Secure Messenger Design

Setup

Server-Client Model Architecture:

This design is a server-client model where the server will be used for initial discovery, key exchange, and user authentication but messages will be transmitted between the clients (peer-to-peer). The server and clients will store the shared server-client keys for the duration that the client is logged in and the server is running.

Assumptions

Type of Keys/Who knows what:

- User only knows their password
- Client software does not store anything regarding users
- Client software is configured to connect to the server's address and port at runtime
- Client software is trustworthy
- Client will know the g and p used by the server to store gWmodp at run time
    - Will be shared securely in the real world
- Server knows which users are registered and their gWmodp's
- Clients and Server stores the generated server-client key only for the duration of the logged in session
- Clients temporarily store client-client generated key for the duration of the session.

Protocols

Authentication Protocol:

I have decided to use password-derived properties in the client, specifically Secure Remote Protocol (SRP) because it allows for mutual authentication of the server and client, protects against any eavesdropping, and eliminates the need to transmit passwords over the network. SRP provides us with a shared key between the client and the server, also allowing for future secure communication between the client and server. A new shared session key will be created every time a user logs out and logs back in. This also provides PFS because the session key is forgotten after that session and cannot be used to decrypt past communication

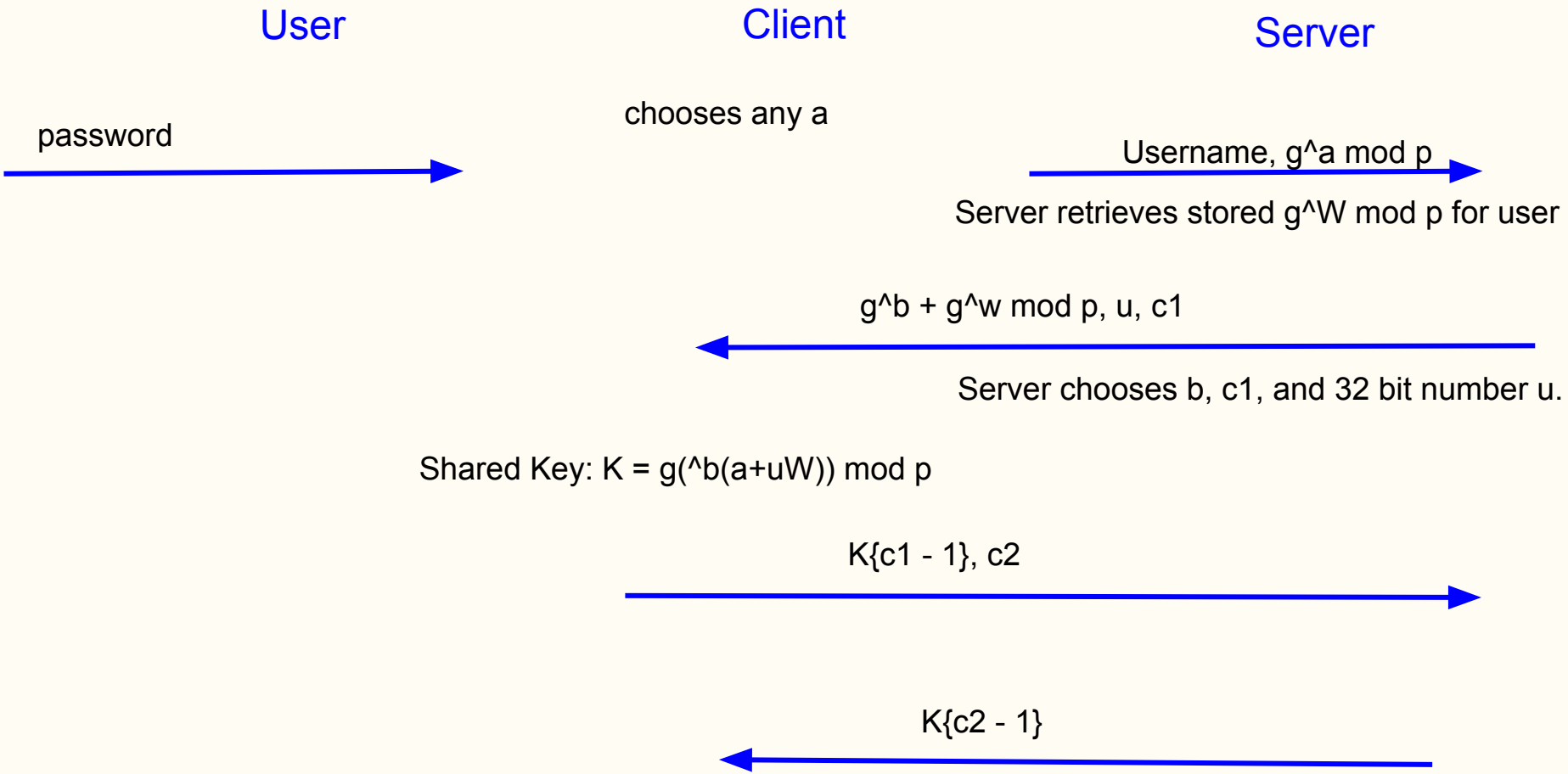
Registration:

