**ENTS640 Networks and Protocols I**

**Section 0201**

**Fall 2015**

**Project Report**

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Honor Pledge:

***"I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/ examination."***

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# Project Description:

The project is aimed at designing a networking application which implements reliable data transfer protocol functionality over unreliable User Datagram Protocol (UDP) communication as well as cryptographic authentication. The application uses JAVA’s UDP socket to interface transmitter and receiver and uses stop and wait protocol for data transfer.

In our approach to this project, we have defined four classes to perform the task of synchronization, integrity check, construct data packet / acknowledgment packet, initialize socket parameters & send/receive packets at both transmitter and receiver side.

The functions performed by the two sides of the application are described as follows:

I. Transmitter side:

* Initializing socket parameters.
* Providing the agreed upon secret key to the RC4 algorithm
* Constructing data packets as per the agreed upon sequence number, maximum payload size
* Calculating the integrity check field of data packet
* Sending the data packets and receiving acknowledgement packets as per stop and wait protocol
* Checking the ACK number, packet type and integrity of the received ACK. If any of these is wrong the ACK is discarded
* At timeout, the data packet is retransmitted. On the fourth timeout, communication failure is declared

II. Receiver side:

* Initializing socket parameters.
* Providing the agreed upon secret key to the RC4 algorithm
* Receiving the data packets and checking for the correct sequence number as per previous agreement.
* Checking the integrity, packet type, payload length of the received data packet. If any of these are wrong, the data packet is discarded.
* If the sequence number indicates that the received packet is duplicate, an ACK with the expected sequence number as ACK number is resent. (Handles loss of ACK)
* Constructing acknowledgment packet with integrity check field calculated as per algorithm.
* If correct data is received, sending acknowledgment packet to the transmitter with expected sequence number as ACK number.

# DESIGN:

## Class Diagram:

\*

IntegrityCheck

1..\*

1

1

1

\*

\*

1

\*

1

Transmitter

TransmitterMainClass

Synchronization

Transmitter side

1..\*

\*

1

DataPacketInfo

\*

1..\*

\*

Receiver

1

AckPacketInfo

\*

1

ReceiverMainClass

Receiver side

1

1..\*

1

\*

\*

Classes common to the Transmitter side and Receiver side:

1. Synchronization
2. IntegrityCheck

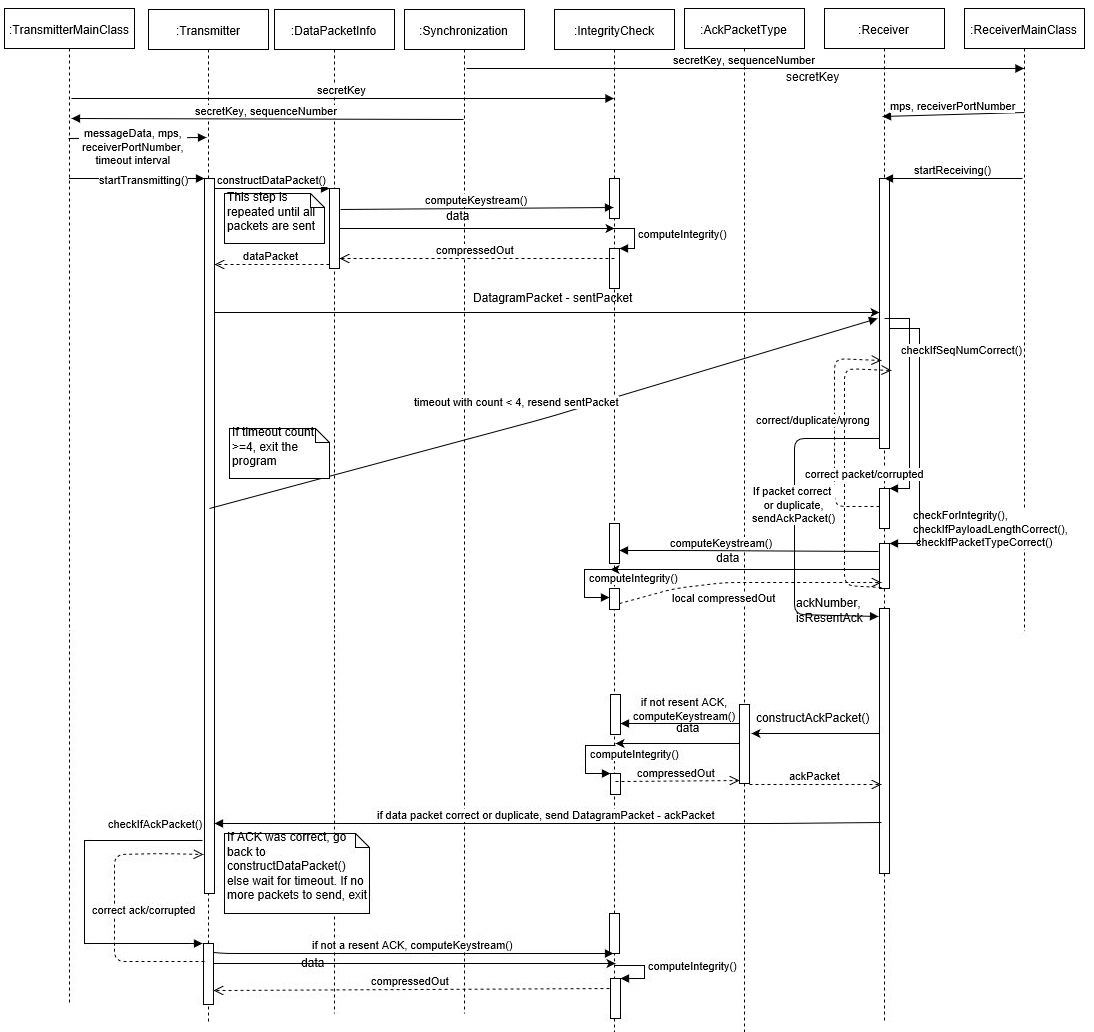
Classes specific to Transmitter side:

1. TransmitterMainClass
2. Transmitter
3. DataPacketInfo

Classes specific to Receiver side:

1. ReceiverMainClass
2. Receiver
3. AckPacketInfo

## Sequence Diagram:

****

The above sequence diagram shows the various interactions between the classes on both sides.

The above sequence of steps are repeated for each packet to send until all the packets are sent.

## Interaction Between Classes:

### Common classes for Transmitter and Receiver side:

#### Synchronization class

|  |
| --- |
| Synchronization |
| * SECRET\_KEY\_LENGTH : int = 16 * secretKey: byte[ ] * SEQUENCE\_NUM\_LENGTH: int= 4 * sequenceNumber: byte[ ] |
| + Synchronization()  + getSecretKey (): byte[ ]  + getSequenceNumber (): byte[ ]   * assignSecretKey () * initializeSequenceNumber () |

* Synchronization class provides the same initial sequence number and secret key to both the TransmitterMainClass and ReceiverMainClass.
* The constructor Synchronization() acts as the interface that assigns a secret key and sequence number using its private methods assignSecretKey () and initializeSequenceNumber ()
* The accessor method getSecretKey() is used by TransmitterMainClass and ReceiverMainClass to initialize the secret key of IntegrityCheck class
* The accessor method getSequenceNumber () is used by TransmitterMainClass and ReceiverMainClass to initialize the sequence number of Transmitter class and ACK number of Receiver class respectively.

#### IntegrityCheck class

|  |
| --- |
| IntegrityCheck |
| * key: byte [ ] * keyLength: int * stateVector: byte[ ] * tempVector: byte[ ] * streamGenCounter1:int * streamGenCounter2:int * keyStream: byte[] * compressedOut: byte[ ] * data: byte[ ] |
| * IntegrityCheck ( aData: byte[ ] ) * initialize (aKey: byte[ ] ) * setKey (aKey: byte[ ] ) * setData ( aData: byte[ ] ) * getIntegrityCheck (): byte[ ] * computeKeyStream (dataLength: int ) * swap ( first: byte, second: byte) * computeIntegrity () |

* IntegrityCheck class implements the RC4 algorithm and returns the compressed 4 byte integrity check field for a given byte sequence to encrypt.
* The static method initialize () method acts as the interface between TransmitterMainClass / ReceiverMainClass and IntegrityCheck class. This method takes the secret key as its parameter and computes the initial permutation of S and T vectors which are static fields.
* The constructor IntegrityCheck() which takes the data to encrypt as its parameter, computeKeyStream() which progresses the RC4 algorithm by generating new key streams and the accessor getIntegrityCheck which internally calls computeIntegrity method and returns the compressed 4 byte integrity field act as the interface between the Integrity check class and various other classes (Transmitter, DataPacketInfo, Receiver and AckPacketInfo).
* Note: computeKeyStream () method is called only if the algorithm needs to progress, else the previous keyStream byte array is used for integrity computation.

### Classes specific to Transmitter side:

#### TransmitterMainClass:

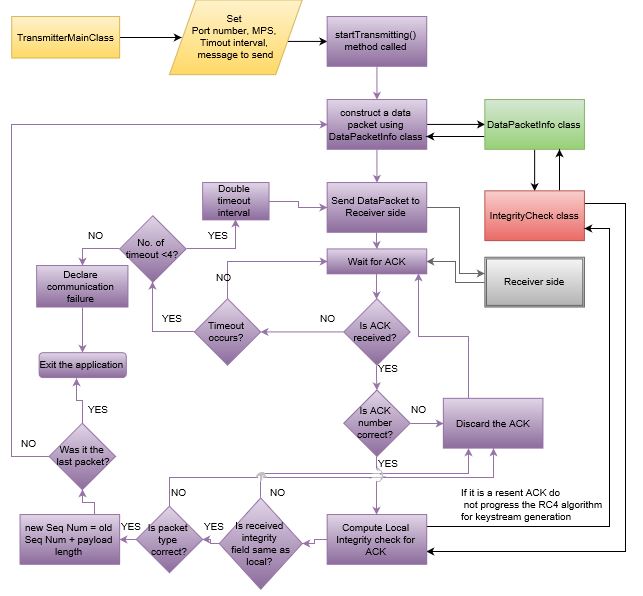
* This Class contains the main () method which is the entry point for Transmitter side of the application.
* Synchronization object is used to get the initial sequence number and secret key.
* The secret key is sent to the IntegrityCheck class via the interface initialize()
* The main () method randomly generated the 500 bytes of data that needs to be sent to the receiver.
* The sequence number along with the receiver port number, randomly generated byte sequence and initial timeout value is passed to the Transmitter class’ object.

#### Transmitter class

|  |
| --- |
| Transmitter |
| * receiverPortNumber: int * mps: int * messageSize: int * messageData: byte[ ] * timeoutInMilliSeconds: int * currentSequenceNumber: byte [ ] * receiverIpAddress: byte [ ] * expectedAckNumber: byte [ ] * shouldAckStateBePrev: boolean |
| * Transmitter (aReceiverIpAddress: byte[ ], aSeqNum: byte[ ] ) * setPortNumber (aPortNumber: int) * setMps (aMps: int) * setTimeout (aTimeout: int) * setMessage (aMessage: byte[ ]) * startTransmitting () * checkAckPacket( receivedAckData: byte[ ], expectedAckNumber: byte[ ] ): boolean * checkIfAckNumCorrect (receivedAck: byte [ ], expectedAckNum: byte[ ] ): boolean * checkForIntegrity (receivedAck: byte[ ] ): boolean * checkIfPacketTypeCorrect (receivedAck: byte[ ]): boolean * findNextSeqNum (currentSeqNum: byte[ ],payloadLength: int ): byte[ ] |

* The startTransmitting () method acts as the interface between the TransmitterMainClass and the Transmitter class.
* The transmitter checks the ACK number of the received ACK first. If it is wrong, the packet is discarded.
* The integrity check and packet type check is performed on the received ACK. If either of these fail, the ACK is discarded and a flag is used to keep track of this so that the RC4 algorithm does not progress for the next received ACK.
* The packet is retransmitted on each timeout and the timeout interval is doubled until the number of timeouts becomes 4. Then, communication failure is declared.
* In order to avoid excessive timeout intervals due to wrongly received ACK packets, the timeout is reset to the difference of timeout interval and the time elapsed since sending the packet.

