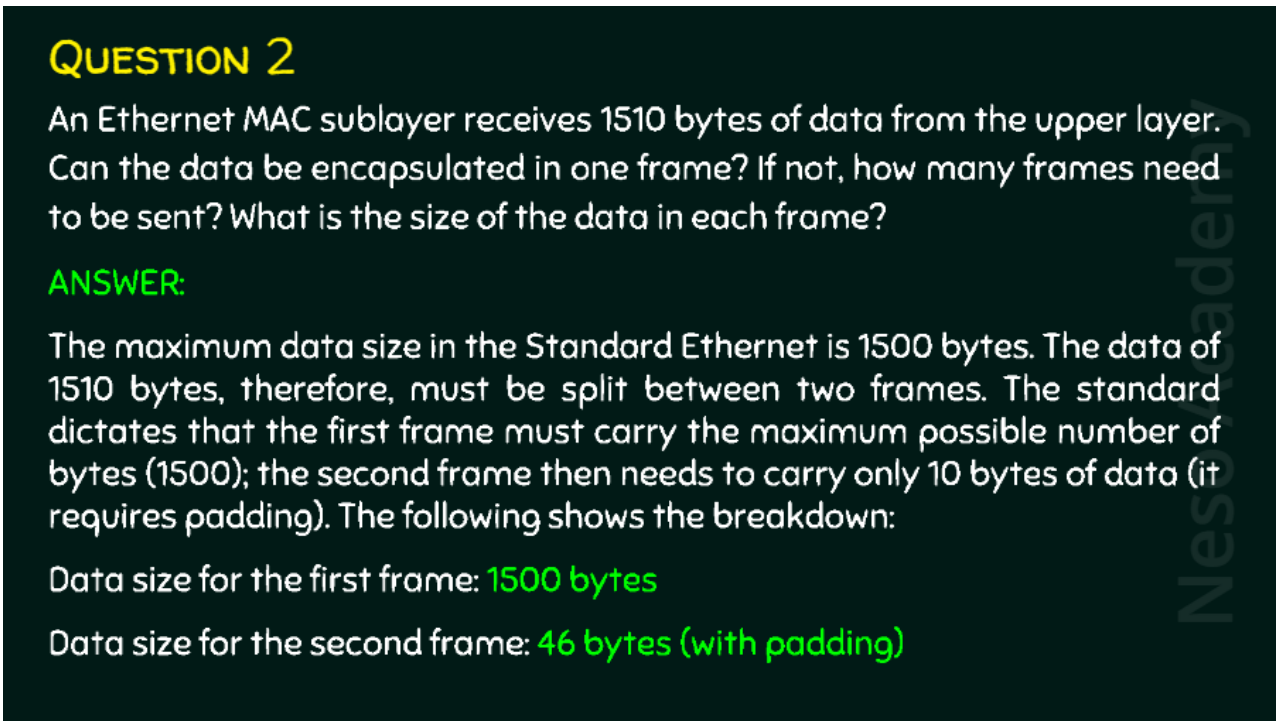
Question 1Neso Academy



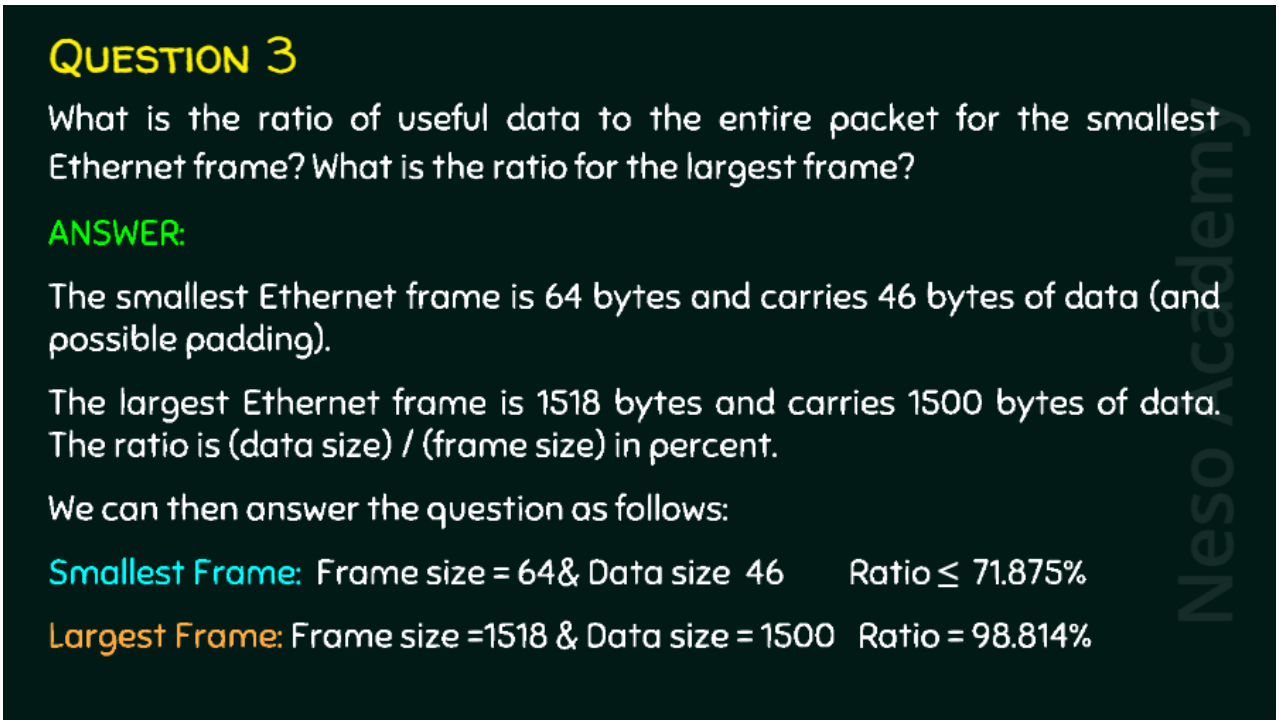
Ethernet frame -Min and Max LengthNeso Academy



Question 1Neso Academy



Question 2Neso Academy



Question 3≤Neso Academy

Question 4

The data rate of 10Base5 is 10 Mbps. How long does it take to create the smallest frame? Show the calculation.

ANSWER:

The smallest frame is 64 bytes or 512 bits. With a data rate of 10 Mbps, we have

$$\text{Transmission Delay} = \frac{\text{Message Size}}{\text{Bandwidth}}$$

$$\text{Transmission Delay} = \frac{512 \text{ bits}}{10 \text{ Mbps}}$$

$$\text{Transmission Delay} = \frac{512 \text{ bits}}{10 \times 1000 \times 1000 \text{ bps}}$$

$$\text{Transmission Delay} = 51.2 \ \mu \text{ s}$$

Neso Academy

Question 4Neso Academy

Homework!

Choose the correct pair from the following <address-size> pairs.

IPv4 – 32 bits	IPv4 – 32 bits	IPv4 – 32 bits	IPv4 – 32 bits
IPv6 – 128 bits	IPv6 – 128 bits	IPv6 – 128 bits	IPv6 – 128 bits
MAC – 40 bits	MAC – 48 bits	MAC – 48 bits	MAC – 46 bits
Port – 16 bits	Port – 32 bits	Port – 16 bits	Port – 16 bits
A	B	C	D

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Homework!Neso Academy

Outcomes

Upon the completion of this session, the learner will be able to

- ★ Understand the Ethernet Transmitter Algorithm.
- ★ Understand Runt Frames.
- ★ Know about Exponential backoff.

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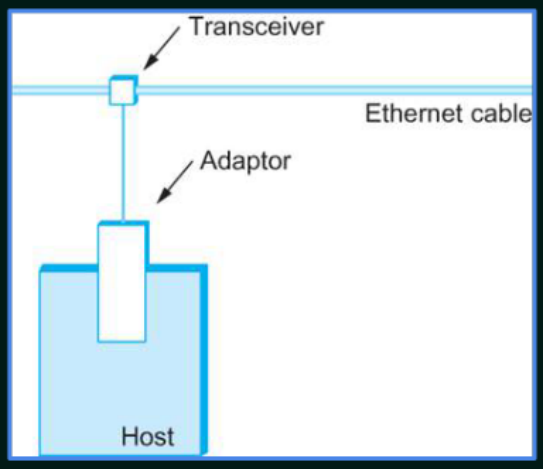
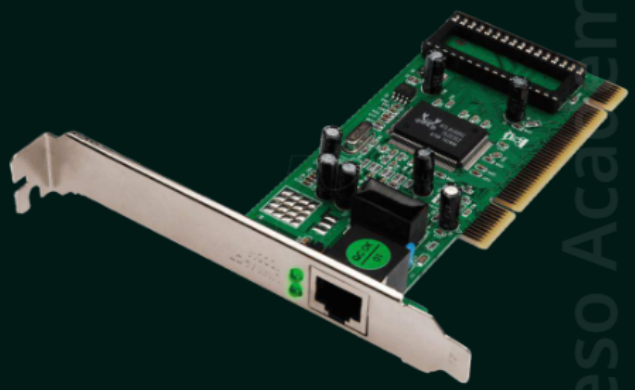
Outcomes★★★Neso Academy

Ethernet Adaptor





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Ethernet AdaptorNeso Academy

Access Protocol for Ethernet

The algorithm is commonly called Ethernet's Media Access Control (MAC) which is implemented in Hardware on the network adaptor.

Access Method of Ethernet: CSMA/CD

Encoding method: Manchester Encoding Technique for converting data bits into signals.

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Access Protocol for EthernetNeso Academy

Ethernet Transmitter Algorithm

- ★ When the adaptor has a frame to send and the line is idle, it transmits the frame immediately.
- ★ The upper bound of 1500 bytes in the message means that the adaptor can occupy the line for a fixed length of time.
- ★ When the adaptor has a frame to send and the line is busy, it waits for the line to go idle and then transmits immediately.
- ★ The Ethernet is said to be CSMA 1-persistent protocol because an adaptor with a frame to send transmits with probability 1 whenever a busy line goes idle.

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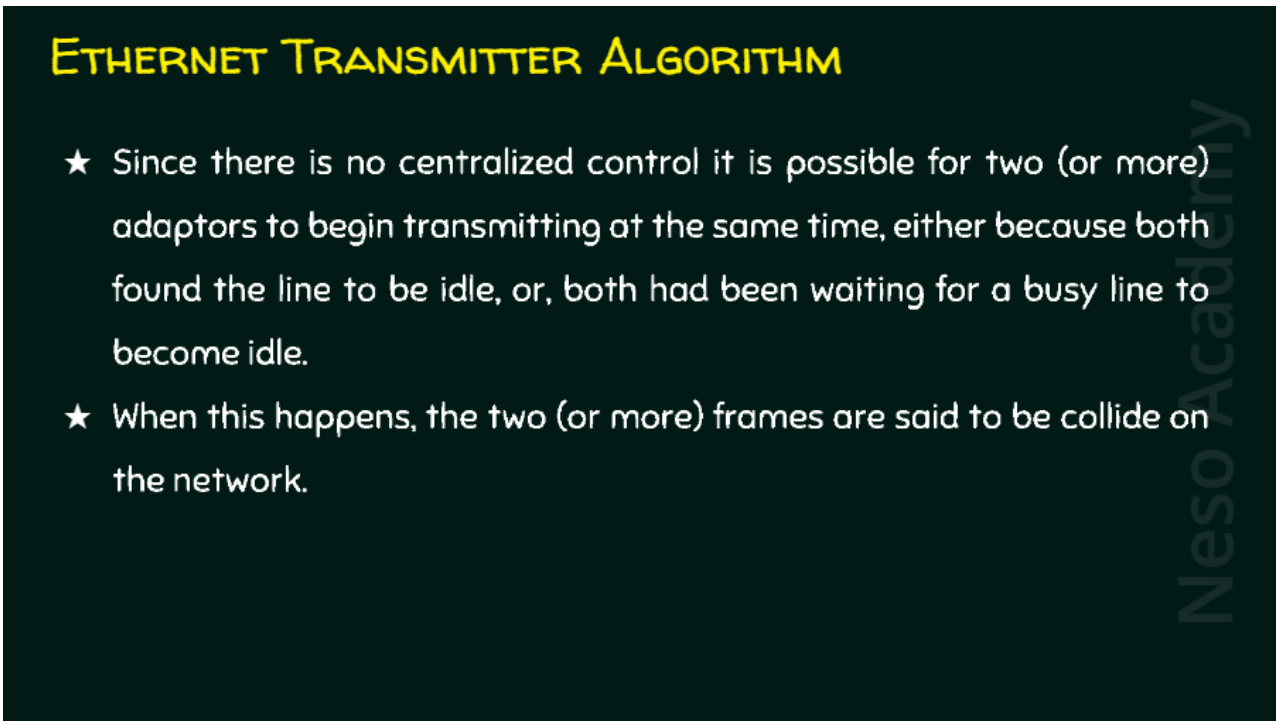
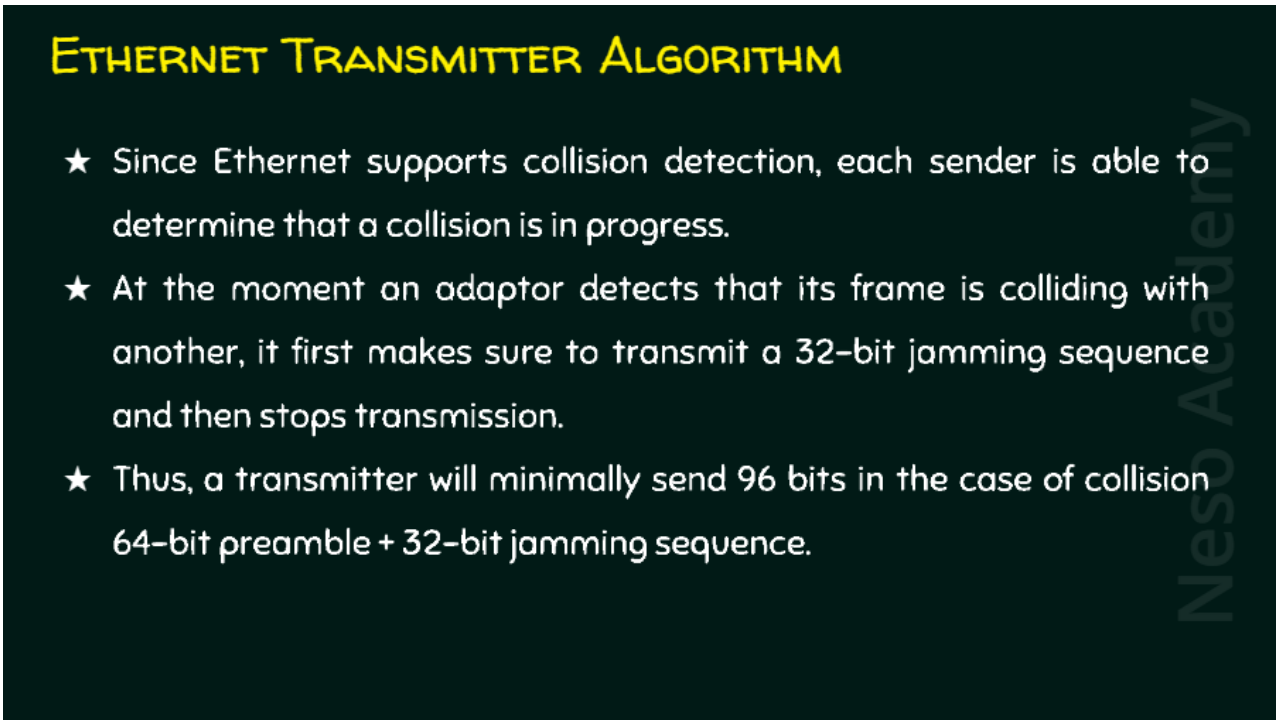
Ethernet Transmitter Algorithm★★★★Neso Academy



Ethernet Transmitter Algorithm★★Neso Academy



Ethernet Transmitter Algorithm★★★Neso Academy

Runt Frames

★ A runt frame is an Ethernet frame that is less than the IEEE 802.3's minimum length of 64 bytes.

★ Runt frames are most commonly caused by collisions.

★ Other possible causes are a malfunctioning network card, buffer underrun, duplex mismatch or software issues.

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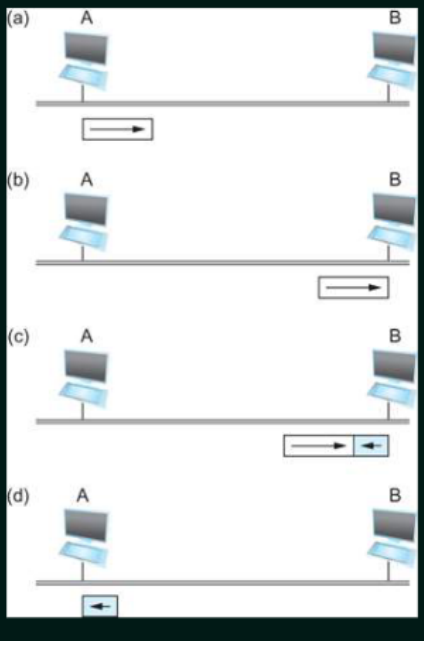
Runt Frames★★★Neso Academy

Ethernet Transmitter Algorithm



Worst-case scenario:

(a) A sends a frame at time t.

(b) A's frame arrives at B at time t + d.

(c) B begins transmitting at time t + d and collides with A's frame.

(d) B's runt (32-bit) frame arrives at A at time t + 2d.

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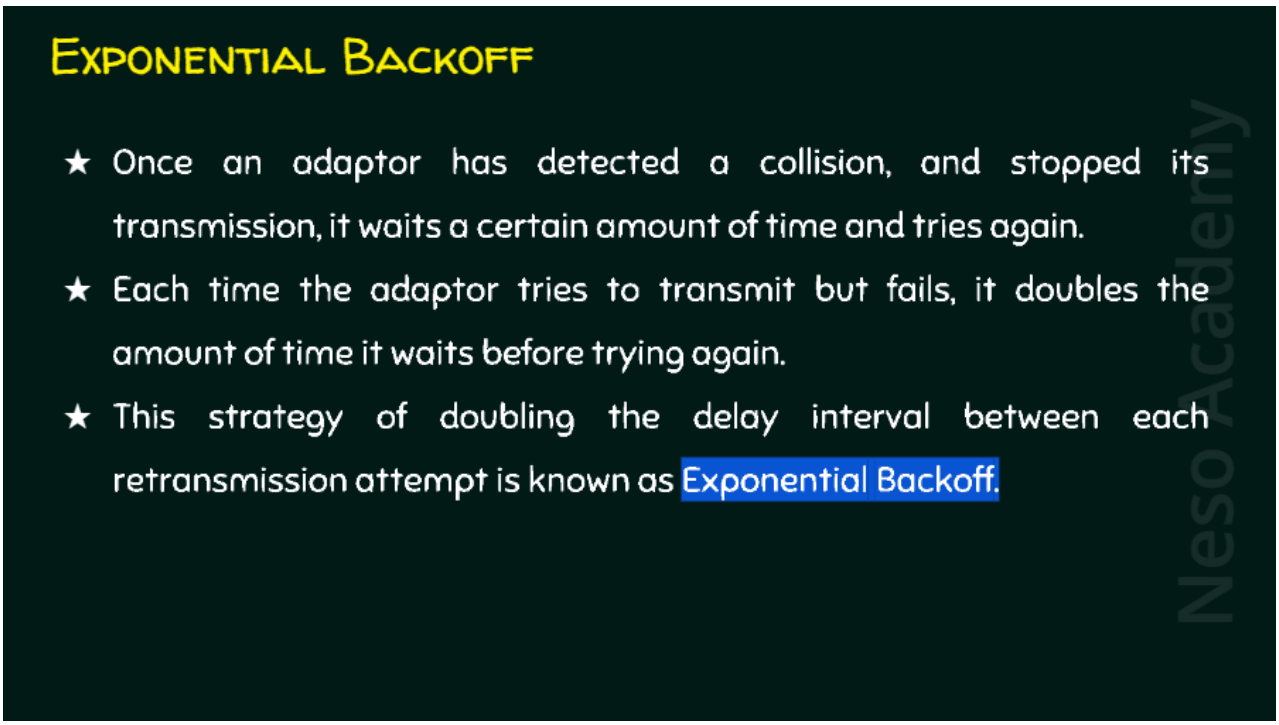
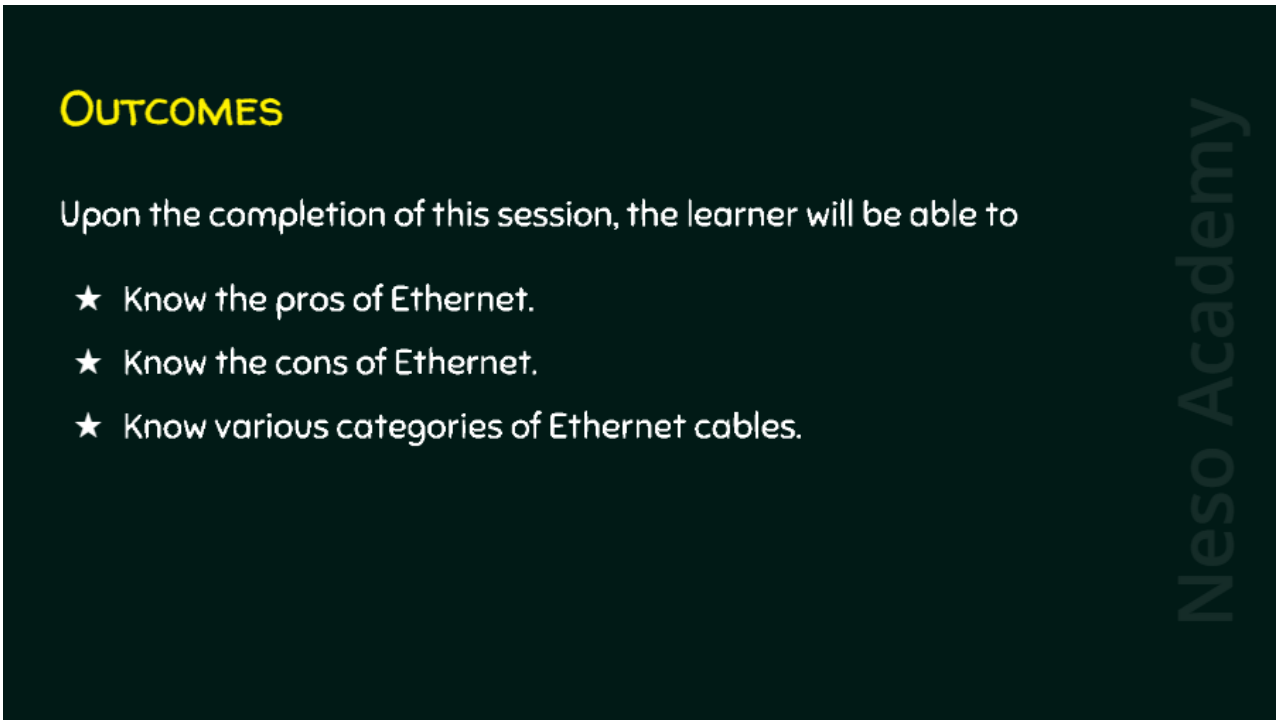
Ethernet Transmitter AlgorithmNeso Academy



Exponential Backoff★★★Neso Academy



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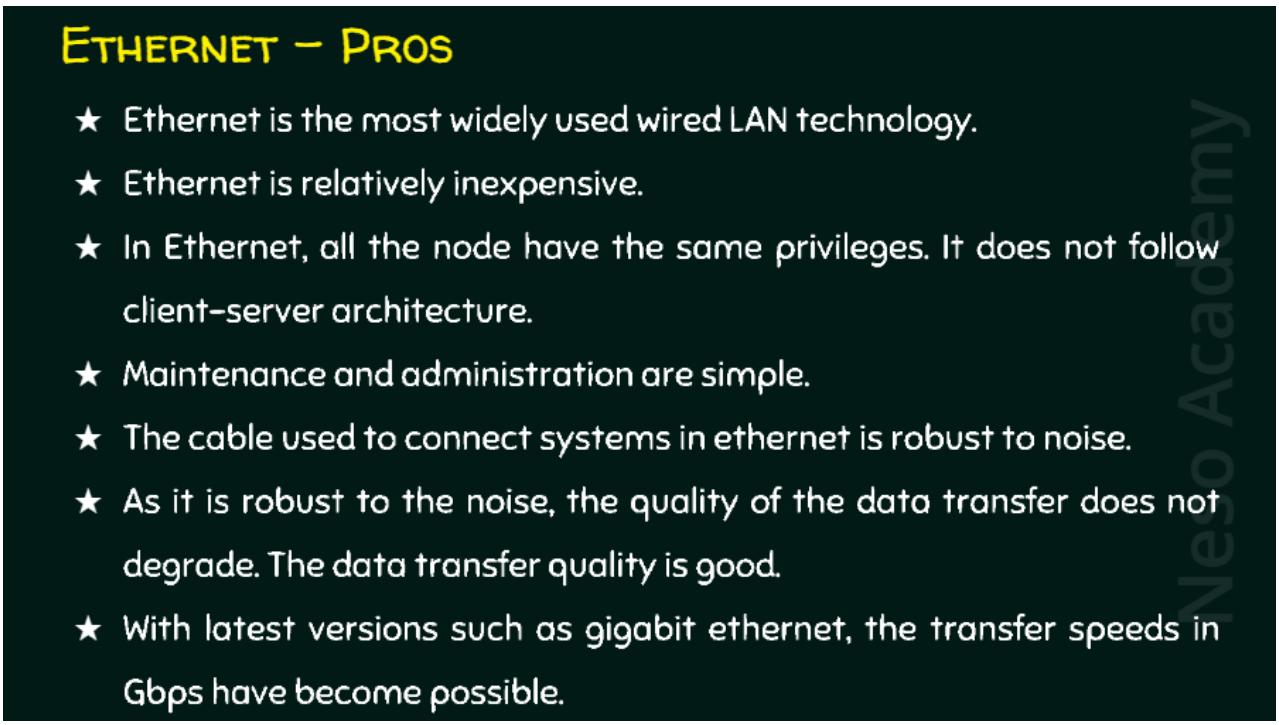
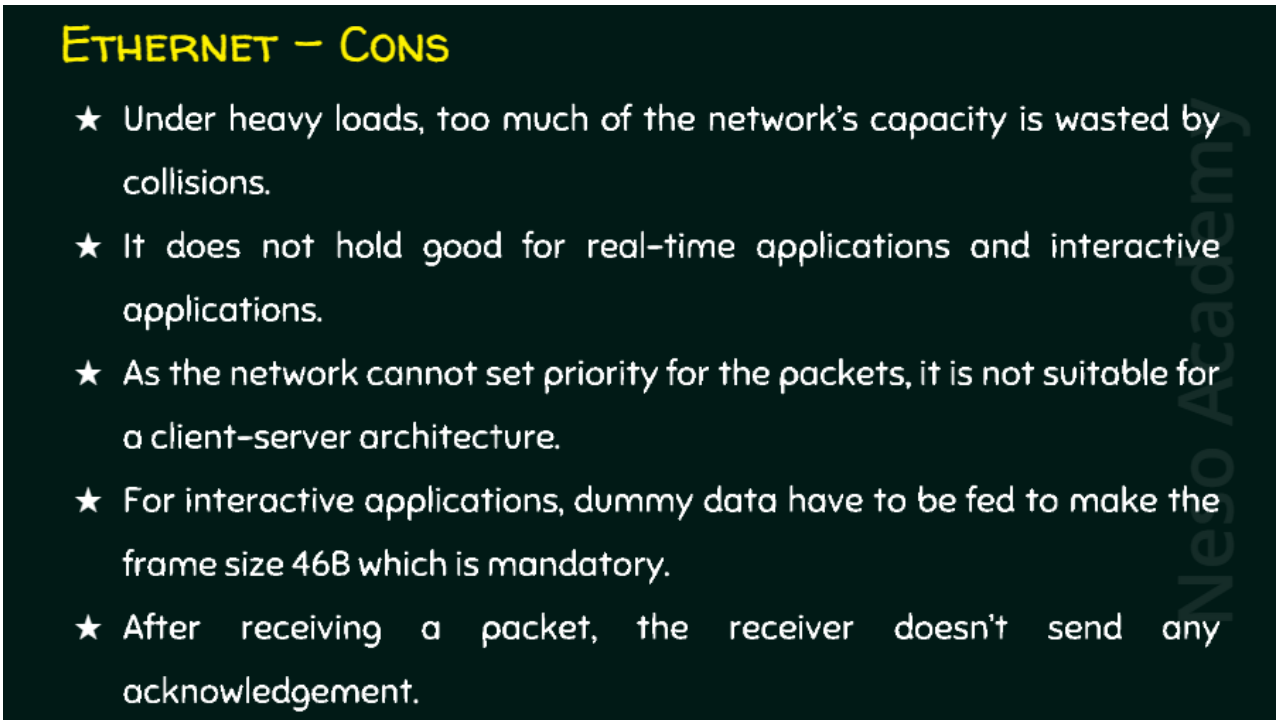


★★★★★★★Ethernet -ProsNeso Academy



Ethernet -Cons★★★★★Neso Academy

ETHERNET CATS

CATEGORY	SHIELDING	MAX TRANSMISSION SPEED (AT 100 METERS)
Cat 3	Unshielded	10 Mbps
Cat 5	Unshielded	10/100 Mbps
Cat 5e	Unshielded	1000 Mbps / 1 Gbps
Cat 6	Shielded or Unshielded	1000 Mbps / 1 Gbps
Cat 6a	Shielded	10000 Mbps / 10 Gbps
Cat 7	Shielded	10000 Mbps / 10 Gbps
Cat 8	Shielded	Up to 40 Gbps

Ethernet catsNeso Academy

QUESTION

In an Ethernet local area network, which one of the following statements is TRUE ? [GATE CS 2016]

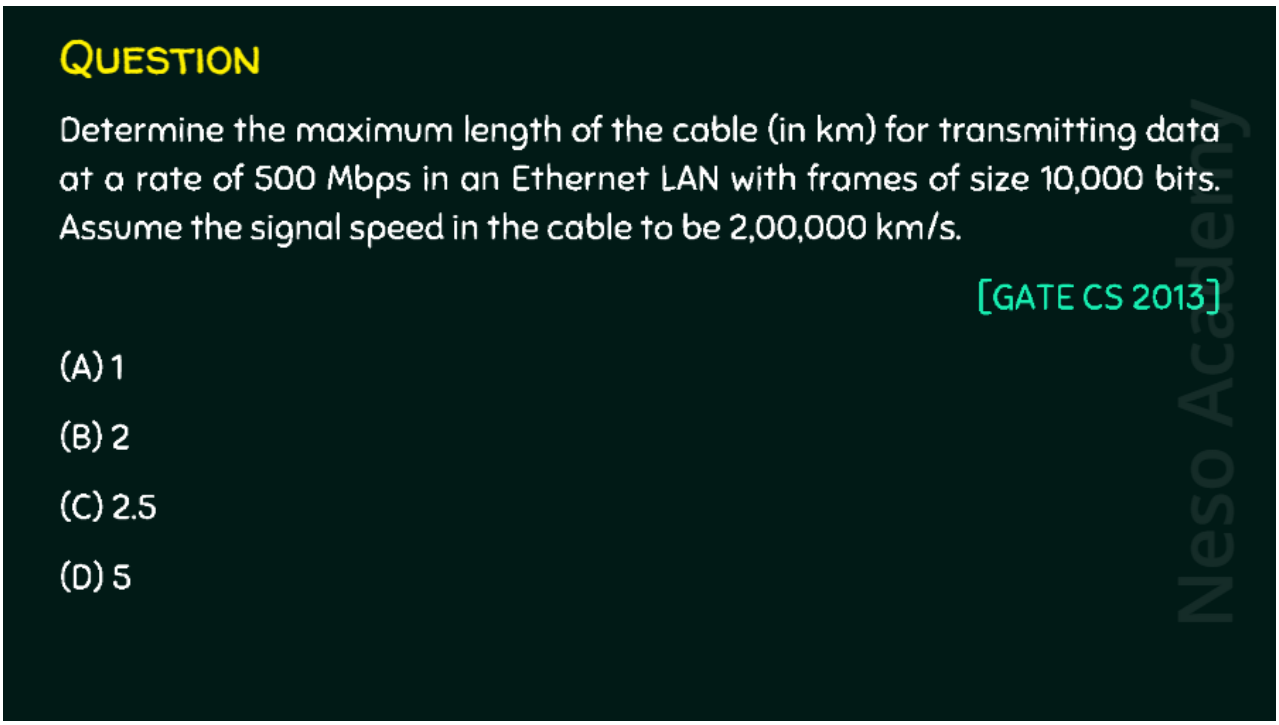
(A) A station stops to sense the channel once it starts transmitting a frame. ✖

(B) The purpose of the jamming signal is to pad the frames that are smaller than the minimum frame size. ✖

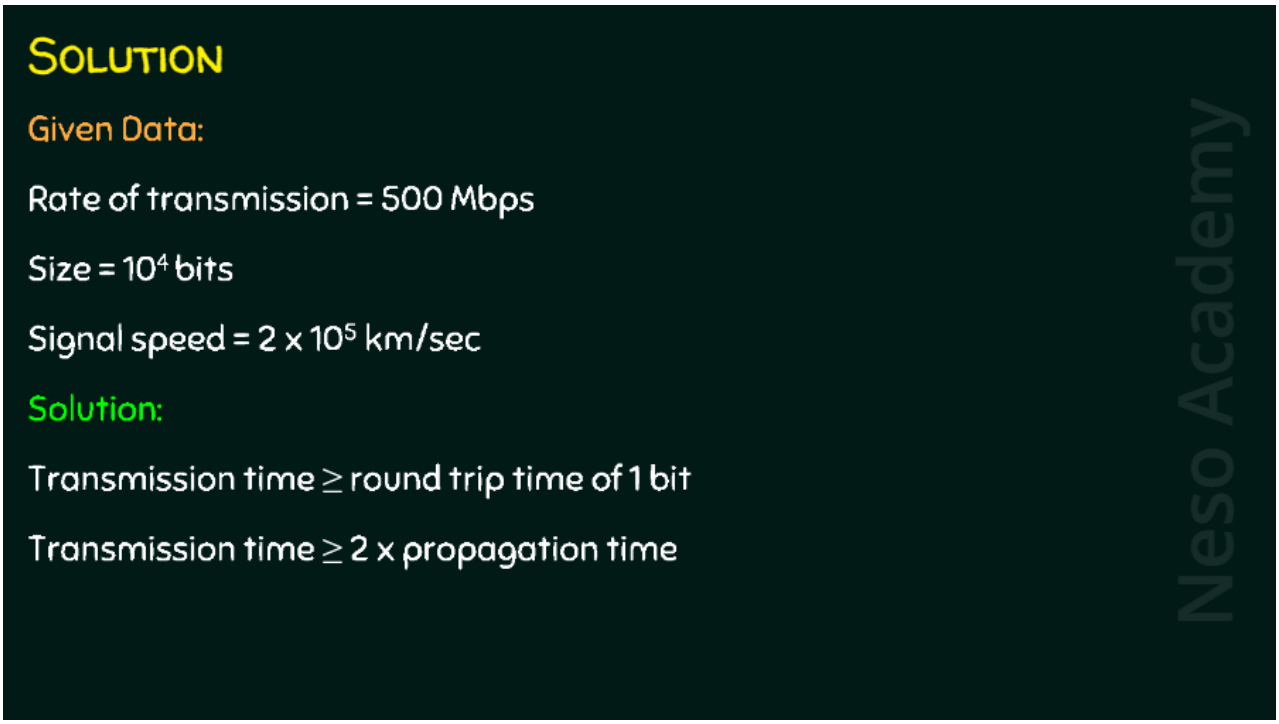
(C) A station continues to transmit the packet even after the collision is detected. ✖

(D) The exponential backoff mechanism reduces the probability of collision on retransmissions. ✔

