

Foundations of Cybersecurity

Project documentation

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# Introduction

This project is about the implementation of a Client-Server application that resembles Cloud Storage.

Each user has a dedicated storage on the server, and each of them can only access their own dedicated storage.

After the authentication phase, in which the client must authenticate with the server, the client can upload, download, rename or delete data to/from the Cloud Storage in a safe manner.

Users are pre-registered on the server, specifically there are four users. Each user has a long-term RSA key-pair, and the long-term private key is password-protected. The server knows the username of every registered user and the RSA public key of every user. For each registered user, the server has already allocated the user dedicated storage. In the following table (Table 1) are show the four pre-registered users with their username and password.

|  |  |  |
| --- | --- | --- |
| User | Username | Password |
| Alice | alice | alice |
| Bob | bob | bobb |
| Carol | carol | carol |
| Dave | dave | dave |

Table 1 - Pre-registered users

# Authentication phase

When the client application starts, Server and Client must authenticate.

The Server must authenticate with the public key certified by the certification authority, while the Client must authenticate with the public key pre-shared with the server.

The communication between the Client and the Server for the authentication and the establishment of the session key is shown in the image below (Figure 1).

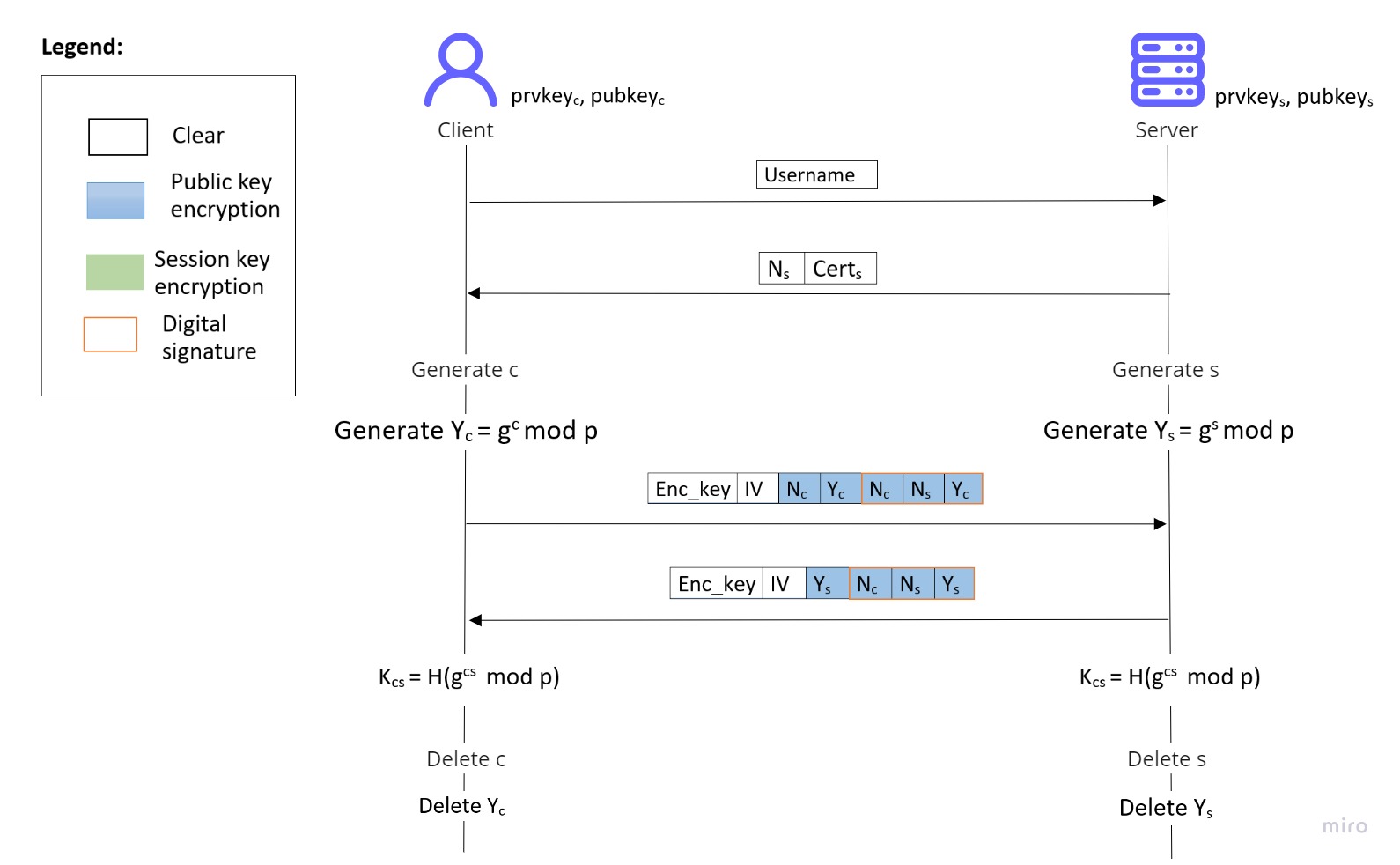


Figure 1 - Authentication phase sequence diagram

As you can see from the sequence diagram, the first message the client transmits is its username. This message is sent in clear.

After receiving the Client’s username, the Server verifies that the username belongs to a pre-registered user. If the check is not successful, the server closes the connection and the authentication phase fails.

If instead the verification is successful, the server sends to the client its nonce and its certificate. This message is sent in clear.

After this message, Client and Server generates their public key following *Diffie-Hellman* key generation protocol.