##### Flow chart of Transmitter class:

****

**TransmitterMainClass**

**Transmitter class**

**DataPacketInfo class**

**IntegrityCheck class**

**Receiver side**

#### DataPacketInfo class

|  |
| --- |
| DataPacketInfo |
| * SEQUENCE\_NUM\_LENGTH: int= 4 * INTEGRITY\_CHECK\_LENGTH: int= 4 * packetType: byte * sequenceNumber: byte[ ] * payloadLength: byte * integrityCheck: byte [ ] * dataPacket: byte [ ] * payload: byte [ ] |
| * setPacketType (aPacketType: byte) * setSequenceNumber (aSequenceNumber: byte[ ]) * setPayloadLength (aPayloadLength: byte) * setPayload ( aPayload: byte [ ] ) * getPayloadLength (): byte * getDataPacket (): byte [ ] * getDataPacketLength (): int * constructDataPacket () * toString (): String |

* The constructDataPacket () method acts as the interface between the Transmitter class and the DataPacketInfo() class.
* An object of IntegrityCheck class is used to compute the integrity check field of the packet. computeKeystream () and getIntegrityCheck() methods are used for this purpose.

### Classes specific to Receiver side:

#### ReceiverMainClass:

* This Class contains the main() method which is the entry point for Receiver side of the application.
* Synchronization object is used to get the initial sequence number and secret key.
* The secret key is sent to the IntegrityCheck class via the interface initialize()
* The sequence number along with the receiver port number is passed to the Receiver class’ object.

#### Receiver class

|  |
| --- |
| Receiver |
| * expectedSequenceNumber: byte [ ] * receiverPortNumber: int * mps: int |
| * Receiver (aSequenceNumber: byte [ ] ) * setPortNumber (aPortNumber: int) * setMps (aMps: int) * startReceiving () * sendAckPacket (receiverSocket: DatagramSocket, transmitterAddress: InetAddress, transmitterPort: int, expectedSequenceNumber: byte[ ], isDuplicatePacket: boolean) * checkForIntegrity (receivedData: byte[ ], receivedDataLength: int, ispacketDiscarded: boolean): boolean * checkIfSeqNumCorrect (receivedData: byte [ ], expectedSeqNum: byte[ ] ): String * checkIfPayloadLengthCorrect (receivedData: byte[ ], receivedDataLength: int, MPS: int ): boolean * checkIfPayloadTypeCorrect (receivedData: byte [ ] ): boolean * findNextAckNum (currentAckNumber: byte[ ], payloadLength: int): byte[ ] |

* The public method startReceving () acts as the interface between the ReceiverMainClass and the Receiver calss. It receives the data packet sent by the transmitter. After the data packet is received, the sequence number is checked first followed by integrity of the received packet, packet type and payload length. If all these parameters of the received data is correct then the data packet is accepted and the acknowledgment packet is sent to the transmitter. If any parameter among sequence number, integrity check and payload length is incorrect then received packet is discarded. If sequence number is same as the previously received packet then the received packet must be a duplicate packet and hence acknowledgment packet with the expected sequence number is sent back to the transmitter.
* The private method sendAckPacket () takes receiverSocket, transmitterAddress, transmitterPort, expectedSequenceNumber and boolean variable isDuplicatePacket as input parameters. This method constructs and sends the acknowledgment packet to the transmitter.
* The private method checkForIntegrity () takes received data, data length as input and checks integrity only if the packet is accepted. This method creates an integrity check object and invokes getIntegrityCheck method.
* The private method checkIfSequenceNumCorrect () takes received data and expected sequence number as input parameters. The method verifies whether the sequence number of the received data packet is equal to the expected sequence number.
* The private method checkIfPayloadLengthCorrect () takes received data, its length and MPS as input; checks for the correct length by comparing received data payload length to MPS and payload length field value.
* The private method checkPacketTypeCorrect () takes received data as an input parameter. The packet type of the received data must be either 0x55 or 0xAA.
* The private method findNextAckNumer () takes current acknowledgment number and payload length as input parameters and determine the next acknowledgment number by adding the current acknowledgment number and payload length.

##### Flow chart of Receiver class:

**ReceiverMainClass**

**Receiver class**

**AckPacketInfo class**

**IntegrityCheck class**

**Transmitter side**

#### AckPacketInfo class:

|  |
| --- |
| AckPacketInfo |
| * ACK\_NUM\_LENGTH: int= 4 * INTEGRITY\_LENGTH: int= 4 * SENT\_MSG\_SIZE: int= 9 * ackPacketType: byte * ackNumber: byte [ ] * integrityCheck: byte [ ] * ackPacket: byte[ ] * isResentAck: boolean |
| * AckPacketInfo (aPacketType: byte, anAckNum: byte [ ], isResentAcknowledgement: boolean) * setAckNumber (aAckNumber: byte [ ] ) * setPacketType (aAckPacketType: byte) * getAckPacket (): byte[ ] * toString (): String * constructAckPacket () |

* The AckPacketInfo constructor which acts as the interface to the Receiver class initializes packet type, acknowledgment number and the boolean variable isResentAck and calls the constructAckPacket() method internally.
* The public mutator method setAckNumber and setPacketType sets acknowledgment number and packet type respectively.
* The public accessor method getAckPacket is used to get the complete acknowledgment packet to be sent to transmitter.
* The private method constructAckPacket () is used to construct the acknowledgment packet. The method creates an integrity check object and invokes getIntegrityCheck method.

# Implementation difficulties and design choices:

The implementation issues in maintaining the state of vectors in RC4 algorithm is handled using boolean variables that dictate if the algorithm should progress to next state or not.

Example scenario:

If an ACK is corrupted by the channel, the transmitter detects this via integrity check. In this case the transmitter discards the received ACK. The timeout value for the transmission socket is recalculated to avoid increased timeout value. At timeout, it retransmits the data packet and the receiver detects that this is a duplicate packet using the sequence number. For this purpose the sequence number is checked before evaluating the packet. The receiver resends the ACK without progressing its state vectors. At the transmitter side too, the algorithm doesn’t progress and checks the integrity with the previously generated key stream byte array.

This implementation is simple and handles all scenarios. The transmitter and receiver are at the same level of the RC4 algorithm for each data packet.

# Future improvements:

To further improve the implementation, stop and wait protocol can be replaced by a more efficient sliding window protocol such as Go Back-N or Selective Repeat.

Another minor improvement that can be made to the implementation is to have 2 temporary variables on each side for the state of the RC4 algorithm vectors. Doing this avoids having to check unreliable sequence numbers and ACK numbers before integrity check. On the other hand, checking Sequence number / ACK number first gives no drawback to the implementation because the receiver just retransmits the ACK on assuming a packet duplicate and does nothing with the data.

In the current design of packet structure, the data is prone to eves-dropping. Encrypting the data being sent strengthens the cryptographic authentication procedure.

# OUTPUT:

Note: A few scenarios are shown here. Various other scenarios are shown in the word document Project\_Output.docx attached along with the project report.

###### Normal operation:

All 500 bytes are sent by the transmitter and received by the receiver.

**Transmitter:**

500 bytes of data to be sent:

51 bb e3 65 84 ed a4 94 15 43 74 56 5a 9a 1 e3 2d d0 10 9c b9 16 3b d5 af e0 35 97 67 28 55 6b 3 29 d3 a b7 2d 41 db 1e 63 e4 cd 72 f8 5e 69 4 9d e2 e3 23 d7 1f b7 94 6c da 76 32 6e de 73 eb 31 f9 ef 68 a4 dd a4 e2 26 61 71 d3 f2 70 31 72 b1 ea 48 23 ee 5f d7 8 18 b3 da f9 6f 33 74 7 a2 9b 11 c0 70 f4 d f 2c 7f fb 4 f7 d1 fc c0 96 a2 be 65 8f c5 bb 15 8 b2 ea 95 18 54 99 8b a 9a ef e 61 95 46 a8 fa 18 a6 51 b0 d8 6b a9 3a d8 16 f8 eb 39 99 57 1d d3 86 e4 28 5c 6f 5c b4 a5 4e 43 33 17 a9 86 7b ba 89 49 7c d0 68 de 89 62 c7 d2 fa 79 32 82 52 38 5c 47 74 7e 79 95 62 95 6c 75 65 80 90 d4 be 94 49 3e ef 1b 61 85 da de 66 4a d1 6b 50 da 6a 3 65 23 2d 7b 12 6 e5 7e 61 5f 96 9 b8 92 12 b4 d6 c8 68 73 b9 b6 26 c1 4a 9c 8b 96 91 b9 f0 46 4f 60 41 e3 63 b0 7a 80 32 e0 75 5b f7 14 69 72 f2 42 b8 b1 9e fd 16 41 f0 69 c5 7e bc c 84 a8 b8 ed c6 ba fa 4a 4 64 e 78 45 6a 41 80 f 60 5d 4c d1 e0 50 db dc ed c0 34 a2 e9 b6 d7 78 8e 85 3a 78 4c 0 bf 6 86 47 ce e8 10 e6 53 b4 1c 4d 47 90 78 4a 45 dd f2 52 e5 65 48 c2 ad c5 f2 db bc 40 40 66 ae 7d aa e1 2c 86 cd 38 dd bd da d8 dc 8e 1 32 23 2b 57 7c 4a 9d ce a3 38 42 35 73 6c d9 46 65 e9 7d a9 f5 1 b7 41 e9 c0 f0 86 89 75 8 8e 58 d2 d1 c1 6f 91 d6 f4 ec b7 35 87 fb 48 75 ec 85 f6 a7 1d c0 5e 48 58 8c 75 66 ce 1f c3 ce ba a3 a3 ef 8c a0 d0 e9 69 af 7b 35 ca 58 d1 7d 64 b 91 6a 7e eb 7a 8b 32 f c7 d3 7c ef 36 4e 2a 26 5a a0 31 5b 7e d1 b4 85 69 53 fc 4d 8c 5f 60 0 28 15 50 89 2e 36 3f f 55 1f ed e4 88 a2 ab 55 af b7 56 d6

Sending data packet number with sequence number: 425064232

[ 55 19 55 f7 28 1e 51 bb e3 65 84 ed a4 94 15 43 74 56 5a 9a 1 e3 2d d0 10 9c b9 16 3b d5 af e0 35 97 67 28 d6 c1 57 6a ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 46 85 48 c7 33 ]

ACK number of the received ACK: 425064262

Sending data packet number with sequence number: 425064262

[ 55 19 55 f7 46 1e 55 6b 3 29 d3 a b7 2d 41 db 1e 63 e4 cd 72 f8 5e 69 4 9d e2 e3 23 d7 1f b7 94 6c da 76 7c 8e 8d ab ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 64 3b 44 5b 42 ]

ACK number of the received ACK: 425064292

Sending data packet number with sequence number: 425064292

[ 55 19 55 f7 64 1e 32 6e de 73 eb 31 f9 ef 68 a4 dd a4 e2 26 61 71 d3 f2 70 31 72 b1 ea 48 23 ee 5f d7 8 18 a8 15 a6 4e ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 82 5b a6 18 8d ]