✔ QuestionNeso Academy



QuestionNeso Academy



Solution≥≥Neso Academy

SOLUTION

Transmission time $\geq$ 2 x propagation time

$$\text{Transmission time} = \frac{\text{Message Size}}{\text{Bandwidth}}$$

$$\text{Propagation time} = \frac{\text{Length}}{\text{Propagation Speed}}$$

$$\frac{\text{Message Size}}{\text{Bandwidth}} = \frac{2 \times \text{Length}}{\text{Propagation Speed}}$$

$$\frac{10^4 \text{ bits}}{500 \text{ Mbps}} \geq \frac{2 \times \text{Length}}{2 \times 10^5 \text{ Km/sec}}$$

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SolutionNeso Academy

SOLUTION

$$\frac{10^4 \text{ bits}}{500 \text{ Mbps}} \geq \frac{2 \times L}{2 \times 10^5 \text{ Km/sec}}$$

$$\frac{10^4 \text{ bits}}{500 \text{ Mbps}} \geq \frac{L}{10^5 \text{ Km/sec}}$$

$$\frac{10^4 \text{ bits} \times 10^5 \text{ Km/sec}}{500 \text{ Mbps}} \geq L$$

$$\frac{10^4 \text{ bits} \times 10^5 \text{ Km/sec}}{500 \text{ Mbps}} \geq L$$

$$\frac{10^4 \text{ bits} \times 10^5 \text{ Km/sec}}{500 \times 10^6 \text{ bps}} \geq L$$

$$\frac{10^4 \text{ Km/sec}}{500 \times 10} \geq L$$

$$2 \text{ Km} \geq L$$

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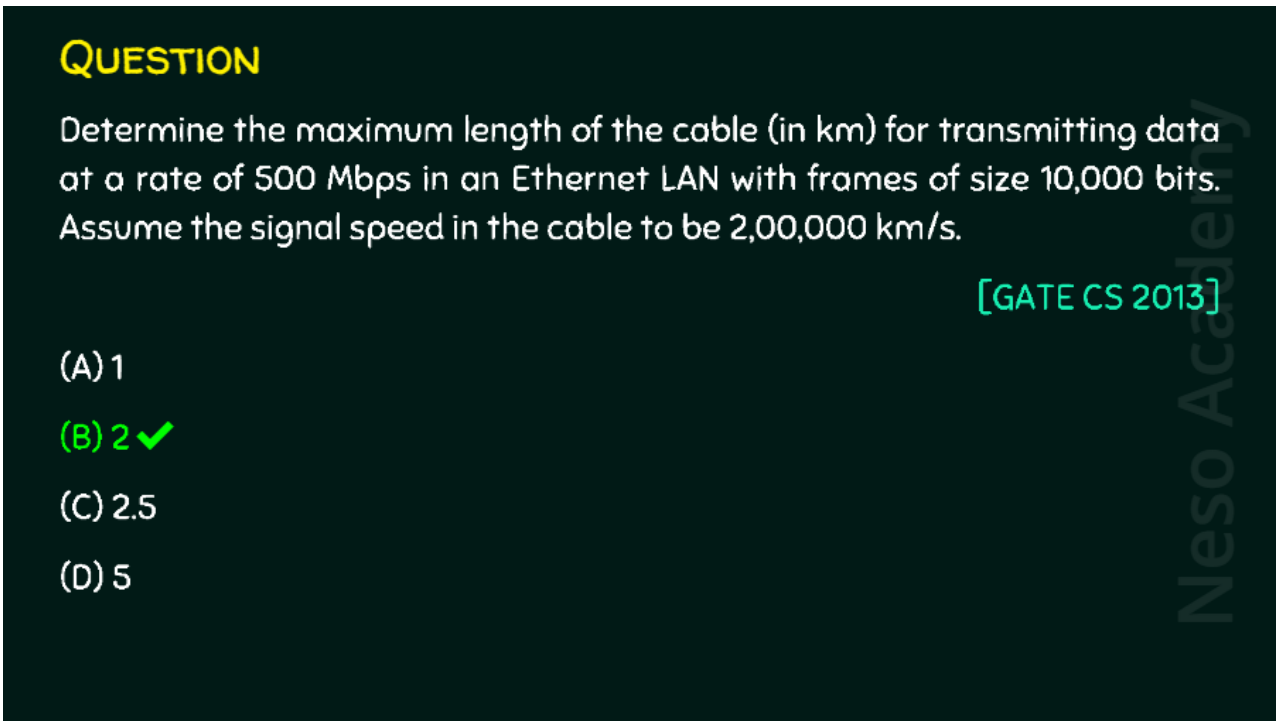
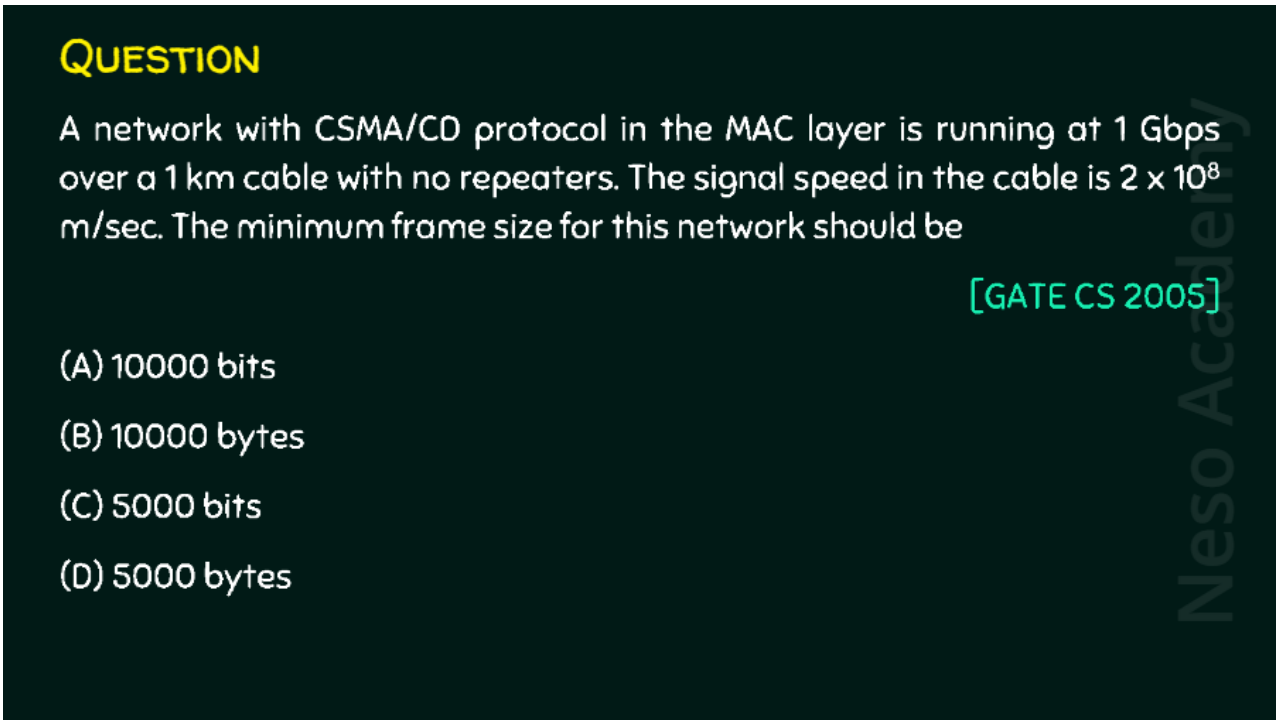
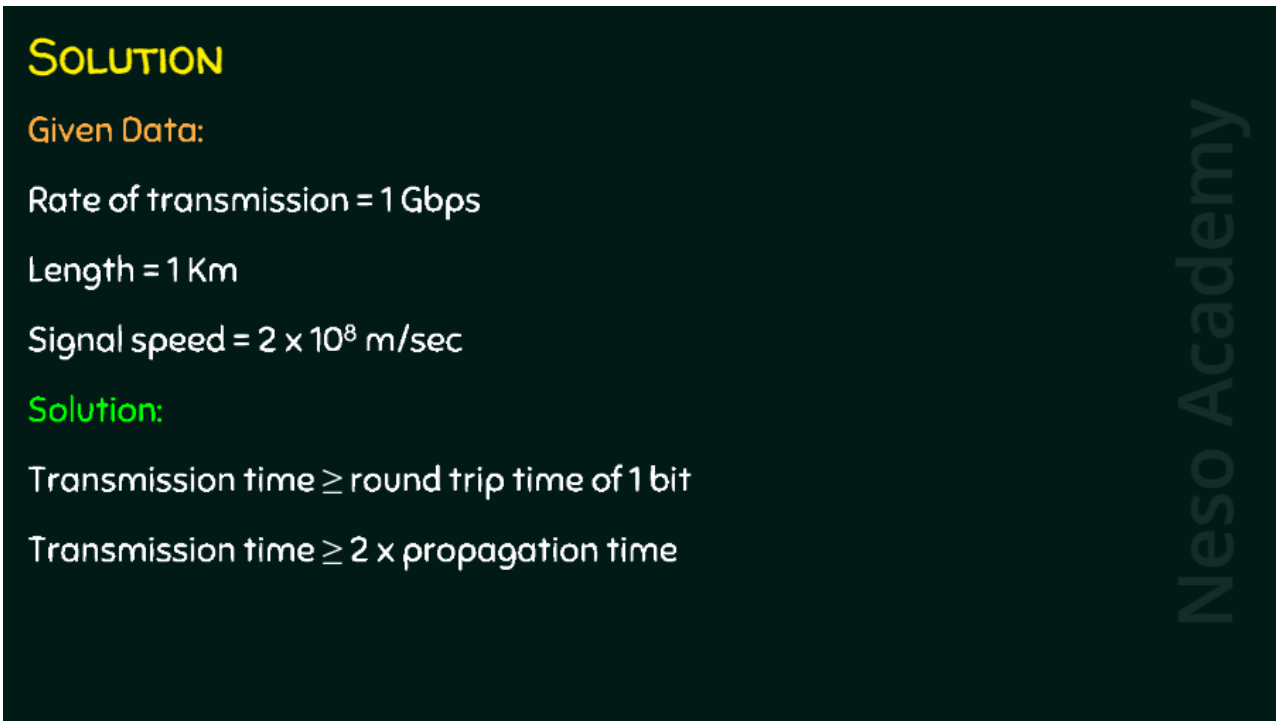
Solution≥Neso Academy



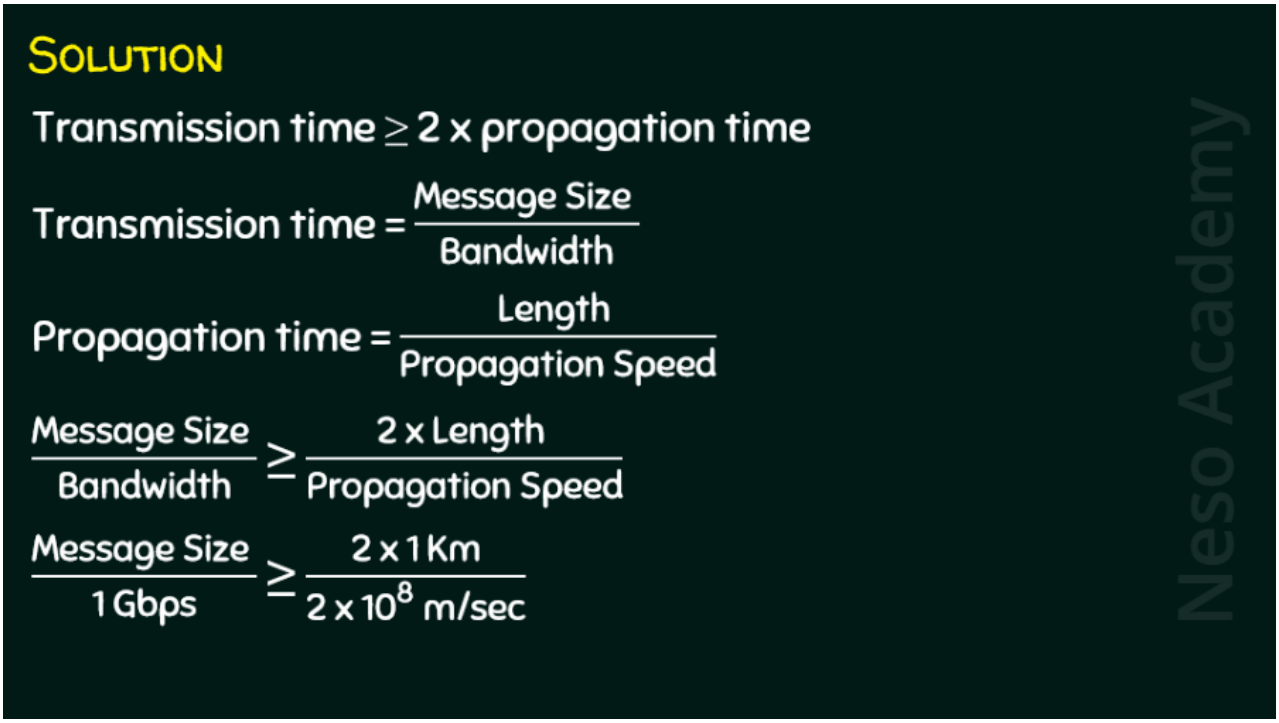
Question ✔ Neso Academy



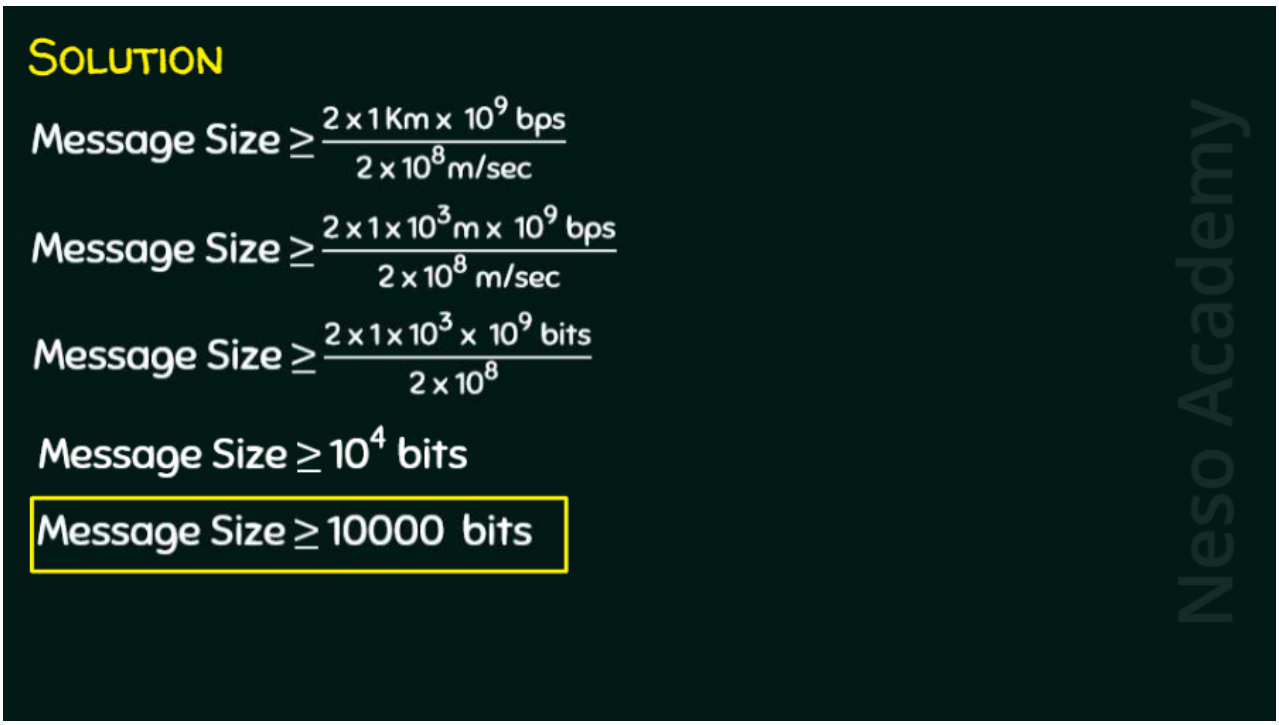
QuestionNeso Academy



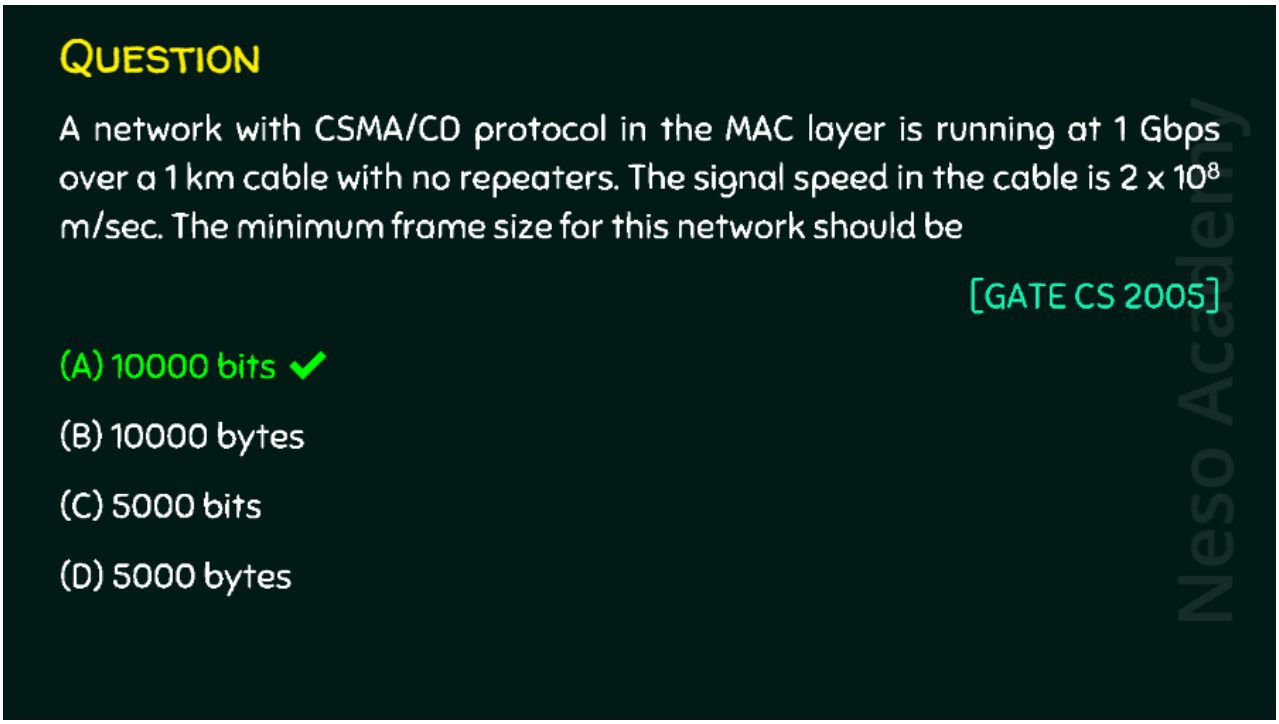
Solution≥≥Neso Academy



SolutionNeso Academy



SolutionNeso Academy



Question ✔ Neso Academy

Outcomes

Upon the completion of this session, the learner will be able to

- ★ Know about IEEE 802.11 Wi-Fi.
- ★ Know the access method of Wi-Fi.
- ★ See Wi-Fi adaptors.
- ★ Understand the modes of Wi-Fi.
- ★ Know different Wi-Fi protocols.

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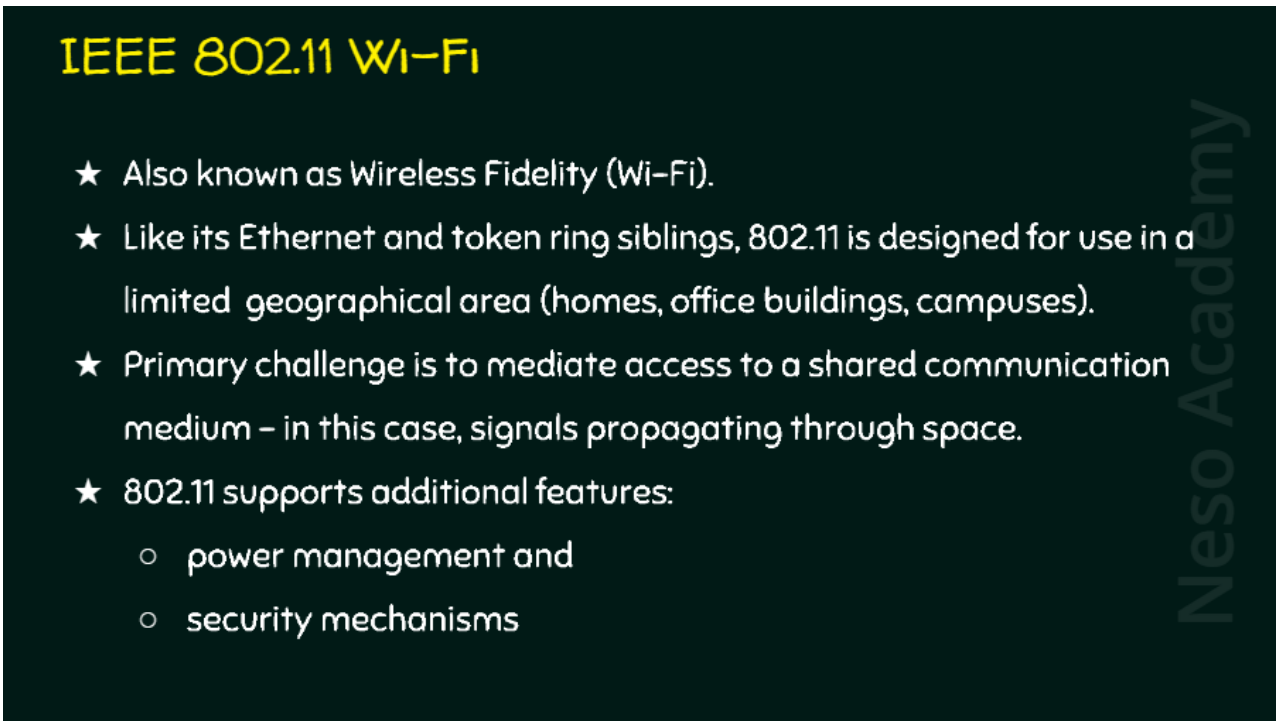
★★★★★OutcomesNeso Academy

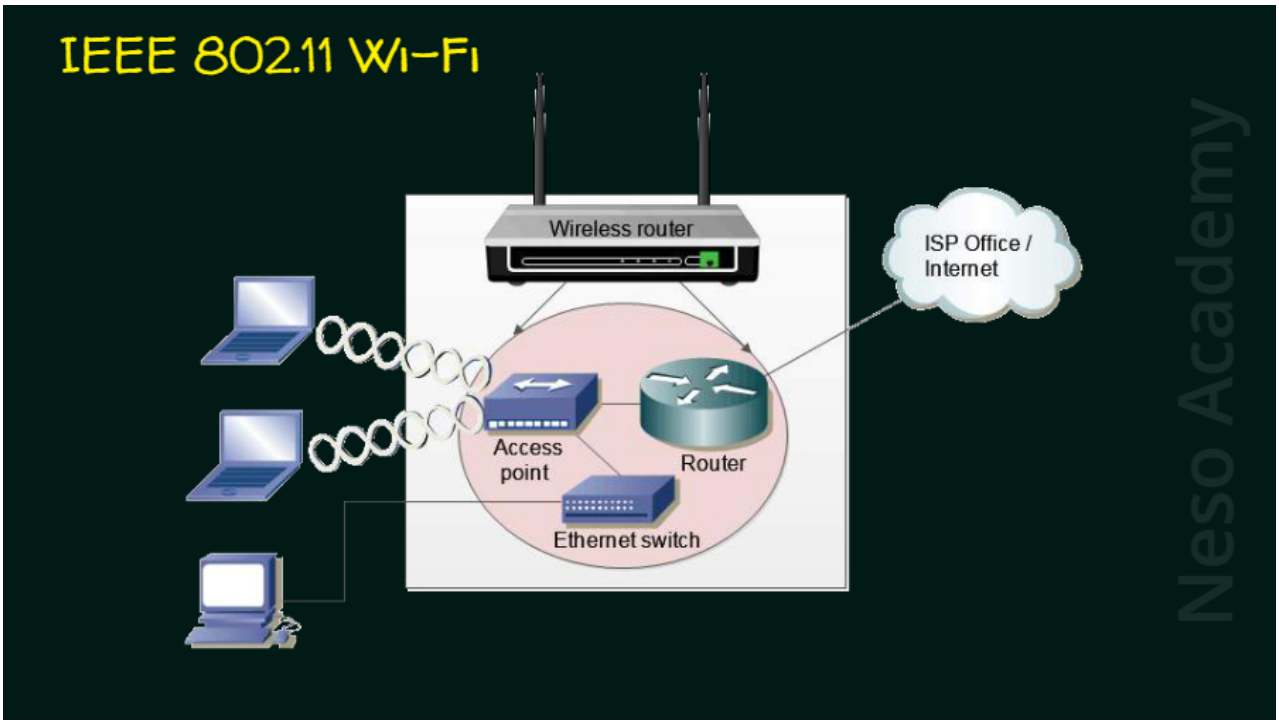
Analogy

Neso Academy

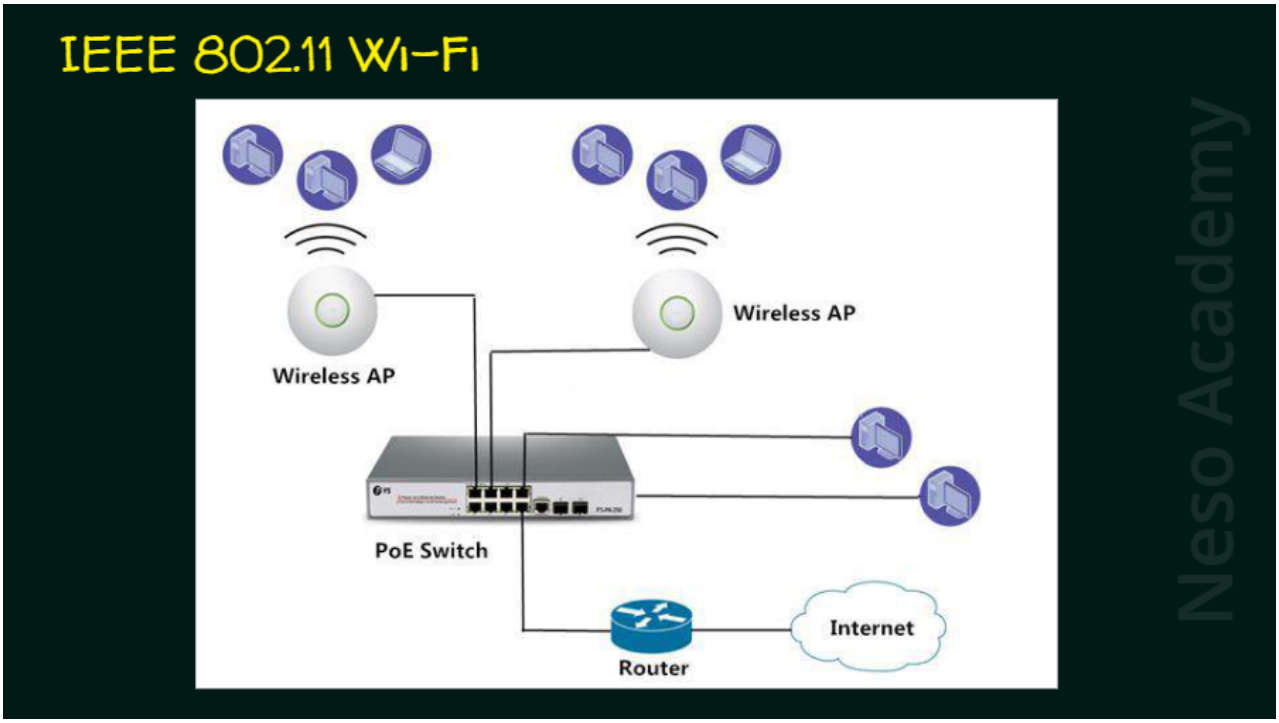
AnalogyNeso Academy



IEEE 802.11 Wi-Fi ★★★★○○Neso Academy



IEEE 802.11 Wi-Fi Neso Academy



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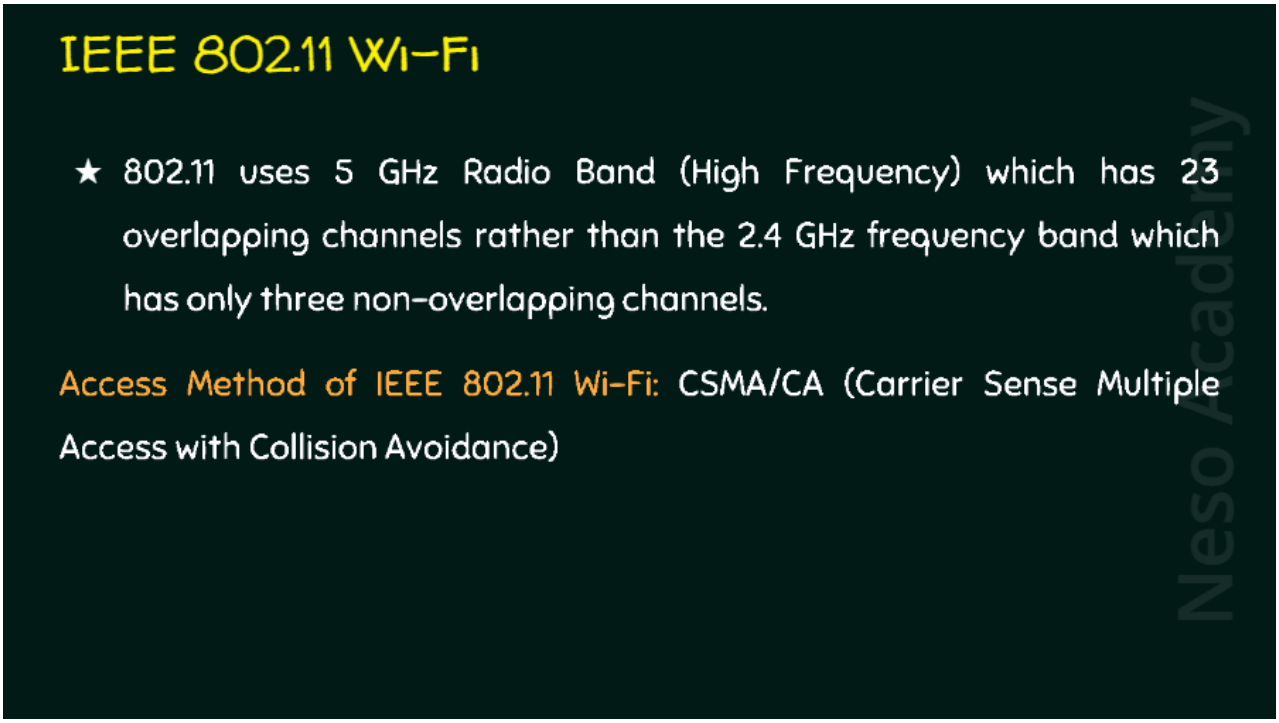
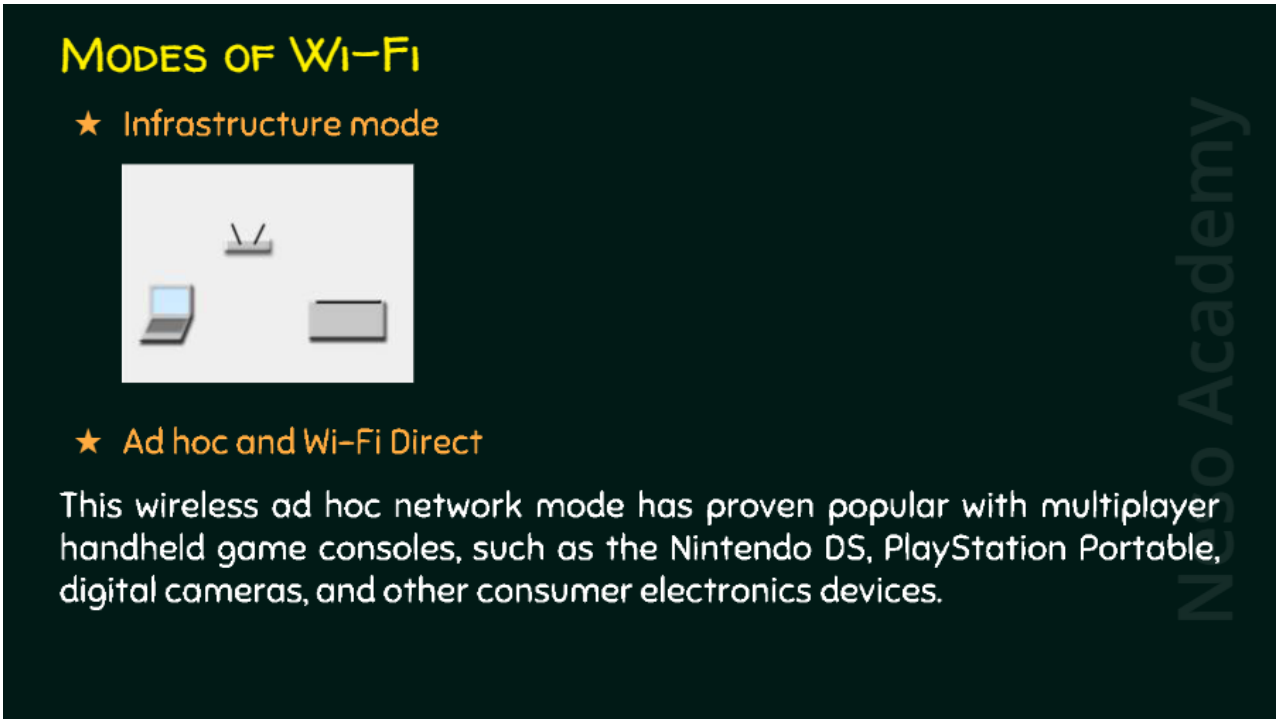


IEEE 802.11 Wi-Fi ★Neso Academy

Wi-Fi AdaptorNeso Academy



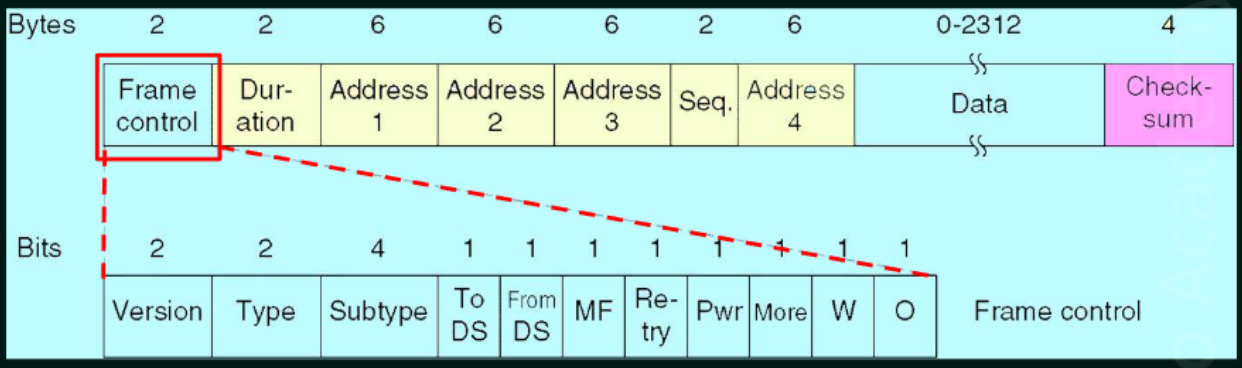
Modes of Wi-Fi★★Neso Academy

Different Wi-Fi protocols

Protocol	Frequency	Channel Width	Maximum data rate (theoretical)
802.11 ax	2.4 or 5GHz	20, 40, 80, 160MHz	2.4 Gbps
802.11 ac wave2	5 GHz	20, 40, 80, 160MHz	1.73 Gbps
802.11 ac wave1	5 GHz	20, 40, 80MHz	866.7 Mbps
802.11n	2.4 or 5 GHz	20, 40MHz	450 Mbps
802.11g	2.4 GHz	20 MHz	54 Mbps
802.11a	5 GHz	20 MHz	54 Mbps
802.11b	2.4 GHz	20 MHz	11 Mbps
Legacy 802.11	2.4 GHz	20 MHz	2 Mbps