Registration is dealt with through a preconfigured file.

Login:

- User provides username and password to client application (assume that the user is already registered).
- Client generates a random private key and computes g^a modp and sends this along with the username to the server.
- Server sends back g^b+g^W mod p, u, c _1
- Client and server compute shared key g^(b(a+uW))mod p
- Client sends c_1 - 1 encrypted using the new shared secret key to prove to the server that it is the user and also sends c_2
- Server decrypts c_1 - 1 using the shared key and verifies that this is the right user and also sends back c_2 - 1 encrypted using the shared key.
- Once the client verifies this, mutual authentication is achieved
- AESGCM is used for encryption

Login:


User
Client
Server
password
chooses any a
Username, g^a mod p
Server retrieves stored g^W mod p for user
g^b + g^w mod p, u, c1
Server chooses b, c1, and 32 bit number u.
Shared Key: K = g(^b(a+uW)) mod p
K{c1 - 1}, c2
K{c2 - 1}

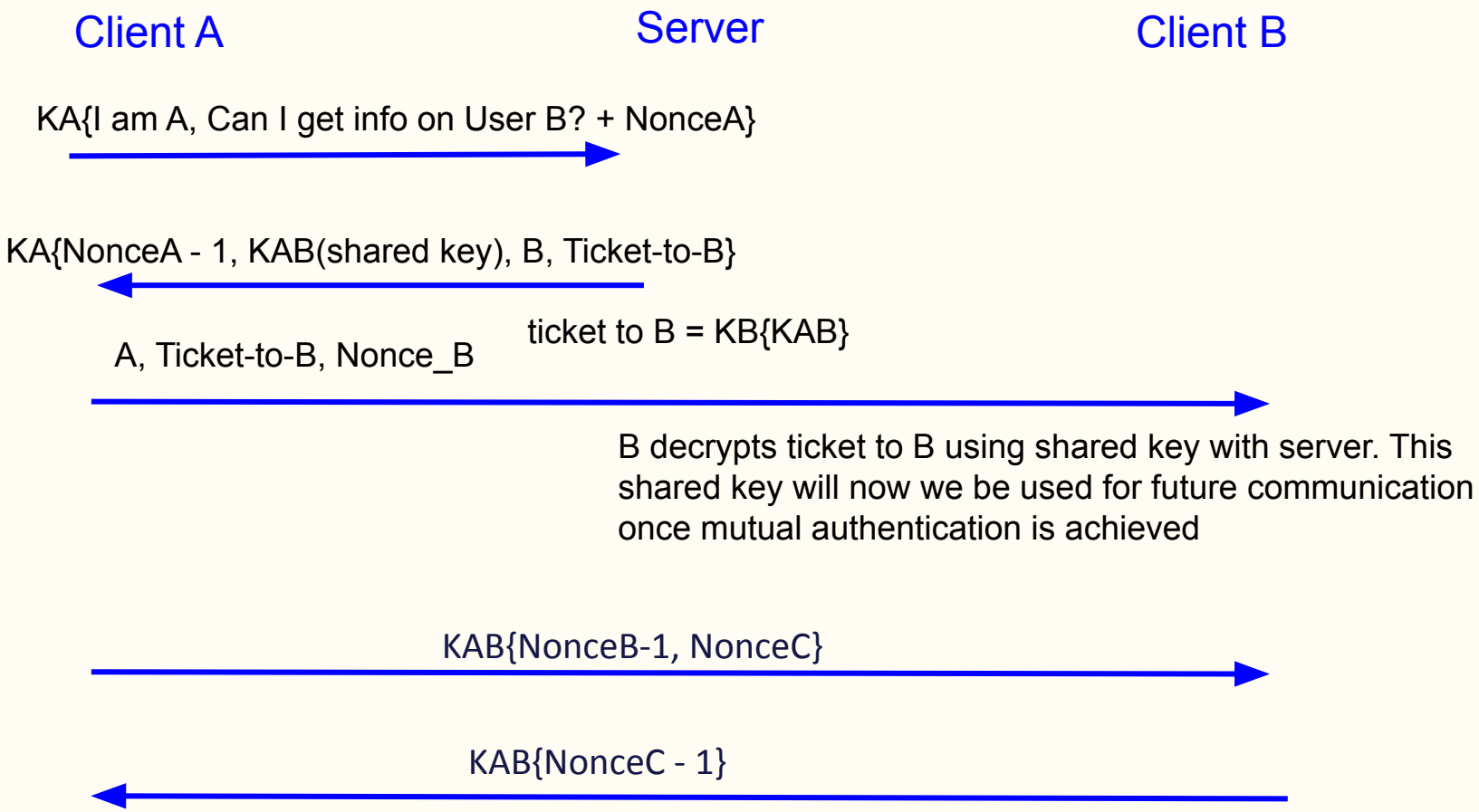
Protocols (Cont.)