ACK number of the received ACK: 425064322

Sending data packet number with sequence number: 425064322

[ 55 19 55 f7 82 1e b3 da f9 6f 33 74 7 a2 9b 11 c0 70 f4 d f 2c 7f fb 4 f7 d1 fc c0 96 a2 be 65 8f c5 bb c8 aa 4c 9 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 a0 c7 dc 5e ec ]

ACK number of the received ACK: 425064352

Sending data packet number with sequence number: 425064352

[ 55 19 55 f7 a0 1e 15 8 b2 ea 95 18 54 99 8b a 9a ef e 61 95 46 a8 fa 18 a6 51 b0 d8 6b a9 3a d8 16 f8 eb 54 97 47 96 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 be ca b 7c 3e ]

ACK number of the received ACK: 425064382

Sending data packet number with sequence number: 425064382

[ 55 19 55 f7 be 1e 39 99 57 1d d3 86 e4 28 5c 6f 5c b4 a5 4e 43 33 17 a9 86 7b ba 89 49 7c d0 68 de 89 62 c7 10 c5 d4 ba ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 dc 99 47 63 b9 ]

ACK number of the received ACK: 425064412

Sending data packet number with sequence number: 425064412

[ 55 19 55 f7 dc 1e d2 fa 79 32 82 52 38 5c 47 74 7e 79 95 62 95 6c 75 65 80 90 d4 be 94 49 3e ef 1b 61 85 da e3 ad 4a 23 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 fa 50 8e a2 a0 ]

ACK number of the received ACK: 425064442

Sending data packet number with sequence number: 425064442

[ 55 19 55 f7 fa 1e de 66 4a d1 6b 50 da 6a 3 65 23 2d 7b 12 6 e5 7e 61 5f 96 9 b8 92 12 b4 d6 c8 68 73 b9 5a a 74 ea ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 18 8f f 64 7a ]

ACK number of the received ACK: 425064472

Sending data packet number with sequence number: 425064472

[ 55 19 55 f8 18 1e b6 26 c1 4a 9c 8b 96 91 b9 f0 46 4f 60 41 e3 63 b0 7a 80 32 e0 75 5b f7 14 69 72 f2 42 b8 7f fe c3 2a ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 36 f9 bc 1d 39 ]

ACK number of the received ACK: 425064502

Sending data packet number with sequence number: 425064502

[ 55 19 55 f8 36 1e b1 9e fd 16 41 f0 69 c5 7e bc c 84 a8 b8 ed c6 ba fa 4a 4 64 e 78 45 6a 41 80 f 60 5d d2 a0 ee 4e ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 54 27 11 53 d4 ]

ACK number of the received ACK: 425064532

Sending data packet number with sequence number: 425064532

[ 55 19 55 f8 54 1e 4c d1 e0 50 db dc ed c0 34 a2 e9 b6 d7 78 8e 85 3a 78 4c 0 bf 6 86 47 ce e8 10 e6 53 b4 d1 5 2f b5 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 72 e3 55 ec bc ]

ACK number of the received ACK: 425064562

Sending data packet number with sequence number: 425064562

[ 55 19 55 f8 72 1e 1c 4d 47 90 78 4a 45 dd f2 52 e5 65 48 c2 ad c5 f2 db bc 40 40 66 ae 7d aa e1 2c 86 cd 38 50 63 8f 81 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 90 5b 73 76 94 ]

ACK number of the received ACK: 425064592

Sending data packet number with sequence number: 425064592

[ 55 19 55 f8 90 1e dd bd da d8 dc 8e 1 32 23 2b 57 7c 4a 9d ce a3 38 42 35 73 6c d9 46 65 e9 7d a9 f5 1 b7 72 b8 b4 cb ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 ae 41 9a 10 2b ]

ACK number of the received ACK: 425064622

Sending data packet number with sequence number: 425064622

[ 55 19 55 f8 ae 1e 41 e9 c0 f0 86 89 75 8 8e 58 d2 d1 c1 6f 91 d6 f4 ec b7 35 87 fb 48 75 ec 85 f6 a7 1d c0 5b 7d b8 83 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 cc 62 13 d5 4b ]

ACK number of the received ACK: 425064652

Sending data packet number with sequence number: 425064652

[ 55 19 55 f8 cc 1e 5e 48 58 8c 75 66 ce 1f c3 ce ba a3 a3 ef 8c a0 d0 e9 69 af 7b 35 ca 58 d1 7d 64 b 91 6a 7d 33 96 21 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 ea f3 98 8 a ]

ACK number of the received ACK: 425064682

Sending data packet number with sequence number: 425064682

[ 55 19 55 f8 ea 1e 7e eb 7a 8b 32 f c7 d3 7c ef 36 4e 2a 26 5a a0 31 5b 7e d1 b4 85 69 53 fc 4d 8c 5f 60 0 74 dd 27 d7 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f9 8 9 19 81 14 ]

ACK number of the received ACK: 425064712

Sending data packet number with sequence number: 425064712

[ aa 19 55 f9 8 14 28 15 50 89 2e 36 3f f 55 1f ed e4 88 a2 ab 55 af b7 56 d6 78 b4 7 7d ]

Waiting for ACK

ACK packet received

[ ff 19 55 f9 1c 7d 76 d 25 ]

ACK number of the received ACK: 425064732

**Receiver:**

Waiting for a packet

Expected sequence number: 425064232

Received a data packet with sequence number 425064232

[ 55 19 55 f7 28 1e 51 bb e3 65 84 ed a4 94 15 43 74 56 5a 9a 1 e3 2d d0 10 9c b9 16 3b d5 af e0 35 97 67 28 d6 c1 57 6a ]

ACK packet with ACK number 425064262 is sent

[ ff 19 55 f7 46 85 48 c7 33 ]

Waiting for a packet

Expected sequence number: 425064262

Received a data packet with sequence number 425064262

[ 55 19 55 f7 46 1e 55 6b 3 29 d3 a b7 2d 41 db 1e 63 e4 cd 72 f8 5e 69 4 9d e2 e3 23 d7 1f b7 94 6c da 76 7c 8e 8d ab ]

ACK packet with ACK number 425064292 is sent

[ ff 19 55 f7 64 3b 44 5b 42 ]

Waiting for a packet

Expected sequence number: 425064292

Received a data packet with sequence number 425064292

[ 55 19 55 f7 64 1e 32 6e de 73 eb 31 f9 ef 68 a4 dd a4 e2 26 61 71 d3 f2 70 31 72 b1 ea 48 23 ee 5f d7 8 18 a8 15 a6 4e ]

ACK packet with ACK number 425064322 is sent

[ ff 19 55 f7 82 5b a6 18 8d ]

Waiting for a packet

Expected sequence number: 425064322

Received a data packet with sequence number 425064322

[ 55 19 55 f7 82 1e b3 da f9 6f 33 74 7 a2 9b 11 c0 70 f4 d f 2c 7f fb 4 f7 d1 fc c0 96 a2 be 65 8f c5 bb c8 aa 4c 9 ]

ACK packet with ACK number 425064352 is sent

[ ff 19 55 f7 a0 c7 dc 5e ec ]

Waiting for a packet

Expected sequence number: 425064352

Received a data packet with sequence number 425064352

[ 55 19 55 f7 a0 1e 15 8 b2 ea 95 18 54 99 8b a 9a ef e 61 95 46 a8 fa 18 a6 51 b0 d8 6b a9 3a d8 16 f8 eb 54 97 47 96 ]

ACK packet with ACK number 425064382 is sent

[ ff 19 55 f7 be ca b 7c 3e ]

Waiting for a packet

Expected sequence number: 425064382

Received a data packet with sequence number 425064382

[ 55 19 55 f7 be 1e 39 99 57 1d d3 86 e4 28 5c 6f 5c b4 a5 4e 43 33 17 a9 86 7b ba 89 49 7c d0 68 de 89 62 c7 10 c5 d4 ba ]

ACK packet with ACK number 425064412 is sent

[ ff 19 55 f7 dc 99 47 63 b9 ]

Waiting for a packet

Expected sequence number: 425064412

Received a data packet with sequence number 425064412

[ 55 19 55 f7 dc 1e d2 fa 79 32 82 52 38 5c 47 74 7e 79 95 62 95 6c 75 65 80 90 d4 be 94 49 3e ef 1b 61 85 da e3 ad 4a 23 ]

ACK packet with ACK number 425064442 is sent

[ ff 19 55 f7 fa 50 8e a2 a0 ]

Waiting for a packet

Expected sequence number: 425064442

Received a data packet with sequence number 425064442

[ 55 19 55 f7 fa 1e de 66 4a d1 6b 50 da 6a 3 65 23 2d 7b 12 6 e5 7e 61 5f 96 9 b8 92 12 b4 d6 c8 68 73 b9 5a a 74 ea ]

ACK packet with ACK number 425064472 is sent

[ ff 19 55 f8 18 8f f 64 7a ]

Waiting for a packet

Expected sequence number: 425064472

Received a data packet with sequence number 425064472

[ 55 19 55 f8 18 1e b6 26 c1 4a 9c 8b 96 91 b9 f0 46 4f 60 41 e3 63 b0 7a 80 32 e0 75 5b f7 14 69 72 f2 42 b8 7f fe c3 2a ]

ACK packet with ACK number 425064502 is sent

[ ff 19 55 f8 36 f9 bc 1d 39 ]

Waiting for a packet

Expected sequence number: 425064502

Received a data packet with sequence number 425064502

[ 55 19 55 f8 36 1e b1 9e fd 16 41 f0 69 c5 7e bc c 84 a8 b8 ed c6 ba fa 4a 4 64 e 78 45 6a 41 80 f 60 5d d2 a0 ee 4e ]

ACK packet with ACK number 425064532 is sent

[ ff 19 55 f8 54 27 11 53 d4 ]

Waiting for a packet

Expected sequence number: 425064532

Received a data packet with sequence number 425064532

[ 55 19 55 f8 54 1e 4c d1 e0 50 db dc ed c0 34 a2 e9 b6 d7 78 8e 85 3a 78 4c 0 bf 6 86 47 ce e8 10 e6 53 b4 d1 5 2f b5 ]

ACK packet with ACK number 425064562 is sent

[ ff 19 55 f8 72 e3 55 ec bc ]

Waiting for a packet

Expected sequence number: 425064562

Received a data packet with sequence number 425064562

[ 55 19 55 f8 72 1e 1c 4d 47 90 78 4a 45 dd f2 52 e5 65 48 c2 ad c5 f2 db bc 40 40 66 ae 7d aa e1 2c 86 cd 38 50 63 8f 81 ]

ACK packet with ACK number 425064592 is sent

[ ff 19 55 f8 90 5b 73 76 94 ]

Waiting for a packet

Expected sequence number: 425064592

Received a data packet with sequence number 425064592

[ 55 19 55 f8 90 1e dd bd da d8 dc 8e 1 32 23 2b 57 7c 4a 9d ce a3 38 42 35 73 6c d9 46 65 e9 7d a9 f5 1 b7 72 b8 b4 cb ]

ACK packet with ACK number 425064622 is sent

[ ff 19 55 f8 ae 41 9a 10 2b ]

Waiting for a packet

Expected sequence number: 425064622

Received a data packet with sequence number 425064622

[ 55 19 55 f8 ae 1e 41 e9 c0 f0 86 89 75 8 8e 58 d2 d1 c1 6f 91 d6 f4 ec b7 35 87 fb 48 75 ec 85 f6 a7 1d c0 5b 7d b8 83 ]