Different Wi-Fi protocolsNeso Academy

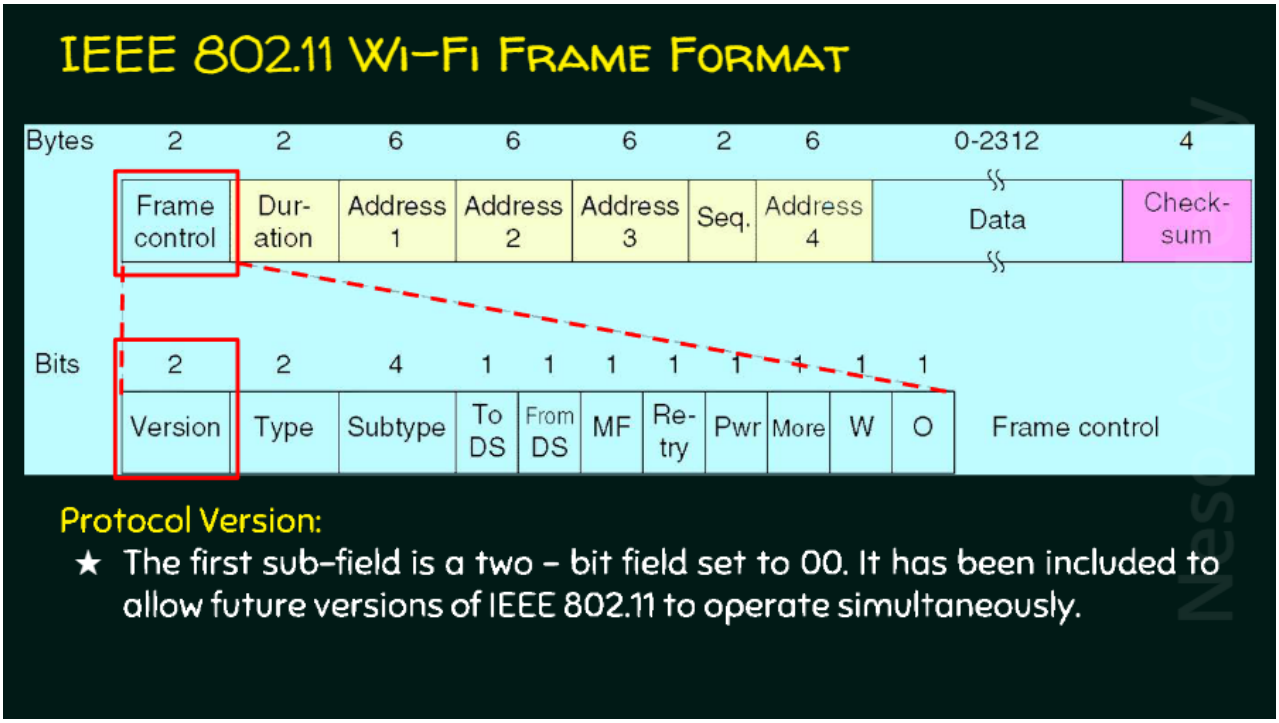
IEEE 802.11 Wi-Fi Frame Format



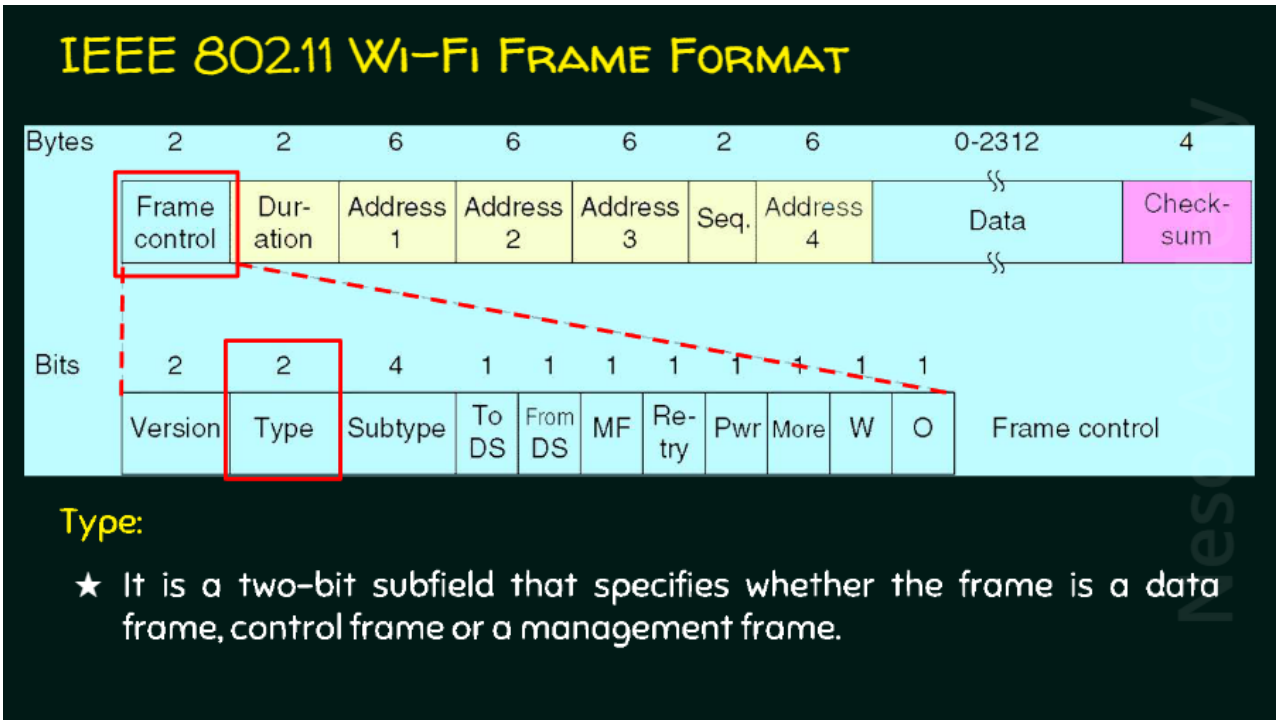
Frame Control:

- ★ It is a 2 bytes starting field composed of 11 subfields. It contains control information of the frame.
- ★ It has 11 subfields.

IEEE 802.11 Wi-Fi Frame Format★★Neso Academy



IEEE 802.11 Wi-Fi Frame Format★Neso Academy



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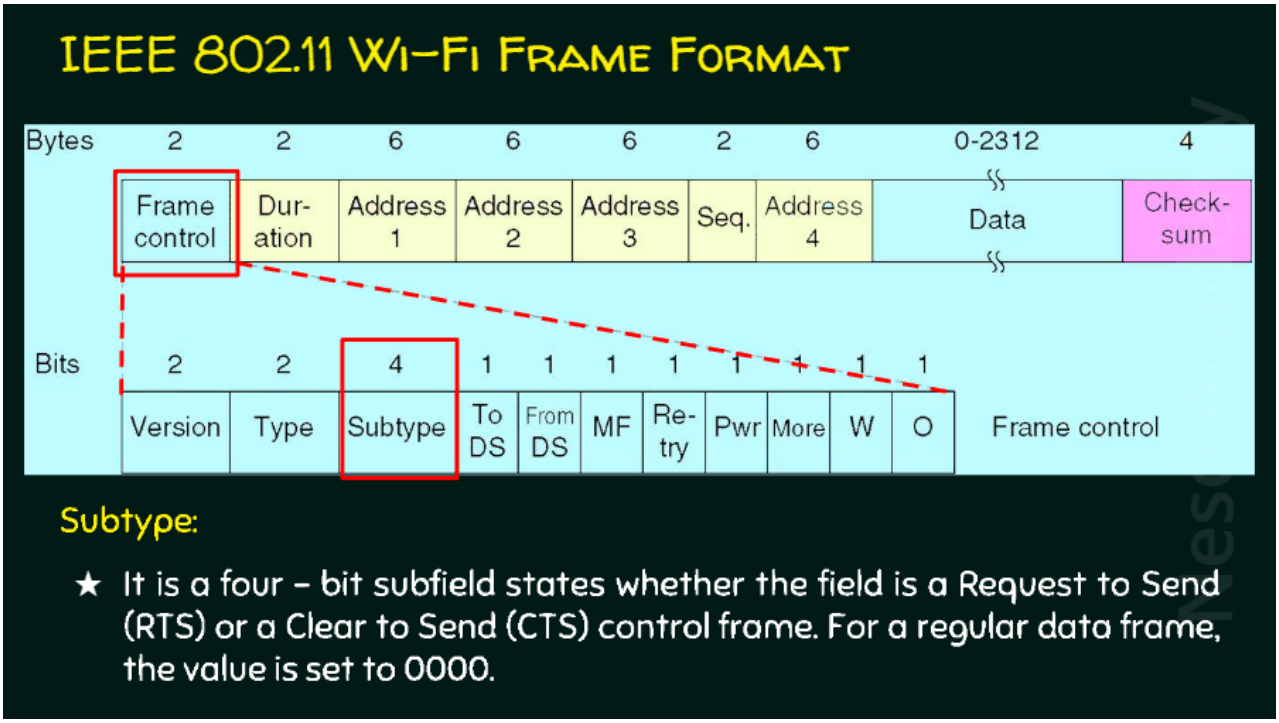
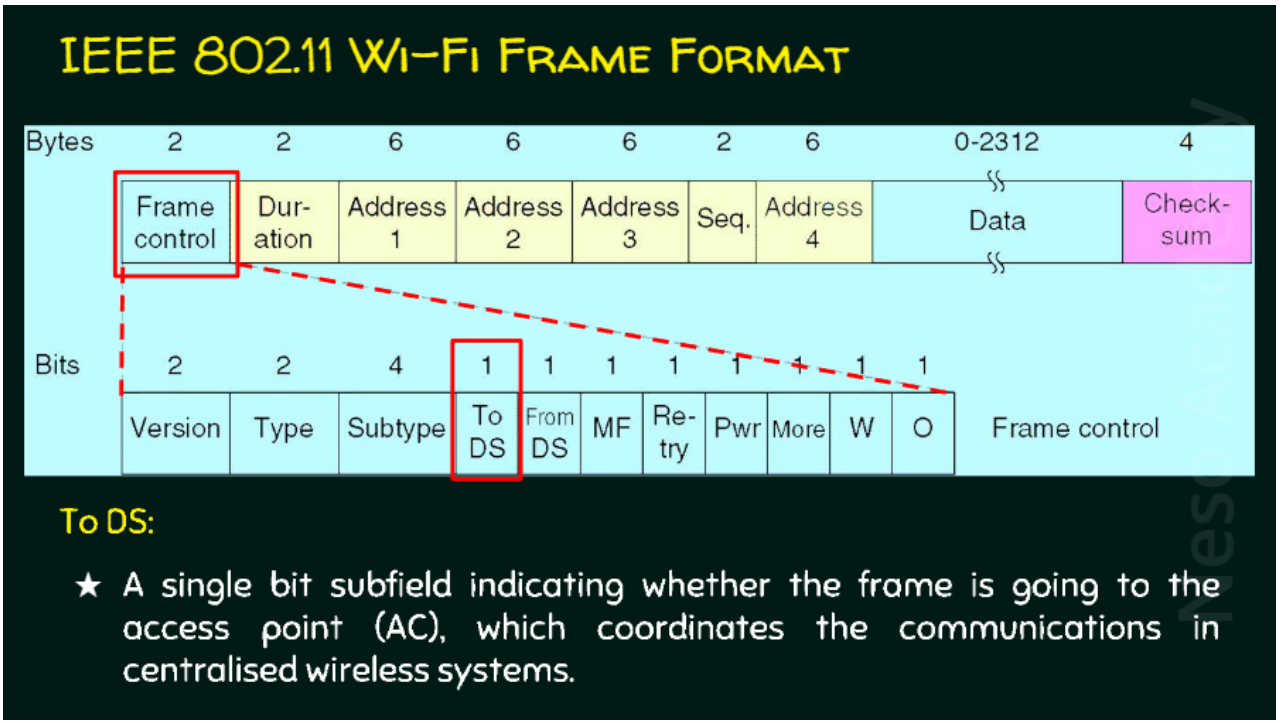
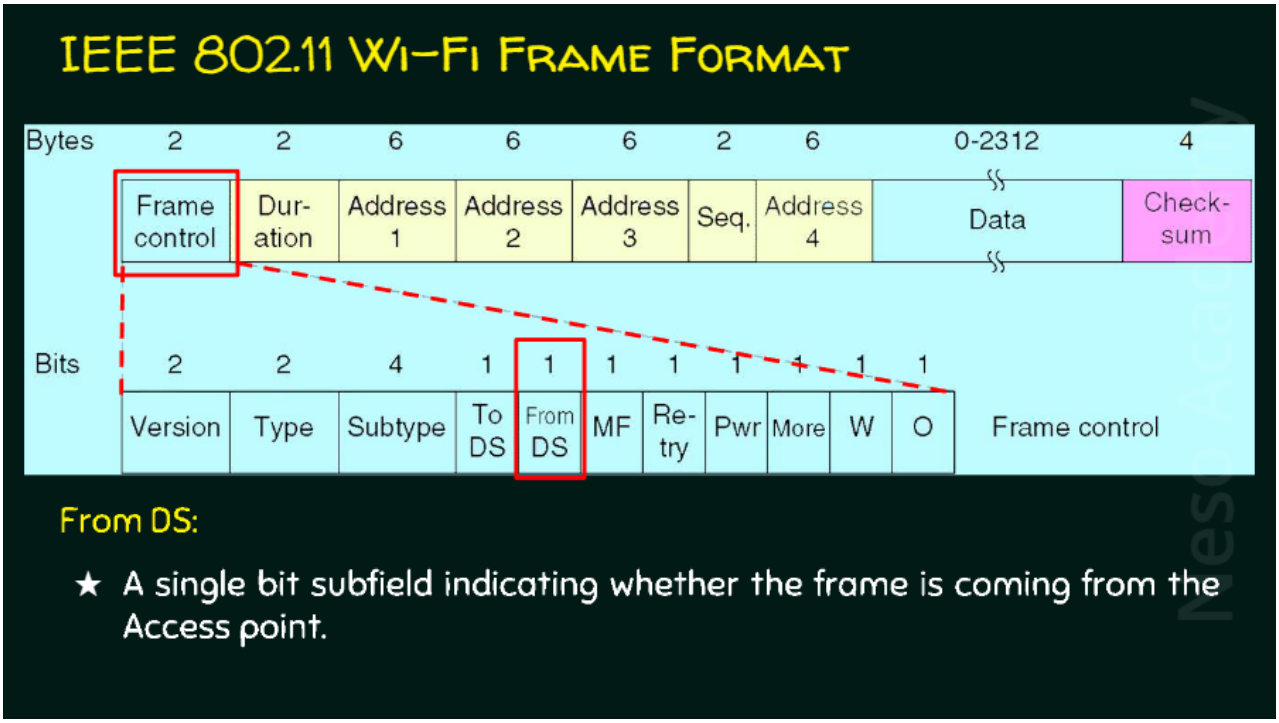


IEEE 802.11 Wi-Fi Frame Format★Neso Academy



IEEE 802.11 Wi-Fi Frame Format★Neso Academy



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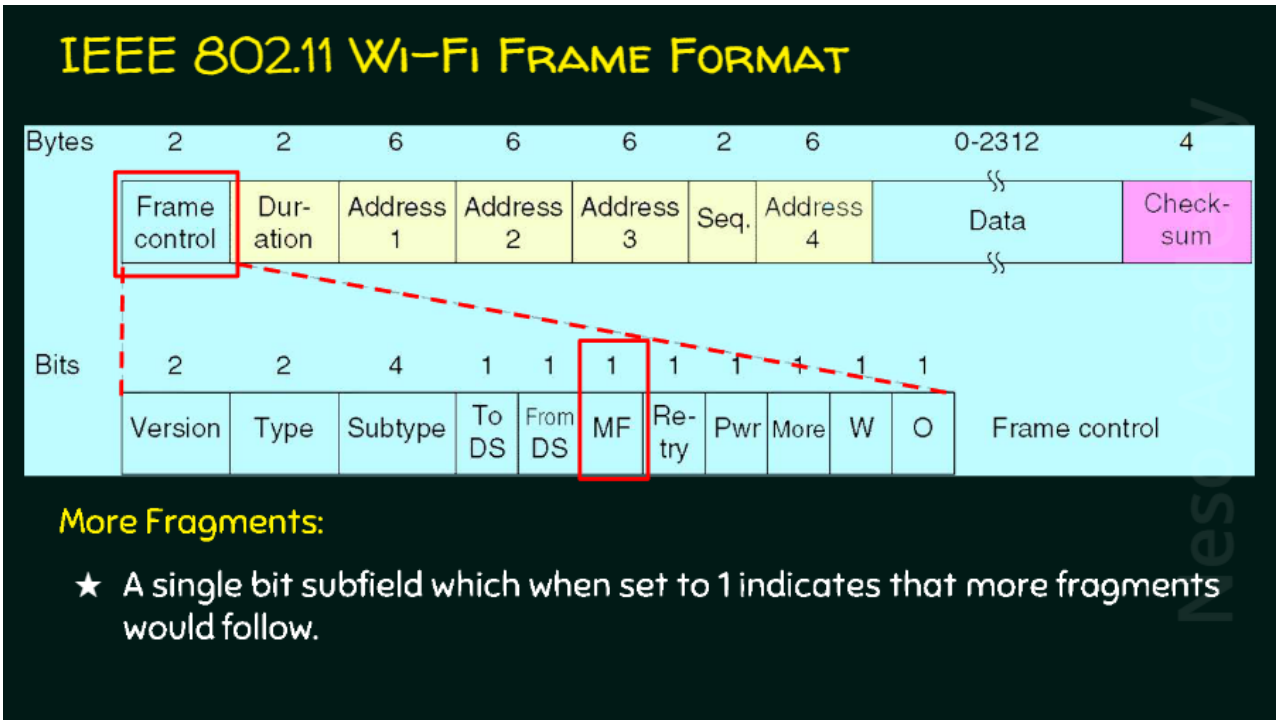
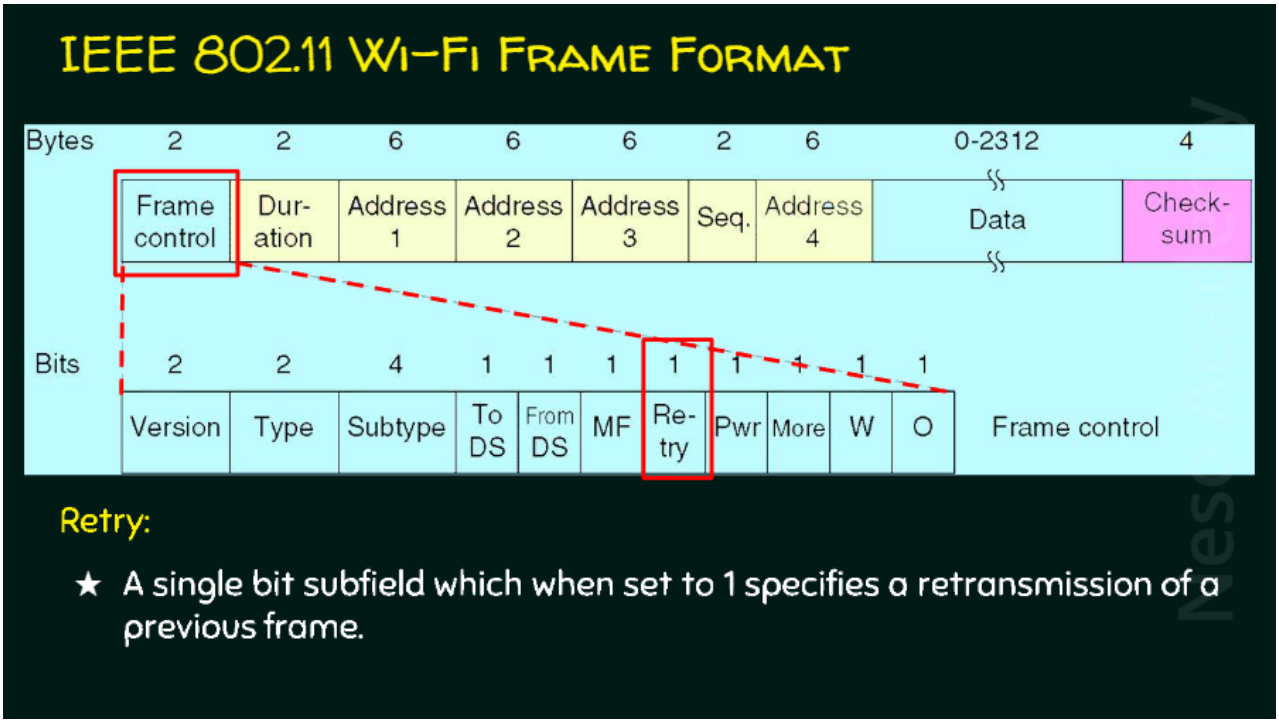
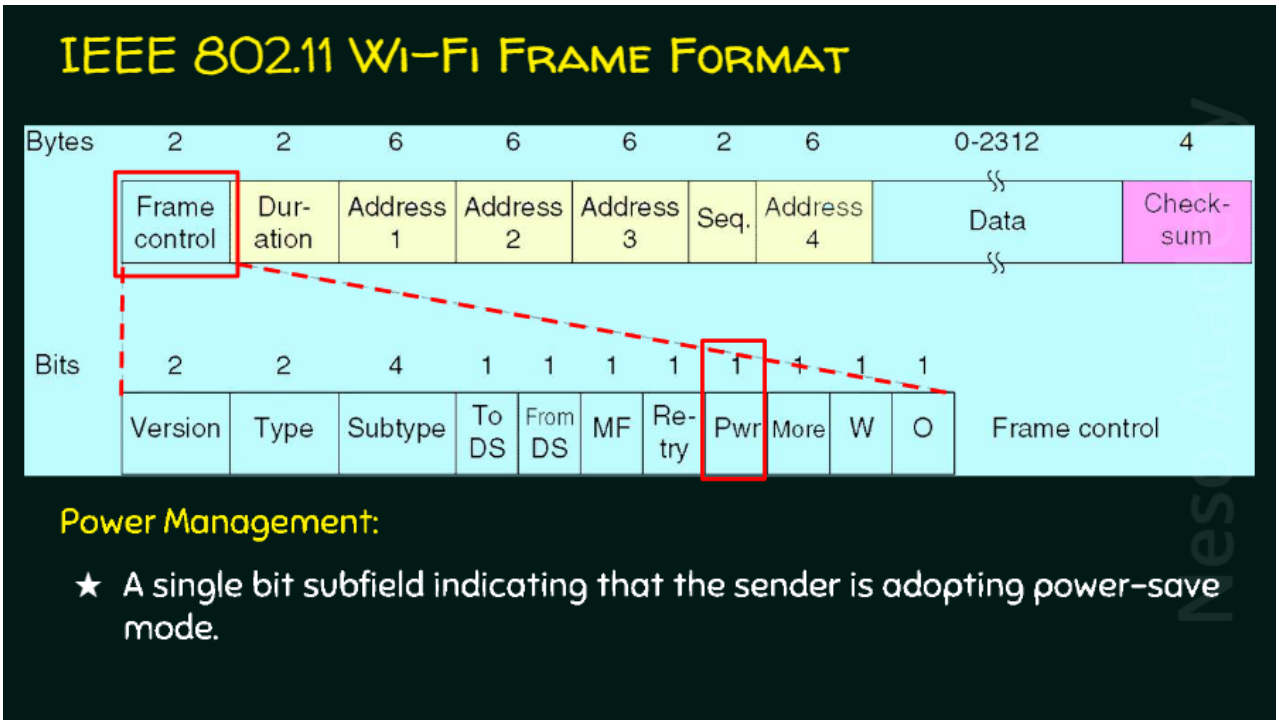


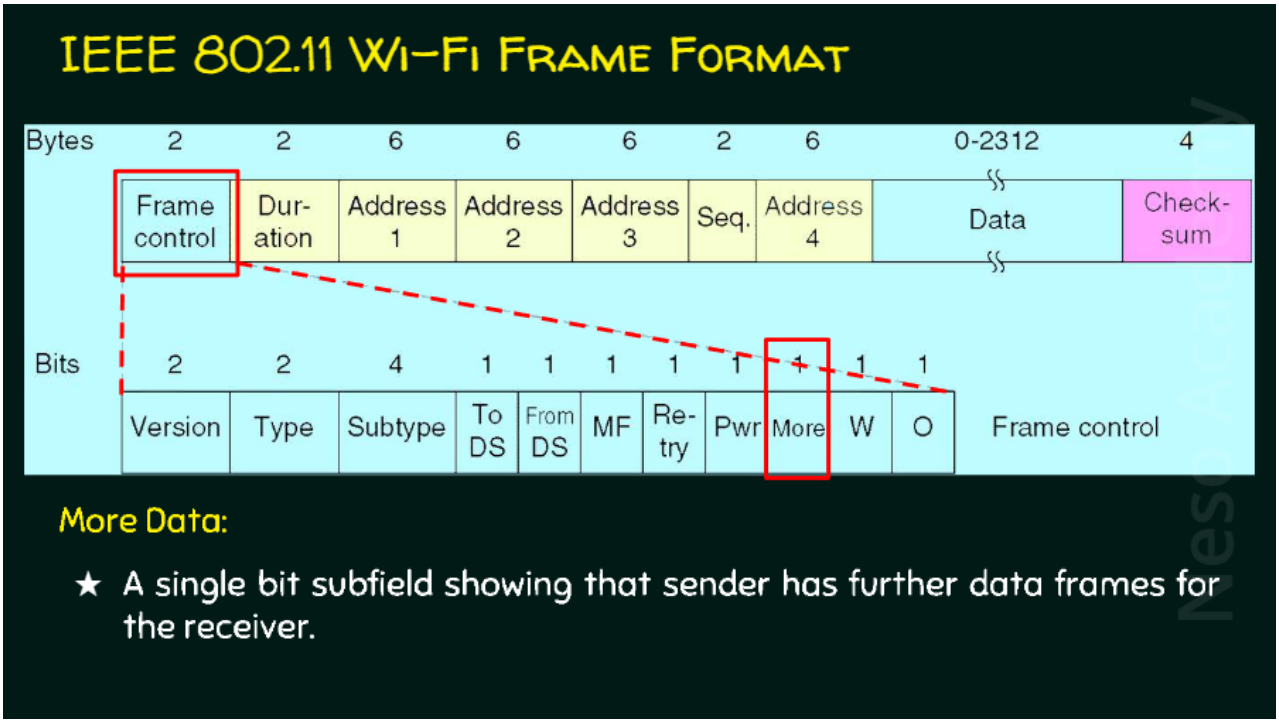
IEEE 802.11 Wi-Fi Frame Format★Neso Academy



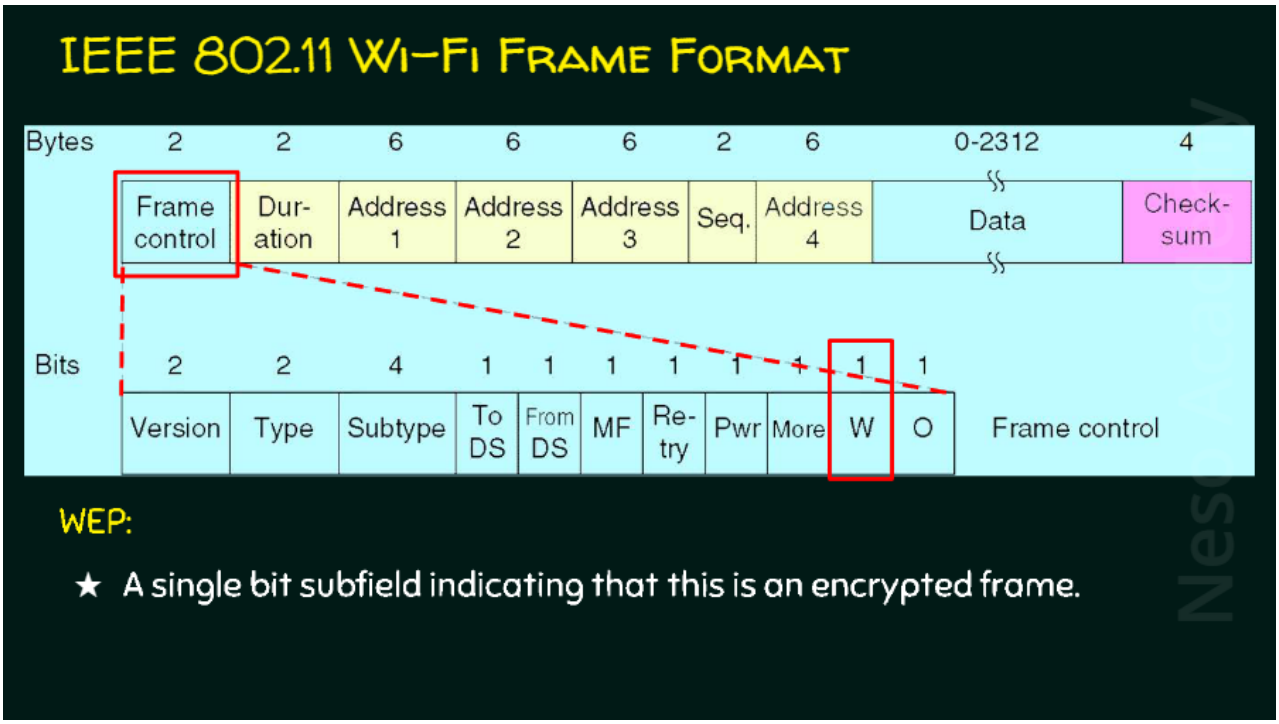
IEEE 802.11 Wi-Fi Frame Format★Neso Academy



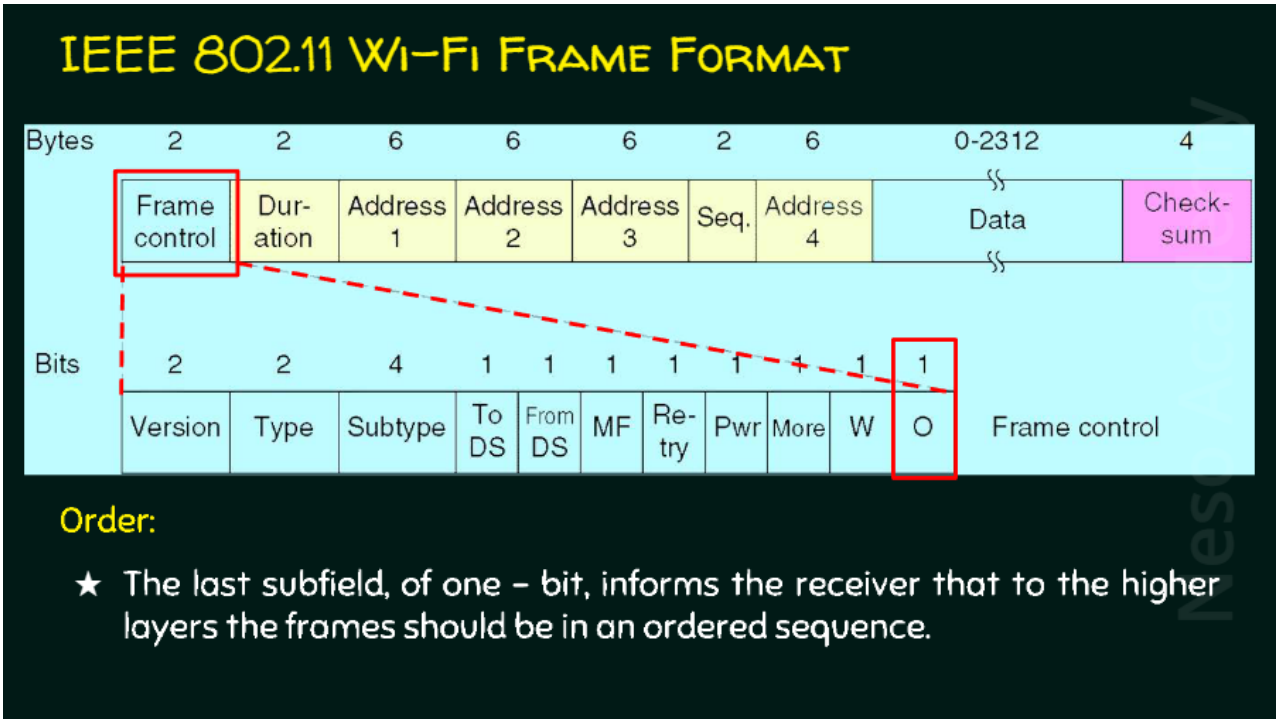
IEEE 802.11 Wi-Fi Frame Format★Neso Academy



IEEE 802.11 Wi-Fi Frame Format★Neso Academy



IEEE 802.11 Wi-Fi Frame Format★Neso Academy



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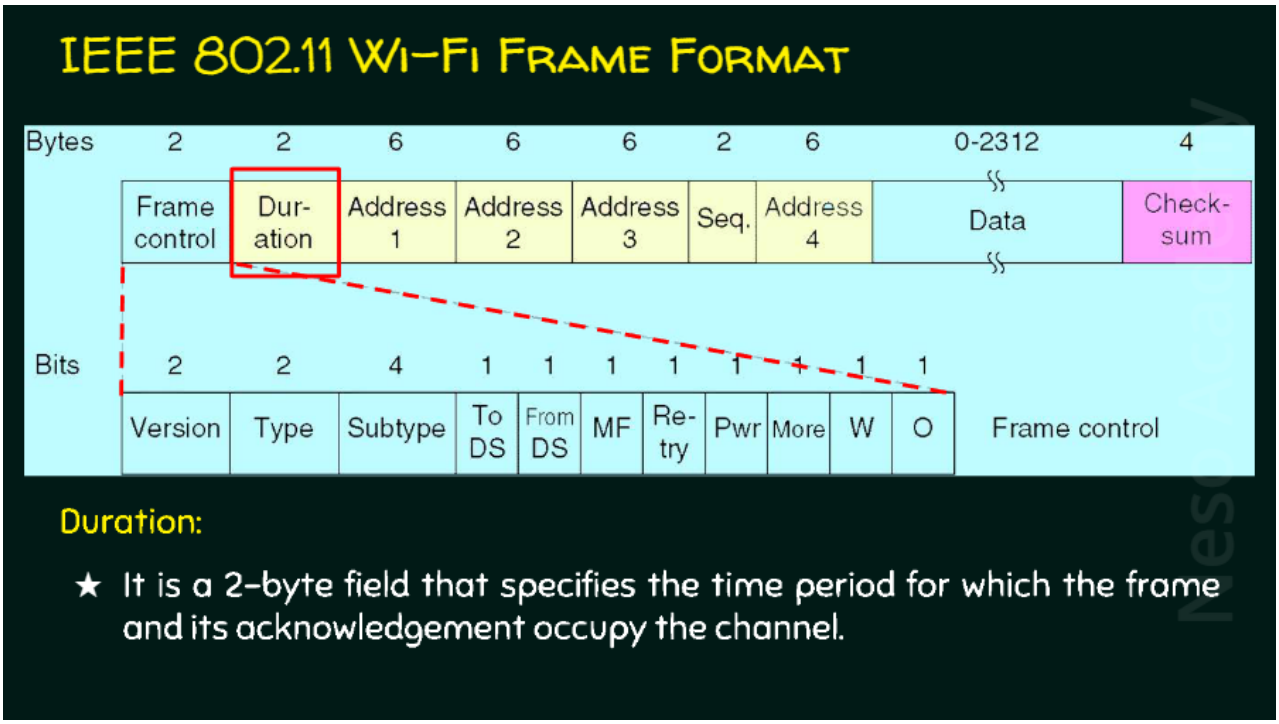