In the next step, the Client concatenates its public key with its nonce and the server nonce. (S)He signs this message with its private key to prove the server his identity. Then, (s)he concatenates this signature with its nonce and its public key and encrypts the concatenation by means of the server’s public key. Finally, (s)he concatenates this message with a random IV and additional information that are necessary for the asymmetric encryption and then (s)he sends the message to the server.

The server follows the same procedure that the Client has followed in the previous message. It takes Client’s nonce, its nonce and its public key and signs the whole message. Then, it concatenates the signature with its public key and encrypts it with client’s public key. Finally, it concatenates this message with a random IV and additional information that are necessary for the asymmetric encryption and then it sends it to the Client.

Finally, client and server are both able to generate the session key using the other part public key and their private key following the *Diffie-Hellman* protocol. The shared key is obtained first by deriving the shared secret using the two *Diffie-Hellman* keys and then it is hashed by using SHA-256 algorithm in order to obtain the symmetric key.

# Operations’ implementation

After the authentication phase, in which the client must authenticate with the server, the client can upload, download, rename or delete data to/from the Cloud Storage in a safe manner.

All the message in the session are encrypted with the session key established in the authentication phase and authenticated using the *authenticated encryption*. In particular, all the messages are been encrypted using AES with a key length of 128 bits as a block cipher and *Galois-counter mode* as the encryption mode. For each symmetric encryption, a random generated IV is used, while the AAD is constituted by a counter that counts the number of messages sent by a certain party. It is useful to avoid reply attacks during a single session.

In the following picture is shown the general message format exchanged during the session (Figure 2).

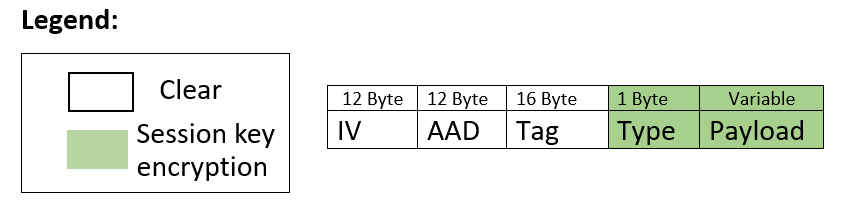
The Type of the message can assume one of the following values:

Figure - General message format

* Update\_request 0x01
* Acknowledgement 0x02
* Not\_ acknowledgement 0x03
* File\_content 0x04
* Download\_request 0x05
* Size 0x06
* Delete\_request 0x07
* Ask\_confirmation 0x08
* List\_request 0x09
* List\_file 0x10
* Rename\_request 0x11
* Logout\_request 0x12

## Upload

The communication between the Client and the Server for the upload operation is shown in the image below (Figure 3).