ACK packet with ACK number 425064652 is sent

[ ff 19 55 f8 cc 62 13 d5 4b ]

Waiting for a packet

Expected sequence number: 425064652

Received a data packet with sequence number 425064652

[ 55 19 55 f8 cc 1e 5e 48 58 8c 75 66 ce 1f c3 ce ba a3 a3 ef 8c a0 d0 e9 69 af 7b 35 ca 58 d1 7d 64 b 91 6a 7d 33 96 21 ]

ACK packet with ACK number 425064682 is sent

[ ff 19 55 f8 ea f3 98 8 a ]

Waiting for a packet

Expected sequence number: 425064682

Received a data packet with sequence number 425064682

[ 55 19 55 f8 ea 1e 7e eb 7a 8b 32 f c7 d3 7c ef 36 4e 2a 26 5a a0 31 5b 7e d1 b4 85 69 53 fc 4d 8c 5f 60 0 74 dd 27 d7 ]

ACK packet with ACK number 425064712 is sent

[ ff 19 55 f9 8 9 19 81 14 ]

Waiting for a packet

Expected sequence number: 425064712

Received a data packet with sequence number 425064712

[ aa 19 55 f9 8 14 28 15 50 89 2e 36 3f f 55 1f ed e4 88 a2 ab 55 af b7 56 d6 78 b4 7 7d ]

ACK packet with ACK number 425064732 is sent

[ ff 19 55 f9 1c 7d 76 d 25 ]

The complete received data:

[ 51 bb e3 65 84 ed a4 94 15 43 74 56 5a 9a 1 e3 2d d0 10 9c b9 16 3b d5 af e0 35 97 67 28 55 6b 3 29 d3 a b7 2d 41 db 1e 63 e4 cd 72 f8 5e 69 4 9d e2 e3 23 d7 1f b7 94 6c da 76 32 6e de 73 eb 31 f9 ef 68 a4 dd a4 e2 26 61 71 d3 f2 70 31 72 b1 ea 48 23 ee 5f d7 8 18 b3 da f9 6f 33 74 7 a2 9b 11 c0 70 f4 d f 2c 7f fb 4 f7 d1 fc c0 96 a2 be 65 8f c5 bb 15 8 b2 ea 95 18 54 99 8b a 9a ef e 61 95 46 a8 fa 18 a6 51 b0 d8 6b a9 3a d8 16 f8 eb 39 99 57 1d d3 86 e4 28 5c 6f 5c b4 a5 4e 43 33 17 a9 86 7b ba 89 49 7c d0 68 de 89 62 c7 d2 fa 79 32 82 52 38 5c 47 74 7e 79 95 62 95 6c 75 65 80 90 d4 be 94 49 3e ef 1b 61 85 da de 66 4a d1 6b 50 da 6a 3 65 23 2d 7b 12 6 e5 7e 61 5f 96 9 b8 92 12 b4 d6 c8 68 73 b9 b6 26 c1 4a 9c 8b 96 91 b9 f0 46 4f 60 41 e3 63 b0 7a 80 32 e0 75 5b f7 14 69 72 f2 42 b8 b1 9e fd 16 41 f0 69 c5 7e bc c 84 a8 b8 ed c6 ba fa 4a 4 64 e 78 45 6a 41 80 f 60 5d 4c d1 e0 50 db dc ed c0 34 a2 e9 b6 d7 78 8e 85 3a 78 4c 0 bf 6 86 47 ce e8 10 e6 53 b4 1c 4d 47 90 78 4a 45 dd f2 52 e5 65 48 c2 ad c5 f2 db bc 40 40 66 ae 7d aa e1 2c 86 cd 38 dd bd da d8 dc 8e 1 32 23 2b 57 7c 4a 9d ce a3 38 42 35 73 6c d9 46 65 e9 7d a9 f5 1 b7 41 e9 c0 f0 86 89 75 8 8e 58 d2 d1 c1 6f 91 d6 f4 ec b7 35 87 fb 48 75 ec 85 f6 a7 1d c0 5e 48 58 8c 75 66 ce 1f c3 ce ba a3 a3 ef 8c a0 d0 e9 69 af 7b 35 ca 58 d1 7d 64 b 91 6a 7e eb 7a 8b 32 f c7 d3 7c ef 36 4e 2a 26 5a a0 31 5b 7e d1 b4 85 69 53 fc 4d 8c 5f 60 0 28 15 50 89 2e 36 3f f 55 1f ed e4 88 a2 ab 55 af b7 56 d6 ]

Waiting for a packet

###### Receiver not started:

The receiver is unreachable. The transmitter retransmits the data packet up to four timeouts and then declares communication failure.

**Transmitter:**

500 bytes of data to be sent:

8c 39 73 cd e3 8b 56 20 35 f8 ea 47 2 93 58 db 8 13 8c ec 7b 2a 2d cf d a9 9a d5 8f 77 b5 ea c6 72 97 a6 7a 36 e 12 94 6d 2c 70 f9 5b 84 82 35 fc 3c ae 2c a2 96 4f 26 32 f4 af f9 16 d5 7c f7 a8 9f 80 55 52 3e 5f d0 29 b2 fe 1f a5 15 5 b3 72 46 47 76 e5 6c 29 47 be 22 16 ae 8b e0 99 29 46 5 ec 4e 2b 7d da 1b b 89 7b c3 5 94 bd 86 93 19 f1 a3 10 2 76 2b 58 89 70 bb 5f 4c 48 f9 f f 3f 41 3 88 d3 5b 47 c fd d6 24 9e f2 85 7c 36 c6 43 12 3a 38 84 a9 3a 6c 17 3 13 b7 19 86 c1 3 90 4e 82 f9 ac 2e 2d 13 6f 89 36 cb dd 12 34 0 a8 2f 31 c0 76 65 ea 29 1a 24 2e 4e ce 90 c 97 a0 0 30 a db bd 0 4a 47 fb a9 24 8c 19 8a fb 6b 99 7e 96 1a 83 b1 20 fe 97 b2 76 72 7f 90 c5 5a e8 7c 2c ed 0 7d 98 3e 73 b1 ad e7 97 17 f9 e5 f 85 20 fc 47 2f 2e 65 d3 50 d6 f3 56 94 a3 ab 1c e3 8c 96 45 90 3 d4 9b b1 bc 14 90 9f da b7 97 83 2b 9e 22 d1 34 d2 f2 3b b0 52 70 7 37 4 79 82 52 c3 1d fc d8 b0 e1 39 71 91 5 b6 c4 42 3e 58 d0 f3 54 4b 38 2e 53 b9 9b 26 67 a8 cb da 29 fb 4b 11 32 9e 28 1d 14 25 d3 ab 53 d7 a5 30 ee 26 ae e4 6e 8c 1f 45 ba da c6 16 58 ab f2 27 49 5d c3 53 e4 10 8e 88 95 fd cb 8 d4 a3 1f e9 53 56 4e cf 98 b5 22 47 f 25 8a 62 6f 79 40 e7 8a bf c0 f c2 cd ef 3 1c 87 9 1e d5 79 34 1f d2 94 a0 3 ae e1 72 47 a3 25 28 5b c7 63 d4 9c f9 4e a3 2 c7 3b 94 c5 1 90 12 b9 e0 e7 68 43 86 d7 e1 45 27 c5 d8 bf 9 38 32 e7 96 63 97 cb c2 e9 60 98 6f 53 d0 a8 25 6c 19 79 52 b1 bd d 5d 85 ed 4d d5 70 de a 81 fe 31 fe af 41 e8 7d 13 97 ec 74 9b c2 9e aa 5b bb 61 51 3e 5f 4

Sending data packet number with sequence number: 425064232

[ 55 19 55 f7 28 1e 8c 39 73 cd e3 8b 56 20 35 f8 ea 47 2 93 58 db 8 13 8c ec 7b 2a 2d cf d a9 9a d5 8f 77 56 dc 38 d5 ]

Waiting for ACK

Timeout occured; Timeout number: 1

New timer value is 2secs

Sending data packet number with sequence number: 425064232

[ 55 19 55 f7 28 1e 8c 39 73 cd e3 8b 56 20 35 f8 ea 47 2 93 58 db 8 13 8c ec 7b 2a 2d cf d a9 9a d5 8f 77 56 dc 38 d5 ]

Waiting for ACK

Timeout occured; Timeout number: 2

New timer value is 4secs

Sending data packet number with sequence number: 425064232

[ 55 19 55 f7 28 1e 8c 39 73 cd e3 8b 56 20 35 f8 ea 47 2 93 58 db 8 13 8c ec 7b 2a 2d cf d a9 9a d5 8f 77 56 dc 38 d5 ]

Waiting for ACK

Timeout occured; Timeout number: 3

New timer value is 8secs

Sending data packet number with sequence number: 425064232

[ 55 19 55 f7 28 1e 8c 39 73 cd e3 8b 56 20 35 f8 ea 47 2 93 58 db 8 13 8c ec 7b 2a 2d cf d a9 9a d5 8f 77 56 dc 38 d5 ]

Waiting for ACK

Timeout occured; Timeout number: 4

Communication Failure; java.net.SocketTimeoutException: Receive timed out

###### 2nd Data packet corrupted by the channel & retransmitted correctly:

The second data packet is corrupted by the channel. The receiver detects this by checking the packet’s integrity. When the transmitter retransmits the correct packet, the packet is accepted. Note: The Receiver’s RC4 algorithm state is not progressed to the next step when a retransmitted packet is received. The receiver keeps track of this by setting a boolean variable when a packet is discarded.

**Transmitter:**

500 bytes of data to be sent:

40 f0 9 b7 b0 50 eb f8 74 47 da e3 e9 2e f8 a9 e3 ff 56 a8 fb 23 da fc 4a d5 12 69 33 dd f2 20 50 92 1b 34 84 27 3c f5 a7 c7 c2 4f 28 b8 18 65 ab 2e d4 3e 34 e1 d8 45 f4 6d da 3b 5d 4c 22 22 6a 20 7d a4 7b 53 93 d dc d3 34 c6 90 6d e3 37 38 42 4c d4 60 38 fe 22 c6 e0 38 3 d8 39 e6 54 1b 13 82 f5 d9 59 90 4f 9f 6b ee 4 1e 9c d6 79 d8 79 54 4e 5c 9b 55 e5 dc 46 6a d2 cb 1 ff f0 95 da 37 49 b5 88 ae d3 bf 88 20 db c2 37 ee eb c0 62 f1 e1 1a 7e 79 36 d8 93 dc 2f 91 a2 69 ee 30 af 27 b5 7c bd 1d 4d ce a3 12 29 e2 45 4e a0 89 30 d5 0 1f 5 a2 b5 5f e2 36 3 37 4f 36 73 e3 f1 51 dc 6c 7b 7d 68 a4 48 2 a d6 17 e0 93 ad a5 e0 f1 5 4 6b d 99 d0 4d 5b 1 d2 ae ed cf 1c 5 5c 1a 52 74 f5 dc ba b0 d 6a 55 6c 17 f 8c a8 a4 fa 4b eb 3 b5 ec 96 96 e5 be f6 6 b5 43 72 95 ed 93 5d 9c 56 aa 50 e3 5f d7 fb 8c 70 bd 1 c6 40 4a f7 df 63 31 ed 78 e 76 8f 35 7a 24 21 f8 a0 5c 87 e b3 f7 c5 9b e9 51 89 d fb bb d5 19 ab f6 a8 3f 58 92 b8 81 5a f6 69 7a aa c7 a5 93 c4 e7 ba 34 dc 88 69 b5 32 cf 4d 42 ba da c1 a4 26 12 87 25 cd 98 ca 65 dd 7f 70 be f3 b0 39 61 3b 37 9 dd 7c 2d c3 77 d6 f9 31 1c 1e f6 42 3e 2e b5 e5 92 1 10 82 e8 5c 6 b2 59 a5 9f 1a 68 be 9 16 ce 81 93 eb c1 66 37 2e 1b 7b bc 6f ba 55 2e 5a 7f b3 c1 7 70 d3 73 99 88 39 df d0 99 58 21 5b f3 9f 4b 88 52 e5 92 a3 86 89 86 83 f8 c0 30 5c 5e a8 42 b6 98 f0 ba da f6 c7 27 bf 5 e9 d9 1d 8b cd dd 93 bc 4e 77 f7 4e e4 bf bb c9 aa 52 6e ad 2b cf fe bb 95 b9 ff 12 8e e 9e cd a5 f 11 dc c5 ed 63 b0 b 3a fc 4f 8d df 49 d2