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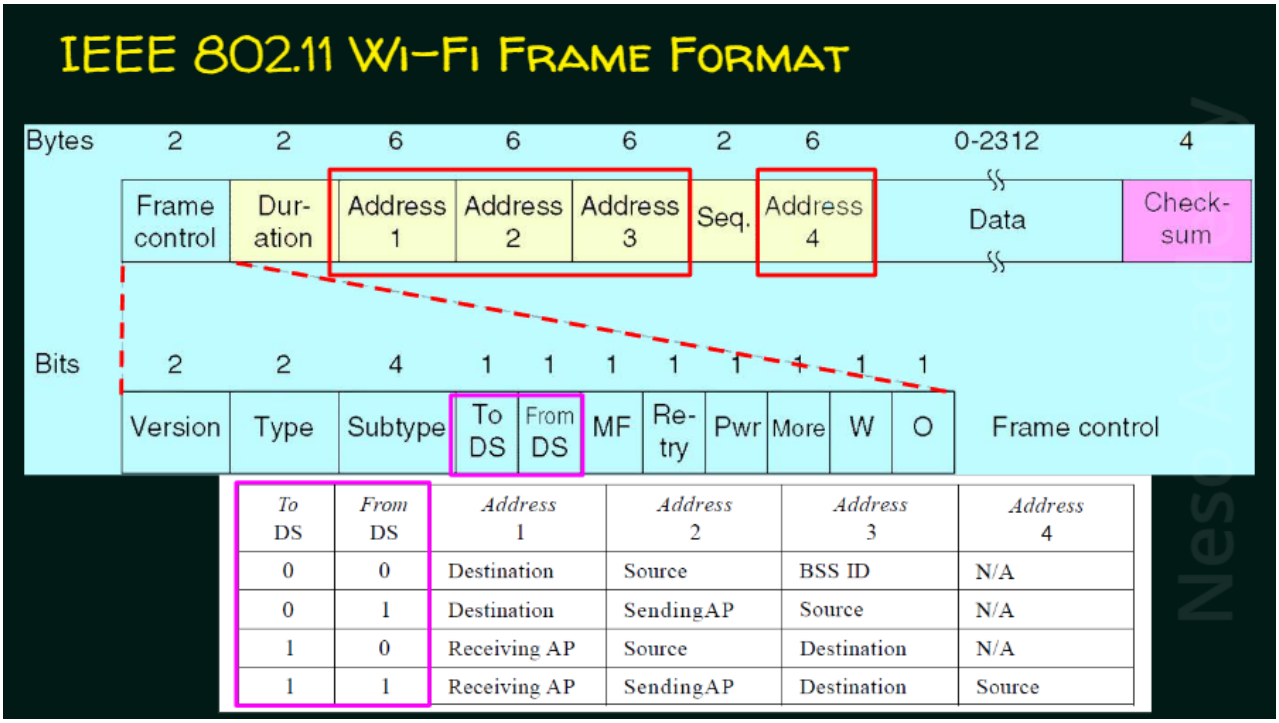
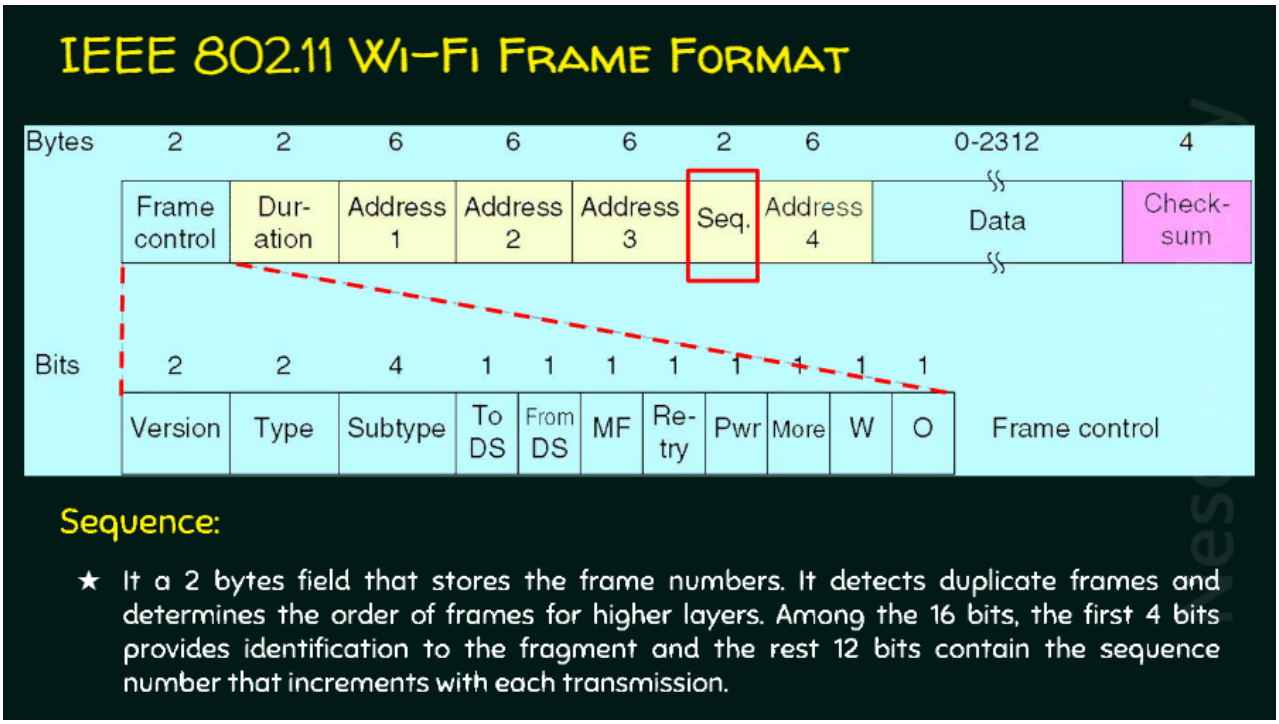
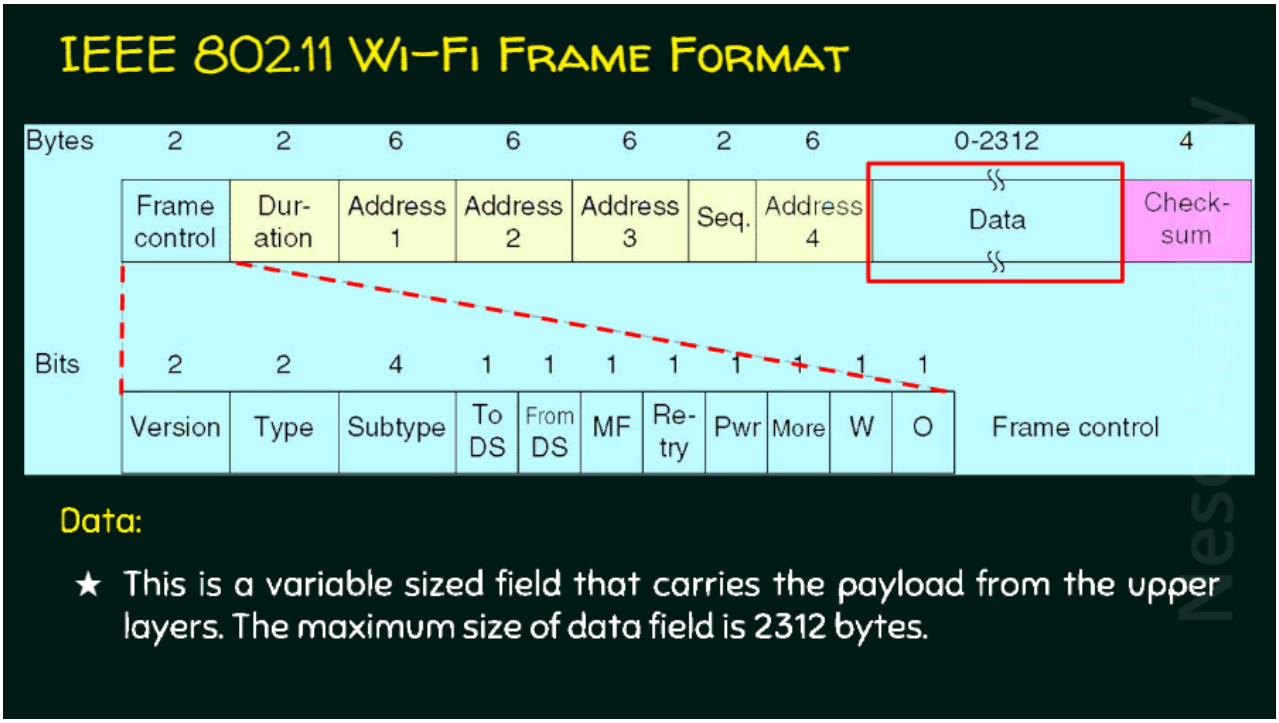


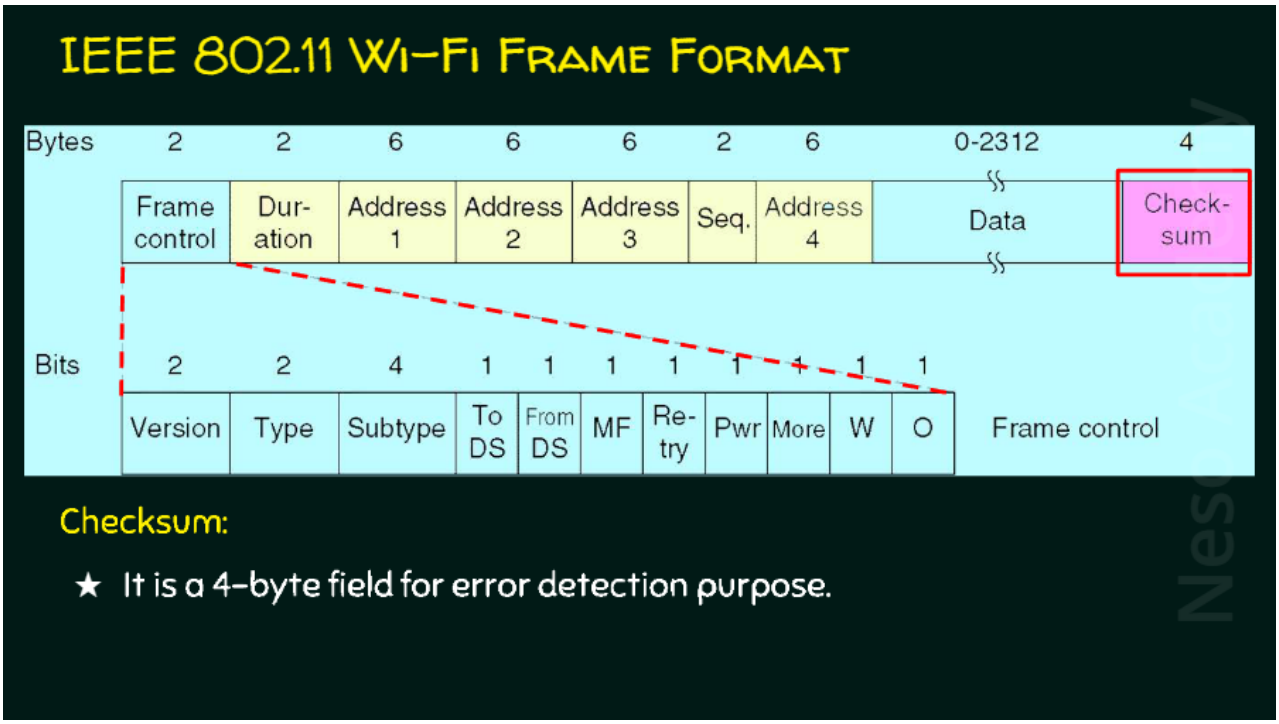
IEEE 802.11 Wi-Fi Frame FormatNeso Academy



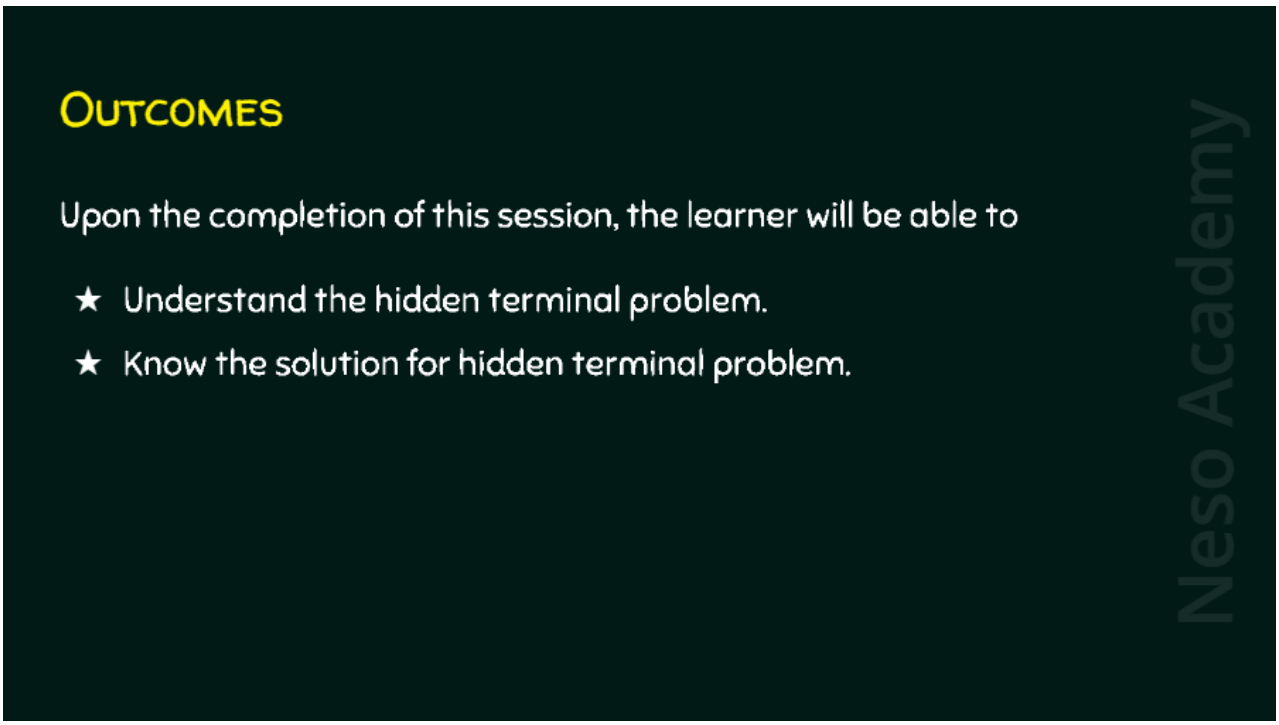
IEEE 802.11 Wi-Fi Frame Format★Neso Academy



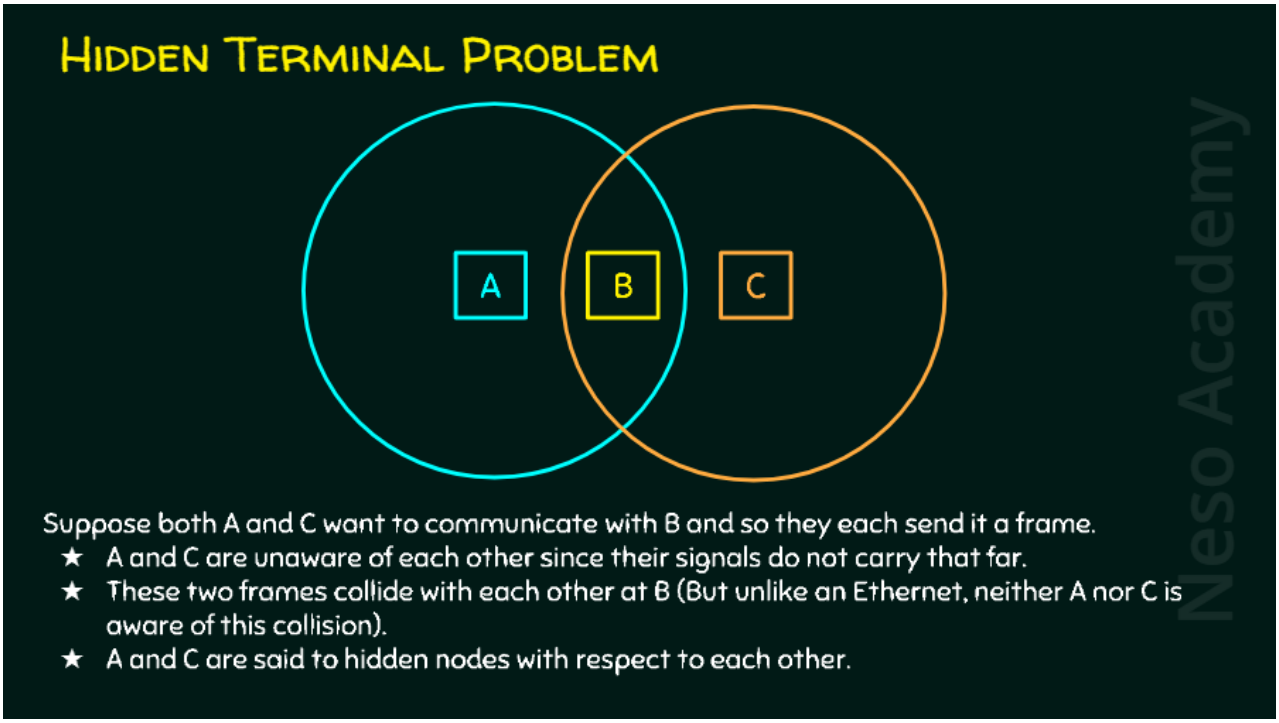
IEEE 802.11 Wi-Fi Frame Format★Neso Academy



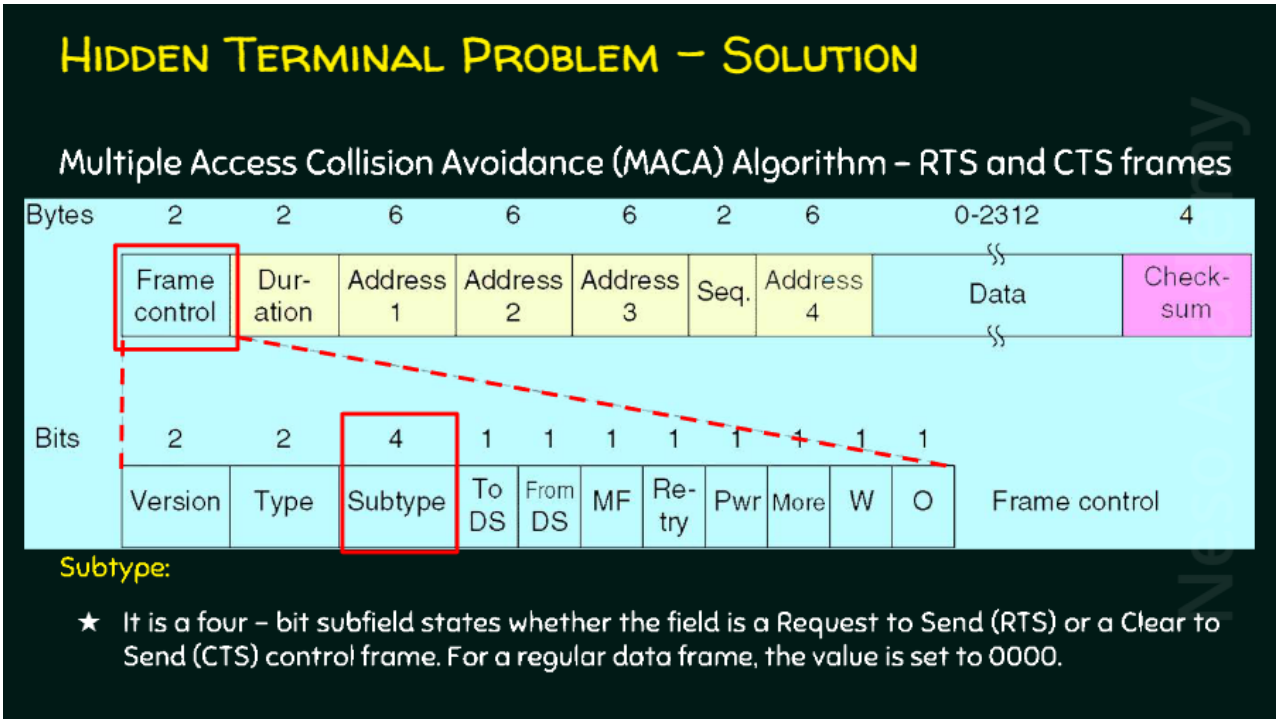
IEEE 802.11 Wi-Fi Frame Format★Neso Academy



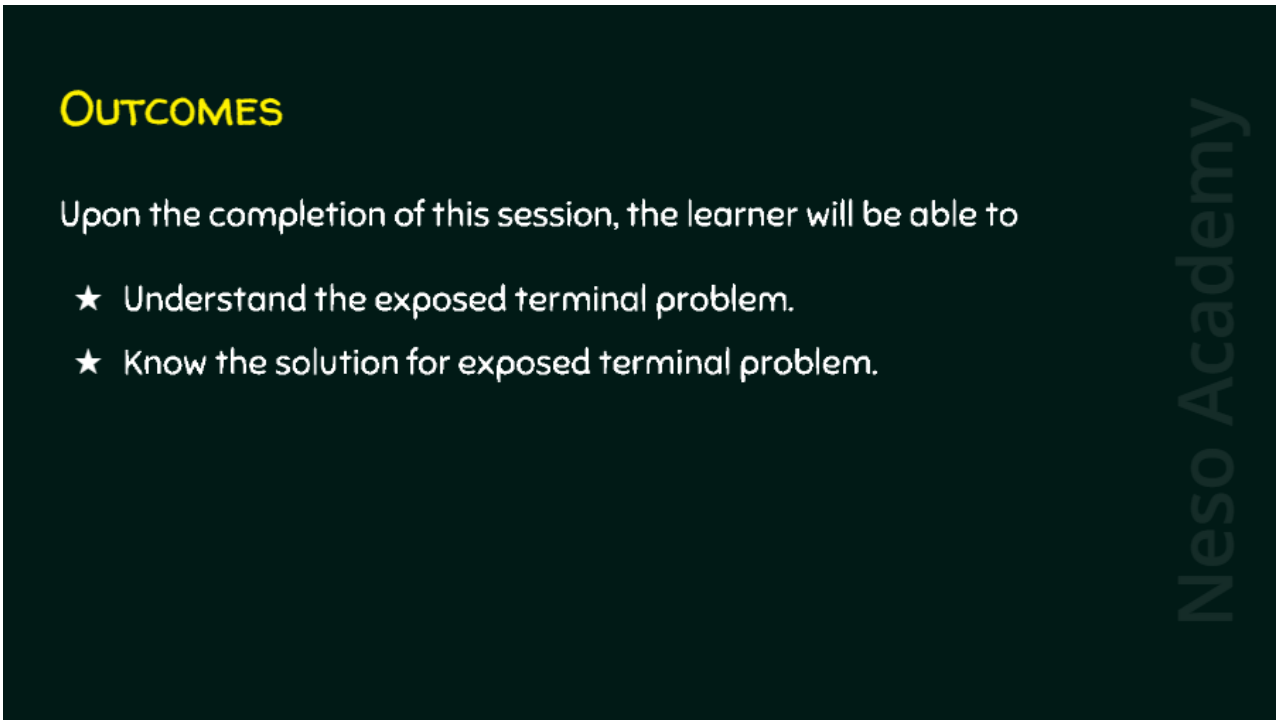
★★OutcomesNeso Academy



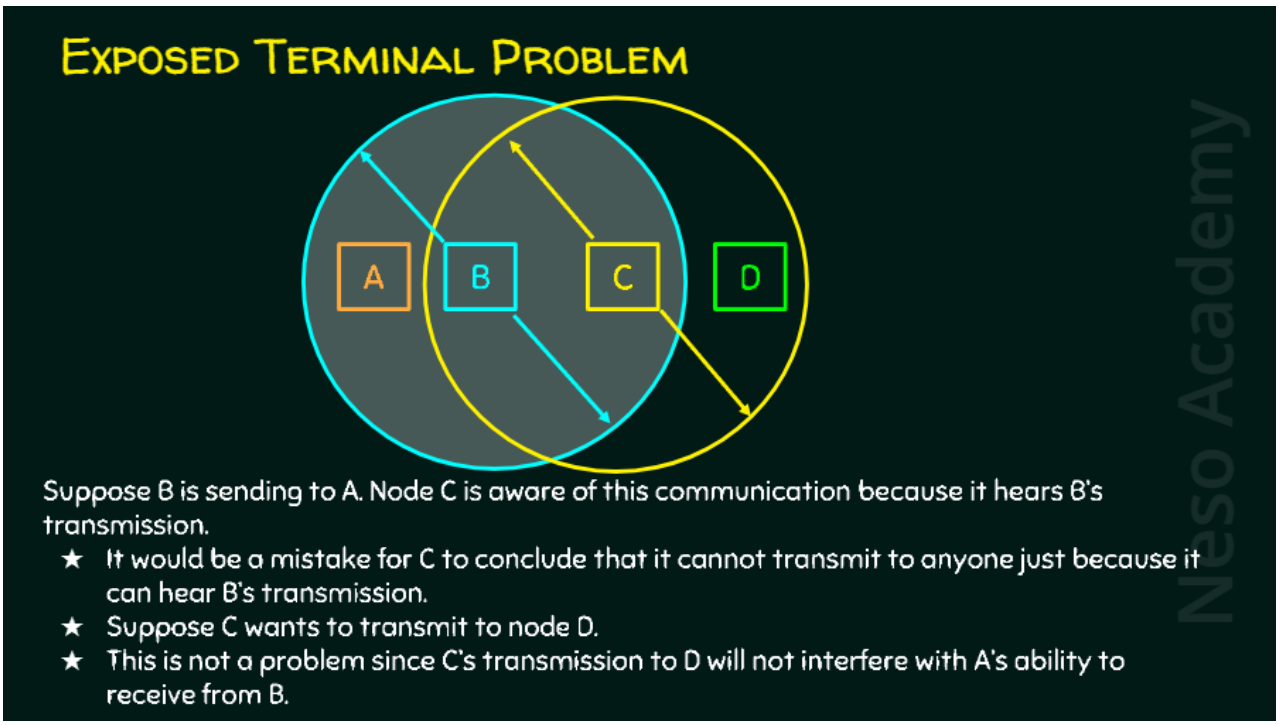
Hidden Terminal Problem★★★Neso Academy



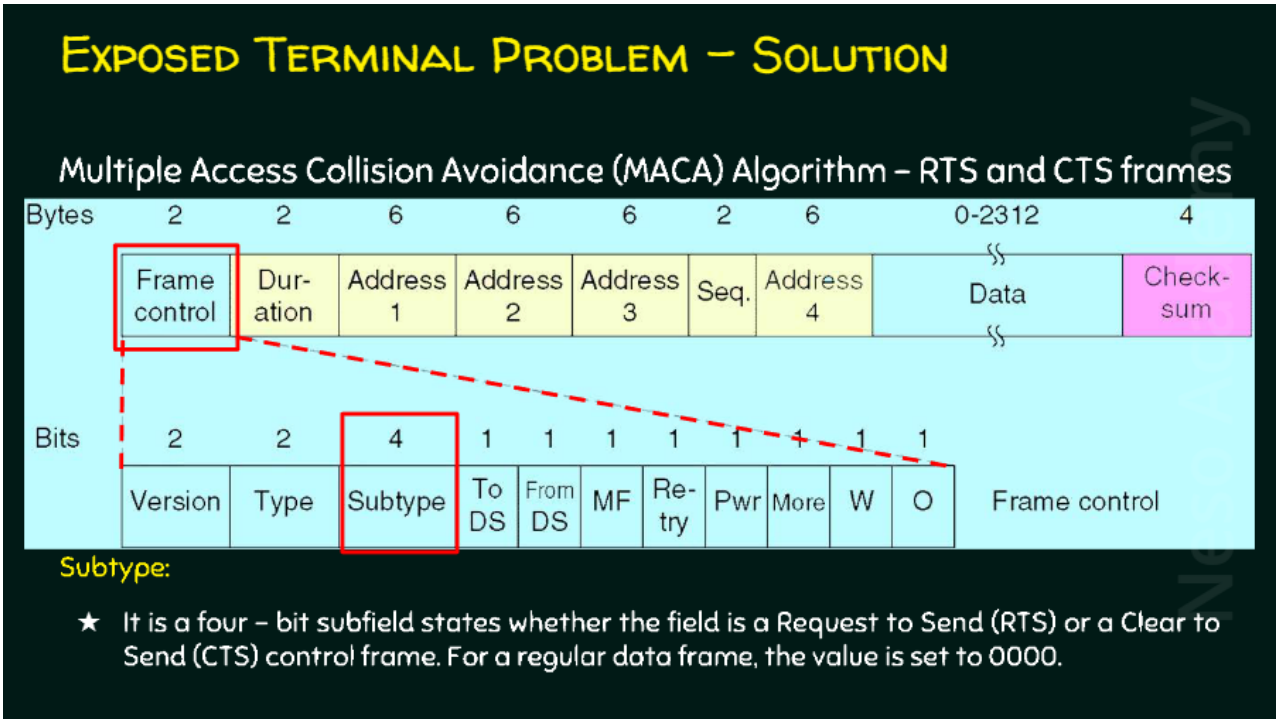
Hidden Terminal Problem -Solution★Neso Academy



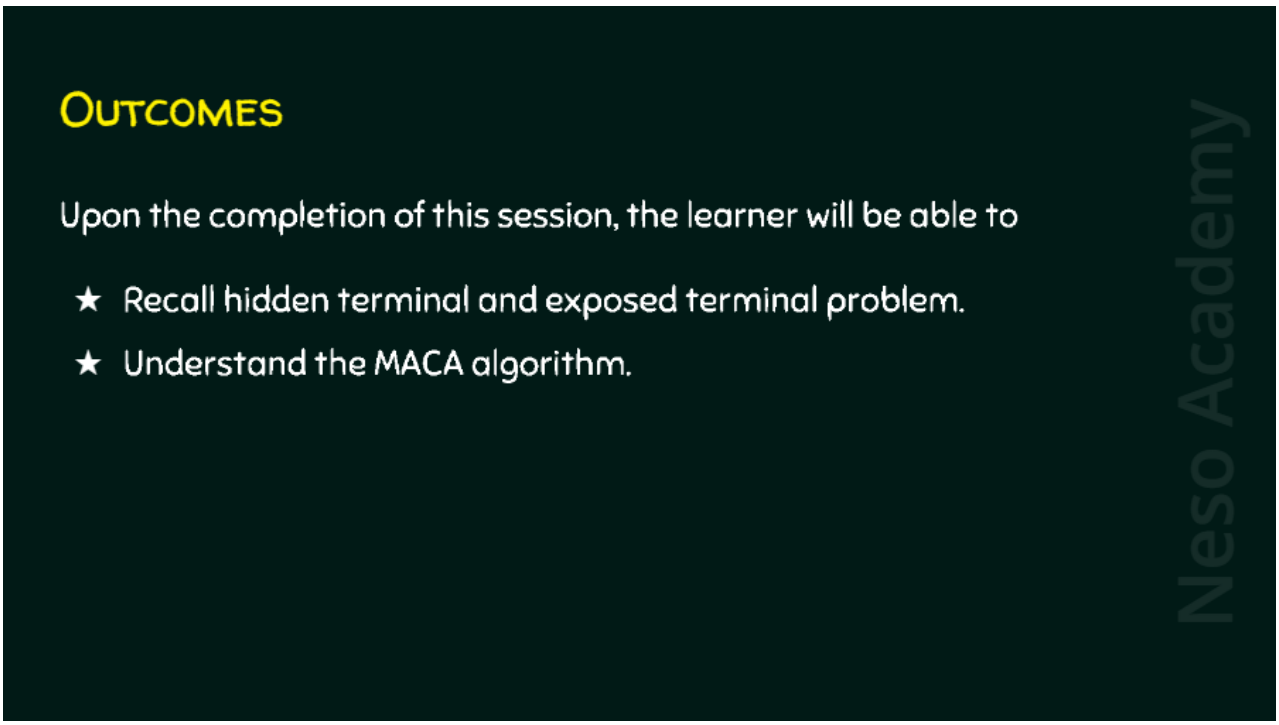
★★OutcomesNeso Academy



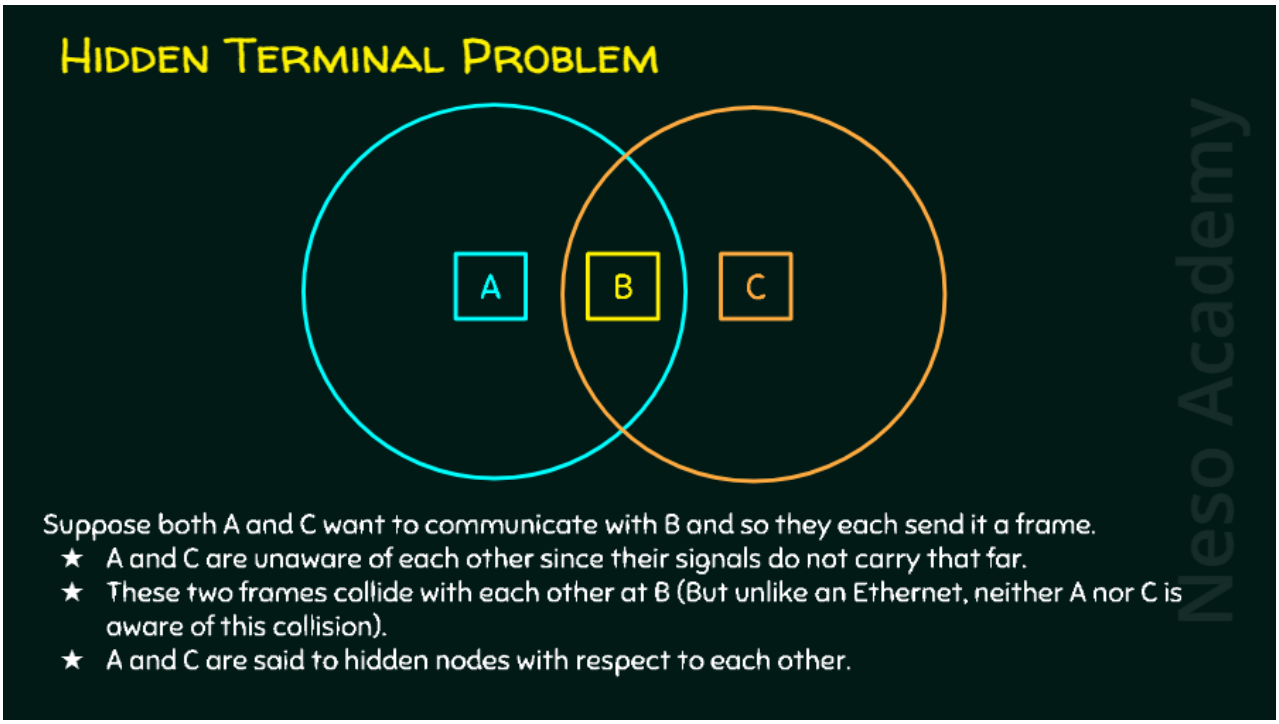
Exposed Terminal Problem★★★Neso Academy



Exposed Terminal Problem -Solution★Neso Academy

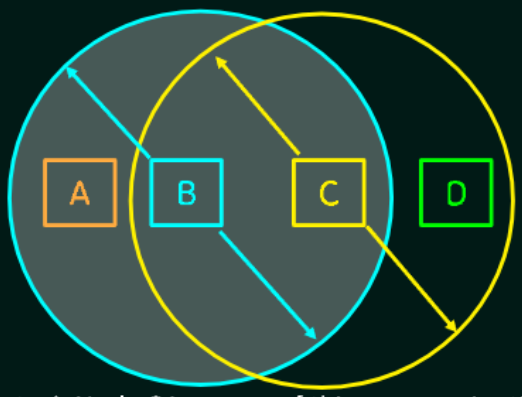


★★OutcomesNeso Academy



Hidden Terminal Problem★★★Neso Academy

Exposed Terminal Problem



Suppose B is sending to A. Node C is aware of this communication because it hears B's transmission.