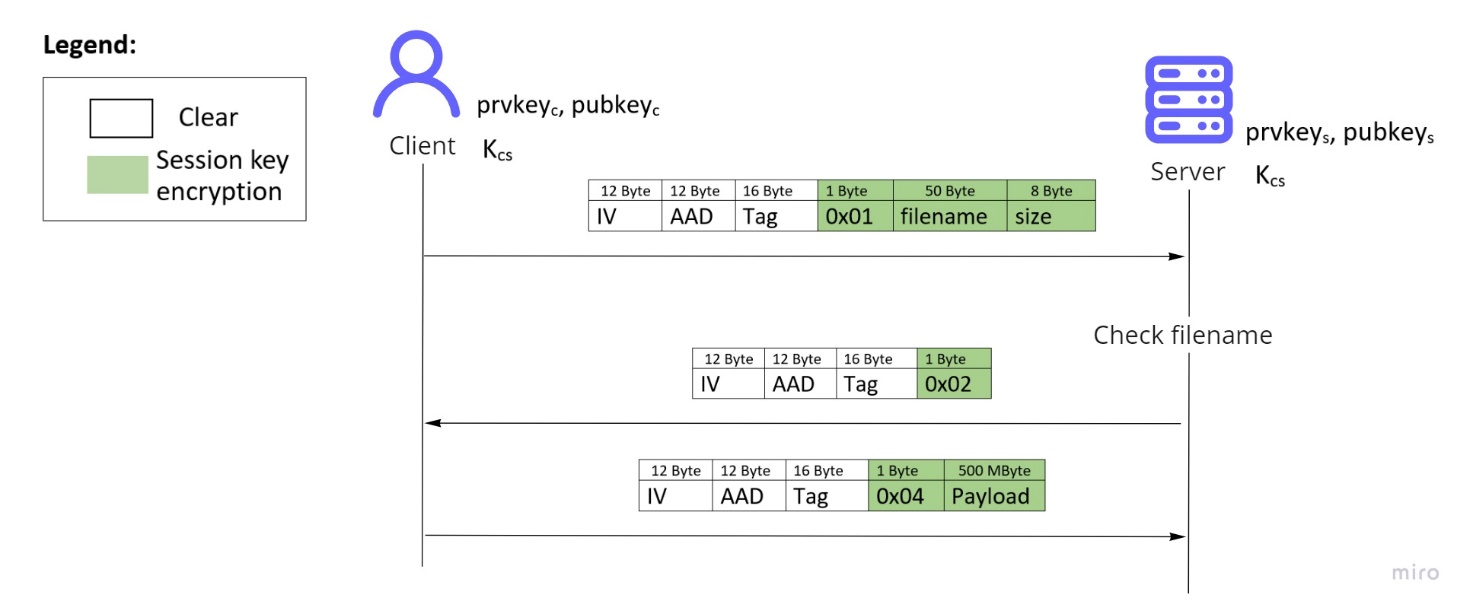
DESCRIZIONE….

Figure - Upload sequence diagram

## Download

The communication between the Client and the Server for the download operation is shown in the image below (Figure 4).