Sending data packet number with sequence number: 425064232

[ 55 19 55 f7 28 1e 40 f0 9 b7 b0 50 eb f8 74 47 da e3 e9 2e f8 a9 e3 ff 56 a8 fb 23 da fc 4a d5 12 69 33 dd a4 63 9d f6 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 46 85 48 c7 33 ]

ACK number of the received ACK: 425064262

Sending data packet number with sequence number: 425064262

[ 55 19 55 f7 46 1e f2 20 50 92 28 34 84 27 3c f5 a7 c7 c2 4f 28 b8 18 65 ab 2e d4 3e 34 e1 d8 45 f4 6d da 3b 27 5f e 1c ]

Waiting for ACK

Timeout occured; Timeout number: 1

New timer value is 2secs

Sending data packet number with sequence number: 425064262

[ 55 19 55 f7 46 1e f2 20 50 92 1b 34 84 27 3c f5 a7 c7 c2 4f 28 b8 18 65 ab 2e d4 3e 34 e1 d8 45 f4 6d da 3b 27 5f e 1c ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 64 3b 44 5b 42 ]

ACK number of the received ACK: 425064292

Sending data packet number with sequence number: 425064292

[ 55 19 55 f7 64 1e 5d 4c 22 22 6a 20 7d a4 7b 53 93 d dc d3 34 c6 90 6d e3 37 38 42 4c d4 60 38 fe 22 c6 e0 5f 7e e1 3d ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 82 5b a6 18 8d ]

ACK number of the received ACK: 425064322

Sending data packet number with sequence number: 425064322

[ 55 19 55 f7 82 1e 38 3 d8 39 e6 54 1b 13 82 f5 d9 59 90 4f 9f 6b ee 4 1e 9c d6 79 d8 79 54 4e 5c 9b 55 e5 47 b3 9f 82 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 a0 c7 dc 5e ec ]

ACK number of the received ACK: 425064352

Sending data packet number with sequence number: 425064352

[ 55 19 55 f7 a0 1e dc 46 6a d2 cb 1 ff f0 95 da 37 49 b5 88 ae d3 bf 88 20 db c2 37 ee eb c0 62 f1 e1 1a 7e 96 ff 7a c0 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 be ca b 7c 3e ]

ACK number of the received ACK: 425064382

Sending data packet number with sequence number: 425064382

[ 55 19 55 f7 be 1e 79 36 d8 93 dc 2f 91 a2 69 ee 30 af 27 b5 7c bd 1d 4d ce a3 12 29 e2 45 4e a0 89 30 d5 0 d c a7 8d ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 dc 99 47 63 b9 ]

ACK number of the received ACK: 425064412

Sending data packet number with sequence number: 425064412

[ 55 19 55 f7 dc 1e 1f 5 a2 b5 5f e2 36 3 37 4f 36 73 e3 f1 51 dc 6c 7b 7d 68 a4 48 2 a d6 17 e0 93 ad a5 2a 86 f5 ab ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 fa 50 8e a2 a0 ]

ACK number of the received ACK: 425064442

Sending data packet number with sequence number: 425064442

[ 55 19 55 f7 fa 1e e0 f1 5 4 6b d 99 d0 4d 5b 1 d2 ae ed cf 1c 5 5c 1a 52 74 f5 dc ba b0 d 6a 55 6c 17 14 32 cc e4 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 18 8f f 64 7a ]

ACK number of the received ACK: 425064472

Sending data packet number with sequence number: 425064472

[ 55 19 55 f8 18 1e f 8c a8 a4 fa 4b eb 3 b5 ec 96 96 e5 be f6 6 b5 43 72 95 ed 93 5d 9c 56 aa 50 e3 5f d7 78 e3 c2 d0 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 36 f9 bc 1d 39 ]

ACK number of the received ACK: 425064502

Sending data packet number with sequence number: 425064502

[ 55 19 55 f8 36 1e fb 8c 70 bd 1 c6 40 4a f7 df 63 31 ed 78 e 76 8f 35 7a 24 21 f8 a0 5c 87 e b3 f7 c5 9b 21 40 10 79 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 54 27 11 53 d4 ]

ACK number of the received ACK: 425064532

Sending data packet number with sequence number: 425064532

[ 55 19 55 f8 54 1e e9 51 89 d fb bb d5 19 ab f6 a8 3f 58 92 b8 81 5a f6 69 7a aa c7 a5 93 c4 e7 ba 34 dc 88 5b 70 4a 90 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 72 e3 55 ec bc ]

ACK number of the received ACK: 425064562

Sending data packet number with sequence number: 425064562

[ 55 19 55 f8 72 1e 69 b5 32 cf 4d 42 ba da c1 a4 26 12 87 25 cd 98 ca 65 dd 7f 70 be f3 b0 39 61 3b 37 9 dd 52 52 6c 63 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 90 5b 73 76 94 ]

ACK number of the received ACK: 425064592

Sending data packet number with sequence number: 425064592

[ 55 19 55 f8 90 1e 7c 2d c3 77 d6 f9 31 1c 1e f6 42 3e 2e b5 e5 92 1 10 82 e8 5c 6 b2 59 a5 9f 1a 68 be 9 95 70 bc 8 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 ae 41 9a 10 2b ]

ACK number of the received ACK: 425064622

Sending data packet number with sequence number: 425064622

[ 55 19 55 f8 ae 1e 16 ce 81 93 eb c1 66 37 2e 1b 7b bc 6f ba 55 2e 5a 7f b3 c1 7 70 d3 73 99 88 39 df d0 99 34 3e 1a 36 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 cc 62 13 d5 4b ]

ACK number of the received ACK: 425064652

Sending data packet number with sequence number: 425064652

[ 55 19 55 f8 cc 1e 58 21 5b f3 9f 4b 88 52 e5 92 a3 86 89 86 83 f8 c0 30 5c 5e a8 42 b6 98 f0 ba da f6 c7 27 d9 b0 c2 74 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 ea f3 98 8 a ]

ACK number of the received ACK: 425064682

Sending data packet number with sequence number: 425064682

[ 55 19 55 f8 ea 1e bf 5 e9 d9 1d 8b cd dd 93 bc 4e 77 f7 4e e4 bf bb c9 aa 52 6e ad 2b cf fe bb 95 b9 ff 12 a4 5e 36 d8 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f9 8 9 19 81 14 ]

ACK number of the received ACK: 425064712

Sending data packet number with sequence number: 425064712

[ aa 19 55 f9 8 14 8e e 9e cd a5 f 11 dc c5 ed 63 b0 b 3a fc 4f 8d df 49 d2 5e 69 1b 5d ]

Waiting for ACK

ACK packet received

[ ff 19 55 f9 1c 7d 76 d 25 ]

ACK number of the received ACK: 425064732

**Receiver:**

Waiting for a packet

Expected sequence number: 425064232

Received a data packet with sequence number 425064232

[ 55 19 55 f7 28 1e 40 f0 9 b7 b0 50 eb f8 74 47 da e3 e9 2e f8 a9 e3 ff 56 a8 fb 23 da fc 4a d5 12 69 33 dd a4 63 9d f6 ]

ACK packet with ACK number 425064262 is sent

[ ff 19 55 f7 46 85 48 c7 33 ]

Waiting for a packet

Expected sequence number: 425064262

Received a data packet with sequence number 425064262

[ 55 19 55 f7 46 1e f2 20 50 92 28 34 84 27 3c f5 a7 c7 c2 4f 28 b8 18 65 ab 2e d4 3e 34 e1 d8 45 f4 6d da 3b 27 5f e 1c ]

Data packet discarded due to integrity fail

Waiting for a packet

Expected sequence number: 425064262

Received a data packet with sequence number 425064262

[ 55 19 55 f7 46 1e f2 20 50 92 1b 34 84 27 3c f5 a7 c7 c2 4f 28 b8 18 65 ab 2e d4 3e 34 e1 d8 45 f4 6d da 3b 27 5f e 1c ]

ACK packet with ACK number 425064292 is sent

[ ff 19 55 f7 64 3b 44 5b 42 ]

Waiting for a packet

Expected sequence number: 425064292

Received a data packet with sequence number 425064292

[ 55 19 55 f7 64 1e 5d 4c 22 22 6a 20 7d a4 7b 53 93 d dc d3 34 c6 90 6d e3 37 38 42 4c d4 60 38 fe 22 c6 e0 5f 7e e1 3d ]

ACK packet with ACK number 425064322 is sent

[ ff 19 55 f7 82 5b a6 18 8d ]

Waiting for a packet

Expected sequence number: 425064322

Received a data packet with sequence number 425064322

[ 55 19 55 f7 82 1e 38 3 d8 39 e6 54 1b 13 82 f5 d9 59 90 4f 9f 6b ee 4 1e 9c d6 79 d8 79 54 4e 5c 9b 55 e5 47 b3 9f 82 ]

ACK packet with ACK number 425064352 is sent

[ ff 19 55 f7 a0 c7 dc 5e ec ]

Waiting for a packet

Expected sequence number: 425064352

Received a data packet with sequence number 425064352

[ 55 19 55 f7 a0 1e dc 46 6a d2 cb 1 ff f0 95 da 37 49 b5 88 ae d3 bf 88 20 db c2 37 ee eb c0 62 f1 e1 1a 7e 96 ff 7a c0 ]

ACK packet with ACK number 425064382 is sent

[ ff 19 55 f7 be ca b 7c 3e ]

Waiting for a packet

Expected sequence number: 425064382

Received a data packet with sequence number 425064382

[ 55 19 55 f7 be 1e 79 36 d8 93 dc 2f 91 a2 69 ee 30 af 27 b5 7c bd 1d 4d ce a3 12 29 e2 45 4e a0 89 30 d5 0 d c a7 8d ]

ACK packet with ACK number 425064412 is sent

[ ff 19 55 f7 dc 99 47 63 b9 ]

Waiting for a packet

Expected sequence number: 425064412

Received a data packet with sequence number 425064412

[ 55 19 55 f7 dc 1e 1f 5 a2 b5 5f e2 36 3 37 4f 36 73 e3 f1 51 dc 6c 7b 7d 68 a4 48 2 a d6 17 e0 93 ad a5 2a 86 f5 ab ]

ACK packet with ACK number 425064442 is sent

[ ff 19 55 f7 fa 50 8e a2 a0 ]

Waiting for a packet

Expected sequence number: 425064442

Received a data packet with sequence number 425064442

[ 55 19 55 f7 fa 1e e0 f1 5 4 6b d 99 d0 4d 5b 1 d2 ae ed cf 1c 5 5c 1a 52 74 f5 dc ba b0 d 6a 55 6c 17 14 32 cc e4 ]

ACK packet with ACK number 425064472 is sent

[ ff 19 55 f8 18 8f f 64 7a ]