- ★ It would be a mistake for C to conclude that it cannot transmit to anyone just because it can hear B's transmission.
- ★ Suppose C wants to transmit to node D.
- ★ This is not a problem since C's transmission to D will not interfere with A's ability to receive from B.

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Exposed Terminal Problem★★★Neso Academy

IEEE 802.11 – Collision Avoidance

- ★ 802.11 addresses these two problems with an algorithm called Multiple Access with Collision Avoidance (MACA).

Key Idea

- ★ Sender and receiver exchange control frames with each other before the sender actually transmits any data.
- ★ This exchange informs all nearby nodes that a transmission is about to begin.
- ★ Sender transmits a Request to Send (RTS) frame to the receiver.
  - ○ The RTS frame includes a field that indicates how long the sender wants to hold the medium. Length of the data frame to be transmitted.
- ★ Receiver replies with a Clear to Send (CTS) frame
  - ○ This frame echoes this length field back to the sender

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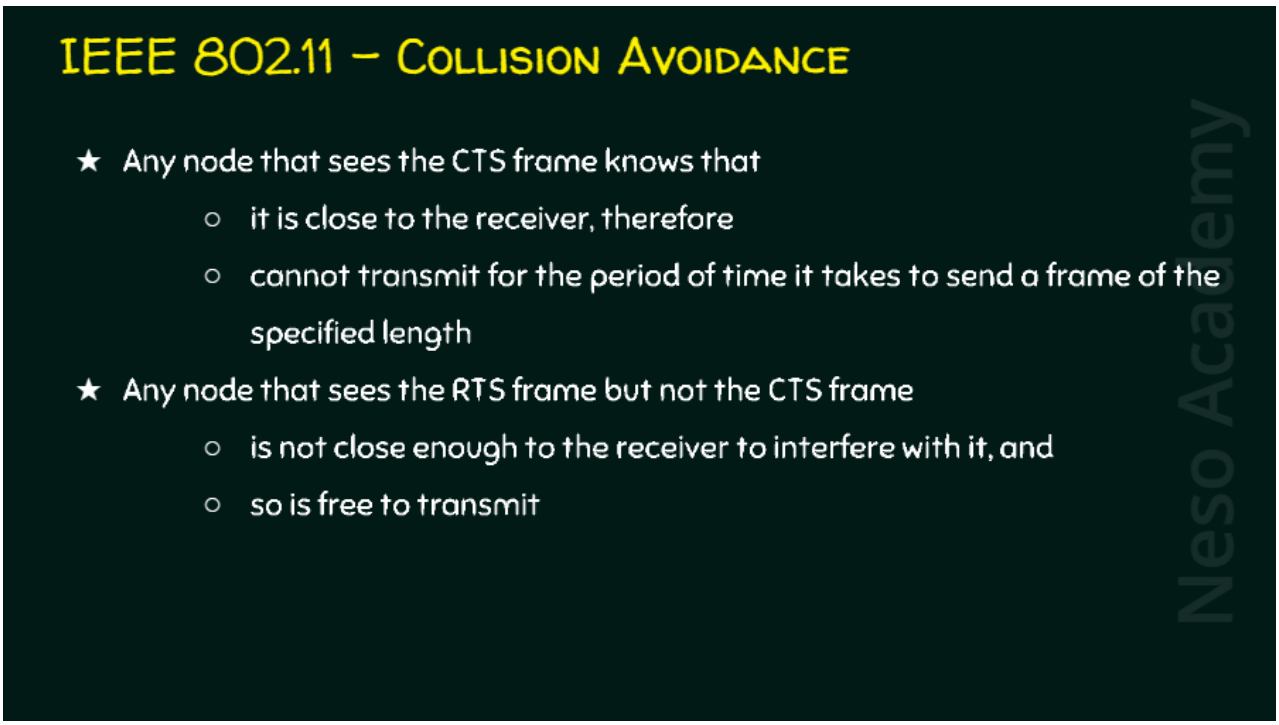
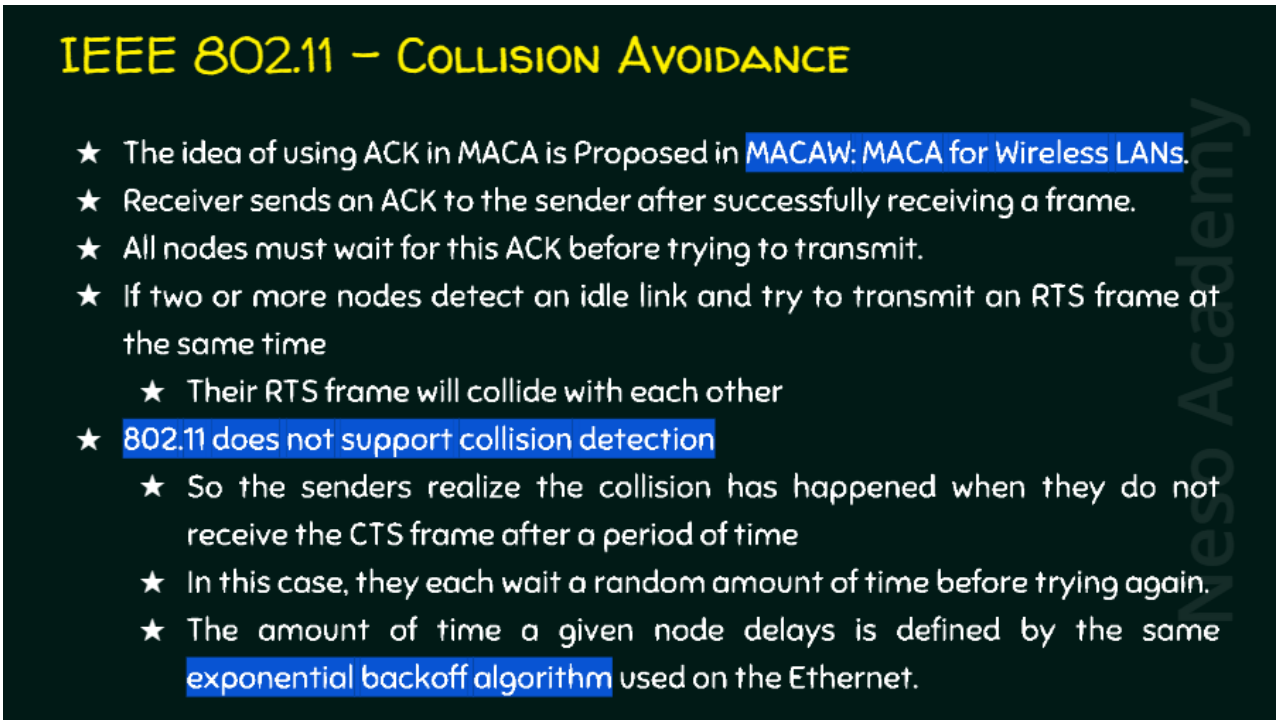
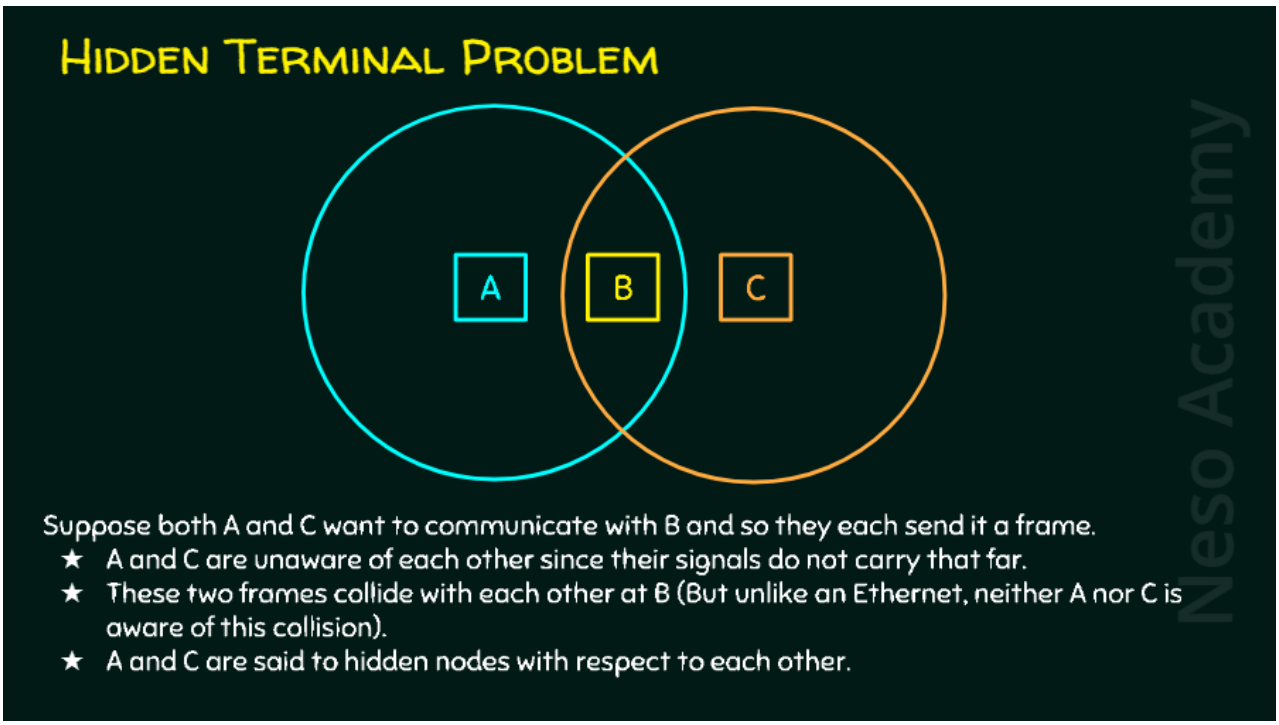
IEEE 802.11 -Collision Avoidance★★★★○★○Neso Academy



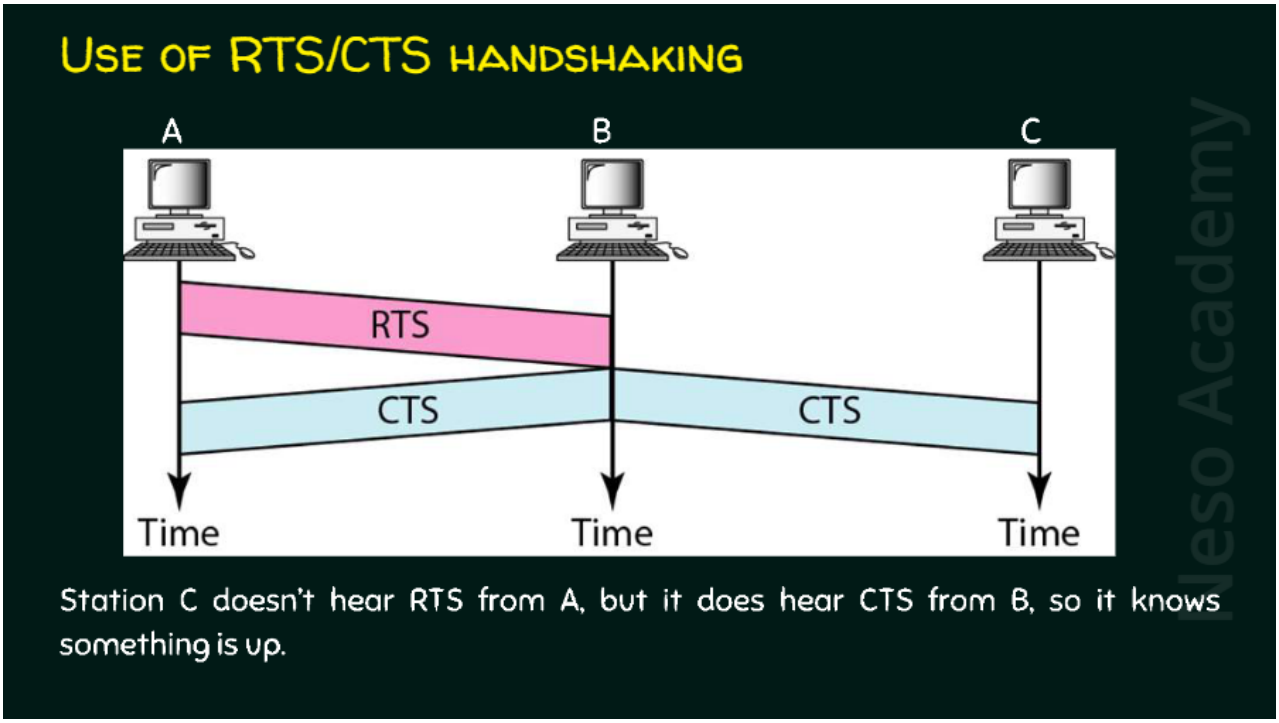
IEEE 802.11 -Collision Avoidance★○○★○○Neso Academy



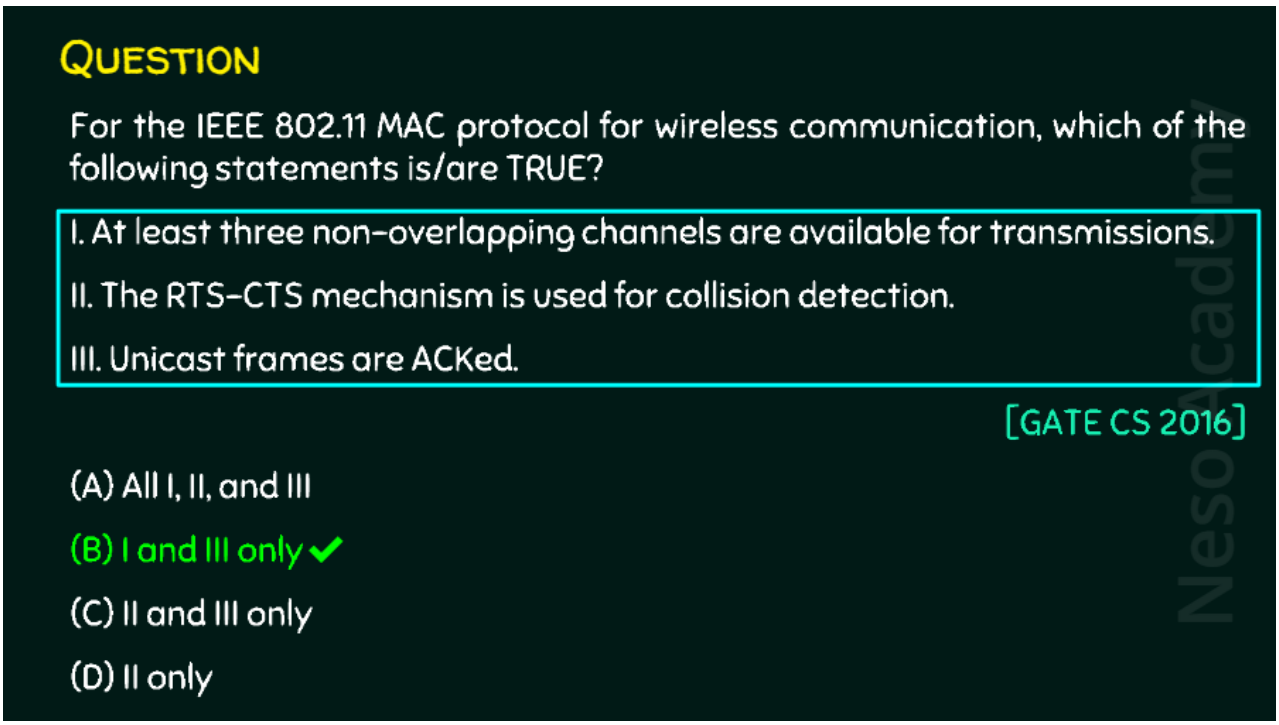
IEEE 802.11 -Collision Avoidance★★★★★★★★★Neso Academy



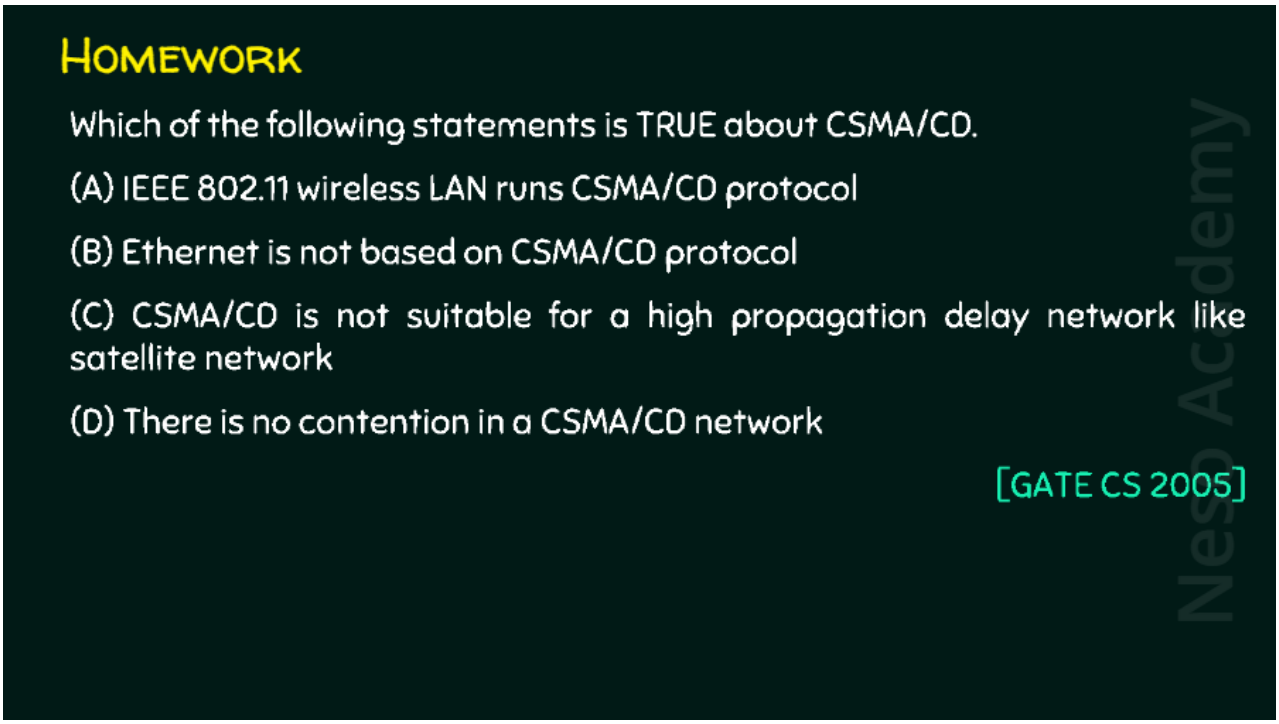
Hidden Terminal Problem★★★Neso Academy



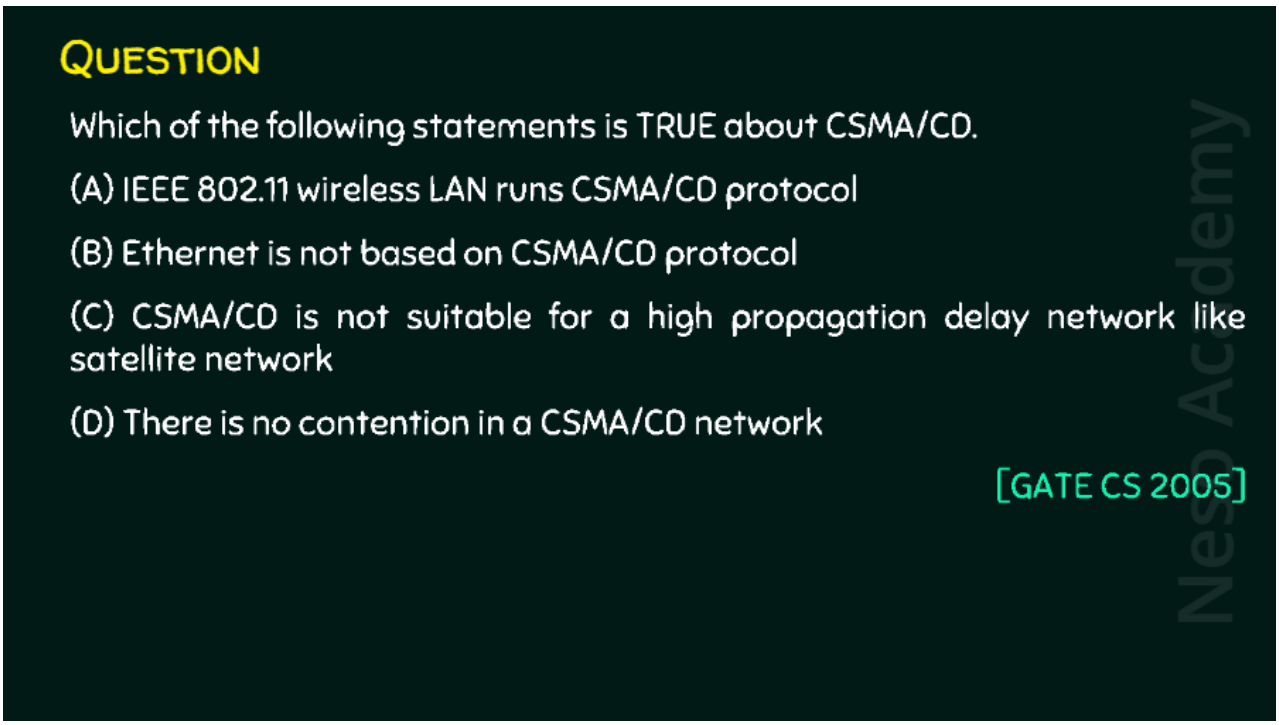
Use of RTS/CTS handshakingNeso Academy



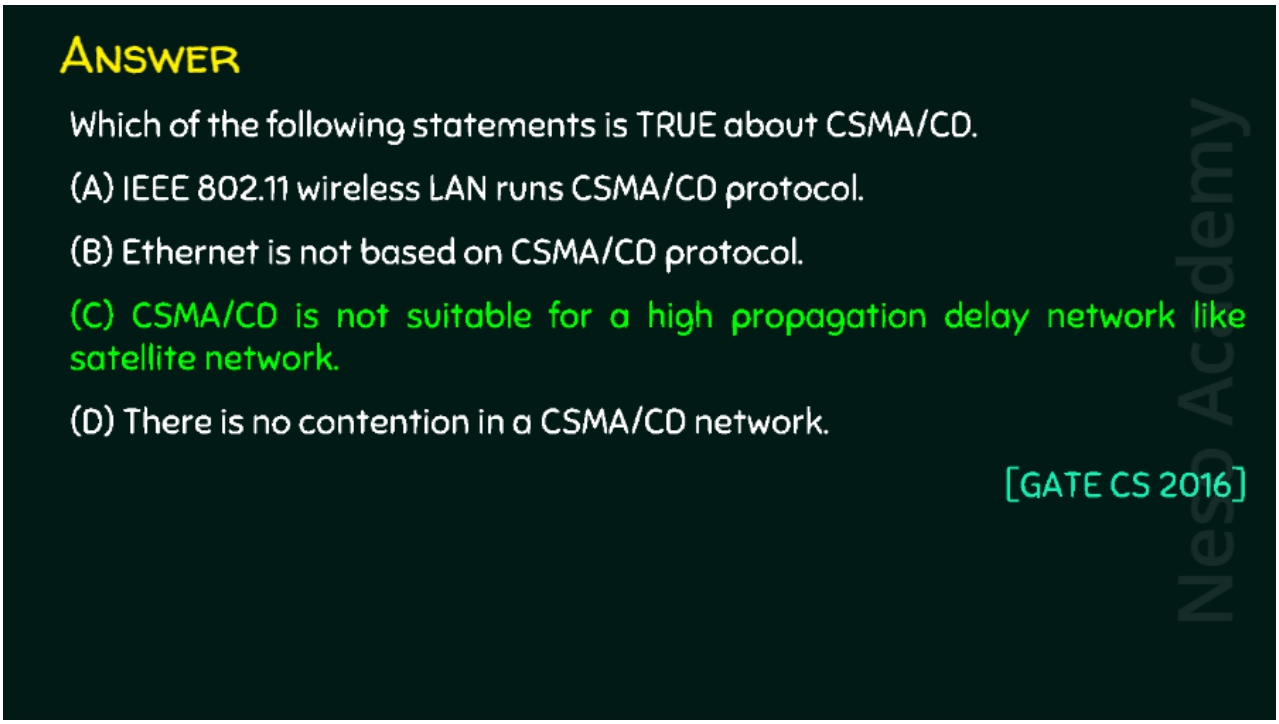
Question ✔ Neso Academy



HomeworkNeso Academy



QuestionNeso Academy



AnswerNeso Academy

Outcomes

Upon the completion of this session, the learner will be able to

- ★ Know the basics of bluetooth.
- ★ Understand piconet and scatternet.
- ★ See the bluetooth adaptors.
- ★ Understand the pros and cons of bluetooth.
- ★ Know about bluesnarfing.

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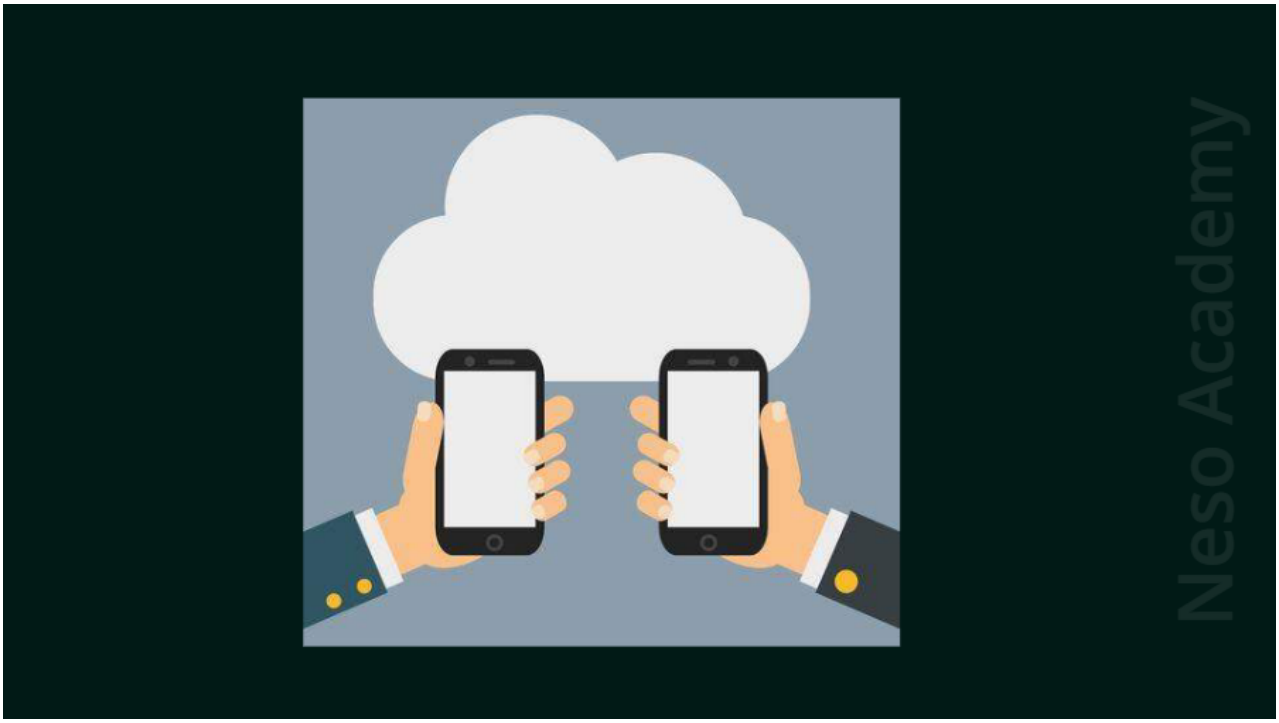
Outcomes★★★★★Neso Academy



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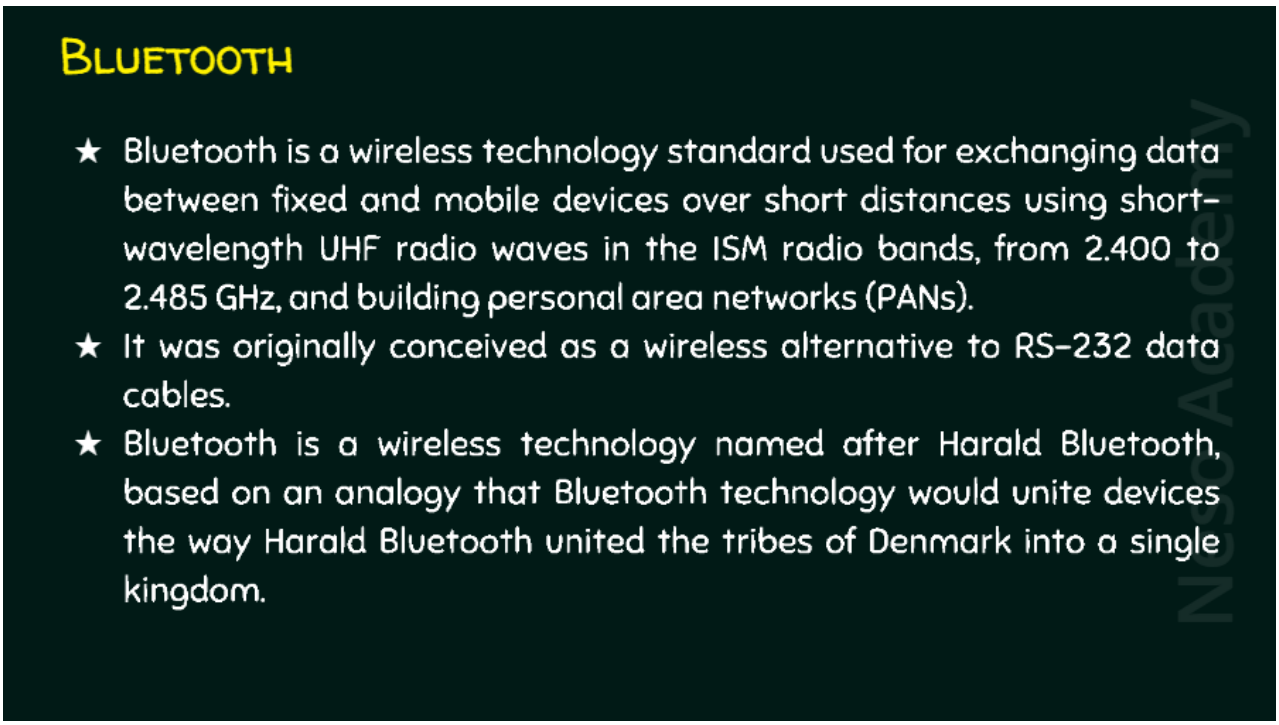
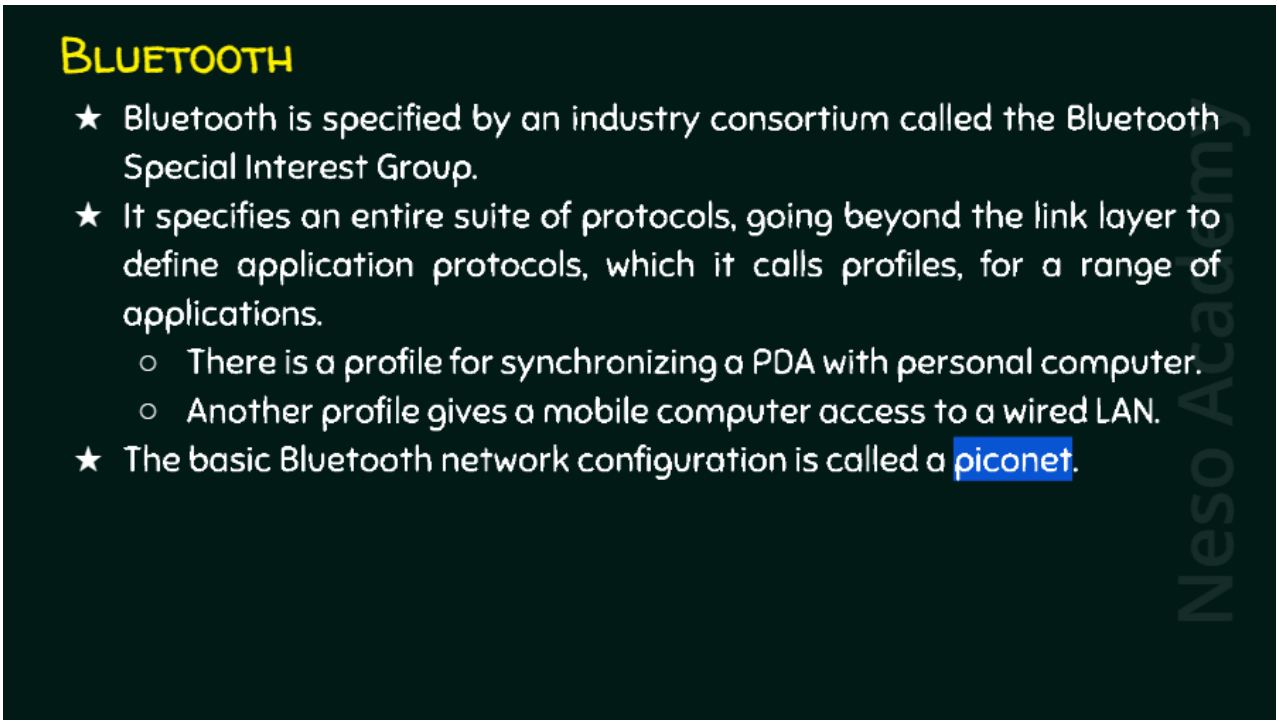
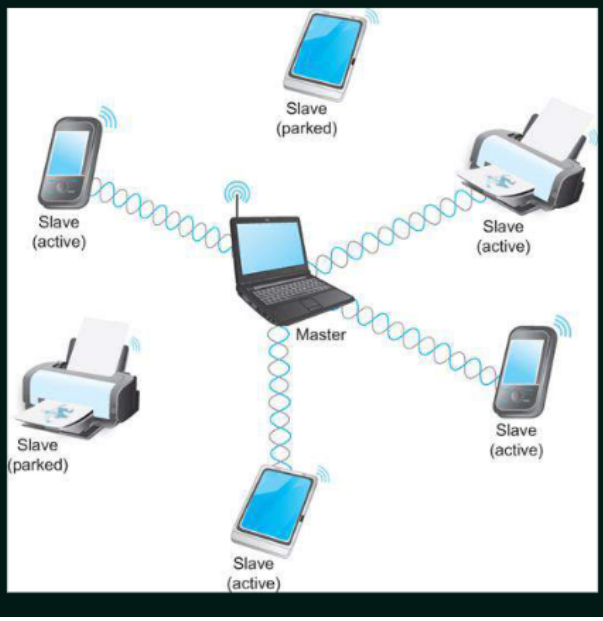


Bluetooth★★★Neso Academy



Bluetooth★★○○★Neso Academy

An example bluetooth piconet



An example bluetooth piconetNeso Academy

Bluetooth

- ★ Bluetooth is specified by an industry consortium called the Bluetooth Special Interest Group.
- ★ It specifies an entire suite of protocols, going beyond the link layer to define application protocols, which it calls profiles, for a range of applications.
  - There is a profile for synchronizing a PDA with personal computer.
  - Another profile gives a mobile computer access to a wired LAN.
- ★ The basic Bluetooth network configuration is called a piconet.
  - Consists of a master device and up to seven slave devices.
  - Any communication is between the master and a slave.
  - The slaves do not communicate directly with each other.