Message protocol:

- Client sends a message to the server encrypted using the shared key K with the server which was created during login requesting info about another user.
- The server will respond back with a message encrypted with their shared key which contains another nonce, a shared key that the two clients can use for initial communication, and the IP address of client B so that client A can message them, This message will also contain another message encrypted using the shared key between the server and client B containing the client to client shared key - ticket to B
- Client A decrypts the part of the message that is encrypted with its shared key with the server and retrieves the shared key with the user it wants to talk to and their address
- Client A will send the message encrypted with the shared key between client B and the server to client B (ticket to B) which contains the shared key between the two (client A cannot decrypt this message). The client will also send its identity and a Nonce.
- Client B will decrypt the client-client shared key using the key it has shared with the server.
- Using the retrieved shared key, client B will decrypt the Nonce and send back the Nonce - 1 along with its nonce
- Client A verifies that it can decrypt the message and that the Nonce sent is the nonce that it had sent (- 1)
- Client A sends back Client B's nonce - 1
- Once Client B verifies that the nonce sent by Client A is the nonce that it had sent - 1, Mutual authentication is achieved.
- Future messages are encrypted using this shared key until the session ends

Logout Protocol:

- When the user decides to log out, the client securely deletes/forgets the session key and any other information stored during the session. So, the client application is left with storing no information relating to the user.
- The client message will also send a logout message to the server.
- The server will then forget the user's shared key, IP address, and other any information other than gWmodp.


Client A
Server
Client B
KA{I am A, Can I get info on User B? + NonceA}
KA{NonceA - 1, KAB(shared key), B, Ticket-to-B}
ticket to B = KB{KAB}
A, Ticket-to-B, Nonce_B
B decrypts ticket to B using shared key with server. This shared key will now we be used for future communication once mutual authentication is achieved
KAB{NonceB-1, NonceC}
KAB{NonceC - 1}

Discussion

Services:

Mutual authentication: Mutual authentication is ensured through the use of Secure Remote Protocol (SRP) and Needham Schroeder.

Offline Dictionary Attacks Our choice to use SRP protects against this. When a user registers with the server, instead of storing the password directly, the server stores the gWmodp of a user where W is the password. So, even if the server database was compromised, it is computationally very difficult to crack a password.

Confidentiality: Confidentiality is achieved by establishing shared symmetric keys between clients during communication and between the client and server during login. Messages are encrypted with the key using AESGCM, making them unreadable to unauthorized parties.

DOS protection: DoS protection is achieved through rate limiting on connection requests from clients (a user can only be logged in once at a time), preventing excessive requests from overwhelming the system and ensuring that legitimate users can access resources without interruption. There will also be a temporary account lockout after 4 failed password attempts. This also protects against online dictionary attacks.

PFS: Perfect Forward Secrecy is provided because past communications cannot be decrypted even if future keys are compromised. The shared key between client to client and client and server are all forgotten after a session ends (user logs out or server shuts down)