Waiting for a packet

Expected sequence number: 425064472

Received a data packet with sequence number 425064472

[ 55 19 55 f8 18 1e f 8c a8 a4 fa 4b eb 3 b5 ec 96 96 e5 be f6 6 b5 43 72 95 ed 93 5d 9c 56 aa 50 e3 5f d7 78 e3 c2 d0 ]

ACK packet with ACK number 425064502 is sent

[ ff 19 55 f8 36 f9 bc 1d 39 ]

Waiting for a packet

Expected sequence number: 425064502

Received a data packet with sequence number 425064502

[ 55 19 55 f8 36 1e fb 8c 70 bd 1 c6 40 4a f7 df 63 31 ed 78 e 76 8f 35 7a 24 21 f8 a0 5c 87 e b3 f7 c5 9b 21 40 10 79 ]

ACK packet with ACK number 425064532 is sent

[ ff 19 55 f8 54 27 11 53 d4 ]

Waiting for a packet

Expected sequence number: 425064532

Received a data packet with sequence number 425064532

[ 55 19 55 f8 54 1e e9 51 89 d fb bb d5 19 ab f6 a8 3f 58 92 b8 81 5a f6 69 7a aa c7 a5 93 c4 e7 ba 34 dc 88 5b 70 4a 90 ]

ACK packet with ACK number 425064562 is sent

[ ff 19 55 f8 72 e3 55 ec bc ]

Waiting for a packet

Expected sequence number: 425064562

Received a data packet with sequence number 425064562

[ 55 19 55 f8 72 1e 69 b5 32 cf 4d 42 ba da c1 a4 26 12 87 25 cd 98 ca 65 dd 7f 70 be f3 b0 39 61 3b 37 9 dd 52 52 6c 63 ]

ACK packet with ACK number 425064592 is sent

[ ff 19 55 f8 90 5b 73 76 94 ]

Waiting for a packet

Expected sequence number: 425064592

Received a data packet with sequence number 425064592

[ 55 19 55 f8 90 1e 7c 2d c3 77 d6 f9 31 1c 1e f6 42 3e 2e b5 e5 92 1 10 82 e8 5c 6 b2 59 a5 9f 1a 68 be 9 95 70 bc 8 ]

ACK packet with ACK number 425064622 is sent

[ ff 19 55 f8 ae 41 9a 10 2b ]

Waiting for a packet

Expected sequence number: 425064622

Received a data packet with sequence number 425064622

[ 55 19 55 f8 ae 1e 16 ce 81 93 eb c1 66 37 2e 1b 7b bc 6f ba 55 2e 5a 7f b3 c1 7 70 d3 73 99 88 39 df d0 99 34 3e 1a 36 ]

ACK packet with ACK number 425064652 is sent

[ ff 19 55 f8 cc 62 13 d5 4b ]

Waiting for a packet

Expected sequence number: 425064652

Received a data packet with sequence number 425064652

[ 55 19 55 f8 cc 1e 58 21 5b f3 9f 4b 88 52 e5 92 a3 86 89 86 83 f8 c0 30 5c 5e a8 42 b6 98 f0 ba da f6 c7 27 d9 b0 c2 74 ]

ACK packet with ACK number 425064682 is sent

[ ff 19 55 f8 ea f3 98 8 a ]

Waiting for a packet

Expected sequence number: 425064682

Received a data packet with sequence number 425064682

[ 55 19 55 f8 ea 1e bf 5 e9 d9 1d 8b cd dd 93 bc 4e 77 f7 4e e4 bf bb c9 aa 52 6e ad 2b cf fe bb 95 b9 ff 12 a4 5e 36 d8 ]

ACK packet with ACK number 425064712 is sent

[ ff 19 55 f9 8 9 19 81 14 ]

Waiting for a packet

Expected sequence number: 425064712

Received a data packet with sequence number 425064712

[ aa 19 55 f9 8 14 8e e 9e cd a5 f 11 dc c5 ed 63 b0 b 3a fc 4f 8d df 49 d2 5e 69 1b 5d ]

ACK packet with ACK number 425064732 is sent

[ ff 19 55 f9 1c 7d 76 d 25 ]

The complete received data:

[ 40 f0 9 b7 b0 50 eb f8 74 47 da e3 e9 2e f8 a9 e3 ff 56 a8 fb 23 da fc 4a d5 12 69 33 dd f2 20 50 92 1b 34 84 27 3c f5 a7 c7 c2 4f 28 b8 18 65 ab 2e d4 3e 34 e1 d8 45 f4 6d da 3b 5d 4c 22 22 6a 20 7d a4 7b 53 93 d dc d3 34 c6 90 6d e3 37 38 42 4c d4 60 38 fe 22 c6 e0 38 3 d8 39 e6 54 1b 13 82 f5 d9 59 90 4f 9f 6b ee 4 1e 9c d6 79 d8 79 54 4e 5c 9b 55 e5 dc 46 6a d2 cb 1 ff f0 95 da 37 49 b5 88 ae d3 bf 88 20 db c2 37 ee eb c0 62 f1 e1 1a 7e 79 36 d8 93 dc 2f 91 a2 69 ee 30 af 27 b5 7c bd 1d 4d ce a3 12 29 e2 45 4e a0 89 30 d5 0 1f 5 a2 b5 5f e2 36 3 37 4f 36 73 e3 f1 51 dc 6c 7b 7d 68 a4 48 2 a d6 17 e0 93 ad a5 e0 f1 5 4 6b d 99 d0 4d 5b 1 d2 ae ed cf 1c 5 5c 1a 52 74 f5 dc ba b0 d 6a 55 6c 17 f 8c a8 a4 fa 4b eb 3 b5 ec 96 96 e5 be f6 6 b5 43 72 95 ed 93 5d 9c 56 aa 50 e3 5f d7 fb 8c 70 bd 1 c6 40 4a f7 df 63 31 ed 78 e 76 8f 35 7a 24 21 f8 a0 5c 87 e b3 f7 c5 9b e9 51 89 d fb bb d5 19 ab f6 a8 3f 58 92 b8 81 5a f6 69 7a aa c7 a5 93 c4 e7 ba 34 dc 88 69 b5 32 cf 4d 42 ba da c1 a4 26 12 87 25 cd 98 ca 65 dd 7f 70 be f3 b0 39 61 3b 37 9 dd 7c 2d c3 77 d6 f9 31 1c 1e f6 42 3e 2e b5 e5 92 1 10 82 e8 5c 6 b2 59 a5 9f 1a 68 be 9 16 ce 81 93 eb c1 66 37 2e 1b 7b bc 6f ba 55 2e 5a 7f b3 c1 7 70 d3 73 99 88 39 df d0 99 58 21 5b f3 9f 4b 88 52 e5 92 a3 86 89 86 83 f8 c0 30 5c 5e a8 42 b6 98 f0 ba da f6 c7 27 bf 5 e9 d9 1d 8b cd dd 93 bc 4e 77 f7 4e e4 bf bb c9 aa 52 6e ad 2b cf fe bb 95 b9 ff 12 8e e 9e cd a5 f 11 dc c5 ed 63 b0 b 3a fc 4f 8d df 49 d2 ]

Waiting for a packet

###### Integrity field of 1st ACK packet set wrong by RX once, next ACK correct:

The integrity field of ACK packet was set wrong by the Receiver for one ACK. The next ACK is set correctly. In this scenario, the transmitter discards the first ACK and keeps track using a boolean variable. The next ACK is checked without progressing the RC4 algorithm.

**Transmitter:**

500 bytes of data to be sent:

31 73 48 8b a 7a 5d 2a 99 e6 c9 ce 28 90 b d7 de 24 ed 34 19 c0 83 36 e2 f5 53 11 8c ab 59 6c fd 5a 71 8c 68 e1 b4 49 3a fd 62 e6 72 5 e3 1c 7f dc 99 1a 69 57 92 56 9a 8e ed aa 16 70 36 e9 8b c8 e3 5b e3 34 38 b5 82 69 30 2 f2 d6 0 8f 6d 1e 54 20 d1 40 af 4f 9 c6 9c c8 3d 2e 67 9e ce 50 a3 b5 8a 5b ab 88 35 bd f7 d6 b4 56 91 cb 25 58 b2 58 21 92 e8 53 8c 62 97 99 9b f9 18 25 6d f8 19 48 e 84 bb 2f eb 62 5f f9 6 a1 bb 81 18 2e 7c d1 d ff 8f 1 95 3c e8 6b 54 90 df a7 43 f6 4a 91 46 f5 5a 7d 8e 64 59 83 fc 20 6f cc 2a e6 36 8 ad 31 b3 58 2a ed 2f e6 8b a7 86 74 dd 45 ab 85 ab 6e 96 57 e0 81 b0 e8 ed 24 ad 32 33 a2 e4 a fe b2 16 69 63 cc 5c de ea 47 10 55 ff 9 8a 41 dc 18 86 d7 f3 96 b1 be f3 82 c0 5a 81 6a 80 6a 5e 63 75 b0 ef 3f f4 96 1f 3a 72 e2 1f bf 32 79 1c 6 3c 4f af 52 2b 0 6f 4d 15 fa 54 8 1 8c 14 83 6 97 90 59 c7 5 59 83 e4 3 e8 3d 33 f7 cf 42 d2 41 4f 3d 3e 84 84 97 a2 4f 61 b0 ec f3 c6 4a 8c 76 9a c5 2c 88 cf f1 d2 95 b9 8d 6f 3b 1 76 fa fb e4 e b7 f3 97 49 18 83 50 7d c7 df 0 14 6d 1e 78 9 1a 12 39 b9 c3 c3 24 87 ed 38 df 11 b1 25 d0 55 ed 85 d5 5 43 97 3e ba e6 df b4 11 99 d5 27 12 b6 76 55 1f c5 f8 6f 46 82 43 3b 14 f6 57 4d 6d 60 33 ad 1c 58 3a 3c fd 72 2b b5 98 3e 71 b9 12 3f e2 63 38 34 6a 16 6e cb 79 c 57 ad 7b e4 c3 8c d9 52 91 1b a3 ce 11 a3 17 3a f8 8e 35 d4 b2 5d fe aa b3 ee 28 47 39 1e 5b ec 70 8 79 f6 71 b3 0 3a 2e 12 d6 6c b3 79 72 62 e2 15 dc 31 8d 3f 83 f1 b7 41 55 64 5e 56 c4 98 25 1c 89 37 20 8e 91 a1 a9 31 22 4 18 90 80

Sending data packet number with sequence number: 425064232

[ 55 19 55 f7 28 1e 31 73 48 8b a 7a 5d 2a 99 e6 c9 ce 28 90 b d7 de 24 ed 34 19 c0 83 36 e2 f5 53 11 8c ab 10 f0 b2 2e ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 46 0 0 0 0 ]

ACK number of the received ACK: 425064262

ack discarded due to integrity fail

Timeout occured; Timeout number: 1

New timer value is 2secs

Sending data packet number with sequence number: 425064232

[ 55 19 55 f7 28 1e 31 73 48 8b a 7a 5d 2a 99 e6 c9 ce 28 90 b d7 de 24 ed 34 19 c0 83 36 e2 f5 53 11 8c ab 10 f0 b2 2e ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 46 85 48 c7 33 ]

ACK number of the received ACK: 425064262

Sending data packet number with sequence number: 425064262

[ 55 19 55 f7 46 1e 59 6c fd 5a 71 8c 68 e1 b4 49 3a fd 62 e6 72 5 e3 1c 7f dc 99 1a 69 57 92 56 9a 8e ed aa 46 71 2c 22 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 64 3b 44 5b 42 ]