Bluetooth★★○○★○○○Neso Academy

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  - ○ Consists of a master device and up to seven slave devices.
  - ○ Any communication is between the master and a slave.
  - ○ The slaves do not communicate directly with each other.
  - ○ A slave can be parked: set to an inactive, low-power state.

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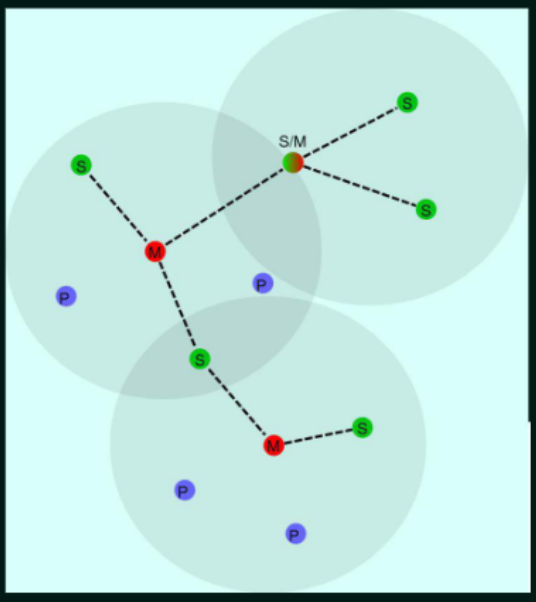
Bluetooth★★○○★○○○○Neso Academy

Piconet and Scatternet



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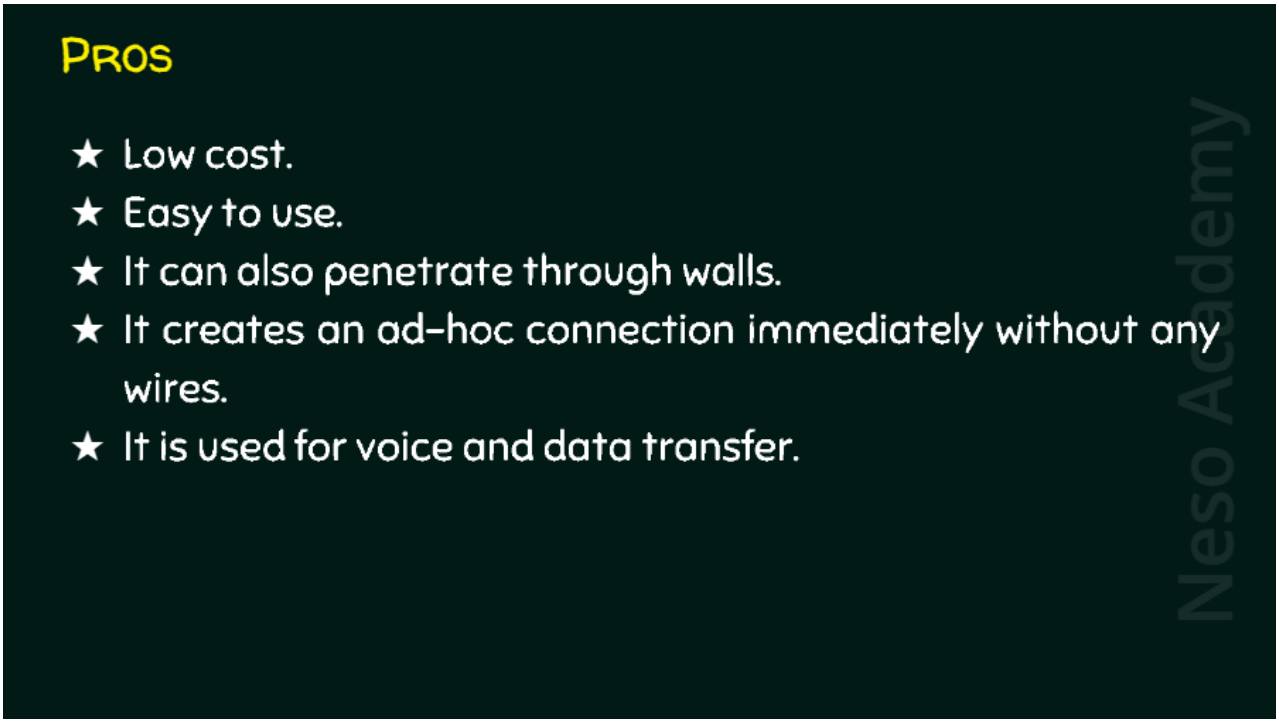
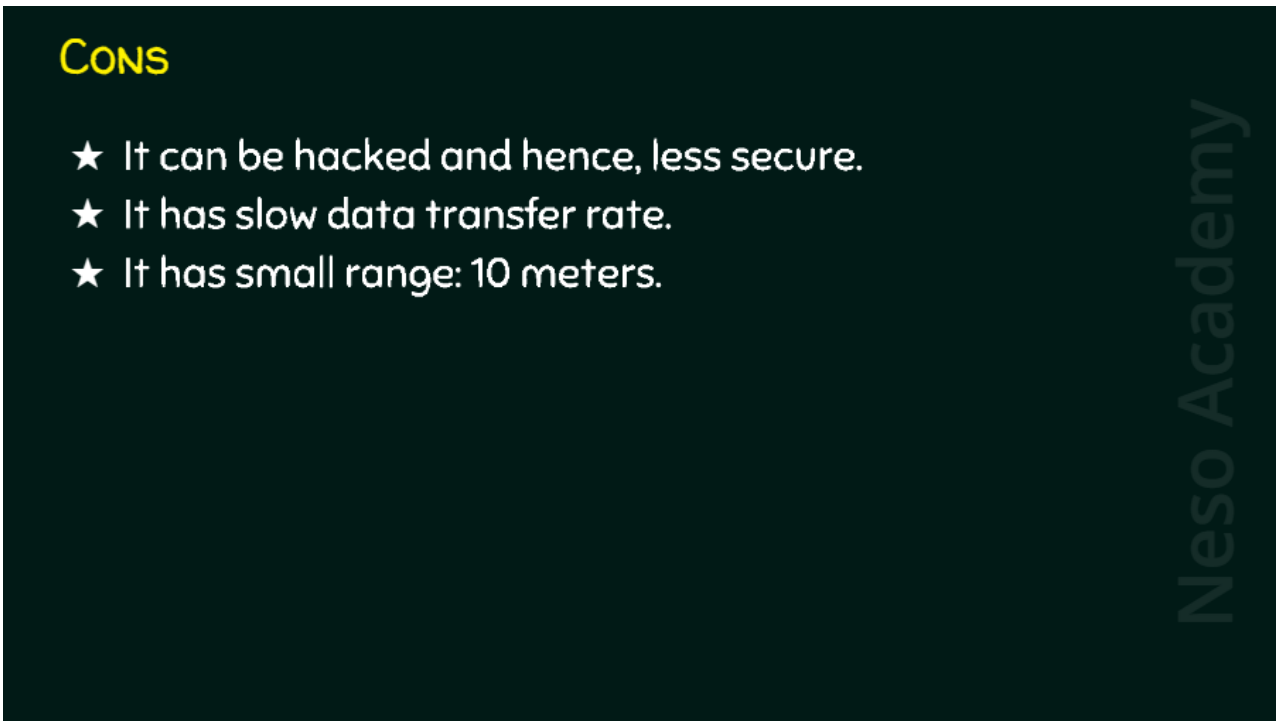
Piconet and ScatternetNeso Academy

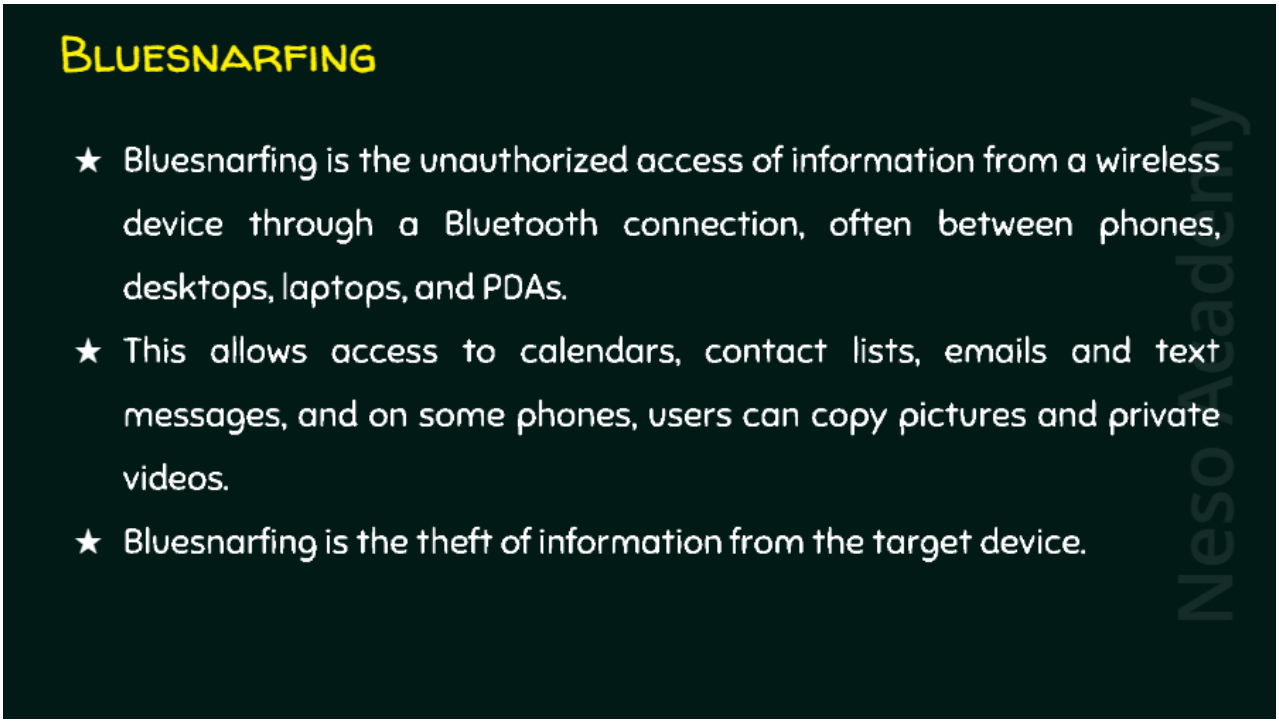
Bluetooth DevicesNeso Academy



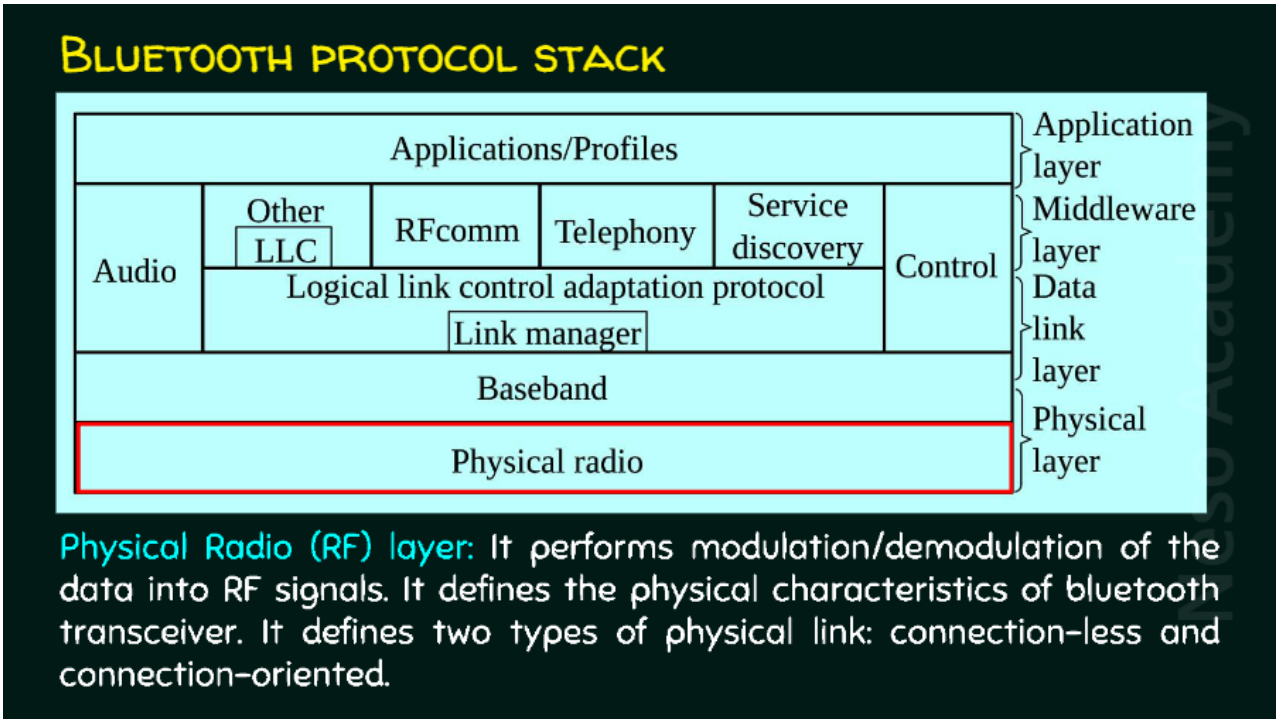
Pros★★★★★Neso Academy



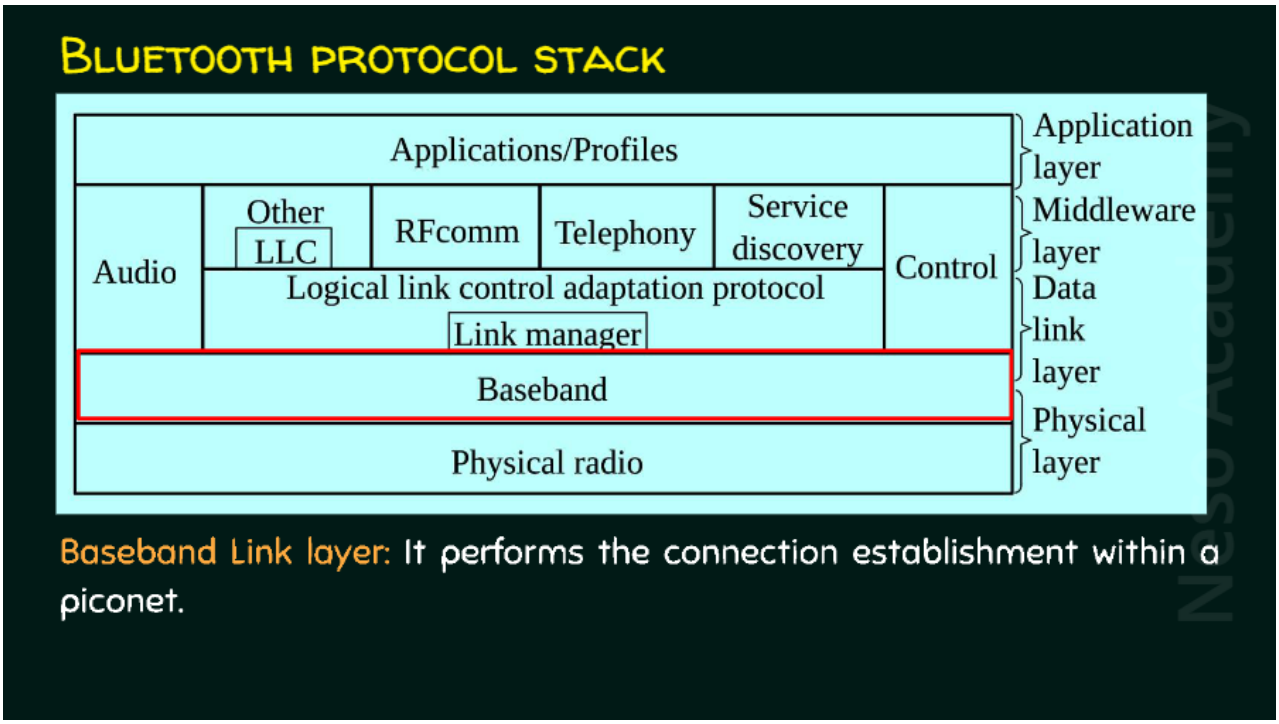
Cons★★★Neso Academy



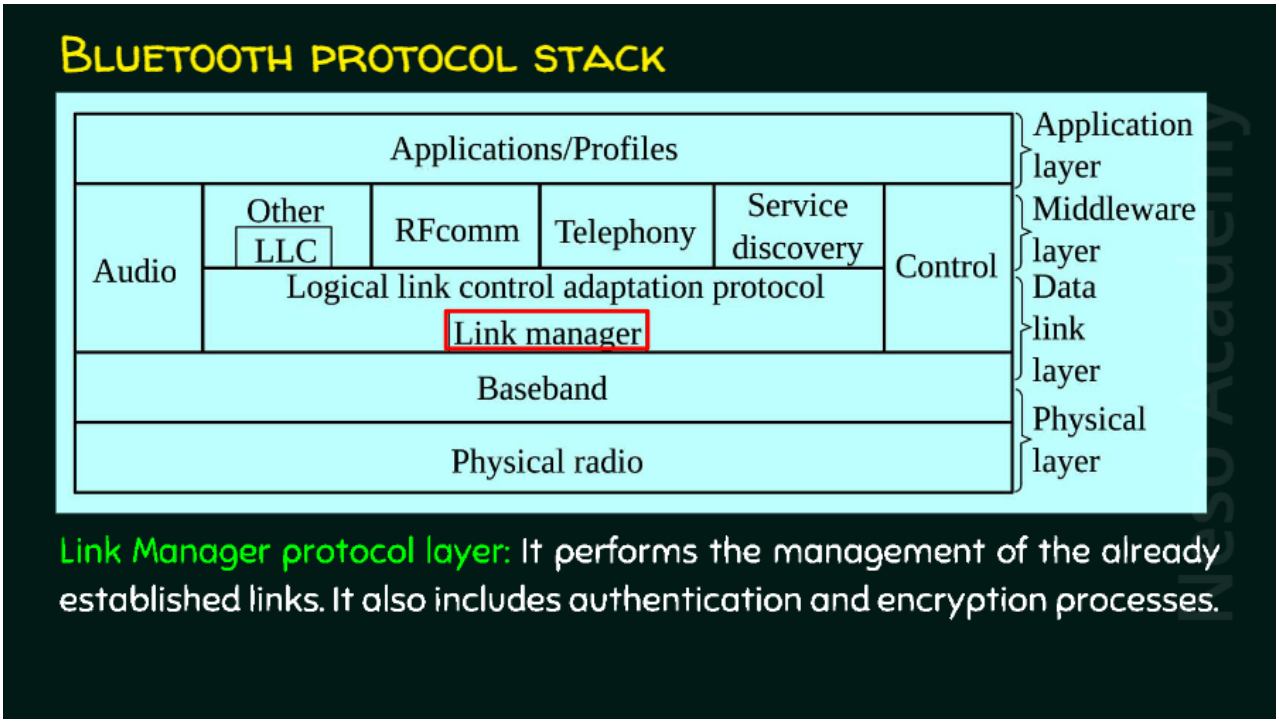
Bluesnarfing★★★Neso Academy



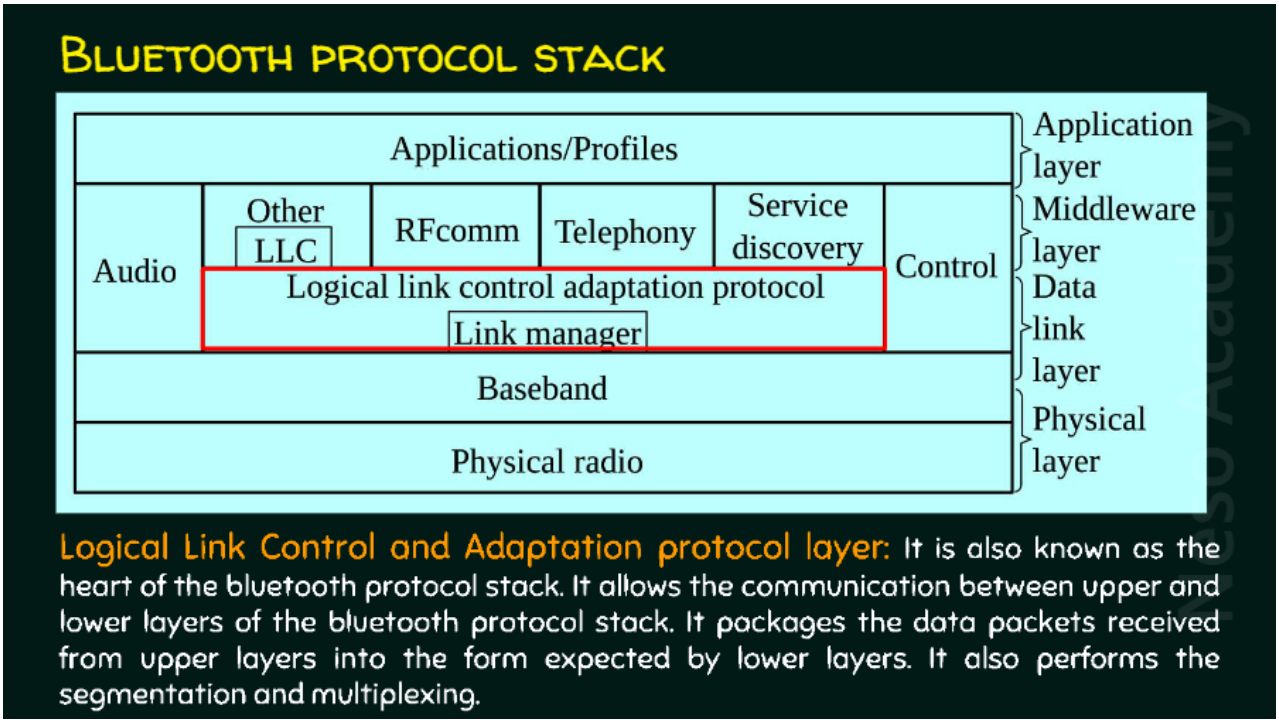
Bluetooth protocol stackNeso Academy



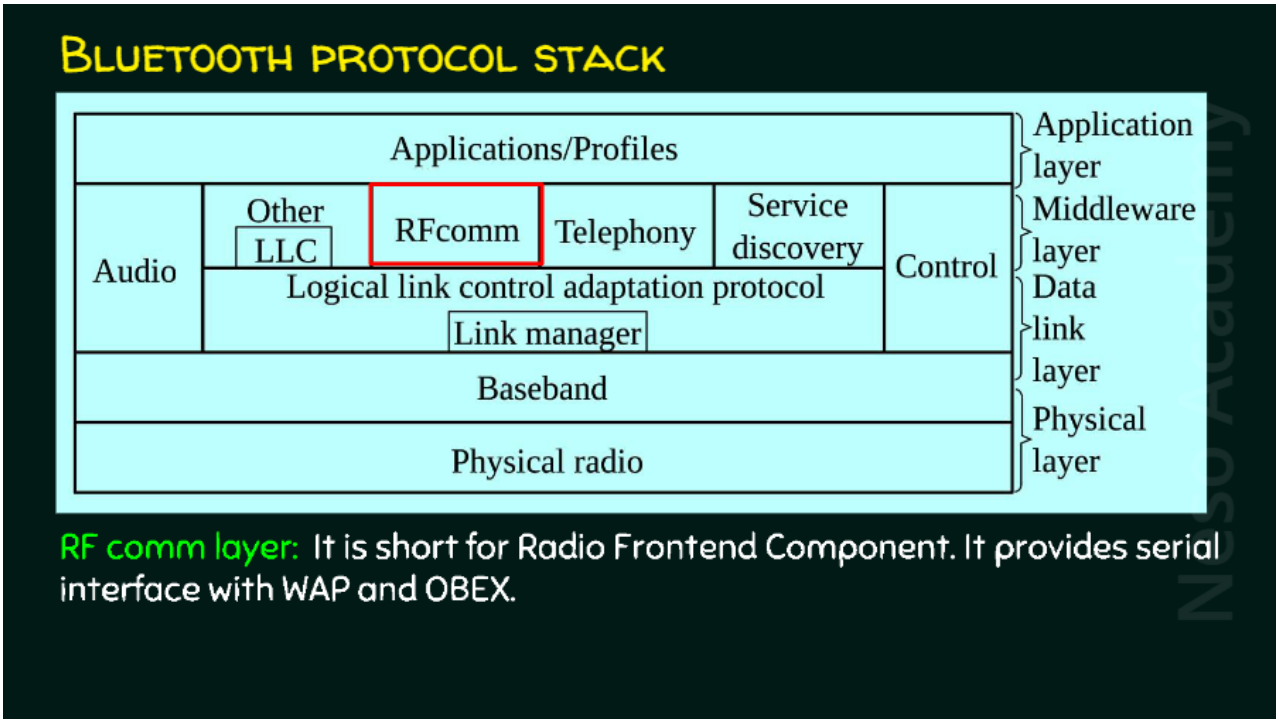
Bluetooth protocol stackNeso Academy



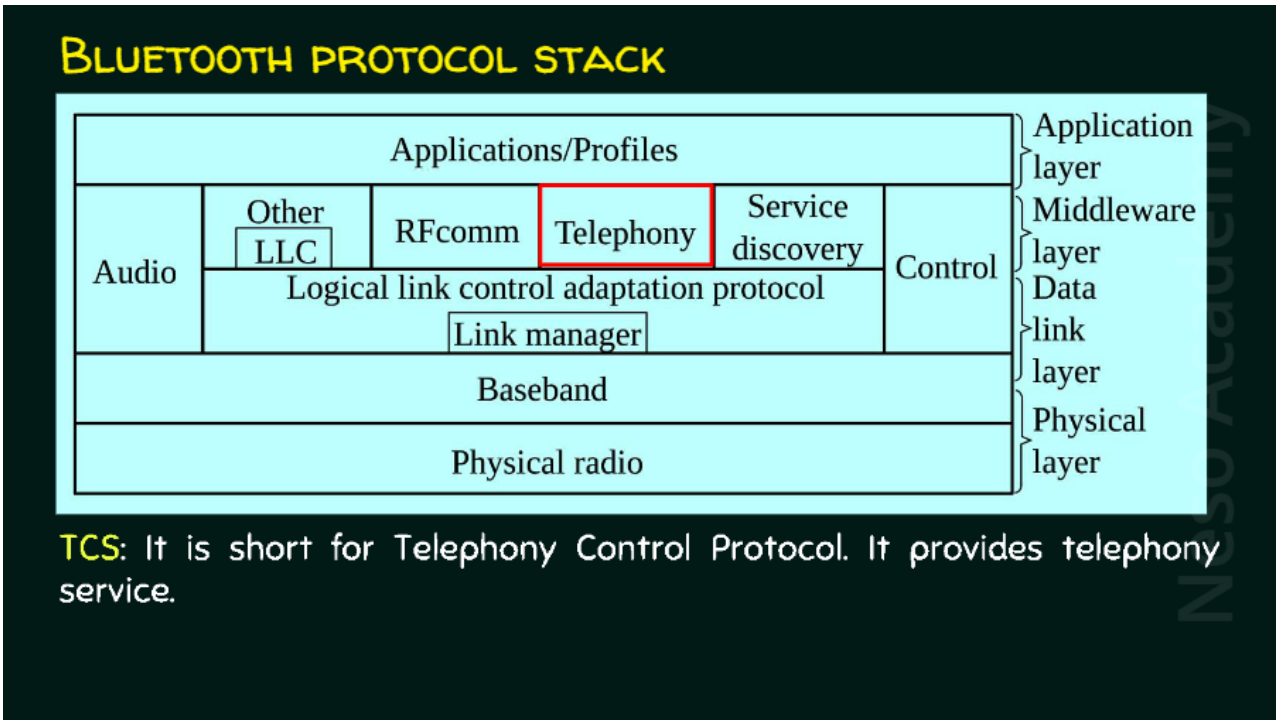
Bluetooth protocol stackNeso Academy



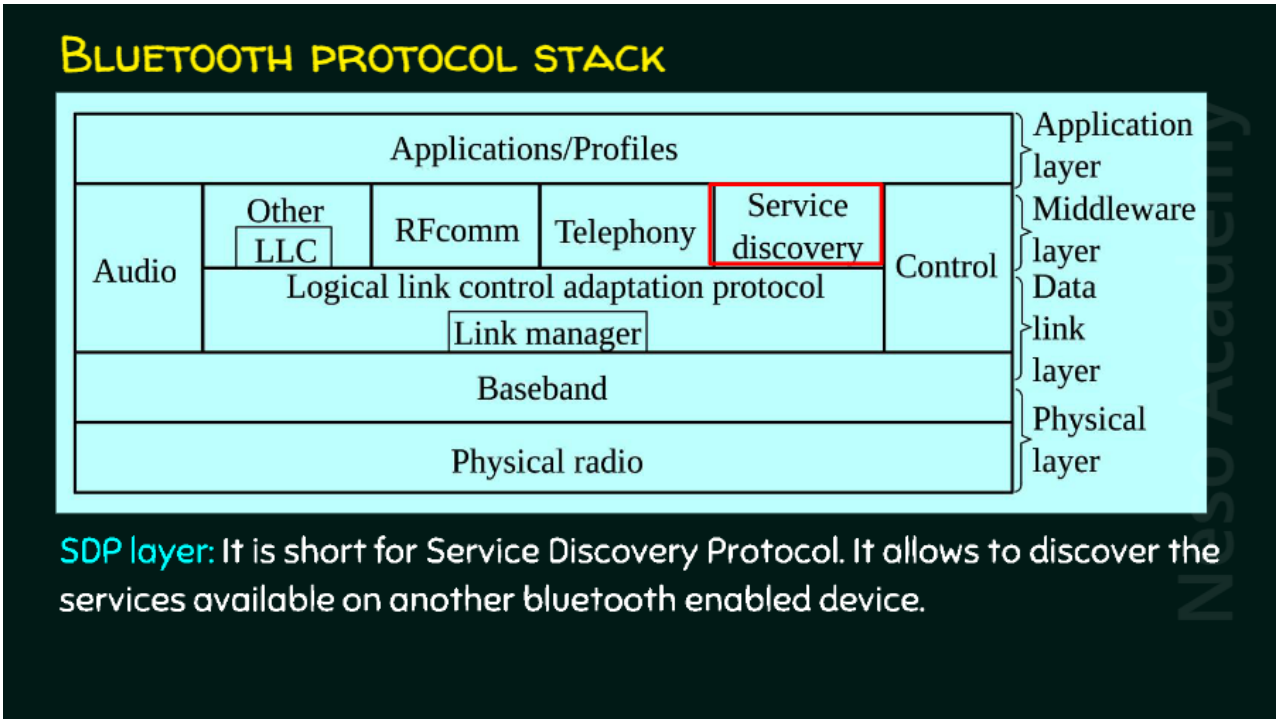
Bluetooth protocol stackNeso Academy



Bluetooth protocol stackNeso Academy



Bluetooth protocol stackNeso Academy



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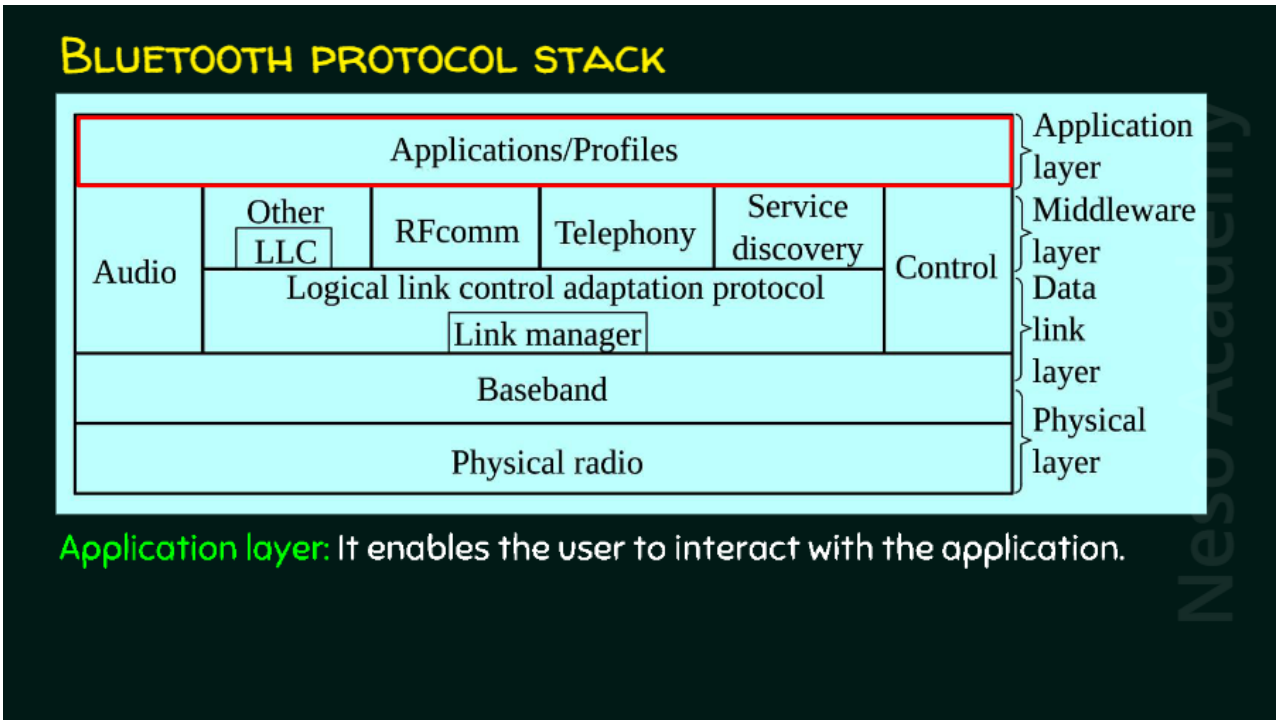
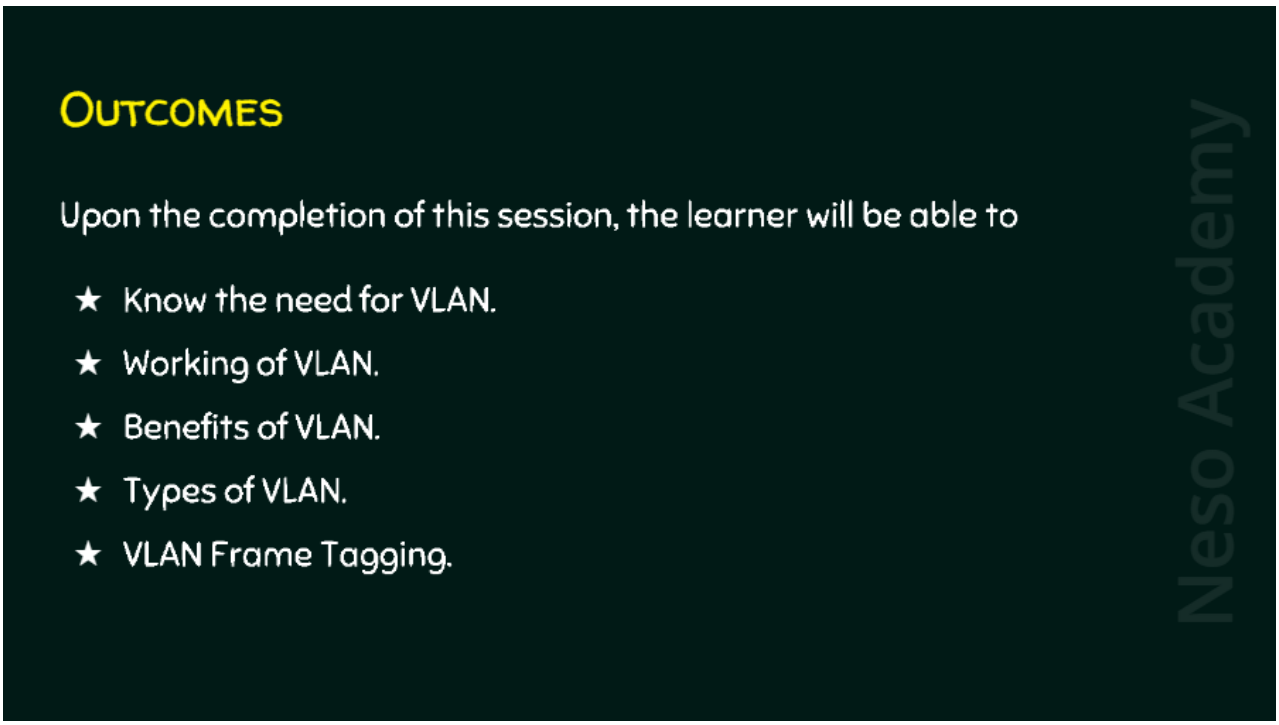
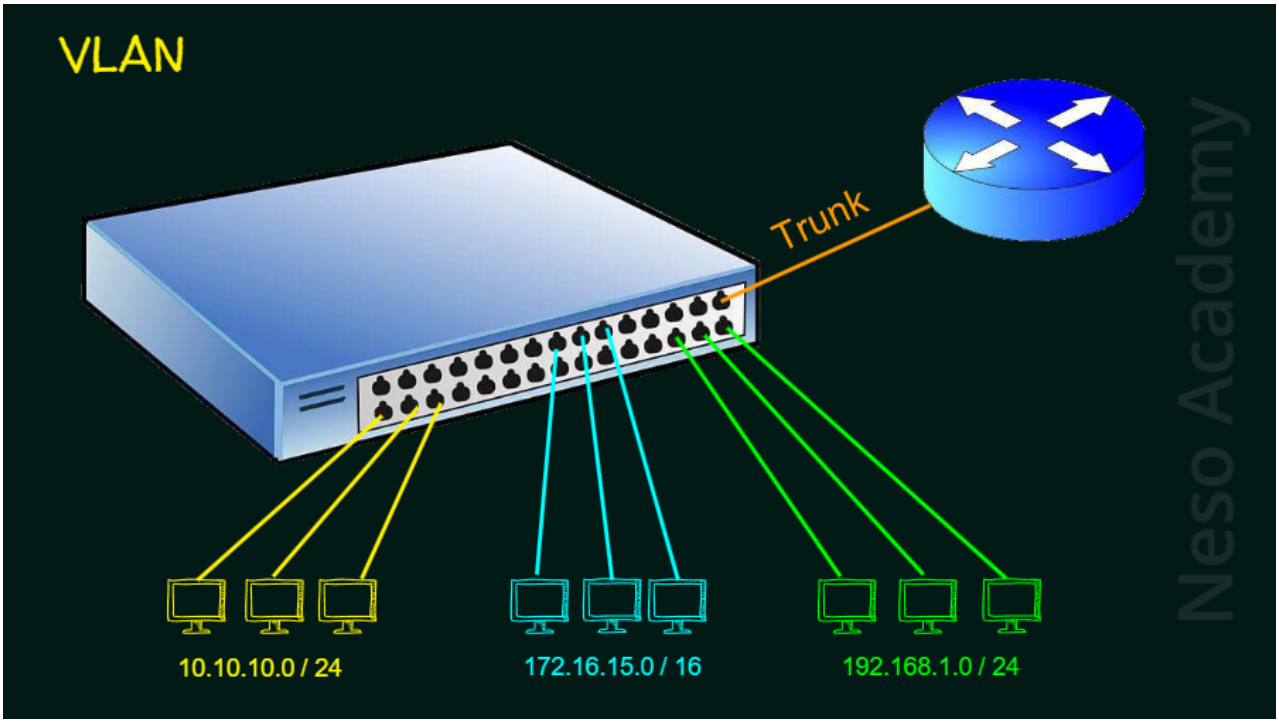


Bluetooth protocol stackNeso Academy



Outcomes★★★★★Neso Academy



10.10.10.0 / 24192.168.1.0 / 24172.16.15.0 / 16VLANNeso Academy

VLAN

- ★ A VLAN is a logical partition of a Layer 2 network.
- ★ Multiple partitions can be created, allowing for multiple VLANs to co-exist.
- ★ Each VLAN is a broadcast domain, usually with its own IP network.
- ★ VLANs are mutually isolated and packets can only pass between them via a router.
- ★ The partitioning of the Layer 2 network takes place inside a Layer 2 device, usually via a switch.
- ★ The hosts grouped within a VLAN are unaware of the VLAN's existence.