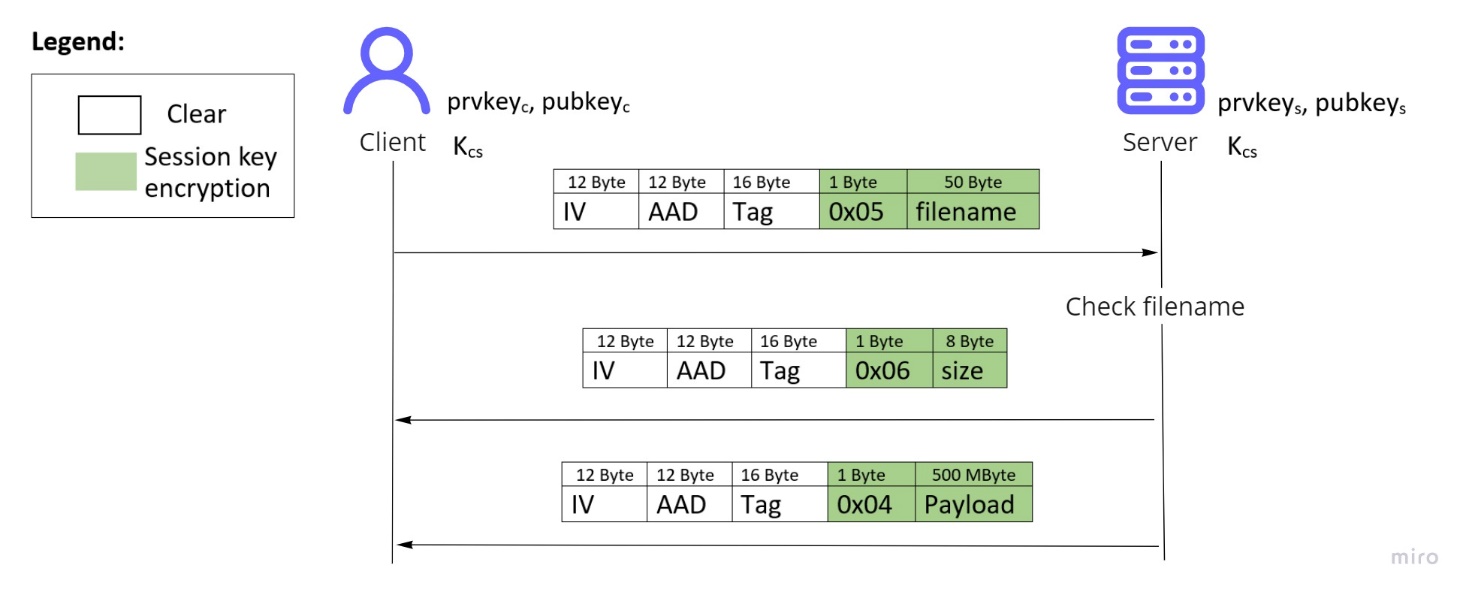
DESCRIZIONE….

Figure - Download sequence diagram

## Delete

The communication between the Client and the Server for the delete operation is shown in the image below (Figure 5).