ACK number of the received ACK: 425064292

Sending data packet number with sequence number: 425064292

[ 55 19 55 f7 64 1e 16 70 36 e9 8b c8 e3 5b e3 34 38 b5 82 69 30 2 f2 d6 0 8f 6d 1e 54 20 d1 40 af 4f 9 c6 d0 17 c4 8d ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 82 5b a6 18 8d ]

ACK number of the received ACK: 425064322

Sending data packet number with sequence number: 425064322

[ 55 19 55 f7 82 1e 9c c8 3d 2e 67 9e ce 50 a3 b5 8a 5b ab 88 35 bd f7 d6 b4 56 91 cb 25 58 b2 58 21 92 e8 53 a4 d1 a5 c4 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 a0 c7 dc 5e ec ]

ACK number of the received ACK: 425064352

Sending data packet number with sequence number: 425064352

[ 55 19 55 f7 a0 1e 8c 62 97 99 9b f9 18 25 6d f8 19 48 e 84 bb 2f eb 62 5f f9 6 a1 bb 81 18 2e 7c d1 d ff 10 e4 66 83 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 be ca b 7c 3e ]

ACK number of the received ACK: 425064382

Sending data packet number with sequence number: 425064382

[ 55 19 55 f7 be 1e 8f 1 95 3c e8 6b 54 90 df a7 43 f6 4a 91 46 f5 5a 7d 8e 64 59 83 fc 20 6f cc 2a e6 36 8 31 f4 70 6d ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 dc 99 47 63 b9 ]

ACK number of the received ACK: 425064412

Sending data packet number with sequence number: 425064412

[ 55 19 55 f7 dc 1e ad 31 b3 58 2a ed 2f e6 8b a7 86 74 dd 45 ab 85 ab 6e 96 57 e0 81 b0 e8 ed 24 ad 32 33 a2 7c ac 96 24 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f7 fa 50 8e a2 a0 ]

ACK number of the received ACK: 425064442

Sending data packet number with sequence number: 425064442

[ 55 19 55 f7 fa 1e e4 a fe b2 16 69 63 cc 5c de ea 47 10 55 ff 9 8a 41 dc 18 86 d7 f3 96 b1 be f3 82 c0 5a be a9 ca 87 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 18 8f f 64 7a ]

ACK number of the received ACK: 425064472

Sending data packet number with sequence number: 425064472

[ 55 19 55 f8 18 1e 81 6a 80 6a 5e 63 75 b0 ef 3f f4 96 1f 3a 72 e2 1f bf 32 79 1c 6 3c 4f af 52 2b 0 6f 4d 72 a6 da 42 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 36 f9 bc 1d 39 ]

ACK number of the received ACK: 425064502

Sending data packet number with sequence number: 425064502

[ 55 19 55 f8 36 1e 15 fa 54 8 1 8c 14 83 6 97 90 59 c7 5 59 83 e4 3 e8 3d 33 f7 cf 42 d2 41 4f 3d 3e 84 f4 6c f2 19 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 54 27 11 53 d4 ]

ACK number of the received ACK: 425064532

Sending data packet number with sequence number: 425064532

[ 55 19 55 f8 54 1e 84 97 a2 4f 61 b0 ec f3 c6 4a 8c 76 9a c5 2c 88 cf f1 d2 95 b9 8d 6f 3b 1 76 fa fb e4 e c8 10 69 ec ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 72 e3 55 ec bc ]

ACK number of the received ACK: 425064562

Sending data packet number with sequence number: 425064562

[ 55 19 55 f8 72 1e b7 f3 97 49 18 83 50 7d c7 df 0 14 6d 1e 78 9 1a 12 39 b9 c3 c3 24 87 ed 38 df 11 b1 25 59 33 4 f ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 90 5b 73 76 94 ]

ACK number of the received ACK: 425064592

Sending data packet number with sequence number: 425064592

[ 55 19 55 f8 90 1e d0 55 ed 85 d5 5 43 97 3e ba e6 df b4 11 99 d5 27 12 b6 76 55 1f c5 f8 6f 46 82 43 3b 14 ca bb c9 bb ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 ae 41 9a 10 2b ]

ACK number of the received ACK: 425064622

Sending data packet number with sequence number: 425064622

[ 55 19 55 f8 ae 1e f6 57 4d 6d 60 33 ad 1c 58 3a 3c fd 72 2b b5 98 3e 71 b9 12 3f e2 63 38 34 6a 16 6e cb 79 1 35 f0 73 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 cc 62 13 d5 4b ]

ACK number of the received ACK: 425064652

Sending data packet number with sequence number: 425064652

[ 55 19 55 f8 cc 1e c 57 ad 7b e4 c3 8c d9 52 91 1b a3 ce 11 a3 17 3a f8 8e 35 d4 b2 5d fe aa b3 ee 28 47 39 be aa 41 31 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f8 ea f3 98 8 a ]

ACK number of the received ACK: 425064682

Sending data packet number with sequence number: 425064682

[ 55 19 55 f8 ea 1e 1e 5b ec 70 8 79 f6 71 b3 0 3a 2e 12 d6 6c b3 79 72 62 e2 15 dc 31 8d 3f 83 f1 b7 41 55 d0 f2 81 e5 ]

Waiting for ACK

ACK packet received

[ ff 19 55 f9 8 9 19 81 14 ]

ACK number of the received ACK: 425064712

Sending data packet number with sequence number: 425064712

[ aa 19 55 f9 8 14 64 5e 56 c4 98 25 1c 89 37 20 8e 91 a1 a9 31 22 4 18 90 80 62 2b 1d be ]

Waiting for ACK

ACK packet received

[ ff 19 55 f9 1c 7d 76 d 25 ]

ACK number of the received ACK: 425064732

**Receiver:**

Waiting for a packet

Expected sequence number: 425064232

Received a data packet with sequence number 425064232

[ 55 19 55 f7 28 1e 31 73 48 8b a 7a 5d 2a 99 e6 c9 ce 28 90 b d7 de 24 ed 34 19 c0 83 36 e2 f5 53 11 8c ab 10 f0 b2 2e ]

ACK packet with ACK number 425064262 is sent

[ ff 19 55 f7 46 0 0 0 0 ]

Waiting for a packet

Expected sequence number: 425064262

Received a data packet with sequence number 425064232

[ 55 19 55 f7 28 1e 31 73 48 8b a 7a 5d 2a 99 e6 c9 ce 28 90 b d7 de 24 ed 34 19 c0 83 36 e2 f5 53 11 8c ab 10 f0 b2 2e ]

Duplicate packet: discarded; ACK with expected seq num sent

ACK packet with ACK number 425064262 is sent

[ ff 19 55 f7 46 85 48 c7 33 ]

Waiting for a packet

Expected sequence number: 425064262

Received a data packet with sequence number 425064262

[ 55 19 55 f7 46 1e 59 6c fd 5a 71 8c 68 e1 b4 49 3a fd 62 e6 72 5 e3 1c 7f dc 99 1a 69 57 92 56 9a 8e ed aa 46 71 2c 22 ]

ACK packet with ACK number 425064292 is sent

[ ff 19 55 f7 64 3b 44 5b 42 ]

Waiting for a packet

Expected sequence number: 425064292

Received a data packet with sequence number 425064292

[ 55 19 55 f7 64 1e 16 70 36 e9 8b c8 e3 5b e3 34 38 b5 82 69 30 2 f2 d6 0 8f 6d 1e 54 20 d1 40 af 4f 9 c6 d0 17 c4 8d ]

ACK packet with ACK number 425064322 is sent

[ ff 19 55 f7 82 5b a6 18 8d ]

Waiting for a packet

Expected sequence number: 425064322

Received a data packet with sequence number 425064322

[ 55 19 55 f7 82 1e 9c c8 3d 2e 67 9e ce 50 a3 b5 8a 5b ab 88 35 bd f7 d6 b4 56 91 cb 25 58 b2 58 21 92 e8 53 a4 d1 a5 c4 ]

ACK packet with ACK number 425064352 is sent

[ ff 19 55 f7 a0 c7 dc 5e ec ]

Waiting for a packet

Expected sequence number: 425064352

Received a data packet with sequence number 425064352

[ 55 19 55 f7 a0 1e 8c 62 97 99 9b f9 18 25 6d f8 19 48 e 84 bb 2f eb 62 5f f9 6 a1 bb 81 18 2e 7c d1 d ff 10 e4 66 83 ]

ACK packet with ACK number 425064382 is sent

[ ff 19 55 f7 be ca b 7c 3e ]

Waiting for a packet

Expected sequence number: 425064382

Received a data packet with sequence number 425064382

[ 55 19 55 f7 be 1e 8f 1 95 3c e8 6b 54 90 df a7 43 f6 4a 91 46 f5 5a 7d 8e 64 59 83 fc 20 6f cc 2a e6 36 8 31 f4 70 6d ]

ACK packet with ACK number 425064412 is sent

[ ff 19 55 f7 dc 99 47 63 b9 ]

Waiting for a packet

Expected sequence number: 425064412

Received a data packet with sequence number 425064412

[ 55 19 55 f7 dc 1e ad 31 b3 58 2a ed 2f e6 8b a7 86 74 dd 45 ab 85 ab 6e 96 57 e0 81 b0 e8 ed 24 ad 32 33 a2 7c ac 96 24 ]

ACK packet with ACK number 425064442 is sent

[ ff 19 55 f7 fa 50 8e a2 a0 ]

Waiting for a packet

Expected sequence number: 425064442

Received a data packet with sequence number 425064442

[ 55 19 55 f7 fa 1e e4 a fe b2 16 69 63 cc 5c de ea 47 10 55 ff 9 8a 41 dc 18 86 d7 f3 96 b1 be f3 82 c0 5a be a9 ca 87 ]

ACK packet with ACK number 425064472 is sent

[ ff 19 55 f8 18 8f f 64 7a ]

Waiting for a packet

Expected sequence number: 425064472

Received a data packet with sequence number 425064472

[ 55 19 55 f8 18 1e 81 6a 80 6a 5e 63 75 b0 ef 3f f4 96 1f 3a 72 e2 1f bf 32 79 1c 6 3c 4f af 52 2b 0 6f 4d 72 a6 da 42 ]

ACK packet with ACK number 425064502 is sent

[ ff 19 55 f8 36 f9 bc 1d 39 ]

Waiting for a packet

Expected sequence number: 425064502

Received a data packet with sequence number 425064502

[ 55 19 55 f8 36 1e 15 fa 54 8 1 8c 14 83 6 97 90 59 c7 5 59 83 e4 3 e8 3d 33 f7 cf 42 d2 41 4f 3d 3e 84 f4 6c f2 19 ]

ACK packet with ACK number 425064532 is sent

[ ff 19 55 f8 54 27 11 53 d4 ]

Waiting for a packet

Expected sequence number: 425064532

Received a data packet with sequence number 425064532

[ 55 19 55 f8 54 1e 84 97 a2 4f 61 b0 ec f3 c6 4a 8c 76 9a c5 2c 88 cf f1 d2 95 b9 8d 6f 3b 1 76 fa fb e4 e c8 10 69 ec ]

ACK packet with ACK number 425064562 is sent

[ ff 19 55 f8 72 e3 55 ec bc ]

Waiting for a packet

Expected sequence number: 425064562

Received a data packet with sequence number 425064562

[ 55 19 55 f8 72 1e b7 f3 97 49 18 83 50 7d c7 df 0 14 6d 1e 78 9 1a 12 39 b9 c3 c3 24 87 ed 38 df 11 b1 25 59 33 4 f ]