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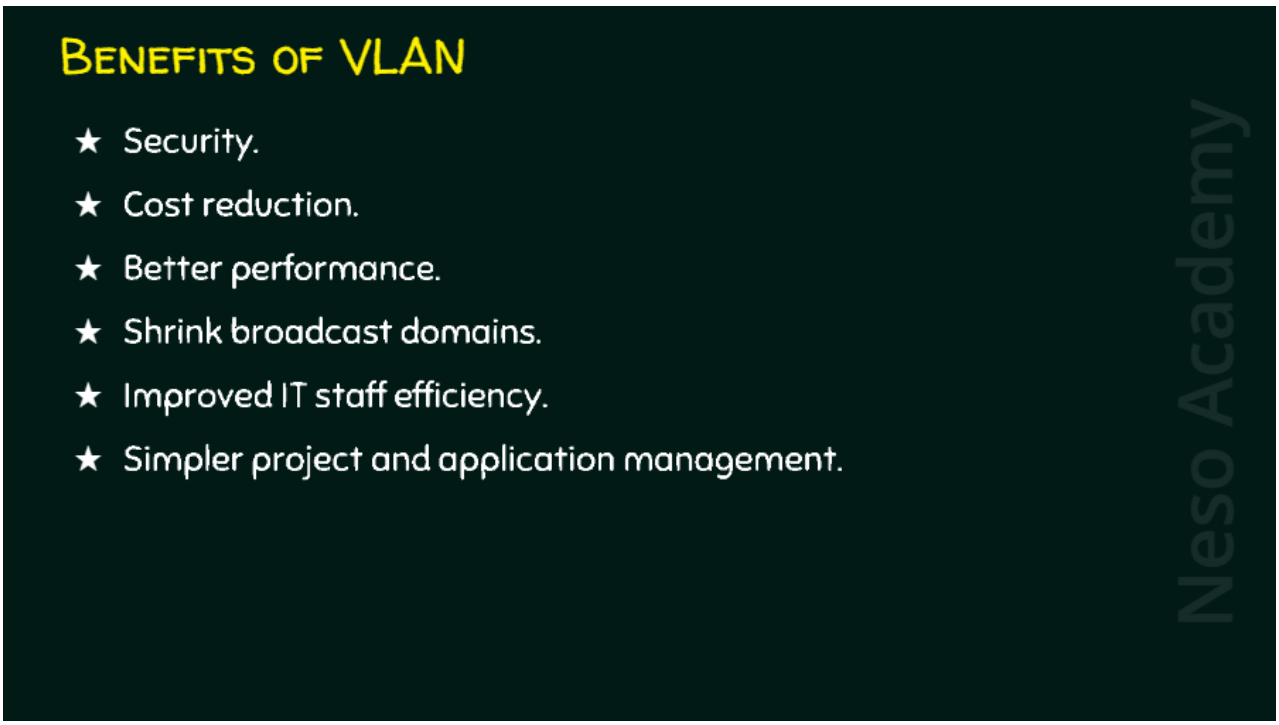
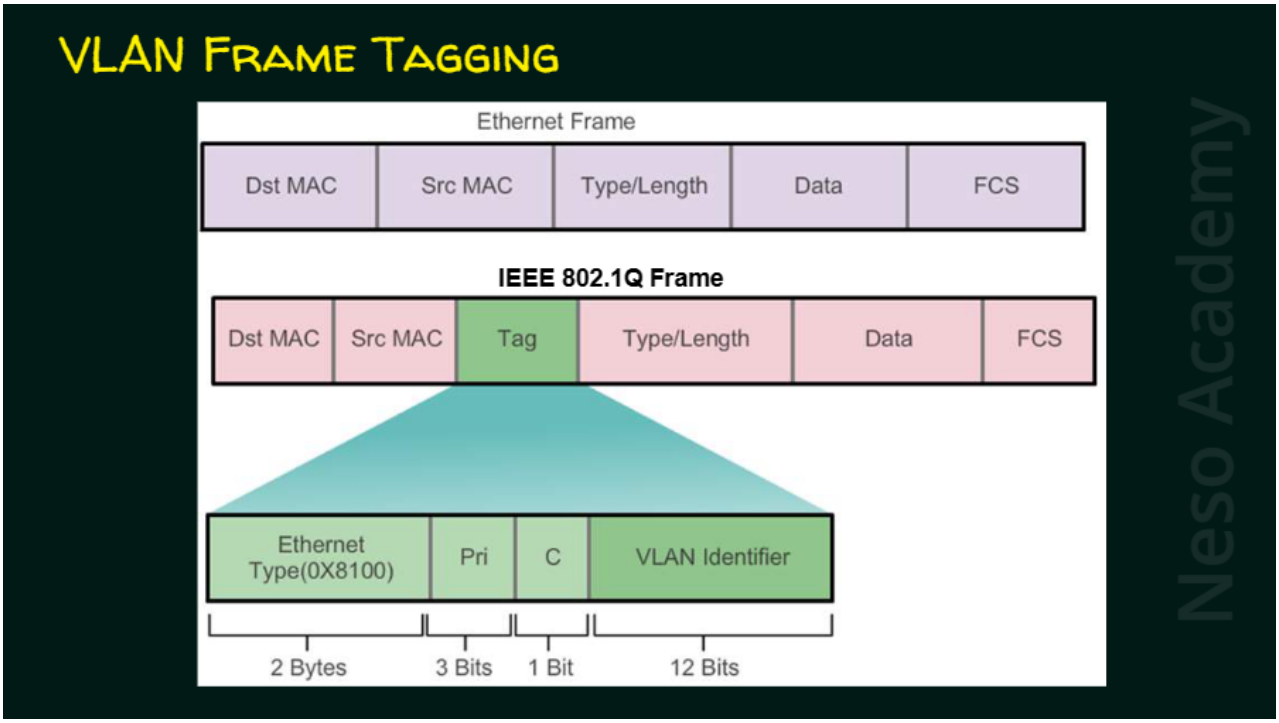
VLAN★★★★★★Neso Academy

VLANNeso Academy

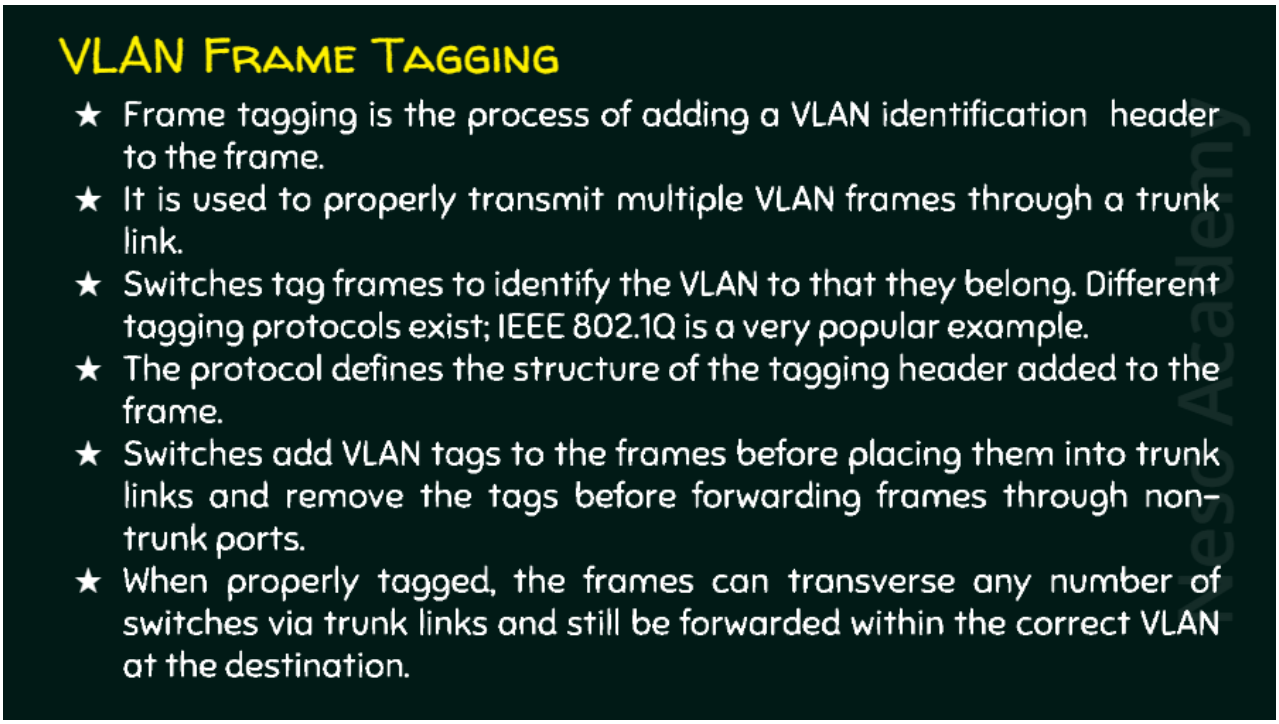


Benefits of VLAN★★★★★★Neso Academy

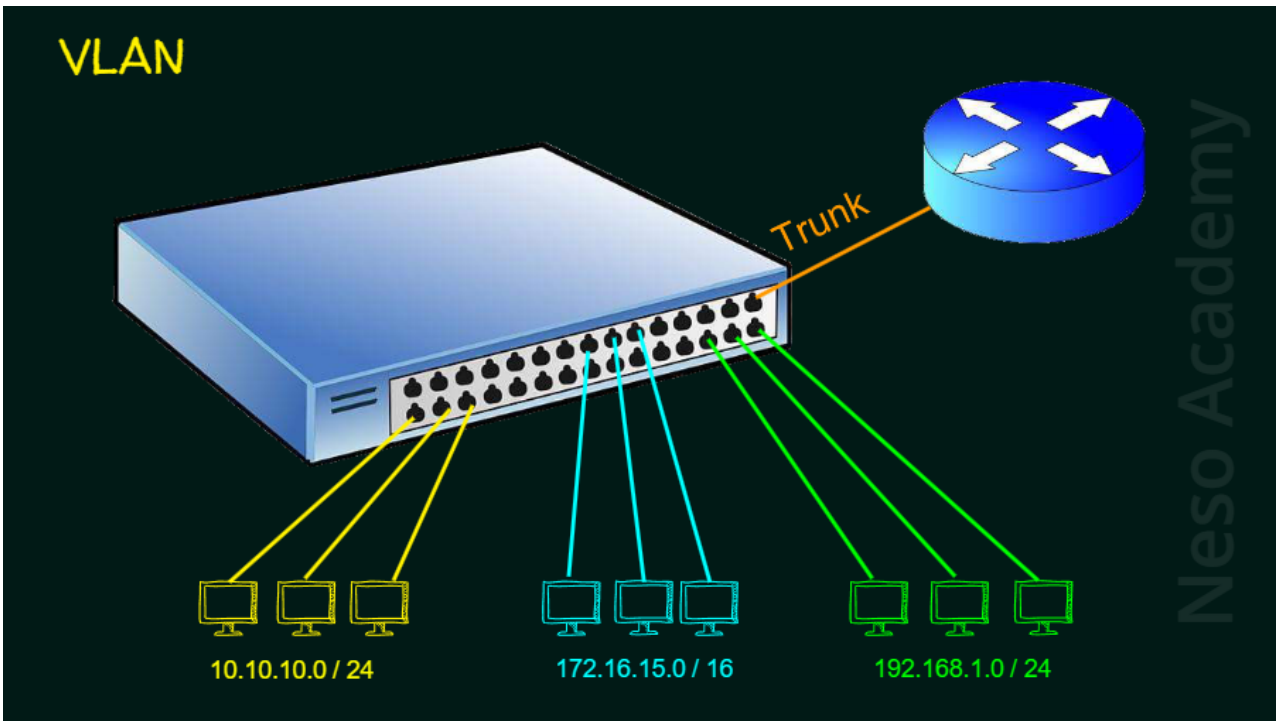
Types of VLAN★★★★★Neso Academy



VLAN Frame TaggingIEEE 802.1Q FrameNeso Academy



★★★★★★VLAN Frame TaggingNeso Academy



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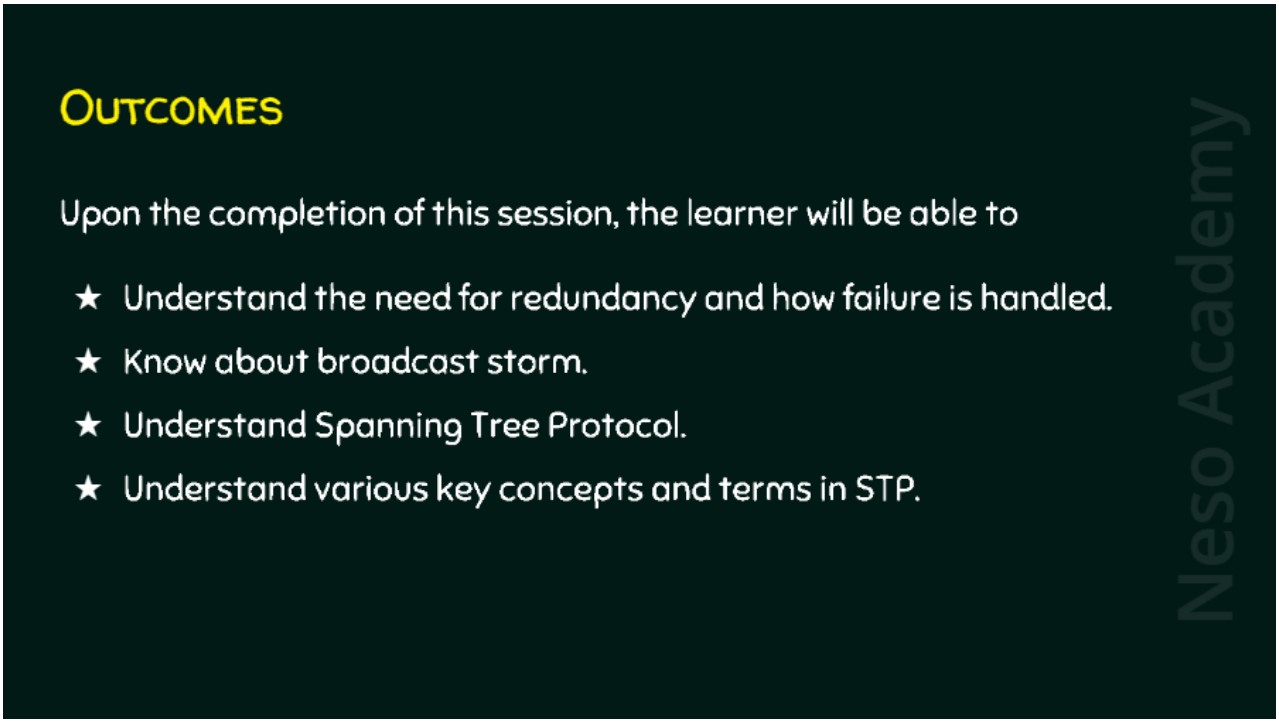
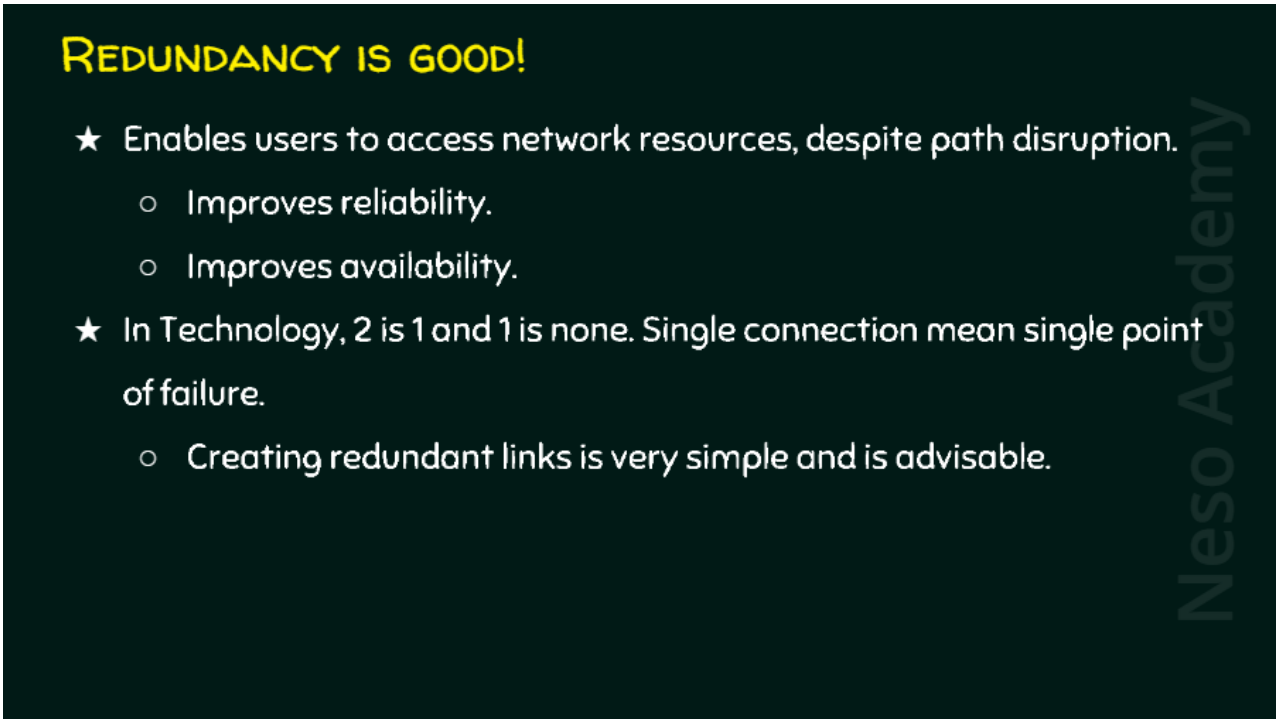
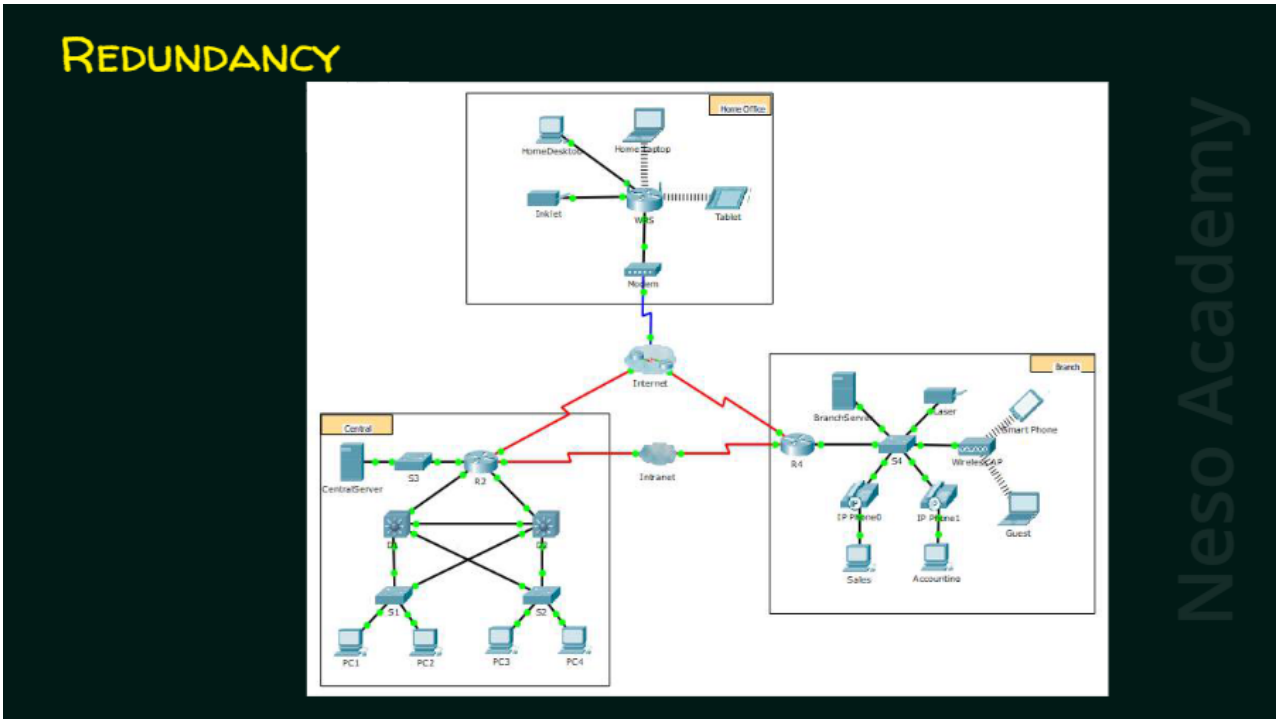


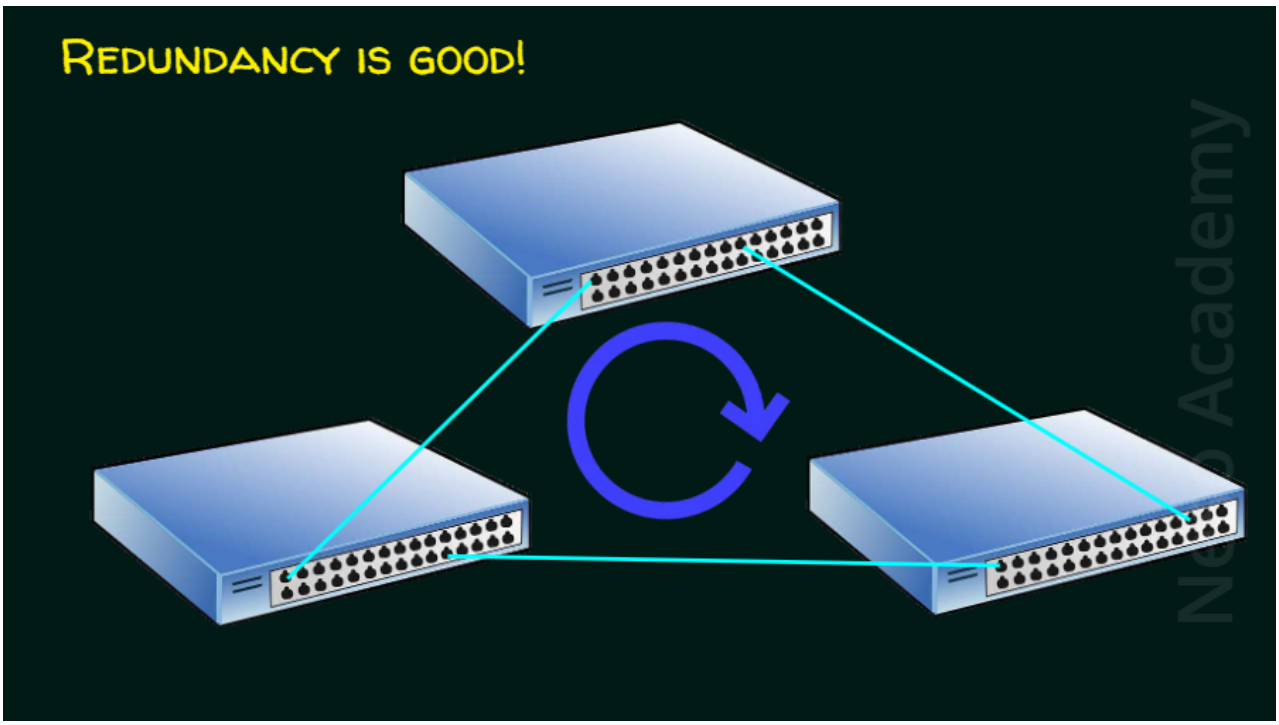
Outcomes★★★★Neso Academy



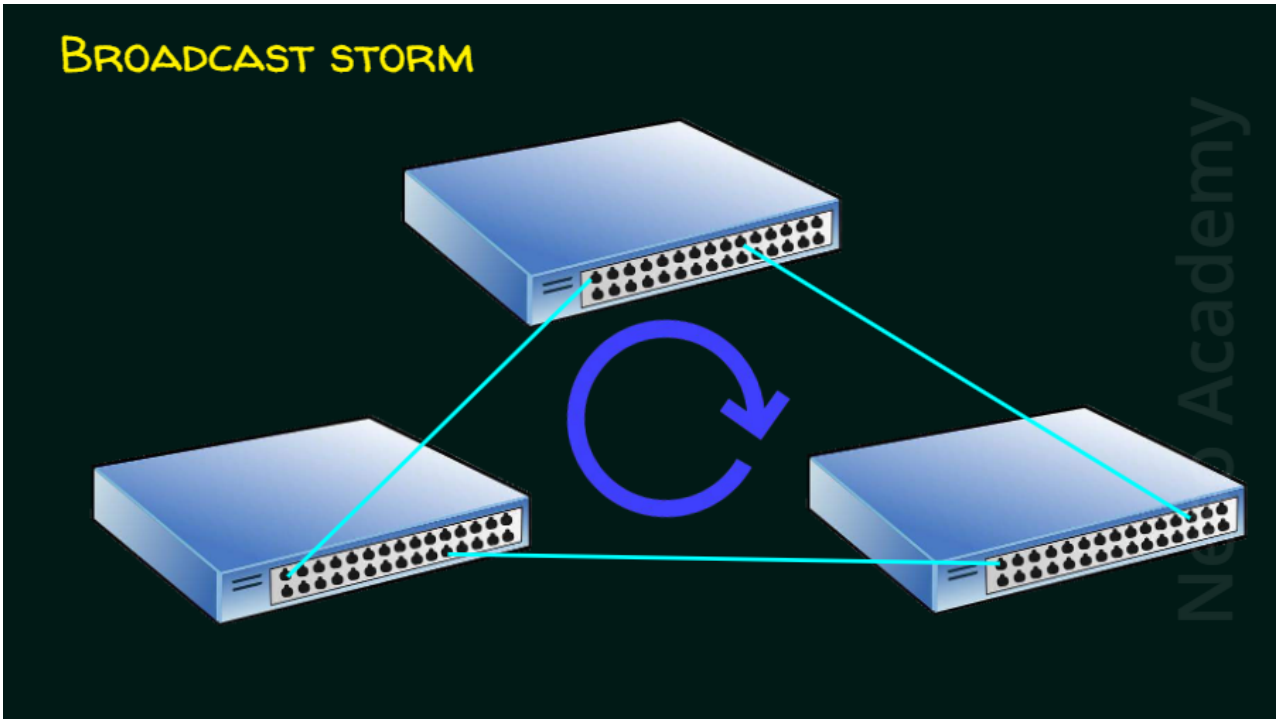
Redundancy is good!★○○★○Neso Academy



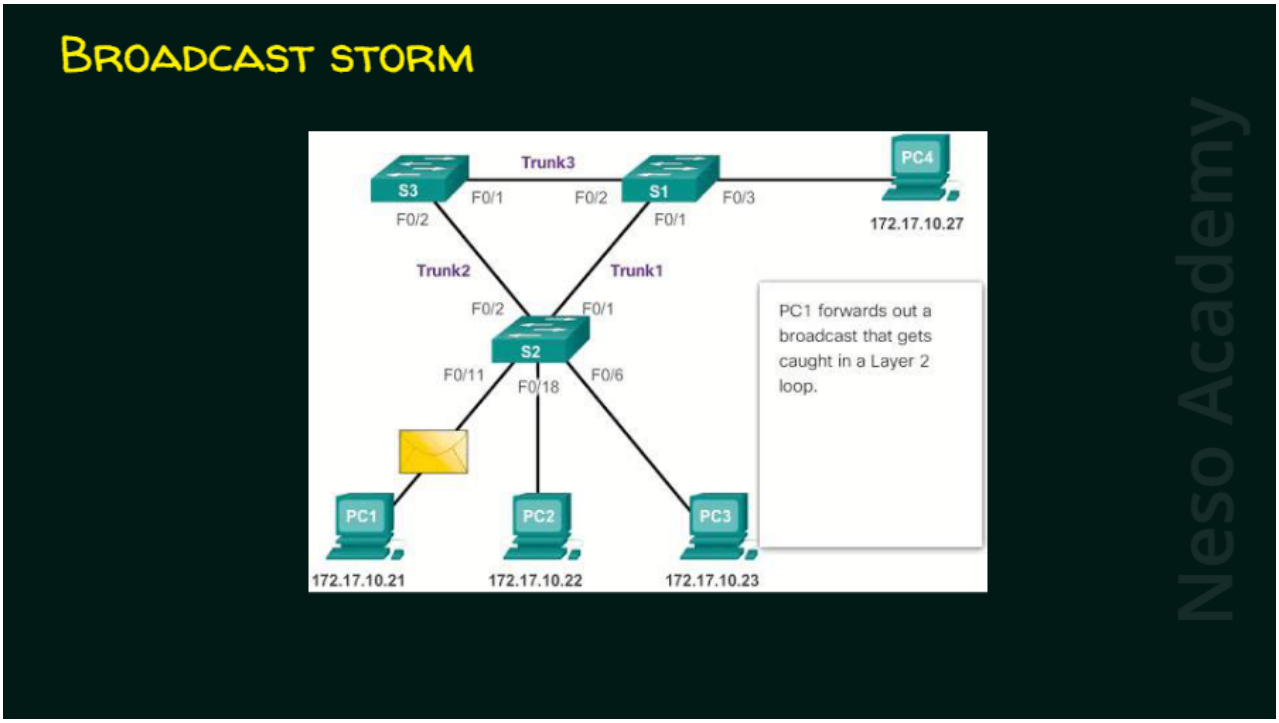
RedundancyNeso Academy



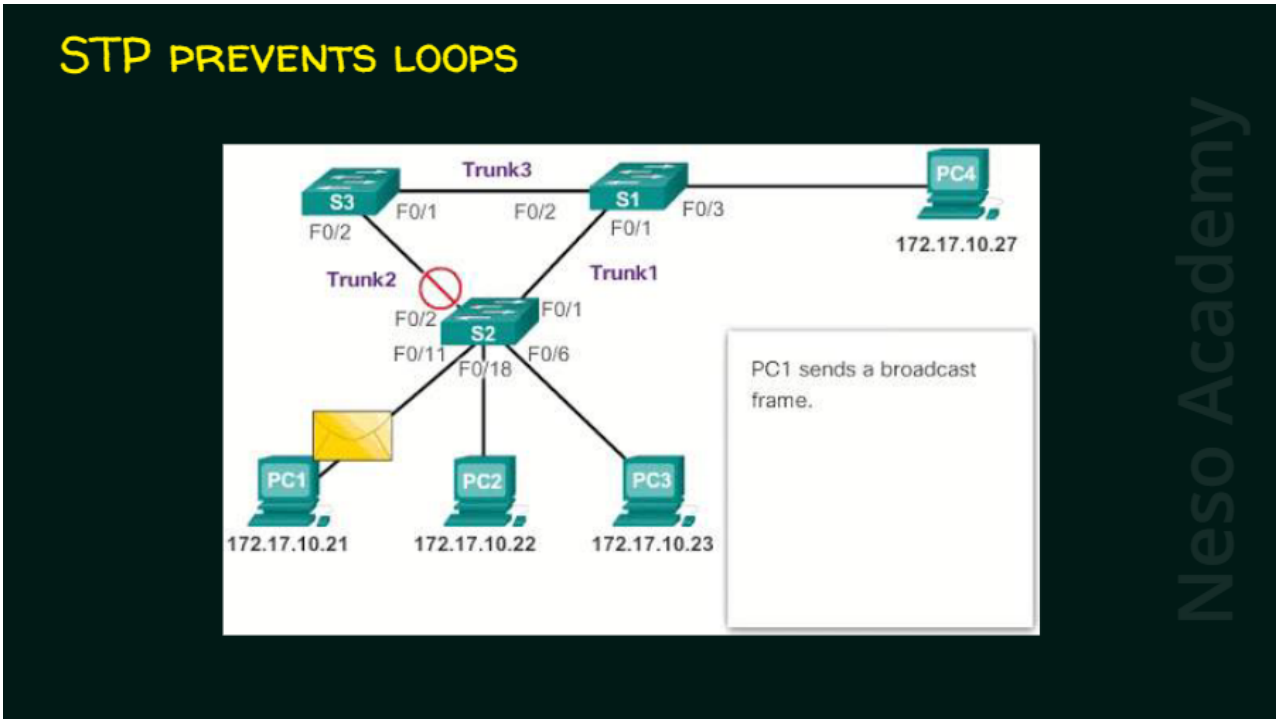
Redundancy is good!Neso Academy



Broadcast stormNeso Academy



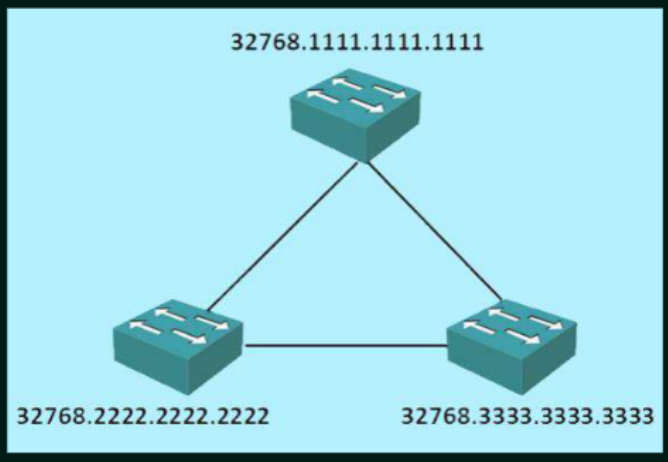
Broadcast stormNeso Academy



STP prevents loopsNeso Academy

Key facts – STP

- ★ Original STP (802.1D) was created to prevent loops.
- ★ Switches send probes into the network to discover loops.