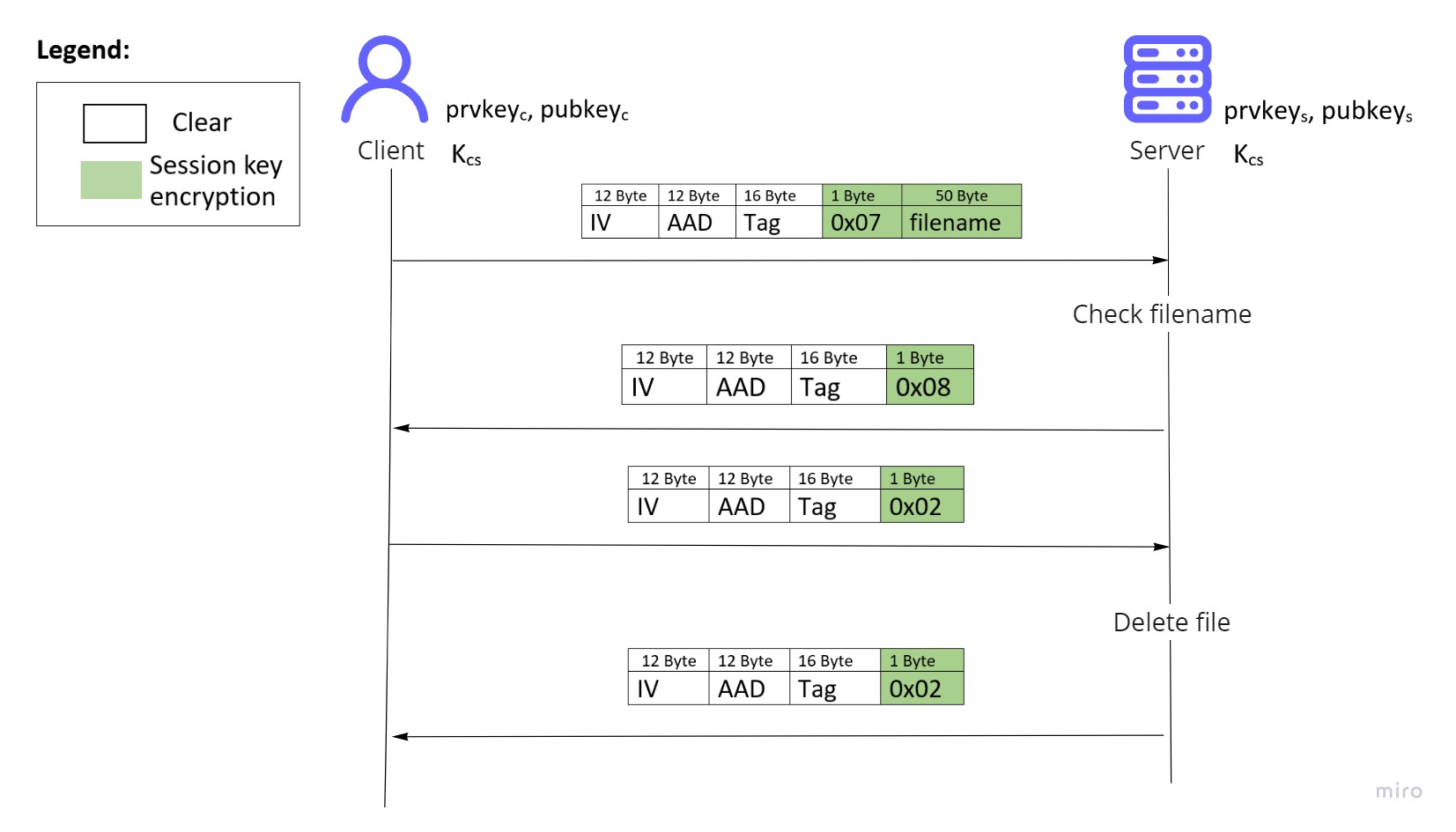


Figure - Delete sequence diagram

DESCRIZIONE….

## List

The communication between the Client and the Server for the list operation is shown in the image below (Figure 6).