ACK packet with ACK number 425064592 is sent

[ ff 19 55 f8 90 5b 73 76 94 ]

Waiting for a packet

Expected sequence number: 425064592

Received a data packet with sequence number 425064592

[ 55 19 55 f8 90 1e d0 55 ed 85 d5 5 43 97 3e ba e6 df b4 11 99 d5 27 12 b6 76 55 1f c5 f8 6f 46 82 43 3b 14 ca bb c9 bb ]

ACK packet with ACK number 425064622 is sent

[ ff 19 55 f8 ae 41 9a 10 2b ]

Waiting for a packet

Expected sequence number: 425064622

Received a data packet with sequence number 425064622

[ 55 19 55 f8 ae 1e f6 57 4d 6d 60 33 ad 1c 58 3a 3c fd 72 2b b5 98 3e 71 b9 12 3f e2 63 38 34 6a 16 6e cb 79 1 35 f0 73 ]

ACK packet with ACK number 425064652 is sent

[ ff 19 55 f8 cc 62 13 d5 4b ]

Waiting for a packet

Expected sequence number: 425064652

Received a data packet with sequence number 425064652

[ 55 19 55 f8 cc 1e c 57 ad 7b e4 c3 8c d9 52 91 1b a3 ce 11 a3 17 3a f8 8e 35 d4 b2 5d fe aa b3 ee 28 47 39 be aa 41 31 ]

ACK packet with ACK number 425064682 is sent

[ ff 19 55 f8 ea f3 98 8 a ]

Waiting for a packet

Expected sequence number: 425064682

Received a data packet with sequence number 425064682

[ 55 19 55 f8 ea 1e 1e 5b ec 70 8 79 f6 71 b3 0 3a 2e 12 d6 6c b3 79 72 62 e2 15 dc 31 8d 3f 83 f1 b7 41 55 d0 f2 81 e5 ]

ACK packet with ACK number 425064712 is sent

[ ff 19 55 f9 8 9 19 81 14 ]

Waiting for a packet

Expected sequence number: 425064712

Received a data packet with sequence number 425064712

[ aa 19 55 f9 8 14 64 5e 56 c4 98 25 1c 89 37 20 8e 91 a1 a9 31 22 4 18 90 80 62 2b 1d be ]

ACK packet with ACK number 425064732 is sent

[ ff 19 55 f9 1c 7d 76 d 25 ]

The complete received data:

[ 31 73 48 8b a 7a 5d 2a 99 e6 c9 ce 28 90 b d7 de 24 ed 34 19 c0 83 36 e2 f5 53 11 8c ab 59 6c fd 5a 71 8c 68 e1 b4 49 3a fd 62 e6 72 5 e3 1c 7f dc 99 1a 69 57 92 56 9a 8e ed aa 16 70 36 e9 8b c8 e3 5b e3 34 38 b5 82 69 30 2 f2 d6 0 8f 6d 1e 54 20 d1 40 af 4f 9 c6 9c c8 3d 2e 67 9e ce 50 a3 b5 8a 5b ab 88 35 bd f7 d6 b4 56 91 cb 25 58 b2 58 21 92 e8 53 8c 62 97 99 9b f9 18 25 6d f8 19 48 e 84 bb 2f eb 62 5f f9 6 a1 bb 81 18 2e 7c d1 d ff 8f 1 95 3c e8 6b 54 90 df a7 43 f6 4a 91 46 f5 5a 7d 8e 64 59 83 fc 20 6f cc 2a e6 36 8 ad 31 b3 58 2a ed 2f e6 8b a7 86 74 dd 45 ab 85 ab 6e 96 57 e0 81 b0 e8 ed 24 ad 32 33 a2 e4 a fe b2 16 69 63 cc 5c de ea 47 10 55 ff 9 8a 41 dc 18 86 d7 f3 96 b1 be f3 82 c0 5a 81 6a 80 6a 5e 63 75 b0 ef 3f f4 96 1f 3a 72 e2 1f bf 32 79 1c 6 3c 4f af 52 2b 0 6f 4d 15 fa 54 8 1 8c 14 83 6 97 90 59 c7 5 59 83 e4 3 e8 3d 33 f7 cf 42 d2 41 4f 3d 3e 84 84 97 a2 4f 61 b0 ec f3 c6 4a 8c 76 9a c5 2c 88 cf f1 d2 95 b9 8d 6f 3b 1 76 fa fb e4 e b7 f3 97 49 18 83 50 7d c7 df 0 14 6d 1e 78 9 1a 12 39 b9 c3 c3 24 87 ed 38 df 11 b1 25 d0 55 ed 85 d5 5 43 97 3e ba e6 df b4 11 99 d5 27 12 b6 76 55 1f c5 f8 6f 46 82 43 3b 14 f6 57 4d 6d 60 33 ad 1c 58 3a 3c fd 72 2b b5 98 3e 71 b9 12 3f e2 63 38 34 6a 16 6e cb 79 c 57 ad 7b e4 c3 8c d9 52 91 1b a3 ce 11 a3 17 3a f8 8e 35 d4 b2 5d fe aa b3 ee 28 47 39 1e 5b ec 70 8 79 f6 71 b3 0 3a 2e 12 d6 6c b3 79 72 62 e2 15 dc 31 8d 3f 83 f1 b7 41 55 64 5e 56 c4 98 25 1c 89 37 20 8e 91 a1 a9 31 22 4 18 90 80 ]

Waiting for a packet

###### Initial sequence number wrong:

There was a problem in synchronizing the sequence number of transmitter and receiver. In this case, no packets are accepted by the receiver or transmitter.

**Transmitter:**

500 bytes of data to be sent:

41 d0 95 15 87 83 80 3e 3 65 68 51 7 3a 34 a8 1 50 2d a5 48 ca 64 6f 96 6 3 e7 bd ff 15 55 94 7e 7d 1c d6 3a 7d 25 49 62 5a 5f 9e 4b a5 81 7d c3 5e a3 b6 78 a9 4f ef 72 f 55 7a dd c f9 13 b1 63 7 94 c8 79 17 23 2e 83 b 4f c 8d d2 ba 92 20 59 63 54 59 52 9c df 3d a0 12 21 fb 5f 53 2a a1 88 c9 d d6 26 c5 65 20 6c ae 19 95 fc f5 50 78 f6 ba d2 99 18 8c 23 94 f2 4c 18 20 bf dc 6e 5c 2d 62 b8 be d0 79 bb e7 aa d5 2 e8 54 a1 fe fe 4f 48 a0 62 8e 3 e8 53 3c b4 16 9b 2f ab 8f fc 16 b0 7b fc c2 1e 5 5 81 e0 74 64 8e e5 fb a5 16 40 e1 37 29 18 1f 3b b5 19 ea 54 df b1 c4 3a f3 e5 d8 41 ba a5 9a 5b 96 71 77 59 21 1b cb 37 e7 f7 1 bc 7e 38 ca ec 2f d 5f f3 b4 51 d7 dc b9 9a 77 39 f4 93 4 25 8b 2d b9 dd d2 53 a3 3e df 68 17 7b e0 a1 10 3c 1e 69 d5 8 58 e6 5c 62 ce 4c e d7 16 83 fa 46 7c 3c ec 13 ee ce d2 3a b0 b0 cf 91 34 e8 a5 53 82 c6 e4 f1 c2 3b c1 2e e3 da da ac 5c a1 b1 fa c3 cd 32 ee f9 83 f1 52 9d 93 f2 11 d5 74 80 f3 cd 4 11 13 0 11 21 fa 62 9 ab 47 4c 2f 7b 9f 91 90 9b 42 b6 9d e3 e7 6a f6 71 46 da 0 e0 3e de c7 8e 68 78 9d f4 92 34 0 75 d3 3e 4 b3 d2 b4 3a ae 42 f3 fa ab b6 a 62 a 39 d6 1d a4 d4 d7 f5 17 9a 45 6 8a 3a 64 cc 7f 8a 80 7 fe 26 a1 4 8 a8 66 ae e 72 ba 88 73 1b b2 ad f2 2b a4 39 d0 4 4e eb 4f 26 9d dd 1b b1 e3 b9 d8 14 41 2d 8 28 fa 7e 3 fe 5d b8 20 76 10 69 2e 6f 36 83 39 6d 8d dc ef ef 64 87 eb 1f 35 a9 75 fe a7 73 8c 0 2f 66 f8 b6 19 68 91 3e 51 5d 3d 4f 8b 86 38 4b d1 dc 38 fe b9 83 bb 9e 1f fd eb 60 14 9e bd af 1a 13 e4 6e 94

Sending data packet number with sequence number: 425064233

[ 55 19 55 f7 29 1e 41 d0 95 15 87 83 80 3e 3 65 68 51 7 3a 34 a8 1 50 2d a5 48 ca 64 6f 96 6 3 e7 bd ff f8 a4 31 84 ]

Waiting for ACK

Timeout occured; Timeout number: 1

New timer value is 2secs

Sending data packet number with sequence number: 425064233

[ 55 19 55 f7 29 1e 41 d0 95 15 87 83 80 3e 3 65 68 51 7 3a 34 a8 1 50 2d a5 48 ca 64 6f 96 6 3 e7 bd ff f8 a4 31 84 ]

Waiting for ACK

Timeout occured; Timeout number: 2

New timer value is 4secs

Sending data packet number with sequence number: 425064233

[ 55 19 55 f7 29 1e 41 d0 95 15 87 83 80 3e 3 65 68 51 7 3a 34 a8 1 50 2d a5 48 ca 64 6f 96 6 3 e7 bd ff f8 a4 31 84 ]

Waiting for ACK

Timeout occured; Timeout number: 3

New timer value is 8secs

Sending data packet number with sequence number: 425064233

[ 55 19 55 f7 29 1e 41 d0 95 15 87 83 80 3e 3 65 68 51 7 3a 34 a8 1 50 2d a5 48 ca 64 6f 96 6 3 e7 bd ff f8 a4 31 84 ]

Waiting for ACK

Timeout occured; Timeout number: 4

Communication Failure; java.net.SocketTimeoutException: Receive timed out

**Receiver:**

Waiting for a packet

Expected sequence number: 425064232

Received a data packet with sequence number 425064233

[ 55 19 55 f7 29 1e 41 d0 95 15 87 83 80 3e 3 65 68 51 7 3a 34 a8 1 50 2d a5 48 ca 64 6f 96 6 3 e7 bd ff f8 a4 31 84 ]

Data packet discarded due to wrong sequence number

Waiting for a packet

Expected sequence number: 425064232

Received a data packet with sequence number 425064233

[ 55 19 55 f7 29 1e 41 d0 95 15 87 83 80 3e 3 65 68 51 7 3a 34 a8 1 50 2d a5 48 ca 64 6f 96 6 3 e7 bd ff f8 a4 31 84 ]

Data packet discarded due to wrong sequence number

Waiting for a packet

Expected sequence number: 425064232

Received a data packet with sequence number 425064233

[ 55 19 55 f7 29 1e 41 d0 95 15 87 83 80 3e 3 65 68 51 7 3a 34 a8 1 50 2d a5 48 ca 64 6f 96 6 3 e7 bd ff f8 a4 31 84 ]

Data packet discarded due to wrong sequence number

Waiting for a packet

Expected sequence number: 425064232

Received a data packet with sequence number 425064233

[ 55 19 55 f7 29 1e 41 d0 95 15 87 83 80 3e 3 65 68 51 7 3a 34 a8 1 50 2d a5 48 ca 64 6f 96 6 3 e7 bd ff f8 a4 31 84 ]

Data packet discarded due to wrong sequence number

Waiting for a packet

**Please refer to Project\_Output.docx for more scenarios.**