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Key facts -STP★★Neso Academy

Key facts – STP

- ★ Original STP (802.1D) was created to prevent loops.
- ★ Switches send probes into the network to discover loops.
- ★ These probes are called as BPDU.
- ★ BPDU = Bridge Protocol Data Unit.
- ★ BPDU will have specific information about the switch.
- ★ Switch multicasts BPDU probes (every 2 seconds) and if it receives its own BPDU back, it means there is a loop in the network.
- ★ Also the BPDU probes helps to elect the root bridge.
- ★ All switches will find the best way to reach the root bridge and the redundant links will be blocked. (Port cost)
- ★ This redundant links will be active only if the existing links or ports goes down.

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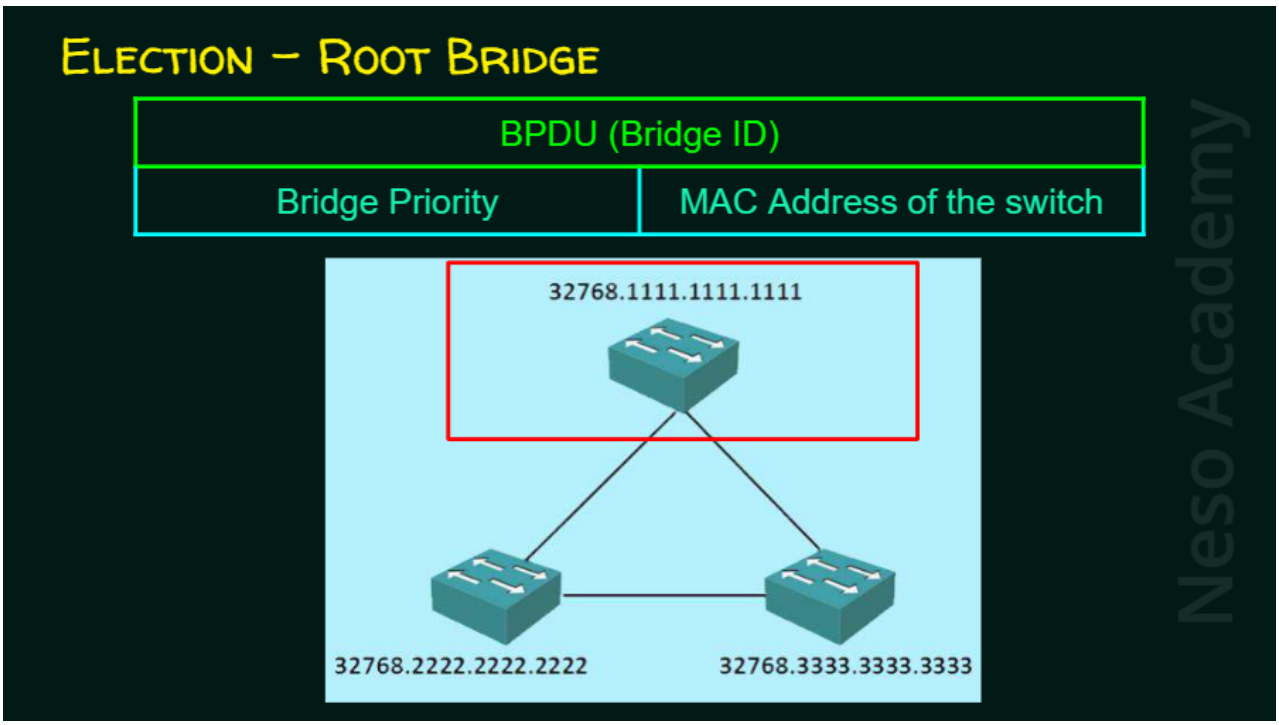
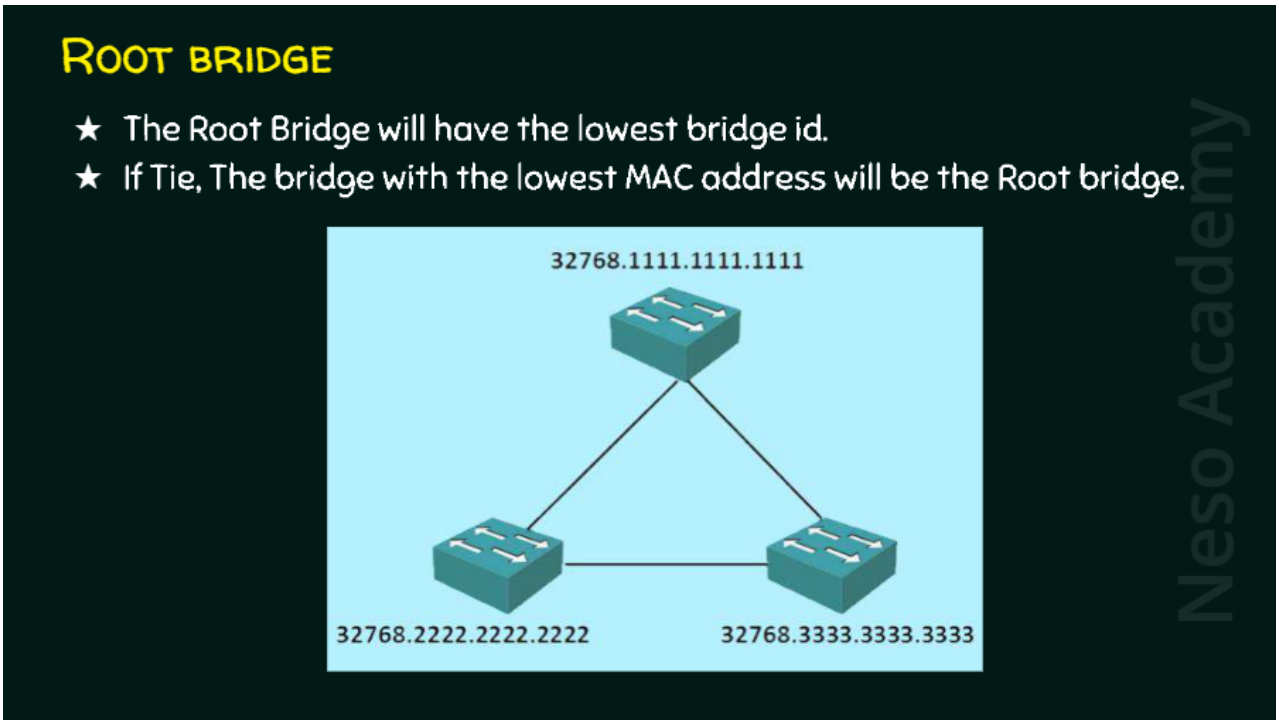
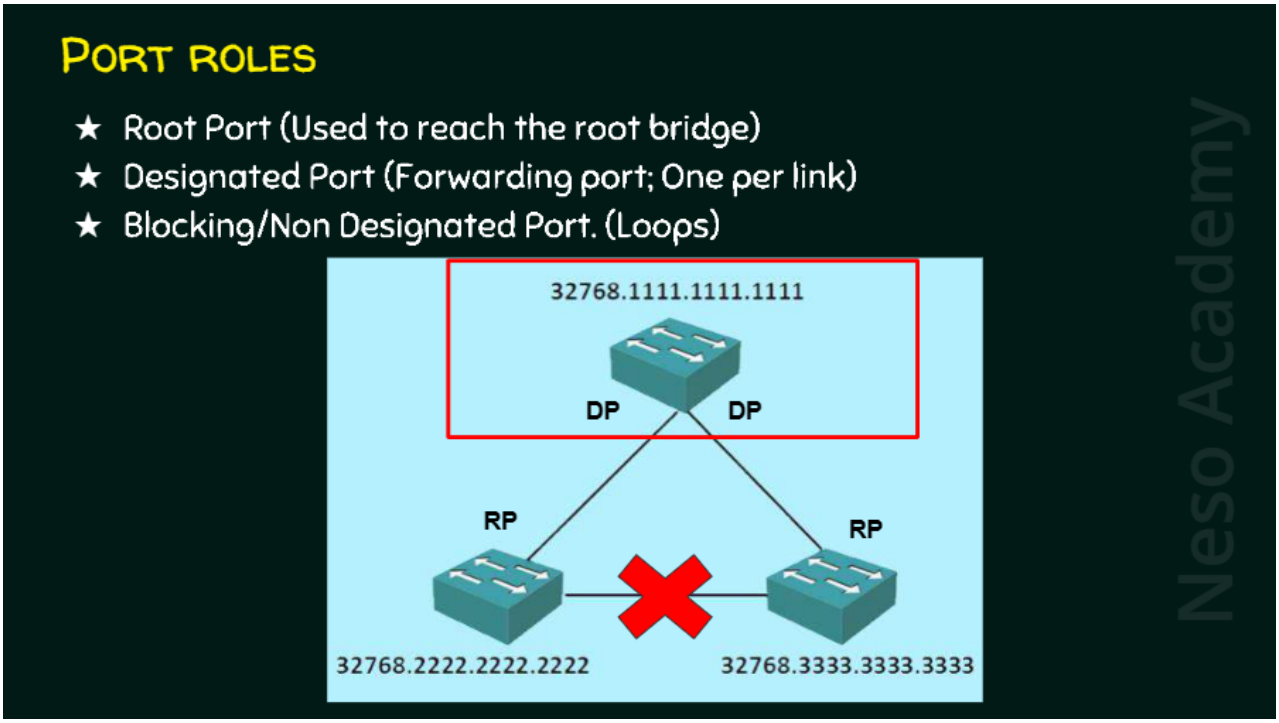
Key facts -STP★★★★★★★★★Neso Academy



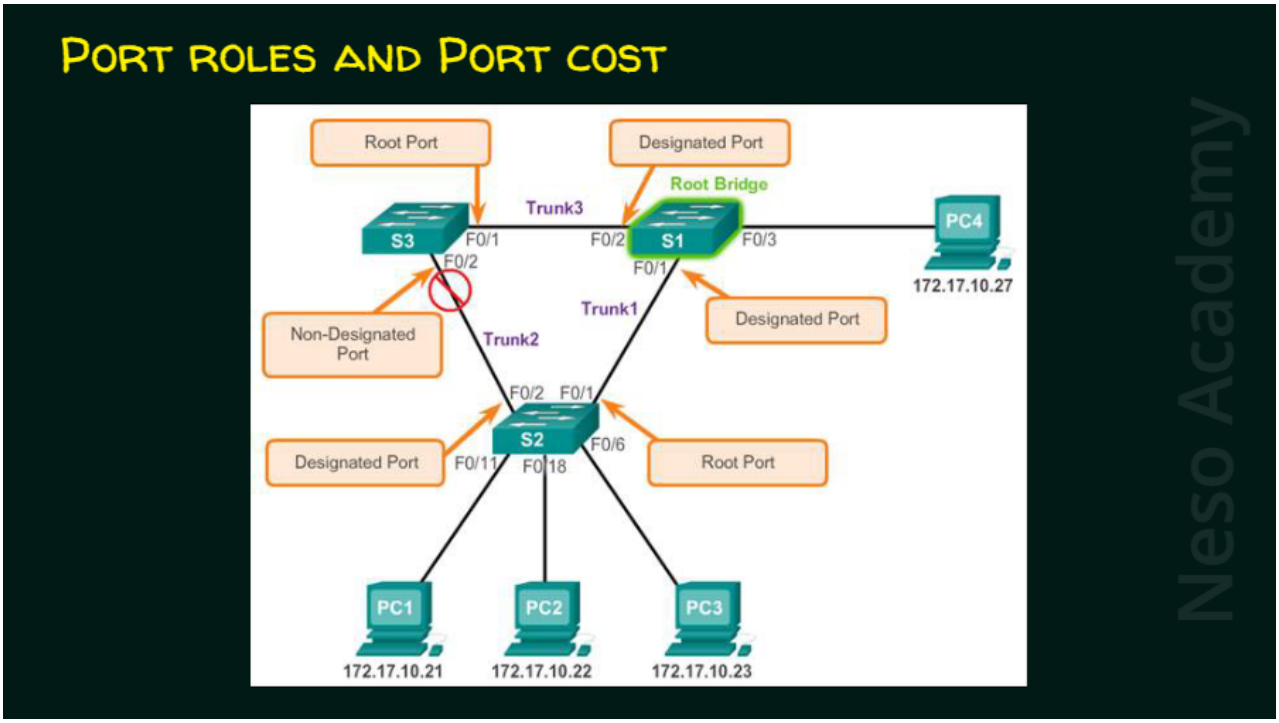
Election -Root BridgeBPDU (Bridge ID)Bridge PriorityMAC Address of the switchNeso Academy



Root bridge★★Neso Academy



Port roles★★★RPDPRPDPNeso Academy



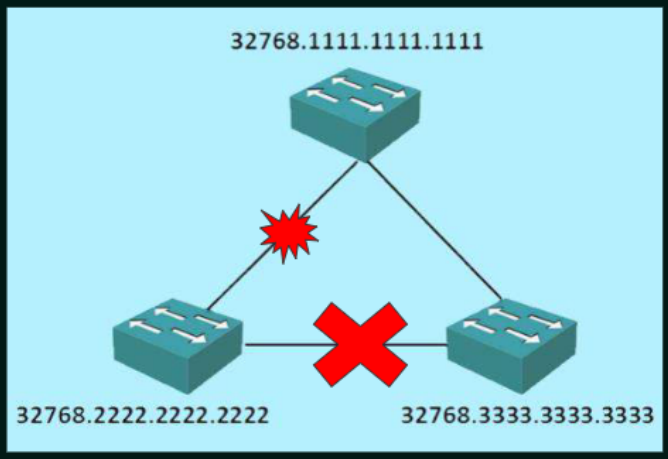
Port roles and Port costNeso Academy

Spanning Tree Protocol

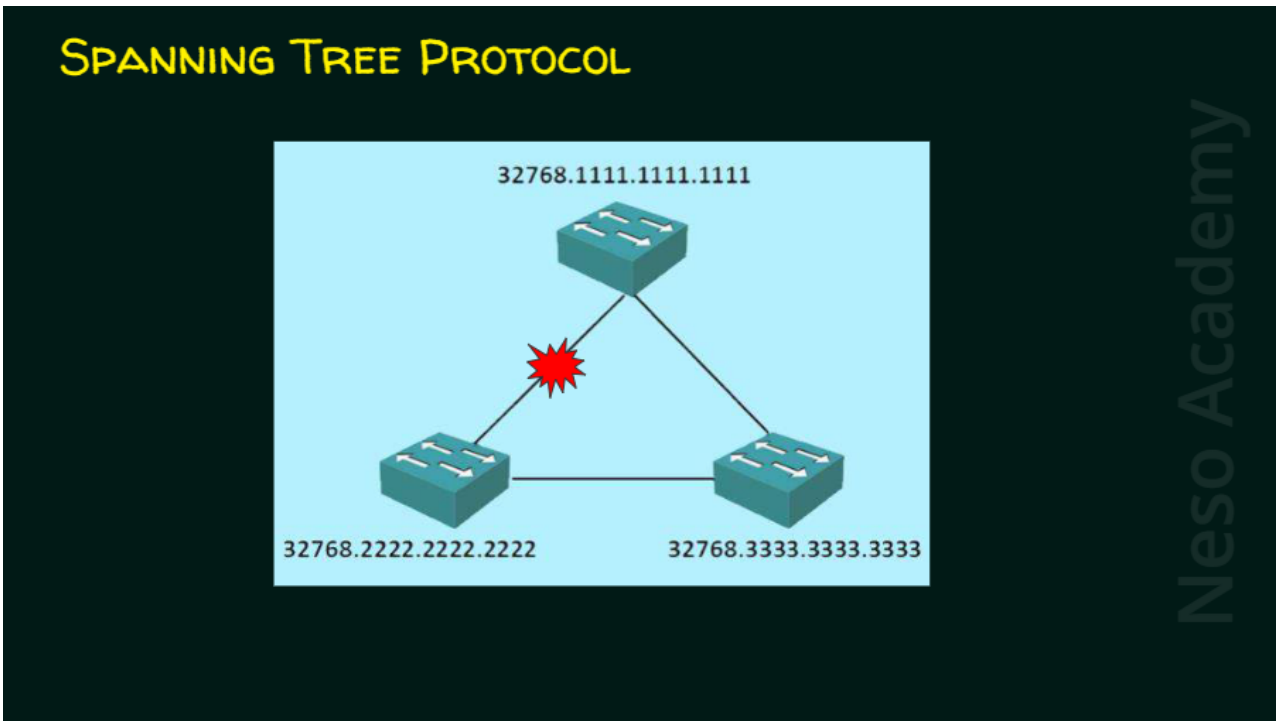
- ★ STP ensures that there is only one logical path between all destinations on the network by intentionally blocking redundant paths that could cause a loop.
- ★ A port is considered blocked when user data is prevented from entering or leaving that port. This does not include bridge protocol data unit (BPDU) frames that are used by STP to prevent loops.
- ★ The physical paths still exist to provide redundancy, but these paths are disabled to prevent the loops from occurring.
- ★ If the path is ever needed to compensate for a network cable or switch failure, STP recalculates the paths and unblocks the necessary ports to allow the redundant path to become active.

Spanning Tree Protocol★★★★Neso Academy

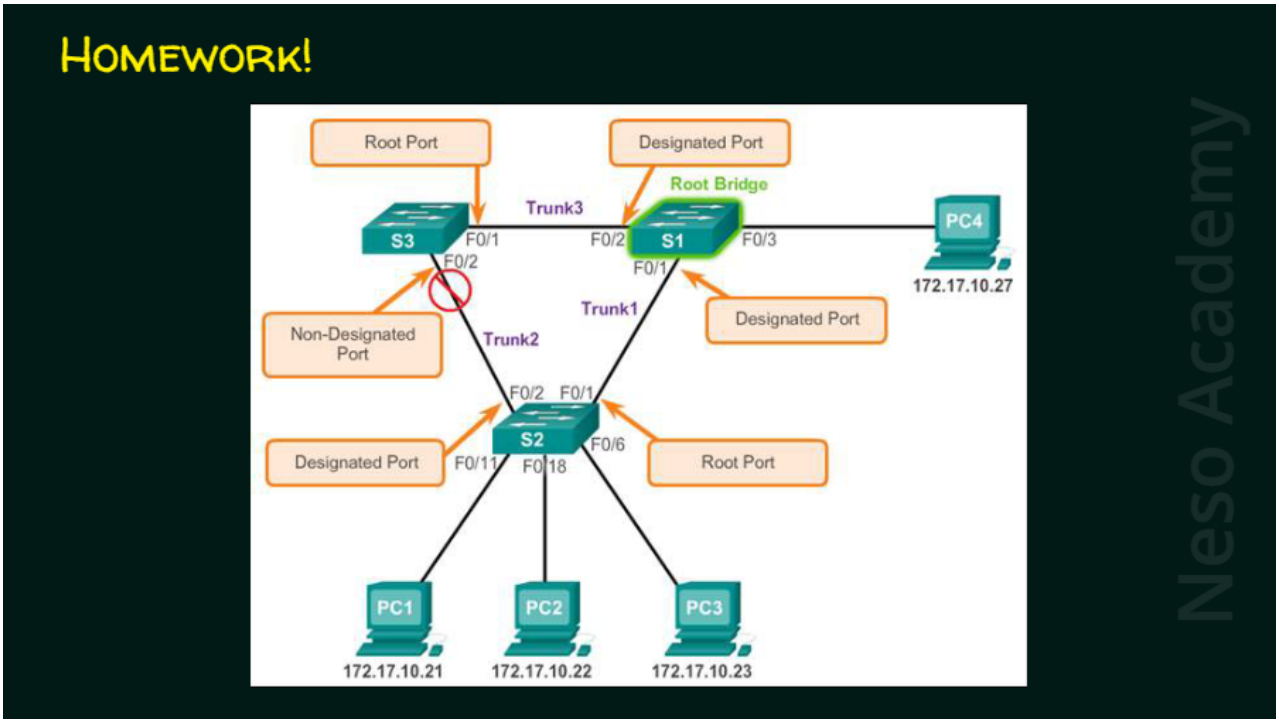
Spanning Tree Protocol



Spanning Tree ProtocolNeso Academy



Spanning Tree ProtocolNeso Academy



Homework! Neso Academy

QUESTION

Consider the diagram shown below where a number of LANs are connected by (transparent) bridges. In order to avoid packets looping through circuits in the graph, the bridges organize themselves in a spanning tree. First, the root bridge is identified as the bridge with the least serial number. Next, the root sends out (one or more) data units to enable the setting up of the spanning tree of shortest paths from the root bridge to each bridge.

Each bridge identifies a port (the root port) through which it will forward frames to the root bridge. Port conflicts are always resolved in favour of the port with the lower index value. When there is a possibility of multiple bridges forwarding to the same LAN (but not through the root port), ties are broken as follows: bridges closest to the root get preference and between such bridges, the one with the lowest serial number is preferred.

[GATE CS 2006]

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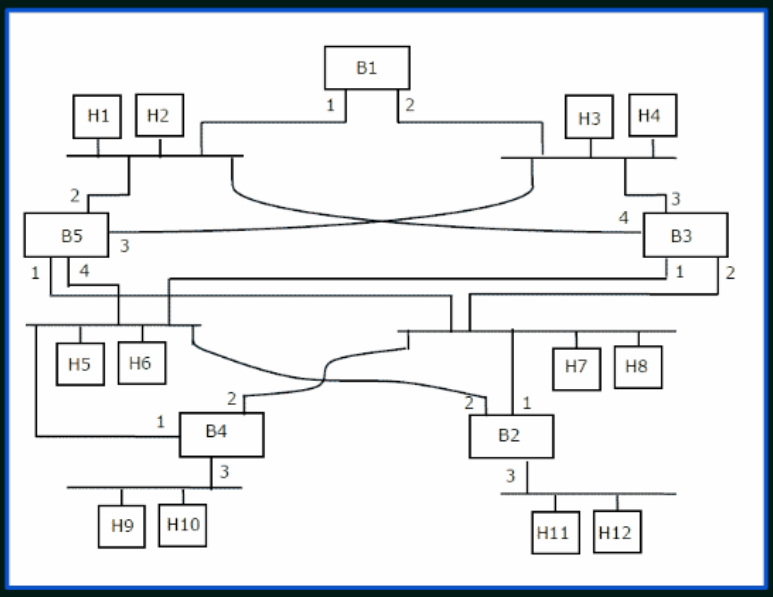
QUESTION



QuestionNeso Academy

QUESTION

For the given connection of LANs by bridges, which one of the following choices represents the depth first traversal of the spanning tree of bridges?

[GATE CS 2006]

(A) B1, B5, B3, B4, B2

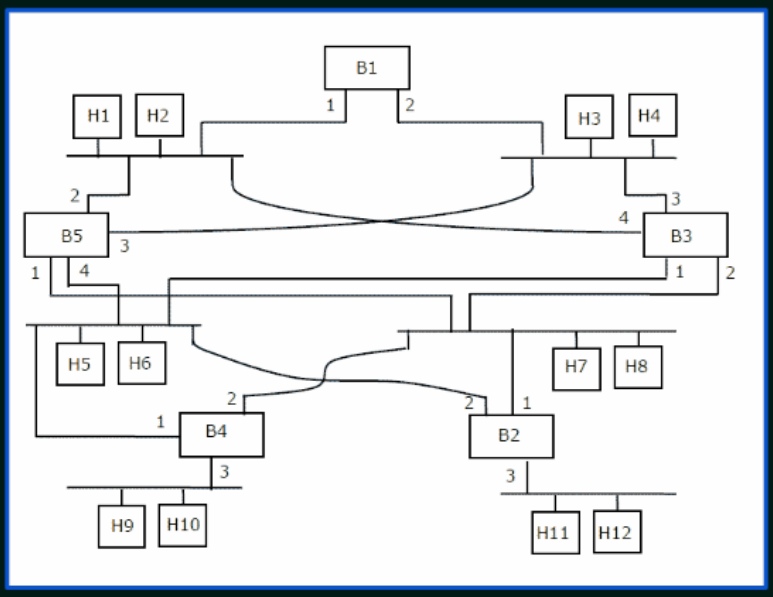
(B) B1, B3, B5, B2, B4

(C) B1, B5, B2, B3, B4

(D) B1, B3, B4, B5, B2

QuestionNeso Academy

QUESTION



QuestionNeso Academy

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[GATE CS 2006]

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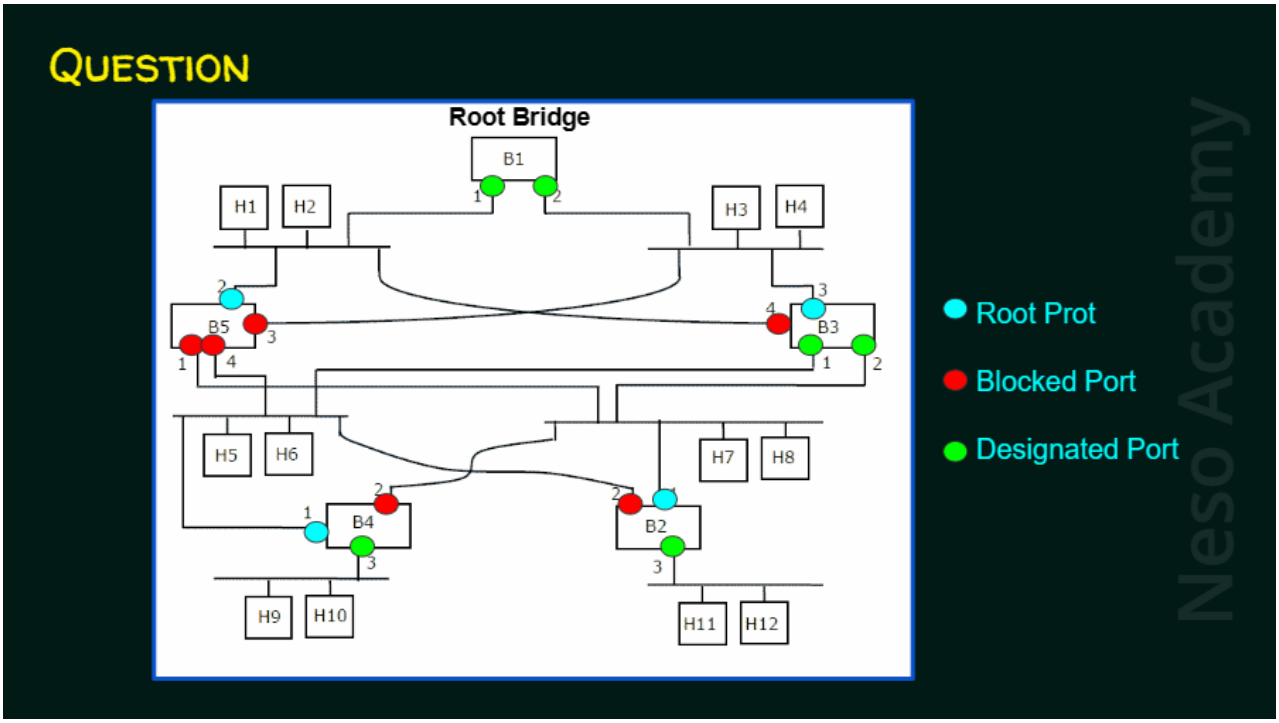
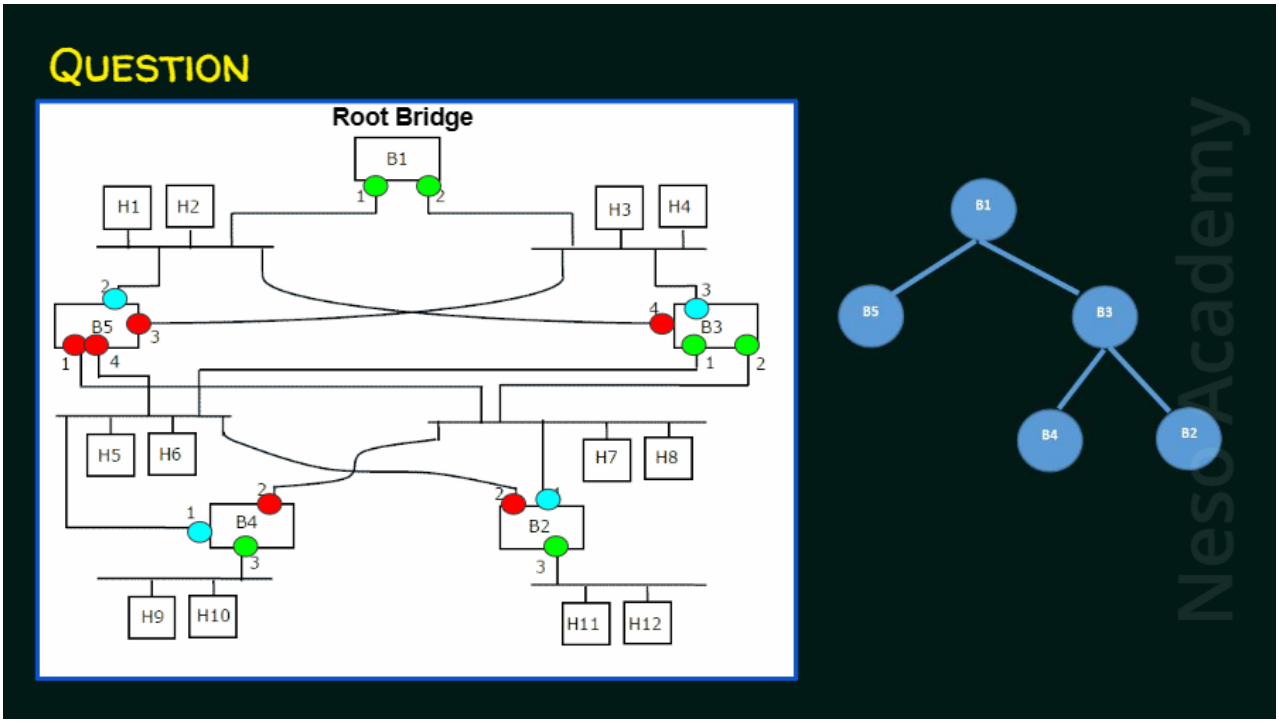
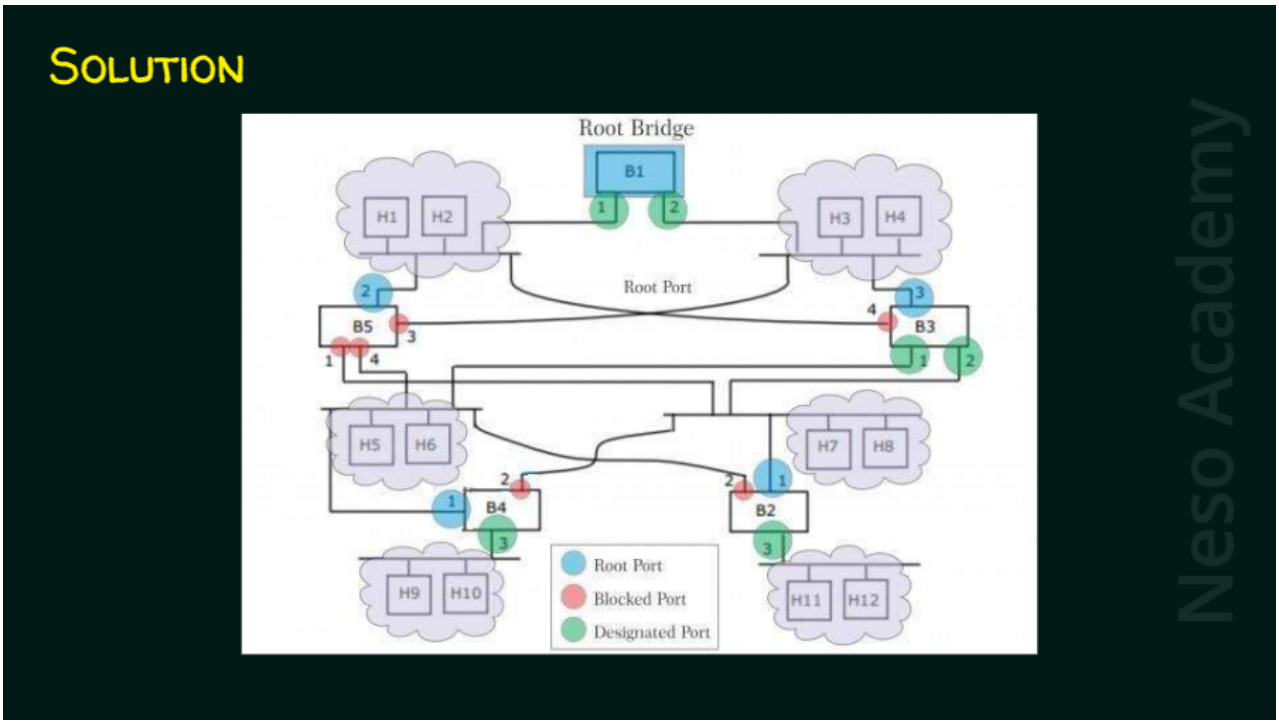


QuestionRoot BridgeRoot ProtBlocked PortDesignated PortNeso Academy

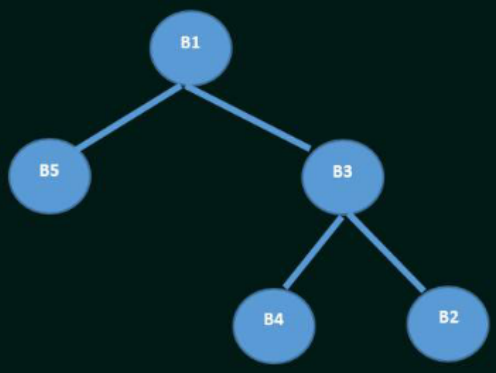


QuestionRoot BridgeNeso Academy



SolutionNeso Academy

Solution



B4 and B2 are connected through B3 (Not B5) because B3 has lower serial number than B5.

One DFS traversal of tree is: B1 – B5 – B3 – B4 – B2

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SolutionNeso Academy

Solution

For the given connection of LANs by bridges, which one of the following choices represents the depth first traversal of the spanning tree of bridges?

[GATE CS 2006]

(A) B1, B5, B3, B4, B2 ✔

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