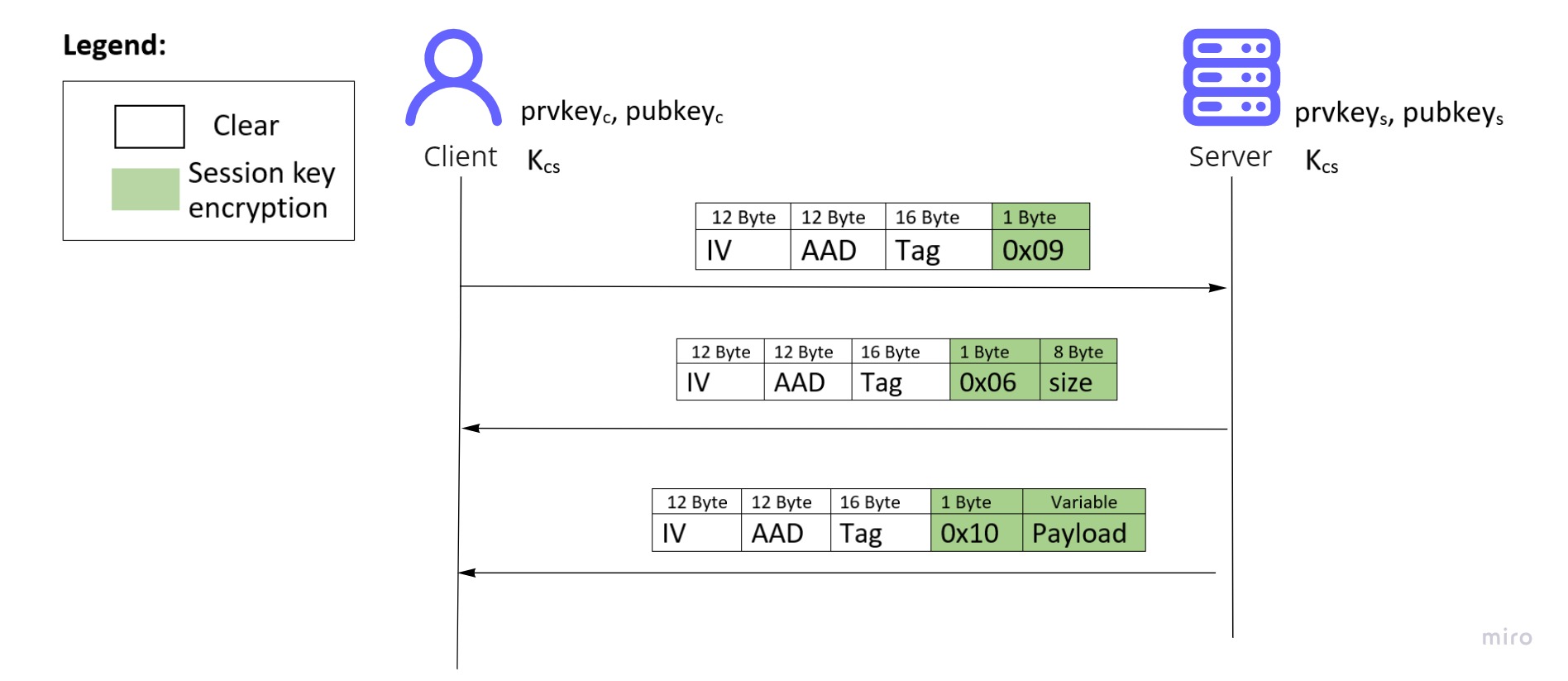


Figure 6 - List sequence diagram

DESCRIZIONE….

## Rename

The communication between the Client and the Server for the rename operation is shown in the image below (Figure 7).

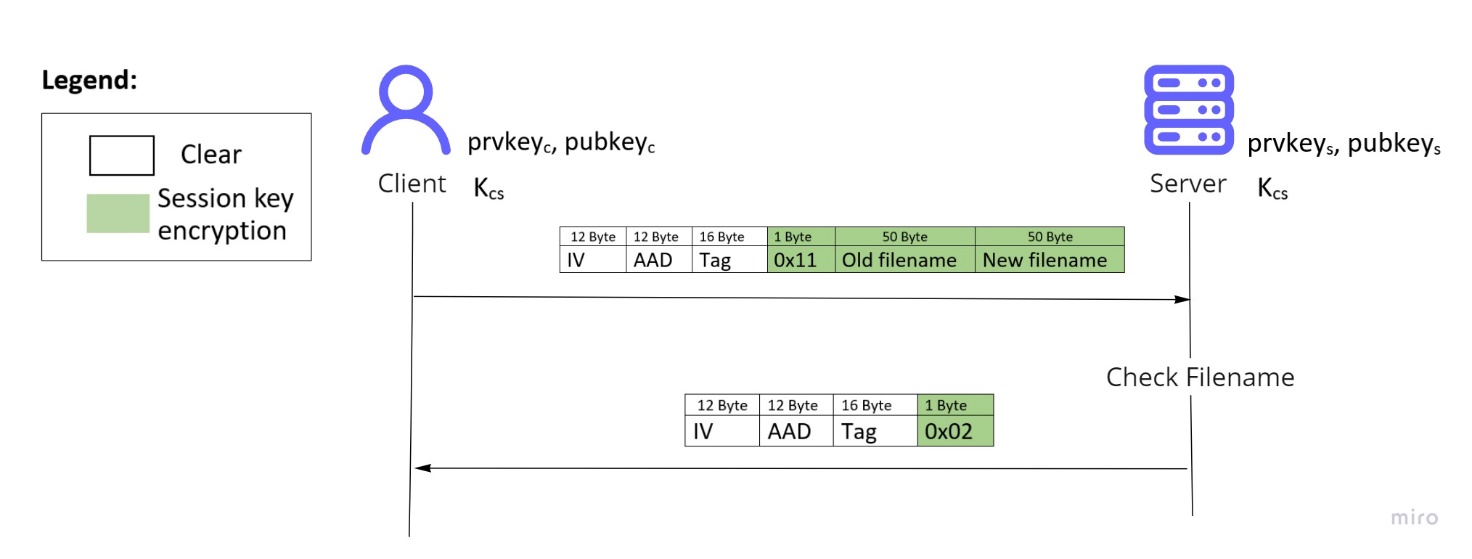
DESCRIZIONE….

Figure - Rename sequence diagram

## Logout

The communication between the Client and the Server for the logout operation is shown in the image below (Figure 8).

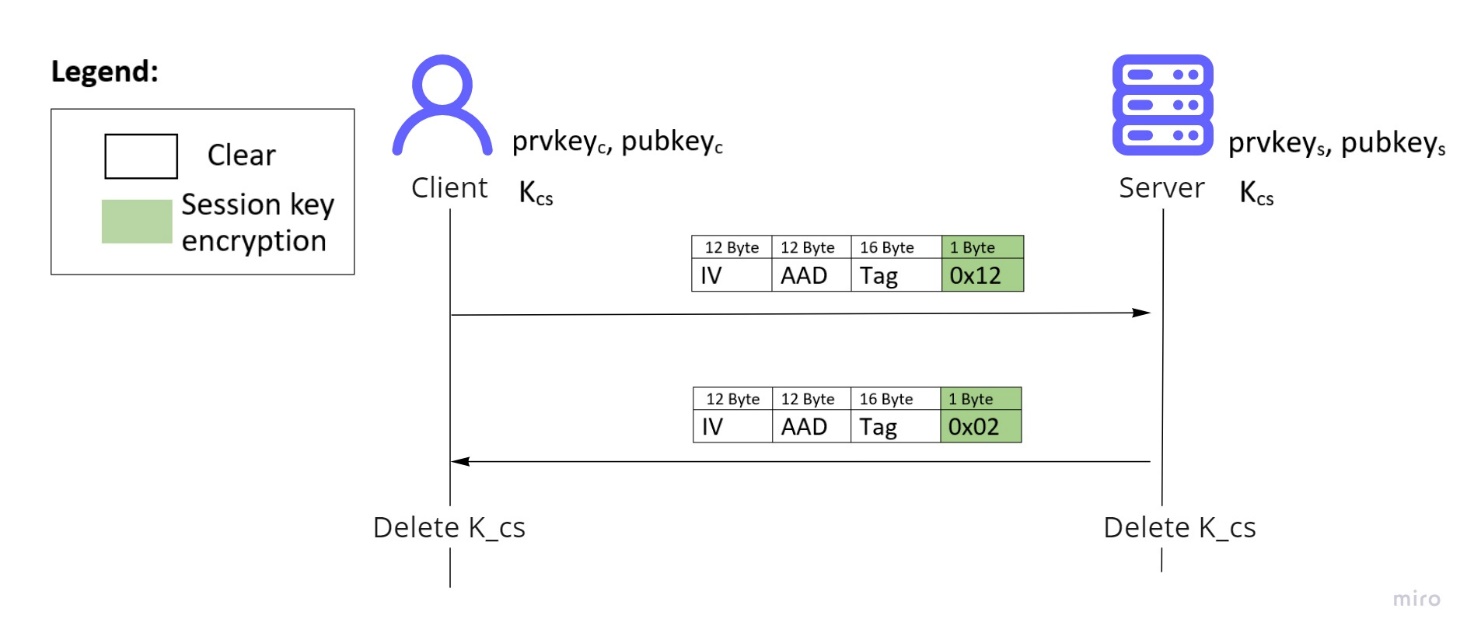
DESCRIZIONE….

Figure - Logout sequence diagram

# Meeting the security requirements

The security requirements where **Perfect Forward Secrecy**, **encryption and authentication** of the entire session and **resistance to reply attacks**.

**Perfect Forward Secrecy** is guaranteed by the *Ephemeral Diffie-Hellman key exchange*.

**Encryption and authentication** is achieved using *authenticated encryption*. In particular, all the session messages are been encrypted using *AES* with a key length of 128 bits as a block cipher and *Galois-counter mode* as the encryption mode. For each symmetric encryption a random generated IV is used to avoid predictability.

**Resistance to reply attacks** in the authentication phase is given by the use of *Ephemeral Diffie-Hellman*, while during data exchange is given by an incremental counter that is sent in the AAD field of every session message.

# User manual